ENERGY SECTOR INDUSTRY OPPORTUNITIES FOR THE PORTS CAMPUS

Analysis conducted by Mike Zimmer for PORTSFUTURE, 2014

Sponsored by Ohio University's PORTSfuture Project

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Energy has unquestionably become one of the most prominent topics at the national and state level in recent years. The economic health of Ohio depends upon our ability to build and maintain strong and resilient communities which includes an energy infrastructure to meet end user demands for transportation, industry, and buildings in the 21st century. These end users will rely heavily upon Ohio's capacity to attract, retain and grow private sector advanced energy companies. In an age of diminishing resources for local governments, communities are looking to invest in new energy technologies, attract energy producers and consumers to co-locate in park-like settings, and be integrated together to increase and promote energy efficiency. Thus, the US Department of Energy (DOE) PORTS campus near Piketon, Ohio needs to be examined to determine the site's suitability for co-locating and integrating various energy industries. Such use of the site could ignite the development and growth of energy clusters in the Appalachian counties of Ohio and demonstrate that the site is a significant asset in the regional economy.

This paper will provide a broad overview of energy related industries, energy efficiency, and renewable energy sub-clusters in particular with additional focus on employment statistics. This document includes a summary of key findings from the analyses, supported by graphical representations of the findings and more detailed data tables. These analyses show the value of both classic energy and clean tech sectors for the future regional economy. Targeted companies will be both established energy companies, utilities, industrial services and new clean tech companies with products and services to meet the new economy of the 21st century. Many of these companies will also integrate and align well with the other energy opportunities reviewed for the PORTS campus, and complement or supplement each other by fostering integrated or co-location strategies for energy production and utilization, as well as, promote efficient transportation and advanced manufacturing that can be leveraged to provide economic benefits.

A unique opportunity exists to integrate renewable energy resources with the strong fossil resources of oil, natural gas, and coal in the region. This provides the opportunity for a joint focus on clean energy research, leveraging technologies for waste heat recovery, combined heat and power (CHP), cogeneration, fuel cells, microgrids and smart grids, with resource recovery while also promoting advanced renewables using solar, biomass from crops and agricultural grasses, geothermal, waste gases and municipal solid wastes. Distributed generation and microgrid solutions could be explored to promote lower cost electric power solutions for oil and shale gas development. Rural co-ops, municipal wastes systems and eco-industrial parks would be the beneficiaries of aligned and integrated energy systems. Thus, a smart energy corridor could emerge from the PORTS campus integrating solar and emerging renewables, with biofuels and biopower rounded out with energy storage, advanced batteries, fuel cells, distributed generation and microgrids. This integrated approach provides opportunities to optimize efficiency and minimize environmental impact while creating a sustainable and predictable energy future.

Methodology

We briefly are examining the economic characteristics of energy in the Appalachian counties of Ohio. We are introducing a concept of industry cluster as a broader and more meaningful category that

can used to better examine relationships between industries comprising energy clusters. Clusters were chosen because they foster innovation, entrepreneurship, productivity, better income levels, and employment growth as discussed by Muro, and Mark and Bruce Katz in "The New Cluster Movement: How Regional Innovation Clusters Can Foster the Next Economy" (Brooking Institute September 2010 p. 5). Using a variety of data sources, we reviewed for selection a number of NAICS[1] industries that constitute an energy cluster and Energy Efficiency and Renewable Energy (EERE) sub-cluster. Using data from IMPLAN we then mapped individual NAICS industries to IMPLAN sectors and aggregated them to estimate a relative size and economic performance of this cluster. IMPLAN was chosen as an economic modeling system created by MIG Inc. of Stillwater, Minnesota. IMPLAN is a well- known analytic tool that is widely used by government agencies, colleges and universities, non-profit organizations, private companies, and business development and community planning organizations. IMPLAN data sets offer the advantage that they combine data from different sources and as such provide a more complete picture including employment statistics since none of the publically available datasets[2] capture all information. It also helps us to get more detailed information for some industries avoiding "disclosure" or confidentiality issues.

The Appalachian region includes 32 counties in Ohio as defined by the Appalachian Regional Commission. Figure1 below shows a map of these counties, which includes a larger footprint surrounding the PORTS campus within a two hour travel radius to illustrate potential positive influence for regional economic performance.

Why Cluster?

The current structure of the North American Industry Classification System does not provide a clear and a direct definition of the energy sector. See http://www.census.gov/EOS/NAICS for more details. This means that practitioners have to devise a set of industries that comprise the energy sector. The question of what industries should be included is always an important one. A cluster is broader than a more traditional definition of the industry sector and includes a broader set of counties than Pike County, Ohio which is the county in which the PORTS campus resides. The cluster can be thought as a concentration of inter-related industries grouped on the basis of geographic, economic, business or any other factors that have the potential to create wealth and economic growth in the regional economy. The definition used is largely based on the review of existing literature, projects and the screening of potential industries. See Greater Ohio Policy Center "Restoring Prosperity: Transforming Ohio's Communities for the Next Economy" (Brookings Institution Metropolitan Policy Program 2010, p. 32) for additional information on clusters. For the complete listing of individual industries that comprise our energy cluster, please refer to the Appendix A, IMPLAN and NAICS comparison. Cluster identification is not a standardized process and relies on a range of simple to very complex statistical methods. Direct, indirect, and derivative industries are featured for the energy sector that reflect dynamics of labor market pooling, supply chain interactions, knowledge management, and leverage reflecting institutional and industry relationships in the region.

Limitations

In using IMPLAN, there are also some data limitations, which should be noted. NAICS and the IMPLAN system use different schemes to classify various industries. Loss of details occurs for some industries when a NAICS industry is mapped to IMPLAN's system. Such aggregation bias can be significant for some sectors. To minimize it, we excluded these industries from the analysis. For example, solar power structure construction (NAICS 237130) is a highly specialized industry. IMPLAN's

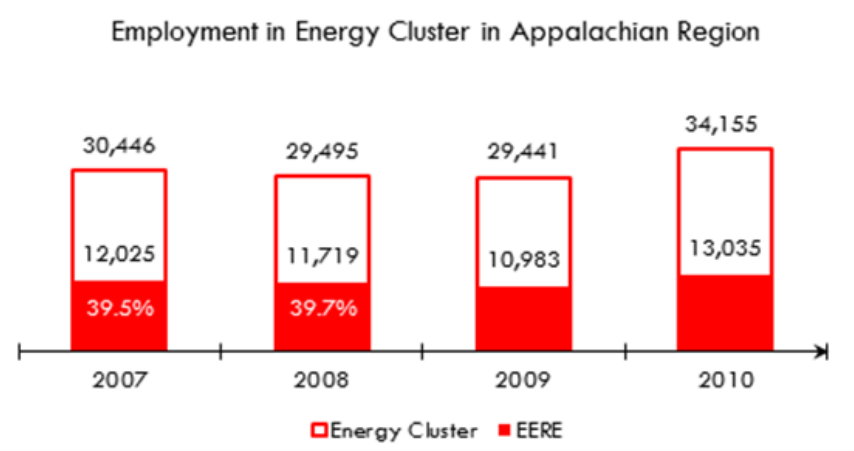
construction sectors on other hand are highly aggregated. Including solar power structure construction in the analysis will considerably overstate numbers.

Figure 1: Appalachian Counties

Source: Voinovich School for Leadership and Public Affairs at Ohio University

Economic Analysis of Energy Cluster in Appalachian Ohio

The results of our analysis illustrate the economic characteristics of an energy cluster and energy efficiency and renewable energy sub-cluster in the Appalachian Region possibly centered using the strengths offered at the PORTS campus. We apply the methodology described above to measure relative size and performance of an energy cluster on the regional economy and to show the potential for using energy as a centerpiece of PORTS redevelopment for the future.



After a slow decline in employment between 2007 and 2009, energy development was followed by a rather large increase in employment between 2009 (37.3%) and 2010 (38.2%) resulting in almost 5,000 jobs in the energy cluster and over 2,000 in the renewable sub-cluster. On average, the energy efficiency and renewables sub-cluster accounts for 37 % of regional employment, which is a lower relative percentage than the rest of the State of Ohio. However as shown on the chart below, the counties shown in the Appalachian Region accounted for a higher percentage of fossil energy than other regions in the state. Attraction of the Office of Energy Efficiency & Renewable Energy (EERE) and Smart Grid subcluster would diversify the energy supply profile for the region, enhance the supply chain and leverage other strengths offered by the PORTS campus.

	2007	2008	2009	2010
Energy Cluster	1.16	1.14	1.16	1.19
EERE	0.86	0.86	0.85	0.95

From our research, between 2009 and 2010, the increase in employment in the energy cluster was much more prominent. Overall, between 2007 and 2010, gain in employment in the energy cluster amounted to more than 12 percent. EERE sub-cluster on the other hand experienced a larger decline in employment between 2007 and 2009. The overall gain in employment between 2007 and 2010 stands at approximately 8.4 percent.

The graph above shows that both the Appalachian region's energy cluster and Ohio's energy cluster have seen positive increases in employment since 2007, with employment accelerating in these sectors since 2010. A focus in this sector for PORTS would build from that pre-established base.

Table 2: Employment in Energy Cluster

County	Employment 2007	% of Total Empl.	Employment 2010	% of Total Empl.	'07-'10 % Change
Adams	917	3.0%	515	1.5%	-43.8%
Ashtabula	1,376	4.5%	1,498	4.4%	8.9%
Athens	745	2.4%	1,079	3.2%	44.9%
Belmont	1,070	3.5%	1,600	4.7%	49.5%
Brown	364	1.2%	584	1.7%	60.3%
Carroll	386	1.3%	443	1.3%	14.9%
Clermont	2,317	7.6%	2,819	8.3%	21.7%
Columbiana	1,127	3.7%	1,106	3.2%	-1.9%
Coshocton	929	3.1%	1,747	5.1%	88.0%
Gallia	1,162	3.8%	1,126	3.3%	-3.1%
Guernsey	826	2.7%	1,385	4.1%	67.7%
Harrison	275	0.9%	445	1.3%	61.8%
Highland	295	1.0%	348	1.0%	17.9%
Hocking	524	1.7%	372	1.1%	-29.0%
Holmes	897	2.9%	777	2.3%	-13.4%
Jackson	524	1.7%	503	1.5%	-4.0%
Jefferson	1,395	4.6%	1,605	4.7%	15.1%
Lawrence	495	1.6%	543	1.6%	9.5%
Mahoning	2,951	9.7%	2,647	7.8%	-10.3%
Meigs	620	2.0%	481	1.4%	-22.4%
Monroe	470	1.5%	842	2.5%	79.3%
Morgan	118	0.4%	129	0.4%	9.2%
Muskingum	1,000	3.3%	1,253	3.7%	25.3%
Noble	252	0.8%	296	0.9%	17.3%
Perry	487	1.6%	679	2.0%	39.4%
Pike	454	1.5%	561	1.6%	23.5%
Ross	564	1.9%	606	1.8%	7.5%
Scioto	1,029	3.4%	1,187	3.5%	15.4%
Trumbull	2,460	8.1%	2,435	7.1%	-1.0%
Tuscarawas	2,285	7.5%	1,895	5.5%	-17.0%
Vinton	208	0.7%	208	0.6%	0.0%
Washington	1,925	6.3%	2,441	7.1%	26.8%
Total*	30,446	100.0%	34,155	100.0%	12.2%

* Totals may not add up due to rounding

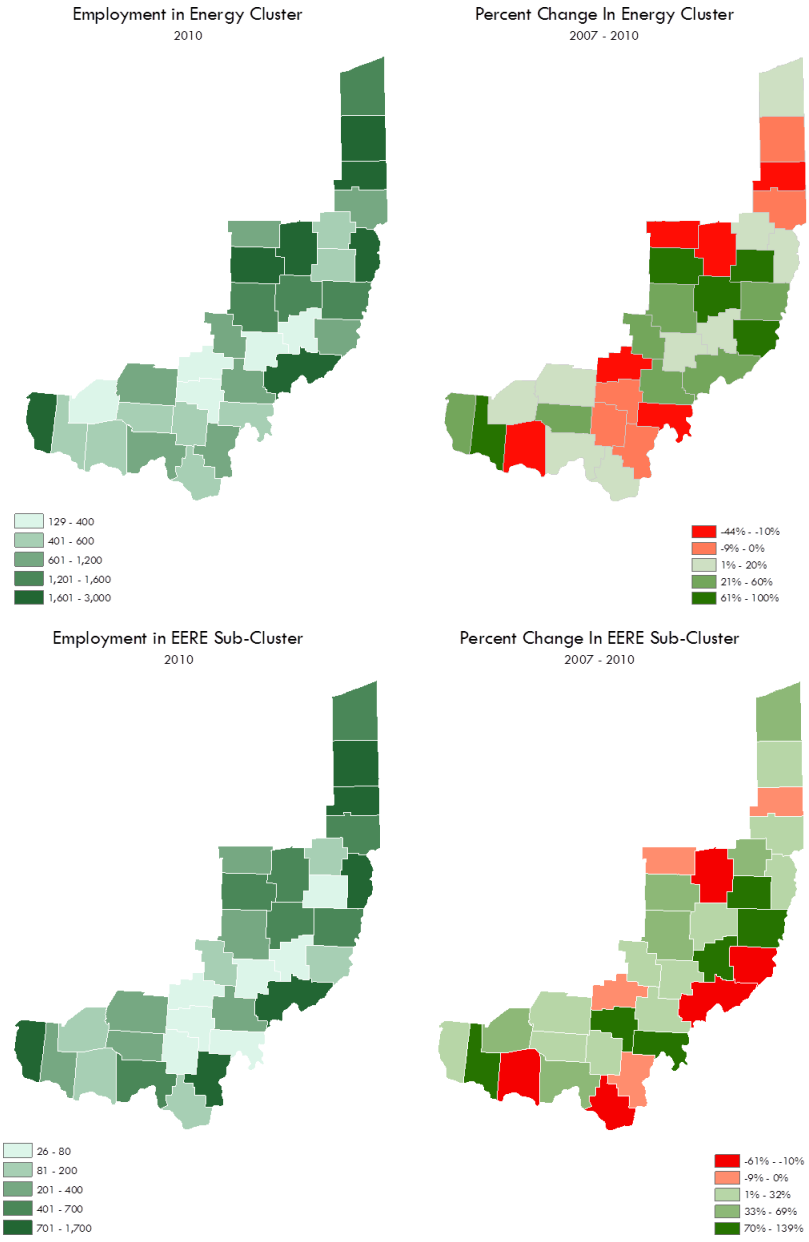
Table 3: Employment in Energy Efficiency and Renewable Energy

County	EERE Empl. 2007	% of Energy Empl.	EERE Empl. 2010	% of Energy Empl.	'07-'10 % Change
Adams	488	4.1%	189	1.4%	-61.3%
Ashtabula	419	3.5%	580	4.4%	38.4%
Athens	211	1.8%	233	1.8%	10.4%
Belmont	234	1.9%	480	3.7%	105.1%
Brown	161	1.3%	384	2.9%	138.5%
Carroll	114	0.9%	153	1.2%	34.2%
Clermont	1,393	11.6%	1,659	12.7%	19.1%
Columbiana	473	3.9%	496	3.8%	4.9%
Coshocton	494	4.1%	685	5.3%	38.7%
Gallia	977	8.1%	891	6.8%	-8.8%
Guernsey	338	2.8%	414	3.2%	22.5%
Harrison	20	0.2%	34	0.3%	70.0%
Highland	117	1.0%	198	1.5%	69.2%
Hocking	43	0.4%	40	0.3%	-9.1%
Holmes	252	2.1%	237	1.8%	-6.0%
Jackson	58	0.5%	78	0.6%	32.2%
Jefferson	927	7.7%	985	7.6%	6.3%
Lawrence	175	1.5%	143	1.1%	-18.3%
Mahoning	1,083	9.0%	1,067	8.2%	-1.6%
Meigs	30	0.2%	61	0.5%	103.3%
Monroe	100	0.8%	82	0.6%	-18.0%
Morgan	24	0.2%	26	0.2%	8.3%
Muskingum	213	1.8%	286	2.2%	33.6%
Nobel	21	0.2%	44	0.3%	109.5%
Perry	84	0.7%	98	0.8%	16.7%
Pike	268	2.2%	339	2.6%	26.5%
Ross	188	1.6%	213	1.6%	13.3%
Scioto	406	3.4%	668	5.1%	64.5%
Trumbull	620	5.2%	787	6.0%	26.9%
Tuscarawas	1,039	8.6%	503	3.9%	-51.6%
Vinton	24	0.2%	50	0.4%	108.3%
Washington	1,039	8.6%	932	7.1%	-10.3%
Total	12,025	100.0%	13,035	100.0%	8.4%

* Totals may not add up due to rounding

Source: Voinovich School of Leadership and Public Affairs at Ohio University

Table 3, similarly to Table 2, reflects an overall increase in employment for the EERE sub-cluster from 2007 to 2010 to supplement the energy cluster results. The region is already showing the benefits of such a co-location strategy between classic energy and EERE based strategies.



Source: Voinovich School of Leadership and Public Affairs at Ohio University

Table 4: Employment in Energy Cluster by Industries: 2007 – 2010

Industries	Appalachian Region Employment		AR % Change '07-'10	Ohio Employment		OH % Change '07- '10
	2007	2010		2007	2010	

Extraction of oil and natural gas	3,497	3,497	5,961	70.4%	10,834	10,834	25,903	25,903	139.1%
Mining coal		2,146	2,866	33.6%		2,250		2,980	32.4%
Drilling oil and gas wells		501	179	-64.4%		952		700	-26.5%
Support activities for oil and gas operations		773	816	5.6%		1,576		1,553	-1.4%
Electric power generation, transmission, and distribution *		4,698	5,036	7.2%		16,569		16,161	-2.5%
Natural gas distribution		739	668	-9.7%		3,517		4,013	14.1%
Petroleum refineries		380	182	-52.1%		1,534		1,680	9.5%
All other petroleum and coal products manufacturing		92	283	206.4%		121		314	158.6%
Petrochemical manufacturing		119	71	-39.9%		487		367	-24.6%
Industrial gas manufacturing		156	155	-0.5%		815		739	-9.4%
Other basic organic chemical manufacturing *		521	663	27.3%		3,737		3,998	7.0%
Power boiler and heat exchanger manufacturing *		98	107	9.1%		1,774		1,748	-1.5%
Metal tank (heavy gauge) manufacturing		431	548	27.2%		2,674		3,335	24.7%
Mining and oil and gas field machinery manufacturing		117	153	31.0%		686		568	-17.2%
Heating equipment (except warm air furnaces) manufacturing *		95	39	-59.1%		932		920	-1.2%
Turbine and turbine generator set units manufacturing *		0	1	NA		619		954	54.2%
Semiconductor and related device manufacturing *		0	0	NA		1,744		1,868	7.1%
Automatic environmental control manufacturing		128	82	-35.9%		1,256		1,160	-7.6%
Electricity and signal testing instruments manufacturing		7	153	2208.4%		1,836		1,767	-3.7%
Power, distribution, and specialty transformer manufacturing *		29	0	-100.0%		768		777	1.2%
Motor and generator manufacturing *		271	134	-50.6%		2,823		2,355	-16.6%
Switchgear and switchboard apparatus manufacturing *		76	199	162.7%		1,798		868	-51.7%

Relay and industrial control manufacturing *	430	330	-23.2%	3,961	3,491	-11.9%
Storage battery manufacturing *	0	0	NA	868	1,118	28.9%
Primary battery manufacturing *	0	0	NA	0	0	NA
Communication and energy wire and cable manufacturing	0	0	NA	245	325	32.5%
Wiring device manufacturing	16	3	-81.0%	2,438	2,224	-8.8%
Carbon and graphite product manufacturing	0	2	NA	689	524	-23.9%
All other miscellaneous electrical equipment and component mfg. *	274	188	-31.2%	1,926	1,553	-19.4%
Retail Stores - Gasoline stations	8,520	7,669	-10.0%	35,841	34,543	-3.6%
Transport by pipeline	166	162	-1.9%	981	968	-1.3%
Lessors of nonfinancial intangible assets	78	132	69.9%	1,189	1,198	0.7%
Architectural, engineering, and related services *	4,900	5,620	14.7%	63,488	57,171	-10.0%
Environmental and other technical consulting services *	574	712	23.9%	6,126	6,234	1.8%
Scientific research and development services	283	848	200.1%	22,483	23,913	6.4%
State and local government electric utilities *	334	194	-42.0%	2,766	1,471	-46.8%
Energy Cluster Total	30,446	34,155	12.2%	202,303	209,461	3.5%
Energy Efficiency and Renewable Energy Total *	12,025	13,035	8.4%	108,218	99,460	-8.1%

Table 4 above shows a detailed breakdown of the employment in both the energy cluster and the EERE sub-cluster by specific industries. It also compares the Appalachian region to the State of Ohio. Overall, the energy cluster in the Appalachian region has experienced a greater gain in employment than the State as a whole. The same applies to the energy efficiency and renewable energy sub-cluster. This foundation should be leveraged for the next decade using PORTS assets working with university support and employing R&D to promote more innovation and new commercialization of advanced energy products. Permitting and regulatory approvals in the region should foster attraction along with supportive air, water and solid waste management regimes.

Multipliers also show additional economic value from the industrial outputs for indirect employment and labor income in the region as illustrated in Tables 5 and 6. Multipliers are used to show broader economic impacts by measuring additional economic impact from a policy or project. Using most recent data available through 2010, the very recent trends in Ohio related to shale development may not be fully represented yet in this analysis. This provides regional insight to guide future targeted investments and overall advanced energy technology-based economic development for this region of Ohio. This illustrates positioning for economic growth over the next 3-5 years with strategies of growing new companies, expanding existing companies and attracting out of state (and international) companies. Specific areas of technology development are essential to illustrate comparative advantages for the state and region surrounding the PORTS campus. Battelle Labs has detailed the industries driving energy and alternative energy growth as electric power distribution, transformer manufacturing, semiconductors and solar PV, and nuclear power as is shown in Ohio Third Frontier's "Targeting Growth Opportunities for the Next 3-5 Years" (Battelle Laboratories, 2011). Battelle also suggests that Ohio offers strong niches in smart grid, smart metering($165 billion market by 20 years), fuel cells and hydrogen ($2.6 billion market by 2015), solar PV (including installers) (compound annual growth of 33%) , energy storage and batteries ($35 billion market in 10 years) , biofuels and biomass ($160 billion market for fuels, biochemicals and power generation) by 2020 (see http://www.battelle.org).

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[1] North American Industry Classification System

[2] Covered Employment and Wages (CEW) by U.S. Bureau of Labor Statistics, County Business Patterns by U.S. Census Bureau, Regional Economic Information Systems (REIS) by U.S. Bureau of Economic Analysis.

BIOMASS

Biomass has offered current power and fuels contributions in Ohio, and provides future potential still in the R&D and pre-commercialization stages. A solid supply chain and network, with transportation/ logistics support provides a foundation for the future growth of this industry in Ohio. Biomass from wood and wood wastes, and municipal solid waste and landfill gas have contributed to Ohio's net electricity generation for some time. These wood wastes also served as a source of pellet production from the region selling to wood fuel markets predominantly in the European Union. Corn and other feedstocks have served to provide fuel for the ethanol industry in the US. And according to the US Energy Information Association (EIA), Ohio researchers are investigating the potential of native Ohio switch grass for cellulosic ethanol production and the biofuel potential for giant miscanthus grass which is a perennial grass native to Asia and brought to the US for domestic production. Methane from manure produced in many Ohio farms can be used to produce electricity using bio-digester technology.

Biomass fuels can be solid, liquid, or gaseous and are all derived from biomass feedstocks. New technologies can efficiently transform biomass energy into new fuels for power generation, to replace diesel with biodiesel and can supply the growing aero fuels market. In Ohio there are over 1,300 wood manufacturing companies. Forests are a primary source of supply (tops and limbs) and wood companies provide sawdust, chips, barks and edgings for use. Biograsses and specialty agricultural crops could supplement these resources and provide a green, renewable source of feedstock supply for state and regional use. Ohio already studies the amount and types of wood residues available in state and their current uses and provides this data in its *Directory of Wood Manufacturing Industry of Ohio*. Industry categories for biomass use are broken down, and a linear programming model is available to identify possible sites for biopower generation. The state regularly surveys these biomass inputs in its research focused on industrial uses of wood residues – which are sold for other uses (45%), moved to landfills (21%), used internally (16%) and otherwise given away (18%).

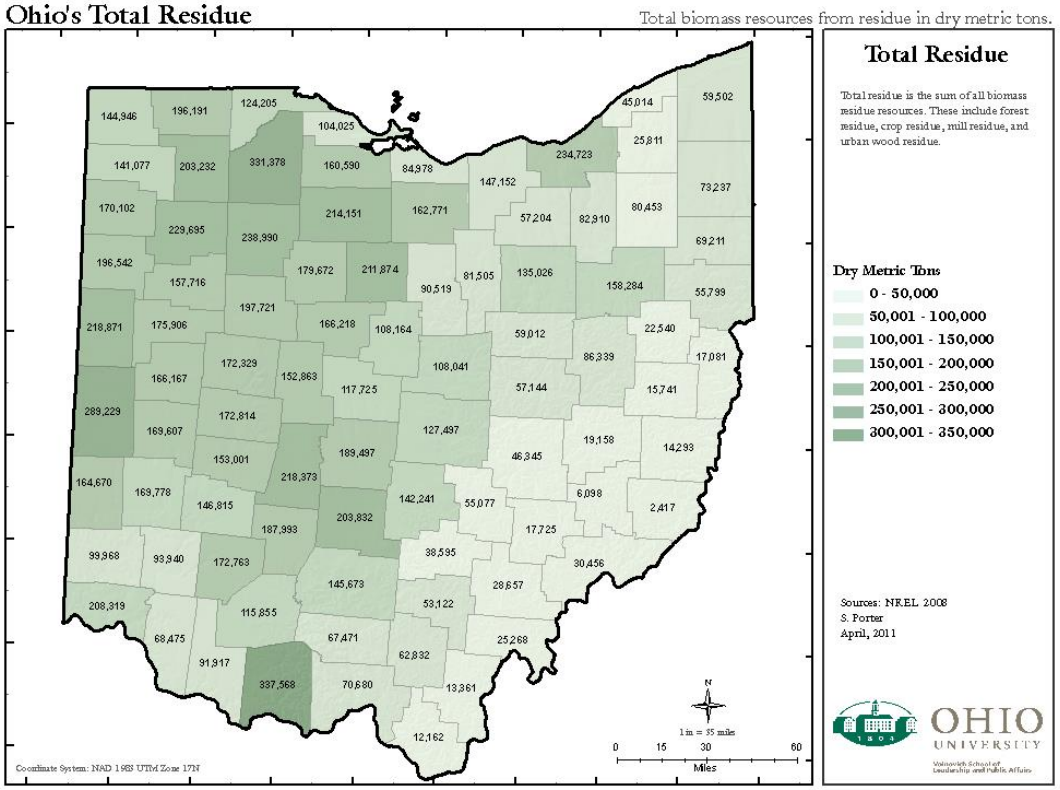
Livestock, food processing and other wastes are part of the Great Lakes Biomass Energy Program. These biomass markets focus on distributed generation, combined heat and power (CHP) and cogeneration, fuel cell applications that offer energy, waste and environmental benefits. This offers important support for biodiesel and ethanol plants in state, coupled with tax credits and financing incentives for these biofuel facilities through the Ohio Air Quality Development Authority (OAQDA). Landfill gas to energy is another state resource led by the cooperation of the Ohio Biomass Energy Program, OAQDA, and the Ohio Environmental Protection Agency (OEPA). Ohio has 17 landfill gas projects in operation but only seven are generating electricity using the gas resources with additional capital investment to support the power generation function. Finally, recovery of municipal solid wastes and wastewater sludge are another biomass resource and are used with anaerobic digesters in Akron and Toledo.

Potential agricultural feedstocks for cellulosic ethanol production, biodiesel and aero derivative fuels are varied in Ohio and can range from specialty energy crops to crop residues (corncobs, stover) or municipal wastes. Counties have been analyzed especially from agricultural sources in Northeast Ohio subject to price increases to incentivize more collection. Lands enrolled in conservation reserve programs (CRP) administered by the US Department of Agriculture will likely become the basis for production from dedicated energy crops.

The PORTS campus offers a convenient location to advance commercialization of agricultural feedstocks and specialty crops focused on biodiesel, aero derivative fuels, and cellulosic ethanol with compatible integration with solid waste, and bio product polymers and resins in the region. Excellent transportation and logistics delivery capacity exists and these can serve the needs of leaders in this space from General Electric, Poet Energy LLC, Marathon Petroleum, MFA Oil, Aloterra Energy and Quesar Energy.

Permitting for pellet production, bio crops, digester gas, distributed generation and CHP facilities should be timely and not difficult. Advanced bio refineries with bio-based polymers and resins along with power generation will require more advanced permitting for air, solid waste management, feedstock handling and disposal, transportation and boiler regulations (where necessary). University support in the region could come through Ohio University, Ohio State University, University of Akron, and/or Case Western Reserve. This commitment could be supplemented through DOE and the National Renewable Energy Laboratory (NREL), and other DOE research laboratories to support the regional commitment on a multi-state basis. Ohio is one of seven states participating in the Great Lakes Regional Biomass Energy Program established in 1983. It was administered by the Council of Great Lakes Governors and received funding from the US DOE and the State of Ohio. This federal program ended in 2009, but the state support continues and is administered through the Public Utilities Commission of Ohio.

Transforming more of our wastes, biomass and specialty agricultural crops into energy products or electricity provides alternative supplies to fossil fuels and provides fuel resilience and security. Waste management and clean tech investments fits well into this profile and offers R&D, innovation and fuel diversity benefits that aligns with advanced manufacturing. Nortech, an organization focused on strengthening Northeast Ohio's economic vitality by accelerating the pace of technology innovation in the region, has identified these areas as representing $1.7 billion in market opportunities offering over 1,800 jobs in eastern Ohio by 2018. Their focus centers especially on thermal depolymerization and anaerobic digestion in Ohio, but other markets exist and can be leveraged. A prior study by the Voinovich School examining biomass availability in the state found biomass resources exist in the four county study region that potentially could serve as feedstock for a biomass industry.



BIOMASS RESIDUE IN 4 OHIO COUNTIES

COUNTIES	TOTAL RESIDUE (in metric tons)
Scioto	70,680
Pike	67,471
Ross	145,673
Jackson	62,832

POLYMERS

Ohio's polymer industry maintains a global leadership position. Including this industry sector in the PORTS campus industrialization strategy could enhance statewide development and commercialization of higher-value technology based products that will meet increasingly demanding market needs. The Ohio polymers and advanced materials industry represents the largest manufacturing sector in the state, and is second by total size of workforce to agriculture. There are almost 2,500 establishments in this industry sector employing over 130, 000 people in the polymer workforce. There is significant opportunity to supply polymers to growing markets: electronics, biomedical, shale energy and renewable energy. There are also opportunities to integrate biomass production with specialty chemicals and polymers production in Ohio. This offers an integrative and leveraging benefit with other energy strategies and transportation and advanced manufacturing strategies for the PORTS campus.

PORTS offers siting benefits, new feedstock supplies, and transportation support that can supplement investment from private companies. Forged collaborations among universities, private companies and public sector entities to secure an operational bio- refinery in the near term could strengthen Ohio's global position in materials science. According to Battelle Laboratories, polymers will serve as the foundation of Ohio's future economy. The polymer industry will impact and contribute to a wide range of other industry sectors, like health, automotive, energy, transportation, construction, bio sciences, sensors and controls. Partnering can leverage resources through such groups/companies as the Ohio Third Frontier Program, Polymer Ohio, the Ohio Polymer Strategy Council, Zyvex Performance Materials, or PolyOne. Polymers are a smart choice for the PORTS campus future use because this technology is similar to information technology – in that its growth will foster the growth of many other technologies and a stronger supply chain to leverage better results for the region and the state. Regional development for polymers will come from leveraging the state's historical assets with resources from the value-chain, companies, specific third party investment and government support.

The Ohio opportunity is driven by materials availability. Clearly global demands for energy and consumer products will cause a shortage of key input materials, such as polymers and resins. Innovative solutions must be developed and deployed to reduce the rate of usage likely based on use of recycled materials and development of bio-based polymers. Traditional and historical reliance on oil and natural gas feedstocks competes with the energy industry demand and as world oil prices exceeding $100 per barrel evolve this will provide an incentive for new polymer development. Recycling of polymers is also becoming more critical in response to e-wastes, increased sustainability and environmental stewardship. Finally, changes in design, development and life cycle product development are changing the polymers sector. Polymer and resins materials are the second most common consumer material in the waste stream (exceeded only by paper).

Major Ohio companies in this sector are Goodyear Tire & Rubber, Eaton Industries, Parker Hannifin, Owens Corning, Cooper Tire & Rubber, PolyOne, Yamashita Rubber, Sherwin Williams, and A. Schulman. The advantages of locating in Ohio for this sector are several:

- Closer proximity to customers/ suppliers, other manufacturers and the supply chain.
- Advanced universities, Federal laboratories and commercial research institutions
- At least six economic development organizations serve this industry sector in Ohio
- Transportation and logistics support
- Existing skills and trained workforce
- State support for technology development in state
- Integration benefits with other industry sectors to support an overall polymers strategy

The PORTS campus and its locational and infrastructural strengths could provide a site for new technology commercialization, an improved value chain through the competitiveness of its small and medium sized manufacturers, talent and training through its universities, unions and economic development organizations, and access to funding from more diverse sources.

Trends

Polymers will continue to replace other materials like metal and glass. This is appearing heavily in the automotive and aerospace sectors to reduce weight, lower fuel operating costs and promote better durability.

Longer term market growth will come from housing, consumer durables and motor vehicle sales. The largest foreign export markets are with our NAFTA partners in Canada and Mexico, with China offering future long-term export growth.

Accelerated permitting through smaller plants, offers more shifts to bio feedstocks, better water, air and solid waste outcomes in Southeast Ohio.

Industry Cluster Analysis

To examine the plastics industry cluster in Ohio, we utilized an industry cluster process developed by Feser and Bergman (2000) and updated by Kelton, Pasquale, and Rebelein (2008) which examines the input-output relationships among firms. The plastics cluster is comprised of 20 industries with buyer-supplier relationships around the plastics industry. Utilizing 2013 Bureau of Labor Statistics Quarterly Census of Employment and Wage data, we examined the annual employment, establishment, and wage data for these industries in Ohio and the United States. We also calculated location quotients (LQ), a measure of relative concentration of the industry in Ohio relative to the US as a whole. A location quotient less than 1 reflect less concentration than the national average, a location quotient of 1 equals the same concentration as the national average, and a location quotient greater than one reflects a concentration greater than the national average. For example, an LQ of 2 could be interpreted as Ohio having two times as many firms in an industry as the US average. Larger location quotients, especially those exceeding 1.5 as a rule of thumb, may represent a competitive advantage for a particular industry. Scores below 1 may indicate areas of opportunity, if the overall cluster is strong, where improvements may occur.

The employment location quotient for the overall plastics cluster is 1.93 representing that Ohio has nearly twice the concentration of plastics industry cluster firms as the national average. Paint and coat manufacturing (3.71), bottles-plastics manufacturing (2.6), and plastics pipe, fittings & profile shapes

(2.54), respectively, are the highest ranking. The petrochemical industry (0.34) is among the least concentrated industries in the state. As discussed in the next section of the report, this could increase with the emerging downstream plastics production from shale gas development and byproducts if a cracker plant were developed in the state.

Ohio Plastics Cluster										
		Ohio			United States			Location Quotient		
2012 NAICS CODE	2012 NAICS Title	2013 annual employment	2013 annual establishments	2013 total wages (in 000s)	US 2013 annual employment	US 2011 annual establishments	US 2011 total wages (in 000s)	LQ Emp	LQ Est	LQ Wage
326160	Bottles, plastics, manufacturing	3,133	27	$149,349	30,847	472	$1,524,716	2.60	1.86	2.83
32611	Plastics Packaging Materials, Film & Sheet	5,301	84	$286,595	84,471	1,315	$4,485,826	1.61	2.08	1.85
337125	Household Furniture (except Wood and Metal) Manufacturing	ND	8	ND	4,791	241	$193,400	#VALUE!	1.08	#VALUE!
321999	All Other Miscellaneous Wood Product Manufacturing	1,105	102	$36,280	21,612	1,845	$760,609	1.31	1.80	1.38
325991	Custom Compounding of Purchased Resins	1,494	32	$74,363	16,672	414	$892,398	2.30	2.52	2.41
32612	Plastics Pipe, Fittings & Profile Shapes	4,931	88	$238,925	49,786	1,088	$2,529,608	2.54	2.63	2.73
326191	Plastics Plumbing Fixture Manufacturing	189	7	$7,522	12,511	377	$482,374	0.39	0.60	0.45
326199	All Other Plastics Product Manufacturing	23,654	366	$955,730	272,565	5,877	$12,281,896	2.23	2.03	2.25
339930	Doll, Toy, and Game Manufacturing	681	22	$28,121	11,525	673	$881,782	1.52	1.06	0.92
325110	Petrochemical Manufacturing	324	5	$30,851	24,116	161	$2,680,271	0.34	1.01	0.33
326192	Resilient Floor Covering Manufacturing	ND	ND	ND	ND	ND	ND	#VALUE!	#VALUE!	#VALUE!
332994	Small Arms Ammunition Manufacturing	225	16	$9,192	18,370	426	$1,169,650	0.31	1.22	0.23
326140	Foam polystyrene products manufacturing	939	32	$43,671	27,779	583	$1,199,281	0.87	1.79	1.05
326150	Foam plastics products (except polystrene) manufacturing	1,607	45	$77,109	31,688	813	$1,447,979	1.30	1.80	1.54
313230	Ribbons made in nonwoven fabric mills	869	8	$36,796	12,276	208	$664,079	1.82	1.25	1.60

326130	Laminated Plastics Plate, Sheet (except Packaging), and Shape Manufacturing	1,089	37	$53,027	16,870	399	$856,254	1.66	3.02	1.79
325510	Paint and Coating Manufacturing	5,564	86	$377,228	38,486	1,318	$2,519,993	3.71	2.12	4.33
321219	Reconstituted Wood Product Manufacturing	211	5	$9,779	12,842	211	$685,431	0.42	0.77	0.41
325190	Other Basic Organic Chemical Manufacturing	4,222	67	$389,524	47,903	1,037	$4,047,910	2.26	2.10	2.78
313320	Fabric Coating Mills	441	11	$30,162	7,830	212	$417,674	1.44	1.69	2.09
	Total Plastics Cluster	**55,979**	**1,048**	**$2,834,224**	**742,940**	**17,670**	**$39,721,131**	**1.93**	**1.93**	**2.06**
	Total Private	4,404,185	273,758	$194,056,495	112,958,334	8,912,174	$5,614,162,352	1	1	1

Ethane and Ethylene Production

Polymers come as a product of Ethane and Ethylene; two chemicals bonds that are found and withdrawn in Ethane Cracker Plants. These plants are often found on the gulf coast, where the largest amount of natural gas is being excavated in the United States. This Natural Gas has the elements needed for Ethane and Ethylene to be created in a Cracker plant and then refined to be used for consumer products. Within 2013, the United States had 361,416 barrels of Ethane and Ethylene supplied through its refineries and crackers. Out if this, the Gulf Coast contributed 333,903 barrels, followed by the Midwest at 23,889 barrels of unrefined Ethane and Ethylene. In 2013, 2,626 barrels of refined Ethane and Ethylene were produced in the United States. Over 2,557 barrels were produced by the Gulf Coast, with most of the refineries being housed near the Texas shore (Petroleum and Other Liquids).

With the large amount of Marcellus Shale being utilized for natural gas extraction in the Appalachian region, gas companies and local governments are looking into utilizing this resource. By building local Cracker plants, it would utilize the nearby natural resources of natural gas by producing the Ethane and Ethylene needed to create polymers for consumer goods and plastics. Several Cracker plants have been under consideration for construction in the Appalachian region, with a price tag ranging from $2 billion to $5 billion for the initial construction.

Appalachian Resins have unveiled plans to lease land in Salem Township, Monroe County, Ohio for a $1 billion ethylene and polyethylene production facility. The company initially planned to lease the land in West Virginia but selected Ohio to accommodate a larger production facility (Appalachian Resins). Once the plant is built, it will process around 18,000 barrels of ethane a day, which is projected to begin occurring in early 2019 (Knox).

Yet eventually, these future plants will be able to integrate into the existing infrastructure of refineries, thus creating more probability of plastic's expansion within the Appalachian market. With the current refineries being placed at such a far distance away from the Marcellus Shale, the transportation of Ethane and Ethylene to the Gulf Coast for refining has many risks and costs (Cantrell et. al). Thus the possibility to utilize potential Ethane sources is lost.

The building of these cracker plants and refineries within the local region of Appalachia allows for the extracted Natural Gas to be altered into Ethane and Ethylene. Without these plants, the current Ethane removed from Natural Gas extraction must be wasted or sent to plants on the Gulf Coast. With plants located nearby, it will cut transportation costs and risks. This opens the door for a possible polymer and plastics market to be built in the Appalachian region.

Industry Profile: Coal

Substantial changes have overtaken the energy landscape including an increased interest in and mandates for moving toward energy efficiency, cost containment, and green-house gas reduction. The traditional primary use for coal is being challenged by competing generation sources, new environmental mandates, and utility business model changes. Coal in the U.S. has taken the brunt of these economic forces and needs to seek other alternative markets in order to remain a viable energy provider in this newly emerging business climate.

Coal has lost 7,700 primary mining jobs in 2012; with similar results in 2013 as U.S. policy on coal shifts, and more U.S. coal is serving export and metallurgical markets. Coal for power generation in the U.S. has declined for successive years this past decade in the face of excess natural gas supplies, regulatory policy shifts and reduced prices.

This reflects a trend of a continuing decline in U.S. coal production of 7.7 % and an over 9% decline in U.S. consumption of coal over the past several years. Of the jobs lost in 2012, almost 65% of the job losses were in KY and WV -- not OH. Ohio has a bit over 2,000 primary jobs left in the coal sector in state. The majority of Ohio coal is exported from the state and is not used to expand the Ohio economy except for coal severance taxes. Coal production is still important for metallurgical coals, power generation and for exports (which have increased to the EU, China and India).

The coal industry has failed to scope the new market opportunities for the future. It has clung to the markets of the past and is fighting environmental, permitting, regulatory and financing risk for new coal projects in the U.S. economy. Carbon conversion and capture, coal to liquids, co-firing strategies, coal washing and beneficiation and coal-based chemicals could open new markets and opportunities for the future. Conversion of coal to synthetic liquids remains viable. But conversion of coal to synthetic natural gas no longer is viable because of the supply and lower prices of shale gas from the Utica and Marcellus shale regions.

The PORTS campus is located in close proximity to coal research capacities and R&D commercialization opportunities in PA, WV, OH. KY and IN to leverage new market development. Company leadership could come from AEP, Consol Energy, B&W, and Alstom.

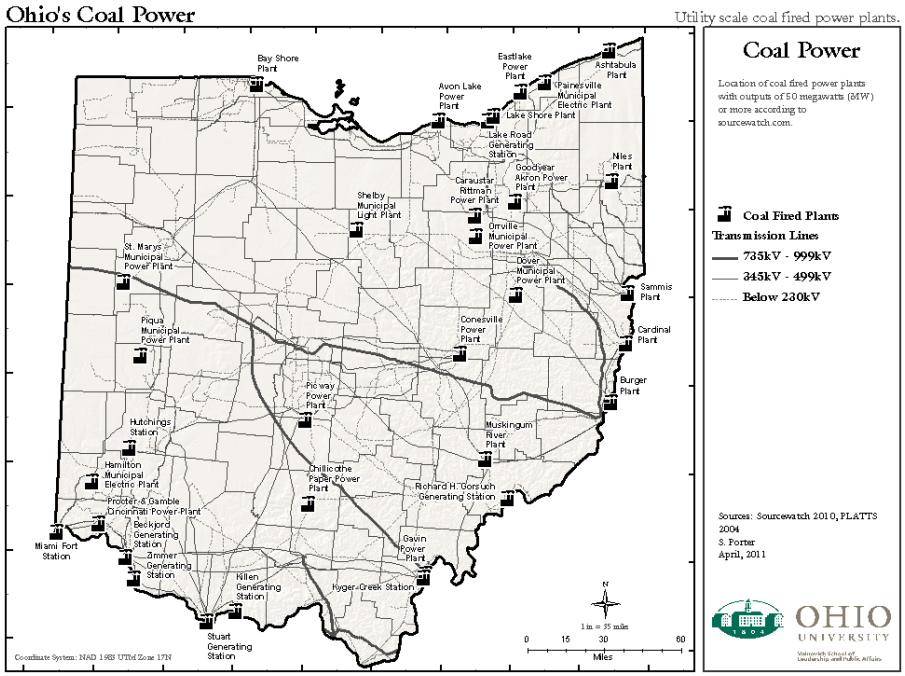
Alternative carbon conversion processes could produce from coal synthetics, such as transport fuels, chemical feedstocks and commodity chemicals that are building blocks for more refined and specialized chemical industry products. The chemical industry presence and strong multi- regional resource, fuel, transportation and construction capacity support this potential PORTS site strategy. Value added coal processes would better increase Ohio GDP for the state economy. This approach will better strengthen the state's resource economy and link well with other PORTS strategies and industrial sectors for enhanced jobs. This focus should center on processing plants for coal to provide diesel and aviation fuels, and a suite of fuel alternatives for the military. Movement into chemical processes and alternatives should be a secondary market building upon the Ohio chemical products, polymers and resins capacity which is world class. Reliance on coal for power generation should diminish in time until the economics of carbon capture and shale gas change in the future.

Coal plants will face unique air, water, solid waste and disposal challenges for permitting. Of all energy strategies, this will engender more delay, costs and permitting risk at higher levels than other energy development options that could be considered for PORTS. For these types of facilities, natural gas would be needed for steam reforming processes to produce the hydrogen required in coal conversion processes. Permitting and capital requirements could be phased while DOE could coordinate with the

various DOE labs to bring pre-commercial coal technologies to PORTS for testing and final R&D in advance of commercialization.

For the first time last year, wind jobs exceeded coal production jobs. Other jobs are appearing in natural gas fracking, gas processing and pipelines, energy efficiency, transportation and logistics, solar development and installation, Smart Grid and micro grids, metering and sensors, chemicals and processing, and water projects and development. All of these sectors offer higher growth prospects in state and nationwide markets. They are picking up the slack of job declines in other sectors such as coal for Ohio. Better job prospects for advanced coal strategies will come through technology, R&D and new markets for coal rather than focusing on coal uses and markets of the past relying on power generation that are declining.

Coal also needs more support in real estate, infrastructure development, manufacturing and construction -- as these are the missing foundation of jobs and economic recovery for the coal sector. Coal projects will contribute more direct and indirect jobs for advanced technologies, but will face equity and debt financing shortfalls for new coal development. U.S. lenders are not lending to this market so unique coal risks will need government loan guarantees or other risk management tools for successful project completion. These risks could be managed through a multi-state regional approach to create a different scale approach with an aggregate solutions approach for water, ash disposal, pre-combustion and coal to liquid alternatives to foster better U.S. market demand, and an export market for advanced U.S. technologies. PORTS infrastructure may make the region a least cost solution for advanced coal solutions to build coal markets for the future. These technologies could avoid the flaws of the past, and offer infrastructure and resource solutions leveraging site, fuel and regional benefits to create a national coal technology laboratory for commercialization of advanced coal alternatives for the national economy. The map below shows the location of coal power facilities in Ohio.



Industry Profile: Solid Wastes and Wastes Resource Recovery

Ohio manages waste reduction and recycling strategies for solid waste streams by coordinating actions of multiple agencies through solid waste management districts. Wastes are materials no longer useful in their current form in a market of single use packaging and disposable items. The most predominant form of waste management is the permitted and licensed modern landfill. With modern growth and development, the most effective way to reduce stress on disposal systems is to reduce the volumes of waste that is produced. This places a renewed emphasis on reduction, reuse and recycling, or recovery before disposal occurs as part of integrated waste management systems and planning.
Ohio and the nation face growing concerns about waste management and disposal but also face the difficulty of achieving a healthy environment with the economic costs of delivering those benefits. Each person in the US generates 4-5 pounds of municipal solid waste (MSW) per day. The contents of the municipal waste stream in descending order are paper and paperboard, tree trimmings, plastics, metals, wood, food and glass. Most communities use integrated waste management to meet the challenges of waste management and disposal. Because waste management is the third highest cost to local governments, communities use cost-benefit analysis varying by region where almost 57% is landfilled, 33% is recycled and 16% is incinerated. The energy content of different kinds of solid waste varies, as paper constitutes almost 50 % and plastics 30% of the energy content from the waste stream.

No single solution is appropriate and each community or region has its own unique profile of solid waste. The composition of solid waste varies depending on variables such as urbanization, commercial enterprises, and degree of construction, manufacturing and service sectors. Complexity is added with hazardous wastes, unique wastes from e-commerce, and wastes, sludges and wastewaters from shale fracking occurring in Ohio.

Public education and involvement are essential for reduction and reuse strategies. Source reductions offer many resource utilization and environmental benefits to the community, including reduced green-house gas (GHGs) production, saving energy, conserving useful resources and reduced volumes of waste streams. Any actions that reduce the volume or toxicity of solid wastes prior to recycling or disposal will be least cost. Reuse of products could constitute 10% or more of the solid waste stream. Reuse is also favored because it delays other more expensive strategies and uses less energy. Recycling offers value recapture, reduced energy consumption and better resource recovery. Value can also be captured through the natural biodegradation process, such as composting for food and yard wastes to turn these organics into a soil conditioner. Finally, value can be recaptured through incineration and using the waste heat for energy heating, cooling or power generation.

Technologies to address these challenges offer growth markets for the future in US and global markets as urbanization is expected to reach 80% of the world population by 2035. Ohio will be reexamining its solid waste scheme starting in 2015 after almost 30 years. Permitting can be challenging and research needs to drive down costs to manage GHGs, combustion gases, particulate emissions, fly ash and bottom ash. Other separate strategies need to be developed for water streams from fracking and underground injection, storm water and water discharges from agriculture causing toxic plumes, construction wastes, and e- wastes from high technology products.

The PORTS campus offers a site with more attractive permitting, energy and related infrastructure and transportation and logistics to support a state center to pilot or demonstrate alternative waste management strategies for the future. Success will need to focus on levels of capital investment for results achieved, levels of operating costs, expenses of sophisticated pollution control equipment and accelerated permitting for sites. The PORTS site can deliver and support those desired outcomes. The prize could be

great as Columbia University recently forecasted that MSW could be used as a fuel to generate 12% of US electricity while reducing GHGs by at least 123 million tons of carbon dioxide equivalents each year.

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