New Jersey Renewable Energy Market Assessment

Final Report to
Rutgers University
Center for Energy, Economic and Environmental Policy

Prepared by Navigant Consulting Inc., Sustainable Energy Advantage LLC, and Boreal Renewable Energy Development

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Notice:

Rutgers University's Center for Energy, Economic and Environmental Policy (CEEEP) has been charged by the New Jersey Board of Public Utilities (New Jersey BPU) to assess market opportunities for Renewable Energy. To meet that objective this report was prepared by Navigant Consulting, Inc.[1] (NCI) for the account of Rutgers University. This report represents NCI's best judgment in light of information made available to us. The reader is advised that in certain cases, NCI has not independently verified the financial models or the information contained therein. The reader understands that no assurances can be made that all financial liabilities have been identified. This report must be read in its entirety. This report does not constitute a legal opinion.

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1. And its subcontractors, Sustainable Energy Advantage LLC, and Boreal Renewable Energy Development.

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Rutgers University's Center for Energy, Economic and Environmental Policy (CEEEP) has been charged by the New Jersey Board of Public Utilities (BPU) to oversee an assessment of market opportunities for Renewable Energy (RE).

- The New Jersey BPU is responsible for determining the appropriate levels of funding for RE programs to be supported by the Societal Benefits Charge (SBC).
- The New Jersey Clean Energy Program goals include:
  - Make New Jersey the world leader for the promotion and use of clean RE.
  - Accelerate its use of renewable energy in support of clean energy and energy security objectives.
  - Transform the energy marketplace to allow for direct competition between renewable energy and conventional energy sources.
- In addition New Jersey has set specific targets for Class I renewables among its goals:
  - Construct 300 MW of new Class I renewable energy capacity in New Jersey by 2008
  - Increase electricity production of solar energy to at least 120,000 MWh per year in 2008 in New Jersey (equivalent to 90 MW).[1]
  - By 2020, 20% of demand sourced from Class I renewables

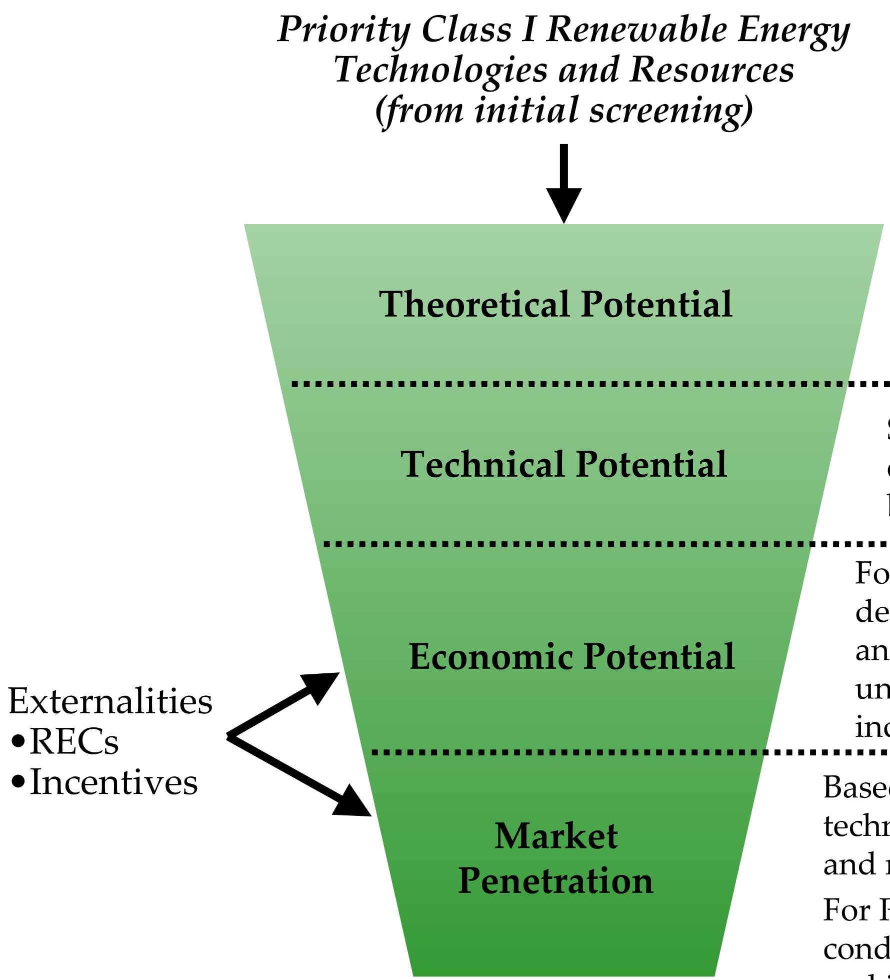
1. This is the current RPS goal for the solar set-aside. The other quantitative goals listed here are separate from the current RPS.

Navigant Consulting, Inc. (NCI) was retained to conduct the renewable energy market assessment.

- Key Tasks:
  - Screen and prioritize among the Class I renewable energy technologies.
  - For leading options assess the market potential and estimate market penetration through 2020.
  - Review progress towards the Clean Energy Program goals (gap analysis).
  - Review the effectiveness of current programs towards meeting Clean Energy Program goals and suggest modifications to programs and new programs.

- Assumptions:
  - This is an assessment of resources within New Jersey, not of the NJ renewable portfolio standard (RPS).
  - Although resources outside of New Jersey are eligible for the New Jersey RPS, for the purposes of the Clean Energy Program, we assume that in-state resources have priority.

The assessment of market penetration followed a successive evaluation to go from theoretical potential to market penetration.



Theoretical Potential: Total resource potential unconstrained by land use considerations or other non-economic factors. Conducted on a technology-by-technology basis.

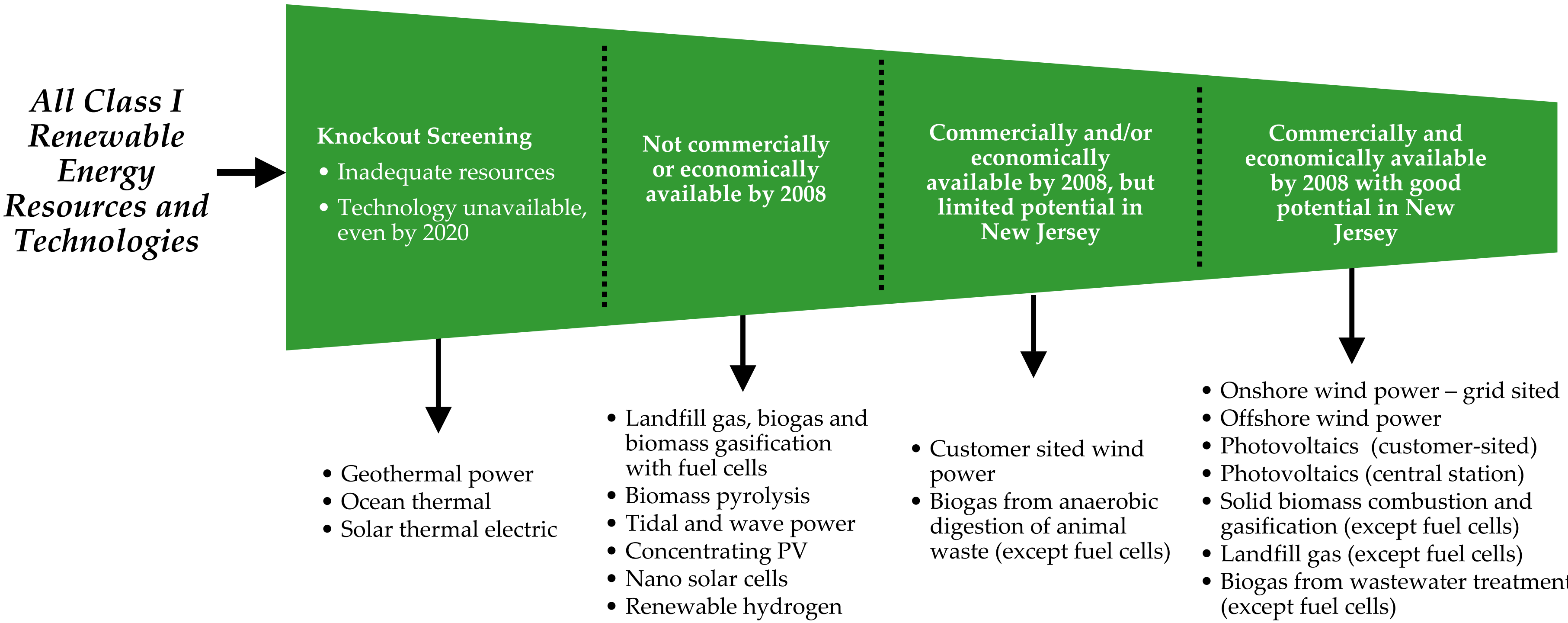
Technical Potential: Screens out resources that cannot be accessed due to non-economic reasons (e.g., land use restrictions). Approach varies by technology.

Economic Potential: For the wholesale tier, screens out resources that cannot be developed because they are more expensive than competing options and then estimates the diffusion of renewables into the marketplace under "business as usual" conditions. Includes impacts of RECs and incentives in different scenarios.

Market Penetration: Based on the economic potential, estimates the diffusion of the technology into the marketplace considering the relative economics and maturity of the options.

For PV, the economic potential and the market penetration were conducted as a single integrated step. Includes the impacts of RECs and incentives in different scenarios.

Seven renewable energy technologies passed through the screening to detailed market assessment.



Scope of Analysis:	**Not Included for Further Analysis**	**Brief Descriptions**		**Detailed Market Assessment**
Relevance for New Jersey Clean Energy Program:	**Not Relevant**	**Monitor for future funding, including RD&D**	**Fund projects as opportunities present themselves**	**Primary options for near-to-medium term deployment**

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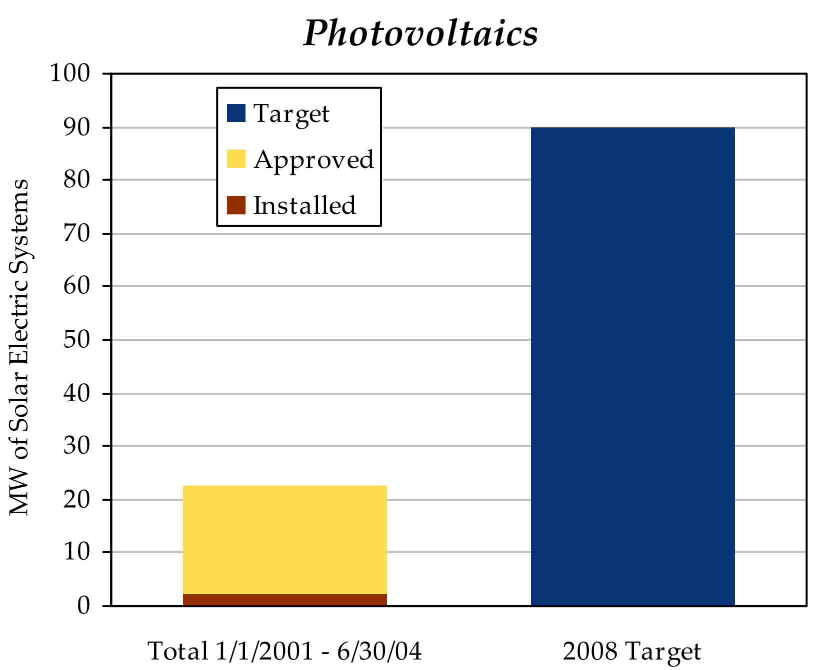
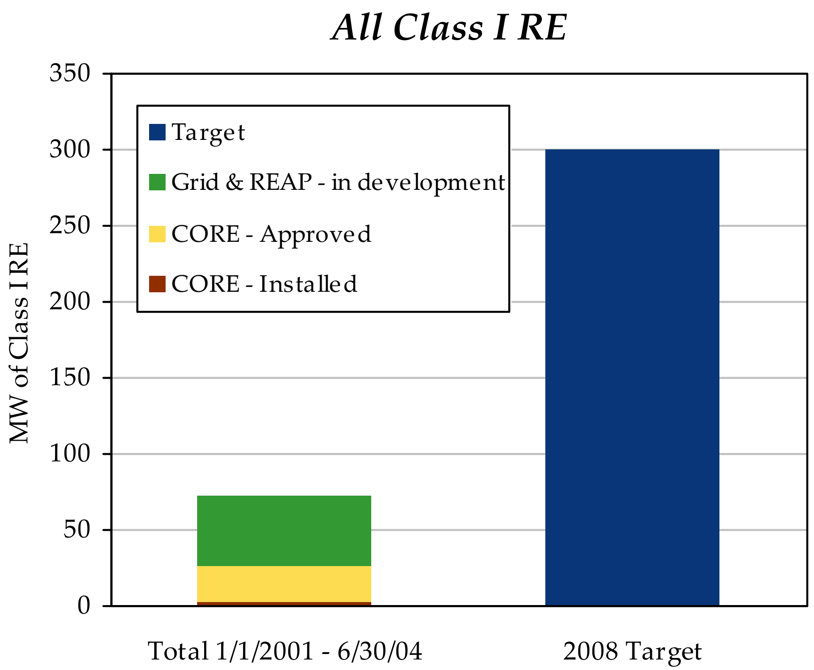
The Clean Energy Program is making progress towards its goals, provided that most capacity that is still in development is eventually placed in service.

Progress Towards the Solar and Class I RE Goals in New Jersey





Note: When a system is installed, it no longer is tracked in the "approved" category. Thus, the total amount of approved systems is the sum of all approved systems that have not yet been installed (i.e., some systems approved in 2003 have not yet been installed).

Source: New Jersey Office of Clean Energy.

Ten key findings are summarized below and are discussed in more detail in the remainder of this section.

Customer-Sited Photovoltaics Markets	1. Financial support is necessary to achieve significant PV market penetration, but RECs may be more cost effective per MW than rebates. 2. New Jersey can likely decrease the amount of the rebate and still meet its 2008 objective of 90 MW of PV.
Grid-Site RE Markets	3. The Clean Energy Program can ensure that cost-effective RE options are developed by 2008, while also focusing on the larger, longer-term potential of offshore wind power, central station PV and biomass gasification. 4. Digester gas from wastewater treatment and landfill gas offer the potential for the lowest electricity costs, followed by onshore wind power options. 5. When the additional revenues from RECs are considered, several resources appear economically viable by 2008, even with modest REC prices. 6. By 2020, NJ may have significant RE potential that is economic, depending on the REC price and the viability of offshore wind power.
Clean Energy Program Options	7. The 90 MW PV goal can be met with adequate funding of existing programs, but other programs may help control costs. 8. The 300 MW Class I goal appears to be a stretch due to near-term resource constraints, but the Clean Energy Program can do several things to help meet the goal. 9. Achieving the goal of 1.5X of Class I RPS load served via green power is an aggressive target but the Clean Energy Program is starting to address it. 10. The ability to enter into long-term contracts for energy and RECs is critical for project financing and development.

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The 90 MW PV goal can be met with adequate funding of existing programs, but other programs may help control costs.

Goal:

Install 90 MW of PV in NJ by 2008

- The 90 MW goal can be met under the existing program structure:
  - CORE is the only current program that directly targets the 90 MW PV goal, but it is effective.
  - Under the existing program structure the 90 MW PV goal can be met if more funds are allocated. Total costs are estimated at about $350 million at current rebate levels.
- **Recommendation:** Modified or new programs would complement existing ones and allow the state to gradually decrease rebate levels and maintain market momentum.
  - A robust solar REC market can provide significant value to a PV project. The state could provide credit quality support to the solar REC market.
  - Targeting new construction can address the high-first cost issue
  - Promoting voluntary green power could increase demand for solar RECs
  - Mandatory PV targets for government buildings would help maintain demand
- **Recommendation:** Several new program options would modify/extend existing programs to also help achieve indirect objectives (e.g., reliability) without substantially changing program costs.
  - Decrease system costs through aggregated, multi-yr PV purchases
  - Improve reliability by targeting installations in load pockets

The 300 MW Class I goal appears to be a stretch due to near-term resource constraints, but the Clean Energy Program can do several things to help meet the goal.

Goal:

Install 300 MW of Class I RE in NJ by 2008

- Several RE options are cost effective and are not likely to need direct financial support, other than from programs aimed at facilitating long-term contracts for energy and RECs. However, total MW are limited.
- **Recommendation:** REAP is the main existing program targeting grid-sited RE. It should be configured to optimize the benefits of the Federal PTC (see below)
- **Recommendation:** In the long term, there are significant RE resources available, especially if offshore wind power is successful. However, these long-term options may require some direct financial support beyond the RPS:
  - Capital grants
  - Production incentives (note: for technologies eligible for the Federal PTC, this is less likely than grants or subsidized financing to trigger PTC double-dipping provisions)
  - Zero-interest loans or debt guarantees
  - Assistance with siting and permitting
- **Recommendation:** The Clean Energy Program should also consider resource-specific programs:
  - Improved wind forecasting
  - Community wind development
  - Grants for bioenergy crops

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Achieving the goal of 1.5X of Class I RPS load served via green power is an aggressive target but the Clean Energy Program is starting to address it.

Goal:

Increase Green Power Participation and Load Served

- RE that is used to meet the green power goals would need to be in addition to the RPS, suggesting that the green power goal will be a challenge to meet.
  - Even by implementing the proposed programs, the green power goals will still be a challenge to meet, based on experience in other states and on historical participation rates in existing green power programs.
- Current programs (with the exception of REED) do not directly address green power markets, but could have some spin-off benefits by making more renewable energy available.
- **Recommendation:** To effectively address this objective the Clean Energy Program will need new initiatives – there are numerous examples from other states to draw upon and the CEP is already developing some new programs. These include:
  - State green power purchases
  - RECs sold via utility bill/check-off program
  - Branding, education and outreach program
  - Customer incentives
  - Support for long-term hedge purchases (RE as hedge against price volatility)
  - Large customer buying group creation and support
- **Recommendation:** Many of these programs work well as a suite (e.g., need incentives + outreach + aggregation +access to utility bill [for small customers/mass market]).

The ability to enter into long-term contracts for energy and RECs is critical for project financing and development.

Long-term contracts for renewable energy and RECs

- The current retail market structure in NJ, as in other deregulated states, is not conducive to long-term contracting. However, the ability to enter into long-term contracts (>10 years) for renewable energy and REC sales is critical to securing financing for projects. Even projects with the most favorable economics (e.g., landfill gas) require moderate-term (4-8 year) contracts. Some options include:
  - Incentives for credit-worthy parties to enter long-term contracts
  - Large retail customer hedge program (long-term RE purchase as hedge against electricity price volatility)
  - Advocate for changes to wholesale rules, as appropriate
- **Recommendation:** Creating a robust market for RECs is critical, as this is the primary support mechanism for most RE. However, there are different approaches that could be taken:
  - Long-term REC purchase contracts with state as market enabler, e.g., extend the redemption window for RECs in the event the state repeals the RPS, or explore changes to the structure of the BGS auction rules that would encourage long-term RE contracts.
  - Long-term REC purchase contracts with state as market participant, e.g., the NJ CEP acts as credit-worthy buyer for RECs only, or NJ CEP acts as credit-worthy market of last resort, ensuring a minimum REC revenue by offering a floor price in the form of a put option, make-up payment, or similar price-support mechanism.

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Some of the programmatic issues discussed can also be framed around technology-specific needs.

Ensuring that currently cost-effective resources are developed rapidly	• The fact that these projects have attractive levelized costs of electricity is not a guarantee that they will be developed. • **Recommendation:** The Clean Energy Program should have a near-tem focus on programs that facilitate the development of RE options that are cost effective today (landfill gas, biogas, some onshore wind power, and potentially customer-sited solid biomass power). • **Recommendation:** Programs that facilitate long-term contracts, cover costs for feasibility studies, and help with siting and permitting should all provide good leverage of CEP funds.
Mitigating risks and addressing cost and non-cost barriers to offshore wind power development	• Offshore wind power is a relatively high risk option but has the greatest potential for in-state RE development. • Because of its relatively high costs and issues regarding siting, REC markets alone may not result in any offshore wind development. • **Recommendation:** Financial incentives will be important, especially if the Federal PTC is no longer in place when projects come on line. However, the Clean Energy Program should focus on options that provide greater leverage than direct subsidies (e.g., debt guarantees, subordinate debt), since direct subsidies for large offshore wind projects will be expensive in absolute terms. • **Recommendation:** Given the risks of offshore wind power development, predevelopment grants to help with the permitting process and/or instituting a collaborative process to work through siting and permitting would provide good cost/benefit.

Five scenarios were selected to examine the potential of the customer-sited photovoltaics market, defined as follows:

PV Market Penetration Scenarios		
Description		Rationale
Scenario A	• No state incentives • Commercial systems benefit from an existing 10% Federal investment tax credit and accelerated depreciation	Reference market potential in absence of state incentives
Scenario B	• Current New Jersey rebate • Value of RECs for PV is held at $100/MWh	Continuation of current rebate program with REC value representative of current market for voluntary solar RECs
Scenario C	• No state rebate program • The value of RECs for PV is held at $250/MWh	Evaluate the effectiveness of RECs at stimulating the market in the absence of a rebate program
Scenario D	• The New Jersey rebate level is reduced to 50% of the current level • The value of RECs for PV is held at $100/MWh	Sensitivity of the market to a reduced rebate with REC value representative of current market for voluntary solar RECs
Scenario E	• Modified rebate formula that maintains a constant net system cost to the buyer ($2,500/kW for residential and $2,400/kW for commercial) • The value of RECs for PV is held at $100/MWh	Sensitivity of the market to a reduced rebate with REC value representative of current market for voluntary solar RECs. Rebate level chosen to provide the same net system cost to the customer as current rebate level.

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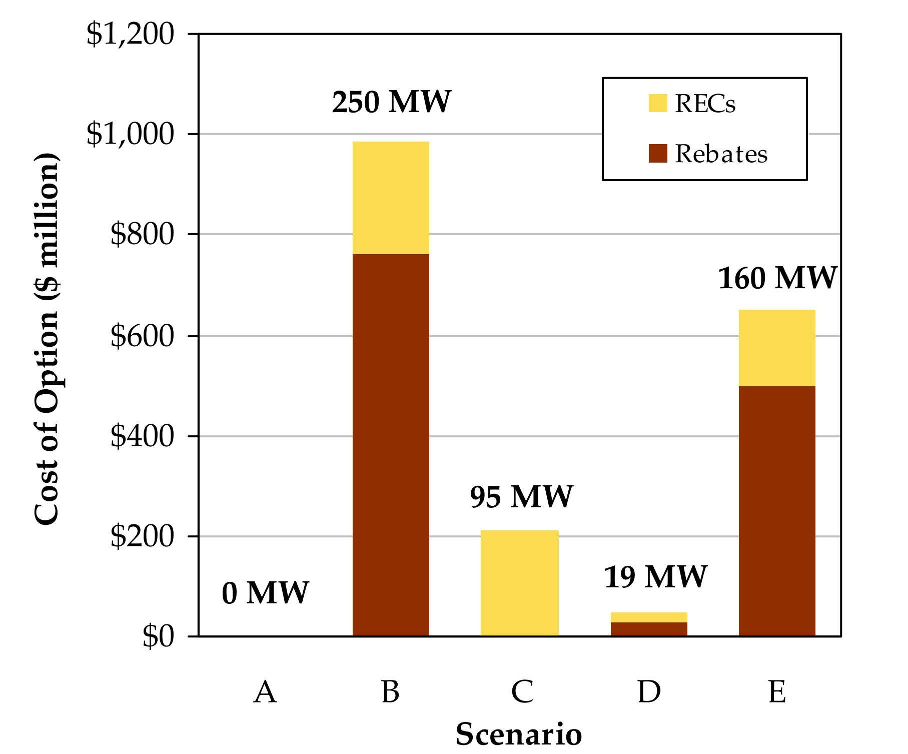
Financial support is necessary to achieve significant PV market penetration, but RECs may be more cost effective per MW than rebates.

- Effectiveness of incentives:
  - Scenario A: Without incentives, PV achieves negligible market penetration
  - Scenario B: 252 MW at a cost of $984 M ($3.90/Watt)
  - Scenario C: 95 MW installed by 2008 with incentives costing $210 M ($2.20/Watt)
  - Scenario D: 19 MW at a cost of $46.1 M ($2.40/Watt)
  - Scenario E: 160 MW at a cost of $649.6 M ($4.10/Watt)
- The economic analysis does not factor in how customers would perceive the risk of the various scenarios, e.g., making buy decisions in the absence of the rebate and instead relying solely on long-term revenue from RECs.

Net Present Value (NPV) Cost[1] of incentives for the different PV scenarios and associated estimated market penetration



1. Cost of RECs is the total cost out to 2020, discounted at 8% per year (for systems installed in 2003-2008). The cost of the rebates is the total cost to 2008, discounted at 8% per year.

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New Jersey can likely decrease the amount of the rebate and still meet its 2008 objective of 90 MW of PV.

- If the current rebate program continues as is (Scenario B), New Jersey is likely to overshoot its target of 90 MW by 2008.
  - This scenario also requires significantly more funding (~$750 million in rebates on an NPV basis) than is available in the Clean Energy Program between now and 2008.
- In comparison, Scenario E, which maintains the same net cost of the PV system to the customer as the current rebate level, still exceeds the 2008 target, but at a lower total cost. In this scenario, Clean Energy Program rebates total approximately $500 million through 2008 on an NPV basis.
- Scenario D, which reduces the current rebate by 50% results in moderate long-term penetration, but falls short of the 2008 target.
- This analysis suggests that a reduced rebate (somewhere in between scenarios D and E) or some sort of block structure similar to what is offered for wind and sustainable biomass through the CORE program, would still allow New Jersey to meet the 90 MW target, but at a lower total cost than is implied by continuation of the the current rebate levels.
- Other factors not evaluated in the market penetration analysis are potentially important to decisions about how to modify the rebate program:
  - For a given levelized cost of electricity (LCOE) reduction impact, rebates will be more attractive to the customer since they eliminate the risks of changes in future REC prices or the elimination of RECs altogether (e.g., if the RPS is repealed).
    - Thus, even though the analysis shows that the 2008 target can be met with high REC prices alone (Scenario C), if the rebate is eliminated or substantially reduced, this will likely result in substantially reduced market penetration.

Approximately 3,200 MW of Class I RE (excluding customer-sited PV) are technically available for development through 2020.

Class I RE Option	Theoretical Potential (MW by 2020)	Technical Potential (MW by 2020)	Comments
Onshore Wind Power	1,842	127	• Largest land class is wetlands, followed by "barren land" (mostly beaches), resulting in significant exclusions when estimating the technical potential.
Offshore Wind Power	24,500	2,500	• Technical potential is a conservative estimate of 10% of theoretical potential
Solid Biomass Power (combustion and gasification)	N/A	114-240	• Data on theoretical potential not available. • Range in technical potential is based on range of conversion efficiencies between direct combustion and gasification combined cycle technology. • Resources from outside of NJ that could be brought into the state have not been included.
Landfill Gas	120	64	• Only landfills closed on or after 1990 and with potential >500 kW are included in the technical potential
Biogas from Wastewater Treatment	32	24	• The use of biogas from wastewater treatment for cogeneration appears to be a largely untapped opportunity in NJ. • Technical potential screens out projects small than 500 kW
Central Station PV	N/A	300	• Theoretical potential is not known • Technical potential is a conservative assumption
Total	**N/A**	**3,129-3,255**	

The Clean Energy Program can ensure that cost-effective RE options are developed by 2008, while also focusing on the larger, longer-term potential of offshore wind power, central station PV and biomass gasification.

Class I RE	Comments
Onshore Wind Power	• Economics are generally favorable, assuming developers can overcome siting issues and can obtain favorable financing predicated on securing long-term contracts for energy and RECs. • Existing programs should be optimized to maximize the benefits of the Federal PTC.
Offshore Wind Power	• Siting has emerged as an important issue • Because of its higher costs relative to onshore wind power, financial incentives will be important, especially if the Federal PTC is no longer in place when projects come on line (expected post-2008).
Solid Biomass Power (combustion and gasification)	• Electricity production costs are relatively high. Furthermore, lower costs in the future are predicated on the commercialization of new technology. • Existing programs can effectively support biomass by helping reduce first costs or in securing capital. • There is a clear need for better information at the state level regarding the resource potential. • Although biomass co-firing is not a Class I resource, it may serve as a good bridge technology for biomass until gasification is commercially available.
Landfill Gas	• The option is largely cost effective. Support from the Clean Energy Program could focus on helping secure long-term contracts and on direct financial support of smaller projects.
Biogas from Wastewater Treatment	• The option is largely cost effective. Support from the Clean Energy Program is expected to be modest and focused, e.g., on direct financial support of smaller projects. The Clean Energy Program should coordinate its efforts with the DEP.
Central Station PV	• Without rebates, central station PV is not likely to be cost effective until after 2015, and then only if solar REC prices are high. However, there may be other reasons for promoting this option (e.g., brownfield redevelopment.

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NCI defined three scenarios for grid-sited RE technologies based on a range of possible incentive levels.

Parameter	Base Case	Low Incentive and REC Price	High Incentive and REC Price	Comments
Production Tax Credit (PTC)	Extended through end of 2006 @ $18/MWh	Not extended	Extended through end of 2006 @ $18/MWh	• Senate and House have passed legislation renewing the credit. Currently in Conference Committee. • Only wind and closed-loop biomass are eligible for PTC.[1]
Class I RPS Average market price for RECs	$20/MWh	$6/MWh	$45/MWh	• $6/MWh is recent price.[2] Landfill gas and biogas potential may keep RECs low in early years. • Low case could also represent a case where the supply of Class I RECs from PJM exceeds demand in New Jersey. • $45/MWh represents the current approximate values of RECs in other RPS markets in the Northeast that are exhibiting scarcity of resources (e.g., MA, CT)
Class I RPS Average market price for Solar RECs	$150/MWh	$100/MWh	$250/MWh	• No rebate assumed for Central PV (>1MW). • $100/MWh is representative of recent prices for voluntary solar RECs (i.e., this is taken to represent a price floor) • $250/MWh represents assumed maximum price supported by the market (above this point, preference would be to pay the alternative compliance payment of $300/MWh)

1. At the time of writing, the House and Senate had passed two version of an extension to the PTC and the associated bills were in Conference Committee. The Senate version (S1637) would expand the credit to other technologies, including open-loop biomass, but at a reduced rate and for 5 years instead of ten years. The House version (HR4520) would simply extend the current credit.
2. Evolution Markets website, accessed in July 2004.

The competitiveness of grid-sited renewable energy is based on comparing the cost of production to the various revenue streams.

Basic Calculation of RE Competitiveness:[1]

RE cost premium = RE LCOE[2] – [(wholesale market price) + (wholesale capacity price) + (RPS REC price)]

- Positive values indicate the RE option is not cost effective
  - Either an additional premium is required as a revenue source or the costs must be reduced (e.g., via an up-front grant or lower cost financing)
- Negative values indicate the RE option is costs effective
  - Anticipated energy and capacity prices, plus the value of RECs from the RPS are sufficient to cover the cost of production
- In this analysis, it has been assumed that wind and solar power receive capacity payments equal to 20% of rated capacity.
  - Capacity prices ($/kW-yr) are converted to $/MWh using the assumed capacity factor for the RE option.
  - The value of capacity is expected to be relatively small (<$2/MWh) until after 2015.

1. In this analysis, which is only of renewable energy within New Jersey, the RPS REC price is taken as an input. If this were an analysis of the entire NJ RPS, then all of PJM would be considered and the output would be the required REC price needed to achieve a given level of renewable energy generation, based on the RE supply curve.
2. LCOE = Levelized cost of electricity, the total lifecycle cost of producing electricity, expressed in constant $2004.

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Digester gas from wastewater treatment and landfill gas offer the potential for the lowest electricity costs, followed by onshore wind power options.

Estimated Cost of Producing Electricity from Renewable Resources in New Jersey, No RECs or rebates

Class I Resource Option	Maximum MW in Block	Real Levelized Cost of Electricity for a Project Installed in the Year Shown ($/MWh in $2004)					
		2005	2006	2007	2008	2015	2020
Biogas from Wastewater Treatment - IC Engine Cogen	23	$ 28.23	$ 27.95	$ 27.66	$ 27.37	$ 26.36	$ 26.01
Landfill Gas- IC engine - collection system in place	51	$ 42.47	$ 41.86	$ 41.24	$ 40.63	$ 37.44	$ 37.44
Developer On-Shore Wind Class 4	10	$ 47.66	$ 45.74	$ 56.30	$ 54.45	$ 44.48	$ 39.14
Community-Owned On-Shore Wind Class 3	29	$ 53.67	$ 52.04	$ 50.44	$ 48.86	$ 40.32	$ 35.82
Landfill Gas- IC engine - no collection system in place	13	$ 51.71	$ 51.09	$ 50.47	$ 49.86	$ 46.67	$ 46.67
Developer On-Shore Wind Class 3	88	$ 59.27	$ 56.97	$ 67.16	$ 64.94	$ 52.84	$ 46.48
Biomass Gasification Combined Cycle - Low Fuel Price ($1.50/MMBtu)	38	N/A	N/A	N/A	$ 72.37	$ 62.36	$ 56.74
Biomass Direct Combustion - Low Fuel Price ($1.50/MMBtu)	20	$ 78.48	$ 77.50	$ 76.53	$ 75.58	$ 71.63	$ 69.87
Developer Off-Shore Wind Class 6	2,500	N/A	N/A	N/A	$ 88.91	$ 75.23	$ 69.75
Biomass Gasification Combined Cycle - Medium Fuel Price ($3.00/MMBtu)	30	N/A	N/A	N/A	$ 88.36	$ 77.41	$ 70.21
Biomass Gasification Combined Cycle - High Fuel Price ($4.00/MMBtu)	52	N/A	N/A	N/A	$ 99.02	$ 87.44	$ 79.19
Biomass Direct Combustion - Medium Fuel Price ($3.00/MMBtu)	16	$ 104.07	$ 102.67	$ 101.30	$ 99.95	$ 93.98	$ 91.56
Biomass Direct Combustion - High Fuel Price ($4.00/MMBtu)	21	$ 121.13	$ 119.45	$ 117.81	$ 116.20	$ 108.88	$ 106.02
Central Station PV	300	$ 445.18	$ 424.15	$ 403.12	$ 382.09	$ 267.10	$ 207.36

Notes:

- "Maximum MW in Block" is the Technical Potential as described earlier. Values may differ due to split among technology sub-categories.
- Estimates for developer-financed wind power projects includes the Federal PTC for 2005 and 2006 (20-year lifecycle value of $12.45/MWh)
- Initial costs for wind power projects includes an additional $50/kW for onshore and $100/kW for offshore to account for grid interconnection above assumed project costs. For small, community-financed projects, an additional $100/kW is added to account for the small scale expected (e.g., solitary turbines).
- For all wind options, an additional O&M charge of $4/MWh is added to account for various ongoing grid integration costs (e.g., scheduling, regulation, reserve requirements), consistent with several recent studies (see Appendix C).
- For landfill gas projects without collection systems, the collection system is assumed to cost an additional $500/kW over the base capital cost.
- Biogas from sewage treatment projects are assumed to be financed by municipalities.
- For biomass gasification combined cycle costs remain relatively uncertain, given the lack of operating experience with the technology.
- See Appendix A for detailed technology assumptions.

When the additional revenues from RECs are considered, several resources appear economically viable by 2008, even with modest REC prices.

- In in the *Base Case* scenario in 2008, biogas from wastewater treatment, landfill gas and some wind options (community-owned Class 3 and Developer-financed Class 4) are all economic. Developer-financed class 3 wind is marginal.
  - The remaining options require additional financial support (e.g., higher REC prices, grants, lower cost financing) to cover the additional premium.
  - For wind power, there is no Federal PTC assumed for projects developed in 2008. Options that are not economic in 2008 could actually be economic in 2005-2006, if the PTC is renewed in 2004.
- In the *Low Incentive and REC Price* scenario, only biogas from WWT, landfill gas at sites with existing collection systems and community owned wind are economic.
- In the *High Incentive and REC Price* scenario, most options are economic, including offshore wind power and the biomass options using low-cost feedstocks.

Note: A "negative premium" indicates that the revenue from energy sales, capacity sales and REC sales exceeds the cost to produce the electricity in that scenario. These projects can therefore be considered economic. However, just because a project has a "negative premium" does not guarantee that the project will be built.

When the additional revenues from RECs are considered, several resources appear economically viable by 2008, even with modest REC prices. (continued)

Estimated Cost Premium for Renewable Resources in New Jersey in 2008, with REC revenues

Class I Resource Option	Maximum MW in Block	Real Levelized Cost Premium per MWh of Electricity ($/MWh in $2004)		
		2008 Base Case	2008 Low Incentive and REC Price Case	2008 High Incentive and REC Price Case
Biogas from Wastewater Treatment - IC Engine Cogen	23	($35.91)	($21.91)	($60.91)
Landfill Gas- IC engine - collection system in place	51	($22.59)	($8.59)	($47.59)
Community-Owned On-Shore Wind Class 3	29	($16.01)	($2.01)	($41.01)
Developer On-Shore Wind Class 4	10	($13.36)	$0.64	($38.36)
Landfill Gas- IC engine - no collection system in place	13	($10.32)	$3.68	($35.32)
Developer On-Shore Wind Class 3	88	$0.07	$14.07	($24.93)
Biomass Gasification Combined Cycle - Low Fuel Price ($1.50/MMBtu)	38	$9.15	$23.15	($15.85)
Biomass Direct Combustion - Low Fuel Price ($1.50/MMBtu)	20	$12.36	$26.36	($12.64)
Developer Off-Shore Wind Class 6	2,500	$24.15	$38.15	($0.85)
Biomass Gasification Combined Cycle - Medium Fuel Price ($3.00/MMBtu)	30	$25.14	$39.14	$0.14
Biomass Gasification Combined Cycle - High Fuel Price ($4.00/MMBtu)	52	$35.81	$49.81	$10.81
Biomass Direct Combustion - Medium Fuel Price ($3.00/MMBtu)	16	$36.73	$50.73	$11.73
Biomass Direct Combustion - High Fuel Price ($4.00/MMBtu)	21	$52.98	$66.98	$27.98
Central Station PV	300	$182.19	$232.19	$82.19

Note: A "negative premium" indicates that the revenue from energy sales, capacity sales and REC sales exceeds the cost to produce the electricity in that scenario. These projects can therefore be considered economic. However, just because a project has a "negative premium" does not guarantee that the project will be built.

By 2020, NJ may have significant RE potential that is economic, depending on the REC price and the viability of offshore wind power.

- In in the *Base Case* scenario by 2020, biogas from wastewater treatment, landfill gas, onshore wind power (all options) and the low-cost solid biomass options (combustion and gasification) are all economic.
  - Offshore wind power is marginal as is biomass gasification with medium-priced biomass fuel.
- In the *Low Incentive and REC Price* scenario, only biogas from WWT, landfill gas and onshore wind power (all options) are economic.
- In the *High Incentive and REC Price* scenario, all options except for biomass combustion with high fuel prices are economic.
  - Central station PV, with a high solar REC price of $250/MWh is also economic in this scenario.

Note: A "negative premium" indicates that the revenue from energy sales, capacity sales and REC sales exceeds the cost to produce the electricity in that scenario. These projects can therefore be considered economic. However, just because a project has a "negative premium" does not guarantee that the project will be built.

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By 2020, NJ may have significant RE potential that is economic, depending on the REC price and the viability of offshore wind power. (continued)

Estimated Cost Premium for Renewable Resources in New Jersey in 2020, with REC revenues

Class I Resource Option	Maximum MW in Block	Real Levelized Cost Premium per MWh of Electricity ($/MWh in $2004)		
		2020 Base Case	2020 Low Incentive and REC Price Case	2020 High Incentive and REC Price Case
Biogas from Wastewater Treatment - IC Engine Cogen	23	($46.99)	($32.99)	($71.99)
Landfill Gas- IC engine - collection system in place	51	($35.19)	($21.19)	($60.19)
Community-Owned On-Shore Wind Class 3	29	($32.77)	($18.77)	($57.77)
Developer On-Shore Wind Class 4	10	($28.20)	($14.20)	($53.20)
Landfill Gas- IC engine - no collection system in place	13	($25.95)	($11.95)	($50.95)
Developer On-Shore Wind Class 3	88	($21.17)	($7.17)	($46.17)
Biomass Gasification Combined Cycle - Low Fuel Price ($1.50/MMBtu)	38	($13.08)	$0.92	($38.08)
Biomass Direct Combustion - Low Fuel Price ($1.50/MMBtu)	20	($1.87)	$12.13	($26.87)
Biomass Gasification Combined Cycle - Medium Fuel Price ($3.00/MMBtu)	30	$1.19	$15.19	($23.81)
Developer Off-Shore Wind Class 6	2,500	$2.84	$16.84	($22.16)
Biomass Gasification Combined Cycle - High Fuel Price ($4.00/MMBtu)	52	$10.69	$24.69	($14.31)
Biomass Direct Combustion - Medium Fuel Price ($3.00/MMBtu)	16	$20.14	$34.14	($4.86)
Central Station PV	300	$22.76	$72.76	($77.24)
Biomass Direct Combustion - High Fuel Price ($4.00/MMBtu)	21	$34.82	$48.82	$9.82

Note: A "negative premium" indicates that the revenue from energy sales, capacity sales and REC sales exceeds the cost to produce the electricity in that scenario. These projects can therefore be considered economic. However, just because a project has a "negative premium" does not guarantee that the project will be built.

In the *Base Case* Scenario, it is estimated that up to 119 MW could be developed by 2008, and 241 MW by 2020 (the market penetration).

- Based on attractive economics and relative ease of siting, the LFG and biogas options could be developed rapidly.
- Onshore wind is economic in this scenario but is expected to develop more slowly, due in part to siting issues.
- In this scenario, offshore wind is not expected to be economically competitive, absent additional incentives or supports.

Cumulative MW Market Penetration

Resource Option	Total MW in Block	2005	2006	2007	2008	2015	2020
Community-Owned On-Shore Wind Class 3	29	1	3	6	12	29	29
Developer On-Shore Wind Class 3	88	4	9	19	35	88	88
Developer On-Shore Wind Class 4	10	0	1	2	4	10	10
Developer Off-Shore Wind Class 6	2,500	-	-	-	-	-	-
Biomass Direct Combustion - Low Fuel Price ($1.50/MMBtu)	20	-	-	-	-	-	16
Biomass Direct Combustion - Medium Fuel Price ($3.00/MMBtu)	16	-	-	-	-	-	-
Biomass Direct Combustion - High Fuel Price ($4.00/MMBtu)	21	-	-	-	-	-	-
Biomass Gasification Combined Cycle - Low Fuel Price ($1.50/MMBtu)	38	-	-	-	-	-	11
Biomass Gasification Combined Cycle - Medium Fuel Price ($3.00/MMBtu)	30	-	-	-	-	-	-
Biomass Gasification Combined Cycle - High Fuel Price ($4.00/MMBtu)	52	-	-	-	-	-	-
Landfill Gas- IC engine - collection system in place	51	2	8	24	40	51	51
Landfill Gas- IC engine - no collection system in place	13	1	2	6	10	13	13
Biogas from Wastewater Treatment - IC Engine Cogen	23	1	4	11	18	23	23
Central Station PV	300	-	-	-	-	-	-
Total MW (Cumulative)	3,192	9	27	67	119	214	241

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In the *Low Incentive & REC Price* scenario, it is estimated that 65 MW could be developed by 2008 and only 196 MW by 2020.

- In this scenario, landfill gas accounts for more than 60% of the Class I grid-sited capacity by 2008.
  - — Biogas from sewage treatment and onshore wind make up the rest
- Neither offshore wind power nor solid biomass power are expected to be developed in this scenario.

Cumulative MW Market Penetration

Resource Option	Total MW in Block	2005	2006	2007	2008	2015	2020
Community-Owned On-Shore Wind Class 3	29	-	1	3	6	29	29
Developer On-Shore Wind Class 3	88	-	-	-	-	-	69
Developer On-Shore Wind Class 4	10	-	-	-	-	9	10
Developer Off-Shore Wind Class 6	2,500	-	-	-	-	-	-
Biomass Direct Combustion - Low Fuel Price ($1.50/MMBtu)	20	-	-	-	-	-	-
Biomass Direct Combustion - Medium Fuel Price ($3.00/MMBtu)	16	-	-	-	-	-	-
Biomass Direct Combustion - High Fuel Price ($4.00/MMBtu)	21	-	-	-	-	-	-
Biomass Gasification Combined Cycle - Low Fuel Price ($1.50/MMBtu)	38	-	-	-	-	-	-
Biomass Gasification Combined Cycle - Medium Fuel Price ($3.00/MMBtu)	30	-	-	-	-	-	-
Biomass Gasification Combined Cycle - High Fuel Price ($4.00/MMBtu)	52	-	-	-	-	-	-
Landfill Gas- IC engine - collection system in place	51	2	8	24	40	51	51
Landfill Gas- IC engine - no collection system in place	13	-	-	-	-	13	13
Biogas from Wastewater Treatment - IC Engine Cogen	23	1	4	11	18	23	23
Central Station PV	300	-	-	-	-	-	-
Total MW (Cumulative)	3,192	3	14	37	65	125	196

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In the *High* incentive & REC price scenario, it is estimated that 238 MW could be developed by 2008. Capacity could expand rapidly beyond then if the price of RECs is maintained at $45/MWh.

- Based on attractive economics and relative ease of siting, the LFG and biogas options could be developed rapidly.
- Onshore wind power is economic in this scenario but is expected to develop slowly, due in part to siting issues.
- Offshore wind power is also economic in this scenario.
- Beyond 2008, if the high REC prices are sustained, market penetration could increase rapidly.

Cumulative MW Market Penetration

Resource Option	Total MW in Block	2005	2006	2007	2008	2015	2020
Community-Owned On-Shore Wind Class 3	29	1	3	6	12	29	29
Developer On-Shore Wind Class 3	88	4	9	19	35	88	88
Developer On-Shore Wind Class 4	10	0	1	2	4	10	10
Developer Off-Shore Wind Class 6	2,500	-	-	-	110	1,250	2,250
Biomass Direct Combustion - Low Fuel Price ($1.50/MMBtu)	20	1	2	4	8	20	20
Biomass Direct Combustion - Medium Fuel Price ($3.00/MMBtu)	16	-	-	-	-	-	13
Biomass Direct Combustion - High Fuel Price ($4.00/MMBtu)	21	-	-	-	-	-	-
Biomass Gasification Combined Cycle - Low Fuel Price ($1.50/MMBtu)	38	-	-	-	2	19	34
Biomass Gasification Combined Cycle - Medium Fuel Price ($3.00/MMBtu)	30	-	-	-	-	12	26
Biomass Gasification Combined Cycle - High Fuel Price ($4.00/MMBtu)	52	-	-	-	-	-	15
Landfill Gas- IC engine - collection system in place	51	2	8	24	40	51	51
Landfill Gas- IC engine - no collection system in place	13	1	2	6	10	13	13
Biogas from Wastewater Treatment - IC Engine Cogen	23	1	4	11	18	23	23
Central Station PV	300	-	-	-	-	-	88
Total MW (Cumulative)	3,192	10	29	71	238	1,515	2,660

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Rutgers University's Center for Energy, Economic and Environmental Policy (CEEEP) has been charged by the New Jersey Board of Public Utilities (BPU) to oversee an assessment of market opportunities for Renewable Energy (RE).

- The New Jersey BPU is responsible for determining the appropriate levels of funding for RE programs to be supported by the Societal Benefits Charge (SBC).
- The New Jersey Clean Energy Program goals include:
  - Make New Jersey the world leader for the promotion and use of clean RE.
  - Accelerate its use of renewable energy in support of clean energy and energy security objectives.
  - Transform the energy marketplace to allow for direct competition between renewable energy and conventional energy sources.
- In addition New Jersey has set specific targets for Class I renewables among its goals:
  - Construct 300 MW of new Class I renewable energy capacity in New Jersey by 2008
  - Increase electricity production of solar energy to at least 120,000 MWh per year in 2008 in New Jersey (equivalent to 90 MW).[1]
  - By 2020, 20% of demand sourced from Class I renewables

1. This is the current RPS goal for the solar set-aside. The other quantitative goals listed here are separate from the current RPS.

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NCI used a six-step approach to help the New Jersey BPU assess the market potential for Class I RE resources and recommend program priorities.

Project Initiation
- Kick-off meeting
- Align on project goals/objectives
- Identify information sources
- Agree to Work Plan

Knowledge Base
- Reliance primarily on existing information for RE
- 1999 Xenergy study
- NCI's 2003 renewable energy multi-client study
- New Jersey and U.S. laws/regulations
- Market/industry conditions in New Jersey
- Existing New Jersey programs

Technology Characterization and Screening[1]
- Desk research
- Interviews[2]
- Review existing data/information on RE technologies
- Develop screening criteria
- Characterize viable technologies

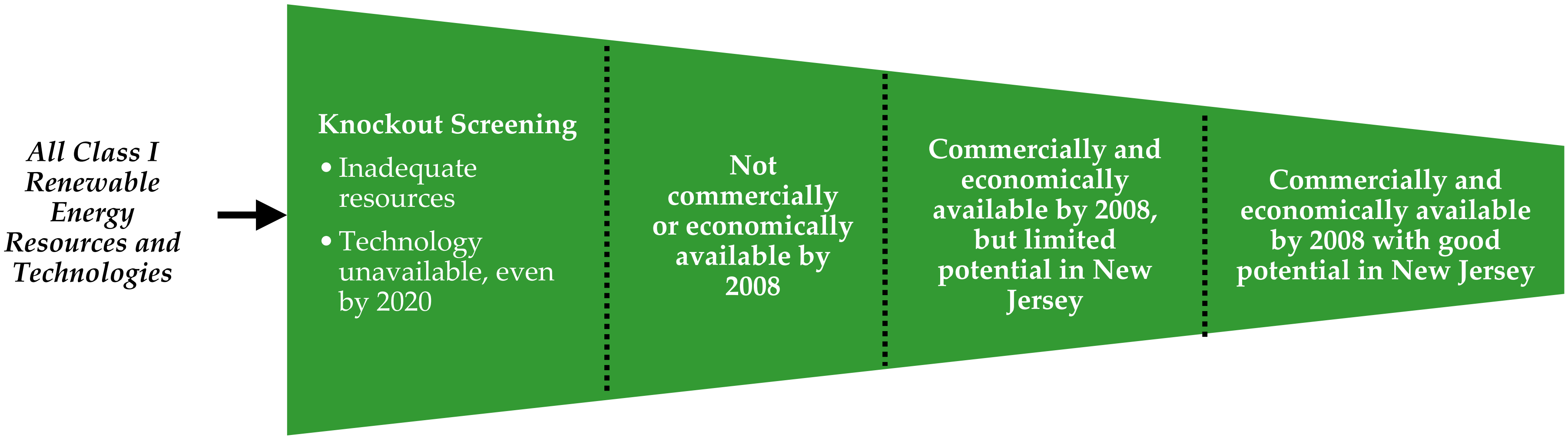
Market Potential
- Grid-connected technologies
- Customer-sited technologies
- Theoretical potential (independent of infrastructure, market & cost barriers)
- Technical potential (independent of cost barriers)

Market Forecasts
- Market potential based on economics and market penetration
- Develop supply curves for priority technologies
- Apply NCI's market penetration methodology
- Forecast market potential to 2008, 2015, 2020

Program Priorities
- Undertake gap analysis vs. New Jersey Clean Energy Program goals
- Apply screening criteria
- Assemble and recommend RE program options

1. Detailed technology profiles are given in Appendix A.
2. Including "lessons learned" from six states with RE programs. See Appendix B for details.

The NCI team adopted a structured screening approach to assessing the market for renewable energy in New Jersey and to aid in identifying RE portfolio priorities for the New Jersey Clean Energy Program.



Scope of Analysis:	Not Included for Further Analysis	Brief Descriptions		Detailed Market Assessment
Relevance for New Jersey Clean Energy Program:	Not Relevant	Monitor for future funding, including RD&D	Fund projects as opportunities present themselves	Primary options for near-to-medium term deployment

As part of Project Initiation, NCI and CEEEP agreed to certain definitions to be used in the screening process.

- **Theoretical Potential**: describes the total resource potential unconstrained by land use considerations or other non-economic factors
- **Technical Potential**: screens out resources that cannot be accessed due to non-economic reasons (e.g., land use restrictions on wind, agricultural residues that must be left in the field to preserve soil quality)
- **Economic Potential**: screens out resources that cannot be developed because they are "substantially" more expensive than competing options
  - For customer-sited PV, this was part of the market penetration analysis (See "market penetration" below)
  - For all other generation technologies, an RE "supply curve" approach was used
- **Market Penetration:** Estimates the diffusion of renewables into the marketplace under "business as usual" (BAU) and other conditions.
- **Geographic Boundaries**
  - This is an assessment of resources within New Jersey
  - Although resources outside of New Jersey are eligible for the New Jersey RPS, for the purposes of the Clean Energy Program, we assume that in-state resources have priority.
- **Business As Usual** means:
  - Current Clean Energy Program activities and funding levels
  - Renewal of the Federal production tax credit (PTC) in its current proposed form in pending legislation (through the end of 2006). No extension beyond current three year period in proposed legislation.

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Based on the final RPS rules (NJAC 14:4-8, effective April 19, 2004), Class I Renewable Technologies are technologies that produce electricity, and include:

- Solar thermal electric
- Photovoltaics
- Wind energy
- Fuel cell that use renewable fuels
- Geothermal technology
- Wave or tidal action
- Landfill methane gas
- Biomass, provided it is cultivated and harvested in a sustainable manner
  - It is NCI's understanding that biomass co-firing (e.g., with coal at an existing coal plant) is explicitly excluded from the Class I definition.

Class I Biomass was further defined, per the final RPS rules (NJAC 14:4-8), effective April 19, 2004:

- Eligible without needing prior approval:
  - Electricity generated by the combustion of methane gas captured from a landfill
  - Electricity generated by a fuel cell powered by methanol, ethanol, landfill gas, digester gas, biomass gas, or other renewable fuel.
  - Electricity generated by the combustion of gas from the anaerobic digestion of food waste and sewage sludge at a biomass generating facility
- Electricity produced through combustion of the following types of biomass, provided that the New Jersey DEP provides Board staff with a biomass sustainability determination:
  - A bioenergy crop, as defined at N.J.A.C. 14:4 -8.2, including wood produced at a biomass energy plantation
  - Wood from the thinning or trimming of trees and/or from a forest floor, provided that the wood is not old-growth timber, as defined at N.J.A.C. 14:4-8.2; and that the wood is unadulterated by non-cellulose substances or material
  - Gas generated by anaerobic digestion of biomass fuels other than food waste and sewage sludge, including bioenergy crops and agricultural waste
  - Either of the following types of wood, provided that the wood is unadulterated by non-cellulose substances or material:
    - Ground or shredded pallets or other scrap wood, with all nails and other metal removed, produced at a facility that is classified as a Class B recycling facility by the New Jersey Department of Environmental Protection's Bureau of Landfill and Recycling Management, or at an equivalent recycling facility approved by the state environmental agency in which the facility is located; or
    - Wood shavings and/or scrap from a lumberyard or a paper mill, excluding black liquor, as defined at N.J.A.C. 14:4 -8.2.
- A sustainability determination is not required in the case of "plant matter that is not used directly as biomass fuel, but is subject to alteration after its harvest and before its use as biomass fuel." We interpret this to include potential feedstocks such as agricultural residues.

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NCI first addressed all RE *resources* and *technologies* in a structured manner, consistent with the Class I definition.

Class I Renewable Energy Resource	Conversion Option	Technology Type
Solar	Solar Thermal	**Parabolic trough**
		Power tower
		Dish Stirling
	Photovoltaics	**Flat plate: crystalline silicon and thin films**
		Concentrating PV
		Nano solar cells
Wind Power		**Onshore – grid sited** (wholesale generation)
		Onshore – customer sited ("behind the meter")
		Offshore
Geothermal Power		**Flash**
		Binary
		Hot dry rock
Ocean Energy		**Wave**
		Tidal and tidal current
		Ocean Thermal

NCI addressed renewable energy *resources* and *technologies* in a structured manner consistent with the Class I definition. (continued)

Class I Renewable Energy Resource		Conversion Option	Technology Type
Solid Biomass	• Wood • Wood waste • Agricultural residues • Food processing residues • Animal wastes	Direct Combustion	Biomass-only Rankine (steam) Cycle
		Gasification[1]	Biomass-only Rankine Cycle
			Biomass-only GT/IGCC
			Biomass-only IC Engine (ICE)
			Biomass-only Fuel Cell
		Liquefaction (Pyrolysis)	Biomass-only Pyrolysis (Rankine, GT, ICE)
Gaseous Biomass	• Landfill gas • Methane from waste and wastewater treatment	Direct Combustion/ Conversion	Biomass-only Rankine Cycle
			Biomass-only GT, GTCC, ICE
			Biomass-only Fuel Cell
Renewable Hydrogen		Derived from wind, solar or biomass	Fuel Cells, IC engines

Note: GT = gas turbine, GTCC = gas turbine combined cycle; IGCC = integrated gasification combined cycle, ICE = internal combustion engine.

1. Gasification could also be used as a "front end" to exiting coal, oil or gas-fired plants in a co-firing configuration.

Seven renewable energy technologies passed through the screening to detailed market assessment.

All Class I Renewable Energy Resources and Technologies →

Knockout Screening
- Inadequate resources
- Technology unavailable, even by 2020

→
- Geothermal power
- Ocean thermal
- Solar thermal electric

Not commercially or economically available by 2008

→
- Landfill gas, biogas and biomass gasification with fuel cells
- Biomass pyrolysis
- Tidal and wave power
- Concentrating PV
- Nano solar cells
- Renewable hydrogen

Commercially and/or economically available by 2008, but limited potential in New Jersey

→
- Customer sited wind power
- Biogas from anaerobic digestion of animal waste (except fuel cells)

Commercially and economically available by 2008 with good potential in New Jersey

→
- Onshore wind power – grid sited
- Offshore wind power
- Photovoltaics (customer-sited)
- Photovoltaics (central station)
- Solid biomass combustion and gasification (except fuel cells)
- Landfill gas (except fuel cells)
- Biogas from wastewater treatment (except fuel cells)

Scope of Analysis:	Not Included for Further Analysis	Brief Descriptions		Detailed Market Assessment
Relevance for New Jersey Clean Energy Program:	Not Relevant	Monitor for future funding, including RD&D	Fund projects as opportunities present themselves	Primary options for near-to-medium term deployment

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Seven renewable energy technologies passed through the screening to detailed market assessment. (continued)

● Good ⦿ Fair ○ Poor

	New Jersey Resource Availability	New Jersey Commercial Potential by 2008	New Jersey Economics by 2008	Analysis Level
Onshore wind power – grid sited	○/⦿	●	⦿	1
Offshore wind power	●	⦿	⦿	1
Photovoltaics – Customer-Sited	●	●	⦿	1
Photovoltaics – Central Station	⦿	●	○	1
Solid biomass combustion and gasification (except with fuel cells)	⦿	⦿	⦿	1
Landfill gas	⦿	●	●	1
Biogas (except fuel cells)	⦿	●	●	1

Analysis Level: 1 – Detailed Market Assessment; 2 – Brief Description; 3 – Not Included

See Appendix A for descriptions of the Level 1 and Level 2 options.

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The remaining technologies were considered marginal for New Jersey at the present time (analysis level 2) or simply not a fit (level 3).

● Good ◉ Fair ○ Poor

	New Jersey Resource Availability	New Jersey Commercial Potential by 2008	New Jersey Economics by 2008	Analysis Level
Customer-sited wind power	○	◉	○	2
Concentrating PV	○	○/◉	○/◉	2
Nano solar cells	●	○	○	2
Wave power	◉	○	◉	2
Tidal power	◉	○	◉	2
Solid biomass – gasification with fuel cells	◉	○	○	2
Biomass pyrolysis	◉	○	○	2
Biogas with fuel cells	◉	○	○	2
Renewable Hydrogen	◉	○	○	2
Geothermal power	○	○	○	3
Solar thermal electric	○	○	○	3
Ocean thermal electric (OTEC)	○	○	○	3

Analysis Level: 1 – Detailed Market Assessment; 2 – Brief Description; 3 – Not Included
See Appendix A for descriptions of the Level 1 and Level 2 options.

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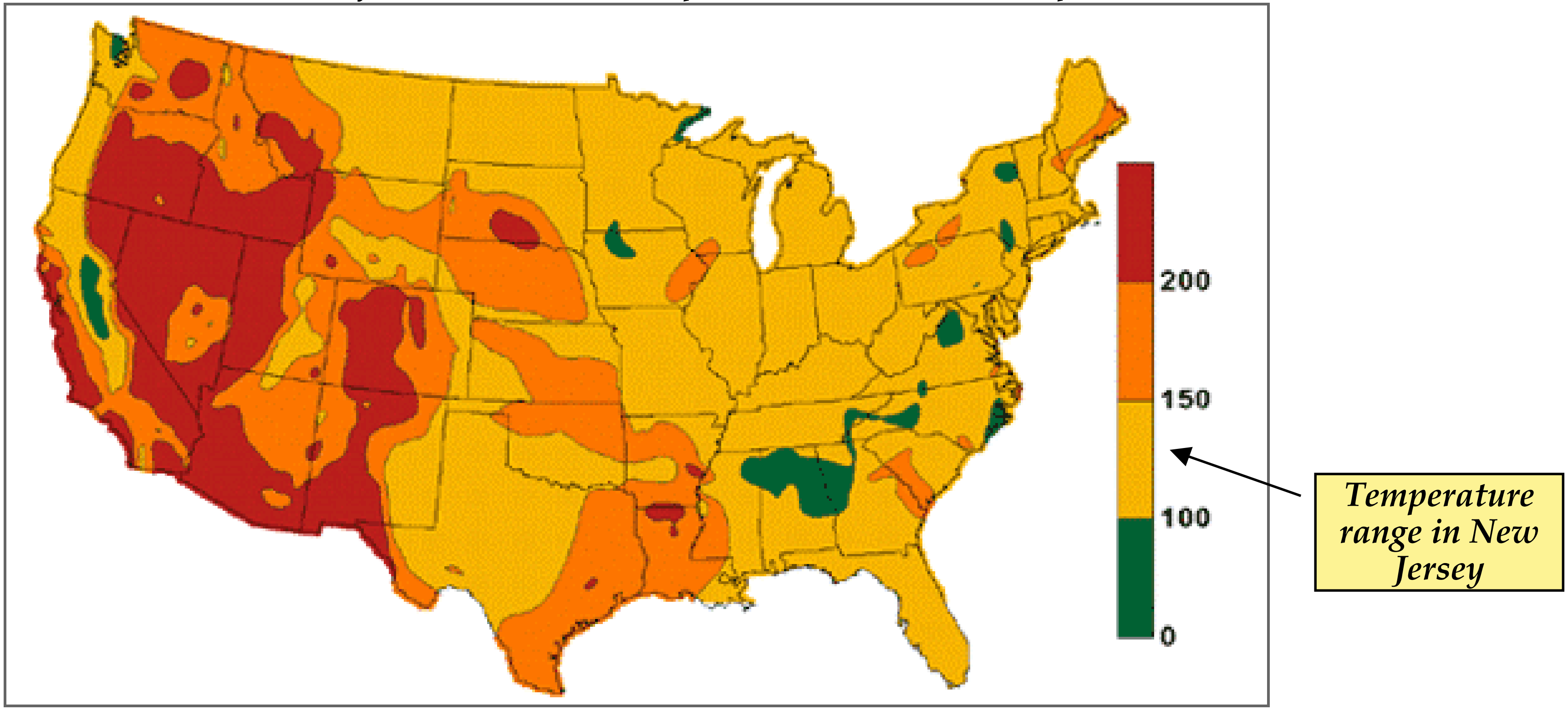
Known geothermal resources suitable for power generation are limited to a few western states. Temperatures in New Jersey are too low for power production. Opportunities are limited to ground-source heat pumps.

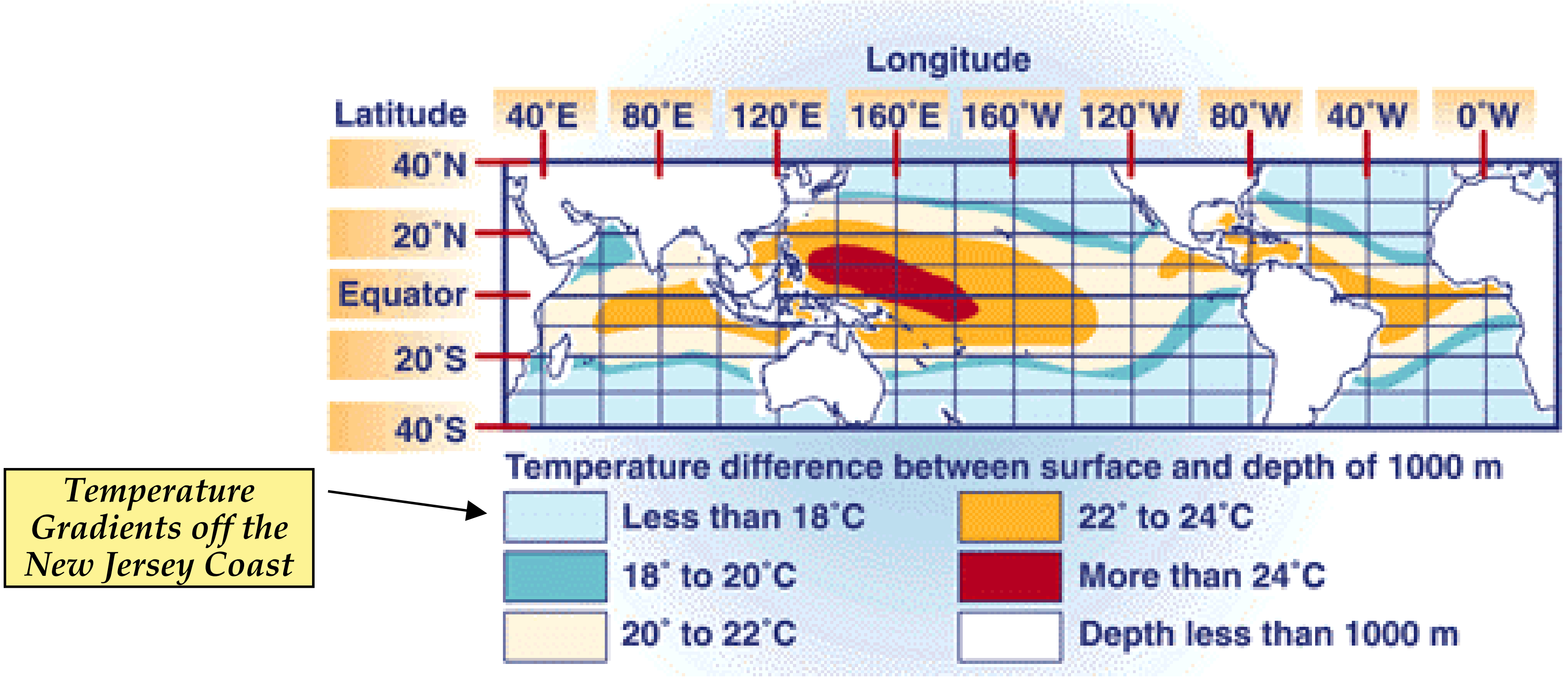
Estimate of the Earth's temperature at 6 km depth



Source: US DOE, Office of Energy Efficiency and Renewable Energy.

When the technology becomes commercially available, ocean thermal energy conversion will be limited to waters with thermal gradients >20^{o}C, i.e., the tropics or sub-tropics.

Temperature Gradients in the World's Oceans

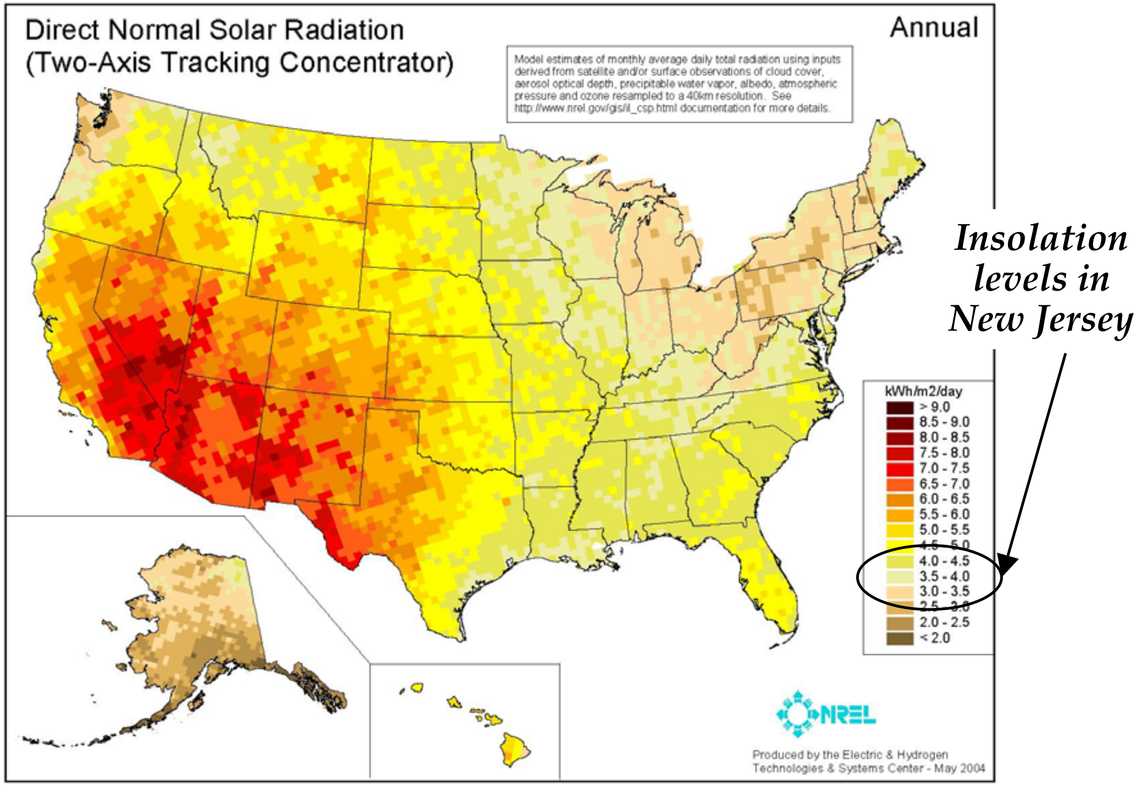


Source: National Renewable Energy Laboratory.

Solar thermal electric requires high levels of direct solar insolation characteristics of the southwest.

*Direct Normal Solar Radiation – Annual Average**

- While technically feasible in New Jersey, concentrating solar technologies require high levels of direct insolation and does not make use of most *diffuse* insolation (e.g., as on cloudy days).
- Flat plate photovoltaics can use both direct and diffuse, and is therefore suitable for use anywhere in the United States.



Source: National Renewable Energy Laboratory, Renewable Resource Data Center.

* The insolation values represent the resource available to concentrating systems that track the sun throughout the day. Such systems include concentrating solar power stations such as trough collectors or dishes. Cloud cover is factored into the data.

Several renewable energy resources have been excluded from detailed analysis for a variety of reasons.[1]

RE Resources that are Marginal for New Jersey by 2008	
Option	**Reasons for Exclusion from Detailed Consideration**
Onshore wind – customer sited	• Limited market potential given the limited land area available near customer sites.
Biogas from Animal Waste	• The technology is relatively mature but the total opportunity in New Jersey is limited to about 2-4 MW by the small number and size of animal farms in the state.
Concentrating PV	• Requires high direct solar insolation (e.g., similar to locations in AZ). In contrast, flat plate PV technologies can work with both direct and diffuse sunlight (i.e., they will work on cloudy days). Often need to track the sunlight for economic performance with one- or two-axis trackers. Given the nature of the solar resource in New Jersey, this technology is not well suited.
Nano Solar Cells	• Limited by low efficiency and raw material cost issues, requiring further technology breakthroughs.
Biomass Pyrolysis	• Biomass pyrolysis technology is still in the R&D/early demonstration phase and progressing relatively slowly. There is more attention focused on gasification than pyrolysis.

1. Brief profiles of these options are given in Appendix A.

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Several renewable energy resources have been excluded from detailed analysis for a variety of reasons.[1] (continued)

RE Resources that are Marginal for New Jersey by 2008	
Option	**Reasons for Exclusion from Detailed Consideration**
Landfill gas, biogas and biomass gasification with fuel cells	• Some fuel cell technologies have been successfully demonstrated on biogas and landfill gas, but costs are expected to remain much higher than incumbent technologies through 2008 and commercialization timelines remain uncertain. • Biomass gasification is in the commercial demonstration phase with boilers and gas turbines. Integration with fuel cells will first require successful integration with gas turbines and further development in fuel cells.
Tidal and Wave Power	• To NCI's knowledge, tidal power sites are not available that would be economically viable. • Wave power technology is limited in operational experience, and economic viability in the near-term is questionable for available sites in New Jersey.
Renewable Hydrogen	• Renewable hydrogen can be derived from any renewable electricity source via electrolysis and biomass gasification. None of these processes are economically feasible or being implemented on a commercial basis today. Renewable hydrogen markets will likely develop slowly in the near term, as is expected in general for the hydrogen energy economy.

1. Brief profiles of these options are given in Appendix A.

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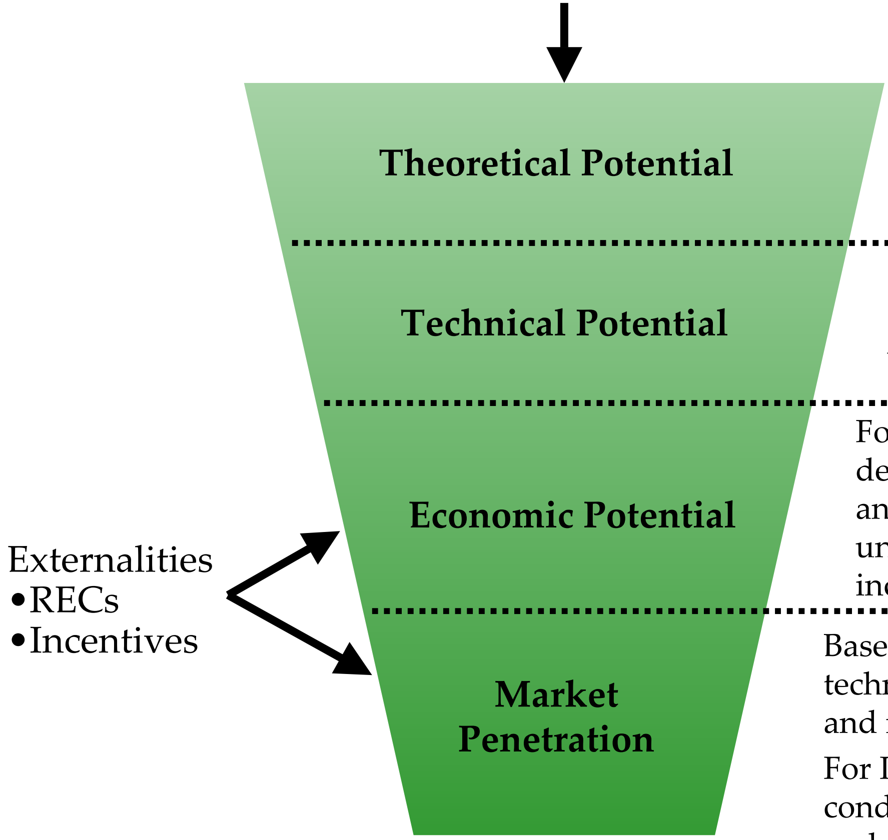
V. Technical Potential and Market Forecasts to 2020

The assessment of market penetration followed a successive evaluation to go from theoretical potential to market penetration.

Priority Class I Renewable Energy Technologies and Resources (from initial screening)



Total resource potential unconstrained by land use considerations or other non-economic factors. Conducted on a technology-by-technology basis.

Screens out resources that cannot be accessed due to non-economic reasons (e.g., land use restrictions). Approach varies by technology.

For the wholesale tier, screens out resources that cannot be developed because they are more expensive than competing options and then estimates the diffusion of renewables into the marketplace under "business as usual" conditions. Includes impacts of RECs and incentives in different scenarios.

Based on the economic potential, estimates the diffusion of the technology into the marketplace considering the relative economics and maturity of the options.

For PV, the economic potential and the market penetration were conducted as a single integrated step. Includes the impacts of RECs and incentives in different scenarios.

Wholesale (grid-sited) and retail (customer-sited) technologies were assessed separately.

Wholesale (Grid-Sited) RE Technologies[1]	Retail (Customer Sited) RE Technologies (Photovoltaics)
• Estimated the technical potential separately for each option. • Estimated the cost of electricity for the different RE technologies over time. • Using the technical potential estimates and economics, built a renewable energy supply curve that ranks the options from least to most expensive. • Compared the supply curve to the expected wholesale market price for power in different years (energy and capacity) to determine the quantity of renewables that are cost-effective. – Included an assumed value for RECs under the RPS, to determine the additional support, if any, required through the New Jersey Clean Energy Program. • For the cost-effective capacity, estimated the market penetration.	• Used NCI's market penetration model to forecast market penetration of PV under different scenarios for REC prices and state incentive levels. – The approach is described later in this section. • For anaerobic digestion of animal waste, the potential is small (~2.6 MW) and is reviewed in Appendix A along with the technology characterization.

1. The supply curve approach and framework was adapted from previous work conducted by Sustainable Energy Advantage LLC (which was a part of the NCI team) and LaCapra Associates.

Onshore wind resources in New Jersey are good (Class 3 and 4 winds[1]) in locations near the coast, but generally limited elsewhere.

- Almost all the Class 3[1] or better wind resources can be found along the coastline.
  - Most of this potential is in land designated as wetlands, followed by "barren land" (mostly beaches
- There are a couple of distinct "ridgelines" at the north end of the state which are the only significant non-shoreline wind resources. Much of this land is labeled as forest according to the land use classification.
- Virtually the entire coastline, with the exception of areas that are particularly sheltered, could be considered potential for small, community-based turbine clusters.
- After factoring in land exclusions the estimated technical potential is 127MW.

Photo courtesy National Renewable Energy Laboratory

1. Higher wind class is better, with Class 3 typically considered the minimum required for wind power development. At 50m wind speeds: Class 6 = 8-8.5 m/s (17.9-190 mph); Class 4 = 7 – 7.5m/s (15.7 – 16.8 mph); Class 3 = 6.4 - 7m/s (14.3 – 15.7 mph)

The wind potential in New Jersey has been estimated from GIS data using the following approach.

- **Theoretical wind resources were computed via GIS analysis with two data layers:**
  - AWS TrueWind wind resource maps at 50m. Provides wind class estimates for all of New Jersey at a spatial grid resolution of 200 meters (656 ft, or one-eighth mile)
  - New Jersey DEP 1995/1997 Land Use / Land Cover data layer. The data layer has a minimum mapping unit of 1 acre.

- **Steps in computation**:
  1. Compute the amount of area (in sq. km) of Class 3 and Class 4 wind resources for each major land use category: Agriculture, Barren Land (mostly beaches), Forest, Urban, Water, Wetlands.
  2. Estimate land exclusion. There are no explicit regulations prohibiting wind turbine development, but to assume maximum build (i.e., 100% of land with Class 3 or 4 resources) is unrealistic. The NCI team has assigned the NREL default maximum build-out factor to each land-use category, as follows: Agriculture 70%; Forest 100% (50% for non-ridge crest, but we have assumed that all is ridge crest in New Jersey); Urban & Wetlands 0%. For Barren land we have also assumed 100%, although in reality this number may be lower.
  3. Compute the adjusted available Class 3 and Class 4 wind resources.
  4. Assign the current maximum MW build out per sq. km. Assume a GE 1.5sl turbine (1.5 MW with 77m rotor diameter). Maximum build-out is based on turbine spacing of 4x rotor diameter intra-row, and 8x rotor diameter inter-row. Results in ~5 turbines/km^2, or 7.5 MW/km^2. Assume Class 3 land will have a capacity factor of 29%, and Class 4, 35% (see Appendix A). Compute the theoretical MWhs by multiplying 7.5 MW: 19,053 MWh/year/ km^2 for Class 3, and 22,995 MWh/year/ km^2 for Class 4.
  5. Compute the theoretical potential by multiplying Step 3 and Step 4 results.

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There are some additional considerations for wind power, when estimating market potential.

- **Turbine sizes will increase over time**. This may increase the total MW potential. However, with larger turbines, fewer can be placed on a given land area, which offsets this size trend and is not expected to have a major impact of power density.
  - For the purposes of this study, we have not accounted for any changes in wind power density (MW/km2), but the improving economics of wind power, driven in part by the trend to larger turbines, is captured in the renewable energy supply curve analysis.
- **Increased wind turbine efficiency and capacity factor** will result in more generation (MWh) per square km for a given power density, depending on when the project is developed (i.e., it is static for a given project, but will be higher for projects developed later in time).
  - This effect is captured in the renewable energy supply curve analysis.
- **It matters when the wind blows** when computing the cost competitiveness of wind power. Energy generated during on-peak hours is worth more than energy generated off-peak.
  - The methodology for estimating this is given in Appendix A and this effect is captured in the renewable energy supply curve analysis.
- **Competing land uses** will decrease the available area for wind power development over time.
  - While the GIS analysis factors in land exclusions, it does not attempt to adjust these exclusions over time.

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Wind resources in New Jersey are expected to have a production profile that matches peak and off-peak periods relatively well.

- The fraction of wind power production that is expected to occur on-peak in both summer and winter exceeds the average number of hours in that time block.
- This finding is consistent with the recently completed New Jersey offshore wind study, which found that offshore wind power output would likely correlate relatively well with peak summer electric load, even though average wind energy output in summer will be lower than in other seasons. The study noted that relatively high output levels could still be achieved on hot summer days during peak demand periods due to the influences of the sea breeze.
- That study looked at the top ten peak load days from 1999-2003 and compared that to measured wind conditions at the Ambrose Light Station (located 8 miles off the northern New Jersey coast). It concluded that average wind plant output would increase sharply beginning near noon, peaking in the late afternoon and early evening when the electric demand also peaks. These results indicate that offshore wind energy can have good load matching value, particularly on peak load days in summer.

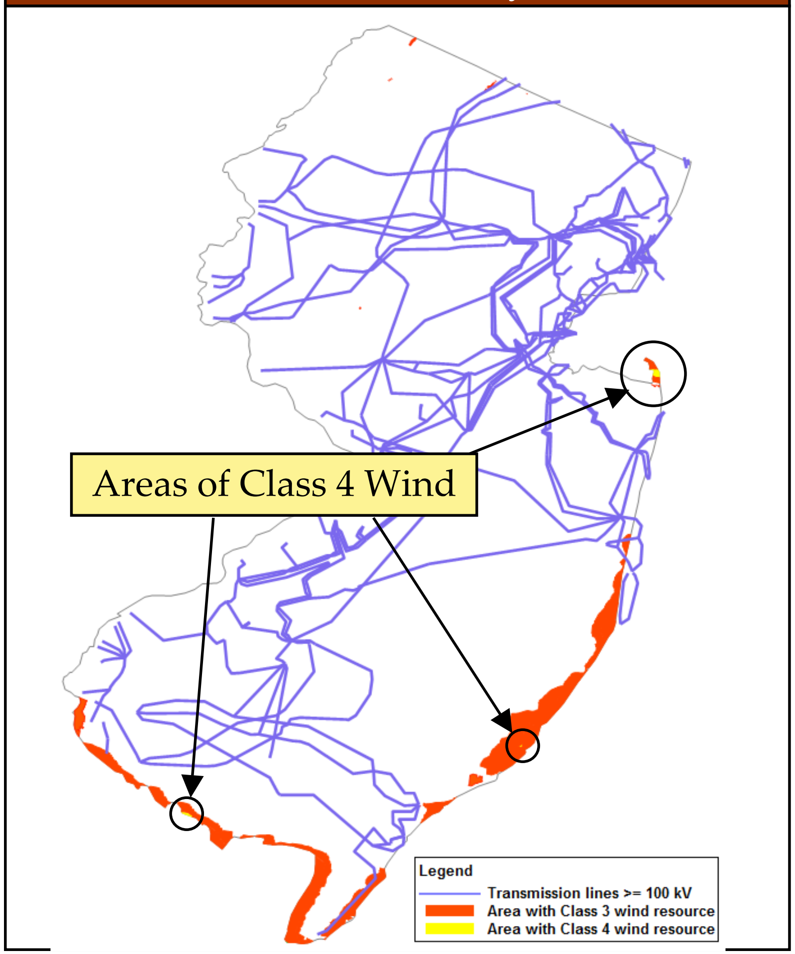
		Percent of Time by Period	
		Summer	Non-Summer
Actual Breakdown of Hours	Peak Hours	13.6%	26.5%
	Off-Peak Hours	19.8%	40.0%
Estimated Class 3 Onshore Wind Farm Output	Peak Hours	16.5%	32.3%
	Off-Peak Hours	16.9%	34.3%

Note:

- Peak Days: All Weekdays, excluding Holidays
  - Holidays: New Year's, MLK, President's, Memorial, Independence, Labor, Columbus, Thanksgiving, Christmas.
- Peak Hours: 8am through 10pm (14 hours/day)
- Summer Months: June, July, August, and September

Virtually all New Jersey onshore wind power potential is Class 3 and along the coast.

New Jersey Wind Resources Based on GIS Analysis



- Almost all the Class 3 or better wind resources can be found along the coastline.
  - Most of this potential is in land designated as wetlands
- Very small amounts of Class 4 can be found along the barrier islands and at the far southern tip, but are highly localized.
- There appears to be a limited amount of Class 3-4 wind in the interior portions of New Jersey, mainly in the Northern part of the state.
- There are a couple of distinct "ridgelines" at the north end of the state which are the only significant non-shoreline wind resources. Much of this land is labeled as forest according to the land use classification.
- Virtually the entire coastline, with the exception of areas that are particularly sheltered, could be considered potential for small, community-based turbine clusters.

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There is about 130 MW of technical potential for onshore wind power in NJ, after factoring in wind resource data and land exclusions.

Results of the GIS Analysis – Onshore Wind Power Potential in New Jersey					
Land Type	Class 3+ Available Land (Theoretical Potential)		Fraction Available that is included	Technical Potential (post land-use inclusion screen)	
	Square km	MW		MW	GWh/yr[1]
Agriculture	0.2	1.3	70%	0.9	2.3
Barren Land[2]	16.0	119.9	50%	60.0	152.3
Forest[3]	7.1	53.5	100%	53.5	135.9
Urban	48.3	362.6	0%	0.0	0.0
Wetlands[4]	174.0	1,305.1	1%	13.1	33.2
Total	**245.7**	**1,842.4**		**127.4**	**323.7**

	New Jersey Onshore Wind Power Technical Potential			
	2005	2008	2015	2020
MW	127.4	127.4	127.4	127.4
MWh per year	323,675	332,604	345,997	352,694

1. GWh computation assumes a 29% capacity factor and no line losses
2. 15.6 of 16.0 sq. km (97.5%) of the barren land is defined as beaches. Established national assumptions for barren land is to include 100%, but here 50% has been assumed since most barren land in NJ is beaches.
3. All forest is ridge crest (if forest is non-ridge crest, then PNL assumes 50% exclusion)
4. See the next page for a more detailed discussion of inclusion of wetlands in the technical potential.

Source: Analysis by NCI and Boreal Renewable Energy, based on GIS modeling by Global Energy Concepts.

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The established exclusion for wetlands is 100%. However, wetlands are by far the single largest land class with suitable wind regimes in New Jersey, suggesting a closer examination is warranted.

- Of the total 174.0 square km of wetlands, 94.25% are either saline marshes or vegetated dune communities. The likelihood of siting a wind turbine in a vegetated dune community is likely close to 0%. Siting in a saline marsh would be similarly difficult. It would disturb the area around where the turbine is located and there would also be a need for access roads. In addition, saline marshes may be important bird habitat, and perhaps migratory bird habitat. So for saline marshes the possibility of siting a wind turbine is also likely close 0%.
- For the remaining 5.75% of wetlands, it will still be difficult to site a wind turbine, but assuming that 10% may be suitable, this suggests that 0.575% of wetlands could support wind turbine development. For the purposes of the analysis here, we have rounded this up to 1%.

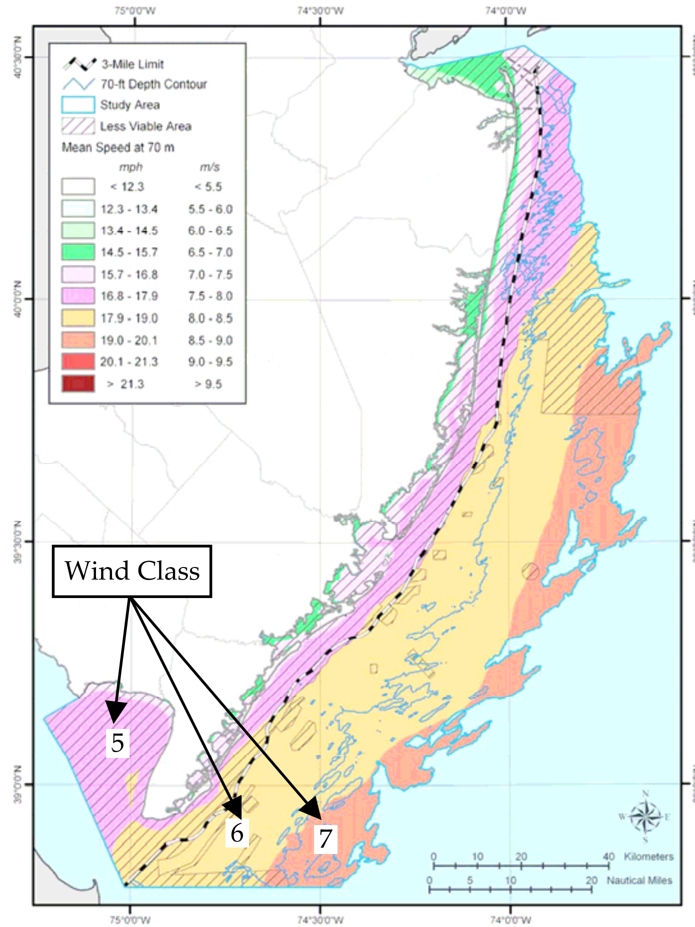
Most on-shore wind development in New Jersey is likely to be small "clusters" of 1-10 MW.

- Cost estimates for wind farms usually assume a 50+ MW installation, and generally a minimum of 10 MW. "Clusters" are in the 1-10 MW range.
- Because of the paucity of New Jersey on-shore wind resources, most installations are likely to be cluster installations. The planned 7.5 MW project in Atlantic City is a good example of a wind cluster. Cluster installations will have:
  - Higher costs for installation because of lower economies of scale. A recent New York[1] study estimated installation costs are 25% to 33% higher than for larger wind farms.
    - The analysis presented here assumes a wind cluster will cost $1,250/kW to install in 2005 vs. $1,050/kW for a 50 MW wind farm. This is also consistent with the February 2001, National Wind Coordinating Council (NWCC) *Distributed Wind Power Assessment*.
  - Lower costs for interconnection. In many cases wind clusters will be able to interconnect into the local distribution system, effectively eliminating the issue of transmission line extensions.
    - Based on the same NWCC study, the NCI team assigned an additional cost of $50/kW to interconnect to the distribution system, but clearly, this cost will be site specific.

1. *New York Renewable Portfolio Standard Cost Study, Appendix A: Renewable Resource Costs & Characteristics*. Revised January 2004.

Significant offshore wind resources, primarily Class 6 winds[1], exist along the New Jersey coastline, reaching up to 20 miles from shore.

- An area extending 20 miles offshore and up to 100 feet in depth was studied (2,465 square nautical miles).
- Offshore wind resources were mapped by wind speed.
- After factoring in exclusions, the remaining area with wind turbine siting potential (~50% or 1,223 square miles) was considered conditionally viable, located primarily beyond the 3-mile limit and extending ~75 miles from Seaside Height south to Cape May.
- The typical wind resource available in New Jersey most appropriate for offshore wind is Class 6 wind sites, with higher Classes generally further from shore.
- Maximum theoretical potential = 24,500 MW, and using the assumed capacity factor in the study, 3,000 MWh per MW of installed capacity (73,500 GWh/yr).



New Jersey Offshore Wind Energy: Feasibility Study, prepared by Atlantic Renewable Energy Corporation and AWS Scientific, Inc., May 2004,

1. As measured at 70M hub height.

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A recent study for the New Jersey BPU[1] examined the offshore New Jersey area for conditional offshore wind energy development potential.

- An area extending 20 miles offshore and up to 100 feet in depth was studied (2,465 square nautical miles).
- Offshore wind resources were mapped by wind speed.
- Exclusions were identified for:
  - 0-3 mile limit from shore
  - Shipping lanes
  - Significant water habitat
  - Average winds below 8 m/s
  - Sand borrow and danger areas
  - Artificial reefs
  - Structure height restrictions due to air traffic
  - Key natural resources
  - Recreational boating and fishing ports
  - Obstructions

1. *New Jersey Offshore Wind Energy: Feasibility Study*, prepared by Atlantic Renewable Energy Corporation and AWS Scientific, Inc., May 2004,

A recent study for the New Jersey BPU[1] examined the offshore New Jersey area for conditional offshore wind energy development potential. (continued)

- The remaining area with wind turbine siting potential (~50% or 1,223 square miles) was considered conditionally viable, located primarily beyond the 3-mile limit and extending ~75 miles from Seaside Height south to Cape May.
- Assumptions used to estimate potential wind energy potential from this area:
  - 100-meter rotor diameter, and 7 rotor diameters between turbines
  - 3MW generated per turbine
  - Density of 20 MW per square mile for maximum wind generation
  - Each 1% of potential area developed can result in 244 MW of wind-based generation
- The typical wind resource available in New Jersey most appropriate for offshore wind is Class 6 wind sites, with higher Classes generally further from shore.
- Maximum theoretical potential = 24,500 MW, and using the assumed capacity factor (34%) in the study, 3,000 MWh per MW of installed capacity (73,500 GWh/yr).

1. *New Jersey Offshore Wind Energy: Feasibility Study*, prepared by Atlantic Renewable Energy Corporation and AWS Scientific, Inc., May 2004,

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Even if only a small fraction of the theoretical potential for offshore wind is developed, the technical potential is large.

- Even after factoring in exclusions, the AWS/Atlantic Renewable Energy study still estimated a theoretical potential of nearly 25,000 MW.
- Since there is little precedent for determining technical potential for offshore wind development, for the purposes of this study, we have conservatively assumed that 10%, or approximately 2,500 MW, of the theoretical potential (after exclusions) could be developed within the study period of 2005-2020.
  - Using the AWS/Atlantic Renewable Energy assumption of 3,000 MWh/yr per MW, this amount of capacity would generate nearly 7.5 million MWh per year, or approximately 10% of electricity retail sales in New Jersey in 2002.

	New Jersey Offshore Wind Power Technical Potential			
	2005	**2008**	**2015**	**2020**
MW	2,500	2,500	2,500	2,500
MWh (with AWS/ARE capacity factor assumption)	7,350,000	7,350,000	7,350,000	7,350,000
MWh (with NCI capacity factor assumptions)	N/A	8,103,000	8,760,000	9,198,000

Significant uncertainties exists regarding offshore wind power market penetration, with minimal deployment expected before 2008.

- Offshore wind installations in New Jersey prior to 2008 are extremely unlikely.
  - Permitting of offshore systems is likely to require 2-3 years
  - Rules and authority with respect to permitting is still uncertain, although Cape Wind permitting will clarify some uncertainties
- Several European countries have been moving aggressively to develop offshore wind power and approximately a dozen sites are operating.[1] These projects are revealing some of the difficulties and challenges with operation and maintenance of offshore wind turbines, but can generally be considered successful.
- Technical potential and market penetration estimates for New Jersey are highly uncertain in the absence of any successful installations in the Unites States. However:
  - A 420 MW project off the coast of Cape Cod has been gathering meteorological measurements and awaits Army Corps of Engineer approval. It has also recently received tentative approval from the Massachusetts Energy Facilities Siting Board (EFSB) on the project's proposal to install electric transmission lines. Recent court challenges to the installation of a meteorological data collection tower also have not been successful. The draft Environmental Impact Statement is due out in August/September of 2004.
  - A developer (FPL Energy) has been tentatively approved for a 100 MW offshore installation south of Long Island, NY. LIPA would purchase the output.
  - Aesthetics and public opposition are expected to continue to weigh on these projects.
- Ultimately, the rate of penetration may depend heavily on the success of initial North American development activity in MA and NY.

1. A total of 529 MW were in operation by the end of 2003. The two largest were 165 and 160 MW each (Source: BTM Consult, *World Market Update 2003*, March 2004. For one of these (Horns Rev) off the coast of Denmark, recurring problems have recently led to the decision to bring all 81 units onshore for repairs.

Class I biomass resources in New Jersey could support up to 240 MW of solid fuel biopower capacity by 2020 (technical potential).

- Consistent with the relatively strict Class I definition, several biomass resources and technologies were not included in the solid biomass fuel supply curve. After screening out biomass resources that do not meet the Class I definition, the following were evaluated in detail.
  - Tree Residues
  - Yard Trimmings
  - Forestry Residues
  - Agricultural Residues
  - Lumber and Mill Waste
  - Bioenergy Crops
- Based on the available data, NCI estimates that there is approximately 14-15 trillion Btu (TBtu) of Class I biomass quantities (technical potential), more than half of which is tree residues.
- The associated technical potential for solid fuel biomass is approximately 110 MW today and could reach 230 MW by 2020, driven by efficiency increases in power generation technology, when switching from combustion to gasification.

Biomass boiler (fuel storage silo is shown) at Rex Lumber, Englishtown, NJ.
150 kW cogeneration facility

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Consistent with the relatively strict Class I definition, several biomass resources and technologies were not included in the solid biomass fuel supply curve.

Solid Fuel Resources Excluded by New Jersey Class I Definition

- Wood waste (from MSW and construction/demolition streams); treated, painted, and coated wood
- Old growth forestry residues
- Harvested wood (except from bioenergy plantations)
- Sewage sludge

Gaseous Resources are Addressed Separately

- Landfill gas
- Biogas from wastewater and animal waste treatment (via anaerobic digestion)

Other Exclusions

- Biomass co-firing with fossil fuels, which is permitted under other RPS standards (e.g., MA, NY [proposed]), PA) is excluded from the Class I definition. However, where it is feasible, co-firing is one of the most cost effective renewable energy options.

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After screening out biomass resources that do not meet the Class I definition, the following were evaluated in detail.

Solid Fuel Resources Included in Analysis (meet the Class I definition)

- Tree Residues
- Yard Trimmings
- Forestry Residues
- Agricultural Residues
- Lumber and Mill Waste
- Bioenergy Crops

Other potential resources not quantified but that would meet the Class I definition

- Food waste (via anaerobic digestion)
- Biomass-based industrial wastewater treatment (via anaerobic digestion)

NCI reviewed a number of prior studies[1] of solid biomass resources to develop the supply curve for New Jersey.

Key Data Sources[1]

- New Jersey BPU RPS – N.J.A.C. 14:4-8, effective April 19, 2004 (for Class I definitions)
- ORNL state-level biomass feedstock availability analysis
- Northeast Regional Biomass Program / CONEG 2003 study
- Northeastern Forest Inventory & Analysis, USDA Forest Service
- USDA/DOE/NREL 2003 Assessment of Power Production at Rural Utilities
- New Jersey DEP Material-Specific Generation and Recycling Rates

NCI Approach

- Evaluate only resources that meet New Jersey Class I definition
- Compare and evaluate quantity estimates across data sources to the extent possible
- Avoid double-counting biomass resources
- Apply experience and professional judgment to quantity estimates
- Develop price point estimates estimates consistent with those in the DOE Energy Information Administration (EIA) national biomass supply curves estimates.

1. See the Appendix for complete references.

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It is difficult to estimate the theoretical potential for biomass resources.

- Estimating the theoretical potential for biomass resources is not practical:
  - The available studies referenced and reviewed here typically provide data on resources that are "available"[1] or available at a particular price, which is more consistent with the definition of technical potential used in this report
  - Estimating the theoretical potential would involve relaxing policy and best management practice constraints on forestry residues, agricultural residues, and bioenergy crop quantities.
    - Best management practices require minimum quantities of residue to be maintained to promote ecosystem health.
    - Best management practices would limit the use of fertilizers, pesticides, etc. on bioenergy crop plantations.
    - National agricultural policy and state/local land policies affect the amount of land available for bioenergy crop production.
  - Theoretical potential could also include resources outside of the Class I definition (notably wood waste, including from municipal solid waste [MSW] and construction and demolition [C&D] streams, and sewage sludge. Rather than combusted, these fuels could be gasified with clean-up prior to combustion, alleviating emissions concerns). Or, if the Class I definition were relaxed, you could bring in timber harvests.

1. Note that the word "available" implies that the resource is not locked up for uses other than power generation.

Based on the available data, NCI estimates that there is approximately 14-15 trillion Btu (TBtu) of Class I biomass quantities (technical potential), more than half of which is tree residues.

	2005		2020	
	MMBtu	MW	MMBtu	MW
Tree Residues (Class B Recycling)	8,894,523	70	8,894,523	133
Yard Trimmings (Class C Recycling)	3,056,590	24	3,056,590	46
Forestry Residues	1,676,078	13	1,676,078	25
Agricultural Residues	354,221	3	354,221	5
Lumber and Mill Waste	513,809	4	513,809	8
Bioenergy Crops	0	0	1,568,298	23
TOTAL	**14,495,222**	**114**	**16,063,520**	**240**

Notes:

- See next page for definitions of Class B and Class C recycling
- Except for bioenergy crops, the MMBtu numbers are assumed constant over time. The MW numbers change over time because conversion technology performance improves over time.
- The MW potential for 2005 assumes the use of direct combustion. The MW potential for 2020 assumes the use of gasification. Assuming some of each technology is deployed over time, the actual technical potential will fall somewhere in between 109 MW and 231 MW.

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Definitions of Class B and Class C recycling facilities are as follows:

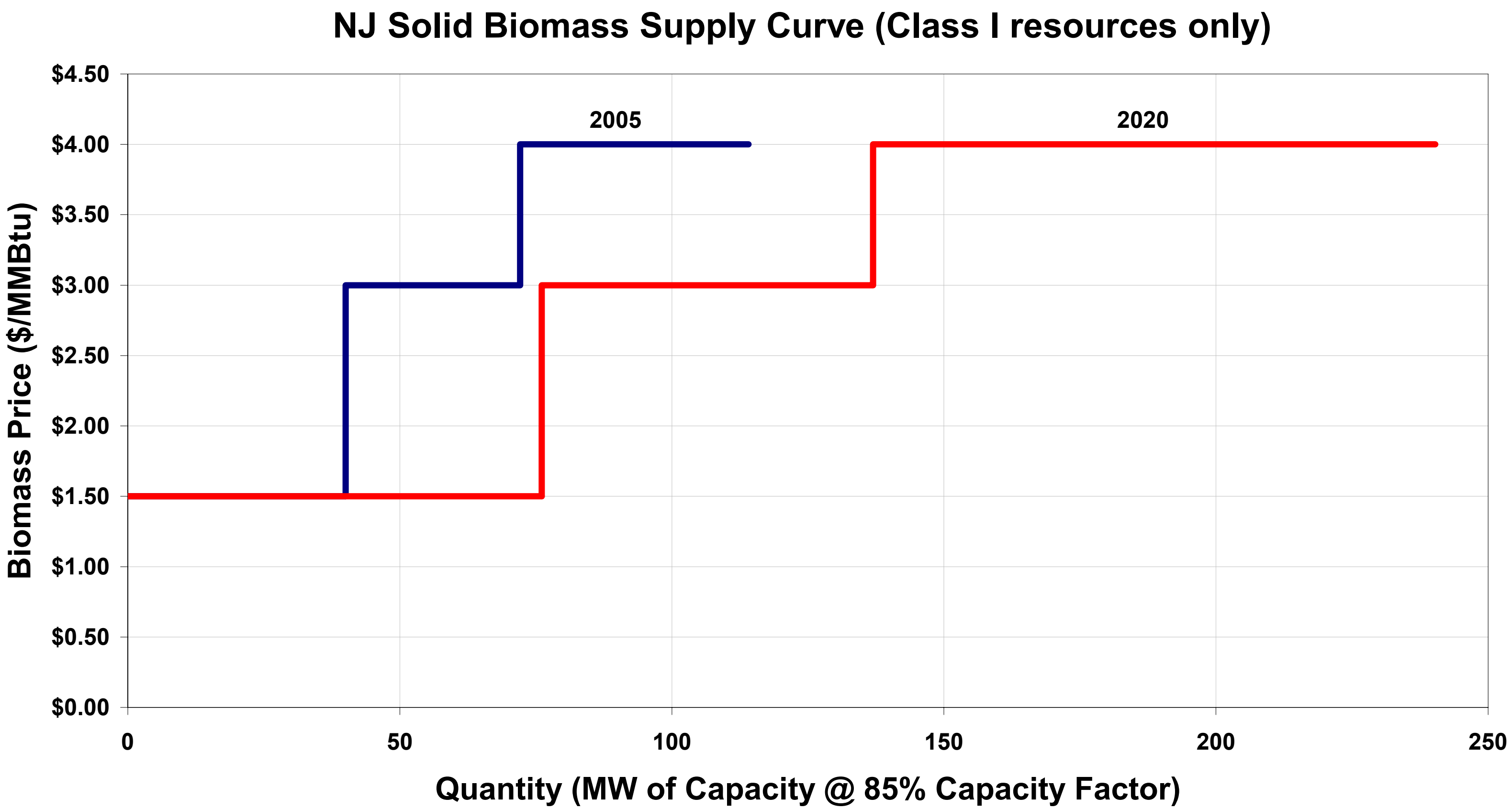
- "Class B recyclable material" means a source separated **recyclable** material which is subject to Department approval prior to receipt, storage, processing or transfer at a recycling center in accordance with N.J.S.A. 13:1E-99.34b, and which includes, but is not limited to, the following:
  - Source separated, non-putrescible, waste concrete, asphalt, brick, block, asphalt-based roofing scrap and wood waste;
  - Source separated, non-putrescible, waste materials other than metal, glass, paper, plastic containers, corrugated and other cardboard resulting from construction, remodeling, repair and demolition operations on houses, commercial buildings, pavements and other structures;
  - **Source separated whole trees, tree trunks, tree parts, tree stumps, brush and leaves provided that they are not composted;**
  - Source separated scrap tires; and
  - Source separated petroleum contaminated soil.

- "Class C recyclable material" means a source separated **compostable** material which is subject to Department approval prior to the receipt, storage, processing or transfer at a recycling center in accordance with N.J.S.A. 13:1E-99.34b, and which includes, but is not limited to, organic materials such as:
  - **Source separated food waste;**
  - **Source separated vegetative food waste; and**
  - **Source separated yard trimmings.**

A biomass supply curve was developed that estimates the fraction of the technical potential that is available at different price points.

Biomass Resource Class	Data Sources for Quantity Estimate	NCI Price Estimate
Tree Residues	Northeast Regional Biomass Program (tempered)	40% @ $1.50/MMBtu 60% @ $4.00/MMBtu
Yard Trimmings	NJ DEP Recycling Report (tempered)	50% @ $1.50/MMBtu 50% @ $3.00/MMBtu
Forestry Residues	ORNL and USDA Forest Service data (on removals)	100% @ $3.00/MMBtu
Agricultural Residues	ORNL and USDA/DOE/NREL	100% @ $3.00/MMBtu
Lumber and Mill Waste	ORNL and USDA/DOE/NREL	100% @ $3.00/MMBtu
Bioenergy Crops	ORNL and USDA/DOE/NREL	100% @ $4.00/MMBtu

A biomass supply curve was developed that estimates the fraction of the technical potential that is available at different price points. (continued)



Note: This supply curve should not be confused with the overall renewable energy supply curve presented later.

A biomass supply curve was developed that estimates the fraction of the technical potential that is available at different price points. (continued)

- Quantity estimates are based on available data (as discussed previously)
- The supply curve shape is based on NCI estimates
  - Eligible Class B and Class C recycled biomass materials comprise the low end of the curve – these are already being collected or can be relatively easily collected and are expected to be available at relatively low cost compared to other biomass resources.
  - The middle of the curve shifts right over time due to projected conversion technology performance improvements: direct-fire in 2005 (20% LHV[1] efficiency), BIGCC[2] in 2008 (32% LHV efficiency), BIGCC in 2015 (34% LHV efficiency), and BIGCC in 2020 (38% LHV efficiency)
  - Top of curve shifts right over time due to the (potential for) introduction of bioenergy crops in 2015
- There is the potential for increased technical potential if resources are transported into New Jersey from NY, PA, MD, or DE. However, it is not possible to estimate these quantities from the available data – a more focused study would be needed to identify the resources in these states that are within a reasonable distance (typically up to ~50 miles).
- Other resource dynamics not considered that may increase or decrease the technical potential include:
  - Population growth
  - Forest and wood products industry dynamics
  - Land use changes / agricultural industry dynamics
  - Competition for available resources (e.g., liquid transportation biofuels production)

1. LHV = lower heating value, a measure of the energy content of fuels when the product water remains in the vapor state.
2. Biomass integrated gasification combined cycle.

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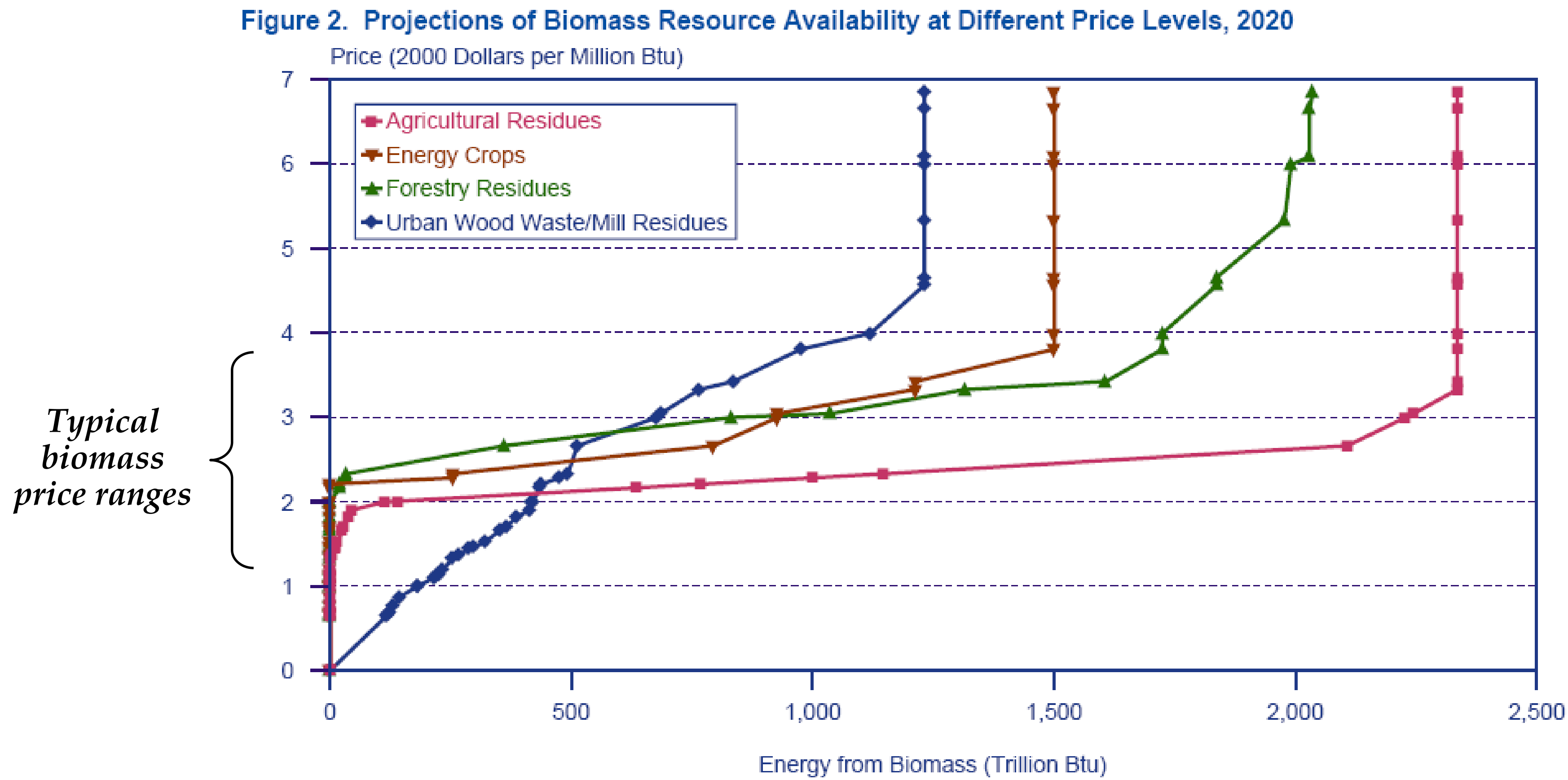
NCI's price point estimates are consistent with those in the DOE Energy Information Administration (EIA) national biomass supply curves estimates.



Source: Zia Haq, *Biomass for Electricity Generation*, DOE Energy Information Administration, 2002.
Note: 1,000 trillion Btu/year is enough biomass for approximately 8,000 MW at today's efficiencies.

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The technical potential for solid fuel biomass is approximately 114 MW today and could reach 240 MW by 2020, driven by efficiency increases in power generation technology.

- The solid fuel biopower technical potential is determined by the top of the Class I biomass supply curve (114 MW in 2005; 240 MW in 2020)
  - The lower estimate for 2005 is based on current direct combustion technology, which has relatively low efficiency (20%), particularly at the relatively small scale expected for plants in New Jersey (5-10 MW)
  - Technical potential increases over time with the addition of bioenergy crops starting in 2015 and by the potential changeover from combustion to gasification, which would significantly increase efficiency (and therefore generate more MW from the same amount of fuel). If this changeover does not occur, then the technical potential by 2020 would only be approximately 150 MW (based on an efficiency of 23.6% in 2020).
  - A small amount of the technical potential is waste that is generated at lumber and other mills. This biomass could potentially be used onsite for cogeneration. If so, this would improve the economics of using this fuel (essentially zero fuel costs). However, the cogeneration potential of this fuel has not been estimated here.

	New Jersey Solid Biomass Power Technical Potential[1]			
	2005	2008	2015	2020
MW (cumulative)	114	183	215	240
MWh per year	849,700	1,359,500	1,600,700	1,789,000

1. Does not include landfill gas or anaerobic digester biogas from wastewater treatment and animal wastes.

Biomass presents a unique set of considerations relative to other renewables energy resources.

- There is a tradeoff between encouraging advanced technology (gasification) over the longer term and meeting near-term RE Primary Objectives:
  - If there is a push to develop biomass in the near-term, this will lock up the least expensive fuel in relatively inefficient plants for the long term, leaving fewer economic resources for biomass integrated gasification combined cycle.
  - As an alternative, if co-firing were pursued in the near term, this would enable an easier transition to gasification, since co-firing involves a lower capital investment and need not tie up biomass resources for a long period of time.
- Unlike other renewables, biomass power carries fuel price and availability risks. Co-firing of biomass with coal is excluded from the Class I definition, but would be a low-cost, lower-risk solution for introducing solid fuel biopower, ultimately leading to improvements in the biomass supply infrastructure that could benefit biomass-only options in the long term.
  - Co-firing capital costs are roughly $1/10^{th}$ those of a new, stand-alone biomass power plant
  - Co-firing is RPS eligible in NY and PA, so a regional biomass supply infrastructure may start to develop. However, given the limited distance biomass can be economically transported, the benefits to New Jersey are uncertain.
- The economic potential will be determined in the overall RE supply curve analysis – solid fuel biopower's economic potential is strongly influenced by the shape of the Class I biomass supply curve (along with technology characteristics, incentives, and competing technology costs).
- Unlike wind and solar, biomass can provide firm capacity and diminish the need for additional fossil-based capacity – this is factored into the economic analysis by way of the expected PJM capacity prices.
- Solid fuel biopower market penetration is a dynamic representation of expected technology adoption under policies in-place (and 3-year extension of the PTC). Since open-loop biomass has not historically qualified for the PTC, and energy crops will likely not be available until the next decade, wind (and LFG) will likely dominate the BAU projection.
- The environmental characteristics of biomass conversion are similar to fossil fuels (better on some areas, potentially worse in others). Biomass is much lower in sulfur than coal. BIGCC is expected to have similar emissions characteristics to natural gas combined cycles. See Appendix A for details.

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Landfill gas (LFG) – a pre-approved[1] Class I resource – could support 64 MW of incremental capacity (technical potential). There is currently about 90 MW of capacity in operation in New Jersey.

- NCI reviewed several data sources, including a detailed New Jersey DEP landfill database, to estimate LFG technical potential.
- Current landfill gas production that is not being utilized could support an additional 120 MW of theoretical potential (above the 90 MW of existing capacity).
- Only about half of the theoretical potential of 120 MW for landfill gas is likely to be realized.
  - When screened for project size and time since the landfill was closed, only 64MW of the 120 MW theoretical potential is estimated to be viable (technical potential).

1. The New Jersey RPS rules define two types of eligible Class I resources: those that require no prior DEP approval, and those that require a biomass sustainability determination from the DEP. Landfill gas is a biomass-based resource that does not require a DEP biomass sustainability determination.

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NCI reviewed several data sources, including a detailed New Jersey DEP landfill database, to estimate LFG technical potential.

Key Data Sources[1]

- New Jersey BPU RPS – N.J.A.C. 14:4-8, effective April 19, 2004 (for Class I definitions)
- Landfill information provided by New Jersey Department of Environmental Protection, Division of Landfill & Recycling Management
- Form EIA-860
- EPA Landfill Methane Outreach Program (LMOP) database

NCI Approach[2]

- Compare and evaluate quantity estimates across data sources
- Estimate the existing, exploited LFG resource
- Estimate incremental technical potential from LFG resources at existing sites, if the site's landfill closed in 1990 or later
- Estimate incremental theoretical potential from LFG resources at new sites
- Estimate incremental technical potential from LFG resources at new sites (if the site's landfill closed in 1990 or later and potential project is larger than 500 kW)
- Breakdown incremental technical potential at new sites by those with and without collection systems

1. See Appendix C for complete references.
2. This analysis did not take a dynamic look at landfill gas production rates at candidate landfills, or consider the effects of future rates of waste generation and landfilling. Both of these are necessary for a more comprehensive assessment of the opportunity.

Current landfill gas production that is not being utilized could support an additional 120 MW of theoretical potential.

- Landfill gas production rates were based on NJ DEP estimates
- The incremental theoretical potential estimate includes all landfill gas production regardless of:
  - Size of landfill
  - Whether or not the landfill was closed, and if closed, in what year
  - Whether or not the landfill currently generates power
  - Whether or not the landfill has a gas collection system in place
- At existing landfills with electric generating capacity in place, there is enough remaining theoretical potential to add another 21 MW. Four potential projects were identified of the following approximate sizes: 1 MW; 2 MW (2 projects); and 16 MW
- At all landfills without electric generating capacity (new sites), there is enough methane production to support a theoretical potential of 99 MW. The breakdown of this theoretical estimate is given below:

Potential Project Size (MW)	No. of Potential Projects	Theoretical Potential (MW, 99 MW total)
<1	58	24
1-3	18	29
3-12	7	33
12-20	1	13

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Only about half of the theoretical potential of 120 MW for landfill gas is likely to be realized.

- Key screens to asses technical potential:
  - Only landfills closed on or after 1990 are included (older projects will have declining gas generation rates)
  - Projects smaller than 500 kW are excluded.
  - Further distinction was made between landfills that either do or do not have existing collection systems (affects economics but not technical potential).
- Based on DEP data, the technical potential at new sites could be achieved through 11 projects.
- According to OCE staff, there is approximately 15 MW of LFG projects in development at three sites.

Landfills with Existing Power Generation Capacity	
Existing Capacity[1]	about 90 MW
Incremental Theoretical Potential (all methane production)	21 MW (123,000 MWh)
Incremental Technical Potential (landfills closed on/after 1990)[2]	16 MW (123,000 MWh)

Landfills without Existing Power Generation Capacity	
Theoretical Potential (all methane production)	99 MW (763,000 MWh)
Technical Potential (landfills closed on/after 1990 and >500 kW)	48 MW (11 sites) (370,000 MWh)
Subset of 48 MW with Collection Systems In-Place	35 MW (270,000 MWh)
Subset of 48 MW without Collection Systems In-Place	13 MW (100,000 MWh)

Total Landfill Gas to Power Potential	
Theoretical Potential (all methane production)	21 + 99 = 120 MW
Technical Potential (landfills closed on/after 1990)	16 + 48 = 64 MW

1. The various data sources on existing capacity are inconsistent, ranging from about 35 MW to 135 MW. The DEP database appears to be the most complete and up-to-date, and it formed the basis for the estimate here.
2. The "incremental technical potential at existing sites" is in actuality located at a single site.

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Biogas[1] cogeneration at wastewater treatment plants – a pre-approved Class I resource[2] – could support ~19 MW of incremental capacity in the near-term (technical potential).

- The use of biogas[1] from the treatment of wastewater to generate electricity and cogenerate heat appears to be a largely untapped opportunity in NJ.
  - The DOE EIA only lists 900 kW of capacity operating in NJ, about 5% of the technical potential.
- The NJ DEP is in the process of collecting data on treatment plants. Based on this partial data, NCI has estimated the technical potential at ~19 MW in 2005.
- There is some uncertainty in this number, but this should be resolved as the DEP completes its data collection.
- Because the fuel is essentially free and the technology is well proven, this application should exhibit attractive economics – similar to landfill gas.
  - The potential for municipalities to finance these projects would improve economics even further.

1. Biogas from wastewater treatment is a mixture of roughly 60% methane and 40% carbon dioxide and is the natural byproduct of wastewater treatment with anaerobic digestion technology. The biogas can be flared, used for heating the digesters or burned to generate electricity in a gas turbine or IC engine. If electricity is produced, the waste heat can be partially recovered (cogeneration) to heat the digesters.
2. The New Jersey RPS rules define two types of eligible Class I resources: those that require no prior DEP approval, and those that require a biomass sustainability determination from the DEP. Landfill gas is a biomass-based resource that does not require a DEP biomass sustainability determination.

To estimate the biogas potential, NCI reviewed several data sources, including NJ DEP's partial listing of treatment plant digester types.

Key Data Sources

- New Jersey BPU RPS – N.J.A.C. 14:4-8, effective April 19, 2004 (for Class I definitions)
- NJ wastewater treatment plant flow rates – NJ DEP
- Partial listing of NJ wastewater treatment plant digester types – NJ DEP
- DOE EIA information about existing projects in NJ (< 1MW)

NCI Approach

- Estimate the flow rate through all NJ wastewater treatment plants (1050 MGD, existing flow rate – not the design maximum)
- Multiply by an estimate of the fraction of WWT plants employing anaerobic digestion (50%)
- Convert daily wastewater flow rate through anaerobic digesters to SCF/day of methane collected. This conversion is based on an NCI estimate of relevant projects (9,700 SCF/day per MGD).
- For technical potential, pare down theoretical potential to those projects that would be 0.5 MW or larger. Theoretical potential and technical potential are 26 MW and 19 MW in 2005, respectively
- Dynamics affecting technical potential (leading to increases over time):
  - WWT flow rate grows with estimated NJ population growth rate (0.76% p.a., NJ Department of Labor)
  - Conversion technology efficiency improvements: 32.5% in 2005, 33.8% in 2008, 35.4% in 2015, and 35.9% in 2020.

NAVIGANT CONSULTING

Based on wastewater treatment methane resource assessment, about 75% of the theoretical potential is classified as technical potential.

- To calculate the theoretical potential, in each year it is assumed that no prior penetration has occurred.
- The estimates do not include the approximately 0.9 MW of existing capacity listed by the DOE EIA
- Without the screen for projects larger than 0.5 MW, the theoretical potential, based on the assumptions listed earlier is approximately 26 MW in 2005, increasing to 32 MW by 2020
- Screening for project size, there are 9 potential projects larger than 0.5 MW (19 MW of incremental capacity in 2005, increasing to 24 MW by 2020), representing the technical potential
  - Of these, there are 2 potential projects larger than 3 MW in 2005 (11.4 MW of incremental capacity)

	NJ Biogas from Wastewater Treatment Theoretical Potential			
	2005	**2008**	**2015**	**2020**
MW (cumulative)	25.5	27.1	30.0	31.6
MWh per year	178,700	189,900	210,000	221,200

	NJ Biogas from Wastewater Treatment Technical Potential			
	2005	**2008**	**2015**	**2020**
MW (cumulative)	19.1	20.3	22.4	23.7
MWh per year	133,800	142,200	157,300	165,700

NAVIGANT CONSULTING

The estimate made here for biogas from wastewater treatment should be considered preliminary, since it is based on partial data from and ongoing DEP review.

- There are two key estimated quantities in need of verification or refinement, which should be possible when the DEP completes its review of WWT plants:
  - 50% of the NJ flow is assumed to be digested anaerobically, but this is based on a partial listing of WWT plants. The total permitted flow in the DEP sample is only 145 MGD (the design maximum in NJ is 1,462 MGD). Depending upon how unidentified digester types in the DEP sample are treated, the anaerobic digestion percentage could fall between 30-85%. NCI chose 50% for the theoretical and technical potential calculations.
  - 9,700 SCF of methane are assumed to be collected for every million gallons of wastewater digested anaerobically. A few projects were assessed, resulting in estimates between 6,000 and 15,000 SCF of methane collected per MGD of wastewater treated anaerobically. NCI chose 9,700 for the theoretical and technical potential calculations.
- 0.5 MW is a good minimum project size to use when assessing the technical potential, but smaller projects could be developed with microturbines or fuel cells in the future, if the cost, performance, and reliability of these technologies improve (one such project has already been funded under the CORE program).

In the absence of readily available data, NCI conservatively assumed a technical potential for central station PV of 300 MW.

- Central station photovoltaics (PV) is unlikely to be cost-competitive with wholesale power until after 2015 in the high incentive scenario presented.
- In the near-term, the market opportunity for PV on residential and commercial buildings is more attractive, as PV competes with higher-priced retail rates and the current CORE rebates favor systems smaller than 500 kW.
- However, the potential exists to use brownfield sites to develop larger, "central station" PV plants.
  - There are no currently available estimates of brownfield acreage. Shell Solar estimates that 1GW of PV could be installed on 4.75 square miles using today's modules.
- In addition to brownfield sites, other sites could be developed, but to estimate this would require analysis beyond the scope of this project.
  - No public data is available to verify land availability. An analysis would require a comprehensive opportunity assessment (e.g., a GIS mapping).
- PV technology costs also continue to decrease at about 5% per year, making this option more attractive in the long term.

Source: Information on land requirements from interview with Shell Solar on July 19, 2004.

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A well designed research program focused on likely brownfield candidates could start to provide some information regarding the PV potential of brownfield sites in New Jersey.

- There is not an existing data set that would allow one to make estimates of brownfield acreage suitable for PV development. However, the state of NJ has a list of sites. The sites are very heterogeneous. Some are gas stations, others are large factories, with many different types in between. They could be in residential, commercial, or industrial areas.
- Possible candidates for PV are brownfield sites that used to be factories. However, this land is typically located near transportation and may have a greater market value for applications other than for PV (assuming that the two applications were mutually exclusive, which they may not be).
- To better characterize the opportunity, one would take the state's list, select those sites from a few counties that look promising and then visit each brownfield site, describe it, and document it. It may then be possible using some statistical sampling techniques, to extrapolate to the larger list without the need to visit all sites within the counties of interest.

Source: Personal communication with Frank A. Felder, Assistant Research Professor, Center for Energy, Economic & Environmental Policy, Edward J. Bloustein School of Planning and Public Policy, Rutgers, The State University of New Jersey, July 27, 2004.

A total of fourteen grid-sited RE resource options were analyzed, comprised of seven different technologies/configurations.

Class I Grid-Sited RE Resources	Technologies/Configurations/Ownership
Onshore Wind Power[1]	• Class 3 – Community Financed • Class 3 – Developer Financed • Class 4 – Developer Financed
Offshore Wind Power[1]	• Class 6 – Developer Financed
Biomass Combustion	• Low Fuel Price ($1.50/MMBtu) • Medium Fuel Price ($3.00/MMBtu) • High Fuel Price ($4.00/MMBtu)
Biomass Integrated Gasification Combined Cycle (BIGCC)	• Low Fuel Price ($1.50/MMBtu) • Medium Fuel Price ($3.00/MMBtu) • High Fuel Price ($4.00/MMBtu)
Landfill Gas – IC Engines	• Landfills with collection systems in place • Landfills without collection systems in place
Biogas from Wastewater Treatment	• IC Engine Cogeneration
Central Station Photovoltaics	• Flat plate, no tracking

1. Wind classes are defined based on average wind speeds as follows at 50m elevation: Class 6 = 8-8.5 m/s (17.9-190 mph); Class 4 = 7 – 7.5m/s (15.7 – 16.8 mph); Class 3 = 6.4 - 7m/s (14.3 – 15.7 mph)

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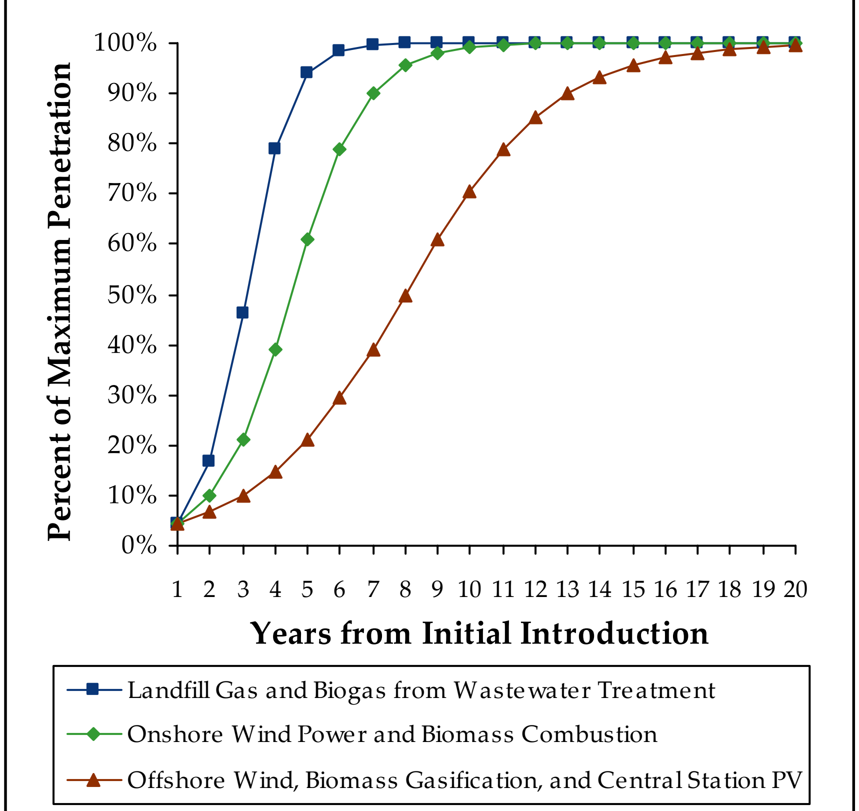
Market penetration for grid-based renewable energy was estimated using a family of S-curves.

- S-curves are well established tools for estimating diffusion or penetration of technologies into the market.
- For purposes of the analysis here, initial introduction is assumed to occur in the first year the technology is economic in New Jersey.
- For resources with relatively limited total technical potential (e.g., Class 4 onshore wind), the market penetration curve may over or understate penetration in early years, since project sizes may not match the curve well.
  - Actual projects will be "lumpier" than the curve suggests, which may result in most capacity being developed in one or two projects, either ahead of or lagging what the penetration curve would suggest.

Market Penetration Assumptions for Grid-Sited RE Technologies in New Jersey



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NCI defined three scenarios for the wholesale RE technologies based on a range of possible incentive levels.

Parameter	Base Case	Low Incentive and REC Price	High Incentive and REC Price	Comments
Production Tax Credit (PTC)	Extended through end of 2006 @ $18/MWh	Not extended	Extended through end of 2006 @ $18/MWh	• Senate and House have passed legislation renewing the credit. Currently in Conference Committee. • Only wind and closed-loop biomass are eligible for PTC.[1]
Class I RPS Average market price for RECs	$20/MWh	$6/MWh	$45/MWh	• $6/MWh is recent price.[2] Landfill gas and biogas potential may keep RECs low in early years. • Low case could also represent a case where the supply of Class I RECs from PJM exceeds demand in New Jersey. • $45/MWh represents the current approximate values of RECs in other RPS markets in the Northeast that are exhibiting scarcity of resources (e.g., MA, CT)
Class I RPS Average market price for Solar RECs	$150/MWh	$100/MWh	$250/MWh	• No rebate assumed for Central PV (>1MW). • $100/MWh is representative of recent prices for voluntary solar RECs (i.e., this is taken to represent a price floor) • $250/MWh represents assumed maximum price supported by the market (above this point, preference would be to pay the alternative compliance payment of $300/MWh)

1. At the time of writing, the House and Senate had passed two version of an extension to the PTC and the associated bills were in Conference Committee. The Senate version (S1637) would expand the credit to other technologies, including open-loop biomass, but at a reduced rate and for 5 years instead of ten years. The House version (HR4520) would simply extend the current credit.
2. Evolution Markets website, accessed in July 2004.

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Digester gas from wastewater treatment and landfill gas offer the potential for the lowest electricity costs, followed by onshore wind power options.

Estimated Cost of Producing Electricity from Renewable Resources in New Jersey, No RECs or rebates

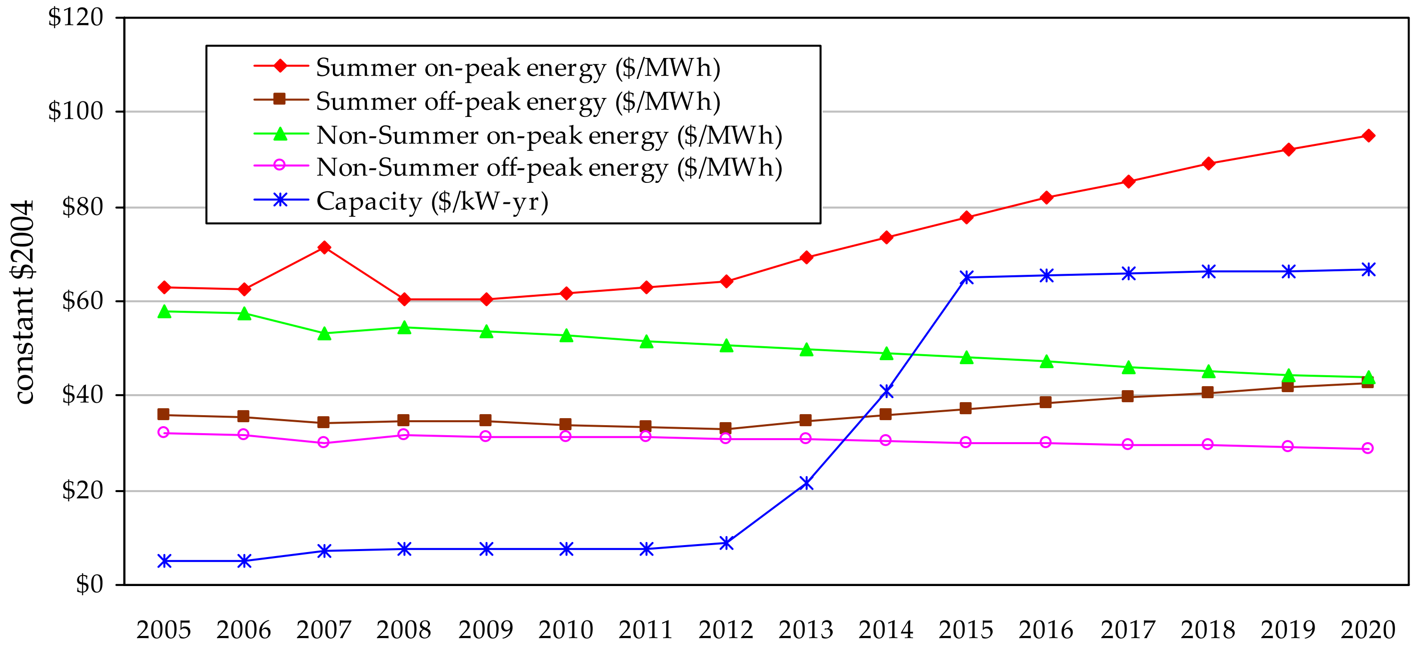
Class I Resource Option	Maximum MW in Block	Real Levelized Cost of Electricity for a Project Installed in the Year Shown ($/MWh in $2004)					
		2005	2006	2007	2008	2015	2020
Biogas from Wastewater Treatment - IC Engine Cogen	23	$ 28.23	$ 27.95	$ 27.66	$ 27.37	$ 26.36	$ 26.01
Landfill Gas- IC engine - collection system in place	51	$ 42.47	$ 41.86	$ 41.24	$ 40.63	$ 37.44	$ 37.44
Developer On-Shore Wind Class 4	10	$ 47.66	$ 45.74	$ 56.30	$ 54.45	$ 44.48	$ 39.14
Community-Owned On-Shore Wind Class 3	29	$ 53.67	$ 52.04	$ 50.44	$ 48.86	$ 40.32	$ 35.82
Landfill Gas- IC engine - no collection system in place	13	$ 51.71	$ 51.09	$ 50.47	$ 49.86	$ 46.67	$ 46.67
Developer On-Shore Wind Class 3	88	$ 59.27	$ 56.97	$ 67.16	$ 64.94	$ 52.84	$ 46.48
Biomass Gasification Combined Cycle - Low Fuel Price ($1.50/MMBtu)	38	N/A	N/A	N/A	$ 72.37	$ 62.36	$ 56.74
Biomass Direct Combustion - Low Fuel Price ($1.50/MMBtu)	20	$ 78.48	$ 77.50	$ 76.53	$ 75.58	$ 71.63	$ 69.87
Developer Off-Shore Wind Class 6	2,500	N/A	N/A	N/A	$ 88.91	$ 75.23	$ 69.75
Biomass Gasification Combined Cycle - Medium Fuel Price ($3.00/MMBtu)	30	N/A	N/A	N/A	$ 88.36	$ 77.41	$ 70.21
Biomass Gasification Combined Cycle - High Fuel Price ($4.00/MMBtu)	52	N/A	N/A	N/A	$ 99.02	$ 87.44	$ 79.19
Biomass Direct Combustion - Medium Fuel Price ($3.00/MMBtu)	16	$ 104.07	$ 102.67	$ 101.30	$ 99.95	$ 93.98	$ 91.56
Biomass Direct Combustion - High Fuel Price ($4.00/MMBtu)	21	$ 121.13	$ 119.45	$ 117.81	$ 116.20	$ 108.88	$ 106.02
Central Station PV	300	$ 445.18	$ 424.15	$ 403.12	$ 382.09	$ 267.10	$ 207.36

Notes:

- "Maximum MW in Block" is the Technical Potential as estimated earlier in this section.
- Estimates for developer-financed wind power projects includes the Federal PTC for 2005 and 2006 (20-year lifecycle value of $12.45/MWh)
- Initial costs for wind power projects includes an additional $50/kW for onshore and $100/kW for offshore to account for grid interconnection above assumed project costs. For small, community-financed projects, an additional $100/kW is added to account for the small scale expected (e.g., solitary turbines).
- For all wind options, an additional O&M charge of $4/MWh is added to account for various ongoing grid integration costs (e.g., scheduling, regulation, reserve requirements), consistent with several recent studies (see Appendix C).
- For landfill gas projects without collection systems, the collection system is assumed to cost an additional $500/kW over the base capital cost.
- Biogas from sewage treatment projects are assumed to be financed by municipalities.
- For biomass gasification combined cycle costs remain relatively uncertain, given the lack of operating experience with the technology.
- See Appendix A for detailed technology assumptions.

Wholesale market prices are forecasted to climb during summer months but decline gradually for non-summer months (in real terms).

Forecast Wholesale Energy and Capacity Prices in New Jersey/PJM



Summer On-peak: June – Sept - weekdays 8:00am to 10:00pm
Summer Off-Peak: June - Sept - 10:00pm to 8am, weekends, and all holiday hours
Non-Summer On-peak: Oct.- May- weekdays 8:00am to 10:00pm
Non-Summer Off-peak: Oct.-May - 10:00pm to 8 am, weekends, and all holiday hours
Source: NCI analysis and modeling of the PJM control area.
Capacity prices are for all of PJM. Energy prices are an average of PJM zones relevant to New Jersey.
Source: NCI analysis and price forecasting.

The NCI market price forecast has modeled a number of key factors.

- Projected fuel prices
  - If actual gas prices are higher than the anticipated fuel prices, the energy prices will be higher.
- Future generation additions and retirements
  - If more generation is developed than anticipated in the forward price projection, both energy & capacity prices will be lower
- Future transmission development
  - If more transmission is developed than anticipated in the forward price projections, particularly between high energy price areas and low energy price areas, the system-wide PJM LMP will be reduced.
- Generation availability
  - If generation availability decreases in the future, capacity prices will increase.
- Market rules
  - If PJM installed reserve margin is increased from 15% to 18%, resulting energy prices will decrease over the long term. In the short term capacity prices could increase due to the higher requirements, but should also decrease over the long term.
  - If transmission owners continue to turn over low voltage facilities (e.g., less than 69kV) for PJM control and operation, this will tend to increase energy prices in and near the region where those facilities were turned over.

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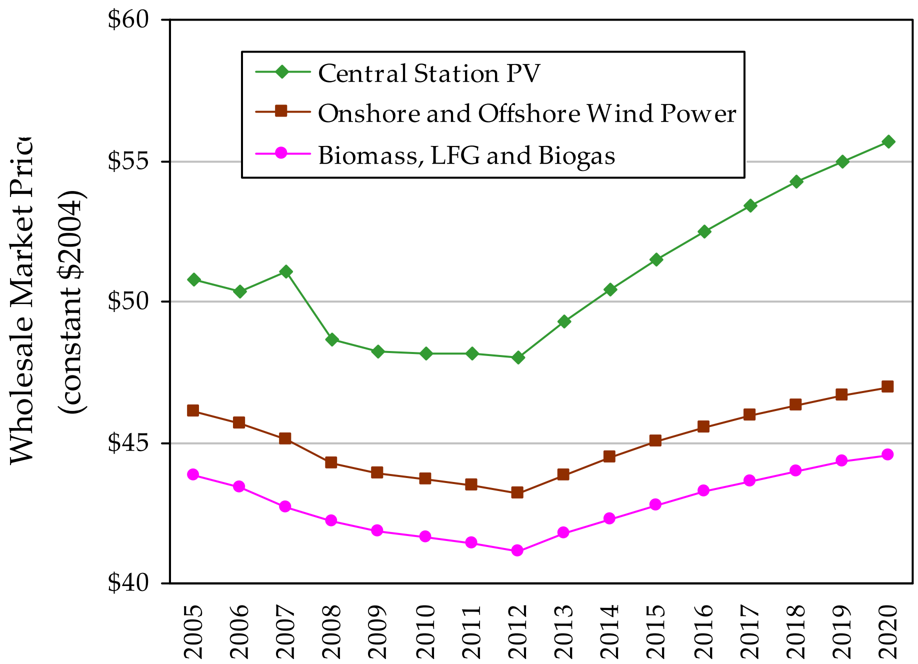
Based on expected time-of-day/seasonal output for the different RE technologies, a weighted average wholesale price was calculated for each – this represents the main source of revenue for these options.



		Output as Percent of Time by Period		
		Onshore and Offshore Wind[1]	Biomass, LFG & Biogas (baseload)	PV
Summer	Peak	16.5%	13.6%	28.9%
	Off-Peak	16.9%	19.8%	16.6%
Winter	Peak	32.3%	26.5%	35.8%
	Off-Peak	34.3%	40.0%	18.8%

1. Since almost all the onshore wind power potential is by the coast, the analysis for onshore wind power was assumed to be valid for offshore as well.

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The competitiveness of grid-sited renewable energy is based on comparing the cost of production to the various revenue streams.

Basic Calculation of RE Competitiveness:[1]

RE cost premium = RE LCOE[2] – [(wholesale market price) + (wholesale capacity price) + (RPS REC price)]

- Positive values indicate the RE option is not cost effective
  - Either an additional premium is required as a revenue source or the costs must be reduced (e.g., via an up-front grant or lower cost financing)
- Negative values indicate the RE option is costs effective
  - Anticipated energy and capacity prices, plus the value of RECs from the RPS are sufficient to cover the cost of production
- In this analysis, it has been assumed that wind and solar power receive capacity payments equal to 20% of rated capacity.
  - Capacity prices ($/kW-yr) are converted to $/MWh using the assumed capacity factor for the RE option.
  - The value of capacity is expected to be relatively small (<$2/MWh) until after 2015.

1. In this analysis, which is only of renewable energy within New Jersey, the RPS REC price is taken as an input. If this were an analysis of the entire NJ RPS, then all of PJM would be considered and the output would be the required REC price needed to achieve a given level of renewable energy generation, based on the RE supply curve.
2. LCOE = Levelized cost of electricity, the total lifecycle cost of producing electricity, expressed in constant $2004.

When the revenue from energy and capacity sales are factored in, some RE options are cost effective, while others will require additional support, via the RPS, the CEP, or both.

Estimated Cost Premium for Renewable Resources in New Jersey, without REC revenues

Class I Resource Option	Maximum MW in Block	Real Levelized Cost Premium for A Project Installed in the Year Shown ($/MWh in $2004)					
		2005	2006	2007	2008	2015	2020
Biogas from Wastewater Treatment - IC Engine Cogen	23	$ (16.29)	$ (16.17)	$ (16.04)	$ (15.91)	$ (17.05)	$ (26.99)
Landfill Gas- IC engine - collection system in place	51	$ (2.01)	$ (2.21)	$ (2.40)	$ (2.59)	$ (4.76)	$ (15.19)
Developer On-Shore Wind Class 4	10	$ 1.26	$ (0.25)	$ 10.74	$ 9.68	$ 4.75	$ (8.20)
Community-Owned On-Shore Wind Class 3	29	$ 7.20	$ 5.98	$ 4.78	$ 3.99	$ (0.32)	$ (12.77)
Landfill Gas- IC engine - no collection system in place	13	$ 7.22	$ 7.02	$ 6.83	$ 6.64	$ 4.48	$ (5.95)
Developer On-Shore Wind Class 3	88	$ 12.80	$ 10.91	$ 21.51	$ 20.07	$ 13.98	$ (1.17)
Developer Off-Shore Wind Class 6	2,500	$ 26.07	$ 27.81	$ 42.03	$ 44.15	$ 37.42	$ 22.84
Biomass Gasification Combined Cycle - Low Fuel Price ($1.50/MMBtu)	38	$ 27.89	$ 28.30	$ 28.73	$ 29.15	$ 23.58	$ 6.92
Biomass Direct Combustion - Low Fuel Price ($1.50/MMBtu)	20	$ 34.00	$ 33.43	$ 32.89	$ 32.36	$ 29.82	$ 18.13
Biomass Gasification Combined Cycle - Medium Fuel Price ($3.00/MMBtu)	30	$ 43.88	$ 44.29	$ 44.72	$ 45.14	$ 39.10	$ 21.19
Biomass Gasification Combined Cycle - High Fuel Price ($4.00/MMBtu)	52	$ 54.54	$ 54.95	$ 55.39	$ 55.81	$ 49.45	$ 30.69
Biomass Direct Combustion - Medium Fuel Price ($3.00/MMBtu)	16	$ 59.59	$ 58.60	$ 57.66	$ 56.73	$ 53.18	$ 40.14
Biomass Direct Combustion - High Fuel Price ($4.00/MMBtu)	21	$ 76.65	$ 75.38	$ 74.17	$ 72.98	$ 68.75	$ 54.82
Central Station PV	300	$ 393.60	$ 372.97	$ 350.91	$ 332.19	$ 273.31	$ 172.76

- A "negative premium" indicates that the revenue from energy and capacity sales exceeds the cost to produce the electricity. These projects can therefore be considered economic.
- The values above assume no RPS REC revenues but do include the renewal of the Federal PTC for developer-financed wind power through 2006.
- The values change from year to year based on improving technology economics and changes in the assumed market prices for energy and capacity. They show the premium in a given year for a project installed in that same year. Once a project is installed the premium will fluctuate with the wholesale market prices for energy and capacity.

There are a number of important caveats about the supply curve analysis.

- The main purpose of the supply curve analysis is to understand the general competitiveness of the different options and the relative roles of different resources absent technology targeted intervention.
  - For RE options that land near the "zero premium", this suggests a more detailed assessment is warranted.
- Just because a project has a "negative premium" does not guarantee that the project will be built.
  - The economic analysis assumed access to long-term financing, which may only be possible with Clean Energy Program support.
  - Other barriers, such as funding for feasibility studies and environmental impacts studies (e.g., for small wind projects) could also impact a project that is otherwise economic.
- Some simplifying assumptions have been made:
  - We use the current year market price for power vs. a long-term levelized value to estimate the value of the premium required. However, since the weighted average market prices used in the analysis do not change significantly over time, this approach is reasonable. Using a levelized value would require a price forecast out to 2040 for projects installed in 2020.
  - We assumed a constant REC price in the scenarios.

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When the additional revenues from RECs are considered, several resources appear economically viable by 2008, even with modest REC prices.

Estimated Cost Premium for Renewable Resources in New Jersey in 2008, with REC revenues

Class I Resource Option	Maximum MW in Block	Real Levelized Cost Premium per MWh of Electricity ($/MWh in $2004)		
		2008 Base Case	2008 Low Incentive and REC Price Case	2008 High Incentive and REC Price Case
Biogas from Wastewater Treatment - IC Engine Cogen	23	($35.91)	($21.91)	($60.91)
Landfill Gas- IC engine - collection system in place	51	($22.59)	($8.59)	($47.59)
Community-Owned On-Shore Wind Class 3	29	($16.01)	($2.01)	($41.01)
Developer On-Shore Wind Class 4	10	($13.36)	$0.64	($38.36)
Landfill Gas- IC engine - no collection system in place	13	($10.32)	$3.68	($35.32)
Developer On-Shore Wind Class 3	88	$0.07	$14.07	($24.93)
Biomass Gasification Combined Cycle - Low Fuel Price ($1.50/MMBtu)	38	$9.15	$23.15	($15.85)
Biomass Direct Combustion - Low Fuel Price ($1.50/MMBtu)	20	$12.36	$26.36	($12.64)
Developer Off-Shore Wind Class 6	2,500	$24.15	$38.15	($0.85)
Biomass Gasification Combined Cycle - Medium Fuel Price ($3.00/MMBtu)	30	$25.14	$39.14	$0.14
Biomass Gasification Combined Cycle - High Fuel Price ($4.00/MMBtu)	52	$35.81	$49.81	$10.81
Biomass Direct Combustion - Medium Fuel Price ($3.00/MMBtu)	16	$36.73	$50.73	$11.73
Biomass Direct Combustion - High Fuel Price ($4.00/MMBtu)	21	$52.98	$66.98	$27.98
Central Station PV	300	$182.19	$232.19	$82.19

Note: A "negative premium" indicates that the revenue from energy sales, capacity sales and REC sales exceeds the cost to produce the electricity in that scenario. These projects can therefore be considered economic.

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When the additional revenues from RECs are considered, several resources appear economically viable by 2008, even with modest REC prices. (continued)

- In in the *Base Case* scenario in 2008, biogas from wastewater treatment, landfill gas and some wind options (community-owned Class 3 and Developer-financed Class 4) are all economic Developer-financed class 3 wind is marginal.
  - The remaining options require additional financial support (e.g., higher REC prices, grants, lower cost financing) to cover the additional premium.
  - For wind power, there is no Federal PTC assumed for projects developed in 2008. Options that are not economic in 2008 could actually be economic in 2005-2006, if the PTC is renewed in 2004.
- In the *Low Incentive and REC Price* scenario, only biogas from WWT, landfill gas at sites with existing collection systems and community owned wind are economic.
- In the *High Incentive and REC Price* scenario, most options are economic, including offshore wind power and the biomass options using low-cost feedstocks.

Note: A "negative premium" indicates that the revenue from energy sales, capacity sales and REC sales exceeds the cost to produce the electricity in that scenario. These projects can therefore be considered economic.

By 2020, NJ may have significant RE potential that is economic, depending on the REC price and the viability of offshore wind power.

Estimated Cost Premium for Renewable Resources in New Jersey in 2020, with REC revenues

Class I Resource Option	Maximum MW in Block	Real Levelized Cost Premium per MWh of Electricity ($/MWh in $2004)		
		2020 Base Case	2020 Low Incentive and REC Price Case	2020 High Incentive and REC Price Case
Biogas from Wastewater Treatment - IC Engine Cogen	23	($46.99)	($32.99)	($71.99)
Landfill Gas- IC engine - collection system in place	51	($35.19)	($21.19)	($60.19)
Community-Owned On-Shore Wind Class 3	29	($32.77)	($18.77)	($57.77)
Developer On-Shore Wind Class 4	10	($28.20)	($14.20)	($53.20)
Landfill Gas- IC engine - no collection system in place	13	($25.95)	($11.95)	($50.95)
Developer On-Shore Wind Class 3	88	($21.17)	($7.17)	($46.17)
Biomass Gasification Combined Cycle - Low Fuel Price ($1.50/MMBtu)	38	($13.08)	$0.92	($38.08)
Biomass Direct Combustion - Low Fuel Price ($1.50/MMBtu)	20	($1.87)	$12.13	($26.87)
Biomass Gasification Combined Cycle - Medium Fuel Price ($3.00/MMBtu)	30	$1.19	$15.19	($23.81)
Developer Off-Shore Wind Class 6	2,500	$2.84	$16.84	($22.16)
Biomass Gasification Combined Cycle - High Fuel Price ($4.00/MMBtu)	52	$10.69	$24.69	($14.31)
Biomass Direct Combustion - Medium Fuel Price ($3.00/MMBtu)	16	$20.14	$34.14	($4.86)
Central Station PV	300	$22.76	$72.76	($77.24)
Biomass Direct Combustion - High Fuel Price ($4.00/MMBtu)	21	$34.82	$48.82	$9.82

Note: A "negative premium" indicates that the revenue from energy sales, capacity sales and REC sales exceeds the cost to produce the electricity in that scenario. These projects can therefore be considered economic.

By 2020, NJ may have significant RE potential that is economic, depending on the REC price and the viability of offshore wind power. (continued)

- In in the *Base Case* scenario by 2020, biogas from wastewater treatment, landfill gas, onshore wind power (all options) and the low-cost solid biomass options (combustion and gasification) are all economic.
  - Offshore wind power is marginal as is biomass gasification with medium-priced biomass fuel.
- In the *Low Incentive and REC Price* scenario, only biogas from WWT, landfill gas and onshore wind power (all options) are economic.
- In the *High Incentive and REC Price* scenario, all options except for biomass combustion with high fuel prices are economic.
  - Central station PV, with a high solar REC price of $250/MWh is also economic in this scenario.

Note: A "negative premium" indicates that the revenue from energy sales, capacity sales and REC sales exceeds the cost to produce the electricity in that scenario. These projects can therefore be considered economic.

In the *Base Case* Scenario, onshore wind power, landfill gas, and biogas from sewage treatment are all economic.[1] Offshore wind power and solid biomass options become economic only beyond 2015.

- Biogas from wastewater treatment and landfill gas at sites with existing collection systems are the most attractive.
- With a $20/MWh REC value and the renewal of the PTC for wind power, all the onshore wind power potential is economic in the short term. This presents a window of opportunity if the PTC is indeed extended.

Cumulative Economic MW Potential

Resource Option	Total MW in Block	2005	2006	2007	2008	2015	2020
Community-Owned On-Shore Wind Class 3	29	29	29	29	29	29	29
Developer On-Shore Wind Class 3	88	88	88	88	88	88	88
Developer On-Shore Wind Class 4	10	10	10	10	10	10	10
Developer Off-Shore Wind Class 6	2,500	-	-	-	-	-	-
Biomass Direct Combustion - Low Fuel Price ($1.50/MMBtu)	20	-	-	-	-	-	20
Biomass Direct Combustion - Medium Fuel Price ($3.00/MMBtu)	16	-	-	-	-	-	-
Biomass Direct Combustion - High Fuel Price ($4.00/MMBtu)	21	-	-	-	-	-	-
Biomass Gasification Combined Cycle - Low Fuel Price ($1.50/MMBtu)	38	-	-	-	-	-	38
Biomass Gasification Combined Cycle - Medium Fuel Price ($3.00/MMBtu)	30	-	-	-	-	-	-
Biomass Gasification Combined Cycle - High Fuel Price ($4.00/MMBtu)	52	-	-	-	-	-	-
Landfill Gas- IC engine - collection system in place	51	51	51	51	51	51	51
Landfill Gas- IC engine - no collection system in place	13	13	13	13	13	13	13
Biogas from Wastewater Treatment - IC Engine Cogen	23	23	23	23	23	23	23
Central Station PV	300	-	-	-	-	-	-
Total MW (Cumulative)	3,192	214	214	214	214	214	272

Note: Since some biomass combustion potential is not economic in this scenario, the potential for Biomass Gasification Combined Cycle is actually larger, since it could access the biomass resources allocated to biomass combustion in the supply curve.

1. The determination of "economic" includes the impacts of RECs.

In the *Base Case* Scenario, it is estimated that up to 119 MW could be developed by 2008 and 241 MW by 2020.

- Based on attractive economics and relative ease of siting, the LFG and biogas options could be developed rapidly.
- Onshore wind is economic in this scenario but is expected to develop more slowly, due in part to siting issues.
- In this scenario, offshore wind is not expected to be economically competitive, absent additional incentives or supports.

Cumulative MW Market Penetration

Resource Option	Total MW in Block	2005	2006	2007	2008	2015	2020
Community-Owned On-Shore Wind Class 3	29	1	3	6	12	29	29
Developer On-Shore Wind Class 3	88	4	9	19	35	88	88
Developer On-Shore Wind Class 4	10	0	1	2	4	10	10
Developer Off-Shore Wind Class 6	2,500	-	-	-	-	-	-
Biomass Direct Combustion - Low Fuel Price ($1.50/MMBtu)	20	-	-	-	-	-	16
Biomass Direct Combustion - Medium Fuel Price ($3.00/MMBtu)	16	-	-	-	-	-	-
Biomass Direct Combustion - High Fuel Price ($4.00/MMBtu)	21	-	-	-	-	-	-
Biomass Gasification Combined Cycle - Low Fuel Price ($1.50/MMBtu)	38	-	-	-	-	-	11
Biomass Gasification Combined Cycle - Medium Fuel Price ($3.00/MMBtu)	30	-	-	-	-	-	-
Biomass Gasification Combined Cycle - High Fuel Price ($4.00/MMBtu)	52	-	-	-	-	-	-
Landfill Gas- IC engine - collection system in place	51	2	8	24	40	51	51
Landfill Gas- IC engine - no collection system in place	13	1	2	6	10	13	13
Biogas from Wastewater Treatment - IC Engine Cogen	23	1	4	11	18	23	23
Central Station PV	300	-	-	-	-	-	-
Total MW (Cumulative)	3,192	9	27	67	119	214	241

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In the *Low Incentive & REC Price Scenario*, landfill gas and biogas from sewage treatment remain economic. Onshore wind power is marginal without the PTC and adequate REC price support.

Cumulative Economic MW Potential

Resource Option	Total MW in Block	2005	2006	2007	2008	2015	2020
Community-Owned On-Shore Wind Class 3	29	-	29	29	29	29	29
Developer On-Shore Wind Class 3	88	-	-	-	-	-	88
Developer On-Shore Wind Class 4	10	-	-	-	-	10	10
Developer Off-Shore Wind Class 6	2,500	-	-	-	-	-	-
Biomass Direct Combustion - Low Fuel Price ($1.50/MMBtu)	20	-	-	-	-	-	-
Biomass Direct Combustion - Medium Fuel Price ($3.00/MMBtu)	16	-	-	-	-	-	-
Biomass Direct Combustion - High Fuel Price ($4.00/MMBtu)	21	-	-	-	-	-	-
Biomass Gasification Combined Cycle - Low Fuel Price ($1.50/MMBtu)	38	-	-	-	-	-	-
Biomass Gasification Combined Cycle - Medium Fuel Price ($3.00/MMBtu)	30	-	-	-	-	-	-
Biomass Gasification Combined Cycle - High Fuel Price ($4.00/MMBtu)	52	-	-	-	-	-	-
Landfill Gas- IC engine - collection system in place	51	51	51	51	51	51	51
Landfill Gas- IC engine - no collection system in place	13	-	-	-	-	13	13
Biogas from Wastewater Treatment - IC Engine Cogen	23	23	23	23	23	23	23
Central Station PV	300	-	-	-	-	-	-
Total MW (Cumulative)	3,192	74	103	103	103	126	214

Note: Since some biomass combustion potential is not economic in this scenario, the potential for Biomass Gasification Combined Cycle is actually larger, since it could access the biomass resources allocated to biomass combustion in the supply curve.

1. The determination of "economic" includes the impacts of RECs.

In the *Low Incentive & REC Price* scenario, it is estimated that 65 MW could be developed by 2008 and only 196 MW by 2020.

- In this scenario, landfill gas accounts for more than 60% of the Class I grid-sited capacity by 2008.
  - Biogas from sewage treatment and onshore wind make up the rest
- Neither offshore wind power nor solid biomass power are expected to be developed in this scenario.

Cumulative MW Market Penetration

Resource Option	Total MW in Block	2005	2006	2007	2008	2015	2020
Community-Owned On-Shore Wind Class 3	29	-	1	3	6	29	29
Developer On-Shore Wind Class 3	88	-	-	-	-	-	69
Developer On-Shore Wind Class 4	10	-	-	-	-	9	10
Developer Off-Shore Wind Class 6	2,500	-	-	-	-	-	-
Biomass Direct Combustion - Low Fuel Price ($1.50/MMBtu)	20	-	-	-	-	-	-
Biomass Direct Combustion - Medium Fuel Price ($3.00/MMBtu)	16	-	-	-	-	-	-
Biomass Direct Combustion - High Fuel Price ($4.00/MMBtu)	21	-	-	-	-	-	-
Biomass Gasification Combined Cycle - Low Fuel Price ($1.50/MMBtu)	38	-	-	-	-	-	-
Biomass Gasification Combined Cycle - Medium Fuel Price ($3.00/MMBtu)	30	-	-	-	-	-	-
Biomass Gasification Combined Cycle - High Fuel Price ($4.00/MMBtu)	52	-	-	-	-	-	-
Landfill Gas- IC engine - collection system in place	51	2	8	24	40	51	51
Landfill Gas- IC engine - no collection system in place	13	-	-	-	-	13	13
Biogas from Wastewater Treatment - IC Engine Cogen	23	1	4	11	18	23	23
Central Station PV	300	-	-	-	-	-	-
Total MW (Cumulative)	3,192	3	14	37	65	125	196

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In the *High* incentive & REC price scenario, all options except central station PV and some biomass are expected to be economic by 2008.

- In the High Incentive Scenario in the near term, the only options that are uneconomic are central station PV and the biomass options with the medium and high fuel prices.
- All options become economic after 2015 except the high biomass fuel price options employing direct combustion.

Cumulative Economic MW Potential

Resource Option	Total MW in Block	2005	2006	2007	2008	2015	2020
Community-Owned On-Shore Wind Class 3	29	29	29	29	29	29	29
Developer On-Shore Wind Class 3	88	88	88	88	88	88	88
Developer On-Shore Wind Class 4	10	10	10	10	10	10	10
Developer Off-Shore Wind Class 6	2,500	-	-	-	2,500	2,500	2,500
Biomass Direct Combustion - Low Fuel Price ($1.50/MMBtu)	20	20	20	20	20	20	20
Biomass Direct Combustion - Medium Fuel Price ($3.00/MMBtu)	16	-	-	-	-	-	16
Biomass Direct Combustion - High Fuel Price ($4.00/MMBtu)	21	-	-	-	-	-	-
Biomass Gasification Combined Cycle - Low Fuel Price ($1.50/MMBtu)	38	-	-	-	38	38	38
Biomass Gasification Combined Cycle - Medium Fuel Price ($3.00/MMBtu)	30	-	-	-	-	30	30
Biomass Gasification Combined Cycle - High Fuel Price ($4.00/MMBtu)	52	-	-	-	-	-	52
Landfill Gas- IC engine - collection system in place	51	51	51	51	51	51	51
Landfill Gas- IC engine - no collection system in place	13	13	13	13	13	13	13
Biogas from Wastewater Treatment - IC Engine Cogen	23	23	23	23	23	23	23
Central Station PV	300	-	-	-	-	-	300
Total MW (Cumulative)	3,192	234	234	234	2,772	2,803	3,171

Note: Since some biomass combustion potential is not economic in this scenario, the potential for Biomass Gasification Combined Cycle is actually larger, since it could access the biomass resources allocated to biomass combustion in the supply curve.
1. The determination of "economic" includes the impacts of RECs.

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In the *High* incentive & REC price scenario, it is estimated that 238 MW could be developed by 2008. Capacity could expand rapidly beyond then if the price of RECs is maintained at $45/MWh.

- Based on attractive economics and relative ease of siting, the LFG and biogas options could be developed rapidly.
- Onshore wind power is economic in this scenario but is expected to develop more slowly, due in part to siting issues.
- Offshore wind power is also economic in this scenario.
- Beyond 2008, if the high REC prices are sustained, market penetration could increase rapidly.

Cumulative MW Market Penetration

Resource Option	Total MW in Block	2005	2006	2007	2008	2015	2020
Community-Owned On-Shore Wind Class 3	29	1	3	6	12	29	29
Developer On-Shore Wind Class 3	88	4	9	19	35	88	88
Developer On-Shore Wind Class 4	10	0	1	2	4	10	10
Developer Off-Shore Wind Class 6	2,500	-	-	-	110	1,250	2,250
Biomass Direct Combustion - Low Fuel Price ($1.50/MMBtu)	20	1	2	4	8	20	20
Biomass Direct Combustion - Medium Fuel Price ($3.00/MMBtu)	16	-	-	-	-	-	13
Biomass Direct Combustion - High Fuel Price ($4.00/MMBtu)	21	-	-	-	-	-	-
Biomass Gasification Combined Cycle - Low Fuel Price ($1.50/MMBtu)	38	-	-	-	2	19	34
Biomass Gasification Combined Cycle - Medium Fuel Price ($3.00/MMBtu)	30	-	-	-	-	12	26
Biomass Gasification Combined Cycle - High Fuel Price ($4.00/MMBtu)	52	-	-	-	-	-	15
Landfill Gas- IC engine - collection system in place	51	2	8	24	40	51	51
Landfill Gas- IC engine - no collection system in place	13	1	2	6	10	13	13
Biogas from Wastewater Treatment - IC Engine Cogen	23	1	4	11	18	23	23
Central Station PV	300	-	-	-	-	-	88
Total MW (Cumulative)	3,192	10	29	71	238	1,515	2,660

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Onshore wind power is likely to be cost competitive in many cases. The main challenges will be in realizing the economic potential.

Onshore Wind Power	
Economics	• Under most circumstances onshore wind power is cost competitive. Only in the *Low Incentive & REC price* scenario is the developer-financed Class 3 wind power option uneconomic for most of the study period. — Assuming the PTC is extended, the Developer Financed Class 4 wind resources offer the best economics of the wind power options in the near term. However, based on the GIS analysis, this resource is very limited (no more than 10 MW) — Community-financed wind power, which NCI has assumed would account for 25% of the Class 3 technical potential is the next most attractive wind power option. — In general, as long as the RPS REC price exceeds about $20/MWh, all the onshore wind options are economic ▪ This value is lower for the community-financed option and the developer-financed option, if the PTC is extended — The economic assumptions made here account for the expected small scale of most wind developments in the state, but these costs may end up being somewhat higher.
Implemen-tation	• Despite relatively attractive economics, the key to implementation of wind clusters will be the identification of suitable sites within the limited technical/economic potential, and then the successful development of those sites. This is not expected to be easy, given the location of most of the Class 3+ wind along the coast. — After factoring land use exclusions on top of the GIS analysis, the largest land type with suitable wind resources is "barren land" almost all of which is beaches. This is expected to present development challenges. • Wind developers are also waiting to see if the PTC will be renewed later in 2004 before committing to projects.

Offshore wind power will only be economic with a moderate-high RPS REC value, absent an extension of the PTC beyond 2006.

Offshore Wind Power	
Economics	• It is assumed that offshore wind power could only be implemented in New Jersey starting in 2008, and thus would not be eligible for the PTC, even if it is extended according to the legislation that is currently in conference committee — Under this assumption, offshore wind power requires a premium of ~$44/MWh in 2008, declining to ~$22/MWh by 2020 ▪ A further extension of the PTC in a similar form to the current PTC would reduce this amount by about $12-13/MWh.
Implemen-tation	• Offshore wind power has, by far, the largest technical potential among renewables in New Jersey • Given the need for long-term support to cover the over-market cost of electricity, this option is perhaps most dependent on the continuation of the RPS out to 2020, plus any Clean Energy Program activities that aid in the securing of long-term contracts for energy and REC sales. — An extension of the Federal PTC beyond 2006 would also help reduce risk and cost. • This technology is still being proven in the field. Recent experience in Europe has been mixed but should help to reduce technology risk by the time projects are developed in the United States • Significant, serious development activities are not likely to proceed in New Jersey until more progress is made on the two most advanced projects in the U.S. – one on MA (Cape Wind) and the other in NY (LIPA). Both are probably 2-3 years away from operation.

Landfill gas to power is a cost effective resource but will likely require low-moderate support available through the RPS.

Landfill Gas to Power	
Economics	• With a levelized cost of electricity of approximately $40/MWh (with existing gas collection system) to $50/MWh (without existing gas collection system) landfill gas to power is competitive with expected wholesale power prices and only requires a RPS REC value of less than $10/MWh to ensure cost competitiveness. — In fact, given the remaining LFG potential in New Jersey, LFG may set the price for RPS RECs in the near term • LFG to power has attractive economics driven by: — Zero cost fuel – landfill gas is a natural byproduct of the decomposition of waste at landfills. Most landfills in New Jersey already have collection systems in place to mitigate emissions (e.g., via a flare). A minority of (mostly smaller) landfills do not have collection systems already in place. • Our analysis has assumed private sector financing. If financing can be done through a municipality, then the cost of electricity could be even lower • In reality, there will be a range of power costs, driven primarily by differences in project size. Nevertheless, LFG to power should be one of the most competitive Class I RE options in NJ.
Implemen-tation	• LFG power production costs are very close to the wholesale market price, there are few expected barriers to siting and permitting, and technology risk is low. As such this option could be developed relatively quickly and approach 100% of the technical potential. — If development activities begin immediately, it may be possible to achieve most of the economic potential of the landfills that already have collection systems in place (51MW) by 2008. The other landfills will take longer.

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Biogas cogeneration from wastewater treatment is cost effective under all scenarios and could be developed relatively quickly

Biogas Cogeneration from Wastewater Treatment (WWT)	
Economics	• In all scenarios, biogas from WWT has a negative cost premium, meaning that it can produce power at a cost below the expected revenue from power sales and RPS REC sales. • Biogas cogeneration from WWT has attractive economics driven by: — Zero cost fuel – biogas is a natural byproduct of WWT using anaerobic digestion. Typically this fuel is either flared or burned in boilers to provide heat for the digesters. — Low operations costs – it has been assumed that staff at the WWT plant can operate the equipment. Thus only the maintenance cost is incremental (~$10/MWh). — Low cost of capital – it has been assumed that financing would be by the municipality via municipal bonds. ▪ If financing were through the private sector, costs would increase by ~$10/MWh but this option would still have a negative cost premium.
Implemen-tation	• While technically a customer-sited technology, the size of the individual installations should often exceed 1 MW, so it has been modeled as a wholesale generation technology. — Most power is expected to be used onsite and the economics would look even more attractive against displaced power purchases. • With few expected barriers to siting and permitting, and low technology risk, this option could be developed relatively quickly and approach 100% of the technical potential. — If development activities begin immediately, it may be possible to achieve most of the economic potential of 23 MW by 2008.

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Solid biomass power faces cost hurdles, especially in the absence of Federal support typically afforded wind and solar power.

Solid Biomass Power (Direct Combustion and BIGCC)	
Economics	• Unlike wind and solar power, biomass power is not currently eligible for Federal incentives. • Biomass direct combustion options are generally only economic in the *High* scenario, and then only for low-cost fuels. For fuel prices higher than $1.50/MMBtu, biomass combustion is not likely to be economic, except potentially beyond 2015 in the *High* scenario. • BIGCC has the potential for better economics due to higher efficiency, but this is predicated on successful commercialization of the technology and achieving the cost reductions assumed in this study. • Onsite biomass power, which was not evaluated here, has the potential for better economics, sue to zero-cost fuel and the ability to displace retail power vs. wholesale.
Implemen-tation	• Despite the relatively unfavorable economics, the magnitude of the biomass opportunity appears larger than onshore wind. Thus, it could be important in reaching Class I RE targets. This suggests that a more detailed assessment of the potential is justified. This assessment would better characterize the resource potential, including the potential for onsite cogeneration. • Even with favorable economics, siting and permitting may be difficult, suggesting a possible role here for the Clean Energy Program as well.

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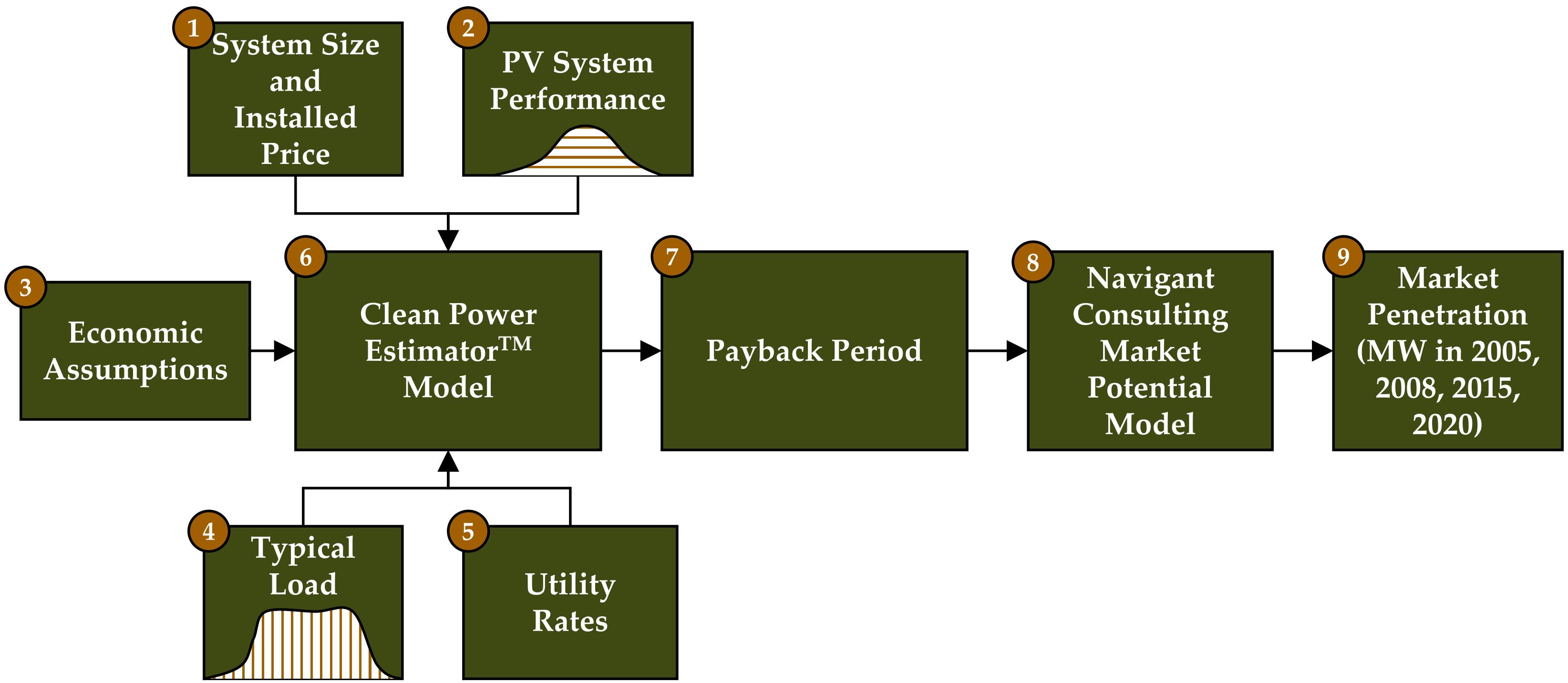
Central station PV can be competitive in the long term (2015-2020), provided solar RECs are above about $200/MWh.[1]

Central Station PV	
Economics	• Central station PV is only economic in the *High* scenario, and then only after 2015. • If the Clean Energy Program were to offer rebates for the application, it could be economic sooner
Implemen-tation	• Brownfields have been identified as potentially attractive for siting central station PV but more research is needed to better understand the magnitude of the opportunity and the barrier that may exist • Other land could also be used, but the economic viability will be driven by the other possible uses for that land • Involving the utilities in this opportunity may be worthwhile.

1. This assumes no state rebates for central station PV.

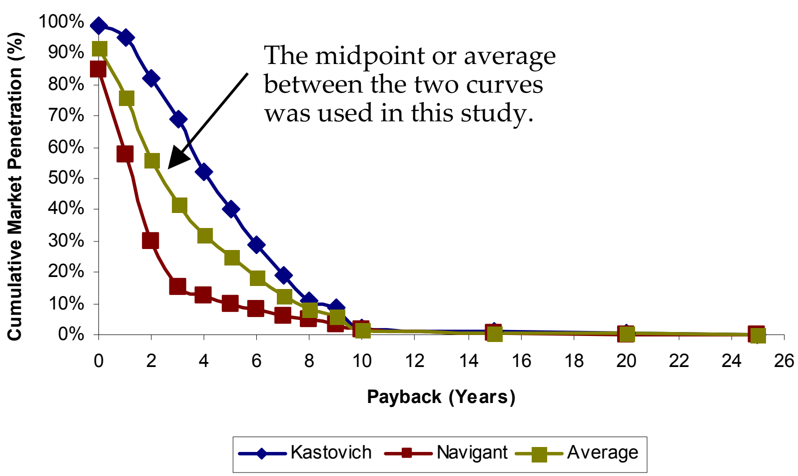
The approach used to assess the market penetration for customer-sited residential and commercial PV is illustrated below.



Note: For customer-sited PV, the analytical approach differed from that used for grid-sited options. Step 8 in the flowsheet above was used to estimate the theoretical and technical potential, as described in the following pages.

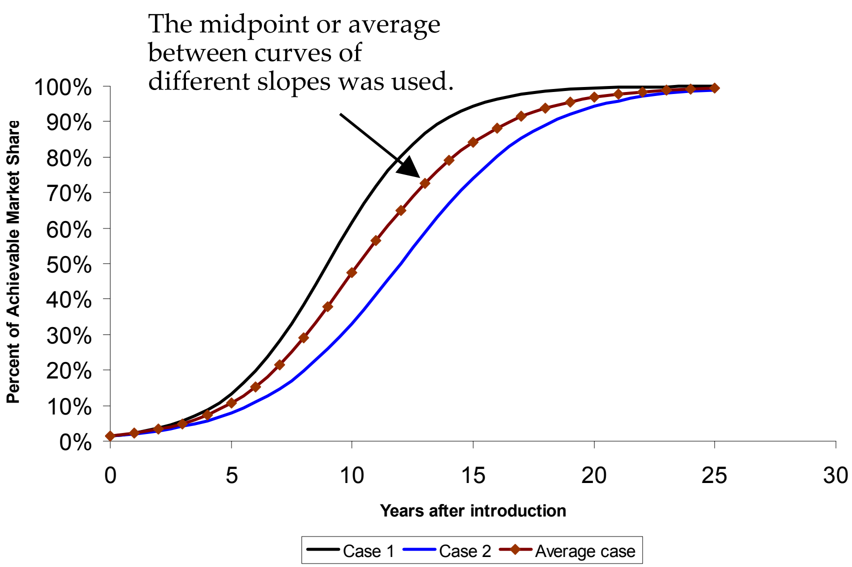
Two curves were used to estimate demand for PV: one links payback to penetration, and the other projects build-up of annual demand.

Payback vs. Cumulative Market Penetration Curves



- The curves provide the cumulative market penetration 10-20 years after product introduction, as a function of payback.
- The Kastovich curve is more aggressive than the Navigant curve: a midpoint between the two was thus considered in the analysis.

Typical S-Curve



- The S-Curve provides the rate of adoption of technologies, which is a function of the technologies characteristics and market conditions.
- An average of two curves was used, given the many factors that will impact penetration of PV.

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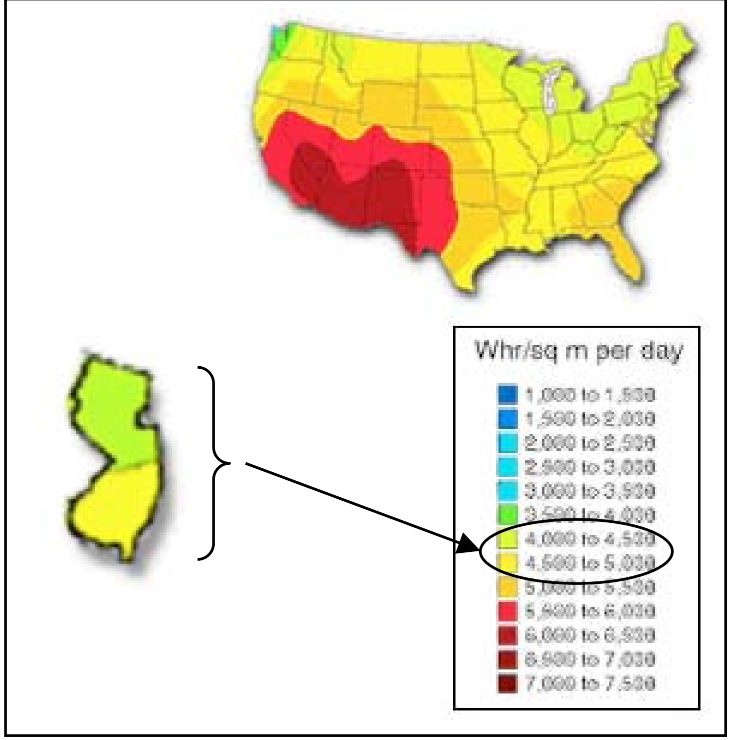
The solar resource in New Jersey is average but the large amount of available roof space makes it a good fit.

Commercial flat-roof installation in NJ

Residential pitched-roof installation in NJ

Solar Radiation Map: Flat-Plate Collector tilted South at Latitude



U.S. DOE – Office of Energy Efficiency and Renewable Energy

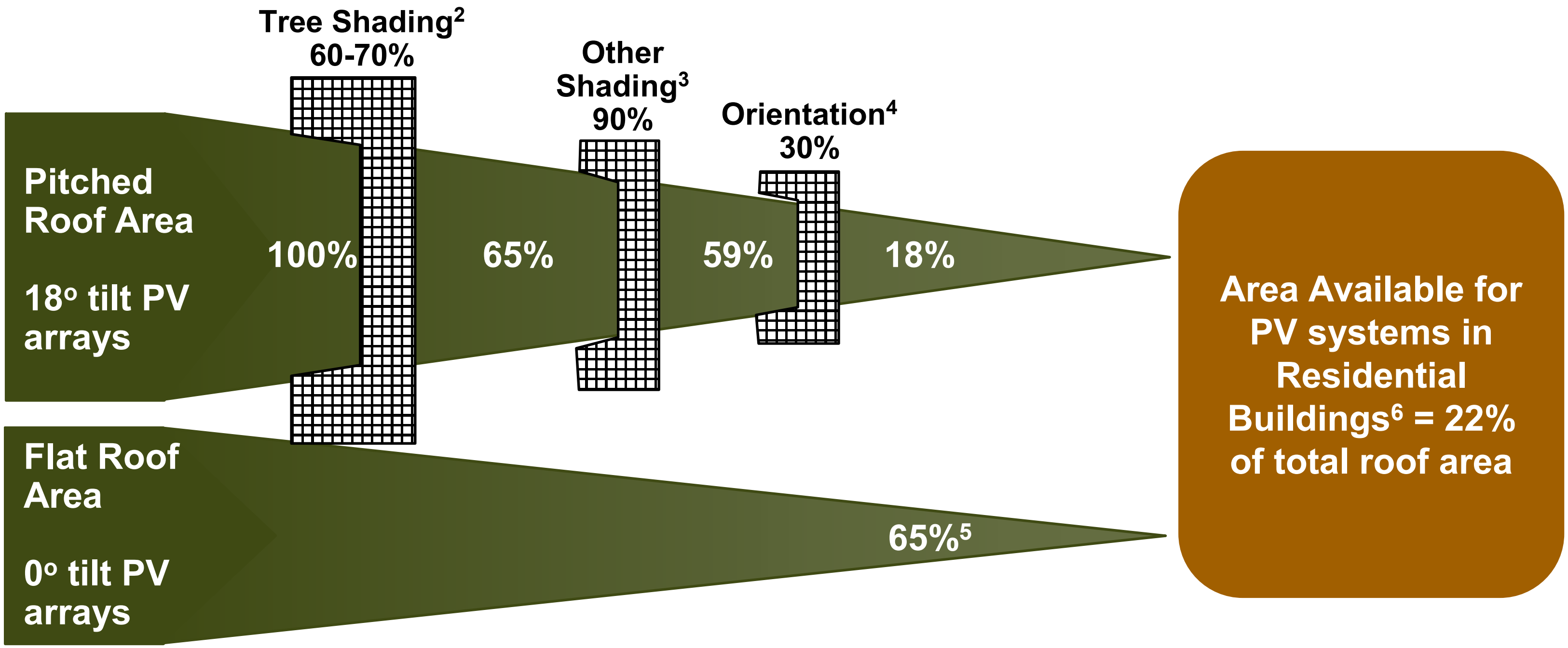
Residential roof area estimates are based on data from the US DOE's *Residential Energy Consumption Survey*.[1]

- The U.S. DOE's Residential Energy Consumption Survey[1] reports 14.8 million households in the Northeast Mid-Atlantic region (New Jersey, NY, PA), with a total floor space of 26,630 million square feet (sq. ft).
- Taking into account the number of stories per building and assuming single and 2-4 family homes have 18° pitched roofs, while larger residential buildings and mobile homes have flat roofs, the total roof area obtained is 14,402 million sq. ft. The roof area available for PV is 3,081 million square feet.
- Given that New Jersey accounts for approximately 21% of customers in the Northeast Mid-Atlantic region, the estimated available roof area in the state is 656 million sq. ft in 2001.
- Projections in later years are obtained using EIA estimated growth rates (growth in number of households: 1.12% for single family, 0.71% for multi-family, 0.46% for mobile; growth in average floorspace per household: 0.25%)

	Estimated Available Residential Roof Space in New Jersey (million sq. ft.)
2005	698
2008	728
2015	798
2020	846

1. U.S. Department of Energy, Energy Information Administration, *Residential Energy Consumption Survey*, 2001.

The roof space available on residential buildings for PV installations is around 22% of total roof area[1].



1. Includes roof space over enclosed garages.
2. Roof area available due to tree shading is around 60% for single homes and higher at 70% for townhouses and other residential buildings. Closely packed homes in high density neighborhoods allow little room for large trees to grow and shade roofs, compared to larger homes in low density neighborhoods.
3. Other shading may be due to chimneys, vent stacks and other roof obstructions.
4. Based on assumptions made for single homes, which account for 70% of the building stock. Assume that orientations from southeast clockwise around to west are appropriate for PV installations. For gable ended roofs with one long ridge line, assume that one of the pitched surfaces will face in the proper direction for 75% of the residences. If each surface is half the roof, 38% of the roof area can accommodate PV arrays. For hip roof buildings, one of four roof area will be facing in the right direction, or 25% of the roof area. The average of 38% and 25% is around 30%, which is what is assumed as the percentage of roof area with acceptable orientation.
5. See analysis of roof area availability for flat roof buildings on next page.
6. Assumes single home and 2-4 unit apartments have pitched roof, which accounts for 92% of total roof space, the balance 8% being flat roof space on 5+ unit apartments and mobile homes.

Note: The data are based on a study conducted by the Navigant Consulting team while at Arthur D. Little. New construction may have higher availability, as solar access issues are taken into account in designing new buildings.

Commercial roof area estimates are based on data from the US DOE's *Commercial Building Energy Consumption Survey.*[1]

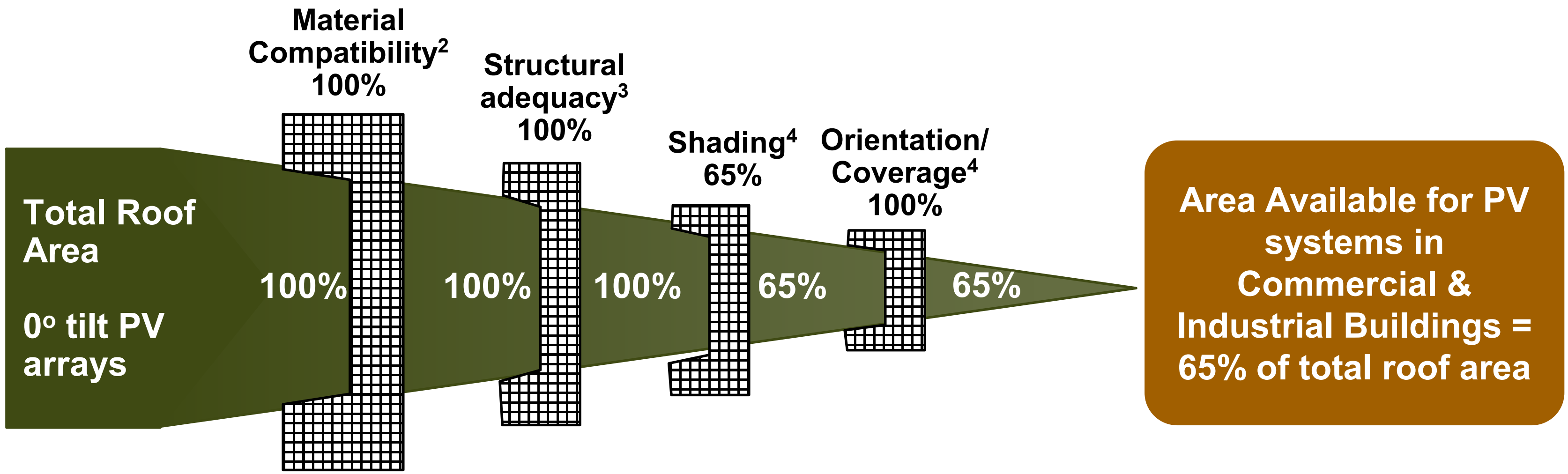
- CBECS[1] reports 479,000 commercial buildings in the Northeast Mid-Atlantic region (New Jersey, NY, PA), with a total floor space of 8,625 million sq. ft.
- Taking into account the number of floors per building, and assuming all commercial buildings have a flat roof, the total roof are for commercial buildings is 4,107 million sq. ft.
- Assuming 65% of the total roof area is available for PV, the total roof area available in 2001 is 2,669 million sq. ft.
- New Jersey accounts for approximately 19.7% of commercial customers in the Northeast Mid-Atlantic region. The available roof area in the state is therefore estimated at 526 million sq. ft. in 2001.
- Projections in later years are obtained using EIA estimates (EIA Annual Energy Outlook 2003 provides a forecast of commercial building floorspace to 2025. These figures are used to derive roofspace by assuming a constant ratio of floorspace to roofspace)

	Estimated Available Commercial Roof Space in New Jersey (million sq. ft.)
2005	555
2008	570
2015	591
2020	602

1. U.S. Department of Energy, Energy Information Administration, *Commercial Building Energy Consumption Survey.* 1999

Note: CBECS data excludes industrial buildings (e.g. manufacturing, agriculture, mining, forestry and fisheries, and construction)

The roof space available in commercial buildings for PV installations is around 65% of total roof area[1].



1. Includes roof space over enclosed garages.
2. Roofing material is predominantly built up asphalt or EPDM, both of which are suitable for PV, and therefore there are no compatibility issues for flat roof buildings.
3. Structural adequacy is a function of roof structure (type of roof, decking and bar joists used, etc.) and building code requirements (wind loading, snow loading which increases the live load requirements). For most buildings, this is not expected to be an issue.
4. An estimated 5% of commercial building roofing space is occupied by HVAC and other structures. Small obstructions create problems with mechanical array placement while large obstructions share areas up to 7x that of the footprint. Hence, around 35% of roof area is considered to be unavailable due to shading. In some commercial buildings such as shopping center, rooftops tend to be geometrically more complex than in other buildings and the percentage of unavailable space may be slightly higher.
5. Flat arrays are assumed. If tilted arrays were assumed, then more space would be required per PV panel due to panel shading issues, which would reduce the roof space available.

Note: The data is based on a study conducted by the Navigant Consulting team while at Arthur D. Little.

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The technical potential, even after accounting for shading, orientation and other losses, is significant for PV in New Jersey – more than two orders of magnitude larger than the 2008 target of 90 MW.

	PV Technical Potential – Residential Buildings			
	2005	**2008**	**2015**	**2020**
MW Cumulative	8,560	8,940	9,790	10,390
MWh per year	11,154,560	11,647,550	12,754,400	13,532,590

	PV Technical Potential – Commercial Buildings			
	2005	**2008**	**2015**	**2020**
MW Cumulative	6,815	7,000	7,260	7,390
MWh per year	8,879,770	9,120,520	9,455,935	9,630,850

Note: The increase in market potential over time is driven by the increase if roof space. The estimate is conservative in that it considers roof space only, and not other potential applications, such as curtain walls, carports, or other structures.

NCI ran a number of scenarios for the PV analysis to assess the impacts of state incentive levels and prices for solar RECs.

- The cost of PV systems was assumed to decline at 5% per year, consistent with historical trends and NCI's expectation of future long-term trends.
- In the Base Case scenario, with the declining cost of PV systems, the rebate will be limited by the maximum allowable incentive as a % of initial system cost: 70% for residential systems and 60% for commercial systems
- A modified rebate formula that keeps a fixed net system cost to the buyer ($2,500/kW for residential and $2,400/kW for commercial) was also tested.
- The maximum Solar REC value for PV has been set at $250/MWh, slightly below the alternative compliance payment of $300.
- In this analysis, REC values of $100/MWh with a State rebate and $250/MWh without a State rebate were also tested. These REC values were assumed constant through time.

	PV Market Model Assumptions – Residential 2.5 kW System			
	2005	2008	2015	2020
Installed Price ($/kWpac)[1]	$8,000	$6,900	$4,800	$3,700
Base Case Rebate Amount ($/kW)	$5,500	$4,830	$3,360	$2,590
Modified Rebate Formula ($/kW)	$5,500	$4,400	$2,300	$1,200

	PV Market Model Assumptions – Commercial 250 kW System			
	2005	2008	2015	2020
Installed Price ($/kWpac)[1]	$6,000	$5,145	$3,590	$2,780
Base Case Rebate Amount ($/kW)	$3,600	$3,090	$2,155	$1,670
Modified Rebate Formula ($/kW)	$3,600	$2,745	$1,190	$380

1. kWpac = kW peak, alternating current.

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Five scenarios were selected to examine the potential of the customer-sited photovoltaics market, defined as follows:

PV Market Penetration Scenarios		
Description		Rationale
Scenario A	• No state incentives • Commercial systems benefit from an existing 10% Federal investment tax credit and accelerated depreciation	Reference market potential in absence of state incentives
Scenario B	• Current New Jersey rebate • Value of RECs for PV is held at $100/MWh	Continuation of current rebate program with REC value representative of current market for voluntary solar RECs
Scenario C	• No state rebate program • The value of RECs for PV is held at $250/MWh	Evaluate the effectiveness of RECs at stimulating the market in the absence of a rebate program
Scenario D	• The New Jersey rebate level is reduced to 50% of the current level • The value of RECs for PV is held at $100/MWh	Sensitivity of the market to a reduced rebate with REC value representative of current market for voluntary solar RECs
Scenario E	• Modified rebate formula that maintains a constant net system cost to the buyer ($2,500/kW for residential and $2,400/kW for commercial) • The value of RECs for PV is held at $100/MWh	Sensitivity of the market to a reduced rebate with REC value representative of current market for voluntary solar RECs. Rebate level chosen to provide the same net system cost to the customer as current rebate level.

State incentives are required for PV market penetration in residential buildings in the near term.

		Estimated Residential PV Market Penetration and Payback			
		2005	**2008**	**2015**	**2020**
Scenario A: No state incentives	**MW Cumulative**	0.0	0.0	0.0	1.4
	MWh/year	0	0	0	1,850
	Payback (yrs)	55.9	47.5	32.6	25.0
Scenario B: Current NJ rebate, Solar RECs = $100/MWh	**MW Cumulative**	17	102	1,593	3,245
	MWh/year	22,150	133,12	2,075,783	4,231,085
	Payback (yrs)	9.1	7.5	5.2	4.0
Scenario C: No state rebate, Solar RECs =$250/MWh	**MW Cumulative**	2	8	112	845
	MWh/year	2,215	10,824	145,305	1,101,072
	Payback (yrs)	17.1	14.6	10.1	7.8
Scenario D: NJ rebate reduced by 50%, Solar RECs = $100/MWh	**MW Cumulative**	1	6	96	646
	MWh/year	1,606	8,212	125,377	841,268
	Payback (yrs)	19.2	16.2	11.2	8.6
Scenario E: Rebate provides constant net system cost to buyer Solar RECs = $100/MWh	**MW Cumulative**	17	57	382	608
	MWh/year	22,150	74,650	498,188	791,782
	Payback (yrs)	9.1	9.1	9.0	9.0

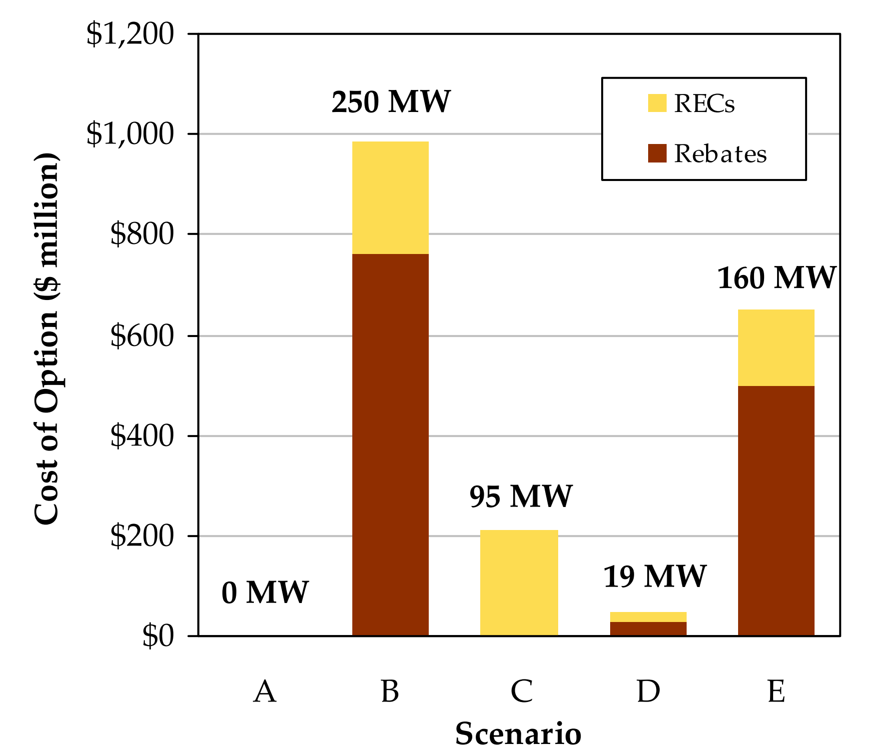
State incentives are also required for PV market penetration in commercial buildings in the near term.

		Estimated Commercial PV Market Penetration and Payback			
		2005	**2008**	**2015**	**2020**
Scenario A: No state incentives	**MW Cumulative**	0	0	0	11
	MWh/year	0	0	0	14,528
	Payback (yrs)	53.0	44.7	30.2	23.0
Scenario B: Current NJ rebate, Solar RECs = $100/MWh	**MW Cumulative**	31	150	1,525	2,840
	MWh/year	40,260	192,900	1,985,253	3,697,930
	Payback (yrs)	6.9	5.9	4.1	3.1
Scenario C: No state rebate, Solar RECs =$250/MWh	**MW Cumulative**	15	87	1,181	2,311
	MWh/year	19,984	113,012	1,538,956	3,011,171
	Payback (yrs)	8.6	7.4	5.1	3.9
Scenario D: NJ rebate reduced by 50%, Solar RECs = $100/MWh	**MW Cumulative**	3	13	590	1,515
	MWh/year	3,967	16,659	769,480	1,972,230
	Payback (yrs)	12.1	10.3	7.1	5.5
Scenario E: Rebate provides constant net system cost to buyer Solar RECs = $100/MWh	**MW Cumulative**	31	102	647	1,007
	MWh/year	40,262	133,471	843,348	1,311,885
	Payback (yrs)	6.9	6.9	6.8	6.8

Financial support is necessary to achieve significant PV market penetration, but RECs may be more cost effective per MW than rebates.

- Effectiveness of incentives:
  - Scenario A: Without incentives, PV achieves negligible market penetration
  - Scenario B: 252 MW at a cost of $984 M ($3.90/Watt)
  - Scenario C: 95 MW installed by 2008 with incentives costing $210 M ($2.20/Watt)
  - Scenario D: 19 MW at a cost of $46.1 M ($2.40/Watt)
  - Scenario E: 160 MW at a cost of $649.6 M ($4.10/Watt)
- The economic analysis does not factor in how customers would perceive the risk of the various scenarios, e.g., making buy decisions in the absence of the rebate and instead relying solely on long-term revenue from RECs.

Net Present Value (NPV) Cost[1] of incentives for the different PV scenarios and associated estimated market penetration



1. Cost of RECs is the total cost out to 2020, discounted at 8% per year (for systems installed in 2003-2008). The cost of the rebates is the total cost to 2008, discounted at 8% per year.

New Jersey can likely decrease the amount of the rebate and still meet its 2008 objective of 90 MW of PV.

- If the current rebate program continues as is (Scenario B), New Jersey is likely to overshoot its target of 90 MW by 2008.
  - This scenario also requires significantly more funding (~$750 million in rebates on an NPV basis) than is available in the Clean Energy Program between now and 2008.
- In comparison, Scenario E, which maintains the same net cost of the PV system to the customer as the current rebate level, still exceeds the 2008 target, but at a lower total cost. In this scenario, Clean Energy Program rebates total approximately $500 million through 2008 on an NPV basis.
- Scenario D, which reduces the current rebate by 50% results in moderate long-term penetration, but falls short of the 2008 target.
- This analysis suggests that a reduced rebate (somewhere in between scenarios D and E) or some sort of block structure similar to what is offered for wind and sustainable biomass through the CORE program, would still allow New Jersey to meet the 90 MW target, but at a lower total cost than is implied by continuation of the the current rebate levels.
- Other factors not evaluated in the market penetration analysis are potentially important to decisions about how to modify the rebate program:
  - For a given levelized cost of electricity (LCOE) reduction impact, rebates will be more attractive to the customer since they eliminate the risks of changes in future REC prices or the elimination of RECs altogether (e.g., if the RPS is repealed).
    - Thus, even though the analysis shows that the 2008 target can be met with high REC prices alone (Scenario C), if the rebate is eliminated or substantially reduced, this will likely result in substantially reduced market penetration.

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The business infrastructure for wind energy in New Jersey is underdeveloped.

- For small behind-the-meter installations, New Jersey has the "right" framework (e.g., policies) but lacks the business infrastructure.
  - Financial incentives, interconnection requirements, and net metering policies are all in place.
- Opportunities exist to improve infrastructure for larger wind developments.
  - Key equipment (turbines, blades, towers) is often imported but several tower and two large turbine manufacturers are located in the United States. Blade production is more labor intensive and is more likely to be imported from Mexico or Canada.
- Some of the manufacturers of secondary equipment (gearboxes, electronics, etc.) are located in New Jersey.
  - Opportunity exists to expand this business segment
  - Opportunity also exists to leverage local intellectual capacity and innovation to advance technology associated with these components
    - Space/land requirements are lower relative to primary components
    - New Jersey is home to numerous research institutions
- Given the small onshore wind power potential in NJ, developing a "native" infrastructure may not be necessary if the necessary ingredients can be acquired from neighboring states.

There are opportunities to develop jobs with wind turbine construction and operation.

- Labor during the construction phase is likely to be split between local and out-of-state entities.
  - Will tap local market for sub-contract work such as general construction, assembly, wiring, and civil engineering
  - Specialists will be brought in from other states including:
    - Representatives from manufacturers in Pennsylvania or Texas where there are established wind developments
      - As wind power capacity increases in New Jersey, there will be increased need for "local" specialists
- Routine O&M requirements can be fulfilled by a local labor pool
  - Requires a minimum of high school education and mechanic skills
  - Can be trained by a wind turbine manufacturer
- Extraordinary problems will require "specialist" skills currently not available in New Jersey
- For offshore projects, there are some unique additional needs:
  - Some onshore facilities during construction (dock to assemble, ship, etc.)
  - Ability to repair equipment (offshore or transport to shore)

New Jersey's location facilitates wind development from a logistics perspective…

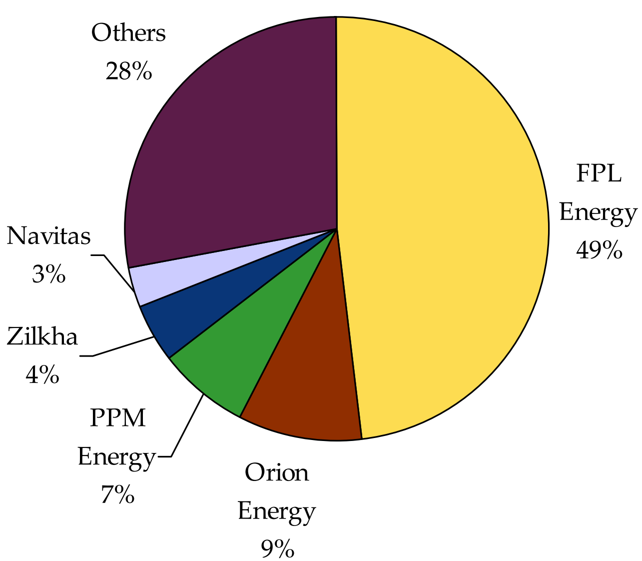
- Extensive transportation network, including freeways and seaport facilitates transportation of heavy equipment (cranes, towers, turbines, etc).
- There is availability of local labor for construction and civil engineering work.
- There are several U.S. wind and other organizations with local chapters.
  - American Wind Energy Association (AWEA)
  - Northeast Sustainable Energy Association (NESEA)
  - New Jersey Public Interest Research Group (New Jersey PIRG)
  - National Wind Coordinating Committee
  - Green-E

…but New Jersey's high population density may also impede wind power development due to siting and other similar constraints.

FPL Energy is the major U.S. wind developer and GE Wind is the leading U.S. wind turbine manufacturer. For offshore systems, leading manufacturers are Vestas (worldwide) and GE Wind (U.S.).

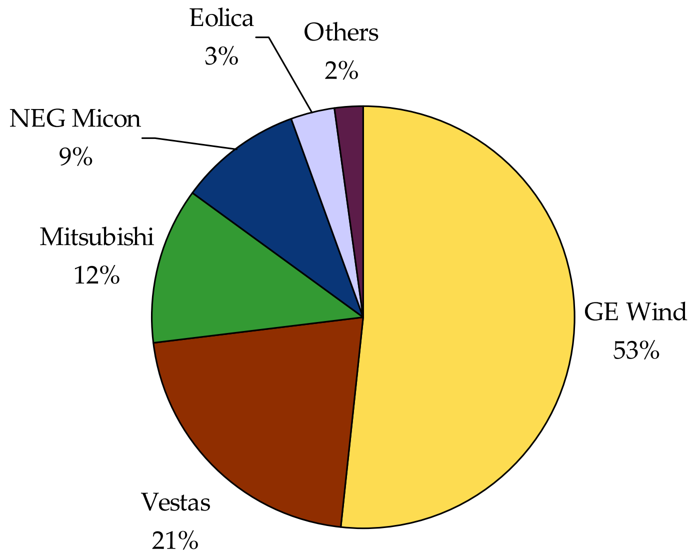
U.S. Wind Installations By Developer (2003)

Total U.S. Installations = 1,687 MW



U.S. Wind Installations By Manufacturer (2003)

Total U.S. Installations = 1,687 MW



Source: NCI data based on AWEA and wind manufacturer interviews, June 2004.

There is virtually no infrastructure for offshore wind development anywhere in the U.S. Several key areas need to be addressed.

- Education of financial community as to technology and viability of offshore wind.
- Education of insurance community as to areas of risk and their components (e.g., percentage of hours with wave heights exceeding threshold for vessel-based O&M).
- Assumption of risk by various parties with expertise in each area (turbine manufacturer for turbine technology lifetime and performance, foundations contractors/engineers for foundation stability and performance, etc.).
- There is little need for a viable infrastructure until offshore installations have been successfully accomplished and the siting and permitting processes have been codified.

New Jersey's biomass processing infrastructure is strong and could support additional power generation capacity.

- New Jersey has a strong existing tree and yard trimming collection and composting facility infrastructure that could potential support power generation applications.
  - Composted material and wood chips are said to be given away from many municipal facilities and sold by some private facilities.
  - And, while stockpiles are typically cleared within a year, during lower demand seasons they can begin to exceed regulatory storage standards limits.
- According to the American Forest & Paper Association, wood and paper products make up approximately 4.9% of New Jersey's total manufacturing workforce.
  - Nationally, the industry is approximately 50% energy self sufficient (i.e., used biomass residuals for energy), but in New Jersey, this number appears to be much lower.
- New Jersey has a large existing network of regulated landfills that produce monitored landfill gas (LFG), some of which produce power.
- New Jersey also has a large existing network of monitored and regulated wastewater treatment facilities that could generate power (where anaerobic digestion is used).
- The state's agricultural crop residues and animal wastes are not considered a large available resource for conversion into bioenergy products.

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Outside of existing LFG capacity, there appears to be minimal biomass power capacity and supporting infrastructure.

- The DOE EIA only lists 1 MW of biomass capacity in New Jersey that is not landfill gas or municipal solid waste incineration.
- There may be forest product facilities in the state that self-generate bio-based energy, as is typical for those types of industries. However, there is little specific data to indicate which wood and paper mills may have biomass-based self-generation facilities.
- There does not appear to be any direct-fire biomass power plants in New Jersey in the >1 MW size range that would qualify as Class I.
- Data regarding existing methane-based capacity and potential incremental capacity at wastewater treatment facilities are not currently available. The existing wastewater methane-based capacity is thought to be small compared to the LFG opportunity. Recently, data concerning digester types have begun to be collected by the New Jersey DEP.
- No information was available regarding agricultural on-site generation projects in New Jersey.
- There appears to be no movement or information related to converting composting operations to anaerobic digester facilities capable of producing energy.

The New Jersey business infrastructure for supplying, designing, and constructing biomass conversion facilities is underdeveloped.

- Relatively few biopower technology vendors, including manufacturers, distributors, consultant engineers, or installers are physically located within New Jersey. Nor, are leading vendors typically visible elsewhere in the US, including:
  - Manufacturers and equipment suppliers: Caterpillar, Solar Turbines, Waukesha, Jenbacher (GE);
  - Engineer, Procurement and Construction (EPC) Contractors: e.g., Black and Veatch, or Stone and Webster
  - Distributors, installers, owner/operators: DTE Biomass, Stewart and Stevenson, Continental Biomass
- The current New Jersey Clean Energy Program Listed Vendors are:
  - Northern Power Systems is currently working and moving into the New Jersey area.
  - Biomass Combustion Systems and ALJ Resources.
- Interviews with representatives listed on the New Jersey Clean Energy Program site indicated the potential for market expansion as well as the expansion of their business into the New Jersey area. One company mentioned commencing work on a vegetable oil resource recovery project in the state.
- In contrast, many surrounding states do have evolved business infrastructure for supplying, designing, and constructing biomass conversion facilities, driven in part by the larger size of the forest products industry in those states.

Research and Commerce Information Exchange infrastructure is strong in New Jersey, but lacks a strong presence from the biomass industry.

- The New Jersey Clean Energy Program offers an easy to use listing of renewable energy vendors. However, only three biomass industry vendors are registered on the list, which is significantly less in comparison to the breadth of vendors listed for other technologies such as solar.
- The US DOE AgStar program has a vendor database for animal waste digester systems, which includes a listing of approximately 10 agricultural biomass energy sector vendors in the region.
  - None of the vendors listed on the AgStar Directory are listed on the New Jersey Clean Energy Program Vendor List.
- New Jersey does have a Commerce and Industry Business Association, which includes an Environmental Commerce Council, that is said to be very active. However, current information within the organization regarding bioenergy commerce was not readily available.
- There are several organizations that provide good industry vendor leads:
  - Green Pages, Green-E, GreenBiz
- New Jersey is home to and in close proximity to numerous research institutions with expertise is forestry, agriculture and bioenergy conversion technologies.
  - Rutgers, Princeton, Northeastern Forest Inventory Analysis (FIA) Research group

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Data relevant to biomass market assessments are not currently readily available.

- Yard trimmings and composting infrastructure facilities are tracked in detail, but relative volume flow, pricing data and specific end-use information is not well-documented or reported.
- Data regarding the New Jersey wood and paper industry were not readily available through state government information networks.
- Landfill methane production and flare data are tracked/estimated and available, but existing LFG generation capacity and potential incremental capacity information are inconsistent.
- Wastewater treatment plant flow data are reported in detail, and anaerobic digester tracking has begun, but data on the wastewater treatment methane resource are incomplete.
- Agricultural reports quantify crop farm sizes in production and livestock headcounts, but do not quantify crop residues or manure waste streams (both are estimable).

Coordination and centralization of information between environmental agencies regarding waste streams and residue availabilities would allow market assessments to be more easily conducted in the area and could facilitate market development.

The PV infrastructure for New Jersey is relatively large with many participants located in New Jersey and in close-by states.

- There are 57 commercial and residential installers of photovoltaic systems registered in New Jersey
  - 43 are registered to perform both residential and commercial installations
  - 4 perform residential installations only
  - 10 perform commercial installations only
- Many distributors, installers, manufacturer/integrators are located in New Jersey or close proximity.
  - 24 located in New Jersey
  - 23 located in PA, NY, MD, or DE
  - 10 located afar (MA, FL, CA, etc.)
- Some installers play along several parts of the value chain, also serving as:
  - Integrators,
  - Distributors, and/or
  - PV module manufacturers.

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Training for installers in New Jersey is widely available.

- Installation is labor intensive
  - Does not require heavy equipment
  - Not required to be a licensed electrician
- Training for installers is widely available from:
  - Large installation companies
  - Community colleges
  - Manufacturers
- Training can usually be completed within 5 days
- May be certified by North American Board of Certified Energy Professionals (NABCEP)
  - However, certification is not necessary to be a "qualified" installer of PV systems

There are 24 PV distributors/installers/manufacturers with offices in New Jersey.

Key PV Stakeholders with New Jersey Offices	Distributor	Commercial Installer	Residential Installer	Manufacturer /Integrators
3rd Rock Systems & Technologies: East Brunswick	●	●	●	●
Absolutely Energized Solar Electric: Perrineville		●	●	
Advanced Building and Solar: Woodbury	●	●	●	
Advanced Solar Products: Hopewell	●	●	●	
Akeena Solar: Clifton		●	●	
Ecological Systems: Atlantic Highlands	●	●	●	
Energy Enterprises: Mays Landing	●	●	●	
Energy Photovoltaics (EPV): Lawrenceville				●
Electric Solar Power: Cedar Knolls	●	●	●	
Fineline Energy Solutions: Hillsborough			●	
First Inc.: Hopewell	●	●	●	
GeoGenix, LLC: Rumson	●	●	●	
Jersey Solar: Hopewell	●	●	●	

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There are 24 PV distributors/installers/manufacturers with offices in New Jersey. (continued)

	Key PV Stakeholders with New Jersey Offices			
	Distributor	Commercial Installer	Residential Installer	Manufacturer /Integrators
LBI Solar: High Bar Harbor	●	●	●	
New Jersey Solar Power: Pine Beach		●	●	
Optimal Energy, Inc.: Moorestown	●	●	●	
Rowson Electric, Inc.: Pitman		●	●	
PowerLight Corporation: Crosswicks		●		●
Sea Bright Solar: Sea Bright	●	●	●	●
Solara Energy Inc.: Folsom	●	●	●	●
Sun Farm Network, Califon	●	●	●	
Electric Solar Power: Cedar Knolls	●		●	
SunLit Systems: Edison	●	●	●	
Solar Integrated Technologies: Belmar		●		●
WorldWater Corporation: Pennington		●		●

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The PV industry is comprised of companies ranging from multinational energy companies to small businesses with fewer than 20 employees.

New Jersey Photovoltaic Infrastructure

- Infrastructure is comprised of organizations of all sizes.
- Sales networks include manufacturer sales force and distribution networks.
  - Manufacturer sales force will often do large project installations.
  - Small commercial and residential installations are referred to distributors.
- Larger organizations are able to offer a complete end-to-end solution, particularly for commercial installations.

Examples of Key Players

- BP Solar
- Shell Solar
- Sharp
- RWE Schott Solar
- PowerLight
- Energy Photovoltaics (EPV)
- Advanced Solar Products
- Sun Farm Ventures
- Jersey Solar
- Ecological Systems
- Princeton Energy Systems
- WorldWater

VII. Program Options

The goal of this task was to review the effectiveness of current New Jersey programs against established RE objectives and assess options to modify or add to these programs.

Direct Objective: XXX				
Existing Programs	Criterion A	Criterion B	…	Criterion G
CORE				
REED				
REAP				
…				
…				
…				

Other SBC and RPS best practices

Gaps in meeting primary objectives or falling short on key criteria.

Direct Objective: XXX				
Potential Programs[1]	Criterion A	Criterion B	…	Criterion G
AAA				
BBB				
CCC				
DDD				
EEE				

1. Or modifications to existing programs.

This assessment was qualitative in nature, based on the collective experience and judgment of the NCI team and on similar experience in other states.

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The 90 MW PV goal can be met with adequate funding of existing programs, but other programs may help control costs.

Goal:

Install 90 MW of PV in NJ by 2008

- The 90 MW goal can be met under the existing program structure:
  - CORE is the only current program that directly targets the 90 MW PV goal, but it is effective.
  - Under the existing program structure the 90 MW PV goal can be met if more funds are allocated. Total costs are estimated at about $350 million at current rebate levels.
- **Recommendation:** Modified or new programs would complement existing ones and allow the state to gradually decrease rebate levels and maintain market momentum.
  - A robust solar REC market can provide significant value to a PV project. The state could provide credit quality support to the solar REC market.
  - Targeting new construction can address the high-first cost issue
  - Promoting voluntary green power could increase demand for solar RECs
  - Mandatory PV targets for government buildings would help maintain demand
- **Recommendation:** Several new program options would modify/extend existing programs to also help achieve indirect objectives (e.g., reliability) without substantially changing program costs.
  - Decrease system costs through aggregated, multi-yr PV purchases
  - Improve reliability by targeting installations in load pockets.

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The 300 MW Class I goal appears to be a stretch due to near-term resource constraints, but the Clean Energy Program can do several things to help meet the goal.

Goal:

Install 300 MW of Class I RE in NJ by 2008

- Several RE options are cost effective and are not likely to need direct financial support, other than from programs aimed at facilitating long-term contracts for energy and RECs. However, total MW are limited.
- **Recommendation:** REAP is the main existing program targeting grid-sited RE. It should be configured to optimize the benefits of the Federal PTC (see below)
- **Recommendation:** In the long term, there are significant RE resources available, especially if offshore wind power is successful. However, these long-term options may require some direct financial support beyond the RPS:
  - Capital grants
  - Production incentives (note: for technologies eligible for the Federal PTC, this is less likely than grants or subsidized financing to trigger PTC double-dipping provisions)
  - Zero-interest loans or debt guarantees
  - Assistance with siting and permitting
- **Recommendation:** The Clean Energy Program should also consider resource-specific programs:
  - Improved wind forecasting
  - Community wind development
  - Grants for bioenergy crops

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Achieving the goal of 1.5X of Class I RPS load served via green power is an aggressive target but the Clean Energy Program is starting to address it.

Goal:

Increase Green Power Participation and Load Served

- RE that is used to meet the green power goals would need to be in addition to the RPS, suggesting that the green power goal will be a challenge to meet.
  - Even by implementing the proposed programs, the green power goals will still be a challenge to meet, based on experience in other states and on historical participation rates in existing green power programs.
- Current programs (with the exception of REED) do not directly address green power markets, but could have some spin-off benefits by making more renewable energy available.
- **Recommendation:** To effectively address this objective the Clean Energy Program will need new initiatives – there are numerous examples from other states to draw upon and the CEP is already developing some new programs. These include:
  - State green power purchases
  - RECs sold via utility bill/check-off program
  - Branding, education and outreach program
  - Customer incentives
  - Support for long-term hedge purchases (RE as hedge against price volatility)
  - Large customer buying group creation and support
- **Recommendation:** Many of these programs work well as a suite (e.g., need incentives + outreach + aggregation +access to utility bill [for small customers/mass market]).

The ability to enter into long-term contracts for energy and RECs is critical for project financing and development.

Long-term contracts for renewable energy and RECs

- The current retail market structure in NJ, as in other deregulated states, is not conducive to long-term contracting. However, the ability to enter into long-term contracts (>10 years) for renewable energy and REC sales is critical to securing financing for projects. Even projects with the most favorable economics (e.g., landfill gas) require moderate-term (4-8 year) contracts. Some options include:
  - Incentives for credit-worthy parties to enter long-term contracts
  - Large retail customer hedge program (long-term RE purchase as hedge against electricity price volatility)
  - Advocate for changes to wholesale rules, as appropriate
- **Recommendation:** Creating a robust market for RECs is critical, as this is the primary support mechanism for most RE. However, there are different approaches that could be taken:
  - Long-term REC purchase contracts with state as market enabler, e.g., extend the redemption window for RECs in the event the state repeals the RPS, or explore changes to the structure of the BGS auction rules that would encourage long-term RE contracts.
  - Long-term REC purchase contracts with state as market participant, e.g., the NJ CEP acts as credit-worthy buyer for RECs only, or NJ CEP acts as credit-worthy market of last resort, ensuring a minimum REC revenue by offering a floor price in the form of a put option, make-up payment, or similar price-support mechanism.

Some of the programmatic issues discussed can also be framed around technology-specific needs.

Ensuring that currently cost-effective resources are developed rapidly	• The fact that these projects have attractive levelized costs of electricity is not a guarantee that they will be developed. • **Recommendation:** The Clean Energy Program should have a near-tem focus on programs that facilitate the development of RE options that are cost effective today (landfill gas, biogas, some onshore wind power, and potentially customer-sited solid biomass power). • **Recommendation:** Programs that facilitate long-term contracts, cover costs for feasibility studies, and help with siting and permitting should all provide good leverage of CEP funds.
Mitigating risks and addressing cost and non-cost barriers to offshore wind power development	• Offshore wind power is a relatively high risk option but has the greatest potential for in-state RE development. • Because of its relatively high costs and issues regarding siting, REC markets alone may not result in any offshore wind development. • **Recommendation:** Financial incentives will be important, especially if the Federal PTC is no longer in place when projects come on line. However, the Clean Energy Program should focus on options that provide greater leverage than direct subsidies (e.g., debt guarantees, subordinate debt), since direct subsidies for large offshore wind projects will be expensive in absolute terms. • **Recommendation:** Given the risks of offshore wind power development, predevelopment grants to help with the permitting process and/or instituting a collaborative process to work through siting and permitting would provide good cost/benefit.

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The New Jersey Clean Energy Program supports a number of funded RE programs.

Overall Remarks

- 2004 funding totals $76 million ($31 million, plus $45 million carry-over.)
  - $31 million is 25% of the total incremental funding collected for energy efficiency and renewable energy for 2004.
- In addition, $4 million discretionary may be allocated
- CORE is 58.1%, REAP 19.7%, REED 8.4%, SBF, Public Entity Financing, and others at <3% each
- Budgets referred to on the following pages apply to the $76 million 2004 funding level

2004 Clean Energy Program RE Budget ($million per year)	
Customer On-site Renewable Energy (CORE)	$44.15
Renewable Energy Advanced Power Plants (REAP)	$15.00
Renewable Energy Economic Development (REED)	$ 6.35
Grid Supply	$ 2.00
Demonstration Programs	$ 2.00
Manufacturing Incentive	$ 2.00
Small Business Financing (formerly FREE)	$ 3.00
Public Entity Financing (formerly REDO)	$1.50
Total	**$76.00**

The Office of Clean Energy oversees seven programs that are either operational or in a formative stage.

CORE (Customer On-site Renewable Energy)	➢ Largest program in terms of total funding ➢ 2004 budget of $44.15 million ➢ Block-based grants for PV, wind and sustainable biomass to reduce initial capital costs of the projects ➢ Incentives amount to maximum of 60% of project cost, although limit declines with increasing scale ➢ May be used for installation, equipment and interconnection in New Jersey

REED (Renewable Energy Economic Development)	➢ $6.35 million in 2004 ➢ Available for research, business and infrastructure development, commercialization and technology demonstrations in New Jersey (i.e., market mechanisms and technological advances) ➢ Aimed at job creation and economic growth in New Jersey, and to dynamically enhance RE business infrastructure in State ➢ Not intended for construction or installation of renewable energy projects ➢ Both public and private entities may apply, with strong preference for latter ➢ Neither equity nor interest-bearing loan, but a recoverable grant program. Allows businesses to leverage funds for additional private funding

NAVIGANT CONSULTING

The Office of Clean Energy oversees seven programs that are either operational or in a formative stage. (continued)

REAP (Renewable Energy Advanced Power Plants)	➢ Replaced Grid Supply program, which is being phased out ➢ $15 million in 2004 ➢ Accelerate rate of deployment for large-scale (> 1MW) RE plants in New Jersey ➢ Seed grants and access to capital to make RE cost-competitive ➢ Designed to ensure diverse portfolio of RE in New Jersey ➢ Projects expected to supply electricity to PJM Power Pool or to large power users, incorporating a minimum of 1 MW of generation capacity
Public Entity Financing (formerly REDO)	➢ To support renewable energy in government and schools ➢ $1.5 million in 2004 ➢ Applicants must combine both EE and RE ➢ Provides low-cost financing to cover the portion of project costs not covered by the CORE rebates
SBF (Small Business Financing; formerly FREE)	➢ $3 million in 2004 ➢ Similar objectives and structure to Public Entity Financing

NAVIGANT CONSULTING

The Office of Clean Energy oversees seven programs that are either operational or in a formative stage. (continued)

Demonstration Program	➢ $2 million in 2004 ➢ New program geared toward novel, first-of-a-kind projects ➢ No projects currently in the pipeline
Manufacturing Incentive	➢ $2 million in 2004 ➢ New program under development. Unlikely to be up and running prior to 2005 ➢ May include provisions that would give priority to supplying local projects with product

Establishing program priorities/options was based on the seven "Renewable Energy Objectives" set by the Clean Energy Council, which we have organized into direct and indirect objectives.[1]

Direct Renewable Energy Objectives

1. Construct 300 MW of new class I renewable energy capacity in New Jersey by 2008.
2. Increase electricity production of solar energy to at least 120,000 MWh per year in 2008 in New Jersey (equivalent to 90 MW).
3. Double the amount of electric customers purchasing green electricity and increase the load served by qualified renewable resources by 50% over and above the Class I Renewable Portfolio Standard.

Indirect Objectives (criteria for evaluating program effectiveness in meeting primary objectives)

1. Use energy efficiency, load shifting, clean distributed generation and renewable energy to produce least cost reliability solutions for New Jersey, especially in constraint areas.
2. Increase the number of jobs in New Jersey in the Renewable Energy Industries by 100% by 2008: an additional 20% per year.
3. Decrease the average installed cost for renewable energy systems by a minimum of $0.25 per watt per year for each technology adding up to a minimum of a 10% reduction by 2008.
4. Increase the number of manufacturing facilities of renewable energy technologies in New Jersey by attracting a minimum of 1 additional manufacturing plant per year.

1. It is possible to design programs aimed primarily at the "indirect" objectives (e.g., grants or investments or tax credits for the manufacturing sector aimed at the export market), but for our analysis of Clean Energy Program priorities we have assumed that the primary interest is in achieving what we term the "direct" objectives, while keeping the indirect objectives "in our sights".

The NCI team framed two additional evaluation criteria that were necessary to evaluate program options.

1. Program cost effectiveness from the perspective of the Clean Energy Program (need to meet goals with finite budget)[1]
2. Market transformation (among the Clean Energy Council's RE Goals)

Other CEC goals that were qualitative in nature did not lend themselves to analysis. In any event, meeting the primary objectives will implicitly contribute to achieving them. They are:

a. Make New Jersey the world leader for the promotion and use of clean, renewable energy.

b. Accelerate the use and adoption of renewable energy in order to reduce pollution, conserve natural resources, increase energy self-reliance and establish a secure energy future for New Jersey.

1. "Cost effectiveness", e.g., program dollars spent per watt of RE capacity, is not the same as "cost/benefit". It is meant to measure the program cost effectiveness towards achieving the specific direct objectives of MW installed, number of green power customer and load served by green power.

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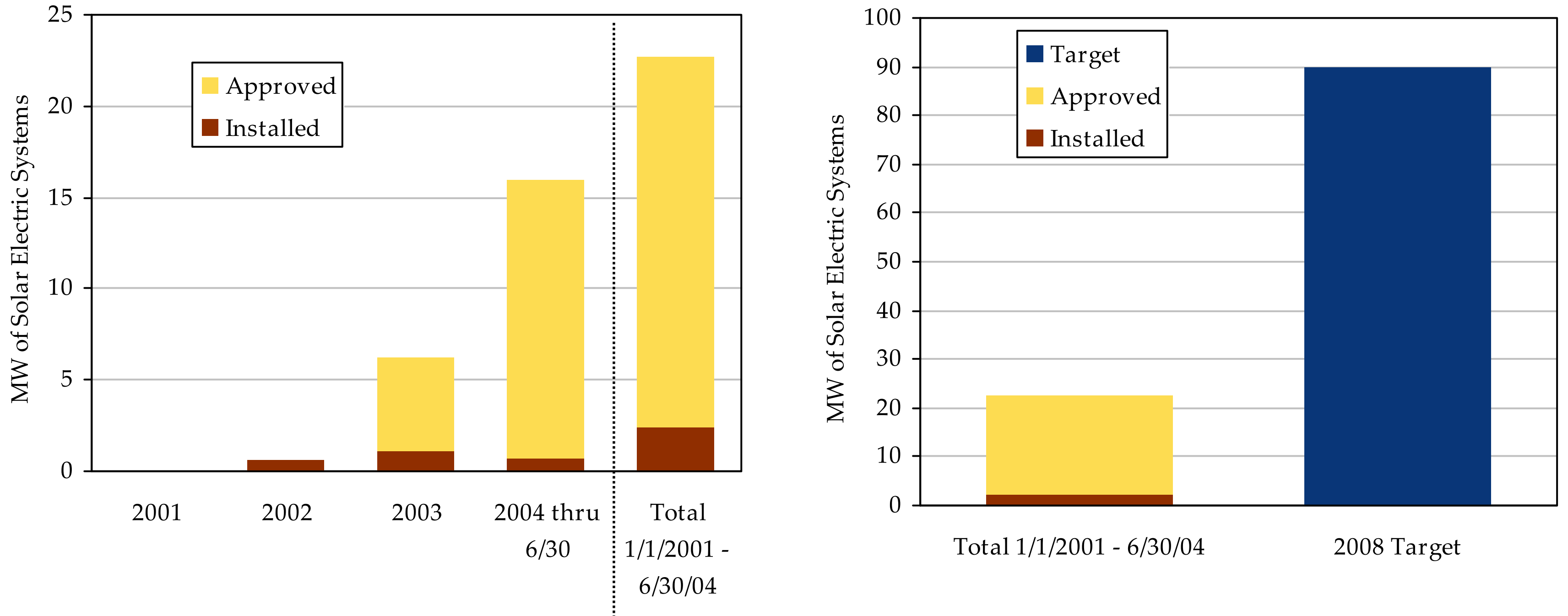
The Clean Energy Program is approaching 30% of the solar target and is on a pace to exceed 40% by the end of 2004, if all the approved systems are installed.

Solar Projects Installed and Approved Under the CORE Program and Gap Relative to 90 MW Goal



Note: When a system is installed, it no longer is tracked in the "approved" category. Thus, the total amount of approved systems is the sum of all approved systems that have not yet been installed (i.e., some systems approved in 2003 have not yet been installed).

Source: New Jersey Office of Clean Energy.

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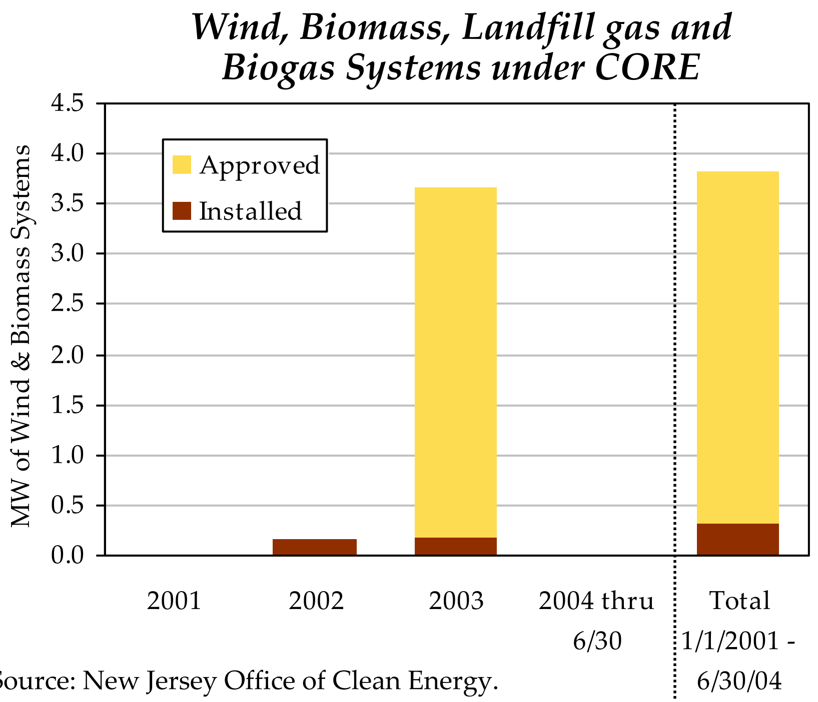
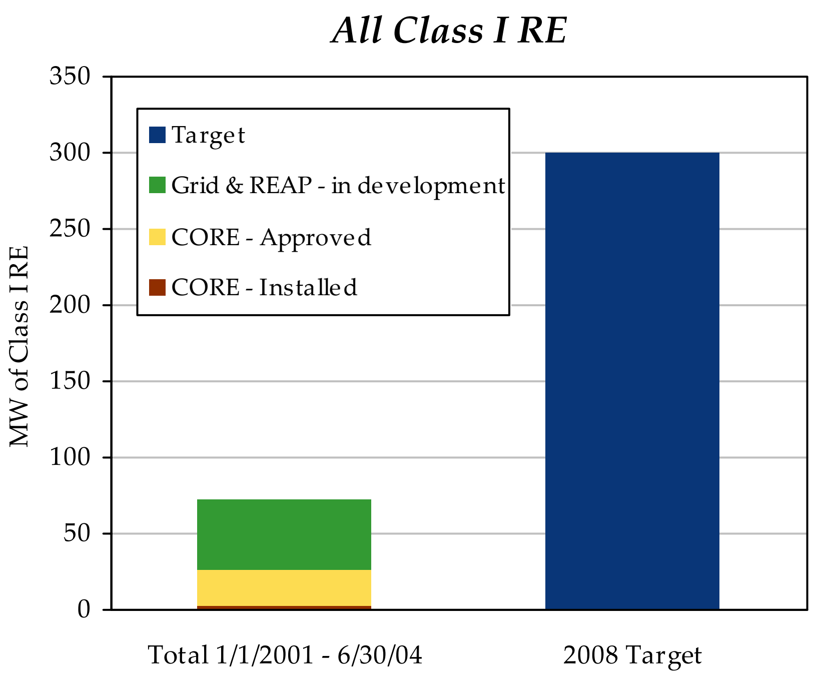
If all projects currently approved under CORE and under development under the Grid and REAP programs are eventually completed, NJ will be 25% of the way to the 300 MW goal.

Gap between current levels of RE installed and approved in NJ and targeted 2008 levels



Source: New Jersey Office of Clean Energy.



However, it should be expected that not all of the projects in the pipeline will actually be built.

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Metrics other than installed MW were difficult to accurately verify, such that a more qualitative gap analysis was conducted.

- **Employment and manufacturing**
  - Assuming 6 employees in each of the 24 PV installers located in NJ, there are a total of 144 employees.
  - There are approximately ten small companies in the startup/product development phase. Most, if not all have received some form of funding under the REED program[1]
  - This suggests a total level of employment of approximately 200 full-time equivalents (FTEs) in RE in NJ
  - Assuming this level of current employment, the New Jersey Clean Energy Program goal of doubling RE-related employment by 2008 would mean growing this number to 400 FTEs by 2008.

- **Green Power**
  - Current levels of enrollment in green power programs in NJ are negligible. Furthermore, there do not appear to be any readily accessible data on the number of green power customers in NJ. This type of information is typically publicly available for utility companies offering green pricing options but not for competitive marketers. Currently, New Jersey's utilities do not offer green pricing.
  - Given the small base, the goal of doubling the number of green power customers should not be a major undertaking. However, the goal of increasing the load served to 1.5X the Class I RPS is a significant goal since it would be over and above the RPS target.
  - In pursuit of these goals, the Office of Clean Energy is in the process of developing programs that will allow customers to purchase RECs through their utility bill.

1. *New Jersey Clean Energy Program Report*, reporting period January 1, 2003 through December 31, 2003. Submitted to the New Jersey board of Public Utilities, June 3, 2004. Also, Personal communication with David Vanluvanee, BPU, July 9, 2004.

Achieving 90 MW (120 GWh/yr) of PV in New Jersey by 2008 is a primary objective and a cornerstone of the Clean Energy Program.

- New Jersey's solar component to the RPS is one of the most aggressive solar targets in the nation
- Programs aimed at promoting customer-sited PV are similarly aggressive and are currently receiving the bulk of the renewable energy funding under the Clean Energy Program (via the CORE program).
- This goal is an explicit target of the RPS.

Barriers to deploying PV are well known and many are currently being addressed in New Jersey.

Barriers[1]	Potential Solutions
Financing* • Lack of "efficient" up front capital availability (e.g., for residential or non-profit customers) • High first cost • Lack of long-term investment perspective by potential hosts (need for short payback)	• Offer streamlined, low-transaction-cost financing options (in concert with other regional entities) • Capital-cost rebates; make financing options available • Target programs to hosts with long-term perspective (municipalities, schools, museums, colleges, hospitals)
Institutional/Regulatory* • Interconnection, net metering, standby charges, solar easement issues	• If not being adequately addressed at state level already, work to make changes to remove barriers by changing the rules.
Infrastructure* sales, service, installation, maintenance	• If this is due to product availability, see above. • If this is structural, address with training programs, licensing, business development grants
Inability to fully capture high value of on-peak energy*	• Encourage broader use of real-time pricing in conjunction with net metering • Encourage utilities to offer LMP-specific real time pricing
Lack of objective source of information and expertise for interested hosts*	• Offer technical assistance • Create programs for installer certification • Provide listing of pre-qualified system designers, distributors and installers on New Jersey Clean Energy Program website that must be used in order to receive PV rebates
REC Markets • Poor credit quality of REC sellers can have negative impact on utilities that must buy RECs	• Have the state provide credit quality support to solar REC market
Product Availability • Can't get PV product (supply/demand issues)	• If this is a short-term issue, do nothing. • If this is a structural issue, offer tax breaks or business development grants to build local manufacturing in exchange for priority in meeting local demand.
Inability to capture distributed generation (DG) value (loss reduction, T&D investment avoidance)	• Advocate for changes in rate design and encourage utilities to offer location-specific incentives reflecting the value provided to their ratepayers from distributed generation

1. **Barrier with an asterisk (*) are currently being addressed, in whole or in part through existing programs or policies.**

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CORE, the largest current program, is the only program with high impact towards meeting the 90 MW PV goal.

Existing and Planned Programs	Description
CORE	• Very effective at addressing the high first cost of PV, leading to significant uptake • Consequently addresses job creation and market transformation by creating demand that leads to the development of a sales, installation and service infrastructure • Can lead to decreased system costs by reducing installation costs through experience and local economies of scale • However, relatively low cost effectiveness, direct rebates are expensive (note: "cost effectiveness" should not be confused with "cost/benefit")
REED	• Targeted mainly at market transformation and job creation. • Cost effective in that the grants are recoverable
REAP	• Not likely to have a significant impact on the solar market in the near term due to the poor economics of "central station PV" in the absence of direct subsidies or other mechanisms to promote large, grid-sites PV installations. • Could become more important in the future as PV costs fall and interest grows in central station PV.
Public Entity Financing	• Relatively cost effective way to assist with PV economics, but small overall program budget will limit overall impacts. Moderately cost effective in that it leverages energy efficiency energy cost savings and is not a direct rebate program. • Minimal impact on indirect objectives
Small Business Financing	• Similar to Public Entity Financing
Demonstration Program (planned)	• Would primarily address market transformation through the demonstration of novel technologies • Not expected to have significant near-term impact on MW installed
Manufacturing Incentive (planned)	• If successful, would have significant impact on job creation and manufacturing objectives. Could lead to lower costs and better conversion rates of "approved" projects if it helps secure PV product for the NJ market.

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CORE, the largest current program, is the only program with high impact towards meeting the 90 MW PV goal. (continued)

Direct Objective: Add 90 MW of PV in New Jersey by 2008						
Existing and Planned Program Options (evaluated "as is")	Potential MW	Job Creation	Increase RE Manufacturing	Increased Reliability	Market Transformation	Decreases System Costs
CORE	●	●	⊙	○	⊙	⊙
REED	○	⊙	○	○	⊙/●	○
REAP	○/⊙	○	○	○	○	○
Public Entity Financing	○	○	○	○	○/⊙	○
Small Business Financing	○	○	○	○	⊙	○
Demonstration Program	○	○	○	○	⊙	⊙
Manufacturing Incentive	○	●	●	○	○	⊙

Key to Effectiveness: High ● Medium ⊙ Low ○

Other existing and planned programs are addressing indirect objectives, but none currently address the objective of increased reliability in load pockets.

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Several other program initiatives and policies could help meet the 2008 PV goal, and some are already in development in New Jersey.

Potential Program[1]	Description
Target installations in load pockets*	• Identify target load pockets, areas with reliability issues, high LMP • Identify customers with appropriate facilities and long-term view in load pockets • Offer additional inducements for installations in those areas. Options cold range from working with utilities and BPU to provide a share of DG benefits to hosts, to bonus CEP financial incentives
Target new construction*	• Target the incorporation of PV into new residential and commercial construction to reduce impacts of up-front costs • Can be part of zero-energy-homes efforts, Energy Star homes • Arrange for lower-interest mortgage options for PV homes • Work with builders to create awareness
Promote voluntary green power*	• Efforts to promote increased participation in green power programs will help create demand for PV, which is often included as a part of the supply mix for green power products.
Aggregated, multi-yr PV purchases	• Multi-year bulk buy with preferred vendor via competitive solicitation • Assures fixed quantity at fixed price with payment to the vendor if not fully subscribed • Clean Energy Program does not take title to the systems but guarantees revenue to manufacturer.
Mandatory PV targets for government buildings	• Help maintain demand for PV by requiring a certain percentage of power used by government facilities to be from onsite PV. • Government entities may or may not be eligible for CORE funding
State provides credit quality support to solar REC market	• Increase confidence in the REC market • Provide guarantees on REC transactions • Clean Energy Program need not take title to RECs

1. **Programs with an asterisk (*) are currently being considered, or are in development in New Jersey.**

Some new PV program initiatives would be modifications to existing programs, while others would be complements or alternatives.

Direct Objective: Add 90 MW of PV in New Jersey by 2008						
Potential Program Options	**Potential MW**	**Job Creation**	**Increase RE Manufacturing**	**Increased Reliability**	**Market Transform-ation**	**Decreases System Costs**
Modifications/Extensions to Existing Programs						
Target installations in load pockets	○	○	○	⊙/●	○	○
Target new construction	⊙	○	○	○	⊙	⊙
Aggregated, multi-yr PV purchases	●	⊙	Varies, depending if production is in/out of state	○	⊙	●
Complements/Alternatives to Existing Programs						
Promote voluntary green power	There is a suite of activities that complement existing programs and that together address the third Direct Objective. See review of options for increasing green power that follows later in this section.					
Mandatory PV targets for state government buildings	⊙ depends on target	⊙	○	○	⊙	⊙
State provides credit quality support to solar REC market	⊙	○	○	○	⊙	○/⊙

* Ranking could be lower if installations for this goal draw on CORE for rebate.

Key to Effectiveness: High ● Medium ⊙ Low ○

Modifications to existing programs would require relatively little incremental funding; complements/alternatives may require shifts or more significant increases in funding.

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The Clean Energy Council has set a goal of developing 300 MW of new Class I RE in New Jersey by 2008.

- Unlike the solar component of the RPS, this objective is not an explicit requirement of the RPS.
- The 90 MW of solar would count towards the 300 MW goal. Assuming the solar target is met, this means that 210 MW of non-solar renewables must be developed by 2008 (less would be required if the solar goal were exceeded).
- The capacity goal of 300 MW of Class I renewables in NJ by 2008 would count towards the RPS, unless applied towards meeting green power sales.

Renewables face a wide range of barriers in the wholesale marketplace, some of which are already being addressed in NJ.

Barriers[1]	Potential Solutions
Financing* • Lack of long-term contracts for energy and/or RECs in a competitive market) • Regulatory risk and finance community comfort with REC market, willingness to lend based on anticipated REC revenues	• Provide long-term contracts, REC floor prices (or more efficiently, REC CFD floor strike price) or put options with sufficient backing to be perceived as credit-worthy. • Provide incentives for credit-worthy parties to enter into long-term contracts sufficient to attract financing. • Assist grid-based generators in accessing large commercial, industrial and institutional customers through aggregation and education regarding hedge value of renewables (like NY, RI).
Above-market costs of electricity for some options*	• Capital grants • Production incentives (note: for technologies eligible for the Federal PTC, this is less likely than grants or subsidized financing to trigger PTC double-dipping provisions) • Zero-interest loans or debt guarantees
Wholesale market rules* • Energy imbalances, regulation, capacity credit, operational and scheduling requirements, all impose burdens on intermittent, small and/or distributed generation sources	• Compared to most markets, PJM is pretty good about these issues. A review should be done before determining whether this is really a barrier in PJM and any action is needed.
Siting • Access to available resources, e.g., adequate wind or biomass • Proximity to transmission	• Incentives for sustainable biomass crop cultivation (e.g., switchgrass, willow) • Community-based initiatives (like MA community wind program)

1. **Barrier with an asterisk (*) are currently being addressed, in whole or in part through existing programs or policies.**

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Renewables face a wide range of barriers in the wholesale marketplace, some of which are already being addressed in NJ. (continued)

Barrier[1]	Potential Solution
Permitting •NIMBY/land-use conflicts •Aesthetic/bird/wildlife concerns •Unclear, multiple-layer permitting	• Non-recourse project pre-development grants or low-interest loans • Education • Streamlining; zoning review • Community-based initiatives (like MA community wind program)
Effect of offset provisions of Federal PTC on the effectiveness of New Jersey Clean Energy Program incentives	• To maximize funding leverage, utilize production incentives, grants for T&D or substation construction, price supports or loan guarantees, rather than capital grants or low-interest capital cost loans, which may trigger PTC double-dipping provisions.
Transmission queue delays	• Advocate for fast-track processing for projects under a certain size threshold (e.g., 20 MW) • Financial support of renewables advocacy efforts
Transmission access • long lead-time for expansion	• Advocate for incorporating needs for access to windy areas in regional planning, incorporating environmental and societal values into regional transmission planning • Financial support of renewables advocacy efforts
Intermittency • Concerns regarding integration costs posed by intermittent resources on grid.	• Establishment of regional wind forecasting capability with shared or socialized costs (New Jersey Clean Energy Program could subsidize) • Support analyses to quantify costs imposed on the grid (these are being done elsewhere) • Encourage introduction of technically and economically feasible interconnection requirements • Support incorporation of storage technologies on-site

1. **Barrier with an asterisk (*) are currently being addressed, in whole or in part through existing programs or policies.**

REAP is the major current program focused directly on meeting the 300 MW goal. Other smaller programs have low to moderate impacts on this direct objective and the other indirect objectives.

Existing and Planned Programs	Description
CORE	• Very effective at addressing the high first cost small onsite power options, but limited potential compared to PV • Consequently addresses job creation and market transformation by creating demand that leads to the development of a sales, installation and service infrastructure • However, relatively low cost effectiveness, direct rebates are expensive (note: "cost effectiveness" should not be confused with "cost/benefit")
REED	• Targeted mainly at market transformation and job creation. • Cost effective in that the grants are recoverable • Can be used to help improve information about resource potential (e.g., Landfill gas, biomass)
REAP	• Main program currently aimed at grid-sited RE • Can achieve significant leverage of other fund by helping economically attractive projects over initial barriers.
Public Entity Financing	• Potential to use this program with biogas cogeneration opportunities at wastewater treatment plants but overall impacts expected to be limited due to small overall program budget.. Moderately cost effective in that it leverages energy efficiency energy cost savings and is not a direct rebate program. • Minimal impact on indirect objectives
Small Business Financing	• Similar to Public Entity Financing if can be applied.
Demonstration Program (planned)	• Would primarily address market transformation through the demonstration of novel technologies • Not expected to have significant near-term impact on MW installed
Manufacturing Incentive (planned)	• If successful, would have some impact on job creation and manufacturing objectives, but likely to have less of an impact with non-PV technologies than with PV.

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REAP is the major current program focused directly on meeting the 300 MW goal. Other smaller programs have low to moderate impacts on this direct objective and the other indirect objectives. (continued)

Direct Objective: Develop 300 MW of Class I RE in New Jersey by 2008						
Existing and Planned Program Options (evaluated "as is")	**Potential MW (for non-PV options)**	**Job Creation**	**Increase RE Manufacturing Facilities**	**Increased Reliability**	**Market Transformation**	**Decreases System Costs**
CORE	○	○	○	○	○/⊙	○
REED	○	⊙	○/⊙	○	○/⊙	⊙
REAP	●	⊙	○	○	○/⊙	○
Public Entity Financing	○/⊙	○	○	○	○	○
Small Business Financing	○	○	○	○	○	○
Demonstration Program	○	○	○	○	⊙	○
Manufacturing Incentive	○	⊙	⊙	○	○	○

Key to Effectiveness: High ● Medium ⊙ Low ○

NAVIGANT CONSULTING

The Clean Energy Program is already considering some additional programs aimed at the wholesale marketplace.

Potential Program[1]	Description
Other financial incentives (production incentives; zero-interest loans; debt guarantees)*	• Modify the REAP program to allow for generators eligible for Federal production tax credits (PTC) to receive support unlikely to trigger PTC double-dipping provisions, such as production incentives, grants for T&D or substation construction, price supports or loan guarantees, rather than capital grants or low-interest capital cost loans. • Consider debt guarantees or low- or zero-interest loans as cost-effective means to support non-PTC-eligible resources.
Pre-development grants or loans*	• Identify promising projects in early stages, through open solicitation • Provide limited non-recourse capital (grants, recoverable grants, low-interest loans) in support of development efforts to establish viability of projects prior to readiness for funding installation.
Programs to encourage voluntary green power purchases*	• By encouraging green power, create additional markets and buyers that can complement RPS demand in supporting investment in RE plants, and provide an outlet for building ahead of RPS demand. • See green power section for further program details.
Large retail customer hedge program	• Facilitate long-term commodity, REC and/or hedge contracts between renewable generators or intermediaries, and large commercial, industrial or institutional electricity consumers. NJ CEP role may range from providing information, aggregating customers, and providing technical assistance, to providing incentives to generators and/or customers to enter such contracts (if necessary). (Could build on efforts currently underway in New York) • Taps interest of risk-averse customers to hedge exposure to rising or volatile electric prices, while allowing generators to secure a financeable revenue stream while allowing large electricity end-users.
Incentives for credit-worthy parties to enter long-term contracts	• Via competitive solicitations, entice credit-worthy electricity and/or REC wholesalers, retailers or end-users to enter into long-term offtake contracts with renewable generators by offering cash incentives of providing assurances of minimum REC revenue. • May require less NJ CEP capital to be committed than prior two programs, while increasing likelihood of market transformation.

1. **Programs with an asterisk (*) are currently being considered, or are in development in New Jersey.**

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The Clean Energy Program is already considering some additional programs aimed at the wholesale marketplace. (continued)

Potential Program[1]	Description
Long-term REC purchase contracts with state as market enabler	Explore policies and programs that enable a robust market for long-term REC contracts between willing buyers and sellers • e.g., extend the redemption window for RECs in the event the state repeals the RPS • e.g., explore changes to the structure of the BGS auction rules that would encourage long-term RE contracts.
Long-term REC purchase contracts with state as market participant	Via competitive solicitations, NJ CEP acts as credit-worthy buyer for RECs only. • Requires commitment of substantial budget, but leaves project at risk to find matching long-term buyer for commodity electricity. • NJ CEP could retire RECs or, more efficiently, could resell RECs to market, eventually recovering some or all of investment, but assuming risk that sales price may fall below purchase price. State created Long-term REC floor prices (or more efficiently, REC contract-for-differences [CFD] floor strike price) or put options • Via competitive solicitations, NJ CEP acts as credit-worthy market of last resort, ensuring a minimum REC revenue by offering a floor price in the form of a put option, make-up payment, or similar price-support mechanism. • May require less NJ CEP capital to initially be tied up than a direct purchase. If option not exercised, capital can be recycled to other projects. • If REC pricing structured like a contract-for-differences, assuring generator of minimum revenue stream for combination of RECs plus electricity, NJ CEP outlay may be reduced due to reduced risk to generator.
Incentives for biomass crop cultivation	• Identify prime locations for biomass generation (possibly including co-firing applications) in proximity to available agricultural land. • Identify bioenergy crops with greatest potential for NJ climate and soil conditions. • Offer multi-year incentives to entice sustainable growth and harvesting of energy crops, initially in pilot/demonstration scale.

1. **Programs with an asterisk (*) are currently being considered, or are in development in New Jersey.**

NAVIGANT CONSULTING

The Clean Energy Program is already considering some additional programs aimed at the wholesale marketplace. (continued)

Potential Program[1]	Description
Promote use of energy storage technologies	• In support of intermittent renewable energy generation (wind, solar), offer incentives for cost-effective energy storage applications on-site at renewable generation installations, to address challenges and costs of intermittence and thereby increase the value of such project's production in electricity markets. • Support could include feasibility studies, research/demonstration projects, capital support for storage installations, and measurement/evaluation of costs and other effectiveness.
Support regional wind forecasting	• Minimize the cost impact of intermittent wind generation on the operation of the PJM Power Pool by supporting a centralized state-of-the-art wind forecasting capability in PJM. • Like California (other pools likely to follow), such a capability can serve to minimize the actual cost imposed by intermittence on the power system (e.g. reduced installed and operating reserve, reduced cost of energy imbalance, etc.), maximize the value of wind energy in PJM through greater predictability, and limit potential exposure of wind generators to onerous scheduling or imbalance penalties. • Support may include advocacy for establishing such a capability, seed capital for establishing the capability, and/or support of operating costs.
Facilitate community wind power development	• Provide to communities within NJ basic information on promising locations (confluence of windy land, land ownership/usage, access to transmission or distribution), information on successful community wind installations and promising financial structures, etc. • Additional support can range from technical assistance (e.g. funding and staffing detailed feasibility studies), preferred vendor programs, seed funding, providing markets for RECs or debt financing.
Advocate for changes to wholesale rules, transmission access and planning	• Fund participation by entities representing renewables generators (particularly small, distributed, and/or intermittent) in the PJM. • Aim to identify wholesale market barriers to RE (operating rules, scheduling requirements, capacity credit, imbalance markets, transmission pricing or reservation), identify feasible changes and advocate for such changes. • Identify and support transmission investment priorities that allow access for NJ-based renewables generators.

1. **Programs with an asterisk (*) are currently being considered, or are in development in New Jersey.**

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Modified or new programs targeting wholesale RE options should focus on securing long-term contracts, facilitating initial project development steps and improving information quality.

Direct Objective: Develop 300 MW of Class I RE in New Jersey by 2008						
Potential Program Options	**Potential MW**	**Job Creation**	**Increase RE Manufacturing Facilities**	**Increased Reliability**	**Market Transformation**	**Decreases System Costs**
Modifications/Extensions to Existing Programs						
Other financial incentives (production incentives; zero-interest loans; debt guarantees)	⊙	⊙	○	○/⊙	⊙	⊙
Pre-development grants or loans	⊙	○	○	○	○/⊙	○
Complements/Alternatives to Existing Programs						
Programs to encourage voluntary green power purchases	There is a suite of activities that complement existing programs and that together address the third Direct Objective. See review of options for increasing green power that follows later in this section.					
Long-term REC purchase contracts with state as market enabler	⊙/●	⊙	○	○	●[1]	○/⊙
Long-term REC purchase contracts with state as market participant	⊙/●	⊙	○	○	⊙/●[1]	○/⊙

Key to Effectiveness:	High ●	Medium ⊙	Low ○

1. If this helps lenders become more comfortable with RECs.

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Modified or new programs targeting wholesale RE options should focus on securing long-term contracts, facilitating initial project development steps and improving information quality. (continued)

Direct Objective: Develop 300 MW of Class I RE in New Jersey by 2008						
Potential Program Options	**Potential MW**	**Job Creation**	**Increase RE Manufacturing Facilities**	**Increased Reliability**	**Market Transformation**	**Decreases System Costs**
Complements/Alternatives to Existing Programs (continued)						
Incentives for credit-worthy parties to enter long-term contracts	⊙/●	⊙	○	○	⊙	○/⊙
Facilitate community wind power development	○/⊙	⊙	○	○	⊙	○
Large retail customer hedge program	⊙	⊙	○	○	●	⊙
Incentives for biomass crop cultivation	○/⊙	⊙	○	○	⊙	○
Promote use of energy storage technologies	○/⊙	○/⊙	○	⊙	⊙	⊙
Support regional wind forecasting	○/⊙	○	○	○	⊙	○
Advocate for changes to wholesale rules, transmission access and planning	●	○	○	●	⊙	○

Key to Effectiveness: High ● Medium ⊙ Low ○

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The Clean Energy Council has also set targets for increasing customer participation in voluntary green power programs and the load served.

- The goals are to double the number of customers participating in green power programs and to increase the load served to 1.5X the Class I RPS.
- This would require 6% of the load to be served via green power. This is substantially higher than typical participation rates in green power programs, which are usually in the low single digits.
- Since RE that is used to meet the RPS would not be eligible also to serve the green power market, and RE used to serve the green power market should not be applied towards the RPS, the green power overlay on the RPS would be incremental to the RPS, suggesting that the green power goal will be a challenge to meet.
  - Even by implementing the proposed programs, the green power goals will still be a challenge to meet, based on experience in other states and on historical participation rates in existing green power programs.

Barriers to increasing customer participation in green power programs are generally well understood and are starting to be addressed in NJ.

Barriers[1]	Potential Solutions
Lack of consumer awareness*	• Education and outreach (like Smartpower/Clean Energy States Alliance [CESA]efforts in New England)
High customer acquisition costs*	• Access to utility bills • Utility co-marketing • Customer acquisition incentives (like in RI) • Education and concept marketing by independent parties (like CESA/Smartpower efforts) • Customer aggregation (e.g., through municipalities, groups of large end-users, oil buying cooperatives)
Higher price than commodity electricity*	• Education on alternatives, benefits • Marketing/branding (implement CESA awareness campaign) • Educate on hedge value of renewables and encourage/incentivize offerings that provide hedge value
Lack of access to cost effective utility billing for green power offering for sale of RECs	• Access to cost-effective utility billing for sale of RECs
Customer perception/connectedness to product • Bundled vs. unbundled effect on customer perception of purchase as akin to a charitable contribution, rather than a product or service purchase.	• Access to cost effective utility billing, so customers see RECs as part of, and associated with, electricity purchases
Fear, uncertainty or doubt about switching electricity providers	• Enable mechanism for green power to be offered via RECs re-bundled electricity and attributes from renewables suppliers • Utility co-marketing or involvement, billing, and education
Difficulty in comparing Green Power offerings	• Fund a consumer-reports-like product rating service

1. For barriers with an asterisk (*) NJ is developing a green power program that would address them.

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None of the current programs directly address the green power goals. REED is best aligned with this goal and has already been used to help with education and outreach.[1]

Existing and Planned Programs	Description
CORE	• Assuming that the RECs created as a result of CORE are applied mainly to the RPS, CORE will not substantially influence the Green Power market
REED	• Can be used effectively for education, outreach and other market transformation activities such as green power customer aggregation
REAP	• Assuming that the RECs created as a result of REAP are applied mainly to the RPS, REAP will not substantially influence the Green Power market.. • However, some New Jersey resource content may be desirable for Green Power Programs
Public Entity Financing	• Not expected to contribute meaningfully to Green Power
Small Business Financing	• Not expected to contribute meaningfully to Green Power
Demonstration Program (planned)	• Not expected to contribute meaningfully to Green Power
Manufacturing Incentive (planned)	• Not expected to contribute meaningfully to Green Power

1. In 2003, Green Mountain Energy received a REED grant for an education campaign aimed out outreach to local governments to include them in aggregated green power purchases.

None of the current programs directly address the green power goals. REED is best aligned with this goal and has already been used to help with education and outreach. (continued)

Direct Objective: Double the Number of Green Power Customers and Increase Load Served to 1.5x Class I RPS							
Current and Planned Program Options (evaluated "as is")	**Potential Number of green power Customers**	**Potential Class 1 RPS MWh**	**Job Creation**	**Increase RE Manufacturing Facilities**	**Increased Reliability**	**Market Transformation**	**Decreases System Costs**
CORE	Assumes RECs are applied mainly to the RPS, such that CORE does not substantially influence the Green Power market						
REED[1]	⊙[2]	⊙[2]	⊙	○	○	⊙/●	○/⊙
REAP	Assumes RECs are applied mainly to the RPS, such that REAP does not substantially influence the Green Power market. However, some New Jersey resource content may be desirable for Green Power Programs						
Public Entity Financing	Not expected to contribute meaningfully to Green Power						
Small Business Financing	Not expected to contribute meaningfully to Green Power						
Demonstration Program	Not expected to contribute meaningfully to Green Power						
Manufacturing Incentive	Not expected to contribute meaningfully to Green Power						

1. Used for recoverable seed grants to local marketer/ aggregator (like in RI, MA, NY, PA, CT)
2. Could be higher; mixed experience in other states; may be more effective in combination with other programs.

Key to Effectiveness: High ● Medium ⊙ Low ○

New programs would be needed to effectively address the green power goals, some of which are in development in New Jersey.

Potential Program[1]	Description
State green power purchases*	• Set example for voluntary green power market by working with state government loads to make moderate- to long-term commitments to purchase RECs (potentially under a hedge-based price structure) in excess of the RPS percentage (or at maximum RPS percentage, but early). • Visibility/publicity creates leverage for other green power activities, helps establish a credit-worthy market. • Role for NJ CEP could include developing, issuing and evaluating proposals, or potential direct or indirect (e.g. through providing financing) subsidization of purchases.
RECs sold via utility bill/check-off program*	• Working with BPU and utilities, establish a mechanism for competitive REC-based offerings from NJ/PJM RE resources to be offered through the distribution utilities via the utility bill (resembling programs in place in NY, MA, RI, OR). • Encourage co-marketing support from utilities of the general program.
Branding, education and outreach program using CESA message*	• In concert with establishing a variety of green power offerings, support general RE education and awareness, coupled with action-oriented message linked to available clean energy choices. • Utilize the Clean Energy States Alliance branding materials (NJ CEP has funded development of the messaging and materials development) akin to current campaign in RI. • Fund creation/adaptation of NJ-specific creative materials, support media placements, additional targeted outreach, tracking research, etc.
Small customer incentives	• Provide incentives to marketers or rebates to customers for signups to high-quality green power offerings. • Shape form of incentive to encourage market transformation, lower customer acquisition cost, encouraging early market entry and sustainable product pricing.
Large customer incentives	• Provide incentives to large end-users willing to make substantial and credible commitments to high-quality green power or REC purchases if supported by publicity, high visibility, or other activities leveraging the visibility of clean power.
Support for long-term hedge purchases	• See description above.
Large customer buying group creation and support	• Identify potential large end-users that may have interest in clean power. • Support education of benefits and opportunities for clean power purchases/usage. • Encourage and support (via technical assistance) aggregated bulk purchasing to attract clean power at attractive pricing.

1. **Programs with an asterisk (*) are currently being considered, or are in development in New Jersey.**

New programs would be needed to effectively address the green power goals, some of which are in development in New Jersey. (continued)

Direct Objective: Double the Number of Green Power Customers and Increase Load Served to 1.5x Class I RPS							
Potential Program Options	Potential Number of green power Customers	Potential Class 1 RPS MWh	Job Creation	Increase RE Manufacturing Facilities	Increased Reliability	Market Transformation	Decreases System Costs
Complements/Alternatives to Existing Programs							
State green power purchases	○	⦿	○	○	○	⦿	⦿
RECs sold via utility bill/check-off program	●	⦿	○/⦿	○	○	●	⦿
Branding, education and outreach program using CESA message	●	⦿	○/⦿	○	○	●	⦿
Small customer incentives	●	⦿	○/⦿	○	○	●	⦿
Large customer incentives	○	⦿	○	○	○	⦿	⦿
Support for long-term hedge purchases	⦿	●	⦿?	○	○	●	●
Large customer buying group creation and support	○/⦿	⦿	○/⦿	○	○	⦿	⦿

Key to Effectiveness: High ● Medium ⦿ Low ○

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The Clean Energy Program should consider modifying existing PV programs to improve cost-effectiveness of direct grants and address additional objectives beyond MW targets.

- Among the current programs, CORE is directly targeted at PV, and is complemented by financing options that are coupled to energy efficiency retrofits.
  - At current rebate levels, the 2008 target of 90 MW appears in reach, but would cost a total of approximately $350 million.
  - A phased reduction in the rebate should be possible (e.g., via a MW block structure or under a specified timetable). A set timetable would encourage early adoption, but also result in declining committed expenditures.
  - The REAP program could be used essentially as is to help target larger PV installations (e.g., at brownfield sites) that do not qualify for CORE.
  - Aggregated multi-year purchases of PV could be a very cost effective way to guarantee product availability an reduce prices through volume purchases. Provided the program were fully subscribed, the cost to the Clean Energy Program would be low.
- Several new program options would modify/extend existing programs to help achieve indirect objectives (e.g., reliability) without substantially changing program costs.
  - Targeting load pockets is possible, but previous NCI analysis suggests that to achieve full distributed generation benefits from the utility perspective requires a high concentration of PV. This option warrants more thorough New Jersey specific analysis.
- Other new programs would complement existing ones and should focus on maintaining market momentum in the face of lower rebate levels.
  - Programs that increase confidence in the solar REC market will help sustain PV installation rates (e.g., credit quality) at lower rebate levels.
  - A successful shift away from direct rebates will also aid in market transformation.

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Although constrained by limited suitable land area, onshore wind power can still benefit from a variety of existing and potential programs, including help with siting and public perceptions.

- Among existing programs, REAP is the most relevant to onshore wind power.
  - REED and the new Manufacturing Incentive program are relevant as they relate to the establishment of infrastructure and potentially the development of businesses to support the developing wind power sector in the broader Mid-Atlantic/Northeast region.
  - REAP should be configured to optimize the benefits of the Federal PTC, to minimize impacts of double-dipping provisions (e.g., via production incentives, grants for T&D or substation construction, price supports or loan guarantees, rather than capital grants or low-interest capital cost loans).
- Almost all new programs options identified also support onshore wind power development
  - Given that economics are generally favorable, assuming project developers can access long-term financing, programs that specifically target long-term contracts (for RECs and energy) should provide good cost/benefits.
  - The Clean Energy Program can also consider targeted programs to improve wind forecasting and the facilitation of community wind projects.
  - As wind power faces some of the most difficult grid integration issues among renewables, programs and policies to help shape the wholesale power markets are also particularly relevant.
- Programs targeted at increasing green power participation will tend to benefit wind the most among the renewable energy options. The combination of moderate costs and customer attractiveness (especially with local projects) makes wind power a preferred supply option for most green power products.
- Some wind power barriers are not cost related (e.g., siting, aesthetics). The Clean Energy Program can also conduct outreach to overcome these barriers.

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Offshore wind power faces some of the same issues as onshore wind power, but a key difference is the higher cost of electricity production. There are numerous other unique challenges.

- In addition to the discussion of onshore wind power, the following are also relevant to offshore wind power:
  - Transmission capability along the coast is an issue for offshore wind.
  - Siting has emerged as an important issue
  - Because of its higher costs relative to onshore wind power, financial incentives will be important, especially if the Federal PTC is no longer in place when projects come on line (expected post-2008). The Clean Energy Program should focus on options that provide greater leverage than direct subsidies (e.g., debt guarantees, subordinate debt), since direct subsidies for large offshore wind projects will be expensive in absolute terms.
  - Given the risks of offshore wind power development, predevelopment grants to help with permitting process and a collaborative process to work through permitting would provide good cost/benefit. The Clean energy Program could serve as an "honest broker" in permitting and also help relieve the initial burden on the developer.
  - For similar reasons, programs aimed at helping secure long term contracts (>10 years) will likely be critical to have offshore wind power projects move forward.
  - Because offshore wind is regional, the Clean Energy Program should collaborate with other eastern coastal states and their SBC programs on issues such as O&M lessons learned, permitting, and community education.

Although offshore wind power is not an immediate opportunity for New Jersey, it represents the largest long-term potential for in-state RE development. As such the Clean Energy Program should be positioning itself for this opportunity.

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Landfill gas-to-power projects can be largely addressed within existing programs.

- Existing programs (mainly REAP) can effectively support the landfill gas opportunity as it is largely cost effective. Nevertheless, it still requires a moderately long-term power purchase agreement (4-8 years), especially for projects without existing collections systems and/or smaller projects (higher costs and risks).
- The Clean Energy Program can also support the LFG opportunity by developing a definitive assessment of the opportunity (e.g., via a REED grant)
  - Existing data sources on existing and potential landfill gas to power potential are inconsistent
  - There are also risks associated with degradation in output for previously capped (closed) landfills. A more detailed understanding of the remaining opportunity in New Jersey, which was beyond the scope of the current project, is needed to better support development of this remaining potential.
  - Changes to future rates of waste generation and landfilling will also affect the long-term potential
- New programs that help provide long-term contracts for energy and RECs and that provide pre-development grants (especially for smaller, riskier projects) would also be beneficial.
- Because of attractive economics and high capacity factors, LFG is often a preferred option for green power offerings. Thus, programs targeted at increasing green power participation will tend to benefit LFG, but somewhat less so than for wind power.

Biogas from wastewater treatment is expected to be cost-effective and can be addressed largely within existing programs. The Clean Energy Program's role is expected to be modest and focused.

- Existing programs (REAP for larger projects, CORE for smaller ones) can effectively support the biogas from WWT opportunity. The opportunity is largely cost-effective.
  - Given the heavy use of electric motors in WWT plants, there may be a good opportunity to use the existing financing programs to support the technology. Biogas is best used in cogeneration, which can also be considered an energy efficiency technology.
- Since much of the electricity would likely be used onsite, there is less of a need for programs that help provide long-term contracts for energy, but they may still be beneficial for RECs.
- The Clean Energy Program can also support the biogas opportunity by working with the Department of Environmental Protection.
  - The DEP is in the process of surveying treatment plants to better characterize their operations, which should improve the understanding of the market potential
  - The Clean Energy Program could interface with the DEP and help raise awareness at the DEP of the potential revenues from RECs
- Program that provide pre-development grants (especially for smaller, riskier projects) would also be beneficial.
- Programs targeted at increasing green power participation may also benefit this option, although there is limited precedent for its use in green power offerings relative to other renewable energy resources.

Power generation from solid biomass is expected to require direct financial support. There is also a need for better information regarding the resource potential.

- Existing programs (REAP for larger projects, CORE for smaller, onsite ones) can effectively support biomass applications by helping reduce first costs or in helping secure capital.
- There is a clear need for better information at the state level regarding the resource potential. An assessment could be funded through the REED program
- Similar to other wholesale technologies, new programs that address the need for long-term contracts would be beneficial.
- Fuel price risk is a unique issue for biomass which may make it unsuitable for customer hedge programs unless the fuel is from a dedicated source.
- Predevelopment grants/loans could relieve the initial burden on the developer
- Although biomass co-firing is not a Class I resource, it may serve as a good bridge technology for biomass until gasification is commercially available.
  - Co-firing is a low capital cost option that offers substantially higher efficiency than small stand-alone biomass power plants of similar size (based on biomass capacity). It also has good emissions avoidance characteristics by directly displacing coal.
  - Because of these attributes it is a better bridge technology to BIGCC than stand-alone power plants, which would tie up the biomass resource for a longer period of time and would also use it at much lower efficiencies.
  - Co-firing would aid in the development of biomass supply infrastructure needed to support gasification in the long term.
- The Clean Energy program could fund demonstrations of gasification and/or co-firing. For co-firing, the funding could help with permitting issues if the coal plant is subject to New Source Review.
- The Clean Energy Program could also consider targeted programs for bioenergy crop cultivation or fund bioenergy crop demonstrations through its new Demonstration Program.

The range of current and planned CEP activities covers all the leading RE options in New Jersey, with REAP offering the most comprehensive impact in terms of technologies.

Mapping of Current Clean Energy Programs to the Leading Renewable Energy Technologies						
Existing and Planned Program Options (evaluated "as is")	PV	Onshore Wind	Offshore Wind	Landfill Gas	Biogas from Wastewater Treatment	Solid Biomass Power
CORE	●	○	○	○	⊙	⊙
REED	○	⊙	⊙	⊙	⊙	⊙/●
REAP	⊙	●	●	●	●	●
Public Entity Financing	⊙/●	○	○	○	⊙	○/⊙
Small Business Financing	⊙/●	○	○	○	⊙	○/⊙
Demonstration Program	○/⊙	○	○	○	○	⊙
Manufacturing Incentive	⊙/●	○	○	○	○	○

Key to Priorities: High ● Medium ⊙ Low ○

New or modified programs would serve to enhance the effectiveness of the existing programs by addressing additional barriers and furthering the Clean Energy Program towards its 2008 goals.

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The following observations are also worth considering in the design of the Clean Energy Program.

- Many of the new programs identified work best in concert with others (i.e., as a suite of programs). This is particularly true for green power, and to a lesser degree for the incremental programs identified to support grid-based Class I RE. Thus, it will be difficult to estimate the cost-effectiveness or effectiveness on a free-standing basis vs. together.
- Biomass co-firing, while not an eligible Class I resource could have impacts on the NJ RPS and the Clean Energy Program.
  - Biomass co-firing is the low-cost option for biomass and could be used as an effective bridge technology until biomass gasification is commercially available
  - There are potential impacts on the RPS REC price
    - Co-firing is RPS eligible in neighboring states within and adjacent to PJM. This may limit competition for RECs in PJM amongst different RPS's, since co-firing RECs cannot be used in New Jersey. This could cause the NJ REC market to diverge from the broader PJM market, with higher Class I RPS REC prices for RECs dedicated to NJ.
    - In the long-term, this issue could abate as biomass supply is exhausted, since other technologies that can compete in all RPS's will be on the margin in PJM.
- New Jersey has a well developed yard waste/composting infrastructure. It may be worth exploring how this can be leveraged as a means of creating higher value from existing biomass streams and supporting development of a biomass fuel supply infrastructure.

As Federal energy policies and programs are somewhat in flux, the Clean Energy Program needs to be able to react to changes.

- There is currently no clear energy policy at the Federal level and it is unclear how this may change or stay the same, depending in part on the outcome of the 2004 elections.
- The Clean Energy Program should be ready and able to adapt to changes in Federal Energy policy and support levels, in order to optimize the use of its own funds and to provide a stabilizing effect.
  - Federal incentives for renewable energy have historically "come and gone", requiring periodic renewals, extensions, or annual appropriations. This leads to uncertainty in Federal support, which has been harmful to the renewable energy industry. One of the roles of the Clean Energy Program can be to help create long-term stability in support levels.
- Renewal of the Federal PTC is currently in conference committee, but the House and Senate versions are different. If passed, it could extend the credit in the same form as when it expired in 2003, or be modified to include other resources (e.g., "open-loop biomass").
  - Even if renewed through 2006, it is uncertain if there will be support for a further extension.
  - The PTC leverage is very substantial. If the PTC is extended through 2006, indications are that it may be the last extension as-is. This possibility suggests that NJ CEP programs might be focused on taking maximum advantage of this leverage while still available, while shifting focus over time to other resource types as the playing field levels.
- In general, Federal incentives do help but are not pivotal, with the principal exception of the PTC and wind power.
  - Other examples of helpful Federal incentives are the solar 10% Investment Tax Credit and the use of accelerated depreciation for wind and solar systems.

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VIII. Appendices

Appendix A – RE Technology Profiles

Flat plate photovoltaic (PV) technology is well proven, but system economics require incentives to be competitive with retail rates.

Flat Plate PV Technology

- Crystalline silicon technologies have module efficiencies of around 14.5% and system efficiencies of 12.3%.
- The technology has over 25 years of proven and reliable performance in the field.
- Inverters, which used to be the main problem area for PV systems, have improved in performance and reliability over the past several years. Inverter efficiency is now about 95%.
- The PV industry is active in terms of R&D: several companies are developing next generation PV technologies such as thin films (CdTe, CIS, Spheral Solar) and there continues to be innovation with proven, crystalline silicon.
  - Sanyo has developed a very high efficiency solar cell (HIT) that results in about 35% increase in an annual output over existing crystalline silicon modules.

Economics

- Residential installed systems costs are about $8,500/kWpac[1] in 2004
- Commercial building installed system costs are about $6,500/kWpac[1] in 2004
- Central station system costs are about $6,000/kWpac[1] in 2004.
- Solar resources in New Jersey are moderate to low, providing an effective capacity factor of 13-14%, which increases cost of electricity relative to places like Phoenix, where capacity factors can be as high as 22% for flat plate PV.

1. kWpac = kW peak, alternating current.

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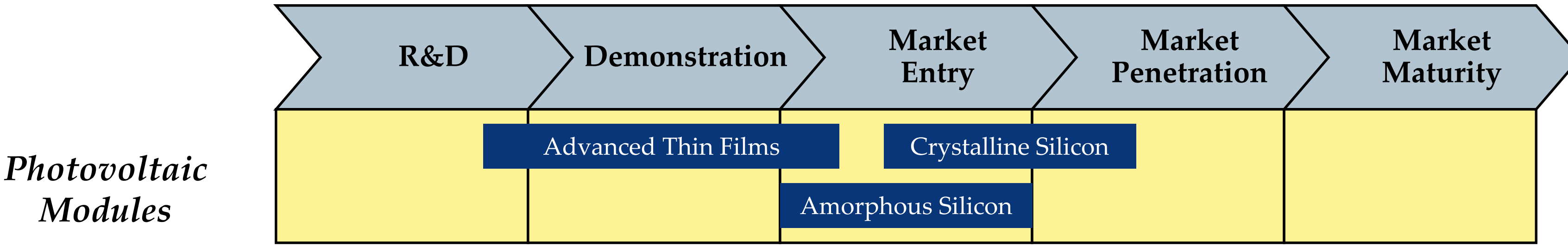
PV can be sited at customer premises to compete with retail power, but high first cost is still a major barrier to broader market penetration.

Advantages	Disadvantages
• Modular • Well suited to customer-sited applications, and can defer some T&D losses and upgrades • No land costs (if building mounted) • Proven reliability • PV output is a good match with peak demand, thus offsetting the most expensive power. • Minimal O&M costs (no moving parts) • Cost-effective today in many off-grid markets such as telecommunications, water pumping, cathodic protection, rural electrification. This is helping to justify larger manufacturing capacities, resulting in technology cost reductions.	• Very high capital costs relative to conventional power options • Intermittent resource – Need energy storage to be able to operate completely independent of the grid • Lack of infrastructure for sales/service (generally) • Poor consumer knowledge about the reliability of systems • Lack of simple interconnection standards (this is not a disadvantage of PV itself, but rather a barrier to more widespread adoption)

Crystalline silicon PV technology has experienced the most market penetration relative to the other solar technologies.



Trend	Description
Modules	• Crystalline silicon is a well proven technology that typically results in over 25 – 30 years of operating life. Crystalline technologies represented about 90% of all modules/cells sold in 2003. The average Standard Test Condition module efficiency in 2003 was 11.5 - 12% efficiency. Some advanced designs achieved higher efficiencies, but at a cost premium. • Amorphous silicon had 6% average Standard Test Condition module efficiency in 2003. • Advanced thin films such as Cadmium Telluride and Copper Indium Diselenide achieved 8% and 9.2% average Standard Test Condition module efficiency in 2003, respectively.
Inverters	• Reliability has improved over the past several years. • Inverter efficiencies are about 95%. • Large companies have entered the business such as GE, Philips Lighting, and Sharp.

O&M costs for rooftop and central station applications of PV are minimal.

	Photovoltaic Major Operations and Maintenance Considerations (New Jersey)
Duty Cycle	• Intermittent • ~1,250 kWh/kWp-year (an effective annual capacity factor of 14% for residential pitched roof and central station applications) • ~1,150 kWh/kWp-year (an effective annual capacity factor of 13% for flat roof commercial building installations)
Operation and Maintenance	• Current O&M costs: $15/kWpdc/yr for residential, $13/kWpdc/yr for larger commercial building installations and $6/kWpdc/yr for central station applications (without tracking) • For grid-connected systems, replacement of inverters is typical in year 10, and the cost is in addition to the annual O&M cost described above.

Sources: Navigant Consulting, Inc. estimates based on discussions with PV manufacturers and distributors/installers, June 2004.

There are no emissions with PV and no major environmental performance issues.

	PV Environmental Performance Assumptions (for Given Year of Installation)			
	2005	**2008**	**2015**	**2020**
Air Emissions (lb/MWh)				
CO_2	0	0	0	0
SO_2	0	0	0	0
NOx	0	0	0	0
Environmental Considerations	• No land use issues for building rooftop applications • For central station applications, approximately 3 acres per MW (DC) is required • There are only minor environmental considerations with some of the module manufacturing processes such as silane gases with amorphous silicon or cadmium use with cadmium telluride modules. These thin film processes, however, are well controlled and minimal amounts of some of these hazardous materials are used.			

There are minimal siting restrictions for PV installations.

	PV Siting
Utility Grid Integration	• Distributed rooftop systems can provide local voltage support, and can defer or replace needed distribution system upgrades.
Land Use Implications	• There are no land use implications if rooftop systems are installed.
Zoning/Building Codes	• Rooftop PV typically requires a building permit, as does any structural or architectural change for a building. However, if the structure is being newly constructed or remodeled, installation of PV typically does not require an additional permit if it is included in the permit application. • Central station PV, on the other hand, would go through a permitting process similar to a new power plant or other use of land, but there are far fewer environmental issues relative to a conventional plant. SMUD, for example, did not incur additional environmental costs other than normal construction limitations in the development of central PV stations at Rancho Seco or at Hedge Substation.

Installed system prices for residential systems are expected to decrease about 5% per year.

	PV Annual Performance Assumptions for Given Year of Installation (Residential)			
	2005	**2008**	**2015**	**2020**
System Size (kW)	3	4	5	5
Total Installed Cost (2004 $/kWpac)[1]	$8,000	$6,900	$4,800	$3,700
Non-Fuel O&M costs ($/kW-yr)[2]	$15	$14	$11	$9
Capacity Factor (%)[1]				
Fixed Tilt	14%	14%	14%	14%
Project Life (yrs)	25	25	30	30

1. kW peak alternating current. An 82% DC to AC rating factor is assumed that takes into account system losses (dust, wiring, module mismatch), system equipment efficiencies (inverter) and impact of temperature on PV system output.
2. Excludes inverter replacement, which is assumed to occur every 10 years.

Source: NCI estimates based on interviews with Sean Seitz, President, American Solar Electric, June 2004.

Commercial building installations are typically on flat roof buildings, are larger, and therefore have system costs that are less than residential systems.

	PV Annual Performance Assumptions for Given Year of Installation (Commercial Building)			
	2005	**2008**	**2015**	**2020**
System Size (kW)	250	250	500	500
Total Installed Cost (2004 $/kWpac)[1]	$6,000	$5,145	$3,590	$2,780
Non-Fuel O&M costs ($/kW-yr)[2]	$12	$11	$9	$8
Capacity Factor (%)				
Horizontal Mount	13%	13%	13%	13%
Project Life (yrs)	25	25	30	30

1. kW peak alternating current. An 82% DC to AC rating factor is assumed that takes into account system losses (dust, wiring, module mismatch), system equipment efficiencies (inverter) and impact of temperature on PV system output.
2. Excludes inverter replacement, which is assumed to occur every 10 years.

Source: NCI estimates based on interviews with Janice Lin, VP Business Development, PowerLight. April 2004.

Central station PV systems without tracking are expected to have similar cost structures to commercial systems.

	PV Annual Performance Assumptions for Given Year of Installation (Central Station – Fixed tilt, no tracking)			
	2005	2008	2015	2020
System Size (kW)	5,000	5,000	5,000	5,000
Total Installed Cost (2004 $/kWpac)[1]	$5,900	$5,060	$3,530	$2,735
Non-Fuel O&M costs ($/kW-yr)[2]	$6.00	$5.50	$4.50	$4.00
Capacity Factor (%)				
Fixed Tilt	14%	14%	14%	14%
Project Life (yrs)	25	25	30	30

1. kW peak alternating current. An 82% DC to AC rating factor is assumed that takes into account system losses (dust, wiring, module mismatch), system equipment efficiencies (inverter) and impact of temperature on PV system output. Excludes land costs. Land required is approximately 3 acres per MW DC or 4 acres per MW AC.
2. Excludes inverter replacement, which is assumed to occur every 10 years.

Source: NCI estimates.

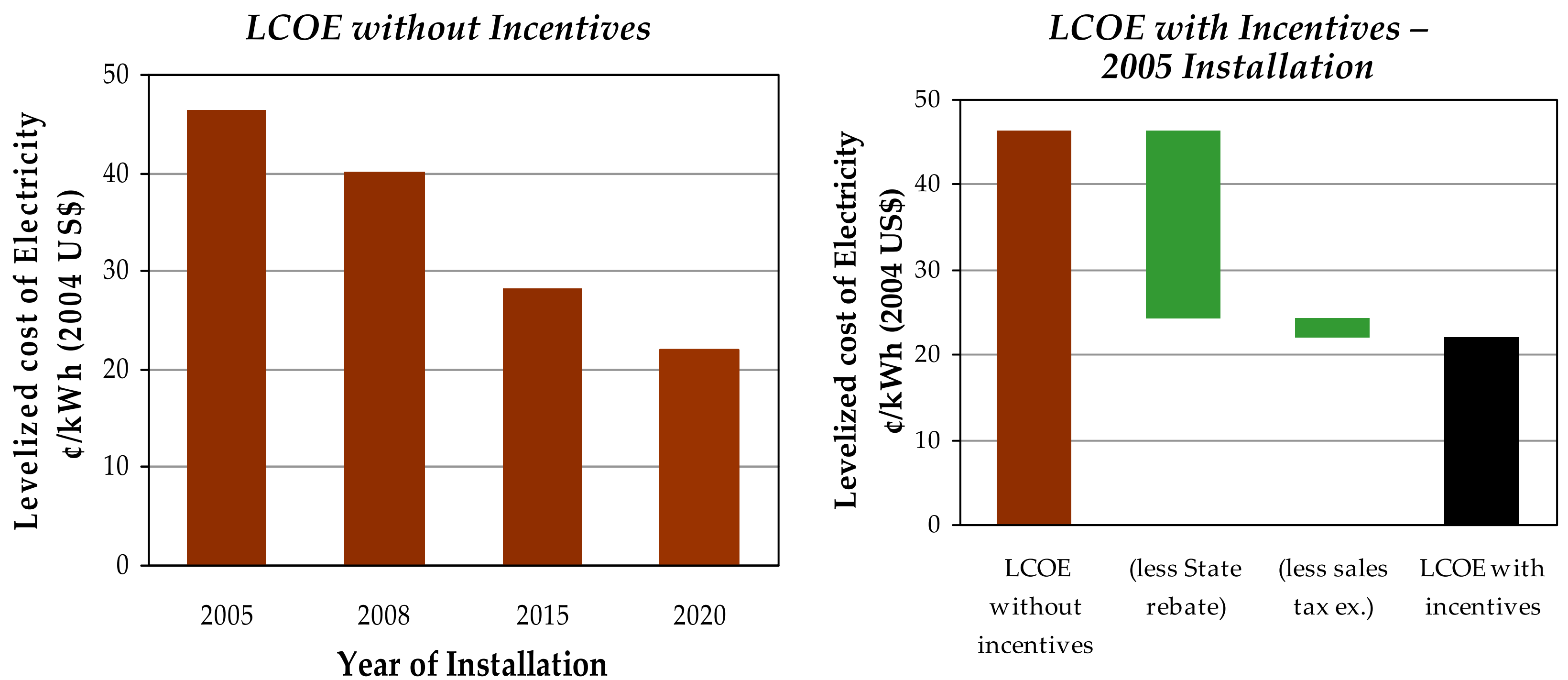
Existing Federal incentives for solar technologies in the U.S. are aimed at reducing the high system capital costs.

Existing Federal Incentives for Solar Power[1]	
Incentive	**Description**
Business Energy Tax Credit (BETC)	For commercial entities, a tax credit of 10% of the installed system price or $25,000, plus 25% of the remaining tax after deducting $25,000, which ever is less
Renewable Energy Production Incentive (REPI)	•Rough equivalent to the PTC but for municipal utilities and other public entities •1.51¢/kWh (1993$) for the first ten years of operation[2].
Accelerated Depreciation	•Solar systems are classified under Modified Accelerated Cost Recovery System (MACRS[3]) property class 5 (6 years accelerated depreciation) •30% depreciation in Year 1 allowed in addition to MACRS

1. The 2003 Energy Bill would have modified the PTC to include solar power, but not allowed a project to claim both the PTC and the 10% investment tax credit. Under current tax reform legislation in conference, the PTC would be extended for 2-3 years but would not modified to include solar power.
2. Total funds available are subject to annual appropriations.
3. MACRS = Modified Accelerated Cost Recovery System

With 100% debt financing (e.g., home equity line of credit), the value of the up-front rebate decreases the cost of electricity by more than 50%.

Levelized Cost of Electricity (LCOE) for Photovoltaic Based Electricity – Residential, 100% debt financing



Key assumptions (without incentives): Discount rate = Weighted Average Cost of Capital = 3.58%, Debt:Equity = 100:0, cost of debt = 5.5%, cost of equity = 10% (assumed to be the opportunity cost). Marginal federal + state income tax = 35%. State sales tax = 6%, Property tax = 1.5%, Insurance = 0.5%, No land lease costs. Project life = 25 years. Length of loan = 10 years.

Key assumptions (with incentives): Rebate $5.5/W up to 10 kW; $4/W for next 90 kW; $3.75 for next 400 kW; $0.3 for next 500 kW; no rebates beyond 1 MW installed capacity.

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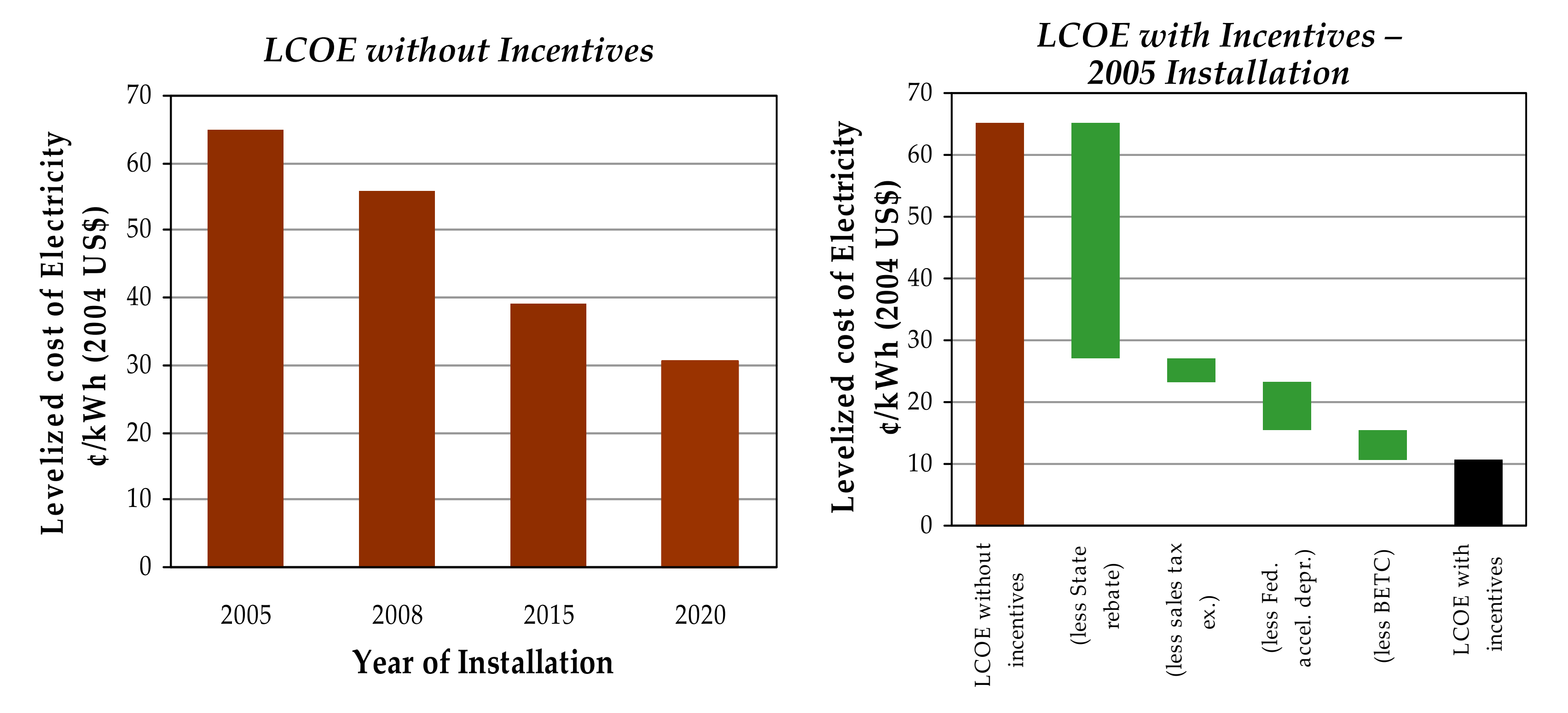
Levelized cost of electricity for commercial customers, with and without incentives.

Levelized Cost of Electricity (LCOE) for Photovoltaic Based Electricity – Commercial System, 45% equity, 55% debt



Key assumptions (without incentives): Discount rate = Weighted Average Cost of Capital = 12.58%, Debt:Equity = 55:45, cost of debt = 10%, cost of equity = 20% (assumed to be the opportunity cost). Marginal federal + state income tax = 35%. State sales tax = 6%, Property tax = 1.5%, Insurance = 0.5%, No land lease costs. Project life = 25 years.

Key assumptions (with incentives): Rebate $5.5/W up to 10 kW; $4/W for next 90 kW; $3.75 for next 400 kW; $0.3 for next 500 kW; no rebates beyond 1 MW installed capacity

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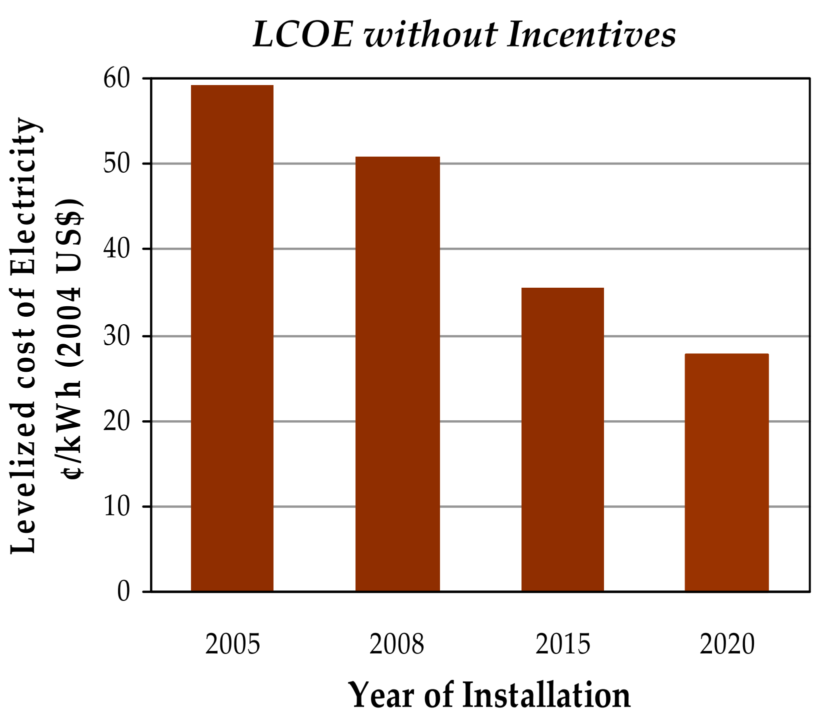
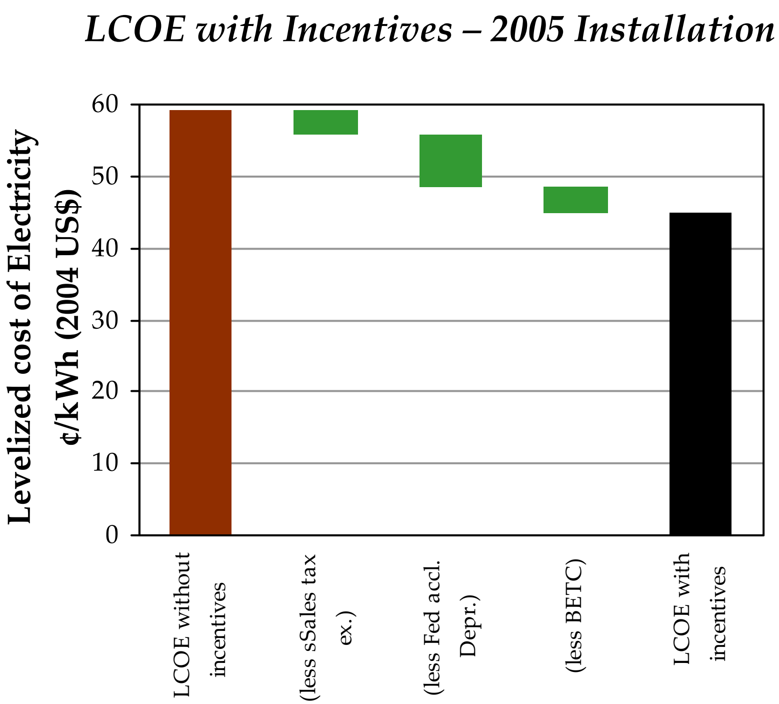
Central station PV costs are similar to commercial sector costs, but no state rebate has been assumed.

Levelized Cost of Electricity (LCOE) for Photovoltaic Based Electricity – Central Station PV, 45% equity, 55% debt





Key assumptions (without incentives): Discount rate = Weighted Average Cost of Capital = 12.58%, Debt:Equity = 55:45, cost of debt = 10%, cost of equity = 20% (assumed to be the opportunity cost). Marginal federal + state income tax = 35%. State sales tax = 6%, Property tax = 1.5%, Insurance = 0.5%, No land lease costs. Project life = 25 years. Cost of land acquisition of $6000/acre included in initial capital.

Key assumptions (with incentives): No state rebate assumed.

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Onshore wind power technology is mature and economics can be competitive with conventional power options.

Onshore Wind Technology

- Technology and performance are well proven and commercially available.
- Many large wind farms are installing 1.0 – 2.0 MW machines.
- Up to 30% of the electric grids connected load can come from intermittent resources without sacrificing reliability.
- Turbines sizes are increasing, tower heights are getting taller and stronger (~60 m vs 50 m) to exploit higher wind speeds, and advances in power electronics have improved technology performance.

Economics

- Incentives enable competition with conventional sources of power.
- The Production Tax Credit (PTC) or the Renewable Energy Production Incentive (REPI) for municipal utilities have made systems eligible for a ten year 1.8¢/kWh (2004 US$) for 10 years of output. These incentives are critical to the financing of wind projects.
- The PTC expired in 12/31/03, but will likely be extended for three years
- Ongoing cost reductions could potentially make onshore wind power competitive in the near-term without incentives

Wind is one of the most economic RE resources, but intermittency, access to transmission, and aesthetic issues need to be addressed.

Advantages

- Among the lowest cost renewable resources – and costs are continuing to fall.
- The wind power market (permitting, project developers, financing, equipment supply and service) is at comparable level of maturity to the broader power market.
- In good wind regimes, economics are approaching competitiveness with conventional power generation, especially with elevated gas prices and including the Production Tax Credit which may get extended with a new Energy Bill.
- No fuel price risk – increasingly recognized as having value within a least-cost planning context.
- No air or water emissions.
- Only uses ~5% of affected land area – remainder can continue to be used for grazing, crops, etc.

Disadvantages

- Market development in U.S. is strongly dependent on the Federal PTC or REPI – which must be periodically renewed by Congress. This creates significant volatility in annual installations.
- Intermittent resource that is difficult to schedule within the structure of existing wholesale markets.
- High first costs relative to some competing technologies such as simple and combined cycle gas turbines.
- Class 4 - 6 wind resources are very localized
- Land availability in high wind areas is often limited or costly.
- T&D systems are often weakest in remote areas where wind resource are best – upgrades are often needed to transport power to load centers
- Concerns remain over aesthetics and environmental impact (e.g., bird kills)
- High population density in New Jersey will make it more difficult to acquire necessary permits for wind energy development.

Offshore wind power technology has yet to be implemented in the United States, but two initial projects are being advanced in MA and NY.

Offshore Wind Power Technology

- Technology and performance track record needs to be established in the Unites States. Commercial offshore installations are relatively new, even in Europe.
- Current projects are using 1.5-3.6 MW machines. Even larger machines are being prototyped.
- Key areas for development are gearless drives (as with onshore models), reliability improvements through built-in redundancy and remote monitoring/controls, and construction of underwater foundations.

Economics

- Offshore wind power is not competitive today despite the incentives and will continue to require government support.
- Ongoing cost reductions are likely to come from improvements in foundation design/construction, O&M efficiencies, and streamlined permitting.
- Construction, operation and O&M costs are strongly affected by the installation's distance from shore and the frequency with which wave heights exceed thresholds for sea-going vessels. Frequent high waves place limits on system availability, delay repairs and servicing, and may force certain tasks to be accomplished via more expensive helicopters rather than sea-going vessels.

Offshore wind offers significant advantages relative to onshore wind, but must address a host of new issues and potential risks.

Advantages

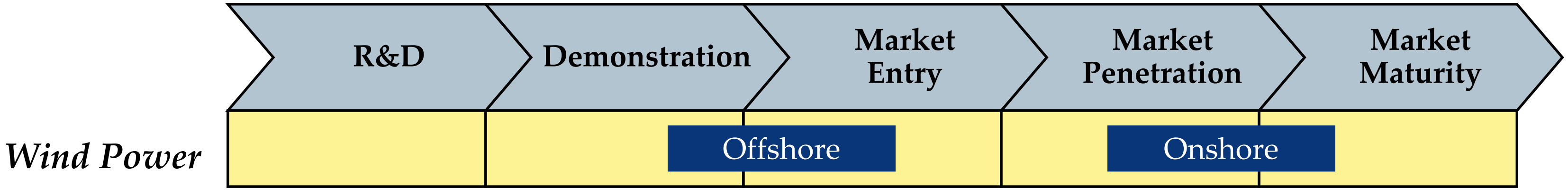
In addition to most of the benefits offered by onshore wind, offshore wind farms:

- Can take advantage of stronger and more consistent winds, resulting in higher performance.
- Open up vast new areas that are technically suitable for siting wind turbines.
- May provide favorable habitat to ocean wildlife by serving as artificial reefs (anecdotal evidence).

Disadvantages

- Lack of maturity -- Limited construction and operational experience
- Viewshed impacts and public acceptability are largely unknown
- 50-100% cost increment relative to onshore wind
- Marine environment: corrosion protection needed; foundations must withstand high waves, strong currents, collision from ships; construction/maintenance delays due to inclement weather; additional risks of lightning strikes
- Additional onshore infrastructure -- harbor with staging area for foundations, barge crane, cable laying vessel, requirements during construction
- Wildlife -- Impact on marine habitats, birds, and fisheries not well documented
- Permitting -- Can take ~3 - 4 yrs for offshore (~2 years longer than onshore), and the process and permitting authority have not been determined
- O&M – Highly site-specific due to wave heights and distance from shore. Need to develop skills for operations & maintenance, especially in bad weather conditions (e.g., high seas, hurricanes)
- Availability -- 90-95% for offshore turbines vs. 98-99.5% for onshore

Wind power technology advances continue to drive cost reductions and performance improvements such as higher capacity factors.



Trend	Description
Turbine Size	• Wind turbines are getting larger: 3 MW Vestas; 3.6 MW GE Wind; 2.75 MW NEG Micon; and 4.5 MW Enercon prototypes erected in 2003. GE announced 2.3; 2.5; and 2.7 MW turbine series in 2003. • U.S. average wind turbine installed in 2003 was ~1.4 MW. New wind farms generally use 1.5+ MW turbines
Tower Design	• Taller and stronger towers are being built to exploit higher wind speeds. • Alternative ways of erecting towers (self-erecting concrete towers to telescoping tubes or jack-up devices) are being explored. Cranes are very expensive for installing/maintaining turbines. • Alternative approaches to offshore wind turbine foundations are also being explored.
Turbine Design	• Gearboxes are being eliminated, with a move towards direct drives and use of advanced electronics and controls. — Direct drive can provide higher capacity factors and offers the prospect of lower O&M costs • Innovative blade designs and manufacture using lighter-weight composite materials such as carbon or glass-carbon hybrids are being developed. • Work is also being conducted on developing wind turbines that can operate more cost-effectively in lower wind speed areas (Class 3 winds). • Active pitch controls and semi- and full-variable speed drive are incorporated to regulate power output.

O&M costs are impacted significantly by local wind conditions (e.g., turbulence, speed) and turbine placement, and for offshore, also wave heights and distance from shore.

	Wind Power Major Operations and Maintenance Considerations
Duty Cycle	• Intermittent. Availability is currently about 98% for onshore. —Two scheduled servicings per year (~30 hours) —Unscheduled maintenance currently averages about 100 hours/yr • Cut in wind speed is ~4 meters/second (~9 mph).
Major Overhauls & Replacements	• Periodic major component overhauls and replacements: gearbox overhaul, generator bearing replacement in years 10 and 20, rebuild pitch, hydraulic and yaw systems, and replacement of blades in year 20. • Total O&M costs during warranty (2-5 yrs) is ~0.5¢/kWh for onshore. After the warranty period (year 5-10) the cost is closer to 0.5¢– 1.0¢ /kWh. After 10 years the O&M cost is about 1.0 – 2.0 ¢/kWh.
Other Considerations	• O&M can be highly variable depending on placement of turbines and need for a crane. • The gearbox is the component with the most maintenance issues. Replacement costs about $85/kW. • An additional $30,000 - $40,000 can be required for a single event onshore crane cost. • Typical repairs range from $10,000 - $50,000 for onshore installations. Some initial experience with offshore wind farms in Europe suggests O&M costs are running ~50% higher, although repair costs vary considerably, depending on sea conditions and what exactly needs to be done. • Scheduled downtime varies significantly depending on the wind turbine location and Class of wind speed. Poorer wind speed sites with more fluctuations tend to require more scheduled downtime. Ranges from 50 – 200 hours per year. Great uncertainty exists regarding offshore turbine downtime. • Larger turbines with hub heights approaching 100 meters (not yet common) will incur larger crane costs

Source: NCI estimates based on interviews with wind turbine developers and manufacturers, February 2004.

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Wind power is emissions free. Environmental issues center primarily around aesthetics and wildlife impacts.

	Wind Power Environmental Performance Assumptions (for given year of installation)			
	2005	2008	2015	2020
Air Emissions (lb/MWh)	None			
Other Environmental Considerations	• Wind farms use ~5% of affected land or ocean area (but a much smaller fraction of seabed - ~0.1%). The remainder can continue to be used for things such as grazing or crops, for onshore wind farms; offshore installations may place some limitations on non-power production use due to safety concerns and the potential for anchors or fishing lines snagging on underwater power lines. Spacing between turbines is very dependent on the turbulence of the wind resource, but a general rule of thumb is two rotor diameters side to side and 5 rotor diameters front to back. • General aesthetic concerns may result in NIMBY issues. • Noise "thumping" issues of the past have largely been resolved due to improved blade technology and lower RPM. Currently ~40dB at 100ft. • No water use • May require aviation warning lights for larger machines. • Avian mortality can be an issue if located in migration paths. Most larger turbines used today have low rotational speed (<18 rpm), so avian deaths are less of an issue and siting plans generally tend to avoid such areas. More recently bat mortality has also become a concern.			

The analysis on wind power economics factored in time of day and seasonal variations in wind power output.

- **General Background: It matters when the wind blows**
  - The value of the energy produced by a wind turbine over the course of a year will depend upon when the energy is produced (i.e., kWh produced during peak hours are more valuable than kWh produced during off-peak hours).
  - The kinetic energy in the wind is a linear function of the air density and a cubic function of the wind speed. Air density is a positive function of increasing relative humidity, decreasing temperature and decreasing elevation.
  - Wind speed has seasonal and diurnal variations (wind generally blows stronger in the winter and during the day in New Jersey). Air density in New Jersey will be most affected by temperature variations.
  - The actual energy produced by a turbine, while positively correlated with wind speed (up to a shutdown speed), is not a linear function of the kinetic energy of the wind, but a function of the wind turbines characteristics. The relationship between wind speed and power production is known as a turbine manufacturer's "power curve".
- **Final Goal**: To take into account the monthly and diurnal variation of wind speed and weather in order to produce a reasonable estimate of the energy production corresponding to the value of the energy by market price period.
  - Specific computational goal: To partition estimates of annual kWh production into four time periods: 1) Summer Peak Hours, 2) Summer Off-Peak Hours, 3) Non-Summer Peak Hours, 4) Non-Summer Off-Peak Hours

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The analysis on wind power economics factored in time of day and seasonal variations in wind power output. (continued)

- **Methodology for computing wind power output for each of four time periods[1]:**
  - — Data Sources (most wind power potential is on the coast)
    - ▪ Atlantic City weather station, 40 year monthly average wind speed
    - ▪ Atlantic City weather station, 2003 hourly (8760 hours) wind speed, humidity, temperature and air pressure
    - ▪ GE 1.5sl Power Curve (assumes sea level, dry air at 15 degrees Celsius)
  - — Create a model wind speed data set characteristic of the New Jersey coast using available data
    - ▪ **Scale 2003 hourly data to match historical averages:** For each month, scale the 2003 hourly wind speed in each hour of the month so that monthly average wind speed is equal to the 40 year average wind speed in that month.
    - ▪ **Adjust wind speed to match conditions used in standard wind turbine power curve:** For each hour adjust wind speed so that it assumes sea level, dry air at 15 degrees Celsius (e.g., if weather is 0 degrees Celsius, adjust the wind speed upward by 5% to account for increased kinetic energy in the wind during colder weather as compared to the reference conditions).
    - ▪ **Scale wind speed up from Class 1 (as measured at weather station) to Class 3 (expected wind speed at the coast):** Adjust wind speed upward for each hour so that the annual average wind speed is 6.75 m/s, the midpoint of Class 3 wind resources.
  - — Using the resultant wind speed for each hour from the previous step and a GE 1.5sl power curve, estimate the kWh produced for each hour of the year.
  - — Compute the fraction of annual kWh for the four periods. 1) Summer Peak Hours, 2) Summer Off-Peak Hours, 3) Non-Summer Peak Hours, 4) Non-Summer Off-Peak Hours.

1. Corresponding to summer and non-summer peak and off-peak periods as defined later in this section.

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Small wind farms or "clusters" are the likely option for onshore wind power development in New Jersey.

	Wind Power Annual Performance Assumptions for Given Year of Installation							
	5 MW Onshore Wind "Cluster"				20 MW Onshore Wind Farm			
	2005	2008	2015	2020	2005	2008	2015	2020
Turbine Size (MW)	1.8	3.0	5.0	5.0	1.8	3.0	5.0	5.0
Total Installed Cost (2004 $/kW)	$1,250	$1,155	$960	$850	$1,185	$1,090	$895	$785
Non-Fuel O&M costs ($/kW-yr)	$25.0	$22.8	$18.4	$15.8	$23.3	$21.3	$18.0	$14.8
Capacity Factor (%)[1]								
High wind area (Class 6)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Moderate wind area (Class 4)	35.0%	36.0%	37.4%	38.2%	35.0%	36.0%	37.4%	38.2%
Low wind area (Class 3)	29.0%	29.8%	31.0%	31.6%	29.0%	29.8%	31.0%	31.6%
Project Life (yrs)	25	25	30	30	25	25	30	30

Source: Interviews with wind turbine manufacturers and Global Energy Concepts, 2004. Costs assume interconnection to the grid within 0.5 miles. Capacity factors are net of all losses at the plant (e.g. blade soiling, aerodynamic losses). Cost and performance assume 80m hub height and large rotors, as is more common in moderate wind speed applications.

1. At 50m wind speeds: Class 6 = 8-8.5 m/s (17.9-190 mph); Class 4 = 7 – 7.5m/s (15.7 – 16.8 mph); Class 3 = 6.4 - 7m/s (14.3 – 15.7 mph)

Capacity factors are expected to increase gradually over the next several years as towers become taller and turbines more efficient.

	Wind Power Annual Performance Assumptions for Given Year of Installation							
	50 MW Onshore Wind Farm				Offshore Wind Farm[2]			
	2005	2008	2015	2020	2005	2008	2015	2020
Turbine Size (MW)	1.8	3.0	5.0	5.0	N/A	3-4	4-5	5
Total Installed Cost (2004 $/kW)	$1,050	$955	$775	$665	N/A	$1,900	$1,700	$1,650
Non-Fuel O&M costs ($/kW-yr)	$20.0	$18.3	$17.2	$12.7	N/A	$49.0	$46.0	$44.0
Capacity Factor (%)[1]								
High wind area (Class 6)	N/A	N/A	N/A	N/A	N/A	37.0%	40.0%	42.0%
Moderate wind area (Class 4)	35.0%	36.0%	37.4%	38.2%	N/A	N/A	N/A	N/A
Low wind area (Class 3)	29.0%	29.8%	31.0%	31.6%	N/A	N/A	N/A	N/A
Project Life (yrs)	25	25	30	30	N/A	25	30	30

Source: Interviews with wind turbine manufacturers and Global Energy Concepts, 2004. Costs assume interconnection to the grid within 0.5 miles. Capacity factors are net of all losses at the plant (e.g. blade soiling, aerodynamic losses). Onshore cost and performance assume 80m hub height and large rotors, as is more common in moderate wind speed applications.

1. At 50m wind speeds: Class 6 = 8-8.5 m/s (17.9-19.0 mph); Class 4 = 7 – 7.5m/s (15.7 – 16.8 mph); Class 3 = 6.4 - 7m/s (14.3 – 15.7 mph)
2. Capacity factors are for a 70m hub height.

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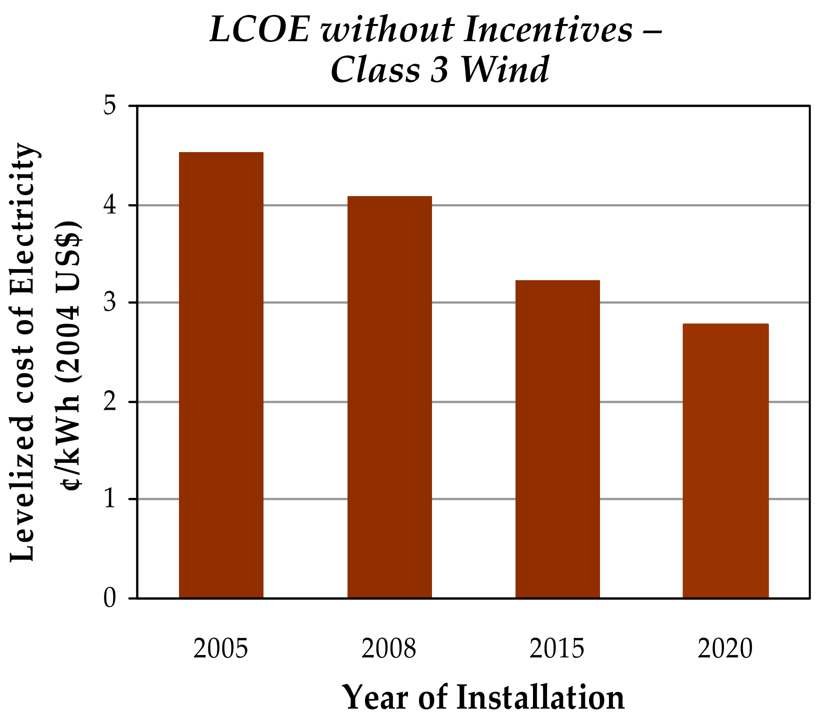
The federal production tax credit has been the most significant incentive for wind power.

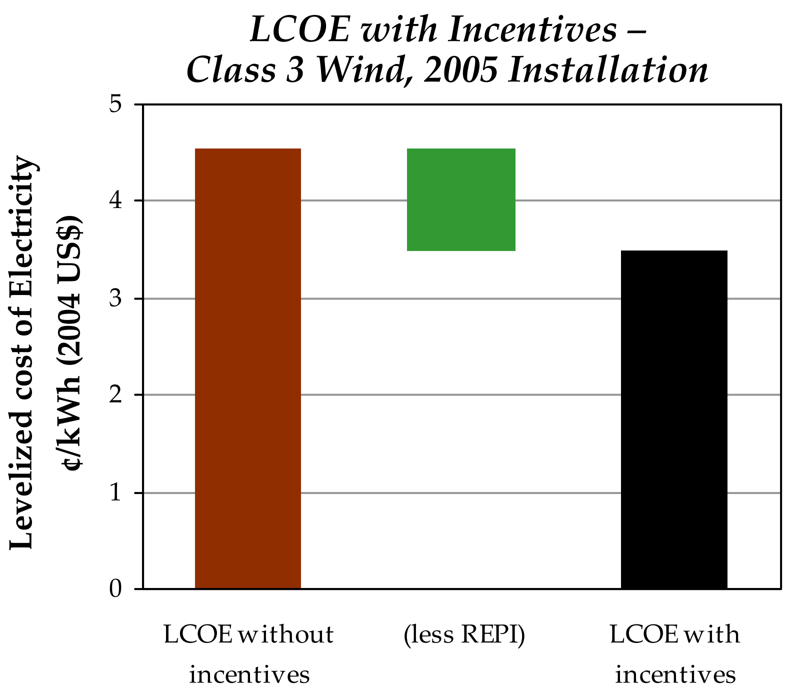
Existing Federal Incentives for Wind Power	
Incentive	**Description**
Production Tax Credit (PTC)	• 1.8 ¢/kWh ($2003) after tax credit, for first 10 years of operation. PTC is indexed to inflation • Commercial entities only. Expired on 12/31/03[1].
Renewable Energy Production Incentive (REPI)	• Rough equivalent to the PTC but for municipal utilities and other public entities • 1.51¢/kWh (1993$) for the first ten years of operation[2].
Accelerated Depreciation	• Wind power investments are classified under Modified Accelerated Cost Recovery System (MACRS[2]) property class 5 (6 years accelerated depreciation) • 30% depreciation in Year 1 allowed in addition to MACRS

1. Under current tax reform legislation in conference, the PTC would be extended for 2-3 years.
2. Total funds available are subject to annual appropriations.
3. MACRS = Modified Accelerated Cost Recovery System

On-shore wind power costs in New Jersey with municipal financing.

Levelized Cost of Electricity (LCOE) for On-Shore Wind Power Projects – Developed by Municipalities, 5 MW Project Size, Class 3 Wind



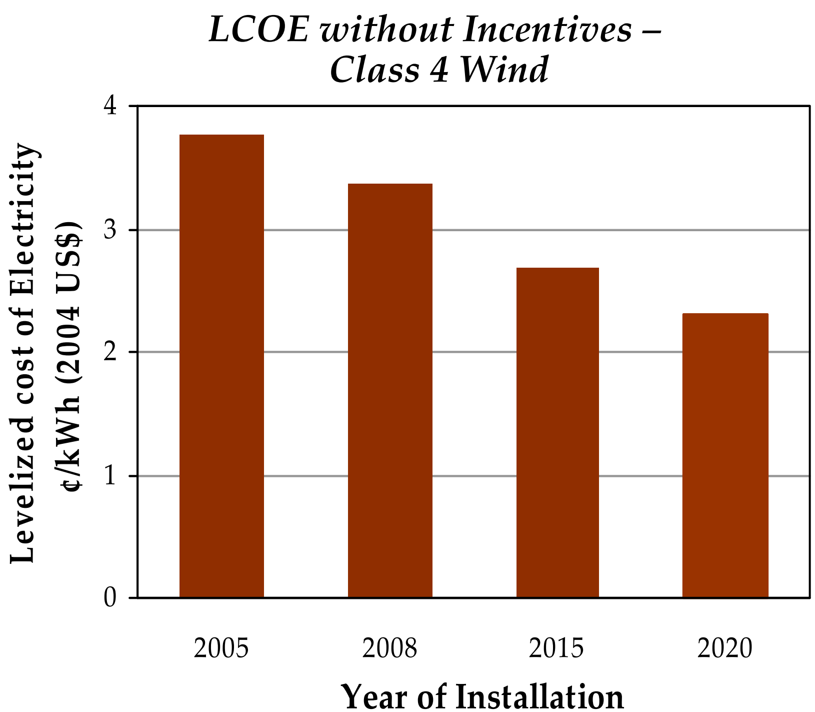


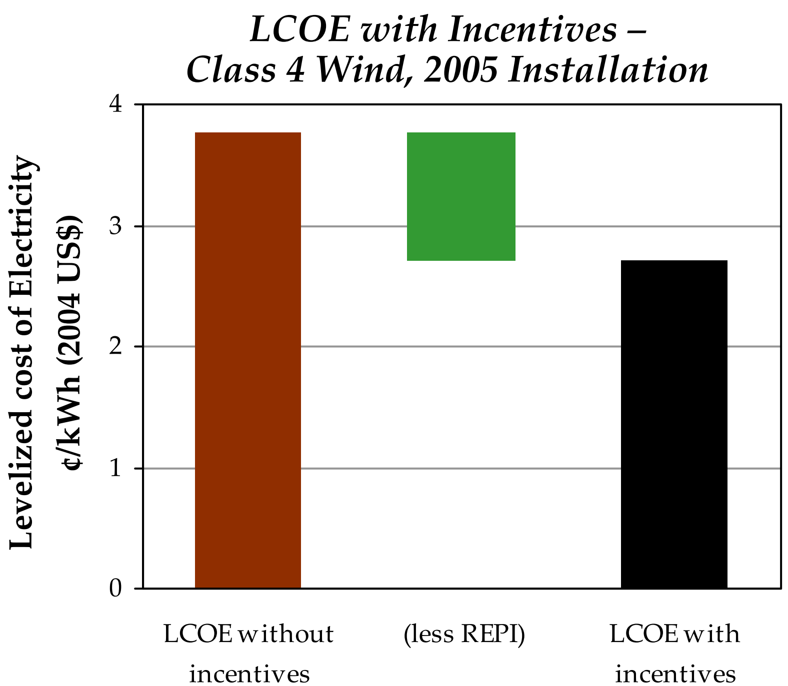
Key assumptions (without incentives): Discount rate = Weighted Average Cost of Capital = 5.50%, Debt: 100%, cost of debt = 5.5%, Federal and state sales taxes= 0%, Property tax = 0%, Insurance = 0.5%, No land lease costs. Project life = 20 years.

Key assumptions (with incentives): Renewable energy production incentive (REPI): 1.8 ¢/kWh (in 2003) for 10 years. Amount shown assumes the full amount of the REPI, but the REPI is subject to annual appropriations, so is some years the amount may be reduced or zero.

On-shore wind power costs in New Jersey with municipal financing.

Levelized Cost of Electricity (LCOE) for On-Shore Wind Power Projects – Developed by Municipalities, 5 MW Project Size, Class 4 Wind



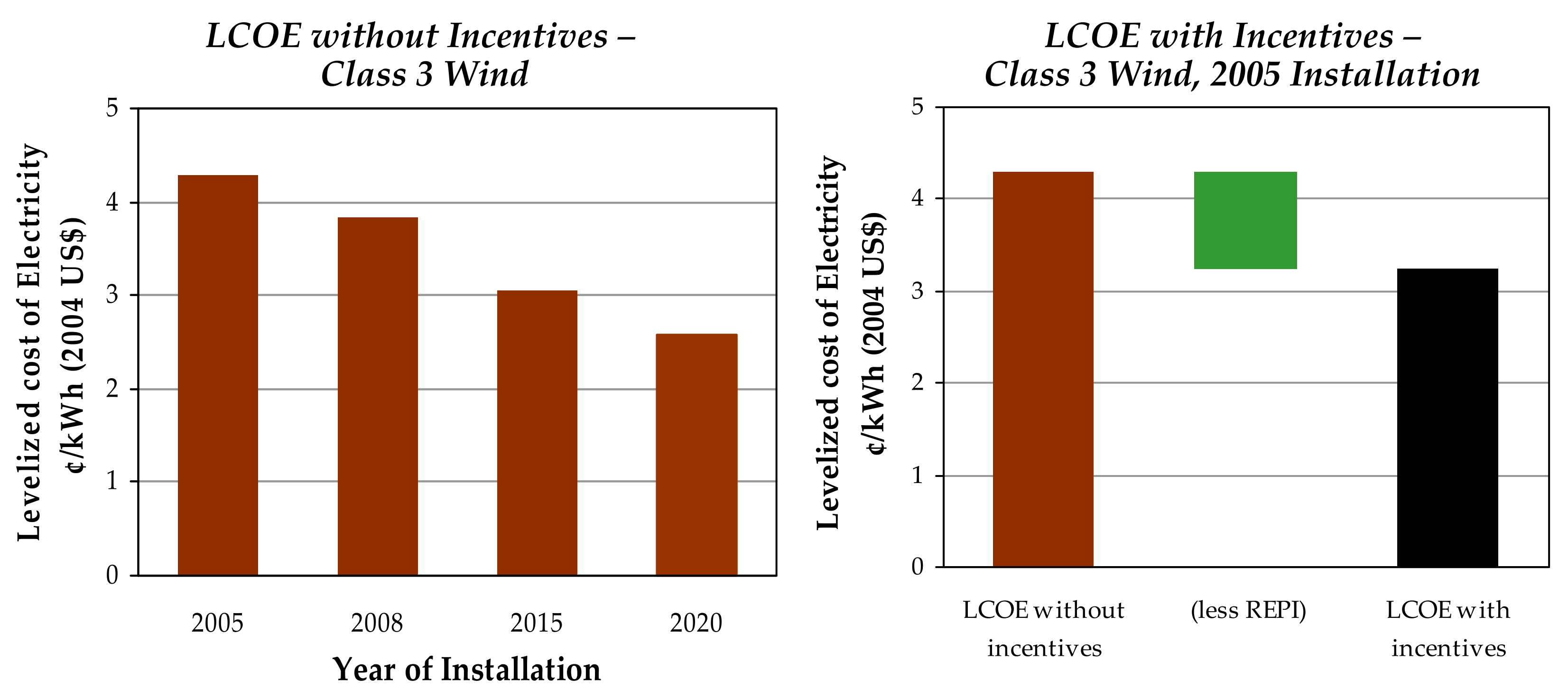


Key assumptions (without incentives): Discount rate = Weighted Average Cost of Capital = 5.50%, Debt: 100%, cost of debt = 5.5%, Federal and state sales taxes= 0%, Property tax = 0%, Insurance = 0.5%, No land lease costs. Project life = 20 years.

Key assumptions (with incentives): Renewable energy production incentive (REPI): 1.8 ¢/kWh (in 2003) for 10 years. Amount shown assumes the full amount of the REPI, but the REPI is subject to annual appropriations, so is some years the amount may be reduced or zero.

On-shore wind power costs in New Jersey with municipal financing.

Levelized Cost of Electricity (LCOE) for On-Shore Wind Power Projects – Developed by Municipalities, 20 MW Project Size, Class 3 Wind



Key assumptions (without incentives): Discount rate = Weighted Average Cost of Capital = 5.50%, Debt: 100%, cost of debt = 5.5%, Federal and state sales taxes= 0%, Property tax = 0%, Insurance = 0.5%, No land lease costs. Project life = 20 years.

Key assumptions (with incentives): Renewable energy production incentive (REPI): 1.8 ¢/kWh (in 2003) for 10 years. Amount shown assumes the full amount of the REPI, but the REPI is subject to annual appropriations, so is some years the amount may be reduced or zero.

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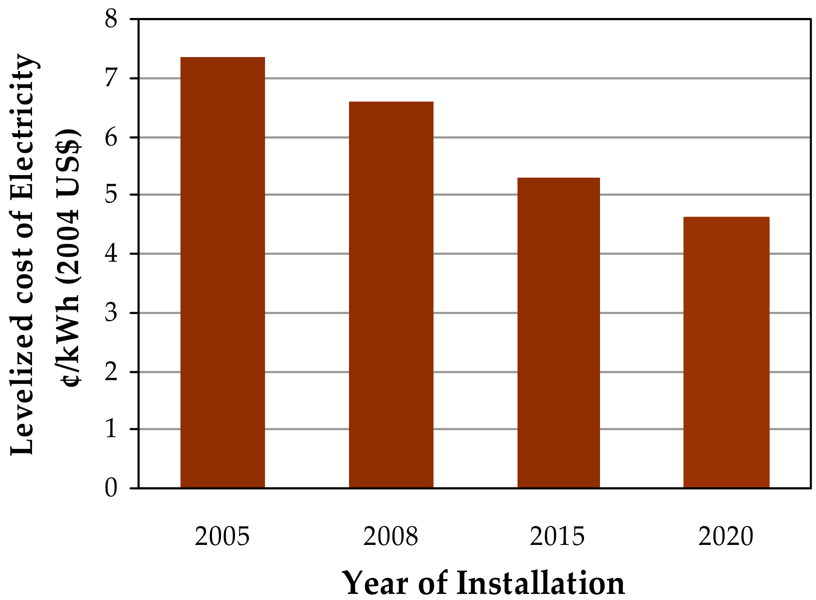
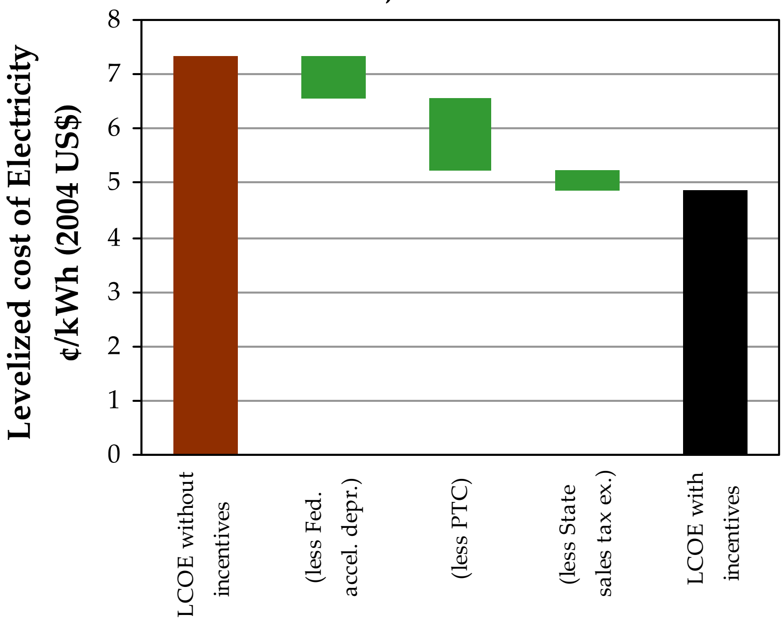
On-shore wind power costs in New Jersey with developer financing.

Levelized Cost of Electricity (LCOE) for On-Shore Wind Power Projects – Developer Financed, 5 MW Project Size, Class 3 Wind





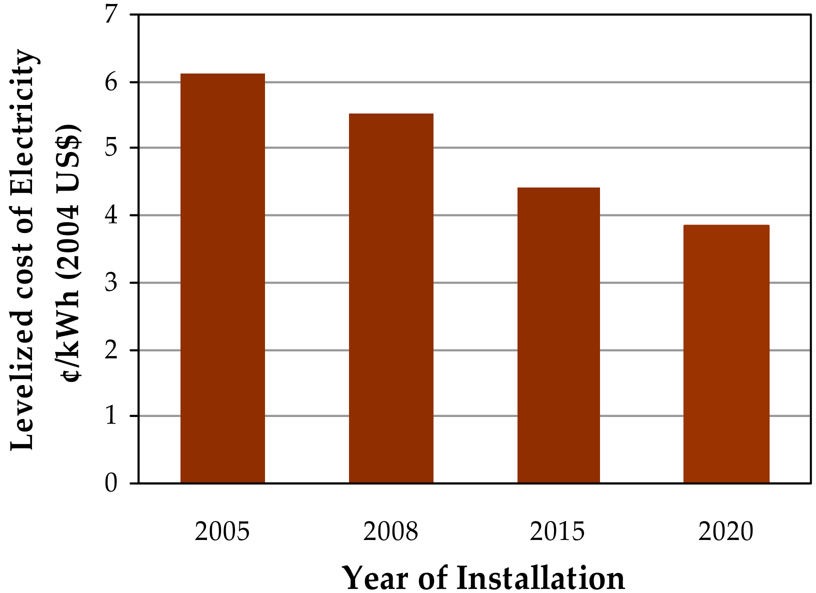
Key assumptions (without incentives): Discount rate = Weighted Average Cost of Capital = 12.58% (Debt equity ratio: 55%:45%, cost of equity = 20%, cost of debt = 10%), Marginal federal + state income tax = 35%. State sales tax = 6%, Property tax = 1.5%, Insurance = 0.5%, Land Lease costs = 5% of electricity sales revenues @ 4¢/kWh. Depreciation under Modified Accelerated Cost Recovery System (MACRS): Depreciation period considered is 15 years and Accelerated Depreciation 5 years. Project economic life = 20 years.

Key assumptions (with incentives): Federal accelerated depreciation and additional 1st year depreciation (30%). Production tax credit (1.8 ¢/kWh in 2003); State sales tax exemption on equipment purchase (6%).

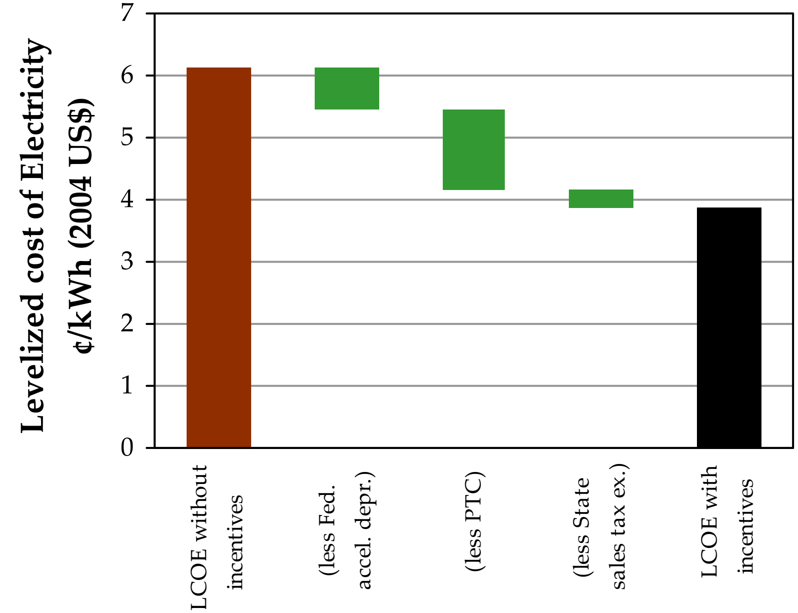
On-shore wind power costs in New Jersey with developer financing.

Levelized Cost of Electricity (LCOE) for On-Shore Wind Power Projects – Developer Financed, 5 MW Project Size, Class 4 Wind

LCOE without Incentives – Class 4 Wind



LCOE with Incentives – Class 4 Wind, 2005 Installation



Key assumptions (without incentives): Discount rate = Weighted Average Cost of Capital = 12.58% (Debt equity ratio: 55%:45%, cost of equity = 20%, cost of debt = 10%), Marginal federal + state income tax = 35%. State sales tax = 6%, Property tax = 1.5%, Insurance = 0.5%, Land Lease costs = 5% of electricity sales revenues @ 4¢/kWh. Depreciation under Modified Accelerated Cost Recovery System (MACRS): Depreciation period considered is 15 years and Accelerated Depreciation 5 years. Project economic life = 20 years.

Key assumptions (with incentives): Federal accelerated depreciation and additional 1st year depreciation (30%). Production tax credit (1.8 ¢/kWh in 2003); State sales tax exemption on equipment purchase (6%).

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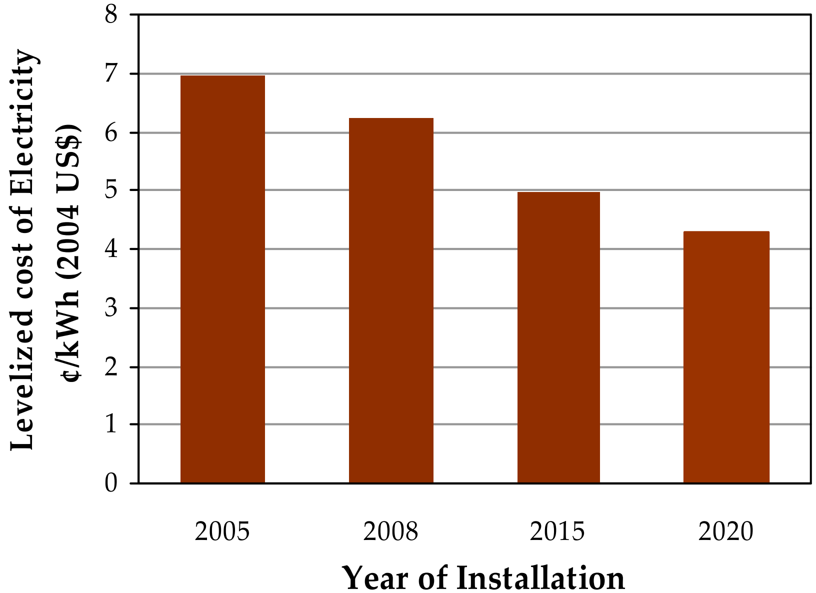
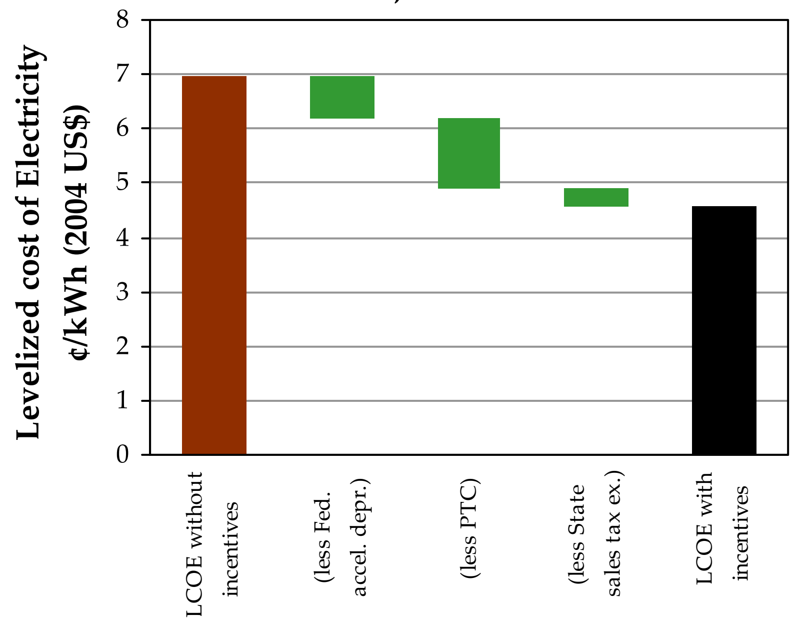
On-shore wind power costs in New Jersey with developer financing.

Levelized Cost of Electricity (LCOE) for On-Shore Wind Power Projects – Developer Financed, 20 MW Project Size, Class 3 Wind

LCOE without Incentives – Class 3 Wind



LCOE with Incentives – Class 3 Wind, 2005 Installation

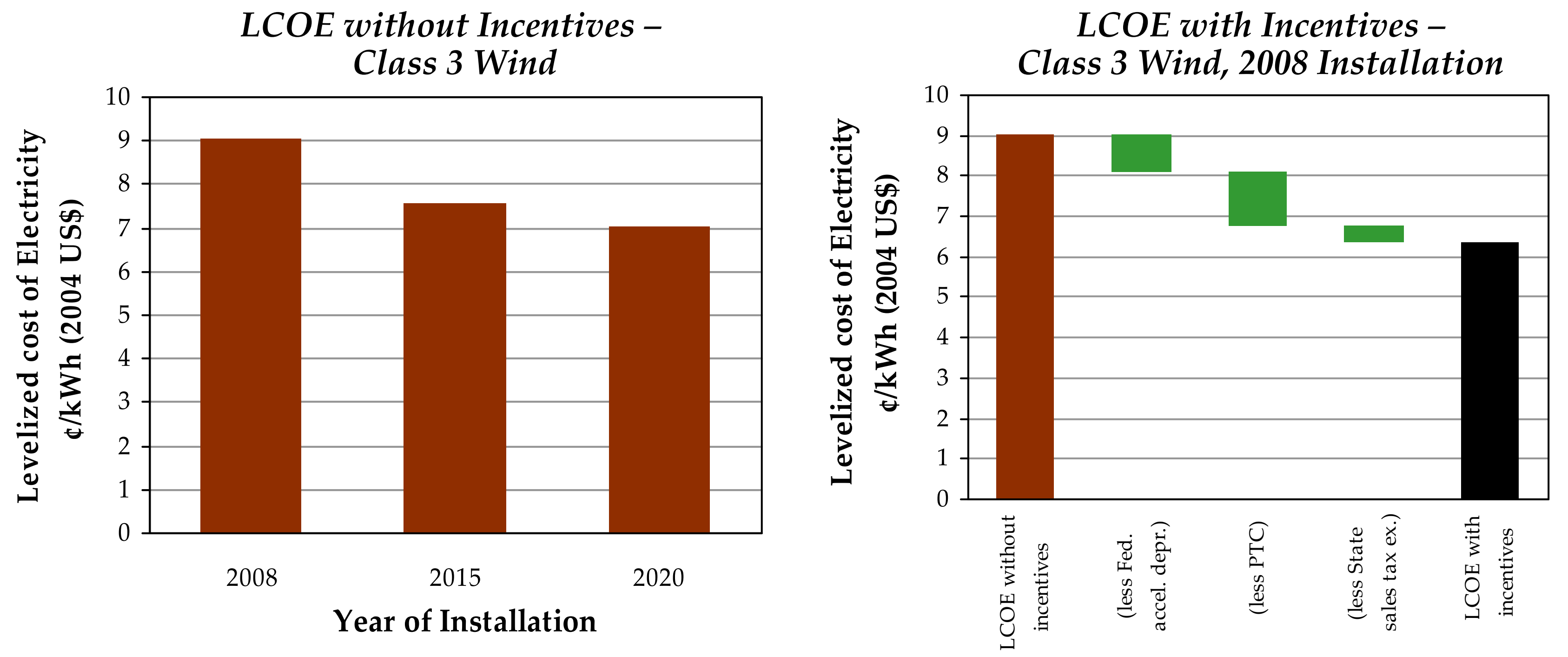


Key assumptions (without incentives): Discount rate = Weighted Average Cost of Capital = 12.58% (Debt equity ratio: 55%:45%, cost of equity = 20%, cost of debt = 10%), Marginal federal + state income tax = 35%. State sales tax = 6%, Property tax = 1.5%, Insurance = 0.5%, Land Lease costs = 5% of electricity sales revenues @ 4¢/kWh. Depreciation under Modified Accelerated Cost Recovery System (MACRS): Depreciation period considered is 15 years and Accelerated Depreciation 5 years. Project economic life = 20 years.

Key assumptions (with incentives): Federal accelerated depreciation and additional 1st year depreciation (30%). Production tax credit (1.8 ¢/kWh in 2003); State sales tax exemption on equipment purchase (6%).

Offshore wind power costs in New Jersey with developer financing.

Levelized Cost of Electricity (LCOE) for Offshore Wind Power Projects – Developer Financed, Class 6 Wind



Key assumptions (without incentives): Discount rate = Weighted Average Cost of Capital = 12.58% (Debt equity ratio: 55%:45%, cost of equity = 20%, cost of debt = 10%), Marginal federal + state income tax = 35%. State sales tax = 6%, Property tax = 1.5%, Insurance = 0.5%, Land Lease costs = 5% of electricity sales revenues @ 4¢/kWh. Depreciation under Modified Accelerated Cost Recovery System (MACRS): Depreciation period considered is 15 years and Accelerated Depreciation 5 years. Project economic life = 20 years.

Key assumptions (with incentives): Federal accelerated depreciation and additional 1st year depreciation (30%). Production tax credit (1.8 ¢/kWh in 2003); State sales tax exemption on equipment purchase (6%).

NAVIGANT CONSULTING

Solid biomass power technology based on direct combustion is commercially available and well proven.

Solid Biomass Power Technology	
	• Direct combustion technology and performance are well proven and commercially available. • Biomass gasification combined cycle technology (BIGCC) has limited demonstration experience in Europe, but none in the United States. RD&D is ongoing but progressing relatively slowly. Several advanced gasification technologies have been demonstrated in the United States, (e.g., Battelle/FERCO gasifier in Burlington, VT) but none in the full BIGCC configuration. • Biomass co-firing with coal has been well demonstrated and is in limited commercial operation in utility boilers in the United States. However, this is not an eligible technology for New Jersey RPS and SBC purposes. Gasification-based co-firing is possible in both coal and gas-fired plants, but is also not eligible in New Jersey.
Economics	• Economics can vary widely. Unlike other renewables, fuel availability and price are major issues affecting economics and project risk. • Unlike wind or solar power, biomass power is not currently eligible for existing Federal incentives (except for closed-loop biomass [bioenergy crops]). • Currently, direct-fired biomass combustion would produce electricity at 7-11 cents/kWh, depending upon biomass price. • By 2008, BIGCC would be able to produce electricity for 7-9 cents/kWh, depending upon biomass price, with further declines possible, assuming the technology is successfully commercialized and more widely deployed.

The main advantage of biomass combustion technology is that it is mature. The main disadvantages are its high cost and low efficiency.

Dedicated Solid Biomass Combustion

Advantages	Disadvantages
• Proven, widely deployed technology • Dispatchable, high capacity-factor • Creates additional economic value for biomass-based industries • Adds more capacity to the overall power supply mix (vs. co-firing, which only displaces existing capacity)	• High capital costs ($1,500-2,500/kW, depending on size) • Low efficiency (20-25%) • Requires long-term biomass fuel supply at reasonable price to avoid risk of stranded investment • Limited incentives relative to other major renewable technologies (specifically wind and PV). • Can be difficult to site due to emissions concerns

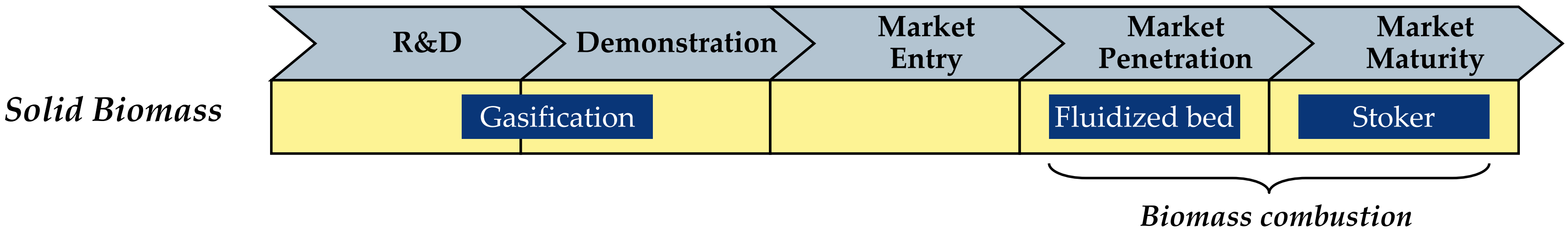
Biomass Integrated Gasification Combined Cycle (BIGCC) technology offers the prospect of significantly better economics than biomass combustion, but is not yet proven.

Dedicated Solid Biomass Integrated Gasification Combined Cycle (BIGCC)

Advantages	Disadvantages
• High efficiency and lower emissions relative to traditional biomass combustion • Creates additional economic value for biomass-based industries • Pulp & paper industry support may aid in technology commercialization • Strong interest in Europe for gasification (in BIGCC and for co-firing applications) • Long-term potential for using gasification for fuels and chemicals production may help move this technology platform into the market	• Relatively high capital costs compared to fossil fuel technologies due to scale limitations • Technology still not "proven" at commercial scales (e.g., gas cleanup, long-term gas turbine operation) • May be an issue with gas turbine manufacturer willingness to provide warranty • Limited incentives relative to other major renewable technologies (specifically wind and PV) • Although easier to permit than direct-fire, siting could still be difficult due to emissions

NAVIGANT CONSULTING

A number of biomass conversion options are at various stages of development and deployment.



Trend	Description
Gasification	• Has higher efficiency and lower emissions than direct-fire combustion, but requires additional cleanup steps • Lack of market success indicative of basic economic, increased risk relative to other renewables, and lack of incentives • The clean syngas can be converted in a small stand-alone *biomass integrated gasification combined cycle* (BIGCC) power plant, or it can be co-fired in a larger natural gas combined cycle plant. The clean syngas can also be co-fired in a coal boiler. Since states like NY and PA allow co-firing to contribute to RPS requirements, there may be a driving force for gasification-based co-firing, which could help with the commercialization of stand-alone BIGCC. • The pulp and paper industry also may be a catalyst for moving biomass gasification into the commercial arena
Fluidized bed boilers	• Similar to technology developed for coal and other solid fuels, this boiler type is well suited to biomass application. Advantages are low emissions and the ability to accept fuel with variable attributes (e.g., moisture, particle size). However, this technology is higher in capital cost than stoker systems.
Modular Systems	• A variety of small-scale combustion- and gasification-based systems are being developed, mostly by small companies. Products are as small as a few kW to 5 MW. • These technologies generally have relatively low efficiencies, but are designed to address the dispersed and small-scale nature of many biomass energy opportunities.
Other	• Newer plants tend to have higher steam pressures (1,300-1,500 psi) compared to older plants (~900 psi), but this has been a gradual change. • Emissions controls, such as an electrostatic precipitator (ESP) or baghouse for particulates, and some form of NOx control, such as ammonia injection or staged combustion, is also standard on new plants today.

NAVIGANT CONSULTING

Biomass power O&M issues are similar to fossil fuel plants.

	Solid Biomass Power Major Operations and Maintenance Considerations
Duty Cycle	• Baseload and dispatchable. • Capacity factors as high as 95% are possible (high capacity factors are desirable to overcome relatively high capital costs) • Gasification-based cogeneration of heat and power is likely for industries that produce biomass residues in large quantities (e.g., pulp and paper). Opportunity are not large in New Jersey.
Major Overhauls & Replacements	• Turbine-generator overhaul, every six years (direct-fire) • 5-7 day annual maintenance shutdown in spring for cleaning, tube repairs, inspection of bearings, gearbox, electrical, etc. (direct-fire) • 2 day maintenance shutdown in fall to clean and inspect (direct-fire) • BIGCC requires periodic overhauls and replacements for gasifier, gas turbine, heat recovery steam generator, steam turbine, and generator. O&M for BIGCC will usually be lower than that for direct-fire.
Other Major O&M Considerations	• The delivered cost of biomass is the main consideration after capital (usually more than non-fuel O&M) • Biomass is virtually free of sulfur (<0.05%) and will not require SO_2 controls • Biomass has a much lower ash content than coal, and since New Jersey rules prohibit the use of contaminated wood, the ash is expected to be usable as fertilizer. • Emissions controls, such as an electrostatic precipitator (ESP) or baghouse for particulates, and some form of NOx control, such as ammonia injection or staged combustion, is also standard on new plants today.

Costs for biomass conventional power plants are not expected to change significantly in the future. For BIGCC, cost reductions are contingent upon successful commercialization.

	Solid Woody Biomass Economic Assumptions for Given Year of Installation							
	Direct combustion				BIGCC			
	2005	2008	2015	2020	2005	2008	2015	2020
Plant Capacity (MW)	10	10	10	10	N/A	10	12	15
Total installed cost ($/kW)[1]	$2,000	$1,900	$1,825	$1,800	N/A	$2,500	$2000	$1,800
Non-Fuel Fixed O&M ($/kW-yr)	$125	$125	$120	$115	N/A	$75	$70	$65
Non-Fuel Variable O&M ($/MWh)[2]	$2.50	$2.50	$2.50	$2.50	N/A	$4.30	$4.30	$4.30
Capacity Factor (%)	85%	85%	85%	85%	N/A	85%	85%	85%
Project Life (yrs)	25	25	25	25	N/A	25	25	25
LHV Efficiency (%)[3]	20%	21.0%	22.9%	23.6%	N/A	32%	34%	38%

Source: NCI estimates based on references given in Appendix C.

1. Includes all development costs, such as permitting and interest during construction. All data are in 2004 US$. Note that a plant of this size could also be built using used equipment for approximately $1,200/kW in 2005.
2. Costs for consumables, ash disposal and chemicals.
3. LHV = Lower Heating Value.

NAVIGANT CONSULTING

Biomass combustion produces almost no SO_2 and can be considered CO_2 neutral (for sustainably grown Class I biomass). The main emissions to consider are NOx (and PM).

	Solid Woody Biomass Environmental Performance Assumptions for Given Year of Installation.							
	Direct combustion				BIGCC			
	2005	2008	2015	2020	2005	2008	2015	2020
Air Emissions[1] (lb/MWh)								
CO_2	0	0	0	0	N/A	0	0	0
SO_2	1.16	1.11	1.02	0.99	N/A	0.66	0.58	0.55
NOx	2.76	2.63	2.41	2.34	N/A	1.02	0.96	0.86
Water Usage[2] (gallons/MWh)	12.9 for direct-fire; approximately 1/3 lower for BIGCC							

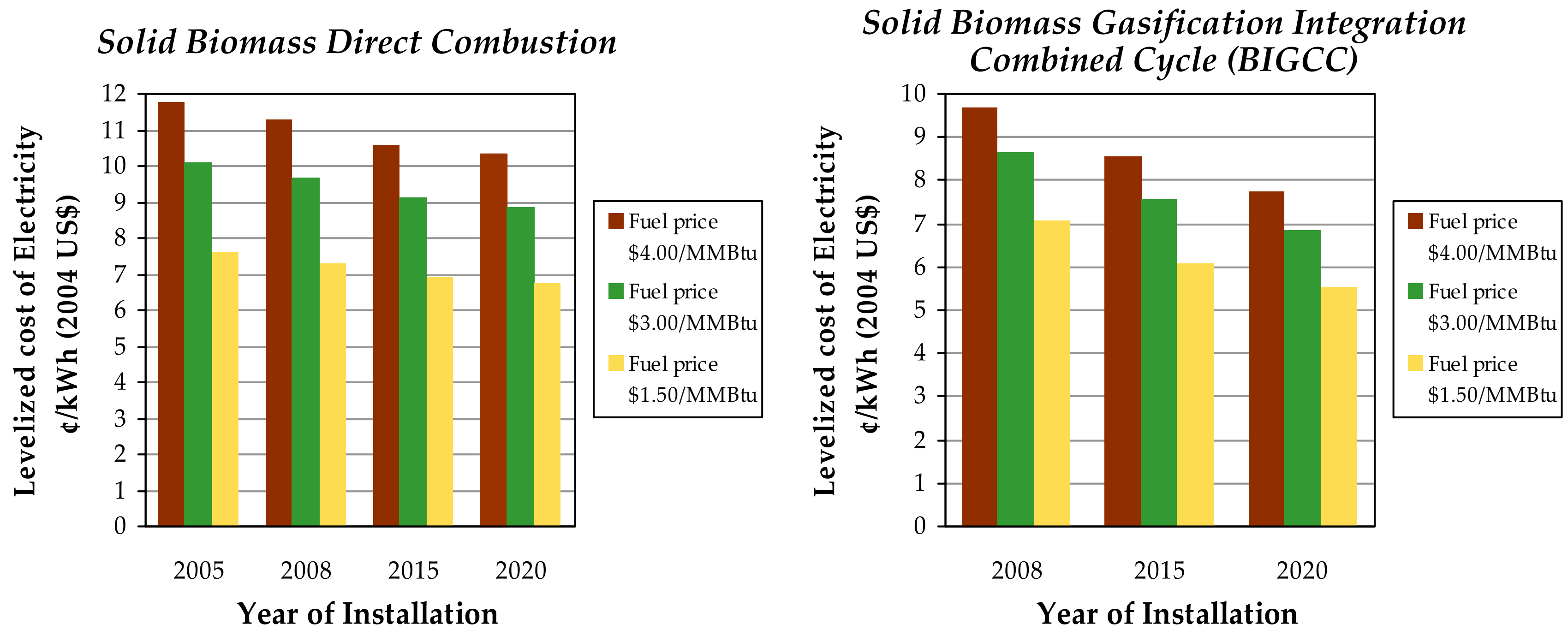
1. SO_2 emissions assume wood is 0.03% S by weight, dry basis; NOx emissions assume 0.15 lb/MMBtu (direct-fire), typical for most permits today. This would require NOx controls such as ammonia injection or staged combustion.
2. Air cooling is assumed for the condenser. Water requirements are for makeup water to the steam cycle assuming 1% steam losses. A 10 MW plant would generate approximately 108,000 lb/hr of steam, resulting in 1,080 lb/hour makeup requirements.

Biomass combustion produces almost no SO_2 and can be considered CO_2 neutral (for sustainably grown Class I biomass). The main emissions to consider are NOx (and PM). continued

	Solid Woody Biomass Environmental Performance	
	Direct combustion	**BIGCC**
Other environmental considerations	• PM emissions easily controlled with ESP or baghouse. • PM10 could be a permitting issue. • Biomass has less mercury than coal.	• Inherently clean because gas needs to be cleaned up prior to combustion in gas turbine. • Mercury emissions are low.
	• Like all other renewable energy resources, biomass can take credit for emissions offsets from the power it displaces. However, unlike other renewables, biomass can also take credit for the emissions avoided from the fate of the fuel had it not been used for energy production (e.g., methane emissions from biomass biodegradation or emissions from forest fires if the source of biomass is forest thinnings from a hazardous fuels reduction project). These emissions can be many times higher than those from the power plant.	

Solid biomass power costs in New Jersey with developer financing range from 7.5-12 ¢/kWh today for direct combustion systems.

Levelized Cost of Electricity (LCOE) for Solid Biomass Combustion and Gasification – Developer Financed, 5-10 MW Project Size



Key assumptions (without incentives): Discount rate = Weighted Average Cost of Capital = 12.58% (Debt equity ratio: 55%:45%, cost of equity = 20%, cost of debt = 10%), Marginal federal tax = 35%, state sales tax = 6%, Property tax = 1.5%, Insurance = 0.5%. Depreciation under 15-year Modified Accelerated Cost Recovery System (MACRS). Project economic life = 20 years.

NAVIGANT CONSULTING

Landfill gas (LFG) to power technology is well proven and is competitive with other wholesale grid power options in New Jersey.

Landfill Gas Power Technology

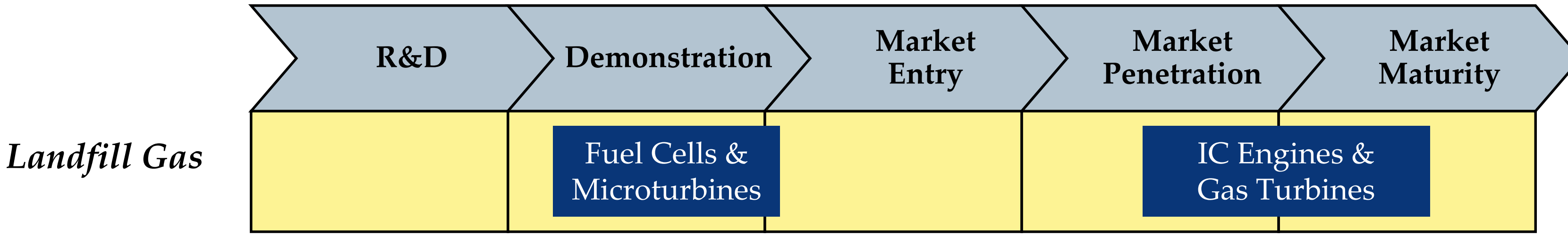
- Landfill gas technology and performance are well proven and commercially available.
- Approximately 3,000 MW installed worldwide with 400-600 MW being added annually. There is approximately 1,000 MW of landfill gas capacity in the US.
- LFG is one the most successful renewable resources in New Jersey to date.
- Conversion technology is supplied by major equipment manufacturers (e.g., Caterpillar, Waukesha, Jenbacher (GE), United Technologies)

Economics

- The levelized cost of electricity can be competitive with wholesale grid power.
- Economics better if gas collection systems are already in place (about $500/kW difference).
- First costs, project development costs, and non-fuel O&M can be relatively high because of small scale.
- Federal incentives (when in place) and New Jersey RPS requirements enhance LFG's competitiveness.
- Federal incentives are more significant for municipalities (e.g., REPI, which is NOT always fully-funded).
- The levelized cost of electricity from LFG is not expected to change much over time (in real terms).
- If costs of microturbines and fuel cells decline, smaller LFG sites could become economic.

NAVIGANT CONSULTING

IC engines and gas turbines are mature technology. Fuel cells and microturbines have been successfully demonstrated on LFG.



Trend	Description
Gas Engines	• Lean burn IC engines produce relatively low NOx without after-treatment • Lower pressure gas requirements depending on model: 1 to 35 psig • More forgiving of poor fuel quality than gas turbines or fuel cells • Able to burn LFG down to 40% methane content
Fuel Cells	• Phosphoric acid (PAFC) and molten carbonate (MCFC) fuel cells have been successfully demonstrated on landfill gas for extended periods • With some minor modifications (e.g., larger piping), fuel cells can readily handle medium Btu gas, but contaminant removal is critical to avoid poisoning of various catalysts used in the fuel reformer and fuel cell stack.
Gas Turbines & Microturbines	• Lean premix combustion produces very low NOx compared to IC engines (<25ppm) • Small gas turbines tend to have lower efficiencies than comparably sized IC engines.

NAVIGANT CONSULTING

LFG to power is a baseload, dispatchable technology. Maintenance requirements and costs are well understood.

	Landfill Gas Power Major Operations and Maintenance Considerations
Duty Cycle	• Baseload and dispatchable. • Capacity factors are high: 85-90%
Operations and Maintenance Requirements	• Varies with the conversion technology selected (microturbine, IC engine, small gas turbine) but generally consistent with the requirements for conventional applications. • Additional requirements for gas treatment/cleaning and the gas collection system. • Gas cleanup for LFG generally consists of pressurizing, chilling and filtration to 0.3 microns. The cleaned gas can then be reheated to reduce the relative humidity of the gas. Additional treatment may be necessary depending on siloxane and sulfur levels. If H2S levels are too high, an iron "sponge" filter is commonly used to reduce residual H2S. Siloxanes would need to be removed using activated carbon or a system that chills the gas to well below 0F. • Since projects are relatively small scale, non-fuel O&M costs are relatively high per MWh • Can sometimes take advantage of labor already at the landfill, bringing O&M costs down.

NAVIGANT CONSULTING

LFG economics are favorable today and are not expected to change significantly in the future.

	Landfill Gas Economic Assumptions for Given Year of Installation			
	2005	**2008**	**2015**	**2020**
Plant Capacity (MW)[1]	5.0	5.0	5.0	5.0
Total installed cost ($/kW)[2]	$1,500	$1,400	$1,300	$1,200
Non-Fuel Fixed O&M ($/kW-yr)[3]	$110	$110	$100	$100
Non-Fuel Variable O&M ($/MWh)	0	0	0	0
Capacity Factor (%)	88%	88%	88%	88%
Project Life (yrs)	15	15	15	15
LHV Efficiency (%)	32.5%	33.8%	35.4%	35.9%

1. 5.0 MW is a representative scale – actual scales vary between 0.1 MW and tens of MW.
2. Assumes that gas collection system is in place. For cases where gas collection needs to be added, it typically costs an additional $500/kW.
3. Does not include the O&M for the collection system.

Air emissions from LFG to power are moderate but are offset by the elimination of a flare or venting.

	Landfill Gas Environmental Performance Assumptions for Given Year of Installation.			
	2005	**2008**	**2015**	**2020**
Air Emissions[1] (lb/MWh)				
CO_2	0	0	0	0
SO_2	0.55	0.53	0.51	0.50
NOx	2.6	2.5	2.4	2.4
Other environmental considerations	• Despite non-zero air emissions, LFG to power offsets emissions from LFG flares or venting. • Air emissions are the main concern. Water or solid waste emissions are minimal.			

1. SO_2 emissions are based on 0.045 lb SO_2 per MMBtu. Expected range of NOx is 0.6-1.2 g/bhp-hr (1.75-3.50 lb/MWh). NOx emissions could be lower with additional controls or after-treatment.

The process of generating power from wastewater treatment methane (biogas) is similar to that for landfill gas.

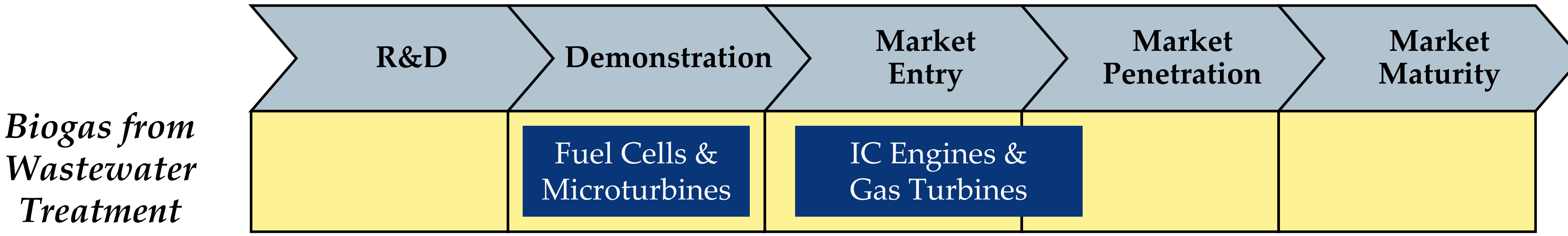
Wastewater Treatment Power Technology

- Wastewater treatment methane technology and performance are well proven and commercially available.
- The technical potential is relatively small in New Jersey, but much of it could be achieved in practice.
- Relative penetration into this sector compared to LFG is lower.

Economics

- Economics are similar to that for landfill gas, but typically includes cogeneration to heat the digesters, adding value by reducing heating fuel purchases (but also increasing capital costs).
- The levelized cost of electricity can be competitive with wholesale grid power.
- First costs, project development costs, and non-fuel O&M can be relatively high because of small scale.
- The levelized cost of electricity from wastewater methane is not expected to change much over time (in real terms).

IC engines and gas turbines are mature technology. Penetration has been slower for WWT methane relative to LFG.



Trend	Description
Gas Engines	• Lean burn IC engines produce relatively low NOx without after-treatment • Lower pressure gas requirements depending on model: 1 to 35 psig • More forgiving of poor fuel quality than gas turbines or fuel cells • Able to burn WWT biogas down to 40% methane content
Fuel Cells	• Phosphoric acid (PAFC) and molten carbonate (MCFC) fuel cells have been successfully demonstrated on biogas for extended periods • With some minor modifications (e.g., larger piping), fuel cells can readily handle medium Btu gas, but contaminant removal is critical to avoid poisoning of various catalysts used in the fuel reformer and fuel cell stack.
Gas Turbines & Microturbines	• Lean premix combustion produces very low NOx compared to IC engines (<25ppm) • Small gas turbines tend to have lower efficiencies than comparably sized IC engines.

Biogas cogeneration is a baseload, dispatchable technology. Maintenance requirements and costs are well understood.

	Biogas from Wastewater Treatment Power Major Operations and Maintenance Considerations
Duty Cycle	• Baseload and dispatchable, if power is exported off-site. Preference is for baseload operation. • Capacity factors are high: 80%
Maintenance Requirements	• Varies with the conversion technology selected (microturbine, IC engine, small gas turbine) but generally consistent with the requirements for conventional applications. • Additional requirements for gas treatment/cleaning and the gas collection system. • Gas cleanup for LFG generally consists of pressurizing, chilling and filtration to 0.3 microns. The cleaned gas can then be reheated to reduce the relative humidity of the gas. Additional treatment may be necessary depending on siloxane and sulfur levels. If H_2S levels are too high, an iron "sponge" filter is commonly used to reduce residual H_2S. Siloxanes would need to be removed using activated carbon or a system that chills the gas to well below 0F. • Since projects are relatively small scale, non-fuel O&M costs are relatively high per MWh • Can sometimes take advantage of labor already at the WWT plant, bringing O&M costs down (this is the assumption here).

NAVIGANT CONSULTING

Biogas cogeneration economics are favorable today and are not expected to change significantly in the future.

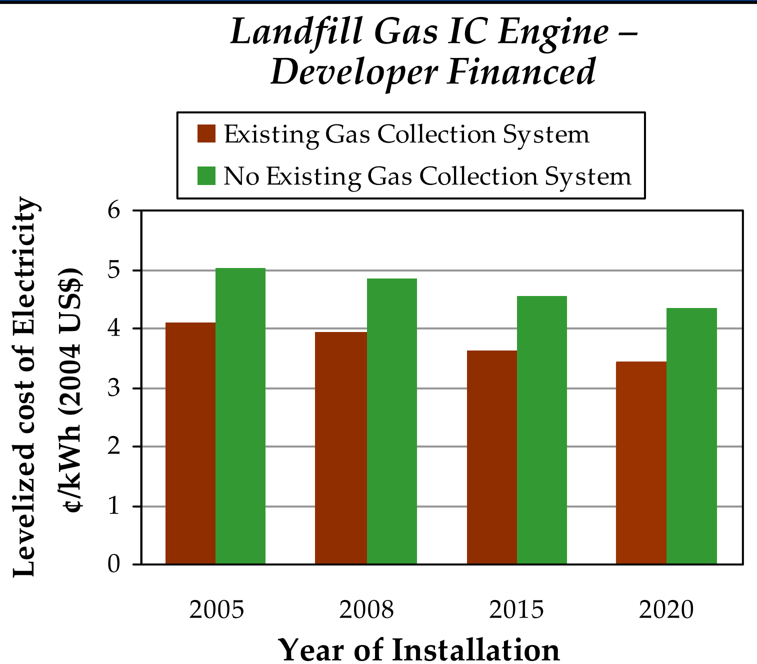
	Biogas from Wastewater Treatment Economic Assumptions for Given Year of Installation			
	2005	**2008**	**2015**	**2020**
Plant Capacity (MW)[1]	1.5	1.5	1.5	1.5
Total installed cost ($/kW)	$1,700	$1,630	$1,560	$1,540
Non-Fuel Fixed O&M ($/kW-yr)	$75	$74	$72	$71
Non-Fuel Variable O&M ($/MWh)	0	0	0	0
Capacity Factor (%)	80%	80%	80%	80%
Project Life (yrs)	20	20	20	20
LHV Efficiency (%)	32.5%	33.8%	35.4%	35.9%

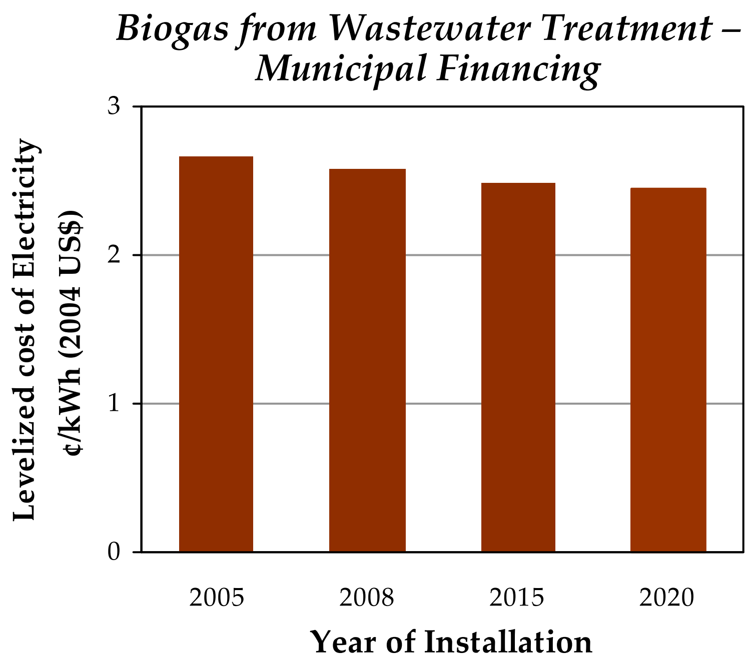
1. 1.5 MW is a representative scale – actual scales will vary.

NAVIGANT CONSULTING

Landfill gas power (developer financing) and biogas cogeneration from wastewater treatment (municipal financing) in New Jersey.

Levelized Cost of Electricity (LCOE) for Landfill Gas and Biogas Cogeneration from Wastewater Treatment – Internal Combustion Engine Technology





Key assumptions for landfill gas: Discount rate = Weighted Average Cost of Capital = 12.58% (Debt equity ratio: 55%:45%, cost of equity = 20%, cost of debt = 10%), Marginal federal + state income tax = 35%. State sales tax = 6%, Property tax = 1.5%, Insurance = 0.5%. Depreciation under 15-year Modified Accelerated Cost Recovery System (MACRS). Project economic life = 15 years. If a gas collection system is needed, capital costs increase by approximately $500/kW.

Key assumptions for biogas from wastewater treatment: Discount rate = Weighted Average Cost of Capital = 5.50%, Debt: 100%, cost of debt = 5.5%, Federal and state sales taxes= 0%, Property tax = 0%, Insurance = 0.5%, No land lease costs. Project life = 20 years. No economic credit assumed for cogeneration because it is assumed that the alternative is to use the biogas directly for heating. Cost also assume no additional staffing is required to operate the plant.

NAVIGANT CONSULTING

Fuel cells are compatible with renewable fuels, but broad application is expected to be several years off, tied to overall fuel cell commercialization efforts.

- Renewable fuels include hydrocarbon-based fuels such as landfill gas, biogas from anaerobic digestion, syngas from biomass gasification and liquid fuels such as ethanol and methanol derived from renewable feedstocks. Hydrogen produced from renewable resources can also be used by some fuel cell types.
- All fuel cells can use carbon-based renewable fuels provided that the gas is properly treated (i.e., contaminants are removed) and reformed into a hydrogen-rich gas.
  - In general, fuel cells will have more stringent fuel purity requirements than gas turbines or reciprocating engines.
- Low-temperature fuel cells can also use pure hydrogen. High temperature fuel cells are less suited to operation on pure hydrogen.
- The key advantages of fuel cells over other small prime movers are low emissions and high efficiency, but the efficiency advantage is largely lost in LFG and biogas applications because the fuel cost is zero.
- United Technologies (UT Fuel Cells) has successfully operated several PC25 200kW phosphoric acid fuel cells (PAFC) on landfill gas and biogas from wastewater treatment, and offered a standard package for this type of fuel.
  - However, the cost of the PC25 remained high (>$4,000/kW) and UT Fuel Cells has decided not to invest further in the technology and is no longer offering new units, only service on existing units.
- Proton exchange membrane (PEM) fuel cells, which are the focus of intense R&D efforts today, are not receiving much attention for the biogas or LFG markets.
  - Product sizes are too small for these applications (generally less than 50 kW) and are currently being designed for residential, small commercial and automotive applications.
- The remainder of this section reviews the two remaining principal fuel cell types (molten carbonate and solid oxide), their development status and suitability/experience with renewable fuels.

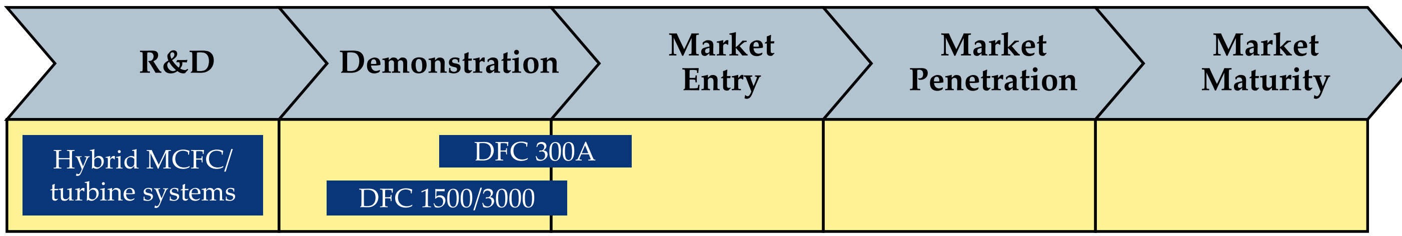
NAVIGANT CONSULTING

FuelCell Energy is the only major developer of molten carbonate fuel cells and has built several prototypes for operation on biogas.

Technology Description	• Also known as direct fuel cell technology, systems are high temperature technology (operating temperature 650°C). Uses a liquid alkali carbonate mixture to form the electrolyte layer, nickel based catalyst material and stainless steel cell use for other hardware. • Internal reforming, with natural gas or biogas directly fed into the fuel cell and converted to hydrogen for generating electricity inside the fuel cell. • High efficiencies are possible as a result of high temperatures, internal reforming and integration of heat recovery into designs. Also, integration of gas turbine in cycle has potential to achieve >70% efficiency in future hybrid products.
Key Activities and Projects	• Only major technology developer is FuelCell Energy, Inc. in Torrington, Connecticut, that has been working on the technology for over 10 years. • Technology investment of over $400 million and approximately 30 units operating in the field. • Continuing to work on cost reduction and product improvements to increase efficiency and lower operating and maintenance costs. • Several recent projects have used biogas as a fuel, including Los Angles Department of Water and Power which installed one to operate on sewage waste digester gas and a 1 MW digester gas facility in Seattle, Washington (King County project). Other projects have been built at breweries, and waste treatment plants in Japan and Europe.
Economics and Performance	• Efficiencies are currently in the range of 45% LHV, and installed costs are in the range of $5,000/kW. Current efforts will increase output of standard systems, which will lower cost. • Early projects ran $10,000/kW installed, have been gradually reduced. • Fuel cell stack must be replaced after approximately 5 years and the company is offering a long term contract that includes this for 5-year periods.
Status	• Considered early commercial technology, with production volumes low, costs remain high.

Initial 250 kW products are considered early commercial units and with improvements these modules will generate 300 kW.

Molten Carbonate Fuel Cells



Development Issue	Description
Cost Reduction	• The major issue facing FuelCell Energy is reducing the cost of its standard products so they will be competitive with conventional engine and turbine technology. • Cost reduction will come from product design improvements, increased output for standard size products and manufacturing efficiencies through volume sales increases. Current DFC 300A capable of 250kW, will generate 300 kW prior to 2008.
Product Life Improvements and Operating Cost Reductions	• Stack life and degradation are issues for long-term operation. Stack needs to be replaced after 5 years which is a major maintenance/overhaul cost. Efforts are focused on material improvements and understanding degradation with lower cost materials. • Long-term service agreements are used to cover stack replacement and other maintenance.
Hybrid Turbine Cycles	• Longer-term efforts focus on integration of fuel cell with gas turbines to achieve >70% electrical efficiency. Concept has been demonstrated using current generation of products as an early prototype. Working toward additional demonstrations in 2007-08. Targeting commercial product by 2015.

NAVIGANT CONSULTING

Near term improvements in cost are driven by increases in rating, with future cost reduction coming from refinements and volume manufacturing impacts.

	Molten Carbonate Fuel Cells Performance Assumptions for Given Year of Installation			
	2005	**2008**	**2015**	**2020**
Product Size	250 kW 1,000 kW 2,000 kW	300 kW 1,200 kW 2,400 kW	300 kW 1500 kW 3000 kW	300 kW 1500 kW 3000 kW
Total Installed Cost ($/kW)	$4,000/ $3,600/ $3,600	$3,000 (target) $2,500 (target) $2,500 (target)	$1,500 Target	NA
Non-Fuel O&M costs ($/kW-yr)[1]	$480/ $350/ $350	$400/ $290/ $290	$233/ $290/ $232	NA
Net Electrical Efficiency (% LHV)	45%	47%	49%	50%
Capacity Factor (%)	90%	95%	97%	NA
Project Life (yrs)[2]	20+	20+	20+	20+

1. Based on an annual, long-term maintenance contract that includes the stack replacement (3-5 years)
2. Project life assumes stack replacement every 3-5 years and long term maintenance contract with manufacturer

Source: Interviews with FuelCell Energy, independent NCI research

NAVIGANT CONSULTING

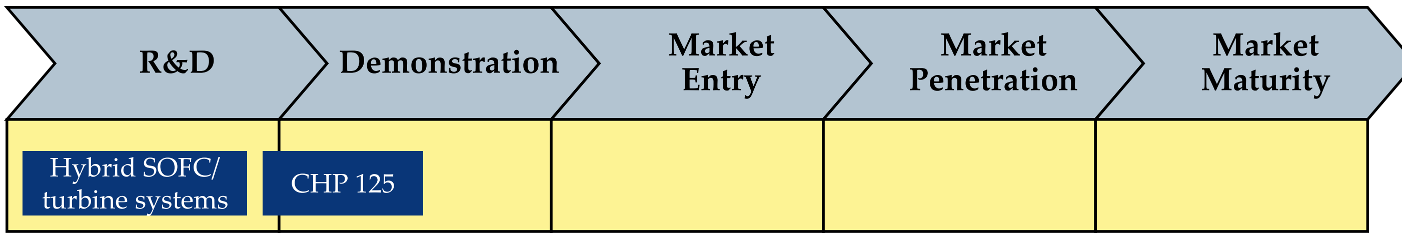
Siemens is the only major developer of tubular solid oxide fuel cell (SOFC) technology and they are currently focused on cost reduction.

Technology Description	• High temperature fuel cell technology with integrated, internal natural gas reformer • The tubular SOFC is made up of an electrolyte and two electrode layers in a unique tubular design. Design eliminates the need for seals required by other fuel cells and also allows for thermal expansion. • As a result of high operating temperature (1,000^{o}C), technology is attractive for cogeneration.
Key Activities and Projects	• Siemens (formerly Westinghouse Electric) is the only major company working on the development of tubular SOFC fuel cell technology. • Several proof of concept units were installed over the past several years from 100-300 kW in size. These units have operated largely successfully and proven the basic technology. Current focus is on 125 kW standard unit and cost reduction. Siemens hopes to have a commercial product available by 2006/2007. • Have also tested a proof of concept SOFC/gas turbine hybrid at SoCalEd and hope to achieve >70% electrical efficiency with these units. No specific schedule has been announced for this product, as there are issues associated with cycle configuration and pressurization that need to be resolved. • No specific experience on biogas, but no significant technical issues are anticipated. • Several companies are also working on planar SOFC, but these units are far too small for biogas or LFG applications.
Economics and Performance	• Efficiencies are currently in the range of 45% LHV, with target for early units of 44-47%. Most applications will be cogeneration which will increase total efficiency. • Early units have cost >$8-10,000/kW, with current costs approaching $5,000/kW. With cost reduction efforts, Siemens hopes to get costs down to $2-3,000/kW by the ‘06/’07 product launch.
Status	• Current efforts are on cost reduction. Siemens does plan to ship a few demonstration units in the ’05/06 period, but are taking no orders for shipments until ’06/’07 timeframe and these will also be defined as “pre-commercial”.

Sources: interviews with Siemens, other NCI research

Initial units installed in the field are considered "proof of concept", with product launch now delayed until at least 2006.

Tubular Solid Oxide Fuel Cells



Development Issue	Description
Cost Reduction	• Major effort currently focused on cost reduction in order to be able to offer competitive pricing. • Standard unit will be skid mounted, CHP 125 unit for cogen applications • Units will operate unattended, with high availability targeted (>98%), along with longer life and lower maintenance costs.
Hybrid Program currently on hold	• Early hybrid gas turbine program is on hold while alternative integration schemes are tested. • Pressurized systems have proved more difficult to construct and are not as robust as needed. • Alternative configurations (low pressure) are currently being investigated with commercialization not expected for several years..
Prototype Demonstrations	• First CHP 125 will be delivered to Stadtwerke Hannover in Germany, and another is planned by BP in Alaska in the '05/06 timeframe. Further prototypes are planned, with options for building cooling, heating and power (BCHP) that will include absorption chillers and steam generation capability.
Alternative fuel designs	• No experience on alternative fuels, such as biogas. Sensitivity to impurities in landfill gas will be an issue, but no problems are expected for fuel from wastewater treatment or anaerobic digesters.

SOFC units are not currently available and projections for cost and performance represent Siemens' current targets for product launch.

	SOFC Fuel Cells Performance Assumptions for Given Year of Installation			
	2005	**2008**	**2015**	**2020**
Product Size	Not available (NA)	125 kW	125 kW	125 kW
Total Installed Cost ($/kW)	>$5000 when first avail.	$2000-3000 (target)	NA	NA
Non-Fuel O&M costs ($/kW-yr)	NA	NA	NA	NA
Net Electrical Efficiency (% LHV)	44-47%	44-47%	NA	NA
Capacity Factor (%)[1]	NA	95%	NA	NA
Project Life (yrs)	NA	10-20	NA	NA

Source: Interviews with Siemens Westinghouse Power, independent NCI research.
Note: Costs are based on operation with natural gas fuel.

Pyrolysis has received little attention compared to other biomass options, but it is already a viable option for certain applications.

Technology Description	• Pyrolysis is a process in which organic materials are rapidly heated to 450 - 600 °C in absence of air. Under these conditions, organic vapors, pyrolysis gases and charcoal are produced. The vapors are condensed to bio-oil. Typically, 70-75 weight percent (wt%) of the feedstock is converted into oil ("bio-oil", "bio-crude") • Offers the possibility of easy storage and handling of the liquids. In addition, bio-oil is generally of a more consistent quality compared to any solid biomass. With fast pyrolysis a clean liquid is produced as an intermediate for a wide variety of applications.
Key Activities and Projects	• Many laboratory-scale and pilot plants have been developed using a variety of reactor technologies. Notable among these is Wellman Process Engineering's advanced fast pyrolysis reactor designed to process 250kg/h of wood in a bubbling fluidized sand bed, which is intended to demonstrate that a good quality pyrolysis oil can be produced without the need for additional heating fuel by a process which is robust and capable of continuous operation. • Pacific Northwest National Laboratory (PNNL) has begun work has begun on improving the technology and the economics for upgrading bio-oil by catalytic hydrogenation.
Economics and Performance	• The cost of bio-oil production depends on many factors, including feedstock (pre-treatment) costs, plant scale, and the type of technology. • Due to the small number and limited scale of existing pyrolysis oil production units, the economics of a commercial scale unit can only be estimated. • Even in small scale plants, the cost of bio-oil can be competitive with conventional fuels for certain applications in certain markets. According to a European study by Joanneum Research (Austria), heat applications are the most economically competitive, followed by CHP applications, with electricity applications only very rarely competitive.
Status	• Pyrolysis technologies have been successfully demonstrated at small-scale, and several larger pilot plants or demonstration projects are in operation or at an advanced stage of construction • Pyrolysis is still relatively expensive compared to fossil based energy in most cases and thus faces economic and other non-technical barriers when trying to penetrate the energy markets • Pyrolysis needs to be demonstrated on a commercial scale, and this is currently the main barrier impeding further development. Power generation based on bio-oil is still in the early development phase.

Sources: Biomass Technology Group: www.btgworld.com; The Pyrolysis Network (PyNe): http://www.pyne.co.uk/

Pyrolysis has yet to be implemented on a commercial scale, although pilot plants have been successful. Power generation from bio-oil is still at an early stage of development.

	R&D	Demonstration	Market Entry	Market Penetration	Market Maturity
Biomass Pyrolysis	Advanced reactors, power generation	Pyrolysis plants, co-firing			

Development Issue	Description
Cost of bio-oil	• except in some niche markets, bio-oil is not competitive with fossil fuels for power generation • Most R&D efforts are focused on the reactor, which only accounts for 10-15% of the capital cost of the complete system. Improvements are needed in other areas as well, notably liquid collection.
Fuel quality standards	• There is a lack of standards for use and distribution of bio-oil and inconsistent quality inhibits wider usage; considerable work is required to characterize and standardize these liquids and develop a wider range of energy applications.
Combustion equipment	• Boilers, IC engines, and turbines must be adapted to bio-oil in order to minimize problems associated with poor combustion, corrosion, fouling, and high emissions (CO, NOx, particulates)
Commercial scale deployment	• Large scale pyrolysis plants have yet to be built, so economics are uncertain; Integration of pyrolysis in a complete biomass system may enhance economic attractiveness
Pyrolysis End Use	• Energy end users are unfamiliar with pyrolysis oil, therefore few applications are developed
Health and Safety	• Standards need to be developed for handling, transportation, and storage of bio-oil.

Electricity Generation from bio-oil is currently more expensive than fossil fuels, but moderate development efforts could reduce costs.

- The cost of bio-oil is estimated at $5-20/MMBtu. The lower bound of this estimate is comparable to the current fossil fuel costs:
  - Diesel: $8.1/MMBtu (assuming a price to industrial customers of $1.05/gal, and 130,000 Btu/gal)
  - Natural Gas: $8.9/MMBtu (Natural gas prices from EIA commercial gas price forecast for the US)
- Bio-oil has particular characteristics that require specially adapted turbines, IC engines, and boilers: Low energy density (~1/2 of diesel), high viscosity, low pH, high ash and char content, poor ignition characteristics, and high potential for polymerization.
- Efforts are underway to develop power systems that utilize bio-oil with high efficiency and high availability, and have a capital cost comparable to current technologies designed for fossil fuels.

	Levelized Cost of Electricity (¢kWh)		
Feedstock price	**Simple Cycle**	**CCGT**	**Co-gen**
$0/metric ton	5.5	5.0	4.0
$10/metric	7.0	6.0	6.0
$20/metric ton	9.0	7.0	7.5

Assumptions:
- Plant size: 2.85 MWe
- Capital cost amortized over 15 years
- Discount rate: 8%
- 90% availability
- Biomass energy content: 9GJ/tonne
- Cogen steam sold at $3.35/1000 lb

Source: DynaMotive Energy, Orenda Aerospace, *Fast Pyrolysis of Biomass for Green Power Generation*, 1st World Conference and Exhibition on Biomass for Energy and Industry, 2000.

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Anaerobic digester applications for animal waste is a mature technology, but due to the relatively small number of applications the business infrastructure is lacking.

Technology Description	• Biogas is generated from animal waste using anaerobic digesters. The technology is well proven and there are several small companies providing products. • Several different designs are used depending on the type of animal waste and the climate. Covered lagoons are frequently used, mixed lagoons are used for situations that involve multiple types of animal waste and plug flow digesters are frequently used for dairy farms. • Conventional natural gas, internal combustion engines or microturbines would be used for generation of electricity. Cogeneration may be used for the digester process to enhance digestion or for heating barns or providing hot water.
Key Activities and Projects	• Biogas applications in Europe are much more prevalent and has been popular since the 1980's. It is estimated there are 100 MW of biogas plants running on animal waste. • It is estimated there are about 40 plants in the US, with another 50 planned or under construction.
Economics and Performance	• Most plants are under 100 kW or even 50 kW which makes the systems more expensive. Cost of systems of 100 kW or smaller will be >$4,000/kW. The cost of electricity produced will be on the order of 6.25 cents/kWh, but with credit for cogeneration and other cogen incentives this may be less than 4 cents/kWh. • Because IC engines are small for these applications, efficiencies are <25% LHV. Because of low electrical efficiency cogeneration is important for heat recovery and can improve overall efficiency.
Status	• Tightening environmental regulations for farmers (e.g. odor, wastewater, land application, etc..) will make use of anaerobic digestion more attractive. • Due to relatively small number of applications, the business infrastructure is lacking for farmers. They need assistance with project development and financing.

Sources: NCI research. See Appendix C for references.

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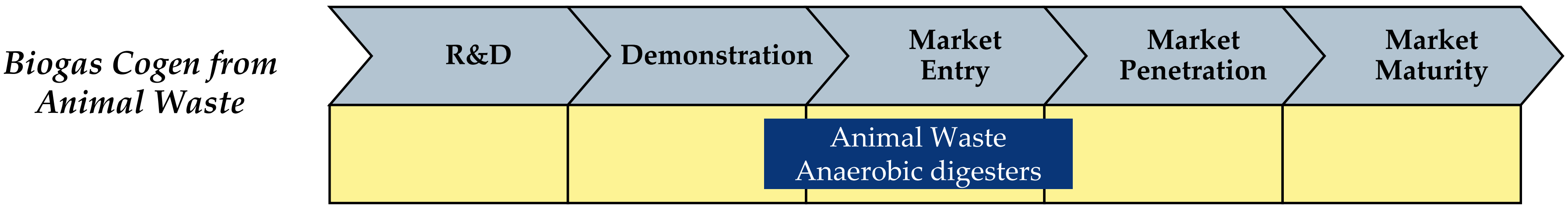
The most significant issues impacting project development are around the lack of business support infrastructure for the farmers.



Development Issue	Description
High Project Development Costs	• Due to the low number of projects and lack of experience, project development costs tend to be high for a small power project. As experience improves with systems, and designs become more standardized, costs are gradually coming down. Other benefits, such as odor control and environmental benefits, and co-product sales (fertilizer) are also helping to offset some of the costs, which may be incurred for those purposes anyways.
Lacking Business Infrastructure	• There does not exist a very extensive network of companies involved in the project development value chain for agricultural waste projects. • Farmers do not have resources to invest in these projects and need outside assistance and help with financing. Risks exist around the long-term potential of the farm required to support the project. • Support may be required in terms of project development assistance and loan guarantees to assist with financing issues.
Lack of Experience	• Because of relatively limited market size in many regions of the country, there is a lack of experience with the technology and project development issues. This is particularly true for smaller farms.

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Costs of current systems are relatively high due to the small size, higher development costs and small number of systems installed.

	Biogas Cogeneration Performance Assumptions for Given Year of Installation			
	2005	**2008**	**2015**	**2020**
Project (kW)	50-100	50-200	50-200	50-200
Total Installed Cost ($/kW)	$4,000	$3,500	$3,000	$3,000
Non-Fuel O&M costs ($/kW-yr)	$100-130	$90-120	$75-110	$75-110
Capacity Factor (%)[1]	50-75%	50-75%	50-75%	50-75%
Project Life (yrs)	20	20	20	20

Sources: NCI estimates. See Appendix C for references.

The biogas cogeneration potential on animal farms in New Jersey, based on a 15 kW minimum project size, is approximately 2.6MW.

- In 2002 there were approximately 42,000 head of cattle and calves in New Jersey
  - Based on a USDA rule of thumb of 100W per cow, this suggests a maximum theoretical potential of 4.2 MW
  - Assuming a minimum project size of 15kW gives a technical potential of 2.6 MW.
- In addition there were ~15,000 hogs/pigs that would produce <0.2 MW based on 11 W per animal, and 40,000 broilers that would produce 0.05 MW based on 1.2 W per animal.

MW Potential of Cattle/Dairy Farms in New Jersey

Number of cattle per farm	number of farms	Average kW tech potential per farm	Total kW
1-9	863	0.5	432
10-19	238	1.5	357
20-49	210	3.5	735
50-99	96	7.5	720
100-199	67	15	1,005
200-499	33	35	1,155
500-999	6	75	450
Technical Market Potential (based on 15 kW minimum project size)			**2,610**

Source: 2002 Census of Agriculture - State Data, USDA, National Agricultural Statistics Service; NCI research and analysis

Modern small wind turbines have a number of benefits including high reliability and low maintenance.

Technology Description	• Typical Sizes: — 3-100 kW (4-10 kW system can meet the needs of a typical home) — Off grid units as small as 300 W exist (battery operation) • Annual Capacity Factors: — 15-20% for Class 3 & 4 wind regimes — Significant decrease with Class 2 wind (~10%)
Key Activities and Projects	• There are approximately a half a dozen U.S. manufacturers, system integrators and distributors of small wind turbines for use in residential, farm and commercial/industrial applications. Examples include Bergey Windpower, Norman, OK, and Wind Turbine Industries Corporation, Prior Lake, MN • In 2001, annual sales of the U.S. small wind turbine industry amounted to about 13,400 turbines valued at about $20 million.
Economics and Performance	• Customers paying 12¢/kWh+ for electricity with average wind speeds of 10 mph or more can expect a payback period of 8-16 years (note: small increases in wind speed result in large increases in annual production)
Status	• Relatively mature technology but expected to remain a niche opportunity for the foreseeable future.

Sources: NCI research, market interviews

The U.S. is a leading producer of small wind turbines, with four manufacturers commanding about one-third of the global wind power market.[1]

- The U.S. has about 15 MW of nameplate capacity of small wind turbines, and the U.S. wind industry averages a 50-50 domestic-international sales mix.
- In 2001, annual sales of the U.S. small wind turbine industry amounted to about 13,400 turbines valued at about $20 million. Bergey Windpower indicated that the market has increased about 30% each year. For example, in 2003, annual sales were ~22,600 units.
  - This is only about 2% of the value of sales of large wind turbines in the U.S.
  - The success of the large wind turbine industry shows the impact of sustained, substantial government support through programs and policies, which are lacking for small wind systems.
    - Federal and state tax credits for small wind systems were discontinued in the mid-1980s, which led to a shrinking of the market and a loss of momentum for development. Despite this, AWEA predicts that the small wind market will grow.

Source: American Wind Energy Association (AWEA) website; Discussions with NW SEED & NREL, May 2004

1. Bergey Windpower, Southwest Windpower, Solar Wind Works, Wind Turbine Industries

Current costs for electricity generated from small wind systems is estimated at 13-46 ¢/kWh.

Costs by Turbine Size					
Size	**Total Installed Cost ($/Watt)**	**O&M (¢/kWh)**	**Annual Energy Output (kWh per year)**	**Tower Height (meters)**	**Estimated Cost of Electricity (¢/kWh)**
10 kW[1]	$3.5 – $5.0*	1.0	8,817	24	33-46
50 kW[2]	$3.0	1.0	36,000	24	34
100 kW	$2.0 – $2.5	1.0	130,000	37	13-16

Note: Smaller systems require a smaller initial outlay, but they cost more per watt. Taller towers cost more, but they usually reduce the payback period.

Assumes average wind speed of 4.4 m/s (Class 1)

*Total installed cost depends on construction, kind of tower, tower height, etc.

[1]Dropping the average wind to 3.5 m/s brings the annual energy output down to 4,478/kWh per year

[2]Changing tower height to 37m brings annual energy output to 46,000/kWh per year. A 0% turbulence factor was used, which shows the effect of turbulence factors on energy output and capacity factors. Note, that a turbulence factor of 15% was used for the 10 kW turbine.

Source: Discussions with AWEA, NREL & NW SEED, May 2004; AWEA website; Bergey Windpower WindCad Performance Turbine Model; NCI analysis

NAVIGANT CONSULTING

Nano solar cells are limited by low efficiency and raw material costs, requiring further breakthroughs for commercial viability.

Technology Description	• The hybrid nano-composite approach incorporates inorganic nanorods (semi-conducting crystals) into organic semiconductor films. • Nano-composite solar cells can be rolled out, ink-jet printed or painted onto surfaces; how to mass produce nano-rods inexpensively requires further research.
Key Activities and Projects	• Konarka has major programs in Europe and North America - largest grants on both continents. They have produced prototypes manufactured similarly as their DSC product. Grants include efficiency targets of 20%. • STMicroelectronics (Europe's largest semiconductor maker) hopes to produce prototypes by the end of 2004.
Economics and Performance	• Published results on initial cells demonstrated 3%-4% best-laboratory efficiency compared to 24% best-laboratory efficiency for single-crystal silicon PV. • Major claims have been made by manufacturers. For instance, STMicroelectronics claims that current R&D advances will allow these cells to achieve efficiencies of ~10% by the end of 2004. • While assembly of nano-rods and polymers is inexpensive, the current raw material cost of these components is not supportable by the PV market's cost structures, despite low raw material use in the modules.
Status	• Organic PV, including organic/inorganic approaches, has been an active area of research for over 20 years; current large research budgets on nano-technology may yield the required breakthroughs. However, technical barriers still exist. • Nanosys, a key player in this area, was launched in Sept 2001; they hope to have PV products available in 3-4 years. Other entrants include GE and Siemens. • Other thin film companies have taken 10+ years to launch mid-efficiency products which face similar stability, cost, and efficiency issues. Power-market shares for these products are currently small.

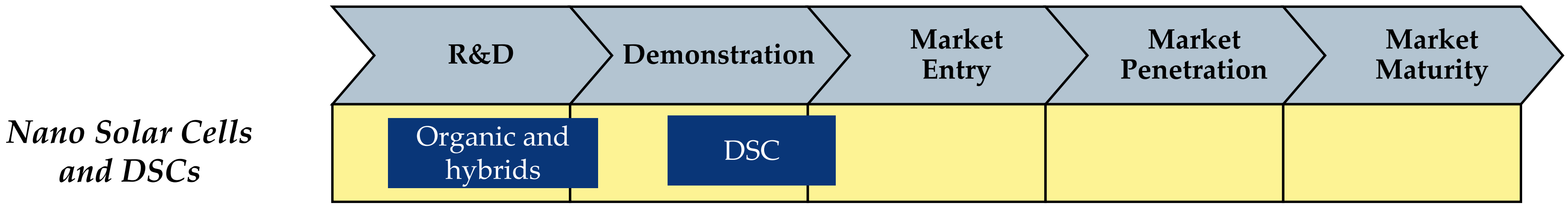
Sources: Forbes/Wolfe, Nanotech Report, Jan 2003; Technology Review, Feb 2003; NCI Interview with Nanosys, April 2003; Personal communication with Konarka, July 2004; www.powerlight.com.

If stability and efficiency issues are resolved, dye sensitized solar cells have the potential for somewhat lower costs relative to silicon.

Technology Description	• DSCs consist of a dye-modified wide-bandwidth semiconductor electrode (such as TiO_2), a counter electrode and a (redox) electrolyte. The dye absorbs sunlight, upon illumination, and is oxidized. • The oxidized dye is reduced by an electron donor in the electrolyte which helps the dye to return to the ground state. • A counter-electrode collects the electrons in the conduction band and the electrons flow through an external circuit.
Key Activities and Projects	• DSCs are produced commercially by STI of Australia. Its facility has 5 MW each of cell and module capacity. The products are designed for wall panels, tiles etc. STI produced 0.5 MW each of cells and modules in 2002. • Konarka Technologies Inc. in the U.S. has been engaged in DSC development since 2001, and has established a pilot line for cell manufacture for higher-value niche markets. • Solarix SA, Greatcell Solar SA, have listed offerings of DSC based products. Konarka Technologies Inc. in the U.S. has been engaged in DSC development since 2001, and is currently establishing a pilot line for cell manufacture for higher value niche markets.
Economics and Performance	• Published results on initial cells demonstrated around 10% cell efficiency at the laboratory level. Typical manufacturing efficiencies are on the order of ~4-5%, and stability is low. • DSC could produce electricity at ~50% lower module costs than silicon-based PV products if sold in high volumes at 10% efficiency. But at the system level, with high fixed system costs, this advantage is reduced. • The modules are light weight and flexible. Modules can be manufactured in any form factor for niche markets.
Status	• DSC is emerging in niche markets that do not require long lifetimes or high efficiency. Despite ten years of intense research worldwide, the stability problem has not been resolved.

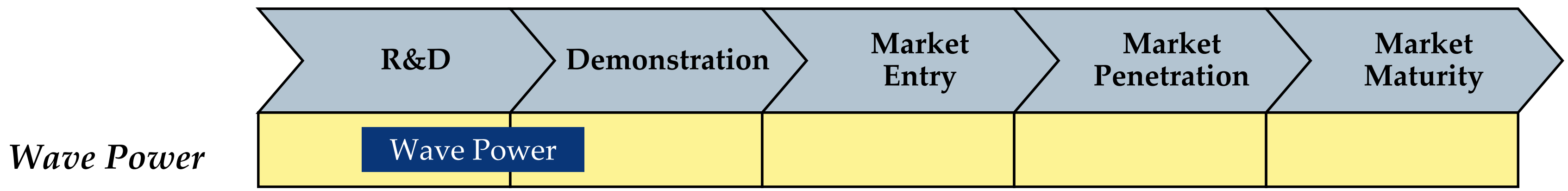
Sources: Kim S., J. Yum and Y Sung. "*Improved performance of a dye-sensitized solar cell using a TiO2/ZnO/Eosin Y electrode*". Solar Energy Materials & Solar Cells, 2003. Pettersson H., T. Gruszecki, L. Johansson and P. Johander. "*Manufacturing method for monolithic dye sensitized solar cells permitting long-term stable low-power modules*", 2003. Solar Energy Materials & Solar Cells 77; pp 405–413; www.oja-services.nl/iea-pvps/isr/31.htm; www.sta.com.au[4]

Current market potential for Nano and DSC solar products exists in high-value niche markets. Application in power markets will require solutions to efficiency, stability, and raw material cost hurdles.



Development Issue	Description
Nano Solar Cells (Nano)	• The development issues are linked not to marketing, but rather to technology. It is expected that in the next 3 to 20 years, plastic nano solar cells will improve as nano-technology matures. Cell efficiencies at present are far lower than established PV products for power markets. This implies that both relatively large space is required for producing the same amount of electricity from nano solar cells, and that balance of system costs (wiring, installation, and glass, if used) may be higher compared to crystalline silicon technologies. Konarka has technology that includes PV fiber.
Dye Sensitized Solar Cells (DSC)	• DSC technology is currently under intense R&D investigation around the world, mainly concentrated in Europe and Japan. The main North American efforts are occurring at Konarka. The technology has already demonstrated commercial viability in niche markets.
Performance Improvement	• Wide-scale commercial success directly depends on solutions to current efficiency, stability, and raw material cost hurdles. Laboratory-scale cell results typically pre-sage full-scale commercial products by ~5-10 years.

Wave power is still in the demonstration phase for most applications.



	Description
Technology Description and Status	• Wave power harnesses energy transmitted to waves by winds moving across the ocean. • There are five general types of wave-energy systems under development, ranging from small-scale near-shore to large-scale offshore systems. • Wave energy generation devices fall into two general classifications, Fixed and Floating. • Several technologies exist. However, wave power's commercial exploitation is limited. The major activity in wave energy development has been in Europe, especially the United Kingdom. • First commercial wave energy project was brought online on the Island of Islay, Scotland, in November 2000.
Market Potential in New Jersey	• EPRI Offshore Wave Project team is engaged in identifying sites for 500kW demonstration projects in states like Maine, Massachusetts, California, Oregon and Washington. • New Jersey State has a tidal shoreline of 1,792 (statute) miles, which could result in large theoretical potential for wave energy in New Jersey. Average wave power is around 30 kW per meter of crest length for the New Jersey region.

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Some utility companies are starting to assess the feasibility of wave power and have entered joint ventures with manufacturers.

Key Activities and Projects	• Port Kembla Wave Energy Project in New South Wales (350kW) became operational at the end of 2002; wave power devices were developed by the private company Energetech. • Wave Energy Converter (WEC) installed off the coast of Portland, Victoria, will be the first commercial offshore wave generator in the world to provide publicly available power (10 MW); the PowerBuoy system was developed by Ocean Power Technologies (OPT). • BC Hydro is working with Energetech Australia Pty on a shore-based ocean wave technology (4MW) on Vancouver Island (2004). • Ocean Power Delivery of Britain signed an agreement with BC Hydro to develop a 4MW floating off-shore wave energy converter facility to be operational in 2004. • Ocean Power Delivery (OPD) teaming with Scottish Power for feasibility study off Scotland. Each generator is 750 kW and test units planned for summer 2004. • Iberdrola (Spanish utility) and Ocean Power Technologies in U.S. developing a 1.25 MW project. Will be installed 2/05 1.2 km off the Northern Coast of Spain. If successful this will be expanded to 2.5 MW. OPT also has a 1 MW project with the Navy in HI. Partnership goal is 100 MW. • Other key projects: Wavegen installation in Faroe Islands in Denmark; Australia Pacific Hydro with Seapower Pacific planning a 5 MW project off Western Australia with test unit started in 2004;WaveDragon test plant in Denmark.
Performance and Economics	• Average turbine efficiency is around 40%. Current R&D is geared towards developing whole cycle efficiency of 70%. • Wave energy technologies are eligible for incentives under the Renewable Energy Economic Development Program (REED) program in New Jersey Sate for New Jersey. • 10 – 60 MW project economics are estimated at 10 – 25 ¢/kWh, assuming a total installed cost of $2,670 – 3,150/kW. Costs are expected to reduce with technology improvements to 4 - 5 ¢/kWh (in 2002 dollars.[1]

1. Source: Feasibility of Developing Wave Power as a Renewable Energy Resource for Hawaii, Report of Department of Business, Economic Development and Tourism, Hawaii, 2002.

Many manufacturers have made claims about wave power economics that still need to be verified in the marketplace.

	Cost Data – Claims by Manufacturers[1]
Wavegen	• 500 kW Islay LIMPET plant cost around $1.44 million to build • Commercial plant used for ongoing R&D equipped with additional features • Capture chamber uses around 1,200 m^3 of reinforced concrete[2]
Ocean Motion International	• Developing Ocean Motion Project for 15 years • Mono-pump design is 600 kW with estimated cost $3 million ($5,000/kW) • Projected costs of production plants are approximately $2,000/kW
Energetech Australia Pty., Ltd.	• Unit capital cost $1,500/kW for a single-device with a 10¢/kWh cost of electricity • Electricity cost with multiple devices is 5¢/kWh • Cost of multi-device installations projected for 2005 is ~3¢/kWh
Ocean Power Technologies	• Claims that Hawaii tested WECS will produce electricity at ~7-10¢/kWh3 • Ocean Power wants to use a test facility to improve efficiency ratios and lower its electricity generation costs to ~3-4 ¢/kWh
WavePlane	• Projected cost of $1,250/kW for a 400kW WECS • Based on 15-year amortization, 7% interest rate, 5%/year maintenance costs results in an expected electricity cost is 14¢/kWh
Danish Energy Agency	• Study indicates using a 100 MW Point Absorber WECS in the North Sea would produce electricity at a cost of 30 - 50¢/kWh (claim costs could decrease to 10-15¢/kWh using large generators at higher voltage) • Project capital costs were $6,400/kW in 2001 with target of $1,820/kW • Calculated capacity factor in wave regime of 5-7kW/ft in 2001 is 11-18.5%

Source: Feasibility of Developing Wave Energy as a Renewable Energy Resource for Hawaii, 2001.

1. Given that there is little operational experience with WEC technology, most of the costing assessments use projected cost figures.

2. Future devices will use less than 600m^3 of reinforced concrete.

Wave power has large potential, but current lack of commercial experience limits large scale adoption in the near-term.

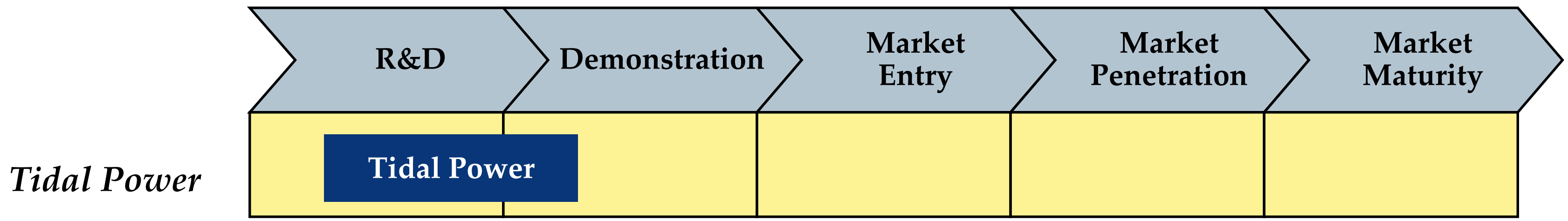
Advantages

- Vast technical potential and is a nonpolluting source of energy.
- High energy density relative to other renewable energy technologies. Also, the wave pattern is predictable that enhances energy availability to 80 – 90%.
- Negligible need for land use.
- Modular in nature. Number of small modules can be connected. Flexibility for expansion capabilities.
- Construction time is less than one year.
- Small devices for use at the shoreline reportedly have 15 years of operating experience at numerous sites.
- No waste disposal.

Disadvantages

- Perceived as a high risk technology since proven track record is limited.
- Lack of experience with commercial systems
- Limited private sector investment in wave energy development.
- Initial cost is high and financing availability is limited
  - Even though Hawaii has one of the better and more consistent wave energy regimes in the world, systems are not cost competitive (including wave energy conversion systems (WECS)
- Reliability of offshore operation is still to be established.
- Devices can potentially alter the flow pattern of sediments. This requires sensitive site selection.
- Both shoreline and offshore systems are at risk of major storm damage, raising concerns about reliability
- May be navigation hazards to ships.

Tidal power is still in the early demonstration phase.



	Description
Technology Description and Status	• A dam across an estuary or coastal bay traps inflowing tidal water which passes through sluices. As the tide recedes, water exits the enclosure via turbines, generating electricity. • Horizontal and vertical axis turbines have also been developed that do not require construction of barrages across the sea for harnessing tidal power. • Examples include: Marine Current Technology Ltd. (MCT) who patented submerged turbines that consist of a pair of axial flow rotors 15 to 20 m in diameter that drive a gearbox/generator. Blue Energy uses Darrieus turbines that are placed underwater and require extremely low head to extract tidal power. The turbines are rated in the range of 500-1,000 W for small scale applications. • MCT, under a 1 million Euro R&D grant from European Commission, plans to design, manufacture, install and test the first "full size" twin rotor system rated at 750 to 1,200kW by 2005. This project is expected to demonstrate commercial viability of the tidal stream turbines.
New Jersey Market Potential	• New Jersey has not been identified as a potential location for good tidal power.

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There are a number of potential tidal power generation sites that are under investigation or in development stages, but none are in New Jersey.

1. Siberia
2. Inchon, Korea
3. Hangchow, China
4. Hall's Point, Australia*
5. New Zealand
6. Anchorage, Alaska
7. Panama
8. Chile
9. Punta Loyola, Argentina
10. Brazil
11. Bay of Fundy, Canada
12. Frobisher Bay, Canada
13. England and Wales (Swansea Bay, Fifoots Point, and North Wales)
14. Antwerp, Belgium
15. LeHavre, France
16. Guinea
17. Gujarat, India
18. Burma
19. Semzha River, Russia
20. Colorado River, Mexico
21. Madagascar

Source: Tidal Electric Inc. & AEA/UNPA Project 2000, updated May 2002

*Plans have been revived for a tidal power plant project in the West Kimberley region of Australia; the preferred bidders are expected to be known by March/April 2003

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There are several experimental and demonstration activities in the UK where sites have good resources/locations for tidal power.

Key Activities and Projects	• Davis hydro turbines with sizes ranging from 7-14 MW (Ocean Class) to 250 kW (Mid Range) have been developed by Blue Energy Canada Inc. • MCT (UK) has been developing turbines of the range 300 kW to 1MW. • Apart from Blue Energy and MCT, entities such as RVco Ltd. (UK), Under Water Electric Kite Corporation (U.S.) and Clean Current (Canada) are major players offering tidal power technologies. • Some other recent activities include: — Tidal Electric is planning 30 MW in the U.K., Swansee Bay. If successful, they will develop 432 MW off Rhyl in North Wales. — Hydro Venturi out of the U.K. is assessing a pilot at Golden Gate, CA.
Performance and Economics	• Capacity factor of turbines range between 40% to 60%. • Future cost of tidal power generation with tidal stream turbines (akin to sub-sea wind mill) could range between 5 – 7¢/kWh. Total installed costs range from $1,200/kW for large plants to $3,000/kW for small and mid sized plants. • Instantaneous power varies significantly throughout the day. Daily average power can fluctuate between 30% and 175% of the average annual output. This results in a need for a distribution/storage system to accommodate the degree of variation. • Technologies are in the early stages of development, often being developed by commercial entities. This inhibits dissemination of information in the public domain.

There has been minimal operational experience with tidal power, and all installations have been outside of the U.S.

	Tidal range (meters)	Basin Area (km^2)	Installed Capacity (MW)	Annual Output (GWh)	Year In Service[1]
La Rance, France	8	17	240	540	1966
Kislaya Guba, Russia	2.4	2	0.4	-	1968
Jiangxia, China	7.1	2	3.2	11	1980
Annapolis, Canada	8.7	6	20	30	1984
Various Sites, China	-	-	2.5	-	-
Kval Sound, Norway	50 (depth)	-	-	32	2002
South of Rio, Brazil[2]	-	-	2	-	2003
Durgaduani, India	-	-	3	-	2004?
Swansea, Wales[3]	-	-	30	-	2005
North Wales	-	-	432	-	2005
Fifoots Point, Wales	-	-	30	-	2005

Sources: "Cavanagh, J.E., Clarke, J.H., and Price, R. "Ocean Energy Systems". Renewable Energy, Sources for Fuels and Electricity, Island Press, 1993, Tidal Electric 2002, and Platts Renewable Energy Report, Nov & Dec 2002

1. The main structure should last over 100 years, and the associated machinery should remain operable 30-40 years.
2. This will be a fully operational pilot tidal plant.
3. Estimates indicate that the internal rate of return (IRR) is about 25%, making it a financially profitable project vs. shoreline projects.

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At good resource sites, tidal power has potential to be a cost-effective power resource, but sites are limited that offer this potential.

Advantages	Disadvantages
• Tidal power is highly efficient with estimates of 80% efficiency. • There is potential for low cost of electricity at good resource sites. • Tidal power can be combined with wind power to increase the output amount, flexibility and revenue income stream (e.g., placing wind turbines on the impoundment structure reduces the fluid / structure interaction). • No emissions. • Free fuel resource.	• Minimal operational experience. • Alters tidal currents which can affect the habitat of seabirds and fish. • Project siting issues are associated with proximity of marine traffic; recreational and commercial fishing; and biological resources in the selected area. • Only a few sites in some counties have been identified as good potential tidal power development prospects (e.g. the UK, France, Canada, Russia, Argentina, western Australia and Korea). • Barrages only provide power for about 10 hours; power for the other 14 hours must be generated by other means. • Tidal power stations are expensive to build. • Permitting issues similar to that of wave power generation would be needed for tidal project implementation.

Although there are limited technical hurdles to producing renewable hydrogen, costs remain high and demand low.

Technology Description	• Production of hydrogen via electrolysis using renewable electricity. Electrolysis splits water into pure hydrogen and oxygen. Wind and solar are most commonly considered. • Renewable hydrogen can also be produced via biomass gasification and subsequent cleaning, upgrading and purification of the synthesis gas produced. • The hydrogen could either be generated onsite in small amounts or in larger scale plants and then shipped via pipeline, truck, rail, etc. to the point of use.
Key Activities and Projects	• Small solar hydrogen systems are being demonstrated as part of the CUTE program (Clean Urban Transport for Europe), which is installing approximately a dozen hydrogen refueling stations in several countries. • Among the various hydrogen fueling station demonstration in North America, a small number have used solar energy (two in California, one in British Columbia, Canada). • There are no major development or demonstration activities ongoing for biomass-to-hydrogen via gasification. Efforts are confined to techno-economic analysis and some bench scale testing at the University level.
Economics and Performance	• There are no major technical hurdles to producing hydrogen from renewables – the hurdles are economic and the fact that the hydrogen economy (market pull) has yet to develop. Hydrogen today remains a chemical feedstock, not an energy carrier. • Alkaline electrolysis is well developed and commercially available, but costs are currently high for energy applications. Other forms of electrolysis are under development. • Hydrogen from biomass gasification has the potential for better near-term economics than renewable electrolytic hydrogen, but gasification technology is not as mature as electrolysis.
Status	• Renewable electrolytic hydrogen and hydrogen from biomass gasification have both been extensively studied • Alkaline electrolysis is well developed and commercially available, but costs are currently high for energy applications. Other forms of electrolysis are under development. • Biomass gasification suitable for hydrogen production has been demonstrated and near commercial scales but not a part of a hydrogen production plant

With the lack of demand and a compelling economic value proposition, renewable hydrogen remains more of a concept than a product.

	R&D	Demonstration	Market Entry	Market Penetration	Market Maturity
Renewable Hydrogen	Wind and biomass H_2	Small Solar Hydrogen			

Development Issue	Description
More efficient and lower cost electrolysis	• The current efficiency of alkaline electrolysis of approximately 55% could be improved significantly with the successful commercialization of PEM, and solid oxide electrolysis • Alkaline electrolysis is mature. Advanced electrolysis offers the prospects of lower costs, but this needs to be proven.
Hydrogen Transportation and Storage	• Hydrogen transportation, storage and delivery options, with costs consistent with the use of hydrogen as an energy carrier (and not a chemical) need to be developed.
Hydrogen End Use	• The hydrogen economy has yet to develop, creating demand for hydrogen • Fuel cell cost and performance needs to improve to help create demand for hydrogen
Commercial biomass gasification options	• Biomass gasification technologies suitable for hydrogen production (those that produce a *syngas* undiluted with nitrogen) are not commercially available. • Full-scale integration of biomass-to-hydrogen has been well studied but has not been demonstrated.
Codes and Standards	• Codes and standards need to be developed and promulgated to facilitate the use of hydrogen as an energy carrier.

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Hydrogen produced by renewable energy options will typically remain much higher cost than natural gas through the study time period.

Hydrogen Production Technology	Cost of Hydrogen Production ($/MMBtu)	
	2005[1]	2020[2]
Low cost electricity/electrolysis (based on $0.03/kWh production cost, and baseload system)	43	20
Wind Power/electrolysis (based on $0.06/kWh production cost in 2005, $0.04/kWh in 2020)[3]	70	22.5
Solar PV/electrolysis (based on $0.20/kWh production cost in 2004, $0.08/kWh in 2020)[3]	132	45
New Jersey Commercial Natural Gas Price[4]	8.86	7.57

Source: NCI analysis

[1] Hydrogen production in 2005 is based on electrolysis technology currently available and costs from demonstration project information

[2] Hydrogen production in 2020 based on advanced electrolysis using SOFC technology and larger scale production.

[3] Wind and solar analysis assumes 50% capacity factors for purposes of illustration. Lower capacity factors would result in higher costs

[4] Natural gas prices from EIA commercial gas price forecast for the US.

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VIII. Appendices

Appendix B – Survey of Selected Other State Programs

We surveyed six other states with SBC funds to understand their experience in deploying RE technologies.

- We selected six other states with SBCs as a representative sample of what other states are doing.
  - Arizona – has state RPS with solar set-aside like New Jersey
  - California – largest state SBC with a strong solar component
  - Connecticut, Massachusetts, New York and Pennsylvania – neighboring states.

We surveyed six other states with SBC funds to understand their experience in deploying RE technologies. (continued)

	Administering Body	Type of Organization	Fund Start Date	State RPS?	PV rebate ($/W)	Prop tax exemption	Sales tax exemption
AZ	Arizona Corporation Commission	Public Regulatory Agency	1996	Yes	Utility rebate. $2-5/W	NA	Yes. On equipment purchase or sale)
CA	California Energy Commission (CEC)	State Department of Energy	1996	Yes	State, Utility and Local rebates. $4-7/W Res., max 50% or $5/W Commercial	Yes. 100% for active solar systems	NA
CT	Connecticut Innovations	Quasi Public Agency	1998	Yes	State and private rebates. State $5/W Res.	Yes. Vary with technology	NA
MA	Massachusetts Technology Collaborative (MTC)	Quasi Public Agency	1998	Yes	State and private rebates. Partially performance-based to $5/W	Yes. 100% for 20 years	Yes. 100% - residential use
NY	New York State Energy Research and Development Agency (NYSERDA)	Quasi Public Agency (Public Benefit Corporation)	1998	Pending but likely	State and Utility rebates. Various, to $4/WDC	Yes. 15 year exemption.	NA
PA	Public Utility Commission	Public Regulatory Agency	1996	Yes	Local rebate. $4/W to $20,000	NA	NA

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We surveyed six other states with SBC funds to understand their experience in deploying RE technologies. (continued)

	1. Over-arching objectives for RE initiatives	2. SBC % allocated to RE and total RE $	3. % SBC going to deployment efforts vs. R&D
AZ	• Build diverse portfolios • Increase use of RE in state • Load-serving entities (LSEs) required to supply 0.2% RE in 2001, to 1.1% by 2007	• 100% • Approximately $15 MM/yr	• Initial expenditures were for R&D, but now 100% for deployment • Fuel cells not authorized technology but may soon be, using renewables
CA	• Develop and increase CA's reliance on RE resources to gain stable electricity prices, improve air and health quality, create jobs and increase energy security.	• Known as "Public Goods Charge" • $135 MM/yr to RE, out of $540 MM PGC • Also, a portion of the $62.5 MM allocated to R&D may be used for RE	• The Public Interest Energy Research (PIER) Fund receives $62.5 MM/yr through 2006
CT	• No stated goal but 100 MW of clean energy implied through long-term purchase agreements by 2007	• No specific RE goals • 60% to fuel cells	• R&D and demo projects <10%
MA	• Significantly increase MWh generated • Grow economy and jobs • Expand ratepayer benefits	• 100% of $25 MM to RE	• 100% on deployment and market development, including funding installations and concept-testing
NY	• Stress both RE and conservation • Build infrastructure rather than sponsor R&D (e.g., PV incentive to installer vs. user; train installer)	• Total SBC is about $150 MM/yr • $14+MM into RE, mostly PV and wind • $4.2MM for EE & RE on farms with $7.4MM in cooperative funding secured by NYSERDA	• $1.2 MM into applied R&D and product commercialization. Remainder for deployment
PA	• Four Public Benefits Funds, each with own Board and Mission statement – First Energy, West Penn , PECO, PP&L	• Utilities do own allocations – First Energy $12 MM – West Penn $11 MM – PECO $32 MM – PP&L $20 MM	• Make loans to many constituencies for various purposes

We surveyed six other states with SBC funds to understand their experience in deploying RE technologies. (continued)

	4. Status of deployment initiatives: grid-connected and customer-sited	5. Priorities given to specific RE resources	6. Initial/subsequent decisions on RE fund allocations
AZ	• 1996 RPS assigned responsibility for funding allocation to utilities, with ACC oversight. Few restrictions/requirements • Now considering % set-aside for DG	• RPS initially 100% solar. Now 60%. • Renamed "Environmental Portfolio Standard"	• Initially portfolio only solar • Today, 60% solar • Solar % may reduce further because of cost competitiveness
CA	• 20% to improve competitiveness of in-state RE facilities • 51.5% for development of new RE • 17.5% consumer-based programs • 10% customer credits	• Driven by RPS; no particular RE identified as 'preferred'	• Initially cost-effective EE and RE technology development • CA power crisis resulted in RE program reallocations • Currently, various RE accounts: New, Emerging, Consumer Ed., etc.
CT	Development & deployment initiatives: • $12 MM for fuel cells • $0.5 MM for wind • $1.7 MM for solar • $0.5 MM for biomass gasification	• Fuel cells, as objective of job growth in CT implied • Just initiating a commercial solar program	• 2001 strategic plan provided initial focus • Plan presently being revised
MA	• 8 programs, each with multiple initiatives. • Both grid-connected and customer-sited.	• Most programs are independent of technology and market driven • exceptions are Solar-to-Market and Community Wind programs	• Initially targeted low-hanging fruit. • Now need- and opportunity-driven
NY	• Currently evaluating programs • Orientation has been to support businesses and economic development	• Market-oriented; no explicit allocations	• No allocations specified • Respond to attractive applications for funds on case-by-case basis
PA	• Each fund required to support: RE and advanced clean energy technologies; programs & design at each fund's discretion	• No priorities. Some confusion between "clean energy" and RE	• Initially no DSM or RE because of objections from utilities • Now allocations up to each of 4 funds

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We surveyed six other states with SBC funds to understand their experience in deploying RE technologies. (continued)

	7. Effective programs	8. Measurement of effectiveness	9. Perspective on other state programs
AZ	• Residential buydowns, at $4/watt • City/utility partnerships • Left to utilities, investment decisions tend to favor central plants rather than DG • RPS sets minimum RE requirement, but electricity provider costs of meeting this standard are recovered both from any existing SBC, as well as an additional portfolio standard charge	• New kWh and $ per incremental kWh • In 2002 and 2003, the Portfolio kWh makeup shall be at least 50% solar electric and no more than 5% on R&D • In 2004, through 2012, the portfolio kWh makeup shall be at least 60% solar electric	• CA's head start and power crisis led to many innovative approaches. In addition, several technology breakthroughs were triggered by CA's implementation of PURPA in the 1980s. These include 354MW of solar trough capacity under SO4 contracts and aggressive wind development that encouraged R&D on new blades and related equipment. • Other states doing mixed things. e.g., ME defined their RPS to match their resource mix so that they could meet it "overnight".
CA	• 2003 report: 275 existing facilities remain competitive; 40 new projects with 1,200 MW planned capacity; 29MW emerging capacity • 200,000 customer purchase RE credits • Fund is capitalized at $135 million per year, with $540 million collected between 1998-2001, and another $1.35 billion to be collected from 2002-2012. At least 51.5% of these funds go into the New Renewable Resources Account	• New capacity additions • Funded by a non-bypassable ratepayer charge of $0.002/kWh - $0.003/kWh on retail sales • As of April, 2004, ~11%, or roughly 30 billion kWh, of the state's total electricity production comes from renewable resources; the resulting reduction in CO_2 is at least 25,000 tons per year • California Power Authority adopted an Energy Action Plan that accelerates the renewable-energy target to reach 20% renewable generation by 2010 instead of 2017 • Current benchmark cost for renewable energy is at 5.37 ¢/kWh and, on contracts that go above the benchmark, the fund will pay the difference	
CT	• Just getting underway in Commercial sector	• None yet. Beginning to develop metrics	• NYSERDA, in understanding, developing and implementing markets • CA strong in deployment

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We surveyed six other states with SBC funds to understand their experience in deploying RE technologies. (continued)

	7. Effective programs	8. Measurement of effectiveness	9. Perspective on other state programs
MA	• REC program to increase MWh • Equity investments to create jobs • Broad promotion of DG	• Draft output and outcome metrics have been developed for all programs and programs will soon be evaluated • RE Trust Fund is supported through an SBC with total funding of roughly $150 MM over a 5-year period • SBC charges are expected to generate $20 M in annual revenue, which will be used for loans and grants to reach the goal of green generation between 750 – 1,000 MW by 2009 • Charge of one half of one mill/kWh was set for 2003 and beyond	• Net metering level of 2 MW in NJ vs. 60 kW in MA. • Emphasis on DG in NJ and MA
NY	• Residential PV; 3 large wind farms in place • Small wind farms (250kW) difficult. • No loans. Recoup investments through negotiated royalty payments	• "NY Energy $mart Program" employs multiple metrics, incl. kWhrs & $ saved; # of jobs retained & created; leverage ratio of $ employed; reductions in peak demand; fuel cost savings; reductions in CO2 emissions • In January, 2001, the fund was extended until June 30, 2006 for $150 MM annually • As of July 2003, R&D results of the program have included the development of over 40 MW of new wind power, R&D in fuel cells and micro turbines, 10 new green building projects and testing to overcome interconnection barriers • During the first three years of implementation, the $mart Program produced annual bill savings of ~$120 MM, reduced annual state electricity consumption by 932 million kWh, and achieved statewide demand reduction of 452 MW	• Texas and Minnesota: wind
PA	• Wind farms are successful: financially sustainable and economically attractive	• "Effectiveness" means that all funds are sustainable. All key success factors are based on economics	• N/A

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We surveyed six other states with SBC funds to understand their experience in deploying RE technologies. (continued)

	10. Advice on fund allocations	Additional remarks
AZ		• Staff report on allocation between central plant and DG was due end of June. To be followed by workshop. Existing standards may be revised this Fall. • Utilities devoted investments to central plants. Distributed PV benefits not being realized
CA		• Goal of accelerating deployment of renewables to augment critical energy supplies, avert blackouts, attain benefits of DG and to increase electric reliability, while reducing investments in infrastructure
CT	• Governance is critical. • Strive for balance among state goals, policies and politics	• PBF administered by Connecticut Innovations, Inc. (CI) • Funds allocation up to CI, within legislated guidelines
MA	• Demonstrate near term success to support public policy goals. • Identify resources/technologies that will be successful over 5-10 years with minimal governmental assistance, and divert funds to those programs that really need assistance	
NY	• Understand your state's strengths and market interests; tailor your programs.	• Energy programs are market-focused on individual end markets.
PA	• Dedicate specific dollars, monitor and measure against specific metrics.	• PBFs set up after regulatory settlement with state's utilities.

VIII. Appendices

Appendix C – References

We consulted a number of documents from New Jersey.

- *The Renewable Energy Task Force Report,* Submitted to Governor James E. McGreevey, April 24, 2003
- *New Jersey Clear Energy Program* 2004 Program Descriptions, Marketing Plans and Budget

McGREEVEY RECEIVES RENEWABLE ENERGY TASK FORCE REPORT

Report calls for doubling the State's Renewable Energy Requirements by 2008

(TRENTON)- The Renewable Energy Task Force - created by Governor McGreevey in January to make recommendations on promoting the use and development of renewable energy in New Jersey - presented its final report to the Governor earlier this week.

"I would like to commend the members of the Renewable Energy Task Force for their substantive work in bringing forward these recommendations which will make New Jersey one of the nation's leading clean-power states," said McGreevey. "This administration remains committed to the creation of a clean, renewable power supply. We will also continue to work hard to promote economic development, future energy independence and greater security for New Jersey's communities."

The Renewable Energy Task Force was charged specifically with strengthening the State's Class I Renewable Portfolio Standard (RPS), which requires all energy suppliers in New Jersey to obtain a percentage of their power from renewable resources, including solar, wind, renewable biomass, landfill gas, geothermal or tidal sources.

The Task Force recommended doubling of the current RPS requirement to 4% by 2008 and establishing a new long-term requirement that New Jersey get 20% of its energy from renewable sources by 2020. The Task Force reported that further analysis of the data might prove that an even larger RPS requirement for 2008 might be feasible.

In addition, the Task Force recommended the establishment of two voluntary customer programs: a sign-up program allowing retail electric customers to select an energy supplier providing even higher amounts of renewable energy than required by the RPS; and, a check-off option on utility bills that would allow customers to make financial contributions to the New Jersey Clean Energy Program, which promotes renewable energy through rebates and incentives.

"Renewable energy is clearly the energy of the future, and this Administration is committed to leading the way," the Governor said. "The Task Force's proposals will make the Garden State a continued leader in the development of clean renewable resources. I accept their recommendations and have asked the Board of Public Utilities to begin implementing them."

"The Board is committed to the Governor's vision for a cleaner, healthier and more energy independent New Jersey," said BPU President Jeanne M. Fox. "We will work with relevant stakeholders to review and implement the recommendations of the Task Force."

In its report, the Task Force elaborated on the many benefits to New Jersey from increasing the use of renewable energy, including: reducing greenhouse gas emissions and other pollution; decreasing our reliance on fossil fuels, which can help reduce reliance on foreign energy sources; promoting economic development around renewable energy industries; and increasing security by relying on cleaner and more distributed sources of energy.

The Task Force also suggested options for programs to specifically promote solar energy in New Jersey, citing its many benefits. The Governor has asked the Board of Public Utilities to examine these options and develop the best programs to promote solar energy.

The Renewable Energy Task Force consisted of 16 representatives from renewable and traditional energy suppliers, utilities, environmental and consumer groups, and energy experts. The Governor initially announced the creation of the Task Force at his Energy Summit in December, during which he highlighted the need for the advancement of renewable energy in New Jersey.

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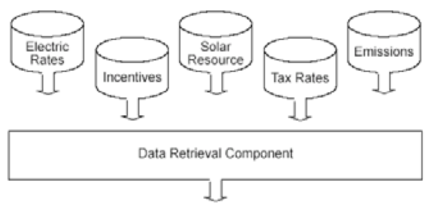
The Clean Power Estimator™ has solar resource data for 237 locations and was used to estimate the PV output for New Jersey.

The Clean Power Estimator™ Model

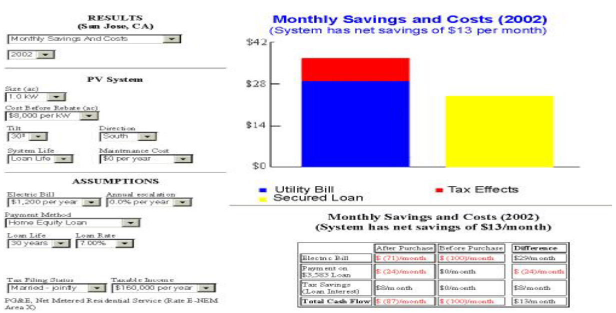
Model Overview[1]

The three key components of the model…

The Data component of the model…



An illustration of one of the model outputs…



Key Comments

- The Estimator is a suite of Internet based applications designed to help consumers evaluate the cost effectiveness of clean energy systems, including PV.
- It provides an estimate of the costs and benefits of a system for residential or commercial customers. It takes into account system size, system installation, system price, financial assumptions, utility rates and solar resources across locations.
- There are three critical components of the Estimator: Data, Analysis and Applications.
- With the Data component, amongst other information, the Estimator has data on the solar resource for 237 locations and includes the utility rates for more than 400 locations (with over 1500 rate schedules, covering residential and commercial customers).
- It produces several outputs. We have used the payback calculation in our analysis to estimate the market potential for PV.

1. Complete model documentation is available at http://www.clean-power.com

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