STATE OF NEW YORK
PUBLIC SERVICE COMMISSION

CASE 20-G-0131 – Proceeding on Motion of the Commission in Regard to Gas Planning Procedures

CASE 22-M-0149 – In the Matter of Assessing Implementation of and Compliance with the Requirements and Targets of the Climate Leadership and Community Protection Act

NATIONAL FUEL GAS DISTRIBUTION CORPORATION
INFORMATIONAL FILING

I. Introduction

On March 19, 2020, the New York State Public Service Commission ("Commission") issued an *Order Instituting Proceeding* [1] (the "Order") in which it initiated a new proceeding to consider issues related to gas utilities' planning procedures (the "Gas Planning Proceeding"). In accordance with the Order, each New York gas utility, including National Fuel Gas Distribution Corporation ("National Fuel" or the "Company") submitted a series of filings that included various supply and demand analyses, proposals for peaking services and moratorium management issues, and reports on current and anticipated demand reducing measures. New York State Department of Public Service Staff ("Staff") also filed a proposal to modernize the gas system planning process, and several stakeholders submitted comments related to the various filings. The Commission reviewed all submissions and on May 12, 2022 issued its *Order Adopting Gas System Planning Process*,[2] which requires each gas utility to develop and file a long-term plan that analyzes, among other things, a 20-year supply and demand outlook.

[1] Case 20-G-0131 – Proceeding on Motion of the Commission in Regard to Gas Planning Procedures, *Order Instituting Proceeding* (issued and effective March 19, 2020).

[2] Case 20-G-0131 – Proceeding on Motion of the Commission in Regard to Gas Planning Procedures, *Order Adopting Gas System Planning Process* (issued and effective May 12, 2022). The Commission also adopted an *Order Adopting Moratorium Management Procedures* as part of the Gas Planning Proceeding. Case 20-G-0131 – Proceeding on Motion of the Commission in Regard to Gas Planning Procedures, *Order Adopting Moratorium Management Procedures* (issued and effective May 12, 2022)

Also on May 12, 2022, the Commission issued its *Order on Implementation of the Climate Leadership and Community Protection Act*[3] (the "CLCPA Implementation Order"). As part of the CLCPA Implementation Order, the Commission initiated a new proceeding to assess the advancements made toward meeting New York's Climate Leadership and Community Protection Act ("CLCPA") mandates and to provide policy guidance for additional actions that are needed to achieve the goals of the CLCPA.

The Gas Planning Proceeding and the proceeding that was initiated under the CLCPA Implementation Order will both play pivotal roles in defining the future of natural gas in New York. Several of the stakeholder comments that were submitted as part of the Gas Planning Proceeding called for the Commission to implement a statewide framework that would facilitate a full transition away from natural gas, permanently phase out natural gas infrastructure, and fully convert to electric service. A statewide requirement for all natural gas customers to fully electrify raises a number of serious concerns for customers generally around affordability and reliability, and would place a significant burden on large industrial customers in particular that rely on natural gas to power their facilities and operations. As the Commission considers the utilities' filings in the Gas Planning Proceeding and continues to develop policies in furtherance of the CLCPA, it is important to consider the practical realities that many long-standing natural gas industrial customers will face if they are obligated to fully electrify. Accordingly, the purpose of the instant informational filing is to share with the Commission what National Fuel has learned from its industrial customers regarding potential barriers to electrification they may face in the future.

II. Natural Gas in New York's Industrial Sector

For years, manufacturers in New York have relied on natural gas as a primary source of energy for their facilities and operations, in part because of the significant cost advantage that it provides. Specifically, according to a 2021 GTI Energy study ("GTI Study"), between 2005 and 2020, natural gas in New York had a 2.4:1 price advantage compared to electricity, which has made it an especially attractive choice for manufacturers with energy-intensive operations.[4]

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[3] Case 22-M-0149 – In the Matter of Assessing Implementation of and Compliance with the Requirements and Targets of the Climate Leadership and Community Protection Act, *Order on Implementation of the Climate Leadership and Community Protection Act* (issued and effective May 12, 2022).

[4] GTI Energy, "New York State Industrial Sector Decarbonization Summary," (December 2021), attached hereto as Attachment A.

Further, the GTI Study indicated that during the same time period New York's industrial sector spent approximately $900 million to $1 billion annually on electricity, while costs for natural gas – which is used in much higher volumes – totaled approximately $600 million to $700 million annually. For these reasons, many manufacturers in New York rely on natural gas to control costs and remain competitive in their local, national and international markets.

Many manufacturers have invested heavily in natural gas equipment to carry out their operations, and certain sectors utilize industrial processes and equipment that would be particularly difficult or impossible to convert to electric service. According to the GTI Study, the most difficult sectors to electrify include: iron and steel production, cement manufacturing, and chemicals and petrochemicals. These sectors are particularly challenging to electrify due to their tightly integrated processes, high-temperature heat demand, long equipment and plant investment lifetimes, and global competition. High-temperature industrial operations are especially difficult to fully electrify. A recent Brookings Institution publication noted the following:

> Process heating is a primary component of industrial energy demand. One of the common challenges in heavy industry is the need for processes to operate at high temperatures. Beyond around 400°C, direct use of renewable heat or electricity for heating, with such equipment as heat pumps or resistance heaters, is impractical. Such temperatures are necessary in the steel, cement, and chemicals industries. Electric arc furnaces can provide very high heat, but they work only in applications where the materials being heated conduct electricity, such as melting steel for recycling. For other applications, combustion is needed.[5]

Similarly, a 2021 report from the Columbia University Center for Global Energy Policy indicated that electrification is not currently a viable pathway to zero emissions for industrial processes like cement and steel production, the fertilizer industry, and heavy-duty transport.[6] Thus, consideration must be given to the practical limitations and barriers to full-electrification of industrial operations.

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[5] Brookings Institution, "The Challenge of Decarbonizing Heavy Industry," (June 2021), available at https://www.brookings.edu/wp-content/uploads/2021/06/FP_20210623_industrial_gross_v2.pdf.

[6] Columbia University Center for Global Energy Policy, "Investing in the US Natural Gas Pipeline System to Support Net-Zero Targets," (April 2021) ("Columbia Study"), available at https://www.energypolicy.columbia.edu/sites/default/files/file-uploads/GasPipelines_CGEP_Report_081721.pdf.

III. Barriers to Electrification for National Fuel's Large Industrial Customers

In late 2020, National Fuel began contacting its large industrial customers to make them aware of the CLCPA and its emissions reduction goals. To date, National Fuel has shared this information with numerous customers and has engaged in more detailed communications with representatives of 24 companies in several different industries, including food, dairy, automotive, chemical, rubber, power generation, steel, paper, asphalt, stone, and wood processing. National Fuel's large industrial customers are generally supportive of emissions reductions, and many have already begun to implement various sustainability programs. Most of these customers, however, expressed serious concerns about full-electrification, particularly due to several anticipated barriers including: (a) availability of technology; (b) upfront capital costs of equipment conversion and capital cost financing; (c) electric utility connection costs; and (d) annual equipment operating costs.

a. Availability of Technology

A major consideration for industrial electrification is whether the requisite technology is available to practically effectuate a full transition from natural gas to electricity as a sole power source. While technology is currently available for certain industrial operations, there are still sectors that are generally more difficult to decarbonize due to technology limitations. Thirteen out of the twenty-four large industrial customers interviewed in-depth indicated that electrification technologies, such as electric boilers and electric arc furnaces, are commercially available. Six out of the twenty-four large industrial customers definitively indicated that the requisite electrification technologies for their operations do not currently exist. Specifically, customers in the high temperature steel processing, chemical and asphault industries, and customers that utilize various drying operations using direct fired heating equipment expressed concern that the technogical advancements are not available at this time. For example, one of National Fuel's large steel rolling customers indicated that it utilizes both natural gas and electric for its furnaces. Natural gas furnaces are used to quickly heat large quantities of steel to temperatures in excess of 2,200°F, while electric furnaces are used to heat smaller quantities of steel up to 1,900°F. The electric furnaces take much longer and can only be used for much smaller quantities of steel. Accordingly, there is no economical way for the customer to utilize electric furnaces for their main rolling mill. Without natural gas furnaces, this customer indicated that it would not be able to continue operating in New York and would be forced to relocate out of state.

b. Upfront Capital Costs of Equipment Conversion and Capital Cost Financing

For those sectors where electrification technologies are available, perhaps the most significant impediment to full-electrification is the cost associated with converting existing equipment that currently operates using natural gas, or installing new equipment. Out of the 24 National Fuel customers interviewed in-depth, 20 expressed major concerns over the cost of conversion, while 2 customers indicated that they would be forced to go out of business if natural gas was not an option. In addition to the equipment conversion costs, the customers also emphasized concerns related to costs associated with engineering and redesiging their processes, lead times associated with procuring new equipment, downtime for the companies and their workers due to the changeover to new equipment, space constraints, and a lack of return on investment on the capital cost. For example, one customer that operates a large industrial steam boiler in National Fuel's service territory investigated electric boilers. While the prices for electric boilers were competitive with the price for natural gas-powered boilers, the customer does not have the capital to replace its current equipment with new boilers.

Further, many of National Fuel's large industrial customers are subsidiaries of national or global organizations, and they are often required to compete within their organizations for capital project funding. Customers expressed concerns about being able to secure funding for the conversion to electrification technologies, which could lead to job and environmental leakage to out of state areas. For example, one of National Fuel's chemical plant customers stated that they do not believe technology exists for their chemical processes to fully electrify, but even if the technology were to develop, the capital cost and increased operating costs would be prohibitive for their business. The customer's product is in an extremely competitive market with no room to adjust margins, so the inability to utilize natural gas as an energy source would ultimately result in site closure and the business being relocated outside of New York.

Additionally, Great Lakes Cheese, a leading national manufacturer and packager of cheese, emphasized how it relies heavily on natural gas-powered equipment, such as steam boilers, water heaters, air heaters, and backup power generators. In total, Great Lakes Cheese estimated that it would cost tens of millions of dollars to convert that equipment to electric, which would be an excessive additional cost of doing business in New York. Great Lakes Cheese recently broke ground on a new $518 million facility in Franklinville and Farmersville, New York, which is the largest economic development project in the history of Cattaraugus County. If Great Lakes Cheese were forced to electrify its operations, however, the cost could have caused the company to choose a different state for the location of its new facility, taking hundreds of jobs and the opportunity for a significant regional economic boost with it.

c. Electric Utility Connection Costs

Customers also expressed concern with the potential lack of electric capacity and the costs associated with upgrading their electric service. To meet growing demand as electric usage increases, infrastruture upgrades will likely be required at various points throughout the electric system, including transmission systems, transformers, substations, service feeds and behind the meter electrical systems. For instance, Great Lakes Cheese has found that there is a significant lack of electrical infrastructure in rural areas of the state, meaning that in many cases, if industrial customers located in these areas were forced to electrify their operations, there is no infrastructure currently in place that would allow them to do so. In fact, Great Lakes Cheese is paying approximately $11,000,000 out-of-pocket for a five mile electric line that was needed just to bring electricity to one of its new facilities.[7] Another large industrial customer esitmated it would cost at least $10,000,000 to make nececessary infrastructure upgrades in order to install and use electric boilers. Based on an estimate of replacing two large steam boilers, the peak electric requirements would double from 12.5 megawatts to 24 megawatts.[8] For this customer and others, full-electrification is cost prohibitive.

d. Annual Equipment Operating Costs

In National Fuel's service territory, natural gas has historically been inexpensive, readily available and reliable. Many customers expressed concern about the impact on their demand

[7] Great Lakes Cheese was originally considering an alternative location for its facility but abandoned the proposal due to a lack of electric infrastructure. The estimated cost to run one electric line was approximately $40,000,000 for a plant that would have operated on both gas and electricity. Great Lakes Cheese estimated that the cost to fully electrify their operations at that location would have exceeded $100,000,000, and the amount of time required to do so would have made the project infeasible.

[8] For additional reference, Great Lakes Cheese indicated that if it were to electrify its operations it would need three electric boilers, and each would consume approximately 12 MW. As estimated by Great Lakes Cheese, high voltage service lines of at least 115 kV would be needed to operate a fully electrified facility, but the infrastructure is not currently in place in many rural areas and it would require significant land acquisition to implement.

charges, commodity prices for electricty, and the delivery charge impact to pay for all the utility upgrades. Specifically, it is likely that it will cost industrial customers at least twice as much to operate solely on electricity as compared to natural gas, which for some of National Fuel's largest customers could equal at least an additional $5 million per year in energy costs. In additon to these concerns, many of National Fuel's industrial customers receive a New York Power Authority ("NYPA") hydropower alottment,[9] which has been an extremely valuable tool for the economic development community in attracting and retaining industrial customers to our region. As the industrial sector electrifies, customers are concerned that the demand for electricity will increase and the availability of relatively inexpensive hydropower will decrease. This may ultimately result in the elimination of one of the area's most effective tools for attracting economic development.

IV. The Natural Gas System is a Solution to Concerns Raised by Industrial Customers

In light of these and other serious concerns, National Fuel urges the Commission to proceed carefully as it considers comments calling for full-electrification of the industrial and other sectors in the state and for decommissioning of all or substantial portions of the natural gas system. The state's extensive network of underground storm-resistant facilities has and can continue to ensure the consistent delivery of energy, and the approximately 50,000-mile system will be available to transport low- and no-carbon energy like renewable natural gas ("RNG") and hydrogen, providing a reliable source of energy for industrial and other customers.

> In the same way that the electric grid allows for increasingly low-carbon electrons to be transported, the natural gas grid should be viewed as a way to enable increasingly low-carbon molecules to be transported.[10]

Studies have demonstrated that there will be significant amounts of available RNG in and around New York to facilitate the state's decarbonization efforts. According to a 2019 study performed

[9] According to the NYPA website:

> Western New York Hydropower, also known as Expansion Power (EP) and Replacement Power (RP), is comprised of 695 megawatts generated at NYPA's Niagara Power Project in Lewiston that may be allocated to eligible applicants upon approval from the NYPA Board of Trustees. The purpose of the program is to attract businesses and spur expansion of existing facilities in the WNY region. Western New York Hydropower is awarded on a competitive basis to qualified businesses within a 30-mile radius of the Niagara Power Project, with 20 MW of the 695 MW program available for business expansion and attraction purposes in Chautauqua County.

See WNY Hydropower: Expansion & Replacement Power, available at https://www.nypa.gov/services/incentives-and-grants/economic-development.

[10] Columbia Study at 6.

for the American Gas Foundation by ICF, a global consulting services company, New York will have an estimated in-state RNG technical potential in 2040 of 271.1 trillion Btu/year from available landfill, animal manure, wastewater treatment, food waste, agricultural residues, forest residue, municipal solid waste resources and energy crops. There are additional amounts of RNG available if one looks outside New York, as the state has when relying on out-of-state renewable generation. According to ICF, the Middle Atlantic and New England regions of the Northeast will have an estimated RNG technical potential by 2040 of up to 952 trillion Btu/year.[11] ICF notes in a February 2022 analysis it prepared for the American Gas Association that the RNG supplies it forecasted in its 2019 study are likely even greater than anticipated.

> A lot has changed since 2019. Climate policy discussions have increasingly focused on the need for deeper reductions and more solutions to be brought to the table to reach net-zero targets. RNG markets have also continued to grow rapidly in regions like California and British Columbia, Canada – where different market mechanisms have assigned a premium value to RNG and driven the construction of projects. Some projects that would not previously have been thought to be economic have also been developed through innovations such as clustering enabling agricultural facilities together to achieve the scale required for an RNG project. There are also several promising technologies for both anaerobic digestion and thermal gasification feedstocks that could unlock more RNG supply potential.[12]

A recent report issued by the State University of New York College of Environmental Science and Forestry confirms that RNG has "the potential to make meaningful contributions to New York's climate and human health targets under the CLCPA",[13] and an analysis conducted for the U.S. Department of Energy's Argonne National Laboratory documents rapid growth in

[11] American Gas Foundation Study prepared by ICF, *Renewable Sources of Natural Gas: Supply and Emissions Reduction Assessment* (December 2019), available at https://gasfoundation.org/2019/12/18/renewable-sources-of-natural-gas/. More recently, in April 2022 the New York State Energy Research and Development Authority ("NYSERDA") also issued a report that addressed the potential for RNG in New York. Similar to the American Gas Foundation report, the NYSERDA report concluded that New York will have an estimated in-state RNG production potential of 272.3 trillion Btu/year in 2040. NYSERDA Report Number 21-34 prepared by ICF Resources, LLC, *Potential of Renewable Natural Gas in New York State* (April 2022), available at https://www.nyserda.ny.gov/-/media/Files/EDPPP/Energy-Prices/Energy-Statistics/RNGPotentialStudyforCAC10421.ashx.

[12] American Gas Association study prepared by ICF, *Net-Zero Emissions Opportunities for Gas Utilities* (February 2022), available at https://www.aga.org/globalassets/research--insights/reports/aga-net-zero-emissions-opportunities-for-gas-utilities.pdf.

[13] State University of New York College of Environmental Science and Forestry, HakSoo Ha, Ph. D and Tristan R. Brown, J.D., Ph. D *A review of the scientific literature on greenhouse gas and co-pollutant emissions from waste- and coproduct-derived biomass-based diesel and renewable natural gas* (January 2022), available at https://static1.squarespace.com/static/53a09c47e4b050b5ad5bf4f5/t/61f9865afb2b77058f2f4515/1643742811198/BBD_RNGwhitepaper.pdf.

RNG production nationwide with production capacity increasing 24% since 2020 and the number of RNG production facilities growing 33.5% since December 2021, including numerous facilities in New York and neighboring states.[14]

Given RNG's potential to facilitate decarbonization in the industrial and other sectors, action should be taken to resolve certain greenhouse gas ("GHG") accounting issues related to RNG that will limit its potential in the state. Specifically, the CLCPA requires the use of a 20-year global warming potential ("GWP") value for methane, which is approximately three times higher than the traditional 100-year GWP. Also, the New York Department of Environmental Conservation regulations create a GHG accounting framework that focuses on setting gross emissions limits for the state. Under gross accounting RNG combustion looks identical to fossil methane, which is not accurate. New York should adopt emissions accounting consistent with federal and other state standards, which can appropriately result in RNG being counted as carbon neutral or even carbon negative.

Like RNG, hydrogen is widely believed to have significant potential to contribute to responsible decarbonization in the future, and there are efforts underway in New York, at the federal level and globally to determine the potential of this technology. The state is already developing its hydrogen strategy in concert with the National Renewable Energy Laboratory and the Center for Hydrogen Safety, among other groups, the New York State Energy Research and Development Authority includes as key actions in its *Strategic Outlook 2022 Through 2025* the development of a comprehensive hydrogen roadmap to advance green hydrogen as a deep decarbonization technology[15], and the Governor recently announced the state's intention to collaborate with New Jersey, Connecticut and Massachusetts to secure a portion of the $8 billion the federal government has earmarked for regional hydrogen hubs.[16] Utilities in New York, and several other states and countries, are currently engaged in a thorough review of the use of their natural gas distribution systems to transport and store hydrogen.

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[14] U.S. Department of Energy Analysis prepared by Energy Vision, *Expanding RNG Could Be a Key Strategy for Cutting Methane Emissions and Tackling Climate Change* (March 2022), available at https://energy-vision.org/rng-project-database/.

[15] New York State Energy Research and Development Authority, *Towards a Clean Energy Future: A Strategic Outlook 2022 Through 2025* (2022), available at https://www.nyserda.ny.gov/-/media/Files/About/Strategic-Plan/strategic-outlook.pdf.

[16] See, https://www.governor.ny.gov/news/governor-hochul-announces-multi-state-agreement-signed-major-hydrogen-ecosystem-partners.

In light of the significant decarbonization potential of hydrogen and RNG, the state should pursue policies that promote the development and use of these technologies. For example, consistent with what has been implemented in other states with emissions reduction goals, like California and Oregon, New York should establish renewable gas procurement standards for utilities whereby they would procure a growing portion of their gas from RNG and hydrogen sources over time. This and related policies would help drive the state toward its emissions reduction goals in a way that leverages the existing natural gas system to ensure the availability of reliable and affordable energy for consumers in the residential, commercial and industrial sectors.

V. Conclusion

For the reasons stated herein, National Fuel urges the Commission to proceed carefully and consider the concerns of large industrial customers as it reviews comments calling for full-electrification of the industrial and other sectors in New York.

Dated: June 15, 2022
Williamsville, New York

Respectfully submitted,

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Attachment A

GTI ENERGY

solutions that transform

GTI ENERGY PROJECT NUMBER 22732

New York Industrial Sector Decarbonization Summary

Report Issued:
December 13, 2021

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New York State Industrial Sector Decarbonization Summary

This brief GTI Energy report provides a high-level summary of the New York State industrial sector and discussion regarding decarbonization pathways. A more thorough techno-economic assessment would be warranted to explore pathways, costs, and potential challenges with transitioning the New York State industrial sector to substantially lower greenhouse gas (GHG) emissions intensity.

New York State Baseline Energy and Emissions

Figure 1 shows trends in industrial natural gas and electricity use since 2005. Natural gas is the leading energy choice by New York's manufacturers, with usage that is about 50% greater than electricity.

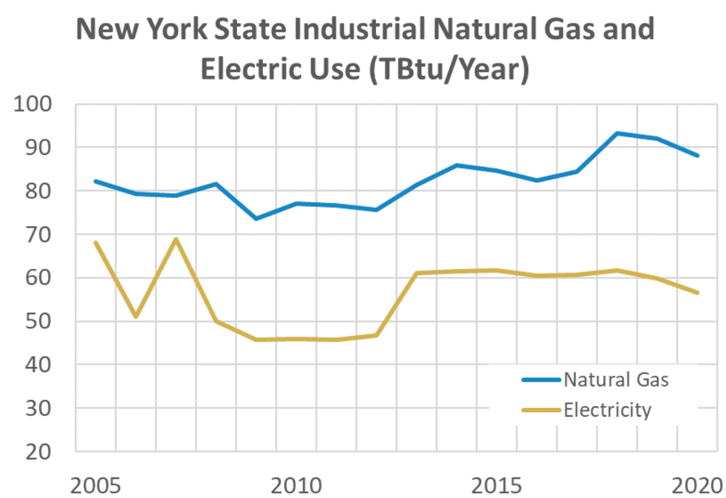


Figure 1: New York State Industrial Energy Use (Gas and Electricity)

Figure 2 shows trends in New York State industrial natural gas and electricity prices (in equivalent $/MMBtu). Natural gas is a 2.4:1 price advantage compared to electricity, making it an attractive choice for energy-intensive manufacturing uses.

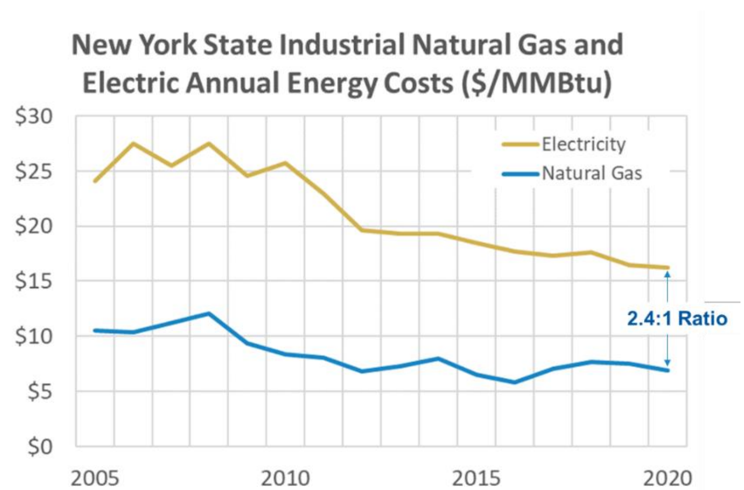


Figure 2: New York State Industrial Energy Prices (Gas and Electricity)

Figure 3 shows annual energy costs for the New York industrial sector, with costs for electricity being around $900 million to $1 billion annually and natural gas – while used in much higher amounts – is in the range of $600-$700 million. Natural gas helps keep energy intensive manufacturers competitive with US, North American, and other international producers.

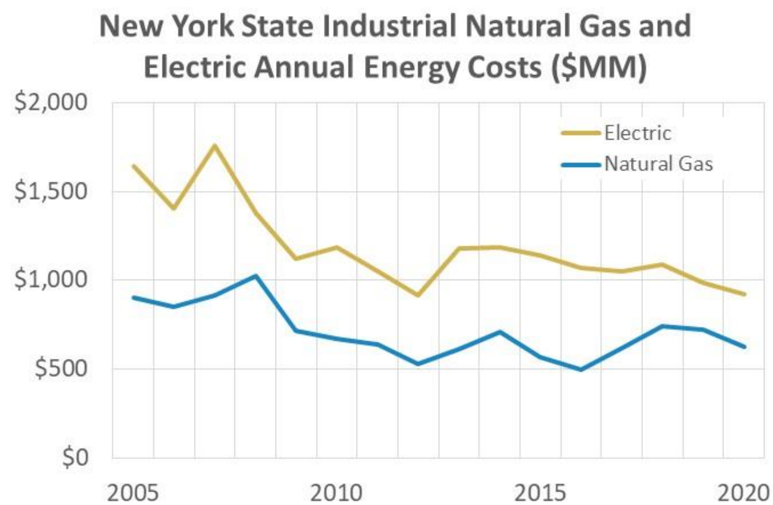


Figure 3: New York State Industrial Annual Energy Costs (Gas and Electricity)

Table 1 shows 2018 DOE-EIA data for New York State industrial sector CO_2 emissions. In 2018, the NY industrial sector comprised a relatively small 6.5% of state CO_2 emissions; in contrast, the transportation sector comprised over 47% of state CO_2 emissions. Industrial natural gas use contributes to 5 million metric tons (MMT) of CO_2, or 2.8% of the state total and 43.5% of the industrial sector (inclusive of source electric CO_2 emissions from power generation plants).

Table 1: New York State Industrial CO_2 Emissions (2018, MMT; DOE-EIA)

New York Carbon Dioxide Emissions

Million metric tons of CO_2		**2018**
Industrial Sector		
	Coal	0.9
	Petroleum Products	2.7
	Natural Gas	5.0
	Sub-Total (Fossil Fuels)	**8.6**
(Included in Electric Sector)	Electric Source Emission	2.9
	Total w/Electricity	**11.5**
	State Total (all sectors)	**175.9**

Industrial Sector Decarbonization

Many industrial processes can be difficult to decarbonize for a variety of reasons (Figure 4), including the level of investment required along with the long equipment life for already installed assets. In addition, manufacturing operations in many instances may have mobility options (i.e., moving to another state or country such as Canada or Mexico) or may be forced to close if not competitive with manufacturers in other regions. High energy costs can be a motivating factor New York-based manufacturers to cease operation if production costs become too high, resulting in a phenomenon referred to as “carbon leakage.” This would have a clearly negative impact on the New York State economy while also not achieving (in aggregate) net greenhouse gas (GHG) reductions.

Careful techno-economic assessments specific to existing NY-based operators are needed to determine practical and implementable GHG reduction solutions. Industrial natural gas energy use is mainly for steam generation and process heating along with gas use for facility space heating during the winter. In some instances, natural gas is used as a chemical feedstock for producing hydrogen, ammonia, methanol, and many other chemical precursors or products. Generally, the most difficult to decarbonize sectors include: **iron & steel production, cement manufacturing, and chemicals and petrochemicals**. Figure 4 illustrates factors that lead to challenges in these sectors: tightly integrated processes, high-temperature heat demand, very long equipment and plant investment lifetimes, global competition, using energy resources as a chemical feedstock. These issues are also prevalent in other segments such as glass and ceramics manufacturing and other high-temperature processes.

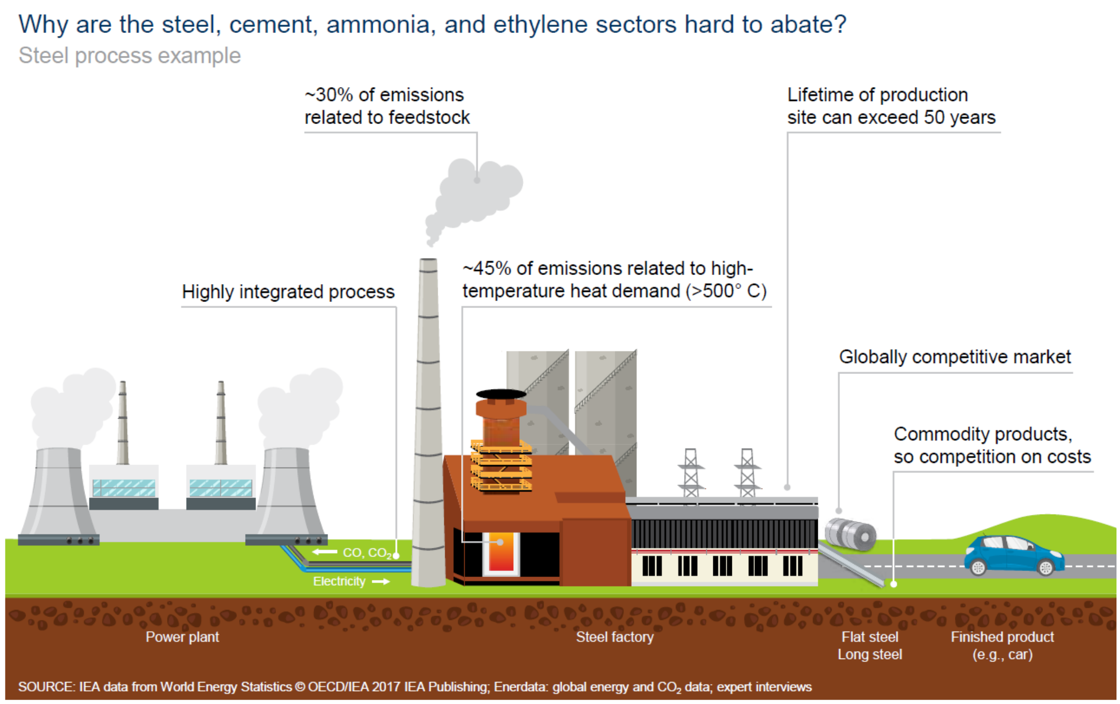


Figure 4: Illustration of Industrial Decarbonization Challenges (Source: McKinsey, IEA)

Figure 5 shows an example of the dual-role natural gas can play in the chemical and petrochemical sector – as an input energy source and as a chemical precursor or feedstock material. Shifting these processes is fundamentally challenging due to the important role natural gas plays for making a host of chemicals (e.g., methanol, hydrogen, ammonia, and many other more complex molecules).

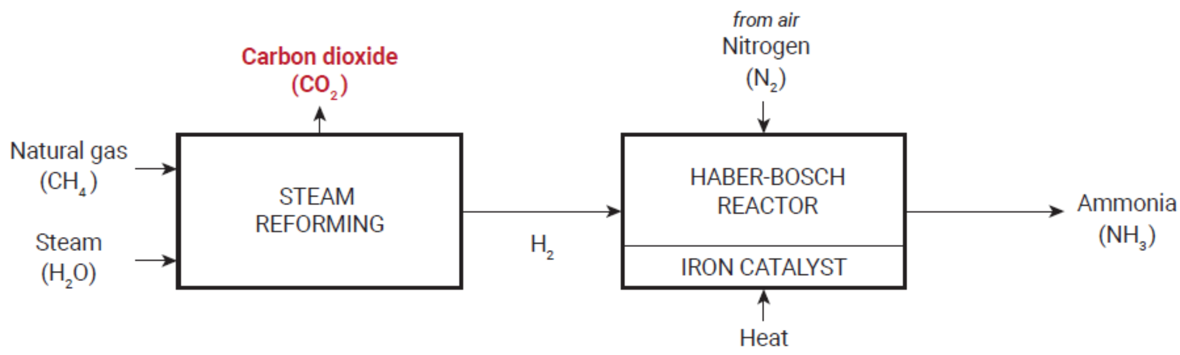


Figure 5: Ammonia Example of Natural Gas as an Energy Source and Chemical Feedstock

There are fundamental challenges with high-temperature industrial applications, as represented by this quote from a recent Brookings Institute publication:

> ***High-temperature processes***
>
> *"Process heating is a primary component of industrial energy demand. One of the common challenges in heavy industry is the need for processes to operate at high temperatures. Beyond around 400°C, direct use of renewable heat or electricity for heating, with such equipment as heat pumps or resistance heaters, is impractical.90 Such temperatures are necessary in the steel, cement, and chemicals industries. Electric arc furnaces can provide very high heat, but they work only in applications where the materials being heated conduct electricity, such as melting steel for recycling. For other applications, combustion is needed."*

There are various strategies and pathways that could be pursued to reduce natural gas-based industrial CO_2 emissions. Examples include:

- Energy efficiency and process improvements that reduce energy consumption (often the most cost-effective option on a $/metric ton of CO_2 reduction)
- Decarbonization of natural gas through methods such as: renewable natural gas (RNG), renewable hydrogen (H_2) or other gases such as ammonia; this can include blends of conventional natural gas and renewable gases
  - In some instances, these options could be used as substitutes for chemical feedstock applications
- Carbon capture, utilization, and storage/sequestration (CCUS)
- Use of renewable thermal energy sources such as solar thermal energy or geothermal energy
- Electrification of natural gas applications (e.g., boilers and process heating equipment)

Figure 6 (from McKinsey) highlight GHG abatement options beyond traditional energy efficiency measures. This provides indications of the level of technology readiness.

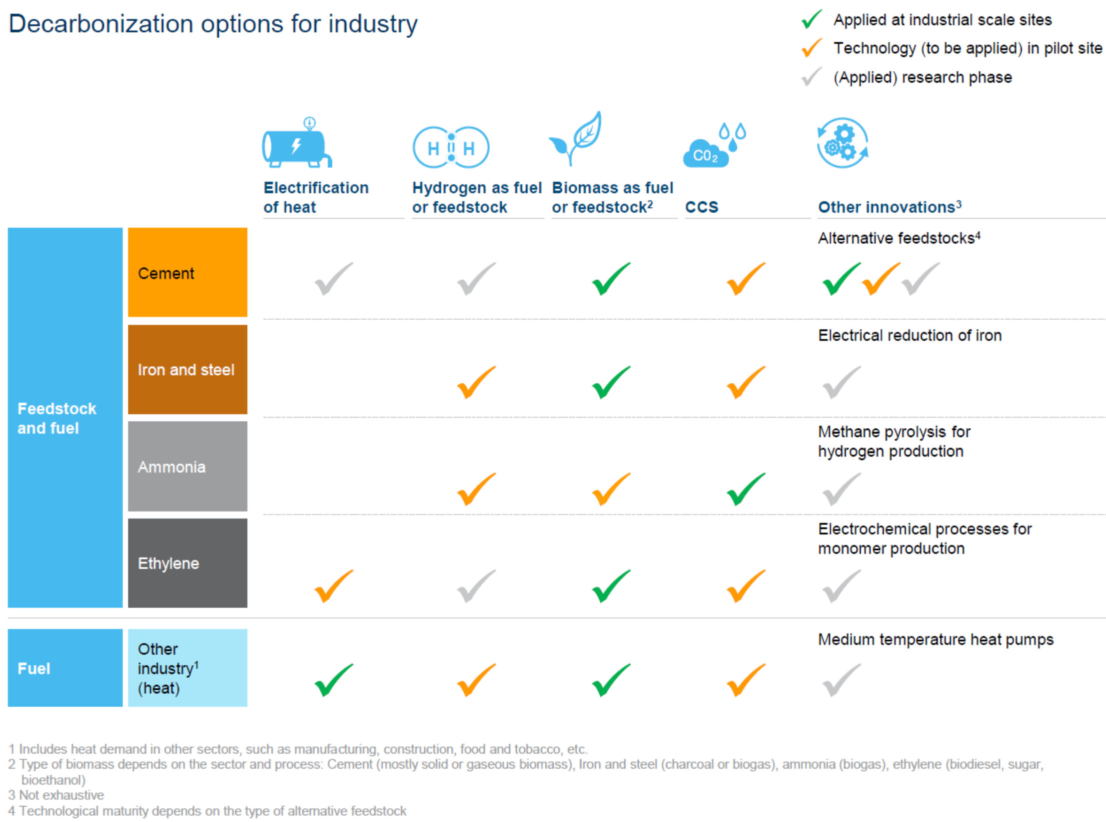


Figure 6: Industrial Decarbonization Options (Excluding Energy Efficiency: McKinsey)

Energy Efficiency

Various methods are available to improve equipment or process efficiency through advancements in combustion efficiency and waste heat recovery and utilization. Depending on the application (e.g., steam generation, low-temperature, medium-temperature, or high-temperature process), efficiency improvements of 15% up to 50% may be possible.

Renewable Gas

There are a range of renewable gas options available in the market today and in development that offer a lower carbon intensity gaseous energy resource. Examples include the use of traditional wastewater, landfill, and digester gas; emerging use of gasification of biomass material; and emerging use of renewable or zero CO_2 generation sources (e.g., hydro, wind, solar PV) to produce a zero-carbon hydrogen gas or synthetic methane. New York State could see expanded use of digesters or gasification technology that leverage biomass (e.g., agricultural byproduct, woody biomass, sorted municipal waste, etc) as feedstock material. This could substantially expand the supply of renewable methane or other gases in the state. Renewable gases can potentially be used with the existing natural gas distribution system as blends with traditional natural gas, with a longer-term shift to 100% renewable gases.

There are several efforts to develop next-generation hydrogen generation systems that use natural gas or renewable/zero electricity and electrolysis. Natural gas-based systems include approaches that include inherent carbon-capture capabilities, including the production of a high-purity CO2 stream for utilization or storage or – via methane pyrolysis – the production of a solid carbon compound that can be used for various commodity applications.

Carbon Capture, Utilization, and Storage

There is an emerging opportunity to expand the use of carbon capture, utilization, and storage. This is motivated in part by existing Federal incentives (e.g., 45Q) and the desire of leading companies to seek out options for reducing their carbon intensity. Figure 7 shows example industrial applications that may be motivated by existing 45Q tax credits to undertake a CO_2 capture program.

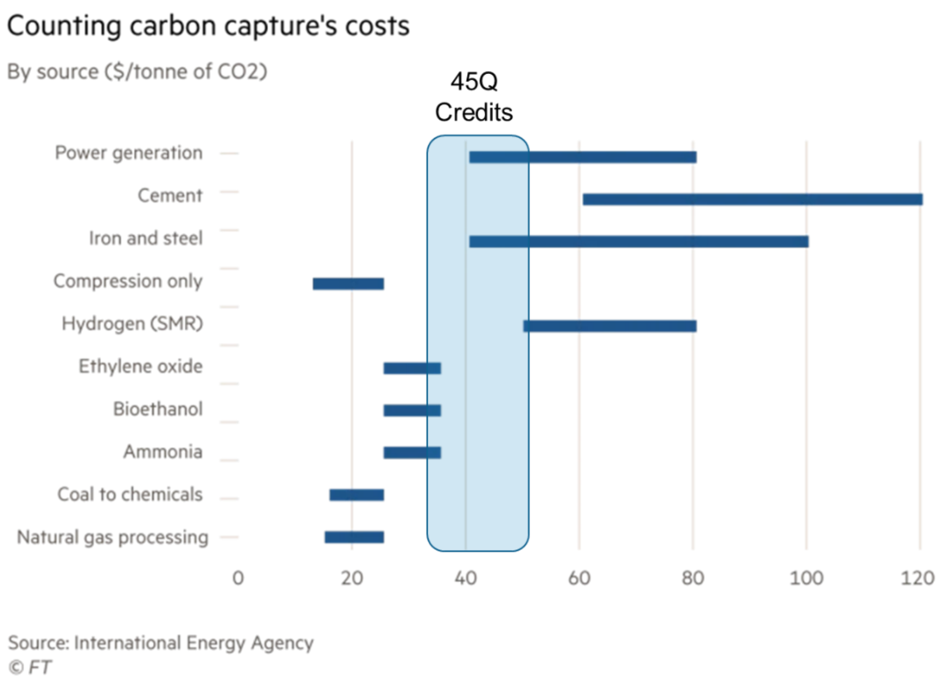


Figure 7: Potential Industrial and Power Generation CO_2 Capture Segments (Financial Times)

There are several potential options for utilization or storage of CO_2 (or derivative carbon) as shown in Figure 8. Significant R&D efforts are underway to develop processes that can valorize CO_2 by converting it into construction materials, chemical, and fuels. Some of these processes rely on renewable or zero carbon power generation sources to enable transformation of CO_2 into other compounds and molecules.

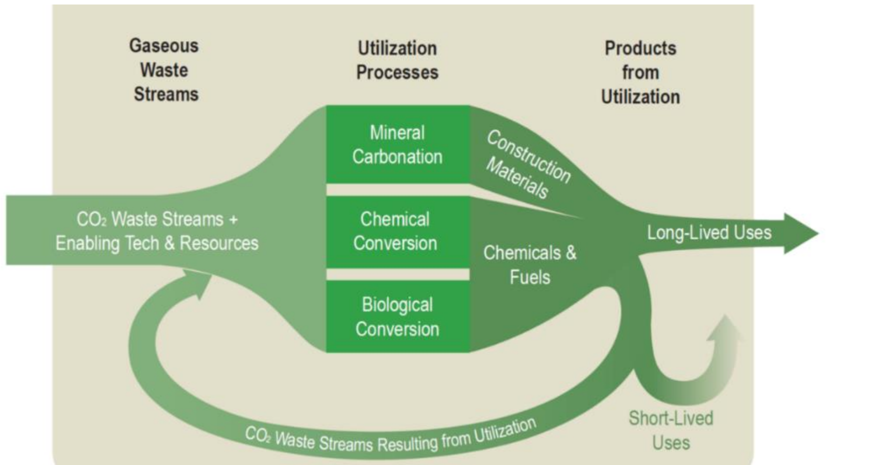


Figure 8: Utilization of CO_2 Waste Streams (National Academy of Sciences)

Figure 9 shows four of the primary options for CO_2 capture – three of these are particularly applicable to larger industrial applications (post and pre-combustion capture along with oxy-gas combustion capture). Figure 10, Figure 11, and Figure 12 provide examples of each of these technology pathways for natural gas decarbonization.

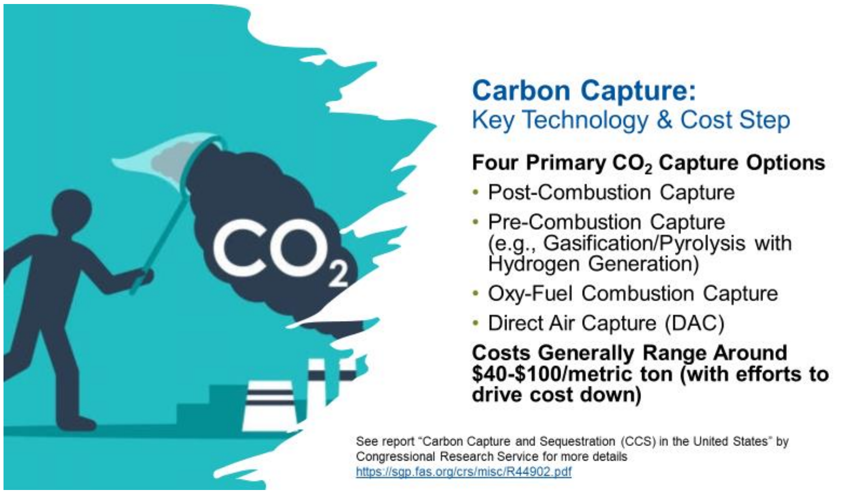
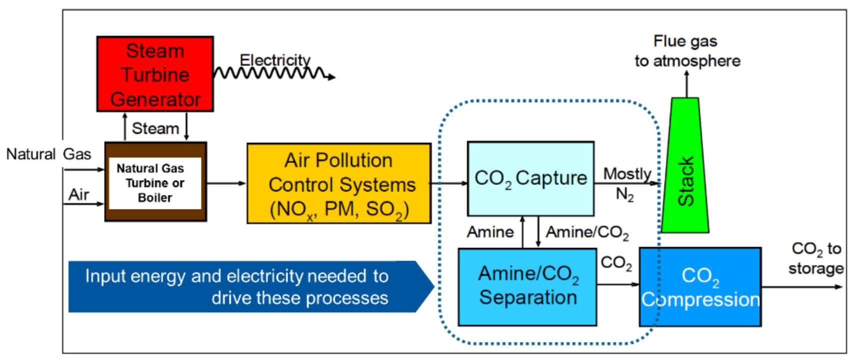


Figure 9: Four Primary CO_2 Capture Options



Adapted from: **Source:** E. S. Rubin, "CO_2 Capture and Transport," *Elements*, vol. 4 (2008), pp. 311-317.

Figure 10: Example Post-Combustion CO_2 Capture

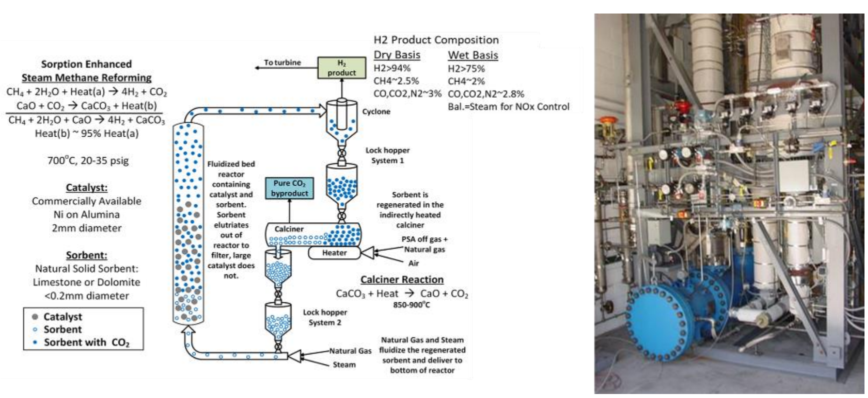


Figure 11: Example Pre-Combustion CO_2 Capture; GTI Energy-Developed H2 Generator With Integrated CO_2 Capture and Recovery

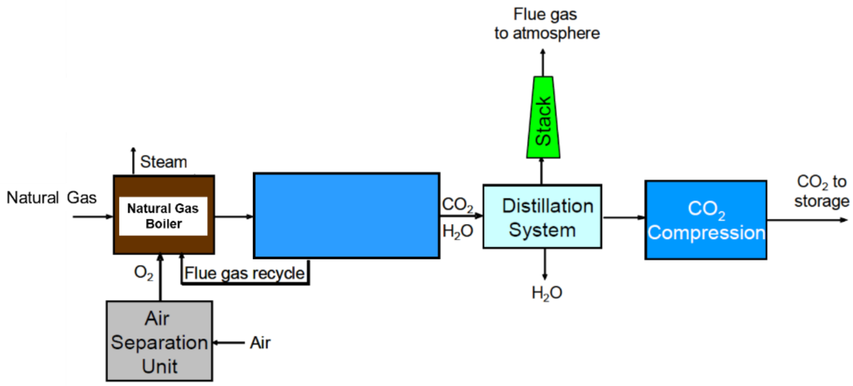


Figure 12: Example Oxy-Gas Combustion With CO_2 Capture

Electrification Options

EPRI conducted a study of electrification options in the State of New York, including the industrial sector. One of the key summary findings from this report is contained in Figure 13. Generally, this report points to more feasible markets in industrial forklifts and other handling equipment and potential options in process heating; use of electric boilers as seen as a difficult and challenging market with high industrial manufacturer costs and low to medium environmental benefits.

A major impediment to many industrial electrification efforts is the complexity and costs associated with adding significant electric transmission, distribution, substation/transformer costs needed to handle the added electric loads.

Electrification Opportunity	Deployment Timeframe (Near/Mid/Long)	Type of Impact		
		Customer Payback	Customer Non-Energy Benefits	Environment
Non-road electric transportation (forklifts, terminal trucks and airport eGSE)	Near or mid/long	Short to long	Medium to high	High
Industrial process heating (infrared curing and drying, induction heating and melting, resistance heating and melting, UV curing)	Mid/Long	Medium to long	High	High
Industrial boilers (electric resistance and electrode boilers)	Mid/Long	Long	Low	Low to medium

Figure 13: EPRI Industrial Electrification Readiness

GTI Energy has developed a tool for analyzing natural gas and electricity options for industrial steam generation and process heating. Figure 14 shows one example of replacing natural gas boilers in the food production segment (SIC Code 20) in National Fuel Gas territory. Industrial users would see a dramatic increase in their annual energy costs using electricity for steam generation, with an estimate CO2 abatement cost of about $350/metric ton. This would require significant but not fully quantified costs for upgrading electric service to these plants (which would add about 50 MW of electricity demand).

Example: Impact of Replacing 100% of Gas Boilers in National Fuel Food & Kindred Products (SIC Code 20)*

Metric	Output
Natural Gas Displaced	2.86 Trillion Btu (2.86 bcf)
Electric Use & Demand Increase	676,178 MWh; 47 MW
Annual Energy Cost Increase	$44.4 million (+317%)
Estimated Lifecycle Cost Increase	$606 million
CO_2 Abatement	0.085 million metric tons (baseload; net increase with marginal generation)
CO_2 Abatement Cost	$354/metric ton (baseload generation)

* Draft results; subject to refinement (particularly for electric service upgrade costs)

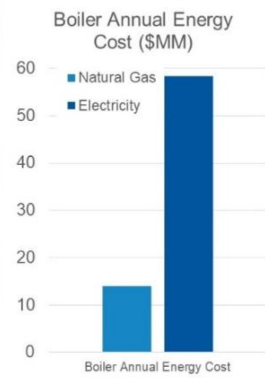


Figure 14: Costs to Electrify National Fuel SIC Code Natural Gas Boilers

The EPRI report on electric-based decarbonization includes this statement with respect to electric boilers (page 54):

> *"Electric resistance boilers…Electric resistance boilers are available in capacities up to ~4MW and have high efficiency (>90%) in converting water to steam as well as low standby losses. However, because of higher capital and annual energy costs compared to gas boilers, adoption is expected to remain low."*

Generally, electric boilers have limited efficiency benefits compared to natural gas (which can have efficiencies of 80% to as high as 95% with heat-recovery economizers. With the much higher costs for electricity (commodity plus demand), the added annual operating costs for industrial users is very expensive.

There is competition between natural gas and electricity in various process heating applications. For more energy intensive and high-temperature processes, there are significant technical and economic challenges that may need to be overcome. The following is a quote from the McKinsey industrial decarbonization report (page 22):

> *"To replace the fossil fuel for heat generation with electricity or hydrogen requires a significant change in the production process and development of alternative furnace designs. Up to ~1,000 °C, adaptation and scale up of electric furnace technology is needed. For temperatures above ~1,000 °C, such as required for cement production, research is required to develop industrial-scale electric furnaces."*

There are fundamental, engineering and manufacturing challenges to produce very high temperatures using electric heating elements at large industrial scales. The heating rate may be an issue when industrial processes require rapid heating and cooling that can be difficult to achieve with electric systems, especially for rotating equipment such as large industrial rotary kilns or calcining hearths, etc.

A 2018 study in the United Kingdom also reinforces the high costs for a range of electro-technologies in energy intensive and high-temperature process applications (Figure 15). While low-temperature electric heat pumps are cost-competitive for lower-temperature applications, there is a steep increase in costs for several energy intensive and high-temperature industrial processes. Many of these exceed $350 (US)/metric ton of CO_2 reduced – which is quite expensive for an industrial manufacturer to take on as a major process change. The UK report highlights options based on using bio-energy as potentially cost effective pathways.

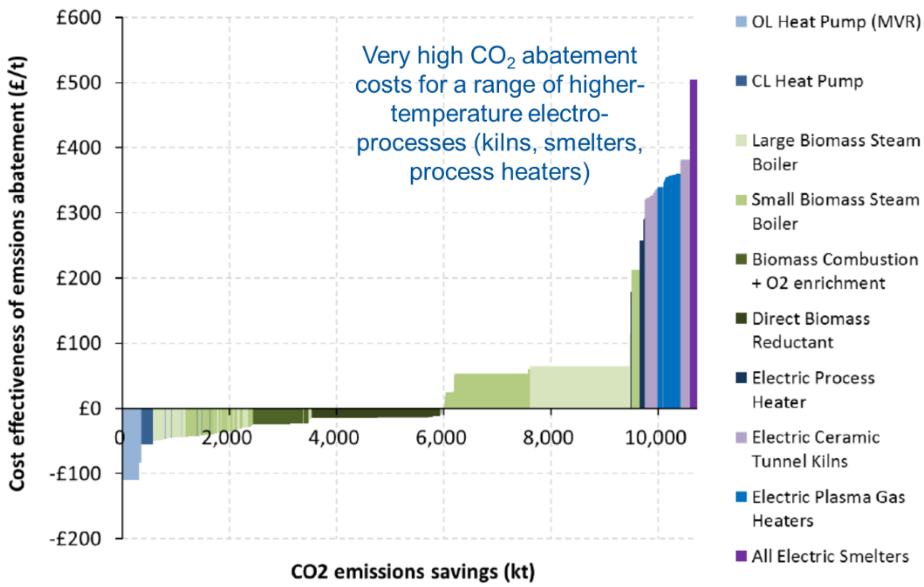


Figure 15: UK Carbon Abatement Cost Curve for Industrial Decarbonization (Source: Element Energy)

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