A METHODOLOGY AND DECISION SUPPORT TOOL FOR

INFORMING STATE-LEVEL BIOENERGY POLICYMAKING:

NEW JERSEY BIOFUELS AS A CASE STUDY

by

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ABSTRACT OF THE DISSERTATION

A Methodology and Decision Support Tool for Informing State-Level Bioenergy Policymaking: New Jersey Biofuels as a Case Study

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This dissertation seeks to provide key information and a decision support tool that states can use to support long-term goals of fossil fuel displacement and greenhouse gas reductions. The research yields three outcomes: 1) A methodology that allows for a comprehensive and consistent inventory and assessment of bioenergy feedstocks in terms of type, quantity, and energy potential. Development of a standardized methodology for consistent inventorying of biomass resources fosters research and business development of promising technologies that are compatible with the state's biomass resource base. 2) A unique interactive decision support tool that allows for systematic bioenergy analysis and evaluation of policy alternatives through the generation of biomass inventory and energy potential data for a wide variety of feedstocks and applicable technologies, using New Jersey as a case study. Development of a database that can assess the major components of a bioenergy system in one tool allows for easy evaluation of technology, feedstock and policy options. The methodology and decision support tool is applicable to other states and regions (with location specific modifications), thus contributing to the achievement of state and federal goals of renewable energy utilization. 3) Development

of policy recommendations based on the results of the decision support tool that will help to guide New Jersey into a sustainable renewable energy future.

The database developed in this research represents the first ever assessment of bioenergy potential for New Jersey. It can serve as a foundation for future research and modifications that could increase its power as a more robust policy analysis tool. As such, the current database is not able to perform analysis of tradeoffs across broad policy objectives such as economic development vs. CO2 emissions, or energy independence vs. source reduction of solid waste. Instead, it operates one level below that with comparisons of kWh or GGE generated by different feedstock/technology combinations at the state and county level. Modification of the model to incorporate factors that will enable the analysis of broader energy policy issues as those mentioned above, are recommended for future research efforts.

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In addition to my family, there were many people along the way who played a key role in this accomplishment. I thank Dean Robert Goodman for first getting me engaged in the field of bioenergy. A simple meeting he arranged changed the course of my academic career. Mark Robson, whose untiring effort to see me complete this degree was the impetus I needed to finally finish. Brian Schilling, my partner in crime, who insisted that I register for the PhD program in the first place. His friendship as we travelled down this road together was a source of strength, encouragement and humor. Friends Jackie Melillo, Kevin Sullivan, Lou Cooperhouse and Brad Hillman who provided a network of support and assistance when I needed it most. My committee chair, Clint Andrews and committee members Mark Robson, Paul Gottlieb and Serpil Guran who provided excellent guidance and critiques that improved the quality of my research and its outcomes. I thank you all for being alongside me on this journey!

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Chapter 1: Introduction

A. Background

1. Global Energy Crisis

As population growth increases and the standard of living improves worldwide, global energy indicators show strong growth in worldwide energy demand to 2030. Total world consumption of marketed energy is projected to increase from 447 quadrillion Btu in 2004 to 559 quadrillion Btu in 2015, with estimated projections of 702 quadrillion Btu in 2030—constituting a 57-percent increase over the length of the projection period (Figure 1)[1]. While there are many reasons for the increase in energy consumption, a major factor is the rise of emerging economies, such as China and India, which are expected to increase their use of energy to 46% of world consumption by 2025, thereby exceeding that of mature economies (Figure 2).[2] This shift has been occurring for decades, as more mature market economies continue transferring their manufacturing and other energy intensive industries to these regions, thereby increasing the standards of living within the growing economy nations. The result is an increased demand for energy.[3]

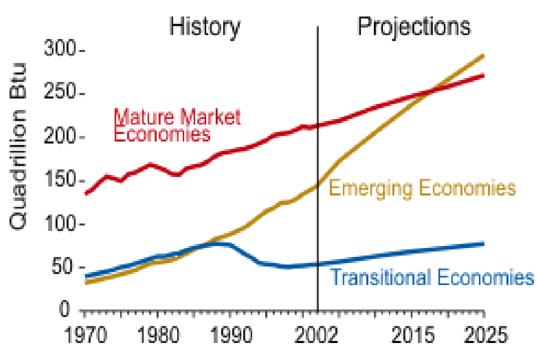
While this energy forecast is dramatic, it is based on the continuing availability of fossil fuels and stable oil prices of $31-$35 per barrel.[4] However, in the first quarter of 2008, oil prices were exceeding $100 per barrel.[5] Though oil prices have since dropped in 2009 to the $50/bbl range, they are extremely volatile.

[1] (U.S. Department of Energy, Energy Information Administration 2009)
[2] (U.S. Department of Energy, Energy Information Administration 2005)
[3] (U.S. Department of Energy, Energy Information Administration 2009)
[4] (U.S. Department of Energy, Energy Information Administration 2005)
[5] (U.S. Department of Energy, Energy Information Administration Office of Coal, Nuclear, Electricity and Alternative Fuels 2009)

Figure 1. World Marketed Energy Consumption 1980-2030

Source: History: Energy Information Administration, International Energy Annual Report 2006 (June-December 2008). Projections: EIA, World Energy Projections Plus (2009).

Figure 2. World Energy Consumption by 1980-2025



Source: History: Energy Information Administration, International Energy Outlook 2005 Report (May 2006), Projections: EIA, World Energy Projections Plus (2009).

Future increases in oil prices will likely lead to a shift in the mix of energy fuels consumed, particularly between oil and coal. A 2007 Dept. of Energy, Energy Information Administration (EIA) report predicts a significant decrease in the use of oil with high prices (over $100/bbl) and an increase in the use of coal as a substitute.[6] Coal is the most carbon-intensive of the fossil fuels, and it is the fastest-growing energy source

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6 (U.S. Department of Energy, Energy Information Administration 2009)

in developing countries, particularly in China and India. By 2030, carbon dioxide emissions from China and India combined are projected to account for 31 percent of total world emissions, with China alone responsible for 26 percent of the world total.[7] As these economies expand, coal will become a greater part of the world energy mix and play a correspondingly larger role in the composition of world carbon dioxide emissions.

Given the significant increase in demand for energy, the concept of "peak oil" becomes very relevant. Peak oil is a term introduced in 1956 by M. King Hubbert,[8] a Shell Oil geologist. His theory states that oil wells increase production to a peak level, than decline steadily and sharply. A recent GAO report on "peak oil," states that U.S. oil production peaked around 1970 and by 2005 the U.S. was importing almost 70% of its oil[9]. The report also stated that most experts project a peak and subsequent decline in world oil production occurring between 2008 and 2040[10]. "Demand for oil will, in turn, be influenced by global economic growth, and may be affected by government policies on the environment and climate change, and consumer choices about conservation."[11]

With world oil production estimated to peak within decades, thus significantly decreasing the supply of oil, a critical issue will be the ability to ensure a sufficient and sustainable supply of energy to meet increasing energy demands. An additional constraint will be the need to minimize environmental impacts, particularly the production of greenhouse gases, in making new energy choices.

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[7] (U.S. Department of Energy, Energy Information Administration 2009)
[8] (Hubbert 1956)
[9] (United States Government Accountability Office 2007, 2)
[10] (United States Government Accountability Office 2007, 1)
[11] (United States Government Accountability Office 2007, 1)

2. Environmental Concerns of Increased Energy Demand

The environmental concerns of using fossil fuels as a significant energy source are based primarily on the negative atmospheric impacts when the fuels are combusted. Combustion releases air pollutants, including ozone, carbon dioxide (CO_2), methane, volatile organic chemicals, sulfur dioxide and various other toxins. Air pollution from fossil fuels has many detrimental effects on the environment, and very likely is contributing to observed changes in climate.[12]

Global warming is an observable phenomenon although to what degree human activities are responsible is still disputed[13]. According to the *Fourth Assessment Report*, released by the Intergovernmental Panel on Climate Change (IPCC), climate change is defined as "a change in the state of the climate that can be identified (e.g. using statistical tests) by changes in the mean and/or the variability of its properties, and persists for an extended period, typically decades or longer."[14] It refers to any change in climate over time, whether due to natural variability, or as a result of human activity. The IPCC report predicts the globe's average air temperature will increase between 1.8 and 4 degrees Celsius by the year 2100.[15] It also finds new and stronger evidence that most of the warming observed over the last 50 years is attributable to human activities, including emissions of carbon dioxide, methane and nitrous oxide[16]. Methane is more abundant in the atmosphere now than at any time during the 400,000 year-long ice core record. CO_2 levels in Antarctica and Greenland are currently at 380 parts per million volume (ppmv), up from 190 ppmv during the ice ages and 280 ppmv during naturally warmer periods

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[12] (Intergovernmental Panel on Climate Change 2007, 138)
[13] (Intergovernmental Panel on Climate Change 2001, 2)
[14] (Intergovernmental Panel on Climate Change 2007, 6)
[15] (Intergovernmental Panel on Climate Change 2007)
[16] (Intergovernmental Panel on Climate Change 2007, 2)

before the Industrial Revolution.[17] U.S. CO_2 emissions are forecasted to increase 3% annually between 2007 and 2030, with electricity production and the transportation sector being the largest generators of CO_2[18].

3. Planning for an Alternative Energy Future

To meet the increasing demand for energy, and to avoid further increases in CO_2 and other greenhouse gases, aggressive energy planning at the state, national and international levels is needed. Solutions will require complex strategies for both energy demand and supply that simultaneously reduce greenhouse gas emissions, and other environmental concerns. Demand strategies could include more aggressive programs at all levels for energy conservation and efficiency — from home heating and lighting to manufacturing and transportation. On the supply side, increases in the use of renewable power and fuel will be critical, and will include solar, wind, hydropower, wave and tidal power, geothermal and biomass (e.g. wood, plant derived fuels such as ethanol, biodiesel and organic waste) options, among others still in development.

Recent policy initiatives at the international, national and regional levels regarding alternative energy represent a fundamental shift in the nature of production and use of resources for energy generation. These initiatives include the Kyoto Protocol on global warming; the Billion Ton Report; Presidential Executive Orders calling for mandatory renewable fuel standards; enhanced CAFE Standards to reduce annual gasoline use by 20 percent (Twenty in Ten Plan); the 2007 Energy Independence and Security Act which focuses on energy security, energy efficiency, biofuel production, and carbon reduction; and the Northeast Regional Greenhouse Gas Initiative (RGGI) that has

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[17] (Intergovernmental Panel on Climate Change 2007, 2-3)
[18] (U.S. Department of Energy, Energy Information Administration 2009)

set a goal to reduce carbon dioxide pollution to a level 10 percent below current emissions by 2019. As a result, issues impacting future resource management and energy policy are moving well beyond traditional health and safety considerations to encompass the broader sustainability concerns of global warming, air and water pollution, water availability, land use change, and renewable sources of energy.

In the most recent data available (2007), renewable energy consumption comprised 7% of total U.S. energy use[19]. Biomass and hydroelectric are the primary alternative energy sources, with solar, wind and geothermal power having minimal market penetration. Biofuels, a small component of bioenergy, has experienced the most rapid growth within the bioenergy category. U.S. biodiesel consumption in the transportation sector nearly quadrupled and ethanol production increased approximately 25 percent from 2005 to 2007[20]. A number of factors contributed to the growth in ethanol production:[21]

- Continued replacement of methyl tertiary butyl ether (MTBE) by ethanol as a gasoline additive.
- Strong world oil demand and higher crude oil prices, which have raised the price of gasoline and thus the demand for, and price of, ethanol as a substitute.
- Federal tax laws that provide incentives, such as the 51 cent per gallon tax credit available to blenders for each gallon of ethanol blended with gasoline.
- The Energy Policy Act of 2005, which mandates annual renewable fuel use in gasoline at 7.5 billion gallons by 2012.

In 1997, renewable energy sources accounted for 2.8% of New Jersey's total energy generation; in 2007, renewables accounted for only 1.3%, demonstrating that growth in the renewable sector has not kept pace with the increased energy demands of the

[19] (U.S. Department of Energy, Energy Information Administration Office of Coal, Nuclear, Electricity and Alternative Fuels 2009, 8)
[20] (U.S. Department of Energy, Energy Information Administration Office of Coal, Nuclear, Electricity and Alternative Fuels 2009, 9)
[21] (U.S. Department of Energy, Energy Information Administration 2007)

state.[22] To meet future demand, New Jersey's growth rate of renewable energy will have to increase substantially over current levels.[23] Meeting future renewable energy goals will require policies that ensure significant conservation, energy efficiencies, and high growth in renewable energy sources. To achieve these goals, many states, including New Jersey, have established renewable energy standards along with economic incentives to encourage the development and utilization of alternative energy. According to the Database of State Incentives for Renewable Energy (DSIRE), [24] all fifty states offer some type of financial incentives for energy efficiency and/or renewable energy. These incentives include rebates, taxes, loans, grants, industry support, bonds and production incentives. Forty eight states have rules, regulations and policies for renewable energy (Alabama and Mississippi do not) and all states have rules, regulations and policies for energy efficiency.

New Jersey has taken significant steps through legislation, mandatory GHG emission reduction programs, and incentives and regional collaborations to increase the development and utilization of renewable energy resources. In February 2007, Gov. Jon Corzine issued Executive Order 54 (EO54) which requires that 20% of electricity in the state come from Class 1 renewable resources by 2020, set GHG emission targets at 1990 levels by 2020 and mandated a reduction of GHG emissions to 80% below 2006 levels by 2050[25]. The 2009 State Energy Master Plan (EMP) for the first time incorporates renewable energy strategies. These strategies are designed to meet several goals,

[22] (U.S. Department of Energy, Energy Information Administration 2009)
[23] (New Jersey Department of Environmental Protection 2005)
[24] (North Carolina State University 2009)
[25] (State of New Jersey 2007)

including that 30% of the state's electricity supply is to be generated from alternative energy sources by the year 2020[26] (10% above those set in EO54).

In addition, New Jersey is a member of the Regional Greenhouse Gas Initiative (RGGI), a cap-and-trade program adopted in 2005 by nine Northeast states to reduce CO_2 emissions. The agreement is designed to stabilize power plant emissions at current levels from 2009 to 2015, followed by a 10% decrease of emissions by 2019.[27] New Jersey proposed its rule on July 7, 2008.

The New Jersey Board of Public Utilities (BPU) Office of Clean Energy establishes and implements the majority of renewable energy programs for the state. BPU approved $1.2 billion for 2009-2012 for its energy-efficiency and renewable energy initiatives. This is an increase of $475 million over the 2005-2008 allocation. In 2009, the Office of Clean Energy expended over $500 million to provide New Jersey residents, municipalities and businesses with incentives to install energy efficient and renewable energy technologies.[28] New Jersey also offers numerous financial incentives for alternative fuel and alternative vehicles in the form of rebates and tax exemptions

The newest BPU program to offer incentives for renewable energy and energy efficiency projects development is targeted to state entities and funded by the American Recovery and Reinvestment Act (ARRA). Total funding availability is $20 million and the primary goals of the program are to "reduce amount of GHG produced ,… support the state's Energy Master Plan (EMP), … and further the goals of the ARRA and EMP."[29]

[26] (New Jersey Board of Public Utilities 2008)
[27] (Regional Greenhouse Gas Initiative 2007)
[28] (New Jersey Clean Energy Program 2009)
[29] (New Jersey Board of Public Utilities 2009)

In addition to the energy programs operated by BPU, the New Jersey Economic Development Authority offers a suite of "Clean Energy Solutions" programs that include the Clean Energy Solutions Capital Investment Program and the Clean Energy Manufacturing Fund[30] that offer grants and low-cost financing. The New Jersey Commission on Science and Technology established the Edison Innovation Clean Energy Fund[31] in 2008 which supports demonstration and developmental activities in renewable energy. In 2005, the Atlantic County Utilities Authority completed construction of the state's first commercial wind farm located in Atlantic City. This project generates 7.5 MW of electricity[32].

Important unanswered questions are: Will these initiatives be enough to meet future energy demand and greenhouse gas reduction targets? How do we determine the potential of alternative energy sources such as bioefuels at the state level? How can realistic and achievable alternative fuel goals be established to meet both state and federal goals?

This research will seek to answer these questions by developing a biomass assessment methodology that will provide reliable data for a decision support system that can be used by policymakers. The information generated by this tool will be valuable when developing alternative energy strategies, specifically those related to biofuels, in order to meet the growing demand for energy sources that have reduced environmental impacts.

[30] (New Jersey Economic Development Authority 2009)
[31] (New Jersey Commission on Science and Technology 2008)
[32] (Atlantic County Utilities Authority 2005)

B. Problem Statement and Objectives

Federal mandates to utilize bioenergy alternatives due to concerns about global warming, energy security, and energy affordability, are making the adoption and implementation of bioenergy technologies a state-level policy priority. However, despite strong demand for bioenergy alternatives, many challenges are facing the growth of the bioenergy sector including: high levels of uncertainty due to early-stage development risk, technological and systematic complexities, lack of coordination in and among states, lack of accurate information on feedstock supplies, and lack of information on the realistic energy potential from biomass resources. Developing this sector's full potential is challenging, and requires new approaches, strong partnerships, and an understanding of the complex arrangements (i.e. technical, logistical, financial, regulatory, environmental and institutional) necessary to move into an alternative energy future. Effective regional and state policy making will need to rely on an accurate assessment of bioenergy availability, which is dependent on knowing the economically viable, technically feasible, and sustainable quantity of feedstocks available at the local and regional level. Accurate and consistent feedstock assessments also provide critical information for private entities interested in investing in bioenergy facilities.

An example of the need for this proposed research is the 2009 New Jersey Energy Master Plan which seeks to achieve the following state goals: thirty percent of electricity used in the state is to come from Class One renewable energy sources by 2020, and future electricity consumption must be reduced by twenty percent from projected 2020 consumption levels[33]. This mandate was established prior to the state obtaining information on its biomass resource base, the energy potential of these resources,

[33] (New Jersey Board of Public Utilities 2008)

technology and infrastructure requirements, and the economics of implementing a bioenergy technology and distribution infrastructure strategy, all of which are necessary for achieving the state's ambitious renewable energy goals.

Thus, the overall objective of this research is to provide the information and tools states need to support long-term goals of fossil fuel displacement. This dissertation will have three outcomes: 1) A methodology that allows for a comprehensive and consistent inventory and assessment of bioenergy feedstocks in terms of type, quantity, and energy potential. Development of a standardized methodology for consistent inventorying of biomass resources will foster research and business development of promising technologies that are compatible with the state's biomass resource base. 2) A unique interactive decision support tool that allows for systematic bioenergy analysis and evaluation of policy alternatives through the generation of biomass inventory and energy potential data for a wide variety of feedstocks and applicable technologies, using New Jersey as a case study. Development of a database that can assess the major components of a bioenergy system in one tool allows for easy evaluation of technology, feedstock and policy options. The methodology and decision support tool will be applicable to other states and regions (with location specific modifications), thus contributing to the achievement of state and federal goals of renewable energy utilization. 3) Development of policy recommendations based on the results of the decision support tool that will help to guide New Jersey into a sustainable renewable energy future.

Numerous reports have been published that quantify the amount of bioenergy feedstocks available in Northeast states (Table 3 – pg. 43). While these reports have provided valuable information, there are limitations in their utility for evaluating the bioenergy potential of the entire region. These limitations include:

- focus on a specific class/type of bioenergy feedstock
- some potential feedstocks that are abundant in the northeast region were not included
- methodology and units of measurement were not consistent
- feedstock production and transportation costs were not assessed
- lack of interchangeability/inclusion of a variety of feedstocks for a single fuel conversion method.

For example, of the three reports that covered the entire northeast region, none included all the potential feedstocks that are abundant in the region, in particular, waste products from the Northeast region's large population base. These wastes include food wastes, landfill gas, etc. that represent a potentially significant quantity of biomass supply in the region. Thus, the bioenergy assessment methodology developed in this research will build upon the information gathered in previous inventories, identify and address the information gaps in those studies, and generate a comprehensive and consistent system of data collection that can be used in the Northeast at the state and regional levels. By developing an integrated system of feedstock sources and measurement units, both government and industry alike will be able to evaluate potential bioenergy sheds, thus facilitating the ability to develop viable nodes of bioenergy production.

C. Dissertation Overview

This dissertation consists of eight chapters as described below.

Chapter One provides an overview of the energy and environmental issues surrounding the continued use of fossil fuels; planning for an alternative energy future; and description of the problem statement and objectives for this research.

Chapter Two provides a discussion and assessment of Federalism as it relates to energy policy, the theoretical framework for this research. It also includes a discussion of intergovernmental coordination for climate change mitigation, and state-level renewable energy policies.

Chapter Three includes a review of bioenergy assessment methodologies at the national and state levels. These include the national Billion Ton Report, and assessments from California, Pennsylvania, Maine, New York, Ohio and Vermont. This review resulted in identification of criteria for the development of an effective bioenergy assessment methodology.

Chapter Four includes a discussion of the role of decision support systems and planning support systems in policy development.

Chapter Five is a case study of New Jersey in developing a decision support tool for bioenergy policy development. A detailed discussion of the proposed bioenergy assessment methodology including a biomass assessment strategy, technology assessment strategy, predictive database/decision support tool, and applicability of the methodology to other states.

Chapter Six provides several policy scenario analyses utilizing the decision support system developed in this dissertation. The scenarios involve the utilization of solid waste for energy production.

Chapter Seven provides a discussion of evaluation criteria for decision support/planning support systems; the results of the evaluation of the methodology and decision support tool developed in this research; and recommended future modifications to the New Jersey Bioenergy Calculator.

Chapter Eight provides a summary of lessons learned about decision support system design; findings regarding the bioenergy capabilities for New Jersey based on analysis of the data in the New Jersey Bioenergy Calculator; policy recommendations for moving New Jersey into the forefront of bioenergy innovation; and recommendations for future research.

Chapter 2: Theoretical Framework – Federalism and National Energy Policy

The purpose of this section is first to provide an overview of the theory of federalism as it applies to energy policy in the United States, as this forms the theoretical framework for this research. Secondly, an assessment of the effectiveness of a federalist approach to energy policy will be discussed. Actions taken by state governments to mitigate climate change through intergovernmental coordination and state-level policies will also be presented.

The U.S. government has cited many rationales when defending its intervention in energy markets. These include "concerns over air pollution, global warming, energy prices, adequacy and reliability of supplies, foreign trade deficits of energy importing nations, and military adventurism."[34] Between 1969 and 2003, all of these rationales were used, although rationales would shift according to the President currently in office and the international and domestic circumstances which he faced.[35]

A. Federalism and U.S. Energy Policy

The tenets of federalism advanced in *The Federalist Papers* written by James Madison, Alexander Hamilton and John Jay were designed to distribute governmental authority among three branches of government and to protect against excess power at the federal level by empowering states with distinct responsibilities and authority.[36] Devolution of power to the states also allowed for recognition of variations across sub-national levels. While striving to maintain a balance of power and optimization of local implementation, federalism also creates a challenge in terms of placing resources outside

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[34] (Andrews 2005, 19)
[35] (Andrews 2005, 20)
[36] (Nathan 2008, 14)

of direct federal control, thus potentially impacting the ability to achieve national policy goals.[37]

The relationship between the federal government and the states has gone through many changes over time, from substantial autonomy between state and federal governments to complex networks of interaction under cooperative federalism to more coercive relationships characterized by contentious interactions.[38] There are many theories espoused regarding the catalysts for changes in this relationship, but all have roots in changes in the socio-economic, demographic, geo-political dynamics of the country and the world, and particularly the shift from a labor based economy to a knowledge based economy.

The beginning of the 21st century is seeing dramatic changes in national economies driven by innovations in technology and globalization. "Essentially, the very basis of economic value has changed: transactions no longer combine natural resources with labor to create value; now, value is created by combining knowledge with technology." [39] These changes are driving the need for a networked state based on federal-state partnerships which are responsive, innovative and efficient. When considering national energy policy, these characteristics are essential in an intergovernmental system striving to deal with very complex issues. Issues such as national security, economic stability and environmental sustainability have implications at the state, national and international level. As previously mentioned, intergovernmental networking and partnerships can result in a diffusion of power. Thus, the interdependence

[37] (Stoker 1991, 4)
[38] (Conlan 2008, 27)
[39] (Scheppach and Shafroth 2008, 43)

of policy issues and decisions multiplies the influence of state and local governments in federal decisions. [40]

However, there is recourse provided to the federal government by the Constitution in the form of preemption. Preemption is the process by which the supremacy clause allows federal enactments to "override conflicting state laws."[41] Preemption is put into action when state regulations produce results that contradict the goals of a federal law. This can occur in the case of energy policy where objectives can be different for federal, state and local governments. For the federal government, objectives include improving "the balance of payments, foreign relations and national security."[42] Conversely, state and local governments are primarily concerned with the "welfare of the state [or locality] and its citizens."[43]

Preemption can also be utilized "when federal regulation is so pervasive as to preclude state authority or where the particular subject regulated demands uniformity among all states."[44] In 1970, the Supreme Court upheld Florida state legislation, which imposed liability standards for damages caused by oil spills in Florida's waters that were stricter than those set forth in the Water Quality Improvement Act of 1970.[45] The Supreme Court issued this ruling despite the "pervasiveness of federal controls … and the federal government's historical domination of maritime law."[46] Similarly, President Obama recently ordered the EPA to grant California a waiver under the Clean Air Act

[40] (Stoker 1991, 11)
[41] (Mills and Woodson 1976, 408)
[42] (Mills and Woodson 1976, 405)
[43] (Mills and Woodson 1976, 405)
[44] (Mills and Woodson 1976, 408)
[45] (Mills and Woodson 1976, 408)
[46] (Mills and Woodson 1976, 408)

which will allow it to pass more stringent automobile emissions standards despite major car manufacturers' opposition to these new state-level standards.[47]

These examples illustrate that a "more modern view of federalism which embraces the concept of state-federal cooperation," is often favored when constructing U.S. energy policy.[48] Just as the "last burst of cooperative federalism arose from the environmental movement of the early 1970's,"[49] state-federal cooperation occurs frequently in energy policy because the costs and benefits of the provision of public goods are perceived differently across jurisdictions [states in this case].[50] The costs and benefits of energy production, for instance, are perceived very differently across states. Andrews noted that "offshore oil and gas drilling has been welcomed along the Gulf coast but resisted in California and Florida, and offshore wind farms are welcomed in New Jersey and resisted in Massachusetts."[51] Consequently, the potential for welfare gains associated with the decentralization of energy policy is large.[52] Additionally, as was seen in the enforcement of the Clean Air Act, "a laggard national effort can [in some instances] be more than offset by well institutionalized sub-national programs."[53]

Many factors influence the drivers of carbon dioxide intensity and a federally mandated GHG emission reductions program would likely generate impacts that vary significantly across states. Some of the state specific drivers of CO_2 intensity include[54]:

- Economic structure – is the state economy based on high or low energy intensive industries.

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[47] (Broder 2009, 1)
[48] (Mills and Woodson 1976, 406)
[49] (Kincaid 1990, 143)
[50] (Oates 1999, 1123)
[51] (Andrews 2006, 24)
[52] (Oates 1999, 1123)
[53] (B. D. Wood 1991, 858)
[54] (Ramseur 2007, 8-11)

- Personal Transportation - vehicle miles traveled per person in the state.
- Public Policy – stringency and scope of energy efficiency and emissions standards, mandates development and use of alternative energy resources, support for development of alternative energy infrastructure, etc.
- Climate – number of heating and cooling degree days will impact amount of electricity and fuel utilization.
- Gross State Product – higher levels of GSP may result in higher energy demand, though this will be dependent on the type of industry that is predominantly influencing economic growth or decline in the state.
- Portfolio of Energy Resources – greater dependence on coal will generate greater carbon emissions then states that are dependent on hydropower, for example.

Factors that can influence impacts at the state level include program flexibility, availability of and cost of mitigation options and the ability of regulated sectors to spread compliance costs to suppliers and consumers[55]. "The stringency, scope and design of the reduction regime would play a large role in determining costs and how the costs are distributed [across states]." [56] Therefore, development and implementation of GHG reduction mandates may best be placed in the realm of the sub-national level to minimize costs and maximize effectiveness of regulations.

B. Assessment of Federalist Approach to Energy Policy

The extent to which sub-national entities will be able to mitigate climate change is yet to be determined. Victor notes that as of 2005, ten states had set emissions targets but none had created a viable plan, which is necessary to achieve its goal. Furthermore, these

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[55] (Ramseur 2007, i)
[56] (Ramseur 2007, 16)

ten states are "among the least carbon-intensive in the nation… [and] generate just 14% of its electricity."[57] Lutsey and Sperling, however, assert that Victor failed to anticipate the "snowball effect" that was well underway as of 2008. By 2008, "state renewable electricity standards cover more than half of the US electricity generation, and states representing about half of US vehicle sales [were] poised to adopt the California GHG regulations for vehicles."[58]

Knigge and Bausch note that the existence of numerous state and local regulations increases uncertainty regarding future regulations, which ultimately hinders the ability of consumers and producers to make long term investment decisions.[59] They also assert that heterogeneous standards will impede commerce.[60] Victor, however, states that lower level government entities are avoiding this problem through the adoption of "consistent sets of mitigation actions" which include "establishing an emissions inventory, developing a mitigation action plan, setting an emission reduction target, enacting sector-specific policies and partnering with other governments to integrate their efforts and leverage their reductions."[61] Furthermore, specific state standards, such as the California low-carbon fuel standard, are being widely adopted and can be met using many different technologies.[62]

Although sub-national entities seem to have overcome many potential hurdles associated with instituting effective climate change mitigation policies, there are still legal, financial, infrastructural and political constraints which limit their efficacy. Talks

[57] (Victor, House and Joy 2005, 1821)
[58] (Lutsey and Sperling 2008, 682)
[59] (Knigge and Bausch 2006, 27)
[60] (Knigge and Bausch 2006, 28)
[61] (Lutsey and Sperling 2008, 682)
[62] (Lutsey and Sperling 2008, 682)

and agreements between states and foreign countries are currently under way, but may be halted on constitutional grounds as this is the purview of the federal government.[63]

States also face financial constraints which may hinder their ability to create new programs or implement existing policies. While only a little more than one-third of all state annual spending comes from the Federal government, this amount is decreasing. Additionally, the majority of EPA budget over the last several years have been in the area of state grants.[64] State renewable energy initiatives are also hindered by the current national electricity transmission system, which makes it difficult to export renewable energy from the middle of the country.[65] Finally, many states lack constituency support for climate change mitigation policies. This explains, in part, why as of 2008 about half of the states were yet to engage in climate change mitigation in any significant way.[66]

Overall, sub-national entities can achieve a certain level of effectiveness contributing to national energy goals. Lutsey and Sperling predict that US emission levels will stabilize at 2010 levels by 2020 if all emission targets, on both the city and state level, are realized.[67] These efforts, however, may ultimately be hindered by factors which are out of state control. Consequently, there is still a need for Federal level leadership and involvement. A “cooperative federalism” approach which empowers sub-national governments to innovate and design efficient programs that best met local needs (while working towards achieving federal goals), will likely be the most constructive path.

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[63] (Lutsey and Sperling 2008, 683)
[64] (Knigge and Bausch 2006, 34)
[65] (Knigge and Bausch 2006, 34)
[66] (Lutsey and Sperling 2008, 683)
[67] (Lutsey and Sperling 2008, 683)

C. Intergovernmental Coordination and Climate Change Mitigation

Effective partnerships between federal and state levels are key to successful implementation of federal policy.[68] A major energy policy initiative currently being undertaken by sub-national actors is climate change mitigation. These policies include multi-government alliances, as outlined in Table 1, state policies and local policies. Multi-government alliances are designed to standardize emissions inventories and greenhouse gas tracking techniques, to develop region-specific energy and emissions technologies and to develop "emissions trading or cap-and-trade mechanisms [in order] to integrate the diverse mitigation programs of the participants."[69] These multi-government alliances, as of the middle of 2007, encompassed about 90% of the sources of GHG emissions (Table 1) [70].

Table 1. Multi-government Climate Change Coordination Involvement in the US

Government Partnership	Current US participation (involvement initiation)	Selected Climate Change Coordinating Action	Percent US Population	Percent US GHG Emissions
New England Governors and Eastern Canadian Premiers (2001)	6 states: CT, MA, ME, NH, RI, VT (2001)	Standardize inventories, coordinate reduction plans, create uniform regional registry to form basis for emissions banking and trading	5	3
West Coast Governors' Global Warming Initiative (2004)	3 states: CA, OR, WA (2003)	Inventory updates, protocol establishment, research collaboration, establish a market-based carbon allowance system	16	10
US Mayors' Climate Protection Agreement (2007)	684 cities (2004-2007)	Urge state and federal governments to enact climate policy and establish an emissions trading system	26	23

[68] (Stoker 1991, xv)
[69] (Lutsey and Sperling 2008, 680)
[70] (Lutsey and Sperling 2008, 681)

Government Partnership	Current US participation (involvement initiation)	Selected Climate Change Coordinating Action	Percent US Population	Percent US GHG Emissions
Regional Greenhouse Gas Initiative (2005)	10 states: CT, DE, MA, ME, NH, NJ, NY, RI, VT, MD, also DC and PA observing (2005-2007)	Develop cap-and-trade program for GHG emissions, first for power plants. Accommodate diversity in participant states' programs, later expansion to other sources, states	16	10
Western Governors' Association (2006)	19 states: AK, AZ, CA, CO, HI, ID, KS, MT, NE, NV, NM, ND, OK, OR, SD, TX, UT, WA, WY (2006)	Coordinate on development of renewable energy, energy efficiency and carbon sequestration, and support market-based policy to reduce GHGs	34	35
Powering the Plains (2007)	5 states: IA, MN, ND, SD, WI (2006)	Develop efficiency, renewable energy, and carbon sequestration technologies; develop renewable energy credit-tracking and trading system	5	7
Southwest Climate Change Initiative (2006)	2 states: AZ, NM (2006)	Collaborate on GHG mitigation strategies, develop consistent forecasting, reporting and crediting practices	3	2
Western Climate Initiative (2007)	5 states: AZ, CA, NM, OR, WA (2007)	Establish registry and tracking systems, regional emissions target, and by August 2008, multi-sector market-based system	19	13
The Climate Registry (2007))	40 states (2007)	Collaboration to develop a common system for reporting greenhouse gas emissions	83	73
Total multi-government coordination initiatives (through September 2007)			94	89

Many states have adopted policies which are designed to contribute to federal GHG reduction goals. These policies include renewable portfolio standards, mandatory GHG emissions reporting and GHG emission targets. In addition, "states pursue these policies to reduce their vulnerability to energy price spikes, promote state economic development and improve local air quality. "[71] As of January 2009, twenty-nine states

[71] (Pew Center for Global Climate Change 2009)

and the District of Columbia had adopted renewable portfolio standards. [72] New Jersey also requires all firms and other entities currently reporting air emissions to the Department of Environmental Protection to also report carbon dioxide and methane emissions.

Other state initiatives include GHG inventories, climate action plans, carbon cap or offset requirements for power plants, vehicle GHG emissions standards, appliance efficiency standards, disclosure policies, green pricing programs and public benefit funds.[73] As of July 2009, forty-two states have added more detailed greenhouse gas inventories to the Environmental Protection Agency's national greenhouse gas inventory.[74] Thirty-six states have climate action plans, or are in the process of revising or developing one,[75] which help them "identify and evaluate feasible and effective policies to reduce their GHG emissions."[76] Over half the states provide incentives for alternative fuels and or vehicles, alternative fuel blends and low emission vehicles. [77]In 2007 California set the first low carbon fuel standard and many states, including New Jersey, are pursuing this as well.

On the local level, an initiative begun by the Mayor of Seattle has been adopted by 684 mayors across the country.[78] Greg Nickels urged mayors to pledge that their cities would adhere to the guidelines set forth in the Kyoto Protocol, which calls for a 7%

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[72] (Pew Center for Global Climate Change 2009, 3)
[73] (Knigge and Bausch 2006, 10,19)
[74] (Pew Center for Global Climate Change 2009)
[75] (Pew Center for Global Climate Change 2009, 7)
[76] (Knigge and Bausch 2006, 11,12)
[77] (Pew Center for Global Climate Change 2009, 5)
[78] (Lutsey and Sperling 2008, 681)

reduction in GHG emissions. The US Mayor's Climate Protection Agreement was the culmination of this effort.[79]

D. State-Level Alternative Energy Policies

A description of alternative fuels and advanced vehicle legislation and regulation for California, Delaware, Maryland, New Jersey, New York and Pennsylvania is provided in this section. California was chosen for inclusion in this research as it is by far the most aggressive state in the country in terms of regulatory efforts. It is setting the standard for the rest of the country, at both state and federal levels, in addressing GHG reductions and minimizing dependence on fossil fuels. Delaware, Maryland, New York and Pennsylvania were selected as they are neighboring states to New Jersey. They represent possible competition for New Jersey in terms of business attraction. An understanding of policies and incentives our neighboring states offer can assist policymakers and state agencies in improving New Jersey's business attraction portfolio, and thus our competitive advantage. A comparison of state renewable energy rules, regulations, policies and financial incentives for these states is provided in Table 2 (pg.35).

For most state programs, only Class I energy sources are eligible for incentive programs. All states included in this review listed the following technologies or energy sources as Class I, Tier I or Main Tier Energy Sources and technologies that can be used to meet mandated Renewable or Alternative Energy Portfolios, except otherwise noted:[80]

1) Solar Technologies/Solar Voltaic Technology
2) Wind Energy

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[79] (Lutsey and Sperling 2008, 681)
[80] (PJM Environmental Information Services 2007) and (North Carolina State University 2009)

3) Fuels Cells, Note: Pennsylvania and New York do not explicitly state that fuel cells must be powered by renewable energy
4) Geothermal energy, Note: All states include this technology except New York
5) Wave/Ocean/Tidal action (except Pennsylvania)
6) Small hydroelectric/ hydroelectric power (except New Jersey)
7) Biologically derived methane gas, including landfill gas generated from municipal solid waste, anaerobically digested biomass and methane from wastewater treatment plants

Pennsylvania also includes coal mine methane in its Tier I alternative energy sources, New York includes liquid biofuels and California includes biodiesel.

Tier II or Class II energy sources or technologies vary considerably from state to state and are either not eligible to participate in renewable energy programs or significantly lower financial incentives apply to these sources. An additional distinction between the states is that Delaware and California do not have Tier II or Class II resources and technologies. Of the states that do, New Jersey defines resource recovery facilities and small hydro power facilities (less than 30 MW) as Class II renewable sources.[81] Maryland defines "hydroelectric power, thermal decomposition incineration of poultry litter [and] waste-to-energy" as Tier II renewable sources.[82] Pennsylvania defines "waste coal, distributed generation systems, large-scale hydropower including pumped storage), municipal solid waste, generation of electricity utilizing by-products of the pulping process and wood manufacturing process [and] integrated combined coal gasification technology" as Tier II alternative energy sources.[83]

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[81] (PJM Environmental Information Services 2007)
[82] (PJM Environmental Information Services 2007)
[83] (PJM Environmental Information Services 2007)

1. State Specific Policies: California

California ranks second in the country in terms of GHG generation[84]. It has by far the most aggressive legislation, regulations and financial incentives to support the development and use of alternative fuels and alternative vehicles. Several of California's regulations exceed federal mandates and are used as a model/reference for other states in the development of alternative energy policy. California was one of the first states in the country to enact a law to address the issue of global warming. The California Vehicle Global Warming Law was enacted in 2002 and "directed the California Air Resources Board (ARB) to adopt regulations that require carmakers to reduce global warming emissions from new passenger cars and light trucks beginning in 2009."[85] The regulations were subject to state court challenges brought by automakers and car dealers[86] but were granted a waiver by President Obama in early 2009.

Other efforts undertaken in California to limit carbon emissions are the Global Warming Solutions Act of 2006 and Governor Schwarzenegger's 2007 Executive Order to create a Low-Carbon Fuel Standard and the major studies by Farrell that have been produced as a result. The 2006 Global Warming Solutions Act is the first US statewide program created to "cap all GHG emissions from major industries that includes penalties for non-compliance." [87] The act charges California's State Air Resources Board (CARB) with creating, monitoring and enforcing a GHG emissions "reporting and reductions program," through a market based compliance mechanism.[88]

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[84] (Ramseur 2007, 23)
[85] (California Clean Cars Campaign 2008)
[86] (Hammond 2008)
[87] (Hamilton, et al. 2007, 12, 14)
[88] (Hamilton, et al. 2007, 14)

In the January 2007 Governor Schwarzenegger established the Low-Carbon Fuel Standard (LCFS) by Executive Order. The Low-Carbon Fuel Standard calls for at least a 10% reduction in the greenhouse gas intensity of transportation fuels by 2020.[89] Governor Schwarzenegger's order "directs the Secretary for Environmental Protection to coordinate the actions of the California Energy Commission, the California Air Resources Board (ARB), the University of California and other agencies to develop the protocols for measuring the 'life-cycle carbon intensity' of transportation fuel" which are to be submitted to the Air Resources Board.[90] The Air Resources Board will use the protocols to create new standards.

Technical and policy analyses of the Low Carbon Fuel Standard have recently been conducted to aid the Air Resources Board in the construction of new standards[91]. The technical analysis determines the global warming intensity of various fuels through the use of life cycle analyses, while the policy analysis examines policies necessary to achieve the goal laid out in the Governor's Executive Order. It should be noted that neither of these include landfill gas as a possible energy source. On January 12, 2010, the Low Carbon Fuel Standard (LCFS) was approved for implementation. Compliance with reporting requirements begins in 2010 and the requirement for carbon reductions begins in 2011. California is the first state to adopt an LCFS[92]. Other states around the country, including New Jersey, are using the California LCFS as a model for developing their own standards.

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[89] (Farrell and Sperling 2007, 8)
[90] (California Energy Commission 2008)
[91] (Farrell and Sperling 2007)
[92] (Pew Center on Global Climate Change 2010)

California also has a number of additional planning efforts underway for alternative fuel and alternative vehicle policy development, including state biofuels development plan, hydrogen energy plan.[93] Other regulations and plans to support the development and use of alternative fuel/vehicles in California include alternative fuel vehicle retrofit regulations, alternative fuel vehicle procurement requirements, hydrogen fuel specifications, low emission vehicle standards, and zero emission vehicle production requirements.[94]

a. California Climate Action Registry

The California Climate Action Registry was created when Senate Bill 527 was signed into law on October 13, 2001. It is a "private non-profit organization" that "serves as a voluntary greenhouse gas (GHG) registry to protect and promote early actions to reduce GHG emissions by organizations" through the creation and promotion of "credible, accurate, and consistent GHG reporting standards and tools for organizations to measure, monitor, third-party verify and reduce their GHG emissions consistently across industry sectors and geographical borders."[95]

Since 2001 the California Registry's membership has grown from 23 to 300 "corporations, universities, cities & counties, government agencies and environment organizations," all of which use the Registry's Protocol to voluntarily measure, monitor, and publicly report their GHG emissions.[96] This is accomplished through the General Reporting and Verification Protocols, as well as numerous industry and project-specific protocols, all of which have been established by the Registry. These protocols have been

[93] (U.S. Department of Energy, Energy Efficiency and Renewable Energy 2008)
[94] (U.S. Department of Energy, Energy Efficiency and Renewable Energy 2008)
[95] (California Climate Action Registry 2008)
[96] (California Climate Action Registry 2008)

converted into the Climate Action Registry Reporting Online Tool (CARROT) to ease and standardize the process of calculating and reporting GHG emissions.

The California Climate Action Registry is now regarded "as a leading international thought center on climate change issues and an intersection where business, government and environmental organizations meet to work together to implement practical and effective solutions."[97] For these reasons, the General Verification Protocol used in the California Climate Action Registry is now being adopted throughout the United States and abroad and called the Climate Registry.

The other industry and project-specific protocols have not yet been considered, although it is probably safe to assume that the exact protocols or some variation there of, will be adopted in the near future. The emissions resulting from the combustion of landfill gas in an engine or turbine for electricity generation or a boiler are taken into consideration however, the "displacement of GHG emissions from fossil fuel combustion from electricity generated using landfill gas" are not.[98]

2. State Specific Policies: New Jersey

New Jersey ranks 18th in the country in terms of GHG generation[99]. Initiatives in New Jersey to reduce the consumption of fossil fuels and reduce emissions in the transportation sector include the Alternative Fuel Vehicle Rebate Program and the Clean Car Bill. The Alternative Fuel Rebate Vehicle program offers rebates based on the "incremental costs of purchasing one or more AFVs, instead of gasoline or diesel-powered vehicles, or converting vehicles to operate using alternative fuel."[100] The Clean

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[97] (California Climate Action Registry 2008)
[98] (California Climate Action Registry 2007, 12)
[99] (Ramseur 2007, 23)
[100] (New Jersey Clean Energy Program 2009)

Car Bill of 2004 will “implement California’s LEVII standards for light duty vehicles starting in 2009.”[101] The NJ Clean Car Program, which was created in 2006 to carry out the mandates in the bill, contains three components: “vehicle emission standards, fleet wide emission requirements and Zero Emission Vehicle sales requirement.”[102] The rules adopted will require that automakers reduce “fleet-wide greenhouse gas emissions from the vehicles they sell in New Jersey 30% by 2016.”[103]

New Jersey currently has no financial incentives to support the development of an alternative fuel infrastructure to serve the general public, which will be needed if the state intends to develop this industry. The Alternative Fuel Infrastructure Rebate only provides limited funding to eligible local governments, state colleges and universities, school districts, and governmental authorities for the purchase and installation of refueling infrastructure for alternative fuels. Lack of public access to alternative fuels will severely impede the state’s goals of alternative fuel use and greenhouse gas reductions. New Jersey has instituted a number of regulations designed to support emissions reductions and use of alternative fuel and vehicles which include biodiesel fuel use rebates, emissions reductions requirements, low emission vehicle standards and plug-in hybrid electric vehicle promotion the following.[104]

3. State Specific Policies: Delaware

Delaware ranks 48th in the country in terms of GHG generation[105]. There have been no state transportation fuel policies enacted thus far in Delaware. However, the Reducing Transportation Energy Use Working Group issued a report in January 2009

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[101] (Alliance to Save Energy 2008)
[102] (State of New Jersey 2008)
[103] (State of New Jersey 2008)
[104] (U.S. Department of Energy, Energy Efficiency and Renewable Energy 2008)
[105] (Ramseur 2007, 23)

which offered eleven recommendations that, if adopted, would both reduce vehicle miles travelled and the fossil fuel consumed per mile of travel.[106] The state does have an alternative Fuel Tax Exemption in which ”taxes imposed on alternative fuels used in official vehicles for the U.S. or any Delaware state governmental agency are waived”. (Reference Delaware Code Title 30, Chapter 51, Subchapter II).[107]

4. State Specific Policies: Maryland

Maryland ranks 30th in the country in terms of GHG generation. Regulatory attempts thus far to reduce carbon dioxide emissions in the transportation sector is an initiative passed in 2005 which “reinstated an expired provision exempting qualified hybrid vehicles from emissions testing and inspection requirements.”[108] Maryland has also adopted the California motor vehicle emission standards in Title 13 of the California Code of Regulations, beginning with Model Year 2011. The state has initiated several incentives to encourage the use of alternative fuels and alternative vehicles including: **c**ellulosic ethanol research and development tax credit, hybrid electric vehicle and electric vehicle tax credit, biofuels production incentives and alternative fuel vehicle acquisition requirements. [109]

5. State Specific Policies: New York

New York ranks 8th in the country in terms of GHG generation. It is the most aggressive northeast state in terms of providing a full spectrum of incentives from infrastructure development to use of alternative fuels. This comprehensive approach is

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106 (Delaware Governor's Energy Advisory Council 2009, 5)
107 (U.S. Department of Energy, Energy Efficiency and Renewable Energy 2008)
108 (Alliance to Save Energy 2008)
109 (U.S. Department of Energy, Energy Efficiency and Renewable Energy 2009)

critical if a state is to successfully build an alternative energy industry and effectively reduce greenhouse gas emissions.

New York State has passed legislation mandating that "state agencies and other affected entities must procure increasing percentages of alternative fuel vehicles, including hybrid electric vehicles."[110] Specifically, by 2005, 50% of the new light duty vehicles acquired by each state agency and affected entity had to be AFVs and by 2010, "100 percent of all new light duty vehicles must be AFVs, with the exception of designated police, emergency or other special purpose vehicles."[111] New York also offers a number of financial incentives to encourage the development of alternative fuel infrastructure, production of biofuels, provision of technical assistance and financial assistance to encourage the transition of public fleets to alternative fuel vehicles.[112]

6. State Specific Policies: Pennsylvania

Pennsylvania ranks 3th in the country in terms of GHG emission generation[113]. However, few of Pennsylvania's regulations deal directly with GHG emission reduction. In 2006, Pennsylvania began efforts to develop an energy independence strategy. The PennSecurity Fuels Initiative aims to reduce dependence on foreign oil by replacing 900 million gallons of the state's transportation fuels with alternative sources over the next decade[114]. The state also invested $30 million in existing funds through the Alternative Fuels Incentive Grant program to build alternative fuel production and fueling infrastructure over the next five years[115]. The initiative includes the creation of incentives

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[110] (Alliance to Save Energy 2008)
[111] (Alliance to Save Energy 2008)
[112] (U.S. Department of Energy, Energy Efficiency and Renewable Energy 2008)
[113] (Ramseur 2007, 23)
[114] (Commonwealth of Pennsylvania, Department of Environmental Protection 2006)
[115] (Commonwealth of Pennsylvania, Department of Environmental Protection 2007)

that open new markets to Pennsylvania farmers who grow the feedstocks used to produce ethanol and biodiesel, and the creation of safeguards against alternative fuel price increases[116].

In October 2005, the Governor's Renewable Agricultural Energy Council was established to make recommendations to the Governor on policies, regulations, and legislation focused on developing and expanding the agricultural energy industries in Pennsylvania[117]. PA regulations and incentives to encourage the development and use of alternative fuels and alternative fueled vehicles include renewable fuels mandates, low emission vehicle standards, alternative fuel production tax credits, and a hybrid electric vehicle pilot program.[118]

[116] (U.S. Department of Energy, Energy Efficiency and Renewable Energy 2008)
[117] (Commonwealth of Pennsylvania 2005)
[118] (U.S. Department of Energy, Energy Efficiency and Renewable Energy 2008)

Table 2. State Renewable Energy Rules, Regulations, Policies and Financial Incentives, 2009

Number of State Rules, Regulation and Policies for Renewable Energy													
	Public Benefits Fund	Disclo sure	RPS	Net Metering	Inter-connection	Extension Analysis	Contract license	Equipment Certification	Access Laws	Construction and Design	Green Power Purchasing	Mandatory Utility Green Power	To tal
CA	1-S	1-S	1-S	1-S	1-S	0	1-S	0	2-S, 8-L	2-S, 7-L	4-L	0	**29**
DE	2-S, 1-U	1-S	1-S	1-S	1-S	0	0	0	0	0	0	2-U	**9**
MD	0	1-S	1-S	1-S	1-S	0	0	0	1-S	1-S	1-S, 2-L	0	**9**
NJ	1-S	1-S	1-S	1-S	1-S	0	0	0	2-S	2-S	0	0	**9**
NY	1-S	1-S	1-S, 1-U	1-S, 1-U	1-S	0	0	0	1-S	1-S, 1-L	1-S, 1-L	0	**11**
PA	1-S	1-S	1-S	1-S	1-S	0	0	0	0	1-S	1-S, 1-L	0	**8**

S = State/Territory L = Local U = Utility
Source: DSIRE Summary Tables, 2009 NC State University, accessed May 2009 at http://www.dsireusa.org/summarytables/index.cfm?ee=1&RE=1

Number of State Financial Incentives for Renewable Energy										
	Personal Tax Credit	Corporate Tax Credit	Sales Tax Credit	Property Tax Credit	Rebates	Grant	Loan	Industry Support	Bond	Production Incentives	Total by State
CA	0	0	0	1-S	6-S, 35-U, 3-L	1-S, 1-L	1-S, 1-U, 4-L	0	0	1-S, 1-U	**55**
DE	0	0	0	0	1-S	2-S	0	0	0	0	**3**
MD	3-S	3-S	2-S	4-S, 6-L	3-S, 1-L	0	2-S	0	0	0	**24**
NJ	0	0	1-S	1-S	4-S	0	1-S, 1-U	1-S	0	1-S	**10**
NY	3-S	1-S	1-S	2-S, 1-L	5-S, 4-U, 1-L	2-S	2-S	2-S	0	1-S	**25**
PA	0	0	0	1-S	2-S	5-S, 1-U, 3-L	2-S, 1-U, 5-L	2-S	0	0	**22**

S = State/Territory L = Local U = Utility
Source: DSIRE Summary Tables, 2009 NC State University, accessed May 2009 at http://www.dsireusa.org/summarytables/index.cfm?ee=1&RE=1

Chapter 3. Review of Federal and State-Level Biomass Assessment Methodologies

A. US Department of Energy Billion Ton Report

1. Report Overview

In April 2005, the largest biomass feedstock assessment in the US was completed and released in a report entitled, *Biomass as Feedstock for a Bioenergy and Bioproducts Industry: The Technical Feasibility of a Billion-Ton Annual Supply*. The Billion Ton Report, as it is became known, was prepared by the US Department of Energy Oak Ridge National Laboratory (ORNL). The goal of this assessment was to determine if "the US land resources are capable of producing a sustainable supply of biomass sufficient to displace at least 30 percent of the country's petroleum consumption by 2030."[119] This goal was set by the Biomass R&D Technical Advisory Committee, established by the Biomass Research and Development Act of 2000, to direct federally funded biomass R&D[120]. The report found that there are over 1.3 billion dry tons per year of biomass potential, primarily from forestry and agricultural resources.

2. Assumptions Used in Biomass Calculations

According to the results of the report, agriculture is by far the primary source of biomass for energy production in the US, almost three times that of forestry. The authors used three scenarios in estimating agricultural biomass availability, as follows:

1) Current availability of biomass feedstocks from agricultural land.

[119] (Perlack, et al. 2005, 1)
[120] (Perlack, et al. 2005,1)

2) Biomass availability through a combination of technology changes focused on conventional crops only.

3) Biomass availability through technology changes in both conventional crops and new perennial crops together with significant land use change.

The authors concluded that agricultural lands in the United states will be able to produce almost 1 billion dry tons of biomass per year by the middle of the 21st century, while at the same time meeting demand for food, feed and agricultural exports. In order to arrive at these conclusions the following assumptions were made:[121]

- Yields of corn, wheat and other small grains were increased by 50%
- The residue-to-grain ratio for soybeans was increased to 2:1
- Harvest technology was capable of recovering 75% of annual crop residues (when removal is sustainable)
- All cropland was managed with no-till methods
- 55 million acres of cropland, idle cropland and cropland pasture were dedicated to the production of perennial bioenergy crops
- All manure in excess of that which can be applied on-farm for soil improvement under anticipated EPA restrictions was used for biofuel
- All other available residues were utilized.
- Land use change was considered in additional scenarios

The major factors that were considered to increase biomass resources from agriculture over time are: increased crop yields, increased residue-to-grain ratios, enhanced residue collection technology for annual crops, the increased prevalence of no-till planting systems, the allocation of cropland acres to perennial crops and the increased utilization of secondary processing and other residues.[122]

In terms of the available biomass from forestry resources, the authors concluded that the "forestlands in the contiguous United States can produce 368 million dry tons"

[121] (Perlack, et al. 2005, 5)
[122] (Perlack, et al. 2005, 24-31)

of woody biomass per year that could then be converted into biofuels or bioenergy.[123] Urban wood residues were included in the biomass from forestland category. Urban wood residues, which are most relevant to New Jersey, consist of woody material found in municipal solid waste (MSW) and wood in construction and demolition debris. Estimates of biomass from forestlands were made using the following assumptions:[124]

1. All forestland areas not currently accessible by roads were excluded
2. All environmentally sensitive areas were excluded
3. Equipment recovery limitations were considered
4. Recoverable biomass was allocated into two utilization groups—conventional forest products and biomass for bioenergy and biobased products.

3. Critique of Billion Ton Report

The Billion Ton Report provides a good baseline of potential biomass resources in the US as a whole, and has served as an impetus for major bioenergy initiatives at federal and state levels. However, there were some weaknesses in the methodology used. 1) The study assessed the amount of forest and agricultural resources that are available for conversion into bioenergy. However, it did not take into account the potential energy available from solid waste or landfill gas. In more urbanized areas, such as New Jersey, these are more likely the primary source of biomass for energy conversion than agricultural or forestry feedstocks. 2) There is an absence of any cost analysis or inclusion of factors that could affect the availability of biomass resources, such as infrastructure requirements. Consideration of these factors may dramatically reduce the amount of biomass realistically available for bioenergy purposes. 3) There is no

[123] (Perlack, et al. 2005, 4)
[124] (Perlack, et al. 2005, 4)

discussion of the energy conversion technologies that could be used to produce biofuels with the biomass feedstocks identified in the report.

4) There is no information from a technology or energy efficiency perspective on how it was determined that a billion tons of biomass could produce enough biofuel to displace 30% of petroleum. The report references a study done by US-DOE – Idaho National lab in 2003 which states that "Considering average conversions of standard lignocellulosic biomass, 1 billion dry tons of lignocellulosic feedstock is required annually to supply the projected biobased industry in 2030" [125]. However, in that report which formed the framework for the Billion Ton Study, there is also no discussion or analysis provided on the conversion technology, energy conversion factors or advances in conversion technologies which may impact the amount of energy produced. Advances in energy conversion technologies over time were not considered. The absence of any discussion of energy conversion technologies is a major flaw in both these reports.

5) The 2003 DOE study also states that the biomass feedstock supply must be "more sustainable than the fossil fuel-based energy system it is replacing."[126] The study cites three critieria for sustainability: "economic viability for all participants in the value chain, acceptable environmental impact of the biomass feedstock system, and positive social impact of the biomass production and products."[127] None of these factors were considered in the determining the available biomass in the Billion Ton Report.

6) There is no information provided on biomass resources available at the local level and no spatial distribution mapping. The team only looked at the quantity of

[125] (U.S. Department of Energy 2003, 11)
[126] (U.S. Department of Energy 2003, 9)
[127] (U.S. Department of Energy 2003, 9)

resources that exist. Understanding the distribution and concentration of biomass feedstocks and whether or not the quantity is sufficiently large enough and available to support the development of bioenergy industries at the local/regional level is key to realizing the goal of 30% petroleum displacement by 2030.

B. Review of State-Level Biomass Assessment Methodologies

In order to determine the strengths and weaknesses of existing state-level bioenergy assessment methodologies, a review was conducted of states that have completed biomass assessments. These include California, and the northeast states of Pennsylvania, Vermont, Ohio, Maine, Massachusetts and Connecticut. The criteria used in the review were: feedstock categories included, was cost analysis information provided, were energy potential calculations provided, was energy efficiency information provided, and was there an interactive database provided for calculating bioenergy potential. Table 3, "Comparison of Biomass Feedstock Reports for the Northeast Region", summarizes the review findings.

Many of the reports included feedstocks relevant for New Jersey, but most did not include solid waste, a primary feedstock for this state. The Pennsylvania Biomass Inventory Assessment and the Vermont Wood Fuel Supply study were the only reports to include databases. However, neither of these reports were very helpful in identifying best practices for New Jersey. The Pennsylvania Biomass Inventory Assessment only included estimates on available biomass.[128] There is no discussion of technologies, energy potential or costs associated with converting biomass to energy.

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[128] (Pennsylvania Biomass Working Group 2008)

The Vermont Wood Fuel Supply study is also of limited use since wood byproducts produced by commercial harvesting or primary processing of forest products[129] were the only feedstocks included. Lignocellulosic biomass in New Jersey includes agricultural residues, cellulosic energy crops, food processing residues, urban wood wastes and yard residues, as well as forest and mill residues. Consequently, the estimated costs of woodchips (made from wood byproducts) that are included in the Vermont study would be of limited use in New Jersey.

The work done in Ohio, entitled *Assessing Ohio's Biomass Resources for Energy Potential Using GIS* is by far the most useful. *Assessing Ohio's Biomass Resources for Energy Potential Using GIS* includes detailed calculations of energy potential for each feedstock (given in btu's).[130] The report estimates the availability of different feedstocks based on different price levels in 2020.[131] It also includes conversion efficiency rates for numerous technologies.[132]

In terms of best practices, Ohio's method of obtaining data on food processing waste is worth noting. Initially a survey was created and distributed on an experimental basis. Due to a low response rate, the food waste produced by each company was estimating using data detailing the annual sales of each food processing company, which was obtained from the Harris Ohio Industrial Directory.[133] The report stated that these numbers will later be altered once the survey is administered in a more effective manner. Hizthusen and Jeanty also created a biomass development progression equimarginal

[129] (Biomass Energy Resource Center 2007, 7)
[130] (Jeanty, Warren and Hitzhusen 2004)
[131] (Hitzhusen and Jeanty 2007, slide 33)
[132] (Hitzhusen and Jeanty 2007, slide 12)
[133] (Jeanty, Warren and Hitzhusen 2004, 79)

principle, which was synthesized to create their energy research and policy recommendations for Ohio.

The principle is a guide to determining a realistic quantity of biomass that could be available for bioenergy production. This principle was used as a reference in developing the biomass screening tool for the New Jersey Bioenergy Calculator.

Biomass Development Progression Equimarginal Principle[134]

1. Start first with biomass residuals/wastes that involve disposal or treatment costs and have already been collected or concentrated in a central location.
    - e.g. livestock manure in large animal confinement operations.
    - e.g. solid waste in landfills and wastes at food processing plants.
    - e.g. unused sawdust and wood waste at sawmills, paper plants, furniture plants, construction sites, etc.
2. Go next to biomass resources that do not have current use/demand and are not imposing major disposal, storage or treatment costs.
    - e.g., forages or other crops grown on USDA Conservation Reserve Program acres.
    - e.g., surplus crop and forest residues still in the fields or forests.
3. Go next to biomass resources that have competing but low value uses.
    - e.g., wood chips or sawdust being burned inefficiently i.e., producing little useable energy.
    - e.g., crop residues for livestock bedding.
4. Go finally to growing energy crops in competition with current food and fiber crops.
    - e.g., land use conversion.

[134] Hitzhuzen and Jeanty (2007)

Table 3. Comparison of Biomass Feedstock Reports for the Northeast Region

Title	Date of Pub	Feedstocks Included	Analysis of Cost Included	Energy Potential Calculation Made	Discussed Energy Efficiencies by Technology	Data-base Includ-ed
PA Biomass Inventory Assess-ment	2009	Agricultural resources, forestry/ wood resources, food and kindred products, misc. resources (yellow grease, trap grease, residual paper)	No	No	No	Yes
Inventory and Economic Assess-ment of Ohio Biomass for Energy	2007	Agricultural residues (corn stover and wheat straw), wood wastes (forest, C&D, Mill, MSW), MSW (paper and other MSW wastes), Animal manure (poultry, swine, dairy cattle and beef cattle), food processing wastes (potato and tomato), harvestable residues from CRP land	Yes, Figure 2 illustrates projected availability of biomass resources at different price levels in 2020. There is not any discussion of cost based on technology utilized	Yes, energy potential given in Btus for each feedstock	Yes, conversion efficiency rate assumptions were given for numerous technologies	No
Assessing Ohio's Biomass Resources for Energy Potential Using GIS	2004	Corn and wheat residues, wood residues (forest residues, primary and secondary wood manufacturers, MSW, C&D debris), methane from livestock manure, food processing wastes	No	Yes, energy potential given in Btus for each feedstock	No	No

Title	Date of Pub	Feedstocks Included	Analysis of Cost Included	Energy Potential Calculation Made	Discussed Energy Efficiencies by Technology	Data-base Included
Biomass and Biofuels in Maine: Estimating Supplies for Expanding the Forest Products Industry	2007	Forest residue and roundwood product removals	Yes, analysis of potential revenues based on the value of F-T diesel and cellulosic ethanol derived from wood products is included. Analysis of harvesting, production and transport-ation costs of the forest removals is forthcoming.	Yes, energy potential given in gallons of ethanol, gallons of F-T diesel and their respective gasoline and petro-diesel equivalencies, and in Billion BTUs	No	No
Vermont Wood Fuel Supply Study	2007	Wood by-products of commercial harvesting or primary processing of forest products	Yes, cost calculated based on extent of demand and extent of supply	Yes	No	Yes
A Geo-graphic Perspect-ive on the Current Biomass Resource Availab-ility in the United States	2005	Crop residues, methane emissions from manure management, forest residues, primary and secondary mill residues, urban wood residues, methane emissions from landfills and from domestic wastewater treatment plants, dedicated energy crops planted on CRP lands and abandoned mine lands	No	Yes, estimates for each feedstock calculated in PJ/Year	No	No

Title	Date of Pub	Feedstocks Included	Analysis of Cost Included	Energy Potential Calculations Made	Discussed Energy Efficiencies by Technology	Data-base Included
The Woody Biomass Supply in MA: A Literature -Based Estimate	2005	Woody biomass residue sources: MSW, C&D debris, Primary and Secondary Wood Manufact-urers, Urban Wood Residues	No	No	No	No
Biomass Feedstock Availab-ility in the United States: 1999 State Level Analysis	2000	Forest residues, primary mill residues, agricultural residues, dedicated energy crops (short rotation woody crops such as hybrid poplar and hybrid will and herbaceous crops such as switchgrass), urban wood waste	Yes, estimated annual quantities based on delivered price and state is included	No	No	No
Biomass Strategies for CT	2000	Landclearing debris, C&D waste, Oversized MSW, Wastewater Treatment Biosolids (dry), Paper Sludges (dry), utility poles	Yes, expressed in dollars/Kw for biomass steam, biomass gasification expressed in dollars/ Kwh	No	Yes, energy efficiencies noted for wood-fired steam power plants and for combined cycle gasification	No

Chapter 4. Decision Support Systems and Role in Policy Analysis

A. Definition and History

Decision Support Systems (DSS) are "computer technology solutions that can be used to support complex decision making and problem solving."[135] The creation of DSS can be attributed to the "theoretical studies of organizational decision making" that were carried out at the Carnegie Institute of Technology between the late 1950s and early 1960s, and the "technical work carried out at MIT in the 1960s."[136] Early DSS tool design included the following components:[137]

1) Sophisticated database management capabilities with access to internal and external data, information and knowledge
2) Powerful modeling functions accessed by a model management system
3) Powerful, yet simple user interface designs that enable interactive queries, reporting and graphing functions

In the 1980s and 1990s, DSS research progressed to include group decision support systems (GDSS) or group support systems (GSS), which provide "brainstorming, idea evaluation and communications facilities to support team problem solving," and executive information systems (EIS), which have "increased the scope of DSS from personal or small group use to the corporate level."[138]

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[135] (Shim, et al. 2002, 111)
[136] (Shim, et al. 2002, 111)
[137] (Shim, et al. 2002 111)
[138] (Shim, et al. 2002, 113)

B. Decision Support Systems and Public Policy Analysis

Decision Support Systems are an important component of policy analysis, which Strauch defined as "the systematic analysis of questions faced [in] the governmental planning or decision-making process."[139] Traditionally, policy analysts studied policy problems by establishing the scope of a research question, outlining key assumptions, performing the analysis and finally delivering policy recommendations to the decision makers.[140] This approach rested largely on a belief in substantive rationality. Individuals who exhibit substantive rationality use "scientifically produced knowledge … which describes phenomena and explains causal factors," to make decisions.[141] Traditional policy analysts largely disregarded procedural rationality, which "specifies the 'who' and 'how' aspects"[142] of a policy.

An approach utilizing Decision Support Systems allows decision makers, instead of analysts, to make important decisions and also is conducive to "repeated interactions between analysts and decision makers."[143] The Decision Support Systems approach can be appropriate problems that include high levels of "behavioral or political content."[144] These problems are often ambiguous and cannot be represented by formulas. Consequently, policy analysts have a difficult time identifying solutions without the aid of DSS. For this reason, the use of DSS in policy analysis is increasingly common. Since the early 2000's DSS has been used in policy areas such as "urban planning,

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[139] As cited by (Gass 1983, 604)
[140] (Andrews 2007, 166)
[141] (Andrews 2007, 162)
[142] (Andrews 2007, 162)
[143] (Andrews 2007, 166)
[144] Strauch, as cited by (Gass 1983, 604, 605)

environmental policy, health policy, energy policy, international relations, and military policy."[145]

C. Planning Support Systems

Planning Support Systems (PSS) are a subset of DSS. PSS, in the form of urban models, dates back to the 1960s and 1970s. In the mid 1990s, a new wave of planning support systems were created. These systems were similar to GIS but focused on aiding planning tasks, specifically, "long-range problems and strategic issues."[146] Geertman and Stillwell consider PSS to be "geoinformation technology-based instruments that incorporate a suite of components (theories, data, information, knowledge, methods, tools, meta-information, etc.) that collectively support some specific parts of a unique professional planning task."[147]

D. Design Principles of Planning Support Systems

Klosterman asserts that individuals attempting to create useful planning support systems should consider and adhere to four principles.[148] The first principle is that every model is wrong because models, by definition, illustrate a simplified version of reality.[149] Consequently, some aspects of reality are bound to be omitted. Klosterman argues, however, that a model can still be useful even if it is not one hundred percent accurate.[150] This will be a consideration in the design of the database for this dissertation, as there are many variables involved in estimating biomass feedstock availability and energy

[145] Sauter (1997), Brail and Klosterman (2001), as cited by (Andrews 2007, 166)
[146] (Geertman 2008, 217)
[147](Geertman & Stillwell, 2000 as cited by Geertman 2008, 217)
[148] (Klosterman, 2008, 88)
[149] (Klosterman 2008, 89)
[150] (Klosterman 2008, 89)

potential, not all of which can be accurately calculated. A best effort will be made to use the most reliable data sources and conversion formulas currently available.

Klosterman's second principle is that predicting the future is extremely difficult. Therefore, planners should not try to make exact predictions, but instead they should "prepare a range of forecast scenarios describing a number of possible futures."[151] The New Jersey Bioenergy Calculator will be designed with the capability to conduct scenario and sensitivity analyses. This will be accomplished by enabling users to modify assumptions in the following categories: Feedstock Net Usability Assumptions, Energy Content and Efficiency Assumptions. Planners can also use the Bioenergy Calculator to generate a range of forecast scenarios by selecting various electricity generation and fuel production technology options.

The third principle is to keep the model as simple as possible so that it can be easily understood by policy makers and the public. If the model is simple, the rate of its adoption will rise. The New Jersey Bioenergy Calculator and Resource Database will be designed to present information in an accessible and organized fashion. Detailed instructions will be provided for users that explain the function and use of each worksheet in the database.

Finally, Klosterman's fourth principle is that planners should use the information that is accessible because it is often the "best available data," even if it is somewhat incomplete or inexact. If planning and decision support tools are constructed in this way, they will be widely adopted on a regional and local level. This principle will be used when estimating the collection, sorting and alternative use rates for each biomass

[151] (Klosterman 2008, 89)

feedstock. There is no way to provide an exact figure on the quantity of feedstocks that are available in the entire state. This is because some data is incomplete and must be calculated using other factors that can provide a reasonable estimate. Data on feedstocks is also a function of how well the information is collected and recorded by those responsible.

Furthermore, Klosterman asserts that models should be able to work with the data that can be obtained, even if this data is sparse. As much data as possible will be included in the biomass resource database, even if it is incomplete. The database will have the functionality to allow for easy updating of data with more accurate and/or complete numbers as it becomes available.

Chapter 5. New Jersey: Case Study for Development of a Biomass Assessment Methodology and Bioenergy Decision Support Tool

A. Background and Overview

The development of the bioenergy calculator and methodology for a biomass resource database was funded by the New Jersey Board of Public Utilities (BPU). The research was led by Margaret Brennan-Tonetta who was responsible for leading the study team, study design, development of methodologies, identification of database contents, calculator parameters and function and development of policy recommendations. The study team of faculty, staff and external experts were assembled to provide input and expertise, and were primarily responsible for data collection. Navigant Consulting Inc, developed the Excel-based software program using stated parameters /functionality requirements.

The BPU was seeking to determine the bioenergy potential for the state of New Jersey in preparation for writing the state's Energy Master Plan. The 2008 EMP would be the first version to contain information and recommendations on bioenergy. The objectives of this research were to: 1) assess the characteristics and quantity of New Jersey's biomass resources; 2) assess technologies (commercially or near commercially available) that are capable of producing biopower or biofuels from New Jersey's biomass resources; 3) develop the first statewide mapping of waste/biomass resources and bioenergy potential; and 4) develop policy recommendations for creating a bioenergy industry in New Jersey[152]. The results of this research provide the information necessary

[152] (Brennan 2007)

to evaluate the current and projected capabilities for New Jersey in terms of feedstock and conversion technology capabilities. This will be critical information in the development of a New Jersey Bioenergy Plan that addresses the environmental and energy issues surrounding the need for bioenergy industry development. In addition, it will inform policy recommendations for moving New Jersey into the forefront of bioenergy innovation. The data generated from this project were also provided to the Center for Energy, Economic and Environmental Policy at Rutgers to conduct their energy modeling scenarios.

An estimation of biomass feedstocks and bioenergy potential had never been conducted for New Jersey. Thus, a methodology and database had to be developed to collect, manage and analyze the huge quantity of data that would be needed. In addition, a decision support tool would need to be created that could calculate energy potential based on a variety of technologies in conjunction with the biomass database. A detailed description of the methodology used to develop the New Jersey Bioenergy calculator and database is provided in the following sections.

Model Limitations: The database developed in this research represents the first ever assessment of bioenergy potential for New Jersey. It will serve as a foundation for future research and modifications that could increase its power as a more robust policy analysis tool. As such, the current database will not be able to perform analysis of tradeoffs across broad policy objectives such as economic development vs. CO2 emissions, or energy independence vs. source reduction of solid waste. Instead, it operates one level below that with comparisons of kWh or GGE generated by different feedstock/technology combinations at the state and county level. Modification of the model to incorporate factors that will enable the analysis of broader energy policy issues as those mentioned above, are recommended for future research efforts.

B. Biomass Resource Assessment: Issues to Consider

Biomass feedstocks can be divided into three broad categories: agricultural crops and residues, forestry and solid waste. These categories include the following specific feedstocks: agriculture crops and residues: soybeans, sorghum, rye, corn for grain, grasses, mixed fields, corn residues, rye residues, alfalfa hay residues, other hay residues, wheat residues, animal manure (cows, equine, pigs, poultry, goats, sheep); forestry: forest wood, forestry residue, short rotation woody crops, stumps, tree trimmings, sawmill residue, wood pulp waste; and solid waste: municipal solid waste, waste paper (landfilled and recycled), corrugated, mixed office paper, newspaper, other paper, food waste (landfilled and recycled), C&D waste (not recycled), used cooking oil (yellow grease), grease trap waste (brown grease), wastewater treatment plant biosolids/biogass, landfill gas, grass clippings and leaves. A description of the biomass assessment issues for each feedstock category follows.

1. Agricultural Crops and Residues

Agricultural biomass, including all commercial field crops, crop residue, animal waste and byproducts (such as biogas from animal waste), is a significant and important portion of America's biomass resources for energy production, due to both the volume of potential feedstock and the implications of using food producing lands for energy purposes[153]. Biomass assessments for field crops have been carried out for many years at the national and regional level as an attempt to quantify the available resources.[154] [155] [156] These assessments have become more numerous in recent years, due to increased interest in biomass energy. Typically, field crop biomass assessments are simpler than those for other land uses such as forests because of the close link to (and significant availability of) food and fiber production data. However, field crop biomass energy assessments are subject to several problems that make them difficult to utilize for advanced research or policy formulation.

Often, biomass energy assessments are based on government crop statistics[157] [158] with assumptions made as to the amount of biomass residue available for each unit of food or fiber produced. While some assessments utilize measured crop yield data and statistical extrapolation, others are based on crop models[159] [160]. The results of either approach can vary considerably depending on the assumptions used for those analyses. Some of these assumptions include fertilizer use, water use, cultivar choice, planting density, grower expertise, and pesticide/herbicide use. Some assessments determine the maximum possible yield for a region (ignoring economic constraints), while others assess the amount of biomass that is likely to be grown in a region, based on assumed costs of production and sale prices [161].

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[153] (Perlack, et al. 2005)
[154] (R. Graham 1994)
[155] (Downing and Graham 1996)
[156] (Burwell 1978)
[157] (USDA Soil Conservation Service 1990)
[158] (Wood and Layzell 2003)
[159] (R. Graham 1994)
[160] (Shulze, et al. 1997)
[161] (De La Torre Ugarte and Ray 2000)

Lastly, it is worthwhile to note that the actual biomass yield from field crops cannot be predicted with perfect accuracy, due to uncertain climatic variations and many other uncontrolled variables in the agronomic system. This problem is exacerbated when future projections are made of biomass yield, often based on questionable assumptions regarding future yields from improved plant varieties.

Due to these variations in methodology and approach, the results of biomass assessments tend to be difficult to interpret and utilize in a meaningful manner. Advanced biomass research and policy development requires reliable, spatially consistent, data.

2. Forestry

Interest is growing rapidly in using woody biomass for energy production and other bioproducts. This interest is driven by the high cost of traditional fossil fuels, a growing national dependence on foreign fossil fuels suppliers, and a desire to reduce atmospheric carbon emissions. Wood is already the most important biomass energy feedstock in the US, largely because the wood products industry is very efficient in using residues produced in sawing lumber and making pulp. Wood is burned directly or co-fired with coal to generate electricity and/or heat in combined heat and power (CHP) facilities. When the promise of cellulosic biofuels is realized, wood-based ethanol and other advanced biofuels could potentially make a significant contribution to offsetting the amount of gasoline used in the US.

The northern US has an abundant supply of wood. Between 1963 and 2002 the estimated net volume of growing stock on forestland in the northern US increased by nearly 60 percent, from 128.3 billion cu ft to 217.6 billion cu ft [162]. This suggests that there is substantial potential for additional sustainable energy-based utilization of wood in the region. However, wood is not a homogeneous resource. There are significant differences between different forms of woody biomass – i.e. green chips contain more than 50 percent water, so a ton of green chips equals only half a ton of dry chips. Finally, there are important differences in the energy content and physical and chemical properties of wood from different tree species.

Numerous assessments have attempted to quantify the availability of wood biomass for energy uses. Because of differences among studies, it is generally not possible to compare results. In order to make such comparisons meaningful, it is important to develop a framework of what to count and how to count it.

3. ***Solid Waste***

Among the most promising streams of biomass available for the creation of bioenergy or other bioproducts are the organic waste streams found in municipal solid waste. Since all of these materials are already classified as MSW, there are models for collection and hauling already in place for transfer to facilities which could convert them to bioenergy or bioproducts. In 2008, BioCycle Magazine, in conjunction with the Earth Engineering Center of Columbia University, published its 16th nationwide survey of municipal solid waste management[163]. Since 1989, when BioCycle first began publishing this survey, it has highlighted the need for standardization in data collection and reporting of MSW. Moreover, the data and analysis results have often underscored the weakness

[162] (Smith, et al. 2003)
[163] (Arsova, et al. 2008)

of estimates of percentages of MSW assigned to each component. For example, New Jersey's original estimates of the percent of food waste in MSW led to a conclusion that it was recycling more than 30 % of its food waste for one year, at a time when there were virtually no food waste recycling facilities in the state. This misleading result was driven by an assigned percentage to food waste which was too low, as well as an outlier estimate from recycling at the Anheuser Busch plant in Newark, whose anaerobic digestion plant recycles thousands of tons of food processing waste water per year.

All studies or data sets which estimate organic waste in MSW point unequivocally to the existence of enormous amounts of such waste, but also highlight the need for more standardization in identifying the quantity of such waste. While the general rule of thumb has been that half of food waste comes from residential settings and half from non-residential, this is clearly not accurate. Looking at New Jersey, some towns or counties have more non-residential food waste generators that serve a large commuter workforce or large tourist/recreation area. These areas will have more non-residential waste, and likely more food waste overall, compared to towns or regions where residences are the primary food waste generators. Various empirical studies have led to the creation of conversion factors for estimating how much food waste is generated from various kinds of non-residential waste generators—these conversions could be correlated with the Industrial Census for developing a more realistic estimate of food waste quantities.

Still another problem in quantification and reporting is the heterogeneity of materials within subcategories of MSW organics. For instance, the Anheuser Busch outlier mentioned previously begs the question whether food processing wastewater should be considered in the same category with waste produce from a supermarket and again, can either the wastewater or the produce be considered the same as waste meats and fats. Within the other categories there are similar divergences as well—leaves have far different characteristics than grass clippings and all paper is not created equal. These issues also contribute to the need to develop a sound methodology that enables states and regions to accurately assess the extent of their MSW biomass resource base.

C. New Jersey Biomass Resource Assessment Methodology

The purpose of the New Jersey biomass resource assessment was to conduct a comprehensive examination of the state's biomass resource base to determine the quantity and availability of feedstocks for bioenergy production. As described below, efforts concentrated on collecting existing data on quantity and location for each type of biomass identified as a potentially significant feedstock for energy production, taking into consideration the issues described in the previous section. The data was evaluated for validity and completeness, and additional data collected as needed to fill existing gaps. The data was then analyzed to generate the most accurate estimates of available feedstocks possible. This data was then used for assessing conversion technologies to identify the most promising and efficient technologies in terms of feedstock needs and cost per unit of fuel/energy production.

The methodology for identification of the type and quantity of biomass resources involved the following steps:

1. Identify all types of biomass resources in New Jersey that are suitable for bioenergy production.
2. Identify, by county, the quantity and location of the resources
3. Place these resources into categories that are identified by similar feedstock characteristics and common type of energy conversion technologies.
4. Determine factors that could reduce the availability of these resources for use as a bioenergy feedstock.
5. Create a screening function in the database to eliminate those resources or percentages of resources that are not realistically able to be used.

Public data on biomass resources for each New Jersey county (21) to determine an estimated total biomass quantity for the state of New Jersey was collected. Forty-one biomass resources were identified as viable for bioenergy production in New Jersey. These were divided into five categories based on their physical characteristics: sugars/starches, lignocellulosic biomass, bio-oils, solid wastes, and other waste (i.e. animal waste). Sugars/starches are traditional agricultural crops and food processing residues suitable for fermentation using first generation technologies. Lignocellulosic biomass is clean, woody and herbaceous material from a variety of sources including: agricultural residues, cellulosic energy crops, food processing residues, forest residues, mill residues, urban wood waste (wood from urban forests, used pallets) and yard waste. Bio-oils are traditional edible oil crops and waste oils suitable for conversion to biodiesel, including soybean oil, used cooking oil (“yellow grease”) and grease trap waste (“brown grease”). Solid wastes are primarily lignocellulosic biomass that may be contaminated or comingled with other biomass types. This category includes the biomass component of municipal solid waste (MSW), construction and demolition (C&D) wood, food wastes, non-recycled paper and recycled materials. Other Wastes are biomass wastes that are generally separate from the solid waste stream, including animal waste, wastewater treatment biogas and landfill gas. Data was collected on all of the feedstocks and put into the biomass resource database which forms the foundation of the bioenergy calculator.

A screening process was created within the database to determine the amount of total theoretically available biomass that was "practically" recoverable for energy production. The following factors were considered in this process: Is/Can the biomass be collected? Is the biomass sortable (or is sorting needed)? Does the biomass have a valuable alternative use? "Typical" moisture and energy content and/or yield assumptions for each resource were developed and used to calculate dry weights and total estimated energy potential. All biomass feedstocks were converted to dry tons to enable a common unit of measurement for energy conversion calculations. The screening analysis has been incorporated into the database, and provides flexible "scenario analysis" capabilities for the user. This screening process was preliminary and would require further research and primary data collection efforts in order to increase the reliability of the data.

For each generator/waste stream the following assessment criteria and assumptions for evaluating the suitability of each biomass generator and waste stream were developed: quantity of production/waste generation; concentration of production (e.g., number and scale of generators, geographic location, spatial concentration, etc.); top generators/sources; flow of production/waste generation (e.g., seasonality issues, peak production times, etc.); current disposal methods, markets, management practices; practicality and feasibility of recovery/diversion, including potential changes to collection and management practices, and economics of recovery. These, and other criteria were used to evaluate the potential volume of recoverable/useable materials for bioenergy production.

1. Methodology for Assessing Agricultural/Forestry/Livestock Waste Feedstocks

a. Crop Residuals and Livestock Waste

1. Compile Farmland Assessment records (municipal level, aggregated to county level) for 2002, 2003 and 2004 tax years
    a. Establish data consistency regarding acreage/livestock numbers
    b. Develop state and county profiles – crop acreage; livestock head
    c. Within each county (and state) develop concentration measures to determine spatial agglomerations (e.g. based on municipal data)
2. Compile NASS-NJ yield and production data for major crops for 2000-2004
    a. Develop low/high range and five year average yield figures for each major crop.
3. Calculate municipal, county and state level production estimates for each major crop/livestock base (for crops: Farmland Tax Assessment acreage*5-year avg. yield; Farmland Tax Assessment acreage*high/low yield figures)
4. Secondary data collection on crop residuals/livestock waste generation in consultation with Rutgers experts.

5. Compile biomass estimates (municipal, county, state level)
    a. Calculate gross manure by municipality – livestock (by type) x manure generation factor.
    b. Calculate municipal net available manure – gross manure x availability factor x dry weight factor.
    c. Calculate county net available manure – aggregated municipal net available manure.
    d. Crop residuals (net, based on gross volume minus volume needed for soil amendment /nutrient replacement, etc.)
    e. Bioenergy crop yields.

b. Bioenergy Crops

1. Compile data on land enrolled in the USDA-Conservation Reserve Program – 2002 Census of Agriculture. These are marginal lands that can be used for energy crop production without affecting acreage in production for food crops.
2. Collect data on bioenergy crop (switchgrass, poplar, willow) production yields from the literature, Rutgers and other experts.

c. Forestry Residues

1. Research New Jersey Forestry Management data from NJ Department of Environmental Protection
    a. Acreage under woodlot management plans
    b. Secondary data collection on forestry residue generation in consultation with Rutgers experts.

c. Production Potential

1. Develop list of key biomass crops (oil crops, starches, cellulosic, woody (including forestry products)
    a. Develop list of production criteria that will determine suitability of crop production (soils, climate, economics, etc.). Consult with Rutgers experts.
    b. Develop rank ordered list based on criteria above.
2. Develop scenarios of biomass production
    a. Develop upper bounds of production based on existing crop production (1-5 above)
    b. Develop hypothetical models of feedstock production
        i. Transistion of existing crops from food to energy (e.g. corn to switchgrass)
        ii. Adoption of new crops (e.g. swichgrass, willow)
            1. Consider policy issues (farmland preserved land, CRP land, forested land adjacent to farms, forested land under woodlot management plans, food vs. fuel debate, land use change, etc.)

***2.* Methodology for Assessing MSW and LFG Feedstocks**

a. Landfill Gas (LFG)

1. Identify all landfills in state that have actively functioning LFG collection systems.

2. Compile data on landfill gas production on the twenty-eight landfills with actively functioning LFG collection systems. Obtain data from the Landfill Methane Outreach

Program, NJ Department of Environmental Protection, US Environmental Protection Authority and County Municipal Authorities.

3. Reconcile differences in LFG production figures from the various sources.

b. Municipal Solid Waste (MSW)

1. Only MSW feedstock components that could be used for Class One[164] renewable energy production were included in the estimates.

2. Municipal solid waste that is currently diverted to incinerators was deducted from total MSW figures. BPU did not want this included in the MSW estimates for bioenergy production since the state's incinerators must continue to have sufficient feedstock to operate given the high capital investment in these facilities. Incinerated waste is also considered a Class 2 feedstock. Quantity of incinerated MSW was calculated using the "Annual Solid Waste Disposal Data, NJDEP. The components of MSW were assumed to be incinerated at the same percentage as total MSW. Total tons of MSW generated was multiplied by .14 to determine amount incinerated. NJDEP has estimated that that 14% of all MSW is incinerated.

Quantity of MSW disposed was obtained from the NJDEP reports, "Annual Solid Waste Disposal Data" and the "Annual Generation, Disposal and Recycling Rates in NJ".

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[164] Class One Renewable Energy definition as provided by DEP: Class I renewable energy is defined as electricity derived from solar energy, wind energy, wave or tidal action, geothermal energy, landfill gas, anaerobic digestion, fuel cells using renewable fuels, and, with written permission of the New Jersey Department of Environmental Protection (DEP), certain other forms of sustainable biomass.

3. Quantity of recycled materials obtained from NJDEP reports, “Annual Material Specific Recycling Rates in NJ”, and “Annual Generation, Disposal and Recycling Rates in NJ”.

4. Sewage sludge is not included because it is not classified as a Class I renewable feedstock in NJ.

c. Grease Waste

1. Yellow and trap grease waste generation estimates were obtained from the Urban Grease Resource Assessment, National Renewable Energy Laboratory, U.S. Department of Energy (Table 4):[165]

Table 4. Annual Grease Waste Generation

	Grease Waste		**Trap Waste**	
	per restaurant	**per person**	**per restaurant**	**per person**
Grease Waste (pounds)	6,254.60	8.80	12,650.00	17.90

2. Trap grease waste data was also checked with a large trap grease hauler in NJ

3. Grease waste estimates were multiplied by the population (US Census Bureau) and

4. Number of restaurants (2002 Economic Census) in each county of New Jersey.

d. Food Waste

1. Identify municipal/area nodes of concentration, particularly those which concentrate one type of generator, make the node particularly advantageous for food waste collection.

[165] (National Renewable Energy Laboratory 1998)

2. Utilize data sources including Census information on population, economic census for data regarding food service and other food waste generating businesses, by county; Department of Education data, for estimating food waste generated by schools; New Jersey Higher Education Partnership for Sustainability for data on food waste generation for colleges and universities; NJ DEP for tonnage generation information; waste composition and waste generation studies from NJ and other states including Vermont, Massachusetts, California and New York, as well as those conducted by BioCycle magazine; county and municipal solid waste and recycling coordinators; NJ Restaurant Association; NJAES Solid Waste Resource Renewal Group for food waste availability factors.

D. Conversion Technology Assessment

There are many bioenergy technologies currently available or in the pipeline that are capable of converting New Jersey biomass resources into bioenergy. Biofuels technologies are sometimes referred to as "1st Generation" or "2nd Generation". Ethanol and biodiesel are considered 1st generation biofuels:

- ***Ethanol*** is a clean burning, high-octane alcohol fuel used as a replacement and extender for gasoline. It has been commercially produced since the 70's in the US and Brazil, still the market leaders.
- ***Biodiesel*** is an alternative to (or extender of) diesel fuel and heating oil. It was commercialized in Europe in the 90's. Worse economics (and smaller market) than ethanol.

- ***Pros**:* ease of use in the petroleum infrastructure; today's only renewable option for liquid transport fuels
- ***Cons**:* limited scalability; not economically sustainable; impact on grain supply for food; uncertainty of their indirect land use change effects.

Indirect land use change is increasing global demand for globally traded feedstocks (e.g. corn, soy, wood) for biofuel production. It has the potential to change world markets such that new lands are cleared or substantially altered to accommodate this additional demand. Initial studies have shown that changes in global land use to meet demand for biofeedstocks have the potential to result in high levels of greenhouse gas emissions, and on a lifecycle basis, eliminate or even outweigh the GHG benefits of displacing fossil fuels with biofuels.[166]

2nd generation biofuel R&D efforts are focused on*:*

- Increasing the range of feedstock from which to produce biofuels
- Reducing the biomass to liquid conversion costs
- Three 2nd generation technology platforms under development:
    - Biochemical pathway: conversion of the cellulose to fermentable sugars to multiple alcohol fuels
    - Thermochemical pathway: conversion of biomass to syngas and synthesis to multiple fuels
    - Purification of biogas (landfill gas and anaerobic digester gas) into biomethane for transportation fuels (as a compressed or liquefied gas)

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[166] (Hertel 2010)

   - Significant private and public money invested in R&D

- High potential for oil displacement

In an effort to identify the most likely technologies that would be applicable for New Jersey's biomass resources, a technology screening analysis was conducted using the following criteria:

- Certain technologies are not well developed yet and/or are likely to be applicable primarily to niche applications. These were excluded from detailed analysis.
- Though there are many biomass feedstocks that could be used with a particular conversion technology, in practice, certain feedstocks are better suited to certain conversion processes. Technologies that could more efficiently utilize New Jersey feedstocks were given priority.
- Given the wide range of technologies within a particular "platform" (e.g., types of biomass gasification reactors), the analysis focused on broad technology platforms with similar characteristics. Representative feedstock-conversion-end use pathways were selected for the economic analysis.
- The technologies were assessed on a Market Readiness scale from 1 to 5, in terms of their development and market maturity: 1. Research and Development stage; 2. Demonstration stage; 3. Market Entry stage; 4. Market Penetration stage; and 5. Market Maturity stage.

The screening process yielded thirteen technologies suitable for consideration. Nine were then considered for further quantitative analysis based on their applicability to produce fuel and power, though all thirteen were included in the final database. Bio-heat applications are similar to power generation in terms of technology, but solid wastes are not typically considered as feedstocks. Historically, most bio-heat applications are “captive” opportunities in biomass based industries like forest products, and are therefore limited in New Jersey. Moreover, since many of these applications would require some sort of retrofit, the economics are expected to be very site specific. For the above reasons, detailed technology and economic analysis was not conducted for bioheat application. This does not mean there will not be some application of this type in New Jersey in the future.

The selected technologies were divided into five major categories: Direct Combustion, Thermo-Chemical Conversion, Fermentation, Anaerobic Digestion and Physio-Chemical Conversion.

The five main biofuel technology options utilize four primary feedstocks - lignocellulosic feedstocks; solid wastes, sugar & starches, Bio-oils, (incl. waste oils & greases). These technology categories include:

1. **Direct Combustion** – burning of biomass in boilers, combusters for power; gasification and pyrolysis – (power and fuels).
2. **Thermo-Chemical Conversion** - conversion of biomass to syngas and then further synthesized to multiple fuels; production of ethers (gasoline blendstock) and esters (diesel blendstock).
3. **Fermentation** - conversion of the cellulose to fermentable sugars to multiple alcohol fuels.

4. **Anaerobic Digestion** – microbial breakdown of biomass to produce biogas, methane, LNG (power and fuels).

5. **Physio-Chemical Conversion** - methyl-esters of fatty acids (biodiesel) are product of chemical reaction between glycerides (oils and fats) and an alcohol in the presence of a base catalyst.

In the biofuels analyses, differences in volumetric energy densities among biofuels were normalized to gallons of gasoline equivalent (GGE) [167]utilizing the conversions below (Table 5):

Table 5. Fuel Type Conversion Table

Fuel Type	Unit of Measure	BTUs/Unit	Gallon Equivalent
Gasoline (regular)	gallon	114,100	1.00 gallon
Diesel #2	gallon	129,500	0.88 gallon
Biodiesel (B100)	gallon	118,300	0.96 gallon
Liquid Natural Gas (LNG)	gallon	75,000	1.52 gallon
Ethanol (E100)	gallon	76,100	1.50 gallon
Methanol (M100)	gallon	56,800	2.01 allon

E. Biomass Data Sources

Sources of all data for biomass feedstock quantities, energy content assumptions, feedstock net usability assumptions, technology efficiency assumptions, fuel production

[167] (US Department of Energy, Energy Efficiency and Renewable Energy- Alternative Fuels and Advanced Vehicles Data Center 2007)

assumptions, gasoline gallon equivalent conversions, landfill gas estimates, fuel yield and county level biomass production data are provided in Appendix A. Data was provided by the New Jersey Department of Environmental Protection, EPA Landfill Methane Outreach Program, New Jersey Department of Agriculture, US Census Bureau, USDA-NASS, USDA-Conservation Reserve Program, US Forest Service, National Renewable Energy Laboratory, U.S. Department of Energy, US Environmental Protection Agency, academic experts, academic publications and other reliable sources. Some primary data collection was conducted to fill gaps in existing data. This was particularly the case for improving the data for landfill gas production in New Jersey.

F. Predictive Database and Decision Support Tool: New Jersey Bioenergy Calculator©

Bioenergy Calculator Specifications

Objective: science-based, easy to use, decision support tool for policymakers/industry considering bioenergy development.

Requirements:

- Excel-based platform
- Ability to aggregate technology and biomass information at county and state levels in dry tons, MMBTU and GGE units
- Ability to change net usable biomass assumptions, energy content assumptions and technology conversion assumptions
- Ability to select biopower or biofuel technologies for energy calculation at county and state levels

- Interactive and dynamic
- Easily updated and modified
- Screening tool embedded in database -allow for sensitivity analyses of recoverable biomass and energy potential
- Provide biopower and biofuel projections for 2010, 2015, 2020

Results: Using the data provided by the bioenergy feedstock and conversion technology assessment, a unique bioenergy calculator was created for the state of New Jersey. This database can be used as a tool for comparing bioenergy technologies for each feedstock in terms of quantities needed and potential energy recovery from each major feedstock for each appropriate technology.

Energy generation data for the thirteen selected bioenergy technologies, which takes into consideration advances in energy output and efficiency over time, was also calculated. Estimated energy potential included energy produced using current or near-term technologies appropriate for each resource. All the resource and technology data was integrated with other information (e.g. technology process efficiencies and yields). A unique bioenergy calculator was then developed to aggregate all biomass and technology information and to automatically calculate energy generation potential for each county in New Jersey. The database is designed to analyze the biomass resource data and technology assessment data in an interactive fashion and can be updated and modified. A screening tool embedded in the database allows for sensitivity analyses to be conducted on the estimates of recoverable biomass and energy potential. The Bioenergy Calculator© yields projected biopower and biofuel estimates for 2007, 2010, 2015, 2020.

G. Using the Bioenergy Calculator© and Biomass Resource Database

The New Jersey Bioenergy Calculator and biomass resource database consists of thirty two worksheets and uses the Microsoft Excel program. The contents and use of each sheet are described below.

1) Bioenergy Calculator – This worksheet functions as a bioenergy potential calculator for electricity and fuel generation. It can only calculate for either biopower OR biofuel yields, it cannot calculate a mix of the two. It contains a summary of all resource, technology, efficiency and energy potential information that has been collected through this research. Details of this information can be found in the remaining worksheets in the database. To operate the calculator, choose an electricity or fuel technology from one of the drop down cells at the top of the worksheet. Set the non-selected output type to "**None**". When a technology is selected the database automatically calculates the selected bioenergy output using only those feedstocks that are suitable for use with the particular technology selected. The estimated bioenergy potential for 2007, 2010, 2015 and 2020 will appear in MWh's for electricity in cells and in gallons of gasoline equivalent for fuels. Energy generation potential (electricity and fuel) for each of the feedstocks can be found in the remaining cells on the worksheet. Only those feedstocks that are suitable for use with the selected technology will have an energy generation figure calculated for them.

Current gross quantity in dry tons of the state's biomass and total net usable quantity of biomass (reduced as result of the screening process described above) for 2007, 2010, 2015 and 2020 are provided.

Updating/Changing Information: All changes need to be made on the relevant supporting worksheets. For changes in biomass quantities, make adjustments to the desired feedstock on the Biomass Assumptions or County worksheets. Modifications will automatically be carried through the database and the energy generation potential estimated on the Bioenergy Calculator worksheet will automatically adjust to reflect the new information. For changes in energy efficiencies go to the Technology Assumptions worksheet and make changes as desired. Additional factors in the calculator can be changed as well, and are described below. Once again, all modifications to the supporting worksheets will automatically create updated energy generation figures on the main Bioenergy Calculator worksheet.

2) Bioproduction Estimates – This worksheet contains five tables that summarize electricity and fuel generation for all New Jersey counties using two biopower technologies (Gasification and Anaerobic Digestion) and four biofuel technologies (Gasification, Fermentation, Transesterification and Anaerobic Digestion). This is a static worksheet and is for informational purposes only. It is not linked to the main Bioenergy Calculator worksheet, thus changes made here will not carry through the program.

3) Net Usable Assumptions - This worksheet contains the net usable percentages of biomass feedstocks. At the bottom of the sheet, there is a list of agricultural crops. To estimate the energy potential that could be generated if the acreage devoted to these crops was converted to a bioenergy crop (poplar or switchgrass) simply use the drop down screen to the left of the crop name and change the cell from No to Yes. To calculate the energy generation potential if only a portion of the acreage was switched to a bioenergy crop, go back to the top of the sheet and make the change in the yellow highlighted area to reflect the percent of acreage that would be devoted to bioenergy crops. These changes will automatically cause the energy generation potential to be recalculated. Additional changes to this worksheet can be made in the yellow highlighted sections to increase or decrease the percentage of usable biomass for each feedstock. Use of food crops for energy conversion was not considered in the estimation of total energy potential for New Jersey. This could be changed however for scenario analyses, by following the instructions above to change the percentage of food crops used for energy conversion. Changes on this sheet will automatically be carried through to the Bioenergy Calculator worksheet and the bioenergy potential will be recalculated to reflect the changes. Sources of information for all data contained on this worksheet are provided.

4) Energy Content Assumptions - This worksheet contains information on energy content and percent dry matter for each feedstock. Changes can be made in the yellow highlighted sections to increase or decrease these figures. Changes on this sheet will automatically be carried through to the Bioenergy Calculator worksheet and the bioenergy potential will be recalculated to reflect the changes. Sources of information for all data contained on this worksheet are provided.

5) Conversion Tables – This worksheet lists the assumed yield of electricity or fuel per given unit of feedstock. Depending on the conversion technology selected, there may be no value given for certain feedstocks in the technology columns that are inappropriate for those feedstocks.

<u>6) Updated Landfill Gas Estimates</u> – This worksheet contains the most current and comprehensive data for landfill gas (LFG) generated in the state. It contains detailed information on the amount of LFG generated, amount of LFG flared, and the amount of electricity produced from LFG for each of the landfills in New Jersey which currently utilizes the gas directly, converts it to electricity or has a flaring system in place. Sources of information for all data are provided.

<u>7) Electricity and Fuel Generation from LFG</u> – This worksheet contains summary information for all New Jersey counties on the current quantity of electricity and fuel generated from landfill gas. It also includes projections for 2010, 2015, and 2020. Projections are based on estimated increases in population from the Department of Labor, but do not take into account any reductions in waste deposited at the landfills as a result of increased diversion for other purposes.

<u>8) Biomass Data Assumptions</u> – This worksheet contains all biomass data assumptions used in the database. Changes on this sheet can be made in the yellow highlighted sections to increase or decrease these figures. Changes will automatically be carried through to the Bioenergy Calculator worksheet and the bioenergy potential will be recalculated to reflect the changes.

<u>9) Fuel Yields for Ethanol and Dilute Acid Hydrolysis</u> – This worksheet contains fuel yield assumptions for ethanol and dilute acid hydrolysis for each feedstock used with these technologies. Projections resulting from increases in technology efficiencies for 2010, 2015 and 2020 are also included.

<u>10 – 31) County Summaries</u> - These worksheets utilize the same categories of information as the Bioenergy Calculator worksheet, but contain data specific for each of New Jersey's 21 counties. Energy generation figures on these sheets automatically change when a technology is selected on the Bioenergy Calculator worksheet. Changes on this sheet can be made in the yellow highlighted sections to increase or decrease these figures. Changes will automatically be carried through to the Bioenergy Calculator worksheet and the bioenergy potential will be recalculated to reflect the changes.

H. Applicability of Methodology and Decision Support Tool to Other States and Regions

The New Jersey Bioenergy Calculator and Resource Database can be easily modified for other states. Data relevant to the state would need to be obtained and substituted for the New Jersey data currently in the model. The calculator and database can also be easily modified for regional bioenergy assessments. By modifying the county pages to instead reflect multiple states, such as the northeast, the program will work to calculate regional bioenergy potiential. However, given that there is no consistent methodology being used across the region for biomass assessments, this would make regional utilization of this DSS difficult.

I. Uncertainty Considerations

The data and model provide point estimates for parameters such as amount of feedstock produced and energy conversion efficiencies, when in fact these variables are sometimes highly uncertain. For instance, the quantity of solid waste is based on US Census population projections and estimated waste generation per person, which are stochastic variables. Also, increases in technology efficiencies over time are only estimates. Users of the model can deal with some of the uncertainties by making changes to some of several model parameters, such as usable amounts of feedstock, and generate a range of possible scenario alternatives. However, there are embedded parameters such as population change and conversion factors, which the user cannot alter. Systematic errors are also present which result from biases in measurement and/or inaccuracies in assumptions.[168] When determining a point estimate from a range of possibilities, the lower end of the range was chosen so as to produce a more conservative estimation of the final calculation. This model is meant to analyze policy alternatives, not for testing the probalistic range of all parameters. A more sophisticated modeling approach would need to be conducted to reduce the uncertainty of the point estimates, such as Monte Carlo simulations, which would identify the probability distribution of the point estimates.

[168] (Morgan and Henrion 1992, 57)

Chapter 6. Policy Scenario Analyses

Policy scenario analyses were developed as examples of how the bioenergy decision support tool developed in this dissertation could be used to help inform state level policymaking. The policy questions relate to the utilization of solid waste as a feedstock for bioenergy. Since solid waste is the most abundant bioenergy feedstock in New Jersey, as identified using the bioenergy calculator, it is an appropriate topic for policy analysis. The policy questions are as follows:

- Which counties in New Jersey should be pursuing an energy-from-waste strategy?
- How would a change in paper or plastics recycling policies change the quantity of solid waste resources available for bioenergy conversion?
- What are the drawbacks of allowing existing incinerators to have a captive market? Do new technologies have better energy conversion efficiencies to justify a move away from incineration?
- What is the impact to waste haulers and landfills of diverting current solid waste streams to new energy conversion facilities? What adaption strategies might they pursue to support the financial viability of their operations?

A. Which counties in New Jersey should be pursuing an energy-from-waste strategy?

Methodology: Using data on waste lignocellulosic biomass, solid waste, bio-oils (used cooking oil and grease trap waste) and other wastes from the *Bioenergy Calculator* to determine the waste energy available in each county (expressed in million BTU's - MMBtu), the top five counties were identified. The 2007 data was updated by using the

Landfill Methane Outreach Program's most recent database[169] to determine quantity of landfill gas that is being converted to electricity.[170] Only the landfill gas estimates were updated because these often comprised a large portion of the total waste available, relative to other feedstocks. Incinerated waste was not included in the overall assessment, as it is considered a Class 2 resource and focus of state biomass policy is only on Class 1 resources. In addition, the amount of power generated by incinerators is less than 1% of state electricity production. They are very inefficient sources of power generation. Landfill gas is considered a Class 1 resource and the major source of renewable energy in the state.

Results: Table 6 below lists the counties that contain the most available waste, both overall and by waste type, and the amount of energy that could be generated.

Table 6. Percentage of Waste Biomass and Energy Potential

Total Waste Biomass		
County	**% Total**	**Btu**
Bergen	8.1%	6,253,588
Burlington	7.8%	6,006,941
Monmouth	7.2%	5,576,743
Middlesex	7.1%	5,438,306
Ocean	5.9%	4,575,921

[169] (United States Environmental Protection Agency 2010)
[170] Electricity generation potential was determined in the bioenergy calculator spreadsheet "Potential Electricity Generation from Currently Flared LFG".

The majority of energy from waste is currently generated from conversion of landfill gas to energy. However, the results of this analysis show that the counties of Burlington, Cumberland, Gloucester, Monmouth and Cape May have significant lignocellulosic biomass resources that could be converted to energy if cellulosic ethanol technologies were available. When these technologies comes on line, policymakers should consider developing incentives for conversion of lignocellulosic feedstocks into energy, as well as the development of an infrastructure to support the logistics and transport of these feedstocks. Other solid wastes currently being landfilled can also be converted to energy using cellulosic energy technologies. Thus, these resources should also be targeted.

B. How would a change in paper or plastics recycling policies change the magnitude of solid waste resources available for bioenergy conversion?

While both paper and plastic can be utilized for energy conversion, plastics were not included in the bioenergy calculator as they are not considered a Class One biomass resource. Thus, changes in the recycling rates of plastics would not affect the amount of bioenergy produced in the state under current policies.

Paper is considered a Class One biomass resource. From a policy perspective however, recycling is a preferred use for waste paper in New Jersey. All paper that is recycled is currently used for that purpose. As a result, changes in recycling rates of paper would have little impact on the availability of this resource for bioenergy production. However, in order to use paper for energy production, it also needs to be source separated via recycling. Thus, there would need to be changes in recycling policy regarding *utilization* of that recycled paper for energy production. Keeping these issues in mind, an analysis was conducted of the impact of changes in recycling rates on the quantity of paper and plastic that could be available for bionergy production, if there were changes in utilization policies regarding these feedstocks.

Methodology: Data provided by the New Jersey Department of Environmental Protection were used to examine how changes in the New Jersey MSW recycling target would affect waste paper and plastic availability.[171] Currently, the target is to recycle 50% of the MSW generated in the State.[172] New Jersey lawmakers have attempted to reach this goal by requiring (via the Recycling Act) each county to mandate "the recycling of at least three designated recyclable materials."[173] The model developed for use in this policy analysis increases or decreases paper and plastic recycling rates in proportion to a change in the recycling target. For instance, if the target decreases from 50% to 25%, the portion of office paper recycled drops from 44.8% to 22.4%. From there, the amount of paper and plastic available is computed by subtracting the tonnage recycled from the tonnage collected. For waste paper, the total was multiplied by 0.8 to account for the percentage of land filled paper that the *Bioenergy Calculator* considered usable. Note: It is unlikely that the recycling rates and recycling target have a perfect linear relationship. Other factors, such as increased or decreased demand for goods produced from the material collected and recycled, or the existence of recycling incentives and disposal penalties, will also play a role in determining actual recycling rates. In an attempt to make the model realistic, only recycling targets ranging from 0%

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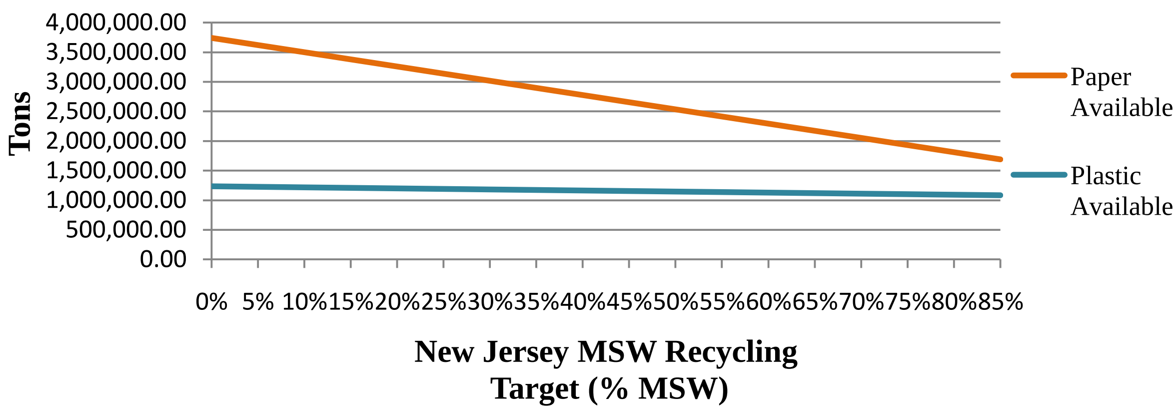
[171] (New Jersey Department of Environmental Protection 2009)
[172] (New Jersey Department of Environmental Protection 2005)
[173] Ibid.

to 85% were included, as the highest recycling target in the United States (San Francisco) is only 75%.[174]

Results: Figure 3 below illustrates the changes in waste paper and plastic resources that are predicted to result from a change in the New Jersey MSW recycling target. Paper availability changes more drastically than plastic availability because paper recycling rates, overall, are much higher than plastic recycling rates.

Figure 3. Waste Paper and Plastic Availability



C. What are the drawbacks of allowing existing incinerators to have a captive market? Do new technologies have better energy conversion efficiencies to justify a move away from incineration?

Methodology: Various costs and benefits associated with incineration, as compared to pyrolysis, gasification, anaerobic digestion and recycling/composting were assessed, in order to determine the drawbacks of allowing incinerators to have a captive market.

[174] (Chambers 2009)

Results: Economic Cost Comparison

In purely economic terms, incineration is less costly relative to other technologies. As seen in the chart below, biomass combustion (incineration) is cheaper than all other waste disposal technologies. The levelized energy costs provided in Table 7 were calculated without incentives in place and without paying for feedstock.

Table 7. Levelized Cost of Electricity (cents/KWH)

Levelized Cost of Electricity (cents/KWh)[175]		
	Year	
Technology	**2007**	**2010**
Biomass Direct Combustion – central	5.25	5
Biomass Integrated Gasification Combined Cycle	7.9	5.25
Biomass Combustion - Distributed CHP	9	8.5
Biomass Gasification	12.5	10.5
Anaerobic Digestion	15	13

Health and Environmental Cost Comparison:

Incineration, while currently the most cost effective energy from waste conversion technology, does not perform as well from an environmental standpoint, particularly in comparison to recycling and composting. As seen in Table 8, the amount of greenhouse gas avoided by recycling is greater than any other waste management technology.

175 Levelized energy costs - an economic assessment of the cost of the energy-generating system including all the costs over its lifetime: initial investment, operations and maintenance, cost of fuel, and cost of capital.

Table 8. Reduction in Emissions Per Ton of Waste Disposed

Reduction in Emissions Per Ton of Waste Disposed[176]	
Waste Management Method	**pounds of eCO2**
Recycle/Compost	-3620
Landfill*	-504
Incineration	-143
Gasification/Pyrolysis	-204

The authors calculated "reductions" in emissions per ton of waste disposed by each method by utilizing data from life cycle assessment tools. The model assessed the energy used and waste and pollution produced in each stage of a product's creation and disposal. In terms of recycling and composting, the authors assumed that these practices would offset the production of glass, plastic and paper products from virgin materials and the production of synthetic fertilizer. This in some cases, also results in continued carbon sequestration and not having to cut virgin wood. The authors also noted that compost production from recycled materials would displace the production of synthetic, petroleum based fertilizers. They also took into account the emissions associated with waste management that would be avoided if a material was continuously recycled.

In terms of the emission of other substances that affect the environment and human health, recycling and composting again perform best, as seen in Table 9. Gasification/Pyrolysis and Incineration emit less of most substances than do landfills.[177]

[176] (Tellus Institute 2008)
[177] Ibid.

Table 9: Environmental Impacts of Waste Disposal Methods

Method of Waste Disposal	Substances that Affect Human Health			Substances that Affect the Environment	
	Particulates	Toxics	Carcinogens	Eutrophi-cation[178]	Acidifi-caton[179]
	ePM2.5	eToluene	eBenzene	eN	eSO2
Recycle/Compost	-4.78	-1587	-0.7603	-1.51	-15.86
Landfill	2.82	275	0.0001	0.1	2.38
Incineration	-0.3	68	0.0019	-0.01	0.04
Gasification/Pyrolysis	-0.36	-1	0	-0.05	-0.93

In 2005, Jeffrey Morris monetized the environmental benefits of recycling realized in Washington State by using survey data and a decision support tool created by Research Triangle Institute, with support from the US EPA and North Carolina State University.[180] In his analysis, Morris assigned monetary values to the prevention of global warming, acidification and eutrophication. He calculated these benefits, as well as the net curbside cost of recycling (curbside cost minus avoided disposal cost) on a monthly, household basis. Morris calculated disposal costs for each of Washington's four regions (Urban West, Urban East, Rural West and Rural East) by evaluating the cost of depositing waste in landfills that had LFG collection and flaring systems in all areas except Urban East. In Urban East, the most densely populated area, he calculated the disposal costs (as well as environmental impacts) by evaluating incineration with electricity generation sold back to the grid.

Table 10 summarizes the total costs of recycling versus waste disposal based on the data presented in Morris' article. As indicated, recycling is less costly than disposal

[178] Eutrophication - process by which a body of water acquires a high concentration of nutrients, especially phosphates and nitrates
[179] Acidification – build-up of elements in soils or water causing a reduction in pH
[180] (Morris 2005)

via landfill or incineration in every region. In the Urban West, the monetized environmental benefit outweighs the net curbside disposal cost. Morris noted that "a greenhouse gas credit of just $9 a ton would by itself offset the net costs of the average recycling program in the Urban West."[181] The Waxman-Markey and Kerry-Boxer bills both included carbon permit price floors of $10/ton and $11/ton, respectively.[182]

Table 10. Total Costs of Recycling Versus Waste Disposal

Region in Washington State	Total Benefit (Cost) of Recycling per Ton	Total Benefit (Cost) of Disposal via landfill or incineration per Ton
Urban West	$ 49.20	$ (146.20)
Urban East	$ (9.83)	$ (130.79)
Rural West	$ (2.79)	$ (137.47)
Rural East	$ (48.38)	$ (118.94)
Washington State Average	$ 11.49	$ (137.14)
Urban Average	$ 30.56	$ (141.33)

Overall, the data derived from Urban East is probably most relevant to New Jersey, given similar population densities. This data, however, will not be completely comparable to conditions in New Jersey because most New Jersey landfill gas is converted to electricity instead of flared. The data is also incomplete because the effects of particulate matter and other toxins and carcinogens emitted from landfills and incineration facilities are avoided when materials are recycled instead of produced from virgin stock, are not taken into account in the Washington State analysis.

Conclusion:

There are significant drawbacks, in terms of health and environmental costs, associated with allowing incinerators to have a captive market in New Jersey. All

[181] Ibid.
[182] (Chameides 2009)

incinerators in the state currently accept MSW and many accept vegetative waste and animal and food processing wastes, much of which could either be recycled or composted.

As of 2008, no commercial scale gasification or pyrolysis plants were operating in the United States.[183] Gasification and Pyrolysis, as seen in Table 11, do not perform significantly better than incineration. For these reasons, and because the net energy generation potentials of incineration, gasification and pyrolysis are similar, it makes more sense to install co-generation technology on existing incinerators (if this has not already been done). Recycling has the highest (by far) energy potential in KWH per ton of MSW because of the energy saved. When products are continuously recycled, virgin material does not have to be harvested, which in some cases results in continued carbon sequestration. The authors also noted that compost from recycled materials would displace the production of synthetic, petroleum based fertilizers. Sending waste to an incinerator or generating electricity through landfill gas, gasification or pyrolysis does not allow one to realize all of these energy savings. It was not clear however, if the authors include the possibility of recycling metal collected after waste incineration.

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[183] (Tellus Institute 2008)

Table 11. Net Energy Generation Potential[184]

Net Energy Generation Potential	
Waste Management Method	Energy Potential (KWh per ton MSW)
Recycling	2,250
Gasification	660
Pyrolysis	660
WTE Incineration	585
Anaerobic Digestion	250
Landfilling	105

Recommendations:

1) Incinerators should not have a captive market on any materials that could be recycled or composted. The health and environmental costs of doing so would be high. Instead, New Jersey should institute policies that encourage recycling, composting or anaerobic digestion (which produces compost as a by-product), as all of these waste management technologies have positive externalities.
2) There are no significant drawbacks of allowing incinerators to have captive markets on waste that is not recyclable or compostable. However, no significantly better, commercially viable technology exists at this time.

D. What is the impact to waste haulers and landfills of diverting current solid waste streams to new energy conversion facilities? What adaption strategies might they pursue to support the financial viability of their operations?

Assessment of Economic Impacts: Table 12 (page 91) contains data that represents the economic impacts associated with either disposing of a ton of waste in a landfill or waste to energy facility or diverting the waste to either a composting or material recovery

[184] Ibid.

facility.[185] All monetary values are from Goldman and Ogishi's 2001 study of Los Angeles and San Diego, and have been adjusted to 2009 dollars using the Producer Price Index.[186] This region is most comparable to the state of New Jersey because it contains higher populations, commercial sectors and waste generation than any other region in California.[187] Therefore, the total sales of waste disposed in the Southern Region of California ($159.69/ton) is a comparable estimate of the sales and revenues that the waste disposal sector (which includes hauling, landfilling and incineration) in New Jersey would earn if one ton of waste is disposed.

Table 12 also reflects the impact on the regional economy, as a result of disposing of one ton of waste. The impacts include an increase in output (sales), income, value added and job creation. Conversely, these numbers can also be interpreted as losses to the waste disposal sector and regional economy per ton of waste diverted instead of disposed. To determine the overall economic effect, these losses would have to be weighed against the gains realized from diversion.

[185] (Goldman and Ogishi 2001, 62)
[186] (St. Louis Federal Reserve 2010)
[187] (Goldman and Ogishi 2001, 46)

Table 12. Average Economic Impacts of Additional Waste Disposal and Diversion

Average Economic Impacts of Additional Waste Disposal and Diversion in 2009 Dollars							
California Region		**Total Sales 1999 ($/ton)**	**Impacts on Regional Economy**				
			Output ($/ton)	**Total Income ($/ton)**	**Value Added ($/ton)**	**Number of Jobs (Per 1,000 tons)**
All California	Disposed	154.50	375.20	140.21	186.95	2.46
	Diverted	329.76	732.23	271.34	376.50	4.73
Northern Region	Disposed	149.30	337.55	122.04	162.28	2.62
	Diverted	241.48	503.73	185.65	258.36	3.9
Bay Area	Disposed	153.20	357.03	137.62	181.76	2.22
	Diverted	290.81	617.98	238.88	329.76	3.78
Central Coast Region	Disposed	149.30	324.57	122.04	159.69	2.3
	Diverted	245.37	502.43	197.34	263.55	3.61
Central Valley Region	Disposed	136.32	312.89	114.25	153.20	2.23
	Diverted	358.32	762.09	288.22	393.38	5.49
Southern Region	Disposed	159.69	372.61	140.21	184.36	2.46
	Diverted	344.04	723.14	259.66	360.92	4.62
Eastern Region	Disposed	170.07	312.89	112.95	148.00	2.42
	Diverted	71.41	110.35	40.25	66.21	0.92

Tipping fee data (Table 13) also demonstrates the financial losses landfills in New Jersey would incur if waste is diverted (either as a result of increased recycling or waste to energy projects).[188]

[188] (New Jersey Department of Environmental Protection 2009)

Table 13. Average Tipping Fees in New Jersey (October 2009)

Average Tipping Fees in New Jersey (October 2009)		
Facility	**MSW**	**Bulky Waste**
Transfer Station	$84.05	$88.42
Landfill	$72.29	$89.12
Landfill / Transfer Station	$57.32	$62.87
Resource Recovery Facility	$85.66	$83.13

As seen above, tipping fees at resource recovery facilities (incinerators) were higher, on average, than tipping fees at landfills as of October 2009. The cost of exporting waste, however, is often cheaper than landfilling or incinerating waste in New Jersey. Jeff Kendall, the CEO of Liberty Waste, has stated that exporting waste by rail becomes economical once transportation disposal prices are around $60/ton.[189] The tipping fees in New Jersey are now well above that. For this reason, Kendall has invested in two landfills in Ohio and a rail trans-loading facility in South Kearny, NJ. Liberty Waste now transports about 3,000 tons of waste per day from New Jersey to Ohio.[190]

Adaptation Strategies

As a result of a 2002 Federal Appeals Court decision, public landfills can utilize flow control directives and petition their municipal utilities authority or another county-level government entity to require waste haulers to transport waste only to their landfill.[191] This helps to support the financial needs of the landfill by covering the costs of construction and operation via tipping fees. The Sussex County Municipal Utilities

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[189] As quoted by Patricia-Anne Tom in (Waste Age 2007)
[190] Ibid
[191] (Waste Age 2004)

Authority recently passed such an ordinance, requiring that all waste in the County be hauled to Sussex County Landfill.[192] These ordinances, however, may not be politically viable in the long term if they are accompanied by large tipping fee hikes, as was the case in Sussex County. Additionally, "flow control" ordinances cannot be applied to privately owned landfills because in 1994 the U.S. Supreme Court determined that these ordinances are unconstitutional, as they interfere with "commerce."[193]

Landfills and haulers can also adapt to changing economic conditions by initiating new waste-to-energy projects at the landfill. Robert Simkins, Solid Waste Coordinator for Burlington County, believes investing in anaerobic digestion will be lucrative, even for landfills that already convert landfill gas to electricity and for waste haulers.[194] Landfills that already convert landfill gas to electricity can use the waste heat from this process to heat the anaerobic digester. If haulers sign advanced contracts with landfills for the methane gas produced in the anaerobic digesters, they will also benefit because the long-term uncertainty of their fuel costs will be mitigated.

Municipalities have the authority to mandate source separation of organic waste, which will still be brought to the landfills (for a separate tipping fee), but deposited in the digester instead of the landfill. Robert Simkins stressed that diverting organics, such as food waste, would not reduce landfill gas production if a certain amount of biosolids is deposited in the landfill. Landfills, Simkins explained, are carbon rich and nitrogen poor, causing decomposition rates to be less than optimal. Adding biosolids increases nitrogen

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[192] (Scruton 2010)
[193] (Waste Age 2004)
[194] Interview with Robert Simkins, District Solid Waste Coordinator, Burlington County Division of Solid Waste Management, 9 June 2010.

levels and causes decomposition rates to rise, thereby mitigating the effect diverting certain organics to the anaerobic digester would otherwise have had. This approach is potential lucrative for all parties involved.

Chapter 7. Evaluation of Decision Support Systems and Planning Support Systems

A. Model Assessment Processes

Gass asserts that policy models should be assessed for three reasons: 1) the decision maker is often distanced from the modeling process and therefore, requires a "basis for deciding when to accept the model's results."[195] 2) new users must be able to decide if the model can be applied to their area of interest. 3) without a formal, autonomous evaluation, it is difficult to determine the "impact of a model's assumptions, data availability and other elements on the model structure and results."[196] These rationales lay the foundation for evaluating the decision support tool for bioenergy policy developed in this dissertation.

In the late 1970's, personnel at the Massachusetts Institute of Technology Energy Laboratory created an assessment process that has been used to evaluate several energy models. The procedure contains four elements: a review of the literature, an overview model assessment, an independent audit and an in-depth assessment.[197] The purpose of the literature review is to identify the model's objectives, confirm that the model's structure is appropriate and that the results generated are plausible. A comprehensive literature review and evaluation of other national and state-level methodologies were conducted. The results were discussed in previous chapters. The overview model assessment is an "analytical evaluation of the model's properties … [which] includes an evaluation of the empirical content of the model, limitations due to the model's structure,

[195] (Gass 1983, 617)
[196] (Gass 1983, 617)
[197] (Gass 1983, 619, 620)

and identification of critical points and issues."[198] The independent audit evaluates the "validity, applicability and performance" of the model using data obtained from experiments.[199] Questions related to overview and independent audit elements will be included in the focused interviews. The fourth element is the in-depth assessment, which is an evaluation undertaken by the assessor team by running the model and identifying "errors and discrepancies between implementation and documentation."[200] Trial runs of the decision support tool were conducted during the development phase and errors and discrepancies were corrected.

1. Adequacy, Value, Effectiveness, and Legitimacy Evaluation Criteria

Given that the bioenergy calculator is intended to be used by a variety of audiences and disciplines – i.e. policymakers, industry, and academics, as well as engineers and planners, it is important to evaluate the tool for its ability to cross boundaries and generate information that can "link knowledge to action"[201]. In order to accomplish this, Clark and Majone site two important criteria in setting up the evaluation methodology: first, identification of a pool of evaluators that can provide a diverse cross section of "interest groups that have a stake in the decisions being contemplated"[202]. This will generate a greater understanding of the importance of various criteria to different users. In selecting participants for the evaluation of the bioenergy calculator, expertise, job function and affiliation were all considered and a diverse pool of candidates was compiled. Candidates were selected from state agencies, universities, industry, regional

[198] (Gass 1983, 620)
[199] (Gass 1983, 620)
[200] (Gass 1983, 620)
[201] (Cash, et al. 2002, 1)
[202] (Clark and Majone 1985, 9)

planning entities, and state government. The group also reflects a diversity of expertise including engineering, policy, business, and agriculture. Additional information on the evaluation group is described in the "Sample of Key Informants" section.

The second criterion that Clarke and Majone puts forward relates to cross-cutting aspects of the evaluation that deal with adequacy, value, effectiveness, and legitimacy. The "criteria of adequacy" deals with the reliability of data and "testing for systematic weaknesses in the materials of data and methods.[203]" Questions relating to adequacy include: "Are the data used in the model from unbiased and reliable sources?" and "Are there errors in the assumptions used to drive the calculations?" .

The "criteria of value" relates to the worth of the model to intended users[204]. If the model does not have value to the end user, than the effort is meaningless and unproductive. Questions relating to value include: "Does the model generate the type of information you find valuable for your work?", " What additional information should be included in the model to make it more useful for you?" and "What elements of the model make it potentially valuable for other uses? ".

The "effectiveness criteria" target the model's ability to move policy forward such that "…the criteria of effectiveness focus[es] on the contribution of scientific inquiry to the policy agenda, rather than policies themselves.[205]" Questions relating to the effectiveness criteria include: "Is the model a valuable tool for informing policymaking?" and "Is the model a valuable tool for informing business decisions?".

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[203] (Clark and Majone 1985, 12)
[204] (Clark and Majone 1985, 13)
[205] (Clark and Majone 1985, 15)

The final criteria is legitimacy, deals with the processes and participants involved with the development of the model and whether they "considered appropriate values, interests, concerns and specific circumstances from multiple perspectives.[206]" A question that addresses legitimacy is one such as, "Were the right people involved with constructing and validating this tool?".

Cash, et.al. adds two more criteria to be use in evaluation, saliency and credibility. Saliency is similar to Clarke's criteria of value and effectiveness, and refers to "the relevance of information for an actor's decision choices.[207]" Credibility is concerned with whether "an actor perceives information as meeting standards of scientific plausibility and technical adequacy.[208]" This is compatible with Clark's criteria of adequacy.

B. Utilization-Focused Evaluation: Definition and Procedure

In addition to the evaluation criteria posited by Clarke and Cash, evaluation criteria that are based on utility and actual use are the basis for utilization-focused evaluation. Utilization focused evaluation is based on the premise that "evaluations should be judged by their utility and actual use."[209] To this end, the New Jersey Bioenergy Calculator and Biomass Resource Database will also be evaluated in terms of ease of use, transferability, ease of making modifications, and whether time and place increments are appropriate. Utilizing the framework developed by Davidson for

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[206] (Cash, et al. 2002, 5)
[207] (Cash, et al. 2002, 4)
[208] (Cash, et al. 2002, 4)
[209] (Patton 2008, 37)

utilization-focused evaluation[210], a description of the evaluation methodology, which also incorporates the evaluation criteria of Clarke and Cash, is as follows:

Primary Purpose: A formative evaluation with a focus on improving program effectiveness [211] is the approach being taken to determine the strengths and weaknesses of the data and assumptions used to develop the database and the bioenergy calculator.

Sampling Strategy: A focused sampling strategy will be used in which key informants comprised of a pool of experts in engineering, agriculture, policy and other relevant fields will form the sample group. A focused sample is being used since it is difficult to accurately identify a population from which to draw a random sample. In addition, it is important to identify an information-rich sample in order to obtain relevant and reliable data that can be used for improving the calculator and database. Drawing on the expertise of selected stakeholders who are in the best position to understand the importance of the calculator and database, as well as the reliability of the data and assumptions, will provide valuable responses for the evaluation[212].

Validation: The interview questions have been designed to evaluate the accuracy and reliability of the assumptions and data used in the calculator, and the usefulness of the results for policymaking.

Data Collection Technique: Each sample member will be sent a copy of the evaluation questions with instructions and a copy of the bioenergy calculator. They will be asked to thoroughly go through each page of the calculator and complete the evaluation form.

[210] (Davidson 2005, 5)
[211] (Patton, 2002)
[212] (Patton, 2002)

Estimated total time for respondents to review the calculator and the database, as well as provide responses to the evaluation form, will be about 30 minutes.

Type of Data Collected: Twenty-three evaluation questions were developed in six categories to determine the “validity, applicability and performance” [213] of the model. These categories include accuracy/reliability, scope, use/transferability, navigation, usefulness, and overall assessment. The twenty- three questions were structured such that both ranking data and written responses could be obtained. A ranking was used for those questions for which general responses in a range of “agree” to “strongly disagree” was sufficient, such as those relating to usefulness and ease of navigation. Rankings of “poor, good, excellent” were used for the overall assessment questions. Responses for questions relating to accuracy, scope, and use/transferability were collected through written comments, as it was important to obtain specific information on any data errors or incorrect assumptions. Responses to the evaluation questions provide specific direction for shaping future modifications and improvements to the calculator and database. A copy of the evaluation tool used can be found in Appendix B.

Data Analysis: The written responses were summarized and needed modifications/improvements on the design and delivery of the calculator and database were identified. Comparisons were also made between the categories to determine which aspects of the database and calculator where best/worst performing Figure 4 (pg. 118).

Sample of Key Informants: Thirteen key informants were identified based on their known expertise and experience in bioenergy and/or biomass assessments. For questions which a respondent may not have the expertise to provide any comment, they were

[213] (Gass 1983, 620)

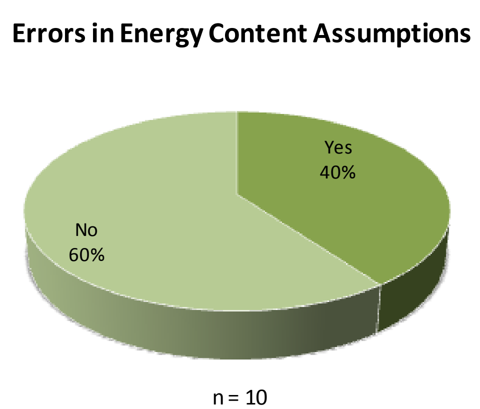
instructed to respond "N/A". Thus the number of responses for certain questions may be less than the total number of respondents.

C. Evaluation Results

The bioenergy calculator evaluation was sent to thirteen key informants. Twelve evaluations were completed and returned. The results of the evaluation and a description of the respondents follows:

<u>Accuracy and Reliability</u>

1.a. Does the information included in the "Energy Content Assumptions" worksheet contain any errors?



<u>Comments</u>

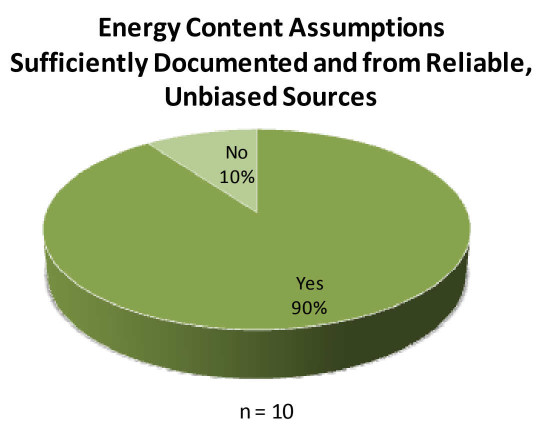
- Do I understand correctly then that you are not including Forest Products harvested as Roundwood or Wholetree Chips to be used for bio-energy production? Or are these considered parts of your "Residue" or "Waste" definitions?
- It looks pretty good, as far as I can tell (I'm more accustomed to using SI units). Of course, the real values are not precise single values, but rather a range of values.
- Possibly. I looked at the spreadsheets but I am not sure how the heating values are used. Initially I though the HHV would be multiplied by the % dry matter to get an as-fired HV for use in the spreadsheets. However, unless I am mistaken, column B is used directly in the calculations of current net energy available in the Bioenergy Calculator via the Conversion Table. In either case, then some of the heating values are not consistent with what I am familiar with. For example, I think 15,000 Btu/lb HHV for yellow grease is low. We have worked with ≈70 samples of animal fats, vegetable oils, fatty acids, and greases, and the heating values have ranged from 15,700 to 17,200 Btu/lb (as fired but with essentially no moisture content so they

can be considered HHV) with the yellow greases ranging from 16,900 to 17,200 Btu/lb. I have less experience with trap grease. I have worked with brown grease, which is what I thought trap grease was, and the samples that I worked with were about 16,750 Btu/lb as fired. I agree with the HHVs of the materials that I am familiar with (they make sense taking into account their variability) but we have seen moisture values vary greatly depending upon many factors.

- Comment on the assumed Btu value for forestry residues. Average dry Btu/lb value for whole tree chips of 7,800 Btu/lb appears low – this is characteristic for some species but I would expect an average to be in the 8,500 Btu/lb range.

- I was unable to open a number of the web links in the comments section.

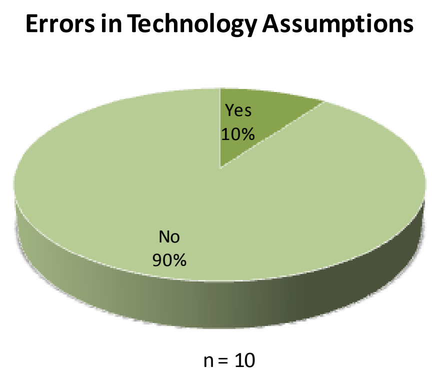
1.b. Are the sources of information in the "Energy Content Assumptions" worksheet sufficiently documented and from reliable, unbiased sources?



Comments

- Very impressively documented.
- More like "yes" and "no". Sources seem reliable but I was unable to open some to check for Bias/reliability - this made impossible to answer "Yes" here.
- Yes, however, it's not clear why so many different sources were used for similar information. For example, why was the National GREET database used for some ag residues, but NREL data for other ag residues? Are these based on similar methodologies? Also, it's difficult to see and read the comments embedded in a few of the cells.

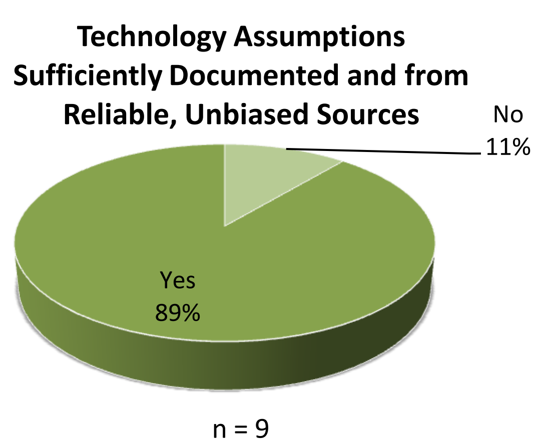
2.a. Does the information included in the "Technology Assumptions" worksheet contain any errors?



Comments

- The only concern would be estimates provided by Steve P. Though under the conversion tables the energy content matches other estimates found in the literature, so it seems like a reasonable approximation.
- The efficiency values for biomass direct combustion electricity production look rather low to me. I would expect conversion efficiency on new equipment to be more in the 30-35% range. Also, it is not immediately clear to me what the two "biomass direct combustion" categories denote.
- I am not familiar with fuel production and cannot comment on that. The assumptions for the electricity production technologies appear reasonable.
- Again, trouble with links but everything looks accurate.
- Suggest expressing soy transesterification in gallons per lb of oil, not lb of soy.

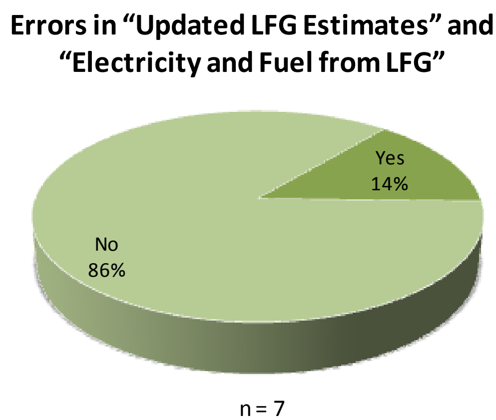
2.b. Are the sources of information in the "Technology Assumptions" worksheet sufficiently documented and from reliable, unbiased sources?



Comments

- I would attempt to consolidate the assumptions pages further – it's a little tough to follow
- [More] Primary sources should be used so they can be verified.

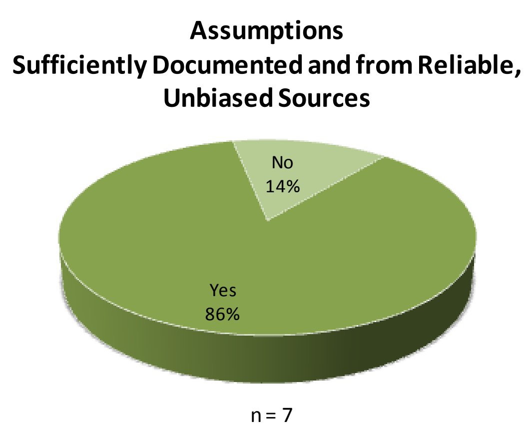
3.a. Does the information included in the "Updated LFG Estimates" and the "Electricity and Fuel from LFG" worksheets contain any errors?



Comments

- Difficult to assess due to rapid changes – While I can't say there are specific errors, there are lots of ongoing landfill gas project development efforts, not sure if LMOP or other data sources do in terms of keeping up with them
- Great information here done by county!

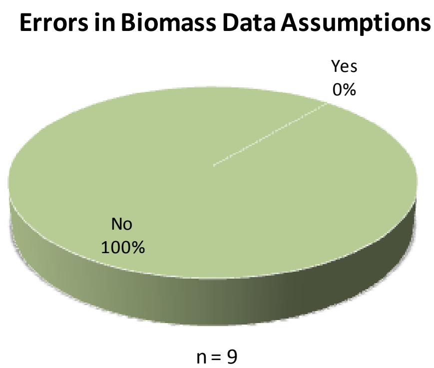
3.b. Are the sources of information in the "Updated LFG Estimates" and the "Electricity and Fuel from LFG" worksheets sufficiently documented and from reliable, unbiased sources?



Comments

- Yes, since it is stated that the figures presented were the only data available at the time. The actual data numbers could be improved upon.
- Suggest citing LMOP as “EPA LMOP” or EPA.
- Similar concern to the above, there’s no documentation other than that the numbers are derived from NJAES.

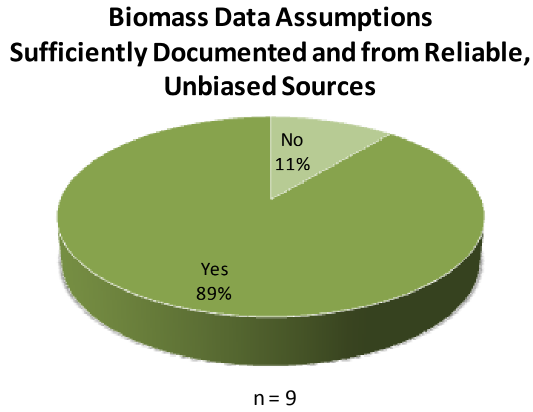
4.a. Does the information in the “Biomass Data Assumptions” worksheet contain any errors?



Comments

- We have some values that differ from yours... some of it might be due to different references. E.G., using an NREL report by Wiltsee yellow grease and trap grease estimates were 8.87 lb/person/year and 13.37 lb/person/year, respectively and lb/person/year and 13.37 lb/person/year, respectively.
- No but sheet could be organized so that it’s easier to read/follow
- We don’t have all these numbers on-hand but your sources seem reliable here.
- Not clear; better documentation required.

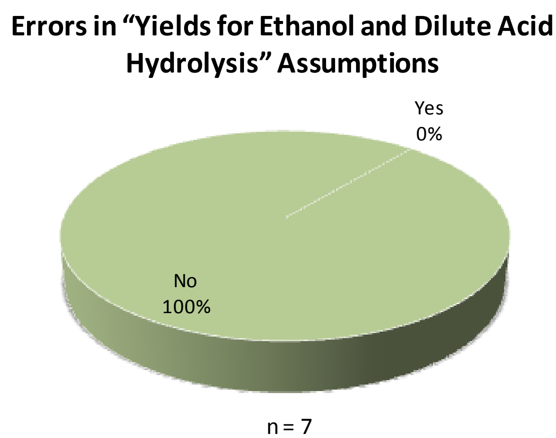
4.b. Are the sources of information in the "Biomass Data Assumptions" worksheet sufficiently documented and from reliable, unbiased sources?



Comments

- It's not clear what the sources are for the Timberland estimates, or whether the 1 ton/acre is based on growth additional to harvest for existing markets. Also, there do not appear to be any references for the energy crop or ag residual calculations, nor is it clear how and whether these numbers are used in the final calculations. How is usable acreage determined, and what is the source/reference for that?
- Better documentation. It should be updated as 2003 is the most recent year for which data is provided.

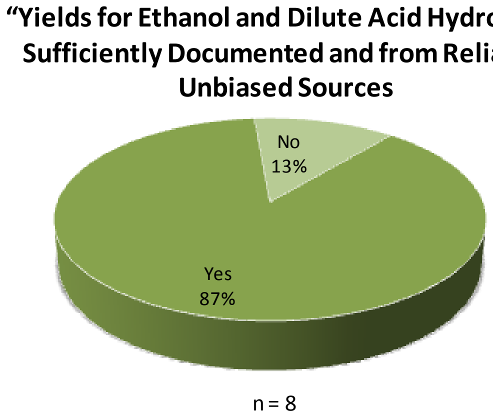
5.a. Does the information in the "Yields for Ethanol and Dilute Acid Hydrolysis" worksheet contain any errors?



Comments

- The estimates could be considered conservative.
- Very impressive compilation of data, but hard to verify and determine errors.

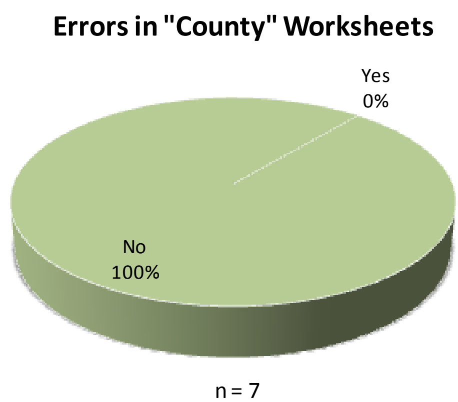
5.b. Are the sources of information in the "Yields for Ethanol and Dilute Acid Hydrolysis" worksheet sufficiently documented and from reliable, unbiased sources?



Comments

- I would expect that the ramp up of yield in cellulosic ethanol in terms of yield in gallons per ton of woody and herbaceous biomass would be slower given the status of industry. I think technical assessments tend to be overly optimistic.
- Much better than some of the earlier data.

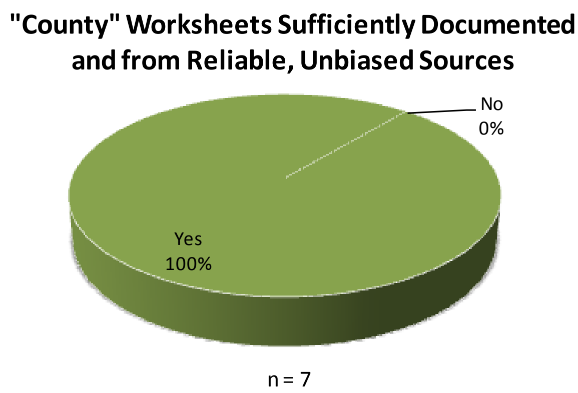
6.a. Does the information in the County worksheets contain any errors?



Comments

- Difficult to tell

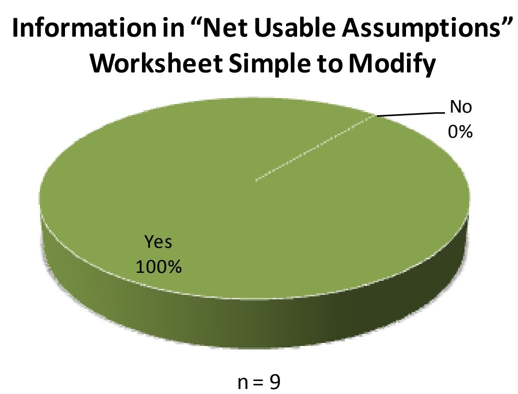
6.b. Are the sources of information in the County worksheets sufficiently documented and from reliable, unbiased sources?



Comments

- This is a tremendous resource.
- Quite good documentation.

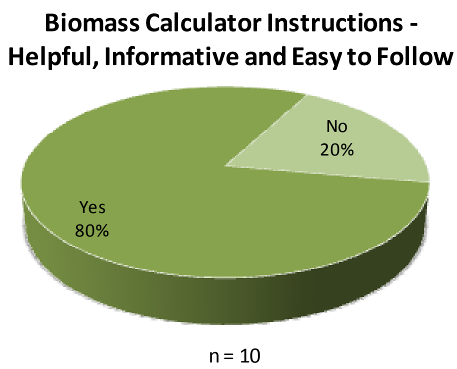
7. Is the information in the "Net Usable Assumptions" worksheet simple to modify?



Comments

- I'm confused about the meaning of changes.
- Extremely user friendly.

8. Were the User Instructions for the NJ Bioenergy Calculator© helpful, informative and easy to follow?

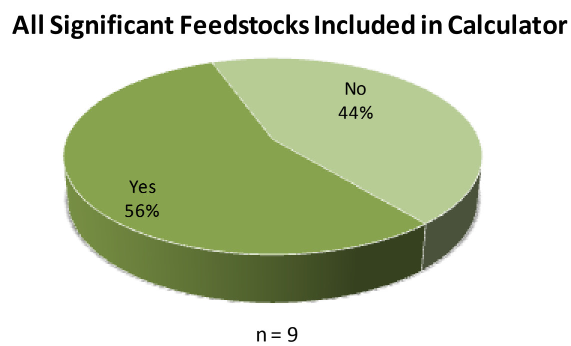


<u>Comments</u>

- They are a good overview of the workbook's contents. However, they don't really tell me what I can do with it or how I should use it.
- I think instructions need to include much less text – some data validation should be incorporated into cell values to prevent user error and spreadsheet protection should be used on Bioenergy Calculator and Bioenergy Production Estimates worksheets to prevent users from mistakenly entering data there instead of in other tabs
- Yes, but more information about some of the higher-level assumptions embedded in the bioenergy calculations would be helpful. For example, how were biomass sources mapped to appropriate technologies? How does the calculator decide whether available biomass is used for electricity production or the production of liquid biofuels? Is there an economic optimization that is embedded in the calculator?
- Yes, but it may be easier in a database format instead of an excel format. While I was able to follow the different tabs, it may be easier and smoother to use a program like Access or another database program to interface with the user. However, I found this spreadsheet to be very informative and user friendly.
- It takes a little time to understand, but generally quite good.

Scope

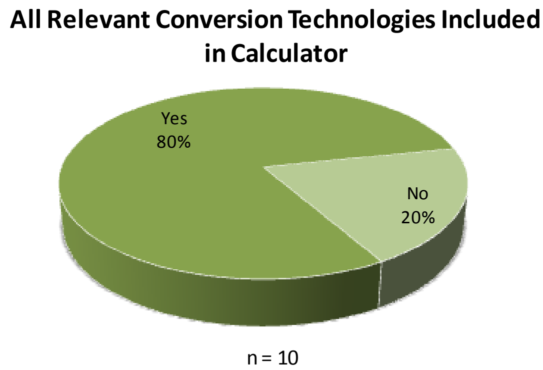
9. Review the list of bioenergy feedstocks found in Column B on the "Bioenergy Calculator" worksheet. Were all significant biomass feedstocks included in the Calculator?



Comments

- Feedstocks, as listed for woody biomass, include Energy Crops, Forestry Residues, Processing Residues (lignocellulosic), Yard Waste (Tree Parts & Stumps), and MSW C&D Wood. Do I understand correctly then that you are not including Forest Products harvested as Roundwood or Wholetree Chips to be used for bio-energy production? Or are these considered parts of your "Residue" or "Waste" definitions?
- However, it is slightly unclear whether residual agricultural waste was included.
- You have "forestry residues" listed as an ag crop residue. Should it be a separate category? Does it include both timber harvest waste wood as well as purpose-harvested "low use wood" for energy?
- Miscanthus, Switchgrass, Canola Oil
- It is an impressive list.
- It's a judgement call, but you could consider oilseed crops other than soybeans even if they haven't been fully deployed – you include lignocellulosic energy crops. There are many – camelina, etc. but would need to evaluate appropriateness for NJ
- Seems like new ideas pop up very day - maybe more to follow!
- Switchgrass and algae were not included. However, I'm not familiar enough with either plant to determine whether they are applicable to NJ and this exercise.
- It seems to be very comprehensive.

10. Review the list of bioenergy conversion technologies found in Column A of the "Technology Assumptions" worksheet. Were all relevant conversion technologies included in the Calculator?

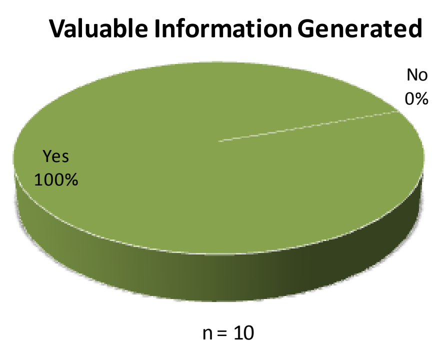


Comments

- Plasma not included
- So many technologies are being proposed for production of cellulosic ethanol. How could only one yield number cover them all? What is the basis for assuming improvements in yield from 2007 to 2020? These projections claim a 50% increase in yield.

Use and Transferability

11.a. Does the NJ Bioenergy Calculator© generate the type of information that you find valuable for your work?



Comments

- I'm interested in this excel spreadsheet format to document a wide, seemingly cumbersome collection of data.
- It allowed me to compare results with NYS. Especially, MSW to ethanol conversion potential.
- This Calculator can be quite useful to state government as it can be used as a tool for ranking projects (seeking state funding) in terms of the reduction in grid demand for electricity and reduction in the amount of non-hazardous waste that would otherwise be transferred to the landfills.
- Well, I think it provides a nice framework for aggregating large amounts of bioenergy resource data. The county-level summaries are especially handy, I think, for helping policy makers understand the magnitude of the potential in different locations.
- Quick estimates of biocrops energy potential
- In a general nature yes. This is the type of information I find useful but I do not work in New Jersey. If this were expanded into a Northeast Regional Biomass Calculator, it would be valuable in my work. In short, this type of calculator for the states surrounding New Jersey would be valuable, especially since biomass is being transported across state lines as well.
- This kind of detailed analysis will be critical in understanding the potential here - incredible click and point resource.
- As a former public policy employee, I would have found this information very helpful to determine the biomass potential for the State. We met countless firms that were proposing various biomass projects. A spreadsheet like this would have been very helpful to provide context around these proposals.
- It provides a very useful comparison of technologies. The breakdown by county is particularly useful.

11.b. What additional information would you like the Calculator to include in order to make it more useful to you?

Comments

- Cost/Benefit Analysis, Transportation Issues, Better description of technologies used.
- None that is apparent.
- Some capability to assess economics/cost of resources and incorporate costs of alternative uses for resources such as urban wood wastes that currently have high-value markets in the form of landscaping mulch. Also, some effort to consider relative merits of different technologies (technology readiness, economics) as a way to develop scenarios and timing of technology deployment.
- I'd like to see this followed with an economic analysis - could really shed some light on biomass potential in NJ.

- I would recommend significantly enhancing the background information in the Instructions section. There are quite a few assumptions embedded in the calculator that are described in the descriptive sections for each page in the worksheet, but do not appear to be made explicit anywhere is the documentation. It seems important to highlight these high-level assumptions somewhere in the background, rather than bury them on the worksheets themselves. Specific examples are below: 1. Bioenergy calculator worksheet: How do you determine which feedstocks are suitable for use with specific technologies? Could these relationships change over time, and if so, how can the calculator be amended to reflect that? Are 2010, 2015, and 2020 estimates reflective of biomass available in that year, or cumulatively over the previous 5 years? 2. Fuel Yields for Ethanol and Acid Hydrolysis worksheet—what are the increases in technology efficiencies in 2010, 2015, and 2020? What citation is used to derive these?
- The only thing that is missing from this chart is the waste stream restrictions in NJ. Many waste flows are already accounted for, and it appears to be a very difficult task to secure waste streams, specifically MSW in NJ. However, while waste streams play a vital part in making a project successful, I don't know how you would incorporate this into the spreadsheet.
- Data updates. A lot of the information is 7 years old. References to operating plants actually using the describe technologies would be very helpful.

12. What elements of the NJ Bioenergy Calculator© might make it potentially valuable for other uses and/or locations?

Comments

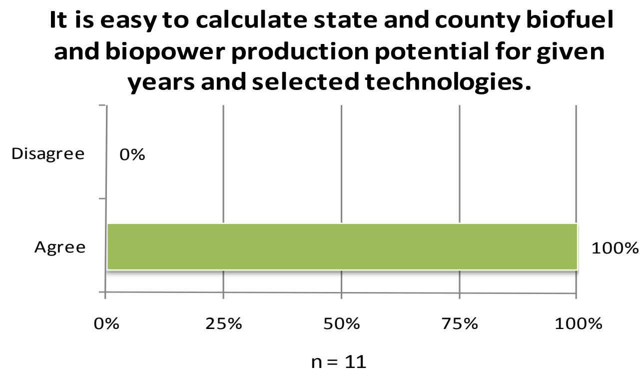
- This may be a bit beyond the scope of your effort, but it would be nice if we could provide some "error bars" on these data – at very least show the variation between a good growing year and a poor one.
- Towns interested in solid waste to energy programs with certain vendors.
- As discussed in No. 11. A more regional calculator, which I realize is outside the scope of a NJ calculator.
- This could easily be extended on a regional or national level, but would require extensive research into current biomass uses
- Flexible worksheets so that data and links embedded in county pages could be easily overwritten with other data. For example, this calculator would be very helpful to us in calculating potential bioenergy production for the regional Low Carbon Fuel Standard if the county-level data can be replaced with data for 11 states. · Develop annual estimates of biomass availability, rather than at 5-yr increments · Add guidance on which assumptions might change with location (eg. crop yields) versus those that are fixed, and will not vary according to location (eg., gallons of ethanol per dry ton biomass)
- If it is expanded to include other elements of the waste stream including Construction and Demolition material, plastic products and tires. Many

companies appear to be looking for ways to convert these products into other useful products, or turn them into a fuel. Also, if the bioenergy calculator is updated frequently. There are constantly new technologies that are being proposed, and it is difficult to determine which ones are real. Having an up to date database of waste streams and technology will be vital to making this database a productive tool in the future.

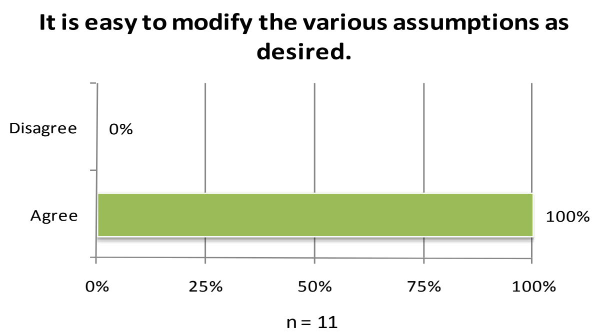
- Information on the status of permitting such facilities in NJ.

Navigation

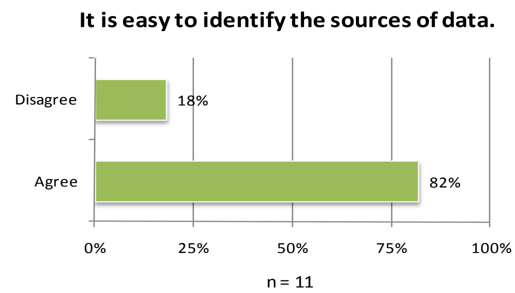
13. It is easy to calculate state and county biofuel and biopower production potential for given years and selected technologies.



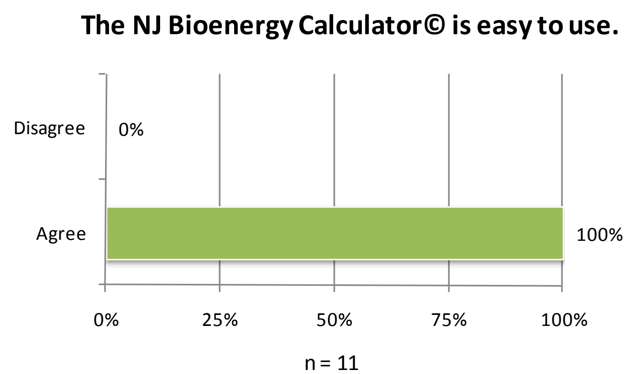
14. It is easy to modify the various assumptions as desired.



15. *It is easy to identify the sources of data*.

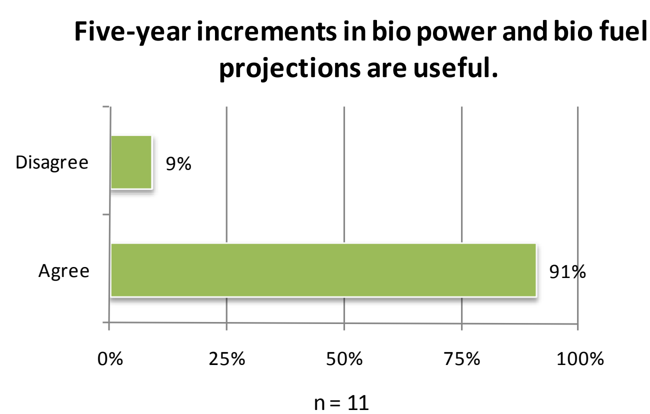


16. The New Jersey Bioenergy Calculator© is easy to use.

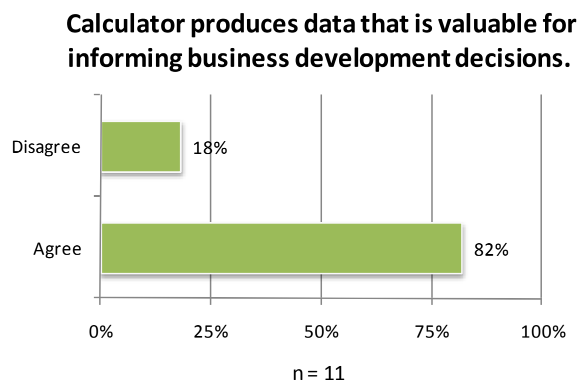


Usefulness

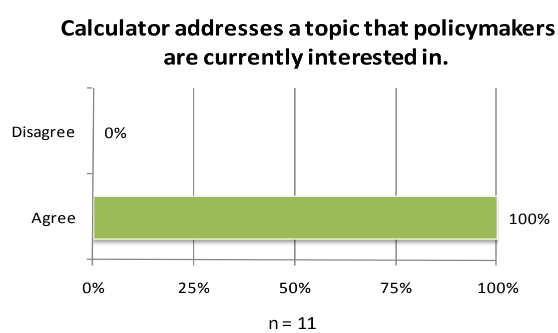
17. The five year increments in bio power and bio fuel projections are useful.



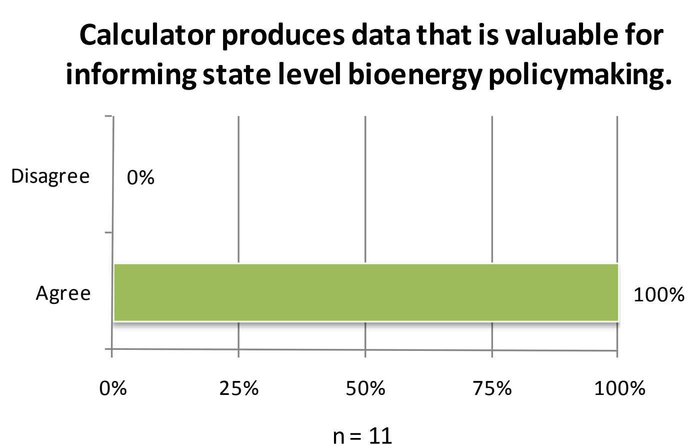
18. The New Jersey Bioenergy Calculator© produces data that is valuable for informing business development decisions.



19. The NJ Bioenergy Calculator© addresses a topic that policymakers are currently interested in.

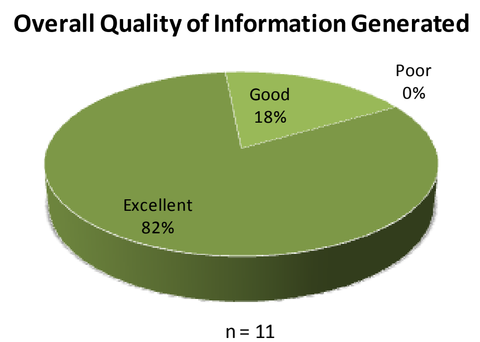


20. The NJ Bioenergy Calculator© produces data that is valuable for informing state level bioenergy policymaking.

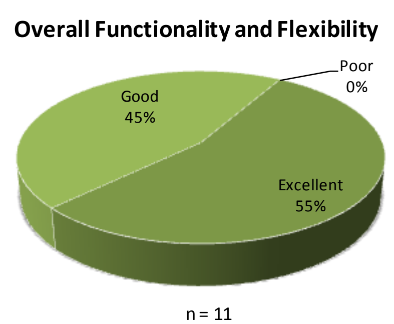


Overall Rating

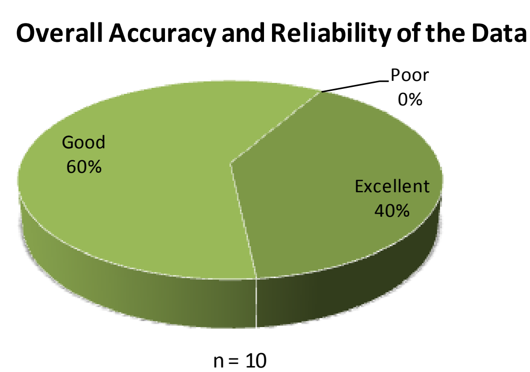
21. The overall quality of the information generated by the Calculator is:



22. *The overall functionality/flexibility of the Calculator is:*



23. The overall accuracy and reliability of the data is:



<u>Additional Comments</u>

- A nice "next step" for the project might be to develop "cost-availability" curves for the biomass. Of course, that would be rather complicated.
- Overall, the calculator is an impressive tool and covers many feedstock categories and utilization technologies.
- All in all this is a heck of a tool that goes to the heart of some of the availability/applicability questions surrounding biomass energy.
- A very good compilation of the potential for biofuels and bio-power in NJ.

<u>Backgrounds and Expertise of Respondents</u>

Respondents had expertise in the following areas:

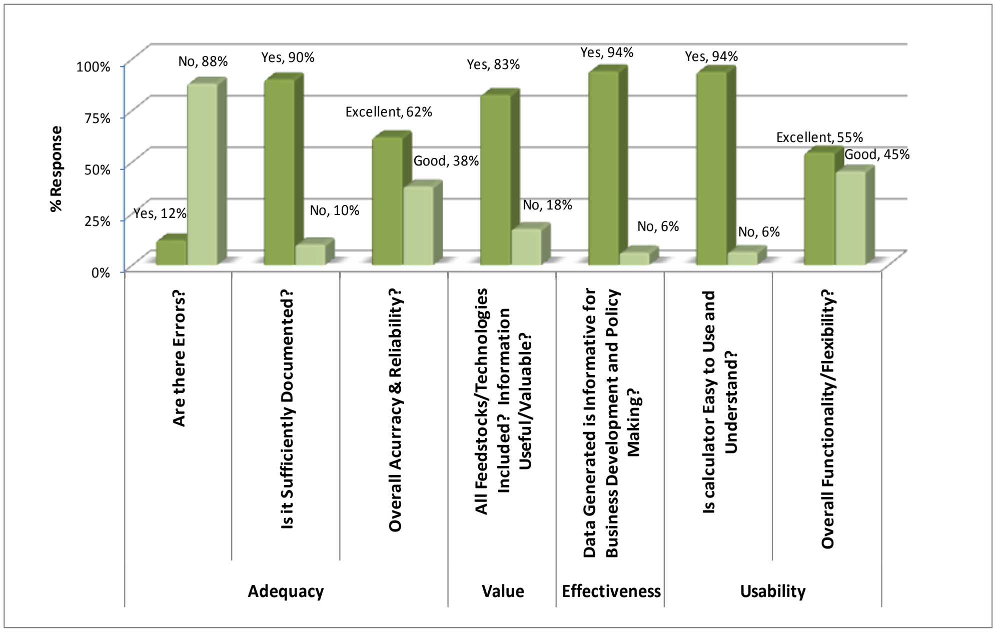
- Agricultural Engineering
- Chemical Engineering
- Fuel (coal and biomass) characterization and utilization (stationary combustion, gasification, pyrolysis).
- MSW-to-Ethanol
- Research and evaluation of technologies associated with drinking water, stormwater, soil remediation and energy applications.
- Biomass resource analysis and technology evaluation
- On-farm applicability perspective
- Economics
- Energy technology
- Alternative energy, nuclear energy
- Energy policy
- Biomass assessments

Respondents represented state agencies and regulatory authorities, universities, industry, agriculture sector, and regional planning authorities.

D. Summary of Evaluation Results

The results of the evaluation were summarized using the evaluation criteria of adequacy, value, effectiveness, and legitimacy as posited by Clarke and Majone. Evaluation criteria of saliency and credibility developed by Cash, et.al. are captured in the categories of value and effectiveness, and adequacy, respectively (Figure 4).

Figure 4: Summary of Evaluation Results



Adequacy - Evaluation results for the adequacy of the reliability of the data and methods indicated that these aspects of the bioenergy calculator were excellent. Approximately 90% of respondents stated that the data was sufficiently documented and free of any major errors. 62% stated that the overall accuracy and reliability of the calculator was excellent, 38% stated that it was good. Common responses included:

- Efficiency values could be considered conservative
- Unable to open reference links
- Difficult to read comments embedded in cells
- [More] Primary sources should be used so they can be verified
- Very impressively documented
- Great information here done by county
- We don’t have all these numbers on-hand but your sources seem reliable
- This is a tremendous resource
- Quite good documentation

Value - Evaluation results for the value of the bioenergy calculator to intended users indicated that this was a valuable tool for making policy and business decisions. 100% of respondents indicated that the calculator generated the type of information that was valuable for their work. They also indicated that the bioenergy calculator included almost all relevant biomass feedstocks and conversion technologies. Common responses included:

- Nice framework for aggregating large amounts of bioenergy resource data.
- The county-level summaries are especially handy for helping policy makers understand the magnitude of the potential in different locations.
- If this were expanded into a Northeast Regional Biomass Calculator, it would be valuable in my work. In short, this type of calculator for the states surrounding New Jersey would be valuable, especially since biomass is being transported across state lines as well.
- This kind of detailed analysis will be critical in understanding the potential here - incredible click and point resource.
- It provides a very useful comparison of technologies. The breakdown by county is particularly useful.
- It is an impressive list.
- It seems to be very comprehensive

Effectiveness - Evaluation results indicated that the bioenergy calculator is an excellent tool for moving state bioenergy policy forward. 100% of respondents stated that the calculator produces data that is valuable for informing state level policymaking and that it addresses a topic that policymakers are currently interested in. 82% of respondents indicated that the tool generates data that is valuable for informing business decisions. Common responses include:

- As a former public policy employee, I would have found this information very helpful to determine the biomass potential for the State. We met countless firms that were proposing various biomass projects. A spreadsheet like this would have been very helpful to provide context around these proposals.

- This Calculator can be quite useful to state government as it can be used as a tool for ranking projects (seeking state funding) in terms of the reduction in grid demand for electricity and reduction in the amount of non-hazardous waste that would otherwise be transferred to the landfills.

<u>Transferability</u> **-** The evaluation also investigated the applicability of the bioenergy calculator to other locations or for other uses. Respondents indicated that the calculator could be used by towns interested in solid waste to energy programs with certain vendors. In addition, the calculator could easily be extended on a regional or national level.

<u>Legitimacy</u> **-** While there were no specific questions on whether the processes and participants involved with the development of the calculator were appropriate and if they provided multiple perspectives, however, this was in fact the case. Experts from academia, state and federal agencies and industry experts representing a broad spectrum of expertise were used to provide the data for this calculator. All references were checked for accuracy, and data not from a published source were provided by experts in the field who made data calculations based on industry standards. Some primary data collection was conducted, particularly in the area of landfill gas. Data sources are listed in Appendix A.

E. Results of Planning Support System Assessment

In evaluating the decision support tool and database against Klosterman's principals of useful planning support systems,[214] the following critiques of the New Jersey Bioenergy Calculator and database can be made:

Principal 1: Every model is wrong because some aspects of reality are bound to be omitted. The decision support tool developed in this dissertation does omit certain aspects of reality. For instance, the collection, sorting and alternate use estimates, which

[214] (Klosterman, 2008, 88)

are used to determine how much biomass is "practically recoverable," are preliminary estimates. The current model also excludes potential variances in moisture and energy content. Additionally, the Model uses the population growth rate in the State of New Jersey as a proxy for the growth rate of Municipal Solid Waste (MSW). This assumption, however, does not account for changes in purchasing patterns, behavior and beliefs which, independent of population growth, may also alter the level of MSW in the State. Finally, the model does not allow additional technologies or feed stocks to be added without significant revamping. Consequently, it will be difficult to use this to account for future, unforeseen technological or agricultural development. However, the decision support tool and database are still useful as they provide reasonable estimates of bioenergy potential and usable feedstock quantities. These estimates are sufficient to guide policy directions in terms of what is and is not feasible for New Jersey to pursue in terms of alternative energy strategies.

Principle 2: Predicting the future is extremely difficult, thus planners should "prepare a range of forecast scenarios describing a number of possible futures."[215] Planners can use the NJ Bieonergy Calculator and database to generate a range of forecast scenarios by selecting various electricity generation and fuel production technology options. Klosterman also stated that the authors of a planning support system should explicitly state any underlying assumptions regarding "future trends and alternative policy choices" in their model and allow users to change these assumptions as they see fit.[216] The decision support tool developed in this dissertation includes initial biomass data, energy

[215] (Klosterman 2008, 89)
[216] (Klosterman 2008, 89)

content, technology and net usable biomass quantity assumptions which policy makers are able to easily modify to conduct scenario and sensitivity analyses.

Principle 3: Keep the model as simple as possible so that it can be easily understood by policy makers and the public. The New Jersey Bioenergy Calculator and Database presents information in an accessible and organized fashion. The tab entitled “bioenergy calculator,” clearly illustrates which electricity generation and fuel production technologies have been selected. It also notes the current gross quantities and current net energy available for each of the forty feed stocks. Finally, this tab demonstrates how much electricity and fuel can be generated by all of the feed stocks in the State of New Jersey for the years 2007, 2010, 2015 and 2020. Subsequent tabs provide policy makers and the public with all of this information on a county-specific basis.

Principle 4: Planners should use the information that is accessible because it is often the “best available data,” even if it is somewhat incomplete or inexact. This principle was followed when estimating the collection, sorting and alternative use rates for each biomass feedstock. Furthermore, Klosterman asserts that models should be able to work with the data that can be obtained, even if this data is sparse. In creating the Biomass Calculator and Biomass Resource Database, this principle was adhered to by including all forty feed stocks in the model, even though the information available for some feed stocks was incomplete. However, all forty feed stocks were included in an attempt to make the inventory as comprehensive as possible.

F. Recommended Future Modifications to the New Jersey Bioenergy Calculator

The database developed in this research represents serves as a foundation for future research and modifications that could increase its power as a more robust policy analysis tool. As such, the current database cannot perform analysis of tradeoffs across broad policy objectives such as economic development vs. CO2 emissions, or energy independence vs. source reduction of solid waste. Instead, it operates one level below that with comparisons of kWh or GGE generated by different feedstock/technology combinations at the state and county level. Modification of the model to incorporate factors that will enable the analysis of broader energy policy issues as those mentioned above, are recommended for future research efforts, and include the following:

- Add capability to assess economics/cost of resources and incorporate costs of alternative uses for resources.
- Add environmental impact information, such as indirect land use change, for various technologies and feedstocks included in the database.
- Add capability to allow mix of power and fuel output options.
- Update data with current information. Having an up-to-date database of biomass resources and conversion technologies is vital to making this database a productive tool.
- Add guidance on which assumptions might change with location (eg. crop yields) versus those that are fixed, and will not vary according to location (eg., gallons of ethanol per dry ton biomass)

Chapter 8: Conclusion

A. Lessons Learned about Decision Support System Design

- When collecting data, there is a likelihood that the information provided by different sources is not consistent. A thorough review of the methods and assumptions used to calculate the data is necessary. If a range of values appear to be valid, either calculate an average figure or use the conservative value. Overestimating can set up false expectations if the data is use to set policy goals.
- Use only valid, reliable data for the DSS that is well documented.
- It is essential that in the initial stages of development that there is a clear understanding of the type of information that needs to be generated by the DSS, how it will be used and by whom.
- It is critical to touch base with your intended audience or funder throughout the development process to ensure that the information being collected and analyzed meets their needs and expectations. It is easier to make modifications in the development phase than once the tool is finished.
- When designing the DSS, user-friendliness is essential if it is expected to have a broad level of adoption.
- Understand the limitations of the DSS you are developing. A determination will usually need to be made on whether the system will be more suitable for macro or micro level decision-making.

- Creating a database structure that can be easily modified to accommodate future changes in technology efficiencies and feedstock availability makes the tool more valuable in the long run.
- Providing data for sub-state levels of government, i.e. counties, is helpful in supporting local planning efforts, as well as industry development.
- A structured process is key to managing data collection and stakeholder input.

B. Summary of Findings Generated by the New Jersey Bioenergy Calculator

Analysis of the data generated by the New Jersey Bioenergy Calculator yielded six major findings about New Jersey's biomass resources: ***1)*** An estimated 8.2 million dry tons (MDT) of biomass is produced annually in New Jersey.[217] ***2)*** Of that 8.2 MDT of biomass, approximately 5.5 MDT (65%) could ultimately be available to produce energy, in the form of power or transportation fuels. ***3)*** New Jersey's estimated biomass resource of 5.5 MDT could deliver up to 1,124 MW of power in 2007, and 1,299 MW of power in 2020 (16% increase), if all biomass is utilized by electricity generating technologies. If all biomass is utilized by fuel production technologies, 311 million gallons of gasoline equivalent in 2007 and 335 million GGE by 2020 (8% increase) could be produced. In other words, the current biomass resource base in New Jersey would be capable of delivering, either ~9% of New Jersey's current electricity demand or ~5% of New Jersey's current transportation fuel demand, if the appropriate technologies and infrastructure were in place to produce the bioenergy. ***4)*** Almost 75% of New Jersey's

[217] This total includes biogas and landfill gas quantities converted to dry ton equivalents on an energy basis. This does NOT include biomass that is currently used for incineration or sewage sludge because these are not classified as Class I renewable feedstocks in New Jersey.

biomass is produced directly by the state's population, in the form of solid waste (e.g. municipal waste). The majority of New Jersey's biomass is concentrated in the counties of central and northeastern New Jersey due to the large populations in those counties. The amount of solid waste in the state will increase by 10.55% by 2020 due to a projected population increase of about 10%, or about 1,000,000 more people. ***5)*** This large proportion of waste-based biomass supports the recommendation that New Jersey pursue the development of an energy from waste industry. Conversion of solid waste to clean energy could become *the* major source of renewable energy to help NJ meet its goal of 20% renewable energy by 2020. Energy from waste in New Jersey is particularly attractive because waste disposal costs are high and the waste collection and consolidation infrastructure is already in place. ***6)*** Agriculture and forestry management comprise the majority of the remaining biomass produced in New Jersey and therefore, are also important potential energy sources. The biomass from agricultural sources includes both crops and crop residues. The use of agricultural crops for energy production would require the decision to convert the current food supply chain into energy production, which could have other major policy implications. Crop residues, however, are generally underutilized and undervalued, which should allow for an easier decision to use these resources. In the case of energy crop production, New Jersey would need to decide whether to maintain current crop varieties (i.e. corn soybean hay, etc.), or introduce new crops that would be better suited for energy production (e.g. Poplar or switchgrass).

Technologies that would be especially useful to New Jersey are combustion, gasification and anaerobic digestion. Biomass co-firing (which falls under combustion) offers environmental benefits to existing coal fired power production. The New Jersey Renewable Portfolio Standards (RPS) provide value for qualifying biomass, but the RPS rules on biomass eligibility are fairly strict. Co-firing biomass with coal is currently not a qualified use.

Despite a lack of commercial status, gasification technology is relatively well developed and can be deployed, at a range of scales, for power generation, which makes it suitable to New Jersey's biomass resources. Gasification is also suitable for municipal wastes, and could produce lower emissions than conventional incineration. Pyrolysis is at a much earlier stage of development than gasification. New Jersey should monitor development in Canada and the European Union, where the most activity is concentrated, to see if this technology will be useful to New Jersey in the future.

Anaerobic digestion is a commercialized and well developed technology that can help capture New Jersey's biomass energy potential. High population density ensures a concentrated stream of food wastes, landfill gas and MSW (the organic component of which will need to be separated from the non digestible materials). Other biomass streams add to this potential. These streams include farm wastes, such as manure, yellow and brown grease, lower value in-state crops and crop residues, organic waste from large industrial and food processing facilities and other cellulose-rich biomass, such as waste paper. New Jersey's yard waste collection system could potentially form the backbone of a biomass supply infrastructure for small distributed bioenergy facilities that represent a higher-value use of the biomass than current practice (assumed to be mainly composting).

Current costs estimates for 2nd generation biofuels are not competitive with either gasoline or corn ethanol, and technology development and demonstration are still needed. The first commercial plants will face significant technology, development and market risks and will need government support to “get steel in the ground.” Progress, however, is being made and by 2015, cost reduction potential should bring additional biopower and technologies into the realm of commercial application. The federal government has already put in place mechanisms for supporting this nascent industry, such as grants, loan guarantees and RPS carve-outs. New Jersey should support these mechanisms by expanding upon them, and in so doing, become a recognized leader in these technologies.

C. Policy Recommendations

Creating an effective institutional, regulatory and feedstock supply infrastructure, as well as comprehensive strategic and tactical industry development plans is vital to the successful achievement of the state's renewable energy goals. The following policy recommendations can help to establish the capacity and infrastructure needed for rapid biofuels and biorefinery development and to create sustainable markets for bioenergy products. They focus on institutional infrastructure, regulations, market-based incentives and market transformation through technological innovation. Market transformation will take place once the technological and infrastructure capabilities exist and can function in an economically viable and environmentally sustainable fashion.

Institutional Infrastructure

Policy recommendations to establish an institutional infrastructure capable of supporting the development of a renewable energy industry in New Jersey are:

- Establish/appoint a state agency with primary responsibility for the development and support of the emerging renewable energy industry. This entity will need dedicated personnel, authority and financial resources to accomplish this goal.
- Policy harmonization must be facilitated across all state agencies so that the state's renewable energy goals can be successfully achieved. This effort will need to be fully integrated, include public and private partnerships, and incorporate comprehensive research, policy and marketing plans.

- Regional partnerships with surrounding states must be built to take advantage of related programs, maximize utilization of biomass feedstock, coordinate research activities and share expertise.

Regulatory

Recommendations regarding new regulations include:

- Introduce a societal benefits charge on petroleum based fuels to support bioenergy incentive programs.
- Regulatory conflicts across permitting agencies must be identified and alleviated in order to streamline and simplify approval processes for demonstration and commercialization of new bioenergy technologies.
- Integrate new bioenergy efforts (i.e. biofuels) into existing policies (e.g. RPS, Clean Energy Program, and MSW recycling requirements).

Market based incentives

Recommended market based incentives include:

- Establish Bioenergy Enterprise Zones around concentrations of biomass feedstocks and/or where bioenergy can be strategically utilized.
- Provide incentives for businesses engaged in energy from waste research, development and production.
- Provide a cost share program for counties seeking to implement demonstration projects, such that the risks associated with these projects are shared between the county, the state and the business entity. This will help to incentivize counties,

particularly county landfills, to participate and support new technology commercialization.

- Continue to provide incentives for 1st generation biofuel technologies, as they lay the infrastructural foundation for 2nd generation technologies.
- Provide additional incentives for development of 2nd generation biofuel technologies which are more energy efficient and with less environmental impact than 1st generation technologies.
- Provide incentives for small companies to pursue bioenergy technology demonstration projects
- Provide incentives and invest in the development of biomass feedstock supply infrastructure.
- Develop a consumer-based biofuels incentive program

Market Transformation through Technological Innovation

- The establishment of a *Bioenergy Innovation Fund* would greatly expedite market transformation for emerging bioenergy technologies. This fund would support research, development and commercialization of new bioenergy technologies, particularly those that utilize waste-based feedstocks. The fund will need to be a joint effort of BPU, EDA, NJCST, NJDA and other state agencies, as well as higher education institutions, federal agencies, private investors, utilities, and foundations with a goal to transform the markets for bioenergy through innovations in technology.

- Bioenergy market development would also be facilitated by identifying ways to take advantage of New Jersey's existing petrochemical, refining and distribution infrastructure.

D. Recommendations for Future Research

The recommended next step for moving New Jersey into an alternative energy future is to conduct a comprehensive analysis which incorporates the interaction of a large scope of issues, including social, environmental, regulatory, economic, technological, and others. This is critically needed for the development of an effective long-term sustainable renewable energy strategy. An analysis such as this can also reveal where the largest opportunities are, and more importantly, how various strategies and policies might impact each other.

A strategy for effective biomass resource utilization is also a valuable next step in understanding New Jersey's biomass potential. Collection and separation plans should be devised in areas where there are large concentrations of a logistically recoverable biomass resource (large concentrations are determined by GIS mapping). These plans should coincide with plant feasibility studies in which infrastructural requirements, such as the infrastructure necessary for the collection, delivery and handling of raw materials and final products at the given facility should be taken into account.

This research represents the first of a possible three-phase project designed to take a systems approach to inform state and regional bioenergy policymaking and industry development. Phase II would involve the development of a regional bioenergy calculator. As a regional renewable energy planning initiative, the RGGI is the most appropriate lead for pursuing the development of a consistent and comprehensive data collection methodology and DSS. RGGI should consider funding the development of an assessment methodology that could be used for relevant feedstocks across the region in order to facilitate regional bioenergy planning. This would include a comprehensive, interactive database of biomass production potential, logistical costs, technology efficiencies and renewable energy potential.

A primary aspect of the regional database will be to account for the fact that feedstock availability and cost is conversion technology dependent. The database would be able to generate information on the most appropriate feedstock and technology candidates for bioenergy conversion based on quantity, energy potential and cost effectiveness at the state and regional levels, as well as locational information (county level) for siting bioenergy conversion facilities, based on county biomass densities and cost factors. Phase III would consist of cross-cutting geospatial analysis of feedstock supplies. The information generated by a systems assessment approach will be valuable for bioenergy SWOT analyses and suitable for GIS modeling in and between states.

Appendix A. Data Sources

New Jersey BioEnergy Resource Database: Sources of Information	
Energy Content Assumptions	**Source**
Energy crops - lignocellulosic	Navigant Consulting Inc.
Oils - Used cooking oil "yellow"	
Sweet Corn, Corn for Grain, and Corn Silage	U.S. Department of Energy:
Wheat	http://www1.eere.energy.gov/biomass/feedstock_databases.html (average of 12
Rye	Argonne National Lab GREET model (Herbaceous Biomass)
Forestry Residues	European Biomass Industry Association
Processing Residues (lignocellulosic)	BIOBIB - A Database for biofuels: http://www.vt.tuwien.ac.at/biobib/biobib.html. Assumes dried for transport
Rye	Argonne National Lab GREET model (Woody Biomass)
Alfalfa Hay	
Other Hay	
Brush/Tree Parts	
Grass Clippings	
Leaves	
Stumps	
C&D, not recycled	
Wood Scraps	
MSW (net of waste paper and food waste)	Heat Content and Moisture provided by NJAES and Biobib - http://www.vt.tuwien.ac.at/biobib/biobib.html
Waste paper, Landfilled	Oregon Dept of Environmental Quality: http://www.deq.state.or.us/wmc/solwaste/documents/LC041681-AppendixE.pdf
Corrugated Cardboard	
Mixed Office Paper	
Newspaper	
Other Paper/Mag/JunkMail	
Food waste, Landfilled	Characterization of Food and Green Waste as feedstock for Anaerobic Digestion, PIER-funded biogas project (an interim report)].
Corrugated Cardboard	Oregon Dept of Environmental Quality: http://www.deq.state.or.us/wmc/solwaste/documents/LC041681-AppendixE.pdf
Oils - Grease trap waste "brown"	Russell Reed, trap grease hauler in New Jersey
All Cattle and Cows (% Dry Matter)	Manure Characteristics, MWPS-18, Manure Management Series, Iowa State University.
Equine (Energy Content & % Dry Matter)	
All Swine (% Dry Matter)	
All Cattle and Cows (Energy Content)	BIOBIB - A Database for biofuels: http://www.vt.tuwien.ac.at/biobib/biobib.html
Sheep (Energy Content)	
Goats (Energy Content)	
Turkeys (Energy Content & % Dry Matter)	
Pigs (Energy Content)	
Poultry (Energy Content & % Dry Matter)	Tom Costello, Biological & Agricultural Engineering Dept. University of Arkansas: http://www.p2pays.org/ref/05/04547.pdf
Wastewater treatment plant biosolids	WEF Manual of Practice FD-19, Sludge Incineration: Thermal Destruction of Residues (1992), Water Environment Federation, Alexandria, VA.)
Wastewater treatment plant biogas	U.S. Department of Energy, Energy Information Administration:
Landfill Gas	http://www.eia.doe.gov/cneaf/solar.renewables/page/trends/table10.html
Feedstock Net Usability Assumptions	**Source**
Rye	USDA, Agricultural Handbook Number 537
Corn for Grain	
Wheat	
Forestry Residues	European Biomass Industry Association
MSW (Landfilled), net of waste paper and food waste	Bob Simpkins (Director Solid Waste - Burlington County)
Food waste, Landfilled	
Construction and Demo, not recycled	
Wood Scraps	
Corrugated Paper	
Mixed Office Paper	
Newspaper	
Used cooking oil "yellow"	
Waste paper, Landfilled	NJ DEP, "2004 Generation, Disposal and Recycling Rates in NJ"
All Agricultural Livestock Waste	Mike Westendorf (NJAES Extension Specialist in Animal Sciences)

Technology Efficiency Assumptions	Source
Biomass Direct Combustion (grid sited)	Renewable Energy Technology Characterizations, TR-109496, Topical Report, December 1997, DOE/EPRI
Biomass Direct Combustion (CHP) (power component only)	Biopower Technical Assessment: State of the Industry and the Technology, Richard L. Bain & Wade P. Amos, National Renewable Energy Laboratory, and Mark Downing & Robert Perlack, Oak Ridge National Laboratory, NREL/TP-510-33132, January 2003.
Gasification Stand Alone BIGCC	DOE/EPRI Renewable Energy Technology Characterizations
Direct Combustion-Co-Firing with Coal	
Direct Combustion-Anaerobic Digestion with Recip Engine	Navigant Consulting Inc.
Small Scale Gasifier with Recip Engine	
Direct Combustion-Landfill Gas with Recip Engine	GE Energy: http://www.ge-energy.com/prod_serv/products/recip_engines/en/downloads/type3_en_new.pdf
Direct Combustion- Waste to Energy	U.S. Department of Energy, Energy Information Administration: http://www.eia.doe.gov/cneaf/solar.renewables/renewable.energy.annual/backgrnd/chap7b.htm
Fuel Production Assumptions	**Source**
Ethanol Conversion- Sorghum	Industry Standard
Ethanol Conversion- Rye	
Ethanol Conversion- Corn for Grain	
Ethanol Conversion- Wheat	
Transesterification- Soy	
Transesterification- Yellow Grease	
Transesterification- Brown Grease	
Cellulosic Ethanol- Woody Biomass	Steve Paul (Research Scientist, Princeton Plasma Physics Laboratory)
Cellulosic Ethanol- Herbaceous Biomass	
Dilute Acid Hydrolysis Conversion for Woody Biomass	
Dilute Acid Hydrolysis Conversion for Herbaceous Biomass	
GGE Conversions	**Source**
Ethanol to GGE	Argonne National Lab GREET model
F-T Diesel to GGE	
Biodiesel to GGE	World Energy (BioDiesel Suupply Company) www.worldenergy.net
P-Series (MeTHF) to GGE	Steve Paul (Research Scientist, Princeton Plasma Physics Laboratory)
Landfill Gas Estimates by Landfill	**Source**
Atlantic County Utilities Authority	"LMOP Landfill and LFG Energy Project Database - New Jersey," Landfill Methane Outreach Program, Environmental Protection Agency, June 27, 2007. http://www.epa.gov/lmop/proj/index.htm.
Balefill	
Kingsland LF	
Cape May County LF	
Monmouth County LF, Phases I, II and III	
Pineland Park LF	New Jersey Dept of Environmental Protection
Florence	
Parklands	
L & D. Mt. Holly	
Big Hill	
SLF, Inc.	
Buzby Bros.	
Gems	
Gloucester County LF	
Kramer	
Kin-Buc	
Combe Fill (North & South)	
Pennsauken LF	Landfill Methane Outreach Program, and Environmental Protection Agency and New Jersey Dept of Environmental Protection
Kinsley's LF	
Hamm's LF	
Warren County LF	
Edgeboro (Middlesex County Utilities Authority LF)	
Industrial Land Reclaiming Landfill	
Edison Township SLF	
Burlington County SLF	David Specca (Rutrgers NJAES, EcoComplex) and Eric Karlberg
Cumberland County LF	James Rocco (Cumberland County Improvement Authority)
Salem County LF	Daniel Jones (DCO Energy) and Michael Chatman (Salem County Utility Authority)
Sussex County 1-E	Thomas Varro (Sussex County Municipal Utilities Authority)

Landfill Gas Estimates by Landfill (cont.)	Source
Other Sources of Information for Landfill Gas Estimates	"NJ Landfill Parameters and Calculated CH4 Generation, Draft," from Michael Aucott (NJDEP)
	"Datasheets for New Jersey Revisions, May 25, 2007," from Amanda Singleton (Eastern Research Group), a contractor hired by the EPA's LMOP
	Eileen Smith, "Plant will Convert Gas to Electricity," Courier Post, July 27, 2007.

Biomass Production Data	Source
Biomass waste in MSW	David Specca (Rutrgers NJAES, EcoComplex)
MSW Incinerated, Food % in MSW, Paper % in MSW	"2005 Annual Solid Waste Disposal Data," from Ray Worob (NJDEP employee)
MSW Disposed	"2004 Generation, Disposal and Recycling Rates in NJ," 2004, NJDEP at http://www.nj.gov/dep/dshw/recycling/stat_links/04_mater.pdf with additional info from Steve Rinaldi (NJDEP Bureau of Recycling and Planning)
Tons of each MSW recycled	"2004 Materal Specific recycling Rates in NJ," June 21, 2006, NJDEP, at http://www.nj.gov/dep/dshw/recycling/stat_links/04_mater.pdf
Yield Estimates for all Crops	NJ NASS Agricultural Statistics 2005 Annual Report for years 2000 -2004.
Manure Production	Manure Characteristics. MWPS-18 Manure Management Series. Iowa State University, Ames.
Manure Availability	Mike Westendorf (NJAES Extension Specialist in Animal Sciences)
Grease Waste	"Urban Grease Resource Assessment", National Renewable Energy Laboratory, U.S. Department of Energy, NREL/SR-570-26141, November 1998.
Trap Waste	
Population Projections 2002 to 2025	NJ Department of Labor and Workforce Development: http://www.wnjpin.net/OneStopCareerCenter/LaborMarketInformation/lmi03/cototal.pdf

Fuel Yield	Source
Fuel Yield Projections	Navigant Consulting Inc.
Fuel Yield Assumptions Provided by Steve Paul (Research Scientist, Princeton Plasma Physics Laboratory)	Arena, Blaise J. and Allenza, Paul, “Monosaccharides from corn kernel hulls by hydrolysis”, US patent #4,752,579, June 21, 1988.
	Clydesdale, F. M. (1994). Optimizing the diet with whole grains. Critical Reviews in Food
	Lasztity, R. (1998). “Oat Grain - A Wonderful Reservoir of Natural Nutrients and Biologically Active Substances”, Food Rev. Int. 14:99-119.
	Betty W. Li, “Determination of sugars, starches, and total dietary fiber in selected high-consumption foods”, Journal AOAC International. 1996;79:718–723.
	Betty W. Li, Karen W. Andrews, Pamela R. Pehrsson, “Individual Sugars, Soluble, and Insoluble Dietary Fiber Contents of 70 High Consumption Foods“, JOURNAL OF
	Nilsson, M., Åman, P., Härkönen, H., Hallmans, G., Bach Knudsen, K.E., Mazur, W. and Adlercreutz, H. “Content of nutrients and lignans in roller milled fractions of rye”, Journal of
	Sorghum and millets in human nutrition, FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS Rome, 1995 (FAO Food and Nutrition Series, No. 27), ISBN
	USDA National Nutrient Database for Standard Reference, Release 17. http://www.nal.usda.gov/fnic/foodcomp/Data/SR17/wtrank/wt_rank.html
	C. Ververis, K. Georghiou, D. Danielidis, D.G. Hatzinikolaou, P. Santas, R. Santas and V. Corleti, “Cellulose, hemicelluloses, lignin and ash content of some organic

County Level Biomass Production Estimates	Source
Commodity Level Agricultural Acreage & # Livestock	Farmland Assessment Data for 2005 tax year, New Jersey Department of Treasury, Division of Taxation
Recycled Production	“2004 Generation, Disposal and Recycling Rates in NJ (tons),” NJDEP Solid and Hazardous Waste, 2004, last Accessed May 21, 2007 at
MSW (Total, Non-Recycled, and Biomass Portion)	
MSW (Incinerated)	Calculated from the “2005 Annual Solid Waste Disposal Data” provided by Ray Worob of NJ DEP. Only type 10 and 23 waste were counted (MSW classifications).
Waste Paper, Landfilled	Calculated from the “2005 Annual Solid Waste Disposal Data”. General percentages of MSW for food waste and other paper were applied to each county’s MSW to
Food Waste, Landfilled	
Construction and Demo	ICF Incorporated (1995) and "Characterization of Building-Related Construction and Demolition Debris in the US" by Franklin Associates (June 1998)
Wood Composition of C&D	

Appendix B: Evaluation Questionnaire

EVALUATION OF THE NEW JERSEY BIOENERGY CALCULATOR©

Thank you for agreeing to evaluate the New Jersey Bioenergy Calculator©. Your input will help in making the Calculator a more effective, accurate and user-friendly tool. There are 23 questions in this evaluation related to the Calculator's accuracy, scope, objectivity, navigation, and usefulness. The first 12 questions allow for open-ended responses. Please provide as much detail as possible in your responses to these questions. The next 11 questions are simply agree/disagree and rating responses. The total time to complete this evaluation is about **30 minutes**. Your opinion regarding the New Jersey Bioenergy Calculator© is valued and greatly appreciated.

To Begin:

Open the NJ Bioenergy Calculator© which is in Excel format. Start at the worksheet labeled "Instructions". Read through the instructions first and then proceed as described below. Printing the instructions may make it easier to refer to as you review the worksheets.

Try it Out:

If you would first like to try out the Calculator before doing the evaluation, go to the "Instructions" tab and review the information. Then go to the "Bioenergy Calculator" page. You can calculate biopower or biofuel projections by selecting a technology in the drop-down cells B3 or B4. Try recalculating these estimates by modifying the net usable biomass assumptions found on the "Net Usable Assumption" worksheet. Projections on the "Bioenergy Calculator" page will automatically be recalculated to reflect your changes. Proceed to review the remaining worksheets to get more familiar with the Calculator's capabilities.

The Evaluation:

To begin the evaluation, go to the "Energy Content Assumptions" worksheet. Carefully review the information and answer the corresponding question (#1) found on the

Evaluation Questionnaire. Follow this same process for each of the additional worksheets identified in the questionnaire.

- Email your completed evaluation form to: brennan@aesop.rutgers.edu or fax to: Margaret Brennan-Tonetta at 732-932-4176.
- If you have any questions, please contact Margaret Brennan-Tonetta at 732-932-1000 x569 or at brennan@aesop.rutgers.edu.

Please return your completed evaluation by April 30, 2010

NAME:______________________________________
DATE:__________________________

EVALUATION QUESTIONNAIRE

Accuracy and Reliability

1. Does the information included in the "Energy Content Assumptions" worksheet contain any errors? YES/NO. If YES, please describe:

   Are the sources of information in the "Energy Content Assumptions" worksheet sufficiently documented and from reliable, unbiased sources? YES/NO. If NO, please describe data sources that need to be improved:

2. Does the information included in the "Technology Assumptions" worksheet contain any errors? YES/NO. If YES, please describe:

   Are the sources of information in the "Technology Assumptions" worksheet sufficiently documented and from reliable, unbiased sources? YES/NO. If NO, please describe data sources that need to be improved.

3. Does the information included in the “Updated LFG Estimates” and the “Electricity and Fuel from LFG” worksheets contain any errors? YES/NO. If YES, please describe:

   Are the sources of information in the “Updated LFG Estimates” and the “Electricity and Fuel from LFG” worksheets sufficiently documented and from reliable, unbiased sources? YES/NO. If NO, please describe data sources that need to be improved:

4. Does the information in the “Biomass Data Assumptions” worksheet contain any errors? YES/NO. If YES, please describe:

   Are the sources of information in the “Biomass Data Assumptions” worksheet sufficiently documented and from reliable, unbiased sources? YES/NO. If NO, please describe data sources that need to be improved.

5. Does the information in the “Yields for Ethanol and Dilute Acid Hydrolysis” worksheet contain any errors? YES/NO. If YES, please describe

   Are the sources of information in the “Yields for Ethanol and Dilute Acid Hydrolysis” worksheet sufficiently documented and from reliable, unbiased sources? YES/NO. If NO, please describe data sources that need to be improved.

6. Does the information in the County worksheets contain any errors? YES/NO. If YES, please describe.

   Are the sources of information in the County worksheets sufficiently documented and from reliable, unbiased sources? YES/NO. If NO, please describe data sources that need to be improved.

7. Is the information in the “Net Usable Assumptions” worksheet simple to modify? YES/NO. If NO, please describe how this page can be improved.

8. Were the User Instructions for the NJ Bioenergy Calculator© helpful, informative and easy to follow? YES/NO. If NO, how could they be improved?

<u>Scope</u>

9. Review the list of bioenergy feedstocks found in Column B on the “Bioenergy Calculator” worksheet. Were all significant biomass feedstocks included in the Calculator? YES/NO

   If NO, please list additional feedstocks that should be added.

10. Review the list of bioenergy conversion technologies found in Column A of the “Technology Assumptions” worksheet. Were all relevant conversion technologies included in the Calculator? YES/NO. If NO, please list additional technologies that should be added.

11. **<u>Use and Transferability</u>**

12. Does the NJ Bioenergy Calculator© generate the type of information that you find valuable for your work? YES/NO. If YES, in what way?

    What additional information would you like the Calculator to include in order to make it more useful to you?

13. What elements of the NJ Bioenergy Calculator© might make it potentially valuable for other uses and/or locations?

<u>Please circle your responses to the following questions:</u>

Navigation

14. It is easy to calculate state and county biofuel and biopower production potential for given years and selected technologies. **Agree/Disagree**
15. It is easy to modify the various assumptions as desired**.** **Agree/Disagree**
16. It is easy to identify the sources of data. **Agree/Disagree**
17. The NJ Bioenergy Calculator© is easy to use. **Agree/Disagree**

Usefulness

18. The five year increments in bio power and bio fuel projections are useful. **Agree/Disagree**
19. The NJ Bioenergy Calculator© produces data that is valuable for informing business development decisions. **Agree/Disagree**
20. The NJ Bioenergy Calculator© addresses a topic that policymakers are currently interested in. **Agree/Disagree**
21. The NJ Bioenergy Calculator© produces data that is valuable for informing state level bioenergy policymaking. **Agree/Disagree**

Overall Rating

22. The overall quality of the information generated by the Calculator is:

    Poor **Good** **Excellent**

23. The overall functionality/flexibility of the Calculator is:

    Poor **Good** **Excellent**

24. The overall accuracy and reliability of the data is:

    Poor **Good** **Excellent**

Additional Comments:

Background Information about Respondent:

Employer:

Job Title:

Expertise:

- **Please email your completed evaluation form to: brennan@aesop.rutgers.edu or fax to: Margaret Brennan-Tonetta at 732-932-4176**
- **If you have any questions, please contact Margaret Brennan-Tonetta at 732-932-1000 x569 or at brennan@aesop.rutgers.edu.**

Thank you for taking the time to complete this important evaluation!

Please return your completed evaluation by April 30, 2010

Appendix C: Energy Policy in the United States

A. Rationale and Approaches for a National Energy Policy

1. Mitigating the Effects of Market Failures

The consumption of fossil fuels and the subsequent emission of carbon dioxide into the atmosphere is perhaps one of the most serious tragedies of the commons problem that society is currently facing. This problem occurs because there is no clear ownership of the atmosphere and consequently, thus there is no direct incentive to protect it by holding those who pollute it liable. Furthermore, if individuals make an effort to reduce the amount by which they pollute the atmosphere, third parties will experience these benefits and be able to "free ride," thus reducing the overall level of pollution abatement that would have otherwise occurred.[218] Currently, as the largest emitter of greenhouse gases, the United States is considered a "free rider."[219] "The per capita carbon dioxide emission of the United States is approximately twice that of the United Kingdom or Japan and three times that of France or Sweden."[220]

Other market failures associated with reliance on fossil fuels are summarized in Table 14 (p.136). The federal government has instituted both regulations and incentives, such as taxes or subsidies, in an attempt to correct these failures. The government's use of taxes, subsidies and regulation is derived from the writings of A.C. Pigou.[221] The basic premise of his argument was that private decision makers fail to take certain costs

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[218] (Anderson and Leal 2001, 13)
[219] (Dreber and Nowak 2008, 2261)
[220] (Dreber and Nowak 2008, 2261)
[221] (Anderson and Leal 2001, 9)

into account, resulting in market failures. For this reason, government intervention to correct these failures is necessary.[222]

Regulations "prescribe the type of technology or equipment for environmental protection, the maximum permitted rate of emission for a particular pollutant, or a minimum energy-efficiency standard, and are a part of the 'command-and-control' approach to environmental protection."[223] Regulations, as compared to taxes, are economically inefficient because they force each firm to take the same actions, regardless of the differences in marginal costs among firms.[224] Conversely, taxes and cap and trade systems allow each individual firm to take its own marginal costs of pollution abatement into account and act accordingly, thus reaching a more efficient outcome than would have occurred as a result of a new regulation.

Subsidies are used to promote the production of goods that have positive external benefits and therefore, are under produced. Publicly funded research and development of technological innovations is an example of such a subsidized good.[225] The production of domestic fossil fuels is also a subsidized good, however, subsidizing this finite good increases its rate of depletion which does nothing to enhance national and economic security, not address climate mitigation efforts, in the long run.[226]

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[222] (Anderson and Leal 2001, 10)
[223] (Lazzari 2005, 21)
[224] (Lazzari 2005, 21)
[225] (Lazzari 2005, 14)
[226] (Lazzari 2005, 7)

Table 14. Energy Market Failure and Energy Policy Remedies

Type of Market Failure	Description	Distortion	Damage/Benefit	Possible Energy Policy	Examples in Current Federal Law
Environmental Externalities	Air pollution, discharge of wastes and effluents	Under pricing of energy resources and higher levels of production; excessive energy use due to uncompensated spillover effects	Harmful to health and environment, property damage, and economic damage	Emission taxes (or energy excise taxes where feasible)	Tax on Ozone Depleting Chemicals Under IRC Section 4681, Corporate Average Fuel Economy Standards (1975), increased in 2007
Oil Import Dependence	Excessive importation of crude oil and petroleum products	Under pricing of crude oil and petroleum products	Harm to national, energy and economic security; excessive defense spending	Oil Import Tax	No oil import taxes have been enacted, but tax breaks for the domestic production of oil, coal and natural gas are in place. The Energy Tax Incentives Act of 2005 mandated the most recent tax breaks.
Public Goods/Energy R&D	Manufacturers do not undertake sufficient R&D activities since they cannot capture full value	Under priced benefits to free riding firms from R&D activities	Undersupply of R&D; costly and insufficient energy efficiency and alternative fuel technologies	Tax subsidies for R&D expenditure	Tax credit under IRC section 30, and expensing under IRC section 174

Type of Market Failure	Description	Distortion	Damage/Benefit	Possible Energy Tax Policy	Examples in Current Federal Law
Public Goods/Energy Complementarity	Private market fails to provide goods that are consumed collectively and for which exclusion is too costly	Under-supply, or no supply of public goods such as infrastructure for alternative fuels technologies	Unrealized benefits; under-developed economy, and slower productivity growth	Benefit charges, and user fees, but also energy taxes and congestion pricing	Excise taxes of gasoline and other motor fuels under IRS sections 4081-4093, which are used primarily for infrastructure development and maintenance.
Landlord/Tenant Problem	Landlords, tenants have no incentive to conserve energy	Underinvestment in energy conservation items in rental housing (over consumption of energy)	Environmental damages, excessive import dependence, and other damages due to excessive energy use	Tax incentives for landlords or tenants for energy efficiency investments	Exclusion of subsidy from gross income under IRC section 136

Source: (Lazzari, Energy Tax Policy, An Economic Analysis 2005, 5) Note: Federal Laws Updated June 2008.

2. History of Energy Regulation, Taxes and Subsidies in the United States

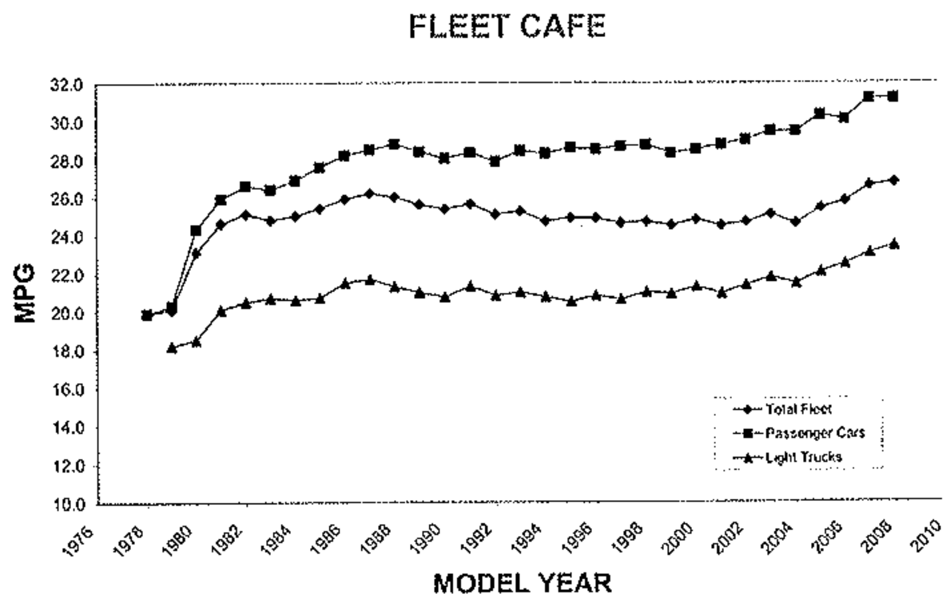
This section examines legislation designed to promote the efficient use of transportation fuels and the development of alternative transportation fuels and other means of transportation (electric cars, etc.). A discussion of incentives passed to promote oil and gas exploration is also provided, as well as an assessment of the impact of these incentives on the renewable fuels industry.

a. Alternative Transportation Fuels and Fuel Efficiency Standards

The Federal government's first attempt to promote fuel efficiency was in the passage of Corporate Average Fuel Economy (CAFE) standards. CAFE standards were signed into law as part of the Energy Policy Conservation Act in 1975, in response to the Arab oil embargo of 1973-74.[227] CAFE standards place a minimum miles per gallon usage on new automobiles. The National Highway Traffic Safety Administration sets fuel economy standards for cars and light trucks sold in the US. The EPA calculates the average fuel economy for each manufacturer. Figure 5 is a summary of CAFE standards from 1975 through 2010. Congress's early goal was to double CAFE standards by 1985 which, clearly, was not realized.[228]

[227] (Union of Concerned Scientists 2009)
[228] (National Highway Traffic Safety Administration 2009, 5)

Figure 5. Summary of CAFE Standards 1975 – 2010[229]



This table includes the increase in CAFE standards mandated by the Energy Independence and Security Act of 2007, which was signed into law on December 19, 2007. This law requires CAFE standards to be raised to 35 mpg by model year 2020. These standards apply to cars and light trucks. It also mandates that stricter standards for "work trucks and commercial medium- and heavy-duty on-highway vehicles" be developed.[230]

The CAFE standards adopted in 2007 still fail to close the gap between US CAFE standards and those in Europe, Japan and even China, as seen in Figure 6. However, in May 2009 President Obama proposed that CAFE standards be raised to 35.5 mpg by 2016.[231] These new CAFE standards, if approved by Congress, will require new cars produced in 2016 to attain an average fuel economy of 39 mpg and light trucks to attain

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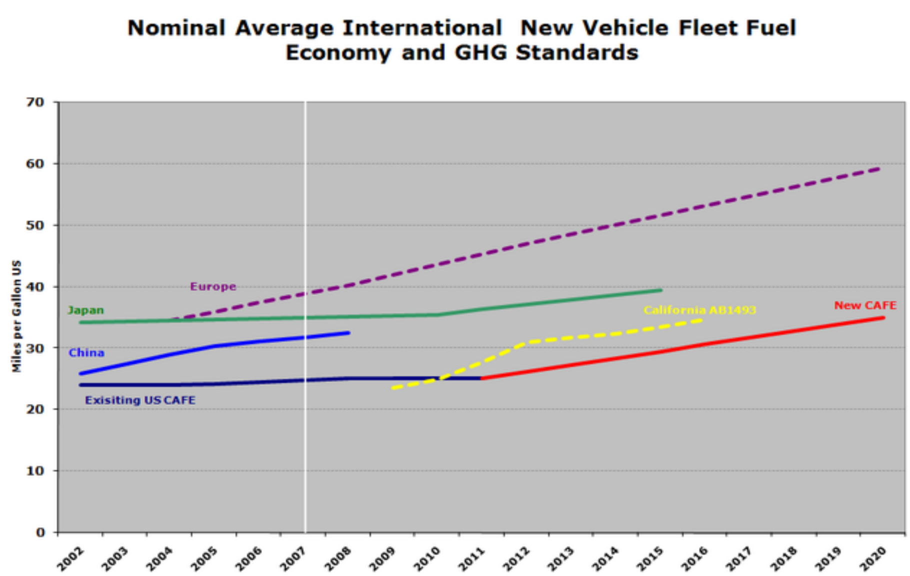
229 (National Highway Traffic Safety Administration 2009, 5)
230 (Sissine 2007, 4,5)
231 (Cassidy 2009, 1)

an average fuel economy of 30 mpg.[232] If the new standards are adopted, the disparity between US and Chinese CAFE standards will be reduced.

Ironically, a "dual-fuel" loophole still remains which provides credits to manufacturers for selling dual-fuel vehicles. Less than one percent of dual-fuel vehicles ever use alternative fuels, yet this loophole allows the production of vehicles that are below CAFE standards and has increased U.S. oil dependence by about 80,000 barrels per day. [233] This loophole will be phased out by 2020.

Figure 6. Comparison of International Fuel Efficiency Standards



Source: (Bioage Group, Aspects of the New CAFE Legislation 2007)

The Federal government's second attempt to increase fuel efficiency was the passage of the "Gas Guzzler Tax," which was part of the Energy Tax Act of 1978 and is

[232] (Cassidy 2009, 1)
[233] (Union of Concerned Scientists 2009)

still in use today.[234] It was designed to discourage the production and purchase of fuel inefficient vehicles. The Gas Guzzler Tax is an excise tax that ranges from $0 if the automobile fuel economy is above 22.5 miles per gallon to $7,700 for vehicles with a fuel economy of less than 12.5 mpg.[235] The Internal Revenue Service is responsible for administering this program. The Gas Guzzler Tax only applies to vehicles that weigh less than 6,000 pounds. Consequently, some of the largest polluters are exempt from the tax, including many sport utility vehicles (SUVs) currently on the market. As of 2006, over fifty-five "different models of luxury automobiles (and SUVs) [were] exempt from this excise tax."[236]

The Energy Tax Act of 1978 also introduced an excise tax exemption ($0.052/gallon out of the required $0.184/gallon gasoline tax) for fuels derived from alcohol.[237] The Crude Oil Windfall Profits Tax Act of 1980 included a production tax credit for unconventional fuels that is still in effect today. Biomass is one source listed under the definition of "unconventional fuel."[238] In 2003 dollars, this credit is "$6.40 per barrel of liquid fuels and about $1.13 per thousand cubic feet (mcf) of gas."[239]

The Alternative Motor Fuels Act of 1988 was the next piece of federal legislation to promote the use of alternative fuels. This act gave "a credit of up to 1.2 mpg toward automobile manufacturer's average fuel economy which helps it avoid penalties of CAFE

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234 (Hymel 2006, 11)
235 (U.S. Environmental Protection Agency 2006)
236 (Hymel 2006, 11)
237 (Lazzari 2005, 11)
238 (Lazzari 2005, 4)
239 (Lazzari 2005, 4)

standards."[240] The provisions in this act were extended by the 2004 Automotive Fuel Economy Manufacturing Incentives for Alternative Fueled Vehicles Rule.[241]

The Energy Policy Act of 1992 included the first federal tax credit for an electric vehicle. Under this act, owners of electric vehicles were eligible for a tax credit equal to "10% of the cost of the vehicle up to $4,000."[242] Additionally, a "tax deduction of up to $100,000 per location" was made available to owners of "qualified electric vehicle recharging property used in a trade or business."[243] This tax credit was extended through 2007 by the Working Families Tax Relief Act of 2004, which was the next piece of legislation to promote the use of renewable fuels.

The Working Families Tax Relief Act (WFTRA) repealed the excise tax exemptions for ethanol instituted by the 1978 Energy Tax act and replaced these with the Volumetric Ethanol Excise Tax Credit, "which provides ethanol blenders with $0.51 per pure gallon of ethanol blended or $.0051 per percentage point of ethanol blended."[244] The WFTRA also created the biodiesel fuels credit. Both the biodiesel mixture credit and the biodiesel credit fall under this tax category. The biodiesel mixture credit is an income tax credit of $0.50 for every gallon of biodiesel used to produce a "qualified biodiesel mixture," that is, "any blend of biodiesel and diesel fuel (determined without regard to any use of kerosene) that is used by the producer or sold by the producer … for use as fuel."[245] The biodiesel credit is $0.50 "for each gallon of biodiesel that is not mixed with diesel fuel and is used by the producer or sold by the producer at retail to any person for

[240] (U.S. Department of Energy, Energy Efficiency and Renewable Energy 2009)
[241] (U.S. Department of Energy, Energy Efficiency and Renewable Energy 2009)
[242] (U.S. Department of Energy, Energy Efficiency and Renewable Energy 2009)
[243] (U.S. Department of Energy, Energy Efficiency and Renewable Energy 2009)
[244] (U.S. Department of Energy, Energy Efficiency and Renewable Energy 2009)
[245] (Hymel 2006, 13)

use as a fuel."[246] This credit increases to $1.00/gallon if agri-biodiesel, instead of biodiesel derived from waste grease, is used.[247] All of the credits for biodiesel described above were made available to blenders and retailers in January 2005.[248]

The Energy Policy Act of 2005 expanded incentives for renewable fuels even further. The act included provisions for a $1.00 per gallon tax credit for renewable diesel, which is defined as "diesel fuel derived from biomass … using a thermal depolymerization process."[249] The Energy Policy Act also included a $0.10 per gallon tax credit for small agri-biodiesel producers, defined as those that produce up to 15 million gallons of biodiesel per year and "whose production capacity does not exceed 60 million gallons per year."[250]

The Energy Policy Act of 2005 added an alternative motor vehicle credit, a hybrid motor vehicle credit and a fuel cell motor vehicle credit. The alternative motor vehicle credit is a tax credit "equal to 50% of the incremental cost of the vehicle, plus an additional 30% of the incremental cost for vehicles with near-zero emissions."[251] The hybrid motor vehicle credit is a tax credit for light-duty hybrid vehicles that have achieved gains in efficiency. The amount of the tax credit is determined by the extent to which the vehicle's fuel economy is improved and its life-time fuel savings potential.[252] The fuel cell motor vehicle tax credit "provides a base tax credit of $8,000 for the

[246] (Hymel 2006, 13)
[247] (Hymel 2006, 13)
[248] (U.S. Department of Energy, Energy Efficiency and Renewable Energy 2009)
[249] (U.S. Department of Energy, Energy Efficiency and Renewable Energy 2009)
[250] (Hymel 2006, 13)
[251] (U.S. Department of Energy, Energy Efficiency and Renewable Energy 2009)
[252] (U.S. Department of Energy, Energy Efficiency and Renewable Energy 2009)

purchase of light-duty fuel cell vehicles."[253] This credit is valid until December 31, 2009, after which time it is reduced to $4,000.

President Bush's last piece of legislation that promotes the use of alternative fuels is the Energy Independence and Security Act of 2007, which includes the new CAFE standard discussed earlier and a renewable fuel standard (RFS). The renewable fuel standard requires that a minimum of 9.0 billion gallons of biofuels be included in US transportation fuel by 2008 (an increase of 3.6 billion gallons when compared to the previous 2008 standard) and 36 billion gallons by 2022. Notably, the legislation also calls for all future increases in biofuels production after 2016 to be in the form of "advanced biofuels, defined as cellulosic ethanol and other biofuels derived from feedstock other than cornstarch."[254] These will be the only biofuels counted toward the increasingly stringent RFS standard. Fuels produced by new biorefineries are also required to reduce lifecycle greenhouse gas emissions by at least 20% relative to the lifecycle emissions of gasoline and diesel. Finally, "fuels produced from biorefineries that displace more than 80% of the fossil-derived processing fuels used to operate a biofuel production facility will qualify for [unspecified] cash awards."[255]

The most recent initiative to promote clean energy is the American Clean Energy and Security Act of 2009 (ACESA), which is now being considered by the House of Representatives. Unlike the Energy Independence and Security Act of 2007, the ACESA focuses more on environmental concerns. The legislation has four titles: Clean Energy,

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[253] (U.S. Department of Energy, Energy Efficiency and Renewable Energy 2009)
[254] (Natural Resources Defense Council 2007, 5)
[255] (Natural Resources Defense Council 2007, 5)

Energy Efficiency, Reducing Global Warming Pollution and Transitioning to a Clean Energy Economy.[256]

The draft of the American Clean Energy and Security Act of 2009 also "provides for strict oversight and regulation of the new markets for carbon allowances and offsets."[257] Finally, Title 3 of the draft mandates the creation of additional greenhouse gas standards, which are intended to address sources of carbon emissions that will not be covered by the broader Global Warming Pollution Reduction Program.[258] Specifically, the draft, if enacted into law, would mandate the creation of programs to reduce hydrofluorocarbons and black carbon, both of which contribute to global warming.[259]

The Lieberman-Warner Climate Security Act, which was defeated in June 2008, would have strengthened the economic competitiveness of renewable fuels by ultimately raising the cost of fossil fuels in the United States, regardless of the competitive world price of oil. It also called for imposing a declining cap on 86% of US GHG emissions, requiring GHG reductions below 2005 levels by 4% by 2012, 19% by 2020 and 71% by 2050, which would be accomplished through a cap and trade system.[260] Currently, 12% of emissions credits will be allocated for free to industry, to be used between 2012 and 2050. These free allocations will be phased out by 2030.[261]

b. Federal Oil and Gas Incentives

The primary goal of federal energy tax policy from 1916 to 1970 was to increase domestic oil and gas production. Consequently, tax incentives were comprised of: 1)

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[256] (Larsen 2009, 1)
[257] (U.S. House of Representatives 2009, 4)
[258] (U.S. House of Representatives 2009, 4)
[259] (U.S. House of Representatives 2009, 4)
[260] (Natural Resources Defense Council 2007, n.d.)
[261] (Natural Resources Defense Council 2007, n.d.)

allowing for the deduction of "intangible drilling costs (IDCs) and dry hole costs," giving the producer the ability to write off most of the startup costs associated with expanded production and 2) giving oil and gas companies a "percentage depletion allowance," which allowed them to "claim 27.5% of revenue as a deduction for the cost of exhaustion or depletion of the deposit."[262] Both IDCs and percentage depletion allowances were reduced in the 1970s, and percentage depletion allowances for the major integrated oil companies were completely eliminated.[263]

The "gas guzzler" tax imposed as part of the Energy Tax Act of 1978 also reduced the gains oil companies had previously realized from energy tax incentives. The expected impact on the energy market that these changes would normally have had was mitigated by new subsidies for fuels from nonconventional sources including shale, tar sands, biomass and coal that were introduced in the Crude Oil Windfall Profit Tax Act of 1980.[264] Furthermore, in 1990, a "general business credit equal to 15% of costs attributable to enhanced oil recovery projects" was instituted in order to promote drilling in domestic wells whose marginal costs had exceeded the marginal costs realized by drilling in foreign wells.

Provisions in the Energy Tax Incentives Act of 2005 "increased the number of oil and gas producers that will be able to claim percentage depletion by qualifying as independent producers," have reduced the period of depreciation for certain natural gas distribution lines, and have created "two new credits for investment in certain clean coal technologies."[265] Many of the provisions included in the 2005 law encourage the more

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[262] (Lazzari 2005, 3)
[263] (Lazzari 2005, 3)
[264] (Hymel 2006, 6)
[265] (Hymel 2006, 7,8)

efficient use of fossil fuels, however, "the overwhelming majority of energy tax incentives continue to support businesses that extract, produce, and transport non-renewable resources. Although federal support is slowly increasing, industries involved in developing renewable energy do not get the government assistance and commitment that the fossil fuel industries have enjoyed."[266]

Between 1978 and 2006, the Federal Government spent $106 billion on oil and gas incentives, as opposed to between $30 and $33 billion dollars in alternative fuel tax subsidies during that same period.[267] Although, when market share for oil and gas versus alternative fuels is taken into account, some actually consider these subsidies to be smaller than those provided for alternative fuels.[268] However, over 94% of the alternative fuel tax incentives have been spent on credits or deductions for alcohol fuels.[269] These incentives inadvertently subsidize petroleum, as blends of ethanol/methanol and gasoline are currently sold. Consequently, it is questionable if dependence on fossil fuel has not been reduced. In addition, the competitive world oil market renders oil and gas subsidies ineffective, as they have little impact on the overall price of crude oil, which determines the economic viability of renewable fuels.

Many of the provisions outlined in the Energy Tax Incentives Act of 2005 are slated to be repealed or counterbalanced by new taxes, as outlined in President Obama's fiscal 2010 federal budget, which was released on May 7, 2009.[270] Over the next nine years, new oil and gas taxes are forecasted to increase federal tax revenue by $31.5

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[266] (Hymel 2006, 9)
[267] (Hymel 2006, 23)
[268] (Lazzari 2005, 19)
[269] (Hymel 2006, 22)
[270] (Snow 2009, 1)

billion.[271] These new taxes will include "an excise tax on new Gulf of Mexico production … [and] increasing independent producers' geophysical and geological amortization period to 7 from 5 years."[272]

B. Global Climate Change

The Intergovernmental Panel on Climate Change (IPCC) was "established to provide the decision-makers … with an objective source of information about climate change."[273] The research and reports generated by the IPCC are considered to be the "standard works of reference" on the subject of climate change and its predicted impacts. The latest report prepared by the IPCC, the *Fourth Assessment Report*, involved contributions from experts from more than 130 countries.[274] The report had over 450 lead authors, 800 contributing authors and was reviewed by an additional 2,500 experts before its release in November 2007.[275]

The latest IPCC report states that "warming of the climate system is unequivocal, as is now evident from observations of increases in global average air and ocean temperatures, widespread melting of snow and ice and rising global average sea level."[276] The IPCC is now 90% certain that the warming is caused by an "increase in anthropogenic greenhouse gas concentrations," as opposed to natural causes.[277] The growth rate of atmospheric CO_2 seems to be accelerating, as the growth rate between 1995 and 2005 (1.9 ppm per year) exceeded the average rate observed between 1960 and

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[271] (Snow 2009, 1)
[272] (Snow 2009, 1)
[273] (Intergovernmental Panel on Climate Change 2001)
[274] (Union of Concerned Scientists 2007)
[275] (Union of Concerned Scientists 2007)
[276] (Intergovernmental Panel on Climate Change 2007, 30)
[277] (Intergovernmental Panel on Climate Change 2007, 39)

2005 (1.4 ppm per year). [278] The growth in atmospheric CO_2 concentration is primarily attributed to the use of fossil fuels.[279]

Ultimately, the IPCC concludes that “reliance on adaptation [to climate change] alone could eventually lead to a magnitude of climate change to which effective adaptation is not possible, or will only be available at very high social, environmental and economic costs.”[280] The IPCC also notes that “any stabilization above 450 parts per million is associated with a significant probability of triggering a large-scale climatic event.”[281] More than half of the emissions scenarios evaluated by the IPCC indicated that this stabilization target will be “virtually out of reach” by 2020.[282] For these reasons, the international community has decided to take actions designed to reduce greenhouse gas emissions and thereby mitigate global warming.

C. National Security vs. Environmental Objectives in Energy Policy and the Role of Biofuels

1. National Security Objectives

Reliance on foreign oil poses multiple risks to United States national security. Consequently, the objective of national energy legislation enacted to encourage the development of domestic oil and gas has been to reduce or eliminate these risks. The Council on Foreign Relations noted five major risks foreign oil dependence posed to national security. The first is that “control over enormous oil revenues gives exporting countries the flexibility to adopt policies that oppose U.S. interests and

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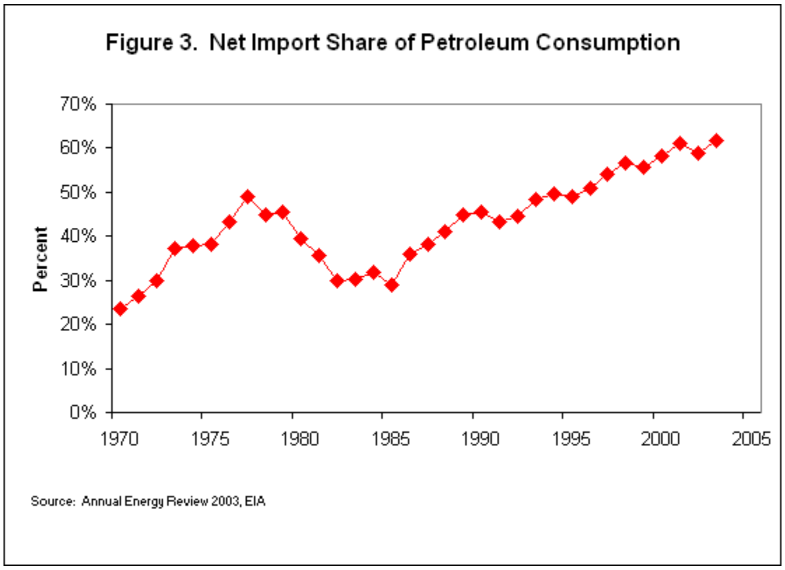
[278] (Intergovernmental Panel on Climate Change 2007, 36)
[279] (Intergovernmental Panel on Climate Change 2007, 37)
[280] (Intergovernmental Panel on Climate Change 2007, 65)
[281] (Intergovernmental Panel on Climate Change 2007, 800)
[282] (Intergovernmental Panel on Climate Change 2007, 800)

values."[283] Secondly, "oil dependence causes political realignments that constrain the ability of the United States to form partnerships to achieve common objectives."[284] Thirdly, fears of scarce supplies prompt countries to enter into "oil and gas deals that include political arrangements," which often create special relationships that "pose difficulties for the United States," and may potentially prevent the proper functioning of open market oil and gas trading.[285]

The fourth risk foreign oil dependence poses to national security is that "revenues from oil and gas exports can undermine local governance," or give totalitarian governments the financial means to "entrench their rule."[286] All of this can increase instability within oil producing states, as was seen in the section on oil exporting nations, which ultimately reduces the amount of oil exported from these countries, thus tightening global supply and driving up global prices. Finally, a significant disruption in foreign oil imports, which would inevitably raise the price of oil, will detrimentally affect the economy. In recent years, net imports of petroleum have increased in the United States, as seen in Figure 7 below.

[283] (Council on Foreign Relations 2006, 26)
[284] (Council on Foreign Relations 2006, 27)
[285] (Council on Foreign Relations 2006, 27)
[286] (Council on Foreign Relations 2006, 28)

Figure 7: Net Import Share of Petroleum Consumption



Furthermore, as seen Figures 8 and 9, there is generally a positive relationship between rising oil prices and inflation, although inflation has not been as severe in recent years. There is also a negative relationship between inflation and GDP growth.

Figure 8: Movements in World Oil Price and Inflation

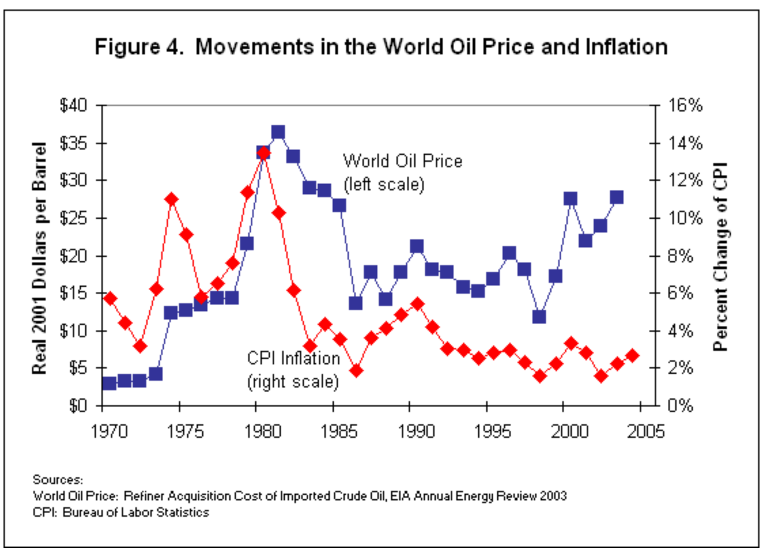
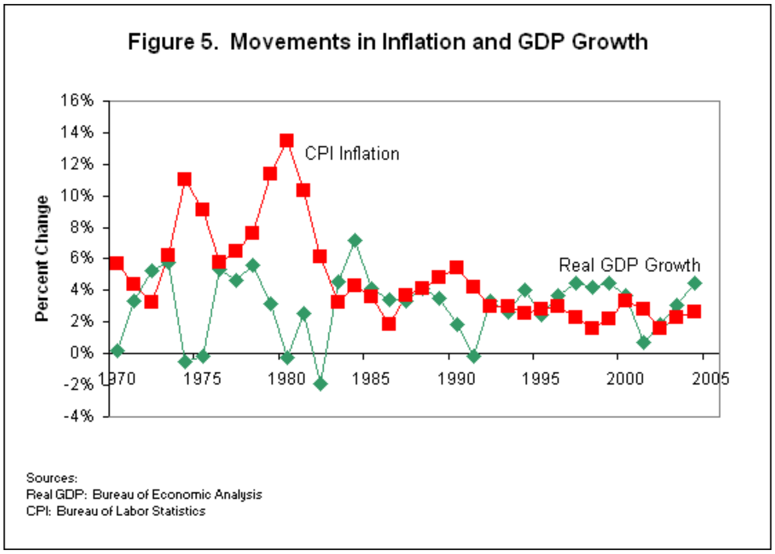
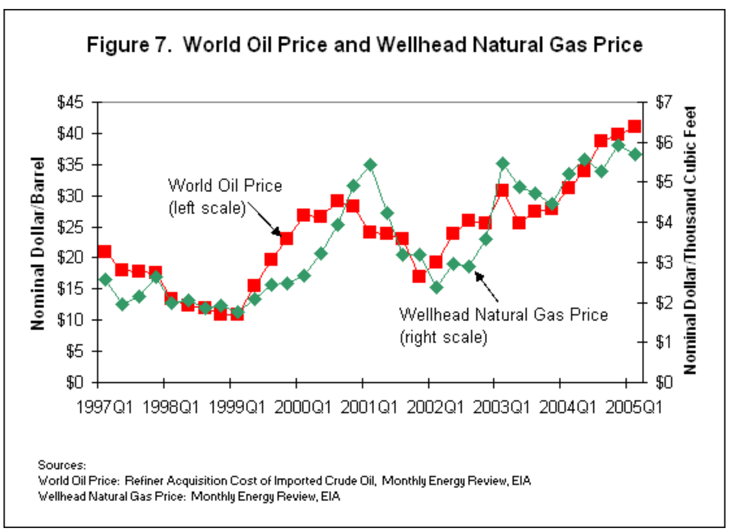


Figure 9: Movements in Inflation and GDP Growth



Finally, there is a strong, positive correlation between natural gas and oil prices, as seen in the Figure 10.[287]

Figure 10: World Oil Price and Natural Gas Price



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[287] Figures 5-8 were retrieved at: (U.S. Department of Energy, Energy Information Administration 2008)

Since natural gas comprises 22.4% of energy consumption in the United States (as of 2006),[288] if natural gas prices follow the current trajectory of oil prices, more inflation is likely to occur, further dampening economic growth.

2. Environmental Objectives

Environmental objectives in renewable energy policies are to reduce the emission of carbon dioxide and other greenhouse gases in order to mitigate the numerous detrimental effects of increased global warming. Scientists predict that global warming will adversely affect human health, terrestrial and marine ecosystems and biodiversity, biogeochemical cycles (one example of this is ocean acidification). They also predict that global warming will reduce food production (after average global temperatures rise more than 3 degrees Celsius) and decrease the availability of water resources, as well as increase the frequency of extreme weather events.[289]

Based on energy policy decisions over the last several decades, it appears that federal policymakers have held a higher priority for mitigating the national security risks of oil importation than mitigating the risks associated with burning fossil fuels in general (i.e. global warming). This is evident in Congress' refusal to repeal the $22 billion worth of oil and gas subsidies in the 2007 Energy Independence and Security Act currently awarded to international oil and gas companies for domestic production. At the same time Congress failed to renew production tax credits for solar and wind energy, which expired in December 2008.[290,291] As a result, it is anticipated that wind installations will drop precipitously, as they did in 2000 (falling by 93%), 2002 (by 73%) and in 2004 (by

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[288] (U.S. Department of Energy, Energy Information Administration 2008)
[289] (Intergovernmental Panel on Climate Change 2007, 787-789)
[290] (Sissine 2007, 2)
[291] (American Wind Energy Association 2008)

77%).[292] These were also years in which Congress failed to extend the alternative fuel production tax credit well in advance of the expiration date.

There are, however, indications that policymakers are beginning to place higher priority on environmental consequences when drafting energy policy. This is evidenced by the stricter CAFE standards and Renewable Fuel Standards mandated by the Energy Independence and Security Act of 2007 and the American Clean Energy and Security Act of 2009. These new mandates are designed to reduce oil consumption, which will ultimately strengthen U.S. national security, as well as reduce carbon dioxide emissions.

While US national energy policy generally prioritizes national security over environmental concerns, international treaties and state policies tend to prioritize environmental concerns and mitigating the impacts of climate change, as will be discussed in the next section. This conflict in priorities impacts the ability to effectively address global environmental concerns.

[292] (Global Wind Energy Council 2008, 64)

D. Alternative Energy Treaties, Legislation, and Policies

1. Alternative Energy Options

In 2007, renewable energy "supplied 18% of the world's final energy consumption, counting traditional biomass, large hydropower, and 'new' renewables (small hydro, modern biomass, wind, solar, geothermal, and biofuels)."[293] Between 2002 and 2006, global capacity for many renewable energy technologies grew at an average rate of 15-30% annually.[294] Of these, grid-connected solar voltaic capacity grew the fastest, at an average rate of 60% growth per year.[295] In 2008, this growth rate reached 70%.[296] Wind power capacity "increased more than any other renewable power technology in 2007, with an estimated 21 GW added," representing a 28% increase in overall capacity[297]. In 2008, wind power capacity grew by another 29%.[298]

Biodiesel production also grew by an average rate of 40% per year between 2002 and 2006, while ethanol production expanded at a more moderate average global growth rate of 15% per year.[299] In 2008, the annual growth rate of both biodiesel and ethanol production was 34%.[300] Of the various renewable energy technologies, large hydropower, biomass power and heat and geothermal power grew at the slowest global average rates of 3 to 5 percent per year.[301] These growth rates, however, are still notable

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293 (Renewable Energy Policy Network for the 21st Century 2008, 9)
294 (Renewable Energy Policy Network for the 21st Century 2008, 10)
295 (Renewable Energy Policy Network for the 21st Century 2008, 10)
296 (Renewable Energy Policy Network for the 21st Century 2009, 8)
297 (Renewable Energy Policy Network for the 21st Century 2008, 10)
298 (Renewable Energy Policy Network for the 21st Century 2009, 8)
299 (Renewable Energy Policy Network for the 21st Century 2008, 10)
300 (Renewable Energy Policy Network for the 21st Century 2009, 8)
301 (Renewable Energy Policy Network for the 21st Century 2008, 10)

when compared to the global growth rate of fossil fuel production, which averaged two to four percent per year.[302]

Despite these encouraging global growth numbers, renewable energy still comprises a small amount of total electricity generated and total fuel consumed. The United States is currently the world's largest producer of fuel ethanol, producing 34 billion liters, over half of the 67 billion liters produced worldwide.[303] Fuel ethanol production in the United States, however, only comprises 4.2% of gasoline consumption per year.[304,305] Conversely, Brazil, the second largest producer in the world (Brazil produced 27 billion liters of ethanol in 2008)[306] has been able to replace over 50% of its gasoline consumption with ethanol.[307] The United States is the second largest biodiesel producer in the world, producing 2.0 billion liters in 2008, slightly lagging behind Germany, which produced 2.2 billion liters in 2008.[308]

2. International Agreements

The first international climate change agreement was the 1992 United Nations Framework Convention on Climate Change (UNFCCC), which was a "legally non-binding treaty" that included a voluntary pledge on the behalf of major industrialized and developed nations to "reduce greenhouse gas emissions to 1990 levels in order to begin mitigating possible global warming."[309] This was to be done through the establishment of national action plans and was to be accomplished by the year 2000. The United States

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[302] (Renewable Energy Policy Network for the 21st Century 2008, 10)
[303] (Renewable Energy Policy Network for the 21st Century 2009, 25)
[304] Note: Liters of ethanol was converted to gallons and then to gallons of gasoline equivalent using a Btu ratio 76,100:114,100 (gal of ethanol : gallon of gasoline) (Gable and Gable 2008)
[305] (U.S. Department of Energy, Energy Information Administration 2009)
[306] (Renewable Energy Policy Network for the 21st Century 2009, 25)
[307] (Hudson 2009, 1)
[308] (Renewable Energy Policy Network for the 21st Century 2009, 25)
[309] (Fletcher and Parker 2007, 1)

quickly ratified this treaty, which in 1994, entered into force.[310] Under the terms of the treaty, all parties were expected to measure their own emissions and report these emissions to the UNFCCC secretariat.

By 1995, it became evident that Japan and the United States would not meet their respective goals, prompting negotiations on legally binding commitments to commence. The product of these negotiations was the Kyoto Protocol, which was completed in 1997 and established legally binding emission reductions for six greenhouse gases, including carbon dioxide, methane, nitrous oxide, hydrofluorocarbons, perfluorocarbons and sulfur hexafluoride.[311]

The countries participating in the Kyoto Protocol were placed in two categories: Annex I and non-Annex I. Annex I is comprised of 38 countries, including "former Communist countries, plus the European Union."[312] China and India are considered developing countries and are therefore placed in the category "non-Annex I" and are not required to reduce their emissions, as opposed to Annex I countries, who in ratifying the treaty must agree to reduce their greenhouse gas emissions to a level 5% below 1990 emissions levels during the commitment period of 2008 - 2012. The Treaty was signed by the US in 1998, but never ratified. In March 2001, President Bush rejected the Kyoto Protocol. As of December 2006, however, "168 nations plus the European Union had ratified the Protocol, representing 61.6% of Annex I countries' GHG emissions."[313]

Countries may meet their compliance requirements through emissions trading, which is conducted through the European Union's Emissions Trading System (ETS), the

[310] (Fletcher and Parker 2007, 1)
[311] (Fletcher and Parker 2007, 2)
[312] (Fletcher and Parker 2007, 2)
[313] (Fletcher and Parker 2007, 2)

Clean Development Mechanism or by Joint Implementation. The Clean Development Mechanism is a project-based plan by which Annex I countries can receive Certified Emissions Reduction credits (CERs) by investing in greenhouse gas reduction projects in various non-Annex 1 countries. [314]

Finally, under the Kyoto Protocol, some offsets are awarded for specific activities such as "afforestation … reforestation … deforestation prevention, forest management, cropland management, grazing land management and revegetation"[315]. These carbon sinks are evaluated on a country specific basis. Furthermore, there is still ongoing debate as to how exactly carbon absorbed by these sinks will be calculated and counted toward a given country's obligations.[316]

Other international agreements created to limit carbon dioxide emissions and promote the use of renewable energy are the Asia-Pacific Partnership on Clean Development and the International Climate Action Partnership (ICAP). The Asia-Pacific Partnership on Clean Development was announced in July 2005. In this nonbinding agreement, Australia, Canada, China, India, Japan, Korea and the United States have pledged to "collaborate to increase access to, and accelerate the uptake of, affordable and reliable renewable energy and distributed generation across the Partnership countries to achieve sustainable economic, social and environmental development."[317] However, no specific targets have been announced thus far.[318] About half of the world's economic activity and energy consumption is carried out in these countries, which are where about half the world's population resides. These seven countries also "produce about 65

[314] (Fletcher and Parker 2007, 5)
[315] (Fletcher and Parker 2007, 6)
[316] (Fletcher and Parker 2007, 6)
[317] (Asia-Pacific Partnership on Clean Development and Climate 2007, 8)
[318] (Fletcher and Parker 2007, 12)

percent of the world's coal, 48 percent of the world's steel, 37 percent of world's aluminum, and 61 percent of the world's cement."[319]

The ICAP agreement is an agreement signed by members of the European Union, the Regional Greenhouse Gas Initiative, the Western Climate Initiative (both of these initiatives are discussed below), New Zealand and Norway. All members have already implemented or are in the process of implementing mandatory cap and trade systems (via the adoption of carbon markets). Ultimately, members of ICAP hope to "contribute to the establishment of a well-functioning global cap and trade carbon market" by ensuring compatibility of carbon markets and "consistent regulatory framework across national borders."[320]

The motivation behind creating such a market is that by doing so, the cost of reducing carbon emissions would be much lower for all regions involved. For example, the cost of eliminating a ton of carbon dioxide emissions in China is $2, while the cost of eliminating a ton of carbon dioxide emissions from a United States power plant is $75.[321] It therefore makes sense for the power plant in the United States to pay for the reduction in China. A summary of the marginal costs for reducing carbon emissions is illustrated in Figure 11.

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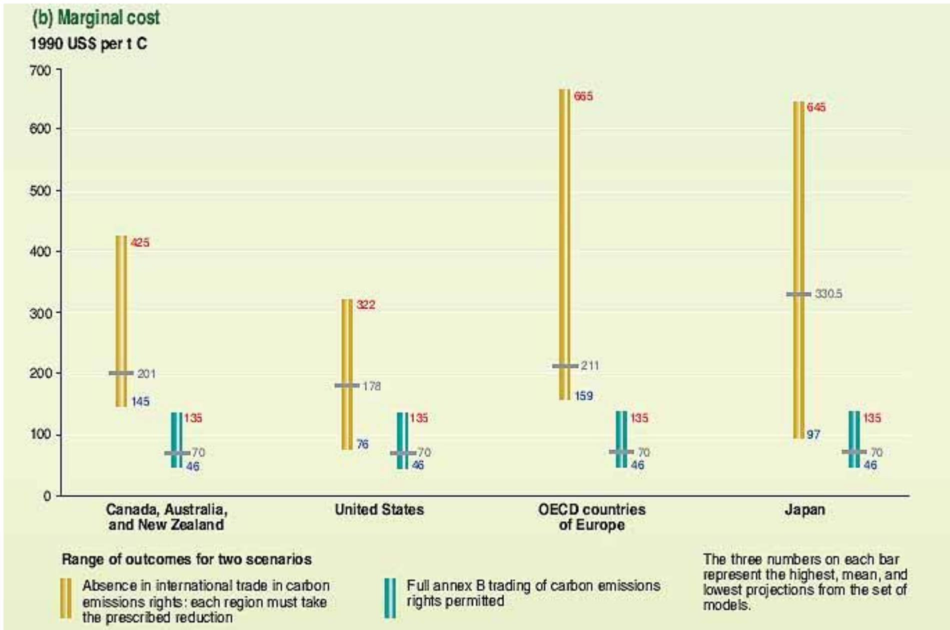
[319] (Asia-Pacific Partnership on Clean Development and Climate 2007)
[320] (International Climate Action Partnership 2007)
[321] (Kosloff 2007, 4)

Figure 11. Projection of Marginal Costs in Annex II Countries[322]



3. Regional Agreements

There are currently three different regional agreements in the United States and Canada to reduce carbon dioxide emissions and encourage the adoption of renewable energy. The Regional Greenhouse Gas Initiative (RGGI), as compared to the other two regional agreements, is the most comprehensive in both its goals and in its plan to achieve said goals. The Western Climate Initiative, however, may be even more progressive than RGGI if a market to cap and trade the emissions produced in various sectors, as opposed to just the electricity sector, is actually accomplished. The final regional agreement, that of the New England Governors and Eastern Canadian Premiers, seems to be faltering, as compared to the others. A climate action plan was drawn up in 2001, but since that time, no concrete measures have been put in place to achieve the

[322] (Intergovernmental Panel on Climate Change 2001)

objectives set forth in that plan, besides pledges to "coordinate and facilitate regional strategies and [a] cooperative approach to addressing energy issues."[323]

a. New England Governors and Eastern Canadian Premiers (NEGECP)

Members of the NEGECP include the Canadian provinces of Nova Scotia, Newfoundland and Labrador, Prince Edward Island, New Brunswick and Quebec and the states of Rhode Island, Maine, Vermont, Massachusetts and New Hampshire.[324] In its 2001 Action Plan, the members of the NEGECP outlined short-term, mid-term and long-term regional goals. The short-term goal is to "reduce regional GHG emissions to 1990 emissions by 2010," the mid-term goal is to "reduce regional GHG emissions by at least 10% below 1990 emissions by 2020, and establish an iterative five-year process, commencing in 2005, to adjust the goals if necessary and set future emissions reduction goal," and the long-term goal is to "reduce regional GHG emissions ... 75-85% below current levels.[325] There is little evidence of concrete effort to put the NEGECP Action Items into effect or to "establish an iterative five-year process," however, many of these states are now members of the Regional Greenhouse Gas Initiative, so it is possible that these efforts have been largely abandoned or simply postponed in favor of RGGI's regional cap-and-trade program.

b. Regional Greenhouse Gas Initiative

The Regional Greenhouse Gas Initiative, which includes Connecticut, Delaware, Maine, New Hampshire, New Jersey, New York, Maryland and Vermont, will facilitate the regional cap and trade of carbon dioxide emissions from electricity production

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[323] (New England Governors and Eastern Canadian Premiers 2005)
[324] (New England Governors and Eastern Canadian Premiers 2007)
[325] (New England Governors and Eastern Canadian Premiers 2001, 7)

beginning in January 2009. This cap and trade program will be based on generators, and in that sense, will be similar to the EU ETS.[326] From 2009-2014 the states will be required to maintain current emissions levels. After that, an emissions decline of 2.5% per year between 2015 and 2018 is required.[327]

Thus far, New York, Vermont, Connecticut and Maine have publically pledged to auction 100% or near 100% of their allowances. The auctioning of most or all of emissions allowances will make RGGI different (and hopefully more effective) than the EU ETS. Members of the RGGI have also taken steps to address leakage, which is the possibility that any carbon savings realized through the cap-and-trade system will be mitigated by the importation of electricity from generators that are not subject to a similar system. In this case, electricity generators within RGGI would be "importing" carbon as well as electricity.[328] One way proposed to deal with this problem is to assign leakage responsibility to importers of electricity within RGGI, requiring them to retire credits to account for increased carbon exports due to their power purchase decisions.

c. Western Climate Initiative

The states and provinces that are part of the Western Climate Initiative are Arizona, British Columbia, California, Manitoba, Montana, New Mexico, Oregon, Utah and Washington.[329] In becoming a partner in this initiative, all of these states and provinces have agreed to participate in a "regional, multi-sector, cap and trade program" in order to reduce aggregate greenhouse gas emissions to a level 15% below that of 2005

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[326] (Western Climate Initiative 2008, 1)
[327] (Regional Greenhouse Gas Initiative 2007, 4)
[328] (Cowart 2006, 1)
[329] (Western Climate Initiative 2008)

by 2020.[330,331] Various allocation options, electricity options, offsets options, reporting options and scope options for the cap and trade program have been made available to stakeholders for comment.[332] The decisions made after the comment period should be acknowledged and analyzed, as they could be a good indication of what works and what does not work in cap and trade markets.

330 (Western Climate Initiative 2008)
331 (Western Climate Initiative 2007)
332 (Western Climate Initiative 2008)

Appendix D. Competition for Land: Food Crops v. Fuel Crops

In 2007, 22% of the U.S. corn crop was devoted to ethanol production[333] and between 2006 and 2007, U.S. corn acreage increased from 78 million to 92 million acres.[334] Between 2005 and 2007, corn prices rose from $2.00/bushel to between $3.75 to $4.00 per bushel, an increase of 87.5 to 100%.[335] Birur et. al. of Purdue University assert that most of the increase in corn acreage was achieved through substitution away from soybean production, which has in turn driven up the price of soybeans.[336] Soybean prices ranged from $10.00 – 10.80 per bushel in 2007, up from $5.66 in 2005, an increase of 76.7 to 90.8%.[337] More recently, between March 2007 and March 2008, "wheat prices increased by 123 %, soybean prices increased by 66%, corn prices have increased by 37% and rice prices have increased by 36%." Given that "U.S. corn accounts for about 40% of global production and roughly 70% of world trade," these shifts have affected both the domestic and world markets.[338]

According to the IMF Global Food Index, between March 2007 and March 2008, global food inflation was 43%.[339] During this same time period, the United States food CPI increased by only 4.5%.[340] The smaller increase is a result of U.S. consumption of highly processed foods as opposed to raw commodities. Typically, about one fifth of every consumer dollar for food purchases can be "attributed to the farm value of the underlying commodities."[341] Other aspects of production, such as "transportation,

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[333] (Capehart and Richardson 2008, 2)
[334] (Birur 2007, 7)
[335] (Capehart and Richardson 2008, 2)
[336] (Birur 2007, 7)
[337] (Capehart and Richardson 2008, 2)
[338] (Elobeid and Hart 2007, 2)
[339] (Lazear 2008, 1)
[340] (Lazear 2008, 2)
[341] (United States Department of Agriculture 2008)

processing, packaging and distribution," account for the other "80 cents of every retail dollar that is spent on food in the United States."[342] The President's Council of Economic Advisors estimates that about 3% of the increase in global food prices can be attributed to an increase in corn-based ethanol production.[343] This estimate includes "the indirect effects of the increase in corn-based ethanol production, through crop substitution and spillover effects into other food products."[344]

The World Bank states that food prices "have risen due to a number of individual factors, whose combined effect has led to an upward price spiral."[345] Among these factors, the "most important was the large increase in bio-fuels production in the US and EU in response to policies that subsidized production of biofuels."[346] Similarly, the International Monetary Fund (IMF) claims that "biofuels production is seriously affecting food markets."[347] Although both the World Bank and the IMF emphasize the impact biofuels have had on the increase in world food prices, neither offers any estimates to demonstrate exactly how large this impact has been. Consequently, it is impossible to directly compare the statements made by the World Bank and IMF to those made by the U.S. Council of Economic Advisors.

There are however, additional reasons for higher food costs that have had a significant impact other than the diversion of corn to biofuels.[348] These include:

1) Markets for soybeans tightened as growers converted their former soybean fields to corn

[342] (United States Department of Agriculture 2008)
[343] (Lazear 2008, 3)
[344] (Lazear 2008, 3)
[345] (The World Bank 2008, 1)
[346] (The World Bank 2008, 1)
[347] (Helbling, Mercer-Blackman and Cheng 2008, 12)
[348] (Capehart and Richardson 2008, 2,3)

2) Global stocks of corn, wheat and soybeans are at historic lows due to adverse weather conditions in Australia, Eastern Europe, Canada, Western Europe and the Ukraine
3) The growing middleclass in Asia, particularly in China and India, is demanding more meats and livestock products. In 1985, "the average Chinese consumer ate 44 pounds of meat a year, now he eats more than 110 pounds."[349] Increased meat consumption increases demand for grains because it "takes eight pounds of grain to produce one of beef."[350]
4) Weaker dollar boosts demand for U.S. exports
5) Rising energy costs affect the price of fertilizer, crop drying and transportation as well as increase ethanol's capacity to compete with gasoline, which further boosts demand for corn.
6) The introduction of "export restrictions and bans … [which have] restricted global supply and aggravated shortages."[351]

1. Other Factors to Consider in the Food vs. Fuel Debate

- Other regions of the world where corn is the dominant grain for food consumption, particularly Sub-Saharan Africa and Latin America, will face much larger increases in food prices than the United States.[352] In the long term, however, these countries may benefit from higher commodity prices if they can increase production levels to take advantage of export opportunities.

349 (The Economist 2007)
350 (The Economist 2007)
351 (The World Bank 2008, 4)
352 (Elobeid and Hart 2007, 14)

- There is evidence suggesting that there is a "corn connection" to Amazonian deforestation.[353] Soybean production in the United States has fallen by 15% since 2006, due to a rise in U.S. corn production. This has led to higher soybean prices. Higher soybean prices also tend to "raise global beef prices because soy-based livestock feeds become more expensive."[354] Consequently, some evidence shows that additional acreage of Brazilian rainforest is being converted for soy production and pastureland.
- Corn requires a large amount of nitrogen fertilizer. Nitrogen fertilizer runoff from the mid-west can contribute to nutrient loading in the Gulf of Mexico which creates a "dead zone."[355] The dead zone has "expanded from an average of 5,000 square miles between 1985 and 2006, to 6,682 square miles in 2006, to an estimated 8,543 square miles in 2007," which is the largest to date.[356]
- Some, such as Michael W. Masters of Masters Capital Management, LLC, claim that institutional investors are "one of, if not the primary factor affecting commodities prices today."[357] Masters states that institutional investors, particularly "corporate and government pension funds, Sovereign Wealth Funds and University Endowments" are Index Speculators because they "distribute their allocation of dollars across the 25 key commodities futures according to the popular indices."[358]

  Today, in many commodities futures markets, index speculators are "the single largest force" and have been largely responsible for the huge growth in demand for

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[353] (Laurance 2007, 1721)
[354] (Laurance 2007, 1721)
[355] (Gulen and Shenoy 2007, 10)
[356] (Gulen and Shenoy 2007, 10)
[357] (Masters 2008, 1)
[358] (Masters 2008, 1)

commodities futures over the last couple of years.[359] Furthermore, there seems to be a correlation between assets allocated to commodity index trading and the price of said commodities, as "assets allocated to commodity index trading strategies have risen from $13 billion at the end of 2003 to $260 billion as of March 2008 and the price of the 25 commodities that compose these indices have risen by an average of 183% in those five years."[360]

The Ethanol Promotion and Information Council notes that "US corn exports in the 2007-2008 market year were 2.25 billion bushels, 6 percent more than in the 2006-2007 market year."[361] Therefore, corn exports are not suffering as a result of ethanol production. The maintenance of exports at the same or higher levels indicates that use of corn for ethanol production could not have had a significant impact on the domestic market.

359 (Masters 2008, 4)
360 (Masters 2008, 3)
361 (Biofuels Digest 2008)

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