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Maxine Goodman Levin College of Urban Affairs

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OHIO MANUFACTURERS' ASSOCIATION

Moving Ohio Manufacturing Forward: Competitive Electricity Pricing

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Executive Summary

Today, the price of electricity has a powerful influence on the competitiveness of manufacturing because manufacturing industries are often electricity's largest consumers. Economic regulation of the electric utility business has changed very little over the last decade while regional and national policy makers debate the volatility of energy markets. The electricity industry, because of the large size of the units of its production, wholesale, and distribution, draws major benefits from the economy of scale. At the same time, energy efficiency has become the by-word of energy-intensive manufacturing businesses, which in the Midwest accounted for 60% of industrial fuel and feedstock energy use in 2006.[1] In 2010, Ohio had the highest level of manufacturing activity among Midwestern states resulting in value added mainly from the energy-intensive sectors such as primary metals, petroleum and coal products, chemicals, food, nonmetallic minerals, paper, and wood products.[2]

The goal of this report is to define electricity-intensive manufacturing export industries in Ohio that are sensitive to electricity pricing and to illustrate the impact of electricity pricing on manufacturing productivity through the industrial electricity pricing model. The first section of the report identifies Ohio's manufacturing industries that are electricity- intensive as part of their production (high costs of electricity per unit of production) and Ohio manufacturing industries that consume large quantities of electricity overall due to the large size of this industry in the state (high total expenditures on electricity). Some of these industries have a competitive advantage in the state and demonstrate a high Location Quotient (LQ)[3] of Gross State Product (GSP) and growth in GSP since the last recession. The second section of this report explores the impact of electricity rates, together with states' efforts to deregulate electricity markets, on the competitiveness of manufacturing industries in Ohio and benchmark states expressed through manufacturing productivity.

Twelve Ohio industries are a part of economic base of the state and manufacture a high number of electricity-intensive products. These industries belong to four industrial sectors: *Primary Metal Manufacturing, Chemical Manufacturing, Food Manufacturing,* and *Nonmetallic Mineral Product Manufacturing*. Together, these 12 industries employed over 86,000 people in Ohio in 2010.

According to our empirical modeling of industrial electricity pricing, the growth of manufacturing employment is negatively related to manufacturing productivity. At the same

[1] J. Bradbury et al. "Midwest Manufacturing Snapshot: Energy Use and Efficiency Policies." World Resource Institute, Working Paper, February 2012. P.5

[2] P.4

[3] Location Quotient measures the specialization of an industry in a region by comparing it to data in a larger region. For our analysis: $LQ = \frac{\frac{g_i}{g}}{\frac{G_i}{G}}$ where g_i = The Ohio Gross Product in industry i; g = Total Gross Product in Ohio; G_i= US Gross Product in industry i; G = Total US Gross Product. A location quotient > 1.0 indicates specialization in an industry.

time, the presence of large manufacturing establishments in the state is, as expected, positively associated with manufacturing productivity. This analysis indicates that manufacturing productivity might benefit from both economies of scale and the ability of large electricity consumers to negotiate individual contracts with suppliers at, most likely, lower than average market prices. This finding allows us to consider whether enabling a lower market price across the board for manufacturing users might further benefit the productivity of the manufacturing sector in the state.

An increase in the industrial electricity price by 1 cent per kilowatt-hour (16.3%) is likely, in 99% of cases, to decrease average manufacturing productivity in the five selected states,[4] on average, by $2,527 of annual gross state product per employee (2.2%). The productivity change associated with the industrial electricity price change has low elasticity: 2.2%/16.3%=0.13. The measure of elasticity below 1 is known as inelastic response. This means that for 1% increase of industrial electricity prices, manufacturing productivity drops by 0.13%.

Description of Ohio Electricity-Intensive Industries

In the first section of the report, a number of variables were analyzed to identify Ohio's economic base. These variables include the LQ of GSP, the growth of GSP, and industries' productivity over three time periods, 2000-2010, 2007-2010, and 2009-2010. With a LQ of greater than 1, fifty-two manufacturing industries (Table 7) potentially represented the economic base of Ohio's economy in 2010.[5] Ohio's economic base was heavily represented by manufacturing industries of *Food* (NAICS 311), *Chemical* (NAICS 325), *Nonmetallic mineral product* (NAICS 327), *Primary metal* (NAICS 331), *Fabricated metal product* (NAICS 332), *Machinery* (NAICS 333), *Electrical equipment* (NAICS 335), and *Transportation equipment* (NAICS 336).

Twenty-eight manufacturing industries in Ohio experienced positive GSP growth (at least 1%) between 2007 and 2010[6] . With a 51% increase, the *Petroleum and Coal Products Manufacturing* industry (NAICS 3241) had the greatest GSP growth during the study period followed by *Electrical Equipment and Component Manufacturing* (NAICS 3359) and *Pharmaceutical and Medicine Manufacturing* (NAICS 3254) industries which grew by 31% in the same time period.

The industries that were growing from 2007 to 2010 and were likely to have high productivity in 2010 were *Petroleum and Coal Products Manufacturing* (NAICS 3241); *Pesticide, Fertilizer, and other Agricultural Chemical Manufacturing* (NAICS 3253); *Household Appliance Manufacturing* (NAICS 3352); *Pharmaceutical and Medicine Manufacturing* (NAICS 3254); *and Basic Chemical Manufacturing* (NAICS 3251).

[4] Ohio, Indiana, Kentucky, Michigan, and Pennsylvania
[5] The industries that represent economic base are also called basic industries.
[6] For more information see Table 8.

Basic manufacturing industries that use electricity intensively as a part of production (those with electricity expenditures greater than 1% of total expenditures) were categorized as high, moderate, or low electricity-intensive industries. Ten industries were classified as high electricity-intensive industries, with average electricity expenditures greater than 2% of total expenditures. The *Alumina and Aluminum Production and Processing Industry* (NAICS 3313) ranked highest, with electricity expenditures composing 5.7% of total expenditures (Table 1).

There were seventeen moderately electricity-intensive industries, spending at least 1% of their total expenditures on electricity. The *Sawmills and Wood Preservation* (NAICS 3211) industry ranked highest in this group, with electricity expenditures composing 1.9% of total expenditures.

Twenty manufacturing industries were identified as large consumers of electricity by total expenditures on electricity (Table 2). The top industry, *Basic Chemical Manufacturing* (NAICS 3251), spends over $357 million on electricity per year, followed closely by *Iron and Steel Mills and Ferroalloy Manufacturing* (NAICS 3311) at $305 million. The top eleven industries in this category spend greater than $67 million per year on electricity expenditures per industry.

The other nine industries are considered moderate consumers (based on total expenditures) and spend individually between $41 and $56 million on electricity per year. This group was led by *Other Fabricated Metal Product Manufacturing* (NAICS 3329), at $59 million per year in electricity expenditures.

Fourteen industries were identified as both (1) electricity-intensive in regards to the unit of production and (2) high overall consumption of electricity. These manufacturing industries create electricity-intensive products while purchasing large volumes of electricity relative to their size in Ohio. This group consisted of primary metal, chemical, food, paper, glass, and nonmetallic mineral industries.

Eleven nonmanufacturing industries and broader sectors were identified in Ohio as those that have high per-unit electricity costs and high total expenditures on electricity. These industries cover diverse activities – from farming to large institutions and accommodations – and can occur on such a large scale that electricity needs are magnified, such as in museums, hospitals, universities, and warehouses. Electricity costs as a percentage of total expenditures for non-manufacturing industries exceed 1%. The *Accommodation* industry (NAICS 721) is atop of the list of large non-manufacturing energy consumers, spending 2.9% of its total expenditures for electricity. Total expenditures for electricity in this group of industries vary from over $103 million for *Construction* to over $15 million for *Newspaper, Periodical, Book, and Directory Publishers*.

Empirical Model

The second part of the report explores the impact of electricity pricing on manufacturing productivity through an industrial electricity price regression model. This model was conducted on the data from five comparable states: Ohio, Indiana, Kentucky, Michigan, and Pennsylvania.

The research team chose neighboring states with economic structures and electricity consumers comparable to those of the state of Ohio as the geographic area for statistical modeling. This analysis seeks to answer two research questions: (1) How does industrial electricity pricing influence the productivity of the manufacturing sector? and (2) What are the influences of electricity market deregulation on the industrial electricity market and manufacturing productivity?

The manufacturing productivity and industrial electricity rates in Ohio, Indiana, Kentucky, Michigan, and Pennsylvania were analyzed for the period between 1990 and 2010 - the latest years for which industrial electricity pricing data were available. A statistical model was built to test the effect of policy variables on manufacturing productivity (industrial electricity price and deregulation variables), controlling for the demand on the electricity market (manufacturing employment and presence of large manufacturing companies), the supply on the electricity market (size of power generation industry), and overall economic conditions (using a business cycle variable to estimate the recession).

The results of this analysis indicate that electricity price had a statistically significant negative effect on manufacturing productivity across the five targeted states between 1990 and 2010. The higher the industrial electricity prices were in the five selected states, the lower manufacturing productivity was in these states in 99% of cases. However, productivity change from the movement of industrial electricity price was inelastic—indicating that electricity is only one of the supply price factors influencing manufacturing productivity.

The deregulation of the electricity market was statistically significant (above the 99% critical value) and positively associated with manufacturing productivity. To further assess the impact of electricity market restructuring, an independent sample t-test[7] was used to compare industrial electricity prices and other economic indicators between the states that deregulated their wholesale electricity markets and those that did not. Generally, deregulation had a positive effect on the change of industrial electricity prices and some economic variables characterizing the state of manufacturing industries in the five targeted states. The most profound effect of deregulation was a significant drop in industrial electricity prices. However, the model is based on a small sample of five states and did not control for the level of industrial electricity pricing at the beginning of the study period.

The variables characterizing the demand side of the electricity market shows that the growth of manufacturing employment is negatively related to manufacturing productivity with statistical significance only above the 90% critical value. Also, it should be noted that the presence of a considerable number of large manufacturing establishments in the state was positively associated with manufacturing productivity at the 99% critical value, which might reflect the benefits from the economy of scale where many large companies share the regional supply chain.

[7] The t-test illustrates whether the differences between the states were statistically significant.

The control variable that represents the supply side of the electricity market, capacity of electricity production and distribution, was also positively related to manufacturing productivity and was statistically significant above the 99% critical value. The variable approximating the national recession was negatively associated with manufacturing productivity, indicating that during economic downturns manufacturing productivity was declining.

Based on the results of this analysis, we can conclude that higher industrial electricity rates in Ohio will most likely be associated with lower manufacturing productivity. Moreover, manufacturing productivity is likely to benefit from both economy of scale and the ability of large electricity consumers to negotiate contracts with suppliers at a lower than average market price. Finally, an increase in the state's capacity to generate, transmit, and distribute electricity will most likely support higher productivity in its manufacturing sector.

↳ not ~~support~~ in all circum

↳ This is referring to a variable

↳ doesn't mean support at any cost

Does not mean steel in the ground.

Introduction

This report is prepared for The Ohio Manufacturers' Association by the Center for Economic Development and the Center for Energy Policy and Applications at the Maxine Goodman Levin College of Urban Affairs at Cleveland State University. The authors of the report would like to acknowledge the research assistance of Ellen Cyran, a senior programmer analyst at the Center for Economic Development for her database support, James Wyles, visiting instructor in GIS and Urban Geography for his mapping, and Joe Andre and Serineh Baboomian, graduate assistants at the Center for Economic Development for their editorial support. We appreciate thoughtful comments by the OMA leaders and staff for their insights and continued support through the duration of this project.

Ohio today faces a considerable challenge in keeping its manufacturing base competitive. Energy-intensive manufacturing, in particular, is threatened by rising electricity costs and the potential need to reduce carbon emissions. One of the responses to mitigate rising electricity prices is developing a model of distributed generation.[8]

In order to examine if electricity rates have a critical influence on Ohio's manufacturing industry, it is imperative to identify Ohio's electricity-intensive manufacturing sector which has comparative advantages across the United States. We present this in the first section of our report, as well as the geographic concentration of electricity-intensive, economic-base manufacturing industries in all Ohio counties. In Ohio's manufacturing base, there are 14 industries that are electricity-intensive industries[9] and industries that are large consumers of electricity.[10] In particular; atop of this list are primary metal manufacturing; chemical manufacturing; food manufacturing; and paper, glass, and nonmetallic mineral product manufacturing.

In the second part of this report, the researchers empirically estimate the impact of electricity rates coupled with the deregulation of electricity markets, and how these impact Ohio's manufacturing competitiveness.

This study is intended to inform manufacturers about the structure of electricity-intense industries of the manufacturing sector, regional distribution of electricity-intense industries, and the largest consumers of electricity in Ohio. Moreover, this study aims to provide insights on major factors influencing electricity pricing. The study empirically illustrates that industrial electricity price is one of the major factors that negatively impacts manufacturing productivity. The authors hope that the study of the state of electricity-intensive manufacturing industries' help craft better electricity pricing public policies in Ohio.

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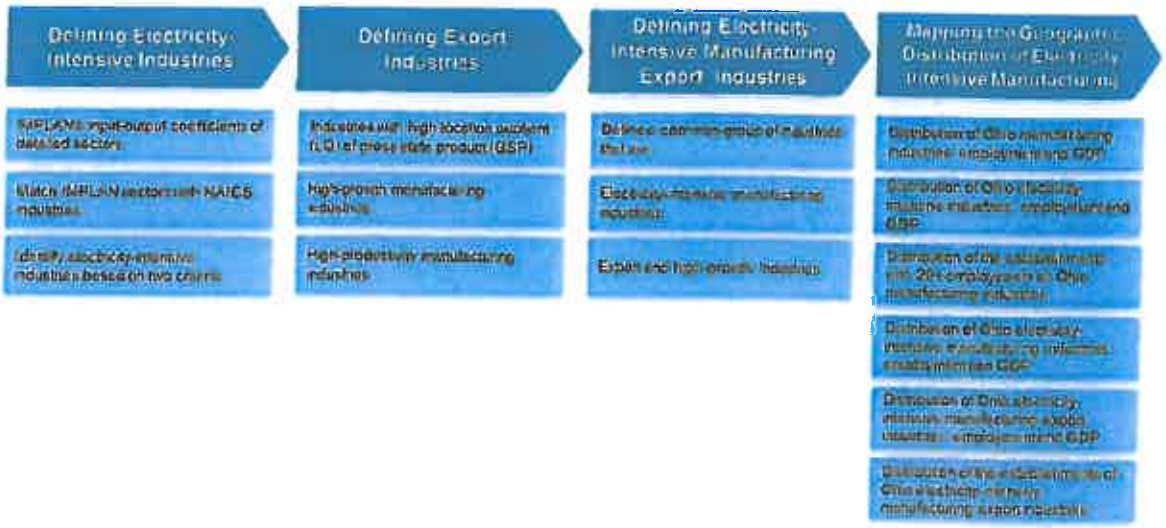
[8] A. Thomas and I. Lendel, "Distributed Generation as a Response to Rising Electricity Costs in Ohio." February 2013.
[9] Electricity-intensive are atop of the list of industries defined by the ratio of an industry's expenditure on electricity to the industry's total expenditures in Ohio, measured as unit expense for electricity.
[10] Large consumers of electricity are industries that pay large shares of their total expenditures for electricity, measured in dollars.

Part 1: Analysis of Ohio Electricity-Intensive Manufacturing Export Industries

The goal of the project is to define a group of electricity-intensive manufacturing export industries that could possibly be eligible for special electricity rates. The Center for Economic Development defines and lists these electricity-intensive industries and then analyzes the distribution and concentration of electricity-intensive industries across the state of Ohio. Steps and methodologies of the analysis are as follows:



Defining Electricity-Intensive Industries

In order to identify electricity-intensive industries, IMPLAN's technical input-output coefficients were used. IMPLAN is a proprietary input-output economic model that provides information on supply relationships (backward linkages) between industries. Two indicators signify electricity-intensive industries:

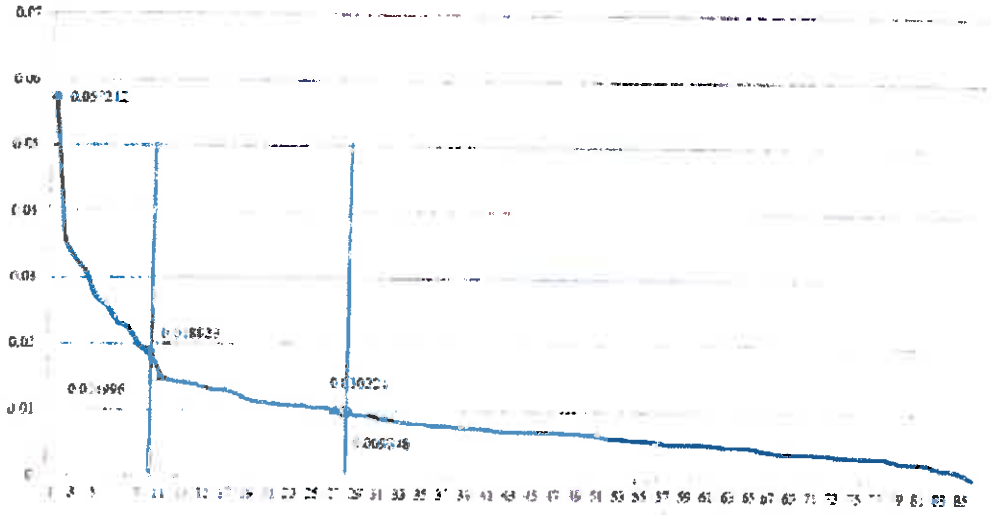
1. The ratio of an industry's expenditure on electricity to the industry's total expenditures in Ohio, measured as unit expense for electricity
2. Industry's total expenditure on electricity (electricity generation and transmission industry), measured in dollars

The indicator unit expenses for electricity reflect the share of electricity cost in $1 of output of IMPLAN industry *Electric Power Generation, Transmission, and Distribution* (industry code 31). Ohio's manufacturing industries (at the 4-digit NAICS classification) were ranked separately by each indicator: unit expense for electricity (Table 1) and industry's total expenditure for electricity (Table 2).

- ✓ Per each $1 of expenses, the Alumina and Aluminum Production and Processing industry spends 5.7cents on electric power generation, transmission, and distribution (Table 1)
- ✓ The same industry spent $144 million in 2009 buying their supply of electricity from Ohio (Table 2)

Using the "natural break" method,[11] Ohio's manufacturing industries were classified into three groups of electricity users: high, moderate, and low electricity-intensive industries (Figures 1 and 2). Our definition of High and Moderate Electricity-Intensive industries is consistent with the Energy-Intensive and Non-Energy-Intensive Manufacturing groups defined for Industrial Demand Module of the National Energy Modeling System[12] (see Appendix Table 1).

Figure 1. Illustration of Break-Point Method Based on Ratio of Expenses for Electricity in $1 of Total Expenditures



[11] The "natural break" method is based on identifying the significant change of a ranked dependent variable between two observation points. The significant variation in a dependent variable points to the change of a phenomenon, which this variable illustrates.
[12] Office of Energy Analysis, U.S. Energy Information Administration, 2011.

Table 1. Electricity-Intensive Manufacturing Industries by Unit Expenditures for Electricity

	NAICS	Industry Name	Electricity Expenditures Per $1 of Industry Expenses
High Electricity-Intensive Manufacturing	3313	Alumina and Aluminum Production and Processing	0.05721
	3221	Pulp, Paper, and Paperboard Mills	0.03534
	3274	Lime and Gypsum Product Manufacturing	0.03280
	3311	Iron and Steel Mills and Ferroalloy Manufacturing	0.03091
	3251	Basic Chemical Manufacturing	0.02702
	3272	Glass and Glass Product Manufacturing	0.02577
	3315	Foundries	0.02311
	3279	Other Nonmetallic Mineral Product Manufacturing	0.02240
	3253	Pesticide, Fertilizer, and Other Agricultural Chemical Manufacturing	0.01975
	3271	Clay Product and Refractory Manufacturing	0.01882
Moderate electricity-intensive Manufacturing	3211	Sawmills and Wood Preservation	0.01500
	3117	Seafood Product Preparation and Packaging	0.01432
	3328	Coating, Engraving, Heat Treating, and Allied Activities	0.01429
	3112	Grain and Oilseed Milling	0.01395
	3252	Resin, Synthetic Rubber, and Artificial Synthetic Fibers and Filaments	0.01343
	3131	Fiber, Yarn, and Thread Mills	0.01309
	3273	Cement and Concrete Product Manufacturing	0 01307
	3132	Fabric Mills	0.01245
	3212	Veneer, Plywood, and Engineered Wood Product Manufacturing	0 01156
	3312	Steel Product Manufacturing from Purchased Steel	0.01132
	3115	Dairy Product Manufacturing	0 01111
	3113	Sugar and Confectionery Product Manufacturing	0.01094
	3114	Fruit and Vegetable Preserving and Specialty Food Manufacturing	0.01086
	3321	Forging and Stamping	0.01082
	3262	Rubber Product Manufacturing	0.01052
	3359	Other Electrical Equipment and Component Manufacturing	0.01047
	3314	Nonferrous Metal (except Aluminum) Production and Processing	0.01022

High Electricity-Intensive Manufacturing Industries

Table 1 includes industries with relatively high unit expenditures on electric power generation, transmission, and distribution. Ranked by this indicator, all manufacturing industries were divided into three groups: High Electricity-Intensive Manufacturing, Moderate Electricity-Intensive Manufacturing, and Low Electricity-Intensive Manufacturing. The High Electricity-Intensive Manufacturing group includes ten manufacturing industries that annually spend 2% or more of their total expenditures on electricity. The *Alumina and Aluminum Production and Processing* industry (NAICS 3313) alone spends 5.7% of all expenditures on electricity. This is

almost twice the next High Electricity-Intensive Manufacturing Industry, *Pulp, Paper, and Paperboard Mills* (NAICS 3221), which spends 3.5% of all expenses annually on electricity. The top ten electricity-intensive manufacturing industries include three groups of industries: metal-product manufacturing, chemical manufacturing, and paper-producing industries. Two out of three groups historically have had a large presence in Ohio.

Moderate Electricity-Intensive Manufacturing Industries

The 17 industries that belong to the Moderate Electricity-Intensive Manufacturing group spend at least 1% of their total expenditures for electricity. *Sawmills and Wood Preservation* (NAICS 3211) and *Seafood Product Preparation and Packing* (NAICS 3117), the two top industries in this group, are not typical for Ohio. The rest of this cohort represents industries related to metal and equipment manufacturing, food manufacturing, resin and rubber industry, and cement and concrete manufacturing. The 17 industries included in the High and Moderate Electricity-Intensive Manufacturing groups are the subject of further investigation.

Figure 2. Illustration of Break-Point Method Based on Indicator of Total Industry Expenses for Electricity

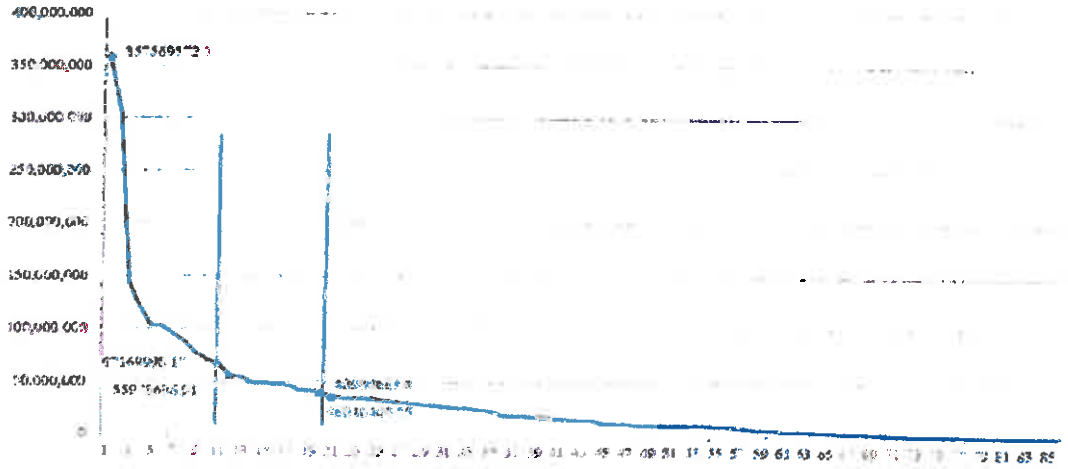


Table 2. Large Consumers of Electricity Identified by Indicator of Total Expenditures for Electricity in Ohio

	NAICS	Industry Name	Total Industry Expenditures for Electricity in OH
High Electricity-Consuming Manufacturing	3251	Basic Chemical Manufacturing	$357,569,572
	3311	Iron and Steel Mills and Ferroalloy Manufacturing	$305,430,664
	3313	Alumina and Aluminum Production and Processing	$144,121,601
	3241	Petroleum and Coal Products Manufacturing	$120,952,662
	3261	Plastics Product Manufacturing	$103,429,390
	3363	Motor Vehicle Parts Manufacturing	$102,961,395
	3221	Pulp, Paper, and Paperboard Mills	$96,450,783
	3252	Resin, Synthetic Rubber, and Artificial Synthetic Fibers and Filaments	$88,811,888
	3253	Pesticide, Fertilizer, and Other Agricultural Chemical Manufacturing	$77,580,568
	3115	Dairy Product Manufacturing	$71,619,224
	3315	Foundries	$67,169,998
Moderate Electricity-Consuming Manufacturing	3329	Other Fabricated Metal Product Manufacturing	$55,978,697
	3114	Fruit and Vegetable Preserving and Specialty Food Manufacturing	$54,834,373
	3312	Steel Product Manufacturing from Purchased Steel	$49,857,376
	3222	Converted Paper Product Manufacturing	$49,737,892
	3272	Glass and Glass Product Manufacturing	$48,513,642
	3279	Other Nonmetallic Mineral Product Manufacturing	$48,513,197
	3112	Grain and Oilseed Milling	$43,094,463
	3314	Nonferrous Metal (except Aluminum) Production and Processing	$42,555,602
	3361	Motor Vehicle Manufacturing	$40,900,683

High Electricity-Consuming Manufacturing

Twenty (20) manufacturing industries were identified as the largest consumers of electricity in Ohio. Each of these manufacturing industries spends at least $40 million per year on electricity supplies. Of those 20 industries, 11 were considered high electricity-consuming manufacturing industries. Each industry in high electricity-consuming manufacturing group spends over $67 million annually on electricity supplies. This group is led by the industry *Basic Chemical Manufacturing* (NAICS 3251), which spends over $358 million annually on electricity supplies, followed by *Iron and Steel Mills and Ferroalloy Manufacturing* (NAICS 3311), which spends over $305 million annually. The other largest consumers of electricity in Ohio belong to industries producing such products as aluminum, petroleum and coal, plastic products, motor vehicle parts, paper, raisin, pesticide and fertilizer, dairy products, and foundries.

Moderate Electricity-Consuming Manufacturing

The Moderate Electricity-Consuming Manufacturing group includes nine industries that spend between $41 and $56 million annually on electricity supply. The largest electricity consumer in this group was *Other Fabricated Metal Product Manufacturing* (NAICS 3329), which pays about $56 million per year for the supply of electricity in Ohio. Other industries in this group include those that manufacture steel products, converted paper products, glass, nonmetallic minerals, motor vehicles, and specialty food. We used both ranked indicators (high unit electricity-intensive and large consumers of electricity) to identify 14 manufacturing industries in Ohio (Table 3).

Table 3. Ohio Manufacturing Industries: Electricity-Intensive and Large Consumers of Electricity

	NAICS	Industry Name
High Electricity-Intensive and Consuming Manufacturing	3313	Alumina and Aluminum Production and Processing
	3221	Pulp, Paper, and Paperboard Mills
	3311	Iron and Steel Mills and Ferroalloy Manufacturing
	3251	Basic Chemical Manufacturing
	3272	Glass and Glass Product Manufacturing
	3315	Foundries
	3279	Other Nonmetallic Mineral Product Manufacturing
	3253	Pesticide, Fertilizer, and Other Agricultural Chemical Manufacturing
Moderate Electricity-Intensive and Consuming Manufacturing	3112	Grain and Oilseed Milling
	3252	Resin, Synthetic Rubber, and Artificial Synthetic Fibers and Filaments
	3312	Steel Product Manufacturing from Purchased Steel
	3115	Dairy Product Manufacturing
	3114	Fruit and Vegetable Preserving and Specialty Food Manufacturing
	3314	Nonferrous Metal (except Aluminum) Production and Processing

Industries that fit both criteria are large, electricity-intensive consumers. This group creates electricity-intensive products and purchases large volumes of electricity due to their industry size in Ohio. Fourteen (14) manufacturing industries are electricity-intensive and large consumers of electricity due to their size in Ohio. These 14 industries include all industries in primary metal manufacturing sector (NAICS 331: NAICS 3311, 3312, 3313, 3314, 3315); three chemical manufacturing industries (NAICS 3251, 3252, 3253); three food manufacturing industries (NAICS 3112, 3114, 3115); and paper, glass, and nonmetallic mineral product manufacturing (NAICS 3221, 3272, 3279).

Table 4. Electricity-Intensive, Non-Manufacturing Industries Identified by Unit Expenses for Electricity

NAICS	Industry Name	Electricity Expenditures Per $1 of Industry Expenses
721	Accommodation	0.029303
2123	Nonmetallic Mineral Mining and Quarrying	0.028517
1119	Other Crop Farming	0.022541
712	Museums, Historical Sites, and Similar Institutions	0.020142
1112	Vegetable and Melon Farming	0 018514
1113	Fruit and Tree Nut Farming	0.017923
611	Educational Services	0.017522
713	Amusement, Gambling, and Recreation Industries	0.016856
2121	Coal Mining	0.016488
722	Food Services and Drinking Places	0.015693
531	Real Estate	0.015551
493	Warehousing and Storage	0.015231
112	Animal Production	0.013455
623	Nursing and Residential Care Facilities	0.012337
8121	Personal Care Services	0 011442
533	Lessors of Nonfinancial Intangible Assets (except Copyrighted Works)	0.010497
622	Hospitals	0 010485

To identify electricity-intensive, non-manufacturing industries in Ohio, we applied the same two criteria used for manufacturing industries: unit expenses for electricity and total industry expenditures for electricity. Seventeen (17) 4-digit NAICS non-manufacturing industries and broader industrial sectors spent at least one cent per each dollar of expenses on electricity supply (1% of their total annual expenditures in Ohio). The largest sectors and industries include farming, accommodations, and industries that utilize large commercial buildings, such as museums, universities, hospitals, and warehouses. To identify the large consumers of electricity among non-manufacturing industries, the total expenditures on the electricity indicator was applied to three groups of industries classified by the level of NAICS: 2-digit sectors, 3-digit sectors, and 4-digit non-manufacturing industries (Table 5).[13]

[13] IMPLAN's industry classification corresponds to a combination of 2-, 3-, and 4-digit NAICS industry classifications for non-manufacturing industries.

Table 5. Non-Manufacturing Industries Identified by Total Industry Expenditures for Electricity

	NAICS	Industry Name	Total Industry Expenditures for Electricity in OH
2-digit NAICS	23	Construction	$103,084,857
	42	Wholesale Trade	$165,244,919
	55	Management of Companies and Enterprises	$91,376,320
3-digit NAICS	531	Real Estate	$385,969,940
	722	Food Services and Drinking Places	$342,473,541
	622	Hospitals	$304,688,721
	611	Educational Services	$124,426,390
	623	Nursing and Residential Care Facilities	$115,215,073
	621	Ambulatory Health Care Services	$90,999,878
	721	Accommodation	$71,800,729
	493	Warehousing and Storage	$50,096,107
	713	Amusement, Gambling, and Recreation Industries	$44,469,557
	813	Religious, Grant making, Civic, Professional, and Similar Organizations	$43,985,471
4-digit NAICS	5415	Computer Systems Design and Related Services	$80,921,712
	1111	Oilseed and Grain Farming	$26,859,565
	8121	Personal Care Services	$26,797,682
	2123	Nonmetallic Mineral Mining and Quarrying	$22,850,089
	8111	Automotive Repair and Maintenance	$18,308,483
	5417	Scientific Research and Development Services	$17,613,731
	2121	Coal Mining	$15,592,757
	5111	Newspaper, Periodical, Book, and Directory Publishers	$15,106,413

Eleven (11) non-manufacturing industries and sectors were identified as large consumers of electricity due both to their significant size in Ohio and the high electricity intensity of their products and services (Table 6). Eight (8) 3-digit NAICS sectors and three 4-digit NAICS industries were the largest electricity consumers and most electricity-intensive non-manufacturing industries in Ohio.

Table 6. Electricity-Intensive, Large Non-Manufacturing Consumers

NAICS	Industry Name
721	Accommodation
2123	Nonmetallic Mineral Mining and Quarrying
611	Educational Services
713	Amusement, Gambling, and Recreation Industries
2121	Coal Mining
722	Food Services and Drinking Places
531	Real Estate
493	Warehousing and Storage
623	Nursing and Residential Care Facilities
8121	Personal Care Services
622	Hospitals

Note: Ranked by unit expenses on electricity

Defining Ohio's Economic Base Industries

To identify Ohio's economic base, we researched the Location Quotient (LQ) of Gross State Product (GSP), the growth of GSP, and industries' productivity over three time periods: 2000-2010, 2007-2010 and 2009-2010. According to GSP LQ, 52 4-digit NAICS manufacturing industries represented the economic base of Ohio's economy in 2010.[14] The manufacturing industries presented in Table 7 are ranked by 2010 GSP LQ.

Table 7. Ohio's Manufacturing Industries

NAICS	Description	GSP LQ, 2010
3352	Household Appliance Manufacturing	4.954
3363	Motor Vehicle Parts Manufacturing	3.722
3321	Forging and Stamping	3.703
3255	Paint, Coating, and Adhesive Manufacturing	3.601
3324	Boiler, Tank, and Shipping Container Manufacturing	3.351
3271	Clay Product and Refractory Manufacturing	3.233
3361	Motor Vehicle Manufacturing	3.200
3312	Steel Product Manufacturing from Purchased Steel	3.198
3322	Cutlery and Handtool Manufacturing	3.186
3328	Coating, Engraving, Heat Treating, and Allied Activities	3.069
3335	Metalworking Machinery Manufacturing	3.017
3262	Rubber Product Manufacturing	2.985
3279	Other Nonmetallic Mineral Product Manufacturing	2.931
3369	Other Transportation Equipment Manufacturing	2.829
3329	Other Fabricated Metal Product Manufacturing	2.802
3256	Soap, Cleaning Compound, and Toilet Preparation Manufacturing	2.617
3272	Glass and Glass Product Manufacturing	2.518
3114	Fruit and Vegetable Preserving and Specialty Food Manufacturing	2.490
3315	Foundries	2.449
3311	Iron and Steel Mills and Ferroalloy Manufacturing	2.441
3327	Machine Shops, Turned Product, and Screw, Nut, and Bolt Manufacturing	2.349
3261	Plastics Product Manufacturing	2.278
3351	Electric Lighting Equipment Manufacturing	2.276
3339	Other General Purpose Machinery Manufacturing	2.112
3115	Dairy Product Manufacturing	2.085
3353	Electrical Equipment Manufacturing	2.001
3332	Industrial Machinery Manufacturing	1.968
3251	Basic Chemical Manufacturing	1.941

[14] Location Quotient measures the specialization of an industry in a region by comparing it to data in a larger region. For our analysis: $LQ = \frac{\frac{g_i}{g}}{\frac{G_i}{G}}$ where g_i = The Ohio Gross Product in industry i; g = Total Gross Product in Ohio; G_i = US Gross Product in industry i; G = Total US Gross Product. A GSP LQ above 1.00 indicates that the share of an industry's gross state product in the total regional gross product exceeds the share of this industry's GDP in the total U.S. GDP. This disproportionally large production of GSP denotes an industry as a potential part of the regional economic base.

Table 7. Ohio's Manufacturing Industries (cont.)

NAICS	Description	GSP LQ, 2010
3253	Pesticide, Fertilizer, and Other Agricultural Chemical Manufacturing	1.825
3111	Animal Food Manufacturing	1.815
3326	Spring and Wire Product Manufacturing	1.809
3252	Resin, Synthetic Rubber, and Artificial Synthetic Fibers and Filaments	1.775
3359	Other Electrical Equipment and Component Manufacturing	1.726
3259	Other Chemical Product and Preparation Manufacturing	1.692
3314	Nonferrous Metal (except Aluminum) Production and Processing	1.671
3371	Household and Institutional Furniture and Kitchen Cabinet Manufacturing	1.518
3362	Motor Vehicle Body and Trailer Manufacturing	1.496
3323	Architectural and Structural Metals Manufacturing	1.482
3118	Bakeries and Tortilla Manufacturing	1.480
3231	Printing and Related Support Activities	1.466
3274	Lime and Gypsum Product Manufacturing	1.438
3325	Hardware Manufacturing	1.398
3313	Alumina and Aluminum Production and Processing	1.397
3119	Other Food Manufacturing	1.389
3334	Ventilation, Heating, Air-Conditioning, and Commercial Refrigeration E	1.374
3222	Converted Paper Product Manufacturing	1.343
3219	Other Wood Product Manufacturing	1.309
3169	Other Leather and Allied Product Manufacturing	1.242
3121	Beverage Manufacturing	1.226
3241	Petroleum and Coal Products Manufacturing	1.167
3113	Sugar and Confectionery Product Manufacturing	1.054
3149	Other Textile Product Mills	1.026

Source: Moody's Economy.com

As shown in Table 7, Ohio's economic base is heavily represented by the following manufacturing industries:

- ✓ Food manufacturing (NAICS 311)
- ✓ Chemical manufacturing (NAICS 325)
- ✓ Nonmetallic mineral product manufacturing (NAICS 327)
- ✓ Primary metal manufacturing (NAICS 331)
- ✓ Fabricated metal product manufacturing (NAICS 332)
- ✓ Machinery manufacturing (NAICS 333)
- ✓ Electrical equipment, appliance, and component manufacturing (NAICS 335)
- ✓ Transportation equipment manufacturing (NAICS 336)

Twenty-eight manufacturing industries in Ohio (26 of these industries are displayed in Table 8) experienced positive GSP growth (at least 1%) between 2007 and 2010.[15] GSP of the *Petroleum and Coal Products Manufacturing* industry (NAICS 3241) increased by 51% over the last 3 years (2007-2010); by 136% from 2000 to 2010. The *Other Electrical Equipment and Component Manufacturing* (NAICS 3359) and *Pharmaceutical and Medicine Manufacturing* (NAICS 3254)

[15] Two very small industries, the Leather and Hide Tanning and Finishing (NAICS 3161) and the Tobacco Manufacturing (NAICS 3122) are removed from the analysis due to data confidentiality.

Industries grew by 31% between 2007 and 2010. The *Pesticide and Other Chemical Manufacturing* (NAICS 3253) industry showed a large growth in GSP from 2009 to 2010. However, the size of the industry is too small to influence the overall economy in Ohio.

Table 8. GSP Growth of Ohio's Manufacturing Industries

NAICS	Description	Employment, 2010	2010 GSP (in 2010 dollars)	% GSP change, 2000-2010	% GSP change, 2007-2010	% GSP change, 2009-2010
3241	Petroleum and Coal Products Manufacturing	3,964	$4,963,152	136%	51%	9%
3253	Pesticide, Fertilizer, and Other Agricultural Chemical Manufacturing	966	$585,050	66%	46%	17%
3359	Other Electrical Equipment and Component Manufacturing	6,280	$1,019,356	7%	31%	9%
3254	Pharmaceutical and Medicine Manufacturing	5,793	$1,883,134	131%	31%	11%
3116	Animal Slaughtering and Processing	8,768	$1,061,118	21%	25%	8%
3114	Fruit and Vegetable Preserving and Specialty Food Manufacturing	11,684	$1,834,442	33%	20%	11%
3115	Dairy Product Manufacturing	8,179	$1,409,510	20%	19%	9%
3346	Manufacturing and Reproducing Magnetic and Optical Media	1,180	$27,903	-66%	18%	19%
3352	Household Appliance Manufacturing	4,533	$1,515,133	-7%	18%	9%
3324	Boiler, Tank, and Shipping Container Manufacturing	8,045	$1,102,876	13%	18%	4%
3369	Other Transportation Equipment Manufacturing	1,386	$332,151	30%	18%	0%
3256	Soap, Cleaning Compound, and Toilet Preparation Manufacturing	10,231	$1,761,906	59%	17%	10%
3119	Other Food Manufacturing	6,196	$1,217,421	9%	17%	12%
3353	Electrical Equipment Manufacturing	7,091	$1,423,332	-6%	16%	-2%
3279	Other Nonmetallic Mineral Product Manufacturing	6,171	$708,435	-11%	16%	11%
3111	Animal Food Manufacturing	2,333	$502,929	-5%	12%	8%
3118	Bakeries and Tortilla Manufacturing	9,856	$1,570,680	6%	12%	7%
3255	Paint, Coating, and Adhesive Manufacturing	6,305	$1,363,263	26%	11%	10%
3274	Lime and Gypsum Product Manufacturing	592	$83,441	-30%	10%	10%
3251	Basic Chemical Manufacturing	8,737	$2,832,472	37%	10%	8%
3121	Beverage Manufacturing	6,870	$1,126,952	16%	8%	6%
3113	Sugar and Confectionery Product Manufacturing	1,488	$321,315	66%	4%	7%
3391	Medical Equipment and Supplies Manufacturing	9,034	$1,107,998	21%	4%	6%
3252	Resin, Synthetic Rubber, and Artificial Synthetic Fibers and Filaments	5,307	$1,286,891	54%	3%	6%
3112	Grain and Oilseed Milling	2,029	$335,240	-21%	2%	7%
3272	Glass and Glass Product Manufacturing	7,685	$750,979	-43%	1%	6%

Source: Moody's Economy.com

Industries that were growing from 2007 to 2010 were likely to have high productivity[16] in 2010 (Table 9):

- ✓ Petroleum and coal products manufacturing
- ✓ Pesticide, fertilizer, and other agricultural chemical manufacturing
- ✓ Household appliance manufacturing
- ✓ Pharmaceutical and medicine manufacturing
- ✓ Basic chemical manufacturing

Table 9. Ohio Manufacturing Industries with High Productivity, 2010

NAICS	Description	Employment, 2010	2010 GSP (in 2010 dollars)	Productivity, 2010 ($ per employee)
3241	Petroleum and Coal Products Manufacturing	3,964	$4,963,152	$1,252,056
3253	Pesticide, Fertilizer, and Other Agricultural Chemical Manufacturing	966	$585,050	$605,642
3352	Household Appliance Manufacturing	4,533	$1,515,133	$334,245
3254	Pharmaceutical and Medicine Manufacturing	5,793	$1,883,134	$325,071
3251	Basic Chemical Manufacturing	8,737	$2,832,472	$324,193
3252	Resin, Synthetic Rubber,& Artificial Synthetic Fibers & Filaments	5,307	$1,286,891	$242,489
3369	Other Transportation Equipment Manufacturing	1,386	$332,151	$239,647
3255	Paint, Coating, and Adhesive Manufacturing	6,305	$1,363,263	$216,219
3113	Sugar and Confectionery Product Manufacturing	1,488	$321,315	$215,938
3111	Animal Food Manufacturing	2,333	$502,929	$215,572
3353	Electrical Equipment Manufacturing	7,091	$1,423,332	$200,724
3119	Other Food Manufacturing	6,196	$1,217,421	$196,485
3259	Other Chemical Product and Preparation Manufacturing	5,482	$1,004,093	$183,162
3361	Motor Vehicle Manufacturing	16,968	$3,027,235	$178,408
3115	Dairy Product Manufacturing	8,179	$1,409,510	$172,333
3256	Soap, Cleaning Compound, and Toilet Preparation Manufacturing	10,231	$1,761,906	$172,213
3112	Grain and Oilseed Milling	2,029	$335,240	$165,224
3351	Electric Lighting Equipment Manufacturing	2,768	$456,119	$164,783

[16] Manufacturing industries' productivity is calculated as industry manufacturing GSP divided by industry's employment for the same time period.

Ohio's Electricity-Intensive Base Manufacturing Industries

Twelve (12) of the 14 manufacturing industries that produce electricity-intensive products and are large consumers of electricity in Ohio are part of the state's economic base (Table 10). These industries have a location quotient (LQ) of gross state product (GSP) above 1. Seven (7) of these industries' LQs exceed 2. The largest electricity consumer in this group is NAICS 3329, *Other Fabricated Metal Product Manufacturing* (LQ 1.4), which spends about $56 million per year on the supply of electricity. Other industries in this group include those that manufacture steel products, converted paper products, glass, nonmetallic minerals, motor vehicles, and specialty food.

Table 10. Economic Base Industries: Electricity-intensive and Large Consumers of Electricity in Ohio

NAICS	Definition	Electricity Intensity (per $, total $)	GSP LQ, 2010
3313	Alumina and Aluminum Production and Processing	H, H	1.397
3311	Iron and Steel Mills and Ferroalloy Manufacturing	H, H	2.441
3251	Basic Chemical Manufacturing	H, H	1.941
3272	Glass and Glass Product Manufacturing	H, M	2.518
3315	Foundries	H, H	2.449
3279	Other Nonmetallic Mineral Product Manufacturing	H, M	2.931
3253	Pesticide, Fertilizer, and Other Agricultural Chemical Manuf	H, H	1.825
3252	Resin, Synthetic Rubber,& Artificial Synthetic Fibers & Filaments	M, H	1.775
3312	Steel Product Manufacturing from Purchased Steel	M, M	3.198
3115	Dairy Product Manufacturing	M, H	2.085
3114	Fruit and Vegetable Preserving and Specialty Food Manufacturing	M, M	2.490
3314	Nonferrous Metal (except Aluminum) Production and Processing	M, M	1.671

Note: Ranked by per dollar expense on electricity.
The first letter in the Electricity Intensity column indicates the group of the electricity-intense industries (High (H) or Moderate (M)); the second letter indicates the group of the high (H) or Moderate (M) consumer of electricity in Ohio.

Data Centers

Data Centers are defined as "Industries [...] that provide the infrastructure for hosting and/or data processing services" by U.S. Census Bureau. Those industries are classified under 2007 NAICS 518/5182: *Data Processing, Hosting, and Related Services*.[17] There are seven types of data centers classified by Brown, et al. (2001)[18] as followed:

[17] Data Centers classified under 1997 NAICS (Darrow & Hedman, 2009):
- ✓ NAICS 514191: *Online Information Services*
- ✓ NAICS 5142: *Data Processing Services*

[18] ACEEE: Overview of Data Centers and Their Implications for Energy Demand, Elizabeth Brown, R. Neal Elliott, and Anna Shipley, American Council for an Energy-Efficient Economy, Washington, DC, Sep. 2001.

- ✓ Telecoms
- ✓ Internet Service Providers (ISP's)
- ✓ Co-located Server Hosting Facilities (CoLos)
- ✓ Server Farms
- ✓ Internet Hotels
- ✓ Corporate Data Centers
- ✓ University, National Laboratory

The site selection of data centers are affected by several factors. Places which have the regional characteristics and economic environment described below are favorable to attract data centers to the location.

- ✓ Less Natural Disasters
- ✓ Favorable Business Climate
  - o Workforce – computer science, information technology, and facility management
  - o Union rules – a "right to work" state
  - o Financial Considerations
    - Tax breaks, incentives, costs of doing business
    - Insurance costs in the area
    - Cost of land
  - o Easy access to a fiber network
  - o Lower power costs

In Ohio, however, no establishments exist in the *Data Processing, Hosting, and Related Services* industry (NAICS 5182), according to data of the Quarterly Census of Employment and Wages (QCEW). The broader industry where the data centers fit has very low unit electricity intensity in Ohio. Per dollar expenses of electricity for NAICS 518 industry was 0.00044 in 2009 data for the IMPLAN model; the average per dollar expense of electricity for a manufacturing industry was 0.00971. Total expenditure of electricity for the NAICS 518 industry was $473,337. The average total expenditure of electricity for a manufacturing industry was $32,559,567. The data centers industry in Ohio does not belong to the state's economic base. The GSP LQ for NAICS 518 was 0.291 in 2010.

There are three Lexis-Nexis establishments in Ohio. LexisNexis' world headquarters is located in Dayton, Ohio.[19]

- ✓ NAICS 5179 – All Other Telecommunications – Cleveland (Cuyahoga County)
- ✓ NAICS 5411 – Offices of Lawyers – Miamisburg (Montgomery County)
- ✓ Unclassified – Springboro (Warren County)

[19] Source: Reference USA

Summary

Twelve Ohio industries manufacture highly electricity-intensive products and, at the same time, are a significant part of the state's economic base.
These industries belong to four broader sectors:

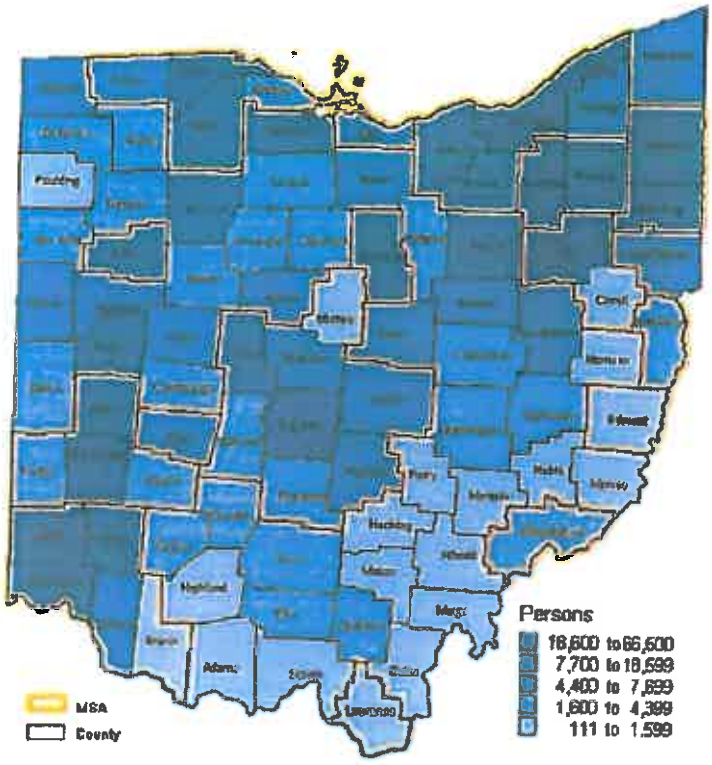
- ✓ NAICS 311: Two industries in *Food Manufacturing* had a total employment over 20,000 and were growing since 2000.[20] Average GSP growth of these industries in 2009-2010 was 10%.
- ✓ NAICS 325: Three industries in *Chemical Manufacturing* experienced GSP growth since 2000. Two of these three industries (NAICS 3251 & 3252) were also among the industries with high productivity in Ohio. Together, these three industries employed almost 15,000 people in Ohio in 2010.
- ✓ NAICS 327: Two industries in *Nonmetallic Mineral Product Manufacturing* experienced GSP growth since 2007.[21] These two industries employed almost 14,000 people in Ohio in 2010.
- ✓ NAICS 331: Five industries in *Primary Metal Manufacturing* sector were not among those with GSP growth or high productivity. However, this industry sector employed 37,297 people in Ohio in 2010.[22]

[20] This statement implies that the industry was growing from 2000 to 2010, from 2007 to 2010, and from 2009 to 2010.
[21] This statement implies that the industry was growing from 2007 to 2010 and from 2009 to 2010.
[22] See additional industry statistics in Appendix Table1.

Mapping the Geographic Distribution of Electricity-Intensive Manufacturing Industries in Ohio

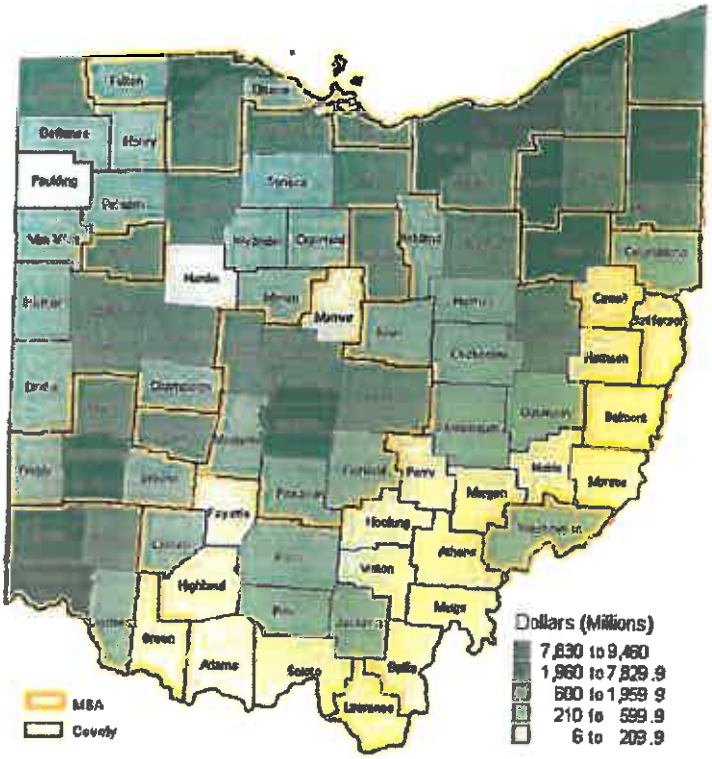
Northeast and Southwest Ohio have relatively dense populations of manufacturing employment (Figure 3). In Northeast Ohio, manufacturing employees are concentrated in Cuyahoga, Lake, Summit, and Stark counties. In Southwest Ohio, Montgomery, Butler, and Hamilton counties have a high concentration of manufacturing employment. Manufacturing employees are also concentrated in Lucas County (Northwest Ohio) and Franklin County (Central Ohio). Manufacturing employment tends to locate in urban areas; counties with large cities are more likely to have a greater number of manufacturing employees: Cuyahoga (Cleveland), Hamilton (Cincinnati), Franklin (Columbus), Lucas (Toledo), and Stark (Canton).

Figure 3. Total Manufacturing Employment



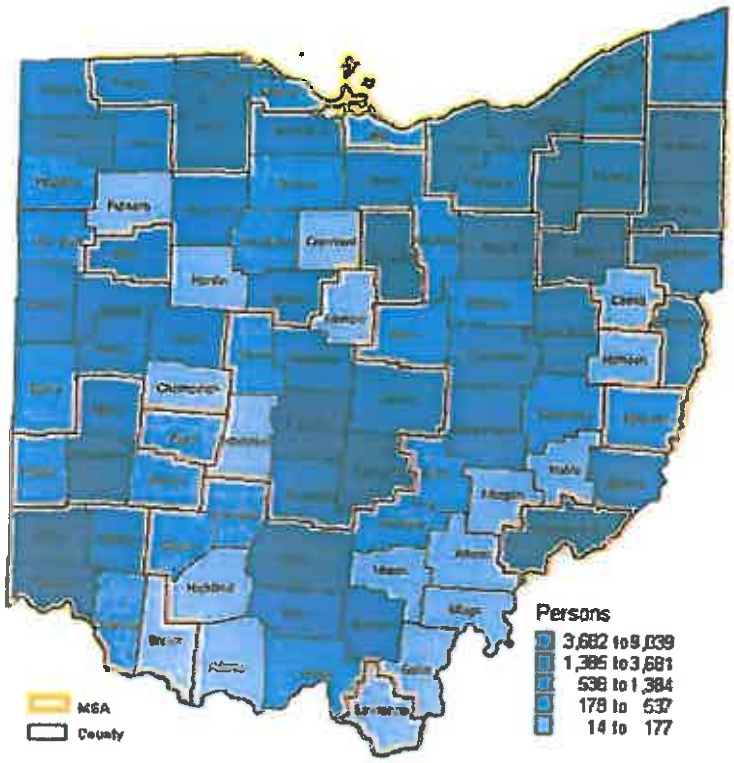
Northeast Ohio shows relatively high levels of the gross state product (GSP). Manufacturing GSP is highest in Cuyahoga County (Northeast Ohio). Hamilton County in Southwest Ohio also has a manufacturing GSP between $7,830 and $9,460 million in 2010 (Figure 4).

Figure 4. Total GSP of Manufacturing Industries



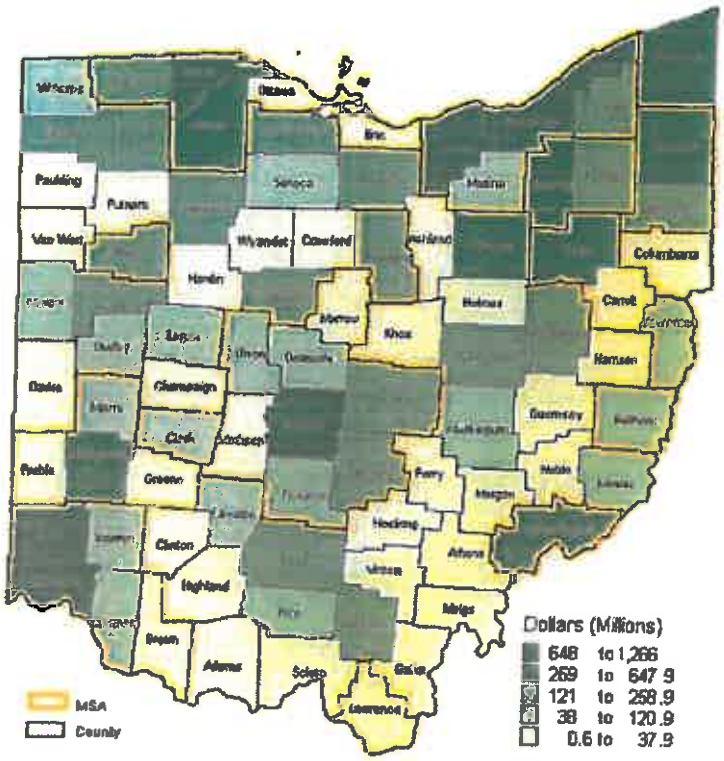
Companies in electricity-intensive manufacturing industries are located primarily in Northeast Ohio (Figure 5). Cuyahoga, Stark, and Trumbull counties each have more than 3,680 employees in electricity-intensive manufacturing. Other counties in the Northeast also have relatively large electricity-intensive manufacturing employment. Other counties with a high concentration of electricity-intensive manufacturing employment include Franklin County in Central Ohio, Hamilton and Butler counties in Southwest Ohio, and Lucas County in Northwest Ohio.

Figure 5. Employment in Electricity-Intensive Manufacturing Industries



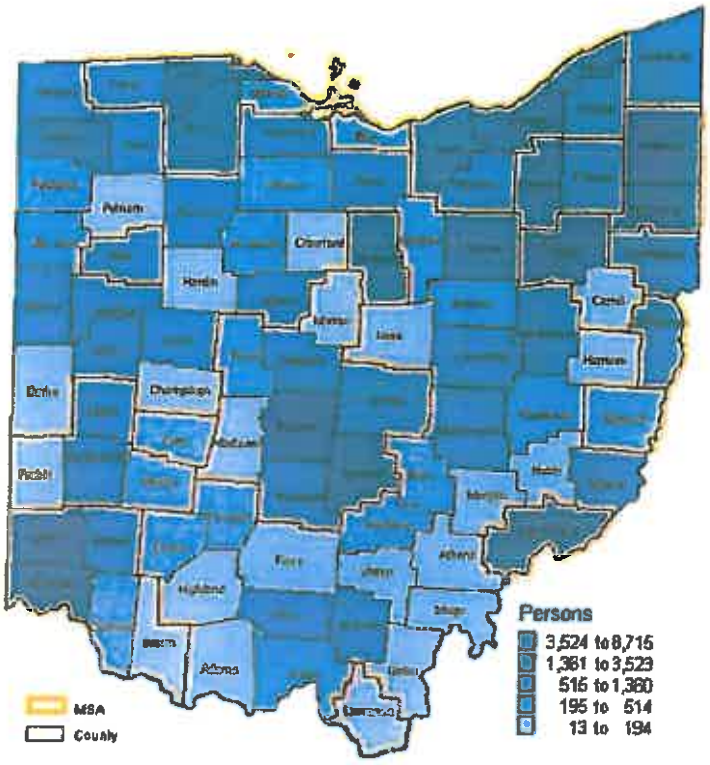
Northeast Ohio counties — Cuyahoga, Lake, and Lorain counties —have higher GSP in electricity-intensive manufacturing industries than other counties in Ohio (Figure 6). Electricity-intensive manufacturing industries also generate high GDP in Franklin County (Central Ohio), Butler and Hamilton counties (Southwest Ohio), and Lucas County (Northwest Ohio).

Figure 6. GSP of Electricity-Intensive Manufacturing Industries



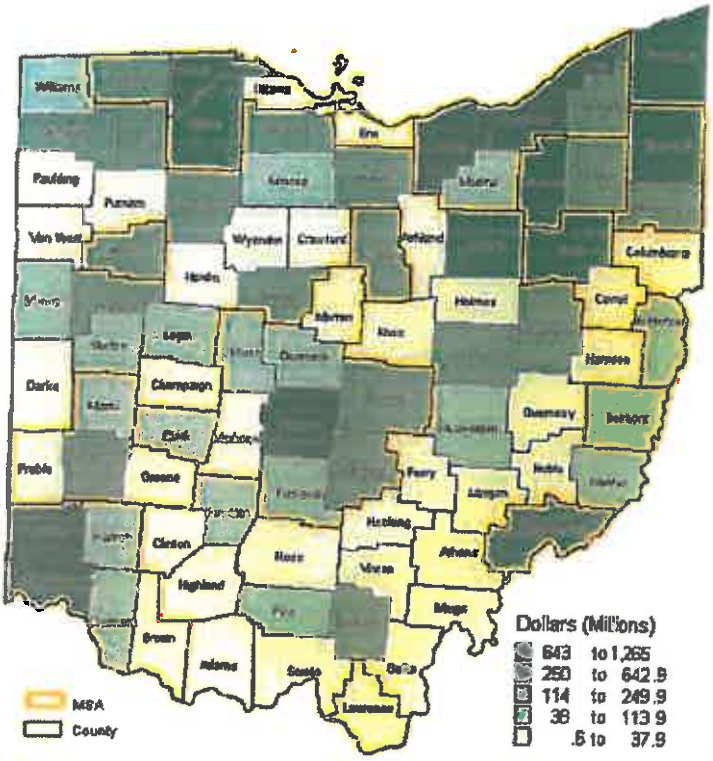
Northeast Ohio has relatively high employment in companies that belong to Ohio's economic base industries (Figure 7). Other regions tend to have companies with high employment in manufacturing economic base industries only within counties with large urban centers: Franklin, Butler, Hamilton, and Lucas counties.

Figure 7. Employment in Manufacturing Base Industries



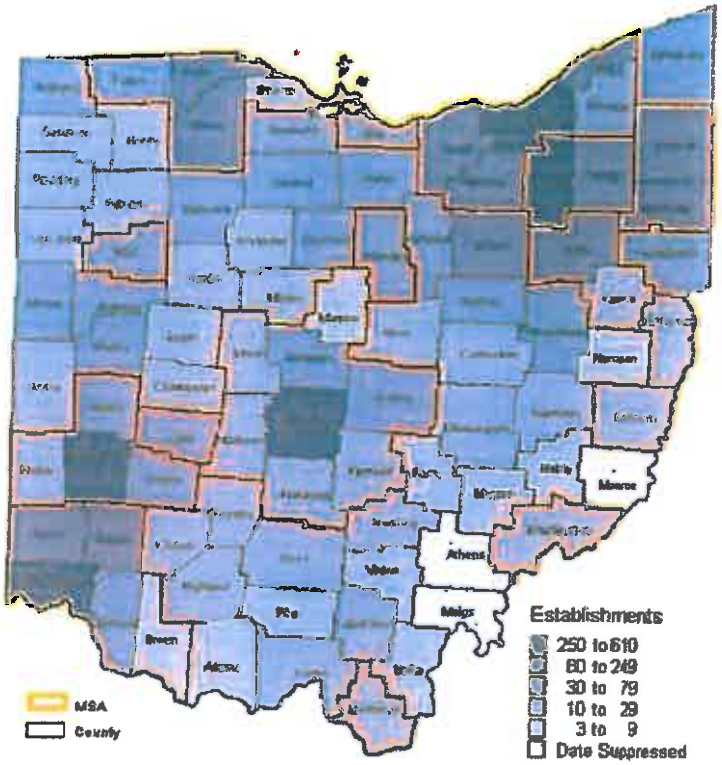
Counties in Northeast Ohio show high GSP in manufacturing base industries (Figure 8). Cuyahoga, Lake, and Lorain counties produce more than $643 million in manufacturing economic base industries. Other counties in the Northeast also have relatively high GSP in manufacturing economic base industries. GSP in manufacturing base industries is high in Franklin County (Central Ohio), Butler and Hamilton counties (Southwest Ohio), and Lucas County (Northwest Ohio).

Figure 8. GSP in Manufacturing Base Industries



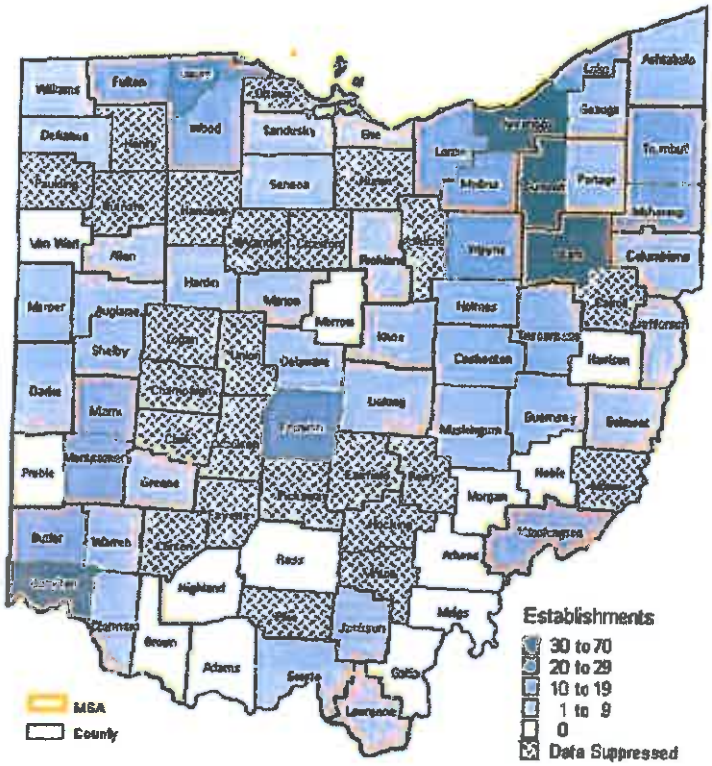
Establishments of all manufacturing industries are concentrated in Northeast and Southwest Ohio (Figure 9). In the Northeast, Cuyahoga and Summit are the most populous counties in terms of number of manufacturing establishments industries. Manufacturing establishments are also highly concentrated in surrounding counties. Hamilton and Montgomery counties in Southwest Ohio have a large number of manufacturing establishments. Franklin County in Central Ohio shows a heavy concentration of manufacturing establishments.

Figure 9. Number of Establishments in All Manufacturing Industries



Electricity-intensive manufacturing base establishments are heavily concentrated in Northeast Ohio (Figure 10), especially among Cuyahoga, Summit, and Stark counties, which are parts of the traditional Cleveland industrial belt. Another county with a large number of electricity-intensive manufacturing establishments is Hamilton County (Southwest Ohio), which has Cincinnati at its core.

Figure 10. Number of Establishments in Electricity-Intensive Manufacturing Base Industries



Part 2: Effects of Electricity Pricing Changes on Manufacturers in Ohio

This part of the study explores the industrial electricity price model through a regression analysis addressing the productivity of the manufacturing sector and industrial electricity pricing. This analysis pursued two research questions: (1) How does industrial electricity pricing influence the productivity of the manufacturing sector; and (2) What are the influences of electricity market deregulation on the industrial electricity market and the productivity of the manufacturing sector? The results of this analysis were applied to a simulation of how Ohio manufacturing productivity responds to changes in industrial electricity pricing and deregulation of Ohio electricity market.

Methodology

The geographic area used for statistical modeling in this study is defined as the state of Ohio and neighboring states Indiana, Kentucky, Michigan, and Pennsylvania. Each of these states is located within the reach of the same industrial electricity market. These states also have similar economic structures and comparable electricity customers, among which are electricity-intensive manufacturing users.

Because the five selected states are located in close geographic proximity and manufacturing represents a significant share of each state's economy, we assume that the data used in the statistical model are homogeneous. Any variation in the data can be explained by different state public policies and other specific factors relevant to industrial electricity pricing and manufacturing productivity.

We analyzed the productivity of the manufacturing industry and industrial electricity rates in Ohio, Indiana, Kentucky, Michigan, and Pennsylvania between 1990 and 2010. The latest year for which industrial electricity pricing data was available was 2010.

This study is based on a total of 105 points of observation, including, for each state, 21 years of history in industrial electricity pricing, manufacturing productivity, electricity market deregulation, and other factors relevant to electricity pricing and manufacturing.

Influence of industrial electricity price on manufacturing productivity

In the model, we hypothesized an inverse relationship between industrial electricity price and performance in the state manufacturing sector over time. To measure the performance of manufacturing, several variables were tested in the model, including manufacturing employment, manufacturing gross state product, and employment and gross state product of electricity-intensive subsectors within the states' manufacturing industries. Due to the short history of statistical data included in the model, none of the proposed variables demonstrated statistical relationships to industrial electricity pricing.

By capturing the peak of economic performance during the last business cycle, including the most recent "Great Recession" that began in 2008, and the slow recovery therefrom, we were able to show the relationship of electricity pricing to a more universal economic variable: productivity. The closest proxy of true labor productivity we were able to derive was an annual amount of gross state product produced per employee. This variable reflects both the shattered employment during the recessionary phase of the business cycle and the enhancement of technology that led to increases in labor productivity. Unfortunately, this variable also reflects the inflationary changes of the products imbedded in the measure of GDP and is ignorant of structural changes in the economy that are likely inflating the value of manufacturing products over time.

We have assumed the states' average industrial electricity prices to explain variation in manufacturing productivity among states and over time. Manufacturing performance, however, was influenced by more than just electricity prices. Some other influences were accounted for in our modeling. We also considered electricity market deregulation as an important policy choice that has influenced manufacturing productivity. In analyzing deregulation, we hypothesized a direct relationship between the variable expressing the year of deregulation in a given state and an increase in lagged manufacturing productivity the subsequent year.

Although industrial electricity prices and energy market deregulation were two policy variables of particular interest, we included a number of additional variables that fit two criteria: (1) they may influence the performance of manufacturing companies, and (2) the data for the variable were available for all five states and over time. This group of control variables included consideration of the following: business cycle phases; the dynamics of manufacturing employment; a presence of large manufacturing companies in the state; and the performance of the "Electric Power Generation, Transmission, and Distribution industry" (NAICS 2211) in the state.

Overall, the statistical model is built to test the effect of policy variables on manufacturing productivity (industrial electricity price and deregulation variables), controlling for the demand on the electricity market (manufacturing employment and significant presence of large manufacturing companies), the supply on the electricity market (size of power generation industry), and overall economic conditions (business cycle variable *"Recession"*). This logic of our statistical model can be expressed in the following equation:

Mnf Productivity = f (Industrial electricity price, Deregulation, Manufacturing employment, Presence of large manufacturing establishments, Size of power generation industry, Recession)

Where:

Mnf Productivity is the approximated productivity of a state's manufacturing sector; and the following variables can be defined as:

Industrial electricity price (IEP) - average state industrial electricity price;

Deregulation – an approximation based upon the change in policy deregulating the electricity market in a given state;

Manufacturing employment (%ch_mnf.emp) – the percentage change of manufacturing employment in a given state;

Presence of large manufacturing establishments (Mnf.1000LQ) – the change in relative number of large manufacturing companies in a state, compared to the number of large manufacturing companies in the United States;

Size of power generation industry (%ch._2211_GSP) – the percent change of gross state product produced by the *Electric Power Generation, Transmission, and Distribution* industry (NAICS 2211) in a state in a given year; and

Recession – approximating the trough of the business cycles between 1990 and 2010.

Variables for the Statistical Model

Dependent variable: Productivity of manufacturing sector in the state

Labor productivity is an indicator of value creation in the economy. Rather than employment or absolute value of gross state product, we believe that the indicator of GSP per employee best reflects the challenges of the manufacturing sector across different phases of the business cycle. Over the last two decades, the Ohio economy has demonstrated prolonged periods between the peaks and troughs of adjoining business cycles. The time period of this study—1990 to 2010—showcases this phenomenon and features several phases of the business cycle: the declining phase from July 1990 to March 1991; the historically long growth of the economy from 1991 to March 2001; the crash between March and November of 1991; the sluggish recovery through December 2007, which represented the shortest expansion phase since the 1990s; a new contraction, which led to a trough in June 2009; and, since then, an uncertain expansion of the economy.

Independent Variables

Industrial Electricity Price

The effect of energy cost on economic performance is a popular topic in academic studies exploring the impact of federal and state policies. In particular, electricity price has been proven to be an important factor in the site selection process of U.S. manufacturing companies. States with relatively low priced industrial electricity are proven to better attract firms looking

to reduce their production costs (Carlton, 1983).[23] Deschenes (2010), who employed a state panel data model similar to ours, was unable to disprove the hypothesis that no correlation exists between manufacturing employment and changes in state electricity prices.[24] This study anticipated that low industrial electricity prices may explain in part the economic growth and competitiveness of manufacturing industries in the five targeted states through demonstrated positive relationships with manufacturing productivity.

We used the annual average price of industrial electricity sold within a state as the measure of industrial electricity price (IEP) for the analysis. Industrial electricity prices vary among states and have changed between 1990 and 2010. The state's annual average industrial electricity price data are derived from the Energy Information Administration (EIA) and all price data are inflation-adjusted to 2012.

Electricity market restructuring in a state

Electricity market deregulation and restructuring was operationalized in the statistical model by a dichotomous variable. A state was coded as 1 if it had an active, restructured energy market or an effective legislative act in place allowing for the presence of a competitive electricity market in a given year. A state was coded as 0 if neither of the preceding elements existed. Information to construct this variable is recorded in Table 11.

Table 11. Status and Year of Electricity Market Restructuring and Deregulation in Selected States

State	Status	Enactment Year	Effective Year
IN	Not active	-	-
KA	Not active	-	-
MI	Active	June 3, 2000	January, 2002
OH	Active	July 6, 1999	January, 2001
PA	Active	December, 1996	January, 2000

Data source: U.S. Energy Information Administration
(http://www.eia.gov/cneaf/electricity/page/restructuring/restructure_elect.html)

This variable approximates the changes in state electricity markets, hypothesizing that the increased availability and diversity of sources for generating industrial electricity is likely to increase the supply of electricity and decrease industrial electricity prices. This variable alone would not explain the difference in electricity pricing among the states as it does not account for the flexibility and competitiveness of corresponding state wholesale and transmission markets. It is expected that states with deregulated electricity markets will show positive changes in manufacturing productivity.

This is hypothesis that they are testing

[23] Carlton, D. (1983). The location and employment choices of new firms: An econometric model with discrete and continuous endogenous variables. *Review of Economics and Statistics, 65*(3), 440-449.
[24] Deschenes, O. (2010). Climate policy and labor markets. *NBER Working Paper* #16111.

Employment in the manufacturing sector of the state (percentage change)

This variable approximates a fluctuation of the change in the whole manufacturing sector at the state level. This variable controls for changes in the demand for electricity in the state from large-scale electricity users such as manufacturers. In regulated electricity markets with low elasticity of demand and high cost of entrance (due to significant capital expenditures), even small changes in demand will influence the market price with restricted access to generation and transmission capacity of neighboring states. This variable will reinforce the disadvantage of regulated market-states in cases of demand fluctuation. We looked at annual percentage changes of manufacturing employment. Employment data estimates were obtained from Moody's Economy.com.

Share of large manufacturing firms (LQ)

The relative share of large manufacturing establishments in the state is calculated as a location quotient (LQ), which is measured as the share of the number of manufacturing establishments with 1,000 or more employees in the state, divided by the same average number in the whole United States. It hypothesizes that states with disproportionally high numbers of large manufacturing establishments might have more individually negotiated contracts (with more customer leverage) between large electricity users and supply companies, which is likely to push down the average industrial electricity price in the state. It also controls for labor productivity advantages within large firms or establishments due to the scale economy found by some academic studies (Miller, 1978).[25] In other word, large firms have a relatively high value added per employee and low unit-cost products, which leads to higher labor productivity when compared to smaller companies and establishments. The number of manufacturing establishments by size classes is available from the U.S. Census Bureau's County Business Pattern (CBP) database.

Size of power industry (% GSP change)

In our study, gross state product of the *Electric Power Generation, Transmission, and Distribution* industry (NAICS 2211) approximates the size and capacity of a state's power generation function. It reflects the supply side of the state's electricity market and, together with the deregulation variable, controls for the state's capacity to supply manufacturing companies with the industrial electricity needed to ensure growth in manufacturing productivity. The source of these data is Moody's Economy.com.

Business cycle (recession)

Variation in the demand for industrial electricity and, consequently, the supply of electricity markets and electricity prices is significantly affected by business cycle fluctuations. Historically,

[25] Miller, E. M. (1978). The extent of economies of scale: The effects of firm size on labor productivity and wage rates. *Southern Economic Journal*, 470-87.

recessionary years of economic activity and contraction of manufacturing production have yielded low demand for electricity and depressed electricity markets. The influence of the business cycle on state economies is approximated through this variable, which indicates business cycle troughs, or the lowest points of economic recession, between 1990 and 2010. For the years 1991, 2001, 2008, and 2009, when the national economy experienced a trough, the dichotomous variable is equal to 1; it is equal to 0 otherwise. Business cycle reference dates are available from the National Bureau of Economic Research.

Analysis Results

Industrial electricity price showed a statistically significant effect on manufacturing productivity across the five targeted states between 1990 and 2010 (Table 12). The industrial electricity price variable is statistically significant above the 99% critical value and is negatively associated with manufacturing productivity across the selected points of observation. In other words, the higher the industrial electricity prices were in the five selected states, the lower manufacturing productivity was in these states in 99% of cases. Using this history, we can assume with high confidence that higher industrial electricity rates in Ohio will most likely be associated with lower manufacturing productivity.

Moreover, the deregulation of the electricity market is positively associated with manufacturing productivity. This relationship is statistically significant above the 99% critical value.

Table 12. Regression Analysis Results: Determinants of Manufacturing Productivity

Manufacturing Productivity	Unstandardized Coefficients		Standardized Coefficients	t	P-value
	B	Std Error	Beta		
(Constant)	108174.453	8370.131		12.924	.000
Industrial Electricity Price	-2527.259	795.915	-.274	-3.175	.002
Percentage Change of Manufacturing Employment	-72750.268	38965.873	-.212	-1.867	.065
Output LQ of Large Manufacturing Firms	13350.313	3099.256	.387	4.308	.000
Recession	-6344.511	3617.226	-.179	-1.754	.083
Percentage Change of Output of Power Industry	45218.611	20626.580	.173	2.192	.031
Deregulation	7263.441	2837.308	.236	2.560	.012

Adjusted R square = .404
N = 105

The variables characterizing the demand side of the electricity market show that the growth of manufacturing employment is negatively related to manufacturing productivity with statistical significance only above the 90% critical value. At the same time, the over-presence of large manufacturing establishments in the state is, as expected, positively associated with

manufacturing productivity at the 99% critical value. This indicates that manufacturing productivity might benefit from both economy of scale and the ability of large electricity consumers to negotiate individual contracts with suppliers at, most likely, lower than average market prices. This finding allows us to consider that enabling a lower market price across the board for manufacturing users might further benefit the productivity of the manufacturing sector in Ohio.

The control variable that represents the supply side of the electricity market, capacity of electricity production and distribution, is also positively related to manufacturing productivity and is statistically significant above the 99% critical value. Together with the positively associated deregulation variable, an increase in the state's capacity to generate, transmit, and distribute electricity will most likely support higher productivity in its manufacturing sector.

Finally, the variable approximating the national recession was negatively associated with manufacturing productivity. However the statistical association was weak, not quite reaching the 90% critical value.

These statistical results do not allow us to disprove the null hypotheses, i.e., that no statistically significant relationships exist between industrial electricity pricing and manufacturing productivity. On the contrary, an increase in the industrial electricity price by 1 cent per kilowatt-hour (16.3%) is likely, in 99% of cases, to decrease average manufacturing productivity in the five selected states, on average, by $2,527 of annual GSP per employee (2.2%). Although the increase of industrial electricity prices is most likely to inversely affect manufacturing productivity, it is necessary to assess the responsiveness of manufacturing productivity to the changes in industrial electricity. The most appropriate measure of a variable's sensitivity or responsiveness to a change in another variable is elasticity, which is usually expressed in the ratio of percentage changes. The productivity change resulting from industrial electricity price change has low elasticity: 2.2%/16.3%=0.13. The measure of elasticity below 1 is known as inelastic response. This means that for 1% increase of industrial electricity prices manufacturing productivity drops by 0.13%. Inelastic productivity change from the movement of industrial electricity price indicates that electricity is only one of the supply price factors influencing manufacturing productivity.

Impact of Electricity Market Deregulation on Electricity Prices and Economic Indicators

To assess the impact of electricity market restructuring, we ran an independent samples t-test to compare industrial electricity prices and other economic indicators[26] between the states that deregulated their wholesale electricity markets and the states that did not. We also probed deeper into the states that deregulated their electricity markets by comparing industrial

[26] The indicators and their abbreviations as listed in the Table 1 should be listed here. See Section IV for detailed definition and measure of variables.

electricity prices and other economic indicators within the states for the years before and after the restructuring. For Tables 3 and 4, a "1" in the "Deregulation" column represents observations across the years and states where electricity market deregulation occurred; "0" represents observations across the years and states (year-states) where deregulation did not take place.

Table 13 shows the results of an analysis comparing observations from all five target states, including Ohio, Michigan, and Pennsylvania, where deregulation occurred in the early 2000s, and Indiana and Kentucky, where the electricity markets were never deregulated.[27] The group of observations for each state in each year (year-states) with deregulated electricity markets contains 30 observations and the group representing markets that have not been restructured contains 75 observations (column "N" in Tables 13 and 14). The comparison of industrial electricity prices and economic indicators across year-states is a comparison of different values due to the existence of the deregulated energy market.

For all variables included in the t-test, the differences between observations representing deregulated and non-restructured markets were statistically significant above the 99% critical value (according to column "t" in Tables 13 and 14). A statistically significant difference exists in industrial electricity prices between deregulated electricity markets and non-restructured markets; specifically, the average industrial electricity price in deregulated markets was 6.8 cents per kilowatt hour (c/kWh) compared to 6.3 c/kWh for regulated markets (Table 13). At first blush, based upon this simple comparison, it appears that deregulation does not work to reduce electricity prices. However such a comparison would be misleading. Each non-deregulated state enjoyed considerably lower electricity prices than the deregulated states, prior to deregulation. To fully understand the effects of deregulation, it is necessary to examine the history of industrial electricity prices for the three deregulated states (Figure 11) before and after deregulation.

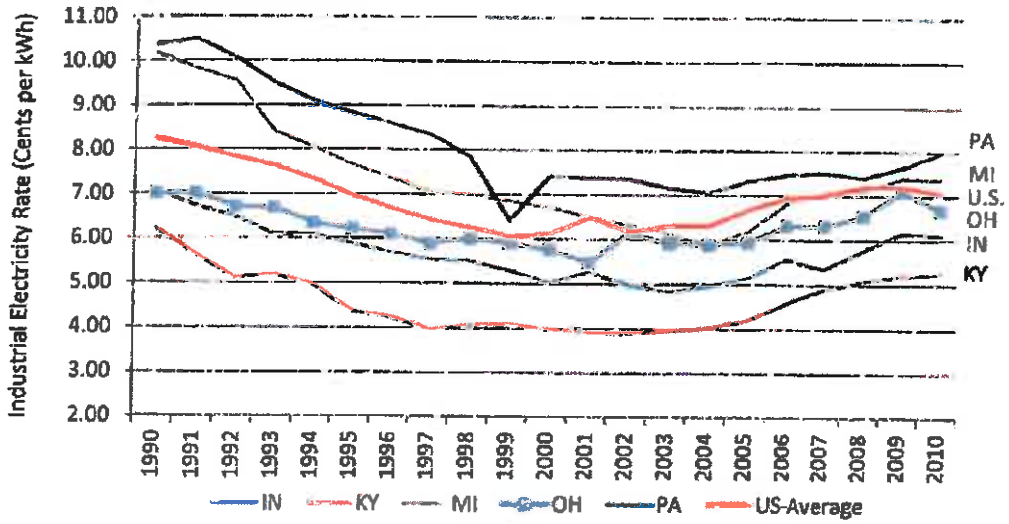
Figure 11 shows that Ohio, Michigan, and Pennsylvania—the three states that deregulated their electricity markets—had higher initial industrial electricity prices than the two states that never deregulated their markets (Indiana and Kentucky). Pennsylvania and Michigan started the study period with industrial electricity prices in 1990 above 10 c/kWh, and Ohio's industrial electricity price in 1990 was 7 c/kWh. In comparison, Indiana and Kentucky started with prices between 6 and 7 c/kWh.

[27] Ohio deregulated wholesale electricity markets in 2001 (Senate Bill 3, passed in 1999); Pennsylvania in 2000; and Michigan in 2002.

Table 13. Comparison of Variables in Regulated vs. Non-regulated Electricity Markets: Five States

Variables	Deregulation	N	Mean	Std. Deviation	t	df	P-value (2-tailed)
Industrial Electricity Price	1	30	6.81269	.665816	2.304	103.944	.023
	0	75	6.27469	1.726396			
Manufacturing Productivity	1	30	119891.59	9151.786	2.710	86.637	.008
	0	75	113335.88	15151.502			
Output LQ of Energy Intensive Manufacturing	1	30	1.62924	.395581	-3.849	93.580	.000
	0	75	2.05604	.728634			
Output LQ of Large Manufacturing Firms	1	30	1.34915	.408251	-2.288	103	.024
	0	75	1.54542	.392583			
Percentage Change of Output of Power Industry	1	30	.0424	.05440	2.378	103	.019
	0	75	.0155	.05166			

Figure 11. Industrial Electricity Price: Five-States and the U.S., 1990-2010



Source: Energy Information Administration

Table 13 and Figure 11 show that if we compare industrial electricity prices for the three states that restructured their markets to prices for those same states after deregulation occurred, the average industrial electricity price dropped from 7.7 c/kWh before deregulation to 6.8 c/kWh post-deregulation.

A similar dynamic related to the averages of indicators was observed on all other tested variables. Manufacturing sector productivity nearly doubled in Indiana and grew by at least $35,000 in the other four states between 1990 and 2010 (Figure 12). The difference in the

productivity of state manufacturing sectors (Mgf_Productivity) was statistically significant between deregulated and non-deregulated markets at the 99% critical value. Comparing average manufacturing productivity in all five target states, the difference in this indicator was $6,556 worth of gross state product per employee annually ($119,892 in deregulated markets compared to $113,336 in non-deregulated markets) (Table 13). If we compared state manufacturing productivity before and after deregulation in only Ohio, Michigan, and Pennsylvania, productivity increased by, on average, $14,869 ($105,023 before deregulation compared to $119,892 after deregulation) (Table 13).

The relative presence of electricity-intensive manufacturing establishments (LQ of mnf high intense)[28] also had larger averages in deregulated markets than in non-deregulated markets (Table 13). The difference between these averages is statistically significant. This finding indicates that in the five target states, the relative share of establishments in industries defined in Lendel (2012)[29] as high users of electricity (Table 15) was, on average, 1.6 times higher than in the national economy in non-deregulated markets and 2.1 times higher than in the national economy in deregulated markets. The relative shares of electricity-intensive manufacturing establishments were virtually the same before and after deregulation when considering only the three states that underwent the process.

The relative share of large manufacturing establishments in a state compared to the U.S. average share (mfg1000 LQ) was 1.55 for non-deregulated markets and 1.35 for deregulated markets in the sample including all five target states. In the sample of three states that experienced deregulation, the relative share was 1.33 before deregulation and 1.35 after deregulation, which shows no statistically significant difference.

Finally, the size of the *Electric Power Generation, Transmission, and Distribution* industry (NAICS 2211) (%change_2211GDP) was larger in states with deregulated markets than in states without deregulated markets (Table 13). The industry was also larger in Ohio, Michigan, and Pennsylvania after deregulation occurred, compared to before. These differences were statistically significant. This indicates that the industry producing and delivering electricity grew and delivered more supply after deregulation took place.

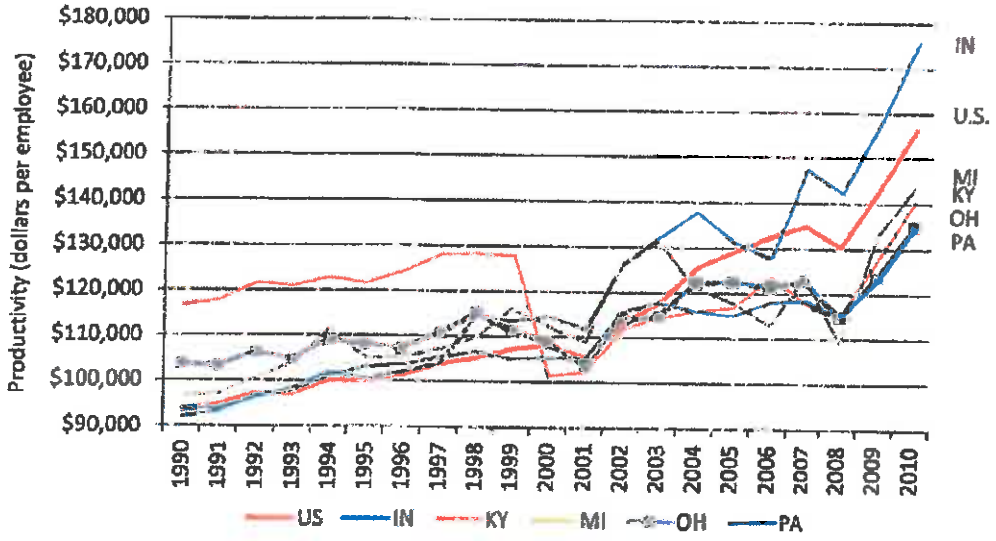
[28] Presence of energy-intense manufacturing establishments (LQ of mnf high intense) is defined as the change in relative number of energy-intense manufacturing companies in a state compared to the number of energy-intense manufacturing companies in the US.

[29] I. Lendel, et al, "Moving Ohio Manufacturing Forward: Competitive Electricity Pricing," the Urban Center, Levin College, Cleveland State University (March 2012).

Table 14. Comparison of Variables in States with Restructured Electricity Markets: MI, OH, PA

Variables	Deregulation	N	Mean	Std. Deviation	t	df	P-value (2-tailed)
Industrial Electricity Price	1	30	6 81269	.665816	-3.108	45.154	.003
	0	33	7.70435	1.492626			
Manufacturing Productivity	1	30	119891 59	9151.786	7.599	48.476	.000
	0	33	105023.28	5848.591			
Output LQ of Energy Intensive Manufacturing	1	30	1.62924	.395581	-.378	56.941	.707
	0	33	1.67591	.575377			
Output LQ of Large Manufacturing Firms	1	30	1.34915	.408251	.216	52.280	.830
	0	33	1.32960	.294151			
Percentage Change of Output of Power Industry	1	30	.0424	.05440	2.752	61	.008
	0	33	.0043	.05547			

Figure 12. Manufacturing Productivity: Five-states and the U.S., 1990-2010



Source: Moody's Economy.com

Table 15. Electricity Intensive Manufacturing Industries

NAICS	Industry Description
3313	Alumina and Aluminum Production and Processing
3221	Pulp, Paper, and Paperboard Mills
3274	Lime and Gypsum Product Manufacturing
3311	Iron and Steel Mills and Ferroalloy Manufacturing
3251	Basic Chemical Manufacturing
3272	Glass and Glass Product Manufacturing
3315	Foundries
3279	Other Nonmetallic Mineral Product Manufacturing
3253	Pesticide, Fertilizer, and Other Agricultural Chemical Manufacturing
3271	Clay Product and Refractory Manufacturing

Overall, deregulation seems to have had a positive effect on the change of industrial electricity prices, and some economic variables characterizing state of manufacturing industries in the five targeted states. The most profound effect deregulation had was on industrial electricity prices, which is evidenced by the significant drops in average price that Ohio, Michigan, and Pennsylvania—the states with the highest average base prices in 1990—experienced after deregulation occurred.

Conclusion

Identifying energy-intensive and large consumers of electricity industries

- ✓ There are 27 unit electricity-intensive industries and 21 industries that are large consumers of electricity in Ohio's manufacturing industries.
- ✓ We found 14 large electricity-intensive consumers (including both high- and medium-) manufacturing industries in Ohio, at the 4-digit NAICS level.
- ✓ All industries in primary metal manufacturing sector (NAICS 331) are defined as large, electricity-intensive consumers of electricity (NAICS 3311, 3312, 3313, 3314, 3315).
- ✓ Three chemical manufacturing industries (NAICS 3251, 3252, 3253); three food manufacturing industries (NAICS 3112, 3114, 3115); and paper, glass, and nonmetallic mineral product manufacturing (NAICS 3221, 3272, 3279) are large electricity-intensive consumer industries.
- ✓ Aluminum manufacturing is the top electricity-intensive consumer, with 5.7% of its expenditures on electricity. The iron and steel, chemical, glass and foundry manufacturing follow, each with a 2.3% or greater portion of its expenses made on the acquisition of electricity. In terms of total dollars spent, chemical manufacturing leads the state, with expenditures of over $352 million per year on electricity. Iron and steel industries, at $305 million, and aluminum at $244 million per year, are next. These industries all employ many thousands in Ohio, and are highly sensitive to increases in electricity costs.

- ✓ Besides manufacturing industries, eight 3-digit NAICS sectors and three 4-digit NAICS industries were identified as the largest electricity consumers and most electricity-intensive non-manufacturing industries in Ohio. They are accommodation (NAICS 721), nonmetallic mineral mining and quarrying (NAICS 2123), educational services (NAICS 611), amusement, gambling, and recreation industries (NAICS 713), coal mining (NAICS 2121), food services and drinking places (NAICS722), real estate (NAICS 531), warehousing and storage (NAICS 493), nursing and residential care facilities (NAICS 623), personal care services (NAICS 8121), and hospitals (NAICS 622).

Defining Ohio's economic base industries

- ✓ According to the location quotient of Ohio manufacturing industries' output or gross product in 2010, 52 4-digit NAICS industries are Ohio's economic base industries. They are represented by food manufacturing (NAICS 311), chemical manufacturing (NAICS 325), nonmetallic mineral product manufacturing (NAICS 327), primary metal manufacturing (NAICS 331), fabricated metal product manufacturing (NAICS 332), machinery manufacturing (NAICS 333), electrical equipment, appliance, and component manufacturing (NAICS 335), transportation equipment manufacturing (NAICS 336).

Ohio's electricity-intensive base manufacturing industries

- ✓ Twelve of 14 large electricity consumer manufacturing industries are part of Ohio's economic base.
- ✓ The Other fabricated metal product manufacturing industry (NAICS 3329) is the largest electricity consumer spending about $56 million per year on electricity consumption.
- ✓ Manufacturing industries that produce steel products, converted paper products, glass, nonmetallic minerals, motor vehicles, and specialty food are also Ohio's base industries that are large consumers of electricity.

Geographic distribution of electricity-intensive manufacturing base establishments

- ✓ The traditional Cleveland industrial belt in Northeast Ohio, especially among Cuyahoga, Summit, and Stark counties are where electricity-intensive manufacturing base establishments are heavily concentrated (Map 8). Southwest Ohio, Hamilton County, which has Cincinnati at its core which has also a large number of electricity-intensive manufacturing establishments.

In the second part, we analyzed how industrial electricity pricing and electricity market deregulation influences the performance/productivity of the manufacturing industry in the state of Ohio and surrounding states

- ✓ Research area: Ohio and neighboring states of Indiana, Kentucky, Michigan, and Pennsylvania

- ✓ Period of study: 1990 and 2010
- ✓ Among five states, Ohio, Michigan, and Pennsylvania, which have relatively high industrial electricity price, deregulated their electricity market around early 2000 while Indiana and Kentucky did not restructure their electricity market.
- ✓ Analysis results present that the lower the industrial electricity prices were in the five selected states, the higher manufacturing productivity was in these state over the last 20 years. We can assume with a high degree of confidence that higher industrial electricity rates in Ohio will most likely be associated with lower manufacturing productivity.
- ✓ Deregulation of the electricity market explains the increase of manufacturing productivity in Ohio and neighboring states.
- ✓ Increasing the state's capacity to generate, transmit, and distribute electricity measured by % GDP change of power industry will most likely support higher productivity in its manufacturing sector.
- ✓ Manufacturing productivity in those five states is affected by the national economic recession.
- ✓ Manufacturing productivity might benefit from both economy of scale and the ability of large electricity consumers to negotiate individual contracts with suppliers at, most likely, lower than average market prices.
- ✓ Examining only three states that have deregulated their electricity market, Ohio, Michigan, and Pennsylvania
    - The average industrial electricity price dropped since deregulation.
    - Productivity in manufacturing industry increased after deregulation.
    - The size of power industry grew after deregulation occurred.

- bringing more power into State ↓ costs.
- Supply & demand argument

Appendix Table 1. Employment and Gross State Product of Electricity-Intensive Industries

NAICS	Description	Employment 2010	2010 GSP (in 2010 $)	% Empl of all OH industries	% GSP of all OH industries
3313	Alumina and Aluminum Production and Processing	3,291	$321,942	0.06%	0.07%
3311	Iron and Steel Mills and Ferroalloy Manufacturing	9,890	$1,117,600	0.19%	0.23%
3251	Basic Chemical Manufacturing	8,737	$2,832,472	0.17%	0.59%
3272	Glass and Glass Product Manufacturing	7,685	$750,979	0.15%	0.16%
3315	Foundries	13,341	$968,942	0.26%	0.20%
3279	Other Nonmetallic Mineral Product Manufacturing	6,171	$708,435	0.12%	0.15%
3253	Pesticide, Fertilizer, and Other Agricultural Chemical Manufacturing	966	$585,050	0.02%	0.12%
3252	Resin, Synthetic Rubber, and Artificial Synthetic Fibers and Filaments	5,307	$1,286,891	0.10%	0.27%
3312	Steel Product Manufacturing from Purchased Steel	5,881	$702,124	0.11%	0.15%
3115	Dairy Product Manufacturing	8,179	$1,409,510	0.16%	0.30%
3114	Fruit and Vegetable Preserving and Specialty Food Manufacturing	11,684	$1,834,442	0.23%	0.38%
3314	Nonferrous Metal (except Aluminum) Production and Processing	4,894	$450,210	0.09%	0.09%
311	**Food Manufacturing**	51,610	$8,256,565	1.00%	1.73%
325	**Chemical Manufacturing**	42,821	$10,716,810	0.83%	2.24%
327	**Nonmetallic Mineral Product Manufacturing**	23,987	$2,478,087	0.46%	0.52%
331	**Primary Metal Manufacturing**	37,297	$3,560,818	0.72%	0.75%

Note. Bolded are industries respective 3-digit NAICS sectors of electricity-intensive industries.
Source: Moody's Economy.com, November 2011.

Appendix Table 2. Industries by Energy-Intensive Categories

Industry Categories
Energy-Intensive Manufacturing
Food Products (NAICS 311)
Paper and Allied Products (NAICS 322)
Bulk Chemicals
Inorganic (NAICS 32512 to 32518)
Organic (NAICS 32511, 32519)
Resins (NAICS 3252)
Agricultural (NAICS 3253)
Glass and Glass Products (NAICS 3272)
Cement (NAICS 32731)
Iron And Steel (NAICS 3311)
Aluminum (NAICS 3313)
Non-Energy-Intensive Manufacturing
Metal-Based Durables
Fabricated Metals (NAICS 332)
Machinery (NAICS 333)
Computer and Electronics (NAICS 334)
Electrical Machinery (NAICS 335)
Transportation Equipment (NAICS 336)
Wood Products (NAICS 321)
Plastic Products (NAICS 326)
Balance of Manufacturing (all remaining manufacturing NAICS, excluding Petroleum Refining (32410))
Non-Manufacturing Industries
Agriculture, Crops (NAICS 111)
Agriculture, Other (NAICS 112-115)
Coal Mining (NAICS 2121)
Oil and Gas Mining (NAICS 211)
Other Mining (NAICS 2122-2123)
Construction (NAICS 233-235)

Note: NAICS = North American Industrial Classification System

Source: Office of Management and Budget, North American Industry Classification System, United States, 2007 (Springfield, VA, National Technical Information Service, 2007)

Summary: Exhibit Attachment EWH-2 to the Direct Testimony of Edward W. Hill electronically filed by Mrs. Kimberly W. Bojko on behalf of OMA Energy Group