BIOMASS RESOURCES FOR PRODUCING RENEWABLE POWER AND FUELS IN THE STATE OF NEW JERSEY AND INCENTIVES TO PROMOTE THEIR DEVELOPMENT

A Report to the New Jersey Board of Public Utilities in Response to a
Request for Input on the 2011 Draft Energy Master Plan

By the

Biomass Work Group

Co-Chairs

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REPORT OF THE BIOMASS WORK GROUP TO THE N.J. BOARD OF PUBLIC UTILITIES (9.26.11)

EXECUTIVE SUMMARY

The 2011 Draft Energy Master Plan (EMP) of the State of New Jersey outlines five broad goals and a plan of action to "manage energy in a manner which saves money, stimulates the economy, creates jobs, protects the environment, and mitigates long-term cumulative impact." One of the EMP's goals is to "*maintain support for the renewable energy portfolio standard (RPS) of 22.5% of energy from renewable sources by 2021".* The principal renewables that the State promotes under the RPS are solar radiation, wind, and biomass. Yet, the EMP notes, current incentives are ineffective when it comes to stimulating the development of the biomass-to-energy sector.

To offer recommendations on how to resolve this challenge, the BPU asked the 31-member, multi-sector, technically expert New Jersey Work Group on Renewable Natural Gas ("RNG Work Group"), coordinated by Energy Vision, a national nonprofit environmental organization, and the Rutgers University EcoComplex, to serve as the Biomass Work Group (BWG) and provide responses to BPU on five questions, especially this: ***What can the State do to incentivize the development of biomass resources to allow [this category of renewables] to "compete" with other renewables*?** In addition, the BPU invited the BWG to report on opportunities identified by the RNG Work Group for producing renewable natural gas from the State's organic wastes, and on the benefits of using this sustainable fuel to replace diesel in medium- and heavy-duty vehicles.

Opportunities, Data Gaps, and the Need for Experience with Biomass-based Facilities

In 2007, the *Assessment of Biomass Energy Potential in New Jersey* ("N.J. Biomass Assessment"), prepared for the BPU by the Rutgers New Jersey Agricultural Experiment Station, analyzed the quantities and energy potential of more than 40 biomass resources ranging from food waste to forest residues. This study reported that the State's sustainable and "practically recoverable" biomass resources could be converted to enough renewable energy to supply every year up to 9% of the State's electricity or up to 5 % of its highway vehicle fuel.

The BWG intensively reviewed the N.J. Biomass Assessment and examined additional data and research. Yet in grappling with key issues of biomass quantities, costs, and availability, the BWG found important information gaps that could not be filled because, apart from power plants at landfills, there is no renewable biomass-to-energy industry in New Jersey. The BWG concluded that the most important step the State of New Jersey could take at this point would be to assist private companies to construct and operate a range of commercial biomass-to-energy facilities. The experience of these facilities would help identify sustainable biomass-based pathways toward the State's RPS and clean fuels goals – that is, pathways with the lowest possible energy costs and no adverse environmental or societal consequences.

Major Recommendation: Target State Resources to Facilitate Public-Private Partnerships to Build and Operate Biomass-to-Power & Fuels Plants in Two to Three Years

The BWG strongly recommends that the State take action – under a new ***Biomass Power & Fuels Initiative*** – to facilitate the rapid construction and operation by private companies and/or public-private partnerships, of renewable biomass facilities to produce electricity and/or vehicle fuels (in line with the EMP's support for "clean fuels") – using technologies new to New Jersey but successfully employed elsewhere in North America and overseas. Key components of this proposal are adapted from the successful Transfer Station Initiative of 1987-1988. A full description of the proposal appears on pages 3 to 7.

A State-driven ***Biomass Power & Fuels Initiative*** would mobilize and target existing resources, including those already available through multiple State and Federal programs, to achieve its goals. No new taxes would be instituted. The program would be grounded in strong interagency collaboration and input from the State's universities. Once up and running, key technical features of the facilities constructed under this program would be analyzed; and their overall costs, returns, and economic and environmental impacts would be measured. Power and fuels produced at these plants would contribute to New Jersey's energy, economic, and environmental goals. Knowledge gained from these facilities would be a strong starting point for incentivizing the growth and spread of a vibrant biomass-to-power & fuels industry across the State.

Additional Recommendations: Technology Demonstrations and Feedstock Studies

- *Facilitate and Incentivize Pilot and Small-scale Biomass-to-Energy Demonstrations*

Recognizing the rapid evolution of new biomass-to-energy technologies and commercial opportunities, the BWG recommends that the State facilitate and incentivize "pilot scale" and "bench-top scale" projects as part of the EMP. New Jersey's 11 "technology incubators," two of which are devoted to energy, are excellent project sites for advancing new biomass-to-energy technologies through successive phases of research, development, and commercial deployment.

- *Commission Studies of Key Economic Aspects of Agricultural and Other Rural Feedstocks*

The BWG was struck by the economic challenges related to rural biomass availability and recommends five studies to develop information needed to resolve these challenges.

⇒ **Alternative values of crop residues and animal wastes** (e.g., as sources of soil nutrients) require analysis to determine how farmers' economic options affect biomass availability.

⇒ **How to compensate farmers for agricultural biomass** needs study to find ways to bring crop residues and animal wastes into energy production. Cooperative structures, for example, could offer farmers in-kind benefits (like electricity or fertilizer) in return for diverting residues and wastes to energy projects.

⇒ **Potential production of sustainable biomass feedstocks on State-influenced lands** could include harvesting grasses and weeds and planting energy crops. A study is needed to identify which acreages of the nearly two million owned, regulated, or influenced by the State could appropriately be used in this way.

⇒ **Partnering with farmers to produce sustainable biomass on State-influenced lands** deserves study as a low-cost way to increase energy resources and bring financial benefits to farmers and the State.

⇒ **Potential energy yield of sustainable forest residues** deserves study – with the assistance of professional foresters – to establish economic incentives for utilizing these plentiful residues.

- *Commission Studies to Fill Data Gaps for Urban and Industrial Feedstocks*

The BWG noted the need for more data about food wastes and organic industrial wastes and recommends that each of these biomass resources be the topic of careful study.

⇒ **Food wastes**, when added to anaerobic digesters along with, e.g., manures or sludges, boost biogas yield. Better data about the amounts and sources of food waste could lead to better incentives for its use. A study by the Department of Environmental Protection to provide such data deserves to be expedited.

⇒ **Organic industrial residues (dry, semi-liquid, and liquid)** generated by the State's industries should be inventoried to identify potentially important feedstocks for energy production.

RNG Work Group Analysis: Renewable Natural Gas, an Action-ready Sustainable Fuel

The RNG Work Group was formed in late 2010 to identify and pursue realistic business models and incentives for producing RNG vehicle fuel in New Jersey and using it to replace diesel in medium- and heavy-duty vehicles, for several compelling reasons:

⇒ RNG along with conventional natural gas is the only fuel pathway today that can simultaneously a) break the oil dependence of trucks and buses; b) slash health-endangering urban air pollution; c) lower greenhouse gas emissions; and d) reduce fuel costs and price volatility.

⇒ RNG, when produced from biogas emissions of organic waste, is the least carbon-intensive fuel in the world and a fuel solution for trucks and buses. Implementation of the EMP's proposal to shift truck and bus fleets to natural gas would expand market incentives for RNG. According to the RNG Work Group's analysis, New Jersey's waste-based biogas resources could produce enough fuel to power up to 1 in 4 trucks and buses in the State, and emerging technologies could expand this potential.

⇒ New Jersey is home to the largest concentration in the U.S. of high-tech companies that produce and market – nationally and internationally – advanced gas-separation technologies that are essential for producing RNG vehicle fuel from biogas. The State should take advantage of its unique access to this cutting-edge sector of the biomass-to-energy industry to promote an indigenous RNG fuel industry, to boost job growth, enhance exports, and better protect the environment.

Biomass Resources for Producing Renewable Power and Fuels in the State of New Jersey and Incentives to Promote Their Development

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1. INTRODUCTION

Questions posed to the Biomass Work Group (BWG), and the approach to answering them.

The 2011 Draft Energy Master Plan (EMP), issued in June 2011 by the New Jersey Board of Public Utilities (BPU), establishes a set of goals and outlines a plan of action, pursuant to the strategic vision of the administration of Governor Chris Christie, to "manage energy in a manner which saves money, stimulates the economy, creates jobs, protects the environment, and mitigates long-term cumulative impact."

One of the EMP's five broad goals is to ***maintain support for the renewable energy portfolio standard (RPS) of 22.5% of energy from renewable sources by 2021***.[1] In reviewing policies in place to achieve this goal, the EMP recognizes a particular need to "reassess existing renewable energy incentives to utilize indigenous biomass resources more effectively" . . . [while] "preserving valuable farmland."[2] To offer input and recommendations on this critical issue, the BPU staff constituted the Biomass Work Group (BWG)[3] in June and posed five questions for its consideration:

1. *What role can agriculturally derived fuels products play in the development of new fuel sources in N.J.?*
2. *Are there any regulatory or legislative barriers to the development of this fuel source?*
3. *Does the [Biomass Work Group] support pursuing changing the classification of waste-to-energy from a Class 2 to a Class 1 resource? If so, does [the BWG) have specific recommendations regarding how this should be done?*
4. *What can the State do to incentivize the development of biomass resources to allow [this category of renewables] to "compete" with other renewables?*
5. *What other biomass opportunities exist in N.J.?*

Because of the inclusion of "clean fuels" transportation goals for the first time in the State's Energy Master Plan, the BWG viewed biomass materials as renewable feedstocks for both power and vehicle fuel. The quantitative starting point for BWG's analysis was the 2007 *Assessment of Biomass Energy Potential in New Jersey*, [4] ("N.J. Biomass Assessment"), a report prepared for the New Jersey Board of Public Utilities by the Rutgers New Jersey Agricultural Experiment Station. This report found the State's sustainable and practically available biomass resources large enough to supply up to 9% of the State's electricity or up to 5% of its highway vehicle fuel. The BWG's members, including a number of authors of the N.J. Biomass Assessment, provided additional data and perspectives regarding feedstock availability across the State's urban and rural sectors.

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[1] "Established under EDECA, New Jersey's RPS is one of the most aggressive in the U.S. The RPS requires each electricity supplier serving retail electricity customers in the State to procure 22.5% of the electricity it sells in New Jersey from qualified renewable energy resources by 2021. New Jersey established the RPS to drive the market deployment of new clean energy technologies, recognizing that expansion of renewable energy generation would provide significant economic development and environmental benefits, thereby advancing New Jersey's greenhouse gas reduction goals." *2011 Draft EMP, p. 45.*

[2] 2011 Draft Energy Master Plan, page 5.

[3] See *Appendix* for a list of Biomass Work Group members and Renewable Natural Gas Work Group members.

[4] http://bioenergy.rutgers.edu

The Uniqueness of "Biomass" Resources and BWG's Approach to Its Task

"Biomass" is unique among renewable energy sources in two key respects: 1) *Diversity of composition*: It encompasses a wide range of organic materials including farm crops and crop residues, food and yard wastes, landfill gas, wastewater sludges, livestock manures, and forestry residues. 2) *Multiplicity of conversion options and end products*: A range of technologies and families of technologies can convert biomass into a variety of liquid and gaseous fuels for producing electricity, providing heat, and powering vehicles.

While grappling with the inherent complexity of biomass policy issues, the BWG discovered that data on key biomass resources in New Jersey are incomplete. In addition the BWG found that broad-stroke distinctions such as those employed for creating "Class 1" and "Class 2" Renewable Energy Certificates, tend to obscure more than they reveal about the very features of biomass-based energy facilities that astute policies should reward, especially high energy-conversion efficiency (maximizing the amount of energy produced for every unit of energy consumed in the production process) and greenhouse gas emissions reduction.

BWG concluded that a system of incentives needs to be created to reward biomass-to-energy technologies on the basis of outcomes, not prior classifications. Yet, to date, there is a dearth of experience with these technologies, and therefore no acknowledged basis for defining which biomass conversion technologies when applied to specified feedstocks under defined economic conditions can achieve the best overall results for the State in terms of power and fuel supplies, economic growth, jobs, and environmental protection.

Against this background, the BWG developed its core recommendation – to establish a *Biomass Power & Fuels Initiative*. Under this *Initiative,* the State of New Jersey would assume a direct role, using existing State and Federal incentives programs, staff resources, and inherent powers, to facilitate over the next two to three years the construction and operation by private companies and public-private partnerships of a number of commercial biomass-to-energy facilities for the production of renewable power and/or vehicle fuel. These plants would be functioning showcases of biomass-to-energy technologies and business models that, although not yet established in New Jersey, resemble those at successful facilities elsewhere in North America and abroad. Once up and running, technical, structural, and financial features of these facilities would be documented; varieties of operational adjustments would be tested and analyzed; and overall costs, returns, and impacts would be measured. Knowledge gained in this way would establish the basis for strengthening policy incentives needed to encourage the spread of a commercial biomass-to-energy industry across the state to help achieve the goals of the Energy Master Plan and other state priorities. A useful template for developing the *Biomass Power & Fuels Initiative* can be found in the Transfer State Initiative of the late 1980s, although a number of its features would obviously need adaptation.

The remainder of this report contains responses to the BPU's questions, somewhat reordered for continuity. Also included is a brief background based on the N.J. Biomass Assessment. A final section presents perspectives of the Renewable Natural Gas (RNG) Work Group on the benefits of RNG vehicle fuel as a replacement for diesel in trucks and buses, and on the promising opportunity to promote RNG fuel production in the State due to the presence within its borders of a unique concentration of high-tech companies at the forefront of this industry.

2. *Recommendation: BIOMASS TO POWER & FUELS INITIATIVE*

The BWG's recommendation of a State-driven program to facilitate the rapid development by private companies and public-private partnerships of commercial biomass-based energy facilities 1) to serve as showcases of effective technologies and business models for producing power and fuels from biomass, and 2) to create the knowledge base needed to establish effective incentives to support the growth of the biomass-to-power & fuels industry in New Jersey

As its central recommendation to the Board of Public Utilities the Biomass Work Group (BWG) recommends that the State's Energy Master Plan include a *Sustainable Biomass Power & Fuels Initiative*" (BPFI): By mobilizing and targeting existing powers, staff, and already committed resources, and without increasing taxes, the State of New Jersey would ensure the speedy construction and operation by private and/or public partners of biomass-to-energy facilities based on technologies not yet in commercial use[5] in New Jersey (although well established elsewhere in North American and abroad), to produce electricity and/or vehicle fuel from the State's available and sustainable biomass resources.

Facilities built under the BPFI would be plants that function in a commercial environment serving paying customers. However, they would be "demonstrations" in the sense that they would exhibit features of structure and operations that could be replicated in other parts of the State. They would also be "demonstrations" in the sense that, without interrupting normal business activity, researchers would collect data on feedstock volumes and composition, energy efficiency, air emissions, nutrient and organic content of residues, and other data needed to evaluate each plant's economic, energy, and environmental performance.

A compelling precedent for the BPFI, and the basis on which specific components of this recommendation are modeled, is the successful Transfer Station Initiative (TSI) of 1987-88. The TSI employed an "RFP process" to achieve the fast-track construction of twelve solid waste transfer stations in the wake of a landfill emergency. The "RFP process" was actually a constellation of strategies based on a high degree of inter-agency collaboration but with no new State funding, which resulted in the selection of private sector companies to build and manage the new transfer stations. Although the circumstances and goals of the BPFI differ significantly from those of the TSI, the overall intent and many specific components of "RFP process" employed by the latter provide a useful template for creating a similarly successful program to meet another critical State need.

This Section outlines the primary general components of the BPFI. However, many of its key features, for example, the criteria for project selection, need to be based on publicly transparent processes of information gathering, qualifications vetting, and the writing of the Request for Proposals itself. The Biomass Work Group looks forward to public feedback on this proposal in November, at a forum planned by the BPU.

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[5] Neither mass burn incineration plants nor facilities designed to generate electricity from landfill gas with internal combustion engines – both of which are well established in the State – would be counted as eligible for support.

Rationale

The Biomass Work Group recommends the BPFI for six major reasons, as follows:

- ***The ineffectiveness of the "REC" system for incentivizing biomass-based energy enterprises*** The State's current approach to incentivizing biomass-to-energy industries, which involves the use of tradable Renewable Energy Certificates (RECs) to increase the revenues of renewable energy producers, is not working for the biomass industry. The value of RECs that apply to this industry is close to zero.

- ***The need for an approach based on the experience of commercial facilities*** Effective incentives for biomass-based production in New Jersey need to be based on a realistic understanding of marketplace opportunities and challenges. However, apart from power plants at landfills, no biomass-based enterprises exist in the State (although they operate successfully elsewhere North American and abroad). State-facilitated development and monitoring of biomass-to-energy enterprises would go a long way toward filling this gap.

- ***The already large role of the State and other public agencies in managing and regulating biomass resources*** In sharp contrast to renewable solar radiation and wind resources, New Jersey's renewable biomass resources – consisting almost entirely of urban and rural wastes and residues – involve a large role for State and other public entities as resource owners, managers, and regulators. If these resources are to be tapped effectively, it is essential that the State play an active role in facilitating the emergence of commercial biomass-to-energy enterprises.

- ***The potential financial benefits to the State in a time of austerity*** The State's active participation in the development of biomass-to-energy facilities could be financially productive. For example, biomass materials that could be sustainably harvested from or grown on some of the State's nearly two million acres of government-influenced land and water resources, could provide a revenue stream to help cover the costs of managing these resources. Or, to take another example, the State in its role as an owner of fleets and purchaser of fuel, could shift public fleets to natural gas technology in support of the EMP's "clean fuels" goals and also introduce RNG vehicle fuel made from indigenous wastes for fuel cost savings.

- ***The need to reward outcomes and results across many feedstocks and technologies*** Biomass-to-energy facilities come in many varieties and produce different outcomes. Incentives need to reward results such as energy efficiency and greenhouse gas reduction, not whole classes of technologies or feedstocks. The BFPI could help define the outcomes that biomass-to-energy incentives should reward.

- ***Limited funding*** Budget deficits at all levels of government in New Jersey and in the U.S. as a whole render it highly unlikely that significant new public funds will be committed to biomass-to-energy projects in the short term. Under the proposed BPFI, the State would make better use of existing resources to take the necessary next steps toward developing effective incentives for the biomass-to-energy industry.

Objectives

The objectives of the BPFI range from making a near-term contribution to the State's supply of renewable electricity and fuels to establishing a sound basis of public knowledge for putting in place effective incentives to stimulate the longer term growth of the State's biomass-to-energy industry. The primary three objectives are these:

- ***Objective 1. Produce a specified quantity of biomass-based renewable energy (power/fuels) beginning in the short term*** To begin at once to help achieve the State's energy, economic, and environmental goals as laid out in the 2011 Draft Energy Master Plan, and to begin to overcome the State's deficit in the production of renewable energy from biomass feedstocks, the emphasis of the BPFI is on the construction within two or three years' time of viable marketplace facilities.

- ***Objective 2. Showcase diverse biomass technologies and business models operating under real-world conditions*** Facilities participating in the BPFI would be selected, as a group, to exhibit diverse technologies, host sites, cost, financing, feedstocks, products, and markets – both to demonstrate different types of commercial opportunities and as a crucial foundation for establishing incentives to spur the emergence and growth of the biomass-to-power & fuels industry.

- ***Objective 3. Identify incentives needed to stimulate the ongoing development of renewable biomass energy resources*** Facilities participating in the BPFI, by virtue of the State's help with various regulatory, financial, and other aspects of their development, would be the source of valuable information related to the type of incentives needed to expand the biomass-to-energy industry over time. Regarding power generation, such incentives might include the creation of a special "bio-REC" modeled after the State's special solar and offshore wind RECs. Regarding vehicle fuels, incentives could be crafted for inclusion in the framework of the low-carbon fuels rule currently being developed by the Northeast States for Coordinated Air Use Management (NESCAUM), in which New Jersey is a participant. Another type of approach would be to create "Biomass Energy Zones" through the use of siting and tax incentives.

Implementation: An "RFP Process"

The implementation of the BPFI would be built around a State-run "Request for Proposals" process, through which State agencies would collaborate to identify and target resources for projects meeting criteria established for the *Initiative*. This process would require high-level political support, innovation across agency programs, regulatory reform, effective and creative use of existing State and Federal economic incentive programs, the commitment of state resources, effective methods of informing the public about the *Initiative* and how to participate in it, and a monitored "fast-track" schedule to ensure that facilities receiving State support are constructed and put into operation quickly.

The agencies that would necessarily be involved would include, at a minimum: the Board of Public Utilities, the Department of Environmental Protection, the Department of Agriculture,

the Economic Development Administration, the Treasury, the Attorney General's Office, and the Governor's Office (from an overarching policy perspective).
Other State agencies that might play more limited but strategic roles include the Departments of Transportation, Community Affairs, and Labor and Workforce Development, as well as "in-but-not-of" State Authorities such as the New Jersey Meadowlands Commission.

The State's universities and colleges would provide valuable expertise and input. They could even play a direct role as project partners in their capacities, for example, as food waste generators or as purchasers of power and vehicle fuel.

Selection criteria for deciding among project bidders would need to be established across a range of practical categories such as number of facilities to be developed, appropriate (or specified) host sites, scale of operations, eligible technologies and feedstocks, geographic distribution of plants, energy products to be developed, and end-user markets. Weighted "outcome" criteria would also be needed to evaluate and compare prospective benefits of the proposed projects across various economic, energy, job, and environmental areas. The feasibility of providing project-specific State resources and the acceptability of a proposed project at the community level would also be crucial considerations in selecting projects for participation in this *Initiative*.

Information and insight necessary for establishing effective and fair selection criteria would need to be provided by private companies and public agencies likely to be bidding on projects; technology experts and potential host sites; community and State-level leaders; environmentalists and economists; trade associations and other stakeholder groups; and others. A "Request for Information" process would be instituted for this purpose as a prelude to drafting the RFP.

An up-front commitment of State staff and other resources (but not involving new taxes or financial commitments) would be essential to justify the time and effort needed by project developers to prepare their bids. (Gaining consensus on what these staff and other resources would consist of would require strong cross-agency and intra-agency cooperation and skilled leadership of the *Initiative* overall.) The types of resources that could be allocated to this program would include:

- Resources already available under existing State and Federal programs, for example, the following:
  - Direct financial support for renewable energy projects available through the Board of Public Utilities and the Economic Development Administration
  - State help in securing Federal renewable energy grants
  - Edison Innovation Clean Energy Manufacturing Fund (CEMF)
  - Business Employment Incentive Program (BEIP)
  - Business Retention and Relocation Assistance Grants (BRRAG)
  - State Recycling Enhancement Fund

- The creative participation of state agencies as actual project partners in their roles, for example, as property owners and as markets for power and fuel products.

- Regulatory reform and the speedy completion of regulatory review, without in any way compromising environmental standards or requirements.

Technology verification to ensure appropriate vetting of technologies new to the State of New Jersey, and protocols for rigorous environmental testing and the collection of energy efficiency performance criteria would need to be established concurrently with regulatory review of permit applications from responsible bidders for their projects.

The State's commitment to monitor and enforce a "fast track" schedule would be necessary to ensure the timely construction of facilities proposed by project developers. A good model of success is the "One Stop" program for environmental permitting that has been established under Governor Christie at the Department of Environmental Protection.

The RFP process would be carried out at the exclusive direction of the State, including final decisions on selection criteria, number of facilities to be supported, technologies employed, time frames, etc. The entire process would be "open and competitive" to ensure compliance with New Jersey's rigorous procurement laws and regulations, which are monitored by the Department of Treasury.

3. *NEW JERSEY'S BIOMASS RESOURCES FOR PRODUCING POWER AND FUELS*

Background drawn from the N.J. Biomass Assessment on the State's rural and urban biomass feedstocks and technologies for converting them to power and fuel

The 2007 *Assessment of Biomass Energy Potential in New Jersey* ("N.J. Biomass Assessment") estimated that the State generates 8.2 million dry tons (MDT) of biomass annually. Of this amount, 5.5 MDT was estimated to be sustainable and available to produce up to 1,124 MW of electric power or 311 million gallons of gasoline equivalent. These energy quantities equal about 9% of the State's electricity consumption or (alternatively) about 5% of its highway fuel consumption.

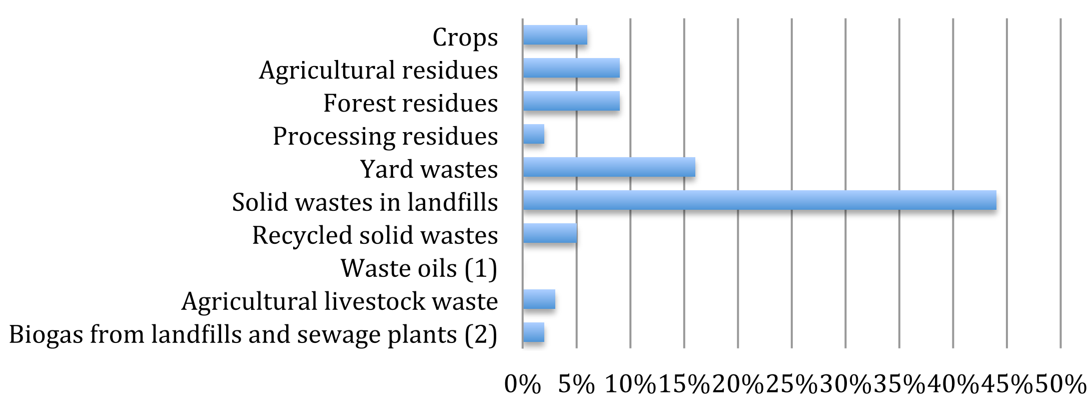
Chart 1 shows the quantities of sustainable biomass resources estimated by the N.J. Biomass Assessment to be available by 2010, as measured in MDTs. The preponderance of biomass materials surveyed falls into the categories of "residues" or "wastes". (Biogas emitted at landfills is considered to be "waste methane".)

However, a measure of available tonnage does not fully define the "energy value" of a particular biomass feedstock. This value also depends on a) the energy content per ton (typically measured in British thermal units, or BTUs); and b) the technology used to convert the organic material to electricity, heat, and/or liquid or gaseous fuels.

Chart 1

Composition of 5.5 Million Dry Tons (MDT) of Sustainable and Available Biomass Resources in New Jersey

2010 Estimates



1. The N.J. Biomass Assessment estimates that 20,638 MDT of waste oils and grease are available in 2010, only 0.4% of total available and sustainable biomass tonnage. However, this category of waste (often called "FOG" for "fats, oils, and grease") has the highest energy density of any feedstock in the Assessment and is a prized "substrate" for addition to other wastes in an anaerobic digester, for example livestock manures, to boost biogas yield.
2. Biogas produced from the anaerobic digestion of organics in landfills or from the digestion of sludges in digesters is already an "energy product," in that it can be used with minimal cleanup for producing electricity, and with more intensive cleanup as a substitute for conventional natural gas, include use as vehicle fuel.

A number of technologies can be used to convert New Jersey's biomass resources to power and fuels. Several of these – especially anaerobic digestion, gasification, and pyrolysis – come in many variations and can be used on multiple feedstocks to make an array of energy products. To further complicate the picture, each combination of technology variant and feedstock (or feedstock mix) differs from others in such features as cost, energy efficiency, greenhouse gas emissions, other environmental impacts, job creation, and additional features.

The N.J. Biomass Assessment identified the following technologies (listed below according to the energy products they are designed to yield) as either commercially available today, or as "near commercial," for converting the State's biomass resources to power and fuel.

Electric Power, Heat, and Vehicle Fuels

- ***Anaerobic digestion***: the breakdown of organic materials by microbes in oxygen-less environments to produce biogas that can be burned directly to generate electricity or upgraded for use in heating, power generation, and as a vehicle fuel.
- ***Gasification*** the reduction of organic materials to gases at high temperatures (>700°C), without combustion but with a controlled amount of oxygen and/or steam. The gases can be used to produce either electricity or liquid or gaseous vehicle fuels.
- ***Pyrolysis***: the thermal decomposition of organic material at relatively low elevated temperatures (>430°C), in the absence of oxygen, to form three products: combustible gases (e.g., hydrogen, carbon monoxide, carbon dioxide, methane); bio-oil, from which biofuels can be produced; and carbon or "char."

Electric Power and Heat

- ***Direct combustion***: the burning of biomass, typically to produce steam that runs turbines and generates electricity. The "recycling" of heat generated during this process increases overall energy efficiency.

Ethanol Fuel

- ***Cellulosic ethanol****:* the hydrolysis of fibrous biomass (e.g., wood) using acids and/or enzymes to free various sugar molecules followed by a fermentation process to produce ethanol.
- ***Dilute acid hydrolysis:*** a process of subjecting wet fibrous biomass to dilute acids to yield levulinic and formic acids which serve as platform chemicals to replace petroleum-base chemicals.

Biodiesel Fuel

- ***Transesterification***: a process that involves reacting vegetable oils and animal fats with alcohols to produce a diesel equivalent.

Charts 2 and 3, on page 10, portray two somewhat overlapping biomass-based energy production scenarios that are compiled from data easily available in the Bioenergy Calculator of the N.J. Biomass Assessment (***http://njaes.rutgers.edu/bioenergy***). One of these scenarios is based on anaerobic digestion technology and the other on gasification technology. Each scenario assumes the conversion to energy of all feedstocks identified as available in 2010 that are suitable for use with the specified technology. The charts suggest and illustrate (<u>but don't begin to define precisely, much less exhaust</u>) the different results that ensue from the use of alternative biomass feedstocks and conversion technologies – which is exactly what the State of New Jersey needs to focus on when developing incentives for producing renewable energy from biomass.

Feedstocks for "anaerobic digestion" are primarily landfill gas, food waste, and animal manures; those for "gasification" are primarily solid wastes (currently landfilled), crop and forest residues, and yard wastes. Total feedstocks available for "anaerobic digestion" (including already "digested" biogas) weigh 0.9 MDT; those for gasification weigh 4.5 MDT, or five times as much, from which eight times more electricity and three times more fuel could be produced.

Chart 2. **Anaerobic Digestion**[6]

Using 0.9 MDT of New Jersey biomass feedstocks suitable for conversion to energy through anaerobic digestion, up to 1.1 megawatt hours of electricity or up to 77.9 million gasoline gallon equivalents could be produced yearly (*2010 estimate*).

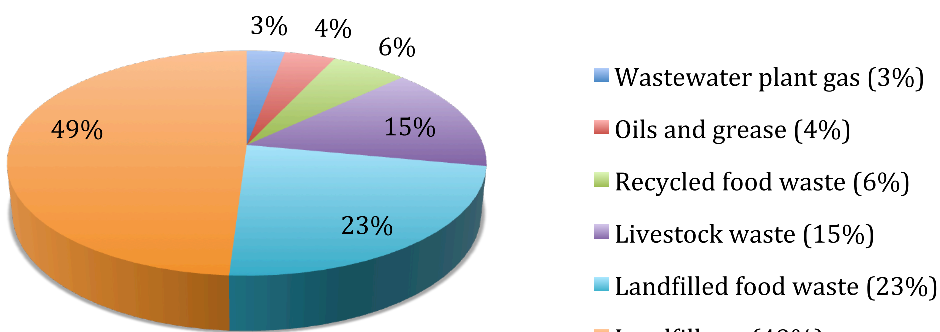
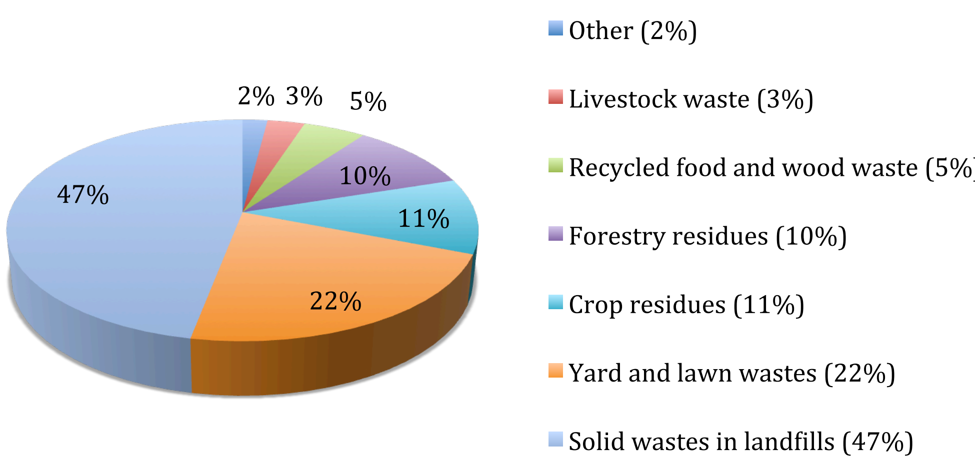


Chart 3. **Gasification**

Using 4.5 MDTs of New Jersey biomass feedstocks suitable for conversion to energy through gasification, up to 7.7 megawatt hours of electricity or up to 210.6 million gasoline gallon equivalents could be produced yearly *(2010 estimate)*.



[6] *Source of data for both Charts:* ***http://njaes.rutgers.edu/bioenergy***,

4. AGRICULTURAL AND OTHER RURAL BIOMASS RESOURCES

Response to Questions 1 & 2. *What role can agriculturally derived fuels products play in the development of new fuel sources in N.J.? Are there any regulatory or legislative barriers to the development of this fuel source?*

The Biomass Work Group (BWG) interpreted this question, based on the N.J. Biomass Assessment, to refer to a) all harvested farm crops and crop residues; b) all livestock manures; c) forestry residues; and d) processing residues (e.g., sawdust). After reviewing all of the potential biomass resources listed by the Assessment in each of these categories, the BWG found that only those shown in *Table 1* are available in significant tonnages for conversion to renewable power and fuels. Detailed findings are described on pages 12 to 14.

Table 1.

AGRICULTURAL & OTHER RURAL FEEDSTOCKS	**NET USABLE DRY TONS 2007**	**% OF TOTAL**
Crop Residues (1)	**214,719**	**23%**
Corn stalks and cobs	*95,010*	
Wheat straw	*42,758*	
Rye straw	*38,087*	
Low grade hay (2)	*38,864*	
Livestock Manures (3)	**167,704**	**18%**
Forestry Residues (4)	**469,050**	**49%**
Processing Residues	**97,193**	**9%**
TOTAL	**948,666**	**99%** (5)

(1) After subtracting the 30% of the gross corn residue that is left on the land for soil and water conservation.
(2) Low grade hay is 30% of the "other hay" listed in the N.J. Biomass Assessment. It is that portion assumed to be undesirable as livestock feed each year because of weather or pest damage.
(3) Some of the manure may contain rye and wheat straw or other residues used as bedding, which would reduce the "Total" for all residues.
(4) Assumes 0.5 dry tons per acre per year on 25% of the State's forested land (instead of on 50% of forested land, as assumed in the N.J. Biomass Assessment).
(5) Due to rounding error.

Recommendations

1. Crop residues and animal wastes are valuable to farmers for land application to preserve the organic content and fertility of soils. Some of these materials also have external markets that are more profitable than those for biomass feedstocks. The BWG recommends that a study be conducted to determine the degree to which these alternative values limit the availability of farm residues and animal wastes as biomass-to-energy feedstocks.

2. The BWG also recommends that a study be carried out to identify special incentives and business models that show promise of attracting farmers and agricultural materials into biomass-to-energy projects. For example, cooperative structures could be explored as a means of compensating farmers for providing feedstocks with in-kind payments in the form of energy products such as electricity or vehicle fuel and/or biomass processing residues (after energy extraction) for use in replenishing soil nutrients and organic content.

3. A significant proportion of the nearly two million acres of State-owned or State-influenced land and water resources are lightly managed at present and are potentially available for more productive use. In some cases the State must pay for the maintenance of these lands. Some of these sites could be used for harvesting grasses and weeds and cultivating energy crops. The BWG recommends that a detailed assessment be performed to determine the availability of such lands, their site characteristics, and the environmental impact of using them for biomass production.

4. The State may have an attractive opportunity, at minimal cost, to bring experienced farmers onto lightly managed lands found to be appropriate for agriculture. The BWG recommends that a study be undertaken to determine what "rules of the game" would be appropriate for enabling farmers to gain access to these lands for agricultural use and what the financial gains for farmers and the State could be.

5. A study is needed to assess the energy potential of sustainable forest residues on both public and private lands to develop incentives for making better use of these biomass resources. The BWG recommends that such a study be carried out with the assistance of professional foresters.

Findings

Limitations on farm-grown energy crops Starch- and sugar-based energy crops and soybeans are feedstocks for ethanol and biodiesel respectively. Together these crops constitute 15% of the State's total "agricultural" biomass identified by the N.J. Biomass Assessment. Yet they are not shown on *Table 1* because the BWG judges their future role to be small. The State's farmland is shrinking and large contiguous acreages are being broken up to make way for suburban development. Remaining farmland is more profitable if used to raise fruit, vegetable, and nursery crops having higher market values than energy crops.

Alternative values of crop residues and animal wastes Crop residues and livestock manures are the primary farm-based feedstocks available in sufficient quantities for energy production. But these materials also have economic value if they remain on farmland, where they supply nutrients and organic matter to enhance soil productivity and conserve soil and water. If these wastes are completely removed from the land, farmers must spend as much as $15 to $40 per acre to replace them with chemical fertilizers and/or other materials.

In addition, some crop residues, even though they could remain on the land, can also be sold at higher prices than those farmers would receive by selling them as energy feedstocks. For example, rye straw is highly valued as horse bedding in the State's equestrian and racetrack sectors.

The need for special incentives to bring crop residues and animal wastes into the biomass-to-energy production system Typically, the discussion of incentives needed to produce energy from wastes rests on the assumption that waste generators will pay to get rid of these materials. This is certainly true for the disposal of mixed solid wastes: landfill tipping fees are very high in New Jersey. It also is true for the processing of sewage and other materials sent through wastewater treatment systems. But it is not true for farm-based biomass.

Farmers usually have no motive to pay "tipping fees" to get rid of residues and wastes which they can either use productively or otherwise accommodate on their land. (An exception can be horse farmers whose small acreages cannot beneficially utilize or safely sequester all the manures produced.) Yet such tipping fees are typically a major source of revenue for developers of commercial anaerobic digestion facilities. Alternative business models are needed that both make agricultural feedstocks economically available to biomass facilities and pay farmers for residues and wastes they move into energy production.

In-kind benefits, such as those typical of cooperative ownership structures, are one avenue to explore. In a cooperatively managed biomass-to-energy plant, farmers who provide feedstocks would receive payment in the form of power or fuel; and/or in the form of liquids and "digestate" that remain behind after energy processing and can be used as fertilizers and soil enhancement materials. The value of such by-products for land application depends on the technology employed: *anaerobic digestion* leaves behind a digestate having significant nutrient and organic content; *direct combustion* leaves behind an ash that is high in potassium but devoid of organic matter; some *gasification* and/or *pyrolysis processes* are reported to leave behind a "bio-char" having beneficial land application value, but more research is needed to specify the benefits.

Until these economic challenges are resolved, strong participation of the farm sector in building the State's biomass-to-energy capability is likely to be minimal. Whether the solution involves cooperatives or other innovative structures, the high costs of waste transport and the intermingling of farms and suburbs across the State indicate that the resulting energy production facilities would need to draw on local feedstocks and would need to process agricultural residues along with wastes from urban sources.

Public lands as biomass production and harvesting sites where farmers could gain for themselves and provide the State significant financial benefits In New Jersey, the State owns, manages, or influences activities on nearly two million acres of land and water resources, more than three times the extent of the land and water areas comprised by the State's farms. These vast properties could become major sites for the cultivation and harvesting of biomass feedstocks. If only 10% of these acres were used productively, they could yield 300,000 dry tons of biomass, equal to close to one-third of the total tonnage of feedstocks listed in *Table 1*. Among the areas included in this estimate are wetlands, where invasive plant species like phragmities spread profusely. Under appropriate conditions, such plants could be harvested as feedstocks for making power and fuels. (In the future, the State could perhaps also use some wetland areas for the cultivation of algae and duckweed to make "third generation" fuels, ones for which the conversion technologies are still in early research stages today).

To harvest weeds and grasses from open and underutilized state-influenced lands or to plant energy crops on them, or both, the State could look to farmers. New Jersey could explore a system whereby experienced farmers could manage suitably identified open lands for reduced or no rent, and could receive a part of a biomass harvest as a takeaway. This system could afford multiple benefits: The State could ensure a predictable supply of high-quality biomass feedstocks. The total land devoted to agriculture across the state could increase. Farmers, seeking land could gain access to additional acres and increase their income. All of these benefits could be realized without requiring significant State funding.

Forestry residues equal to crop residues Residues removed from state-owned forests as part of a program of sustainable forest management could provide more usable dry tonnage of biomass than crop residues and livestock manures combined.

***Response to Question 2*:** Are there any regulatory or legislative barriers to the development of this fuel source?

The BWG could not answer this question fully in the absence of details about the technologies, sites, and other factors involved in developing particular fuel sources. The time allotted for preparing this report did not allow for an investigation of alternative scenarios.

Yet, some likely barriers to the development of agricultural and other rural biomass resources fall into three categories: *transportation-related* barriers linked to waste hauling permits and truckload size; *land use* restrictions affecting, for example, farm rental agreements for State-managed lands, and the land application of bioenergy processing residues; and *environmental regulation barriers* such as waste determinations that affect the handling of biomass materials; air-quality standards that may not be appropriately designed for biomass-to-energy facilities; and wetlands management rules that could inhibit the harvesting of invasive species.

Economic studies of agricultural and other rural biomass feedstocks, as recommended by the BWG on pages 11 and 12, would provide crucial information for identifying legislative and regulatory barriers more systematically. The development of biomass-to-power & fuels facilities using farm residues and wastes – under a *Biomass Power and Fuels Initiative* – would be even more helpful in demonstrating, as part of the State's facilitation role, why particular obstacles need to be removed and what the economic impact of doing so would likely be.

5. *URBAN BIOMASS RESOURCES*

Response to Question 5*: What other biomass opportunities exist in N.J.?*

The Biomass Work Group interpreted this category of wastes to mean those shown on *Table 2*, compiled from data provided in the N.J. Biomass Assessment. This huge agglomeration of materials consists principally of landfilled solid wastes, yard wastes, food wastes, and biogas gas emissions from landfills.

Table 2.

"Non-Agricultural" Biomass Feedstocks	**Net Usable Dry Tons 2010**	**% of Total**
Yard Waste	**904,712**	**23%**
Brush/Tree Parts	*278,765*	
Grass Cuttings	*49,003*	
Leaves	*289,354*	
Stumps	*287,590*	
Solid Waste - Landfilled	**2,398,998**	**61%**
MSW net of waste paper & food	*575,701*	
Waste paper	*1,111,156*	
Food waste	*227,440*	
Construction & demolition	*484,701*	
Recycled Materials	**276,857**	**7%**
Food waste	*59,702*	
Wood scraps	*60,945*	
Magazines, junk mail, etc. (1)	*156,210*	
Waste Oils	**20,638**	**>1%**
Used cooking oil	*16,653*	
Grease trap oil	*3,985*	
Waste Biogas Emissions (2)	**349,193**	**9%**
Wastewater treatment plants	*21,987*	
Landfills	*327,206*	
TOTAL	**3,950,398**	**100%**

1. This is one of several recycled-paper categories included in the N.J. Biomass Assessment. The other categories – mixed office paper, newspapers, and corrugated paper – have availability for energy production estimated at zero. The same is true for recycled wood chips.

2. This is a measure of dry tons of raw biogas, which is about 50% methane when it is emitted from landfills and about 60% methane when emitted from digesters of wastewater sludges.

Recommendations

1. New Jersey is not only the most densely populated state in the country, but an intensely food-dense state—and food waste-dense state. Yet current food waste data are incomplete. This is a concern because of the importance of this feedstock for boosting biogas yields when "co-digested" with livestock manures and wastewater sludges. The Department of Environmental Protection has designed a food waste study and the BWG recommends that it be expedited.

2. Industrial organic wastes – non-hazardous dry, semi-liquid, and liquid wastes – are potentially a major source of biomass feedstocks for energy production. The BWG recommends that a study of these wastes be undertaken and their power and fuel potential assessed.

Findings

Landfills as solid waste destinations and biogas sources As shown in *Table 2*, landfills are the destination of vast amounts of waste. And more than half of landfilled wastes are organic materials, largely waste paper and food waste.

Yet, precisely because of the high concentration of organics they sequester, landfills are also the source of the State's largest feedstock (biogas) related to making power and fuel through anaerobic digestion (*see Chart 2 on page 10*). Indeed, landfills are already giant digesters: They lock up organic materials (as part of the mixed waste stream) in airless chambers where natural processes of decay occur and produce biogas. By law, landfill gas (about 50% methane and 40% carbon dioxide) must be collected and used or destroyed by flaring to prevent the escape of methane, a powerful greenhouse gas, into the atmosphere.

In the future, if significant amounts of organic materials are diverted from landfills, as the State of New Jersey is committed to doing but making slow progress in achieving, the distribution and locations of key biomass feedstocks will be dramatically altered, as will a host of factors related to options for making renewable energy from wastes. In this complex and potentially high-stakes environment, the solid waste managerial districts with operating landfills may find opportunities to play a leadership role for achieving a transition to a more efficient and profitable system than traditional landfilling. Their options could include, for example, the co-location of stand-alone anaerobic digestion facilities at landfill sites. These digesters could process segregated organics by making use of stranded waste heat from gas-to-electricity plants – which are in operation at ten of the State's operating landfills. (Middlesex County Utilities Authority is the only solid waste district that currently utilizes waste heat from a landfill gas-to-electricity plant, but for another purpose.)

Incomplete data for developing food waste estimates This category of biomass feedstocks is an important source of energy-yield increasing "substrates" for co-digestion with animal manures, wastewater sludges, and other materials. However, data needed for planning the careful management of food wastes is not available. Historically, data on amounts of food waste generated in New Jersey have been based on estimates from the U.S. Environmental Protection Agency (EPA). The most recent such EPA estimates, which the N.J. Department of Environmental Protection no longer uses, date from the 1990s and indicate that, nationally speaking, food waste constitutes 7.4% of the total solid waste stream (excluding agricultural residues, manures, and biosolids). With respect to food that is "recycled" in New Jersey, 565 municipalities report these tonnages, and there are known problems of both double reporting and under-reporting, as well as under-staffing of the reporting function.

Alternative definitions for resource "availability" of landfill and wastewater treatment biogas Among all the sources of biogas-based energy, landfill gas is widely recognized as the "low-hanging fruit". It costs less to build a power plant and/or high-grade fuel plant using "free" landfill gas than it does to first build an in-vessel digester to make biogas and then, in addition, build a power plant and/or biogas upgrading facility. Thus how much landfill gas is available in New Jersey is a pivotal question and one, as it turns out, that has more than one good answer.

The N.J. Biomass Assessment defines as "available" only the landfill gas that is currently being flared. This is, indeed, the gas that is most readily available. However, other sources could also be counted as available under alternative scenarios for the near future

- Landfill gas gas that is now used to make electricity, at 35% efficiency, could be considered at least partly available. By adding heat recovery systems to landfill-based power plants, 70 to 80% efficiencies could be achieved. Higher recovery rates would be possible if the biogas were converted to RNG vehicle fuel or pipeline gas.
- The potential biogas yield of the 2.6 million tons of solid waste shipped yearly to out-of-state landfills could also be counted as an available resource for New Jersey. At present, the value of this resource as an energy feedstock accrues to out-of-state landfill gas developers, who reap returns from materials that New Jersey counties pay a lot of money to throw away. Contractual arrangements for "payback" to New Jersey counties from landfills receiving "energy-rich" wastes could be explored.
- Uncaptured methane emissions from landfills could also be tallied and taken seriously. These emissions, if curtailed, could both reduce the global-warming impact of landfills and become an important source of energy and revenue. Tighter landfill management practices could achieve these results.

Regarding wastewater treatment plants, the situation is analogous, although the relevant facts are very different. The N.J. Biomass Assessment estimates that the biogas already being produced by New Jersey wastewater plants equipped with digesters (primarily to reduce odors and biosolid volumes) is less than 7% of that produced at landfills. Yet, if the goal of managing sewage sludges for energy production were embraced, and even if only 35% of the State's sewage sludges were digested – along with limited food waste quantities – the biogas yield could be ten to twenty times higher, or more.

Broad dispersion and destinations of yard waste feedstocks Various categories of yard waste (grass clippings, leaves, and woody materials) add up to nearly 20% of the State's currently sustainable and available biomass resources. Managing this waste is the responsibility of New Jersey's communities. Leaves, banned from New Jersey landfills decades ago, go to municipal compost piles. Grass clippings often end up at landfills. Brush and tree parts and stumps are generally ground up and used as mulch. Unlike agricultural crops, yard wastes have no competitive "alternative" economic values. Using them as biomass feedstocks makes economic, energy, and environmental sense, but means and incentives to achieve this goal need to be developed.

6. *WASTE-TO-ENERGY "REC" DESIGNATION*

Does the Biomass Work Group support pursuing changing the classification of waste-to-energy from a Class 2 to a Class 1 resource? If so, do you have specific recommendations regarding how this should be done?

Recommendation

Based on a consideration of the economics of conventional RECs and of recent Legislative history, the Biomass Work Group finds that an effort to modify the waste-to-energy REC definition would be ill advised and does not recommend it.

Findings

Class 1 and Class 2 – A Distinction Without a Difference The 2011 Draft Energy Master Plan (EMP) describes the steep decline of REC markets: *"Since 2009 . . . the price for Class 1 RECs has fallen dramatically, recently converging on the price of Class 2 RECs for the current vintage. This trend is consistent with REC markets elsewhere in the U.S., primarily reflecting the increasing supply of renewable energy, and to a lesser extent, renewable technology progress and the decline in load growth"*.[7] Additional factors contributing to the bottoming out of the REC markets include the anticipated creation of a special "OREC" for offshore wind development in New Jersey (which would attract investors toward this renewable energy sector) and the low prices for conventional natural gas and energy. Thus, the BWG concludes that a Class 1 definition for waste-to-energy would not stimulate the growth of this sector.

REC Policy "Exhaustion" In 2010 the New Jersey Legislature extensively debated broadening the definition of Class 1 renewable energy in the context of A. 2529 (as proposed by Assemblyman Chivikula on March 18) and S. 2306 (as proposed by Senator Van Drew on September 23). Early versions of these bills contained substantive amendments that would significantly have broadened the Class 1 definition. However, both A. 2529 and S. 2306 retained a Class 2 definition for waste-to-energy technologies. The Legislature subsequently passed A. 2529 retaining this definition. Although Governor Christie vetoed A. 2529 on grounds unrelated to RECs, there is no reason to believe that the Legislature is likely any time soon to reconsider Class 1 and Class 2 definitions, and it appears that there is a clear policy position to retain waste-to-energy as a Class 2 resource.

***Biomass Renewable Energy Certificates*:** Notwithstanding the current ineffectiveness of RECs as incentives for biomass-to-energy facilities, the Biomass Work Group (BWG) recommends that a market-based approach to incentives be further explored in the future. It is possible that it will prove effective to create a "Bio-REC" patterned after the SREC and OREC "carve-out" programs, whereby New Jersey electricity suppliers, by buying tradable certificates, must demonstrate that a percentage of their power comes from specific in-state renewable energy sources.

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[7] 2011 Draft Energy Master Plan, pages 99-101.

7. RENEWABLE NATURAL GAS (RNG) VEHICLE FUEL

New Jersey's leading edge in advanced technologies for producing RNG vehicle fuel from biogas, the compelling rationale for using RNG to displace diesel in trucks and buses, the economic benefits of building an RNG industry based on converting biogas to power and fuels, and hurdles to surmount

The 31-member Renewable Natural Gas Work Group ("RNG Work Group") was formed in December 2010 by Energy Vision (www.energy-vision.org) and Rutgers University EcoComplex (http://ecocomplex.rutgers.edu) as a voluntary, multi-sector technical group having two broad goals: 1) to identify realistic pathways for developing a statewide waste-based RNG fuel industry at multiple existing biogas production locations – including landfills, wastewater plants, and livestock or horse farms; and also at many other sites of organic waste generation, aggregation, recycling, and recovery where "free-standing" or "co-located" anaerobic digesters could produce biogas in the future; and 2) to conduct outreach activities to engage policy makers in supporting incentives for building this new industry and to assist prospective partners in launching facilities.

In July 2011, the President and staff of the New Jersey Board of Public Utilities asked the RNG Work Group to form the Biomass Work Group to assist the State's Energy Master Plan (EMP) effort and provide input on the Draft EMP. Previous sections of this report contain that input. The BPU also invited the RNG Work Group to submit additional perspectives based on its original mission, which are briefly outlined in this section. A full account of the findings and specific recommendations of the RNG Work Group will be published separately.

New Jersey's Leading Edge in Producing Advanced Biogas Cleanup Technologies for National and World Markets

Biogas cleanup technologies – gas-separation techniques for extracting nearly pure methane from raw biogas produced at landfills or in digesters – are at the cutting edge of the emerging RNG fuel industry in the U.S. and in the world. New Jersey has had a deeper involvement with this industry than any other state in the U.S. and boasts a greater concentration of companies that are world leaders.

New Jersey was the first state in the U.S. to demonstrate the production of RNG vehicle fuel from raw biogas. This occurred in 2004-2005 when Rutgers University EcoComplex and the Burlington County Landfill partnered with Acrion Technologies, Mack Trucks, Air Products & Chemicals, Chart Industries, and Waste Management Inc. to convert landfill gas to a high-grade, very clean-burning liquid fuel and to test this fuel in heavy-duty vehicles. Due to the success of this demonstration, Acrion's "CO2 WASH" technology is now licensed by AB Volvo and destined for use in a large RNG production plant in Sweden that is expected to be operational by 2013. The same technology is being used on a much smaller scale at the SWACO Landfill near Columbus, Ohio, to produce compressed RNG vehicle fuel.

Companies located in New Jersey that are world leaders in technologies required for upgrading biogas to make RNG fuel and pipeline quality gas include the following:

- Linde N.A, a German-owned company with 900 employees and headquarters in Murray Hill, is a joint-venture partner with Waste Management Inc. (WM) in the world's largest liquefied RNG plant, located at WM's Altamont Landfill in California.
- Linde is also a partner with the Rutgers EcoComplex, Acrion, and Fuel Cell Energy in a feasibility study involving the use of biogas from the Burlington County Landfill to produce several energy products including heat and electricity for the EcoComplex, RNG fuel for refuse and recycling trucks, and hydrogen.
- The Engelhard Corporation (now BASF) of Iselin, another large New Jersey-based firm, pioneered the Molecular Gate Technology for removing nitrogen and carbon dioxide from landfill biogas as a crucial step for making vehicle fuel and pipeline quality gas. This technology, licensed by Guild Associates, also of New Jersey, is used at multiple sites internationally, including a large landfill in Brazil.
- Adsorptech of Middlesex has recently developed a state-of-the-art "vacuum-pressure swing adsorption" (VPSA) technology to upgrade biogas to nearly pure methane in a single procedural step. Some of the developmental work for this technology was carried out at the Rutgers EcoComplex.
- Kryos Energy of Metuchen developed the Kryosol biogas cleanup technology that utilizes refrigerated methanol to wash contaminants from biogas.

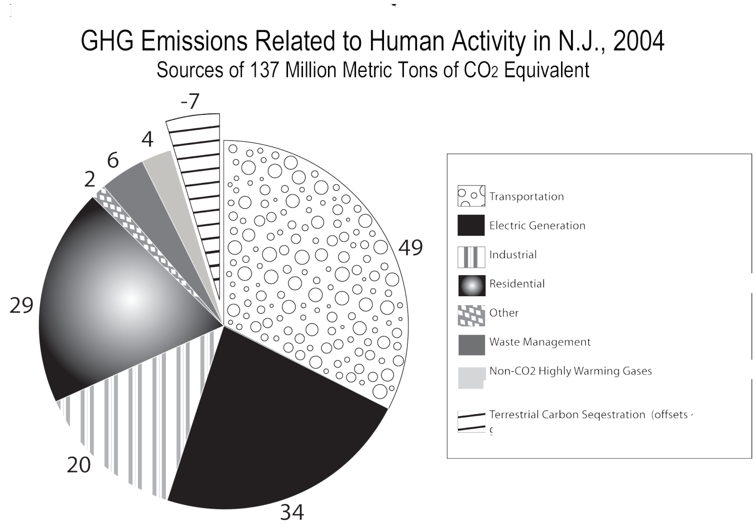
New Jersey has a unique opportunity to build on the presence of these companies to launch an indigenous RNG fuel industry, accelerate the pace of biogas-related research and development at State university labs and elsewhere, and stimulate the export of high-tech products and services to other states and to foreign markets. These measures would boost economic growth, attract new talent to the State's firms and communities, and create jobs across a wide range of sectors.

Compelling Reasons to Support the Development and Use of RNG as a Vehicle Fuel

The RNG Work Group has identified RNG vehicle fuel made from wastes as a precious sustainable fuel resource that deserves priority policy support for seven reasons:

- ***RNG along with conventional natural gas, with which it is interchangeable, can achieve oil independence for the most oil-dependent energy sector in New Jersey*** The transportation sector is the primary reason for the dependence of New Jersey on oil imports. Nearly 100% of road vehicles in the State use either gasoline or diesel. By contrast, less than 1% of the State's electrical power generation depends on oil.
- ***RNG is a sustainable fuel solution for medium- and heavy-duty vehicles*** **A** shift to RNG vehicle fuel – the logical goal of a path toward sustainability for trucks and buses that begins with a shift to conventional natural gas – is the only sustainable fuel solution available with today's technology for medium and heavy duty vehicles.

- ***RNG vehicle fuel made from waste-based biogas could potentially displace between 10% and 25% of highway diesel consumption in New Jersey*** *Using* readily available feedstocks (e.g., flared biogas at landfills), New Jersey could produce up to 70 million diesel gallon equivalents per year (approximately 10% of current diesel fuel consumption), according to the N.J. Biomass Assessment. Preliminary findings of the RNG Work Group indicate that this potential could rise over the next decade or so to as high as 25% if current management strategies for mixed solid waste (MSW) and wastewater were reconfigured to handle wastes, not as throwaways but as commodities. The advent of thermal gasification technologies for converting woody feedstocks to RNG could raise this potential much higher.
- ***No new scientific or technical breakthroughs are needed in engines or infrastructure Natural*** gas engines capable of hauling the heaviest loads are now available from North American companies and can use RNG seamlessly, alone or blended with conventional natural gas. RNG can be dispensed through the same fueling stations, transported in the same tankers, compressed or liquefied with the same technology, shipped through the same pipelines, and stored in the same structures as conventional natural gas.
- ***RNG vehicle fuel has a higher market value than other energy products made from landfill or digester biogas*** In New Jersey, the market value of RNG vehicle fuel (assuming, very conservatively, a pump price of $2.50 per diesel gallon equivalent) is $18.50 per "decatherm" (one million BTUs), compared to the delivered price for pipeline gas of $8.00 to $10 per decatherm, and the price paid for electricity sold into the grid of approximately $5.50 per decatherm.
- **RNG is the lowest of low-carbon fuels in the world today and therefore of utmost value in reducing greenhouse gas emissions from transportation** The transportation sector is the largest contributor to anthropogenic (human-related) greenhouse gas emissions in New Jersey, accounting for 49 million metric tons (MMTs) of CO_2 equivalent in 2004, approximately 35% of the net emissions. Diesel trucks and buses accounted for close to 9 MMTs – and this could be carved back to near zero (pending the availability of supplies) by a shift to RNG vehicle fuel. The use of conventional natural gas would achieve a smaller but still significant reduction of 20% to 30% of greenhouse gas emissions, compared to diesel.



***Source**: Meeting New Jersey's 2020 Greenhouse Gas Limit: New Jersey's Global Warming Response Act Recommendations Report. Executive Summary. December 2009*. Adapted from the graphic on page 2.

- **Cleaner air** RNG, like conventional natural gas, as compared to pre-2010 diesel technology, emits an exhaust stream that is virtually free of soot and lower in nitrogen oxides by up to 80% – thereby reducing to negligible amounts pollutants linked to cardiorespiratory disease and childhood asthma.

Economic Benefits of Building a Biogas-to-Power & Fuels Industry

The RNG Work Group focuses on biogas as a particularly important energy product to be derived from biomass because it can easily be captured or produced and then converted, using today's off-the-shelf technologies, into RNG vehicle fuel.

The RNG Work Group recognizes that several products can be made from landfill or digester biogas – electricity, local heat, pipeline quality gas, and vehicle fuel. And, in the case of in-vessel digesters, the liquids and digestate that remain after the biogas is drawn off have value as fertilizers and soil amendments. Whatever the energy end-product (and often two or more products must be marketed to ensure an adequate revenue stream for the developer), the emergence of a vibrant biogas-to-energy industry in New Jersey at multiple production sites that generate and/or manage large amounts of organic waste would contribute to New Jersey's economy in three major ways:

- ***Conversion of low-value feedstocks into high-value energy*** The most readily available sources of biogas are landfill emissions, food waste, and livestock manures (*see page 10*). Available tonnages of these feedstocks and similar materials, including emissions from organics already sequestered in landfills, amount to nearly 20% of all the biomass available in the State (0.9 million out of 5.2 million dry tons). These wastes are the State's most readily available biomass resources because, for the most part, they are still being managed as discards rather than as precious energy commodities and so are available for "free" or even bring "tipping fees" to developers who are paid to take them off the hands of communities and companies.

- ***Reduction of waste management costs*** At present, solid waste management is a big budget item for town and county governments. Landfill "tipping fees" are high for wastes that are disposed of inside the State. Trucking costs are high for entities that ship their wastes to less expensive out-of-state landfills. To the degree that local governments can extract value out of their solid waste streams by energy production, they can lower their overall waste management budgets and save taxpayer dollars at a time of severe fiscal constraint. Analogously, wastewater treatment utilities could increase their income by becoming energy producers, which would typically begin with retrofitting or building digesters to produce biogas from sludge. The addition of food wastes and waste oils to digesters processing sludges could greatly expand biogas yields and energy production, as shown by research and practice.

- ***Job creation*** The construction of anaerobic digestion plants on farms, at wastewater plants, and at sites close to concentrations of organic waste; as well as their "co-location" at sites that already manage and recycle solid waste streams, such as landfills, transfer stations, materials recovery facilities, and even mass burn incinerators – could potentially create hundreds of new jobs directly or indirectly, according to a new report by the American Gas Foundation.[8] The number of jobs to be created depends on the degree to which the State supports this family of technologies and encourages its spread.

Hurdles: Securing Feedstocks, Developing Vehicle Markets, and Managing Risk

Three obvious challenges stand in the way of developing RNG fuel production in New Jersey. Identifying incentives that would enable project developers to surmount these hurdles is of top priority in developing the State's RNG fuel industry in New Jersey. Including RNG production plants in the *Biomass Fuel & Power Initiative* would be a crucial first step in this direction.

- ***Uncertain supply of feedstoc*ks**. The underdeveloped markets for waste biomass, the largely decentralized approach to waste stream management, and uncertainties about the future amounts and values of different segments of the digestible waste stream pose significant hurdles to project developers of anaerobic digestion facilities across the entire array of energy end-products.
- ***Small natural gas vehicle markets*** The most obvious challenge to developing RNG fuel production in New Jersey is the small number of vehicles currently equipped with natural gas engines. Implementation of the Energy Master Plan's recommendation of a shift of medium and heavy-duty fleets to natural gas fuel would also simultaneously expand the potential RNG markets. It makes sense for the EMP to support the shift of trucks and buses along the entire path to sustainability – beginning with a shift of these vehicles to conventional natural gas and proceeding to introduce the interchangeable but renewable form of this fuel, which is a true sustainable fuel solution for this vehicle class.

  In the interim, in advance of the widespread development of natural gas and RNG vehicle fuel markets, along with a transport and fueling infrastructure, RNG projects can be commercially viable if they "build in" their own customers and fueling. For example, at the Altamont Landfill in California, Waste Management (WM) and Linde produce liquefied RNG to meet the fuel needs of 300 to 400 WM refuse trucks, including some of those hauling wastes to the WM-owned landfill.

- ***Reducing commercial project risks*** The low cost of fossil natural gas imported from other states creates economic challenges for the development of greener, New Jersey-based projects. Since relatively few biomass-based fuel projects have been developed in the U.S., the first several commercial projects in New Jersey will not enjoy the same economies that will be possible for future projects to realize as the business matures. Appropriate incentives in the form of grants, renewable fuel credits, and fuel purchase agreements could help overcome these hurdles, effectively encouraging the production of RNG vehicle fuel.

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[8] American Gas Foundation . *The Potential for Renewable Gas: Biogas Derived from Biomass Feedstocks and Upgraded to Pipeline Quality*. The (www.gasfoundation.org), September 2011

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