
# CREATING POWER, TECHNOLOGY AND PRODUCTS:

# The Role of Coal Gasification in Ohio's Economy and Energy Future

Working Paper
Prepared for
The Pew Center on Global Climate Change

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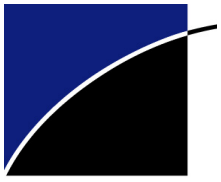

KLEINHENZ
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## Preface

The Pew Center on Global Climate Change, with the support of the Joyce Foundation, commissioned Kleinhenz & Associates of Cleveland, Ohio to analyze, study and report on the current market status and economic implications of building a coal gasification plant in Northeast Ohio.

This report was prepared jointly by Jack Kleinhenz, Ph.D. and Russ Smith, Ph.D. of Kleinhenz & Associates with assistance from Jim Robey, Ph.D. and the research department at TeamNEO and Terry Uhl of Landau Public Relations.

We would like to thank Kurt Waltzer of the Clean Air Task Force for his overall project guidance, comments and support.

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# Executive Summary

Although U.S. natural gas prices have retreated from their highs, recent changes in market dynamics, interest in energy independence, and the need for competitively priced energy are leading to renewed interest in coal. Coal gasification technology has been around for decades and can produce both power and a variety of other products. Coal gasification can also produce electricity while meeting extremely high environmental regulatory standards. Recently, coal gasification technology was given a boost by the U.S. Federal Energy Bill authorizing $200 million per year from 2006 to 2014 for a Clean Coal Power Initiative and $1.1 billion in funding for clean coal research and development.

The Pew Center on Global Climate Change commissioned Kleinhenz and Associates to examine how coal gasification (CG) combined with Carbon Capture and Sequestration (CCS) technology could play a role in Ohio's economy and energy future – particularly in Northeast Ohio, a major center of manufacturing in the U.S. This working paper focuses primarily on opportunities for gasification projects to augment Ohio's economy. A forthcoming companion paper focuses on opportunities provided by use of CCS.

Gasification may also benefit from growing concern about greenhouse gas emissions and their impacts on climate. Gasification is a process by which a fossil fuel -- such as coal -- or biomass -- such as switch grass -- is turned into a synthetic gas made up primarily of hydrogen, carbon dioxide, and carbon monoxide. This "syn-gas" can be used to produce electricity, transportation fuels, and a variety of chemicals. The carbon dioxide in the "syn-gas" can be separated from the hydrogen, captured, and stored in deep underground formations, where it is expected to remain secure over very long time frames.

This study examines economic activity factors related to coal gasification and how the location of a number of key support industries in Ohio could provide the state with a competitive advantage in this area. Companies that participate in the gasification value chain include suppliers to gasification facilities (coal and biomass producers), suppliers of equipment (plumbing and pipefitting, containment vessels), companies that operate the facilities, and customers (purchasers of electricity, natural gas, transportation fuels, specialty chemicals). This study focuses on a polygeneration facility that would supply electricity and some other products as an example of the type of gasification facility that could, if a sufficient number of similar facilities were located in the area, serve as the stimulus for a new or expanded industry cluster. A polygeneration unit was used to determine industries that would form such a cluster. However, due to data limitations, costs and suppliers for construction of the plant were calculated from information for an integrated gasification plant (IGCC), i.e., a plant designed to produce electricity, or only heat and power.

Previous studies have defined an industry cluster as a geographic location where a number of firms along an industry value chain, from supply to demand, are co-located and strategically linked, resulting in improved product development, technology spin-offs, and overall robust industry growth. Determining the concentration of, and interactions between, firms needed to achieve a cluster and its advantages is difficult. Defining policies that can stimulate emergence of such a cluster is equally challenging. This study focuses on identifying the potential for Ohio-based firms (with a particular focus on Northeast Ohio) that could participate in the supply side of a polygeneration industry cluster. Since demand for products such as electricity, synthetic natural gas, and transportation fuel is ubiquitous, this study focuses on specialty and bulk chemicals markets.

## FINDINGS

Ohio, and Northeast Ohio in particular, could provide the foundation for a gasification industry cluster. This was confirmed by:

a) Data analysis of suppliers of inputs and purchasers of power and products from poly-generation plants;

b) Discussions held with industry executives whose companies might buy from or sell to such plants, and

c) Economic analysis of a single plant's multiplier effect on the local and state economy, with the understanding that these economic impacts would scale up with additional units.

Although not further discussed in this paper, any Ohio gasification facility would be in close proximity to oil and gas fields that can serve as sites for sequestering the carbon dioxide ($CO_2$) separated out from the coal-gasification process.

*a) Data Findings*

- The Northeast Ohio region is home to over one-third of the Ohio-based firms that might directly participate in the development and operation of coal gasification facilities.

- There are over 200 firms in Northeast Ohio totaling nearly $2 billion in annual payroll that purchase sulfur and ammonia, two of the many possible chemicals that can be produced at a polygeneration facility.

*b) Findings from Industry Interviews*

- Northeast Ohio has a wealth of experienced industrial workers, for both construction and operation of a coal gasification plant. However, business executives as well as industrial literature point to a potential construction-labor shortage.

- The favorable environmental profile, including opportunities to capture $CO_2$, coupled with the capability of producing both electricity and a variety of chemicals, renders coal-based polygeneration of considerable interest to private sector businesses, public utilities, and government policy makers. Stakeholders in Ohio have expressed interest in this technology.
- Since coal gasification is in the very early stages of development in the United States, undertaking projects involving this technology entails many risks and raises many questions. Questions include: the shape of partnerships that might be formed to help advance this technology; sources of financing; markets for gasification products; the availability of coal, including its transport, and the state of $CO_2$ sequestration and emission credit programs. Answering these questions will encourage business participation in the development of coal gasification facilities in Ohio.

*c) Findings from Economic Analysis*

- The potential economic impact of locating a polygeneration gasifier in Northeast Ohio is large. A significant portion of the inputs required for one $1.1+ billion facility can be supplied either within northeastern Ohio or from elsewhere in the state. The economic model reveals that construction of a single polygeneration facility would increase state personal income by over $700 million and gross Ohio output by $1.1 billion. Northeast Ohio is estimated to receive 95 percent of the benefits from the construction phase. Operation of the facility is estimated to increase annual statewide personal income by $39 million and Ohio output by $161 million. The Northeast Ohio region will account for 98 percent of the operational benefits.

- The facility would be near a key input, coal, and a large industrial economy with many firms needing chemicals that could be produced at polygeneration facilities.

**Recommendations**

1. Develop public mechanisms that help facilitate the financing of polygeneration gasifier facilities. The development of poly-generation plants will require multiple partners to ensure markets for products such as electricity, natural gas, or specific feedstock chemicals. Potential financing mechanisms include providing grants or low-interest loans through Third Frontier or a similar program, and favorable tax provisions. The program could provide incentives to encourage a critical portion of the work to be carried out by Ohio firms.

2. Create an industry database and information system. Many potential participants, both governmental and industrial, do not fully understand coal gasification's benefits or the technologies involved. Ohio should develop a database of all coal-gasification and polygen related companies in the State, including current contact information and accurate descriptions of products and capabilities.

3. Expand networking among firms by conducting roundtables, including both industry and philanthropic groups, to discuss the issues identified in this report.

A core team of state officials, administrators, industry executives and foundation program directors could provide the leverage needed to create and sustain support for a coal gasification strategy for Ohio.

4. Undertake in-depth studies of inputs to, and potential markets for products from, a *polygeneration* facility*:* Key studies should include assessments of markets for:
    i. Specialty and bulk coal-based chemicals
    ii. Electricity
    iii. Natural gas
    iv. $CO_2$ for EOR
    v. Emission reduction credits
    vi. Coal prices and availability

**Summary**

This report provides high-level, background information on the economic impact on Ohio and its northeastern region of polygeneration facilities that can produce both power and other products. It provides data that reveal local conditions that appear to be favorable to the development of coal gasification. It estimates the potential economic impact of the construction and operation of an IGGC project as a conservative proxy for a polygeneration facility. The various sources of information and conclusions drawn are relevant to development of policies that could foster development of this technology. The report should help connect potential market actors that are not yet aware of each other, and lay the foundation for a coal gasification strategy for Ohio.

# Introduction and Overview

The Pew Center on Global Climate Change engaged Kleinhenz and Associates to examine how the potential use of coal gasification and carbon capture and sequestration (CCS) technology may play a role in Ohio's economy and energy future – particularly Northeast Ohio, which is a major center of manufacturing in the U.S. This working paper focuses on opportunities that coal gasification can furnish. A forthcoming companion analysis will focus on opportunities provided by sequestration.

Although gasification technology has been around for decades, its commercial applications have mostly been in niche markets, in energy or chemical industries. Coal gasification technology, however, is now attracting considerable interest among energy industry experts and appears to be at a strategic crossroads. Though U.S. natural gas prices have retreated from historic highs, recent fuel price volatility and interest in energy independence has been driving a fresh look at coal-fueled electric generation. Other developments are generating new interest in technologies that may be capable of reducing greenhouse gas emissions, such as coal gasification. These include the Supreme Court's decision in April 2007 regarding the EPA's authority to regulate greenhouse gases,[1] and the gathering political momentum in Congress to address greenhouse gas (GHG) emissions. Finally, the use of gasification technology has been given a boost by recent state-based and federal incentives – including the federal Energy Policy Act of 2005 that authorized $200 million per year from 2006 to 2014 for a Clean Coal Power Initiative. This program provides for a government cost-share program to conduct demonstrations of commercial-scale advanced clean coal technologies. In addition, the legislation authorizes a total of $1.1 billion over three years to fund clean coal research and development programs.

Several large energy companies are currently investing in the commercialization of gasification technology. There are 19 announced or contemplated coal gasification projects in the United States. (see Appendix A). These include a proposed 600 MW Integrated Gasification Combined Cycle (IGCC) facility by AEP in Miegs county Ohio; a 630 MW proposed IGCC facility by Duke Energy in Edwardsport, Indiana; and a 530 MW proposed polygen facility (electricity and natural gas) proposed by ERORA in Clifty Creek, Kentucky.

Given this significant interest, Ohio and Northeast Ohio are well situated in the mid-section of the United States to pursue large-scale development and construction of coal gasification facilities, including manufacture of components. A number of factors could support the development of a regional industrial gasification concentration or cluster[2] in Ohio generally and northeast Ohio in particular, including:

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[1] See *Massachusetts et al. v. Environmental Protection Agency et al.*, decided April 2, 2007. Full summary available online at http://www.supremecourtus.gov/opinions/06pdf/05-1120.pdf

[2] An industry cluster, by definition, develops when the synergy between a network of firms that are connected through a value chain in a geographic area promote the competitiveness and growth of an industry. For a discussion of the research related to Northeast Ohio's

- The likely significant growth of gasification to supply the natural gas market in response to high prices and price volatility of petroleum and natural gas
- Interest in developing domestic alternatives to imported fuels and technologies that create a "low-carbon" path for coal
- The richness of geologic formations that are capable of storing captured carbon dioxide, including the potential for enhanced oil and gas recovery
- The abundance of coal from the Appalachian coal fields in southern Ohio and West Virginia
- The large skilled manufacturing sector including steel; fabrication; and instruments, controls, and electronics
- The large chemical/polymer industry that requires reliable, affordable supplies of chemical feed stocks
- An existing market for specialty chemicals

This paper provides data on local conditions that have the potential to support development of a gasification industry cluster; identifies industries that could supply inputs for construction and operation or markets for products; and estimates the potential economic impact on Ohio and its northeast region of the construction and operation of a polygeneration facility. As a conservative proxy for impacts due to such a facility, cost information for an IGCC[3] facility is used. The information provided and conclusions drawn are applicable to the development of federal and state policy supportive of gasification projects.

We assess the potential implications of polygeneration development for Ohio and Northeast Ohio firms who would be suppliers (referred to as *backward linkages*) in the construction of a facility and the manufacturing of components used in its operation. The paper also examines *forward linkages* – buyers of the products of coal gasification located within the region.

An input/output model is used to estimate the potential direct economic impact from the development of a conceptual gasification project. Previous studies of coal gasification have focused on the technical aspects of a gasifier capable of producing electricity as well as a variety of bulk chemicals. This paper is not intended to serve as a business plan for the development of a coal-based IGCC facility in Northeast Ohio. Rather, its purpose is to provide information in support of further efforts towards development of a gasification industry or industry cluster in Ohio, particularly in northeast Ohio.

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competitive clusters industries see Jack Kleinhenz, An Introduction to the Northeast Ohio Clusters Project, Economic Development Quarterly, Vol. 14 No 1, p 63

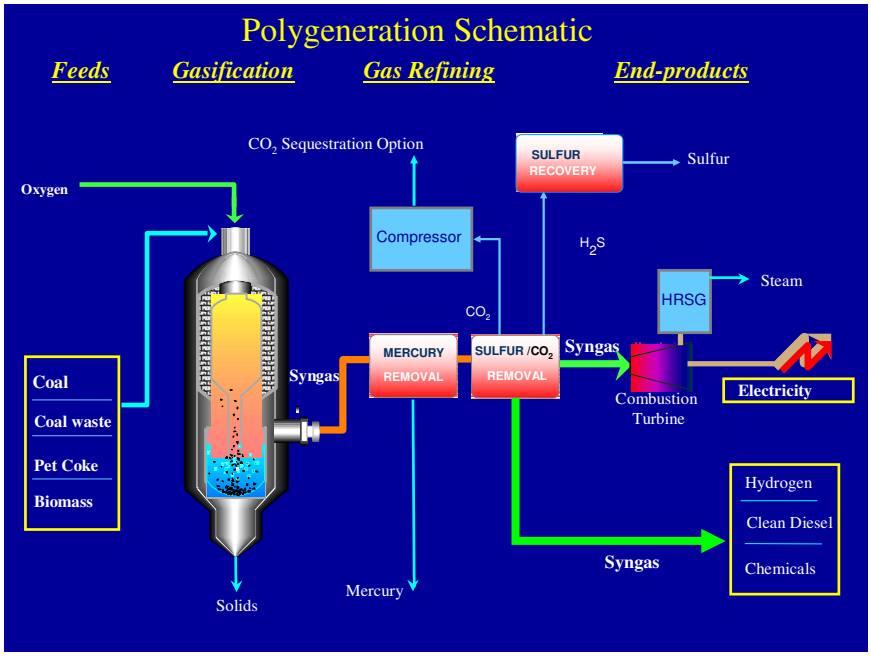
[3] IGCC is used to refer to a facility that would produce power or heat and power. Polygeneration is used to refer to a facility that would produce additional products, e.g., chemicals or natural gas.

## Gasification Process

Gasification is a proven technology that was used in the early 19th century to produce "town gas" to heat and light homes. The technology has been used extensively by the chemical industry to produce products such as hydrogen and ammonia. Gasification is a thermochemical process by which solid fuels such as coal (which contains contaminants) are transformed into a clean combustible gas (synthesis gas) by means of partial oxidation with air, oxygen, or water steam. The resulting gas is mainly carbon monoxide and hydrogen and retains most of the energy of the initial fuel used. Gasification is a clean and efficient way to convert coal to energy with low emissions of mercury and other air pollutants, while allowing carbon dioxide to be captured for underground storage. Two coal gasification plants are in operation in the U.S. and several new coal gasification projects are progressing (see Appendix A).

As shown in Figure 1, gasification has multiple applications and can produce a range of products, including clean "designer" synthetic fluid fuels. Organic plant material can be gasified along with coal. Polygeneration could benefit the many industrial chemical producers and purchasers in the Northeast Ohio market. These firms would enjoy a greater supply of feedstock chemicals. In particular, depending upon the partnerships developed, project financing, and market interest, specific chemicals could be produced to replace those currently shipped into Ohio. Overall, polygeneration could enhance local production capacity and further boost Northeast Ohio's economy.

Figure 1




Source: Clean Air Task Force

# 1. Methodology of the Study

In order to provide an initial understanding of key factors relating to industry cluster development as they relate to gasification, this analysis includes:

- An assessment of potential firms in the region that could act as suppliers (backward links in the supply chain) and customers (forward links in the supply chain)
- Results of Interviews with key industry leaders who provide practical insight into the analysis
- An economic impact study of siting an IGCC facility in Northeast Ohio

In order to better understand the firms that could act as backward links of the supply chain, we first identified potential contractors, manufacturers, and suppliers for an IGCC plant utilizing construction bid sheets that were developed for a proposed IGCC plant that would produce electricity and synthetic gas.[4] The bid sheets, obtained from Southern Illinois University, were made available through a program in Illinois that provides state grants for engineering design packages to developers of coal gasification facilities. The North American Industrial Classification codes (NAICS) were identified for firms on the bid sheets and then cross referenced to Ohio industries in order to identify Ohio-based firms that could provide needed products and services. The firm data was then tabulated and mapped geographically. [5]

The next step involved seeking feedback from major firms that provide integrated engineering, construction, and management services for industrial processes. Firms were chosen who could supply these services for a coal-gasification plant. Structured interviews focused on views on IGCC plant construction, how such a plant might impact Ohio, and perceived benefits of coal-gas plants in Ohio.

Potential forward-linkages firms located within the region -- the buyers of polygeneration products -- were also interviewed. These discussions centered on gaining a better understanding of downstream use of chemicals produced by a polygeneration plant. Firms engaged in manufacturing chemicals or using them as feedstocks were identified, tabulated and mapped for Ohio and Northeast Ohio. Finally, an interview with a large Midwest utility captured perspectives on near and long-term prospects, Ohio's distinctive advantages, and priorities for action for a coal-fueled polygeneration facitiliy.

The final step in this analysis was an economic impact study of a polygeneration facility on the economies of northeast Ohio and the state as a whole. The estimates

[4] The bid sheets are from Steelhead Energy Companies proposed facility to produce electricity and natural gas in Williams County, Illinois.
[5]These are firms that can provide the basic components for a gasifier, plus the components needed for generating base-load power, synthetic natural gas, Fischer-Tropsch fuels, ammonia, and capture and sequestration of $CO_2$, including compressors and pipelines. It includes firms involved in constructing the common facilities (excavation, concrete, structural steel, piping, electrical instrumentation, etc) as well as in operation of the coal gasification process (air separation equipment, gasification, syngas treatment, sulfur and CO2 recovery, CO2 compression, power island etc.). Not included were other, construction bid components, e.g., electrical, civil engineering and security.

and projections used for economic impacts due to construction and plant operation are drawn from a recently released study by the Electric Power Research Institute on the construction and operation costs of a full-scale IGCC facility to be constructed in Texas. The capital cost, performance, operations, maintenance costs, availability factors, and emission rates from this study were used as proxies for a polygeneration facility sited in Ohio.

A companion study to this report will identify the oil and gas producers in Ohio that could benefit from a facility that separated and captured its waste $CO_2$ by using it for enhanced oil or gas recovery. Oil and gas recovery with $CO_2$ has been in use for several decades in the southwest and western United States, but has not been applied in Ohio. Capturing exhaust $CO_2$ from large, stationary sources (e.g. electric power plants, or ethanol, cement, or aluminum plants) and sending it by pipeline to geologic reservoirs where it can be injected and stored has gained prominence as a strategy to reduce $CO_2$ emissions of $CO_2$ into the atmosphere. This strategy is known as $CO_2$ capture and geologic storage, or CCS. Because $CO_2$ has physical properties that enhance oil recovery, it is an attractive option for the oil and gas industry.

# Polygeneration: Backwards- and Forward-Linkages

The potential value to Northeast Ohio of developing polygeneration facilities has many dimensions. Purchases made during the construction phase of the project would include parts, components, and systems, as well as engineering and planning services. The degree to which these purchases are made from existing businesses in Ohio will determine the value of the construction phase to the state. A polygeneration plant would also create value downstream through local production of chemicals. U. S. Energy Information Agency data are used to identify chemical use by industry classification and northeast Ohio firms within those groups. This section provides insights into the potential magnitude of market stimulation, both upstream and downstream, that a polygeneration facility could provide.

### Identification of Ohio Firms that Could Supply Equipment to the Construction and Operation of Polygeneration Gasifier Facilities

In order to better understand the potential for Ohio firms to participate in the upstream supply chain, the research team attempted to quantify the number of potential contractors, manufacturers, and suppliers for a coal gasification plant. Bid sheets for the construction of a proposed plant that would generate electricity and produce syngas were used for this purpose. Table 1 shows the bid sheet components for which quantification of Ohio firms was attempted. Quantification was not attempted for a number of construction bid components, including electrical and civil engineering, security, and buildings. Thus, the components listed in Table 1 cover only a sub-set of the firms that would be engaged in building and operating a polygeneration plant.

**TABLE 1: IGCC Major Components**

| |
|---|
| Coal Feed Conveyor |
| Air Separation Unit |
| Rectisol Acid Gas Removal Unit |
| Gasifier and Hot Gas Path Vessels |
| Shift Reactor |
| Acid Gas Absorber |
| Syngas Scrubber Columns |
| Gas Turbine Generator |
| Steam Turbine Generator |
| Syngas Recycle Compressor |
| Auxilliary Boiler |
| Slurry Feed Pump |
| Steam Turbine Condenser for SNG |
| Dry Char Filter |
| Process Water Recovery Unit and Demin Water System |
| Moi Sieve |

The NAICS codes of the firms bidding on each component were determined. The Dun & Bradstreet database was then used to estimate the number of Northeast Ohio and Ohio firms that provide products and services in the relevant NAICS codes. As

shown in Table 2, nearly 3,500 firms in Ohio are listed as potential contractors to build or supply materials for coal-gasification plants. Nearly half of these firms are located in Northeast Ohio. The three sectors with the greatest number of firms are "Other Commercial & Service Industry Machinery Manufacturing, "Other Heavy & civil Engineering Construction," and "Sheet Metal Work Manufacturing."

**Table 2: Potential Northeast Ohio and Ohio Contractors for IGCC Plant Construction**

| NAICS code | Major IGCC Component Suppliers | # NEO Firms | # Ohio Firms |
|---|---|---|---|
| 213112 | Support Activities for Oil & Gas Operations | 108 | 241 |
| 221210 | Natural Gas Distribution | 45 | 164 |
| 237990 | Other Heavy & Civil Engineering Construction | 184 | 576 |
| 238120 | Structural Steel & Precast Concrete Contractors | 81 | 236 |
| 325120 | Industrial Gas Mfg. | 28 | 83 |
| 325131 | Inorganic Dye & Pigment Mfg. | 23 | 34 |
| 332313 | Plate Work Mfg. | 75 | 177 |
| 332322 | Sheet Metal Work Mfg. | 130 | 353 |
| 332919 | Other Metal Valve & Pipe Fitting Mfg. | 33 | 58 |
| 333132 | Oil & Gas Field Machinery & Equipment Mfg. | 9 | 22 |
| 333319 | Other Commercial & Service Industry Machinery Mfg. | 322 | 714 |
| 333412 | Industrial & Commercial Fan & Blower Mfg. | 34 | 86 |
| 333513 | Machine Tool (Metal Forming Types) Mfg. | 76 | 164 |
| 333611 | Turbine & Turbine Generator Set Units Mfg. | 5 | 16 |
| 333911 | Pump & Pumping Equipment Mfg. | 37 | 89 |
| 333912 | Air & Gas Compressor Mfg. | 9 | 34 |
| 333922 | Conveyor & Conveying Equipment Mfg. | 33 | 104 |
| 333994 | Industrial Process Furnace & Oven Mfg. | 38 | 64 |
| 334113 | Semiconductor & Related Device Mfg. | 6 | 20 |
| 335312 | Motor & Generator Mfg. | 58 | 169 |
| 336322 | Other Motor Vehicle Electrical & Electronic Equip.Mfg. | 24 | 39 |
| | Totals = | 1358 | 3443 |

The firm location information from the Dun and Bradstreet database, displayed in Figure 2, shows the high concentration of potential contractor firms in Northeast Ohio.

**Figure 2: Coal Gas Industry Supply Chain**

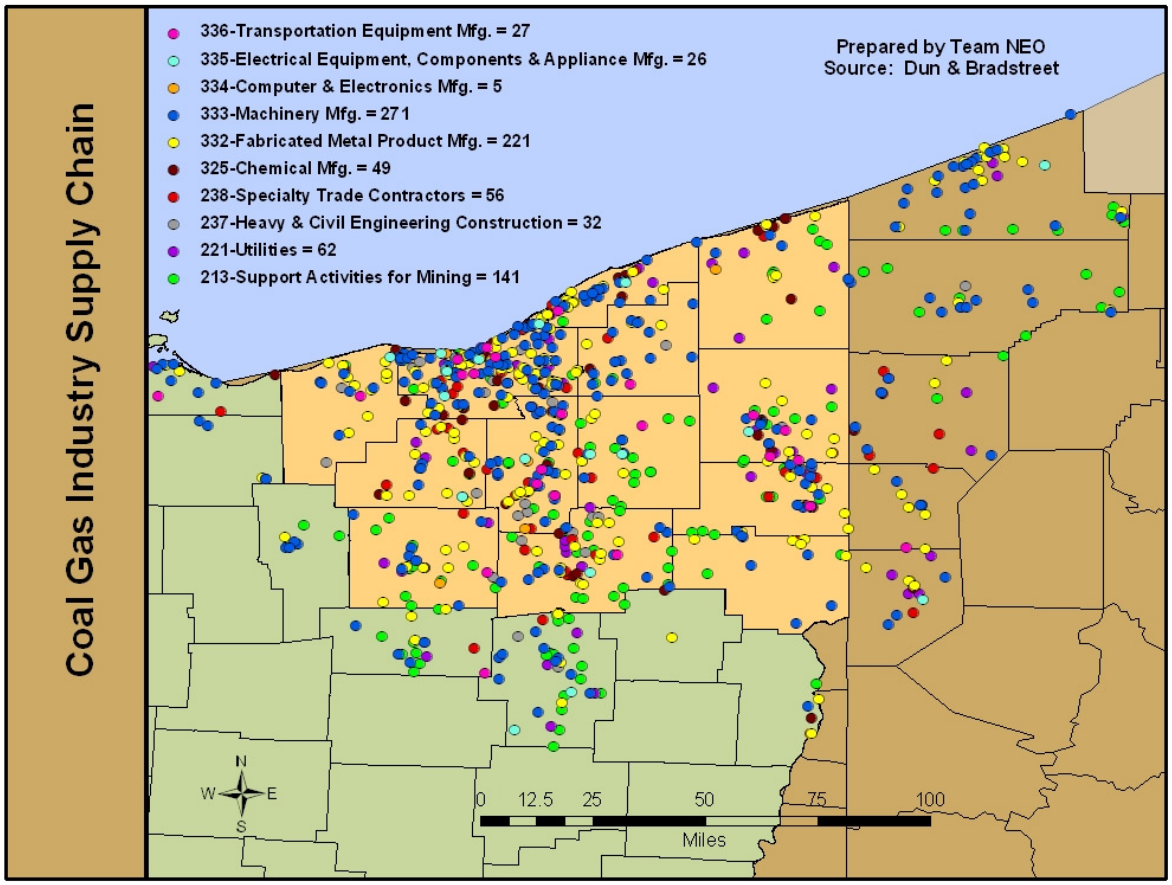



Table 3 provides the 4-digit NAICS codes for the industry categories related to coal gasification. This data reinforces the characterization of Northeast Ohio as a center of manufacturing in Ohio and Ohio as a center for the United States. Northeastern Ohio is responsible for over one-third of the state's employment and value generated by firms in these NAICS codes. Ohio is also responsible for a significant share of these industries' national employment and value (5.5 % and 5.7% respectively).

**Table 3: Northeast Ohio and Ohio Industry Employment and Output Comparisons at NAICS 4 Digit Level & US Summary Level**

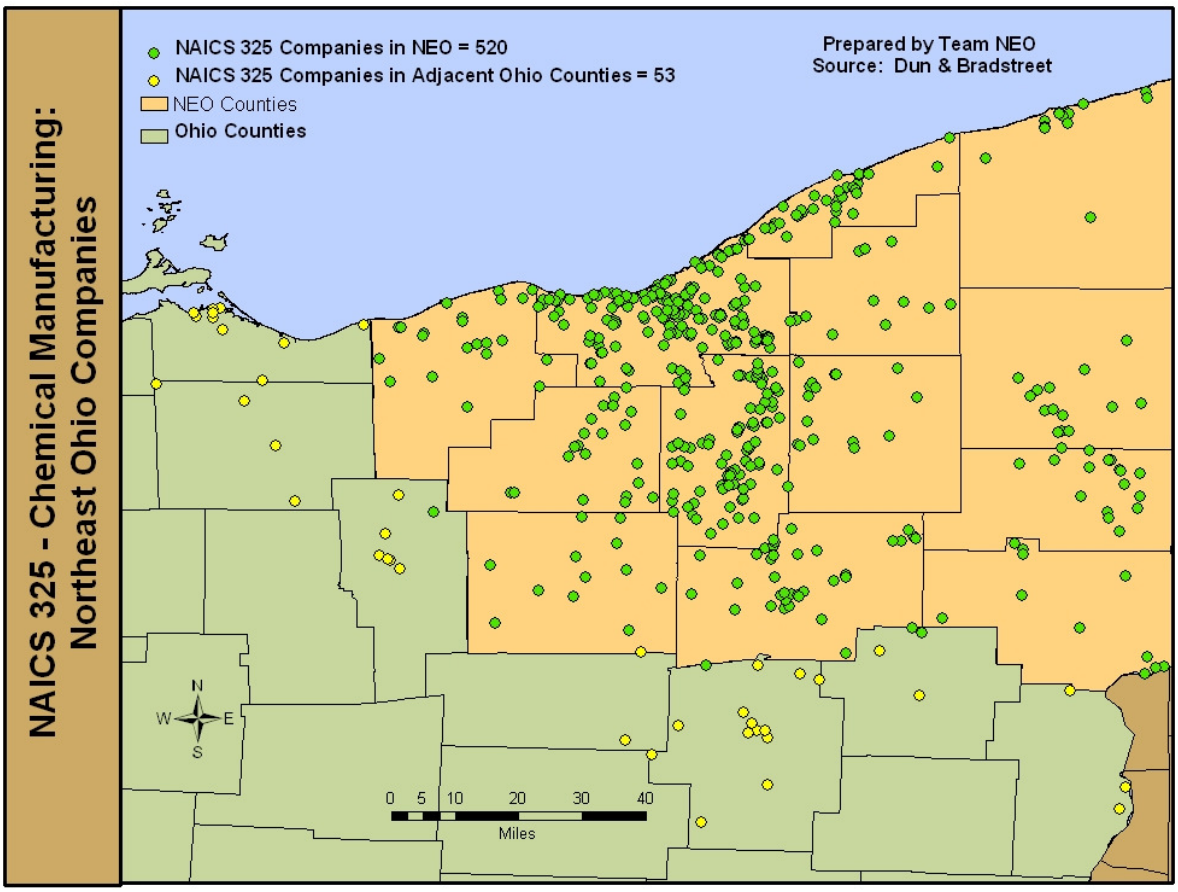
| | | Northeast Ohio | | State of Ohio | | Employment | Output |
|---|---|---|---|---|---|---|---|
| NAICS | Industry | Employment | Gross Regional Product | Employment | Gross State Product | NEO as % of State | NEO as % of State |
| 2131 | Support Activities for Mining | 1,174 | $25,715,576 | 2,333 | $52,743,455 | 50% | 49% |
| 2212 | Natural Gas Distribution | 1,170 | $440,047,504 | 3,453 | $1,331,361,870 | 34% | 33% |
| 2379 | Heavy and Civil Engineering | 6,798 | $509,776,474 | 24,618 | $1,736,837,012 | 28% | 29% |
| 2381 | Foundation, Structure, and Building Exterior Contractors | 12,022 | $562,693,178 | 34,279 | $1,593,758,060 | 35% | 35% |
| 3251 | Basic Chemical Manufacturing | 3,879 | $795,596,243 | 10,636 | $2,085,757,119 | 36% | 38% |
| 3323 | Architectural and Structural Metals Manufacturing | 6,547 | $587,754,181 | 19,112 | $1,588,151,606 | 34% | 37% |
| 3329 | Other Fabricated Metal Product Manufacturing | 15,142 | $1,446,693,450 | 25,808 | $2,457,116,764 | 59% | 59% |
| 3331 | Agriculture, Construction, and Mining Machinery Manufacturing | 2,214 | $107,781,473 | 6,308 | $546,312,444 | 35% | 20% |
| 3333 | Commercial and Service Industry Machinery Manufacturing | 1,419 | $117,306,124 | 3,812 | $323,930,715 | 37% | 36% |
| 3334 | Ventilation, Heating, Air-Conditioning, and Commercial Refrigeration Equipment Manufacturing | 3,148 | $191,535,915 | 8,232 | $536,211,296 | 38% | 36% |
| 3335 | Metalworking Machinery Manufacturing | 10,286 | $820,507,555 | 25,273 | $1,845,066,425 | 41% | 44% |
| 3336 | Engine, Turbine, and Power Transmission Equipment Manufacturing | 1,725 | $90,083,037 | 5,350 | $498,572,106 | 32% | 18% |
| 3339 | Other General Purpose Machinery Manufacturing | 9,527 | $845,346,305 | 25,904 | $2,054,679,506 | 37% | 41% |
| 3341 | Computer and Peripheral Equipment Manufacturing | 864 | $102,483,710 | 1,939 | $390,039,056 | 45% | 26% |
| 3353 | Electrical Equipment Manufacturing | 4,068 | $665,188,097 | 8,715 | $1,422,288,834 | 47% | 47% |
| 3363 | Motor Vehicle Parts Manufacturing | 21,421 | $2,781,483,191 | 93,714 | $11,143,982,037 | 23% | 25% |
| | **NEO or State of Ohio Totals** | 101,404 | $ 10,089,992,013 | 299,486 | $ 29,606,808,305 | 34% | 34% |
| | **US Totals** | 5,409,972 | $ 516,257,236,000 | 5,409,972 | $ 516,257,236,000 | | |
| | **NEO or State as % of US** | 1.9% | 2.0% | 5.5% | 5.7% | | |

**Estimation of Downstream Chemical and Natural Gas Usage**

Chemical products from a polygeneration facility could find markets in a wide variety of industries. Broadly defined, chemical manufacturing (NAICS 325) transforms organic and inorganic feedstocks into desired products, including resins and synthetic rubber (3252), pesticides (3253), pharmaceuticals (3254) paints (3255), soaps (3256) and other chemical products (3257). One key issue is whether the specific feedstocks can be produced from coal or need to be organic-based.

According to the American Chemistry Council, [6] Ohio is the 9th leading state in terms of the value of chemical shipments ($22.8 billion in 2004), employing 46,900 workers (ranking 7th) in approximately 728 establishments (ranking 3rd). As shown in Figure 3, Northeast Ohio has a high concentration of chemical manufacturing establishments and dominates Ohio's chemical industry.

**Figure 3: Northeast Ohio Chemical Manufacturing Companies**




Although polygeneration plants can produce a wide variety of chemicals, the specific chemicals that could be produced in a given facility will depend upon details

[6] *Guide to the Business of Chemistry 2006.* American Chemistry Council

of plant design. The discussion below provides insight into potential markets; it is not intended to be comprehensive.

Industry experts pointed out that some of the potential chemical products of a polygeneration facility are considered commodities. These “bulk” chemicals, which include sulfur, ammonia, and methanol, are homogenous in nature and widely traded. As a consequence, agreements to produce and sell specialty chemicals are more likely to focus on specific Ohio firms. Unfortunately, information on specialty chemicals was insufficient to estimate market size. These “higher end” products command significantly higher per ton prices than commodity chemicals, and long-term contracts for purchase of these chemicals could considerably improve prospects for return on investment for a polygeneration plant, significantly improving outlooks for securing financing.

**Sulfur and Ammonia Use in Ohio**

U.S Energy Information Agency data provides information on sulfur and ammonia usage by industry. Both sulfur and ammonia are commodity chemicals with large potential markets. Ammonia is an important commodity for agricultural fertilizer and sulfuric acid is one of the most important industrial chemicals. The major use of sulfuric acid is in the production of fertilizers, but it is also widely used in the manufacture of chemicals such as hydrochloric acid, nitric acid, sulfate salts, synthetic detergents, dyes and pigments, explosives, and drugs. Non-feedstock uses of sulfur include washing impurities out of gasoline in refineries; processing metals, e.g., in cleaning iron and steel before plating; and as an electrolyte in lead-acid storage batteries. Table 4 shows industrial users of ammonia, sulfur, and natural gas by NAICS category.

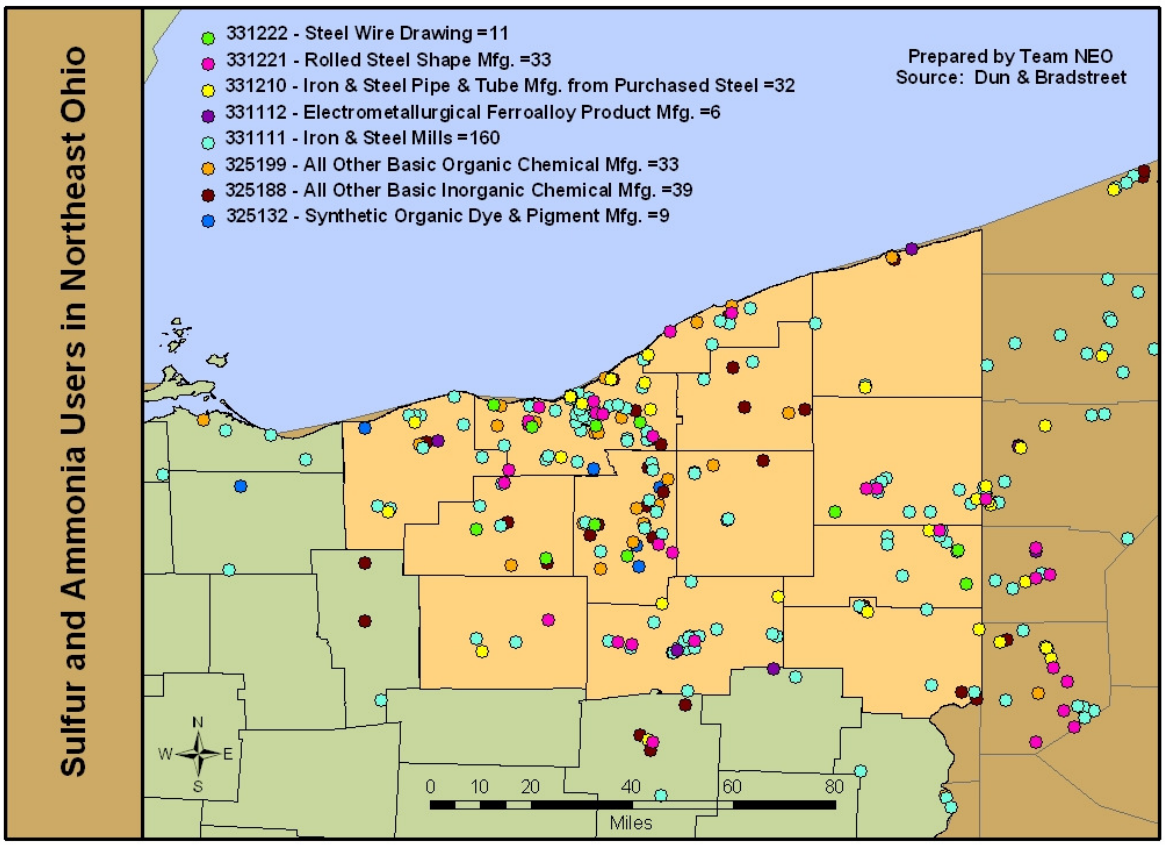
| Table 4: Chemical Users by NAICS. | |
|---|---|
| **Products of Gasification Process** | **Industry Users of Products** |
| Ammonia, synthetic anhydrous (100 percent $NH_3$) | 325199 All other basic organic chemical mfg |
| | 325192 Cyclic crude & intermediate mfg |
| | 325193 Ethyl alcohol mfg |
| | 325920 Explosives mfg |
| | 325314 Fertilizer (mixing only) mfg |
| | 325311 Nitrogenous fertilizer mfg |
| | 325110 Petrochemical mfg |
| | 325312 Phosphatic fertilizer mfg |
| | 325132 Synthetic organic dye & pigment mfg |
| Crude chemical nonmetallic minerals (bauxite, etc.) | 325181 Alkalies & chlorine mfg |
| Industrial chemicals (excluding sulfuric acid & oxygen) | 331112 Electrometallurgical ferroalloy product mfg |
| | 331111 Iron & steel mills |
| | 331210 Iron & steel pipe & tube mfg |
| | 331221 Rolled steel shape mfg |
| | 331222 Steel wire drawing |
| Sulfur | 325188 All other basic inorganic chemical mfg |
| | 325199 All other basic organic chemical mfg |
| | 325314 Fertilizer (mixing only) mfg |
| | 325311 Nitrogenous fertilizer mfg |
| | 325312 Phosphatic fertilizer mfg |
| Sulfuric acid, new and spent (100 percent H2SO4) | 331111 Iron & steel mills |
| | 331210 Iron & steel pipe & tube mfg |
| | 331221 Rolled steel shape mfg |
| | 331222 Steel wire drawing |
| | 335911 Storage battery mfg |
| Sytnthetic Gas | Fisher Tropsch synthesis |
| | Diesel |
| | Naptha |

Table 5 shows the number of Ohio firms in the NAICS categories of industries that purchase sulfur and ammonia. Even this short list of potential purchasers of two possible products of a polygeneration facility includes over 200 firms with a nearly $2 billion payroll. There are, for example, 11 synthetic organic dye & pigment manufacturers in Ohio. Together, these employ 900 workers, have a combined payroll of $48 million, and annual shipments worth $320 million.

| Table 5: Ohio Users of Sulfur and Ammonia 2002 Economic Census | | | | | |
|---|---|---|---|---|---|
| 2002 NAICS | Description | Number of establishments | Number of employees | Annual payroll ($1,000) | Total value of shps ($1,000) |
| 325132 | Synthetic organic dye & pigment mfg | 11 | 912 | $48,143 | $321,024 |
| 325188 | All other basic inorganic chemical mfg | 43 | 2,887 | $174,176 | $900,132 |
| 325199 | All other basic organic chemical mfg | 39 | 3,082 | $162,657 | $1,496,301 |
| 331111 | Iron & steel mills | 48 | 19,483 | $1,000,519 | $6,680,584 |
| 331112 | Electrometallurgical ferroalloy product mfg | 6 | 1,645 | $82,672 | $618,870 |
| 331210 | Iron & steel pipe & tube mfg | 27 | 3,940 | $161,746 | $1,006,549 |
| 331221 | Rolled steel shape mfg | 22 | 3,149 | $170,919 | $1,554,353 |
| 331222 | Steel wire drawing | 16 | 1,198 | $52,279 | $293,265 |
| | Total | 212 | 36,296 | $1,853,111 | $12,871,078 |
| Release Date: 5/26/2005 | | | | | |
| Manufacturing: Industry Series: Industry Statistics for Selected States: 2002 | | | | | |

According to the interviewed executives, proximity and transport costs are key elements considered when purchasing commodity chemicals. If this is the case, the 212 establishments in Ohio, employing 36,000 people, could benefit from Ohio-produced ammonia and sulfur. Figure 4 maps northeastern Ohio and western Pennsylvania firms in the relevant NAICS codes in.

**Figure 4: Sulfur and Ammonia Users in Northeast Ohio**



## Industrial Natural Gas Usage in Ohio

Synthetic natural gas or methane is likely to be among the products of a polygeneration gasification facility. Synthetic natural gas can either be combusted onsite to generate electricity or sold. If not combusted for electricity production, syngas is used either as a feedstock for manufacture of other goods or for heating. This section presents an overview of the Ohio natural gas market, providing information on sources of demand, growth sectors, prices, magnitude of the market, and Ohio's status as a net importer of natural gas.

Industrial users account for 36 percent of Ohio's natural gas usage. In 2005, this amounted to 293.9 mcf (thousand cubic feet) of natural gas. As shown in Table 6, since 2000, natural gas usage as a vehicle fuel and for electric power has more than doubled, while use in the residential, commercial and industrial sectors has decreased.

**Table 6: Ohio's Natural Gas Usage (Million Cubic Feet)**

| | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 |
|---|---|---|---|---|---|---|
| Sector | | | | | | |
| Residential | 343,920 | 308,534 | 321,317 | 343,037 | 320,823 | 322,697 |
| Commercial | 177,917 | 172,555 | 163,274 | 179,611 | 170,240 | 166,821 |
| Industrial | 339,060 | 295,556 | 305,883 | 290,483 | 302,023 | 293,857 |
| Vehicle Fuel | 424 | 529 | 539 | 659 | 740 | 803 |
| Electric Power | 10,123 | 10,545 | 22,722 | 18,774 | 18,258 | 27,941 |
| Total | 871,444 | 787,719 | 813,735 | 832,564 | 812,084 | 812,119 |

Source: Energy Information Agency

Ohio has 8,300 industrial natural gas users that currently pay an average of $11.22 per mcf. As natural gas prices have increased, average consumption per industrial consumer has declined, as shown in Table 7.

**Table 7: Number of Industrial Natural Gas Consumers and Average Price Paid in Ohio**

| | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 |
|---|---|---|---|---|---|---|
| Number of Industrial Consumers | 8,267 | 8,515 | 8,111 | 8,098 | 7,899 | 8,321 |
| Ave. Consumption per Consumer (Thousand Cubic Ft.) | 41,014 | 34,710 | 37,712 | 35,871 | 38,236 | 35,315 |
| Industrial Price $/Thous. Cubic Feet) | 5.14 | 6.54 | 5.67 | 8.06 | 8.84 | 11.22 |

Source: Energy Information Agency

Dominion East Ohio, a subsidiary of Dominion Resources of Richmond, VA, is the major supplier of natural gas in the 13-county northeastern Ohio region. This region accounts for about 35 percent of Ohio's total natural gas use and 29 percent of Ohio's industrial natural gas use. Industrial consumption of natural gas represents 30 percent of all natural gas used in Northeast Ohio. See Table 8.

**Table 8: 2005 Natural Gas Usage -- Northeast Ohio Versus State-wide**

| | Northeast Ohio* (Million Cubic Feet) | Percent of NEO | Ohio (Million Cubic Feet) | Percent of Ohio | NEO as % of Ohio |
|---|---|---|---|---|---|
| Residential | 130,232 | 46% | 322,697 | 40% | 40% |
| Commercial | 55,666 | 20% | 166,821 | 21% | 33% |
| Industrial | 85,808 | 30% | 293,857 | 36% | 29% |
| Other | 10,357 | 4% | 28,744 | 4% | 36% |
| Total | 282,063 | 100% | 812,119 | 100% | 35% |

Sources: Dominion East Ohio Gas, EIA. *Dominion East Ohio Gas Utility Sales (transport & tariff), 2005

Ohio has over 33,000 natural gas wells, ranking 6th in the nation, but production is insufficient to meet Ohio demand.

**Table 9: Number of Producing Gas and Gas Condensate Wells**

| Rank | Region | 2005 |
|---|---|---|
| | U.S. | 425,303 |
| 1 | Texas | 74,827 |
| 2 | West Virginia | 49,335 |
| 3 | Pennsylvania | 46,654 |
| 4 | New Mexico | 40,157 |
| 5 | Oklahoma | 36,704 |
| 6 | Ohio | 33,735 |
| | Source EIA | |

As shown in Table 10, Ohio is a net importer of natural gas, receiving the bulk of its imports from Indiana and Kentucky.

| Table 10. Ohio's Movement of Natural Gas (MCF) | |
|---|---|
| | 2005 |
| Total Interstate Receipts From: | 2,050,884 |
| Indiana | 918,057 |
| Kentucky | 909,100 |
| Michigan | 33,092 |
| Pennsylvania | 868 |
| West Virginia | 189,766 |
| | |
| Total Interstate Deliveries To: | 1,307,853 |
| Indiana | 18,125 |
| Kentucky | 0 |
| Michigan | 168,634 |
| Pennsylvania | 460,328 |
| West Virginia | 660,767 |
| | |
| Net Interstate Receipts for Ohio: | 743,030 |
| Indiana | 899,932 |
| Kentucky | 909,100 |
| Michigan | -135,541 |
| Pennsylvania | -459,459 |
| West Virginia | -471,001 |

**Methanol and Hydrogen**

Two additional commodity chemicals that can be produced at a coal-gasification facility are methanol and hydrogen. Methanol and methanol derivatives are used in a wide variety of products. Methanol is used in silicones, refrigerants, adhesives, windshield antifreeze, specialty plastics and coatings, textiles, and water-treatment chemicals. Methanol's purity and physical properties enable it to be used to extract, wash, dry and crystallize pharmaceuticals and agricultural chemicals. It also acts well as a solvent in the production of ethyl cellulose, polyvinyl acetate, nitrocellulose, dyes, shellacs and numerous other chemicals. Use of methanol as a solvent is expected to slowly decline due to health and environmental concerns.

Methyl methacrylate, a methanol derivative, is used to make acrylic plastics, and acrylic polymers are used in water-based interior and exterior coatings. Methyl chloride is used in the production of silicone fluids and elastomers, markets that are growing. Methylamines are used as intermediates in a diverse range of specialty chemicals, with applications in water-treatment chemicals, solvents, shampoos, liquid detergents and animal feed. Growth in many of these product lines is largely driven by general economic growth, including growth in housing construction, new car production, and industry.

Hydrogen is used extensively to make ammonia, methanol, gasoline, heating oil, and rocket fuel. It is also used to make fertilizers, glass, refined metals, vitamins,

cosmetics, semiconductor circuits, soaps, lubricants, cleaners, and even margarine and peanut butter. However, the market for hydrogen may expand significantly. In the future hydrogen may be used as a transportation fuel in conjunction with fuel-cell technologies, as a gas in turbines to generate electricity, and as a means to store energy, particularly from intermittent renewable generation. The potential for a polygeneration facility to provide hydrogen for these potentially very large markets should be taken into consideration by utility, industrial and government stakeholders.

# Industry Observations: Upstream and Downstream Impacts

> *"There is a great chance for leadership from Ohio and the technology should be encouraged."*
>
> "*Polygeneration technology is low pollution, high efficiency, and uses domestic (Ohio) coal*."

A dozen industry executives were interviewed regarding locating a polygeneration facility in Northeast Ohio and the potential for a coal-gasification industry cluster to flourish. Interviewees included three executives from power plant construction and design firms, seven from firms representing potential buyers of chemicals, and one from a utility and one from a firm trying to establish a coal-gasification facility in the region (Appendix A provides further information on characteristics of the firms represented). The executives were thoughtful, knowledgeable, and aware of current coal-gasification projects. They understood the potential to produce both power and chemicals and to capture and sequester, or use for EOR, exhaust $CO_2$. They all believed that a polygeneration project had merit and that there were economic opportunities related to coal gasification. Potential financing, siting advantages, and partnerships strongly appealed to the business executives who indicated interest in study results and further initiatives in this field.

**Key Results**

- Executives from construction and design firms and firms that would be potential buyers of chemicals saw economic value and opportunity for the region from a polygeneration facility.
- Construction and design executives cited local production of major facility components, and local use of skilled construction and operation labor, engineering, and ancillary services as potential benefits.
- Executives representing potential buyers were particularly interested in the possibility of natural gas production.
- All respondents stated price of the gasification products was the critical issue.
- It was pointed out that purchasing contracts and relationships between buyers and sellers in the case of both bulk and specialty chemicals are complex.
- Many of those interviewed expressed a need to better understand the facility's business plan in order to evaluate the value of a local, coal-based supplier of chemicals and chemical feedstocks.
- A former Economic Development official noted that there was an active effort to recruit this type of facility to their area.
- Some Ohio utilities are interested in pursuing coal gasification for power generation (i.e., an IGCC plant). Polygeneration gasification is currently not part of electric utility business models.
- While gasifier reliability was an issue 20 years ago, respondents feel that with today's better technology coal-gasification systems will work.

**Economic Development Benefits: Views from Industry Executives**

*"…most of the plant would be built with products and services from NEO. In particular, piping, pumps, compressors, civil and electrical work and other balance-of-plant type work."*

Siting a polygeneration plant drives regional economic development in three distinct ways. First, the sheer magnitude of constructing a $1.0± billion facility creates a breadth of employment and associated spending in a region. Secondly, the operation of a polygeneration power plant would offer ongoing, well-paid jobs, tax revenues, and spending spin-offs. The third driver of economic development would result from use of the chemicals and power produced. Local production of chemicals could result in lower costs to Ohio industries, increased sales within the region, establishment of new plants using the chemicals, and increased chemical exports. A polygeneration facility might also be able to provide electricity at lower costs than a dedicated utility power plant.

However, as one executive pointed out, "*You need more than one plant to create a cluster*."

This problem was echoed by many participants, one of whom pointed out that currently, "*The projects are still big and expensive*…"

Therefore it is likely to be challenging for any single region to host multiple coal-gasification facilities, whether they are designed to produce heat and power only or function as polygeneration facilities. One respondent pointed out that one advantage the region enjoys is that *"Ohio sits at the hub of energy demand and coal availability*." Furthermore, according to another interviewee, "*Proximity to coal will be critical as to where a plant is sited. Railroads have the coal users over the barrel…*"

**A Proposed Polygen Project**

The Director of the Growth Partnership for Ashtabula County was interviewed regarding an Ashtabula site where several firms have shown an interest in locating a polygeneration facility. The Ashtabula site is of interest since there are a number of industrial gas companies within a mile or two. The prospects are good for building a coal gasification plant that would also provide products to existing nearby businesses. The existing facility and site are ready for acquisition and use, according to the director.

One of the nation's largest utility companies, Dominion Resources Inc. of Richmond, Virginia, had been pursuing this site for a coal-fired electric generating plant, but stopped its pursuit. Since Dominion abandoned the project, a number of smaller independent companies have initiated discussions regarding a coal gasification plant. Recently, a company has come forward with a plan to build such a plant at the site and is in serious discussion with appropriate businesses, government agencies and civic organizations. They expect to make a decision by mid to late March.

**Backward Linkage Industries: Views from Facility Construction Firms**

*"These are high paying jobs."*

Many Ohio firms could benefit from building a coal-gasification plant in the state. In particular, the piping, pumps, compressors, civil and electrical work could be supplied by Ohio firms. Local steel would most likely be used in the duct work, building, and chimney steel and Ohio firms could be competitive in making other materials needed throughout the plant. In-state benefits would increase if the gasifier, turbines, generators, and other major components were built in Ohio. However, respondents held a variety of views as to the feasibility or likelihood of, for example, the gasifier being built in Ohio. Respondents agreed that some major facility components would probably be imported.

"*Not just anyone can build turbines. It's probably going to be GE or Siemans.*"

GE makes its turbines in South Carolina and Siemens Westinghouse is in the Atlanta area. Concerns shared by interviewees were labor shortages, coal transport costs, and, their firms' lack of a partnership with any of the gasification process technology owners.

The nascent market in coal gasifiers makes it difficult to predict where a gasifier vessel would actually be built. Gasifier vessels are big, comprised of large, high-pressure, alloyed steel pieces transported to the site for final assembly. A gasifier might be constructed elsewhere and shipped into Ohio, although some executives believed that the gasifier could be built in Ohio. One Ohio-based firm with the capability to undertake such a project, Babcock and Wilcox, currently produces heat-recovery steam generators, which are large gasifier components. One executive suggested that Ohio might serve as an ideal location to build a gasifier. If pre-built along the Ohio River, the gasifier could be barged to its destination.

**The Construction Process**

1) The Company or municipality financing a polygeneration facility selects a particular gasification process-design using a Consulting Engineer. There are six designs that are actively being marketed today by GE, Conoco-Phillips, Siemans, Shell, Mitsubishi, and British Lurgi.
2) A general contractor or EPC (Engineering, Procurement, Construction) firm is selected. Examples include Bechtel, Fluor, Peter Kewitt, Foster Wheeler, and Black & Veatch. The EPC will bring together the mechanical and electrical aspects of the plant and will hire some of the sub-contractors. In some cases, the owner of the gasifier technology will use their pre-aligned partner, e.g. Bechtel or others, to serve as the EPC. The EPC designs and provides specifications for the plant.
3) Competitive bids go out. Anyone can bid; however, major component parts are often not let out to bid but are given to aligned partners or, in the case of GE and its turbines, parent companies.

**A Strategy to Foster Coal-gasification in Ohio**

Ohio could effectively boost its coal gasfication development strategy by offering target set-aside requirements for the construction of a polygeneration facility. Such programs typically offer tax incentives for contracting with in-state or local firms to do work. Such a strategy both increases support for the project and has economic payoffs for the community. Without prompting, the interviewed executives mentioned set-aside programs, citing their successful use in Wisconsin.

Assuring labor for the project is a significant concern. Power plant construction labor is scarce and accounts for 40 to 60 percent of total construction costs. Canadian Sands projects, recovery efforts in the aftermath of hurricanes Katrina and Rita, and the oil and refinery industry in general are strong competitors for construction trades. Furthermore, many gas construction projects – all of which would need laborers – are in various states of the proposal process. Bechtel and other EPCs often "direct-hire" rather than sub-contract to ensure their labor supply. An EPC with no more than a few projects in Ohio would probably rely more on local sub-contractors. Such hiring decisions depend upon the particular tasks demanded by a project as well as its location. For example, sub-contract labor in southern states is less expensive.

> *"You need welders, tradesmen, concrete layers for all of the projects."*

**Forward Linkage Industries: Views from Purchasers of Chemicals**

There are over 80,000 commercial chemical molecules, of which 300 to 400 are major industrial chemicals. Precisely which of these a polygeneration plant could produce depends on plant design. While a polygeneration plant offers opportunities to meet the chemical needs of a wide variety of firms, the very diversity of potential production platforms makes chemical market predictions difficult. Nonetheless, one executive commented that the immediate opportunity for a coal-gasification plant was not in production of electricity but rather in production of chemicals. Respondents were keenly aware of the costs of chemical feedstocks and repeatedly cited the complexity of obtaining chemicals in general.

In general, demand has increased for all kinds of chemicals and costs of many have increased. One respondent gave the example of a feedstock resin that has increased from 35 cents to 70 cents since January 2002. According to this manufacturer, this resin price has doubled due to crude oil prices and spikes. Consequently, if suitable feedstock chemicals could be produced from coal -- with its relatively low, stable prices -- at competitive prices, they would be a welcome addition to supply. Demand for most products of the chemical manufacturing firms represented has also been strong and is forecast to remain so. One executive pointed out that demand had been growing by 8 to 10 percent per year and that this trend was expected to continue. Others were unwilling to state specifics and, in more than one case, declined to comment. Demand for anhydrous ammonia is an exception to this generally upward demand trend; its use is declining primarily due to

its toxic nature. Nevertheless, there was interest in ammonia from a polygeneration facility.

Executives were asked: From where are Ohio firms purchasing chemicals? Will a polygeneration plant offer a local source of chemicals? What might be the market's response? As indicated in the below responses, the ability to sell chemicals into the Ohio market will depend on a number of factors, particularly price and characteristics of chemicals needed:

*"I am mercenary about buying my materials. In general, if anyone produces it cheap enough and the transportation costs are good, we buy it from them."*

*"Opportunities in the Midwest that are dependent on natural gas are good targets – polymers, chemicals, fertilizer…Proximity counts for a lot."*

*"Production would probably increase at Ohio plants if feedstock costs were reduced for those plants…Ohio plants would benefit from reduced production costs."*

*"Most firms in Cleveland would not benefit from the polygeneration plant since they are mineral based or organic type of chemical companies."*

In addition to price and chemical characteristics, proximity to final customers is a factor. Respondents guessed that purchased chemicals generally come from out-of-state. Transportation costs are a concern, but are simply factored into purchase decisions as a necessary cost, typically accounting for 3 to 5 percent of total costs. One executive used the rule of thumb of 3 to 5 cents per pound to move chemicals coast-to-coast. However, one executive discounted the impact of transportation costs, saying, "If our feedstock chemicals were to be produced locally there would be savings but there probably would not be a big advantage. The material's cost fluctuates a great deal and transportation costs are swamped."

Respondents did not have a simple answer when asked about the magnitude of cost reduction that would trigger increased purchases of Ohio-produced chemicals, explaining that switching decisions are complex and depend not only on price, but on volume and quality factors as well. For example, a switch might be relatively easy for commodity products such as ammonia and ethanol; firms might jump at a two percent reduction in those costs. Changes are less clear for other, more complex chemicals whose specifications and delivery issues factor into any switch in supplier or increase in volumes.

The scope of this study did not include determining whether a coal-fueled polygeneration plant could produce chemicals suitable for firms currently utilizing organic chemicals. However, a limited number of Ohio-based firms use coal-based chemicals in high volumes, including Lubrizol, RPM, PolyOne, PPG in Barberton, and BP in Lima. The main factor these firms would weigh in determining whether or not to purchase from a polygeneration plant would be the price of the chemicals.

Industry executives from firms employing chemicals that could be produced at a polygeneration plant agreed that their firms could benefit, if not directly, then indirectly from a polygeneration plant in the area (assuming product costs were favorable). They believed their suppliers would actually be the ones purchasing chemicals from such a facility. When asked about the degree to which their company might benefit, respondents raised a number of caveats – for instance, that too many unknowns still exist. Contracts to purchase chemicals are complex and there is no industry standard length, time, or delivery format. One executive indicated that he would like to see an actual 500 or 1000 megawatt (MW) IGCC viably up and running before getting excited about the potential.

Respondents are intrigued yet concerned about polygeneration plant economics. Their comments highlight the need for a clear, well-developed business plan:

> *"Where is the coal and where are the customers?"*
>
> *"Politics and regulation will make the electric energy side less appealing."*
>
> *"The approach makes sense when natural gas is over $7.00 Mcf."*
>
> *"Who has such deep pockets?"*
>
> *"Any such plant should be built near the coal mine and if possible at the mouth of the coal mine, using a coal slurry system to avoid the cost of rail transportation."*

**Polygeneration: Viewpoint from a Major Utility**

Ohio utilities could play a major role in developing a polygeneration plant in Ohio. They could contract to purchase electricity produced from such a plant, or help finance and build it. The utility executive interviewed was a supply expert who indicated that energy purchase decisions are based on their value to shareholders. The executive actively tracks technology development and was aware of the benefits and costs of carbon capture and sequestration. He expressed a willingness to consider polygeneration like any other source of energy. For example, the respondent's utility currently has a contract to purchase several hundred MW of power from a wind-energy firm. Although not obliged to purchase from these plants, it is currently profitable to purchase their power. The utility also uses natural gas for peak loads. The executive pointed out that:

"The concept of selling co-produced products like methane, sulfur, etc., that would be generated by a polygeneration facility would be a new or a-typical project for utilities in general. Typically, our business model deals with the purchase or generation of electricity from various sources, in various regional settings."

"It takes six to seven years to actually build a power plant, not including siting the facility. The degree of regulation, in particular securitization, would be a primary factor for a utility to address."

Finally, it must be noted that while this particular executive knew of no plans his firm had to build a polygeneration plant, there is at least one utility in Ohio actively seeking to build a coal-gasification facility in Ohio.

# Economic Impact of Construction and Operation of an Integrated Gasification Combined-Cycle Facility

This section of the report describes the economic impact of an IGCC facility on two levels: the Northeast Ohio region – and the State of Ohio. As a conservative proxy for economic impacts of a polygeneration facility, the report uses estimates and projections from a 2006 study by the Electric Power Research Institute (EPRI) for construction and operation of a proposed IGCC facility in Texas. It is assumed that the capital cost, performance, operations, maintenance costs, availability factors, and emission rates for an IGCC facility (i.e., a unit generating electric only) would approximate those of a facility sited in Ohio.[7] A polygeneration facility would, in fact, yield larger benefits due to greater construction expenditures.

### Measuring Economic Impact: Methodology and Assumptions

A model developed by Regional Economic Models, Inc. (REMI) was used to estimate the construction and operational impacts of a gasification facility. The REMI model is the preeminent model of its type and is widely recognized to be at the forefront of modeling with clients not only in North America but also in the European Union. The REMI model was custom-designed and tailored to the greater northeastern Ohio regional economy based on unique specifications, resulting in the NEO REMI model. The model represents the major inter-industry linkages among private industries aggregated into 70 major industrial sectors, including three public sectors (state and local, federal, and military). The model combines county data to create "regions", or spatial units of analysis. In this study, impacts are estimated for two regions: the 13-county Northeast Ohio region [8] and the entire state of Ohio. Due to the project's size and location, it is expected that impacts will accrue not only to these regions but to counties in neighboring Pennsylvania, New York, and West Virginia as well.

Fundamentally, construction and operation expenditures will have three economic effects:

- Direct economic impacts are those changes in the flow of dollars that result directly from the initial capital spending for land acquisition, equipment, construction of facilities, engineering and design, and all system components.
- Indirect economic impacts are investment or spending by suppliers whose goods and services are used in the project.
- Induced economic impacts result as household income changes (created by direct and indirect effects on wages) lead to further effects on consumer spending throughout the regional economy.

[7] Feasibility Study for an Integrated Gasification Combined Cycle Facility at a Texas Site. EPRI, Palo Alto,CA:2006.1014510

[8] The Northeast Ohio region includes Ashtabula, Columbiana, Cuyahoga, Geauga, Lorain, Lake, Mahoning, Medina, Portage, Stark, Summit, Trumbull, and Wayne counties

The total estimated economic impact as reported within this document is therefore the sum of the direct, indirect and induced economic effects of the investment in the study areas of Northeast Ohio and the entire state. We provide the total change in economic output, employment, personal income, and local and state revenue generated by successive rounds of spending by businesses and households associated with this project.

**Measuring Economic Impacts: Indicators**

The investment and operation of a gasification facility is expected to yield several forms of economic impact to the region and the state. To determine a consistent and reliable set of meaningful results, the analysis focuses on four indicators of economic output – employment, gross regional product, personal income, and output (described below). Estimates for the various measures from each of the simulations are analyzed and reported as differences from the base forecast.

*Employment:* The Bureau of Economic Analysis (BEA) definition is based on place of work including full-time and part-time employees, as well as seasonal employees. Total "new" jobs are attributable to the normal operations after construction and jobs created as part of the design, planning and construction of the IGCC plant. It is important to note that these jobs are simply "jobs." These jobs are distributed across a number of industries and so, in any given industry, a "job" may represent a summation of positions across a number of industries in which each industry has less than one complete or full-time-equivalent (FTE) position.

*Gross Regional Product (GRP):* This is an economic measure of the value-added that labor contributes to the final product or service. This measure is used more often than output as it does not include the value of "intermediate goods" or inputs in estimating the economic impact. For example, if a $25,000 auto is comprised of $15,000 in parts (intermediate goods) and $10,000 in labor to assemble the parts into a complete car, then the $10,000 in GRP is what the region uses to measure its input or contribution into the value of the vehicle (output).

*Personal Income:* This measure consists of total increases in payroll costs paid by local industries, plus income from self-employment, other property income and transfer payments.

*Output:* Output is analogous to sales and is a measure of the total value of both the inputs to labor as well as the value of inputs from materials. For example, if a $25,000 auto is comprised of $15,000 in parts (intermediate goods) and $10,000 in labor to assemble the parts into a complete car, then the $25,000 in sales is what the region uses to measure its output.

The model estimates the net impact of an IGCC project by estimating the difference between gross regional product, employment, output, and income in two separate forecasts. The first forecast is a baseline forecast for the region which excludes the project; the second forecast includes the project and its impact on the regional economy.

The scenarios that follow include economic impacts of construction and operations on the Northeast Ohio region and to the state of Ohio. The construction phase impacts cover four years from 2008 through 2011 and are combined for discussion below. The operations phase impacts are for the first full year of operation (2012).

**Inputs for modeling the impact of constructing and operating an IGCC Facility**

Input estimates and projections contained in the October 2006 EPRI study are used as proxy measures for the costs and economic impacts of investment and operation of an IGCC facility in the northeastern Ohio region and the state.

Table 11 on the next page displays the estimated capital costs associated with the construction of a 550 MW IGCC facility. In this report we employ EPRI study parameters and its assumed capacity factors for generator units to model the economic impact of construction and operation of the facility in Ohio. Column 2 shows the overall construction expenditure of $1.4 billion as estimated in the EPRI report. Several construction cost adjustments for the NEO project were made including:

1. Construction is expected to span approximately 4 years. It is assumed construction would begin in 2008 and should finish sometime in 2011.
2. The average 2006 construction wage per worker was estimated at $45,458.
3. Nearly $300 million of contractor or owner indirect costs were not included in the NEO REMI model. Indirect costs in the EPRI model include costs of land and contingencies and fees. However, in the case of land, wealth is simply transferred from one owner to another. In regard to the contingencies and fees included in the EPRI estimates, they are not specific enough to be modeled and may also give a false read on the impacts if included in the initial impact of the construction or operation of the facility. A false read would occur if the contingency funds were not spent. This would result in a gross overstatement of benefits. Another type of false read would occur should the contingency funds be mis-allocated, being attributed to an economic sector that would over- or understate benefits. By not modeling these (potentially phantom) indirect costs a more conservative, yet tractable, estimate is arrived at.

**Table 11: Total Construction Costs for IGCC Plant sited in Northeast Ohio**

| | 550 MW (Net) IGCC | Percentage of Total Project Cost | Amount Modeled |
|---|---|---|---|
| **Procurement** | | | |
| Gas Turbines | $86,000,000 | 5.83% | $86,000,000 |
| Steam Turbine | $22,950,000 | 1.56% | $22,950,000 |
| HRSGs | $28,080,000 | 1.90% | $28,080,000 |
| Other Mechanical | $46,720,000 | 3.17% | $46,720,000 |
| Electrical | $47,820,000 | 3.24% | $47,820,000 |
| Water & Chemical Treatment | $2,380,000 | 0.16% | $2,380,000 |
| Structural | $1,600,000 | 0.11% | $1,600,000 |
| **Construction** | | | |
| *Furnish and Erect* | | | |
| Material Handling | $36,660,000 | 2.49% | $36,660,000 |
| Air Separation Unit and N2 Storage | $102,400,000 | 6.95% | $102,400,000 |
| Gasification | $354,310,000 | 24.03% | $354,310,000 |
| Syngas Treatment | $149,990,000 | 10.17% | $149,990,000 |
| GTG/STG/HRSG Erection | $20,730,000 | 1.41% | $20,730,000 |
| Civil / Structural Construction | $94,740,000 | 6.43% | $94,740,000 |
| Mechanical Construction | $42,070,000 | 2.85% | $42,070,000 |
| Electrical Construction | $23,030,000 | 1.56% | $23,030,000 |
| **EPC Contractor Indirect Costs** | | | |
| *Construction Indirects* | | | |
| Construction Management | $24,710,000 | 1.68% | $24,710,000 |
| Pre-oper,startup and test (not modeled) | $8,230,000 | 0.56% | |
| Other (not modeled) | $4,790,000 | 0.32% | |
| Project Indirects | | 0.00% | |
| Project Management and Engineering | $40,000,000 | 2.71% | $40,000,000 |
| EPC Contingency (not modeled) | $57,100,000 | 3.87% | |
| EPC Fee (not modeled) | $119,910,000 | 8.13% | |
| Other (not modeled) | $4,760,000 | 0.32% | |
| **Total EPC Contractor Cost (2006 US $)** | $1,318,980,000 | 89.47% | $1,124,190,000 |
| **Owner Indirect Costs** | | | |
| Owner's Engineer | $23,000,000 | 1.56% | $23,000,000 |
| Permitting and Licensing Fees | $2,910,000 | 0.20% | $2,910,000 |
| Land (not modeled) | $7,500,000 | 0.51% | |
| Initial Fuel Inventory (not modeled) | $10,930,000 | 0.74% | |
| Operating Spare Parts | $10,060,000 | 0.68% | $10,060,000 |
| Permanent Plant Equipment and Furnishings | $4,600,000 | 0.31% | $4,600,000 |
| Builder's Risk Insurance | $5,940,000 | 0.40% | $5,940,000 |
| Owner Contingency (not modeled) | $70,200,000 | 4.76% | |
| Other (not modeled) | $20,100,000 | 1.36% | |
| **Total Owner's Cost (2006 US $)** | $155,240,000 | 10.53% | $46,510,000 |
| **Total Project Cost (2006 US $)** | $1,474,220,000 | 100.00% | |
| **Total Modeled Costs (2006 US $)** | | | $1,170,700,000 |

**EPC = engineering, procurement and construction**

As with the case of the construction expenditures, several operating assumptions were made that have an effect on estimated macroeconomic effects.

1. The NAICS designation for the facility for modeling the operations phase is 324, utilities.
2. 126 full time operations and maintenance personnel have been assumed
3. Based on the EPRI – Texas Project, estimates for labor costs, the average annual compensation for utilities related operations is $93, 934. The Ohio Labor Market Information 2005 annual average utilities wage in Ashtabula County, where the plant is assumed to be located, is $66,752.

**Construction Impacts of a IGCC Facility on the Regional and State Economies**

Table 12 summarizes the total effects of the direct construction expenditures on the Northeast Ohio region and the State.

* Employment is averaged, and is equivalent to one year's worth of employment for each year -- 2008, 2009, 2010 and 2011. The other components are the cumulative effect across the 4 years.

*Employment:* During the construction period the planned capital expenditures will create, on average, 3190 and 3344 new jobs in the northeastern region and state respectively, over the 2006 baseline estimates. These jobs include direct, indirect,

and induced employment.

Employment occurs across a number of industries during the construction period. As might be expected, the industry that is impacted the most is construction, with approximately 1500 jobs created. Tables 13 and 14 show estimated increases in employment by major sector for the State and for Northeast Ohio. As part of the supply chain of goods and services needed to build the project, approximately 435 manufacturing jobs are created within NEO and across the State and between 820 and 875 jobs are created in services.

**Table 13: Construction Employment Impacts State of Ohio**

| Industry Sector | 2008 | 2009 | 2010 | 2011 | Average |
|---|---|---|---|---|---|
| Total Employment | 3374 | 3381 | 3344 | 3279 | 3344 |
| Private Non-Farm | 3335 | 3316 | 3257 | 3174 | 3271 |
| Natural Resources, Mining, Utilities, Construction | 1492 | 1519 | 1519 | 1503 | 1508 |
| Forestry, Fishing, Other | 1 | 1 | 0 | 0 | 1 |
| Mining | 1 | 1 | 0 | 0 | 0 |
| Utilities | 5 | 5 | 5 | 5 | 5 |
| Construction | 1486 | 1513 | 1513 | 1498 | 1503 |
| Manufacturing | 470 | 447 | 423 | 400 | 435 |
| Trade | 313 | 312 | 306 | 296 | 307 |
| Wholesale Trade | 60 | 58 | 55 | 52 | 56 |
| Retail Trade | 253 | 254 | 251 | 244 | 250 |
| Transportation, Information, Financial Accounting | 156 | 152 | 146 | 138 | 148 |
| Transportation, Warehousing | 25 | 24 | 23 | 22 | 23 |
| Information | 17 | 16 | 16 | 16 | 16 |
| Finance, Insurance | 71 | 66 | 61 | 55 | 63 |
| Real Estate, Rental, Leasing | 44 | 46 | 46 | 45 | 45 |
| Services | 903 | 885 | 863 | 837 | 872 |
| Professional, Technical Services | 330 | 322 | 313 | 304 | 317 |
| Managemet of Companies, Enterprises | 22 | 21 | 20 | 19 | 21 |
| Administration, Waste Services | 119 | 119 | 118 | 115 | 118 |
| Educational Services | 30 | 28 | 26 | 24 | 27 |
| Health Care, Social Assistance | 78 | 77 | 76 | 74 | 76 |
| Arts, Entertainment, Recreation | 40 | 40 | 39 | 38 | 39 |
| Accomodation, Food Services | 160 | 157 | 154 | 149 | 155 |
| Other Services (excl Government) | 123 | 120 | 117 | 113 | 118 |

| Table 14: Construction Employment Impacts Northeast Ohio | | | | | |
|---|---|---|---|---|---|
| **Industry Variable** | **2008** | **2009** | **2010** | **2011** | **Average** |
| Total Employment | 3219 | 3225 | 3188 | 3126 | 3190 |
| Private Non-Farm | 3181 | 3163 | 3105 | 3027 | 3119 |
| Natural Resources, Mining, Utilities, Construction | 1484 | 1507 | 1505 | 1490 | 1496 |
| Forestry, Fishing, Other | 1 | 0 | 0 | 0 | 0 |
| Mining | 0 | 0 | 0 | 0 | 0 |
| Utilities | 5 | 5 | 4 | 4 | 4 |
| Construction | 1478 | 1503 | 1501 | 1485 | 1492 |
| Manufacturing | 416 | 394 | 372 | 352 | 384 |
| Trade | 292 | 291 | 285 | 276 | 286 |
| Wholesale Trade | 54 | 52 | 50 | 47 | 51 |
| Retail Trade | 238 | 238 | 235 | 229 | 235 |
| Transportation, Information, Financial Accounting | 139 | 136 | 130 | 123 | 132 |
| Transportation, Warehousing | 19 | 19 | 18 | 17 | 18 |
| Information | 14 | 14 | 14 | 13 | 14 |
| Finance, Insurance | 65 | 60 | 55 | 50 | 58 |
| Real Estate, Rental, Leasing | 41 | 43 | 43 | 42 | 42 |
| Services | 850 | 834 | 812 | 786 | 821 |
| Professional, Technical Services | 322 | 314 | 305 | 296 | 309 |
| Managemet of Companies, Enterprises | 20 | 19 | 18 | 17 | 19 |
| Administration, Waste Services | 111 | 111 | 110 | 107 | 110 |
| Educational Services | 27 | 25 | 24 | 22 | 24 |
| Health Care, Social Assistance | 73 | 72 | 70 | 69 | 71 |
| Arts, Entertainment, Recreation | 37 | 36 | 35 | 34 | 35 |
| Accomodation, Food Services | 147 | 144 | 140 | 136 | 142 |
| Other Services (excl Government) | 114 | 112 | 109 | 106 | 110 |

*Gross Regional Product (GRP),* or the value-added created by labor within the region, increases by more than $726 million for the region and $781 million for the State (2006 dollars).

*Personal Income,* the amount of income earned by Northeast Ohio households, increases by $704 million for the region and $741 million for the State (2006 dollars) over the baseline for the regional economy.

*Output* is also included in this study as an indicator of impact and is equivalent to total sales. It is estimated that an increase of $1.4 billion for the NEO Region and $1.5 billion (2006 dollars) is generated for the State by this project over the baseline.

State Wage Taxes, from personal income taxes increase by almost $14.8 for and $14 million from the Northeast Ohio during the construction period.

**First Year Operations Impacts of an IGCC Facility on the Regional and State Economies**

Table 15 shows the economic effects that an IGCC facility is expected to have on the northeastern Ohio region and the State during a typical year of operation. Unlike the effect for the construction effects, which are singular, the modeling assumes that the region and the State will reap the benefits of typical operations expenditures annually for the life of the plant.

| Table 15: Summary: Annual Operations Impacts (2006 Dollars) | | |
|---|---|---|
| | **Ohio** | **Notheast Ohio** |
| Employment | 465 | 443 |
| Gross Regional Product | $93,635,482 | $ 91,399,323 |
| Personal Income | $39,242,000 | $ 38,040,000 |
| Wage Tax (@ 2%) | $784,840 | $ 760,800 |
| Output | $161,363,821 | $ 157,244,890 |

The operations' impacts to the region are based on first full year operations at the processing facility as a component of the utilities industry. The estimated facility positions and additional employment will provide a total of between 443 and 465 jobs within the region and across the state. These jobs generate nearly $40 million in personal income, which includes both resident and commuter earnings. The income will create a municipally taxable pool of more than $750,000.

**Table 16 Operations Employment Impacts: Ohio and Northeast Ohio**

| Industry Variable | Ohio | NEO |
|---|---|---|
| Total Employment | 438 | 417 |
| Private Non-Farm | 432 | 411 |
| Natural Resources, Mining, Utilities, Construction | | |
| Forestry, Fishing, Other | 0 | 0 |
| Mining | 4 | 2 |
| Utilities | 128 | 128 |
| Construction | 37 | 35 |
| Manufacturing | 15 | 13 |
| Trade | | |
| Wholesale Trade | 8 | 8 |
| Retail Trade | 43 | 40 |
| Transportation, Information, Financial Accounting | | |
| Transportation, Warehousing | 7 | 5 |
| Information | 3 | 3 |
| Finance, Insurance | 13 | 12 |
| Real Estate, Rental, Leasing | 9 | 8 |
| Services | | |
| Professional, Technical Services | 31 | 30 |
| Managemet of Companies, Enterprises | 2 | 2 |
| Administration, Waste Services | 38 | 36 |
| Educational Services | 7 | 7 |
| Health Care, Social Assistance | 16 | 15 |
| Arts, Entertainment, Recreation | 9 | 8 |
| Accomodation, Food Services | 38 | 36 |
| Other Services (excl Government) | 24 | 23 |

# Conclusions and Implications

Northeast Ohio is a suitable location for a polygeneration gasification plant in terms of potential markets for chemicals, synthetic gas, and electricity, and could yield large benefits to the region and state of Ohio. This evaluation is based on a) analysis of backwards and forwards linkages to such a plant, b) discussions with industry executives, and c) an economic analysis of the plant's multiplier effect on the local and state economy. Furthermore, any Ohio facility would be in close proximity to oil and gas fields that could sequester $CO_2$ captured from a coal-gasification plant. $CO_2$ capture is critical for coal-fueled facilities due to the need to reduce greenhouse gas emissions.

The economic impact of locating a polygeneration gasifier in Northeast Ohio is large. A polygeneration facility would cost in the neighborhood of $1.1billion and a significant portion of inputs could be supplied by Ohio firms. The economic model reveals that for the entire state of Ohio personal income would increase by over $700 million and gross Ohio output would increase by $1.1 billion just for the construction of such a facility.

The Northeast Ohio region is estimated to account for 95 percent of the benefits from the construction phase of a plant located in that region. The Northeast Ohio region is home to over one-third of the Ohio-based firms that might directly participate in the construction of the facility. The northeastern region has a wealth of experienced industrial workers both for the construction and the operation of such a plant. However, business executives as well as industrial literature reveal a potential construction-labor shortage.

State-wide economic impacts from the operation of a coal-gasification plant are estimated to be $39 million in annual personal income and $161 million in terms of increased Ohio output. The Northeast Ohio region will account for 98 percent of the operational benefits. A facility in northeastern Ohio would be located near a key input, coal, and within a large industrial economy with many firms needing chemicals, some of which could be produced by a polygeneration facility.

Coal gasification is in the very early stages of development in the United States, resulting in many questions on the part of private industry. Reduction of the many unknowns and risks involved in polygeneration would help the private sector to evaluate this option. Key questions raised by executives include which products would be forthcoming and at what price, and how a polygeneration plant would be financed. Formation of the partnerships likely to be necessary to realize such a plant depends on the ability to answer such questions. These questions can be translated into public policy initiatives that could move an Ohio polygeneration facility forward. Public policy initiatives could include:

1) Financing of the project: Government policy might provide for low interest loans, incentives to encourage a critical portion of the work to be carried out by Ohio firms, favorable tax treatment, or participation by local governments, etc.

2) Coal transportation: Nearly half the business respondents claimed that coal and its transportation would be a critical factor in the success of such an endeavor. Policies might arrange for inclusion of the coal and rail firms as part of a polygeneration partnership.

3) Selection of products: Prospects for long-term purchasing agreements, thus ensuring revenue streams and improving chances of obtaining financing include firms that purchase specialty and bulk coal-based chemicals, electricity, and natural gas. Further study of the market potential for a range of products should be undertaken, together with a study of the feasibility of producing chemicals with characteristics acceptable for firms currently utilizing organic-based chemicals. Based on study results, more in-depth discussions to include both with promising purchasers and potential plant owners could be undertaken.

Potential Next Steps

The findings from this initial research suggest several possible steps to convert this analysis to an action plan to build support for, and interest in, a coal-gasification industry cluster in Northeast Ohio. Outreach should focus on engaging industry leaders, foundations, and state and regional economic development leaders. Steps might include:

1. Using this study as a springboard for discussion, meetings should be facilitated among key IGCC-related firms and stakeholders to identify priorities, incubate action plans, and build commitment. The first step should be to meet with, and identify promising participants through, organizations such as the Ohio Manufacturers Association, the Ohio Department of Development, and Chambers of Commerce. Following this, a stakeholder meeting should be held to begin formalizing a group. The group could generate a list of experts in target industries, including the financial industry, and leaders who could champion this concept.
2. A database should be developed that identifies: suppliers of components, materials, and services for a polygeneration plant; firms and public groups involved in provision of infrastructure; and other potential participants in an industry cluster. The group established under the first step should invite additional members based on information gathered in the data-based compilation process.
3. An action plan should be developed to remove barriers to a successful industry cluster focused on coal-gasification. Barriers are likely to include financing, and regulatory issues.
4. A public communications strategy should be developed and deployed. Team members should engage the press to explain and promote the concept.

# APPENDIX A

**Appendix Table 1: Gasification Projects -United States Dec 2006**

| | Project name | State | Location | Coal rank | Developer | Nameplate MW | Non-electric component | Status |
|---|---|---|---|---|---|---|---|---|
| 1 | Taylorville Energy Center | Illinois | Taylorville, Christian County | Bituminous | ERORA/Tenaska | 630 MW | One gasifier capable of swinging to methane production | FEED package complete, Equity funding complete, draft air permit expected 10/06 |
| 2 | Cardinal | Illinois | undetermined | Bituminous | Peabody/Arclight | | SNG production | FEED package started |
| 3 | Steelhead | Illinois | undetermined | Bituminous | Arclight | 630MW | | FEED package started |
| 4 | Power Holdings | Illinois | Jefferson County | Bituminous | Power Holdings | | 50 Bcf SNG | Output sold, air permit pending |
| 5 | Rentech | Illinois | East Dubuque | Bituminous | Rentech | 34 MW | Ammonia, naphtha, F-T liquids | FEED package started |
| 6 | American Clean Coal Fuels | Illinois | Coles or Champaign Counties | Bituminous | American Clean Coal Fuels | | F-T liquids | Early development |
| 7 | Edwardsport | Indiana | Edwardsport | Bituminous | Duke | 630 MW | | PSC approval for FEED package, air permit application filed |
| 8 | | Indiana | unknown | Bituminous | Indiana Gasification | | SNG | early development |
| 9 | AEP | Ohio | Meigs County | Bituminous | AEP | 630 MW | | Air permit filed, FEED package underway |
| 10 | Global Energy | Ohio | Lima | Bituminous | Global Energy | 600 MW | 75,000 mmBTu/day SNG | Air permit received |
| 11 | Baard | Ohio | Columbiana | Bituminous | Baard | | 35,000F-T liquids | |
| 12 | Great Lakes Energy Research Park | Michigan | Alma | | M&M Energy | 600 MW | 75,000 bpd F-T | early development |
| 13 | Messaba | Minnesota | Messaba | Subbituminous | Excelsior | 630 MW | | PSC hearings underway, air permit filed |
| 14 | WMPI | Pennsylvania | Gilberton | Anthracite waste | John Rich | | F-T | Air permit received |
| 15 | ERORA | Kentucky | Henderson | Bituminous | ERORA | 630 MW | Possible methanol or SNG | Air permit filed |
| 16 | Indian Creek | Delaware | Indian Creek | coal/petcoke/ biomass | NRG | 630 MW | | detailed development phase |
| 17 | Montville | Connecticut | Montville | coal/petcoke/ biomass | NRG | 630 MW | | detailed development phase |
| 18 | Huntley | New York | | Bituminous | NRG/New York Power Authority | 630 MW | | detailed development phase |
| 19 | Mountaineer | West Virginia | Mountaineer | Bituminous | AEP | 630 MW | | Air permit filed, FEED package underway |

**Source: Clean Air Task Force**

# Appendix B: Interview Questionnaires

## 1) Questions for Feedstock Purchasers

### Chemical Needs:

How would you describe your primary products?

What are your major feedstocks or chemicals that go into your products?

Would the coal-gas list of families of produced chemicals fit into your needs?

| | | |
|---|---|---|
| Hydrogen | Olefins | Fisher Tropsch synthesis: |
| Carbon Monoxide | Methanol | Diesel |
| Ethanol | Dimethyl Ether, | naptha, |
| Ammonia | Acetic Acid | Jet Fuel. |
| Acetic Anhydride | Methyl Acetate | |
| SNG | | |

How do you currently get your chemical feed stock (for Ohio facilities)?

- Local? (What is the local distribution system...who?)
- Out-of-state?
- Method of transportation? Pipeline?

Has your demand for these chemicals increased in the past few years (4 or 5 yrs)?
What is your general outlook for needing these chemicals in the next 4 or 5 years? (approximate annual rate of growth of demand, e.g. 1%, 3%, 15%??)

### What about price & volume?

If the chemical (s) were available locally...could costs be reduced? (% savings?)

Can you roughly say what your price is for the chemicals? or what your annual feedstock expenditures are roughly?

Can you give me an estimate of the average volume amount that you consume?

How much (%) of a cost reduction in feedstocks would trigger an increase in your production. E.g. would a 20% decrease in feedstocks allow you to enter new product markets or steal market share?

### Background Info

How many employees work at your plant?
What is the plant's output?...volume per year? Or sales value per year?

## Any Closing Comments?

Are you familiar with the coal-gas concept? What are your thoughts?

# 2) Questions for Backward Linkage Companies

## I. How the market works: construction & development of a coal-gas polygeneration project

Major components under consideration:

| | | | | |
|---|---|---|---|---|
| oxygen plant | gasifier | soot blower | MDEA (acid gas Absorber), | |
| Claus | SCOT | Gas turbine system | steam turbine | Water Proc/recovery systems |
| Civil engin. | Piping | Controls, Electrical | Boilers | Coal feed converyor |
| Moi sieve | syngas scrubber columns | | | |

**How are Suppliers of these major components determined? Which components have limited suppliers (specialty firms) vs commodity components that anyone can build if given specs?**

(General contractor v subs?)
(Typical Timeframe?)

## II. Ohio's Competitiveness (Our focus is to generate economic development)

**To what degree would local or Ohio firms get a piece of the action? Why or why not?**

What types of Ohio firms would qualify for bidding? (name of firm or what it makes)

**Would local or Ohio firms provide leadership/general contracting/ sub contracting for this project? Who have you worked with on these large installations in past?** (Do Ohio firms have any particular expertise in these components or in project design?)

**How much would the cost of construction (%) of this coal gasification plant be reduced if all the components are made and built locally? (transport costs avoided, synergies in engineering design and installation?)**

## III. Local Production Issues

**What impact would the construction of a $1 billion coal gasification plant have on your firm or other contracting firms? What would this mean in terms of business for you? $10 million? $100 million? How do your costs break out in terms of labor v materials v admin?**

In terms of *labor?* (for example:new jobs, extra training required (what kind?), ability to ramp up, to what degree?)

In terms of *materials* and supplies you'd need to buy to go into production (will

certain materials be difficult to get? Cost increases? Do what degree?

Are your suppliers local? What percent of the materials you buy are produced locally?

What one or two materials make up the biggest part of your expenses?

## IV. Background Info

How many employees work at your Ohio plants? Do you have installations in Ohio now? What is the plant's output (volume per year?....sales per year?

# APPENDIX C: Additional Interview Details

Executives from firms involved in construction and design.

One executive represents a strong player in the market for engineering and construction of power plants, currently developing several projects in Wisconsin and Michigan. He is not aligned with any gasifier technology supplier company and is not currently working on any gasifier plants. The second executive works for a major corporation that provides balance-of-plant equipment and especially controls, drives, motors, pumps, and fans. He independently works with Bechtel on an ongoing basis as a sub-contractor with regards to their coal-gas interests. The third executive was from a well-known gasifier-technology provider.

Executives from firms representing potential buyers of chemicals

One was in charge of fertilizer production for his firm, a large Midwestern company with outlets and customers in Ohio. Two executives were Vice Presidents with global portfolios. Their firms would be considered competitors within the petroleum products (coatings and sealants) industries. Each boasted several Ohio production plants and many customers (residential and industrial) in Ohio. Two more interviewees were executives in industry associations -- one a National association and the other an Ohio-based association. Finally, an executive from a nationally known coatings firm with two plants in Ohio was interviewed. These industry executives interviewed represented at least eight plants in Ohio that employ a total of between 1,500 and 10,000 people.

Utility and Coal Gasification Executives

One was a Northeast Ohio economic development director who is currently in conversations with a major company seeking to establish itself at an existing coal-gasification site in the region. The other was an executive with a major Northeast Ohio utility, a potential buyer of power produced from the coal-gas process.