Assessment of Biomass Energy Potential in New Jersey

Draft Executive Summary

Spring 2007

The New Jersey Agricultural Experiment Station

DRAFT REPORT

The NJ Board of Public Utilities retained the New Jersey Agricultural Experiment Station to evaluate the state's bioenergy potential

- The four major deliverables of this project are:
  - Assessment of the characteristics and quantity of New Jersey's biomass resources;
  - Assessment of technologies (commercially or near commercially available) that are capable of producing bioenergy, in the form of electric power and transportation fuels from New Jersey's biomass resources.
  - Development of the first statewide mapping of waste/biomass resources
  - Development of policy recommendations for moving New Jersey into the forefront of bioenergy innovation.
- These deliverables will result in the establishment of an outstanding capacity to further develop the bioenergy potential for New Jersey.

Study Team

- **Project Director –** Margaret Brennan
- **Waste Stream/Biomass Assessment**
  - Team Members: Brian Schilling (Team Leader), Priscilla Hayes (Co-Leader), Zane Helsel, Kevin Sullivan, Mike Westendorf, Dave Specca, Bob Simkins (Burlington County), Lucas Marxen
- **Bioconversion Technology Assessment Team**
  - Team Members: David Specca (team leader), A.J. Both, Donna Fennell, Priscilla Hayes, Mike Westendorf, Rhea Brekke (NJ CAT), Steve Paul (Princeton University), Bob Simkins (Burlington County)
- **Waste Stream/Biomass Mapping**
  - Team Members: David Tulloch (Team Leader), Caroline Phillipuk, Lucas Marxen
- **Policy Recommendations**
  - Team Members: Margaret Brennan (Team Leader), all members of project teams, Rutgers Center for Energy, Economic and Environmental Policy
- **Navigant Consulting**
  - Provided technology cost and performance data; developed interactive database with information provided by NJAES.

A range of biomass resources were examined; these were divided into 5 categories based on their physical characteristics.

Feedstock Type	Definitions	Resources
Sugars/Starches	Traditional agricultural crops suitable for fermentation using 1st generation technologies Some food processing residues are sugar and starch materials	• Agricultural crops (sugars/starches) • Food processing residues (w/residual sugars)
Lignocellulosic Biomass	Clean woody and herbaceous materials from a variety of sources Includes clean urban biomass that is generally collected separately from the municipal waste stream (wood from the urban forest, yard waste, used pallets)	• Agricultural residues • Cellulosic energy crops • Food processing residues • Forest residues, mill residues • Urban wood wastes • Yard wastes
Bio-oils	Traditional edible oil crops and waste oils suitable for conversion to biodiesel	• Agricultural crops (beans/oils) • Waste oils/fats/grease
Solid Wastes	Primarily lignocellulosic biomass, but that may be contaminated (e.g., C&D wood) or co-mingled with other biomass types	• Municipal solid waste (biomass component) • Construction & Demolition (C&D) wood • Food wastes • Non-recycled paper • Recycled materials
Other Wastes	Other biomass wastes that are generally separate from the solid waste stream Includes biogas and landfill gas	• Animal waste (farm) • Wastewater treatment biogas • Landfill gas

NJ produces an estimated 8.2 million dry tons (MDT) of biomass annually. Individual county amounts range from 210,000-680,000 DT.

County	Sugar/ Starch	Ligno	Bio-Oils	Solid Waste			Other Wastes	Totals (Tons)
				Recycled	Landfilled Biomass	C&D non-recycled		
Atlantic	3,170	108,957	1,179	31,919	115,217	25,602	30,315	316,358
Bergen	4	87,455	3,779	169,401	294,436	69,209	115,775	740,060
Burlington	29,787	255,697	23,040	60,576	149,554	32,570	130,609	681,833
Camden	2,477	118,822	2,550	29,799	39,659	41,743	34,565	269,615
Cape May	831	145,752	851	24,249	42,421	24,471	8,925	247,500
Cumberland	26,681	216,226	10,823	54,495	56,829	13,574	42,461	421,088
Essex	-	37,392	3,313	76,587	87,559	71,750	40,251	316,851
Gloucester	15,206	173,089	11,462	27,420	15,704	20,022	58,327	321,229
Hudson	-	7,949	2,527	109,051	191,915	41,639	19,328	372,410
Hunterdon	25,370	138,574	5,985	11,304	42,090	56,986	31,986	312,295
Mercer	9,306	80,835	8,101	75,089	113,978	25,883	12,200	325,393
Middlesex	11,212	95,451	8,216	169,437	260,179	81,044	52,927	678,466
Monmouth	11,537	151,043	8,639	92,865	199,296	49,677	54,940	567,996
Morris	4,429	114,985	2,431	71,636	165,620	38,695	33,375	431,170
Ocean	2,239	156,619	2,833	85,768	221,097	43,008	17,981	529,543
Passaic	6	52,724	2,090	94,517	177,172	38,164	3,308	367,980
Salem	59,560	135,424	18,675	5,396	17,035	14,625	37,777	288,492
Somerset	9,267	67,465	2,282	40,404	104,843	1,482	14,546	240,289
Sussex	6,796	160,795	653	17,667	40,322	11,216	35,978	273,427
Union	5	42,242	2,225	46,261	60,536	48,164	10,022	209,455
Warren	48,006	135,236	5,014	10,588	11,150	7,822	53,302	271,117
TOTALS	265,887	2,482,731	126,666	1,304,429	2,406,613	757,346	838,899	8,182,570

•Biogas (in Other Wastes) is based in Tons Equivalent biomass, assuming 500 Btu/scf and 8000 Btu/lb

Although the theoretical potential is large, there are several reasons why it will not be practical to recover all of NJ's biomass.

1. ***Lack of collection and transport infrastructure for certain feedstocks***

   New Jersey's municipal solid waste and agricultural crops maintain a well established collection and delivery infrastructure. For agricultural and forestry residues, such a system may have to be created or revamped. Economic incentives may be needed to incentivize the owners of transportation vehicles to add to or convert their fleet for these purposes.

2. ***Co-mingling of significant quantities of biomass with other wastes***

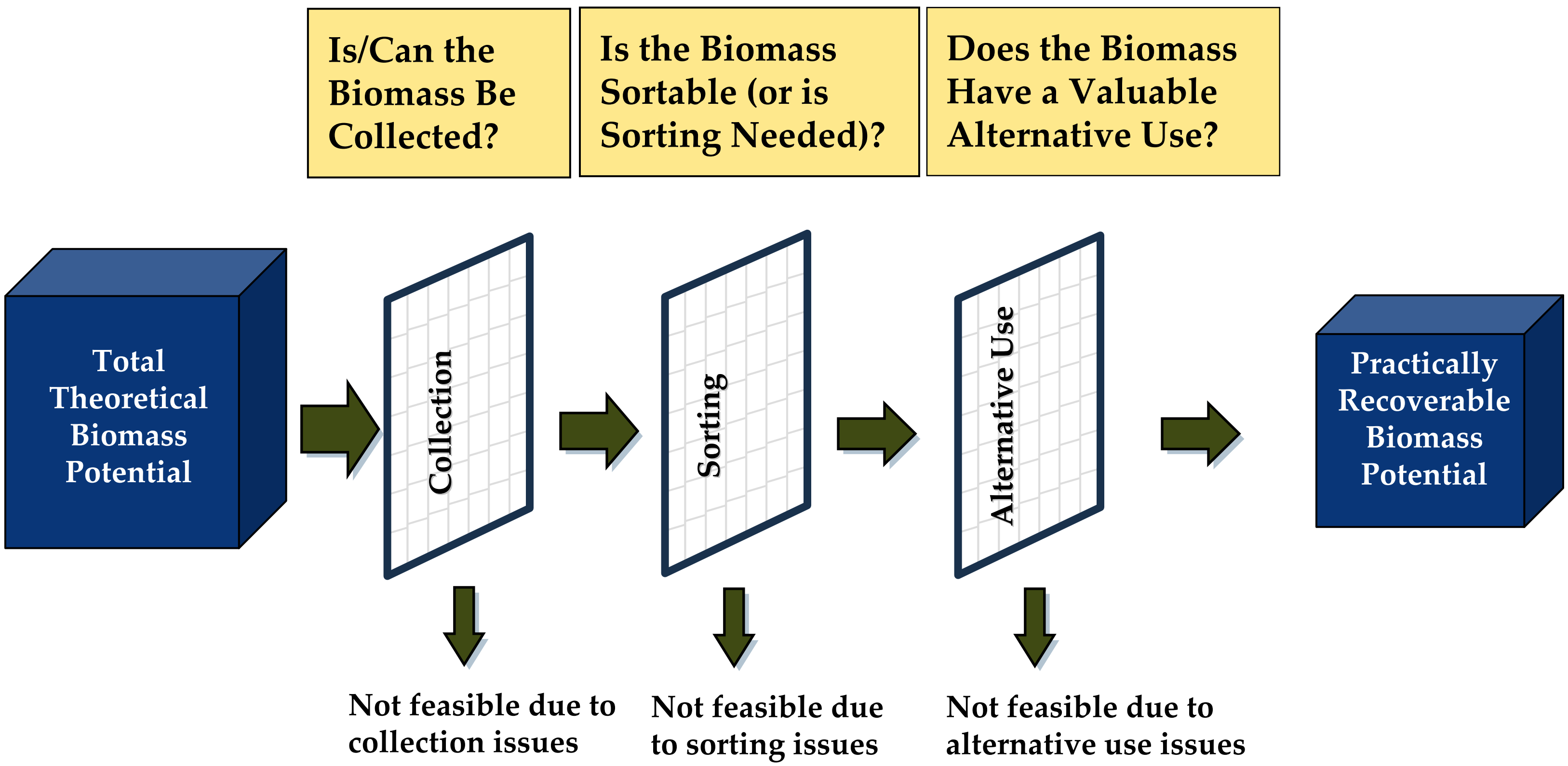
   Further source separation practices will be needed if NJ is to take advantage of wastes that are now not fully separated, such as food waste and C&D wood.

3. ***Competition from existing uses***

   Much of NJ's urban waste biomass is currently recycled and used in alternative markets. These markets are well established, and may offer a higher value than (today's) energy cost (especially given the technology costs for converting that resource to energy).

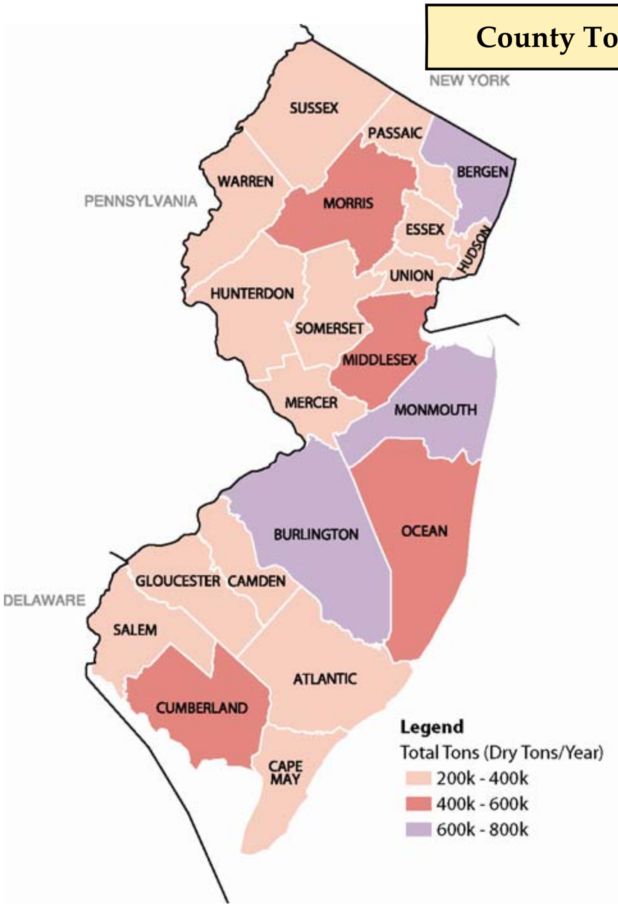
NJ's practically recoverable biomass resource is estimated at 5.2 MDT

A screening process was developed to help estimate how much of NJ's theoretically available biomass might be recoverable.



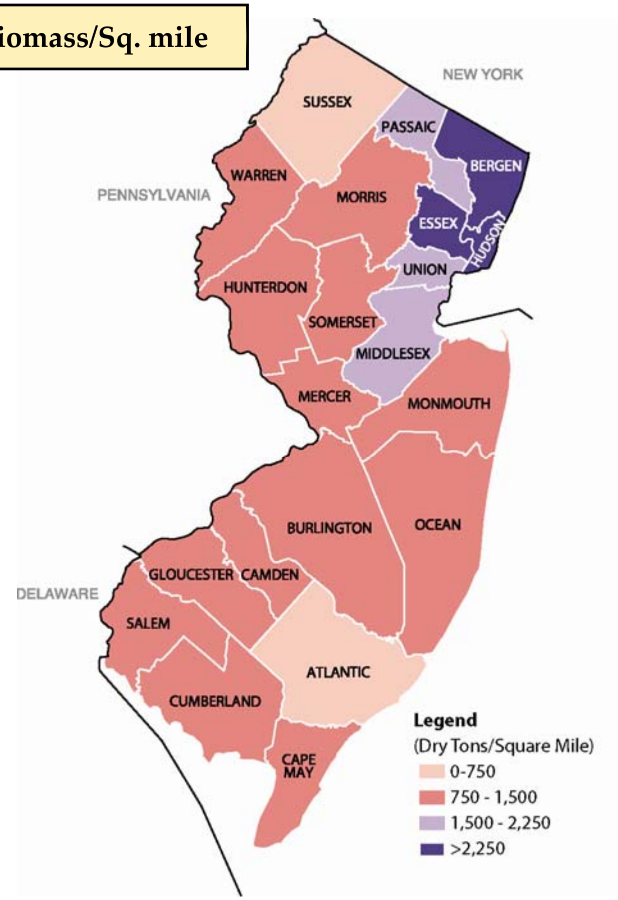
Biomass is concentrated in the counties of central and northeastern New Jersey.

County Totals



Almost 75% of NJ's biomass resources is produced directly by the state's population, much of it in the form of municipal solid waste.

Biomass/Sq. mile



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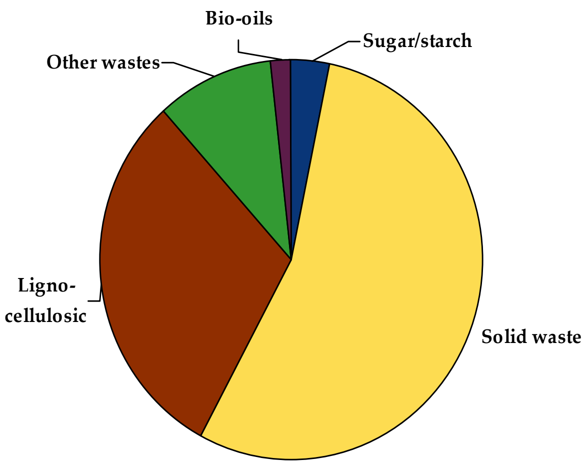
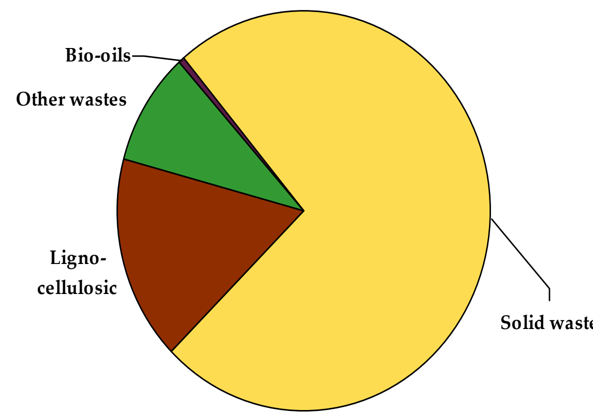
Total Available Biomass Resources by Type (dry tons/yr)



Total = 8.2 million dry tons/yr[1]

The chart on the left shows NJ's total biomass. The chart on the right shows just the population-related biomass waste stream.

Biomass Resources Associated with Population (dry tons/yr)



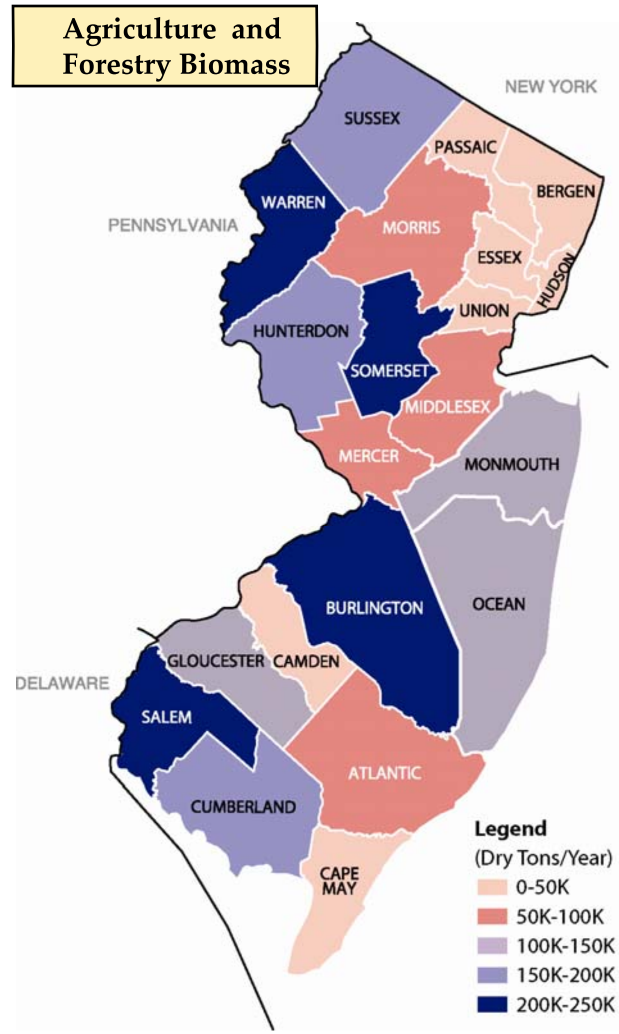
Total = 6.1 million dry tons/yr[1]

In the past, generating energy from solid waste typically involved incineration. Several new technologies described in Section IV are becoming capable of converting solid waste into energy without incineration.

1. This total includes biogas and landfill gas quantities converted to dry ton equivalents on an energy basis. Note that these are gross quantities, not taking into account differences in heat content per ton.

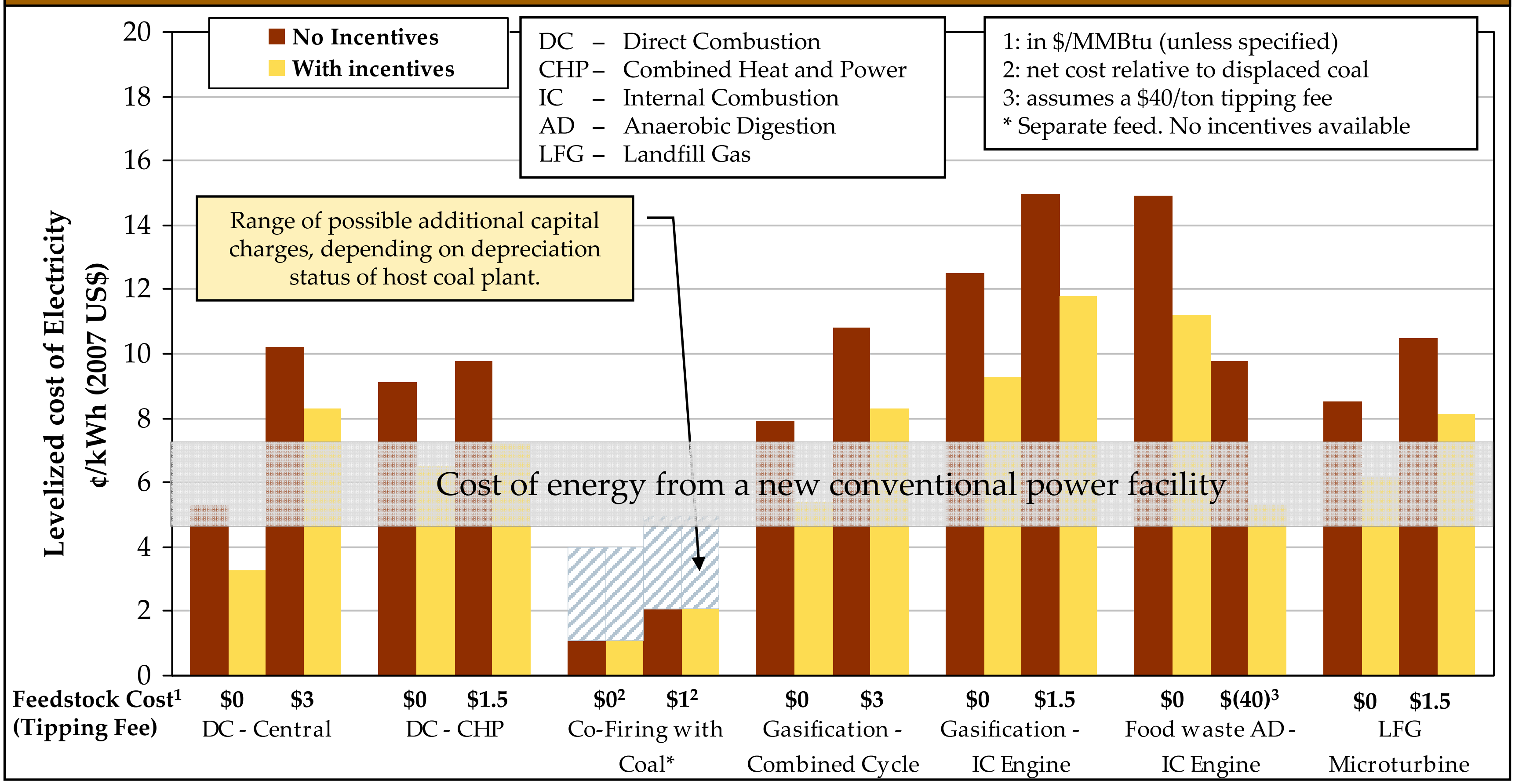
Agriculture and forestry management are important potential sources of biomass

- Biomass from agricultural sources include 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, on the other hand, are generally underutilized and undervalued, which should allow for an easier decision to use these resources.
- In the case of energy crops, NJ would also need to decide whether to maintain the current crop varieties, or introduce new crops that may be better suited to energy production (eg. poplar or switchgrass).



Some biopower technologies are becoming cost competitive. Economics are driven by feedstock cost, incentives, and technology type.

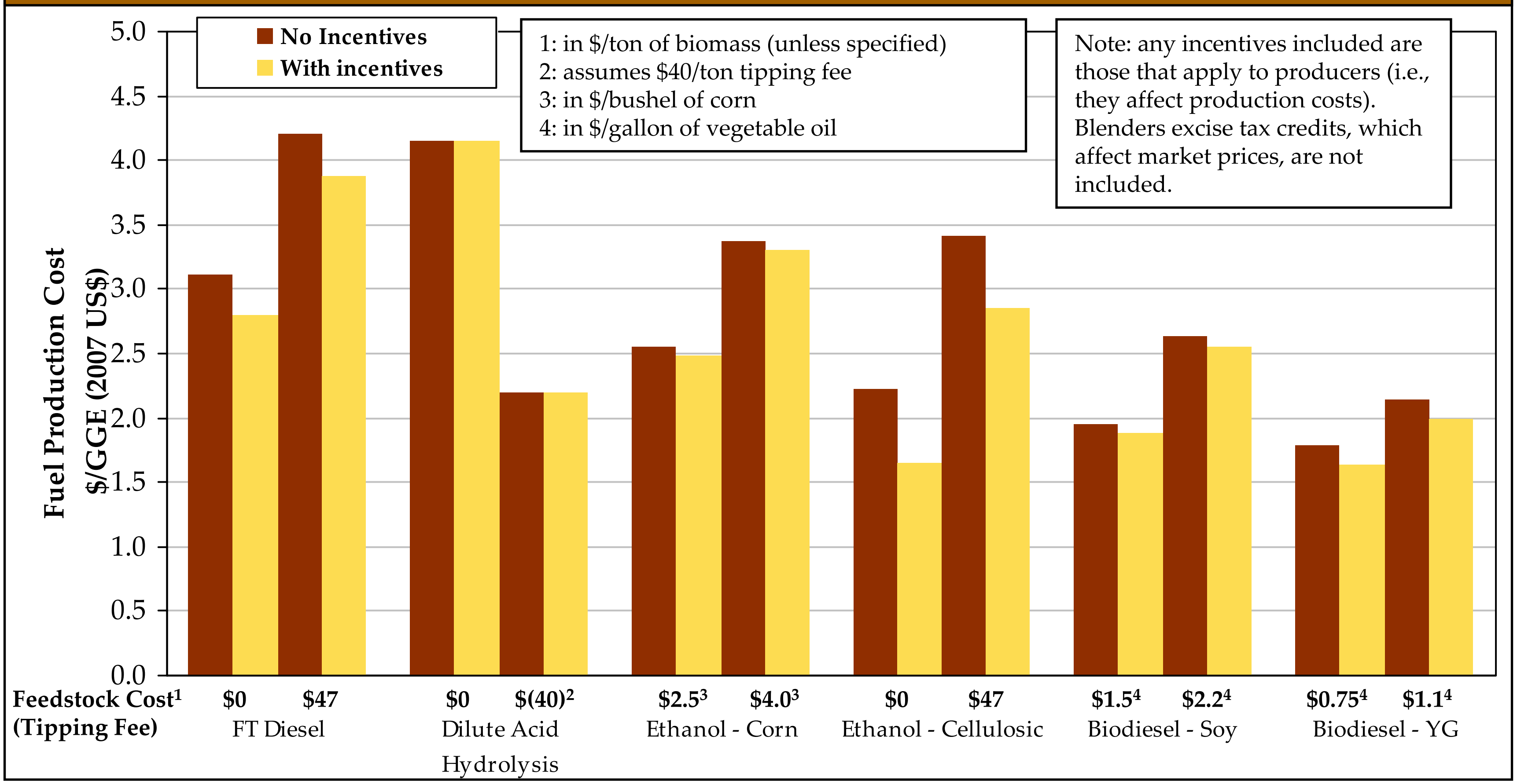
LCOE[1] Comparison for Biomass Power Options: 2007 with and without incentives



1 - LCOE: The present value of the total cost of building and operating a generating plant over its economic life, converted to equal $/kWh unit payments. Costs are levelized in real dollars (i.e., adjusted to remove the impact of inflation).

Incentives, feedstock costs, and possible tipping fees are also a key to promoting the production of biofuels.

Fuel Production Cost Comparison for Biofuels Options: 2007 with and without incentives



The energy that could be created if NJ's recoverable biomass were converted to energy suggests substantial benefits can be achieved.

1. NJ's 8.2 million dry tons/year of biomass represents a theoretical energy potential of almost 1,700 megawatts (MW) of electricity or 455 million gallons of gasoline equivalent (GGE)[1] of biofuel[2].
2. NJ's estimated practically recoverable biomass resource of 5.2 MDT could deliver up to 1,075 MW of NJ's electricity power demand or 290 million gallons of gasoline equivalent of transportation fuel consumed.
3. This practically recoverable energy potential equals approximately 9% of NJ's electricity consumption or 5% of its transportation fuel consumed.
4. Bioenergy will likely require moderately high fuel prices, technology advances, and financial incentives to be commercially competitive.
5. Based on assumptions about population growth and efficiency improvements, the potential exists for this to grow to over 1,350 MW or 375 M GGE of biofuel by 2015.

1. One gallon of gasoline contains approximately 125,000 Btu of energy. Biofuels have different volumetric energy densities (some lower, some higher). Estimates of biofuel yields have been converted to "gallons of gasoline equivalent" based on the ratio of volumetric energy densities, to allow for consistent comparisons among the various fuels.
2. The total energy potential from feedstock that could classify as Class II Renewables could potentially add up to 500 MW or 85 M GGE biofuels if it were included in these totals (it is not).

NJ's large municipal waste biomass resource, combined with its proximity to a petrochemical infrastructure, makes it a good location to utilize advanced power and fuels technologies

- Some technologies approaching commercial use appear better suited to exploit NJ's largest biomass resources:
  - For fuels, emerging biomass-to-liquids technologies, such as cellulosic ethanol, Fischer-Tropsch (FT) diesel, dilute acid hydrolysis, and biogas to LNG/CNG present some of the best opportunities
  - For power, direct combustion, biomass gasification and anaerobic digestion are among the most developed technologies to process waste biomass streams

Technology development and commercialization proceeds through a number of basic stages.

R&D	Demonstration			Market Entry	Market Penetration	Market Maturity
	Initial System Prototypes	Refined Prototypes	Commercial Prototypes			
• Research on component technologies • General assessment of market needs • Assess general magnitude of economics	• Integrate component technologies • Initial system prototype for debugging	• Ongoing development to reduce costs or for other needed improvements • "Technology" (systems) demonstrations • Some small-scale "commercial" demonstrations	• Commercial demonstration • Full size system in commercial operating environment • Communicate program results to early adopters/ selected niches	• Commercial orders • Early movers or niche segments • Product reputation is initially established • Business concept implemented • Market support usually needed to address high cost production	• Follow-up orders based on need and product reputation • Broad(er) market penetration • Infrastructure developed • Full-scale manufacturing	• Roll-out of new models, upgrades • Increased scale drives down costs and results in learning
10+ years	4 - 8 years			1 - 3 years	10 - 20 years	Ongoing

The time required to pass through any given stage can vary considerably. The values shown here are representative of a technology that passes successfully from one stage to the next without setbacks.

Bioenergy Technology Summary

Application	Core Technology Platform and typical applications				
	1 Direct Combustion	2 Thermo-chemical Conversion	3 Fermentation	4 Anaerobic Digestion	5 Physio-chemical Conversion
Power/CHP	●	●		●	○
Heat Only	●	●		●	○
Transportation Fuels		●	●	●	●
Example Technologies	Biomass boiler coupled to steam turbine generator	Biomass gasifier coupled to IC engine generator	Corn-ethanol Cellulosic ethanol	Wastewater treatment plant (WWTP) biogas coupled to IC engine generator	Biodiesel blended with petroleum diesel or heating oil
Typical Feedstocks	Lignocellulosic biomass Solid wastes	Lignocellulosic biomass Solid wastes	Sugars/starches (1st generation) Lignocellulosic biomass (2nd generation) Solid wastes	Sewage sludge, manure, food waste, and landfill wastes (that produce landfill gas)	Bio-oils

Primary application ● **Secondary Application** ○ **Blank** indicates generally not applicable.

Bioenergy will likely require moderately high fuel prices, technology advances, and financial incentives to be commercially competitive.

Biopower

- Some biopower technologies are becoming cost competitive. Economics are driven by feedstock cost, incentives, and technology type.
- By 2010 and 2015, cost reduction potential should bring additional technologies into the realm of commercial application.

Biofuels

- Incentives, feedstock costs, and possible tipping fees are also key to promoting the production of biofuels.
- Major cost reductions are expected over the next 3-8 years that will allow new biofuels technologies to become more cost competitive.

NJ's large municipal waste biomass resource, combined with its proximity to a petrochemical infrastructure, makes it a good location to utilize advanced power and fuels technologies

Next Steps:

– Identify environmental impacts of the bioenergy technologies discussed in this report.

– Develop the first statewide mapping of waste/biomass resources.

– Develop policy recommendations for moving New Jersey into the forefront of bioenergy innovation.