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A Clean Energy Economy for Montana

Analysis of the Rural Economic Development Potential of Renewable Resources

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Executive Summary

Montana, the fourth-largest state, is known as "Big Sky" country for its extensive vistas. It also has a remarkably varied landscape, with mountains and valleys, rivers and plains, lakes, forests, and farmlands. Rich in natural resources and fertile land, Montana has a historically stable and increasingly diverse economy. But the global economic downturn has been felt across the state, with the number of unemployed Montanans climbing by 69 percent since the beginning of 2008.[1]

Montana can use its bountiful renewable resources to build a strong long-term economy and secure a prosperous future for the 21st century. Vast areas of land, a multitude of wind energy sites, and a capable workforce combine to give Montana the potential to become a national leader in producing clean energy. Taking advantage of these opportunities for renewable energy development would create tens of thousands of new Montana jobs and give a big boost to rural communities across the state. Instead of sending more Montana dollars out of state to pay for fossil-fueled energy, Montana could become a key supplier of homegrown renewable energy and the tools to produce it—provided that national policies are enacted to spur the development of clean energy resources.

The following chart summarizes the estimated realizable energy potential of key Montana renewable resources over a period of years, if a national clean energy strategy is put in place:

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

Energy Source	Potential Output Estimate	Effect on Montana Energy Production	Carbon Dioxide Emissions Reduction	Economic Benefit
Wind Power	25 wind farms averaging 150 MW = 12.4 million MWh of electricity per year[2]	Wind energy worth $700 million could be produced each year[3]	10.9 million metric tons[4]	1,050 permanent jobs, $152 million per year in local economic impact
Biofuels	175 million gallons potential from existing crop residues[5]	Equivalent to 37% of Montana gasoline replaced with biofuels	1.5 million metric tons[6]	Adding dedicated energy crops, 10 cellulosic ethanol plants would create 2,310 total jobs
Biopower	Replacing 10% of coal use with biomass would mean 1.8 million MWh[7]	1/8 of Montana's electricity consumption would be biopowered	1.6 million metric tons	520 net new jobs created
Biogas	4,000 metric tons of methane	14,000 MWh of electricity	Equivalent to 84,000 metric tons of CO_2[8]	$1 million worth of homegrown energy per year
Energy Efficiency	15% electricity savings and 10% natural gas savings by 2020[9]	Annual electricity savings of 1.1 million MWh, gas savings of 32.9 million therms	800,000 metric tons	533 net jobs created, $342 million in net energy savings

Energy Imports Are a Drag on the Montana Economy

Montana's energy usage is substantially higher than average—the state ranks sixth in the country in per capita energy consumption—but most of Montanans' energy dollars are literally going up in smoke.[10] Fossil fuels dominate, although the state is a leading producer of hydroelectric power. Each year Montanans spend $4.1 billion on gasoline and other petroleum fuels; natural gas for heating, power, and industrial use; and coal for electricity production.[11] That translates to more than $4,200 in yearly fuel costs per person. Even though the state is the nation's 15th-largest fossil fuel producer, the cost of Montana's fossil fuel imports exceeds its total production by 28 percent, resulting in a net economic outflow of more than $1 billion.[12,13]

About $500 million worth of natural gas is produced annually in Montana, which is not much more than in-state consumption.[14,15] Production of oil totaled 31.5 million barrels in 2008, about 2 percent of U.S. production, but statewide petroleum consumption exceeded that by 21 percent.[16] Only coal shows a significant surplus of production over consumption, with exports to other states accounting for about three-quarters of the coal mined in Montana.[17] However, the state's coal output has grown very slowly in the past 15 years because of high mining costs and pollution levels.[18,19] Shipping costs are also very high, making coal an increasingly uneconomic resource.[20] In addition, coal faces an uncertain future in a carbon-constrained world.

New national policies are needed to propel clean energy development and reduce energy consumption. The Energy Information Administration (EIA), a division of the U.S. Department of Energy, forecasts that a rebounding economy and growing population will drive an average increase in domestic electricity demand of 1 percent per year in the long run.[21] If Montana's generating capacity were to increase at this rate, almost 900 megawatts (MW) of new generating capacity would be built in Montana over the next 15 years.[22,23] Meeting such increased electricity demand with today's fuel mix would add 1.6 million metric tons of carbon dioxide to Montana's annual emissions by 2025, which is the equivalent of putting 335,000 more cars on the road.[24]

Clean Energy Policy Can Create Good Jobs in Montana

New clean energy jobs would be especially valuable to Montana, which ranks 42nd in the nation in per capita income.[25] A study cosponsored by NRDC and conducted by the Political Economy Research Institute (PERI) of the University of Massachusetts found that clean energy employment in the United States expanded by more than 9 percent during the 10 years ending in 2007. However, Montana had less than 1 percent growth in clean energy jobs during a decade in which overall Montana jobs grew by almost 13 percent.[26] Policies to promote renewable resource development could provide a big boost to Montana's economy.

Many more jobs are created in the production of clean energy compared to fossil fuel, 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. The study found that clean energy investment creates 3.6 times more jobs for people without a college education and 2.6 times more jobs for people with a college degree.

Montana could become a center of clean energy production and of manufacturing components for clean 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 10 years would largely stabilize emissions of global warming pollution by producing 25 percent of America's electricity from renewable resources. This increase could result in the creation of 750 additional manufacturing jobs in Montana.[27] REPP calculated that wind and solar energy generate 5.7 person-years of employment per million dollars in investment over 10 years, whereas the coal power industry generates only 3.96 person-years per million dollars over the same period.[28]

"Renewable energy provides the opportunity for jobs, economic growth, and tax base enhancement all across Montana," said Montana governor, Brian Schweitzer, as he began a trip to Europe in the summer of 2009 for meetings with eight firms considering investing in Montana. One of these firms, Fuhrlaender AG, a German wind turbine manufacturer, is proposing to build a $25 million plant in Butte to produce some of the world's largest wind turbines.

The facility would initially employ 150 people, with potential for a workforce of 750. Although the economic downturn and uncertainty about federal energy policy have delayed construction, the company is committed to building the plant when demand for wind power components expands.[29]

Energy Efficiency Investment Would Be a Boon for Montana

Increasing energy efficiency is vital for Montana. In 2009 the state ranked 31st in the "2009 State Energy Efficiency Scorecard" published by the American Council for an Energy-Efficient Economy (ACEEE).[30] The United States could reduce its non-transportation energy usage 23 percent by investing in cost-effective energy efficiency, according to a study cosponsored by a broad group of utilities, the Environmental Protection Agency (EPA), and NRDC.[31] 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."[32]

Greater energy efficiency can lead to lower energy bills and eliminate the need for new fossil-fueled power plants. The Northwest Power and Conservation Council (NWPCC), the regional energy planning agency for western Montana, Idaho, Washington, and Oregon, reports that over the next 20 years the region could meet 85 percent of its new power needs through energy efficiency.[33] Montana's Climate Change Advisory Committee found that investment in energy efficiency and conservation would reduce emissions and save consumers $15 in lower energy bills for each ton of carbon dioxide reduction.[34]

ACEEE studied the projected economic impacts of a proposed national goal of 15 percent electricity savings and 10 percent natural gas savings by 2020. Achieving this goal would create 533 net new jobs within 10 years in Montana and $342 million in savings for the state's consumers. In addition, the energy savings would reduce carbon dioxide emissions in Montana by 800,000 tons, the equivalent of taking 150,000 cars off the road.[35] Today's fossil-intensive energy industry produces only one job in Montana per million dollars of spending, compared with an average of 10 jobs per million dollars of spending in other sectors of the state's economy. ACEEE calculated that an overall 6 percent gain in energy efficiency across all sectors of the Montana economy would produce a net gain of 2,311 jobs.[36]

Renewable Energy Provides Opportunities for Agriculture

Among all states, Montana has the second-largest amount of agricultural land, with 61.4 million acres of actively managed farms and ranches.[37] National policy that curbs greenhouse gas (GHG) emissions and supports renewable resource development would provide excellent business opportunities for farm and ranch operators, including:

- Land leases for wind turbines
- Sale of bioenergy feedstocks
- Sale of energy to local utilities
- Sale of renewable energy credits (RECs)
- Sale of carbon offset credits
- Sale of organic fertilizer
- Sale of animal processed fiber (APF)

MONTANANS OVERWHELMINGLY SUPPORT RENEWABLE ENERGY AND ENERGY EFFICIENCY

Montanans are strongly in favor of renewable resource development and energy efficiency. A scientific survey conducted by the Opinion Research Corporation found that:[38]

- 90 percent of Montanans think the United States should begin phasing out fossil fuels and phasing in clean, renewable energy sources;
- 56 percent of Montanans believe the number one energy priority for elected officials should be fostering energy independence by promoting alternative energy sources such as wind, solar, and efficiency in homes and vehicles;
- 66 percent of Montanans would choose clean energy to power their home if they had a choice, while only 3 percent would choose coal;
- 58 percent of Montanans think national action to address global warming will create new jobs and investment;
- 69 percent of Montanans would support a five-year moratorium on building new coal-fired power plants if there was increased investment in renewable energy and energy efficiency instead.

This report examines the potential for renewable resource development in Montana. Clean energy technologies, particularly wind, biofuels, biopower, biogas, and geothermal energy, present unprecedented opportunities for long-term economic growth in the state's rural communities.

Wind Power

In wind power potential, Montana is second only to Texas, with accessible potential of 370 times the electricity usage of the entire state.[39] However, Montana ranks 18th in wind power development, with existing wind capacity of 375 MW.[40] If 25 commercial-scale wind farms were built in Montana, the result would be tens of thousands of construction jobs, 1,050 permanent jobs, $56 million in annual property tax revenue, and $152 million per year in ongoing positive economic impact on local communities.

Biofuels

Cellulosic ethanol (made from organic waste materials, crop residues, and nonfood plants) and biodiesel (made from algae and oilseeds) are the next generation of smart biofuels. Existing usable Montana crop and timber residues could generate as much as 175 million gallons of transportation biofuels each year, equivalent to 37 percent of all the gasoline used in Montana. An average winter wheat farm could see potential gross revenue of $18,500 annually from harvesting biomass residue. Ten cellulosic plants, each with capacity of 50 million gallons per year, would create 2,310 long-term jobs, $219 million in annual economic activity, and $12.4 million in local property taxes.

Biopower

The same energy crops that can be converted into ethanol-based transportation fuels can also be used for direct production of heat and electricity when chopped, pelletized, or gasified and burned as fuel in biomass-fired power plants. Many sources of sustainably produced biomass are particularly valuable renewable feedstocks because they can be converted into electricity whenever they are needed. If 10 percent of Montana's coal-fired power capacity were replaced with biopower plants, more than 350 long-term jobs would be created.

Biogas

Methane from decomposing manure is a powerful greenhouse gas, with 21 times the global warming effect of carbon dioxide. But burning methane curbs its harmful effect on the environment and creates valuable energy with many ancillary benefits. In addition to providing a potential source of revenue and energy for livestock operations, anaerobic digestion systems (biogas) create high-quality fertilizer and other by-products while reducing odors, water pollution, and emissions. Montana is one of the nation's leading livestock producers but has very few 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. Agstar initiated a new program to help states such as Montana overcome deployment barriers and capture the benefits of biodigester technology.

Geothermal

Geothermal power can supply continuous clean energy with a very small land footprint and almost zero GHG emissions. Use of Montana's many hot springs and wells—not including the lands adjacent to Yellowstone National Park, where geothermal wells are prohibited—can be expanded for heating buildings and for agricultural and industrial processes. Montana also has potential to generate electricity through enhanced geothermal systems that tap the earth's heat from deep underground. However, environmental issues, such as potential seismicity and groundwater effects must be closely examined. Government support of research and development in geothermal technology is crucial to opening the door to this almost limitless clean energy resource.

Solar

Montana's long summer days and plentiful sunshine make it a good place for solar energy production, especially as 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.

NRDC opposes locating any of the new energy facilities discussed above in sensitive areas, such as national parks and monuments, critical wildlife habitat, wild and scenic river corridors, and undeveloped wildlands. In some of these places, energy development is prohibited or limited by law or policy, and in others it would be highly controversial. Natural values are very important to the public, and all energy development decisions must be made carefully. Disruption should be limited to the smallest and least sensitive areas possible, with impacts thoroughly mitigated and operations conducted in an environmentally responsible manner.

Policy Recommendations to Cultivate Clean Energy in Montana 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 level the playing field for renewable energy resources, encourage more efficient energy use by businesses and individuals, and stabilize emissions of global warming pollution. These include:

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

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

- Full-life-cycle carbon accounting that does not result in emissions increases outside the energy system
- Greatly improved vehicle emissions standards
- Transportation planning standards targeted at reducing total vehicle miles traveled by integrating public transit and expanded passenger and freight rail, land use, road congestion relief, and housing strategies
- A low-carbon fuels standard (LCFS)
- Expanded support for renewable energy research and development
- Consistent and fair net metering and interconnection standards for utility-customer-generated renewable electricity
- Enhanced incentives for deployment of advanced energy efficiency technology
- Compliance with the most recent building energy codes for newly constructed buildings and added resources for localities to enforce the codes
- Promotion of performance-based sustainable management practices to protect wildlife habitat, soil, and water resources and to improve the livelihood of local communities

CHAPTER 1

Montana's Wind Power Potential

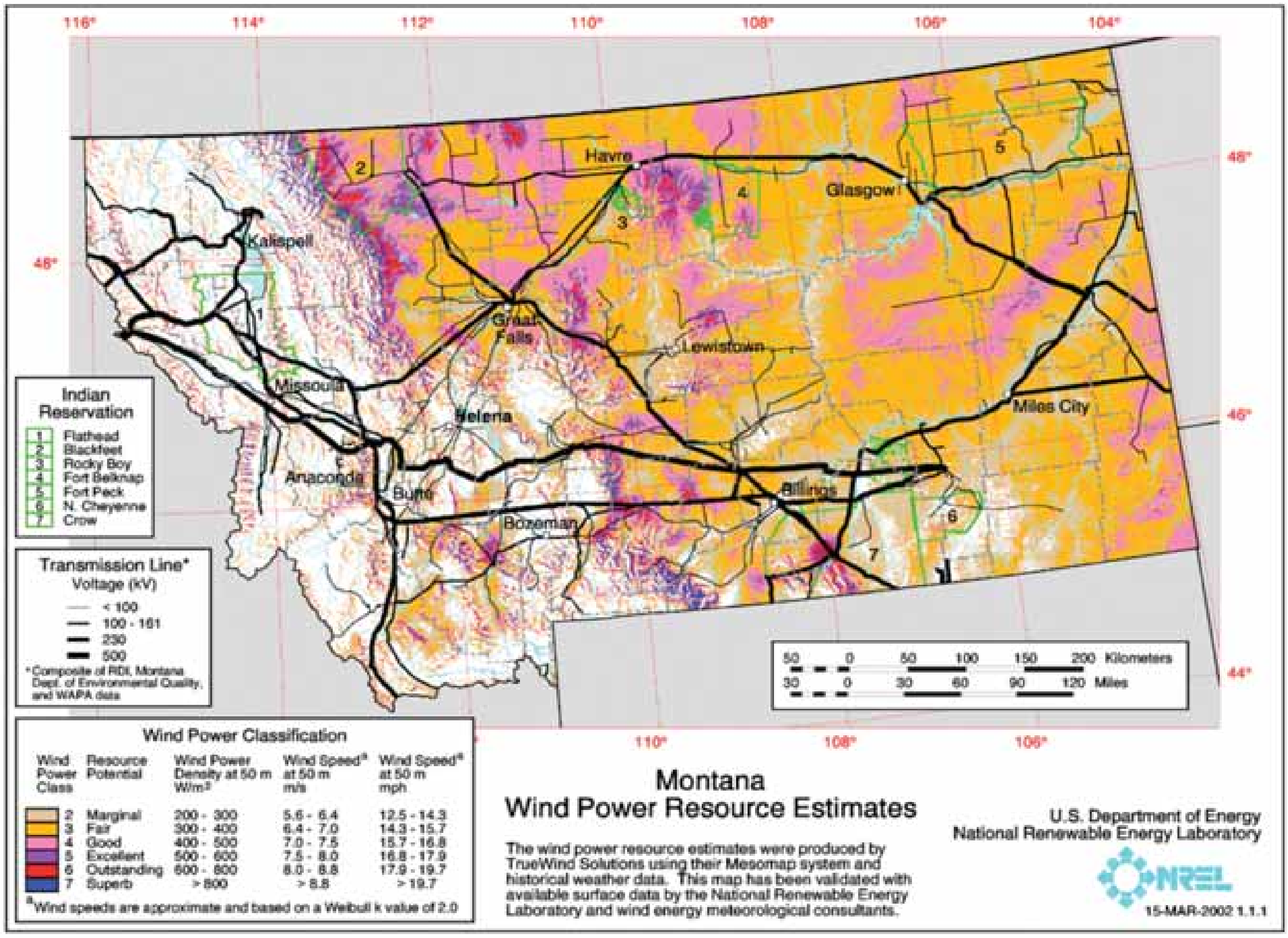
Like other renewable energy sources, wind is inexhaustible, produces no waste, and causes no pollution, and its costs are subject to neither market nor geopolitical volatility. Improvements in wind technology have brought its long-term costs down to a level that is competitive with fossil-fuel energy generation.[41] Wind power continues to be the fastest-growing energy resource in the United States, accounting for 42 percent of all new electric generating capacity in 2008. However, the absence of a coherent national energy strategy caused construction of new wind facilities to fall from 8,500 megawatts (MW) in 2008 to an estimated 5,000 MW in 2009. Total installed wind power capacity has grown to 30,000 MW, enough to supply the electricity needs of 7 million households, which is a small fraction of U.S. potential.[42] Although 1 percent of total U.S. electricity supply comes from wind today, a Department of Energy (DOE) report concluded that 20 percent of America's electric power could be wind generated within 20 years if the right policies are pursued.[43]

Noise from wind turbines was a problem with early designs, but today's turbines are "no noisier than the reading room of a library" from 300 meters, an industry association reports.[44] Modern wind turbines turn relatively slowly, although they still pose a hazard to birds and bats. Constructing turbines and the associated roads and transmission infrastructure can also affect wildlife habitat. A thorough environmental impact analysis in advance of project siting is necessary to mitigate wildlife and natural resource impacts. Some states, such as California, Minnesota, and Washington, have adopted policies requiring environmental review of wind projects, but Montana has no such regulatory framework.

Despite concerns that wind development would reduce the value of surrounding property, a new study by Lawrence Berkeley National Laboratory finds no statistical evidence that local property sale prices decrease after construction of a wind facility.[45] From an agricultural perspective, the presence of wind facilities may actually help maintain the value of nearby farms by demonstrating the commercial viability of local wind resources and the potential income for neighborhood property owners from additional wind development.

Montana has some of the best wind resources in the United States, ranking fifth among all states in commercial wind energy potential, according to the American Wind Energy Association.[46] A study from Harvard University pegs Montana's wind potential as second only to Texas, with accessible wind resources 370 times greater than the state's electricity usage.[47] After completion of several recent projects, Montana ranks 18th in wind power development, with an existing capacity of 375 MW. This tally includes a recent addition of 103.5 MW to the Glacier wind farm, developed by Naturener, a Spanish

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



firm.[48] Taking advantage of a new transmission line between Montana and Alberta, Canada, Naturener is also planning to construct a 300 MW project north of its existing wind farm.

Wind density, a measure of how strongly and steadily 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 strength for wind power development. Following is a map produced by the National Renewable Energy Laboratory (NREL) of the Montana wind technical potential 50 meters above the ground, showing that many parts of the state have commercially viable wind density at that height. The region just east of the Rocky Mountains in northern Montana has exceptional wind resources, as do areas around Great Falls, Lewistown, Havre, Billings, and Bozeman. Many areas on the map would yield much higher wind potential than indicated by using wind turbines 80 or 100 meters tall, which are typical heights for large new wind facilities. After subtracting land that is unsuitable for energy development, such as protected wilderness areas and parks, NREL found that 49.6 percent of Montana's land has good wind power potential, with technical potential totaling 944,000 MW.[49] Although only a tiny fraction of that would ever be developed, almost every county in Montana has some areas suitable for commercial production of wind energy. A national commitment to clean energy would help the state realize the vast potential of its wind resources.

Wind Power Can Pump Up Rural Economies

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

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

Wind Farm—Project Data Summary Based On Model Default Values	
Project Location	MONTANA
Year of Construction	2009
Total Project Size—Nameplate Capacity (MW)	150
Number of Projects (included in total)	1
Turbine Size (kW)	1,500
Number of Turbines	100
Installed Project Cost ($/kW)	$1,969
Annual Direct Operations and Management Cost ($/kW)	$18.88
Money Value (Dollar Year)	2008
Installed Project Cost	$295,296,663
Local Spending	$51,430,453
Total Annual Operational Expenses	$49,923,077
Direct Operating and Maintenance Costs	$2,831,909
Local Spending	$830,204
Other Annual Costs	$47,091,168
Local Spending	$2,678,550
Debt and Equity Payments	$0
Property Taxes	$2,228,550
Land Lease	$450,000

Local Economic Impacts—Summary Results	Jobs	Earnings	Output
During Construction Period			
Project Development and On-site Labor Impacts	92	$4.07	$5.23
Construction and Interconnection Labor	78	$3.57	
Construction-Related Services	15	$0.50	
Turbine and Supply Chain Impacts	538	$14.84	$59.79
Induced Impacts	176	$4.46	$16.17
Total Impacts	**806**	**$23.37**	**$81.19**
During Operating Years (Annual)			
Onsite Labor Impacts	9	$0.41	$0.41
Local Revenue and Supply Chain Impacts	13	$0.40	$3.80
Induced Impacts	20	$0.51	$1.85
Total Impacts	**42**	**$1.32**	**$6.06**

NOTE: Earnings and Output values are millions of dollars in year-2008 dollars. Construction and operating jobs are full-time equivalent for a period of one year (1 FTE = 2,080 hours). Wind farm workers include field technicians, administration, and management. Economic impacts "During Operating Years" represent impacts that occur from wind farm operations/expenditures. The analysis does not include impacts associated with spending of wind farm "profits" and assumes no tax abatement unless noted. Totals may not add up due to independent rounding. Results are based on model default values.

According to this DOE analysis, a 150-MW wind project in Montana would produce 806 jobs and $81.2 million in local economic activity during its construction phase. Operating the plant would generate 42 full-time-equivalent local jobs, $2,228,550 in property taxes, and $6.1 million in economic benefit to the local economy each year. If 25 such wind facilities were built in Montana (for 3,750 MW of wind power, an achievable goal), the result would be tens of thousands of construction jobs, 1,050 permanent jobs, $56 million in annual property tax revenue, and $152 million per year in ongoing positive economic impact on local communities.[50] At a market price of $60 per megawatt-hour (MWh), these projects could generate almost $750 million in annual sales.[51]

Wind Power Creates Opportunities for Farmers and Communities

The average-size private landholding that is actively managed in Montana (e.g., farms and ranches) is 2,079 acres. Almost 10,000 of these holdings are larger than 1,000 acres, and 7,000 exceed 2,000 acres.[52] A typical wind project would involve dozens of turbines erected on a group of adjacent farms. Large turbines are typically 1.5 to 2.5 MW in capacity.[53] 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 reach them have a footprint of only about one-half acre per turbine—the rest of the land can be farmed or grazed—but the towers need to be spaced apart to take maximum advantage of the wind and avoid interfering with each other. A 2,000-acre farm could accommodate 16 to 25 wind turbines totaling 40 MW and receive $120,000 in guaranteed annual income from land-lease payments without significantly reducing its crop or livestock production. A 150-MW wind project would have 60 to 100 turbines spread across three or four typical Montana ranches.

Under the most common model for wind power development, a private project developer raises the capital, arranges for construction, leases the necessary land from farmers, arranges contracts for the sale of the energy output, and owns and operates the facility. However, a promising option known as community wind provides greater local benefits than does wind development by distant third parties. 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 have 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 did "not show strong evidence of economies of scale."[54] Smaller-scale projects producing power for local consumption don't need direct connections to interstate transmission lines.

Financing a wind facility of any size 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 up-front grants instead of long-term tax credits, making it easier to build new facilities in the economic downturn. The Government Accountability Office (GAO) reports that farmers could "double or triple" their wind power income through ownership rather than land-lease arrangements.[55]

Transmission Expansion Must Minimize Environmental Impacts

With just 3 percent of its electricity generation coming from wind today, Montana has a long way to go before it will meet a significant portion of in-state electricity demand with wind power.[56] But if cleaner energy becomes national policy, Montana has the ability to capitalize on its extraordinary wind resources and become a cost-effective source of energy for places with less-robust wind—if transmission capacity can accommodate it.

Several Montana transmission projects are at various stages of development. A 214-mile high-voltage transmission line between Great Falls and Alberta, Canada, is under construction, with its capacity contracted to wind power developers. A line with capacity of 1,500 MW, the Mountain States Transmission Intertie, has been proposed by NorthWestern Energy, the dominant utility in Montana, to expand transmission capacity from southwestern Montana to southern Idaho. A Canadian company recently received permission from the Federal Energy Regulatory Commission (FERC) to begin marketing its Chinook project, which, if eventually approved by regulators and constructed, would be able to carry 3,000 MW of power along a 1,000-mile route from Harlowtown, Montana, to south of Las Vegas.[57]

However, a continuing series of piecemeal development initiatives is not likely to result in a sound long-term solution to the transmission problem. Every transmission line has some negative effect on the landscape and the local ecosystem, so it is essential to use existing corridors and rights-of-way where possible. How to expand interstate transmission capacity to most efficiently meet the nation's clean energy needs is the subject of intense study and policy analysis by DOE, FERC, the North American Electric Reliability Corp. (NERC) and its delegate entities like the Western Electricity Coordinating Council (WECC) and regional utilities. The relative costs and benefits of different transmission policy options must be weighed in the context of achieving overall clean energy goals. As a first step, transmission expansion policy should be coupled with constraints on carbon dioxide emissions in order to realize the potential of wind and other renewable energy resources without increasing global warming pollution from fossil-fuel-based generators.

All energy and transmission development in Montana, a state with some of the nation's largest intact natural ecosystems, must be carefully planned, sited, and constructed to avoid putting new lines in sensitive wildlife areas and to minimize impact on the landscape. By taking a long-term, proactive, and comprehensive approach rather than allowing ad hoc transmission expansion, policy makers can assure that Montana achieves the complementary goals of clean energy development and protection of the natural environment.

Growth of Wind Power Will Provide a Big Economic Boost to Montana

The emergence of a large domestic wind power industry would be a boon to many rural communities in Montana. It would also mean a new market for manufacturers of the components that go into wind turbines, towers, and other renewable energy facilities. A Renewable Energy Policy Project (REPP) study identified 90 firms in Montana with capability to manufacture components of clean energy facilities.[58] In fact, because of its location in one of the nation's prime wind zones, Montana has the potential to become a center of advanced wind component manufacturing. Fuhrlaender AG, a German wind turbine manufacturer, is already planning to build a $25 million plant in Butte to produce some of the world's largest wind turbines. The facility would initially employ 150 people, with potential for a workforce of 750. Although the economic downturn and uncertainty about federal energy policy have delayed construction, the company remains committed to building the plant when demand for wind power components expands.[59]

CHAPTER 2

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

The term "biomass energy" refers to a wide range of fuels derived from crops, wood, and waste. The energy in plants starts out as solar energy, which is absorbed through photosynthesis and can later be converted to other forms of energy, either by burning biomass as a solid, fermenting it into a liquid, or decomposing it into gases. In solid dry form, energy crops and crop residues can be used to replace coal and natural gas as fuel for "biopower" electricity. Biochemical and thermal processes are employed to turn biomass into liquids such as ethanol and biodiesel, known as "biofuels," which can replace or be blended with gasoline and diesel fuel for cars and trucks. "Biogas" produced from animal waste and other organic waste materials can be used to generate heat and electricity. Biomass recently surpassed hydropower as the largest source of renewable energy in the United States, but it still accounts for just 3 percent of all domestic energy consumption.

Using biomass energy can result in far less global warming pollution than fossil fuels, if the release of carbon dioxide when plants are converted into energy is balanced by the absorption of carbon dioxide from the air when new plants grow. To fully understand the carbon balance of different biomass resources, we have to thoroughly account for direct impacts to the soil, the energy and emissions involved in cultivation, and indirect land use impacts. Some sources of biomass are actually carbon sinks over time, while others release more carbon than fossil fuels. It is important to the environment that biomass resources be managed and produced sustainably. Practices should avoid direct impacts to resources such as soil, water, and wildlife habitat, as well as indirect land use impacts.

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

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

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

Sustainably Produced Biofuels Can Reap Economic and Environmental Benefits

National policies to support growth of a sustainable biomass energy industry would open big new markets for Montana agricultural products. According to studies by the National Research Council and the Union of Concerned Scientists, the United States could produce between 370 and 550 million tons of biomass for energy use by 2020 from sustainably sourced lands and feedstocks.[60] Such resources would provide real climate benefits and be protective of wildlife and soil and water quality, but the market will move away from conventional food-based bioenergy to these low-carbon sources only if our policies account for the carbon correctly.

Crops with usable energy content are already grown across much of Montana, and the state ranks third nationally in the production of wheat. Using wheat straw can create valuable energy without any sacrifice in food production. Montana is also well suited for growing nonedible oil feedstocks for biofuel production. A crop such as camelina, also known as wild flax, can be inexpensively grown on marginal land with little moisture. Camelina has twice the oil yield of soy, and residues left over after the oil is extracted can make high-quality animal feed and other products such as fiberboard. When rotated with wheat, cultivation of camelina increases subsequent wheat yields by 15 percent.[61] Sustainable Oils, based in Bozeman, has an initial contract to supply 40,000 gallons of camelina-based jet fuel for testing by the U.S. Navy.[62]

Most gasoline in the United States already comes blended with 10 percent ethanol, a biofuel produced today primarily from corn. Wheat can also be fermented to produce ethanol. However, producing ethanol from food crops like corn and wheat can drive up food prices (as well as ethanol prices) and cause undesirable land use changes. Crucial new technology is being developed to make ethanol from crop residues and nonfood plants and to make oil-based biofuels from nonfood crops like camelina and algae.

Instead of using edible plant sugars and starches, next-generation biofuels are made by breaking down the fibrous material that makes up the nonedible cellulose structure of plants. These cellulosic biofuels can be made from almost any kind of plant or wood waste, including wheat straw, corn stover, forest residue, mill waste, and high-density energy crops such as switchgrass and poplar.

Creating four to ten times as much energy output as the amount of energy used to grow the crops and produce the fuel, cellulosic biofuels have a relatively high energy balance.[63] In contrast, ethanol produced from corn today provides only about 25 percent more energy than the amount that goes into it. Adding to its advantages over conventional biofuels, potential cellulosic ethanol yield using dedicated energy crops is far greater than the 400 gallons per acre achieved by the most efficient corn ethanol production process.[64] The by-products of cellulosic ethanol production can include protein for animal feed and enough solid matter to fuel electricity generation to run the production plant, with potentially some excess power and renewable energy certificates left over to sell on the market.[65]

Just as growing corn can have significant impacts on soil, water, and wildlife, so can all the different potential sources of cellulosic biomass. Whatever feedstock is used to produce energy, biomass resources must be managed in a way that protects soil fertility, water quality, and wildlife habitat. Montana is not part of the corn belt and is well equipped to benefit from a move beyond food crops as a source of biomass, provided that careful bioenergy policies are put in place to fully account for the environmental effects of different types of biomass management practices.

Cellulosic Ethanol Is on the Verge of Commercialization

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. 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 12 years from now. 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 production to industrial scale, and more than a dozen pilot plants are at different stages of design, construction, and operation.[66] A plant is being built by AE Biofuels in Butte, Montana, to demonstrate new technology employing both starch-based and cellulosic feedstocks to produce ethanol in an integrated process.[67]

Montana legislators passed a bill in 2005 mandating that all gasoline be blended with 10 percent ethanol, but it doesn't go into effect until after the state's annual ethanol production capacity reaches 40 million gallons.[68] Today the state has no commercial facilities producing ethanol, but the emergence of sustainably produced cellulosic ethanol could become the catalyst for a new industry in Montana. In order for real climate and environmental benefits to be realized from any type of renewable biomass, we must account for all emissions associated with production of the resource, including direct and indirect land use changes, and we must safeguard sensitive federal lands and critical wildlife habitat. Failure to measure these impacts correctly will mean more conventional biofuels in the states that already dominate that market and less investment in new sources of biomass where Montana can play an important role.

Montana Already Has Feedstock for Biomass Energy

Montana has a small population but the seventh-largest acreage of cropland, with ample resources for large-scale biomass energy production.[69] The initial feedstocks needed to launch a biopower industry are literally lying on the ground. Taking into consideration only those feedstocks that would be available for energy production (after leaving a portion of crop residue in the field to maintain soil productivity and subtracting wood waste that is already productively used), Montana annually produces the following:[70]

- 1.56 million dry tons of crop residue, primarily wheat straw[71]
- 704,000 dry tons of forest residues[72]
- 41,000 dry tons of unused primary mill residues[73]
- 13,000 dry tons of secondary mill residues[74]
- 106,000 dry tons of urban wood residues[75]

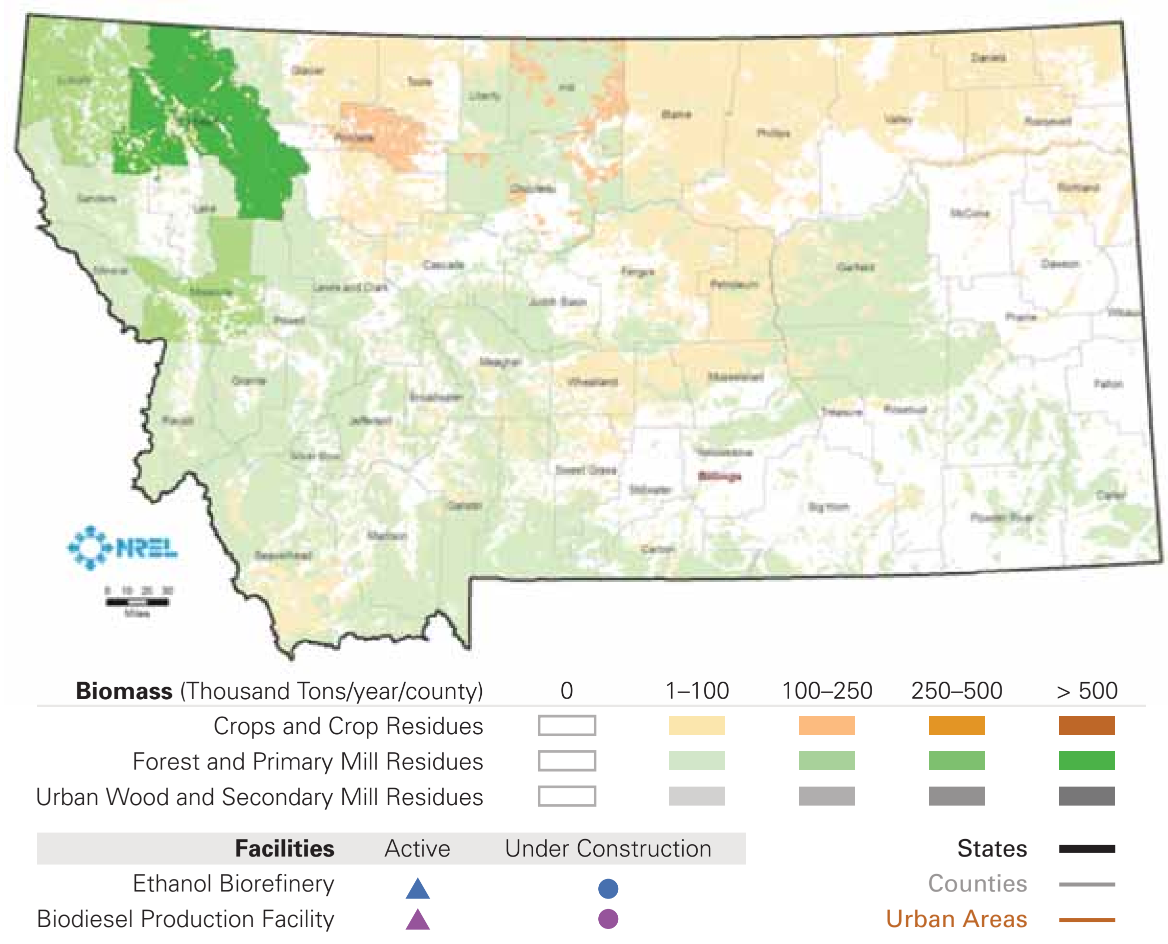
Altogether, the potential biomass feedstock in Montana amounts to almost 2.5 million tons each year—without including any new dedicated energy crops. However, these estimates need to be carefully evaluated to determine whether they adequately account for potential impacts to soil fertility, water quality, and critical wildlife habitat.

What can be done with 2.5 million tons of biomass? If all of it were devoted to producing cellulosic ethanol, it would be enough feedstock to produce 175 million gallons of biofuels each year, equivalent to 37 percent of all the gasoline used in Montana.[76,77] Burned in power plants, it would be enough biomass to generate 6.3 million megawatt-hours (MWh) of electricity, which is more than one-fifth of Montana's annual electricity production.[78] Replacing that much fossil fuel with clean energy would reduce carbon dioxide emissions by more than 1.5 million tons, equivalent to removing 326,000 cars from Montana roads.[79]

Sustainably harvesting farm and forest residue as biomass feedstock could also produce significant revenue. Current estimates for the future value of crop-residue biomass are about $35 to $60 per ton, so the gross revenue derived from agricultural waste materials could be about $54 to $94 million.[80] Assuming a price of $40 per ton, and a yield of 0.6 dry ton of usable residue per acre, this equates to about $18,500 in potential gross revenue for the average Montana wheat farm of 730 acres.[81] The typical Montana corn farm is much smaller, averaging 130 acres. But with a usable yield of about 1.3 tons of stover per acre, it could see gross revenue of $6,700.[82] Net income would be reduced by the costs of collecting, processing, and storing the biomass, and transporting it more than about 50 to 100 miles could be uneconomical. The costs of recovering forest residues from logging in Montana and other northwestern states has been estimated at $32 to $92 per ton, depending on location and other site-specific factors.[83]

The following map of potential crop and forest residue biomass in Montana was created by NREL.

Figure 2: Map of Existing Residue Biomass in Montana Counties



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.

The potential for biomass production from Montana crops can be further supplemented by dedicated energy crops grown sustainably on appropriate marginal or degraded lands. In addition to oil crops such as camelina, many other fast-growing plants can be cultivated in Montana's climate as feedstock for biofuels or biopower. Perennial plants such as switchgrass, a tall-growing native prairie grass that does well in much of eastern Montana, and fast-growing hybrid poplars and willow trees can be cultivated without much fertilizer on marginal land that is not suitable for row crops.[84] These plants have shown yields of 10 to 25 dry tons per acre (far more than the biomass yield of corn or soybeans) and they will regenerate without replanting, some for decades.[85] Just as corn yields have increased fourfold 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. When evaluating the potential for any new energy crop, it will be important to assess the crop's potential invasiveness to avoid introducing a plant that could threaten native biodiversity. In addition, the establishment of bioenergy crops should not displace food or fiber crops, or the impact on land use from that displaced demand will need to be taken into account. Native habitat, such as natural forests, wetlands and native grasslands, should not be converted to bioenergy production. On the other hand, if energy 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 Montana. The DOE's Jobs and Economic Development Impact (JEDI) model 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 biochemical cellulosic ethanol plant in Montana that produces 50 million gallons per year.

Table 3: Predicted Economic Impact of a Montana Cellulosic Ethanol Plant

Cellulosic Ethanol Plant—Project Data Summary	
Project Location	MONTANA
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)	$34.74
Produced Locally	100%
New Production	25%
Feedstock Supplier	
Farmer	100%
Wholesaler	0%
Fixed Operations and Maintenance Cost ($/Gal.)	$0.11
Non-Fuel Variable Operations and Maintenance Cost ($/Gal.)	$0.22
Money Value—Current or Constant (Dollar Year)	2005
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 On-site Labor Impacts	525	$37.53	$55.79
Construction Labor	416	$34.14	
Construction-Related Services	109	$3.39	
Equipment and Supply Chain Impacts	364	$9.19	$31.31
Induced Impacts	286	$6.70	$24.28
Total Impacts (Direct, Indirect, Induced)	**1,175**	**$53.41**	**$111.38**
During Operating Years (Annual)			
On-site Labor Impacts	57	$2.07	$2.07
Local Revenue and Supply Chain Impacts	124	$2.82	
Agricultural Sector Only	23	$0.49	
Other Industries	101	$2.33	
Induced Impacts	51	$1.19	$4.30
Total Impacts (Direct, Indirect, Induced)	**231**	**$6.08**	**$21.90**

NOTE: Earnings and Output values are millions of dollars in year-2005 dollars. Construction period–related jobs are full-time equivalent for the three-year construction period. Plant workers include 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.

According to this DOE analysis, a cellulosic ethanol plant producing 50 million gallons per year would generate 390 full-time jobs for the duration of its three-year construction phase and $111 million in local economic activity. Operation of the plant would create 231 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 Montana (if dedicated energy crops and/or forest residues are used as feedstock in addition to crop residue), would produce 2,310 jobs, $219 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 liquid transportation fuels can also be used for direct production of heat and electricity when shredded, gasified, or pelletized and burned as fuel in biomass-fired power plants. As with biofuels, the same consideration must be given to the appropriateness of the land and crop for cultivation; the need to avoid displacement of food and fiber crops; and the adoption of practices that enhance soil fertility, maximize water efficiency, protect water quality, and ensure that native wildlife habitat is protected. Dried manure from cattle feedlots can also be a cost-effective biopower fuel.

Sustainably produced biomass energy feedstocks can be stored to make biopower when it is needed, making biopower a perfect clean-energy complement to the variable output of wind and solar power. Biomass boilers are already used to heat buildings in Montana, including schools in 10 districts that participate in the state's Fuels for Schools program. A study conducted under the joint DOE/USDA Biomass Research and Development Initiative indicates that biomass potentially could provide nearly one-quarter of Montana's energy consumption.[86]

Today there are 120 biomass-fired electric power plants in the United States and 48 facilities that co-fire biomass with coal; none are located in Montana.[87] The largest biopower facility in the United States, a 100-MW plant fueled by wood residue, is under construction in Texas.[88] The Montana Community Development Corporation has begun working with eight sawmills and NorthWestern Energy to overcome existing barriers to the use of sawmill waste to produce electricity.[89] State grants have been awarded for feasibility studies of the construction of biomass plants in western Montana that would primarily burn forest residue to generate electricity.[90]

Harvesting Biomass Can Cultivate Jobs

If 10 percent of the coal Montana currently burns to generate electricity were replaced by biomass, it would create annual demand for about 2.5 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 of them 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 3 direct and indirect new jobs per megawatt of biopower capacity, if 10 percent of Montana's coal-fired capacity were replaced with biopower, more than 435 net long-term jobs would be created to produce and harvest the biomass feedstock, providing an indirect local economic stimulus.[95]

Dedicated Energy Crops Could Fire Up Bioenergy Output

The energy content of biomass varies, but it takes about 400 to 700 acres of dedicated biomass crops to fuel 1 MW of generating capacity for a year, producing enough electricity to power 600 to 900 homes.[96] While the amount of land needed for substantial electricity production from dedicated energy crops is not insignificant, and while many areas are inappropriate for energy crops, sustainable cultivation of energy crops on a very small portion of Montana's 94 million acres would be sufficient for extensive biopower production.

Biogas Has Multiple Benefits

When animal manure or other organic matter decomposes in the absence of oxygen, it produces a gas containing 60 to 70 percent methane. If released into the atmosphere, methane is a powerful greenhouse gas, with 23 times the global warming effect of carbon dioxide. But burning methane curbs its harmful effect on the climate and releases large amounts of useful energy. Methane is a relatively clean fuel that is the main component of the natural gas and propane used to heat homes; to fire stoves, ovens, and hot water heaters; and to generate electricity. By capturing methane, 496 landfills across the country turn decomposing garbage into a valuable energy resource.[97] Montana has four landfills that have been identified as good candidates for landfill gas projects, but the only operating facility is in Flathead County, where each year 1.6 million tons of garbage generate 1 MW of power for the local electric cooperative.[98] Other Montana cities and counties, in cooperation with their local utility, are also evaluating the development of a landfill gas project to produce pipeline-quality gas for use in homes, businesses, and facilities.

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 in use, the most common of which is a heated plug flow tank system. Other biodigester types include covered manure lagoons from which biogas is piped to a generator, and complete mix systems, which are primarily used in dairy operations. Some systems are capable of codigestion, which allows other kinds 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 by-products

Sizable biodigesters and related equipment require an investment of $300,000 to $900,000 or more, with many site-specific cost variables.[99] Although some support is available in the form of state and federal grants and tax credits, the technology is presently used only at 135 large-scale concentrated animal feeding operations (CAFOs) in the United States (compared with about 3,000 farm-scale biodigesters operating in Europe).[100] The joint EPA, DOE, and USDA AgSTAR program estimates that there are 7,000 dairy and swine operations in the United States with more than 500 head of dairy cows or 2,000 swine that are good candidates for profitable biodigester systems.[101]

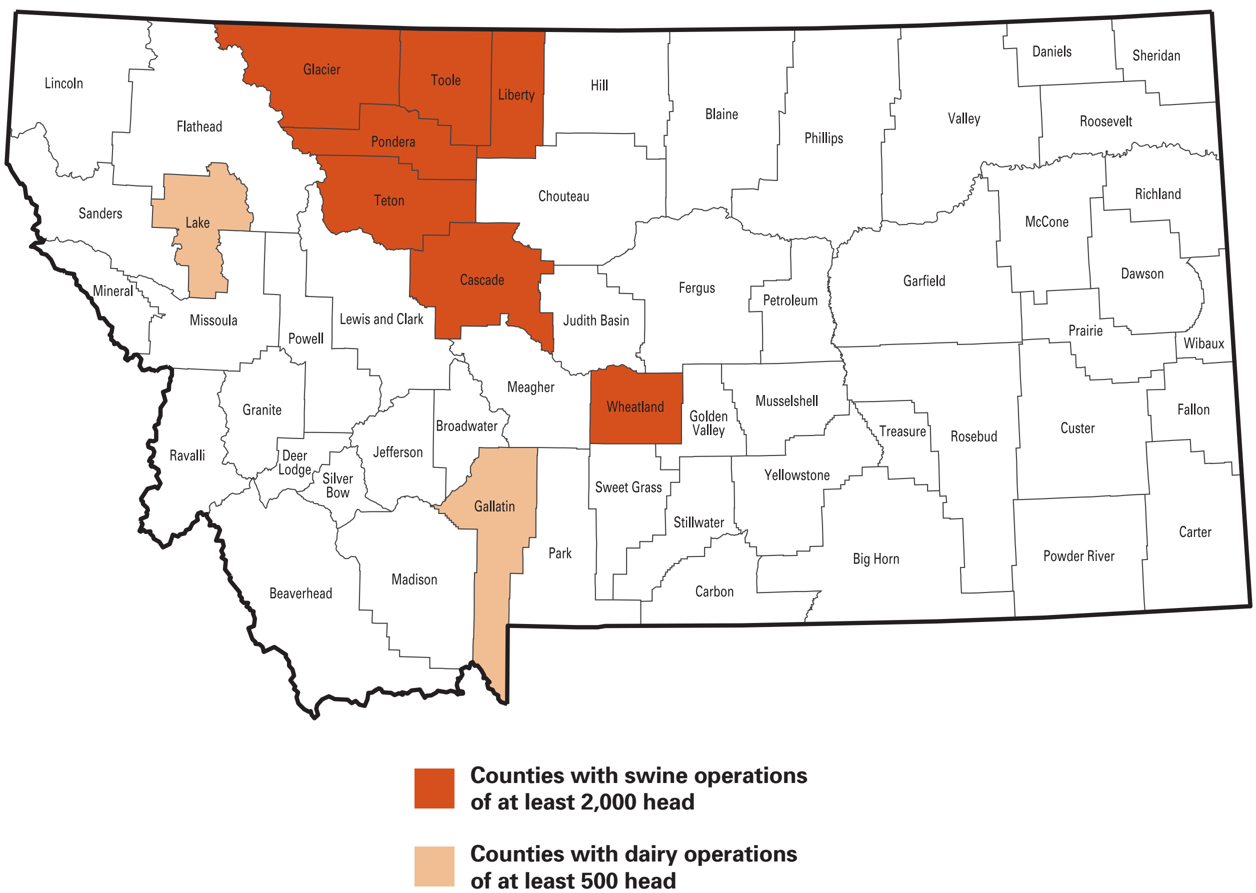
Montana is a leading livestock producer, ranking 11th in the United States in cattle and 26th in swine.[102] According to NREL, Montana has manure management systems producing more than 4,000 tons of methane per year.[103] If all these emissions were converted into energy, livestock manure could generate almost 14,000 MWh of energy per year.[104] At the average commercial retail electricity rate of $0.08/KWh, this would yield more than $1 million of homegrown power each year, assuming biogas production were eligible for net metering treatment.[105] Additional future revenue could be derived from renewable energy certificates and the potential value of carbon emission credits for burning 4,000 tons of methane, if federal policies to limit greenhouse gas emissions were enacted.[106] While not all manure-based methane can be captured for energy use, Montana has potential for biogas production.

The statewide livestock inventory includes 181,000 hogs and pigs, with 37 swine operations of more than 2,000 head and 14 with more than 5,000 head.[107] 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. Montana is home to just four dairy farms 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 22 Montana dairies with 200 to 500 cows, to pool their manure resources to create scale economies, as is presently done at several locations in other states.

Montana's first anaerobic biodigester at a dairy farm is operational in Corvallis, where the waste from 360 cows produces enough electricity to provide heat and power to the whole operation, including the farm home.[108]

Following (on page 13) is a Montana map showing nine counties with livestock operations large enough to potentially benefit from farm bioenergy systems:

Figure 3: Montana Counties with Livestock Operations Able to Support Methane Biodigester Systems



Montana has barely begun to take advantage of its animal-based bioenergy potential. But with the right set of supportive government policies in place, the benefits of these technologies to Montana's livestock operators and its environment could be realized within a few years.

Montana Farmers Can Benefit from Bioenergy Production

Just as conventional biofuels have boomed in the corn states of the Midwest, production of bioenergy in Montana can likewise become an important farm business opportunity if curbing greenhouse gas emissions becomes national policy. Farmers would benefit from multiple potential revenue streams in addition to the sale of energy crops and residues, including:

- Sale of energy to local utility companies. Producing renewable electricity on the farm can reduce or eliminate monthly electric bills through net metering. Montana is among 44 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. Production of renewable energy makes the customer's electric meter run backward to reduce the net monthly electricity bill.[109] However, in a national assessment by the Network for New Energy Choices, Montana received a grade of F for its restrictive policies on interconnecting small renewable electricity generators to the utility grid.[110] It got a C for its net metering policies because eligible technologies are currently limited to solar, wind, and hydro, with eligible system sizes capped at 50 kilowatts. Rural cooperatives and municipal electric companies are not required to participate.[111] New federal and state laws are needed to make sure all renewable technologies, including biogas-generated energy, are eligible for net metering and to standardize interconnection policies and make it easy to plug in clean energy.

- Sale of renewable energy certificates (RECs). Each megawatt-hour of renewable electricity is given a REC (sometimes called a Green Tag) as proof of its clean origin. These RECs can be bought and sold in trading markets. The buyers include utilities that are required to purchase green power as well as 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 bioenergy production.
- Sale of carbon offset credits. Under a national carbon reduction strategy that includes offsets (which the U.S. Senate is considering in several bills), when a project in a sector not covered by the emissions cap 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. Because agriculture is not covered under the emissions cap, agricultural producers can generate carbon offset credits for sale to industries operating under emissions caps. These carbon offset credits could become a valuable new source of revenue for Montana farmers and ranchers.[112]

In addition to reducing direct greenhouse gas emissions—for example, by capturing livestock methane through biodigesters or reducing the use of nitrogen fertilizers—another opportunity for farmers to generate carbon offset credits is to enhance the process by which carbon dioxide is absorbed from the air and stored in the soil. Certain soil management 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. Other examples of carbon-sequestering practices include cover cropping, planting trees on marginal lands, and maintaining riparian buffers. Any assessment of soil carbon sequestration must be subject to site-specific review of soil capacity and farming practices. Future innovations in farm-level enhancement of carbon sequestration methods may provide new options for generating offset credits.

A carbon offset program must include strict measurement and verification standards to ensure that any claims of direct emissions reduction and/or carbon sequestration are demonstrably over and above what would have happened under business as usual in the absence of the offset credit. In 2015, Montana will have the potential to produce carbon offsets totaling 5 million metric tons of carbon dioxide equivalent ($MMtCO_2e$) from projects in agricultural, landfill gas, and forestry, bringing in revenue of $35.5 million. In 2030 this potential will increase to 10.3 $MMtCO_2e$ and revenue of $109 million.[113]

- Sale of fertilizer. The value of digested solids may be even greater than the value of electricity produced by an anaerobic biodigester system. The chemical process of biodigestion converts the organic nitrogen in manure into ammonium, the primary component of commercial fertilizer. Biodigesters create high-quality organic fertilizer that is biologically stable and largely sterilized, with far fewer pathogens and weed seeds than in standard chemical fertilizers as well as less likelihood of water pollution.
- 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.[114]

CHAPTER 3

Montana's Geothermal Potential

Geothermal energy production puts the earth's natural heat to work. By circulating water through buried pipes, geothermal heat pump systems can take advantage of the constant 55-degree temperature just a few feet underground to cool a building in the summer and heat it in the winter, dramatically reducing utility bills. According to the EPA, geothermal heat pump systems are the most clean and cost-effective systems for maintaining 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.

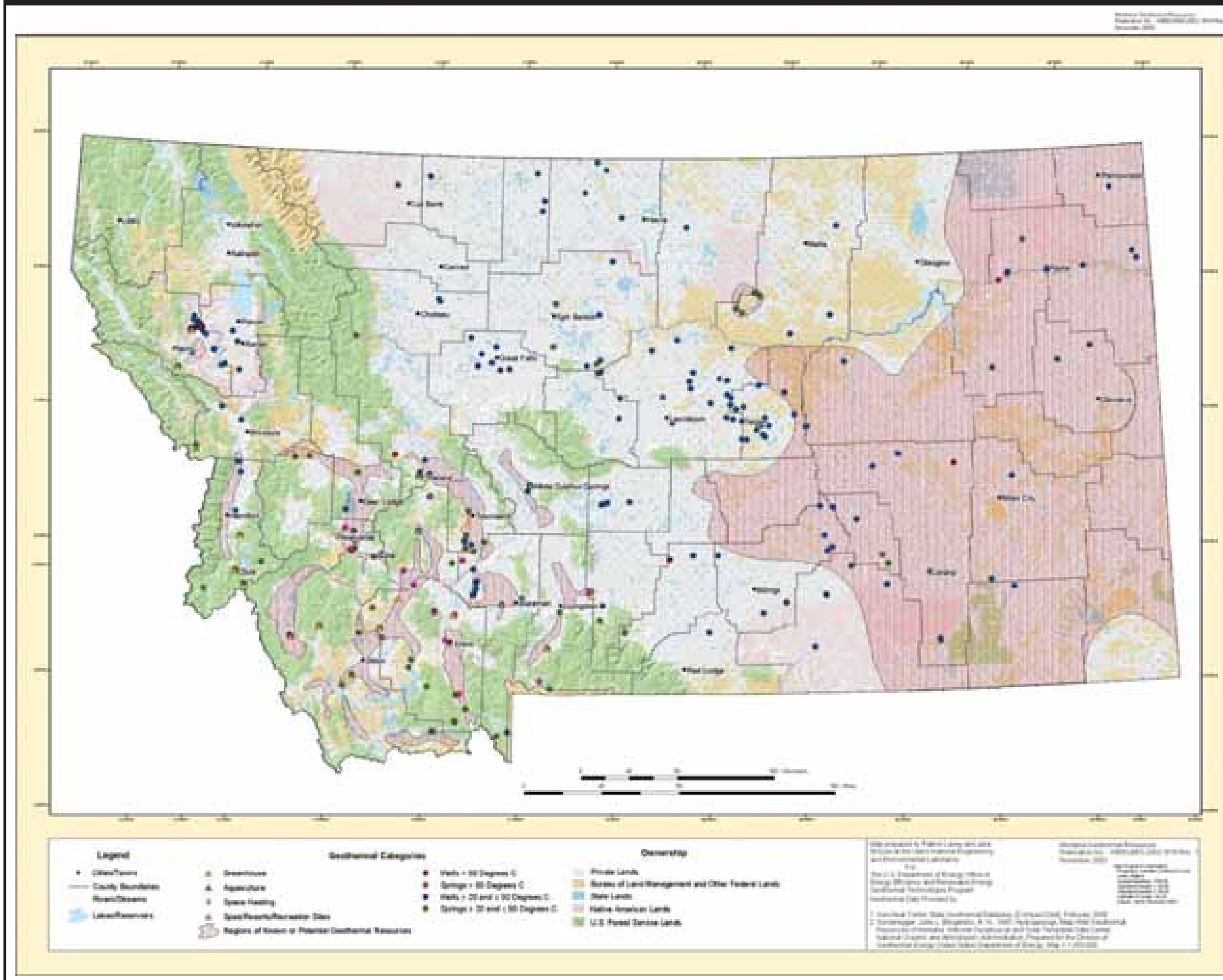
Although the entire United States is suitable for geothermal heat pumps, there are far greater geothermal opportunities in Montana than in most states because Montana has energy-rich hot water close to the surface. More than 40 facilities in the state, such as pools, spas, aquaculture facilities, and greenhouses, already take advantage of natural hot springs for steam and heat. However, the state also has enormous potential to use direct hydrothermal technology for heat in buildings, industrial processes, biofuel refining, and agricultural applications such as crop and lumber drying. Geothermal energy also can be used to generate electricity. Warm-water wells and springs occur in areas across the state, as shown in the following map, produced by the DOE's Idaho National Laboratory, of existing geothermal resources in Montana.[115]

It is very important to consider the environmental issues associated with geothermal development and to mitigate any potential negative impacts, such as threats to local groundwater and increased seismicity from drilling activity. Geothermal development is prohibited on lands adjacent to Yellowstone National Park, demarcated on the surface by the underground hot water aquifer that extends 12 miles north as well as to the northwest and northeast of the park.[116] Development should not go forward in other sensitive areas, including all the state's national parks and monuments, critical wildlife habitat, wild and scenic river corridors, and wilderness-quality lands.

Geothermal energy can become a sizable contributor to a national clean energy portfolio. Montana is one of 13 states identified by the U.S. Geological Survey (USGS) as having geothermal energy resources sufficient for economically feasible commercial electricity production. California has 43 operating geothermal power plants totaling 1,800 MW of generating capacity, and plants in other states account for an additional 1,200 MW. According to the Northwest Power and Conservation Council, the regional development potential of conventional geothermal power totals 416 MW over the next two decades.[117] Montana has 15 geothermal sites already identified, with additional potential across most of the Bitterroot Valley and the eastern plains.[118] In Lake County, Flathead Electric Cooperative has received a federal grant to drill a well 2,000 feet deep to test the energy potential of hot water at that level.[119] If successful, this project could demonstrate the feasibility of generating energy from the hot water present at moderate depths in many areas of Montana.

Newly developed technology for lower-temperature geothermal electricity generation holds the promise of cost-effective, small-scale distributed geothermal electricity production.[120] However, the biggest advance in geothermal

Figure 4: Montana Geothermal Resources



technology is EGS, or Enhanced Geothermal Systems, which is based on improved deep-drilling techniques that are beginning to provide access to the massive energy of "hot rocks" 1 to 5 miles underground. A comprehensive study conducted by MIT found that a total investment of $1 billion over the next 15 years in EGS research and development would propel commercialization of this technology on a massive scale.[121] The USGS estimates that Montana has more than 9,000 MW of accessible geothermal electricity generation potential.[122]

Construction of geothermal wells may involve hydraulic fracturing of underground formations, similar to the process used in oil and gas production. Hydraulic fracturing operations related to geothermal production are currently exempt from underground injection control regulations under the federal Safe Drinking Water Act. Strong protections must be in place to guard underground sources of drinking water from contamination during the fracturing process. Drilling or associated activities at the site can threaten the environment and human health in other ways as well. For example, chemical additives may be used in geothermal production. All drilling and fracturing activities, as well as management of toxic waste, should be conducted with the highest level of environmental protection.

Geothermal power is one of the few energy resources that can provide continuous clean energy with a very small land-surface footprint and almost zero carbon emissions. Increased government support for research, development, and environmentally responsible deployment of geothermal technology is the crucial next step in opening the door to this almost limitless clean energy resource.[123]

CHAPTER 4

Montana's Solar Potential

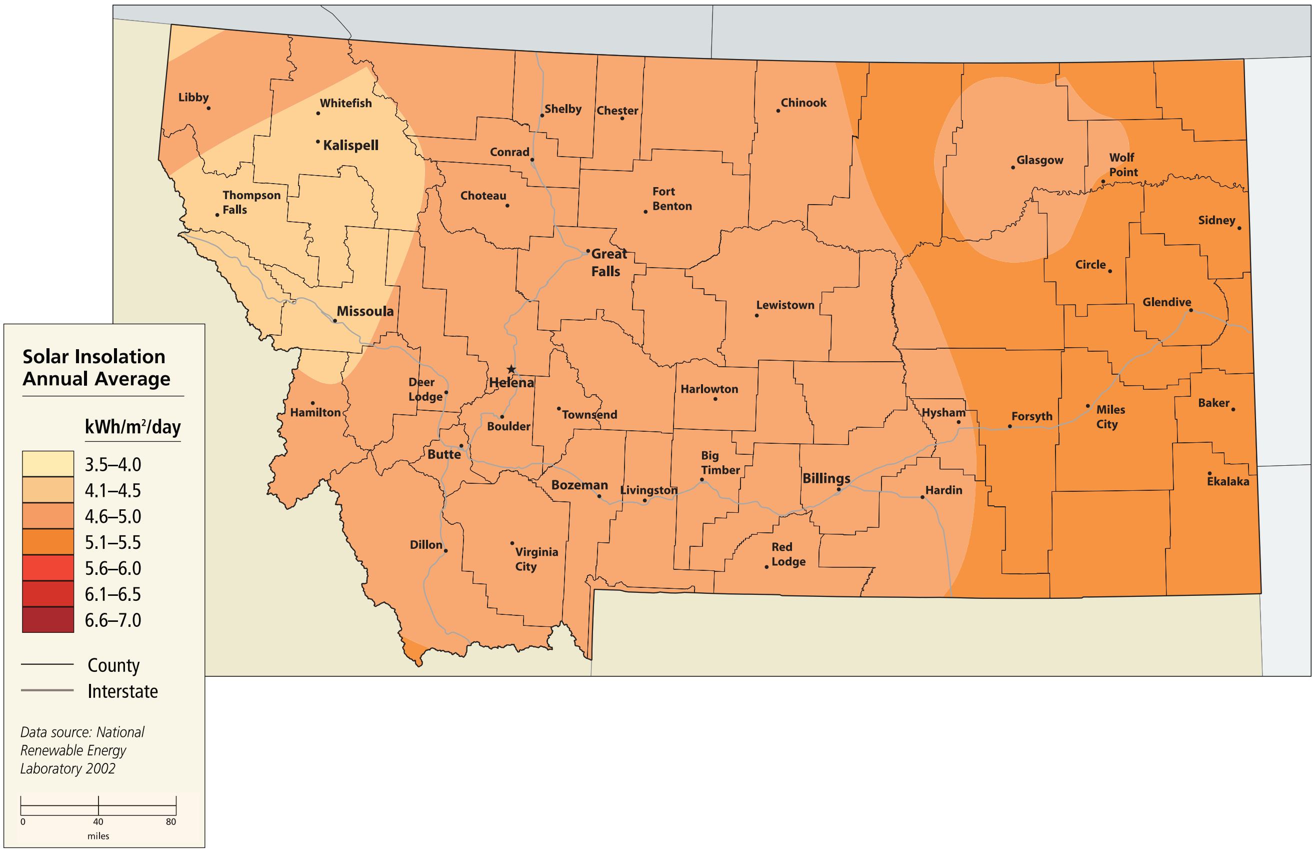
Solar energy is a rapidly growing U.S. energy source, with more than 81,000 solar installations in place at the end of 2008.[124] Photovoltaic capacity installed in 2008 grew by 63 percent compared with 2007 and was triple the capacity installed in 2005.[125] Montana's long summer days give it greater solar electricity potential than places like Jacksonville, Florida, and Houston, Texas. Montana 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. Solar electricity was expensive in the past, but today its price is dropping rapidly. Farm-scale solar electricity production is eligible for sale to utilities under Montana's net metering law, making photovoltaic solar installations a potentially cost-effective long-term investment. 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, running irrigation pumps, grain drying, greenhouse heating, and small-scale electricity production.[126]

Montana has a small but rapidly growing number of solar installations. NorthWestern Energy, the state's dominant electric utility, has more than 500 net metering customers who are producing solar electricity and sending it back to the grid, about 140 of which went on line in 2009.[127] The Montana Renewable Energy Association has grown to more than 70 members, including more than 25 small businesses that sell and install solar facilities. With the right set of supportive policies in place, small-scale solar could become a big source of jobs and economic development in Montana.

Solar technology continues to expand while its price continues to shrink. Recently developed flexible thin-film solar cells are far less expensive than rigid polycrystalline photovoltaic panels and have many more potential applications because they can be put on the sides of buildings, on roof shingles, and on windows. Montana also has some potential for larger-scale electricity production using mirrors to concentrate sunlight, which could become a cost-effective clean energy source as the technology improves and its costs decline.

The map on the following page (page 18) shows solar insolation levels across Montana.

Figure 5: Montana Solar Potential



CHAPTER 5

Reaching the Clean Energy Future: Getting From Here to There

Montana 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 the development of homegrown renewable energy.

National Policies Needed to Realize Montana's Clean Energy Potential

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

The most promising comprehensive approach is a cap-and-trade framework, under which overall annual limits on global warming pollutants are set, and emitting companies must comply by either reducing their emissions or obtaining emission allowances or offsets. The price of allowances would be established in a competitive market, providing an incentive for businesses to find the least costly ways to reduce emissions. Generating fossil-fuel power would require allowances while generating carbon-free energy would not, thus leveling the playing field for renewable energy, making it an attractive investment, and spurring innovation in clean energy technologies. The American Clean Energy and Security Act (ACES, H.R. 2454), passed by the House of Representatives in June 2009, proposes this kind of framework and includes stringent targets: a 17 percent reduction in emissions 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-trade system was employed in the 1990s to reduce acid rain caused by power plants, and it led to so much innovation that compliance costs turned out to be 75 percent lower than initial projections.[128] If allowances are fully or partially auctioned under a federal program, part of the money generated could be used to invest in energy efficiency and renewable technologies so net costs to energy consumers are minimized.

A strong Renewable Energy Standard achieving 25 percent of U.S. electricity from renewable sources by 2025 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 Montana jobs and revitalize rural communities
- Support the growth and prosperity of Montana farms
- Ensure a healthy and sustainable environment for future generations

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

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

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

Improved energy efficiency is the quickest and most cost-effective way to reduce consumption of fossil fuels. A national energy efficiency resource standard (EERS) requiring utility companies to phase in programs to save 15 percent of electricity and 10 percent of natural gas by 2020 would cut $170 billion from energy bills and create more than 220,000 jobs, including 533 jobs in Montana, and $342 million in annual savings for Montana consumers. Such a commitment to energy efficiency would also eliminate the need to build 390 new power plants in the United States and avoid pollution emissions equivalent to the output of 48 million automobiles.[129]

The small additional cost to make home appliances more energy efficient is far outweighed by the savings consumers achieve when using them. That is why strengthened national energy efficiency standards for home appliances are a critical part of a long-term energy strategy.[130] Similarly, a national energy efficiency building code for new construction would immediately begin to save occupants money on energy bills and help the environment while reducing electricity demand and improving system reliability.

Any serious effort to reduce our dependence on fossil fuels also must include vastly increased support for renewable energy research, development, and deployment (RD&D), which continues to lag far behind government funding for fossil fuels and nuclear power.[131] In their developing phases, the nuclear, coal, and oil industries received subsidies an order of magnitude larger than the amount renewable technologies have received. A recent study by the Environmental Law Institute found that this disparity continues, with fossil fuels garnering 2.5 times more government support than renewable resources from 2002 through 2008.[132] Clean energy RD&D has fallen since the 1970s and is now a small portion of overall government RD&D spending. In order to jump-start clean energy development at this critical juncture, the level of clean energy RD&D must be increased dramatically.

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

1. Accurate accounting for biomass emissions from sources covered by the cap. Not all renewable biomass produces zero carbon energy, and the current legislation lacks a way to differentiate low-carbon from high-carbon biomass.
2. Accurate accounting for emissions from land-use change in the Renewable Fuels Standard. The 2007 RFS requires a science-based, full-life-cycle analysis that includes the global ripple effect of increased biofuels production, also known as indirect land-use change. The latest scientific research confirms that whether biofuels create or reduce global warming pollution hinges on where and how the feedstocks are produced.
3. An appropriate definition of renewable biomass. Use of renewable biomass helps protect sensitive wildlife habitat and natural ecosystems while making a wide diversity of feedstocks available for compliance with the renewable electricity and renewable fuels standards. Biomass sourcing guidelines should provide safeguards for native grasslands; sensitive wildlife habitat; old-growth, wilderness, and roadless areas; and other especially sensitive components of our federal lands. It should also include sustainability measures that protect wildlife habitat, soil productivity, and biodiversity in working forests and discourage the conversion of natural forests to less diverse, planted forests or energy crops. Loss of forests is one of the greatest threats to biodiversity worldwide and a huge contributor to global warming.[133]

No single deployment support mechanism is optimal for all stages of innovation. Investment tax credits, for example, can be effective in providing up-front 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. To date, legislation under consideration by Congress aims to balance these needs to research, develop, and deploy the innovations and technological breakthroughs required to meet the climate challenge, including significant funds for energy efficiency and renewable energy technologies and carbon capture and sequestration (CCS) technology.

Going forward, Congress must 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.

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 Montana.

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

- Expansion of net metering, including making bioenergy eligible under Montana law. In addition, any clean energy production above the customer's own electricity usage in a given year should be carried over to the next year or be compensated by the utility or co-op. Many other states have more supportive net metering rules, allow for larger systems, and make it much easier for consumers to connect to the utility grid.[134] New state laws could improve net metering policies and promote on-site clean power production.
- Expanded program assistance for farmers and business owners who want to take advantage of opportunities to produce and sell renewable energy certificates (RECs) and/or carbon offsets under a new federal cap-and-invest program.
- Policies to promote energy efficiency, such as electric utility revenue decoupling, with clear incentives and penalties for investor-owned electric utilities that achieve quantifiable levels of energy reductions via energy efficiency programs within their service territory.[135] Well-designed regulatory initiatives to decouple electricity sales from earnings can remove the disincentive for utilities to achieve reductions in customers' electricity usage, which, under traditional regulation, reduce utilities' profits.[136]

Smart grid technology deployment and optional time-of-use rates to encourage customers to use less electricity, particularly during peak periods.

APPENDIX I

Federal Programs and Funding for Clean Energy Development in Montana

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 and support for transmission infrastructure, smart grid investment, low-income housing weatherization, plug-in hybrid electric vehicles, carbon capture and sequestration technology development, state and local energy efficiency programs, and loan guarantees for renewable energy projects. Among the existing, new or expanded programs are:

- USDA Rural Energy for America Program (REAP) grants[137]
- USDA Rural Energy for America Program (REAP) loan guarantees[138]
- Business Energy Investment Tax Credit (ITC)[139]
- Renewable Electricity Production Tax Credit (PTC)[140]
- Modified Accelerated Cost-Recovery System (MACRS)[141]
- U.S. Department of Treasury renewable energy grants[142]
- Residential Renewable Energy Tax Credit[143]
- Clean Renewable Energy Bonds (CREBs) for municipalities[144]
- DOE loan guarantees for electric transmission infrastructure (section 1705)[145]
- USDA business and industry loan guarantees for economic growth in rural communities[146]
- AgSTAR program to support biodigester technology installations[147]
- Biomass Crop Assistance Program (BCAP)[148]
- Biomass Research and Development[149]

APPENDIX II

State-Level Programs and Funding for Clean Energy in Montana

In addition to a range of state energy tax credits and incentives, there are a number of existing state programs providing support to clean energy in Montana. These include:

- Alternative Energy Loan Program[150]
- Growth Through Agriculture Program[151]
- Renewable Resource Grant Program[152]
- Energy Conservation Bond Program[153]
- Utility-specific rebate and loan programs[154]

It is becoming clear that Montana's 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 Montana environment and a robust Montana economy.

Endnotes

1 http://data.bls.gov/PDQ/servlet/SurveyOutputServlet?data_tool=latest_numbers&series_id=LASST30000003; increasing from 19,900 to 33,672 unemployed.
2 Based on conservatively projected 38 percent average wind capacity factor; generators annually produce an amount of energy equal to their rated capacity x capacity factor x 8,760 (number of hours in a year).
3 These numbers are consistent with a report by NREL on the benefits of 1,000 MW of wind development in Montana, http://www.windpoweringamerica.gov/pdfs/economic_development/2008/mt_wind_benefits_factsheet.pdf
4 All calculations use 2,095 pounds carbon/MWh of average coal
5 This number reflects the sum of the actual usable portion of crop residues as calculated by NREL, http://www.afdc.energy.gov/afdc/pdfs/39181.pdf
6 19.4 pounds carbon/gallon x 175 M gallons / 2,205 pounds/metric ton = 1,539,683 metric tons
7 According to http://www.sourcewatch.org/index.php?title=Existing_U.S._Coal_Plants#Statistical_Data_On_Existing_U.S._Coal-Fired_Generating_Stations, the total power production of coal plants in Montana was 17,844 GWh.
8 Not including the reduction in carbon dioxide emissions from replacing other energy sources.
9 Energy efficiency savings estimates based on ACEEE, "State Benefits from a Federal EERS," http://aceee.org/pubs/e091.pdf?CFID=3643806&CFTOKEN=11807860
10 http://tonto.eia.doe.gov/state/state_energy_profiles.cfm?sid=MT
11 Estimate based on EIA data showing coal costs of $228 million, petroleum costs of $3.6 billion, and $300 million of natural gas, using estimated 2008 population of 967,440.
12 http://www.eia.doe.gov/emeu/states/sep_prod/P2/P2.xls
13 Estimate based on subtracting Montana's annual fuel production of approximately 45 million tons of coal, 1.2 billion therms of natural gas and 31.5 million barrels of oil (total value of about $2.9 billion) from its total fuel costs.
14 1.2 billion therms of natural gas produced, http://tonto.eia.doe.gov/state/state_energy_profiles.cfm?sid=MT, at a current price of about $0.40-50 per therm, http://tonto.eia.doe.gov/dnav/ng/ng_pri_sum_a_EPG0_PG1_DMcf_m.htm
15 In-state consumption of 738 million therms, http://tonto.eia.doe.gov/state/state_energy_profiles.cfm?sid=MT, accounts for over 60 percent of Montana's natural gas production.
16 http://tonto.eia.doe.gov/state/state_energy_profiles.cfm?sid=MT, and http://www.eia.doe.gov/emeu/states/sep_use/notes/use_print2007.pdf , showing petroleum consumption of 38.2 million barrels, which is 21 percent greater than production.
17 44.8 million tons of coal produced, http://tonto.eia.doe.gov/state/state_energy_profiles.cfm?sid=MT, at average value of $12.31 per ton, http://www.eia.doe.gov/cneaf/coal/page/acr/table28.html; $228 million spent on coal for electricity production, http://www.eia.doe.gov/emeu/states/hf.jsp?incfile=sep_fuel/html/fuel_pr_cl.html
18 http://deq.mt.gov/Energy/HistoricalEnergy/default.mcpx, sheet C-2
19 http://www.energywatchgroup.org/fileadmin/global/pdf/EWG_Report_Coal_10-07-2007ms.pdf
20 http://leg.mt.gov/content/publications/Environmental/2004deq_energy_report/coal_text.pdf
21 http://www.eia.doe.gov/oiaf/aeo/electricity.html
22 A megawatt (MW) is a measure of electricity production equal to 1,000 kilowatts (kW) or 1,000,000 watts. Therefore, 1 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.
23 Based on 5,479 MW of existing generating capacity and a 1 percent annual demand increase, as forecast by the EIA; additional capacity estimate does not count any replacement of existing power plants.
24 This number is extrapolated using Montana electricity consumption of 15.5 million MWh in 2007 (as per EIA data), supplied by 66 percent coal, producing 2,095 lbs carbon dioxide/MWh, and assuming an average car is driven 12,000 miles/year @22.4MPG (as per Dept of Transportation data), emitting 19.4 lbs carbon/gal, http://www.eia.doe.gov/oiaf/aeo/overview.html#trends, also http://epa.gov/otaq/climate/420f05001.htm#carbon
25 http://www.census.gov/statab/ranks/rank29.html
26 http://www.pewcenteronthestates.org/uploadedFiles/Clean_Economy_Report_Web.pdf
27 http://www.repp.org/articles/BGA_Repp.pdf
28 http://www.repp.org/articles/static/1/binaries/LABOR_FINAL_REV.pdf

29 http://www.windenergyinvesting.com/2008/03/17/german-company-has-plans-for-wind-turbine-manufacturing-site-in-montana/, and http://www.greatfallstribune.com/article/20090915/NEWS01/909150310
30 http://aceee.org/pubs/e097.pdf?CFID=3643806&CFTOKEN=11807860
31 http://www.mckinsey.com/clientservice/electricpowernaturalgas/downloads/US_energy_efficiency_full_report. pdf
32 http://yosemite.epa.gov/opa/admpress.nsf/0/5B2E6D9AA8D257758525760200686356
33 http://www.nwcouncil.org/energy/powerplan/6/default.htm
34 http://www.mtclimatechange.us/ewebeditpro/items/O127F14041.pdf, EX-7
35 http://aceee.org/pubs/e091.pdf?CFID=3643806&CFTOKEN=11807860, p.19
36 http://www.e3network.org/papers/Preliminary_Insights_on_Montana_Energy_Productivity_Gains.pdf
37 This consists of 18.2 million acres of cropland, 2.3 million acres of woodland, 40 million acres of pasture and 1 million acres of ponds, roads, and homes, plus about 3.6 million acres in conservation or wetlands programs, http://www.ers.usda.gov/StateFacts/MT.HTM
38 http://theclean.org/t-clean/survey_2008_10_23_mt.pdf
39 http://www.pnas.org/content/106/27/10933.full.pdf
40 http://www.awea.org/Projects/ProjectsNew.ASPx?s=Montana
41 http://www.windpoweringamerica.gov/pdfs/2007_annual_wind_market_report.pdf p.17-20
42 Source: American Wind Energy Association (AWEA), http://www.awea.org/newsroom/releases/wind_energy_growth2008_27Jan09.html; Household-equivalent number per MW is smaller than average because of the variable output of wind facilities.
43 http://www.20percentwind.org/report/Chapter1_Executive_Summary_and_Overview.pdf
44 http://www.awea.org/faq/wwt_environment.html#Noise
45 It actually found an increase in property values compared to other comparable local property, http://www.repp.org/articles/static/1/binaries/wind_online_final.pdf
46 http://www.awea.org/faq/wwt_potential.html#How%20much%20energy
47 http://www.pnas.org/content/106/27/10933.full.pdf
48 http://www.naturener.net/naturener/eng/index.php?option=com_content&task=view&id=118&Itemid=86; Note: the first phase (106.5 MW) interconnects to the NorthWestern transmission system and the second phase (103.5 MW) interconnects to the Glacier co-op and BPA systems
49 See table linked to http://www.windpoweringamerica.gov/wind_resource_maps.asp?stateab=mt&print
50 http://eetd.lbl.gov/ea/emp/reports/lbnl-2829e.pdf. Another earlier study 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
51 Based on an average capacity factor of 38 percent.
52 http://www.ers.usda.gov/Statefacts/MT.HTM
53 http://www.awea.org/faq/wwt_basics.html#How%20many%20turbines%20does%20it%20take%20to%20make %20one%20megawatt%20(MW)
54 http://www1.eere.energy.gov/windandhydro/pdfs/43025.pdf p.21
55 http://www.gao.gov/new.items/d04756.pdf
56 In-state energy consumption was approximately 525 GWh in 2008, http://tonto.eia.doe.gov/state/state_energy_profiles.cfm?sid=MT
57 http://www.transcanada.com/company/zephyr_chinook.html
58 http://www.repp.org/articles/BGA_Repp.pdf
59 http://www.windenergyinvesting.com/2008/03/17/german-company-has-plans-for-wind-turbine-manufacturing-site-in-montana/, and http://www.mtstandard.com/articles/2008/03/05/butte_top/20080305_butte_top.txt
60 According to the National Research Council (NRC) study, 384 million dry tons is available from agricultural and forestry residues and municipal solid waste. Early studies suggest that today cover crops could produce between 2 and 3.6 tons per acre of biomass when harvested and up to 5 tons with good weather and soil fertility. If 10 percent of the nation's 220 million acres of field cropland was cover cropped and the biomass harvested, this would produce between 44 and 110 million tons per year. If incentives boosted cover crop adoption rates to 30 percent, we could expect 66 million acres of land to be planted in cover crops, yielding between 132 and 330 million tons per year of biomass. Because cover crops are best managed as a system with agricultural residues, these numbers may not be entirely additive to the NRC's 130 million tons of residues. Thus, combining innovate farm practices, such as double cropping and winter cover crops, with potential dedicated energy crops on marginal or abandoned lands, an additional 40-330 million dry tons could be available. These estimates do not include the potential from biofuel production from algae.

61 http://domesticfuel.com/2008/09/03/worlds-biggest-camelina-grower-fueling-biodiesel-production/, 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
62 http://www.ethanolmt.org/php/headlines.php?id=45
63 Worldwatch Institute, "Smart Choices for Biofuels," p.8, http://www.worldwatch.org/files/pdf/biofuels.pdf
64 http://www.ers.usda.gov/AmberWaves/April06/Features/Ethanol.htm
65 http://www.harvestcleanenergy.org/enews/enews_0505/enews_0505_Cellulosic_Ethanol.htm
66 http://www.ethanolrfa.org/resource/cellulosic/documents/CurrentCellulosicEthanolProjects-January2009.pdf
67 http://www.ethanolproducer.com/article.jsp?article_id=4638
68 http://data.opi.mt.gov/bills/2005/billhtml/SB0293.htm
69 http://www.statemaster.com/state/MT-montana/geo-geography
70 See chart on P.14 for the usable portion of Montana crop residues as estimated by NREL, http://www.afdc.energy.gov/afdc/pdfs/39181.pdf
71 A study conducted by the Princeton Environmental Institute for a briefing of Governor Schweitzer in 2006 found usable crop residue quantities as high as 3.09 millions tons, Eric D. Larson, 2006,"Supplies and Cost of Crop an Forest Residues in Montana."
72 This estimate is likely to be lower in reality as it does not take into account any ecological considerations (e.g., areas that should not be harvested due to high conservation values) for logging residues and other removals (trees cut down for reasons other than round wood production).
73 Bark, sawdust, and other residues from pulping mills. The actual amount of mill residue is many times larger, but most is already being used.
74 Scraps and sawdust from woodworking shops.
75 Primarily yard trimmings, wood packaging, and other household and commercial wood waste
76 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.
77 Based on Federal Highway Administration Statistics, http://www.fhwa.dot.gov/policy/ohim/hs06/htm/mf21.htm, and http://www.afdc.energy.gov/afdc/sabre/sabre.php?mode=prod
78 Conservatively assuming biomass average BTU content about half of coal by weight; see: http://bioenergy.ornl.gov/papers/misc/energy_conv.html; http://www.eia.doe.gov/cneaf/solar.renewables/page/state_profiles/montana.html
79 Assuming 19.4 pounds of carbon/gallon, http://epa.gov/otaq/climate/420f05001.htm#carbon, and typical average gas usage per vehicle of 536 gallons per year.
80 See reports of the multi-agency Biomass Research and Development Initiative (BRDI) http://www.brdisolutions.com/default.aspx
81 0.63 tons/acre x $40/ton x 733 acres (2.2 million acres of wheat / 3,000 farms in 2007) = $18,472
82 1.3 tons/acre x $40/ton x 128 acres (38,000 acres of corn/297 farms in 2007) = $6,656
83 http://bioweb.sungrant.org/Technical/Biomass+Resources/Forest+Resources/Logging+Residues/Default.htm, and http://www.energy.wsu.edu/documents/renewables/SupplyCurveReport.pdf
84 http://agbiopubs.sdstate.edu/articles/SGINC2-07.pdf, switchgrass summary
85 BRDI, "Increasing Production for Biofuels," p.23; also see http://farmindustrynews.com/biofuels/0501-popular-trees-study/
86 http://www.brdisolutions.com/web%20pages/News%20Center/Spotlight/April%202006.aspx?PageView= Shared
87 See table at http://cta.ornl.gov/bedb/biopower.shtml
88 http://www.renewableenergyworld.com/rea/news/article/2009/10/american-renewables-sells-100-mw-biomass-project-to-southern-power
89 http://www.biomassmagazine.com/article.jsp?article_id=3158&q=montana
90 http://www.thewesternnews.com/articles/2009/09/22/news/doc4ab90ae238ce8807322939.txt
91 Calculated by converting 10 percent of the 12.1 million tons of coal used in Montana each year (as per EIA data at http://www.eia.doe.gov/cneaf/coal/page/coaldistrib/2007/d_07state.pdf) 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 percent of Montana coal power capacity = 254 MW = 635 new jobs, reduced by a proportional share of coal O&M and fuel procurement (total of 456 Montana jobs in coal O&M, 942 in mining), http://www.sourcewatch.org/index.php?title=Coal_and_jobs
96 See Oak Ridge National Lab reports, http://bioenergy.ornl.gov/main.aspx#
97 http://www.epa.gov/lmop/projects-candidates/operational.html
98 In Billings, Bozeman, Great Falls, and Missoula
99 Agstar estimates the cost range at $150-$400 per 1,000 lbs livestock weight, http://www.epa.gov/agstar/pdf/manage.pdf
100 http://www.adnett.org/
101 U.S. EPA Agstar, 2006, "Market Opportunities for Biogas Recovery Systems."
102 http://www.ers.usda.gov/data/agproductivity/
103 http://www.nrel.gov/docs/fy06osti/39181.pdf, p.16
104 Extrapolated from http://www.epa.gov/agstar/pdf/biogas%20recovery%20systems_screenres.pdf
105 http://www.eia.doe.gov/cneaf/electricity/epm/table5_6_b.html
106 The market value of RECs and carbon credits depends on the specific policies adopted. Today, RECs cost from about $7 to $35/MWh.
107 U.S. Department of Agriculture 2007 Census of Agriculture
108 http://www.mt.nrcs.usda.gov/news/projects/huls.html
109 For Montana net metering rules see http://data.opi.mt.gov/bills/mca_toc/69_8_6.htm.
110 http://www.newenergychoices.org/uploads/FreeingTheGrid2008_report.pdf
111 Montana's electric cooperatives have resisted net metering, claiming concerns about safety, reliability, and customer cross subsidization.
112 The National Carbon Offset Coalition (NCOC) is working with rural economic interests throughout North America to expand the market of tradable and verifiable carbon offset credits, http://www.ncoc.us/
113 Based on University of Illinois, Yale University, and the University of California EAGLE analysis, 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/basic-info/index.html#03
114 Agstar PowerPoint presentation by Chris Voell
115 Additional geothermal resource maps are available at http://www.deq.mt.gov/Energy/geothermal/sites.mcpx
116 In 1986 the Church Universal Triumphant illegally drilled a well on its land, stopping the flow of the Laduke Hot Springs, which is tied to Yellowstone Park and probably to the Mammoth Terraces and Norris Geyser basins. After expensive, long-term research by the U.S. Geologic Survey, they could not figure out the hydrologic connections between Yellowstone Park geothermal features and those hot springs and geothermal features outside the park. Hence, the compact put these areas off limits.
117 http://www.nwcouncil.org/energy/powerplan/6/draft/I_090309.pdf p.I-30
118 http://commerce.mt.gov/energy/geothermal.asp
119 http://www.flatheadelectric.com/newnews/newnews.html
120 http://www.technologyreview.com/read_article.aspx?id=17524
121 See in depth MIT report at http://geothermal.inel.gov/publications/future_of_geothermal_energy.pdf
122 http://pubs.usgs.gov/fs/2008/3082/pdf/fs2008-3082.pdf
123 http://www1.eere.energy.gov/geothermal/
124 Source: Interstate Renewable Council.
125 http://irecusa.org/wp-content/uploads/2009/10/IREC-2009-Annual-ReportFinal.pdf
126 For a detailed description of agricultural solar applications, see: http://www.nyserda.org/programs/pdfs/agguide.pdf
127 Numbers provided in conversation with John Campbell of Northwestern Energy
128 http://www.epa.gov/airmarkets/cap-trade/docs/ctresults.pdf
129 http://aceee.org/pubs/e091.pdf?CFID=3643806&CFTOKEN=11807860
130 http://www.nrdc.org/air/energy/fappl.asp and http://www.nrdc.org/globalWarming/cap2.0/files/kick.pdf
131 http://www.eia.doe.gov/oiaf/servicerpt/subsidy2/pdf/subsidy08.pdf
132 http://www.elistore.org/Data/products/d19_07.pdf
133 Intergovernmental Panel on Climate Change, Climate Change 2007: Synthesis Report Summary for Policymakers, pg. 5, http://www.ipcc.ch/pdf/assessment_report/ar4/syr/ar4_syr_spm.pdf
134 For detailed comparison of state net metering policies, see: http://www.irecusa.org/index.php?id=90

135 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
136 A basic overview of utility revenue decoupling - structure and mechanics is explained at http://www.raponline.org/docs/RAP_Sedano_UtilityBusinessModelAndEE_2009_07_15.pdf
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