



## ASSESSMENT OF BIOMASS ENERGY POTENTIAL IN NEW JERSEY



Prepared for: The New Jersey Board of Public Utilities

**July 2007**

Prepared by: The New Jersey Agricultural Experiment Station

**Executive  
Summary**

**In September 2006, the New Jersey Board of Public Utilities retained the New Jersey Agricultural Experiment Station to evaluate the state's bioenergy potential.**

- The four major goals of this project were to:
  - Assess the characteristics and quantity of New Jersey's biomass resources;
  - Assess 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;
  - Develop the first statewide mapping of waste/biomass resources and bioenergy potential;
  - Develop policy recommendations for moving New Jersey into the forefront of bioenergy innovation.
- These deliverables will result in the establishment of an outstanding foundation upon which to 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, Stacy Bonos, Jacqueline Melillo, Bob Simkins (Burlington County Solid Waste Office)
- **Bioconversion Technology Assessment Team**
  - *Team Members:* David Specca (Team leader), Steve Paul (Princeton University), Bob Simkins (Burlington County Solid Waste Office), Jacqueline Melillo, A.J. Both, Donna Fennell, Rhea Brekke (NJ CAT)
- **Waste Stream/Biomass Mapping**
  - *Team Members:* David Tulloch (Team Leader), Caroline Phillipuk
- **Policy Recommendations**
  - *Team Members:* Margaret Brennan (Team Leader), all members of project teams
- **Navigant Consulting**
  - Provided technology cost and performance data; developed interactive database with information and functionality specifications provided by NJAES.

**Research yielded six major findings about New Jersey's biomass resources:**

1. New Jersey produces an estimated 8.2 million dry tons (MDT) of biomass<sup>1</sup> annually.
2. Screening process developed to estimate practically recoverable biomass. Approximately 5.5 MDT (~65%) of New Jersey's biomass could ultimately be available to produce bioenergy.
3. Almost 75% of New Jersey's biomass resources produced directly by state's population, majority in solid waste (e.g., municipal waste). Biomass concentrated in central and northeastern counties.
4. Agriculture and forestry management also important potential sources of biomass, account for majority of remaining amount.
5. New Jersey's estimated practically recoverable biomass resource of 5.5 MDT could deliver up to 1,124 MW of power, (~9% of New Jersey's electricity consumption) or 311 million gallons of gasoline equivalent (~5% of transportation fuel consumed) if appropriate technologies and infrastructure were in place.
6. Large proportion of waste-based biomass supports recommendation that New Jersey pursue development of an energy from waste industry.

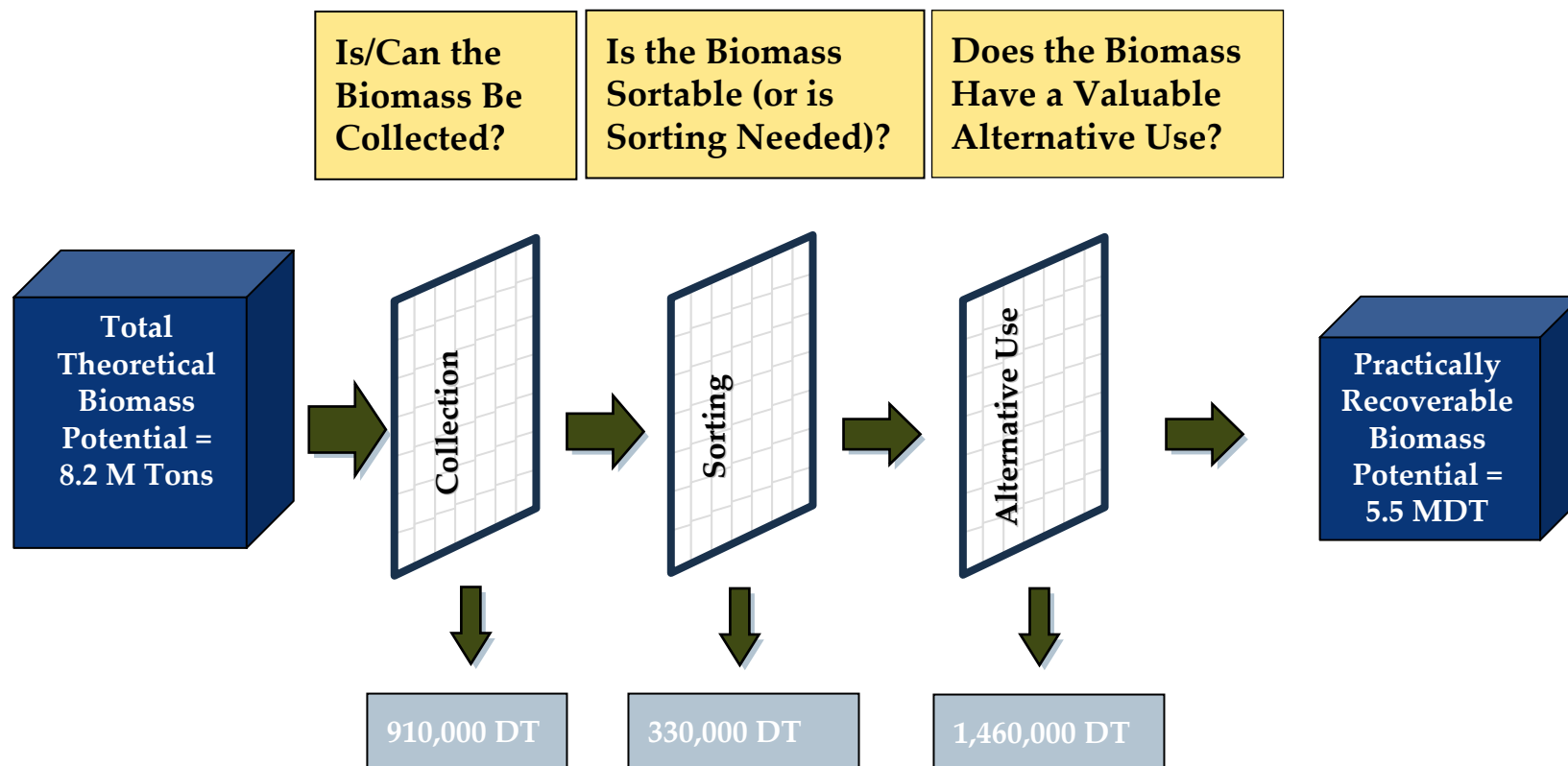
1. This total includes biogas and landfill gas quantities converted to dry ton equivalents on an energy basis. This does NOT include biomass that is currently used for incineration or sewage sludge because these are not classified as Class I renewable feedstocks in NJ.

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

Feedstock Type	Definitions	Resources
<b>Sugars/Starches</b>	Traditional agricultural crops suitable for fermentation using 1 <sup>st</sup> generation technologies Some food processing residues are sugar and starch materials	<ul style="list-style-type: none"> <li>• Agricultural crops (sugars/starches)</li> <li>• Food processing residues (w/residual sugars)</li> </ul>
<b>Lignocellulosic Biomass</b>	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)	<ul style="list-style-type: none"> <li>• Agricultural residues</li> <li>• Cellulosic energy crops</li> <li>• Food processing residues</li> <li>• Forest residues, mill residues</li> <li>• Urban wood wastes</li> <li>• Yard wastes</li> </ul>
<b>Bio-oils</b>	Traditional edible oil crops and waste oils suitable for conversion to biodiesel	<ul style="list-style-type: none"> <li>• Agricultural crops (beans/oils)</li> <li>• Waste oils/fats/grease</li> </ul>
<b>Solid Wastes</b>	Primarily lignocellulosic biomass, but that may be contaminated (e.g., C&D wood) or co-mingled with other biomass types	<ul style="list-style-type: none"> <li>• Municipal solid waste (biomass component)</li> <li>• Construction &amp; Demolition (C&amp;D) wood</li> <li>• Food wastes</li> <li>• Non-recycled paper</li> <li>• Recycled materials</li> </ul>
<b>Other Wastes</b>	Other biomass wastes that are generally separate from the solid waste stream Includes biogas and landfill gas	<ul style="list-style-type: none"> <li>• Animal waste (farm)</li> <li>• Wastewater treatment biogas</li> <li>• Landfill gas</li> </ul>

## Biomass Supply Analysis » Practically Recoverable Biomass

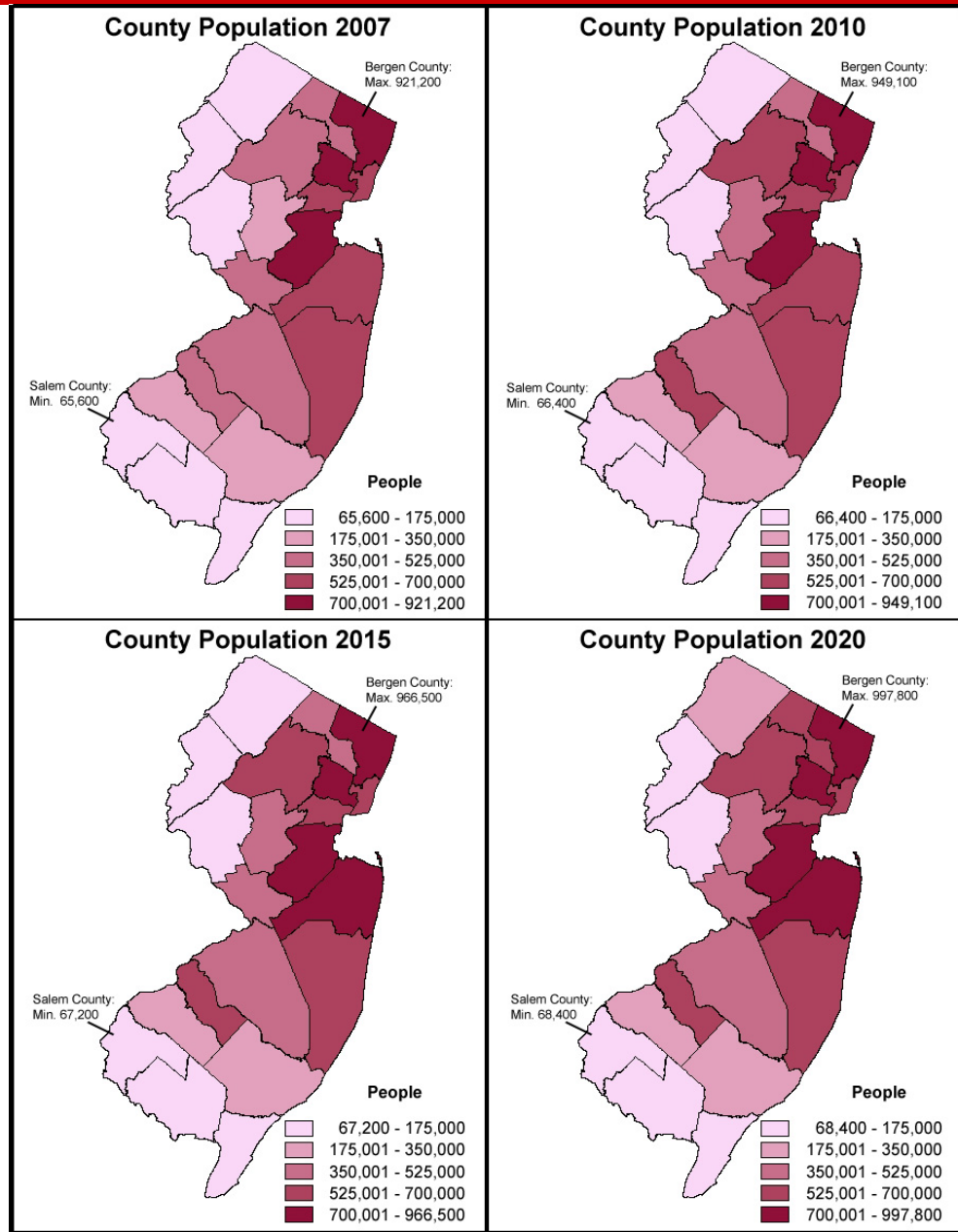
A screening process was developed to estimate how much of New Jersey's theoretically available biomass might be recoverable. The results indicate that approximately 5.5 MDT (~65%) of New Jersey's biomass could ultimately be available to produce energy, in the form of power, heat, or fuels.



*Note:* This screening process is preliminary and would require considerably more analysis to reach any final conclusions. The screening analysis has been incorporated into the database, and provide flexible "scenario analysis" capabilities for the user.

### New Jersey Population Projections by County

Between 2007 and 2020,  
New Jersey's  
population is expected  
to grow by about 10%  
adding about 1,000,000  
more people.

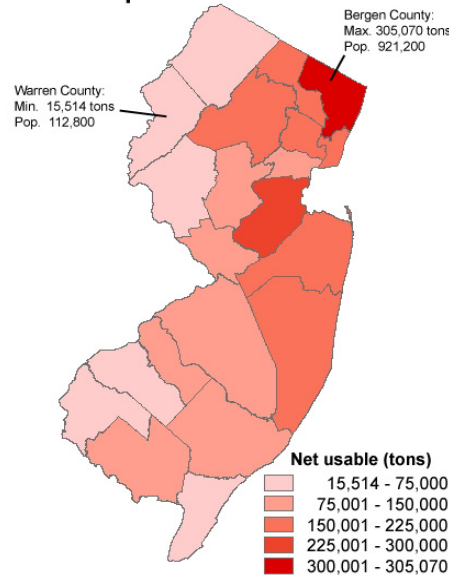


### Municipal Solid Waste Projections by County

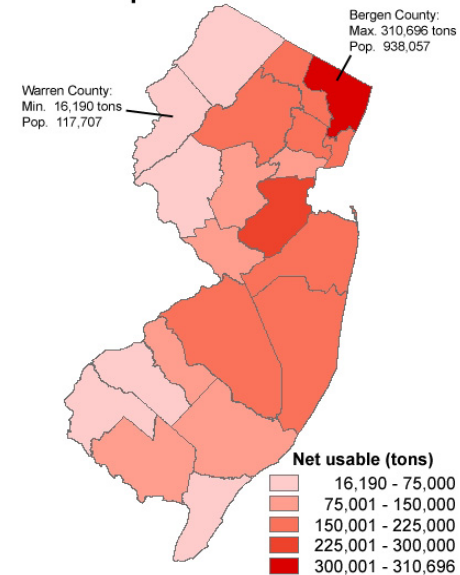
Almost 75% of New Jersey's biomass resource is produced directly by the state's population, much of it in the form of municipal solid waste

With increases in population comes increases in the amount of solid waste generated in the state. MSW is expected to increase by 10.55% by 2020.

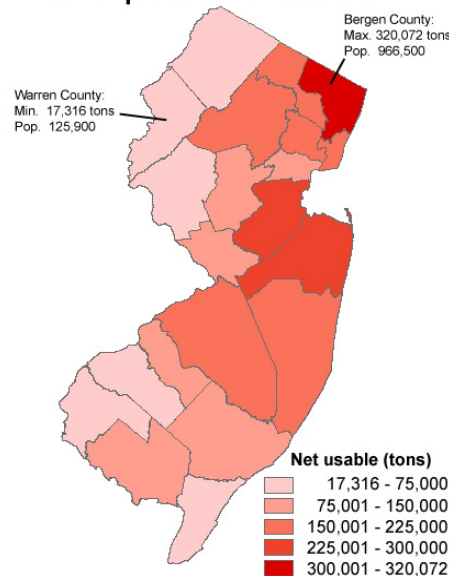
**Municipal Solid Waste 2007**



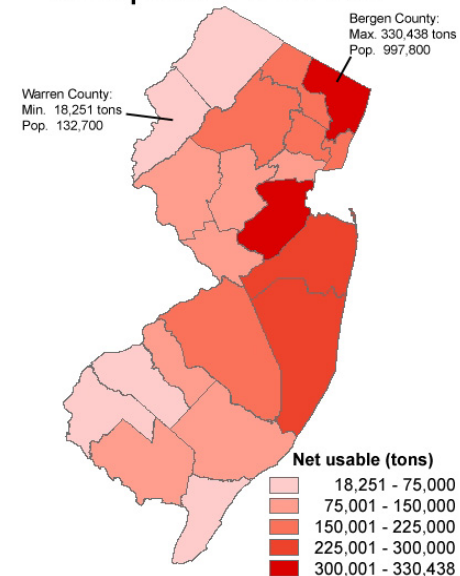
**Municipal Solid Waste 2010**



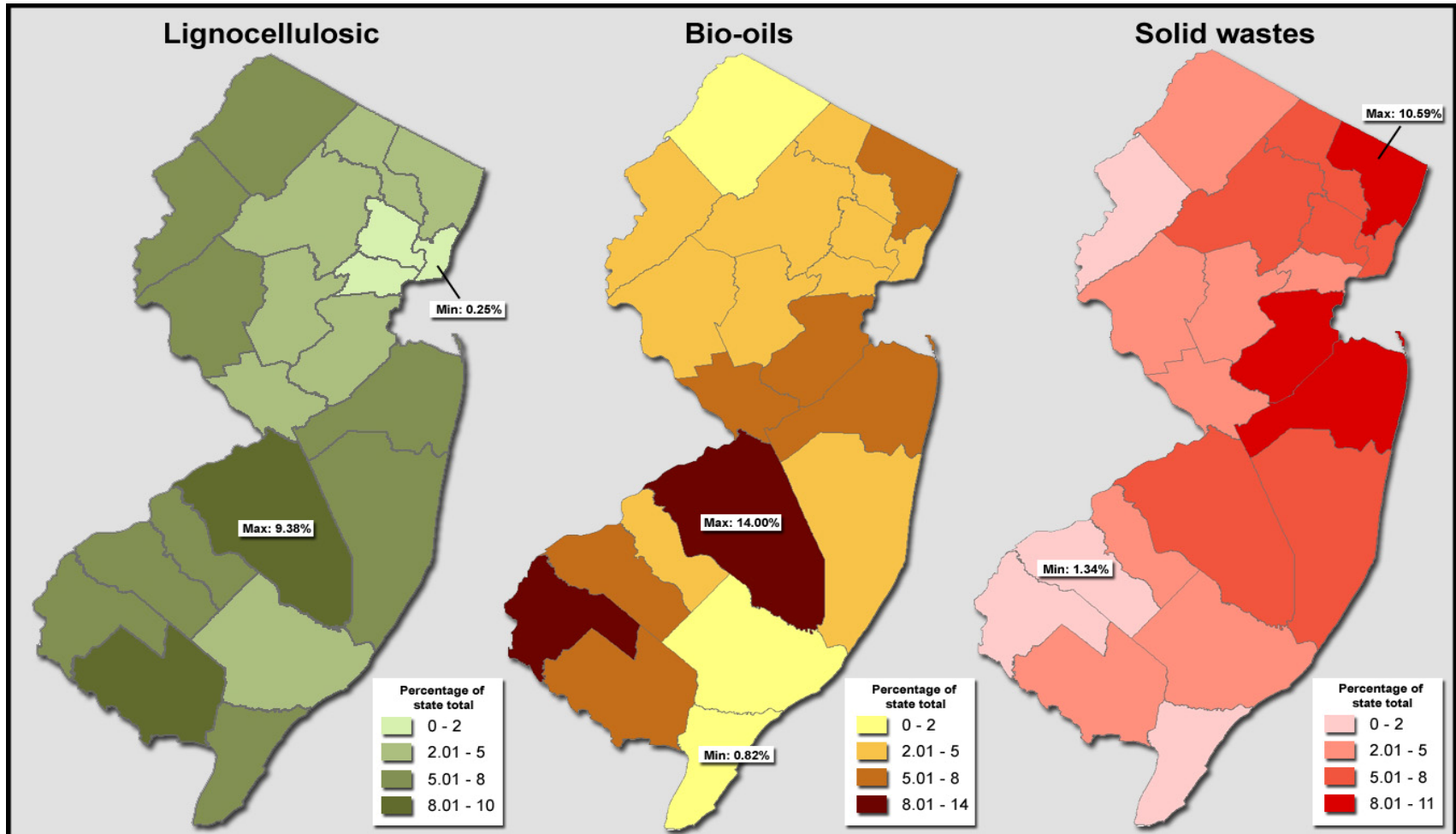
**Municipal Solid Waste 2015**



**Municipal Solid Waste 2020**



### Biomass Resources by Feedstock Category 2007



Mapping out a strategy for effective biomass resource utilization is a valuable next step for New Jersey to understand the actual potential.

Biomass Resource Utilization Strategy					
Biomass Locational Mapping	Understand Quality Characteristics	Determine Infrastructure Requirements	Determine Most Appropriate Use	Develop Collection Plan	Develop Separation Plan
Use GIS mapping to determine location of resources, including central nodes that might make good plant locations	Compile quality characteristics of proximal resources to determine compatibility with prospective facility	Evaluate collection, delivery, and handling infrastructure needed to process resources at each facility or node	For those resources that have an alternative use, decide whether the alternative use is preferred to energy production	For resources not currently collected, develop a viable collection plan	For resources not currently separated from the waste stream, develop separation plan

**An early part of the project design was to identify the leading biomass to energy conversion technologies that should be evaluated**

**Considerations for this analysis included:**

- Technical feasibility/niche applications
- Compatibility with New Jersey biomass
- Focused on broad technology platforms with similar characteristics
- Market Readiness scale

The decision to screen out specific technologies *for the current analysis* does not mean that it will not find some application in New Jersey in the future.

## 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			
<ul style="list-style-type: none"> <li>• Research on component technologies</li> <li>• General assessment of market needs</li> <li>• Assess general magnitude of economics</li> </ul>	<ul style="list-style-type: none"> <li>• Integrate component technologies</li> <li>• Initial system prototype for debugging</li> </ul>	<ul style="list-style-type: none"> <li>• Ongoing development to reduce costs or for other needed improvements</li> <li>• “Technology” (systems) demonstrations</li> <li>• Some small-scale “commercial” demonstrations</li> </ul>	<ul style="list-style-type: none"> <li>• Commercial demonstration</li> <li>• Full size system in commercial operating environment</li> <li>• Communicate program results to early adopters/selected niches</li> </ul>	<ul style="list-style-type: none"> <li>• Commercial orders</li> <li>• Early movers or niche segments</li> <li>• Product reputation is initially established</li> <li>• Business concept implemented</li> <li>• Market support usually needed to address high cost production</li> </ul>	<ul style="list-style-type: none"> <li>• Follow-up orders based on need and product reputation</li> <li>• Broad(er) market penetration</li> <li>• Infrastructure developed</li> <li>• Full-scale manufacturing</li> </ul>	<ul style="list-style-type: none"> <li>• Roll-out of new models, upgrades</li> <li>• Increased scale drives down costs and results in learning</li> </ul>
10+ years	4 - 8 years			1 - 3 years	10 - 20 years	Ongoing

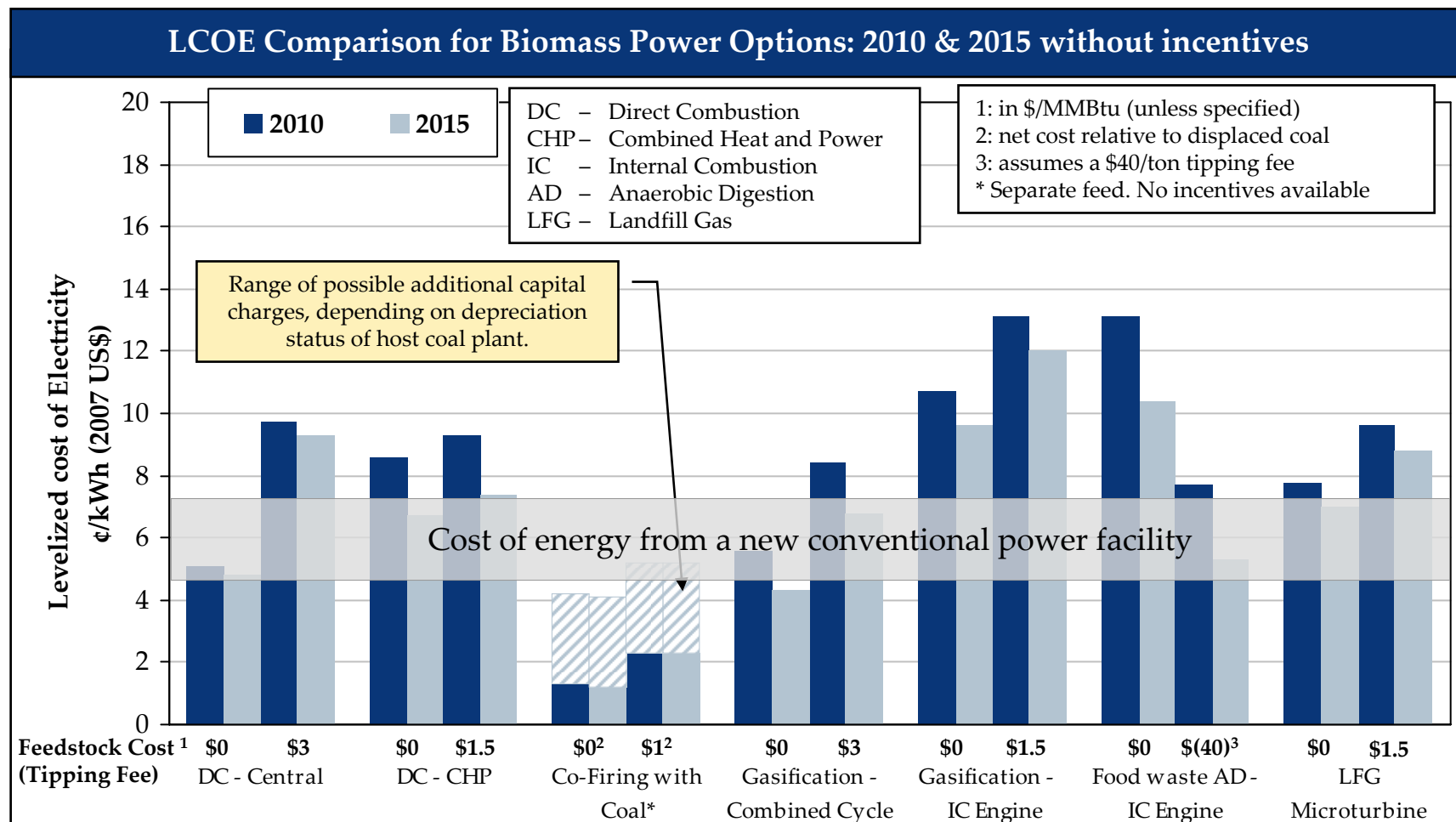
**The time required to pass through any given stage can vary considerably. The values shown here are representative of a technology that passes successfully from one stage to the next without setbacks.**

## Thirteen bioenergy applications were included in the analysis

Application	Core technology platforms and applications				
	Direct Combustion	Thermo-chemical Conversion	Fermentation	Anaerobic Digestion	Physio-chemical Conversion
<b>Power/CHP</b>	1. Stand-alone rankine (steam) cycle plant 2. Small-scale rankine cycle CHP plant 3. Biomass co-firing with coal	4. Stand-alone BIGCC plant 5. Small-scale gasification-IC engine CHP plant 6. Stand-alone pyrolysis plant		11. Food waste anaerobic digester with IC engine CHP plant/ Landfill gas with microturbine	
<b>Heat Only</b>	• Discussed qualitatively and shown in context of CHP applications above.				
<b>Transportation Fuels</b>		7. Biomass-to-liquids plant (Fischer-Tropsch) 8. Dilute acid hydrolysis for biofuels production <sup>1</sup>	9. Corn-ethanol dry mill 10. Cellulosic ethanol plant	12. CNG or LNG from landfill gas/AD gas	13. Transesterification Biodiesel

1. Involves the production of ethers (gasoline blendstock) and esters (diesel blendstock).

**By 2010 and 2015, cost reduction potential should bring additional biopower technologies into the realm of commercial application.**



**Market transformation will occur once the technological and infrastructure capabilities exist and can function in an economically viable and environmentally sustainable fashion.**

### **1) *Institutional Infrastructure***

- Establish/appoint a state agency with primary responsibility for developing the bioenergy industry. This entity will need dedicated personnel, authority and financial resources to accomplish this goal.
- Facilitate policy harmonization across all state agencies so that the state's alternative energy goals can be successfully achieved. This effort will need to be fully integrated, include public and private partnerships, and incorporate comprehensive research, policy and marketing plans.
- Build regional partnerships with surrounding states to take advantage of related programs, maximize utilization of biomass feedstocks, coordinate research activities and share expertise.

### **2) *Regulations***

- Identify and alleviate regulatory conflicts across permitting agencies to streamline and simplify approval processes.
- Integrate new bioenergy efforts (i.e. biofuels) into existing policies (e.g. RPS, Clean Energy Program, & MSW recycling requirements).
- Consider a societal benefits charge on petroleum based fuels to support bioenergy incentive programs.

### ***3) Market Based Incentives***

- Establish Bioenergy Enterprise Zones around concentrations of biomass feedstocks and/or where bioenergy can be strategically utilized.
- Develop a consumer-based biofuels incentive program
- Provide incentives for energy from waste research, development and production
- Provide incentives for small companies to pursue bioenergy technology demonstration projects
- Provide incentives for development of biomass feedstock infrastructure

### ***4) Market Transformation Through Technological Innovation***

- Establish a ***Bioenergy Innovation Fund*** to support the research, development and commercialization of new bioenergy technologies. Build partnerships with BPU, EDA, NJCST, NJDA and other state agencies, as well as higher education institutions, federal agencies, private investors, utilities, and foundations with a goal to transform the market for bioenergy through innovations in technology.
- Facilitate bioenergy market development by identifying ways to take advantage of New Jersey's existing petrochemical, refining and distribution infrastructure.

**A unique Bioenergy Calculator and interactive biomass resource database was developed to aggregate all biomass and technology information. This database contains a number of important features:**

- Detailed biomass resource data, by county, for more than **40 biomass resources**.
- Energy generation data for **13 bioenergy technologies** that takes into consideration advances in energy output and efficiency over time.
- The database was designed to analyze the biomass resource data and technology assessment data in an interactive fashion. The database is:
  - Structured by county and resource type
  - Contains technology performance estimates to convert biomass quantities into energy (electricity and fuel) potential.
- The **Bioenergy Calculator** yields projected biopower and biofuel estimates for 2007, 2010, 2015, 2020.
- The database allows for continual updating as additional data is collected and refined.
- A screening tool is imbedded in the database to conduct sensitivity analyses on the estimate of recoverable biomass.

### Bioenergy Potential by County

TYPE	POWER (MWh) TOTAL				FUELS (GGE)			
County	2007	2010	2015	2020	2007	2010	2015	2020
Atlantic	314,881.11	328,749.72	355,478.29	367,122.70	11,823,683	12,082,097	12,528,498	12,970,734
Bergen	664,828.98	693,861.18	749,852.80	774,451.06	23,661,464	24,115,715	24,892,782	25,730,144
Burlington	710,094.49	739,098.42	794,775.95	820,201.33	31,727,019	32,330,126	33,371,647	34,435,818
Camden	342,322.04	354,458.01	378,166.63	385,925.63	10,598,947	10,695,522	10,858,657	11,079,685
Cape May	314,374.07	325,265.09	346,641.55	352,843.81	8,941,315	9,027,148	9,174,121	9,370,800
Cumberland	485,905.53	501,315.20	531,507.22	536,380.39	18,621,363	18,733,853	18,923,595	19,078,796
Essex	338,982.74	349,505.05	370,045.75	374,828.95	13,245,096	13,344,433	13,511,658	13,686,640
Gloucester	410,326.59	432,814.74	476,320.72	501,635.35	15,365,062	15,791,440	16,540,332	17,356,599
Hudson	286,466.01	297,010.58	317,552.06	324,466.44	9,748,537	9,853,621	10,031,318	10,250,743
Hunterdon	324,248.50	337,117.35	362,372.39	369,735.23	11,433,543	11,559,243	11,778,999	11,975,681
Mercer	330,997.01	345,948.13	374,927.40	386,724.06	11,469,646	11,664,408	11,998,315	12,345,934
Middlesex	661,582.44	693,385.53	754,409.91	787,056.71	26,645,402	27,289,741	28,402,093	29,603,575
Monmouth	656,519.07	688,537.02	750,438.38	781,031.71	22,555,350	23,078,199	23,983,715	24,940,502
Morris	433,595.14	454,727.55	495,558.15	513,734.70	17,302,975	17,740,519	18,498,309	19,247,212
Ocean	496,042.96	524,558.96	579,944.01	610,054.42	15,646,435	16,138,561	17,001,555	17,911,546
Passaic	335,791.32	346,499.44	367,541.42	372,010.62	11,172,986	11,240,097	11,352,900	11,493,522
Salem	267,545.73	274,758.43	289,070.87	290,342.49	14,373,720	14,394,895	14,430,614	14,473,284
Somerset	221,650.91	233,174.94	255,604.33	266,081.30	7,968,678	8,169,713	8,522,937	8,865,053
Sussex	292,933.04	303,039.45	322,872.59	329,104.34	9,463,309	9,576,391	9,774,154	10,004,845
Union	216,722.59	224,103.36	238,557.79	242,293.28	6,845,042	6,898,498	6,988,562	7,099,243
Warren	264,582.84	272,332.91	287,628.24	289,927.67	12,607,823	12,675,699	12,795,245	12,892,537
TOTAL	8,370,393.10	8,720,261.07	9,399,266.46	9,675,952.18	311,217,394	316,399,920	325,360,004	334,812,894
Total (MW)	1,124	1,171	1,262	1,299				

#### Technologies Used:

#### Power

Gasification BIGGC  
Anaerobic Digestion

#### Fuels

Gasification  
Fermentation  
Transesterification  
Anaerobic Digestion

**Full Report and Bioenergy Calculator is available on-line at:**

**[njaes.rutgers.edu/bioenergy](http://njaes.rutgers.edu/bioenergy)**

**Contact Information**

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