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A Clean Energy Economy for Arkansas

Analysis of the Rural Economic Development Potential of Renewable Resources

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Table of Contents

Executive Summary

With an abundance of wildlife, hot springs, 600,000 acres of lakes, and almost 10,000 miles of rivers and streams, Arkansas is known as "The Natural State." Rich in natural resources and fertile land, Arkansas has a historically stable and diverse economy. But the global economic downturn is being felt across the state, with 41,000 jobs lost since the middle of 2008, most of them in rural areas.[1] To secure its economic future, Arkansas has the opportunity to build a strong long-term economy on the solid foundation of its bountiful renewable resources.

The state's vast areas of productive farmland, ample water, windy heights, and favorable climate combine to give Arkansas the potential to become a national leader in producing the clean energy that America needs. And its dependable workforce and strong business community have the tools for leadership in manufacturing equipment for clean energy industries. Taking advantage of these opportunities in renewable resource development would create tens of thousands of new Arkansas jobs and give a big boost to rural communities across the state. Instead of importing energy from across the globe, Arkansas could become a key supplier of clean energy and the tools to produce it—provided that national policies are enacted to spur the development of renewable energy resources.

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

Table ES1: Arkansas' Clean Energy Resource Potential, Energy Advantages, and Environmental Benefits

Energy Source	Potential Output Estimate	Effect on Total Arkansas Usage	Carbon Reductions	Economic Benefits
Wind Power	2,460 MW = 7.5 million MWh of electricity[2] per year	16% of all electricity would be wind-powered	7.1 million metric tons[3]	For 1,000 MW of capacity: 500 permanent jobs, $830 million in economic activity over 30 years
Biofuels	770 million gals per year just from existing crop residues	50% of all gasoline would be replaced with biofuels	6.7 million metric tons[4]	$38,000 in revenue to average rice farm
Biopower	Replace 10% of coal = 2.35 million MWh per year	5% of all electricity would be biopowered	2.2 million metric tons[5]	700 permanent jobs
Biogas	145,000 metric tons of methane	336,000 MWh of electricity per year	Equivalent to 3 million metric tons of CO_2[6]	$23 million worth of homegrown energy per year
Energy Efficiency	Energy efficiency resource standard of 15% electricity savings and 10% natural gas savings[7]	Annual electricity savings of 6.4 million MWh, gas savings of 73.5 million therms	4.2 million metric tons	2,570 net jobs created, $1.8 billion net energy savings

Fossil-Fueled Energy Imports Are a Drag on the Arkansas Economy

Each year Arkansans spend a total of $10.1 billion on gasoline and other petroleum fuels, natural gas for heating, power, and industrial use, and coal for electricity production.[8] That translates to more than $3,500 in energy costs for every person in Arkansas[9]—and 78 percent of those Arkansas energy dollars leave the state, never to return.[10]

About $2 billion worth of natural gas—1.3 percent of the nation's total—is produced in Arkansas.[11] But Arkansas is still a major net importer of fossil fuels. Coal is used to produce half of the state's electricity,[12] and almost all of the 16 million tons of coal used each year is imported all the way from Wyoming.[13] Arkansas' energy usage is substantially above average—13th in the country in per capita energy consumption—but most of Arkansan's energy dollars are literally going up in smoke.[14] If nothing is done to develop homegrown energy resources and to reduce energy consumption, the drag of wasted energy spending on Arkansas' economy will only get worse.

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.[15] Such an increase would create a need for almost 2,500 megawatts (MW)[16] of new generating capacity in Arkansas over the next 15 years.[17] If Arkansas doesn't improve its delivery of energy efficiency and invest in new renewable energy resources, its continued overdependence on fossil fuels could mean higher electricity rates to pay for unpredictable fuel prices and supply swings. Meeting tomorrow's demand with today's fuel mix would also mean a substantial increase in global warming pollution. According to the Arkansas Governor's Commission on Global Warming (GCGW), present trends in electricity consumption and production, including two big new coal plants scheduled to come online by 2012, will add 7.2 million metric tons of carbon dioxide to Arkansas' annual emissions by 2025—the equivalent of putting 550,000 more cars on Arkansas roads.[18]

That's why Arkansans overwhelmingly support renewable resource development and energy efficiency. A recent scientific survey found that more than half of Arkansas voters want to see a decrease in coal usage and 81 percent would support a requirement that utilities use renewable energy and energy efficiency to meet electricity demand.[19] After thorough study, the Governor's commission found renewable energy and energy efficiency to be more cost-effective methods of reducing global warming pollution than building more nuclear power plants or attempting to sequester carbon dioxide at coal plants.[20] However, Arkansas is one of only 18 states without a renewable energy standard—a statutory goal or requirement that utility companies meet a growing portion of their customers' electricity needs with clean energy.

In the crucial area of improving energy efficiency, Arkansas also lags behind most other states, ranking 41st in the "2009 State Energy Efficiency Scorecard" published by the American Council for an Energy Efficient Economy (ACEEE).[21] According to a study co-sponsored by a broad group of utilities, the EPA, and NRDC, the United States can reduce its non-transportation energy usage by 23 percent by investing in cost-effective energy efficiency.[22] 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."[23] Greater energy efficiency can lead to lower energy bills, even as we make the investments needed for the long and necessary transition to clean power production.

Clean Energy Policy Can Create Good Jobs in Arkansas

Renewable energy production is already one of the nation's fastest growing areas of job creation. A study co-sponsored by NRDC and conducted by the Political Economy Research Institute (PERI) of the University of Massachusetts found that clean energy jobs in Arkansas grew by almost 8 percent over the ten year period ending in 2007, more than twice the growth rate of overall jobs.[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 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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New clean energy jobs would be especially valuable to Arkansas, which ranks 48th in the nation in per capita income and has 70,000 unemployed workers.[25] 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 , aka the "stimulus" bill) and the American Clean Energy and Security Act (ACESA, aka "Waxman-Markey")—Arkansas' share would be $1.3 billion in investment and 18,000 new jobs.[26]

The huge economic opportunity of clean energy development, especially for a state with the renewable energy potential of Arkansas, is being recognized by the state's business community. A large group of Arkansas businesses called the Arkansas Business Leaders for a Clean Energy Economy are advocating for the passage of national climate and energy policies to put Arkansas and the United States on a clean energy path.

These business leaders recognize that Arkansas' central location makes it a prime spot for the manufacture of components for renewable energy production facilities. A study by the Renewable Energy Policy Project (REPP) found that a national commitment to build 185,000 MW of renewable electricity capacity over the next ten years (an amount that would largely stabilize emissions of global warming pollution by producing 25 percent of America's electricity from renewable resources) could result in the creation of 8,600 manufacturing jobs in Arkansas.[27] REPP calculated that wind and solar energy generate 5.7 person-years of employment per million dollars in investment over ten years, whereas the coal power industry generates only 3.96 person-years per million dollars over the same period.[28]

Energy efficiency investment also creates high-quality jobs, while saving consumers money on their monthly utility bills. ACEEE studied the projected economic impacts of a proposed national goal of 15 percent electricity savings and 10 percent natural gas savings by 2020, and found that it would create 220,000 net new jobs within ten years, including 2,572 jobs in Arkansas and $1.8 billion in savings for Arkansas consumers. In addition, achieving these energy savings would reduce carbon dioxide emissions in Arkansas by 4.2 million tons, the equivalent of taking 300,000 cars off Arkansas roads.[29]

Renewable Energy Development Can Provide New Income Opportunities for Arkansas Farmers

If curbing greenhouse gas emissions and supporting renewable resource development become national policy, the production of clean energy would likely become an attractive 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 (RECs)
- Sale of Carbon Offset Credits
- Sale of organic fertilizer
- Sale of Animal Processed Fiber (APF)

This report examines the potential for renewable resource development in Arkansas 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

At least 40 Arkansas counties have commercially viable wind resources. But Arkansas has no commercial wind facilities and has yet to begin to tap this substantial resource. A federal government study projects that 1,000 megawatts of Arkansas wind power—about eight or ten utility-scale wind farms—would create $830 million in economic benefits over 20 years, 3,496 construction and locally stimulated indirect jobs, and 504 permanent operations jobs.

Biofuels

Cellulosic ethanol (made from organic waste materials, crop residue, and non-food plants instead of edible sugars and starches) and biodiesel (made from algae instead of soybeans) are the next generation of smart biofuels. Arkansas is perfectly situated to become a center of the next generation of biofuels production. Existing usable Arkansas crop and timber residues are sufficient to produce 770 million gallons of transportation fuels each year, equivalent to 50 percent of all the gasoline used in Arkansas. An average rice farm could see potential gross revenue of $38,000 from harvesting biomass residue. Ten cellulosic plants, each with a 50 million gallon capacity, would create 2,090 long-term jobs, $216 million in annual economic activity, and $12.4 million in local property taxes. Farm-raised algae for biodiesel production could become a valuable re-use of idle catfish ponds if national policies to reduce atmospheric carbon are enacted.

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 in Arkansas and cut back on coal consumption. Many sources of biomass are renewable fuels that can be stored to make biopower whenever they are needed, making them a perfect complement to the variable output of wind and solar power. Farms across much of Arkansas are close enough to an existing coal-fired plant to cost-effectively supply biomass feedstock for co-firing with coal. If 10 percent of Arkansas' coal-fired power capacity were replaced with biopower plants, more than 700 new long-term jobs would be created, not including new agricultural jobs to produce and harvest the biomass fuel.

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 create high-quality fertilizer and other byproducts while reducing odors, water pollution, and emissions. Using available poultry litter to generate electricity would not only create a cost-effective power source, but could alleviate a devastating water pollution problem plaguing Arkansas and neighboring Oklahoma.

Arkansas is one of the nation's leading livestock and poultry producers but currently has no operating biodigesters. "Agstar," a joint program of the EPA, the U.S. Department of Agriculture (USDA), and the U.S. Department of Energy (DOE), provides information resources and financial support for biodigester installations. A new program has been initiated by Agstar to help states overcome deployment barriers and capture the benefits of biodigester technology.

Other Clean Energy Opportunities for Arkansas Farmers

- **Solar:** Although solar power remains a relatively expensive renewable energy source, the cost of photovoltaic installations continues to drop. Because of their intensive energy needs and location in open areas, 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:** Home to the nation's first geothermal facility in Hot Springs, Arkansas has the potential to make productive energy—both utility-scale electric and local thermal supply—from the hot water flowing not far underground in many locations. The entire state is suitable for local geothermal heating and cooling systems, which circulate fluid through pipes in the constant-temperature stratum a few feet underground and then through buildings. Geothermal technology is especially suitable for rural areas where buildings are not densely situated and digging and installation may be less expensive.

- **Soil Carbon Sequestration:** By employing "no till" or "low till" farming methods, farm fields may be able to absorb and retain 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 provide income to farmers under some carbon reduction strategies. Future innovations that enhance farm-level carbon sequestration may provide new opportunities for generating these carbon "offset" credits.
- **Energy Storage Potential:** Wind and solar power are variable resources with peaks and valleys of output. New advances in battery and other technologies to store electricity cost-effectively are beginning to overcome these challenges of variable output and have the potential to revolutionize our energy system. A company in Batesville, Arkansas recently won a federal stimulus grant to develop anodes for lithium-ion batteries to be used in electric cars. With a boost from national clean energy policies, energy storage technology has the potential to become a growth industry in Arkansas.

Policy Recommendations to Cultivate Clean Energy in Arkansas and Across America

The U.S. Congress is considering legislation to begin the transition to a clean energy economy through a range of polices designed to stabilize emissions of global warming pollution, enable renewable energy resources to compete on a level playing field, and encourage more efficient energy use by businesses and individuals.

Arkansas farmers can reap big gains from the transition to a low-carbon economy—gains that will outweigh predicted increases in fossil energy costs. The American Clean Energy and Security Act (ACESA, H.R. 2454) passed by the House of Representatives, 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.

Specific elements of the ACESA Bill that will benefit the rural and agricultural economy of Arkansas include:

- A renewable energy standard (RES) that promotes truly clean and renewable resources
- Economy-wide "cap and trade" with strong targets for reducing global warming pollution
- Using a portion of emission credits toward incentives for renewable energy technologies and efficiency measures

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

- Mandated reduction of 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
- Transportation planning standards targeted at reducing total vehicle miles traveled by integrating public transit, land use, road congestion relief and housing strategies
- A low-carbon fuels standard (LCFS) to ensure that the entire mix of transportation fuels moves toward a lower average level of carbon when measured on a total full-fuel-cycle basis that includes accounting for indirect land use change and other land, water, and wildlife impacts
- Expanded support for renewable energy research and development (R&D)
- 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 (such as through indirect land use change)
- Enhanced incentives for deployment of advanced energy efficiency technology
- Mandate the most recent building energy codes for newly constructed buildings and provide more direct resources for localities to enforce the codes.
- Promotion of performance-based sustainable management practices that ensure the protection of wildlife habitat, soil, and water resources and that improve the livelihood of local communities.

Arkansas' energy path must lead in a new direction on both the supply and demand sides of the equation if we want to build a healthy economy and healthy communities.

CHAPTER 1

Arkansas' Wind Power Potential

Like other renewable energy sources, wind supply is inexhaustible, produces no waste, causes no pollution, and its costs are neither subject to 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 generation.[30] While 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.[31]

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."[32] 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).[33]

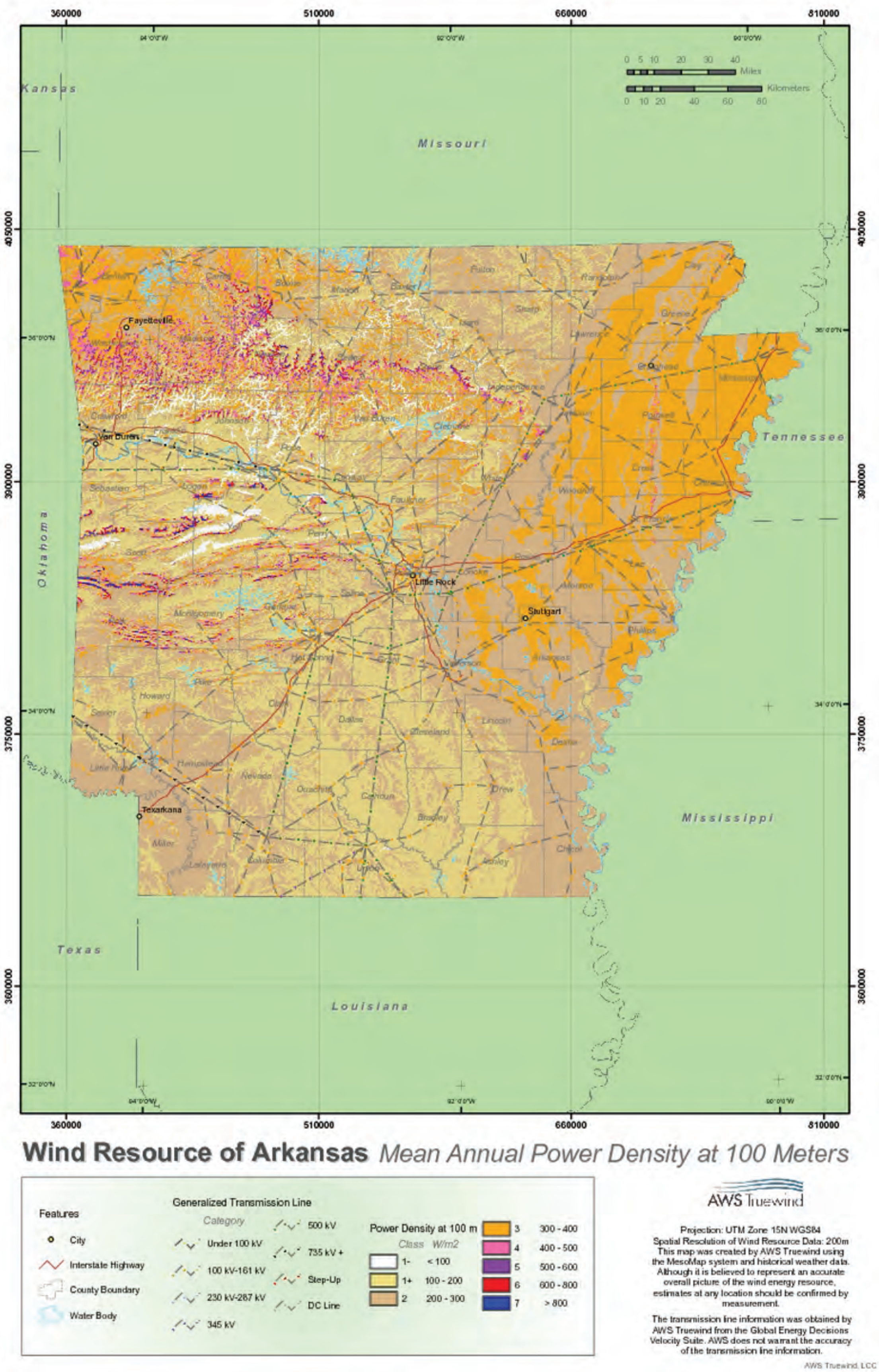
Despite concerns that wind development would reduce the values of surrounding property, a detailed study by REPP has found the opposite effect, with wind development positively influencing property values.[34] The presence of wind facilities may actually help maintain the value of nearby farms by demonstrating 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.[35] But Arkansas has no commercial wind facilities and just seven small wind turbines operating today in the entire state, with a combined capacity of only about one-fifth of 1 MW.[36] Arkansas wind capacity may begin to grow soon, as a 20 MW wind power project is currently being planned for Benton County.[37] But that is just a start toward fulfilling the state's substantial wind power potential.

When wind power first began to be commercially developed in the 1980s, Arkansas was thought to have insufficient wind for commercial wind development. But recent advances in wind power technology have doubled the height of turbines and the efficiency of production. Today, Arkansas is ranked 27th in the United States in developable wind power capacity, with potential wind generation of 2,460 MW, or about 16 percent of its total generating capacity from all sources.[38]

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 following map was produced by the National Renewable Energy Laboratory (NREL) of Arkansas, recording wind potential at 100 meters and showing that a significant portion of the state has commercially viable wind. The strongest Arkansas wind is in the pink and purple map area along ridge tops in the Boston and Ouachita Mountain regions.

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



At least 40 Arkansas counties have winds of class 3 and above at 100 meters, and the following 20 counties have some areas of class 4 and 5 wind:

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

Counties			
Benton	Jackson	Newton	Sebastian
Boone	Johnson	Perry	Stone
Carrol	Logan	Polk	Van Buren
Garland	Madison	Scott	Washington
Independence	Montgomery	Searcy	White

Some of Arkansas' windiest areas are in the Ouachita and Ozark-St. Francis National Forests.[39] While federal policy generally supports sustainable development of renewable energy resources in national forests, all proposed renewable energy projects, whether on public or private land, must be thoroughly assessed on the merits of key conservation values. Land that is already intensively disturbed and therefore of relatively low conservation value should always be preferred for development over high conservation value intact land.

Wind Power Can Pump Up Rural Economies

A study by the NREL projects that 1000 MW of wind development in Arkansas would produce the following benefits:[40]

Table 2: Predicted Economic Impact of 1000 MW of Wind Development in Arkansas

Local Economic Impacts - Summary Results				
	Jobs	**Direct Impacts**	**Induced Impacts**	**Total Economic Benefit**
Construction Phase	3,496	$188.5 million to local economies	$129.1 million to local economies	$317.6 million
Operational Phase (20+ years)	504	$21.2 million/year to local economies $2.7 million/year in payments to landowners $9.3 million/year in property tax revenue	$20.3 million/year to local economies	$830 million over 20 years

Wind Power Creates Opportunities for Farmers and Agricultural Communities

The average size of an Arkansas farm is 281 acres. More than 22,500 farms are larger than 100 acres, and 6,100 are larger than 500 acres.[41] A typical wind project would involve dozens of turbines erected at a group of adjacent farms. Large turbines are typically from 1 to 2 MW in capacity.[42] 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 a 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 about five or six wind turbines totaling about 10MW, and receive $30,000 in guaranteed annual income from land-lease payments, without significantly reducing its crop production. A 150-MW wind project would have 70 to 100 turbines spread across the equivalent of more than 15 typical Arkansas 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. However, 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."[43] 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.[44]

Expanded Wind Power Will Provide a Big Economic Boost to Arkansas (Even If It's Located Elsewhere)

The emergence of a large domestic wind power industry would be a boon to many rural communities in Arkansas, and it would also mean a new market for manufacturers of the components that go into wind turbines, towers, and other renewable energy facilities. The REPP study referenced earlier in this report identified 384 firms in Arkansas with the capability to manufacture components of wind power facilities.[45] Some of them are already doing so. In fact, Arkansas is becoming a center of advanced wind component manufacturing, with three sizeable plants locating here recently:

- LM Glasfiber opened a $150 million turbine blade plant in Little Rock in 2008. The plant expects to have 630 jobs at full capacity, but because of the difficulty in financing wind farms today, current employment has been cut to 300.[46]
- Nordex USA Inc. broke ground in July 2009 on a $100 million plant in Jonesboro that is expected to employ 700 people, making some of the world's largest wind turbines.[47]
- Polymarin Composites USA and Wind Water Technology are jointly building a factory in Little Rock to make blades and turbines, with expected employment of 830.[48]

These companies have cited similar reasons for their decisions to locate in Arkansas: its stable workforce, mild climate, excellent transportation options, supportive government, and central location close to big wind development markets in Texas and the Southwest Power Pool region.

Arkansas has started down the road to becoming a renewable energy manufacturing center by taking advantage of its enterprising strengths. The University of Arkansas has gone one step further to cultivate entrepreneurial talent by initiating a Renewable Energy Technology program to give students at three community colleges the skills necessary to become renewable energy professionals.[49] What is needed now is national policy that puts renewable energy resources at the center of America's energy future, transforming this economic 'boomlet' into a long-term clean energy boom for Arkansas.

CHAPTER 2

Arkansas' Biomass Potential: Biofuels, Biopower, and Biogas

Almost any organic material can be used to produce energy, either by burning it as a solid, fermenting it into a liquid, or decomposing it into gases. When plants grow they absorb carbon dioxide from the air, and when they are converted into energy they release this carbon. However, 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, and 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.

The energy contained in plants starts out as solar energy, which is absorbed through photosynthesis. Some of the energy is passed on to animals when they eat the plants and some of it is stored in the soil. The term "biomass energy" refers to a wide range of fuels derived from crops, wood, and waste. In solid dry form, energy crops and crop residues can be grown or collected and 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 produces 15 percent of all renewable electricity in the United States today (primarily from landfill gas and solid waste), second to hydropower among renewable resources.

The emergence of a vibrant new biomass energy industry would open big new markets for Arkansas farm products, with greater potential for rural economic development than wind power, because energy crops can be grown—in fact are already grown—throughout Arkansas. Despite its relatively small population and its ranking 27th among all states in size, Arkansas ranks first in rice production, second in poultry, third in cotton, fifth in sorghum, and ninth in soybeans.[50] These resources provide tremendous clean energy opportunities.

Biofuels Must Be Done Right to Reap Environmental Benefits

Most gasoline in the United States already comes blended with 10 percent ethanol, a biofuel produced today primarily from corn. Biodiesel fuel is usually made from soybean oil.

Arkansas does not require any ethanol to be added to gasoline, and as a producer of less than 1 percent of U.S. corn, it presently has no facilities making ethanol. Four biodiesel production facilities have been built in Arkansas, with a total annual capacity of 81 million gallons, about 3 percent of the national capacity of 2.69 billion gallons.[51,52] A proposed state law mandating that diesel fuel contain 5 percent biodiesel has not yet come up for a vote in the legislature, and the rules for a pending federal biofuels mandate have not yet been finalized. 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.[53] That's why crucial new technology is being developed to make biofuels 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.

Algae Could Be a Green Energy Gold Mine

Many species of algae—a water-based crop that grows well in Arkansas' climate and has productivity rates per acre as much as 100 times greater than soybeans—can be converted into liquid and gas fuels.[54,55] More than 200 companies are researching algae biofuels, and a commercial facility to produce algae-based fuels is under development in Drew County in southeast Arkansas.

As a leading producer of farm-raised catfish, Arkansas is home to 141 commercial catfish operations comprising 20,500 acres of ponds. But increasing costs have made catfish farming a difficult business and more than 10,000 acres have been taken out of production in Arkansas over the past three years.[56] It may well be possible to renovate these non-producing ponds to produce algae instead of catfish. In fact, this transition is already beginning to occur in neighboring Mississippi, where an energy company is beginning to lease old catfish ponds to grow algae. Projected annual royalties for pond owners are upwards of $1,000 per acre, making algae a potentially valuable cash crop.[57] While algae biofuels are not yet commercially viable, and there are many questions about water use, land use, and energy balance that remain to be answered, that could change quickly if national polices are implemented to ramp up algae-based biofuels R&D and reduce atmospheric carbon dioxide.[58]

Cellulosic Ethanol Is on the Verge of Commercialization

Advanced ethanol and other biofuels are on track toward mass production in the coming years. Instead of using edible plant sugars and starches, these biofuels are made by breaking down the fibrous material that makes up the non-edible cellulose structure of plants. Cellulosic biofuels 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, poplar, and miscanthus. Cellulosic biofuels 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.[59] 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.[60] The byproducts of cellulosic ethanol production can 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 on the market.[61] And of course, just as corn can have significant impacts on soil, water, wildlife, and greenhouse gas emissions, so can different sources of cellulosic biomass.

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. While the initial targets are intentionally stretch goals and may not be met, cellulosic biofuels are the biofuels of the future, with potential to eventually replace a large portion of petroleum-based transportation fuels.

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.[62] A biorefinery to make ethanol from rice straw and hulls has been planned for Stuttgart, in Arkansas County, the nation's largest rice producing county, but financial issues have delayed its construction. A pilot plant to produce ethanol from solid municipal waste using new treatment processes developed at the University of Arkansas has been operating in Fayetteville.[63]

The fact that Arkansas has no investment in corn ethanol but is a leading agricultural state with immense existing biomass resources could make it a prime beneficiary of pro-cellulosic national policies. The U.S. Department of

Agriculture (USDA) and the DOE found that more than 1.3 billion tons of cellulosic biomass in the United States could be collected and converted into liquid biofuels, eventually replacing one-third of gasoline consumption, without displacing any food crop acreage.[64] Only a portion of this is likely to be available soon and in a way that provides real climate benefits and is protective of wildlife and soil and water quality.

Arkansas Already Has Feedstock for Biomass Energy

Arkansas has the highest growth in farm output of any state in the United States since 1960.[65] Now the nation's 11th largest agricultural producer, Arkansas is perfectly situated to become a center of biomass energy production.[66] And the initial feedstocks needed to launch the biomass industry in Arkansas are literally lying on the ground. Arkansas farms annually harvest:

- 580,000 acres of corn, producing 775 thousand usable dry tons of stover
- 850,000 acres of cotton, producing more than 120 thousand usable dry tons of residue
- 1.3 million acres of rice, producing 2.66 million usable dry tons of residue
- 690,000 acres of wheat, producing more than 110 thousand usable dry tons of residue[67]
- 4.6 million dry tons of usable forest residues and 2.5 million dry tons of usable mill residues[68]

Altogether, the potential biomass feedstock in Arkansas amounts to more than 11 million tons each year—without including any new production of energy crops.[69]

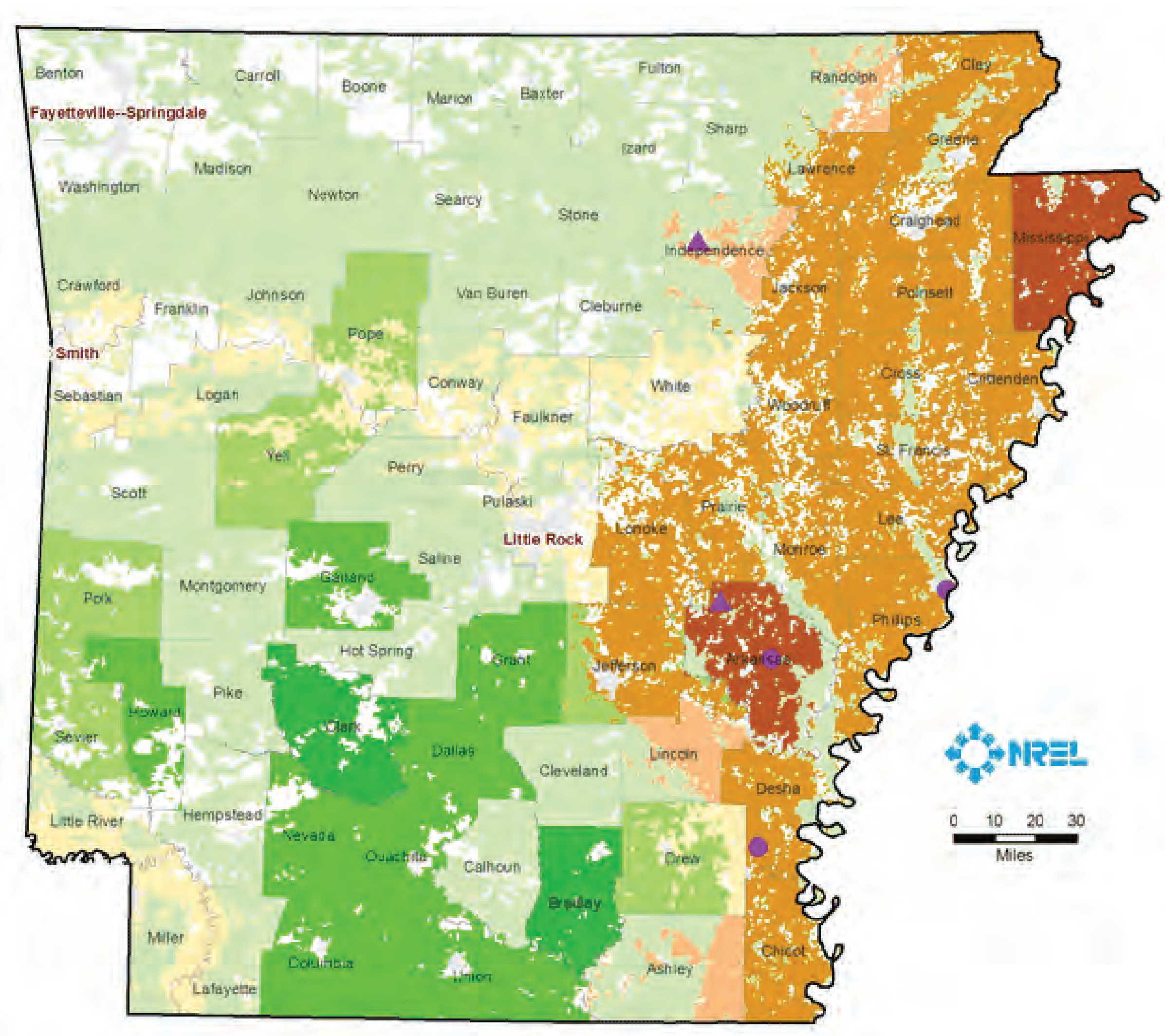
Again, the real sustainability of these resources needs to be assessed to address potential impacts of their use on the environment, such as soil fertility, water quality, and wildlife habitat. But what could be done with 11 million tons of biomass? If all were devoted to producing cellulosic ethanol, that would be enough feedstock to produce 770 million gallons of "biofuels," equivalent to 53 percent of all the gasoline used in Arkansas each year.[70,71] Burned in power plants, that's enough biomass energy to generate almost 28 million MWh of electricity, or the equivalent of more than 50 percent of Arkansas' annual electricity production.[72] Replacing that much fossil fuel with clean energy would reduce carbon dioxide emissions by more than 6.7 million tons, having the same effect as removing 1.1 million cars from Arkansas roads.[73]

And 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 the agricultural waste materials could be about $145-180 million.[74] For a rice grower, at a usable yield of 2 dry tons of residue per acre, this equates to about $38,000 in potential revenue for the average Arkansas rice farm of 480 acres.[75] The average Arkansas corn farm of 415 acres, with a usable yield of about 1.3 tons of stover per acre, could see gross revenue of about $22,500.[76] 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 road-side stacking of straw to be about $20 per dry ton.[77] 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 of between $9 and $38 per acre, depending on amount harvested and delivery distance.[78] Following is a map created by the NREL of crop residue biomass in Arkansas, also showing the location of existing biodiesel production facilities.

The potential for biomass production from Arkansas crops is far greater 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.

Perennial plants such as miscanthus (a woody bamboo-like plant), hybrid poplar (a fast-growing tree), and switchgrass (a tall-growing native prairie grass) can be grown without much fertilizer on marginal land that is not suitable for row crops. These plants have shown yields from 10 to 30 dry tons per acre (far more than the biomass yield of corn or soybeans) and they will regenerate without replanting, some for decades.[79] It will be critical, however, when evaluating the potential for any new energy crop, to ensure that diverse native habitat—such as natural forests, wetlands, and native grasslands—is not converted to bioenergy plantations, and that a full assessment of the crop's potential invasiveness

Figure 2: Map of Existing Residue Biomass in Arkansas 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.

is carried out within the local context. If such an assessment determines that there is an unknown or high risk of invasiveness in the local area of production, then the crop should not be considered for production.

An oil-producing crop, camelina (also known as wildflax) can be inexpensively grown on marginal land with little moisture and when rotated with wheat has been shown to increase subsequent wheat yields by 15 percent.[80] Camelina has twice the oil yield of soy and its residues left over after extracting the oil can make a high-quality animal feed and other products such as fiberboard.

Just as corn yields have increased four-fold in the past 30 years, as energy crop hybrids are developed, biomass yields will grow and certain plants will emerge as best suited for particular growing conditions and different types of energy production.

Of course the availability of suitable land for these crops is still being assessed. If these crops simply displace food or fiber crops, the impact on land use from that displaced demand needs to be accounted for. If these crops are grown on degraded or abandoned agricultural land, they may be able to significantly improve the soil quality and wildlife habitat.

Biofuels Boost Rural Economic Development

Biofuels production could provide enormous benefits to rural communities in Arkansas. The DOE has developed a "Jobs and Economic Development Impact" model (JEDI) to project the local economic impact of building energy facilities. This tool estimates the direct and indirect ripple effects on overall economic activity resulting from the construction and operation of cellulosic ethanol production plants, using state-specific data. Table 3, excerpted from JEDI, details the predicted economic impact of a 50 million gallon-per-year biochemical cellulosic ethanol plant in Arkansas.

According to this DOE analysis, a 50 million gallon per year cellulosic ethanol plant would generate 365 full-time jobs for the duration of its 3-year construction phase and $112 million in local economic activity. Operation of the plant would create 209 long-term jobs and a total of almost $22 million annually in direct and indirect economic impact, plus $1.24 million in annual property taxes. Ten ethanol plants of that size, an achievable goal for Arkansas in the coming years, would produce 2,090 jobs, $216 million in annual economic activity, and $12.4 million in total local property taxes.

Biopower Works Around-the-Clock

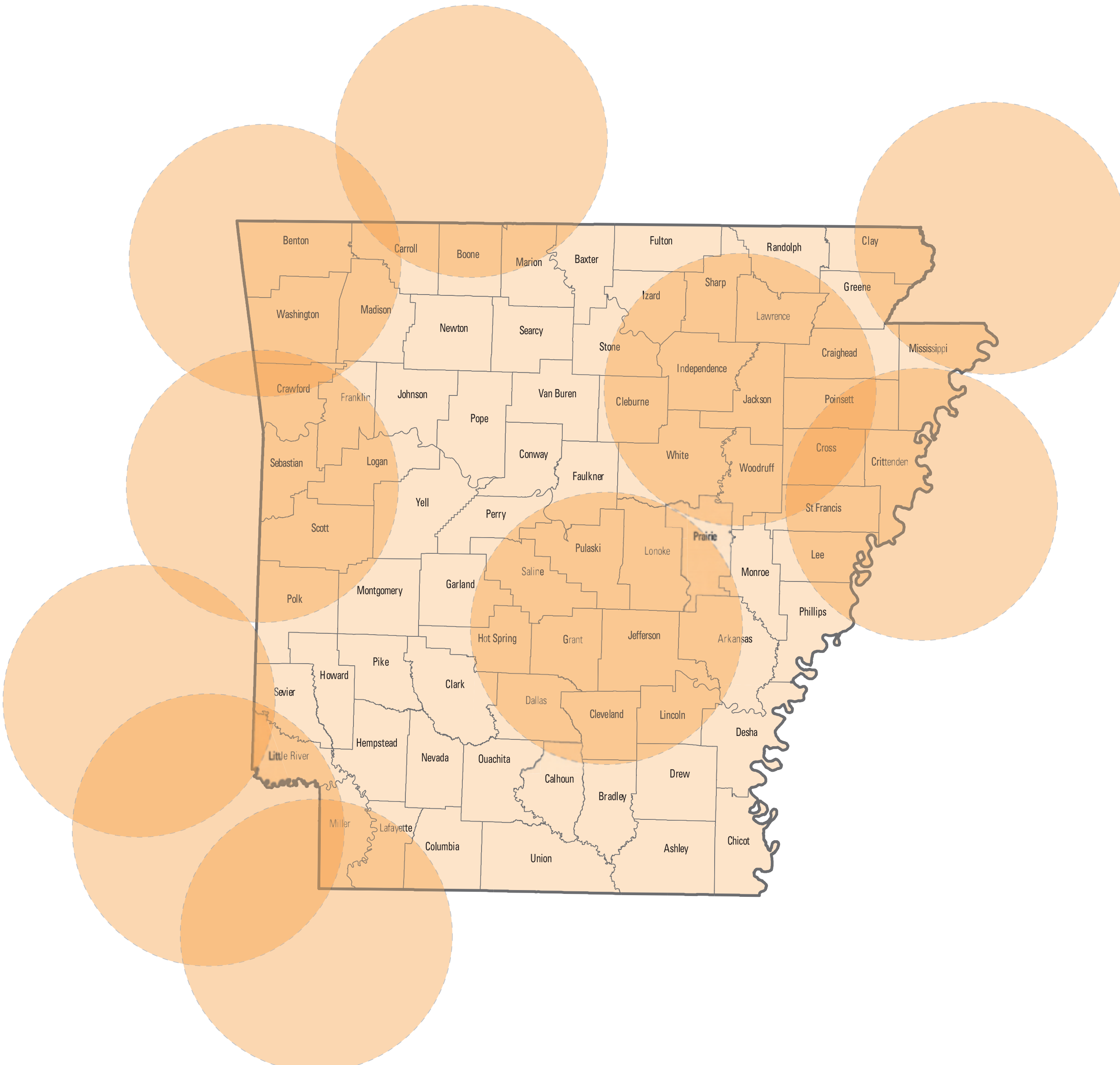
The same energy crops that can be converted into ethanol-based transportation fuels can also be used for direct production of electricity when chopped up or pelletized and burned as fuel in biomass-fired power plants. Biomass is a renewable energy resource that can be stored to make biopower when it is needed, making it a perfect clean energy complement to the variable output of wind and solar power. The Arkansas Energy Office has calculated that Arkansas has sufficient biomass potential to supply 150 percent of the state's residential electricity use.[81]

Today there are 120 biomass-fired power plants in the United States and 48 facilities that "co-fire" biomass with coal (none of which are located in Arkansas).[82] Sustainable biomass power production in Arkansas is limited to three generators operated by companies to supply electricity for their own use, by burning scrap wood and sawdust left over from wood products manufacturing and crop residue from food processing.[83] Total biomass production from these facilities amounts to two-tenths of 1 percent of electricity generated in Arkansas.[84]

Because biomass can be substituted for a portion of coal used in existing utility-scale power plants without massive investment in new facilities, it is a relatively low-cost and quick way to ramp up renewable electricity generation in the near-term.[85] 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 part biomass. The retrofit costs are a small fraction of the costs for a new coal or biomass plant, which are estimated at $2550-$5350/kW, depending on the technology employed.[86] 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.[87] Although building a new power plant that would burn any coal at all cannot be justified on economic nor environmental grounds, in some locations it may be cost-effective to build a separate biomass boiler next to an existing coal-fired plant to feed steam into a common turbine. In Ohio, a sizeable coal plant that was putting out so much pollution that the EPA had ordered it to be shut down is instead being converted to run on 100 percent biomass, at a retrofit cost of less than $650 per kW.[88]

Transporting large quantities of solid fuel for long distances is costly, but energy crops and residues in Arkansas could be harvested from areas close to existing coal-fired power plants.[89] Following is an Arkansas county map showing each

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



coal plant with a 50 mile radius circle drawn around it to highlight the areas that could conveniently provide feedstock if it were converted to co-fire with part biomass.[90] Note that the appropriateness of these lands for energy crops has not been assessed. Also included on the map are areas of Arkansas that are within 50 miles of a coal-fired plant in an adjacent state.

This map illustrates the geographic potential of cost-effective biomass production for co-firing in Arkansas—an area of more than 25,000 square miles.

Harvesting Biomass Can Cultivate Jobs

If 10 percent of Arkansas' existing coal used to generate electricity were replaced by biomass, it would create annual demand for about 2.9 million tons of energy crops and residues.[91]

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.[92] Developers of a 50 MW biomass plant in Florida forecast 2.5 permanent jobs per megawatt.[93] A similar facility in Texas expects three jobs per megawatt.[94] Assuming two new jobs per megawatt of biopower capacity, if 10 percent of Arkansas' coal-fired capacity were replaced with biopower, more than 700 net new long-term jobs would be created, not including new agricultural jobs to produce and harvest the biomass feedstock.[95]

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.[96] While the land that would be needed for substantial electricity production from dedicated energy crops is not insignificant and a lot of land is inappropriate for energy crops, Arkansas covers 33 million acres. Cultivating energy crops on a very small portion of it would be sufficient for extensive biopower production.

High density crops, cultivated to maximize their energy content, can dramatically increase energy yields per acre. Giant miscanthus, now being grown commercially in Europe and Asia, is a very productive energy crop, well-suited to Arkansas' climate and conditions.[97] It grows 14 feet tall in one season at densities of 15 tons per acre or more, regenerates for 20 years without replanting, and packs almost as much energy per pound as Wyoming coal.[98] Miscanthus has been successfully grown in test plots for 20 years in climates very similar to Arkansas'. Its high productivity, however, also raises concerns about the risk of it becoming an invasive species. Adequate scientific assessments and controlled field trails will be necessary to determine whether miscanthus is appropriate for this region. If assessments conclude it is not potentially invasive, then it appears to be a superb and cost-effective feedstock for both biopower and biofuel production. However, because its one-time planting costs are relatively high—three times the cost of planting corn—and it takes two to four years for it to reach maximum yield, growing miscanthus is a long-term investment.

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

Why are energy crops like poplars or switchgrass not being cultivated in the United States? The answer lies in our failure to adopt a national energy strategy. If Arkansas farmers were confident in a long-term market for energy crops, they would invest in planting them. If American farm equipment manufacturers were confident in a long-term market for energy crops, they would invest in producing the equipment needed to plant and harvest it. And if power generators were confident about long-term feedstock supply and sales opportunities, they would build facilities to generate energy crop-fueled biopower. But without a set of national policies designed to move America toward a clean energy economy, no single actor 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 transform the market and assure both long-term supply and demand for renewable energy.

Table 3: Predicted Economic Impact of an Arkansas Cellulosic Ethanol Plant

Cellulosic Ethanol Plant—Project Data Summary	
Project Location	ARKANSAS
Year Construction Starts	2012
Conversion Process	Biochemical
Project Size—Production Capacity (Mil. Gal./Year)	50
Construction Period (Years)	3
Plant Construction Cost ($/Gal. Fuel Produced)	$2.93
Plant O&M Cost ($/Gal. Fuel Produced)	$0.72
Feedstock (Type)	Ag Residue
Cost of Dry Feedstock ($/Ton)	$34.74
Produced Locally (Percent)	100%
New Production (Percent)	25%
Feedstock Supplier	
Farmer (Percent)	100%
Wholesaler (Percent)	0%
Fixed Operations and Maintenance Cost ($/Gal.)	$0.11
Non-Fuel Variable Operations and Maintenance Cost ($/Gal.)	$0.22
Money Value—Current or Constant (Dollar Year)	2009
Project Construction Cost	$146,349,526
Local Spending	$69,269,045
Total Annual Operational Expenses	$55,577,256
Direct Operating and Maintenance Costs	$35,893,245
Local Spending	$12,370,499
Other Annual Costs	$19,684,011
Local Spending	$1,243,971
Debt and Equity Payments	$0
Property Taxes	$1,243,971

Local Economic Impacts - Summary Results			
	Jobs	**Earnings**	**Output**
During Construction Period			
Project Development and Onsite Labor Impacts	506	$38.46	$55.79
Construction Labor	435	$34.25	
Construction-Related Services	71	$4.21	
Equipment and Supply Chain Impacts	314	$9.86	$29.54
Induced Impacts	281	$7.96	$26.60
Total Impacts (Direct, Indirect, Induced)	**1,101**	**$56.28**	**$111.94**
During Operating Years (Annual)			
Onsite Labor Impacts	57	$2.07	$2.07
Local Revenue and Supply Chain Impacts	105	$3.00	
Agricultural Sector Only	17	$0.37	
Other Industries	88	$2.63	
Induced Impacts	48	$1.35	$4.52
Total Impacts (Direct, Indirect, Induced)	**209**	**$6.43**	**$21.57**

NOTE: Earnings and Output values are millions of dollars in year 2009 dollars. Construction period related jobs are full-time equivalent for the 3 year construction period. Plant workers includes operators, maintenance, administration and management. Economic impacts "During operating years" represent impacts that occur from plant operations/expenditures. The analysis does not include impacts associated with spending of plant "profits" and assumes no tax abatement unless noted. Totals may not add up due to independent rounding.

Biogas is a Gas

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 and is the main component of natural 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 resource.[99] Arkansas has five landfills that have been identified as good candidates for landfill gas projects, but the only operating facility is in Pulaski County, where each year half a million tons of garbage generate 4.8 MW of power for North Little Rock.

For decades, a growing number of large swine and dairy operations across the United States have been managing the immense amounts of manure they produce by processing it using "anaerobic digesters" to make methane biogas, which is then used to power generators and for thermal energy. Several anaerobic digester technologies are operating, 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 company:** Producing renewable electricity can reduce or eliminate monthly electric bills through "net metering." Arkansas 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.[100] However, Arkansas received an "F" grade for its restrictive policies on interconnecting small renewable electricity generators to the utility grid in a national assessment by the Network for New Energy Choices.[101] New federal laws could enhance and standardize net metering and interconnection 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. Any carbon offsets 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 Arkansas, that translates into a carbon offset potential of 4.3 million tons and revenue of $30 million by 2015, growing to 6.4 million tons and a revenue potential of $69 million by 2030.[102]

- **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, which 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.[103]

Sizable biodigesters and related equipment require an investment of $300,000 to $900,000 or more, with many site-specific cost variables.[104] Although some support in the form of state and federal grants and tax credits is available, the technology is presently used only at 135 large-scale concentrated animal feeding operations (CAFOs) in the United States (compared to about 3,000 farm-scale biodigesters operating in Europe).[105] Agstar, a joint program of the EPA, the U.S. Department of Agriculture (USDA), and the DOE provides information resources and financial support to biodigester installations. Agstar 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.[106] A new program has been initiated by Agstar to help states like Arkansas overcome deployment barriers and capture the benefits of biodigester technology.

Arkansas is a leading livestock producer, ranking in the top 20 in cattle and swine.[107] According to the NREL, Arkansas is second in the nation in manure-based methane emissions, producing more than 145,000 tons per year.[108] If all these emissions were converted into energy, livestock manure could generate 336,000 MWh of energy per year.[109] At 6.91 cents/KWh (the average commercial retail electricity rate in Arkansas) that would be more than $23 million worth of homegrown power each year (assuming net metering treatment).[110] Adding additional future revenue of perhaps two to four cents/KWh would be the value of renewable energy credits and the potential value of carbon emission credits for burning 145,000 tons of methane, if federal policies to limit greenhouse gas emissions were enacted.[111] While not all manure-based methane is ever likely to be captured for energy use, Arkansas has great potential for biogas production, although there are no anaerobic biodigesters operating in the state today.

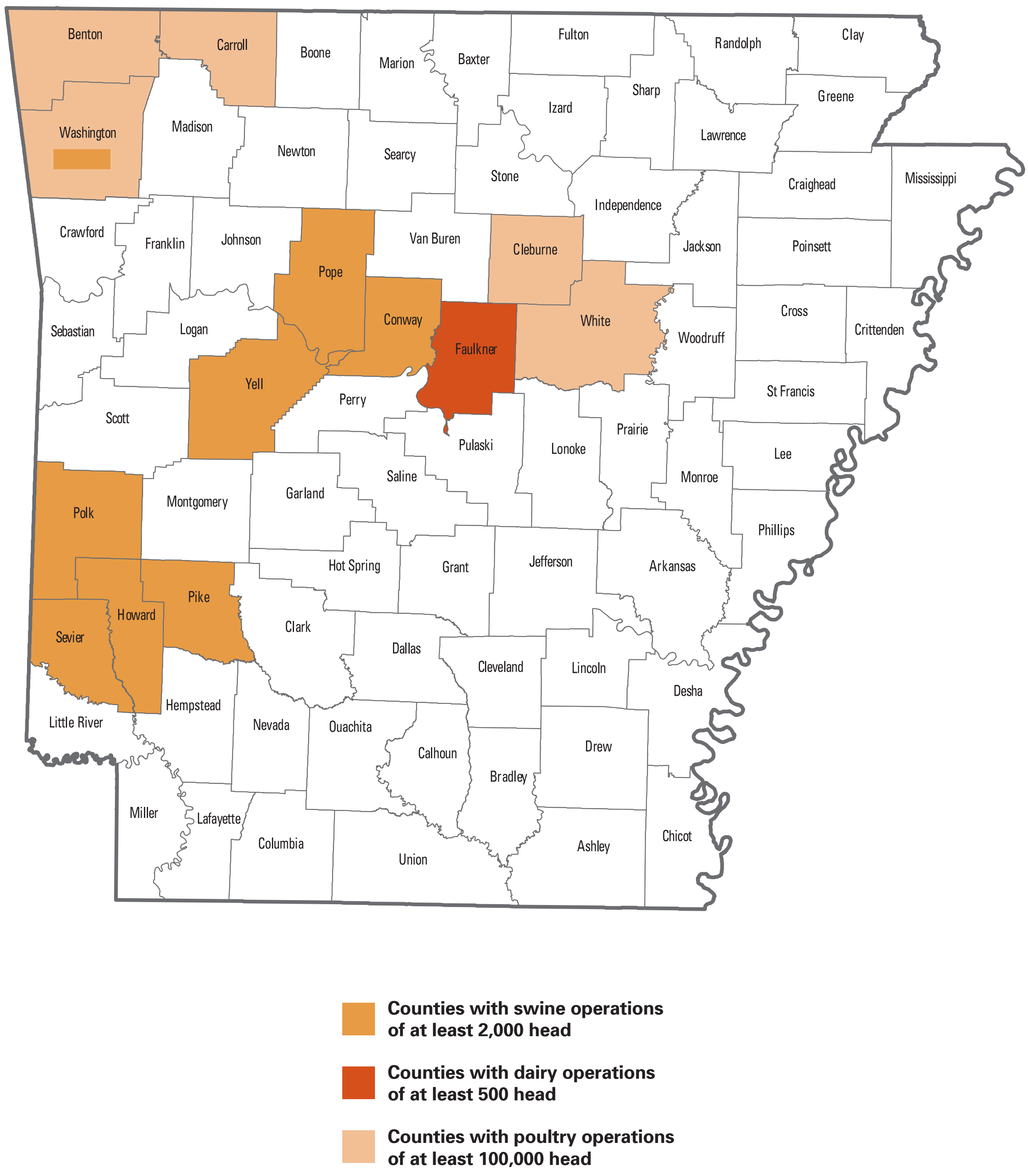
The statewide livestock inventory includes 1.8 million hogs and pigs, with 41 swine operations of more than 2,000 head, including six with more than 5,000 head.[112] Some of these may not be ideal for biodigester technology because of the design of their manure systems, but many are likely to be feasible sites. Arkansas is home to just one dairy farm with more than 500 cows. However, smaller operations could also benefit from biogas production because centralized systems can allow farms—such as some of the 16 Arkansas dairies with 200-500 cows—to (literally) pool their manure resources to create scale economies, as is presently done at several locations in other states.

With output of more than 1.5 billion birds per year, Arkansas is third in the nation in poultry production. Five giant farms have inventories totaling 3.6 million layers, 843 farms sell more than 500,000 broiler chickens each year, and 121 farms produce an average of 175,000 turkeys each.[113,114] Some of these operations may have potential for cost-effective biogas recovery systems, particularly as improved technology reduces biodigester costs and the combination of higher energy prices, renewable resource requirements, and new carbon emission standards increase potential revenue. Another innovative energy production technology already commercialized is the direct use of poultry litter as power plant fuel. The first such plant in the country is operating in Minnesota, using turkey litter from 300 area farms to generate 55 MW of electricity, enough to power about 40,000 homes.[115] 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.[116] Certainly in Arkansas, far more poultry waste is produced than can be used locally for fertilizer, and turning some of it into energy could not only create value for poultry operators but also address the severe water and air pollution problem caused by intensive poultry production in western Arkansas and neighboring Oklahoma.[117]

Figure 4 on the following page is an Arkansas map showing 13 counties with livestock operations large enough to potentially benefit from farm bioenergy systems.

Arkansas has not yet begun to take advantage of its animal-based bioenergy potential. But with the right set of enabling government policies in place, the benefits of these technologies for Arkansas' livestock operators and its environment could be realized within just a few years.

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



CHAPTER 3

Further Renewable Energy Opportunities for Arkansas

Advancements in renewable technologies are expanding the range of cost-effective clean energy opportunities for Arkansas. Solar power, geothermal, soil carbon sequestration, and energy storage are some of the innovative technologies with the potential to power a clean energy future for Arkansas and the United States as a whole.

Solar potential

Although solar electricity has been relatively expensive, 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—on almost anything. Arkansas has an average solar energy density of 4.5 to 5.5 kWh per square meter per day, enough sunlight to derive significant amounts of energy. This potential is just beginning to be tapped, with 31 photovoltaic installations today and a total installed electric generation capacity of nearly 100 kW.[118] Farm-scale solar electricity production is eligible for sale to utilities under Arkansas' 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.[119]

Geothermal Potential

Geothermal energy takes advantage of the natural heat occurring underground. In 1830, Hot Springs, Arkansas witnessed the first known commercial use of geothermal energy when Asa Thompson charged visitors one dollar to bathe in the spring's water.[120] Now home to Hot Springs National Park, the springs are used to generate 2,000 MWh of electricity per year.[121] Arkansas also produces more than 250 million barrels annually of equivalent oil output of "co-produced geothermal fluids"—hot water and steam coming from oil and gas wells. This is enough energy to generate 60 MW of power if it were captured.[122]

Many parts of Arkansas have underground hot water close enough to the surface to use "direct hydrothermal" technology for heating buildings, industrial processes, biofuels refining, and agricultural uses such as crop and lumber drying. New low-temperature electricity generation technology under development may greatly increase the potential for cost-effective geothermal power production from this vast resource.

Geothermal heat pump technology takes advantage of the constant temperature of about 55-degrees several feet underground. 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 and cost-effective systems to maintain building temperatures, and they are well-suited for farms and rural areas where buildings are not densely situated and digging and installation are less expensive.

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, depending on depth of plowing and soil characteristics. 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” (as described earlier), 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 Arkansas farmers.

Energy Storage Potential

Wind and solar power are variable resources with peaks and valleys of output. New advances in battery and other technologies to store energy cost-effectively are beginning to add value to these renewable generation resources and could eventually revolutionize our energy system. One promising innovation on the cusp of commercialization is the plug-in hybrid electric vehicle (PHEV). When connected to the “smart grid” under development by utility companies, plugged-in electric cars can become electric storage units, filling up on energy in off-peak hours (such as at night when the wind is often blowing hardest) and providing energy from their batteries to the grid during afternoon hours of peak usage. Future Fuels, a company in Batesville Arkansas, has been awarded a federal stimulus grant to develop anodes for lithium-ion batteries to be used in electric cars.

CHAPTER 4

Reaching the Clean Energy Future: Getting from Here to There

Arkansas can be at the heart 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. Some policies and programs to support clean energy development have been implemented but much more needs to be done.

National Policies Needed to Realize Arkansas' Clean Energy Potential

While 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 approach is a "cap-and-invest" system, under which overall annual limits on global warming pollutants are set, and emitting companies must comply by either reducing their emissions or obtaining pollution permits or "emission allowances." 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), currently being considered in the U.S. Congress, proposes this kind of framework and includes strong targets: a 17 percent reduction below 2005 levels by 2020; a 42 percent reduction below 2005 levels by 2030; and an 83 percent reduction below 2005 levels by 2050. A cap-and-invest 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.[123] If allowances are fully or partially auctioned under a federal program like ACESA, 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) 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 jobs.[124] An RES coupled with energy efficiency through a national Energy Efficiency Resource Standard (EERS), which is the cheapest and fastest energy resource available, will provide even greater economic benefits and lower energy bills. An 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 220,00 jobs, including 2,572 jobs in Arkansas and $1.8 billion in savings for Arkansas consumers. Such a commitment to energy efficiency would also eliminate the need to build 390 new power plants and avoid emissions of pollution equivalent to 48 million automobiles.[125] Also making appliances more energy efficient saves consumers in energy costs over the lifetime of the product. That's why strengthened national energy efficiency standards for home appliances are a critical part of a long-term energy strategy.[126] 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.

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, an 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

Any serious effort to reduce our dependence on fossil fuels must also 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.[127] In their developing phases, the nuclear, coal, and oil industries received subsidies an order of magnitude larger than existing renewable technologies. Clean energy RD&D has fallen greatly since the 1970's, and is now a very small portion of overall RD&D spending. In order to give a necessary boost to clean energy development at this critical juncture, the level of clean energy RD&D should be doubled.

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 that installed systems deliver the energy they promise. Net metering and interconnection rules enable simple access and price certainty for small, distributed installations. ACESA aims to balance these needs to research, develop, and deploy the innovations and technological breakthroughs required to meet the climate challenge, including $90 billion for energy efficiency and renewable energy technologies and $60 billion toward carbon capture and sequestration (CCS) technology.

Going forward, Congress needs to craft deployment policies that effectively address challenges specific to each phase of technology development, while providing needed long-term confidence, security, and stability to drive capital investment.

ACESA includes a Renewable Energy Standard to achieve 20 percent of U.S. electricity from renewable sources and efficiency improvements by 2020, which would drive economies of scale for maturing technologies in the renewables industry. Such a national commitment to sustainable energy production would:

- Reduce our dependence on foreign oil and improve our energy security
- Create tens of thousands of new Arkansas jobs and revitalize rural communities
- Support the growth and prosperity of Arkansas farms
- Ensure a healthy and sustainable environment for future generations

Prosperity, security, and a healthy planet cannot 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 Arkansas.

State-Level Policies Needed to Boost Arkansas' Clean Energy Economy

- Expanded net metering: An array of renewable technologies are eligible for net metering in Arkansas, but any annual production above the customer's own electricity usage must be given to the utility without compensation. Many other states have more supportive rules, allow for larger systems, and make it much easier for consumers to

connect to the utility grid.[128] New laws could improve net metering policies and more effectively promote on-site clean power production.
- Improved program assistance for farmers and business owners who are considering earning additional revenue through 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 non-binding 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.[129]
- Statewide electric utility revenue decoupling, whereby investor-owned electric utilities are compensated for achieving quantifiable levels of energy reductions via energy efficiency programs and measures within their service territory.[130,131] As an analogue, the three major investor-owned gas utilities in Arkansas have been 'decoupled' and now make a solid return on investment by reducing their customers' gas usage through a suite of self-administered, "Commission-approved" buildings and equipment gas efficiency programs.[132]

Federal Programs and Funding for Clean Energy Development in Arkansas

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 extension of clean energy production tax credits, support for transmission infrastructure, "smart grid" investment, low-income housing weatherization, plug-in hybrid electric vehicles, anaerobic biodigesters, 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[133]
- USDA - Rural Energy for America Program (REAP) Loan Guarantees[134]
- Business Energy Investment Tax Credit (ITC)[135]
- Renewable Electricity Production Tax Credit (PTC)[136]
- Modified Accelerated Cost-Recovery System (MACRS)[137]
- U.S. Department of Treasury - Renewable Energy Grants[138]
- Residential Renewable Energy Tax Credit[139]
- Clean Renewable Energy Bonds (CREBs) for Municipalities[140]
- Farm Service Agency (FSA) Biomass Crop Assistance Program (BCAP) providing matching payments for collection, harvest, and storage of biomass[141]
- DOE loan guarantees for electric transmission infrastructure (section 1705)[142]
- USDA Business and Industry loan guarantees for economic growth in rural communities[143]
- Agstar program to support biodigester technology installations

State-Level Programs and Funding for Clean Energy in Arkansas

There are several small clean energy programs operating in Arkansas, including:
- Small Business Revolving Loan Fund[144]
- Utility-specific rebate and loan programs[145]

It is becoming clear that Arkansas' economic future is inextricably linked to its energy future. With a commitment to energy efficiency and renewable resource development at the core of a state and national energy strategy, clean energy could become a key homegrown component of a healthy Arkansas environment and a robust Arkansas economy.

Endnotes

1 See http://www.bls.gov/lau/; the number of jobs in Arkansas decreased from 1,302,765 in July, 2008, to 1,260,904 in August, 2009. See also: http://www.allbusiness.com/economy-economic-indicators/economic-indicators/12526196-1.html

2 Based on projected 35% 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 2095 pounds carbon/MWh of coal * 7.5 M MWh / 2205 pounds/metric ton = 7,125,850 metric tons

4 19.4 pounds carbon/gallon * 770 M gallons / 2205 pounds/metric ton = 6,774,603 metric tons

5 2095 pounds carbon/MWh of coal * 2.35 M MWh / 2205 pounds/metric ton = 2,232,766 metric tons

6 Not including the reduction in carbon dioxide emissions from replacing other energy sources.

7 Energy efficiency savings estimates based on ACEEE , "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 $454 million, petroleum costs of $7.7 billion, and natural gas costs if $2 billion.

9 Based on the estimated 2008 population of 2,855,390, http://quickfacts.census.gov/qfd/states/05000.html.

10 Estimate based on subtracting Arkansas' annual fuel production of approximately 69,000 tons of coal, 2.7 billion therms of natural gas and 6.1 million barrels of oil (total value of about $2.2 billion) from its total fuel costs.

11 http://tonto.eia.doe.gov/state/state_energy_profiles.cfm?sid=AR

12 Arkansas electricity is 51% coal, 11% natural gas, 8% hydro, and 30% nuclear

13 http://www.eia.doe.gov/cneaf/coal/page/coaldistrib/2007/d_07state.pdf

14 http://tonto.eia.doe.gov/state/state_energy_profiles.cfm?sid=ar

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

16 A megawatt (MW) is a measure of electricity production equal to 1000 kilowatts (kW) 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.

17 Based on 15,296 MW of existing generating capacity and a 1% annual demand increase, as forecast by the EIA; additional capacity estimate does not count any replacement of existing power plants.

18 This number is calculated assuming average car driven 12,000 miles/year @22.4MPG (as per Dept 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

19 http://ar.audubon.org/issues-action/new-poll-shows-arkansans-support-green-jobs-energy

20 See http://www.arclimatechange.us/ewebeditpro/items/O94F20310.pdf

21 see http://aceee.org/pubs/e097.pdf?CFID=4232386&CFTOKEN=41130567

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

23 http://yosemite.epa.gov/opa/admpress.nsf/0/5B2E6D9AA8D25775852576020068635

24 http://www.pewcenteronthestates.org/uploadedFiles/Clean_Economy_Report_Web.pdf

25 http://www.census.gov/statab/ranks/rank29.html

26 http://images2.americanprogress.org/CAP/2009/06/factsheets/peri_ar.pdf

27 http://bluegreenalliance.articulatedman.com/assets/pdf/AR-Report.pdf

28 http://www.repp.org/articles/static/1/binaries/LABOR_FINAL_REV.pdf

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

30 See: http://www.nrel.gov/docs/fy07osti/41435.pdf

31 http://www.20percentwind.org/report/Chapter1_Executive_Summary_and_Overview.pdf

32 See: http://www.awea.org/faq/wwt_environment.html#Noise

33 http://www.awea.org/faq/sagrillo/swbirds.html#13.

34 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

35 Source: 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.

36 See http://arkansasenergy.org/solar-wind-bioenergy/wind.aspx and http://www.awea.org/projects/projects.aspx?s=Arkansas

37 http://arkansasmatters.com/content/fulltext/?cid=244822

38 http://www.awea.org/projects/projects.aspx?s=Arkansas

39 See: http://www.nrel.gov/wind/pdfs/36759.pdf, Appendix C, P.14

40 http://www.arkansasrenewableenergy.org/wind/08%20wind%20energy%20conf/Flowers.pdf

41 http://www.ers.usda.gov/Statefacts/AR.HTM

42 http://www.awea.org/faq/wwt_basics.html#How%20many%20turbines%20does%20it%20take%20to%20make %20one%20megawatt%20(MW)

43 http://www1.eere.energy.gov/windandhydro/pdfs/43025.pdf p.21

44 http://www.gao.gov/new.items/d04756.pdf

45 See: http://www.repp.org/articles/BGA_Repp.pdf

46 http://www.arkansasbusiness.com/article.aspx?aid=115273.54928.127402

47 http://www.nordex-online.com/en/news-press/news-detail.html?tx_ttnews[backPid]=45&tx_ttnews[tt_news]=2031&cHash=40610868e9

48 http://www.tradeandindustrydev.com/ID-922-news.aspx

49 http://www.helena-arkansas.com/homepage/x2145959341/New-Renewable-Energy-Technology-program-to-kick-off-at-Phillips-College-this-fall

50 http://www.worldatlas.com/aatlas/infopage/usabysiz.htm

51 Existing plants are in Dewitt, Batesville, Crossett, and Helena; another plant is being built is in Rowher.

52 See http://www.biodiesel.org/buyingbiodiesel/producers_marketers/Producers%20Map-Existing.pdf Estimated production of biodiesel is only about 1/4th 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.

53 http://www.arkansasbusiness.com/article.aspx?aid=116490.54928.128619

54 See http://www.nrel.gov/docs/fy08osti/42414.pdf

55 See http://www.nrel.gov/biomass/proj_microalgae.html

56 http://usda.mannlib.cornell.edu/usda/current/CatfProd/CatfProd-07-24-2009.pdf

57 http://www.msnbc.msn.com/id/29638561

58 See for example http://www.reuters.com/article/earth2Tech/idUS215512868020090817

59 http://www.worldwatch.org/files/pdf/biofuels.pdf

60 See http://www.ers.usda.gov/AmberWaves/April06/Features/Ethanol.htm

61 http://www.newrules.org/de/energyselfreliantstates.pdf, p.24

62 hhttp://www.ethanolrfa.org/resource/cellulosic/documents/CurrentCellulosicEthanolProjects-January2009.pdf

63 http://chooseethanol.com/news/entry/bio-ethanol-plant-may-be-worth-a-shot-scientist-says/

64 http://www1.eere.energy.gov/biomass/pdfs/final_billionton_vision_report2.pdf#search=%22Biomass%20as%20Feedstock%20for%20A%20Bioenergy%22

65 http://www.ers.usda.gov/Data/AgProductivity/

66 http://www.ers.usda.gov/Data/StateExports/

67 http://arkansasenergy.org/solar-wind-bioenergy/bioenergy/biomass/agriculture.aspx spreadsheet updated for 2007

68 Arkansas has 4.6 million dry tons of forest biomass after applying ecological safeguards and deducting forest service and BLM lands. Sources: Strittholt, James R. and Jocelyn Tutak, “Assessing the Impact of Ecological Considerations on Forest Biomass Projections for the Southeastern U.S.” and http://arkansasenergy.org/solar-wind-bioenergy/bioenergy/biomass/forestry.aspx

69 A portion of crop residues must be left in the field to prevent soil erosion and maintain soil productivity; these numbers are the actual usable portion of the crop residues as calculated by the Arkansas Energy Office.

70 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.

71 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

72 11 million tons of biomass x 2000 pounds x 4300 Btu/pound * .000000293 mWh/Btu = 27,717,800 – see http://bioenergy.ornl.gov/papers/misc/energy_conv.html; Arkansas' annual electricity production 2007 = 54,596,000 mWh, see http://www.eia.doe.gov/cneaf/solar.renewables/page/state_profiles/arkansas.html

73 Assuming 19.4 pounds of carbon/gallon, see http://epa.gov/otaq/climate/420f05001.htm#carbon, and Arkansas average gas usage as per Arkansas Energy Office estimate of 687 gallons of gasoline per car per year, higher than the typical average per vehicle of 536 gallons per year.

74 See reports of the multi-agency Biomass Research and Development Initiative (BRDI) http://www.brdisolutions.com/default.aspx

75 2 tons x $40/ton x 480 acres (1.3 million acres of rice / 2,752 farms in 2007) = $38,400

76 1.3 tons x $40/ton x 415 acres (580,000 acres of corn / 1,395 farms in 2007) = $21,580

77 SOURCE TO COME

78 See: http://www.nrel.gov/docs/fy01osti/29691.pdf

79 BRDI, "Increasing Production for Biofuels," p.23; also see http://farmindustrynews.com/biofuels/0501-popular-trees-study/

80 See http://domesticfuel.com/2008/09/03/worlds-biggest-camelina-grower-fueling-biodiesel-production/, also http://www.biofuelsdigest.com/blog2/2008/08/18/special-biofuels-digest-report-on-camelina-an-advanced-biodiesel-wonder-crop/ and http://www.biodieselmagazine.com/article.jsp?article_id=171

81 http://arkansasenergy.org/solar-wind-bioenergy/bioenergy/biomass.aspx

82 See http://cta.ornl.gov/bedb/pdf/Biopower.pdf

83 https://cta.ornl.gov/bedb/biopower/Current_Biomass_Power_Plants.xls The three plants are Century Flooring Co in Izard County, Potlatch Southern Wood Products in Bradley County, and STEC-S LLC in Arkansas County

84 http://arkansasenergy.org/media/ArkansasEnergy/pdf/Energy%20Data%20Profile%202007.pdf

85 Biomass can also be liquefied through a process of "pyrolysis," or gasified and then used as power plant fuel; these processes may eventually be more efficient than solid biomass for electricity generation, however, the technologies remain under development.

86 Lazard, "Levelized Cost of Energy Comparison" 2/08

87 http://www.nrel.gov/docs/fy00osti/28009.pdf

88 See: http://news.prnewswire.com/DisplayReleaseContent.aspx?ACCT=104&STORY=/www/story/08-11-2009/0005075796&EDATE, also http://www.powermag.com/renewables/waste_to_energy/1874.html

89 Arkansas has 3 very large coal-fired power plants, with a total capacity of 3,958 MW http://www.sourcewatch.org/index.php?title=Coal_and_jobs

90 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

91 Calculated by converting 10% of the 14 million tons of coal used in Arkansas each year (as per EIA data) and assuming 9,000 btu/lb for coal, and 4,300 btu/lb for biomass. Some biomass crops such as switchgrass and miscanthus have energy densities as high as 7,500 btu/lb.

92 http://nrel.gov/docs/fy00osti/27541.pdf

93 http://us.arevablog.com/2009/05/27/adage-announces-proposed-site-of-first-us-biopower-facility/

94 http://www.news-journal.com/hp/content/region/ETtoday/stories/2008/02/05/plant.html

95 Estimate based on: 10% of Arkansas coal power capacity = 396 MW = 792 new jobs, reduced by a proportional share of coal O&M and fuel procurement (total of 712 Arkansas jobs in coal O&M, 43 in mining), http://www.sourcewatch.org/index.php?title=Coal_and_jobs .

96 See also Oak Ridge National Lab report http://bioenergy.ornl.gov/main.aspx#

97 See: http://www.hort.purdue.edu/newcrop/ncnu07/pdfs/long39-42.pdf

98 See: http://www.ienica.net/crops/miscanthus.htm, http://www.aces.uiuc.edu/news/stories/news3623.html

99 http://www.epa.gov/lmop/proj

100 For Arkansas net metering rules see http://170.94.29.3/rules/net_metering_rules.pdf .

101 http://www.newenergychoices.org/uploads/FreeingTheGrid2008_report.pdf

102 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

103 Agstar Powerpoint presentation by Chris Voell

104 Agstar estimates the cost range at $150-$400 per 1,000 lbs livestock weight; see http://www.epa.gov/agstar/pdf/manage.pdf

105 See: http://www.adnett.org/

106 "Market Opportunities for Biogas Recovery Systems," U.S. EPA Agstar, 2006
107 http://www.agcensus.usda.gov/Publications/2007/Online_Highlights/County_Profiles/Arkansas/cp99005.pdf
108 See http://www.afdc.energy.gov/afdc/pdfs/39181.pdf p.16
109 Extrapolated from http://www.epa.gov/agstar/pdf/biogas%20recovery%20systems_screenres.pdf
110 See: http://www.eia.doe.gov/cneaf/electricity/esr/esr_sum.html
111 The market value of RECs and carbon credits depends on the specific policies adopted. Today, RECs cost from about $7 to $35/MWh
112 U.S. Department of Agriculture 2007 Census of Agriculture
113 Any chicken that is raised to lay eggs, either for consumption or propagating chickens is defined as a layer.
114 http://www.agcensus.usda.gov/Publications/2007/Full_Report/Volume_1,_Chapter_1_State_Level/Arkansas/st05_1_027_028.pdf
115 http://www.fibrowattusa.com/
116 http://www.ers.usda.gov/Publications/AP/AP037/AP037.pdf
117 See http://www.pww.org/article/articleview/16771/ regarding the pending lawsuit against 12 large poultry companies by the Attorney General of Oklahoma
118 http://arkansasenergy.org/solar-wind-bioenergy/solar.aspx
119 For a detailed description of agricultural solar applications, see: http://www.nyserda.org/programs/pdfs/agguide.pdf
120 http://www1.eere.energy.gov/geothermal/history.html
121 http://geoheat.oit.edu/directuse/all/dus0025.htm
122 http://www1.eere.energy.gov/geothermal/pdfs/40665.pdf
123 http://www.epa.gov/airmarkets/cap-trade/docs/ctresults.pdf
124 http://www.ucsusa.org/assets/documents/clean_energy/Clean-Power-Green-Jobs-25-RES.pdf
125 http://aceee.org/pubs/e091.pdf?CFID=3643806&CFTOKEN=11807860
126 See http://www.nrdc.org/air/energy/fappl.asp and http://www.nrdc.org/globalWarming/cap2.0/files/kick.pdf
127 http://www.eia.doe.gov/oiaf/servicerpt/subsidy2/pdf/subsidy08.pdf
128 For detailed comparison of state net metering policies, see: http://www.irecusa.org/index.php?id=90
129 http://www.dsireusa.org/summarymaps/index.cfm?ee=0&RE=1
130 A national map of states where electric and gas utility revenue decoupling is both pending and implemented: http://www.raponline.org/docs/NRDC_Decoupling%20Maps%20US_2009_08.pdf
131 A basic overview of utility revenue decoupling - structure and mechanics is explained: http://www.raponline.org/docs/RAP_Sedano_UtilityBusinessModelAndEE_2009_07_15.pdf
132 http://www.aga.org/Legislative/RatesRegulatoryIssues/ratesregpolicy/Issues/Decoupling/
133 http://www.dsireusa.org/library/includes/incentive2.cfm?Incentive_Code=US05F&State=federal&currentpageid=1&ee=1&re=1
134 http://www.dsireusa.org/library/includes/incentive2.cfm?Incentive_Code=US46F&State=federal&currentpageid=1&ee=1&re=1
135 http://www.dsireusa.org/library/includes/incentive2.cfm?Incentive_Code=US02F&State=federal&currentpageid=1&ee=1&re=1
136 http://www.dsireusa.org/library/includes/incentive2.cfm?Incentive_Code=US13F&State=federal&currentpageid=1&ee=1&re=1
137 http://www.dsireusa.org/library/includes/incentive2.cfm?Incentive_Code=US06F&State=federal&currentpageid=1&ee=1&re=1
138 http://www.dsireusa.org/library/includes/incentive2.cfm?Incentive_Code=US53F&State=federal&currentpageid=1&ee=1&re=1
139 http://www.dsireusa.org/library/includes/incentive2.cfm?Incentive_Code=US37F&State=federal&currentpageid=1&ee=1&re=1
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145 http://www.dsireusa.org/incentives/index.cfm?re=1&ee=1&spv=0&st=0&srp=1&state=AR