NRDC Issue Paper
May 2010

A Clean Energy Economy for Indiana

Analysis of the Rural Economic Development Potential of Renewable Resources

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Acknowledgments
The Natural Resources Defense Council gratefully acknowledges The Joyce Foundation and the Legacy Fund for their generous support of our work.

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Executive Summary

Indiana's advanced network of rail lines, interstate highways, and waterways has made it "The Crossroads of America." But the global economic downturn has hit Indiana hard, causing the loss of almost 200,000 jobs since the beginning of 2008.[1] Facing an unprecedented set of economic challenges, Indiana stands at a new crossroads and is poised for healthy growth if it can take advantage of the enormous potential for development of its exceptional renewable resources.

With some of the world's most productive farmland, ample water, and steady winds, Indiana has all the ingredients needed to be at the center of a new energy economy for America. Tapping into this vast reservoir of clean energy would create tens of thousands of high-quality jobs and give a big boost to farm income and rural economies across the state. Policies to spur the development of clean energy resources could position Indiana as a national leader in producing renewable energy, income, and jobs, and could export homegrown energy to other states.

The following chart summarizes the estimated potential of key Indiana renewable energy resources:

Table ES1: Indiana's Clean Energy Resource Potentials and Energy and Environmental Benefits

Energy Source	Potential Energy Estimate	Effect on Indiana Electricity Usage	Carbon Reductions	Economic Benefits
Wind Power	4,500 MW = 13.8 million MWh of electricity[2] per year	12.5% of all electricity would be wind powered	13.1 million metric tons[3]	1,260 permanent jobs, $200 million per year in economic impact
Biofuels	770 million gals per year just from existing crop residues	28% of all gasoline would be replaced with "grassoline"	6.7 million metric tons[4]	$14,500 in annual revenue to average corn farm
Biopower	Replace 10% of coal = 10.5 million MWh per year	9.5% of all electricity would be biopowered	10 million metric tons[5]	3,600 permanent jobs
Biogas	2.2 billion cubic feet of methane just from swine operations	145,000 MWh of electricity per year	equivalent to 600,000 metric tons of CO_2[6]	$10 million worth of homegrown energy each year
Energy Efficiency	Energy efficiency resource standard of 15% electricity savings and 10% natural gas savings by 2020[7]	Annual electricity savings of 13.7 million MWh, gas savings of 230 million therms	13.6 million metric tons	5,350 net jobs created, $3.6 billion net energy savings

Energy Imports Are a Huge Drag on the Indiana Economy

People in Indiana spend more than $24 billion per year on gasoline and other petroleum fuels, natural gas, and coal for electricity production, building heat, transportation, and industrial use.[8] That translates to almost $3,800 in fuel costs per person—and 91 percent of those Indiana energy dollars leave the state, never to return.[9]

Indiana's total fuel production amounts to 6 percent of the nation's ethanol and 3 percent of U.S. coal annually.[10] Coal is used to produce 95 percent of the state's electricity. Because Indiana coal is high in pollutants and relatively expensive to mine, however, utilities import most of their coal from other states, with more than one-third of it shipped from Wyoming.[11]

As an industrial center and transportation hub, Indiana is a big energy user—ninth in the country in per capita energy consumption—but most of Indianan's energy dollars are literally going up in smoke.[12] This drag on Indiana's economy will only get worse if nothing is done to reduce energy consumption and to develop homegrown clean energy resources.

The Energy Information Administration (EIA), a division of the Department of Energy, forecasts that a growing economy and population will mean an average increase in U.S. electricity demand of 1 percent per year in the long run.[13] Such an increase would create a need for almost 4,000 megawatts (MW) of new generating capacity in Indiana over the next 15 years.[14,15] If Indiana doesn't improve its delivery of energy efficiency and invest in new renewable energy resources, its continued overdependence on coal could mean higher electricity bills to pay for unpredictable fuel price and supply swings. Meeting tomorrow's demand with today's coal-intensive fuel mix would also mean a substantial increase in global warming pollution, equivalent to putting 3 million more cars on Indiana roads by 2025.[16]

Indiana is home to the highest polluting power plants in the United States, which is why Hoosiers overwhelmingly support renewable resource development.[17] A scientific survey conducted by the Opinion Research Corporation found that just 7 percent of Indiana residents favor coal as the fuel for new power plants, and 75 percent want to see investment in clean energy and energy efficiency instead.[18]

In 2007, however, only 0.5 percent of Indiana's electricity was generated using renewable resources.[19] And Indiana is one of just 18 states without a renewable energy standard—a statutory goal or requirement that utilities meet a portion of their customers' electricity needs with renewable resources such as wind, solar, and biofuels.

In the crucial area of improving energy efficiency, Indiana is also lagging behind most other states, ranking 38th in the "State Energy Efficiency Scorecard" published by the American Council for an Energy-Efficient Economy (ACEEE).[20] The United States could reduce its non-transportation energy usage by 23 percent by investing in cost-effective energy efficiency, according to a study co-sponsored by a broad group of utilities, the Environmental Protection Agency (EPA), and NRDC.[21] As EPA Administrator Lisa P. Jackson stated upon release of the report, "The energy that most effectively cuts costs, protects us from climate change, and reduces our dependence on foreign oil is the energy that's never used in the first place."[22] Improved energy efficiency can lead to lower energy bills, even as we make the investments needed for the transition to clean power production. With a commitment to energy efficiency and renewable energy production at the core of a national energy strategy, clean energy has the potential to join agricultural and industrial products as a major export from Indiana to other states.[23]

Clean Energy Policy Can Create High-Quality Jobs in Indiana

Renewable energy production is already one of the nation's fastest growing areas of job creation. A study conducted by the Political Economy Research Institute (PERI) of the University of Massachusetts and co-sponsored by NRDC found that clean energy jobs in Indiana grew by almost 18 percent over the 10 years ending in 2007, a period when overall employment in Indiana fell by 1 percent.[24]

Clean energy is far more job intensive than the fossil fuel supply chain, which is based on mining, drilling, and long-distance transportation of fuel. "Green jobs" are primarily in construction, engineering, installation, agriculture, and operation of rural energy production facilities. The local economic benefits of clean energy are therefore multiplied—and the jobs can't be exported. The PERI study found that investments in clean energy and energy efficiency create, on average, more than three times as many jobs as fossil-fueled energy for every dollar spent. Most of those jobs generate relatively high wages and are spread across a wide range of skill and education levels. Compared to fossil energy, the PERI study found that clean energy investment creates 3.6 times more jobs for people without college education, and 2.6 times more jobs for people with college degrees.

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If $150 billion were invested annually in clean energy in the United States—an amount equal to the estimated combined effect of the American Recovery and Reinvestment Act (ARRA, or the stimulus bill) and the American Clean Energy and Security Act (ACESA)—Indiana's share would be $3.1 billion in investment and 38,000 new jobs. Clean energy jobs would be especially valuable to Indiana, which ranks 38th in the nation in per capita income and has the 12th highest unemployment rate.[25] A recent study by ACEEE found that meeting a proposed national goal of 15 percent electricity savings and 10 percent natural gas savings by 2020 would produce 5,350 net new Indiana jobs and $3.6 billion in annual savings for Indiana consumers. In addition, achieving these energy savings would reduce carbon dioxide emissions by 11.6 million tons, the equivalent of taking more than 2 million cars off Indiana roads.[26]

Indiana's underutilized industrial capacity and central location make it a prime site for the manufacture of components for renewable energy production facilities. A study by the Renewable Energy Policy Project (REPP) ranks Indiana second in the nation in per capita potential manufacturing job creation from renewable resources.[27] Referring to Indiana's opportunity to become a center for wind power components, Governor Mitch Daniels said, "There is no better place in America, perhaps on the planet, to manufacture the necessary equipment."[28] REPP found that wind energy generates 5.7 person-years of employment per million dollars in investment over 10 years, whereas coal industry spending generates only 4.0 person-years per million dollars over the same period.[29] The REPP study calculates that a national commitment to build 185,000 MW of renewable electricity capacity over the next 10 years could result in the creation of more than 39,000 manufacturing jobs in Indiana, not including the potential of energy storage technologies such as advanced batteries.

Innovation in battery and other technologies to store electricity will add tremendous value to variable-output energy resources like wind and solar power. Because wind tends to blow hardest during the night when electricity demand is lightest, the growth of wind power is complementary to the imminent arrival of electric vehicles, which will be charged primarily at night. When connected to the "smart grid" under development by utility companies like Duke Energy Indiana, plugged-in electric cars eventually can become electric storage units, filling up on energy in off-peak hours and providing energy from their batteries to the grid when it is needed.[30] Batteries in electric cars could help power homes, making the electricity system more efficient and less costly.

Manufacturing advanced batteries and other electric vehicle components could be a tremendous boon to Indiana's sputtering auto parts industry. EnerDel, an Indianapolis maker of innovative lithium-ion vehicle batteries, recently won a $118 million federal stimulus grant to double its capacity, and many other Indiana companies are positioned to shift into high gear if producing electric cars becomes part of a national clean energy strategy.[31]

Renewable Energy Development Provides New Income Opportunities for Indiana Farmers

If curbing greenhouse gas emissions and supporting renewable resource development become national policy, production of clean energy could be a good business opportunity with multiple revenue streams for farm operators, including:

- Land leases for wind turbines
- Sale of energy crops
- Sale of energy to local utility companies
- Sale of renewable energy credits
- Sale of carbon offset credits
- Sale of fertilizer
- Sale of animal processed fiber[32]

This report examines the potential of Indiana's renewable resources and finds unprecedented opportunity for long-term economic growth in rural communities as well as new income sources for farmers from an array of emerging clean energy technologies, particularly wind, biofuels, biopower, and biogas.

Wind Power

Almost one-third of Indiana has commercially viable wind resources. Although Indiana saw the largest percentage jump in wind development of any state in 2008, it ranks just 14th in operating capacity. If 30 commercial-scale wind farms were built in Indiana, the result would be tens of thousands of construction jobs, including 1,260 permanent jobs, $71 million in annual property tax revenue, and $201 million per year in ongoing positive economic impact on local communities.

Biofuels

Cellulosic ethanol, made from organic waste materials, crop residue, and nonfood plants is the next generation of smart biofuels. Existing usable Indiana crop and timber residues are sufficient to produce 770 million gallons of transportation fuels annually, equivalent to 28 percent of all the gasoline used in Indiana each year. An average corn farm could see potential gross revenue of $14,500 from harvesting corn stover.[33] Ten cellulosic plants, each with a 50-million-gallon capacity would create 1,940 long-term jobs, $207 million in annual economic activity, and $12.4 million in local property taxes.

Biopower

Electricity generation that combines solid biomass with coal at existing power plants would be a relatively low-cost way to ramp up renewable resource development across Indiana and cut back on coal consumption. Biopower is a renewable energy resource that can be stored and converted into electricity whenever it is needed. Farms across most of Indiana are close enough to an existing coal-fired plant to supply biomass feedstock. If 10 percent of Indiana's coal-fired power capacity were replaced with biopower plants, more than 3,600 new long-term jobs would be created to produce and harvest the biomass fuel.[34]

Biogas

Methane from decomposing manure is a powerful greenhouse gas with 21 times the global warming potential of carbon dioxide. But burning methane curbs its harmful effect on the environment and creates valuable energy with many ancillary benefits. In addition to providing a potential source of revenue and energy for livestock operations, anaerobic digestion systems (biogas) create high-quality fertilizer and other byproducts while reducing odors, water pollution, and emissions. Biogas production is currently feasible at 234 Indiana large-scale swine operations in 34 counties, and potentially at livestock operations in 67 counties as technology improves.

Other Renewables

- **Solar:** Although solar power remains a relatively expensive renewable energy source, the cost of photovoltaic installations continues to drop. Farms have great potential for using solar energy applications such as water and space heating, grain drying, greenhouse heating, and small-scale electricity production.
- **Geothermal:** Geothermal systems circulate fluid through pipes in the constant-temperature stratum a few feet underground and then through the building. Geothermal technology is especially suitable for rural areas where buildings are not densely situated and digging and installation may be less expensive.
- **Aquatic Biomass:** Aquatic plants can thrive in many areas of Indiana and have far higher productivity than soil-based crops. These water crops have the potential to be cultivated as biomass feedstocks for electrical generation and transportation fuels.
- **Soil Carbon Sequestration:** By employing no-till or low-till farming methods, one acre of cornfield may be able to absorb and retain half a ton of carbon dioxide that would otherwise be released using conventional tilling methods. Measurable and verifiable long-term soil carbon sequestration may generate tradable carbon credits that could be monetized under some carbon reduction strategies. Future innovations that enhance farm-level carbon sequestration may provide new opportunities for generating these carbon "offset" credits.

Policy Recommendations to Cultivate Clean Energy in Indiana and across America

Indiana farmers are in a unique position to reap gains from the transition to a low-carbon economy. The American Clean Energy and Security Act (ACESA, H.R. 2454) passed by the House, and bills coming up for a vote in the Senate, provide significant benefits for farmers, including incentives to cut costs and raise new income by increasing energy efficiency and selling renewable energy. In addition, farmers would earn new income by selling high-quality emissions offsets.

The elements of ACESA that will benefit the rural and agricultural economy in Indiana include:

- Renewable energy standards
- Economy-wide "cap-and-trade" with strong targets for reducing global warming pollution
- Incentives for renewable energy technologies and efficiency measures

In addition to the full passage of ACESA, NRDC continues to advocate for the following policies to make clean energy supply and energy efficiency twin engines of strong and stable economic growth:

- Mandated reduction of greenhouse gas emissions through a "cap-and-invest" system. Federal legislation would set a limit (or cap) on the amount of CO_2 emitted in the United States. Emission allowances could be auctioned, with a portion of the proceeds dedicated to funding incentives to invest in cost-effective energy efficiency.
- Greatly improved vehicle emissions standards
- A low-carbon fuels standard
- Transportation planning standards targeted at reducing total vehicle miles traveled by integrating public transit, land use, road congestion relief, and housing strategies
- Expanded support for renewable energy research and development
- Enhanced incentives for deployment of clean energy and energy efficiency technology
- Consistent and fair net metering and national interconnection standards for utility customer-generated renewable electricity
- A complete accounting of emissions from the production and use of bioenergy and biofuels, and assurance that their use does not result in emissions increases outside of the energy system

CHAPTER 1

Indiana's Wind Power Potential

Like other renewable energy sources, wind supply is inexhaustible, produces no waste, causes no pollution, and its costs are subject to neither market nor geopolitical volatility. Improvements in wind technology have brought its long-term costs down to a level that is becoming competitive with fossil-fueled energy generation.[1] Whereas just 1 percent of total U.S. electricity supply comes from wind today, a report by the U.S. Department of Energy (DOE) concluded that 20 percent of America's electric power could be wind generated within about 20 years if the right set of policies is pursued.[2]

Compared with coal, gas, and oil, wind is a benign source of power with little negative effect on the local environment. While noise from wind turbines was a problem with early designs, today's wind turbines at 300 meters away are "no noisier than the reading room of a library."[3] Modern wind turbines turn relatively slowly, although occasional bird and bat collisions occur. A recent study showed that the bird mortality rate for existing wind turbines is only about two bird deaths per turbine each year, which is a miniscule number when compared with other human sources of avian hazards (e.g., power lines, cell towers, and reflective glass on buildings).[4]

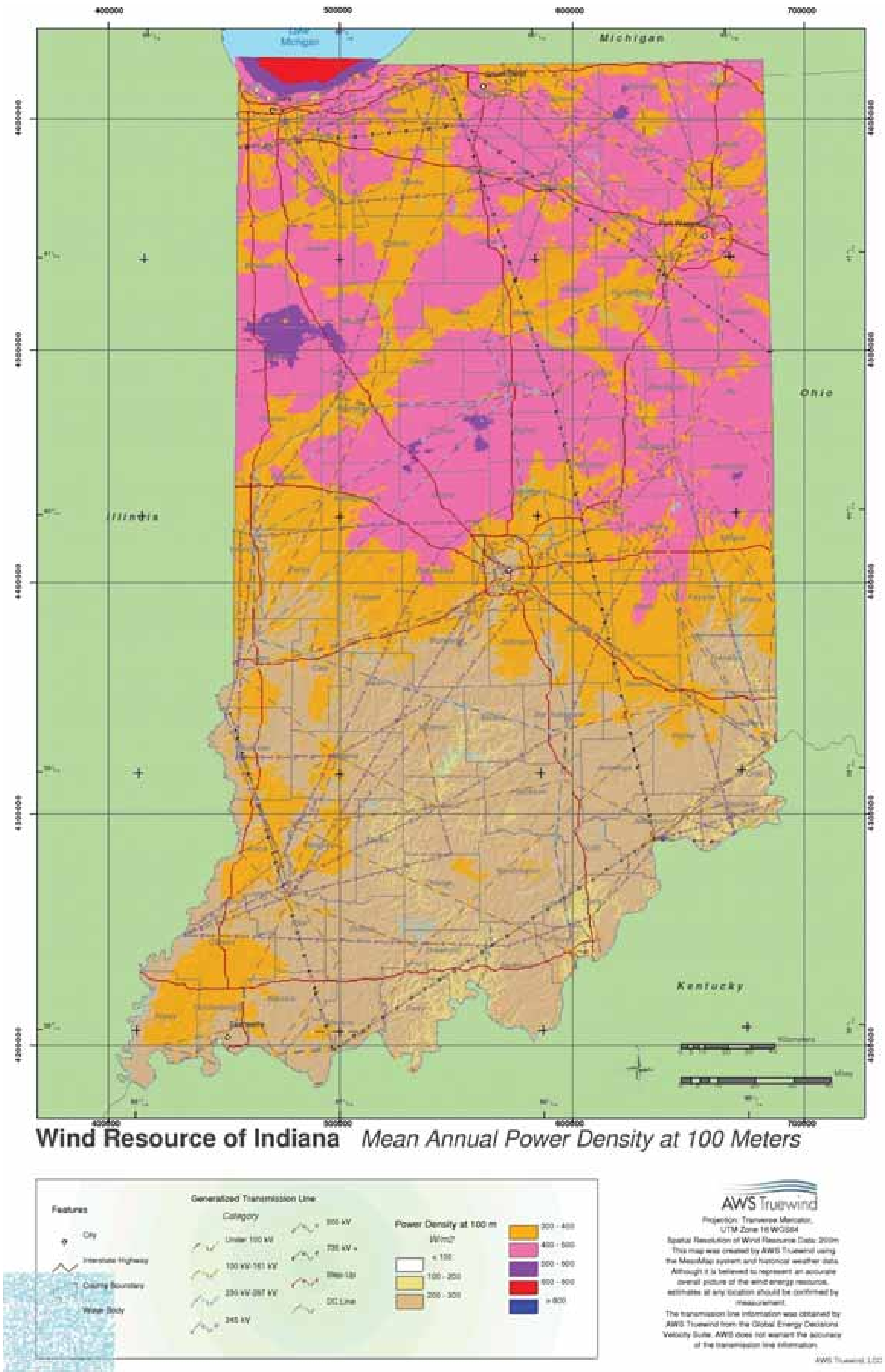
Despite concerns that wind development would reduce the values of surrounding property, a detailed study by the Renewable Energy Policy Project (REPP) has found the opposite effect, with wind development positively influencing property values.[5] The presence of wind facilities may actually help maintain the value of nearby farms by demonstrating the viability of—and potential income for neighborhood property owners from—additional local wind development.

Wind power continues to be the fastest growing energy resource in the United States, with a total installed capacity of more than 25,000 MW, enough electricity to supply the needs of 7 million households.[6] The opening of the Fowler Ridge wind facility in Benton County gave Indiana the biggest jump in wind power of all states last year. But with 530 MW of existing capacity, Indiana ranks 14th in wind development and has just begun to tap into its substantial wind resources.[7] Even with its new wind farms operational, Indiana will only derive 1 percent of its electricity from wind power,[8] as compared to 7 percent in Iowa and Minnesota.[9]

When wind power first began to be commercially developed in the 1980s, Indiana was thought to have insufficient wind to be a leader in commercial wind development. But recent advances in wind power technology have doubled the height of turbines and the efficiency of production, greatly raising Indiana's future wind potential.

The following map, produced by the Department of Energy's National Renewable Energy Laboratory (NREL), illustrates Indiana's wind potential at 100 meters and shows that much of the northern half of the state has significant commercially viable wind. Wind density, a measure of how hard and steady the wind blows in a given area, is the standard used to assess the quality of wind for electricity production. Wind density is classified on a scale from 1 to 7, with class 3 and higher of sufficient quality for wind power. The pink areas on the map have average wind speeds of above 7.5 meters per second at 100 meters. The strongest Indiana wind is in the purple area in parts of Benton, Clinton, Newton, Jasper, White, and LaGrange counties.

Figure 1: Mean Wind Power Density of Indiana at 100 Meters



The 44 Indiana counties with commercially viable wind density are listed below, along with their estimated land area. These areas total more than 11,000 square miles, almost one-third of the state.

Table 1: Indiana Counties with Significant Areas of Commercial-Grade Wind Density

County	Estimated Wind Dense Area (sq miles)	County	Estimated Wind Dense Area (sq miles)
Adams	275	LaGrange	300
Allen	350	Lake	300
Benton	400	Madison	300
Blackford	125	Marshall	300
Boone	400	Miami	150
Carroll	275	Montgomery	300
Cass	275	Newton	275
Clinton	400	Noble	375
DeKalb	200	Porter	175
Delaware	325	Pulaski	200
Elkhart	300	Randolph	450
Fayette	30	Rush	75
Fulton	300	St. Joseph	250
Grant	350	Steuben	275
Hamilton	150	Tippecanoe	300
Hendricks	150	Tipton	250
Henry	275	Wabash	150
Huntington	175	Warren	200
Jasper	350	Wayne	75
Jay	350	Wells	350
Kosciusko	425	White	400
La Porte	300	Whitley	200

Wind Power Can Be an Economic Boon to Indiana

Development of just a small fraction of Indiana's wind power potential would create enormous local economic benefits. The U.S. Department of Energy (DOE) has developed a "Jobs and Economic Development Impact" model (JEDI) to estimate the local economic impact of different types of energy projects. This tool calculates the direct and indirect ripple effects on overall economic activity resulting from the construction and operation of wind facilities, using state-specific data. Table 2, excerpted from JEDI, details the predicted economic impact of a 150 MW Indiana wind facility.

Even with its new wind farms operational, Indiana will only derive 1 percent of its electricity from wind power, as compared to 7 percent in Iowa and Minnesota.

According to this DOE analysis, a 150 MW wind project in Indiana would produce 75 jobs and $86.2 million in local economic activity during its construction phase. Operating the plant would generate 42 full-time-equivalent local jobs, $2,369,700 in property taxes, and $6.7 million in economic benefit to the local economy each year. If 30 such wind facilities were built in Indiana (an achievable goal of 4,500 MW of wind power, about 17 percent of total installed generating capacity of 27,021 MW) the result would be not only tens of thousands of construction jobs but also 1,260 permanent jobs, $71 million in annual property tax revenue, and $201 million per year in ongoing positive economic impact on local communities.

Table 2: Predicted Economic Impact of a 150-MW Indiana Wind Facility

Wind Farm—Project Data Summary Based On Model Default Values	
Project Location	INDIANA
Year of Construction	2010
Total Project Size - Nameplate Capacity (MW)	150
Number of Projects (included in total)	1
Turbine Size (kW)	1500
Number of Turbines	100
Installed Project Cost ($/kW)	$2,032
Annual Direct Operations and Management Cost ($/kW)	$19.83
Money Value (Dollar Year)	2010
Installed Project Cost	$304,731,313
Local Spending	$53,845,200
Total Annual Operational Expenses	$51,625,696
Direct Operating and Maintenance Costs	$2,974,407
Local Spending	$972,702
Other Annual Costs	$48,651,290
Local Spending	$2,819,700
Debt and Equity Payments	$0
Property Taxes	$2,369,700
Land Lease	$450,000

Local Economic Impacts - Summary Results			
	Jobs	**Earnings**	**Output**
During Construction Period			
Project Development and Onsite Labor Impacts	89	$5.31	$6.40
Construction and Interconnection Labor	78	$4.70	
Construction-Related Services	11	$0.60	
Turbine and Supply Chain Impacts	492	$18.16	$59.75
Induced Impacts	195	$6.18	$20.03
Total Impacts	**775**	**$29.64**	**$86.17**
During Operating Years (Annual)			
Onsite Labor Impacts	9	$0.55	$0.55
Local Revenue and Supply Chain Impacts	13	$0.47	$4.00
Induced Impacts	21	$0.66	$2.15
Total Impacts	**42**	**$1.68**	**$6.69**

NOTE: Notes: Earnings and output values are millions of dollars in year-2010 dollars. Construction and operating jobs are full-time equivalent for a period of one year (1 FTE = 2,080 hours). Wind farm workers include field technicians, administration, and management. Economic impacts "During operating years" represent impacts that occur from wind farm operations/expenditures.The analysis does not include impacts associated with spending of wind farm "profits" and assumes no tax abatement unless noted. Totals may not add up due to independent rounding. Results are based on model default values.

Wind Power Creates Opportunities for Farmers and Communities

The average size of an Indiana farm is 242 acres.[10] More than 21,000 farms are larger than 100 acres, and 7,400 are larger than 500 acres. A typical wind project would involve dozens or even hundreds of turbines erected at a group of adjacent farms. Large turbines are typically from 1 to 2 MW in capacity.[11] There are many factors determining how many wind turbines can be built in a particular location, but the rule of thumb is about 1 MW per 50 acres. The wind towers and the roads to get to them have a footprint of only about one-half acre per turbine—the rest of the land can be farmed—but the towers need to be spaced apart to take maximum advantage of the wind and avoid interfering with each other. A 500-acre farm could therefore have five or six wind turbines totaling about 10 MW and receive $30,000 in guaranteed annual income from land-lease payments, without significantly reducing its crop production.[12] A 150 MW wind project would have 70 to 100 turbines spread across the equivalent of more than a dozen typical Indiana farms.

Under the most common model for wind power development, a private project developer raises the capital, contracts for construction, leases the necessary land from farmers, and owns and operates the facility. A promising option with potential to provide far greater local benefits than wind development by distant third parties is known as "community wind." Several states, led by Minnesota, have successfully implemented policies to promote ownership of wind facilities by individual farmers, groups of adjacent farms, and local communities. They've shown that facilities with a small number of turbines—or sometimes even just one—can produce power cost effectively. A study at Lawrence Berkeley National Laboratory found that wind project development costs in 2007 did "not show strong evidence of economies of scale."[13] And smaller-scale projects producing power for local consumption don't need direct connections to interstate transmission lines.

Financing any size wind facility remains a significant hurdle, particularly under current economic conditions. The 2009 federal economic stimulus package contains new support for renewable energy projects, including the option of upfront financial grants instead of long-term tax credits, making it easier to finance smaller facilities. The General Accounting Office (GAO) has reported that farmers could "double or triple" their wind power income through ownership rather than land-lease arrangements.[14]

The emergence of a large, domestic wind power industry would be a boon to the economy of many parts of rural Indiana, and it would also mean a huge new market for manufacturers of the components that go into wind turbines, towers, and other renewable facilities. The Renewable Energy Policy Project (REPP) recently completed a detailed state-by-state study of the potential for existing companies to supply parts for renewable energy facilities.[15] REPP identified 1,321 firms in Indiana with the capability to manufacture components of renewable power plants, ranking the state seventh among all states in the amount of manufacturing activity that could be created by burgeoning demand for renewable energy.[16]

Indiana's Location Provides a Competitive Advantage

Although Indiana does not have the strongest winds in the Midwest region, its central location gives it a distinct advantage for wind development due to its close proximity to urban centers and areas of high electricity demand. Like any other large power plants, wind farms must be connected to the electricity transmission grid to be able to send power where it is needed. Because wind development is usually in remote locations, new transmission lines often must be built, but Indiana can avoid many of these infrastructure costs and hurdles. With some of the best accessible wind resources in the eastern third of the United States, Indiana is positioned to become a major supplier of wind power production and wind turbine manufacturing.

CHAPTER 2

Indiana's Biomass Potential: Biofuels, Biopower, and Biogas

The term "biomass energy" refers to a wide range of fuels derived from crops, wood, and waste. The energy in plants starts out as solar energy, which is absorbed through photosynthesis and can later be converted to other forms of energy, either by burning it as a solid, fermenting it into a liquid, or decomposing it into gases. In solid dry form, energy crops and crop residues can be used to replace coal and natural gas as fuel for "biopower" electricity. Biochemical and thermal processes are employed to turn biomass into liquids such as ethanol and biodiesel, known as "biofuels," which can replace or be blended with gasoline and diesel fuel for cars and trucks. "Biogas" produced from animal waste and other organic waste materials can be used to generate heat and electricity.

Biomass has recently surpassed hydropower as the largest source of renewable energy in the U.S., but still accounts for just 3% of all domestic energy consumption. Using biomass energy can result in far less global warming pollution than fossil fuels, if the release of carbon dioxide when plants are grown and converted into energy is balanced by the absorption of carbon dioxide from the air when new plants grow. To fully understand the carbon balance of different biomass resources, we have to thoroughly account for direct impacts to the soil, the energy and emissions involved in cultivation, as well as indirect land use impacts. Some sources of biomass are actually carbon sinks over time, while others can actually end up releasing more carbon than fossil fuels. Equally important to achieving a positive environmental outcome is ensuring that biomass resources are managed and produced sustainably. This requires an assessment of, and the adoption of practices to avoid, direct impacts to resources such as soil, water and wildlife habitat, as well as indirect land use impacts.

The emergence of a vibrant new biomass energy industry would open big, new markets for Indiana farm products, with even greater potential for rural economic development than wind power, because energy crops are already grown throughout Indiana.

A National Strategy Is Needed to Address Biopower's Chicken and Egg Dilemma

Why are dedicated energy crops being cultivated in Europe and Asia and not the U.S.? The answer lies in our failure to adopt a national energy strategy. If Indiana farmers were confident of a long-term market for energy crops, they would invest in planting it. If American farm equipment manufacturers were confident of a market for new machinery to process energy crops, they would invest in producing it. And if power generators were confident of ample feedstock supply and long-term energy sales opportunities, they would build facilities to generate biopower. But without a set of national policies designed to move America toward a clean energy economy, nobody in the supply chain – and certainly not the banks and investors that are needed to underwrite it -- will take the necessary first step toward creating a viable biopower market.

The clean energy market is replete with similar "chicken or egg" dilemmas that can be effectively and immediately addressed only through federal policies that assure both long-term supply and demand for renewable energy.

Sustainably Produced Biofuels Can Reap Economic and Environmental Benefits

National policies to support growth of a sustainable biomass energy industry would open big new markets for Indiana agricultural products. According to studies by the National Research Council and the Union of Concerned Scientists, the U.S. can produce between 370 and 550 million tons of biomass for energy use by 2020 from sustainably sourced lands and feedstocks.[1] Such resources would provide real climate benefits and be protective of wildlife and soil and water quality, but the market will only move away from conventional food-based bioenergy to these low carbon sources if our policies account for the carbon correctly.

Indiana has five facilities making corn ethanol, with capacity to make 470 million gallons per year, or about 5 percent of the 9 billion gallons produced nationwide.[2] Four plants have been built in Indiana to make biodiesel fuel (largely from soybeans), with a total annual capacity of 105 million gallons, or about 4 percent of the national capacity of 2.69 billion gallons.[3,4] However, producing ethanol and biodiesel exclusively from crops like corn and soy can drive up food prices (as well as ethanol and biodiesel prices) and cause undesirable land use changes. That's why new technology is being developed to make biodiesel from algae oils and ethanol from crop residues and nonfood plants—keeping in mind that even this new generation of biofuels resources must be managed in a way that protects soil fertility, water quality, and wildlife habitat.

Instead of using edible plant sugars and starches, the new type of ethanol is made by breaking down the fibrous material that makes up the nonedible cellulose structure of plants. Cellulosic ethanol can be made from almost any kind of plant or wood waste, including corn stover, forest residue, mill waste, and high-density energy crops such as switchgrass and poplar. Cellulosic ethanol can produce more energy than corn ethanol—from four to ten times as much energy output relative to the amount of energy required to grow the crops and produce the fuel.[5] Cellulosic ethanol yields from dedicated biomass energy crops have also been shown to be greater than the 400 gallons per acre of corn achieved at the most efficient existing ethanol plants.[6]

Cellulosic Ethanol Is on the Verge of Commercialization

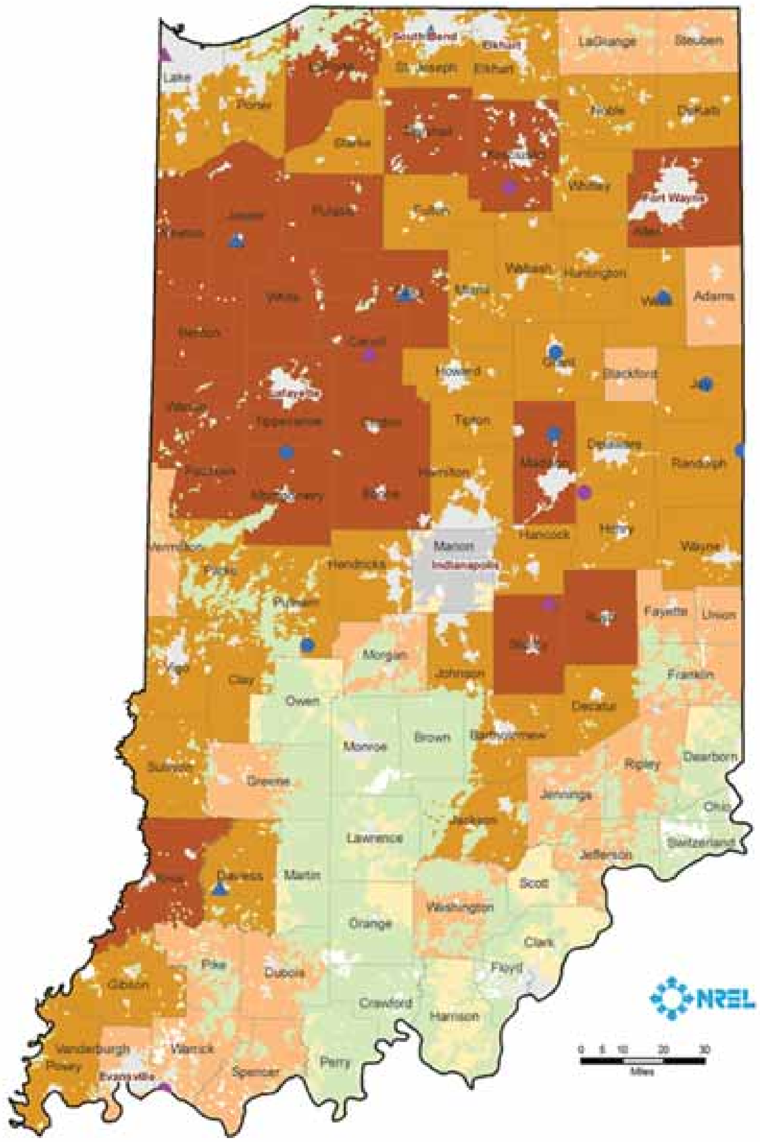
In 2008, the Lake County Solid Waste Management District in Merrillville, Indiana, authorized a private firm to build the nation's first facility capable of converting municipal solid waste into cellulosic ethanol. Although this project is temporarily on hold because of the current economic climate, the race is on to bring cellulosic ethanol production to commercial viability. More than 20 U.S. companies have invested in developing the specialized enzymes and processes needed to bring laboratory production to industrial scale and more than a dozen pilot plants are at different stages of design, construction, and operation.[7]

The Energy Independence and Security Act of 2007 contains a renewable fuel standard (RFS) mandating that at least 36 billion gallons of biofuels per year be blended into gasoline and diesel fuel by 2022, but it includes a cap on corn ethanol of 15 billion gallons. That means at least 21 billion gallons of "advanced biofuels" such as cellulosic ethanol and biodiesel must be produced annually 13 years from now, beginning with a goal of almost 1 billion gallons in 2010.

Whereas the initial target date may not be met, cellulosic ethanol and biodiesel are the fuels of the future, with potential to eventually replace a large portion of petroleum-based transportation fuels. A study by the U.S. Department of Agriculture (USDA) and the DOE found that more than 1.3 billion tons of cellulosic biomass could be sustainably collected and converted into liquid biofuels, eventually replacing one-third of U.S. gasoline consumption, without displacing any food crop acreage.[8]

The byproducts of cellulosic ethanol production include protein for animal feed and enough solid matter to power electricity generation to run the production plant, with some excess power and renewable energy credits left over to sell in the energy market.[9]

Figure 2: Map of Existing Residue Biomass in Indiana Counties



Biomass (Thousand Tons/year/county)	0	1–100	100–250	250–500	> 500
Crops and Crop Residues					
Forest and Primary Mill Residues					
Urban Wood and Secondary Mill Residues					

Facilities	Active	Under Construction
Ethanol Biorefinery	▲	●
Biodiesel Production Facility	▲	●

States
Counties
Urban Areas

NOTE: The map is color-coded: dark brown are counties with potential to produce more than 500,000 tons of crop-based biomass annually, medium brown = 250–500,000 tons, light brown = 100–250; dark green = 100–250,000 tons of forest and primary mill residue, lighter green = less than 100,000 tons; gray areas can produce 100–500,000 tons of urban wood residues. Only the uncolored areas on the map lack significant biomass potential.

Indiana Already Has Feedstock for Biomass Energy

Indiana is ranked fifth in the United States in productivity growth in the agricultural sector since 1960.[10] Now the nation's ninth-largest agricultural producer, it is perfectly situated to become a center of biomass energy production.[11] And the initial feedstocks needed to launch the biomass industry in Indiana are literally lying on the ground. Indiana farms annually harvest:

- 5.6 million acres of corn, producing more than 23 million dry tons of stover
- 5.5 million acres of soybeans, producing more than 7.4 million dry tons of residue
- 431,000 acres of winter wheat, producing 1.4 million dry tons of wheat stalks[12]
- 1.4 million tons of timber harvest residues per year[13,14]

Of course, not all the crop residues can be harvested and a portion must be left in the field to prevent soil erosion and maintain soil productivity.[15] But the potential biomass feedstock in Indiana, including just one-third of the residue from existing crops, amounts to 11 million dry tons each year—without including any new production of energy crops.

What can be done with 11 million tons of biomass? If all were devoted to producing cellulosic ethanol, that's enough feedstock to produce 770 million gallons of "grassoline," equivalent to 28 percent of all the gasoline used in Indiana each year[16,17] Burned in power plants, that's enough biomass energy to generate almost 28 million MWh of electricity, or the equivalent of more than 20 percent of Indiana's annual electricity production.[18] Replacing that much fossil fuel with clean renewable energy would reduce carbon dioxide emissions by more than 6.7 million tons, having the same effect as removing 1.4 million cars from Indiana roads.[19]

What would harvesting that crop residue as a biomass feedstock be worth to farmers? Current estimates for the future value of crop residue biomass at the "farmgate" is about $40-$50/ton, so the gross farm revenue to be derived from these waste materials could be about $440-$550 million.[20] For a corn grower, at a usable yield of at least 1.4 dry tons of stover per acre, this equates to about $14,500 in potential revenue for the average Indiana corn farm of 230 acres.[21] The average Indiana soybean farm of 250 acres, with a usable yield of about 0.5 tons of dry crop residue per acre, could see gross revenues of about $5,500.[22] Net income would be reduced by costs to harvest, handle, and store the material. A detailed study of labor and equipment by the Oak Ridge National Lab found the total costs of collecting, baling, and roadside stacking of straw to be about $20 per dry ton.[23] Another study cited by the DOE's National Renewable Energy Laboratory (NREL) found that a corn stover collection process in Iowa provided profit to farmers from $9 to $38 per acre, depending on the amount harvested and delivery distance.[24] Figure 2 on the left is a map created by NREL of crop residue biomass in Indiana, which also shows the location of existing corn ethanol and biodiesel production facilities.

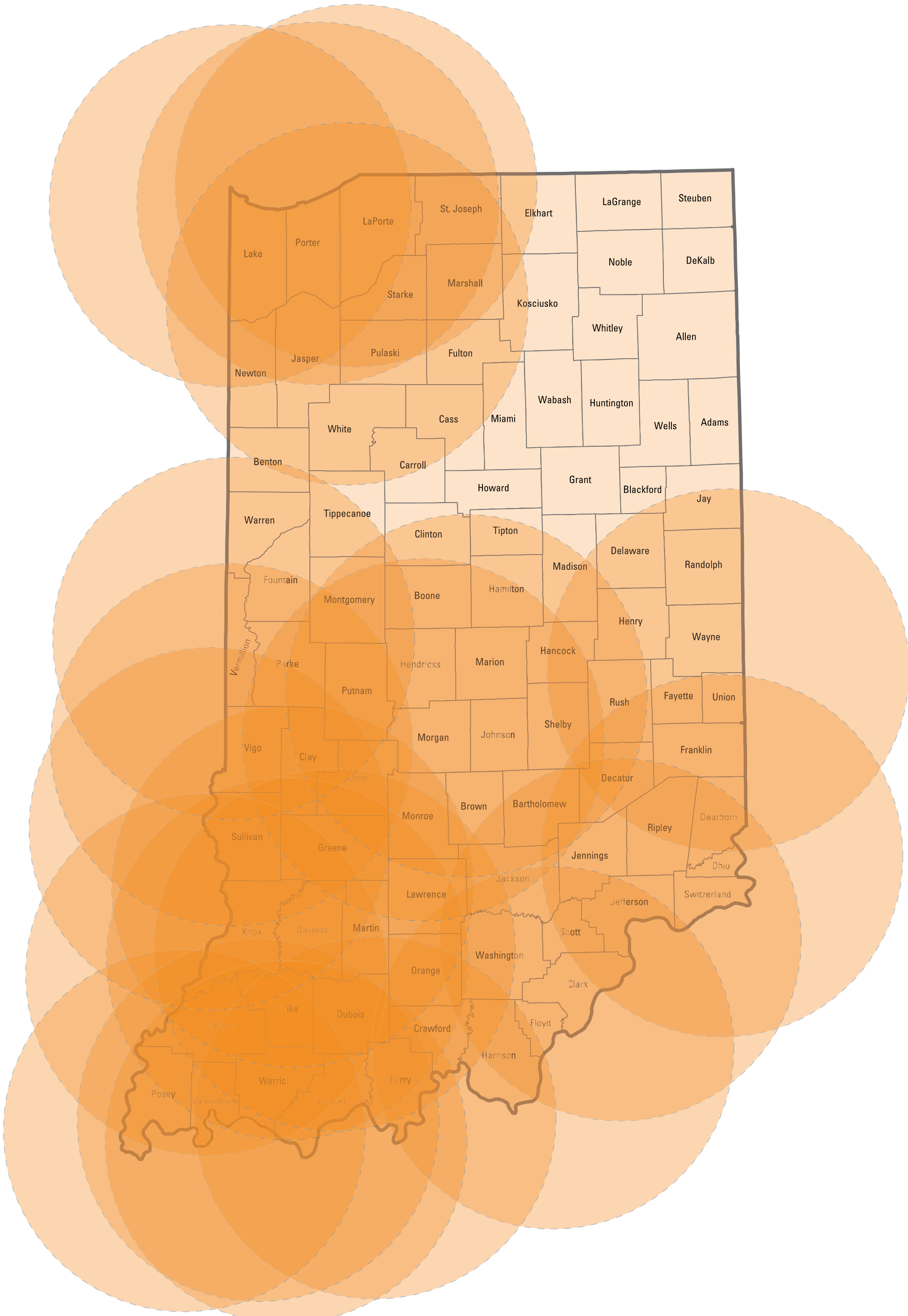
The potential for biomass production from Indiana crops is far larger if dedicated energy crops are included, but they will deliver environmental benefits only if they are produced sustainably—using practices, for example, that enhance soil fertility, maximize water efficiency, protect water quality, and ensure that native wildlife habitat is protected. Several promising efforts are currently underway to develop voluntary practice and performance-based sustainability standards for biomass production. These standards will provide guidance, tools, and certification for growers seeking access to new markets for sustainably grown biomass.

Biofuels Boost Rural Economic Development

Biofuels production could provide enormous benefits to rural communities in Indiana. This opportunity was recognized by the Indiana State Department of Agriculture when, in 2005, it named Reynolds, Indiana, "BioTown USA" and embarked on a long-term project to make this community of 500 people the first in the nation to meet all its energy needs by using local agricultural byproducts. While this ambitious goal of true energy independence hasn't yet been met, BioTown is beginning to demonstrate how an integrated approach to energy independence based on biomass technology can lead to both economic and environmental benefits.

The DOE's JEDI model (referenced earlier in the wind power section of this report) calculates that a 50-million-gallon-per-year biochemical cellulosic ethanol plant in Indiana would generate 332 full-time jobs for the duration of its three-year construction phase and $113 million in local economic activity. Operation of the plant would create 194 long-term jobs and a total of almost $21 million annually in direct and indirect economic impact, plus $1.24 million in annual property taxes. Ten cellulosic ethanol plants of that size would produce 1,940 jobs, $207 million in annual economic activity, and $12.4 million in total local property taxes.

Figure 3: Map of Potential Biomass Resources for Co-firing Using Existing Indiana Coal Plants



Biopower Works Around-the-Clock

The same energy crops that can be converted into ethanol-based transportation fuels can also be used for direct production of electricity when burned as fuel in biomass-fired power plants. Unlike wind and solar, biopower is a renewable energy resource that can be stored—a valuable option for energy suppliers who can use it to produce electricity whenever it's needed. According to a study at Purdue University, Indiana has sufficient biomass potential to supply 100 percent of the state's residential electricity use.[25]

The DOE reports that there are 120 biomass-fired power plants in the United States and 48 facilities that co-fire biomass with coal, nine of which are commercial power plants (and none of which are located in Indiana).[26] Biomass can be substituted for a portion of coal used in existing power plants without massive investment in new facilities, so it is a relatively low-cost way to ramp up renewable electricity generation in the near term. The city of Jasper, Indiana, is considering converting its small municipal coal-fired power plant to run on 100 percent biomass, at a cost of about $750 per kilowatt.[27] A study for the National Renewable Energy Lab found a median estimate of $200-$400 in capital costs per kilowatt of capacity to retrofit a coal plant to co-fire with biomass. The retrofit costs are a small fraction of the costs for a new coal or biomass plant, which are estimated at $2,550-$5,350/KW, depending on the technology employed.[28] Biomass can provide 15 percent of the total energy in a coal-fired boiler without any changes beyond adjusting the fuel intake system and modifying the burners.[29] Although building a new power plant that would burn any coal at all cannot be justified on economic or environmental grounds, in some locations it may be cost effective to build a separate 100 percent biomass boiler next to an existing coal-fired plant to feed steam into a common turbine.

Because biomass crops are heavy and bulky, transporting them across long distances is not economical, so the crops should be grown close to the biopower plants. Indiana is the second-biggest coal-burning state and has 21 existing large, coal-fired generating stations, each with a median size of about 650 MW.[30,31] Figure 2 on the left is an Indiana county map showing each coal plant with a 50-mile-radius circle drawn around it to highlight the areas that could conveniently provide feedstock if the coal plants were converted to co-fire with part biomass.[32]

Harvesting Biomass Can Cultivate Jobs

If 10 percent of Indiana's existing coal used to generate electricity were replaced by biomass, it would create annual demand for 12.6 million tons of energy crops and residues.[33]

There are multiple ways to project the employment effects of building and operating new biopower plants. A report commissioned by the National Renewable Energy Lab estimates that each megawatt of biopower capacity creates almost five jobs, with roughly two out of five being direct production jobs.[34] Developers of a 50 MW biomass plant in Florida project two and one-half permanent jobs per megawatt.[35] A similar facility in Texas expects three jobs per megawatt.[36] Assuming two new jobs per megawatt of biopower capacity, if 10 percent of Indiana's coal-fired power plants were replaced with biopower, more than 3,600 net new long-term jobs would be created, not including new agricultural jobs to produce and harvest the biomass feedstock.[37]

Dedicated Energy Crops Could Fire Up Bioenergy Output

The energy content of biomass varies, but it takes about 400-700 acres of dedicated biomass crops to fuel one megawatt of electric generating capacity for a year, producing enough electricity to power about 600-900 homes.[38] Although a significant amount of land would be needed for substantial electricity production from dedicated energy crops, Indiana, the smallest state west of the Appalachians, covers 23 million acres. Cultivating energy crops on a very small portion of it would be sufficient for extensive biopower production. For example, energy crops grown on the 280,000 acres of Conservation Reserve Program land that Indiana landowners are paid not to farm—about 1 percent of the state—could produce 400 to 700 MW of year-round biopower, an electricity output equal to a large coal-fired plant.[39]

Biogas

When animal manure or other organic matter decomposes in the absence of oxygen, it produces a gas containing 60–70 percent methane. If released into the atmosphere, methane is a powerful greenhouse gas, with 21 times the global warming effect of carbon dioxide. But burning methane curbs its harmful effect on the climate and releases large amounts of useful energy. Methane is a relatively clean fuel that is the main component of the natural gas and liquefied petroleum gas used to heat homes and to fuel electricity generation. By capturing methane, 480 landfills across the country turn decomposing garbage into a valuable energy source.[40] For decades, some large dairy and swine operations have been managing their immense amounts of manure by processing it using anaerobic digesters to produce and store biogas, which is then used to power generators and for thermal energy.

Several anaerobic digester technologies are in use, the most common of which is a heated plug flow tank system. Also in use are covered manure lagoons—from which biogas is piped to a generator and complete-mix systems, which are primarily used for dairy operations. Some systems are capable of co-digestion, which allows other types of organic wastes to be processed along with manure.

Whatever technology is employed, a biodigester system is a waste management solution with many benefits, including:

- Energy production (electricity and heat)
- Substantially reduced odor from animal facilities
- Reduced potential for groundwater and surface water contamination
- Production of high-quality fertilizer and other byproducts

If curbing greenhouse gas emissions becomes national policy, production of biogas can become a good farm business opportunity as well, with multiple potential revenue streams:

- **Sale of energy to local utility companies:** Indiana is among 42 states with a net metering statute that allows small-scale renewable electricity generators to connect to the grid, and requires utility companies to buy their electricity output at the retail utility price, up to the amount of usage by the customer. In effect, production of renewable power makes the customer's electric meter run backwards to reduce the net monthly electricity bill. However, Indiana presently limits eligibility for net metering to small-scale wind, solar, and hydropower installations. Because most other states allow for larger systems to net meter and have rules that are more supportive of a wider range of renewable energy, Indiana received a "D" on the 2008 national net metering report card issued by the Network for New Energy Choices.[41,42] New federal laws could enhance and standardize net metering policies to ensure the eligibility of biogas and to more effectively promote on-site clean power production.
- **Sale of renewable energy credits (RECs):** Each MWh of renewable electricity is given an REC, (sometimes called a "green tag") which is proof of its clean origin. These RECs can be bought and sold in trading markets. The buyers include utilities that are required to buy green power, plus corporations and individuals who do so voluntarily to support renewable energy development. National clean energy policy directives would add to the long-term value of RECs and stimulate biogas production.
- **Sale of carbon offset credits:** Under certain carbon reduction plans, such as the pending American Clean Energy And Security Act of 2009 (ACESA, H.R. 2454) or the Northeast Regional Greenhouse Gas Initiative (RGGI), when a project verifiably reduces greenhouse gas emissions or removes carbon from the atmosphere, each ton of reduction generates a carbon credit that can be used to offset emissions elsewhere. A carbon offset program must include strict measurement and verification standards to ensure that any tons of direct emissions reduced and/or carbon sequestered are demonstrably over and above what would have happened under business as usual. In 2015 at a carbon price of $15 per ton, the EPA estimates that roughly 310 million tons of offsets can be available from agricultural, landfill gas, and forestry-related projects in the United States. In Indiana, that translates into a carbon offset potential of 4.8 million tons and revenue of $30 million in 2015, growing to 6.4 million tons and revenue potential of $73 million in 2030.[43]
- **Sale of fertilizer:** The value of digested solids may be even greater than the value of electricity produced by an anaerobic biodigester system. The chemical process of biodigestion converts the organic nitrogen in manure into ammonium, the primary component of commercial fertilizer. Biodigesters create high-quality, organic fertilizer that is biologically stable and largely sterilized, with far fewer pathogens and weed seeds, and less likelihood of water pollution than standard chemical fertilizers.
- **Sale of animal processed fiber (APF):** Some biodigester residues contain reclaimable fiber that can be used for horticulture products and building materials such as fiberboard and plant containers.[44]

Sizable biodigesters and related equipment require an investment of $300,000 to $900,000 or more, with many site-specific cost variables.[45] Although some support in the form of state and federal grants and tax credits is available, the technology is presently used in only approximately 135 large-scale concentrated animal feeding operations (CAFOs) in the United States (compared to about 3,000 farm-scale biodigesters operating in Europe).[46] The joint U.S. EPA, DOE, and USDA AgSTAR program estimates that there are 7,000 dairy and swine operations in the United States that are good candidates for profitable biodigester systems, having more than 500 head of dairy cows or 2,000 swine.[47]

Indiana is among the top five U.S. hog-producing states, with 491 swine operations of more than 2,000 head, including 171 with more than 5,000 head.[48] Some of these may not be ideal for biodigester technology because of the design of their manure systems, but AgSTAR reports that 234 operations are feasible sites. These swine operations are capable of producing 2.2 billion cubic feet of methane each year and generating 145,000 MWh of electricity.[49] At 7.29 cents/KWh (the average commercial retail electricity rate in Indiana), that would be more than $10 million worth of homegrown power each year (assuming net metering treatment).[50] Adding additional future revenue of 2-4 cents/KWh would be the value of renewable energy credits and the potential value of carbon emission credits for burning 28,000 tons of methane, if federal policies to limit greenhouse gas emissions are enacted.[51]

Indiana also has 37 farms with more than 500 dairy cows each (including 8 farms with more than 2,500 cows) that would be ideal candidates for methane production.[52] In addition, smaller operations could profit from biogas because centralized systems can allow nearby dairy farms, such as some of the 78 Indiana dairies with 200-500 cows, to (literally) pool their manure resources and create scale economies, as is presently done at several locations in other states.

Indiana has 36 large poultry farms with inventories averaging more than 600,000 layers, 23 farms with average sales of more than 1.1 million broiler chickens annually, and 23 farms with average production of more than 200,000 turkeys.[53,54] Some of these operations may have potential for cost-effective biogas recovery systems, particularly as improved technology reduces biodigester costs and the combination of policies promoting renewables and new carbon emission standards increase potential revenue. Another innovative energy production technology is the direct use of poultry litter as power plant fuel. The first such plant in the United States is operating in Minnesota, using turkey litter from 300 area farms to generate 55 MW of electricity, enough to power about 40,000 homes.[55] While poultry litter is a good organic fertilizer, a report by the USDA has concluded that using manure for energy won't adversely affect fertilizer supplies.[56]

Indiana has hardly begun to take advantage of its farm bioenergy potential, and currently has just six anaerobic biodigesters in operation at large dairy farms in Jasper County. But with the right set of supportive government policies in place, the benefits of these technologies for Indiana's livestock operators and its environment could be realized within a few years.

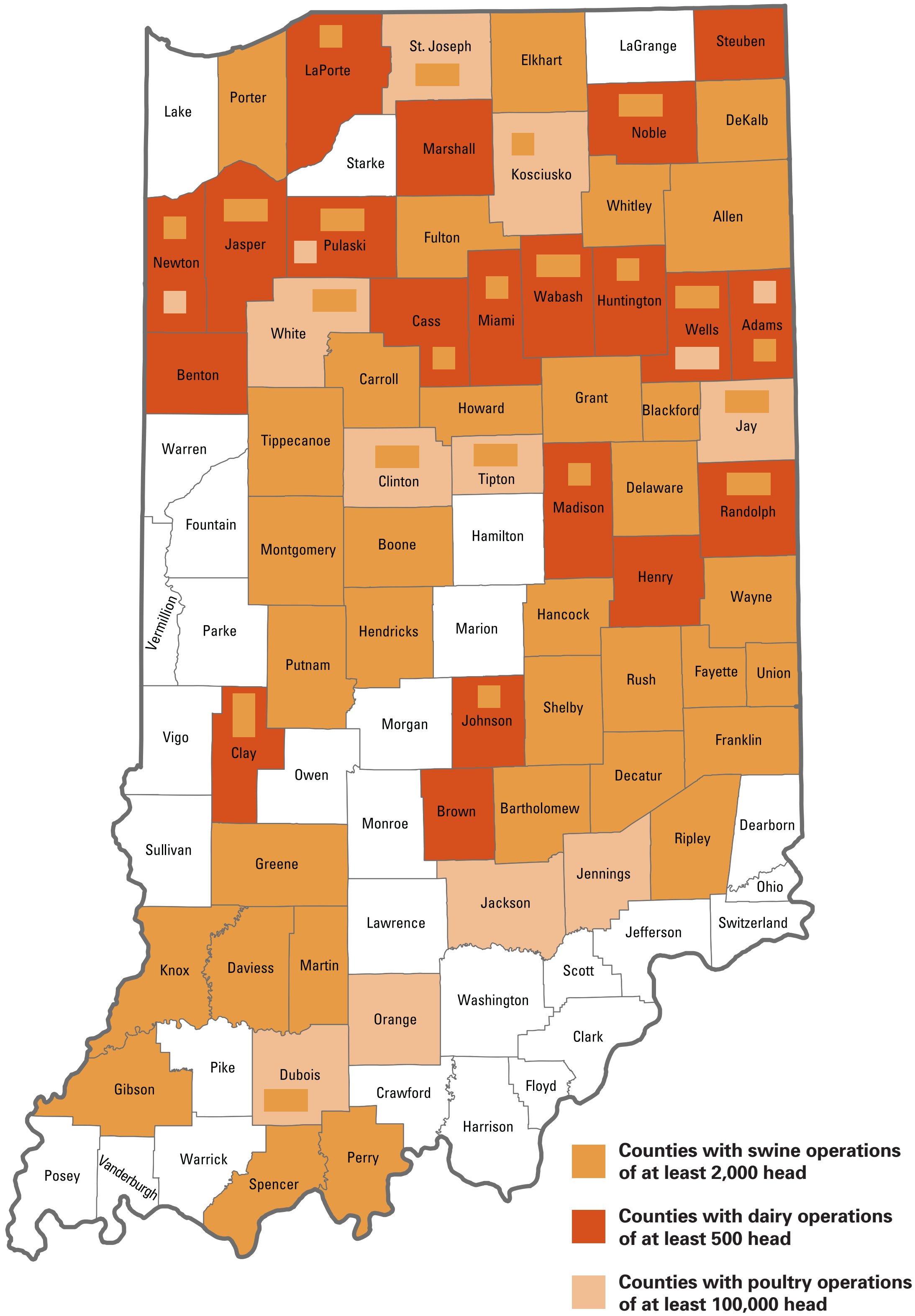
The map on page 14 (Figure 4) indicates 67 Indiana counties with livestock operations large enough to potentially benefit from farm bioenergy systems.

Wastewater Is Another Beneficial Feedstock Source for Biogas

Anaerobic decomposition of sludge at wastewater treatment plants is another potentially cost-effective source of biogas energy. Whereas the methane content is slightly less than gas from animal manure, the economics of using wastewater biogas for electricity production improve as fossil fuel energy costs rise, and are already cost competitive for wastewater facilities that employ anaerobic digestion as part of the treatment process.

For years, the only electricity-generating wastewater treatment plant in Indiana was in Jasper, where the overall costs are estimated at just 4 cents/KWh. The city of West Lafayette is beginning to operate a set of new equipment to generate both electricity and heat from biogas for its treatment plant.[57] Indiana has 113 facilities that treat a minimum of 1 million gallons of wastewater per day, and at least 28 Indiana cities have been identified as large enough to cost effectively produce biogas energy.[58]

Figure 4: Indiana Counties with Livestock Operations Able to Support Methane Biodigester Systems



CHAPTER 3

Further Renewable Energy Opportunities for Indiana

Advancements in renewable technology are expanding the range of cost-effective clean energy opportunities for Indiana. Solar power, geothermal, aquatic biomass, and soil carbon sequestration are some of the innovations with the potential to power a clean energy future for Indiana and the U.S.

Solar Potential

Solar electricity has always been relatively expensive, but its price is dropping rapidly. Compared to rigid polycrystalline photovoltaic panels, recently developed flexible "thin film" solar cells are far less expensive and can be put on the sides of buildings, on roof shingles, windows, etc. Although Indiana is not high in average solar energy density, a study by NREL demonstrates it has potential to produce significant amounts of electricity from rooftop solar arrays.[1] Farm-scale solar electricity production is eligible for sale to utilities under Indiana's net metering law (described earlier). Because of their high energy needs and location in open areas, farms have great potential for solar energy applications, such as water and space heating, grain drying, greenhouse heating, and small-scale electricity production.[2]

Geothermal Potential

Geothermal heat pump technology takes advantage of the constant underground temperature of about 55 degrees Fahrenheit. By circulating water through buried pipes, geothermal systems can cool a building in the summer and heat it in the winter, dramatically reducing utility bills. According to the EPA, geothermal systems are the most clean, cost-effective systems to maintain building temperatures and are well-suited for farms and rural areas where buildings are not densely situated and digging and installation are less expensive.

Aquatic Biomass Potential

Aquatic plants such as duckweed and algae are so prolific that they are major nuisances in some waterways. But they are also potential energy crops with a per acre productivity rate that is 10 times greater than soil-based energy crops like switchgrass. Southern Indiana has a climate suitable for aquatic biomass, which can be used to produce transportation and electricity fuels, plus a residue of animal feed. Many species of algae, a water-based crop that grows in many climates, can be converted into a variety of liquid and gas fuels.[3] More than 200 companies are researching algae biofuels and one has opened a pilot facility in Indianapolis to attempt to convert the algae oils into commercially viable biodiesel.[4] National policies to reduce atmospheric carbon dioxide could further assist in turning aquatic biomass into a commercially viable product.

Soil Carbon Sequestration Potential

Soil carbon sequestration is the process by which carbon dioxide is absorbed from the air and stored in the soil. Certain practices, such as no-till or low-till farming, can retain organic materials and carbon in the soil that would otherwise be released into the atmosphere using conventional plowing methods. For example, some studies suggest that cornfields can take in and retain about one-half ton of carbon dioxide per acre annually using no-till farming methods; this effect can also be enhanced by careful fertilizer use or reduced by overfertilization. Any assessment of soil carbon sequestration must be subject to site-specific review of soil capacity and farming practices, and rigorous measurement and verification standards to assure performance above and beyond what would have occurred under "business-as-usual" practices. Under a national carbon reduction strategy that includes emissions offsets, modifying farming methods to verifiably sequester carbon in soils could generate offset credits for farmers that could then be sold to industries with mandatory emissions reductions requirements. In that case, soil carbon sequestration could become a new source of revenue for Indiana farmers.

CHAPTER 4

Reaching the Clean Energy Future: Getting from Here to There

Indiana can be at the center of a new clean energy future for America if the right policies are put in place, starting with a national commitment to reduce emissions of global warming pollution, support energy efficiency, and advance development of homegrown renewable energy.

National Policies Needed to Realize Indiana's Clean Energy Potential

Although federal and state programs are playing a critical role in supporting the embryonic renewable energy industry, they are insufficient to the long-term task of transforming our energy economy, which requires a set of innovative energy policies in addition to substantial program funding.

The most promising comprehensive approach is a "cap-and-trade" framework, under which overall annual limits on global warming pollutants are set, and emitting companies must comply by either reducing their emissions or obtaining "emission allowances" or offsets. The price of allowances would be established in a competitive market, providing incentive for businesses to find the least costly ways to reduce emissions. Generating fossil-fueled power would require allowances while generating carbon-free energy would not, thus leveling the playing field for renewable energy, making it an attractive investment, and spurring innovation in clean energy technologies. The American Clean Energy and Security Act (ACES, H.R. 2454), passed by the House of Representatives in June 2009, proposes this kind of framework and includes strong targets: 17 percent reduction below 2005 levels by 2020; 42 percent reduction below 2005 levels by 2030; 83 percent reduction below 2005 levels by 2050. A cap-and-trade system was employed in the 1990s to reduce "acid rain" caused by power plants, and it led to so much innovation that compliance costs turned out to be 75 percent lower than initial projections.[1] If allowances are fully or partially auctioned under a federal program, part of the money generated could be used to invest in energy efficiency and renewable technologies, so that net costs to energy consumers are minimized.

A national renewable energy standard (RES) is another policy that would put consumers' energy dollars to work at home, creating jobs and building local communities. A mandate that all states derive 25 percent of their electricity from renewable resources by 2025 would save families and businesses $64 billion in lower energy costs and create almost 300,000 U.S. jobs, in addition to substantially reducing harmful emissions from power plants.[2] The hidden costs of fossil fuels from air pollution alone are $120 billion per year, according to a study by the National Academy of Sciences. That comes to $878 per U.S. household, not including the costs of global warming, damage to ecosystems, or the geopolitical costs of oil dependence.[3]

Our national energy strategy also needs to include a low-carbon fuels standard (LCFS) to gradually reduce the overall carbon level of the pool of transportation fuels, when measured on a full-fuel-cycle basis. As a performance standard, LCFS would work hand-in-hand with the emissions cap to ensure that vehicle fuels gradually shift to cleaner alternatives.

Solving the long-term energy crisis will take intensive focus on both the supply and the demand sides of the energy equation. A portfolio of demand-side policies is essential to reducing energy usage, including:

- New vehicle emissions requirements
- National appliance standards
- Energy-efficient building codes
- Expanded energy efficiency investment incentives, loans, and tax credits

Improved energy efficiency is the quickest and most cost-effective way to reduce consumption of fossil fuels. A national energy efficiency resource standard (EERS) requiring utility companies to phase in programs to save 15 percent of electricity and 10 percent of natural gas by 2020 would save $170 billion in lower energy bills and create more than 220,000 jobs. Such a commitment to energy efficiency would also eliminate the need to build 390 new power plants in the United States and avoid pollution emissions equivalent to 48 million automobiles.[4]

The small additional cost to make home appliances more energy efficient is far outweighed by the savings consumers achieve when using them. That's why strengthened national energy efficiency standards for home appliances are a critical part of a long-term energy strategy.[5] Similarly, a national energy-efficient building code for new construction would immediately begin to save occupants money on energy bills and help the environment, while reducing electricity demand and improving system reliability.

Any serious effort to reduce our dependence on fossil fuels also must include vastly increased support for renewable energy research, development, and deployment (RD&D), which continues to lag far behind government funding for fossil and nuclear power.[6] In their developing phases, the nuclear, coal, and oil industries received subsidies an order of magnitude larger than renewable technologies. A recent study by the Environmental Law Institute found that this disparity continues, with fossil fuels receiving 2.5 times more government support than renewable resources from 2002 through 2008.[7] Clean energy RD&D has fallen since the 70s and is now a small portion of overall government RD&D spending. In order to jump start clean energy development at this critical juncture, the level of clean energy RD&D must be increased dramatically.

Finally, as mentioned before, sustainable biomass energy must account for real climate and environmental benefits. For this to happen, three critical provisions should be included in the national-level clean energy and climate legislation now before the Senate:

1. Accurate accounting for biomass emissions from sources covered by the cap. Not all renewable biomass produces zero carbon energy and the current legislation lacks a way to differentiate low-carbon from high-carbon biomass.
2. Accurate accounting for emissions from land use change in the Renewable Fuels Standard. The 2007 RFS requires a science-based, full lifecycle analysis that includes the global ripple effect of increased biofuels production, also known as "indirect land use change." The latest scientific research confirms that whether biofuels create or reduce global warming pollution hinges on where and how the feedstocks are produced.
3. An appropriate definition of renewable biomass. Renewable biomass helps protect sensitive wildlife habitat and natural ecosystems, while making a wide diversity of feedstocks available for compliance with the renewable electricity and renewable fuels standards. Biomass sourcing guidelines should provide safeguards for native grasslands, sensitive wildlife habitat, old-growth, wilderness, and roadless areas, and other especially sensitive components of our federal lands. It should also include sustainability measures that protect wildlife habitat, soil productivity, and biodiversity in working forests and discourage the conversion of natural forests to less diverse, planted forests or energy crops. Loss of forests is one of the greatest threats to biodiversity worldwide and a huge contributor to global warming.[8]

No single deployment support mechanism is optimal for all stages of innovation. Investment tax credits, for example, can be effective in providing upfront capital incentives to expensive high-risk new technologies. Production tax credits are preferable for more mature technologies to ensure installed systems deliver the energy they promise. Net metering and interconnection rules enables simple access and price certainty for small, distributed installations. To date legislation under consideration by Congress aims to balance these needs to research, develop and deploy the innovations and technological breakthroughs required to meet the climate challenge, including significant funds for energy efficiency and renewable energy technologies and carbon-capture-and-sequestration (CCS) technology.

Prosperity, security, and a healthy planet can't be achieved in the long run without transforming the way we produce and use energy. The nascent transition from fossil fuels to renewable resources will neither be easy nor quick, but it presents an unprecedented set of opportunities for a state with the natural resources of Indiana.

Federal Programs and Funding for Clean Energy Development in Indiana

The federal government offers a number of programs to support renewable energy investors, developers, and property owners. The American Recovery and Reinvestment Act of 2009 (the $786 billion stimulus package) contains about $50 billion in energy program funding, including an extension of clean energy production tax credits, support for transmission infrastructure, "smart grid" investment, low-income housing weatherization, plug-in hybrid electric vehicles, carbon capture and sequestration technology development, state and local energy efficiency programs, and loan guarantees for renewable energy projects. Among the existing, new, or expanded programs are:

- USDA - Rural Energy for America Program (REAP) grants[9]
- USDA - Rural Energy for America Program (REAP) loan guarantees[10]
- Business Energy Investment Tax Credit (ITC)[11]
- Renewable Electricity Production Tax Credit (PTC)[12]
- Modified Accelerated Cost-Recovery System (MACRS)[13]
- U.S. Department of Treasury - renewable energy grants[14]
- Residential Renewable Energy Tax Credit[15]
- Clean Renewable Energy Bonds (CREBs) for municipalities[16]
- Farm Service Agency (FSA) Biomass Crop Assistance Program (BCAP), providing matching payments for collection, harvest, and storage of biomass[17]
- DOE loan guarantees for electric transmission infrastructure (section 1705)[18]
- USDA business and industry loan guarantees for economic growth in rural communities[19]

State-Level Policies Needed to Boost Indiana's Clean Energy Economy

- Expanded net metering: Indiana limits eligibility for net metering to small systems, but most other states allow for larger systems to net meter and have rules that are more supportive of a wider range of renewable energy.[20] New laws could improve net metering policies to ensure the eligibility of biogas and to more effectively promote on-site clean power production.
- Improved program assistance for farmers and business owners who are considering earning additional revenue through the sale of renewable energy credits (RECs) and/or carbon offsets under a new federal cap-and-invest program.
- A statewide renewable portfolio standard (RPS). Twenty-nine states now have statewide RPS laws (and three states have nonbinding RPS goals) requiring electric utilities to purchase an increasing percentage of their electricity supply from qualified renewable energy sources via the market-based mechanism of annualized tradable RECs.[21]

State-Level Programs and Funding for Clean Energy in Indiana

There are several existing clean energy programs in Indiana:

- Renewable energy property tax exemption[22]
- Alternative power and energy grant program[23]
- Utility-specific rebate and loan programs[24]

Endnotes

Executive Summary

1 http://data.bls.gov/PDQ/servlet/SurveyOutputServlet?series_id=LASST18000005&data_tool=XGtable

2 Based on a projected 35 percent average wind capacity factor; generators annually produce an amount of energy equal to their rated capacity x capacity factor x 8,760 (number of hours in a year).

3 2,095 pounds carbon/MWh of coal x 13.8M MWh ÷ 2,205 pounds/metric ton = 13,111,565 metric tons.

4 19.4 pounds carbon/gallon x 770 M gallons ÷ 2,205 pounds/metric ton = 6,774,603 metric tons.

5 2,095 pounds carbon/MWh of coal x 10.5M MWh ÷ 2,205 pounds/metric ton = 9,976,190 metric tons.

6 This does not include the reduction in carbon dioxide emissions from replacing other energy sources.

7 Energy efficiency savings estimates are based on ACEEE's "State Benefits from a Federal EERS," http://aceee.org/pubs/e091.pdf?CFID=3643806&CFTOKEN=11807860

8 Estimate based on EIA data showing coal costs of $3.4 billion, petroleum costs of $16.1 billion, and $4.9 billion of natural gas, using the estimated 2008 population of 6,376,792.

9 Calculation based on subtracting Indiana's annual fuel production of approximately 36 million tons of coal, 36 thousand therms of natural gas, 1.7 million barrels of oil, and 470 million gallons of ethanol (total value of about $2.1 billion) from its total fuel costs, including natural gas, coal, and petroleum blends.

10 Plus a tiny amount of oil and gas as detailed above; see http://tonto.eia.doe.gov/state/state_energy_profiles.cfm?sid=in

11 Thirty-six percent of the total coal used in Indiana for electricity production comes from Wyoming; 55 percent of the coal is from out of state, http://www.eia.doe.gov/cneaf/coal/page/coaldistrib/2007/d_07state.pdf

12 http://tonto.eia.doe.gov/state/state_energy_profiles.cfm?sid=in

13 http://www.eia.doe.gov/oiaf/aeo/electricity.html

14 A megawatt (MW) is a measure of electricity production equal to 1,000 kilowatts or 1,000,000 watts. Therefore, one megawatt is enough power for 10,000 lightbulbs of 100 watts each. A megawatt-hour (MWh) is the amount of power that would be consumed by those bulbs if they were all left on for one hour.

15 Based on 27,021 MW of existing capacity and a 1 percent annual demand increase, as forecast by the EIA; the additional capacity estimate does not count any replacement of existing power plants.

16 This number is extrapolated using Indiana electricity consumption of 109.4 million MWh in 2007 (as per EIA data), supplied by 95 percent coal, producing 2,095 lbs carbon dioxide/MWh, and assuming the average car is driven 12,000 miles/year @22.4 mpg (as per Department of Transportation data), emitting 19.4 lbs carbon/gal; see http://www.eia.doe.gov/oiaf/aeo/overview.html#trends, also http://epa.gov/otaq/climate/420f05001.htm#carbon

17 Two out of the worst three and four out of the worst eight sulfur dioxide emitting plants in the country are in Indiana. See rankings at: http://www.sourcewatch.org/index.php?title=Existing_U.S._Coal_Plants#Statistical_Data_On_Existing_U.S._Coal-Fired_Generating_Stations

18 http://www.insideindianabusiness.com/newsitem.asp?id=28991

19 http://www.eia.doe.gov/cneaf/solar.renewables/page/state_profiles/indiana.html

20 http://www.aceee.org/pubs/e086_es.pdf

21 http://www.mckinsey.com/clientservice/electricpowernaturalgas/downloads/US_energy_efficiency_full_report.pdf

22 http://yosemite.epa.gov/opa/admpress.nsf/0/5B2E6D9AA8D257758525760200686356

23 http://www.incontext.indiana.edu/2008/sept-oct/2.asp

24 http://www.peri.umass.edu/fileadmin/pdf/other_publication_types/green_economics/green_prosperity/Green_Prosperity.pdf ; also see http://www.pewcenteronthestates.org/uploadedFiles/Clean_Economy_Report_Web.pdf

25 http://www.bls.gov/news.release/laus.nr0.htm

26 http://aceee.org/pubs/e091.pdf?CFID=3643806&CFTOKEN=11807860 p.19

27 http://www.repp.org/articles/BGA_Repp.pdf and http://www.hecweb.org/File/Indiana_as_a_Manufacturing_Hub_for_Renewable_Energy-HEC-Feb_2009.pdf

28 See Governor Daniel's speech to the "Windiana" Conference, July 21, 2009, http://www.youtube.com/watch?v=e4-kjq6rgQk

29 Ibid, Study 6, Appendix 1

30 http://www.bizjournals.com/cincinnati/stories/2009/06/08/daily2.html

31 http://industry.bnet.com/auto/10002147/enerdel-ev-battery-company-lands-1185-million-doe-grant/
32 Agstar PowerPoint presentation by Chris Voell.
33 Corn stover consists of the leaves and stalks of corn that remains in the field after harvest.
34 Estimate based on: 10 percent of Indiana's coal power capacity = 2,155 MW = 4,310 new jobs, reduced by a proportional share of coal O&M and fuel procurement (existing total of 3,879 Indiana jobs in coal O&M, 2858 in mining), http://www.sourcewatch.org/index.php?title=Coal_and_jobs

Chapter 1

1 http://www.nrel.gov/docs/fy07osti/41435.pdf
2 http://www.20percentwind.org/report/Chapter1_Executive_Summary_and_Overview.pdf
3 http://www.awea.org/pubs/factsheets/WE_Noise.pdf
4 http://www.nationalwind.org/publications/wildlife/avian_collisions.pdf
5 It actually found an increase in property values compared to other comparable local property. See: http://www.repp.org/articles/static/1/binaries/wind_online_final.pdf
6 American Wind Energy Association (AWEA), http://www.awea.org/newsroom/releases/wind_energy_growth2008_27Jan09.html; The household-equivalent number per MW is smaller than average because of the variable output of wind facilities.
7 http://www.awea.org/projects/projects.aspx?s=Indiana
8 Percent of annual electricity generation from wind = 530 MW x 35% capacity factor x 8,760 hours/year ÷ 130,637,999 MWh (total Indiana electric power generation in 2007, see http://www.eia.doe.gov/cneaf/solar.renewables/page/state_profiles/indiana.html) = 1.2%
9 http://www.awea.org/newsroom/releases/Annual_Industry_Rankings_2009_041309.html
10 http://www.ers.usda.gov/Statefacts/IN.HTM
11 http://www.awea.org/faq/wwt_basics.html#How%20many%20turbines%20does%20it%20take%20to%20make %20one%20megawatt%20(MW)
12 Based on typical annual payments of $3,000/MW, as used in the JEDI model described above
13 http://www1.eere.energy.gov/windandhydro/pdfs/43025.pdf p.21
14 http://www.gao.gov/new.items/d04756.pdf
15 http://www.repp.org/articles/static/1/binaries/IN_BG_report.pdf
16 http://www.hecweb.org/File/REPP_Indiana_short_report.pdf; This report finds 1,321 firms in Indiana with the capability to manufacture components for wind, solar, geothermal, and biomass facilities.

Chapter 2

1 According to the National Research Council study, 384 million dry tons is available from agricultural and forestry residues and municipal solid waste. Early studies suggest that today cover crops could produce between 2 and 3.6 tons per acre of biomass when harvested and up to 5 tons with good weather and soil fertility. If 10 percent of the nation's 220 million acres of field crop land was cover cropped and the biomass harvested, this would produce between 44 and 110 million tons per year. If incentives boosted cover crop adoption rates to 30 percent, we could expect 66 million acres of land to be planted in cover crops, yielding between 132 and 330 million tons per year of biomass. Because cover crops are best managed as a system with agricultural residues, these numbers may not be entirely additive to the NRC's 130 million tons of residues. Thus, combining innovate farm practices such as double cropping and winter cover crops with potential dedicated energy crops on marginal or abandoned lands,, an additional 40-330 million dry tons could be available. These estimates do not include the potential from biofuel production from algae.
2 The EIA, State Energy Profiles, http://tonto.eia.doe.gov/state/state_energy_profiles.cfm?sid=in
3 http://www.biodiesel.org/buyingbiodiesel/producers_marketers/Producers%20Map-Existing.pdf
4 Estimated production of biodiesel is only about one-fourth of capacity because the biodiesel market is not profitable under current economic conditions and federal fuel blending rules have not yet been issued. The industry also suffers from the fact that Congress has yet to extend biodiesel production tax credits, which are set to expire in December 2009.
5 Worldwatch Institute, "Smart Choices for Biofuels," p.8
6 http://www.ers.usda.gov/AmberWaves/April06/Features/Ethanol.htm
7 http://www.ethanolrfa.org/resource/cellulosic/documents/CurrentCellulosicEthanolProjects-January2009.pdf
8 http://www1.eere.energy.gov/biomass/pdfs/final_billionton_vision_report2.pdf#search=%22Biomass%20as%20Feedstock%20for%20A%20Bioenergy%22

9 http://www.newrules.org/de/energyselfreliantstates.pdf, p.24
10 http://www.ers.usda.gov/Data/AgProductivity/
11 http://www.ers.usda.gov/Data/StateExports/
12 Crop acreage based on 1999-2008 average from the National Agricultural Statistics Services' data (http://www.nass.usda.gov/QuickStats/PullData_US.jsp). Dry tons derived by multiplying the total crop production (in bushels per year, from the NASS) by the ratio of straw to grain (1:1 for corn, 1:1 for sorghum, 1.7:1 for winter wheat, and 1:1 for soybeans) and by the tons of grain per bushel (.028 tons per bushel of corn, .028 tons per bushel of sorghum, .03 tons per bushel of winter wheat, and .03 tons per bushel of soybeans); see http://www.dnr.mo.gov/energy/renewables/biomass-inventory2005-07.pdf.
13 Calculated base on hardwood conversion: 1 cubic foot = 0.02265625 tons; softwood conversion: 1 cubic foot = 0.0208984375 (from http://forestry.about.com/library/blwoodconvert.htm); see: "Indiana Timber Industry Ð An Assessment of Timber Product Output and Use," 2005, by Ronald J. Piva and Joey Gallion, http://nrs.fs.fed.us/pubs/rb/rb_nrs22.pdf.
14 This amount does not include 4.5 million acres of Indiana forestland from which dead and fallen trees could be collected.
15 http://bioenergy.ornl.gov/main.aspx
16 Various studies have estimated cellulosic ethanol yields of up to 110/gal per dry ton; this number assumes no increase in the current yield of about 70 gal/ton.
17 Based on Federal Highway Administration Statistics, see http://www.fhwa.dot.gov/policy/ohim/hs06/htm/mf21.htm and http://www.afdc.energy.gov/afdc/sabre/sabre.php?mode=prod
18 11 million tons of biomass x 2,000 pounds/ton x 4,300 Btu/pound x .000000293 MWh/Btu = 27,717,800 MWh; see http://bioenergy.ornl.gov/papers/misc/energy_conv.html; Indiana's annual electricity production 2007 = 130,638,000 MWh
19 Assuming 19.4 pounds of carbon/gallon, (see http://epa.gov/otaq/climate/420f05001.htm#carbon), and typical usage of 536 gallons of gasoline per car per year (22.4 mpg and 12,000 miles driven).
20 See reports of the multiagency Biomass Research and Development Initiative (BRDI) http://www.brdisolutions.com/default.aspx
21 1.4 tons x $45/ton x 230 acres (5.6 million acres of corn Ö 24,400 farms in 2007) = $14,490
22 .5 x $45/ton x 250 acres (5.5 million acres of soybeans Ö 21,973 farms in 2007) = $5,625
23 http://bioenergy.ornl.gov/ornl/fileresources/FactSheets/3e91456a-ea45-4c7f-8c5b-caf0c1d60e7f.doc
24 http://www.nrel.gov/docs/fy01osti/29691.pdf
25 http://www.purdue.edu/dp/energy/pdf/Renewables_Report_2006.pdf
26 "Biomass Energy Databook," https://cta.ornl.gov/bedb/biopower.shtm; also http://cta.ornl.gov/bedb/pdf/Biopower.pdf
27 AP: http://www.14wfie.com/global/story.asp?s=10769311
28 Lazard, "Levelized Cost of Energy Comparison," February 2008
29 http://www.nrel.gov/docs/fy00osti/28009.pdf
30 http://www.eia.doe.gov/cneaf/coal/page/acr/table26.html
31 EIA State Energy Profile: Indiana
32 The EIA uses 50 miles as a feasible distance for economic transportation of energy crops; see http://tonto.eia.doe.gov/FTPROOT/modeldoc/m069(2008).pdf
33 Calculated by converting 10 percent of the 60 million tons of coal used in Indiana each year (as per EIA data) and assuming 9,000 Btu/lb for coal, and 4,300 Btu/lb for biomass, the low end of the range of biomass energy content. Some biomass crops such as switchgrass and miscanthus have energy densities as high as 8,000 Btu/lb.
34 http://nrel.gov/docs/fy00osti/27541.pdf
35 http://us.arevablog.com/2009/05/27/adage-announces-proposed-site-of-first-us-biopower-facility/
36 http://www.news-journal.com/hp/content/region/ETtoday/stories/2008/02/05/plant.html
37 Estimate based on: 10 percent of Indiana's coal power capacity = 2,155 MW = 4,310 new jobs, reduced by a proportional share of coal O&M and fuel procurement (total of 3,879 Indiana jobs in coal O&M, 2,858 in mining), http://www.sourcewatch.org/index.php?title=Coal_and_jobs
38 See also Oak Ridge National Lab report, http://bioenergy.ornl.gov/main.aspx#
39 See national CRP statistics at http://content.fsa.usda.gov/crpstorpt/rmepehh/MEPEHHR1.HTM
40 http://www.epa.gov/lmop/proj
41 For detailed comparison of state net metering policies, see: http://www.irecusa.org/index.php?id=90
42 http://www.newenergychoices.org/uploads/FreeingTheGrid2008_report.pdf
43 Extrapolated from USDA farm output data at http://www.ers.usda.gov/Data/AgProductivity/, forestry potential from http://www.statemaster.com/graph/geo_lan_acr_tot_for_lan-geography-land-acreage-total-forest, and new landfill gas potential from http://www.epa.gov/lmop/proj

44 Agstar PowerPoint presentation by Chris Voell
45 Agstar estimates the cost range at $150-$400 per 1,000 lbs livestock weight; see http://www.epa.gov/agstar/pdf/manage.pdf
46 http://www.adnett.org/, and http://www.epa.gov/agstar/operational.html#addatabase
47 U.S. EPA Agstar, "Market Opportunities for Biogas Recovery Systems," 2006
48 U.S. Department of Agriculture 2007 Census of Agriculture
49 U.S. EPA AgSTAR
50 http://www.eia.doe.gov/cneaf/electricity/esr/esr_sum.html
51 The market value of RECs and carbon credits depends on the specific policies adopted. Today, RECs cost from about $7 to $35/MWh
52 http://www.agcensus.usda.gov/Publications/2007/Full_Report/Volume_1,_Chapter_1_State_Level/Indiana/index.asp
53 Any chicken that is raised to lay eggs, either for consumption or propagating chickens, is defined as a layer.
54 http://www.agcensus.usda.gov/Publications/2007/Full_Report/Volume_1,_Chapter_1_State_Level/Indiana/st18_1_027_028.pdf
55 http://www.fibrowattusa.com/
56 http://www.ers.usda.gov/Publications/AP/AP037/AP037.pdf
57 http://www.westlafayette.in.gov/department/division.php?fDD=3-56&fDD=11-0
58 http://www.purdue.edu/dp/energy/pdfs/SUFG/publications/Renewables_Report_2006.pdf, see Appendix C

Chapter 3

1 http://www.nrel.gov/docs/fy08osti/42306.pdf
2 For a detailed description of agricultural solar applications, see: http://www.nyserda.org/programs/pdfs/agguide.pdf
3 http://www.nrel.gov/docs/fy08osti/42414.pdf; see also http://www.nrel.gov/biomass/proj_microalgae.html
4 http://www.biodieselnow.com/forums/t/24281.aspx, http://www.indy.com/posts/indiana-algae-the-next-green-fuel, http://www.indy.com/posts/indiana-algae-the-next-green-fuel

Chapter 4

1 http://www.epa.gov/airmarkets/cap-trade/docs/ctresults.pdf
2 http://www.ucsusa.org/assets/documents/clean_energy/Clean-Power-Green-Jobs-25-RES.pdf
3 http://www8.nationalacademies.org/onpinews/newsitem.aspx?RecordID=12794
4 http://aceee.org/pubs/e091.pdf?CFID=3643806&CFTOKEN=11807860
5 http://www.nrdc.org/air/energy/fappl.asp and http://www.nrdc.org/globalWarming/cap2.0/files/kick.pdf
6 http://www.eia.doe.gov/oiaf/servicerpt/subsidy2/pdf/subsidy08.pdf
7 http://www.elistore.org/Data/products/d19_07.pdf
8 Intergovernmental Panel on Climate Change, *Climate Change 2007: Synthesis Report Summary for Policymakers*, pg. 5, http://www.ipcc.ch/pdf/assessment_report/ar4/syr/ar4_syr_spm.pdf
9 http://www.dsireusa.org/library/includes/incentive2.cfm?Incentive_Code=US05F&State=federal&currentpageid=1&ee=1&re=1
10 http://www.dsireusa.org/library/includes/incentive2.cfm?Incentive_Code=US46F&State=federal&currentpageid=1&ee=1&re=1
11 http://www.dsireusa.org/library/includes/incentive2.cfm?Incentive_Code=US02F&State=federal&currentpageid=1&ee=1&re=1
12 http://www.dsireusa.org/library/includes/incentive2.cfm?Incentive_Code=US13F&State=federal&currentpageid=1&ee=1&re=1
13 http://www.dsireusa.org/library/includes/incentive2.cfm?Incentive_Code=US06F&State=federal&currentpageid=1&ee=1&re=1
14 http://www.dsireusa.org/library/includes/incentive2.cfm?Incentive_Code=US53F&State=federal&currentpageid=1&ee=1&re=1
15 http://www.dsireusa.org/library/includes/incentive2.cfm?Incentive_Code=US37F&State=federal&currentpageid=1&ee=1&re=1
16 http://www.dsireusa.org/library/includes/incentive2.cfm?Incentive_Code=US45F&State=federal&currentpageid=1&ee=1&re=1
17 http://www.fsa.usda.gov/FSA/newsReleases?area=home&subject=prod&topic=ner&newstype=newsrel&type=detail&item=nr_20090729_rel_0348.html
18 http://www.lgprogram.energy.gov/2009-CPLX-TRANS-sol.pdf
19 http://www.rurdev.usda.gov/rbs/busp/b&I_gar.htm
20 For detailed comparison of state net metering policies, see: http://www.irecusa.org/index.php?id=90
21 http://www.dsireusa.org/summarymaps/index.cfm?ee=0&RE=1
22 http://www.dsireusa.org/incentives/incentive.cfm?Incentive_Code=IN01F&re=1&ee=0
23 http://www.dsireusa.org/incentives/incentive.cfm?Incentive_Code=IN02F&re=1&ee=0
24 http://www.dsireusa.org/incentives/index.cfm?re=1&ee=0&spv=0&st=0&srp=1&state=IN