ASSURING OHIO'S COMPETITIVENESS IN A CARBON-CONSTRAINED WORLD:

A Collaboration between Ohio University and The Ohio State University

Executive Summary

OHIO UNIVERSITY 1804
Voinovich School of Leadership and Public Affairs

THE OHIO STATE UNIVERSITY

MILLENNIUM INSTITUTE

HIGH ROAD STRATEGIES

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INTRODUCTION

Many questions face Ohio policymakers regarding energy and climate policy including: What federal actions will be taken in the near future on energy/climate issues? If policies were enacted, how would they impact Ohio's economy? What actions should be considered by businesses and communities now to preempt and minimize these impacts? And more broadly, what policies could Ohio adopt to support economic development, job creation and competitive advantage while reducing energy and climate policy risks? This report attempts to evaluate and answer these questions.

Ohio is currently the seventh highest energy-consuming state in the nation.[1] Ohio also depends heavily on coal for the energy it consumes, which has contributed to its ranking of third in the nation for carbon dioxide (CO_2) emissions from its electricity generation.[2] Ohio is also at increasing risk of becoming noncompliant with tightening federal air quality standards. Noncompliance impacts the state's ability to site new industrial facilities and grow its economy. Vacillating energy and climate policy priorities at the federal level create an environment of uncertainty for communities and businesses in Ohio—additionally hampering their strategic preparations for economic growth and prosperity.

A partnership between a team of researchers at Ohio University and The Ohio State University considered these facts and these questions. The team's findings are presented in this report across nine chapters. The result of this project ultimately provides state policymakers with options for both discussion and action to manage Ohio's carbon emissions.

Project Team Acknowledgment. Researchers from Ohio University's Russ College of Engineering and Technology and Voinovich School of Leadership and Public Affairs, in partnership with researchers from The Ohio State University's Center for Resilience in the College of Engineering and John Glenn School of Public Affairs prepared this report. Additional collaborators included the Millennium Institute and High Road Strategies, LLC.

Project Background. The major tasks of the project that were requested by the Ohio Department of Development and are presented in the report include:

[1] U.S. Energy Information Administration. State Energy Data System (SEDS). (2011, June 30). *Table C10. Energy Consumption by End-Use Sector, Ranked by State, 2009*. Retrieved from http://www.eia.gov/state/seds/hf.jsp?incfile=sep_sum/html/rank_use.html

[2] U.S. Energy Information Administration. State Electricity Profiles: Ohio. (2011, April). *Table 1. 2009 Summary Statistics (Ohio)*. Retrieved from http://www.eia.gov/cneaf/electricity/st_profiles/ohio.html

- Chapter 1: A review of federal climate change legislation
- Chapter 2: Opportunities and risks for energy-intensive, trade-exposed (EITE) manufacturers as a result of federal climate proposals
- Chapter 3: The viability of biological carbon offsets in Ohio
- Chapter 4: The prospects for geologic carbon sequestration in Ohio
- Chapter 5: Existing and potential future deployment of commercial-scale renewable energy in Ohio
- Chapter 6: Growth opportunities for Ohio businesses resulting from climate legislation
- Chapter 7: An analysis of policy scenarios that could be options for Ohio moving forward in a lower-carbon economy
- Chapter 8: The development of a greenhouse gas (GHG) emissions inventory for Ohio from stationary, mobile and area sources
- Chapter 9: The development of a detailed economic modeling tool that allows state policymakers to analyze the economic, environmental and social impacts of selected climate/energy policies on Ohio

The project and this summary report have been conducted in regular consultation with the Ohio Department of Development, the Ohio Environmental Protection Agency and the Public Utilities Commission of Ohio, and are meant to inform and serve Ohio policymakers and stakeholders. The project team also convened an independent Advisory Committee to provide input to the process, representing sectors such as agriculture, automotive, consumers, the environmental community, labor, local government, manufacturing and utilities. To make this information accessible to all Ohioans, the full report and related web-based tools can be found online at www.ohioenergyresources.com.

Report Summary. Each chapter in this report is meant to highlight important factors related to Ohio's exposure to climate policies and the ways in which Ohio can capitalize on the opportunities created by such policies.

Of specific interest are the online tools developed for this project including the statewide GHG emissions inventory—the most complete picture to date of Ohio's emissions—and the economic modeling application—which can be used to analyze the economic, environmental, and social impacts of select climate change policies on Ohio. These tools are Ohio-specific and offer unique information and analysis about Ohio's emissions and its energy future. For more information about these tools, please visit: www.ohioenergyresources.com.

CHAPTER 1: OVERVIEW OF U.S. CLIMATE CHANGE POLICIES

In the late summer of 2010, the 111th Congress concluded that neither version of the then-current House or Senate climate legislation would be considered for the remainder of the year. In early 2011, the U.S. Environmental Protection Agency (U.S. EPA) began promulgating rules in response to a 2007 Supreme Court ruling (*Massachusetts v. EPA*) to implement the endangerment finding and regulate GHGs under the Clean Air Act. U.S. EPA action is seen by opponents as highly contentious, and since the beginning of 2011, the EPA has delayed some of its original timelines for regulating affected entities. The back and forth between legislative and regulatory action on GHGs will likely not be worked out until after the 2012 election.

Congressional proposals for the advancement of climate regulations may tend to focus more on energy management as a proxy for GHG mitigation measures. Options could include a clean tech portfolio standard (promoting clean, lower-emitting generation sources, not solely renewables, similar to Ohio's Senate Bill 221), tax and financing incentives, smart grid/advanced metering and energy efficiency legislation. Additional reductions could be fostered by federal or state policies to: modernize commercial and residential buildings; deploy increased automobile efficiency through higher CAFE standards, lower speed limits and low emission vehicles; and through the promotion of lighting and appliance efficiency upgrades.

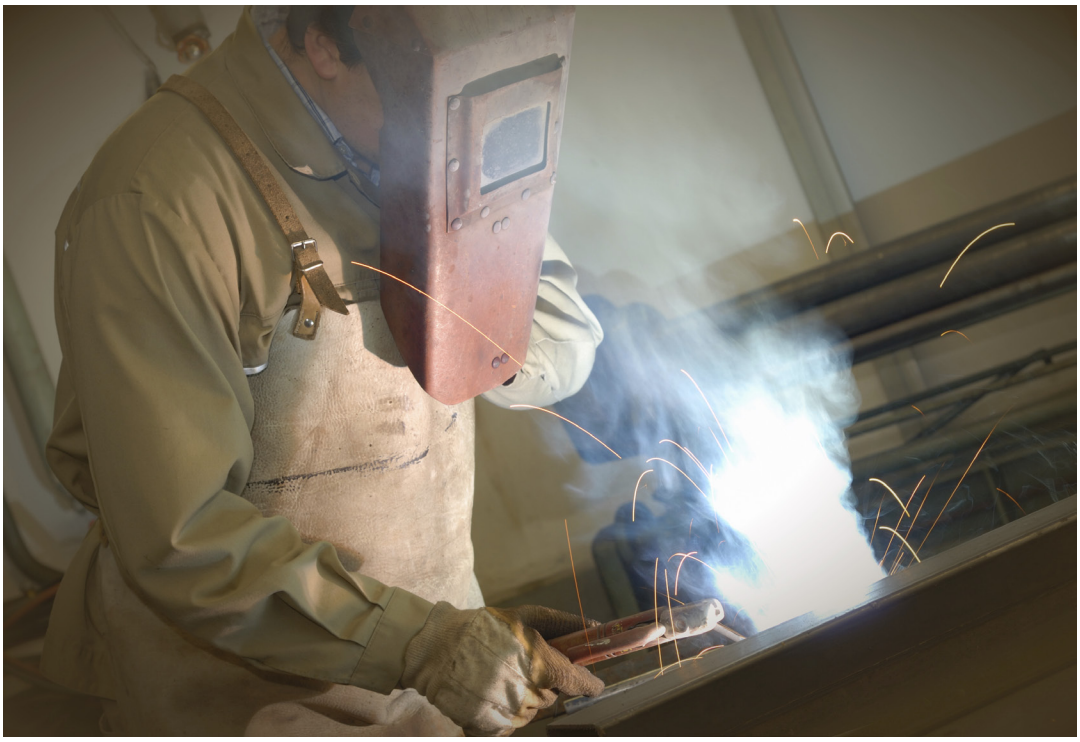
Design and implementation of any federal legislative or regulatory action on energy or climate change will benefit from additional agency coordination at the state level—and the involvement of affected consumers, industry and local government. Any federal policies that reduce GHG emissions must first and foremost be balanced to create jobs, spur investment, generate innovation and have beneficial economic impacts on the state.

Given Ohio's energy-intensive economy, the state is ripe for improvement in the areas of portfolio diversification, energy efficiency and consumption improvements. Ohio SB 221 has laid the groundwork for a suite of such energy initiatives. Ohio policymakers will need to stay apprised of the key provisions and issues that differentiate the (current and future) House and Senate versions of climate change legislation and how they could impact Ohio. As reflected in Chapter 1, these issues include:

1. GHG Reductions – Targets, Schedule and Scope
2. Distribution of Emissions Allowances
3. Emission Offset Credits
4. Carbon Market Regulation
5. Effect on Clean Air Act and Regional Programs
6. Industrial Competitiveness and Leakage
7. Offshore Oil and Gas
8. Electricity Provisions
9. Transportation and the Built Environment
10. Gasoline Impacts
11. Considerations for Ohio under Climate Legislation
12. Differences in Legislation Impacting Allowance Prices
13. Critical Nature of Offsets

A limited number of studies have been conducted to date regarding the impacts of climate change legislation specifically on Ohio, and their conclusions can vary widely depending on differing baselines, assumptions and different modeling strategies. This study, the "Assessing Ohio's Competitiveness" study, is the most comprehensive review of these topics to date. Unless substantial progress is made in identifying low-carbon and no-carbon technologies beyond electricity generation, emissions targets that were proposed for 2030-2050 will likely be very challenging, more speculative and more expensive to achieve. Policy actions and incentives to foster improved environmental performance will become more apparent if and when federal action on these issues comes to fruition.

CHAPTER 2: RISKS AND OPPORTUNITIES FOR OHIO'S MANUFACTURERS



Ohio businesspeople, workers and their political representatives are always concerned about higher energy bills and the possible loss of more factories and jobs. It is easy to appreciate the concerns over how climate policies that can drive up the cost of energy—a key production factor in many industries—could further hurt the competitiveness of the manufacturing sector if carbon legislation was enacted, especially if foreign competitors were not subject to similar carbon policies and/or cost constraints because of high-carbon generation sources. Similarly, the long-term closure or movement of plants offshore, the steady, large-scale job loss over the past decade, and an unemployment rate indicating that approximately one in ten Ohioans are jobless, are not conducive to enacting environmental policies that many perceive could put Ohio manufacturing firms at a competitive disadvantage.

Manufacturing dominates Ohio's industrial sector's energy use—the other industrial subsectors, such as agriculture, construction, and mining use only a small fraction of the energy consumed by the overall industrial sector. Manufacturing leads Ohio's end-use energy consumption, largely due to several energy-intensive industries, such as chemicals, iron and steel, aluminum, metal

casting, and glass, among others. Based on the available data, Ohio's largest emitting manufacturing industry is primary metals, which includes both the iron and steel and aluminum industries. The second largest emitting industry is chemical manufacturing, followed by petroleum and coal products, nonmetallic material products, and transportation products. Taken together, the top five industries account for over 70% of all emissions in manufacturing—and when indirect fuel combustion is combined with direct emissions, these five industries account for 9.1% of the state's GHG emissions. The details of any federal or state policies that attempt to mitigate GHG emissions are very important since these industries are central to Ohio's economy.

A portion of the U.S. business community, including many companies which are at greatest risk under a carbon-constrained future, are calling upon legislative leaders to provide the certainty needed for long-term strategic planning and investment. Policies designed solely to reduce GHG emissions will not be beneficial unless these policies help mitigate the costs of carbon pricing for energy-intensive industries in the short-run while also promoting investments in the long-run. Such policies will help drive the development and diffusion of clean and energy-efficient technologies and jobs economy-wide. The best approaches will harness the power of the markets under a clear and regimented regulatory framework. This approach will provide the necessary financial incentives, market opportunities, and phase-in requirements for Ohio's manufacturers and other industrial sectors to help assure that they remain competitive domestically and abroad.

Concerns for industry, consumers and businesses under climate change legislation or regulation are tempered by some studies that have found the macroeconomic impacts would actually be smaller than expected, both for the economy as a whole, and industrial activity in particular. Other studies have found that if climate legislation that includes measures to limit the costs of carbon mitigation (similar to HR 2454, "Waxman-Markey") were enacted, Ohio's EITE manufacturers would not face any significant economic threats until well into the 2020 decade. Impacts on Ohio's non-EITE industries are less clear.

While climate legislation has not yet been enacted at a federal level, Ohio's industries could still be subject to the U.S. EPA's efforts to regulate GHGs. Although the U.S. EPA GHG regulations are controversial, they may not have a very large impact on Ohio's industries in the short-term—especially compared to the likely long-term cost impacts of legislative options like a cap-and-trade bill such as Waxman-Markey. The EPA estimates that fewer than 15% of all major U.S. sources of GHG emissions from the manufacturing and electric

power sectors will be required to address GHG emissions through its proposed permitting process.

What is needed over the long-term is a comprehensive policy framework, coordinated and implemented at both the federal and state levels, to unleash the industrial energy and electricity energy efficiency potential for the U.S. and Ohio manufacturing sector. This would include financial incentives, promotion of energy-management practices, research, development, deployment, demonstration and education (RD3E), and regional energy innovation clusters.

Fortunately, many companies across Ohio are taking advantage of energy-efficiency best practices through existing state-level and utility programs to reduce energy use and cost, and an even larger number of companies are conducting energy audits to begin the process of saving energy to reduce their exposure. There should be a strong competitive motive for U.S. and Ohio manufacturers to invest in energy-saving technologies and practices, despite the challenges of technical limitations, a lack of information and awareness, and financial hurdles and rapid payback requirements. Existing programs at the federal and state level that address some of these barriers could be greatly expanded to encourage the ongoing competitiveness of Ohio manufacturers.

CHAPTER 3: BIOLOGICAL CARBON OFFSET OPPORTUNITIES

The use of carbon emissions offsets is meant to provide flexibility to regulated entities to reduce the compliance costs associated with greenhouse gas regulation. Ohio has an opportunity to be competitive in a carbon offset market due to its geography and agricultural strengths. Identifying the "low-hanging fruit" for carbon offset projects in the state in part depends on market pricing, policy incentives and individual project development.

The types of biological carbon offset projects ultimately appropriate for Ohio depend on several factors including natural resource availability, economic drivers, regulatory incentives, current and future land use practices, a fully accredited exchange where offsets can be traded, verified and aggregated, and market recognition. The types of biological carbon offset projects that may be appropriate for Ohio include:

- Forestry carbon sequestration (afforestation, reforestation, sustainable management);
- Continuous conservation tillage/soil sequestration;

- Agricultural methane capture and combustion;
- Nitrous oxide reductions from fertilizer applications;
- Algal carbon recycling; and
- Biofuel production.

Non-biological offset categories such as energy efficiency, landfill methane capture, renewable energy and reclaimed mineland sequestration could also be explored by the state.

Additional factors affect the types of projects that make financial sense for Ohio landowners. For example, the clearing price for carbon offsets must be significant enough to encourage project development and attract capital and technical resources. Policies must also be in place at a national, regional and/or state level to encourage the development of projects. Landowners must have excellent technical resources at their disposal to help inform the process and their participation in the market. And finally, the markets in which Ohio participates must provide the stability and credibility needed to be a trusted market player. Early entry into the voluntary market would allow Ohio to gain experience in the offset marketplace prior to a compliance situation. Ohio policymakers have numerous stakeholders (in-state private organizations and academic/research institutions) and counterparts (state governments and regional partnerships) to look to for experience and expertise in carbon offset projects/programs.

CHAPTER 4: GEOLOGIC CARBON CAPTURE AND SEQUESTRATION OPPORTUNITIES

Carbon capture and sequestration (CCS) is a grouping of GHG mitigation technologies that incorporates CO_2 capture, transport, sequestering in geologic formations, and monitoring to ensure secure, long-term placement. Despite the fact that few large-scale projects are underway, research efforts are further defining the deep geology requirements in Ohio and nationwide to identify potential CCS sites. Small-scale test projects are simultaneously producing useful results and information. In fact, state and regional efforts have identified numerous potential areas for CO_2 sequestration in Ohio, and additional research is needed to determine if CCS will be a viable and cost-effective option for the state.

Research on Ohio geology suggests that the possibility of carbon sequestration varies greatly across the state. Specific CCS site suitability will depend on multiple factors, including public acceptance, proper permitting, superior geology formation that will accept and maintain well injection integrity, location of proximal fault zones, distance from CO_2 sources (i.e., coal power plants) to suitable sequestration sites, the extent and number of rules and regulations

put in place to control the industry, and local costs to bring a CCS plant online. Ohio projects such as the Ohio River Valley CO_2 Storage Project, the Ohio Stratigraphic Borehole, the Baard Energy Ohio River Clean Fuels Project, and others are providing essential research and information. Groups like the Midwest Regional Carbon Sequestration Partnership are constantly refining Ohio's sequestration potential.

The creation of CCS jobs in research, application, monitoring, construction and management will boost local economies and energy-related businesses. However, the long-term effects of CCS remain unknown including the impact of underground CO_2 injection on the "biological communities" living near the storage sites, CO_2 leakage, potable aquifer contamination, and/or earthquakes due to underground movement of displaced fluids. Risk management and safety considerations are a critical component to the implementation of CCS technology. Ohio's risk management strategy could include in part:

1. Establishment of appropriate site selection rules based on thorough geologic characterization;
2. A monitoring program to detect problems during or after injection;
3. Public outreach and involvement at all stages of the process;
4. Appropriate remediation methods available if necessary; and
5. A regulatory system to protect human health and the environment.

The current legislative framework behind CCS can be considered an impediment to large-scale CCS deployment. Extensive incentives for advanced emissions reduction technologies will be necessary to commercialize CCS at scale; however, before these are in place, there is a need for financing and regulatory guidance for early, large-scale, in-state demonstration projects. A review of existing legislation produced by other states could help guide Ohio to be better positioned to make successful decisions.

CHAPTER 5: OHIO'S RENEWABLE ENERGY RESOURCES

Energy policies, such as Ohio's alternative energy portfolio standard established through Ohio SB 221, are harnessing Ohio resources, creating domestic jobs, and securing clean and efficient power for Ohio. The state's geographic proximity to other markets and other states that are deploying low-carbon generation technologies support economic opportunities here in Ohio, while the scale of such projects deployed in-state (residential, commercial or utility scale) depends on the regional strengths and resources that are available. The right combination of policies, renewable and energy-efficiency incentives and market conditions will enable continued growth in Ohio's renewable industry.

Wind. Harnessing Ohio's wind energy potential holds great promise in the northern and western portions of the state, including the potential of offshore wind in the eastern basin of Lake Erie. Wind resources vary greatly around the state, but assessments are being conducted that evaluate turbine height as a function of wind strength and consistency, opening the door to smaller-scale installations statewide. Current utility-scale wind farms are being developed in Ohio's central northwest region where higher levels of available wind resources exist and where existing high-voltage electric transmission lines simplify the connection of wind energy generation from the turbine to the electric grid. As

of August 3, 2011, Ohio had a total potential of 1,451.0 MW from 765 total potential turbines, which includes certified and pending statewide projects.[3]

Wind, like other forms of renewable energy being explored in Ohio, has deployment challenges including investor risk, community acceptance, land ownership, environmental disturbances, the inconsistent nature of wind, and electric grid connection issues. Federal and state incentives such as wind energy production tax credits and/or investment tax credits help subsidize deployment. Ohio's strong wind energy supply chain network is a testament to both Ohio manufacturing's ability to adapt to market demands and to the strength of its workforce, which should help serve the deployment of utility-scale wind installations in Ohio for years to come.

Solar. Solar resource potential maps indicate that Ohio holds great potential to expand the state's renewable energy portfolio—potential that could even exceed the "solar carve out" established in Ohio SB 221. Main limitations for solar projects include technology deployment costs and development lead times. Drawing on Ohio's numerous solar manufacturing and installation companies located throughout the state, the northwest region of the state is establishing a solar manufacturing hub (with First Solar and the news of Isofoton's choice of nearby Napoleon, Ohio, as the new home for its North American manufacturing facility). Because its evolving technology allows for diverse applications, solar power development in Ohio has seen an increase in deployed applications on residential homes, commercial, and industrial settings. Utilization of the state's solar resources are improving and growing in project number and size, but large-scale, public utility solar projects have yet to be deployed en masse. As of the summer of 2011, Ohio is utilizing 13.1 MW of solar power from public utility solar projects.[4] Additional public and private projects, both large and small, are planned and under development statewide.

Hydroelectric. Large-scale hydroelectric power is increasing at multiple facilities along the Ohio River as existing "run-of-the-river" facilities are retrofitted for optimization and efficiency. These projects (mainly spearheaded by American Municipal Power) are utilizing a greater portion of the Ohio River's natural flow to produce utility-scale hydroelectric power. As soon as the recently proposed projects within the Ohio portion of the Ohio River's Huntington District are added to existing capacity, the Ohio River will see 410.9 MW of

[3] Ohio Power Siting Board. (2011, Aug. 3). *Wind Projects. Ohio Wind Totals.* Retrieved from http://www.opsb.ohio.gov/opsb/?LinkServID=895FE98C-C363-FCF9-6BFDC7DF3A3F7AA2. Note: The Ohio Power Siting Board website should be consulted regularly for the most recent updates to Ohio's wind project database as projects change status and as additional projects are proposed and approved by the Board.

[4] This estimate includes both the Wyandot Solar (American Electric Power) and Yankee Solar (Dayton Power & Light) power projects. The estimate is not representative of Ohio's total solar power production, as it does not capture the numerous residential, commercial, industry and private existing and planned statewide solar projects.

hydroelectricity generated from eight locks and dams with hydroelectric plants. Ohio has an additional 31.93 MW of hydroelectric producing plants located throughout the state. Ohio's future growth in the hydroelectric industry will likely come from efficiency retrofits to existing locks, run-of the river projects and dams, and the installation of new run-of-the-river projects. This includes optimizing existing infrastructure, adding generating stations to existing dams and constructed waterways, further developing run-of-the-river technologies, and developing the potential for pumped storage opportunities throughout the state.

Biomass. A large amount of biomass across the agricultural and forested areas of Ohio could be available for harvest and application towards large-scale biomass operations. Biomass from crop residue, woody waste and municipal solid waste is renewable, replenishable, plentiful, easy to cultivate or harvest, and offers stored energy potential which make its continued use in numerous applications very valuable. Captured biogas facilities (from landfill gas capture and anaerobic biodigester facilities) are increasingly using multiple waste streams to successfully generate power. Co-firing existing fossil fuel power plants with biomass is a technology that is being widely implemented and studied by utilities throughout Ohio. Currently in Ohio, two plants are operating with partial biomass in their fuel supply, six plants are approved for operating with partial biomass, and four additional projects are proposed. Only one plant, South Point Biomass Generation Plant, is approved for full biomass utilization. Each plant's status is subject to change as their biomass supply chain fluctuates and as approved cases move toward operational projects. Market influence and industry costs will likely drive the current biomass power production industry. In addition, ethanol and/or biodiesel extracted from Ohio's biomass are supporting the alternative transportation fuel industry and could be ramped up to increase domestic supply. Other benefits to using crop residues exist, such as utilizing a domestic and renewable fuel source, reducing dependence on imported fossil fuel, increasing energy independence and security, and reducing GHG emissions from fossil fuel combustion.

Geothermal. Knowledge about Ohio's utility-scale geothermal electricity generation potential is expanding, in part through a grant from the U.S. Department of Energy to the Ohio Department of Natural Resources and others to integrate geothermal data into a new National Geothermal Data System (NGDS) as part of the State Geothermal Data Project.[5] Utility-scale geothermal electricity generation in Ohio has historically not been utilized due to limited

[5] Ohio Department of Natural Resources Division of Geological Survey. *Geothermal Energy Information*. Retrieved from http://www.dnr.state.oh.us/OhioGeologicalSurvey/tabid/23422/Default.aspx

large-scale project feasibility because of the state's geographic location (not residing over hot springs or geologic regions of activity). Advancements in geothermal well technology maximize the relatively lower temperature rocks found in Ohio's geology. More appropriate smaller applications of residential, commercial or industrial ground-source heat pumps show near-term energy savings and investment cost returns soon after installation. Ohio's long history in drilling for oil, gas and minerals bodes well for the exploration of geothermal applications, but small-scale, non-commercial-scale projects are likely to dominate into the foreseeable future.

Fuel Cells. Due in large part to state investments in this technology, a "focus on business attraction and development, building supply chain and manufacturing base," Ohio ranks in the top five states for fuel cells in the U.S.[6] Fuel cells have a versatile range of applications, supplying onsite backup or base load power and offering clean and efficient energy production. The field of fuel cell research and development is expanding as application and usage meet growing residential, commercial and industrial markets. Ongoing research is identifying new materials that reduce fuel cell production costs, increase manufacturing capabilities, extend the life of fuel cell components, and combine fuel cells with other energy applications, such as combined heat and power, conventional combustion-based power plants, and advanced automotive technologies.

[6] Fuel Cells 2000. (2011, June). *State of the States: Fuel Cells in America*. Retrieved from http://www.fuelcells.org/StateoftheStates2011.pdf

CHAPTER 6: BUSINESS GROWTH OPPORTUNITIES

Just as the definitions of "green business" and "clean tech" are very broad, so too are the opportunities for Ohio businesses to take advantage of Ohio's clean energy and advanced technology future. Companies are steadily entering into new sectors or new markets to cross-market existing skills and/or products for energy-related (or carbon-mitigation) purposes. Entrepreneurs are developing new skills, technologies and products to meet the niche need created by energy policies. Opportunities extend beyond the "obvious" arenas such as advanced energy and technologies for manufacturing. For example, consulting service companies in Ohio are auditing businesses to maximize energy efficiency, and others are working to transition company fleets to alternative fuels. Making the most of these opportunities is a function of the innovation and motivation of the Ohio business community—in conjunction with the policies that make these efforts profitable.

Certainly, many businesses and facilities that are affected by air quality regulations will experience increased costs. However, U.S. businesses that are on the path to adopting energy-efficiency or emissions-reduction practices are in a better position to anticipate, and even mitigate, these impending costs. Ohio's strong foundation in manufacturing, transportation, distribution and logistics, and agriculture, and its growth in the retail and service sectors, creates a diverse industry portfolio that can be well positioned to grow in the face of carbon constraints. There are numerous examples of Ohio-based industries and companies providing a product or service to help reduce carbon emissions and/or energy usage.

- The experience of Ohio's aerospace and aviation industry is valuable in terms of its ability to adapt and its highly-skilled workforce that specializes in integrating and/or re-purposing technology.
- Ohio food processors and agricultural industrial producers are minimizing their waste footprint and honing their methods to reduce landfilling, energy and water use.
- Process and operational shifts in the medical-related bioscience industry are helping to reduce energy usage through advanced technological applications, building envelope efficiency, refrigeration efficiencies, and combined heat and power projects.
- Existing audit services, data management groups and R&D companies are facilitating energy-efficient retrofits in the residential, commercial and industrial sectors.
- Ohio's manufacturing sector is providing products and technologies that are helping to control their own energy costs and the energy costs of other Ohio companies.
- R&D in polymers, resins and other advanced materials industries are positioned to experience growth as new energy-related applications for these products are developed.

If the U.S. or Ohio were to transition to an energy-managed, carbon-constrained future, a skilled workforce is of vital importance. Supportive policies for this sector should be encouraged. Growth in the educational and workforce training sectors is expected to continue to see tremendous advancement potential as new businesses funnel job opportunities into the state. Competition with other states, regions and countries will prove to be an ongoing challenge, but Ohio's current focus on economic development and job growth will serve Ohio businesses—current and future—well in the market if it is confronted with escalating regional and global pressures to reduce carbon emissions.

CHAPTER 7: OHIO CLIMATE POLICY CONSIDERATIONS

While potential policy considerations are prevalent in many sections of this report, Chapter 7 aggregates numerous policies that could be adopted and implemented at the state level to reduce climate change risk. Six technical factors were developed to evaluate the potential benefit of each policy option to Ohio. These factors included: how directly a policy targets climate change risk; locus of authority; governmental resources; economic costs and benefits; degree of intrusiveness; and economic development, caps and taxes.

The state policy options evaluated include:

- Carbon Caps and Taxes
- Portfolio/Green Power Requirements and Goals
- Energy-Efficiency Portfolio Standards
- Energy-Efficiency and Conservation Programs
- Energy-Efficiency Standards for Buildings
- Energy-Efficiency Standards for Vehicles and Appliances
- Transportation Fuels Policy
- Transportation Infrastructure Investments
- Integration with National Ambient Air Quality Standards Policy
- Workforce Development in Clean Energy Technology and Distribution
- Adaptation

An additional list of potential state policy considerations is contained in Addendum 7-1. Given the potential impact of federal policy actions on Ohio, Addendum 7-1 begins with issues that state policymakers should be sensitive to as they advocate for Ohio's continued competitiveness. The remaining policy options in the addendum are then grouped into the following 12 overarching categories:

1. Portfolio Diversification
2. Amending the Regulatory Infrastructure
3. Leading by Example
4. Manufacturing Policy Considerations
5. Carbon Offset Policy Considerations
6. Carbon Capture and Sequestration Policy Considerations
7. Wind Policy Considerations
8. Solar Policy Considerations
9. Hydroelectric Policy Considerations
10. Biomass Policy Considerations
11. Geothermal Policy Considerations
12. Fuel Cell Policy Considerations

CHAPTER 8: CREATION OF A STATEWIDE EMISSIONS INVENTORY

The emissions inventory developed through this project—the "Graphical Emissions Analysis and Reporting System" (GEARS) tool—is the most comprehensive assessment of climate-changing gases ever assembled for the state. The database is coupled with an online GIS-based mapping tool and analytical tools to generate and provide information on emissions sources for public and private agencies, community stakeholders and businesses. This data is exported to the model developed for this project, which in turn can be used to help understand the economic and social conditions stemming from climate and energy policy options.

The inventory aggregates real and estimated emissions of CO_2, methane (CH_4) and nitrous oxide (N_2O) from 2008 from three primary sources:

- Point: Includes individual facility stacks that have fixed locations and emit pollutants above a certain identified threshold.
- Area/Non-Point: Includes sources without a fixed location such as residential heating, small commercial utilities, livestock and agriculture practices and more.

- Mobile: Emissions emitted by vehicles, engines and equipment that travel on roads and those that work/travel off roads.

According to the estimates derived from this project's analysis, the energy sector (a broad category that includes all combustion processes) contributed 93% of the state's total emissions (in CO_2 equivalent, or CO_2e) in 2008. The bulk of emissions in the energy sector came from electric utilities (46%) and transportation (26%). Fuel combustion and industrial processes in the manufacturing sector accounted for 13% of the state's GHG emissions, while combustion activities in the residential and commercial sectors also accounted for about 13% combined. Minor contributions were estimated from the agriculture and waste categories. A more detailed inventory can be accessed on the project website at www.ohioenergyresources.com.

CHAPTER 9: ENERGY-ECONOMIC POLICY SCENARIO MODELING

The detailed emissions inventory data has been coupled with a system dynamics model to determine the impact of climate legislation on Ohio's transportation, commercial, industrial and residential sectors. The modeling tool developed for this project, the "Dynamic Energy-Economic Policy Simulation" (DEEPS) tool, allows Ohio policymakers to analyze the net societal, economic and environmental impacts of possible climate change policies and carbon emissions reduction scenarios. It is important to note that the DEEPS tool has limitations and does not seek an "optimal" solution; rather, it is a flexible "what if" simulation tool that helps to explore, both graphically and quantitatively, the broad direct and indirect effects of different policy options.

The *Economy* "sphere" of the model contains major production sectors: agriculture, mining, industry, services, waste management services and government. The *Society* sphere contains detailed population dynamics by sex and age cohort, health and education infrastructure, employment and income distribution. The *Environment* sphere tracks fossil fuel emissions and their impacts on health, and eventually on production. It also estimates the consumption of natural resources, both renewable and non-renewable (often

in both monetary and biophysical form) and examines the effects of soil erosion and other forms of environmental degradation and their impact on other sectors, such as agricultural productivity and forestry production.

The DEEPS model compares a business-as-usual, or base case scenario, which assumes a continuation of policies currently in place in Ohio, with alternative scenarios based on selected federal and state policies. For this project, DEEPS was designed to consider variations on three main federal policies, namely renewable portfolio standards, EPA greenhouse gas standards, and accelerated coal power plant retirement. The model also incorporates a broad range of potential state-level policies, which can be combined into alternative future scenarios. The state policy options currently represented include renewable portfolio standards, GHG reduction instruments, energy-efficiency standards, conservation programs, and transportation policies. However, the model is easily extensible to explore the implications of other types of policies.

Based on the policy scenarios investigated in this report and modeled in DEEPS, it appears that electric power demand-side policies (e.g., energy efficiency, smart grids) and supply-side policies (e.g., renewable sources, waste-to-energy) aimed at reducing carbon emissions will also result in an improvement of economic performance in terms of gross state product, household income and new jobs. However, renewable energy initiatives require significant initial investment. Also, biofuel generation from crops may have trade-offs in terms of land-use.

The modeling work indicates that the most positive overall outcomes will result from the simultaneous implementation of several policies or interventions, within and across sectors. However, there is not one ideal scenario that would "optimize" Ohio's future. The DEEPS model provides an integrated framework for testing a variety of policy options and evaluating their impacts across sectors in order to inform decision makers. The DEEPS model is designed to be used by state agency personnel and interested researchers to investigate the broad impact of policy options that aims to help assure the competitiveness of Ohio industries in the face of changing energy markets and potential future climate change legislation.

CONCLUSION

Energy and climate policies are not—and will never be—simple solutions that affect just one activity, one sector, or one group of stakeholders. The persistent and unresolved climate debates at the national and international levels demonstrate this complexity of interests, actions and consequences. However, uncertainty and conflict do not need to prevent or delay action to conserve energy usage and reduce emissions at the state level. A myriad of options exist for Ohio policymakers to tackle climate policies either directly or indirectly. Keeping Ohio's economy thriving if carbon is constrained in the future, and finding the most cost-effective means to meet those requirements, should be goals shared by all Ohioans.