NEW JERSEY COMPREHENSIVE RESOURCES ANALYSIS MARKET ASSESSMENT

Prepared for

New Jersey Utilities Working Group

Prepared by

XENERGY Inc.
Burlington, Massachusetts

August 19, 1999

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EXECUTIVE SUMMARY

E.1 OVERVIEW

As part of its utility restructuring deliberations and to assist it in its policy development role, the New Jersey Board of Public Utilities (BPU) required in a June 9 order that the state's investor owned gas and electric utilities complete a Comprehensive Resource Assessment (CRA) of energy efficiency and renewable technologies and programs. In response to this directive, the utilities determined that a they would need to complete a market assessment of energy efficiency and Class 1 renewables[1] potential in New Jersey. The findings from this market assessment will help inform both the utilities and the BPU on how best to allocate the Societal ms Benefits Charges collected as part of the state's electric utility restructuring.

This report, completed by XENERGY Inc. with the assistance of Ed Holt & Associates and Robert Grace of Sustainable Energy Advantage, LLC, is the market assessment component of the CRA for the New Jersey Utilities Working Group. The Working Group consists of the following electric and gas utilities:

- Public Service Electric and Gas
- GPU Energy
- Conectiv Power Delivery
- Orange and Rockland Utilities
- South Jersey Gas Company
- New Jersey Natural Gas Company
- Elizabethtown Gas Company

In undertaking the market assessment of energy efficiency and renewable resources, the Working Group agreed on a multiple-attribute approach to assessing and ranking potential measures and program concepts. This allowed the examination of traditional program characteristics (size of market and cost-effectiveness) as well as the consideration of other measure and program features that expand the definition of program attributes normally considered in such a market assessment.

[1] Defined as renewable resources using solar, wind, and biomass, including landfill gas to generate electricity.

E.2 ENERGY EFFICIENCY ANALYSIS - SUMMARY OF APPROACH AND FINDINGS

While the market assessment analyses of energy efficiency and renewables were done separately, we examined four similar criteria for each energy efficiency and renewable measure and program concept. For the energy efficiency market assessment, the following four criteria were examined and quantified to characterize and rank each measure and program concept:

Market Potential - the statewide energy savings potential for each measure[2] or program concept was calculated. An interim value, technical potential, reflecting the maximum feasible savings from a measure or program concept, was first calculated. The technical potential estimates are then adjusted for the likely penetration of the measure or program over the time frame of the analysis. This calculation of market potential is performed by estimating measure or program-specific market penetration rates. The values for this criteria are first year savings for technical potential and cumulative energy savings through 2012 for market potential.

Cost of Saved Energy - to determine relative cost effectiveness the cost of saved energy was calculated for each measure or program concept. This value represents the levelized annual cost per unit of saved energy over the measure's life. These values can be compared to a levelized avoided cost stream to perform a more traditional assessment of cost effectiveness. The values for this criteria are expressed in $/kWh or $/therm.

Need for Program - the need for utility energy efficiency programs is predicated, in part, by the need to overcome market barriers to increase measure or program penetration. This criteria examines the extent of these market barriers and assesses whether utility intervention might be required to help overcome them. This criteria is scored on a range of values from 1 to 5.

Likelihood of Success - this criteria measures the likelihood that a given program concept promoting one or more measures will succeed. This attributes considers several factors including, but not limited to, the extent of a measure or program concept's market barriers, whether there are federal or regional initiatives that would complement a utility program, and if non-energy benefits increase the attractiveness of a measure or program to a customer group. This criteria is scored on a range of values from 1 to 5.

For each measure or program concept, the values or scores for each of these four criteria are calculated or estimated. Within a given market, e.g., commercial retrofit, all of the measures or program concepts are ranked within each criteria based on these scores. A normalized score of 0 - 100 is then calculated based on each criteria's rankings, and a weighted, overall score determined across all four criteria. Within each market the measures or programs are then ranked based on these weighted, overall scores.

[2] Throughout this report the term *measure* refers both to hardware-based approaches to energy efficiency and to changes in design, operation and specification practices among end users, contractors, architects, engineers and other trade allies.

Tables E-1 through E-9 show the measure and program rankings, and the specific criteria values or scores, for the following electric and gas energy efficiency markets:

- Residential existing and new construction- electric
- Residential - gas
- Residential low income - electric
- Residential low income - gas
- Commercial existing - electric
- Commercial renovation and new construction- electric
- Commercial - gas
- Industrial - electric
- Industrial - gas

Table E-1
Residential - Electric Program Concept Rankings - Existing and New Construction

Measure	Market Potential GWh	Market Potential Rank	Market Score 0 - 100	CSE $/kWh	CSE Rank	CSE Score 0 - 100	Barriers	Barriers Score 0 - 100	Likelihood of Success	Likelihood Score 0 - 100	Weighted Score	Final Rank	Sorted Measure/Programs	Final Rank
A/C Equp/Proper Instrallation	275.4	4	40	$0.132	5	20	4.0	50	3.5	50	37.7	5	CFL Lighting	1
Appliances	224.3	5	20	$0.075	3	60	4.0	50	3.0	0	38.0	4	Other	2
CFL Lighting	1,448.1	1	100	$0.044	2	80	4.0	50	3.5	50	75.7	1	Envelope/Direct Install	3
Envelope/Direct Install	1,178.7	2	80	$0.130	4	40	4.0	50	3.0	0	52.0	3	Appliances	4
Other	387.8	3	60	$0.031	1	100	3.5	0	4.0	100	60.0	2	A/C Equp/Proper Instrallation	5
New Construction	41.4	6	0	$0.148	6	0	4.5	100	4.0	100	36.7	6	New Construction	6

Table E-2
Residential - Gas Program Concept Rankings

Measure	Market Potential 10^6 therms	Market Potential Rank	Market Score 0 - 100	CSE $/therm	CSE Rank	CSE Score 0 - 100	Barriers	Barriers Score 0 - 100	Likelihood of Success	Likelihood Score 0 - 100	Weighted Score	Final Rank	Sorted Measure/Programs	Final Rank
Envelope/Direct Install	207.9	1	100	$0.650	3	0	4.0	100	3.0	0	60.0	2	Furnaces/DHW/Appliances	1
Furnaces/DHW/Appliances	24.3	3	0	$0.272	1	100	4.0	100	4.0	100	66.7	1	Envelope/Direct Install	2
Other	152.0	2	50	$0.272	1	100	3.5	0	4.0	100	56.7	3	Other	3

Table E-3
Residential Low Income - Electric Program Concept Rankings - Existing and New Construction

Measure	Market Potential GWh	Market Potential Rank	Market Score 0 - 100	CSE $/kWh	CSE Rank	CSE Score 0 - 100	Barriers	Barriers Score 0 - 100	Likelihood of Success	Likelihood Score 0 - 100	Weighted Score	Final Rank		Sorted Measure/Programs	Final Rank
A/C Equp/Proper Instrallation	56.4	4	40	$0.132	5	20	4.5	67	3.5	0	37.2	4		CFL Lighting	1
Appliances	46.0	5	20	$0.075	3	60	4.0	33	3.5	0	33.5	5		Other	2
CFL Lighting	296.6	1	100	$0.044	2	80	5.0	100	3.5	0	84.0	1		Envelope/Direct Install	3
Envelope/Direct Install	241.4	2	80	$0.130	4	40	4.0	33	3.5	0	47.5	3		A/C Equp/Proper Instrallation	4
Other	79.4	3	60	$0.031	1	100	3.5	0	4.0	100	60.0	2		Appliances	5
New Construction	8.5	6	0	$0.148	6	0	4.5	67	4.0	100	27.9	6		New Construction	6

Table E-4
Residential Low Income - Gas Program Concept Rankings

Measure	Market Potential 10^6 therms	Market Potential Rank	Market Score 0 - 100	CSE $/therm	CSE Rank	CSE Score 0 - 100	Barriers	Barriers Score 0 - 100	Likelihood of Success	Likelihood Score 0 - 100	Weighted Score	Final Rank	Sorted Measure/Programs	Final Rank
Envelope/Direct Install	42.6	1	100	$0.650	3	0	4.0	33	3.5	0	42.1	3	Furnaces/DHW/Appliances	1
Furnaces/DHW/Appliances	5.0	3	0	$0.272	1	100	5.0	100	4.0	100	66.7	1	Envelope/Direct Install	2
Other	31.1	2	50	$0.272	1	100	3.5	0	4.0	100	56.7	2	Other	3

Table E-5
Commercial - Electric Program Concept Rankings - Existing

Measure	Market Potential GWh	Market Potential Rank	Market Score 0 - 100	CSE $/kWh	CSE Rank	CSE Score 0 - 100	Barriers	Barriers Score 0 - 100	Likelihood of Success	Likelihood Score 0 - 100	Weighted Score	Final Rank		Sorted Measure/Programs	Final Rank
Chiller Early Retirement	18.5	5	20	$0.068	5	20	4.0	100	1.0	0	39.4	4		Lighting	1
Controls	815.6	1	100	$0.172	6	0	3.0	0	2.5	100	43.3	3		Motors	2
HVAC	225.5	3	60	$0.053	4	40	3.0	0	1.5	33	35.3	6		Controls	3
Lighting	771.6	2	80	$0.035	2	80	3.0	0	2.0	67	57.3	1		Chiller Early Retirement	4
Motors	3.9	6	0	$0.012	1	100	3.5	50	2.0	67	50.1	2		Other (refrig, DHW, insulation)	5
Other (refrig, DHW, insulation)	32.2	4	40	$0.053	3	60	3.0	0	2.0	67	38.0	5		HVAC	6

Table E-6
Commercial - Electric Program Concept Rankings - Renovation and New Construction

Measure	Market Potential GWh	Market Potential Rank	Market Score 0 - 100	CSE $/kWh	CSE Rank	CSE Score 0 - 100	Barriers	Barriers Score 0 - 100	Likelihood of Success	Likelihood Score 0 - 100	Weighted Score	Final Rank
Chiller Early Retirement	67.5	5	33	$0.068	6	17	3.0	67	3.0	50	39.0	6
Controls	1,926.4	1	100	$0.172	7	0	3.0	67	3.0	50	56.2	4
HVAC	601.5	3	67	$0.053	5	33	3.0	67	3.0	50	55.1	5
Lighting	1,739.4	2	83	$0.035	3	67	2.5	33	3.0	50	61.6	2
Motors	13.6	7	0	$0.012	1	100	3.5	100	2.5	0	56.7	3
Other (refrig, DHW, insulation)	61.4	6	17	$0.053	4	50	2.0	0	3.5	100	30.7	7
Integrated Design Approach	342.1	4	50	$0.030	2	83	3.5	100	3.0	50	73.3	1

Sorted Measure/Programs	Final Rank
Integrated Design Approach	1
Lighting	2
Motors	3
Controls	4
HVAC	5
Chiller Early Retirement	6
Other (refrig, DHW, insulation)	7

Table E-7
Commercial - Gas Program Concept Rankings

Measure	Potential 10^6 Therm	Market Potential Rank	Market Score 0 - 100	CSE $/therm	CSE Rank	CSE Score 0 - 100	Barriers	Barriers Score 0 - 100	Likelihood of Success	Likelihood Score 0 - 100	Weighted Score	Final Rank		Sorted Measure/Programs	Final Rank
Commercial Insulation	0.6	3	0	$0.012	1	100	2.0	0	2.5	0	30.0	2		Heating Equipment	1
Water Heating Measures	34.3	2	50	$0.150	3	0	2.0	0	3.5	100	26.7	3		Commercial Insulation	2
Heating Equipment	64.9	1	100	$0.133	2	50	3.0	100	3.0	50	80.0	1		Water Heating Measures	3

Table E-8
Industrial - Electric Program Concept Rankings

Measure	Market Potential GWh	Market Potential Rank	Market Score 0 - 100	CSE $/kWh	CSE Rank	CSE Score 0 - 100	Barriers	Barriers Score 0 - 100	Likelihood of Success	Likelihood Score 0 - 100	Weighted Score	Final Rank		Sorted Measure/Programs	Final Rank
Chiller Early Retirement	1.2	7	0	$0.038	5	33	3.5	100	2.0	0	36.6	6		Process	1
Controls	581.8	2	83	$0.053	7	0	3.0	67	3.0	100	55.5	4		Motors	2
HVAC	71.5	4	50	$0.017	2	83	3.0	67	2.5	50	64.4	3		HVAC	3
Lighting	198.4	3	67	$0.034	4	50	2.5	33	2.5	50	51.1	5		Controls	4
Motors	53.8	5	33	$0.003	1	100	3.5	100	2.5	50	72.7	2		Lighting	5
Other (refrig, DHW, insulation)	1.8	6	17	$0.046	6	17	2.0	0	2.5	50	15.8	7		Chiller Early Retirement	6
Process	2,731.8	1	100	$0.022	3	67	3.5	100	2.0	0	80.1	1		Other (refrig, DHW, insulation)	7

Table E-9
Industrial - Gas Program Concept Rankings

Measure	Market Potential 10^6 therms	Market Potential Rank	Market Score 0 - 100	CSE $/therm	CSE Rank	CSE Score 0 - 100	Barriers	Barriers Score 0 - 100	Likelihood of Success	Likelihood Score 0 - 100	Weighted Score	Final Rank		Sorted Measure/Programs	Final Rank
Building Insulation	0.0	3	0	$0.012	1	100	2.0	0	2.5	0	30.0	2		Heating Equipment	1
Water Heating Measures	0.1	2	50	$0.150	3	0	2.0	0	3.5	100	26.7	3		Building Insulation	2
Heating Equipment	1.6	1	100	$0.126	2	50	3.0	100	3.0	50	80.0	1		Water Heating Measures	3

E.3 RENEWABLE ENERGY ANALYSIS - SUMMARY OF APPROACH AND FINDINGS

The New Jersey Electric Discount and Energy Competition Act calls for a renewables initiative that represents a substantial challenge -- stimulating the commercialization of new and generally expensive technologies in a relatively short time and in the context of a rapidly changing power marketplace, with little or no basis to start from in terms of technologies, market participants or programs.

In addition to the inherent difficulty of commercializing unfamiliar technologies with costs above those of competing power products, each of these renewable technologies face some unique barriers in the market, along with some unique opportunities. This calls for an overall market transformation approach for renewables that encompasses a range of strategies tailored to the needs of particular technologies, complemented by others designed to support renewables in general.

In order to make the determinations of funding levels and program types required by the law, it will be necessary to make meaningful comparisons between renewable technologies. As described in Section 4, we have utilized a renewable assessment framework with five primary criteria for this purpose:

- Short Term Market Potential (as of 2003),
- Mid-Term Market Potential (as of 2012),
- Cost Competitiveness or Affordability of Power Generation (as of 2003),
- Need for Program Support to Overcome Market Barriers, and
- Likelihood of Success (Prospects for Market Transformation).

The application of this renewable assessment framework shows that it is realistic to expect to achieve significant environmental benefits from these technologies, as intended by the legislature. Each kWh generated by solar PV, wind power and fuel cells creates virtually no air emissions and avoids burning coal and other fossil fuels in the power plants serving New Jersey. In addition, generating power from landfill gas[3] provides a substantial reduction in the release of methane gas, a "greenhouse gas" with a much higher carbon content than the more common greenhouse gas, CO2, as described in Appendix R-2, entitled "Green Power Supply."

[3] While landfill generators do emit air pollutants, the relevant comparison is to the base case, without such generation. This could be either a landfill from which methane and other gasses are escaping, or landfill gas collected and flared. In the former case, the net emissions for the emissions of greatest concern are offset at a CO2-equivalent ratio of greater than one, while there may be some small increase in NOx emissions. In the later case, the net emissions produced due to the insertion of a generator in place of a flare are negligible or non-existent.

Also, this assessment of technologies and the barriers they face provides a framework for identifying the greatest opportunities for supporting and encouraging renewable technologies for each 4-year planning period. These opportunities are summarized in the following section.

E.4 SUMMARY OF RENEWABLE RESOURCE ASSESSMENT

The renewable resource opportunities are compared relative to one another[4] against five criteria in Table 3-10 below. The results shown in this Table should be interpreted in the context of the more detailed assessments of individual technologies later in the document, and should not be assumed to pertain to any particular existing or future facility. Some of the overall results include the following:

- Fuel cells for large commercial, industrial and institutional applications received the highest scores because they are expected to have relatively low costs and relatively high short-term market potential, as well as the greatest longer-term potential among the customer sited technologies and the best prospects for market transformation, largely due to their value in the niche market for premium or assured power quality applications.
- Photovoltaics and fuel cells for residential applications also offer opportunities among the technologies suited for customer sited DG, due to a combination of substantial barriers with prospects for overcoming them in certain market segments with well-designed program support.
- Based on existing information, biomass offers a particularly promising opportunity to support and encourage Class 1 renewable technologies for green power supply to the bulk power market. Biomass has attractive economics and mid-term market potential. Biomass also represents a technology for which additional information is needed to better understand the costs infrastructure needs for sustainable cultivation, collection and transportation of biomass fuels.
- Power from landfill gas is nearly competitive in bulk power markets, and is the one Class 1 renewable for which substantial capacity already exists in New Jersey, but as a result it also has a lower level of need for targeted program support. This technology is estimated to achieve the most attractive costs and market potential.
- Large scale wind power projects represent one of the most competitive technologies for the green power market in the 2003 time frame, but the potential of wind power is limited by available wind resources. Smaller wind installations, like other residential scale distributed generation, is expected to be hindered by higher costs, compared with wind projects based on multiple larger turbines.

[4] It should be kept in mind that comparisons are most meaningful between technologies within the same category. Comparisons between distributed generation technologies and wholesale generation projects to supply the green power market should recognize the fundamental differences between these applications.

Table E-10
Summary of Renewable Resource Assessment

	(a) Short Term Potential (2003 gWh)	(b) Mid-Term Potential (2012 gWh)	(c) Cost Competitiveness (2003 projects)	(d) Need (Barriers)	(e) Market Transformation Prospects	(f) Relative Assessment of Resource Opportunity	(g)
Criteria Weights:	**10%**	**15%**	**15%**	**30%**	**30%**	**Weighted Score**	
<u>**Technology**</u>							
Renewable Distributed Generation (Customer Sited):							
Solar PV Installations	1.2	1.7	1.0	3.5	3.5	2.7	*Moderate*
Fuel Cells: Residential	1.0	1.5	2.6	3.6	3.5	3.0	*Moderate*
Fuel Cells: C/I (> 50 kW)	3.2	2.8	3.0	3.0	5.0	3.8	*High*
Wind: Small	1.0	1.2	1.8	3.8	2.0	2.4	*Lower*
Green Power Supply:							
Wind Power (> 500 kW)	2.0	2.5	4.9	2.0	3.0	3.1	*Moderate*
Biomass Power	3.6	4.0	4.4	2.9	2.8	3.6	*High*
Landfill Gas Power	5.0	5.0	5.0	1.4	2.5	3.4	*Moderate*
Advanced and Other Renewable Supply:							
Tidal Power	1.0	1.0	4.1	3.4	1.0	2.4	*Lower*
Wave Power	1.0	2.7	3.6	3.3	1.0	2.5	*Lower*

Notes: Summary of opportunity scores: High: above 3.5, Moderate: 2.5 to 3.5, Low: below 2.5
The technology with the best prospects for inclusion in the SBC program(s) are those with:
- -- high potential (e.g., scored a 4 or 5) in 2003 and 2012;
- -- greatest cost competitiveness or affordability;
- -- high need for program support (greater barriers needing program attention);
- -- high prospects for overcoming barriers and transforming markets (liklihood of success).

E.5 OPPORTUNITIES FOR TRANSFORMATION OF KEY MARKETS

One of the questions posed for the CRA proceeding is "What resources and opportunities are available?" Table 3-11 provides part of the answer to this question by illustrating for each technology the key opportunities to achieve renewable energy policy goals by addressing the key categories of market barriers. This view of the pattern of barriers faced by the different technologies can be used to identify key opportunities for developing strategies, and can shed light on priorities among those strategies, without ignoring the need for a comprehensive approach in order for market transformation to be successful. For example, results illustrated in this Table include:

- For Customer Sited applications, an integrated approach can be used to transform this market for renewable technologies, including strategies to address the full range of barriers, with:

  - some strategies targeted to particular technologies (e.g., fuel cell demonstrations),
  - other strategies targeting particular market sectors (e.g., a program to encourage renewables through residential mortgages), and
  - some strategies needed to address a barrier that could impede all or most renewable DG technologies (i.e., regulatory and marker reforms needed to assure customers that they will be able to interconnect their generating equipment once it is installed and that any standby, backup or other auxiliary rates will reflect the benefits of DG to the distribution system as well as the costs).

- Incentive programs provide opportunities to put competitive market forces to work in transforming markets for renewable technologies. These programs need not be targeted at specific technologies, instead letting the market determine which qualifying resources need what degree of assistance. These programs can be made available to generators, to developers or directly to suppliers (or customers) of retail green power product offerings.
- Some market niches present an opportunity to focus on a single technology in a single market, for example to leverage the value of fuel cells to business and institutional customers dependent on the highest levels of power quality in support of essential computer and related functions.
- For some barriers it may be appropriate to customize the program response to each technology in the context of a coordinated initiative. For example, to address "information barriers," an initial explanation of ways to purchase PV may be of value for potential residential PV customers, while improved distributed generation planning and acquisition methods may be needed for T&D systems to be prepared for widespread use of residential fuel cells, and C/I and institutional prospects for fuel cells may respond to an outreach campaign with technical workshops and on-site audits.
- Many of the barriers require coordinated actions on the part of multiple government agencies, between the public and private sectors and/or between companies responsible for distribution, transmission and the ISO. For example, green power regulatory and market development could include coordinated action to establish transmission and distribution tariffs, auxiliary rates, interconnection standards and other procedures, potentially including assistance with the development of a power exchange institution or market mechanism to facilitate the packaging and balancing of renewable portfolios at wholesale and retail levels.

Table E-11
Key Barriers and Types of Responses for Renewable Technologies

	(a)	(b)	(c)	(d)	(e)	(f)	(j)
Technology	Regulatory Barriers	Lack of Information	Limited Infrastructure	Limited Technology Experience	Financial Constraints, Risks	High Technology Cost	Need Rating (see scores)
Customer Sited DG:							
PV		2) Dissem. of DG information;		4) Demos of PV distribution integration	5) Renewable residential mortgages	6) PV rebates	*Moderate*
Fuel Cells: Residential	1) Regulatory and market reforms to remove barriers to DG; development of DG rates & regulatory framework for T&D systems	DG planning & acccquisition methods for T&D systems;	3) Support of renewable industry "clusters" and ventures in NJ	Fuel cell demonstration projects; T&D pilot projects for DG		Resid. fuel cell rebates, O&M service support	*Moderate*
Fuel Cells: C/I		Outreach to institutional fuel cell candidates			7) Premium power niche financial support		*Moderate*
Wind (<300 kW)							*Moderate*
Green Power Supply:							
Wind							*Lower*
Biomass	8) Green power regulatory and market development	9) Green power education	assistance as needed, such as sustainable biomass cluster		11) Rebates and other financial assistance for developers & gencos		*Moderate*
Landfill Gas							*Lower*
Advanced and Other Supply:							
Tidal							*Moderate*
Wave				12) RD&D support to NJ instit's	Financial assistance for developers & gencos (subject to ability to compete)		*Moderate*
Geothermal							*n/a*

The likelihood of success and the prospects for sustained market transformation in particular, vary from technology to technology and are discussed in each technology assessment in Appendices R-1 through R-3.

E.6 REPORT FORMAT

The remainder of this report is presented as follows:

Section 1 - Introduction and Study Objective
Section 2 - Energy Efficiency Analysis - Methodology
Section 3 - Energy Efficiency Analysis - Results
Section 4 - Renewable Analysis: Methodology
Section 5 - Renewables Results

Appendix E-1 - Technical Potential Results
Appendix E-2 - Residential NFP and LOS Scores
Appendix E-3 - C&I Need for Program and Likelihood of Success Scores

Appendix R-1 - Renewable Distributed Generation
Appendix R-2 - Green Power Supply
Appendix R-3 - Advanced and Other Renewable Technologies

1 INTRODUCTION AND STUDY OBJECTIVE

1.1 REGULATORY CONTEXT

The need for the Working Group's energy efficiency and renewable energy market assessment arises directly from New Jersey's electric utility deregulation legislation, the Electric Discount and Energy Competition Act, which was signed into law on February 9, 1999. The Act requires that the Board of Public Utilities initiate a proceeding to undertake a Comprehensive Resource Analysis of energy resources in New Jersey. On July 9, the BPU established an Energy Efficiency and Renewables Proceeding which set a deadline of August 23 for utility Comprehensive Resource Analysis and Energy Programs filings. The BPU's July order noted that under the Act,

> ...it has become necessary to re-evaluate existing DSM policies and programs and to consider the new energy efficiency alternatives to either replace or supplement existing programs in the State and allow for the fostering of energy efficiency measures in such alternatives as renewable energy resources.

As directed by the BPU, each utility filing is to, at a minimum, address, three principal areas: I) Overall Policy and Funding Guidelines; II) Resource Assessment and Program Plan; and III) Program Plan Administration and Implementation. Further, the BPU's order puts forward a number of questions and/or filing requirements that it expects the Comprehensive Resource Analysis submissions to address. Among these are specific questions and requirements related to the CRA's resource assessment task and which are to be applied to the following markets:

- Class 1 Renewables
- Residential Energy Efficiency Markets
- Commercial/Industrial Energy Efficiency Markets
- New Energy Efficiency Markets

To respond to these questions and requirements, the Working Group undertook this market assessment of energy efficiency and renewable energy in New Jersey.

1.2 STUDY OBJECTIVE

Based on the BPU's order and discussions with the Working Group's members, the objective of this study is to characterize and rank potential energy efficiency and renewable energy measures, technologies and program concepts. The criteria used to characterize and rank these measures, technologies and program concepts go beyond those usually considered within a resource acquisition framework. Typically, these criteria are the size of the potential markets - how much efficiency savings or renewable generation can be attained by a given date - and the cost-effectiveness of the measures, technologies and program concepts - whether, in the case of energy efficiency, the measures or program concepts generate net benefits, or, for renewables, if the cost of generation is competitive with conventional resources.

While these criteria remain valid metrics to assess market potential, changes in the electric utility industry and in the underlying strategic rationale for energy efficiency programs argue for a broader set of screening attributes. Electric utility deregulation, and the real or functional separation of generation, distribution and retail functions brings into question sole reliance on a resource acquisition model to support the need for utility-supported energy efficiency. More recently, climate change and other environmental considerations have been used to buttress the continued need for efficiency programs at all levels - federal, regional, state, and utility. Further, the methods in which these efficiency goals are being pursued are more strategic in their planning, design, and implementation. Many efficiency programs and initiatives now seek to first identify and then to lessen or remove market barriers to energy efficiency. These efforts are often coordinated on a state, regional, or national level. The goal of these market transformation efforts is to affect long term, sustainable changes in the markets for energy efficiency.

To help characterize these additional energy efficiency market assessment considerations, the methodology employed in this study incorporates additional criteria to provide a more comprehensive characterization of measures, technologies and programs.

Similarly, utility restructuring has brought about changes in the way renewable resources are promoted and developed. The most striking of these is the creation of “green” power products offered to customers in several states with retail access. Currently, most, if not all, renewable generation technologies are priced above central power plant generation. Green power products allow customers to pay a higher price for the real or perceived premium value associated with renewable energy resources. Further, many green power offerings mitigate the cost differential of higher priced renewables by blending renewable energy with lower cost electricity produced by natural gas or large-scale hydroelectric.

Utility restructuring has also been seen as a potential boon to distributed generation technologies such as fuel cells and photovoltaics. Further, fuel cell deployment is most likely to develop in niche markets where reliability and power quality can exact a price premium. The identification of such niche markets will be an important step in the commercialization of certain renewable technologies.

As with market transformation efforts to promote energy efficiency, current efforts to develop renewables are increasingly focused on lessening market barriers and leveraging market forces to accelerate renewable energy development.

1.3 USE OF THE STUDY'S FINDINGS

It is anticipated that the results from this study will inform the BPU, the utilities, and other interested parties on how energy efficiency and renewable energy funds may be dedicated over the next several years. It is important to note that the right "answers" do not fall out from the ranking process used in this study. While we have employed a multiple attribute approach to scoring and ranking measures, technologies and program concepts, there are other factors that must be considered in developing any final set of program recommendations. For example, the gas and electric utilities have been offering DSM programs for upwards of 15 years in New Jersey. Any set of final program recommendations must consider the extensive hands-on experience from these past and current program efforts. Program successes should be built upon, to the extent they are consistent with state energy policy.

While a similar set of criteria have been used for both the energy efficiency and the renewables analysis, each set of results should be viewed independent of each other. As energy efficiency and renewables will not be competing for the same sources of funding in New Jersey, there was no compelling rationale to develop an identical methodology to rank both energy efficiency and renewables. Rather, we have defined each set of criteria relative to the market being assessed. As a result, the scales and units used for some of the criteria scoring differs between renewables and energy efficiency. Market potential is measured in MWh for energy efficiency, in part to allow ranking of relatively large sets of measures. In the renewable analysis, the market potential criteria is scored on a scale of 1 to 5, reflecting both the smaller number of technologies being assessed, as well as the somewhat greater uncertainty in developing point estimate projections of renewable energy generation in the future.

2 ENERGY EFFICIENCY ANALYSIS - METHODOLOGY

2.1 OVERVIEW OF APPROACH

This section describes the methodology used to develop the market assessment of energy efficiency potential in New Jersey.

XENERGY's energy efficiency market assessment for the New Jersey utilities builds on a solid foundation of related work completed in the areas of market potential and market transformation program screening and ranking. Specifically, XENERGY's 1996 *Comprehensive DSM Assessment* study for PSE&G served as the basis for the calculation of the statewide market potential and cost of saved energy criteria. A comprehensive market transformation planning project for Pacific Gas And Electric in 1998, done with the American Coalition for an Energy Efficient Economy (ACEEE) and E-Source, formed the basis for our overall approach to the multiple attribute measure and program ranking methodology used.

The principal steps in the energy efficiency market assessment are summarized below and then discussed in more detail.

- Define ranking criteria
- Specify measures and measure bundles to be analyzed
- Develop statewide, baseline estimates of energy use by market and, within markets by building type (commercial) or SIC code grouping (industrial)
- Calculate, using the DSM ASSYST model, technical potential and cost of saved energy (CSE) for the specified measures and measure bundles
- Develop Need for Program and Likelihood of Success scores for the specified measures and measure bundles
- Develop criteria weights
- Aggregate discrete measures into one or more program concepts and determine market potential of revised measure and program concepts list
- Complete final ranking of measures and program concepts using market potential estimates

2.2 RANKING CRITERIA

XENERGY proposed and developed four ranking criteria to be used to complete the overall ranking of each measure, measure bundle or program concept.

Market Potential - using XENERGY's DSM ASSYST model, the statewide energy savings potential for each measure or program concept was calculated. An interim value, technical potential, reflecting the maximum feasible savings from a measure or program concept, was first calculated. These values were then adjusted to reflect the estimated net market penetration of the measure or program concept through 2012 due to utility intervention. Market potential is always equal to or smaller than technical potential. This lower market penetration reflects the time lag for a measure or practice to fully penetrate a market, or that a measure may not fully penetrate the market within the time frame of the analysis.

The values for this criteria are first year savings for technical potential and cumulative energy savings through 2012 for market potential. With the exception of AC cycling, demand savings are not calculated for the selected measures and program concepts.

Cost of Saved Energy - to determine relative cost effectiveness the cost of saved energy (CSE) was calculated for each measure or program concept. This value represents the levelized annual cost per unit of saved energy over the measure's life. The calculation of the CSE includes measure capital cost and operation and maintenance costs and benefits. CSE was used in lieu of performing a total resource cost (TRC) test given the uncertainty of what appropriate state-wide avoided cost values would be for either electricity or gas. If such avoided costs are developed, then the calculated CSEs can be compared to a levelized avoided cost stream to determine measure or program cost effectiveness. However, note that the calculated CSEs only consider energy savings and do not consider any demand reduction benefits.

The values for this criteria are expressed in $/kWh or $/therm.

Need for Program - the need for utility energy efficiency programs is predicated, in part, by the need to overcome market barriers to increase measure or program penetration. This criteria examines the extent of these market barriers and assesses whether utility intervention might be required to help overcome them. This criteria does not assess whether a given program concept will overcome these barriers.

This criteria is scored on a range of values from 1 to 5.

Likelihood of Success - this criteria measures the likelihood that a given program concept promoting one or more measures will succeed. This criteria considers several factors including, but not limited to, how intractable the measure or program concept's market barriers are, the existence of complementary federal or regional initiatives, non-energy benefits to consumers, and the presence of an adequate support and service infrastructure.

This criteria is scored on a range of values from 1 to 5 with the qualitative meaning of the point scores defined as follows:

1. Very difficult to succeed. There are many large barriers to overcome, limited end-user benefits, little success with similar programs to date or no work in this market to date.
2. Difficult to succeed. Similar to above, but one of the factors does not apply.
3. Moderate chance of success. There are substantial societal benefits, but also substantial customer or producer benefits. Some progress already made in the area.
4. Good chance of success. The benefits of the measure are large; some progress in overcoming barriers already made; potential for sustainability strategies, such as government standards to lock in progress or voluntary labeling by manufacturers.
5. Excellent chance of success. The measure has been proven technically, has gained some measure of market penetration, and lends itself to a clear sustainability strategy.

2.3 SPECIFY MEASURES AND MEASURE BUNDLES

While relying primarily on the 98 measures already analyzed as part of XENERGY's 1996 *Comprehensive DSM Assessment* study for PSE&G, XENERGY also considered several additional sources for potential measures or program concepts:

- Draft program designs developed by the non-utility parties of the PSE&G and Conectiv DSM Collaboratives
- DOE and EPA program offerings including ENERGY STAR, Motor Challenge and Compressed Air Challenge
- Regional Initiatives administered by the Northeast Energy Efficiency Partnerships (NEEP) and the Northwest Energy Efficiency Alliance (NEEA). Several New Jersey utilities currently participate in select NEEP initiatives
- An earlier market transformation assessment completed by XENERGY, ACEEE and E-Source for PG&E in 1998 - PG&E Market Transformation Planning Project, Volume 1: Selecting Targets for New Market Transformation Initiatives, Phase II

The final measure and measure bundles lists were developed with significant Working Group input and review. Tables 2-1 (residential) and 2-2 (C&I) list the discrete measures to be analyzed individually and the measures which are bundled and analyzed as a set.

Measures in *italics* are gas only measures and measures in **bold** were analyzed as both gas and electric measures. For bundled measures, only the primary measure heading, e.g., New Construction in the residential table below, is so annotated.

Table 2-1
Residential Measure Groupings

Market Grouping/Individual Measures	Market Grouping/Bundled
Low Income & Direct Install	**New Construction**
ceiling insulation	ceiling insulation
wall insulation	wall insulation
floor/basement insulation	floor/basement insulation
southern low-e/**high performance windows**	low-e/high performance windows
storm doors/windows	blower down air sealing
blower door air sealing	duct leakage diagnostics & mitigation
duct balancing	tier I & II efficiency HVAC (CAC, HP, furnaces, boilers)
tier I & II efficiency HVAC (CAC, HP, *furnaces, boilers*)	proper HVAC installation (sizing/charge/air flow)
	efficient ventilation
proper HVAC installation (sizing/charge/air flow)	programmable thermostats
programmable thermostats	high efficiency refrigerators, clothes & dishwashers
high efficiency refrigerators, **clothes &** dishwashers	high efficiency DHW (electric and gas)
high efficiency DHW (electric and *gas*)	low flow fixtures
low flow fixtures	tank/pipe wrap
tank/pipe wrap	CFL lamps & fixtures
CFL lamps & fixtures	
HVAC	
tier I & II efficiency CAC	
tier I & II efficiency HP	
high efficiency gas furnaces	
high efficiency gas boilers	
proper sizing	
proper charging	
proper air flow	
duct pressure balancing	
programmable thermostats	
Other Measures	
high efficiency RAC	
geothermal HP	
solar DHW	
second refrigerator removal	
Load Control – AC cycling	

Table 2-2
Commercial/Industrial Measure Groupings

Market Grouping/Individual Measures	Market Grouping/Bundled
Chiller Replacement/Conversion	New Construction
early chiller retirement	roof insulation
other chiller replacement (high efficiency and VSD)	window film
chiller optimization	tier I & II efficiency HVAC (DX, chiller, furnace, boiler)
high efficiency ventilation motors	proper HVAC installation (sizing/charge/air flow)
variable air volume controls	duct leakage diagnostics & mitigation
t8/electronic ballast	energy management systems
lighting redesign (reflectors)	high efficiency water heaters (electric and gas)
	t8/electronic ballast
	lighting redesign (reflectors)
	occupancy sensors/daylight controls
	CFL lamps & fixtures
HVAC	
tier I & II packaged HVAC (DX and HP)	
high efficiency AC (window units)	
high efficiency gas furnaces	
high efficiency gas boilers	
proper installation	
high efficiency ventilation motors	
variable air volume controls	
Lighting Renovation	
t8/electronic ballast	
lighting redesign (reflectors)	
Interior Lighting	
HID	
CFL lamps and fixtures	
exit signs (LED)	
occupancy sensors	
daylight controls	

Table 2-2 (continued)

Market Grouping/Individual Measures	Market Grouping/Bundled
Exterior Lighting	
MV to HID	
incandescent to HID	
photocell controls	
Miscellaneous	
O&M improvement	
Commissioning	
Process	
high efficiency motors	
VSDs	
process support	
process overhaul	
compressed air systems	
NEEP Motors	
high efficiency motors	
downsizing	
improve rewind practices	
Other Measures	
commercial refrigeration doors	
high efficiency water heaters (electric and *gas*)	
heat pump water heaters	
low flow fixtures	
roof insulation	
Load Control	
energy management systems	

2.4 SOURCES OF DATA AND MARKET SEGMENTATION

Tables 2-3 through 2-5 below list the data used for the technical and market potential analyses. The most complete data were available from XENERGY's PSE&G's *Comprehensive DSM Assessment* study and from a similar study completed for GPU by SRC. Blanks denote that no data were received. Following the tables are descriptions of how the data were used in the analyses and what the final market segmentations were for each class. Other than PSE&G, XENERGY received limited customer-level data from the gas utilities. As a result, the natural gas analysis is based primarily on the assumptions and data used by XENERGY for the 1996 PSE&G study.

In addition to the data submitted by the utilities, XENERGY obtained 1998 energy consumption and revenues for the residential, commercial and industrial customer classes for each of the electric utilities from EIA, and from FERC for the gas utilities. These data also include number of customers. As discussed below, the individual utility data were aggregated to the statewide level and reconciled to the totals of end use energy consumption and number of customers represented by these data.

2.4.1 Residential Data

Table 2-3
Available Residential Data

Data Item	PSE&G	GPU	Conectiv	Rockland
Energy Sales by House Type	1995 data from previous work for single meter, multi-metered and Acquisition	1994 Energy breakout by single family and multifamily	Total 1998 sales from EIA	Total 1998 sales from EIA
Number of Customers by House Type	Total number for 1998 from EIA, 1995 house type split similar to the sales data	Total number for 1998 from EIA, 1994 data by single family and multifamily	Total number for 1998 from EIA	Total number for 1998 from EIA
Appliance/End Use Unit Energy Consumption	1995 data from previous study	1994 data		
Appliance/End Use Contribution to Peak Demand	1995 data developed in previous study	1994 data		
Stock Efficiency	1995 data developed in previous study	1994 data		
Appliance/End Use Saturations	1995 data from previous study	1994 data		

Energy Sales by House Type:

The PSE&G data were compared to the GPU data to develop the saturations and unit energy consumption (UECs) that were used to calculate energy by house type. The sum of the total energy sales by house type were reconciled to the sum of the residential energy consumption from EIA for each utility. Gas sales data by house type were taken from the PSE&G study and scaled up to 1998 for all gas utilities.

Number of Customers by House Type

GPU developed estimates of the number of households by income levels for each of the service territories. These data were used to develop the low income customer segmentation. Low income households are estimated to represent 17 percent of the total residential households. The data also provided the number of total residential households by single family, multifamily and mobile home, though ultimately these housing type data were not used. XENERGY used these data to obtain the number of customers by service territory and house type. We relied on PSE&G data from the previous study to develop estimates of new construction activity.

Appliance/End Use Unit Energy Consumption

The PSE&G data and GPU data were compared and updated to reflect efficiencies gains since 1994/5 when the data were originally developed. The UECs were also adjusted so that the calculated total energy consumption from the UECs agreed with the total residential consumption from EIA.

Appliance/End Use Contribution to Peak Demand

Demand data are only of interest for the air conditioning cycling measure and were only developed for this end use. This value was derived from a PSE&G program evaluation.

Stock Efficiencies

No new data was received on stock efficiency. Adjustments were made to what was used in the 1995 PSE&G study consistent with the UEC adjustments. New construction stock efficiency were derived, in part, from the baseline and evaluation studies.

Appliance/End Use Saturations

No new data were received on appliance saturations. A combination of the PSE&G and GPU data were used.

Residential Market Segmentation

The residential customer class analysis was done by the following segments:

- existing households
- new construction
- low income households

Other segmentation schemes are possible, including multifamily and mobile homes. However, we did not have sufficient information on the saturations or UECs for these housing types to warrant this level of market segmentation. For the low income market segmentation we performed a post-analysis segmentation of the results to reflect the relative share of low income customers in the residential sector. While this may overestimate some low income end use consumption, no low income-specific saturations or UECs were available. The base residential market potential estimates were also adjusted downward (83 percent of the original residential total) to reflect the separation of the low income segment.

2.4.2 Commercial and Industrial Data

Table 2-4
Available Commercial and Industrial Data

Data Item	PSE&G	GPU	Conectiv	Rockland
Commercial and Industrial Annual Energy Sales by SIC Code/Building Type	1998 Energy sales and Square footage by 2 digit SIC. 1995 data for 8 commercial and 3 industrial building types	1995 Energy breakout and square footage by end use and 12 commercial building types. 1994 industrial data for 22 2-digit SIC codes	Total 1998 sales from EIA	Total 1998 sales from EIA
Energy and Demand Data by Building Type and End Uses	1995 data developed for previous study of 11 C&I building types and 8 end uses.	1995 energy and demand data for 12 commercial building types and 1994 energy data for 22 2-digit industrial SIC codes.	Energy percentage breakout for 21 commercial building types and 8 end uses and 17 industry types and 5 end uses	
Stock Efficiencies	1995 data developed for previous study			
Equipment Saturations	1995 data developed for previous study	1994 data		

Commercial and Industrial Annual Energy Sales by SIC Code/Building Type

The commercial sales by building type are based on the data from PSE&G and GPU. The twelve GPU building types were combined into eight building types consistent with the PSE&G data. Similarly, the sales for industrial building types represented by 2-digit SIC codes were combined such that only the largest industry groups representing the majority of sales were analyzed separately. The remaining SIC code groupings were combined and analyzed together. Total commercial and industrial sales were adjusted and reconciled to the sum of 1998 EIA data by service territory.

For the commercial gas class, the same building type segmentation was use. For the gas industrial analysis, the class was segmented into large and small users based on consumption. Gas sales by building type were taken from the PSE&G study and scaled up to 1998 FERC data to represent all gas utilities.

Energy and Demand Data by Building Type and End Uses

Energy splits by end use for each building type were estimated using the information obtained from PSE&G, GPU and Conectiv and employed the bottoms-up approach described below. The data were first combined into a consistent set of end uses. The end use energy consumption was then calculated as the product of square footage, end use market share, and energy use intensities (EUI). This product was then compared with known control totals and reasonable midpoints developed for each variable to represent the combined utilities. Demand data were not developed.

Stock Efficiencies

No new data were received on stock efficiencies. Adjustments were made to the efficiencies used in the 1996 PSE&G study consistent with adjustments to the EUIs.

Equipment Saturations

Data from the PSE&G and GPU were compared and reasonable midpoints chosen to represent all utilities.

Commercial Segmentation

The gas and electric commercial customer class analysis was done by the following segments:

- office
- retail
- health
- education
- warehouse
- grocery
- lodging
- miscellaneous commercial

This appears to be the lowest common denominator among the data received from the three electric utilities.

Industrial Segmentation

The industrial customer class analysis was done by the following segments:

- 1st largest 2 digit SIC (SIC 28)
- 2nd largest 2 digit SIC (SIC 33)
- 3rd largest 2 digit SIC (SIC 30)
- 4th largest 2 digit SIC (SIC 20)
- 5th largest 2 digit SIC (SIC 32)
- Other industrial

2.4.3 Utility Rate and Cost Data

Table 2-5
Available Utility Data

Data Item	PSE&G	GPU	Conectiv	Rockland
Retail Rates	Have	Have	Have	
Avoided Costs				
T&D Losses	Line losses by rate class.			
Discount Rates	8.42%	8.46%	8.45%	
Number of Participants in Current Programs	Have for 1996, 1997 and 1998	Have for 1998	Have 1998 data and 1st 4 months of 1999	

Retail Rates

An average energy rate was developed for each of the three customer classes based on the EIA revenue and consumption data. These data were used to calculate customer paybacks which were used as a quality control check of some of the interim results.

Avoided Costs

These were not used in the market assessment analysis. As described above, a CSE was calculated for each measure or program concept in the absence of statewide avoided cost figures.

Discount Rates

For the CSE calculation an average discount rate of 8.44 percent was calculated from the PSE&G, Conectiv and GPU discount rates.

Number of Participants in Current Programs

The data from PSE&G, GPU and Conectiv were summed across similar programs. These data were used to inform the penetration rates for predicting market potential.

2.5 DEVELOP STATEWIDE BASELINE ENERGY USE

The objective of this task is to estimate the current energy and demand contributions by end use for each customer segment. These baselines establish the maximum amount of usage which can be affected by an energy efficiency measure or program.

2.5.1 Developing End Use and Building Level Consumption Estimates

End-use energy can be calculated using either a top-down or a bottom-up approach. The top-down approach starts with total sector or class energy and disaggregates it into building type or SIC code level usage. The bottom-up approach begins with end-use market shares and energy use intensities (EUIs) for C&I end uses , and appliance saturations and corresponding or unit energy consumption (UECs) for residential end uses. For the estimation of technical and market potential, most of the baseline energy consumption estimates were developed using a bottom-up approach. Starting at the end use level, consumption is aggregated to the building type or housing type level and then aggregated to the entire customer class. These class-level estimates of energy consumption are then reconciled with known 1998 class-level sales for both electricity and gas.

The bottom up approach starts at the end-use level using the EUI (or UEC for residential) and market share (saturation for residential) for each end-use and then aggregates the end-uses into total building or housing type energy. *End Use Energy* is calculated as:

$$End\ Use\ Energy = EUI_{end-use} * MarketShare_{end-use} * Square\ Footage$$

where *Number of Dwelling Units* replaces *Square Footage* and *Saturation* replaces *Market Share* in the residential analysis.

The *Total Energy* and *End Use Percent of Total* can then be calculated directly from the *End Use Energy* as follows:

$$Total\ Energy = \sum_{all\ end-use} End\ Use\ Energy$$

$$End\ Use\ Percent\ of\ Total = \frac{End\ Use\ Energy}{Total\ Energy}$$

To use this method, the EUI and the saturation are typically set at known levels for initial iterations. The amount of end-use and total energy are calculated values. However, current and consistent EUIs, UECs, and saturations were not available across all utilities and all customer classes and segments in this study. As a result, the class level reconciliation process required adjustments to some of the EUI, UEC, saturation, and square footage inputs.

For this analysis customers with similar patterns of energy consumption were grouped into appropriate market segments for which end-use baseline usage estimates were developed. The first level of segmentation is by customer class: residential, commercial and industrial. For each of the classes, customers were further segmented by vintage or activity (retrofit, renovation, or new construction), and/or by building type and SIC code grouping. Table 2-6 shows the electric commercial class building type segmentation used and each building type's share of total class usage. Table 2-7 shows similar data for the five electric industrial SIC code groupings developed for this analysis.

Table 2-6
Commercial Class Segmentation and Energy Use

	Percentage of Annual Commercial Energy Consumption
Office	34.3%
Retail	15.7%
Health Care	6.9%
Education	10.9%
Warehouse	5.4%
Grocery	12.2%
Lodging	3.2%
Miscellaneous Commercial	11.6%
TOTAL	100.0%

Table 2-7
Industrial Class Segmentation and Energy Use

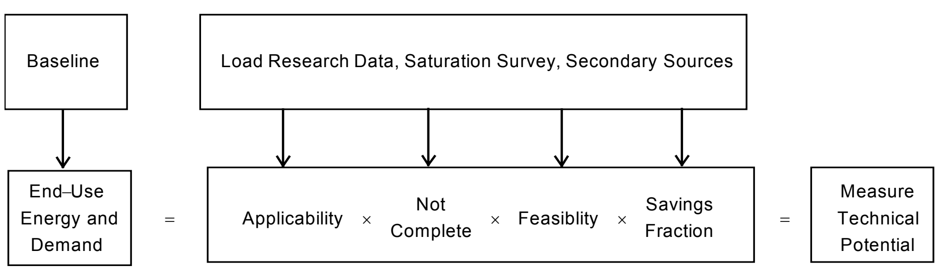
SIC Code	Description	Percentage of Annual Industrial Energy Consumption
28	Chemicals And Allied Products	21.3%
33	Primary Metal Industries	11.3%
30	Rubber And Misc. Plastics Products	10.7%
20	Food And Kindred Products	9.4%
32	Stone, Clay, and Glass Products	6.9%
	Miscellaneous Manufacturing Industries	40.5%
	TOTAL	100.0%

2.6 DEVELOP TECHNICAL POTENTIAL AND COST OF SAVED ENERGY ESTIMATES

Because of the dynamic and complex nature of the data required to perform energy efficiency screening and potential studies, it is important to use analytical systems that can be easily updated and that will prove to be useful on an on-going basis to our clients. The model used for this study, DSM ASSYST™ uses a series of macro-linked spreadsheets to estimate energy efficiency potential.

Annual energy was calculated using the central equation shown in Figure 2-1 to determine measure technical potential. A set of measure factors were applied to the end-use energy and demand to obtain the measure impacts. For each measure, the *applicability*, *not complete*, *feasibility* and *savings fractions* are developed for each customer segment. These measure factors are defined below:

Figure 2-1
Equation for Measure Technical Potential



- **Applicability Factors.** The applicability factor for an energy efficiency measure represents the proportion of end-use energy and demand used by the technology to which that energy efficiency measure applies. The applicability of a particular measure depends upon the type of equipment currently in place. For example, the high efficiency fluorescent lighting energy efficiency measure applies to fluorescent lighting. Fluorescent applicability, therefore, represents the proportion of the lighting end-use attributable to fluorescents for which there are high efficiency replacements.

- **Not Complete Factors.** Not complete factors represent the proportion of equipment that is not yet energy efficient, and is therefore the eligible market for the DSM measure. XENERGY estimated these for existing customers based on PSE&G program data.
- **Feasibility Factors.** The feasibility factors are used to adjust for the amount of load and energy of a technology for which a DSM measure would be impractical or otherwise not feasible. The feasibility of a measure accounts for physical or technical barriers to implementation of the technology. XENERGY developed these based on energy audit experience and knowledge of the energy technology marketplace.
- **Savings Fractions.** The savings fractions represent the change in consumption of energy and demand from implementation of a energy efficiency measure. These fractions are developed by comparing the baseline efficiency and consumption with data on efficiency and consumption for the high efficiency DSM technologies. The residential analysis incorporated the National Appliance Energy Conservation Act of 1987 (NAECA) which sets minimum energy-efficiency standards for 11 equipment types. The commercial and industrial baseline analysis incorporates standards and codes that are established in the Energy Policy Act of 1992 (EPACT) and ASHRAE/IES 90.1 of 1989. Trade associations such as the Gas Appliance Manufacturers Association (GAMA), Association of Home Appliance Manufacturers (AHAM) and the Air-Conditioning and Refrigeration Institute (ARI) were also sources for baseline efficiencies, UECs and sales date on high efficiency equipment.

In order to obtain information regarding energy savings potential, costs, equipment life and energy service comparability, each energy-efficient technology had been researched extensively. Some, but not all, of these data were updated for this study. Information on items such as residential appliances, HVAC equipment and installation practices, shower heads, commercial lighting and other measures is readily obtainable from secondary sources such as previous work done by Lawrence Berkeley Laboratories (LBL), the American Council for an Energy Efficient Economy (ACEEE), the Rocky Mountain Institute's (RMI) Competitek publication and XENERGY’s Measure Cost Study for a group of California utilities and non-utility parties. Much, although by no means all, of this data is fairly consistent from source to source in terms of the technologies' savings characteristics.

These data were supplemented with energy-efficiency technology information from XENERGY's in-house technology studies. These studies are the result of work conducted by XENERGY's staff of HVAC, refrigeration and lighting engineers and energy efficiency analysts.

The results from the technical potential analysis, showing both total maximum potential energy savings and the corresponding cost of saved energy, are included in Appendix E-1. These results were used as an internal check of the underlying DSM ASSYST input assumptions which also drove the market potential analysis.

2.7 Need for Program and Likelihood of Success Scores

Tables 2-8 and 2-9 provide the Need for Program and Likelihood of Success scores for the residential and C&I measures, respectively. Appendices E-2 and E-3 provide supporting documentation for the derivation of these values. All of the scores are scaled from 1 to 5.

Table 2-8
Residential Need for Program and Likelihood of Success Scores (Scale of 1 to 5)

Low Income and Direct Install				
	Need for Program		Likelihood of Program Success	
Measure	Low-Income Customers	All Other Customers	Low-Income Customers	All Other Customers
Ceiling insulation	5	3.5	4	4
Wall insulation	5	4	2	2
Floor/basement insulation	5	4	4	4
Low-e/high performance windows	5	4	4	3.5
Storm doors/windows	4	4	3	3
Blower door air sealing	5	4	3.5	3
Duct leakage diagnostics & mitigation	4.5	4	3.5	3
Tier I & II efficiency HVAC (CAC, HP, furnaces, boilers)	5	4	3	4
Proper HVAC installation (sizing/charge/air flow)	4	4.5	3.5	3
Programmable thermostats	3	3	4	4
High efficiency refrigerators	4.5	4	3.5	3.5
High efficiency clothes washers	5	4	3	4
High efficiency dish washers	5	4.5	3	4
High efficiency DHW (electric and gas)	4	4	4	4
Low flow fixtures	5	4	5	4
Tank/pipe wrap	5	4	5	4
CFL lamps & fixtures	5	4	5	3.5
HVAC Measures				
Tier I (SEER 13) CAC		3.5		4
Tier II (SEER 14) CAC		4		4
Tier I (SEER 13) HP		3.5		4
Tier I (SEER 14) HP		4		4
High efficiency gas furnaces		4		4
High efficiency gas boilers		4		4
Proper HVAC sizing		4.5		3

Table 2-8 (continued)

Low Income and Direct Install				
Measure	**Need for Program**		**Likelihood of Program Success**	
	Low-Income Customers	**All Other Customers**	**Low-Income Customers**	**All Other Customers**
Proper HVAC charging		4.5		3
Proper HVAC air flow		4.5		3
Duct leakage diagnostics & mitigation		4		3
Programmable thermostats		4		4
Other Measures				
High efficiency RAC		3		4
Geothermal HP		5		2.5
Solar DHW		5		2
Second refrigerator removal		3		3.5
Load Control – AC cycling		4		3.5
Bundled New Construction Program				
Bundled New Construction Program		4.5		4

Table 2-9
Commercial and Industrial Need for Program and Likelihood of Success Scores

(Scale of 1 to 5)

Measure	Retrofit		Renovation	
	Need for Program	Likelihood for Success	Need for Program	Likelihood for Success
Early chiller replacement	4.0	1.0	3.0	3.0
HE or VSD chiller	3.0	1.0	2.5	3.5
Chiller optimization	4.0	2.5	4.0	2.5
HE ventilation motors	3.5	2.0	3.0	2.5
VAV controls	3.0	2.0	2.5	4.0
Tier 1 HP	2.5	1.0	3.0	2.5
Tier 1 DX	2.0	1.5	2.5	3.5
Tier 2 HP	3.0	1.0	3.5	2.0
Tier 2 DX	2.5	1.0	3.0	3.0
High efficiency window units	2.0	3.5	1.5	4.0
HE gas furnaces	3.5	1.5	3.0	3.5
HE gas boilers	3.5	1.5	3.0	3.5
Proper installation of HVAC	4.0	2.5	4.0	2.5
T8/electronic ballast	2.0	3.0	1.0	4.5
Reflectors	3.5	1.0	3.0	2.0
HID	3.0	2.0	3.0	2.5
CFL lamps and fixtures	2.5	3.0	2.0	4.0
LED exit signs	3.0	2.0	3.0	3.0
Occupancy sensors	3.0	2.5	2.0	3.5
Daylight controls	4.0	2.0	4.0	3.0
Exterior MV to HPS	4.0	2.0	3.0	4.0
Exterior incandescent to HPS	3.0	2.0	3.0	2.5
Exterior photocells	3.0	3.5	2.0	4.0
O&M improvement	3.0	2.5	2.5	3.0
Recommissioning	4.0	1.5	3.5	3.5
HE motors	3.5	2.0	3.0	2.5
Motor downsizing	3.0	2.0	3.0	2.5
Improve motor rewind practices	N/A	N/A	4.0	2.0

Table 2-9 (continued)

	Retrofit		Renovation	
Measure	**Need for Program**	**Likelihood for Success**	**Need for Program**	**Likelihood for Success**
VSDs	4.0	1.5	2.5	2.5
Process support	4.0	2.0	3.5	2.5
Process overhaul	3.5	1.5	3.0	2.0
Compressed air systems	3.0	2.0	3.0	3.0
LED traffic lights	4.0	2.0	3.5	2.5
Commercial refrigeration doors	2.0	2.0	2.0	3.0
HE water heaters	2.5	3.0	2.0	4.5
HP water heaters	3.5	1.0	3.0	1.5
Low flow fixtures	2.0	3.0	1.0	4.5
Window film	3.0	2.5	2.5	3.0
EMS	4.0	2.0	3.5	2.5
All new construction			3.5	3.0

2.8 Develop Criteria Weights

To combine the scores of the four different criteria, criteria weights were developed based on Working Group member recommendations. The average of the three sets of weights provided were used in the final measure and program concept ranking:

- Market Potential - 33.3%
- Cost of Saved Energy - 30.0%
- Need for Program - 26.7%
- Likelihood of Success - 10.0%

2.9 Aggregate Measures and Determine Market Potential

The market potential is that portion of the technical potential realized by normal market forces, with or without the intervention of a utility program. In this analysis, market potential is defined as the cumulative net measure or program penetration in 2012 caused by potential utility intervention over an assumed baseline.

Market penetration was evaluated by bundling together measures that are likely to be offered within a single program. Further, electric energy efficiency measures with a CSE of more than $.20/kWh were excluded from the analysis. This value is estimated to be two to four times the likely levelized avoided costs. Measures with significant demand savings, whose value would not be captured fully in a CSE calculation, were excluded at a higher threshold of $.40/kWh. For gas measures a threshold of $2.00 per therm was used.

Electric efficiency measures that were excluded:

- Solar DHW
- Wall Insulation R11 - R19
- Ceiling Insulation R19 - R38
- Ceiling Insulation R30 - R38
- Storm Windows
- High Efficiency Dishwasher
- Daylighting Controls
- Window Film

Gas efficiency measures that were excluded:

- Solar DHW
- Wall Insulation R11 - R19
- Ceiling Insulation R19 - R38
- Ceiling Insulation R30 - R38
- Storm Windows

The tables below (Table 2-10 and Table 2-11 for residential, and Table 2-12 and Table 2-13 for C&I) show how the remaining measures were grouped. For some measures, adjustments within DSM ASSYST had to be made if a measure was part of more than one program concept. For low income customers, the same set of residential program concepts was assumed, and separate market potential estimates were calculated as 17 percent of the residential total. New construction measures are not listed in the tables below as the new construction measure bundles were analyzed as a single set of measures for each market in the technical potential analysis.

Table 2-10
Electric Residential Retrofit Program Concepts

Envelope/Direct Install	Appliances	HVAC	Lighting	Other/Direct Install
Southern Low-e Glazing	H.E. RAC	Geothermal	CFL Fixtures	Low Flow Fixtures
Blower Door Air Sealing	H.E. Refrigerators	Tier I CAC & HP	CFL Lamps	Programmable T'stats
Ceiling R0 - R38	H.E. Clothes Washers	Tier II CAC & HP		2nd Refrigerator Removal
Ceiling R11 - R38	H.E. Water Heater	HVAC Airflow		Tank/Pipe Wrap
Duct Insulation		HVAC Charge		
Duct Pressure Balancing		HVAC Sizing		
Floor insulation		Tier I CAC and H.E. RAC		
Wall R0 - R11				

Table 2-11
Gas Residential Program Concepts

Envelope/Direct Install	Equipment	Other/Direct Install
High Performance Glazing	H.E. Furnaces and Boilers	Low Flow Fixtures
Blower Door Air Sealing	Condensing Furnaces and Boilers	Programmable T'stats
Ceiling R0 - R38	H.E. Clothes Washers	Tank/Pipe Wrap
Ceiling R11 - R38	H.E. DHW	
Duct Insulation		
Duct Pressure Balancing		
Floor insulation		
Wall R0 - R11		

Table 2-12
Electric C&I Retrofit/Renovation Program Concepts

Motors	Process	HVAC	Chiller Early Retirement	Lighting	Controls	Other
H.E. Motors	Compressed Air (H,M,L)	Tier I CAC & HP	Chiller Early Retirement	CFL Fixtures	Additional O&M	Refrigerator Doors
Motor Sizing	Process VSD Control	Tier II CAC & HP		CFL Lamp	EMS	HP Water Heater
Motor Rewind	Process Overhaul (H,M,L)	H.E. Chillers		LED Exit Signs	Occupancy Sensors	H.E. Water Heater
	Process Support (H,M,L)	Proper Installation		HID	Photocell Controls	Low Flow Fixtures
		HVAC Charge		Incandescent - HID		Roof Insulation
		VAV Control - VSD		MV - HID		
		VSD Chillers		Reflectors/ Redesign		
				T/8 Electronic Ballasts		

Table 2-13
Gas C&I Program Concepts

Equipment	DHW
H.E. Furnaces and Boilers	Low Flow Fixtures
Condensing Furnaces and Boilers	H.E. DHW
Vent Damper	Tank/Pipe Wrap

For each of the program concepts in the tables above, estimated market penetration rates to 2012 were estimated. While DSM ASSYST can determine market penetrations through the use of an embedded market diffusion model, this approach was not used for this analysis. The diffusion model requires that program budgets are known, as this information affects customer payback and customer awareness, direct inputs into the diffusion model. While the Working Group members are developing these budgets, this process was on-going and not yet complete within the time frame of this analysis.

In lieu of using the embedded diffusion model, market penetrations were estimated. These estimates were informed by:

- The prior market penetration rates developed in the 1996 PSE&G study. Similar groupings of measures were considered in this earlier study and the resulting market penetrations rates reflected modifications to those directly calculated by DSM ASSYST.

- XENERGY staff program design and evaluation experience, much of which has been focused on utility and government market transformation initiatives.
- A recent report completed for Boston Edison measuring the market effects of potential clothes washer and motors programs[1].

The results from the market potential analysis are presented in the next section.

2.10 Complete Final Program Rankings

The results from the market potential analysis (market potential and cost of saved energy) were combined with modified Need for Program and Likelihood of Success scores to initialize the measure and program ranking spreadsheets. The market potential and cost of saved energy scores are used to rank the program concepts within each market. The rankings are then used to develop a pair of normalized scores of 0 - 100 for each of the program concepts. The Need for Program and Likelihood of Success scores can be directly converted into a 0 - 100 normalized range. For each program concept, the normalized scores for each criterion are then weighted and a total, overall score for each measure concept calculated. This final score is then used to rank program concepts within a market.

The results from this scoring and ranking process are presented in the next section of this report.

[1] GDS Associates, Inc. and Shel Feldman Management Consulting. *Market Effects - Delphi Survey for Resource Efficient Clothes Washers and Premium Efficient Motor Applications.* July 1999.

3 ENERGY EFFICIENCY RESULTS

This section presents the results of the energy efficiency analysis. Two sets of results are presented.

First, Table 3-1 presents the annual market potential estimates for each of the program concepts. These results are ordered by market (identified as "Class, Vintage" in the table).

Tables 3-2 through 3-10 present the scoring and ranking of the program concepts. This ranking integrates the market potential, CSE, Need for Program, and Likelihood of Success values for each program concept. Program concepts are ranked within their appropriate markets. The make-up of each program concept is defined in Tables 2-10 through 2-13 in the previous section.

The residential electric new construction and integrated design approach (the commercial new construction proxy) program concepts are the only program concepts developed for their respective markets. However, to provide some context for their scores, we have included them in one of the other market rankings. The residential new construction program concept is ranked with the residential existing program concepts, and the integrated design approach program concept is ranked with the commercial renovation program concepts.

The program ranking tables consist of:

- Residential existing and new construction- electric (Table 3-2)
- Residential - gas (Table 3-3)
- Residential low income - electric (Table 3-4)
- Residential low income - gas (Table 3-5)
- Commercial existing - electric (Table 3-6)
- Commercial renovation and new construction- electric (Table 3-7)
- Commercial - gas (Table 3-8)
- Industrial - electric (Table 3-9)
- Industrial - gas (Table 3-10)

Table 3-1
Annual Program Concept Market Potential

Class, Vintage	Program	Energy Savings 1998	Energy Savings 1999	Energy Savings 2000	Energy Savings 2001	Energy Savings 2002	Energy Savings 2003	Energy Savings 2004	Energy Savings 2005	Energy Savings 2006	Energy Savings 2007	Energy Savings 2008	Energy Savings 2009	Energy Savings 2010	Energy Savings 2011	Energy Savings 2012	Energy Savings 2013	Energy Savings 2014	Energy Savings 2015	Energy Savings 2016	Energy Savings 2017
Residential, Existing	Insulation, Etc.	264.0	515.9	714.8	860.9	951.1	1,009.2	1,057.1	1,103.8	1,150.0	1,195.9	1,241.4	1,286.6	1,331.4	1,375.9	1,420.1	1,464.0	1,507.6	1,550.8	1,593.7	1,636.3
Residential, Existing	Appliances	0.9	3.0	6.4	14.0	25.1	39.0	54.6	71.8	92.4	115.7	141.5	169.9	200.8	234.1	270.3	310.8	353.0	396.6	440.9	489.3
Residential, Existing	AC Equipment/Proper Installation	16.8	35.2	56.3	79.9	105.2	130.9	157.0	182.6	207.4	230.7	252.8	273.9	294.0	313.2	331.8	349.7	367.0	383.8	400.2	416.1
Residential, Existing	CFL Lighting	419.6	810.3	1,159.4	1,435.7	1,616.0	1,712.3	1,756.4	1,771.6	1,773.9	1,771.0	1,766.4	1,761.1	1,755.7	1,750.2	1,744.7	1,739.2	1,733.8	1,728.3	1,722.9	1,717.6
Residential, Existing	Other	42.3	82.7	121.3	158.2	193.3	226.9	258.9	289.5	318.7	346.5	373.0	398.3	422.4	445.4	467.3	488.1	508.0	526.9	544.9	562.0
Residential, NC	New Homes	1.2	2.6	4.2	6.3	8.9	12.2	16.2	20.2	24.4	28.5	32.6	36.6	40.7	44.7	49.9	55.1	59.4	63.4	67.3	70.9
Commercial, Existing	Motors	0.0	0.1	0.2	0.4	0.8	1.2	1.7	2.2	2.7	3.1	3.4	3.7	3.9	4.0	3.9	3.7	3.3	2.8	2.0	1.1
Commercial, Existing	HVAC	18.5	52.4	98.7	147.5	196.9	243.5	279.1	308.1	321.9	322.2	312.1	296.9	277.1	253.0	225.5	192.8	157.1	118.9	78.9	37.7
Commercial, Existing	Chiller Early Retirement	0.0	0.0	0.5	2.0	4.8	8.9	12.4	15.3	17.5	19.1	20.2	20.6	20.5	19.8	18.5	16.7	14.3	11.4	8.0	4.0
Commercial, Existing	Lighting	262.4	806.3	1,392.9	1,802.4	1,957.5	1,924.8	1,810.7	1,683.3	1,554.4	1,425.1	1,295.1	1,164.8	1,034.0	902.9	771.6	640.2	508.9	377.8	247.1	116.8
Commercial, Existing	Controls	590.2	1,115.5	1,524.2	1,794.8	1,932.5	1,960.7	1,910.1	1,809.6	1,681.6	1,540.7	1,395.1	1,248.7	1,103.0	958.6	815.6	674.0	533.8	394.9	257.4	121.3
Commercial, Existing	Other (refrig, DHW, insulation)	1.7	5.1	8.9	13.9	18.0	22.2	26.3	30.5	34.4	37.0	38.2	38.2	37.2	35.1	32.2	28.4	23.8	18.6	12.7	6.2
Commercial, Renovation	Motors	0.0	0.1	0.2	0.5	1.0	1.6	2.5	3.4	4.6	5.8	7.1	8.6	10.1	11.8	13.6	15.6	17.6	19.7	22.0	24.3
Commercial, Renovation	HVAC	5.4	16.2	32.3	60.6	94.8	134.5	186.6	245.6	300.8	355.1	406.4	456.5	506.0	554.1	601.5	668.8	733.0	794.2	852.8	908.9
Commercial, Renovation	Chiller Early Retirement	0.0	0.0	0.6	2.5	6.3	12.6	18.8	25.0	31.1	37.3	43.4	49.4	55.5	61.5	67.5	73.4	79.3	85.2	91.1	96.9
Commercial, Renovation	Lighting	15.2	56.9	127.1	223.5	341.2	476.4	612.6	746.6	880.7	1,013.9	1,159.3	1,301.6	1,447.1	1,592.0	1,739.4	1,883.2	2,022.6	2,167.4	2,309.3	2,446.9
Commercial, Renovation	Controls	27.4	88.7	184.6	310.0	456.8	615.9	779.5	942.1	1,100.8	1,254.5	1,403.5	1,538.8	1,669.5	1,798.5	1,926.4	2,053.6	2,180.1	2,305.9	2,431.2	2,555.8
Commercial, Renovation	Other (refrig, DHW, insulation)	0.1	0.5	1.3	2.7	4.5	6.9	10.1	14.4	20.0	25.9	32.3	39.1	46.2	53.7	61.4	69.4	77.6	86.1	94.8	103.7
Commercial, NC	Integrated New Building Design	0.0	0.0	3.8	13.2	28.4	49.1	72.8	97.9	134.6	169.7	206.2	243.6	281.7	313.8	342.1	369.6	397.7	425.5	448.6	473.1
Industrial, Existing	Motors	0.1	0.4	0.8	1.9	3.7	6.4	9.6	13.4	17.8	22.6	27.9	33.7	40.0	46.5	53.8	61.4	69.6	78.3	87.4	97.0
Industrial, Existing	Process	167.5	504.9	931.2	1,386.4	1,810.1	2,168.3	2,420.3	2,583.8	2,668.3	2,709.5	2,729.9	2,738.7	2,742.8	2,731.1	2,731.8	2,730.2	2,731.6	2,731.3	2,731.0	2,731.1
Industrial, Existing	HVAC	1.7	5.1	10.2	16.5	23.6	31.4	38.7	46.1	52.1	56.8	60.2	63.5	66.5	68.7	71.5	73.9	76.1	78.0	79.6	81.0
Industrial, Existing	Chiller Early Retirement	0.0	0.0	0.0	0.0	0.1	0.2	0.3	0.4	0.5	0.7	0.8	0.9	1.0	1.1	1.2	1.3	1.4	1.5	1.6	1.7
Industrial, Existing	Lighting	19.3	62.0	113.0	155.5	180.4	190.3	192.1	193.5	194.7	195.9	196.9	197.9	198.7	197.7	198.4	198.9	199.5	200.0	200.6	201.1
Industrial, Existing	Controls	120.1	238.1	343.5	430.1	494.5	537.8	562.3	576.6	583.7	586.4	587.2	587.1	586.7	582.2	581.8	581.1	580.9	580.5	580.0	579.6
Industrial, Existing	Other (refrig, DHW, insulation)	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.8	0.9	1.1	1.2	1.4	1.5	1.6	1.8	1.9	2.0	2.1	2.2	2.3
Gas Residential, Existing	Gas Insulation, Etc.	66.2	127.8	174.3	205.4	220.3	226.0	229.1	231.9	234.7	237.4	240.1	242.7	245.3	247.9	250.5	253.0	255.5	257.9	260.4	262.8
Gas Residential, Existing	Gas Appliances	0.1	0.3	0.7	1.4	2.6	4.1	5.7	7.6	9.8	12.3	15.1	18.2	21.6	25.3	29.3	33.4	37.7	42.2	46.6	51.1
Gas Residential, Existing	Direct Install	17.0	33.1	48.5	63.1	77.0	90.2	102.8	114.7	126.1	136.9	147.1	156.8	166.1	174.8	183.1	190.9	198.4	205.4	212.1	218.4
Gas Commercial, Existing	Commercial Insulation	0.0	0.0	0.0	0.1	0.1	0.1	0.2	0.2	0.3	0.3	0.4	0.5	0.5	0.6	0.6	0.7	0.7	0.8	0.8	0.9
Gas Commercial, Existing	Water Heating Equipment	0.4	1.2	2.4	4.0	5.9	8.3	11.0	14.3	17.5	20.7	23.7	26.6	29.3	31.9	34.3	36.4	38.1	39.4	40.6	41.5
Gas Commercial, Existing	HVAC Equipment	0.8	2.3	4.6	7.7	11.5	16.0	21.2	27.5	33.7	39.8	45.6	51.0	56.0	60.6	64.9	68.8	72.4	75.5	78.5	81.5
Gas Industrial, Existing	Commercial Insulation	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Gas Industrial, Existing	Water Heating Equipment	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Gas Industrial, Existing	HVAC Equipment	0.0	0.1	0.1	0.2	0.3	0.4	0.5	0.7	0.8	1.0	1.1	1.3	1.4	1.5	1.6	1.7	1.8	1.9	2.0	2.0

Table 3-2
Residential - Electric Program Concept Rankings - Existing and New Construction

Measure	Market Potential GWh	Market Potential Rank	Market Score 0 - 100	CSE $/kWh	CSE Rank	CSE Score 0 - 100	Barriers	Barriers Score 0 - 100	Likelihood of Success	Likelihood Score 0 - 100	Weighted Score	Final Rank	Sorted Measure/Programs	Final Rank
A/C Equp/Proper Instrallation	275.4	4	40	$0.132	5	20	4.0	50	3.5	50	37.7	5	CFL Lighting	1
Appliances	224.3	5	20	$0.075	3	60	4.0	50	3.0	0	38.0	4	Other	2
CFL Lighting	1,448.1	1	100	$0.044	2	80	4.0	50	3.5	50	75.7	1	Envelope/Direct Install	3
Envelope/Direct Install	1,178.7	2	80	$0.130	4	40	4.0	50	3.0	0	52.0	3	Appliances	4
Other	387.8	3	60	$0.031	1	100	3.5	0	4.0	100	60.0	2	A/C Equp/Proper Instrallation	5
New Construction	41.4	6	0	$0.148	6	0	4.5	100	4.0	100	36.7	6	New Construction	6

Table 3-3
Residential - Gas Program Concept Rankings

Measure	Market Potential 10^6 therms	Market Potential Rank	Market Score 0 - 100	CSE $/therm	CSE Rank	CSE Score 0 - 100	Barriers	Barriers Score 0 - 100	Likelihood of Success	Likelihood Score 0 - 100	Weighted Score	Final Rank	Sorted Measure/Programs	Final Rank
Envelope/Direct Install	207.9	1	100	$0.650	3	0	4.0	100	3.0	0	60.0	2	Furnaces/DHW/Appliances	1
Furnaces/DHW/Appliances	24.3	3	0	$0.272	1	100	4.0	100	4.0	100	66.7	1	Envelope/Direct Install	2
Other	152.0	2	50	$0.272	1	100	3.5	0	4.0	100	56.7	3	Other	3

Table 3-4
Residential Low Income - Electric Program Concept Rankings - Existing and New Construction

Measure	Market Potential GWh	Market Potential Rank	Market Score 0 - 100	CSE $/kWh	CSE Rank	CSE Score 0 - 100	Barriers	Barriers Score 0 - 100	Likelihood of Success	Likelihood Score 0 - 100	Weighted Score	Final Rank		Sorted Measure/Programs	Final Rank
A/C Equp/Proper Instrallation	56.4	4	40	$0.132	5	20	4.5	67	3.5	0	37.2	4		CFL Lighting	1
Appliances	46.0	5	20	$0.075	3	60	4.0	33	3.5	0	33.5	5		Other	2
CFL Lighting	296.6	1	100	$0.044	2	80	5.0	100	3.5	0	84.0	1		Envelope/Direct Install	3
Envelope/Direct Install	241.4	2	80	$0.130	4	40	4.0	33	3.5	0	47.5	3		A/C Equp/Proper Instrallation	4
Other	79.4	3	60	$0.031	1	100	3.5	0	4.0	100	60.0	2		Appliances	5
New Construction	8.5	6	0	$0.148	6	0	4.5	67	4.0	100	27.9	6		New Construction	6

Table 3-5
Residential Low Income - Gas Program Concept Rankings

Measure	Market Potential 10^6 therms	Market Potential Rank	Market Score 0 - 100	CSE $/therm	CSE Rank	CSE Score 0 - 100	Barriers	Barriers Score 0 - 100	Likelihood of Success	Likelihood Score 0 - 100	Weighted Score	Final Rank	Sorted Measure/Programs	Final Rank
Envelope/Direct Install	42.6	1	100	$0.650	3	0	4.0	33	3.5	0	42.1	3	Furnaces/DHW/Appliances	1
Furnaces/DHW/Appliances	5.0	3	0	$0.272	1	100	5.0	100	4.0	100	66.7	1	Envelope/Direct Install	2
Other	31.1	2	50	$0.272	1	100	3.5	0	4.0	100	56.7	2	Other	3

Table 3-6
Commercial - Electric Program Concept Rankings - Existing

Measure	Market Potential GWh	Market Potential Rank	Market Score 0 - 100	CSE $/kWh	CSE Rank	CSE Score 0 - 100	Barriers	Barriers Score 0 - 100	Likelihood of Success	Likelihood Score 0 - 100	Weighted Score	Final Rank	Sorted Measure/Programs	Final Rank
Chiller Early Retirement	18.5	5	20	$0.068	5	20	4.0	100	1.0	0	39.4	4	Lighting	1
Controls	815.6	1	100	$0.172	6	0	3.0	0	2.5	100	43.3	3	Motors	2
HVAC	225.5	3	60	$0.053	4	40	3.0	0	1.5	33	35.3	6	Controls	3
Lighting	771.6	2	80	$0.035	2	80	3.0	0	2.0	67	57.3	1	Chiller Early Retirement	4
Motors	3.9	6	0	$0.012	1	100	3.5	50	2.0	67	50.1	2	Other (refrig, DHW, insulation)	5
Other (refrig, DHW, insulation)	32.2	4	40	$0.053	3	60	3.0	0	2.0	67	38.0	5	HVAC	6

Table 3-7
Commercial - Electric Program Concept Rankings - Renovation and New Construction

Measure	Market Potential GWh	Market Potential Rank	Market Score 0 - 100	CSE $/kWh	CSE Rank	CSE Score 0 - 100	Barriers	Barriers Score 0 - 100	Likelihood of Success	Likelihood Score 0 - 100	Weighted Score	Final Rank		Sorted Measure/Programs	Final Rank
Chiller Early Retirement	67.5	5	33	$0.068	6	17	3.0	67	3.0	50	39.0	6		Integrated Design Approach	1
Controls	1,926.4	1	100	$0.172	7	0	3.0	67	3.0	50	56.2	4		Lighting	2
HVAC	601.5	3	67	$0.053	5	33	3.0	67	3.0	50	55.1	5		Motors	3
Lighting	1,739.4	2	83	$0.035	3	67	2.5	33	3.0	50	61.6	2		Controls	4
Motors	13.6	7	0	$0.012	1	100	3.5	100	2.5	0	56.7	3		HVAC	5
Other (refrig, DHW, insulation)	61.4	6	17	$0.053	4	50	2.0	0	3.5	100	30.7	7		Chiller Early Retirement	6
Integrated Design Approach	342.1	4	50	$0.030	2	83	3.5	100	3.0	50	73.3	1		Other (refrig, DHW, insulation)	7

Table 3-8
Commercial - Gas Program Concept Rankings

Measure	Potential 10^6 Therm	Market Potential Rank	Market Score 0 - 100	CSE $/therm	CSE Rank	CSE Score 0 - 100	Barriers	Barriers Score 0 - 100	Likelihood of Success	Likelihood Score 0 - 100	Weighted Score	Final Rank	Sorted Measure/Programs	Final Rank
Commercial Insulation	0.6	3	0	$0.012	1	100	2.0	0	2.5	0	30.0	2	Heating Equipment	1
Water Heating Measures	34.3	2	50	$0.150	3	0	2.0	0	3.5	100	26.7	3	Commercial Insulation	2
Heating Equipment	64.9	1	100	$0.133	2	50	3.0	100	3.0	50	80.0	1	Water Heating Measures	3

Table 3-9
Industrial - Electric Program Concept Rankings

Measure	Market Potential GWh	Market Potential Rank	Market Score 0 - 100	CSE $/kWh	CSE Rank	CSE Score 0 - 100	Barriers	Barriers Score 0 - 100	Likelihood of Success	Likelihood Score 0 - 100	Weighted Score	Final Rank		Sorted Measure/Programs	Final Rank
Chiller Early Retirement	1.2	7	0	$0.038	5	33	3.5	100	2.0	0	36.6	6		Process	1
Controls	581.8	2	83	$0.053	7	0	3.0	67	3.0	100	55.5	4		Motors	2
HVAC	71.5	4	50	$0.017	2	83	3.0	67	2.5	50	64.4	3		HVAC	3
Lighting	198.4	3	67	$0.034	4	50	2.5	33	2.5	50	51.1	5		Controls	4
Motors	53.8	5	33	$0.003	1	100	3.5	100	2.5	50	72.7	2		Lighting	5
Other (refrig, DHW, insulation)	1.8	6	17	$0.046	6	17	2.0	0	2.5	50	15.8	7		Chiller Early Retirement	6
Process	2,731.8	1	100	$0.022	3	67	3.5	100	2.0	0	80.1	1		Other (refrig, DHW, insulation)	7

Table 3-10
Industrial - Gas Program Concept Rankings

Measure	Market Potential 10^6 therms	Market Potential Rank	Market Score 0 - 100	CSE $/therm	CSE Rank	CSE Score 0 - 100	Barriers	Barriers Score 0 - 100	Likelihood of Success	Likelihood Score 0 - 100	Weighted Score	Final Rank		Sorted Measure/Programs	Final Rank
Building Insulation	0.0	3	0	$0.012	1	100	2.0	0	2.5	0	30.0	2		Heating Equipment	1
Water Heating Measures	0.1	2	50	$0.150	3	0	2.0	0	3.5	100	26.7	3		Building Insulation	2
Heating Equipment	1.6	1	100	$0.126	2	50	3.0	100	3.0	50	80.0	1		Water Heating Measures	3

4 RENEWABLES ANALYSIS: METHODOLOGY

4.1 RENEWABLE TECHNOLOGIES TO BE ASSESSED

"Class I renewable energy" is defined in the restructuring legislation to include the technologies listed in Column 1 of Table 4-1 below. Column 2 shows the corresponding category used in this assessment and indicates the number of the Appendix in which each technology assessment is presented.

Table 4-1
Class 1 Renewables

(1) Definition in Legislation	(2) Categories in this Assessment (with Appendix Numbers)
"electric energy produced from solar technologies	Solar Thermal (R-3)
photovoltaic technologies	Solar Photovoltaic (R-1)
wind energy	Wind (2 sizes, R-1 and R-2))
fuel cells	Fuel Cells (residential & C/I, R-1)
geothermal technologies	Geothermal (R-3)
wave or tidal action	Wave & Tidal (separate categories, R-3)
methane gas from landfills	Landfill Gas (R-2)
biomass facility, provided that the biomass is cultivated and harvested in a sustainable manner"	Biomass (R-2)

This assessment separates the renewable technologies into those which are most suitable for distributed generation applications at customer sites and those which are generally used to provide a power supply (generation service at wholesale) from sites based on proximity to the resource. More specifically, the technology assessments are presented in the following categories, each in a separate Appendix:

Appendix R-1: "Customer-Sited Renewable Distributed Generation,"
Appendix R-2: "Green Power Supply," and
Appendix R-3: "Advanced and Other Renewable Supply."

Appendix R-1 contains the technology assessments for the technologies primarily used for "Customer-Sited Renewable Distributed Generation," including solar PV, fuel cells as well as small wind and other installations. Most PV and fuel cell applications will be located at end-user sites primarily to supply local loads. For these on-site applications, the primary opportunities are to serve part of the loads of customers seeking to use "green power" at their sites, or otherwise seeking premium quality power (in the case of fuel cells) as well as publicity and goodwill in some cases. Most generating installations using these PV and fuel cell technologies will be small in scale, generally less than 1 MW in capacity. While most customer sited PV generation will be grid-connected, it will most likely be connected directly to the customer's side of the utility meter.[1]

Appendix R-2 contains the technology assessments for Green Power Supply.[2] For example, most of the wind and LFG opportunities will be at locations selected for their generating characteristics (e.g., good wind conditions, landfill sites). For biomass, most generation will be located near the fuel resource to minimize fuel transportation costs. These three technologies are covered in Appendix R-2.

Finally, Appendix R-3, "Advanced and Other Renewable Supply" addresses tidal, wave, solar thermal and geothermal power, which could also be used to supply green power to the market, but which are currently either less commercialized or less applicable to New Jersey than those in the previous two categories, Customer-Sited Renewable Distributed Generation and Green Power Supply.

These three categories are not intended to be mutually exclusive. For example, some customer sited applications may be developed not just to serve on-site customer(s) but also to supply generation service to "green" customers in deregulated or competitive retail electric markets, although this application will depend upon BPU and/or ISO market regulations which allow this practice. In addition, any renewable installation that is connected to the electric distribution system may be owned or operated by the utility distribution company as a distributed resource.

The individual technology assessments presented in these Appendices R-1 through R-3, provide information to address the following BPU questions on a statewide basis:

- What resources and opportunities are available?
- What is the size and status of each potential resource and opportunity in New Jersey?

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1 Some PV installations in the near term will be in niche markets that are at off-grid (e.g., remote) locations or that are not connected to the user's AC wiring system. However, the overall capacity potential for such applications is relatively small and this kind of application is not addressed in detail in this assessment.

2 The legislation identifies two other types of power supplies as "Class II renewable energy," including resource recovery and hydropower. This assessment does not address these Class II renewables, which are defined as "electric energy produced at a resource recovery facility or hydropower facility, provided that such facility is located where retail competition is permitted and provided further that the Commissioner of Environmental Protection has determined that such facility meets the highest environmental standards and minimizes any impacts to the environment and local communities." Class II renewables are treated differently for purposes of the Renewables Portfolio Standards (RPS), which are discussed briefly in Section 5 below (Results), along with the legislation's other provisions to encourage renewable and environmentally preferable sources of power generation.

- What are the barriers to market-based development of each resource or opportunity?
- What technologies need assistance?
- What are the costs and benefits of pursuing a particular resource or opportunity?
- What information is still needed concerning each resource or opportunity?

4.2 MULTI-ATTRIBUTE TECHNOLOGY ASSESSMENT PROCESS

Four criteria are combined to assess each technology in a multi-attribute rating framework. This assessment process is designed to be used as a guide to the formulation of policy judgments, and not as the basis for mechanical calculations of winners and losers among renewable technologies. The ratings and scores are not intended to be strictly comparable, but to provide a framework for consideration of the relevant issues.

4.2.1 *Cost of Power Generation*

In order to determine relative cost effectiveness, the cost-competitiveness of power generation for each technology was rated on a scale from 1 to 5, with 5 representing the most attractive (lowest) generating cost. This value is a proxy for the levelized annual cost per unit of energy ($/kWh) generated over the technology's life. For renewables, the cost criteria is based on generating projects of each type that would be placed in service by the end of 2003.

These cost rating values do not reflect the benefits of the technologies, nor do they reflect any adjustments for the different levels of market prices or regulated rates against which different kinds of customers would appropriately compare against the renewable technologie(s). Therefore, they are not intended to be strictly comparable, and the ratings and scores in the assessment tables should be used as a guide to the formulation of policy judgments, not as the basis for mechanical calculations of winners and losers among renewable technologies. Comparisons of cost-competitveness values are most meaningful between technologies within the same category. Comparisons between distributed generation technologies and wholesale generation projects to supply the green power market should recognize the fundamental differences between these applications.

The actual cost of a renewable technology can be compared to a levelized market price stream to develop an assessment of the technology's cost effectiveness relative to the price which each type of customer would have to pay for a non-renewable power supply. It would be important for such a comparison to distinguish between the retail prices for power supply (e.g., competitive generation service) which a "green power" consumer would compare, on the one hand, with the potentially higher cost that results on the other hand from adding some of the other components of an end user's regulated electric rates to the power generation itself. Some of these regulated charges may be avoided to some degree by the use of a renewable distributed generation technology to provide power to the customer's side of the meter. For example, a small customer with a net metering rate available would probably compare the generation cost of a renewable technology with the full cost of electricity, so that the technology would be more affordable or competitive for a given generation cost level. This is one reason for the separation of renewable technologies into categories for this assessment.

4.2.2 *Market Potential*

This criteria addresses the BPU question "What is the size and status of each potential resource and opportunity in New Jersey?" Market potential is defined for renewables as the upper limit for capacity (or energy) as of the year cited, taking into account the technical status of the technology to date together with existing RD&D support; potential uses and promising markets for the technology; the variety of technical, economic, regulatory and other barriers facing the technology in the market; and the impact that strong policy and RD&D support could have for the technology.

This definition of market potential is appropriate to the unique characteristics of renewable technologies and the policy goals for their support. Nevertheless, this definition is different from the market potential criteria used for the energy efficiency analysis described above, in the following ways:

- First, for renewables, this criteria is intended to represent the ***potential*** market to which this particular technology is likely to be marketed and for which it is suited. In the case of efficiency, the "market potential" criteria is designed to represent a forecast of likely market ***penetration***, but in the case of renewables it represents the overall size of the market -- or market niche -- which each technology could be expected to penetrate under reasonably positive market and program conditions.
- The market potential of renewables is based on a continuing program of financial incentives and other market transformation support on the scale anticipated (i.e., at approximately the same level of annual funding that is currently expected for the period 2000 - 2003 from the societal benefits charge, SBC).
- The renewables potential is intended to represent the entire potential for the particular year, not just the impact of a particular program above an assumed "baseline" level of market penetration in that year, except in the case of power from Landfill Gas, where the potential figures do *not* include the approximately 135 of capacity that already exists.
- The potential for renewables is presented separately for two periods, 2003 and 2012, with the "Short Term Potential" intended to reflect primarily the practical constraints on the number of renewable generating projects and capacity tat could be expected to be planned, negotiated, sited, manufactured, built and placed in service in the relatively short elapsed time between now and the end of 2003, and the "Mid-Term Potential" designed to emphasize the level of potential market demand for each technology, given expected levels of program support and expected changes in equipment cost and performance and other market forces.

- Finally, the renewables potential is presented as the potential electricity generated (kWh) in each year, not the cumulative electricity saved over the period through that year as we are doing for efficiency.

There are important differences between efficiency and renewable technologies underlying these distinctions. For efficiency measures, a new high efficiency technology can be expected to substantially replace the "older generation" equipment or practice for its end use, over a period of time. In contrast, for renewables, while market transformation is expected to "take root" for some renewable market segments, it is expected that in many other market segments, most of these technologies will continue to be higher in cost than alternative ways of buying electricity, and will not be seen by end users as competitive with commodity electric supply through an economic analysis based on market prices. Therefore, it is not realistic to achieve a total or predominant shift to renewable technologies for the planning period through 2012. Rather than completely replacing the conventional fossil combustion technologies, the goal is to encourage and assist the New Jersey market to invest in substantial new renewable generating capacity and to achieve market transformation in one or more market niches where renewable technologie(s) have significant value to customers beyond the avoidance of purchases of some other power sources (e.g., fossil power generation).

4.2.3 Need for Program

This criteria is used to address the following two questions posed by the BPU:

- What are the barriers to market-based development of each resource or opportunity?"
- What technologies need assistance?

As with energy efficiency, the need for utility program support is predicated, in part, on the need to overcome market barriers to increase measure or program penetration. This attribute reflects the nature and extent of the market barriers and assesses whether intervention in the market might be required to help overcome them. This criteria is scored on a range of values from 1 to 5. The particular barriers experienced by renewable technologies are described in Appendices R-1 through R-3 and summarized in Section 5 below.

4.2.4 Likelihood of Success

This attribute measures the likelihood that a given program concept promoting one or more measures will succeed. This attributes considers several factors including, but not limited to, how intractable the measure or program concept’s market barriers are, the existence of complementary federal or regional initiatives, and non-energy or non-economic values to consumers (such as the value of green power or high power quality). This criteria is scored on a range of values from 1 to 5.

The meaning of this criteria for a renewables technology is defined by the following seven components taken together. Some of these elements are a function of market barriers that are targeted by the program and the market and other forces that will affect the program. Other possible elements, based on the impact of the program's design on its own success, are not appropriate until programs have been developed further.[3] As indicated by the last two elements, the Likelihood of Success is a function of *both* the "Availability of Short-Term Results" and the "Long-Term Impact of Technologie(s)." One key factor underlying this criteria is the prospect of achieving enough market transformation so that the market segments for key technologies can become self-sustaining and the program can be phased down or out over an acceptable period of time.

1. **Technology Maturity**: the technologie(s) targeted by the program are (a) sufficiently mature in 1999 for market penetration to begin to occur soon, **or** (b) sufficient information is available in 1999 about the technology to provide a rationale for expecting it to be a viable energy resource in the future; and in either case, (c) the technologie(s) have an acceptably low level of technical risk viewed from the 1999 vantage point.
2. **Market Demand**: market demand for the technology is expected to be significant, based on (a) significant current levels of market activity; (b) a reasonable expectation that significant customer awareness and/or preference can be achieved by 2012 through private sector marketing and/or through the program; (c) current (1999) information on the suitability of identified market segments, niches or applications; and (d -- not required for *this* criteria) a strong prospect for more nearly affordable or competitive prices over time (i.e., technologie(s) are expected to reach a price that significant number of consumers will be willing to pay, in one or more market niches or segments).
3. **Supply Infrastructure**: (a) there is a "renewable technology supply chain" for NJ with sufficient existing capacity (or potential capacity as a result of the proposed set of NJ programs and complementary forces) so that the new renewable technologie(s) can be introduced over an acceptable period of time, or substituted for existing products or power sources; (b) there is sufficient transmission and distribution and gas transportation capacity and other energy industry infrastructure to support the technologie(s) at the scale targeted by the program; (c -- not *required* for *this* criteria) there is a basis for an "industry cluster" effect in NJ through a critical mass of generators, suppliers, researchers, incubators, investors, lenders, manufacturers, distributors and/or contractors (as appropriate). To the extent that little or no new infrastructure is needed, this would contribute to a high score for likelihood of success.
4. **Market Transformation Strategy**: (a) the elements of the program are targeted to the key unmet needs that we have identified for the targeted technologie(s) in the market (i.e., the program addresses the key barriers and risks that are not otherwise being addressed -- the "missing pieces" of the pie); (b) the program elements, together with other forces, are sufficient to significantly overcome the identified market barriers (i.e., all the missing pieces will be addressed and these barriers *can be* overcome); (c) the

[3] It is beyond the scope of this project to design or propose particular programs.

program is designed to leverage and have a positive interaction with the market forces affecting the technologie(s) (for example, lowers cost of market entry, lowers cost of generation, or triggers more private sector investment); (d) the program is compatible with competitive markets in the context of a partially regulated industry (i.e., avoids anti-competitive impacts, maintains a level playing field, and is neutral as between competitors and incumbents); and (e) the program is expected to achieve sufficient self-sustaining market transformation so that the program can be phased out over an acceptable period of time (perhaps by 2012, depending on then-current conditions and policy objectives). For most renewable technologies, the key to achieving a sustainable presence in a market or a market niche is to bring down capital costs through economies of scale in manufacturing (which may not respond to the action of any single state) and in the entire design, development and installation process. This is difficult to assess years into the future from the present, and is one factor among many in the technology assessment process.

5. **Complementary Programs**: (a) there are or will soon be federal or other public and/or private sector policy and program initiatives which are consistent with -- and which complement or supplement -- the NJ program under consideration so as to increase the prospects for overcoming the identified market barriers; (b) the program is designed to build on and leverage such programs so as to achieve a comprehensive market transformation approach; (c) these other programs cover areas beyond NJ so as to stimulate a sufficiently widespread regional or national market; and (d) while the complementary programs may increase renewable market penetration in NJ in any event, the NJ program under consideration is designed to meet an otherwise unmet need, so that incremental benefits are achieved for NJ (i.e., NJ goals would not be met without the NJ program, a criteria that somewhat overlaps with item 1(a) above).

6. **Availability of Short Term Program Results**: In addition to the long-term impacts of the intended market transformation, some program success can be expected by year 4 (2003) and 8 (2007) including: (a) the program's original goals for accomplishments in the short term (as defined in each program definition) can likely be met for the applicable technologies; (b) significant program results can be achieved in the short term (preferably by 2003) that demonstrate the **value** of the program to the public and to legislators and regulators (which results could be in the form of new renewable generating capacity **or** intermediate "customer-side market effects" such as customer awareness of emerging technologies through demonstrations and public education); and (c) market **transformation** is likely to be substantially underway by 2003 or 2007, in that there are measurable short-term indications by then of progress toward a significant long-term potential -- that is, progress has been made toward establishing all the necessary conditions for the success of the renewable technologie(s), and the technologie(s) are (still) expected to be a viable energy resource in the future.

7. **Long-Term Impact of Technologie(s)**: The technologie(s) targeted by the program are expected to eventually have a substantial impact on the supply of electricity to NJ customers, even if the potential defined by Criteria #1 as of 2003 (or even 2012) is modest. In other words, the technology may not be expected to achieve its long-run

potential by 2012, but the magnitude of that potential is expected to be very large, either because (a) its technical potential is expected to increase over time (through technological or other developments beyond those assumed for Criteria #1), and/or (b) its economic potential is expected to improve over time (e.g., through cost reductions), and/or (c) it is expected to reach its full long-run market potential after 2012. This element of Criteria 4 is an estimate of the ultimate magnitude of the market potential of the targeted technologie(s) *after* such anticipated long-run changes have taken place.

For each technology, the scores for each of these four criteria are estimated. Using a set of weights for each criteria, a weighted, overall score is determined across all four criteria. Since the renewables assessment is applied to a smaller number of technologies or opportunities, it is not necessary to develop ordinal rankings. Rather, the scores are all maintained on the same scale of 1 to 5.

The context for these technology assessment criteria is the legislation establishing the goals, charges and other elements of program support for renewables, which is reprinted below in Figure 4-1 for reference.

Figure 4-1
Excerpts from Legislative Mandate for CRA

"For the purpose of establishing initial unbundled rates pursuant to section 4 of this act, the **societal benefits charge** shall be set to recover the same level of demand side management program costs as is being collected in the bundled rates of the electric public utility on the effective date of this act. Within four months of the effective date of this act, and every four years thereafter, the board shall initiate a proceeding and cause to be undertaken a **comprehensive resource analysis of energy programs**, and within eight months of initiating such proceeding and after notice, provision of the opportunity for public comment, and public hearing, the board, in consultation with the Department of Environmental Protection, shall determine the appropriate level of funding for energy efficiency and Class I **renewable** energy programs that provide environmental benefits above and beyond those provided by standard offer or similar programs in effect as of the effective date of this act; … provided that 25% of this amount shall be used to provide funding for Class I **renewable** energy projects in the State. In each of the following fifth through eighth years, the Statewide funding for such programs shall be no less than 50 percent of the total statewide amount being collected in public electric and gas utility rates for demand side management programs on the effective date of this act, …. After the eighth year the board shall make a determination as to the appropriate level of funding for these programs. Such programs shall include a program to provide financial incentives for the installation of Class I **renewable** energy projects in the State, and the board, in consultation with the Department of Environmental Protection, shall determine the level and total amount of such **incentives** as well as the renewable technologies eligible for such incentives which shall include, **at a minimum, photovoltaic, wind, and fuel cells**. The board shall simultaneously determine, as a result of the comprehensive

> resource analysis, the programs to be funded by the societal benefits charge …. The board shall make these determinations taking into consideration **existing market barriers and environmental benefits**, with the objective of transforming markets, capturing lost opportunities, making energy services more affordable for low income customers and **eliminating subsidies for programs that can be delivered in the marketplace** without electric public utility and gas public utility customer funding…."

5 RENEWABLES RESULTS

5.1 INTRODUCTION

The Act calls for a renewables initiative that represents a substantial challenge -- stimulating the commercialization of new and generally expensive technologies in a relatively short time and in the context of a rapidly changing power marketplace, with little or no basis to start from in terms of technologies, market participants or programs.

In addition to the inherent difficulty of commercializing unfamiliar technologies with costs above those of competing power products, each of these renewable technologies face some unique barriers in the market, along with some unique opportunities. This calls for an overall market transformation approach for renewables that encompasses a range of strategies tailored to the needs of particular technologies, complemented by others designed to support renewables in general.

In order to make the determinations of funding levels and program types required by the law, it will be necessary to make meaningful comparisons between renewable technologies. As described in Section 4, we have utilized a renewable assessment framework with five primary criteria for this purpose:

- Short Term Market Potential (as of 2003),
- Mid-Term Market Potential (as of 2012),
- Cost Competitiveness (or Affordability) for Power Generation (as of 2003),
- Need for Program Support to Overcome Market Barriers, and
- Likelihood of Success (Prospects for Market Transformation).

The application of this renewable assessment framework indicates that it is realistic to expect to achieve significant environmental benefits from these technologies, as intended by the legislature. Each kWh generated by solar PV, wind power and fuel cells creates virtually no air emissions and avoids burning coal and other fossil fuels in the power plants serving New Jersey. In addition, generating power from landfill gas[1] provides a substantial reduction in the release of

[1] While landfill generators do emit air pollutants, the relevant comparison is to the base case, without such generation. This could be either a landfill from which methane and other gasses are escaping, or landfill gas collected and flared. In the former case, the net emissions for the emissions of greatest concern are offset at a CO2-equivalent ratio of greater than one, while there may be some small increase in NOx emissions. In the later case, the net emissions produced due to the insertion of a generator in place of a flare are negligible or non-existent.

methane gas, a "greenhouse gas" with a much higher carbon content than the more common greenhouse gas, CO2, as described in Appendix R-2, entitled "Green Power Supply."

Also, this assessment of technologies and the barriers they face provides a framework for identifying the greatest opportunities for supporting and encouraging renewable technologies for each 4-year planning period. These opportunities are summarized in the following section.

5.2 SUMMARY OF RENEWABLE RESOURCE ASSESSMENT

The renewable resource opportunities are compared relative to one another[2] against five criteria in Table 5-1 below. Four criteria are combined to assess each technology in a multi-attribute rating framework. However, the ratings and scores are not intended to be strictly comparable, and they are not presented as a sufficient basis for policy conclusions. This multi-attribute process is designed to provide a framework for consideration of the relevant issues. The assessment results should be used as a guide to the formulation of policy judgments, and not as the basis for mechanical calculations of winners and losers among renewable technologies. The results shown in Table 2 should be interpreted in the context of the more detailed assessments of individual technologies later in the document, and should not be assumed to pertain to any particular existing or future facility. Some of the overall results include the following:

- Fuel cells for large commercial, industrial and institutional applications received the highest scores because they are expected to have relatively low costs and relatively high short-term market potential, as well as the greatest longer-term potential among the customer sited technologies and the best prospects for market transformation, largely due to their value in the niche market for premium or assured power quality applications.
- Photovoltaics and fuel cells for residential applications also offer opportunities among the technologies suited for customer sited DG, due to a combination of substantial barriers with prospects for overcoming them in certain market segments with well-designed program support.
- Based on existing information, biomass offers a particularly promising opportunity to support and encourage Class 1 renewable technologies for green power supply to the bulk power market. Biomass has attractive economics and mid-term market potential. Biomass also represents a technology for which additional information is needed to better understand the costs infrastructure needs for sustainable cultivation, collection and transportation of biomass fuels.
- Power from landfill gas is nearly competitive in bulk power markets, and is the one Class 1 renewable for which substantial capacity already exists in New Jersey, but as a result it

[2] It should be kept in mind that comparisons are most meaningful between technologies within the same category. Comparisons between distributed generation technologies and wholesale generation projects to supply the green power market should recognize the fundamental differences between these applications.

also has a lower level of need for targeted program support. This technology is estimated to achieve the most attractive costs and market potential.

- Large scale wind power projects represent one of the most competitive technologies for the green power market in the 2003 time frame, but the potential of wind power is limited by available wind resources. Smaller wind installations, like other residential scale distributed generation, is expected to be hindered by higher costs, compared with wind projects based on multiple larger turbines.

Table 5-1
Summary of Renewable Resource Assessment

	(a)	(b)	(c)	(d)	(e)	(f)	(g)
	Short Term Potential (2003 gWh)	**Mid-Term Potential (2012 gWh)**	**Cost Competitiveness (2003 projects)**	**Need (Barriers)**	**Liklihood of Success**	**Relative Assessment of Resource Opportunity**	
Criteria Weights:	**10%**	**15%**	**15%**	**30%**	**30%**	**Weighted Score**	
Technology							
Renewable Distributed Generation (Customer Sited):							
Solar PV Installations	1.2	1.7	1.0	3.5	3.5	2.7	*Moderate*
Fuel Cells: Residential	1.0	1.5	2.6	3.6	3.5	3.0	*Moderate*
Fuel Cells: C/I (> 50 kW)	3.2	2.8	3.0	3.0	5.0	3.8	*High*
Wind: Small	1.0	1.2	1.8	3.8	2.0	2.4	*Lower*
Green Power Supply:							
Wind Power (> 500 kW)	2.0	2.5	4.9	2.0	3.0	3.1	*Moderate*
Biomass Power	3.6	4.0	4.4	2.9	2.8	3.6	*High*
Landfill Gas Power	5.0	5.0	5.0	1.4	2.5	3.4	*Moderate*
Advanced and Other Renewable Supply:							
Tidal Power	1.0	1.0	4.1	3.4	1.0	2.4	*Lower*
Wave Power	1.0	2.7	3.6	3.3	1.0	2.5	*Lower*

Notes: Summary of opportunity scores: High: above 3.5, Moderate: 2.5 to 3.5, Low: below 2.5
The technology with the best prospects for inclusion in the SBC program(s) are those with:
-- high potential (e.g., scored a 4 or 5) in 2003 and 2012;
-- greatest cost competitiveness or affordability;
-- high need for program support (greater barriers needing program attention);
-- high prospects for overcoming barriers and transforming markets (liklihood of success).

5.3 KEY BARRIERS TO COMMERCIALIZATION OF RENEWABLE TECHNOLOGIES

Table 5-2 presents the derivation of the scores for each technology's need for program support in order to achieve renewable energy policy goals. The ratings in Columns (a) through (f) of Table 5-2 are summarized in Column (g), which is the source for the Need score in Table 5-1, Column

(d) above. The ratings in Table 5-2 [3] are based on the assessments of barriers to each technology and to the categories of Customer Sited Distributed Generation in Appendix R-1, Green Power Supply Generation in Appendix R-2, and other technologies Generation in Appendix R-3.

Table 5-2
Level of Need to Address Barriers to Each Renewable Technology

	(a) Regulatory Barriers	(b) Lack of Information	(c) Limited Infrastructure	(d) Limited Technology Experience	(e) Financial Constraints, Risks	(f) High Technology Cost	(j) Final Rating
Criteria Weight:	**10%**	**10%**	**10%**	**20%**	**20%**	**30%**	
Technology							
Customer Sited DG:							
PV	3.0	3.5	3.0	1.0	4.0	5.0	3.5
Fuel Cells: Residential	4.0	3.5	4.0	4.0	3.0	3.4	3.6
Fuel Cells: C/I	4.0	3.5	4.0	3.0	2.0	3.0	3.0
Small Wind	4.0	3.5	4.0	3.0	4.0	4.2	3.8
Green Power Supply:							
Wind	4.0	2.5	2.0	2.0	2.0	1.1	2.0
Biomass	3.0	2.5	4.0	3.5	4.0	1.6	2.9
Landfill Gas	2.0	2.0	1.0	1.0	2.0	1.0	1.4
Advanced and Other Supply:							
Tidal	5.0	1.0	2.0	5.0	5.0	1.9	3.4
Wave	4.3	1.0	2.0	5.0	4.0	2.4	3.3
Geothermal							

The categories assessed for each column of Table 5-2 include the following examples of particular barriers:

REGULATORY & MARKET BARRIERS

- Siting and permitting process is lengthy and costly.
- Permitting process is uncertain (e.g., hasn't been done before).
- Negative perceptions about specific technology impacts.
- Local opposition delays projects.
- Tariffs and procedures for T&D access and pricing, and/or for treatment in wholesale power markets, are unfavorable to the technology (market mechanisms to support the unique characteristics of the renewable power source have not been sufficiently developed).

INFORMATION BARRIERS

[3] The shading in this table is only intended to make it easier to read and to be consistent with the illustration of types of responses to these barriers in the subsequent Table 5-3.

- Perceived performance risk from unfamiliar technologies (for financiers and the general public),
- Lack of information about who to contact, how to proceed (for customer sited renewables),
- Lack of information about how electricity is generated,
- Lack of information about environmental impacts of electricity generation and use,
- Lack of information about what constitutes renewable energy,
- Difficulty in comparing green power offers,
- Fear, uncertainty and doubt about switching electricity providers,
- Inaccurate (or lack of) information about siting impacts.

INFRASTRUCTURE BARRIERS

- Lack of trained installers,
- Lack of installation standards,
- Lack of service capability,
- Lack of performance and technology insurance,
- Lack of sufficient infrastructure to ensure competition.

TECHNOLOGY BARRIERS

- Technology concept not yet proven,
- Technology not yet demonstrated,
- Technology is immature (not standardized, or evolving rapidly),
- Performance risk associated with new technologies.

FINANCIAL BARRIERS

- High capital cost,
- Credit risk from new/under-capitalized companies,
- Perceived performance risk from unfamiliar technologies (also an information barrier, but this barrier affects ability to finance the investment),
- Uncertainty of demand for green power.

ECONOMIC BARRIERS

- Not competitive with market price of power,
- High customer acquisition cost (e.g., green power).

These barriers are discussed in greater detail for each category of technologies in the corresponding Appendix, R-1 through R-3.

5.4 OPPORTUNITIES FOR TRANSFORMATION OF KEY MARKETS

One of the questions posed for the CRA proceeding is "What resources and opportunities are available?" Table 5-3 provides part of the answer to this question by illustrating for each technology the key opportunities to achieve renewable energy policy goals by addressing the key categories of market barriers. This view of the pattern of barriers faced by the different technologies can be used to identify key opportunities for developing strategies, and can shed light on priorities among those strategies, without ignoring the need for a comprehensive approach in order for market transformation to be successful. For example, results shown in Table 5-3 include:

- For Customer Sited applications, an integrated approach can be used to transform this market for renewable technologies, including strategies to address the full range of barriers, with:
    - some strategies targeted to particular technologies (e.g., fuel cell demonstrations),
    - other strategies targeting particular market sectors (e.g., a program to encourage renewables through residential mortgages), and
    - some strategies needed to address a barrier that could impede all or most renewable DG technologies (i.e., regulatory and marker reforms needed to assure customers that they will be able to interconnect their generating equipment once it is installed and that any standby, backup or other auxiliary rates will reflect the benefits of DG to the distribution system as well as the costs).
- Incentive programs provide opportunities to put competitive market forces to work in transforming markets for renewable technologies. These programs need not be targeted at specific technologies, instead letting the market determine which qualifying resources need what degree of assistance. These programs can be made available to generators, to developers or directly to suppliers (or customers) of retail green power product offerings.
- Some market niches present an opportunity to focus on a single technology in a single market, for example to leverage the value of fuel cells to business and institutional customers dependent on the highest levels of power quality in support of essential computer and related functions.

- For some barriers it may be appropriate to customize the program response to each technology in the context of a coordinated initiative. For example, to address "information barriers," an initial explanation of ways to purchase PV may be of value for potential residential PV customers, while improved distributed generation planning and acquisition methods may be needed for T&D systems to be prepared for widespread use of residential fuel cells, and C/I and institutional prospects for fuel cells may respond to an outreach campaign with technical workshops and on-site audits.
- Many of the barriers require coordinated actions on the part of multiple government agencies, between the public and private sectors and/or between companies responsible for distribution, transmission and the ISO. For example, green power regulatory and market development could include coordinated action to establish transmission and distribution tariffs, auxiliary rates, interconnection standards and other procedures, potentially including assistance with the development of a power exchange institution or market mechanism to facilitate the packaging and balancing of renewable portfolios at wholesale and retail levels.

Table 5-3
Key Barriers and Types of Responses for Renewable Technologies

Technology	(a) Regulatory Barriers	(b) Lack of Information	(c) Limited Infrastructure	(d) Limited Technology Experience	(e) Financial Constraints, Risks	(f) High Technology Cost	(j) Need Rating (see scores)
Customer Sited DG:							
PV	1) Regulatory and market reforms to remove barriers to DG; development of DG rates & regulatory framework for T&D systems	2) Dissem. of DG information;	3) Support of renewable industry "clusters" and ventures in NJ	4) Demos of PV distribution integration	5) Renewable residential mortgages	6) PV rebates	*Moderate*
Fuel Cells: Residential		DG planning & acccquisition methods for T&D systems;		Fuel cell demonstration projects; T&D pilot projects for DG		Resid. fuel cell rebates, O&M service support	*Moderate*
Fuel Cells: C/I		Outreach to institutional fuel cell candidates			7) Premium power niche financial support		*Moderate*
Wind (<300 kW)							*Moderate*
Green Power Supply:							
Wind							*Lower*
Biomass	8) Green power regulatory and market development	9) Green power education	assistance as needed, such as sustainable biomass cluster		11) Rebates and other financial assistance for developers & gencos		*Moderate*
Landfill Gas							*Lower*
Advanced and Other Supply:							
Tidal							*Moderate*
Wave				12) RD&D support to NJ instit's	Financial assistance for developers & gencos (subject to ability to compete)		*Moderate*
Geothermal							*n/a*

The likelihood of success and the prospects for sustained market transformation in particular, vary from technology to technology and are discussed in each technology assessment in Appendices R-1 through R-3.

E1 TECHNICAL POTENTAL RESULTS

E2 RESIDENTIAL NFP AND LOS SCORES

A. General Discussion of Rationales for Assigning "Need for Program" and "Likelihood of Program Success" Ratings to the Low-Income and Direct Install Measures

The biggest barrier to market transformation for direct installation of energy efficiency measures for low-income customers is the inability of these customers to afford such services, even if they are aware of their benefits. The first costs of most of these measures are too high and many low-income households do not stay in one place long enough to reap long-term energy savings benefits. In addition, low-income renters often do not have the authority to make many decisions that affect their energy use. While many owners of low-income housing are able to afford such efficiency measures, since the tenants usually pay the energy bills, the property owners have little incentive to pay for these efficiency measures. Consequently, energy service companies are reluctant to market to these customers due to concerns about payment problems and because of the higher costs of locating customers and other transaction costs.

For this reason, low-income customers will continue to be very dependent on energy efficiency programs that are funded by societal benefit charges. However, even if such low-income energy assistance programs are funded, they still face additional implementation barriers. It is often difficult to insure that the low-income customers that are most in need receive the proper assistance. As noted, low-income customers are more likely to move their place of residence than typical customers. In addition, there are elements of the low-income population – i.e., the elderly – that energy assistance programs often overlook because these people are more tied into social networks than government service networks.[i] Furthermore, these assistance targeting problems may be exacerbated by welfare reform, because low-income households not involved in other social services are less likely to participate in energy assistance programs.[ii]

However, the size of an energy efficiency measure's market barriers should not be the only criterion for determining program need for low-income customers. Low-income housing is less energy efficient, on average, than the housing of non-low-income customers and consequently great energy savings opportunities exist per household. Low-income energy efficiency programs can also reap many non-energy benefits. Energy efficiency can allow low-income customers to enjoy increased comfort, health, and safety, and leave them more disposable income to meet their other payment obligations. Energy efficiency for low-income customers can also benefit utilities and ratepayers by reducing carrying costs on arrearages, bad debt write-offs, shutoffs and reconnects, notices and customer calls, and general collection costs. Low-income energy efficiency programs can also produce broader societal benefits such as secondary economic and environmental benefits.[iii]

This analysis gave high "Need for Program" ratings (4s and 5s) for most of the low-income direct install measures because societal benefits charge-funded energy efficiency programs are likely the only way that the energy efficiency of low-income households can be improved.

This analysis usually gave "Likelihood of Program Success" ratings for the low-income measures that were lower than the "Need for Program" ratings. These lower ratings were due to the existence of the market barriers discussed above.

This analysis, in general, assigned lower "Need for Program" ratings to energy efficiency measures targeted at non-low-income customers, than it assigned to the same measures when they are targeted at low-income customers. These lower ratings are justified by the reality that the non-low-income customers can better afford these energy efficiency measures and their longer lengths of home occupancy allow them to enjoy more of the energy savings benefits. In addition, New Jersey has a healthy performance contracting industry which is willing to offer energy efficiency services to these lower risk customers, provided societal benefits charges are provided for this purpose.

However, non-low-income customers do face educational and financial barriers which SBC-funded energy efficiency programs can help overcome. In addition, such programs can also help overcome other barriers, such as a scarcity of trained technicians, that affect all customer classes. Finally, while non-low-income customers do face fewer market barriers than their low-income counterparts, the quantity of these barriers is not the only criterion for program need. Potential energy savings is another "Need for Program" criterion and non-low-income customers account for the lion's share of such energy savings.

In general, higher "Likelihood of Success" ratings were assigned to energy efficiency measures which New Jersey utilities have past experience in implementing.

B. Measure-Specific Rationales for Assigning "Need for Program" and "Likelihood of Program Success" Ratings to the Low-Income and Direct Install Measures

Ceiling Insulation

Without a baseline study of existing housing in New Jersey, it is difficult to precisely weigh the relative need of this measure. The PSE&G baseline study for new construction found that ceiling insulation practices were adequate, but existing housing, especially low-income housing, is likely to have lower, average insulation levels than new housing. However, the portion of the existing housing stock that could take advantage of this measure is not known. The cost barriers of ceiling insulation are lower than those of wall insulation and high efficiency appliances, but the incremental costs are still high enough to warrant energy efficiency program assistance. The ENERGY STAR insulation program may help overcome some of the informational barriers to greater use of attic insulation.

Wall Insulation

The PSE&G new construction baseline study found wall insulation in New Jersey homes to be adequate[iv], but average wall insulation levels in existing housing are likely to be lower, especially in low-income housing. However, the portion of the existing housing stock that could take advantage of this measure is not known. The installation costs of wall insulation are much higher than those for ceiling insulation, which makes this measure more dependent on financial incentives. It is also difficult to insure that this measure has been installed correctly in existing construction because without expensive scoping equipment it is hard to tell whether the insulation has reached all the open wall areas. The ENERGY STAR insulation program may help overcome some of the informational barriers to greater use of wall insulation.

Floor/Basement Insulation

The PSE&G new construction baseline study found this insulation to be inadequate in newly built homes and the baseline levels are likely to be even worse for existing housing, especially for existing housing occupied by low-income customers. The ENERGY STAR insulation program should help overcome some of the educational and product availability barriers to greater use of floor insulation.

Low-e/High Performance Windows

Low-e and other types of high performance windows can provide significant energy savings as well as other benefits. The ENERGY STAR program claims that 15% energy savings can be obtained with its energy-efficient windows. Windows have other selling points beside energy savings including comfort, noise reduction, and reduced fading of upholstery, carpets, etc. from low-e windows.

CEE ranked "efficient windows" 19th out of 56 energy efficiency measures (both residential and C& I) screened, giving it a score of 3 (out of 5) for likelihood of program success.

A number of existing regional, national initiatives should increase this measure’s chance of success including ENERGY STAR, Alliance to Save Energy's Efficient Window Collaborative, and a new NEEP windows initiative. However, currently no New Jersey utility is an ENERGY STAR Windows partner.

As of fall 1998, no window manufacturers in Northeast were ENERGY STAR partners. NEEP notes that although many national window makers are ENERGY STAR partners, regional companies likely have larger shares of the replacement market and their windows may not be ENERGY STAR efficient and/or NFRC certified & labeled. For this reason NEEP recommended that a baseline study be done, with a focus on regional manufacturers.

Although many market barriers for energy-efficient windows have been overcome, many barriers still persist including high first costs (10% incremental costs which are amplified when considering the high cost of replacing windows), consumer lack of awareness of high-efficiency options and benefits, and limited support from retailers and contractors in terms of differentiating efficient windows from standard offers.

Blower Door Air Sealing

The PSE&G new construction baseline found that even new construction homes were leaky. The existing housing stock is likely to be have even greater air infiltration problems, with low-income housing being among the worst.

Although the energy savings opportunity is great for non-low-income customers, a healthy performance contracting industry in New Jersey means that less utility support is needed for non-low-income customers.

As with windows, comfort benefits make air sealing an easier sale for residential customers, and the installation costs of this measure are typically less than those for insulation.

Duct Leakage Diagnostics & Mitigation

The PSE&G baseline new construction found that leaky duct systems were "a consistent finding in the surveyed homes." The duct systems leaked, on average, 17% compared to 5% for efficient levels. In addition, duct system design was found to be lacking resulting in unbalanced HVAC systems that further decreased the comfort and efficiency of the systems.

A number of energy efficiency organizations and utilities have ranked duct leakage correction highly in their evaluations of the promise of various energy efficiency measures. The CEE rated duct sealing as the 12^{th} highest priority of the 56 energy efficiency measures (both residential and C & I) and PG&E ranked it 15^{th} out of 64 measures(both residential & C& I). NEEA ranked the measure among its top 10 measure list. CEE rated the measure's "Likelihood of Success" as 3 out of 5.

Based on anecdotal information, it appears that few if any New Jersey HVAC contractors currently offer duct sealing services to consumers. The fact that few New Jersey HVAC contractors are offering duct sealing services suggests a large training gap as well as a lack of consumer demand. Such a large training gap will be difficult to overcome. Feedback from the New Jersey contractor training programs sponsored by the New Jersey utilities suggests that there would be substantial additional value from expanding training offerings to include ACCA Manual D (duct design).

The slightly higher program likelihood for low-income customers assumes that installers for low-income programs are more likely to be given duct sealing training. However, low-income program planners may still wish to give higher priority to energy efficiency measures that more directly affect the comfort of the household.

Tier I & II Efficiency HVAC (CAC, HP)

Programs to improve the energy efficiency of residential central air conditioners (CACs) and heat pumps have long been popular because CACs typically represent one of the largest sources of residential electric use, especially during peak usage periods.[v] Central air conditioning typically accounts for 50% or more of the average New Jersey's household's contribution to system peak.[vi] Central air conditioning also typically accounts for 10-20% of average household electricity consumption. In electrically heated homes, HVAC systems can be responsible for 50% or more of total electricity consumption.

The main market barrier to improving the efficiency of residential CACs is the higher cost of the more efficient systems. The systems take longer to install which means higher labor costs. Typically home buyers do not have the spare capital to pay for these higher upfront costs. As a result, many contractors are not willing to submit bids for these higher-priced systems. Rebate offerings from the major New Jersey utilities are the primary strategies used to overcome these financial market barriers. These incentives are designed to cover 80% of the incremental costs of the more efficient systems.

There is good evidence that utility programs that use incentives to promote high efficiency equipment can be successful. For example, a 1998 study of eight leading utility residential HVAC incentive programs found that all but one were able to achieve participation rates for equipment with SEERS of 12 or greater that were considerably higher than the national average of 18%.[vii] Six of the eight were able to achieve participation rates of at least 35% and some had participation rates of 60%.

However, it is difficult to determine how well these rebate programs are working in New Jersey in particular, because there is a dearth of current and reliable data that is specific to the state. The Air Conditioning and Refrigeration Institute (ARI) reported in 1994 that New Jersey ranked second among all states in the percentage (34.9%)of its CACs and heat pumps that had SEERs of 12 or higher and ranked first among all states in the percentage (10%) of CACs and heat pumps that had SEERS of 13 or higher. However, ARI has not published any state-specific data of this type since 1994.

The 1998 study referenced above did find that PG&E had the second lowest participation rate among the eight utility programs for CACs with SEER 12 or greater but had the second highest participation rates for CACs with SEER 13 or greater. The study attributed this disparity to the fact that PSE&G's $370 rebate for a SEER 13 CAC was much larger than its $210 rebate for a SEER 12 CAC. However, the programs examined in the 1998 study differed widely in the incentive mechanisms they offered and it is therefore difficult to draw conclusions about their relative success. For example, many of the other utility programs offered both rebates and loans, while the PSE&G program offered only rebates. In addition, although PSE&G's participation rate for CACs with SEERs of 12 or greater of 25-35% was second lowest among the programs examined in the study, these participation rates were still higher than the national average participation rate of 18%.

Conectiv reported that its program issued 1,070 CAC and heat pump rebates in 1998 which slightly exceeded its program goal of 1,031 rebates. However, utility program goals are also not reliable benchmarks for program success.

As market penetration of high efficiency HVAC equipment in New Jersey increases, incremental costs will likely decrease and utility incentives will become less necessary. However, incentives are still likely to be needed in the near-term as a part of a complete market transformation package that includes education, contractor training, product placement, etc. Incentives are also needed to reduce the economic risk to HVAC contractors of experimenting with quality installation procedures. In addition, as explained below, rebates are currently being used as a carrot to encourage HVAC contractors to provide evidence of proper HVAC installation.

While home buyers may see the higher costs of these more efficient systems, they are often unaware of their benefits. Many do not realize that more efficient systems have energy savings that outweigh the higher startup costs. They also fail to realize that properly-installed high efficiency CAC systems have comfort and maintenance advantages over conventional systems. Instead many home buyers subscribe to the "bigger is better" philosophy.

To overcome this information gap, the New Jersey Residential HVAC Equipment and Installation Working Group is working to distribute over 70,000 customer education booklets. The booklets inform consumers about the benefits and key elements of efficient HVAC systems and provide guidance on the what to ask and how to select an HVAC contractor.

However, the current distribution mechanisms for this brochure is limited to website postings and customer inquiries and bill inserts.

An additional market barrier for high efficiency residential CACs and heat pumps was the lack of consistency among New Jersey utilities on their requirements for rebating these systems. Inconsistent standards made it difficult for HVAC contractors who were ordering equipment for different utility service territories and created other logistical problems. The same Working Group initiative has been trying to make the New Jersey utility rebates offers for high efficiency residential CACs and heat pumps to be more consistent.

Overcoming Problems with Suboptimal Installation (sizing, charging, air flow problems)

Even though higher efficient CAC systems and heat pumps do save energy over conventional systems, there is much evidence that most of these systems (both standard efficiency and high efficiency) are improperly installed. A few recent studies even suggest that the manner in which equipment is installed may have much greater impact on actual operating efficiency than whether or not it has a high efficiency rating.[viii] For example, a 1999 paper found that the cumulative potential energy savings from addressing various residential HVAC installation problems (including sizing, charge, air flow, and duct leakage) was 24-35% for kWh and 14-25% for peak kW.[ix]

Some of these installation problems stem from inadequate training of HVAC contractors. The New Jersey Residential HVAC Equipment and Installation Working Group has been active in trying to overcome this barrier. Through the end of June 1999, over 500 contractors had been trained with 300 different companies. One day classes on Manual J load calculations have been offered by both GPU and Connectiv. Jointly sponsored, two-night classes on charging and air flows were first offered in November 1998.

In addition to inadequate training, another market barrier is inadequate diagnostic equipment for technicians. Graduates of the training program received magnehelic gauges to measure air flow. However, the New Jersey Working Group acknowledges that many contractors lack the necessary equipment for ensuring that HVAC systems are properly sized and charged, and have the proper air flow characteristics.

All participating New Jersey utilities have agreed to begin requiring HVAC contractors to submit documentation of proper sizing (Manual J calculations), proper charging, and proper air flow as a condition for providing a rebate. All participating utilities have agreed to use forms with the same technical inputs for documentation purposes.

However, it is unclear whether these new preconditions for receiving HVAC rebates will be sufficient for getting HVAC contractors to properly install new systems, since it is more expensive and customers are not yet able to differentiate proper installation from improper installation. For this reasons, other long-term initiatives, such as certification of contractors, and stricter enforcement of building codes, are being considered.

High Efficiency Refrigerators

In most households, the refrigerator is the single biggest power-consuming device. Low-income advocates and utility DSM programs have also long recognized that low-income households often have very inefficient refrigerators and that the replacement of these with high efficiency refrigerators is a measure with great potential energy savings.[x]

Under the National Appliance Energy Conservation Act (NAECA) refrigerator-freezers are required to meet certain minimum energy-efficiency standards. The initial standards went into effect January 1, 1990 and were revised in 1993 which resulted in a cumulative 40% reduction in energy consumption. The next revision, scheduled for implementation in July 2001, will require an additional 30% reduction in energy consumption.

This Federal law requires that yellow labels be placed on all new refrigerators which inform consumers how much electricity in kilowatt-hours (kWh) a particular model uses in one year. The ENERGY STAR program also promotes ENERGY STAR Refrigerators which must be at least 20% more efficient than minimum federal standards. Thanks to the ENERGY STAR program and other energy conservation initiatives, most of the major refrigerator manufacturers now produce refrigerator and freezer models that meet ENERGY STAR standards. Amana, Kenmore, and Whirlpool each make over 50 models that qualify for the ENERGY STAR rating.[xi]

One significant market barrier for high efficiency refrigerators is the high incremental cost. A 1998 NEEP study of the market for ENERGY STAR appliances in Massachusetts found that there was an average $268 incremental cost for an ENERGY STAR refrigerator, representing a 54% higher cost than the standard efficiency model. In contrast, the ENERGY STAR dishwasher only had an $112 average incremental cost (28% higher) and the ENERGY STAR room air conditioner only had a $60 average incremental cost (18% higher).[xii] The NEEP report found that ENERGY STAR refrigerators accounted for 32% of total refrigerator sales and 25% of total refrigerator stock, but it provided no historical sales figure for the sake of comparison.

These higher costs may be deterring more extensive use of high efficiency refrigerators in New Jersey. The 1997 PSE&G baseline study for new construction found that the average annual consumption of the installed refrigerators was 840 kWh, compared to the 555-640 kWh annual consumption of the 17 most efficient models.

High Efficiency Dishwashers

As with refrigerators, dishwashers must meet certain minimum energy consumption standards (the current standard is an Energy Factor of at least 0.46) under NAECA. The ENERGY STAR program promotes its ENERGY STAR dishwashers which must exceed these federal standards by at least 13%.

Energy efficiency advocates, government agencies and utilities have made progress in tackling one of the market barriers to greater use of energy efficient dish washers – the scarcity of available models. A 1998 NEEP-sponsored report found that at least 16 different manufacturers produce ENERGY STAR dishwashers with Bosch, Frigidaire, and General Electric producing over 25 different models that meet the ENERGY STAR standard and with Gibson, Miele, and White- Westinghouse each producing more than a dozen ENERGY STAR models.[xiii]

The higher first costs of the more efficient dishwashers still remains a barrier although these incremental costs are not as high as the incremental costs of high efficiency refrigerators, for example. The 1998 NEEP-sponsored report found that in Massachusetts the ENERGY STAR dishwasher only had an $112 average incremental cost (28% higher than standard efficiency model) compared to a $268 average incremental cost for high efficiency refrigerators. However, despite these relatively lower incremental costs, the ENERGY STAR dishwashers only accounted for 29% of the average sales, compared to a 32% share for the more expensive refrigerators.

Educational and informational barriers are also likely discouraging wider use of energy efficient dishwashers. High efficiency dishwashers and clothes washers not only save energy, they also save water, an important added benefit for the drought-stricken Mid-Atlantic region. The ENERGY STAR program has been promoting these water savings benefits of the high efficiency dishwashers. However, it is possible that some customers may fear that the lower water consumption of the high efficiency models means that they will not wash dishes as well as the standard efficiency models.

In addition to concerns about performance, many customers are not choosing high-efficiency dishwashers simply because energy efficiency is not a very important criterion for them for selecting an appliance. One of the findings of the ENERGY STAR pilot program in Washington State was that promoters of the ENERGY STAR appliances should not focus too much on the energy savings of these appliances:

> **Do not focus solely on energy savings.** Remember this is not a good primary argument to use when recruiting industry members; research has shown that low energy consumption is not on the top of the list of attributes consumers are looking for in appliances. Instead, stress how a quiet, energy-efficient dishwasher will reduce noise and improve comfort in an open floor plan. Stress how they will increase usable space in utility rooms with an energy-efficient, stackable clothes washer. Show how publicity from program participation can boost the company's image.[xiv]

The Department of Energy came to similar conclusions when it was implementing its E-Rated Appliance Program. "It is no secret that energy efficiency is not on the top of most consumers' lists of purchasing criteria when it comes to appliance purchases," wrote two of the program implementers. They also advised program implementers to promote the low noise levels of efficient dishwashers.[xv]

For the sake of comparison, the PG&E screening test gave high efficiency residential dishwashers a "Likelihood of Success" score of 4 (on a scale of 1 to 5) and ranked it 4th out of 64 residential and C & I energy efficiency measures. CEE ranked high efficiency residential dishwashers 10th out of 56 high efficiency measures (both residential and C & I) and also gave it a Likelihood of Success score of 4. NEEA ranked high efficiency dishwashers as 4th of the 15 residential and C & I measures that it ranked. The high efficiency dishwasher measure also reached the top 10 rankings on measure screenings conducted by BECo and NEEP.

High Efficiency Clothes Washers

Federal regulations require that top-loading standard capacity clothes washers have a minimum energy factor equal to or greater than 1.18 cubic feet per kWh. Current efficiency standards went into effect in 1994 and treat top loading and front loading machines as different product classes. Front-loading washers are not required to meet energy efficiency requirements.

However, there are tremendous energy savings opportunities in clothes washing technology. Researchers estimate energy efficiency gains of 32% for vertical axis design and 60% for horizontal axis design with lower life-cycle costs and payback periods shorter than the life span of the appliance.[xvi]

NEEP has been very active in promoting the use of high efficiency clothes washers. NEEP's 1998 activities included:

- Completing a residential clothes washer and ENERGY STAR Appliance Baseline Market Study;
- Selecting advertising and retailer support "circuit rider" contractors which have since begun their activities;
- Choosing the "TumbleWash" label to promote the benefits of high-efficiency clothes washers;
- Developing and launching an integrated advertising and public relations campaign to support TumbleWash;
- Beginning outreach and recruitment of retail appliance dealers into the program;
- Completing planning for Phase 2 of the Baseline Market Study, which is scheduled to be finalized by mid-1999

According to the 1998 tumble washer market baseline study commissioned by NEEP, the biggest market barrier to increased sales of tumble washers is the higher cost of these washers. Forty-one percent of the surveyed dealers felt price was the main barrier.[xvii] The NEEP market baseline study found the incremental difference in retail price for the tumble washer to be $530-$610. However, when these incremental prices were examined separately between domestic and import tumble washer models, the domestic incremental difference was $486 while the import incremental price was $1,079.

The NEEP market baseline study found that other dealer complaints about the tumble washers included the fact that customers have to bend over more to use it, the perception that tumble washers cost more to repair than top-loading clothes washers, and the misperception that tumble washers have a smaller capacity than top loaders.

However the NEEP market baseline study found that the program participants who used the tumble washers were generally very pleased with them. Eight-five percent said the tumble washer was worth the price, 96% said they would recommend the tumble washers. Over 50% rated noise level, capacity and use of detergent as much better than prior machine while over 75% rated cleaning as better. Twenty-five percent of the respondents were unsure of energy savings, claiming that they would value third party input. Complaints about the tumble washers included the difficulty of finding special detergents and claims that the bleach did not dispense evenly.

The NEEP market baseline study found that the informational barriers concerning tumble washers were being reduced. The study made mystery shopper calls and visits and found that manufacturer toll-free numbers generally gave accurate information about tumble washers and that 50% of salespeople showed the tumble washer without prompting, 17% showed it first, and 72% of the salespeople eventually recommended tumble washers. The baseline study found that 61% of randomly selected consumers were aware of tumble washers.

The baseline study found that an average of 29% of those planning to purchase, or 3.4% of the entire pool, stated they were likely to buy a tumble washer. The study conducted a census sample of the dealers in the Clothes Washer Study region and found that all of the chain stores sold the tumble washers, while a portion (66%) of the independents did.

It is difficult to determine how the tumble washer market environment of New Jersey compares to those in the states in NEEP's Clothes Washer Study region. However other energy efficiency advocates have identified high efficiency clothes washers in general, and tumble washers in particular, as very promising energy efficiency measures. CEE ranked it 2nd out the 56 residential and C & I measures that it screened. NEEA ranked tumble-action clothes washers 1st out of the 15 energy efficiency measures it reviewed. The tumble-action clothes washer also reached the top 10 rankings on measure screenings conducted by BECo and NEEP.

High Efficiency Domestic Water Heaters (DHWs)

After space heating, water heating is the second largest end use in the residential sector. Primary energy consumption for water heating accounts for 13% of total sector energy use.

The National Appliance Conservation Act has established minimum energy efficiency standards for water heaters measured by Energy Factor (EF) with the minimum EF for gas (40 gallon tank) being 0.54 and the minimum EF for electricity (50-gallon tank) being 0.86. However, by using promising DHW technologies, consumer operating savings can range from 15-100% over the present installed stock. [xviii]

With a sizable share of residential energy use going to domestic water heating and with the potential for great efficiency gains from existing water heater technologies, it is not too surprising that many energy efficiency experts see high efficiency water heating as a very promising measure. CEE ranked high efficiency electric water heating 4th out of the 56 residential and C & I energy efficiency measures it reviewed with a Likelihood of Success score of 5. CEE also ranked high efficiency gas storage water heating as the 8th highest measure and also gave it a Likelihood of Success rating of 5. PG&E ranked high-efficiency storage-type residential water heaters first among the 64 measures its screened and also gave it a Likelihood of Success rating of 5. NEEA ranked high-efficiency electric storage water heaters 2nd among the 15 measures it reviewed.

However, high-efficiency DHW still faces many formidable market barriers. The high-efficiency and solar water heating units account for less than 1% of yearly residential water heater sales annually. The EFs for gas water heaters can range from 0.42-0.86 but the great majority are below 0.65. [xix] The 1997 PSE&G new construction baseline study found that the water heater efficiencies in new New Jersey homes were just barely over the federal minimum level and few had EFs that exceeded 0.57.

One of the market barriers for the high efficiency DHW is its higher first cost. The intense competition in the domestic water heater market has widened the gap between the first costs of the standard- and high- efficiency DHWs. Water heater manufacturers are more willing to discount the standard efficiency models than they are the high-efficiency models. [xx] For example, the highest efficiency gas water heater cost about $940 compared to $422 for a standard-efficiency gas water heater. It would take over 20 years for the purchaser of the high-efficiency gas water heater to recoup his/her investment in energy savings.[xxi]

The classic split incentive market barrier also discourages the purchase of high efficiency gas water heaters. Landlords who are responsible for purchasing the water heater but who are not responsible for the electric or gas bills have the incentive to disregard efficiency and purchase the least expensive model. Builders and developers also have little incentive to purchase high-efficiency water heaters since the water heater is invisible and it competes with other features of the house that are visible and which make the house more salable.

Geothermal Heat Pumps

In 1994 the Department of Energy joined with the EPA and a number of electric research and trade associations for the "National Earth Comfort Program" which was going to spend $100 million ($35 million from the DOE and $65 million from the electric industry) for an ambitious transformation of the market for geothermal heat pumps (GHPs). The coalition hoped to increase annual sales of GHPs from 40,000 per year to 400,000 per year. The goals proved to be too ambitious and neither DOE nor the utilities produced all the money that had originally promised. In addition, electric restructuring caused many utilities to lose interest in the project. One of the administrators of the initiative acknowledged that the GHP industry "was insufficiently capitalized to overcome the entrenched barriers of low public awareness and deficient market infrastructure without utility marketing and communications support."[xxii]

Another market barrier to the wider use of GHP is the scarcity of ground loop and mechanical installers who have experience installing ground source heat pump systems. In 1997 only 11% of HVAC contractors installed a geothermal heating and cooling system and the median of these only installed 5 systems.[xxiii] Even a GHP advocate had to acknowledge that "[w]ith such low participation and sales volume, one can expect customers to find it hard to find an experienced installer if they do, the prices they face are likely to be much higher than what they would see in a more mature, higher-volume and more competitive market."[xxiv]

Another GHP market barrier is the high first cost of the systems. One reason that the GHP's business has begun to shift from the residential to the commercial sectors is that commercial and institutional customers can afford the high first costs of the systems.

In order to help develop this market, GPU Energy competed for, and was awarded a grant from the Geothermal Heat Pump Consortium (GHPC) to form the Geothermal Resource Group (GRG). GRG is an independent, non-profit organization whose mission is to assist in the development of the infrastructure for geothermal applications, and to guide both residential and commercial customers through the design and installation process. GRG provides Design Assistance Grants to commercial customers, schools, and municipalities interested in using geothermal technology. Several thousand tons of high efficiency geothermal heat pump installations have been affected through this partnership. GRG is currently working on a

Demonstration Home project that would be used to showcase geothermal technology as well as other energy efficient residential technologies.

The GHP initiative and its industry partners have begun to focus their marketing and educational efforts towards the commercial and institutional markets. After describing the many advantages of these new markets, one GHP advocate explained the limitations of the residential market:

> Residential markets, on the other hand, are much more diffuse, with millions of individual decision-makers served by tens of thousands of HVAC contractors - both of which groups are often relatively unsophisticated compared to their non-residential counterparts. Residential markets therefore require more resources such as mass advertising and public education sustained over time in order to affect lasting market transformation.[xxv]

The ENERGY STAR program also promotes geothermal heat pumps. The program maintains on its website a list of geothermal heat pumps that qualify for its ENERGY STAR label. The EPA estimates that, on average, a properly sized and installed ENERGY STAR-labeled geothermal heat pump can save consumers 30-40% on heating and cooling bills.

While there are good market transformation opportunities for GHPs in the commercial and institutional sectors, high first costs, steeper educational and information barriers, and a scarcity of experienced GHP installers make residential market transformation much more difficult.

<u>Solar Domestic Water Heaters (DHWs)</u>

Sales of solar thermal collectors have declined from a peak of 20 million square feet in 1981 to a level of 7.7 million square feet in 1995. Only about 10% of these collectors are used for solar DHWs.[xxvi]

The major market barrier for the solar DHW is its high first cost, especially for installation. For example, the installed cost of a solar DHW can range from $1,650- $4,300 depending on how many utility rebates are available and the size of the installer's markups.[xxvii] The most economically attractive application of solar DHWs are to use them to replace electric resistance water heaters. At the lowest $1,650 installation cost, a solar DHW could have a 3-5 year payback. However, at the $4,300 price, which assumes full installer markup and no utility rebate, the payback period could be over ten years.

Another barrier to wider use of solar DHW is the limited familiarity of many plumbers with this option. For example, Barbour, Brodrick, and Ryan describe a typical situation:

> In residential replacements, 80 percent of the water heater market, most water heaters are brought in emergency situations – the existing water heater has begun leaking. The plumber explains the available options to the water heater purchaser. If the plumber does

> not install heat pump water heaters or solar water heaters, most likely the consumer will not be informed about them.[xxviii]

Barbour, Brodrick, and Ryan cite other market barriers for solar DWHs including "a somewhat negative public image due to past problems unscrupulous or unqualified contractors."[xxix] In addition, past problems with loan defaults have made banks reluctant to loan money for solar projects. Without bank financing or tax incentives, many interested customers are unable or unwilling to shoulder the large first cost of the solar DHW system.

Second Refrigerator Removal

According to evaluators, these programs are very popular. In a Southern California Edison (SCE) refrigerator program, for example, there were very high participation rates. Many SCE customers told the program evaluators that they had wanted to get rid of their refrigerators for some time but could not summon the energy to act.

GPU Energy ran this program from 1993-1996. During this period, GPU Energy collected 39,457 refrigerators and freezers. This represents an annualized saving of 45,271 MWh.

However, despite these high participation rates, the SCE program produced relatively small energy saving impacts. Part of this was due to the fact that the program had a relatively high free-ridership rate (around 40%). The small energy savings also resulted from the fact that many of the people did not use the second refrigerators year round.

Second refrigerator replacement programs can have other benefits. These programs can better ensure that old refrigerators are disposed of and recycled properly. Refrigerators contain chlorofluorocarbons (CFCs), in their refrigerant (Freon) and foam insulation. However, while, many refrigerator recycling places retrieve the Freon, few also recover CFCs from insulating foams. Yet nearly 85% of the CFCs in a typical U.S. refrigerator is contained in the insulating foam.

Air Conditioning Cycling

Because of the recent trend of high summer temperatures and record peak loads, the need for air conditioning cycling programs could not be greater. With wholesale electricity prices also hitting records levels in recent years, the avoided cost savings of such programs could be significant.

The usefulness of air conditioner cycling programs, however, are very dependent on the program implementation. High tariff rates and the basic utility fear of making their customers unhappy can deter utilities from actually doing the cycling. For example, MG&E's air conditioning cycling program has rarely been used because it has a very high $8 per kWh tariff rate. PSE&G paid out participants in its air conditioning cycling program $8 per month whether they were cycled or not, so the tariff was not a deterrent. GPUE offers $6 per month. However, according to evaluators of PSE&G's program, PSE&G also rarely did any cycling, mainly because they did not want to inconvenience their customers.

Compact fluorescent lamps and fixtures

Compact fluorescent lamps (CFLs) can use 75% less energy than standard incandescent bulbs and can last up to 10 times longer. Despite these benefits, however, CFLs have yet to grab a significant share of the residential lighting market. For example, the PSE&G residential new construction baseline found that only 4.4% of the fixtures examined were fluorescent and an even smaller percentage of these were CFLs. New Jersey utilities are close to completing a more comprehensive study of baseline residential lighting practices.

A number of national and regional initiatives are in place to promote the use of CFL lamps and fixtures. The ENERGY STAR program currently has approved 21 lamps as meeting its ENERGY STAR criteria. The ENERGY STAR program has also established a specification for residential lighting fixtures.

The primary market barrier to wider use of CFLs is the high first cost of these lamps. CFLs typically cost $16-$18 more than standard incandescent lamps. These incremental costs are even higher for hard-wired fixtures. The NEEP initiative is trying to reduce these cost barriers by offering $10 rebates for each lamp.[xxx]

Another market barrier is the unawareness of consumers, retailers, and builder/contractors of the wide range of CFL products available. To help remedy this problem, the NEEP initiative developed a catalog of lighting products that contained the most popular fixtures and CFLs. NEEP is also developing a major marketing/consumer education effort as well as joint promotional efforts with manufacturers and retailers that includes retail training, Point-of-Sale materials, and other customer education tools.

Many consumers may avoid purchasing CFLs because they have had bad experiences in the past with CFLs and other types of fluorescents of uneven quality. By advertising that its CFLs meet stringent quality criteria, the Energy Star program is already trying to address this fear. The Energy Star website claims that its CFLs "distribute light symmetrically, providing high-quality, warm and inviting light without the flickering and humming of older fluorescent bulbs." NEEP is also developing comprehensive, national product eligibility criteria and is establishing a testing regime to qualify products for inclusion in its initiative.

CEE ranked screw-in CFLs as 14th out of the 56 energy efficiency measures that they screened with a Likelihood of Success score of 3. PG&E ranked its "fluorescent fixtures - residential" measure as 5th out of the 64 measures it reviewed, also giving it a Likelihood of Success score of 3. Its evaluation also ranked the "CFL buydown - residential" as 34th of its 64 measures with a Likelihood of Success rating of 3. NEEA listed screw-in CFLs as 10th out of the 15 measures they ranked.

High-efficiency gas furnaces and boilers

EPA estimates that, on average, a properly sized and installed ENERGY STAR -labeled furnace can save consumers 15% on heating bills. To meet the Energy Star standard furnaces must have an AFUE of 90. The PSE&G residential new construction baseline study found that only 12% of the homes surveyed had gas heating equipment with AFUEs of 90 or better. Most of the new furnaces had AFUEs in the 80-84 range. High incremental costs are the primary barrier to the wider use of high-efficiency furnaces or boilers.

The classic split incentive market barrier also discourages the purchase of high efficiency furnaces and boilers. Landlords and building managers who are responsible for purchasing a new furnace or boiler who are not responsible for the electric or gas bills have the incentive to disregard efficiency and purchase the least expensive model. Builders and developers also have little incentive to purchase high-efficiency furnaces or boilers since this equipment is relatively invisible to most home buyers and it competes with other features of the house that are visible and which make the house more salable.

C. The Bundled New Construction Program

PSE&G's 1997 baseline study found that energy-efficient building practices in New Jersey were inadequate in a number of areas including:

- No basement/floor insulation - A vast majority of the homes had neither basement nor basement ceiling insulation.
- Leaky building shells - The surveyed homes had building shells which are relatively leaky. The leakage levels shown to be reasonably attainable under leading utility sponsored program to promote efficiency in new construction are 30-40% lower than those found in the survey.
- Leaky duct systems and poor duct system design - On average, the surveyed duct systems leaked approximately 17% of all conditioned air to the outside. A more acceptable and achievable level of efficiency would be a leak rate of less than 5% of conditioned air flow. Duct system design was also found to be lacking with the result that most of these systems were significantly unbalanced
- The HVAC equipment was almost universally just above the bare minimum possible efficiency given the equipment available in the marketplace. - High-efficiency gas furnaces (> 90%) were found in only 12% of homes. The mean efficiency of CAC was only 10.36, just barely above the minimum Federal standard of 10.0.
- Significant problems were found with the sizing and installation of HVAC systems. Both heating & cooling systems were almost universally oversized relative to actual home loads. The average cooling system was oversized by 60% & the average heating system had 75% more capacity than necessary. In addition, the air flow over the CAC's indoor

coil was found to be within 25 cfm of the manufacturer-recommended level of 400 cfm per ton of equipment capacity for only 22% of installations.

- 80% of the homes would not meet the commonly accepted national energy efficiency standard (CABO MEC 1995). New Jersey's energy code is based on ASHRAE 90A-1980 and 90B-1975, both of which predate CABO MEC 1995.
- About 50% of the homes had "low-E" windows, but if more of the new homes had these, along with basement insulation, they would have been able to meet the CABO MEC standard.

In summary, this study showed that there was a great need for energy-efficiency improvement in the building envelope and HVAC systems of new homes in New Jersey.

Despite the great opportunities for savings, a number of market barriers have discouraged builders and developers from improving the energy efficiency of these new homes. One of these is the split incentive problem. Because the builder or developer will not be paying the future energy bills and because home buyers are typically not seeking or demanding high-efficiency HVAC and water heating systems, the builders or developers have little incentive to install these high efficiency systems. Builders and developers would rather save money on the first cost of the HVAC or water heating system and spend this extra money on features that are likely to sell the home.

The fact that home buyers are not demanding high-efficiency features points to another large market barrier, the inadequate consumer awareness the benefits of energy efficiency and the related lack of demand for energy-efficiency homes. This lack of consumer awareness and demand not only discourages builders and developers from installing energy efficient measures, it also can deter many builders and realtors from even participating in utility-sponsored market transformation programs that might cause them to change their thinking and behavior.

Another market barrier is that many builders and developers like to purchase all their appliances from the same company. This means that if the supplier of the appliances does not have many energy efficient models in its portfolio, the builder or developer will be unwilling to shop around to find the missing energy efficient models. The increased proliferation of ENERGY STAR products, thanks to the efforts of the ENERGY STAR program as well as other utility and regional DSM initiatives that promote ENERGY STAR products, should reduce this barrier somewhat in the future.

In situations where the profit margins of builders are very low, such as in very competitive housing markets or with the construction of lower cost housing, builders and developers may avoid higher efficiency measures because their higher first costs threaten to cut into their already slim margins. In such markets, many builders feel that they are unable to pass along the additional cost of improved insulation, higher SEER values, and high efficiency windows, because if they did, the house would not sell.

However, there are reasons for hope. A number of recent residential new construction market transformation programs have reported moderate levels of success. These programs have found that improved energy efficiency can sometimes be used as a marketing tool which builders, especially in high-end markets, can use to legitimize the quality of their building practices. The fact that all the major New Jersey utilities have committed to new construction energy efficiency programs also will increase the likelihood of success of this measure.

[i] See Kushler, Martin G., James P. Malinowski, Nicholas P. Hall, *Serving Low Income Households In A Competitive Environment: It's A Tough Job, But Someone's Got To Do It*, In Proceedings of the 1998 ACEEE Summer Study on Energy Efficiency in Buildings, Washington, D. C.: American Council for an Energy-Efficient Economy, for a more detailed discussion of the segmentation of the low-income population.
[ii] See Tannenbaum, Bobbi and Kathy Kuntz, *Low-Income Energy Service in a Competitive Environment*, In Proceedings of the 1998 ACEEE Summer Study on Energy Efficiency in Buildings, Washington, D. C.: American Council for an Energy-Efficient Economy, for a more detailed discussion of the possible effects of welfare reform on energy assistance.
[iii] See Lisa Skumatz and Chris Ann Dickerson, *Recognizing All Program Benefits: Estimating the Non-Energy Benefits of PG&E's Venture Partners Pilot Program (VPP)*, In Proceedings of the 1997 International Program Evaluation Conference, Chicago, IL for a more detailed discussion of these non-energy benefits.
[iv] Public Service Electric and Gas, 1997, *Baseline Survey of Residential New Construction,* Prepared by Vermont Energy Investment Corporation and Proctor Engineering Group, October 1997.
[v] Central cooling accounts for 11.4% of residential electricity use. Only refrigeration (13.9%) and primary/secondary space heating (12.3%) are larger sources (EIA 1995).
[vi] Neme, C. et al., *PSE&G Lost Opportunities Study: Preliminary Residential Market Analysis*, May 1994.
[vii] Neme, C, J. Peters, and D. Rouleau, 1998, *Promoting High Efficiency Residential HVAC Equipment Equipment: Lessons Learned from Leading Utility Programs*, In Proceedings of the 1998 ACEEE Summer Study on Energy Efficiency in Buildings, . Washington, D. C.: American Council for an Energy-Efficient Economy.
[viii] For a discussion of these CAC installation problems see C. Neme, J. Proctor, and S. Nadel, *National Energy Savings Potential From Addressing Residential HVAC Installation Problems*, February 1999.
[ix] Ibid, p. 16.
[x] For example, see NCLC (National Consumer Law Center) 1996. *A Guide to Low-Income Energy Efficiency.* Boston, Mass.: National Consumer Law Center, Inc. and NCLC (National Consumer Law Center) 1995. *Cleveland State University Surveys Low-Income Households' Electrical Demand*. FaxAlert Number 59. Boston, Mass.: National Consumer Law Center, Inc.
[xi] RLW Analytics 1998. Market Assessment for Tumble Clothes Washers and Other ENERGY STAR Appliances Phase 1: The Baseline Assessment FINAL REPORT Prepared for: Northeast Energy Efficiency Partnerships, p. 40.
[xii] Ibid., p. 44.
[xiii] Ibid., p. 41.
[xiv] Sandahl, Linda and Theresa Odell, 1998, *Northwest Manufactured Homes: A Key Market for Energy Star Products,* In Proceedings of the 1998 ACEEE Summer Study on Energy Efficiency in Buildings, Washington, D. C., p. 11.
[xv] Sandahl, Linda and Jim Russell, 1996, *A Unique Approach to Promoting Energy- and Resource-Efficient Home Appliances: The E-Rated Appliance Program*, In Proceedings of the 1996 ACEEE Summer Study on Energy Efficiency in Buildings, Washington, D. C., p. 9.192
[xvi] Biermayer, Peter J., 1996, *Energy and Water Savings Potential of Dishwashers and Clothes Washers: An Update*, In Proceedings of the 1996 ACEEE Summer Study on Energy Efficiency in Buildings, Washington, D. C., p. 2.1
[xvii] RLW Analytics 1998, p. 21.
[xviii] Barbour, Edward, Jim Brodrick, and John Ryan, 1998, *Water Heating: Large Energy Savings that are Hard to Heat Up*, In Proceedings of the 1998 ACEEE Summer Study on Energy Efficiency in Buildings, Washington, D. C., p. 1.
[xix] Ibid.
[xx] Barbour, Edward, Jim Brodrick, and John Ryan, 1998, p. 10.13.
[xxi] Ibid., p. 10.16
[xxii] L'Ecuyer, Michael and Harvey Sachs, 1998, *Geothermal Heat Pumps: A Mid-Term Status Report on a $100 Million Public/Private Market Transformation Effort*, In Proceedings of the 1998 ACEEE Summer Study on Energy Efficiency in Buildings, Washington, D. C., p. 7.188.
[xxiii] Ibid.
[xxiv] Ibid.
[xxv] Ibid., p. 7.197.

[xxvi] Barbour, Edward, Jim Brodrick, and John Ryan, 1998, p. 10.13.
[xxvii] Ibid. p. 10.16. The source of the cost figures in this Barbour, Brodrick, and Ryan analysis is Arthur D. Little, Inc. August 1996. *Market Disposition of High Efficiency Water Heating Equipment*. Prepared for the U.S. Department of Energy.
[xxviii] Ibid.
[xxix] Ibid., p. 10.17.
[xxx] Wall, Bruce. J. and David Hewitt, Regional Market Transformation: A Regionally Reasonable Approach?, 1998, In Proceedings of the 1998 ACEEE Summer Study on Energy Efficiency in Buildings, Washington, D. C., p. 7.353.

E3

C&I NEED FOR PROGRAM & LIKELIHOOD OF SUCCESS SCORES

Cooling Measures

NEEP has implemented a regional initiative to promote the Consortium for Energy Efficiency unitary cooling equipment standards as well as improved contractor practices to save energy by properly installing, and sizing, this equipment. If successful, this effort may be expanded to include HVAC equipment maintenance improvements.

Initiative activities to promote high efficiency equipment and practices include:

- Technical and market research,
- Equipment incentives and coordinated marketing of high efficiency equipment,
- Customer education, and
- Trade ally outreach.

A program is suggested that attempts to transform elements of the markets including the efficiency baseline of equipment specification. This program hopes to lay the groundwork for an upgrade to New Jersey's commercial building code by advancing efficient equipment and practices. This program will use specialized marketing and services for targeted market segments, which is the shared responsibility of a program implementation contractor and utility field staff and marketing representatives.[i]

Early Chiller Replacement

In their paper, Nadel and Suozzo give optimization of chiller and tower systems a 3 on their likelihood of success scale (Selecting Technologies and Practices for New Market Transformation Initiatives-ACEEE 1998). [ii]

Chillers are an expensive item to purchase and install. It is sometimes necessary to make major building modifications to allow installation. Therefore, early retirement is not often considered. However, if CFC is an issue, this may become an attractive option.

	Retrofit	Renovation
Likelihood of Success	1.0	3.0
Need for Program	4.0	3.0

HE Chiller

In their paper, Nadel and Suozzo give optimization of chiller and tower systems a 3 on their likelihood of success scale.[iii]

If a chiller has reached the end of its life, and a new chiller has to be installed anyway, the incremental cost of a high efficiency chiller is not as large a barrier as trying to get an organization to retire an operating chiller early. Chiller salespeople do a fairly good job already of explaining the energy saving potential of a HE chiller. Also, chillers last may years, so the incremental cost doesn't look as large when you think about it over the life of the equipment.

	Retrofit	Renovation
Likelihood of Success	1.0	3.5
Need for Program	3.0	2.5

Chiller Optimization

In their paper, Nadel and Suozzo give optimization of chiller and tower systems a 3 on their likelihood of success scale.[iv]

This measure is after the chiller has been purchased, so it has the same likelihood of success and need for program scores under the retrofit and renovation scenarios.

Likelihood of Success	2.5
Need for Program	4.0

HE ventilation motors (see HE motors)

VAV Controls

VAV systems are the system of choice for many types of facilities. They can provide better occupant comfort and energy savings over some other systems. They have been around for a while now.

	Retrofit	Renovation
Likelihood of Success	2.0	4.0
Need for Program	3.0	2.5

High Efficiency DX (A/C and HP)

For heat pumps, the Tier 1 efficiency is a 9.6, while for DX units, the Tier 1 efficiency is a 9.9. For both heat pumps and DX units, the Tier 2 efficiency is a 10.9.

In their paper, Nadel and Suozzo give Tier 2 commercial packaged A/C a 4 on their likelihood of success scale, and Tier 1 commercial packaged A/C a 5.[v]

There are more Tier 1 units available, and at a lower cost. Based on anecdotal information, it appears that the lack of awareness may be higher for HP than for DX units. The incremental costs associated with installing a higher efficiency unit are relatively small, but these installations are unlikely as a renovation.

Tier 1	DX-Retrofit	HP-Retrofit	DX-Renovation	HP-Renovation
Likelihood of Success	1.5	1.0	3.5	2.5
Need for Program	2.0	2.5	2.5	3.0

Tier 2	DX-Retrofit	HP-Retrofit	DX-Renovation	HP-Renovation
Likelihood of Success	1.0	1.0	3.0	2.0
Need for Program	2.5	3.0	3.0	3.5

High Efficiency Window Units

Several different manufacturers produce window units. These units are rated by the Energy Star program.

Window units, tend to be smaller, and thus use less energy. Therefore, the amount of possible savings are also smaller. They are relatively low cost items.

	Retrofit	Renovation
Likelihood of Success	3.5	4.0
Need for Program	2.0	1.5

High Efficiency Gas Furnaces and Boilers

Several different manufacturers produce high efficiency gas furnaces and boilers. Many people nowadays realize the benefits associated with purchasing efficient furnaces and boilers. If the old boiler/furnace has to be replaced anyway, the incremental costs associated with purchasing a more efficient boiler/furnace can be minimized.

In their paper, Nadel and Suozzo give high efficiency commercial gas furnaces and boilers a 4 and Energy Star furnaces and boilers a 3 on their likelihood of success scale.[vi]

Because boilers and furnaces are relatively expensive, the need for program is higher and the likelihood for success is lower then in a retrofit case.

	Retrofit	Renovation
Likelihood of Success	1.5	3.5
Need for Program	3.5	3.0

Proper HVAC Installation

In their paper, Nadel and Suozzo give high quality commercial A/C installation and maintenance a 3 on their likelihood of success scale. [vii]

This measure is after the HVAC system has been purchased, so it has the same likelihood of success and need for program scores under the retrofit and renovation scenarios.

Likelihood of Success	2.5
Need for Program	4.0

Interior Lighting

NEEP, the coordinator of the DesignLights Consortium, is bringing together regional utilities and other stakeholders to support regional market transformation efforts that promote energy-efficiency and high quality lighting design and specification in commercial buildings throughout the Northeast. The initiative initially targeted property management firms, large retail chains, state government, and municipal facilities and other market players that influence design, specification, selection, and installation of lighting systems. More recently the program has been focusing its efforts on electrical contractors who might have the greatest need for the lighting design guidelines produced by the initiative.

NEEP is sending out a request for proposals to develop, promote and coordinate training seminars for electrical contractors, to demonstrate the use of commercial lighting design guidelines for the office, school and small retail markets.[viii]

T8/Electronic Ballasts

The installation of energy-efficient electronic ballasts and T8 lamps in U.S. commercial and industrial buildings has been encouraged by tightened federal energy standards, government programs, and utility and energy service company initiatives.[ix]

In their paper, Nadel and Suozzo give T8 lamps with electronic ballasts a 4 on their likelihood of success scale.[x]

Early electronic ballasts had reliability and performance problems, though most of these problems have been corrected. One unresolved problem with T8 lamps is, in the longer fixtures, the lamps can bow. Currently, it is possible to purchase a four foot T8 lamp that has a lower initial cost than a four foot 34W T12, so under the renovation scenario, the likelihood of success is high and the need for program is low. However, under retrofit assumptions, the savings are there, but the incentive to make the change without a program may not be.

	Retrofit	Renovation
Likelihood of Success	3.0	4.5
Need for Program	2.0	1.0

Reflectors

Proper lighting design is important if one wishes to reduce the number of lamps/fixtures. Building managers, owners, etc. do not like to hear complaints about insufficient light, so it is much easier to overlight an area. Reflectors save money in two ways, they reduce energy costs and they reduce the number of lamps that will have to be purchased now and in the future. They require cleaning to operate efficiently. As with many other technologies, the likelihood for success is higher and the need for program lower under the renovation assumption.

	Retrofit	Renovation
Likelihood of Success	1.0	2.0
Need for Program	3.5	3.0

Interior HID

End users usually consider HID lamps as being large, very bright, exterior light sources often without good color rendering properties. HID lamps require ballasts and a special fixture. The savings are there in both cases, which is why the need for a program was rated a 3 under both scenarios.

	Retrofit	Renovation
Likelihood of Success	2.0	2.5
Need for Program	3.0	3.0

CFL Lamps and Fixtures

In their paper, Nadel and Suozzo give screw-in CFLs a 3 on their likelihood of success scale.[xi]

In addition to being more energy efficient, CFLs are longer lasting than incandescents. This means lower maintenance costs. Although they have a higher first cost, this cost has been dropping. The color rendering has also been improving. Some fixtures will not take CFLs lamps. Screw-in CFLs can too easily be replaced with incandescents. To overcome the limitations of screw-in CFLs, utility programs have been increasingly promoting fixtures with hard-wired CFL ballasts that will only except CFL lamps. Because CFLs have a relatively high first cost, when compared to the baseline of incandescents, the likelihood of success is lower under the retrofit scenario.

	Retrofit	Renovation
Likelihood of Success	3.0	4.0
Need for Program	2.5	2.0

Exit Signs

Innovations in light-emitting diode (LED) exit signs may make LED signs the best choice among the energy efficient options available. These signs have low power consumption, projected long lamp life, and low maintenance requirements. [xii]

LED exit signs are rated in the Energy Star program, providing assurance that you are purchasing an efficient sign. However, CFL exit signs are also more efficient than the incandescent variety, and are also ENERGY STAR rated.[xiii]

In their paper, Nadel and Suozzo give LED exit signs a 5 on their likelihood of success scale.[xiv]

LED exit signs have a longer life, thus reducing maintenance costs. Some of the early LED signs were not bright enough, thus lowering customer acceptance. LED exit signs also tend to be more expensive. The market eventually will move from the traditional incandescent signs, but it remains to be seen whether the new signs will be electrolumenesent, LED, or CFL.

	Retrofit	Renovation
Likelihood of Success	2.0	3.0
Need for Program	3.0	3.0

Occupancy Sensors

In their paper, Nadel and Suozzo give occupancy sensors a 3 on their likelihood of success scale.[xv]

The choice of location and type of sensor is important. Often the wrong choice, or improper installation, will make the lamp turn off at inopportune times. This bad experience has turned off many people who might otherwise use the sensors. Occupancy sensors are relatively inexpensive.

As with many other technologies, the likelihood for success is higher under the renovation assumption.

APPENDIX E3 C&I NEED FOR PROGRAM & LIKELIHOOD OF SUCCESS SCORES

	Retrofit	Renovation
Likelihood of Success	2.5	3.5
Need for Program	3.0	2.0

Daylight Dimming Controls

In their paper, Nadel and Suozzo give daylight dimming controls a 2 on their likelihood of success scale.[xvi]

Daylight dimming controls offer an opportunity for large energy savings. One problem is that people have different ideas about how much light is needed and like to be able to control the illumination in their work space. Building managers, owners, etc. do not like to hear complaints about inadequate light levels, so it is much easier to overlight an area and let the occupant control the lights. As with many other technologies, the likelihood for success is higher the renovation. assumption. However, the savings potential is so high and the use so infrequent that the need for program is high under both scenarios.

	Retrofit	Renovation
Likelihood of Success	2.0	3.0
Need for Program	4.0	4.0

Exterior Lighting

MV to HID (HPS)

HPS lamps are more energy efficient than MV lamps. However, standard HPS lamps have poor color rendering. Improved HPS lamps are available with better color rendering properties.[xvii] Cost is not a major issue, at least not if the MV lamp needs replacing anyway, since the cost of the lamps is comparable (even the improved HPS lamps).[xviii] If the MV lamp is operating properly, it may be harder to for the facility personnel to justify the costs associated with changing the lighting system, but the energy savings are significant. It may also be necessary to convince people that the improved HPS lamps provide good color rendering.

	Retrofit	Renovation
Likelihood of Success	2.0	4.0
Need for Program	4.0	3.0

Exterior Incandescent to HID

When people think of HID technologies, they often think of switching between them, not from a different type of lamp to a HID lamp. People also often think of HID lamps as being larger, brighter, and without good color rendering properties.[xix] Incandescents have a very low first cost, so their replacement cost is not a major concern. HID lamps require ballasts and a new fixture.[xx] The savings are significant in both cases, which is why the need for a program was rated a 3 under both scenarios.

	Retrofit	Renovation
Likelihood of Success	2.0	2.5
Need for Program	3.0	3.0

Photocell Controls

Photocell technology is well understood and has been around for many years. Some fixtures even come with a photocell installed. It is often not difficult to add a photocell control. The savings potential is highest with the less energy efficient lighting technologies.

	Retrofit	Renovation
Likelihood of Success	3.5	4.0
Need for Program	3.0	2.0

O&M improvement

Limited program experience, including some in the Northeast, demonstrate potential energy savings of 6% to 14% in commercial and industrial facilities from improved equipment operation and maintenance. NEEP is considering options for operator training and certification as well as promotion of improved practices to increase efficiency, comfort and productivity.[xxi]

There are often difficulties in getting O&M dollars from management, since some managers see O&M as a place to save money, not spend it, although some O&M improvements are low/no cost items.

	Retrofit	Renovation
Likelihood of Success	2.5	3.0
Need for Program	3.0	2.5

Recommissioning

In their paper, Nadel and Suozzo give recommissioning a 3 on their likelihood of success scale.[xxii]

Recommissioning is an often overlooked way to save energy. A system that is out of balance, or not operating properly can, if recommissioned, save energy, improve occupant comfort, and maybe even extend the life of the equipment. However, it is often difficult for facility management staff to get O&M money for this purpose.

	Retrofit	Renovation
Likelihood of Success	1.5	3.5
Need for Program	4.0	3.5

Motors

High Efficiency Motors

In 1998, NEEP coordinated the Premium Motors Working Group to develop a regional market transformation strategy for premium motors including common goals, objectives and program requirements. To date, about 95% of motor distributors and dealers in those states are participating in a special promotion that offers incentives and technical information for CEE complying premium efficiency motors. The sponsoring utilities are also marketing this program directly to their commercial and industrial customers.

NEEP is working with initiative sponsors in New England, New Jersey and New York to promote premium efficiency motors as the standard for motors sold in the Northeast region for commercial and industrial uses. The Northeast Premium Efficiency Motors Initiative is now offering incentives for motors that meet the Consortium for Energy Efficiency standard for premium motors purchased in New Jersey and several New England states. Other initiative activities include coordinated marketing, technical assistance to trade allies and customers, and program evaluation. This initiative is actively coordinated with U.S. DOE's Motor Challenge Program.[xxiii]

There are many different manufacturers of high efficiency motors. However, pre-EPACT motors are still available through vendors and are sold at low prices.[xxiv]

Training curriculum has been developed by the Energy Center of Wisconsin, the Hydraulic Institute, and Motor Challenge that educates industry on fluid system optimization principles - - pump and fan systems training.[xxv]

In their paper, Nadel and Suozzo give premium efficiency motors a 3 on their likelihood of success scale.[xxvi]

It is possible to purchase a motor with a higher efficiency and a lower price. In addition, the savings possible from properly sizing a motor can offset any additional costs associated with an increased efficiency. Since cost is an issue with motors, the likelihood of success is higher in the renovation scenario. Because of the high savings potential, the need for program was set at 3 for both scenarios.

	Retrofit	Renovation
Likelihood of Success	2.0	2.5
Need for Program	3.5	3.0

Motor Downsizing

A properly sized motor will operate more efficiently because it will be operating at a higher load factor. It is easy to put in an oversized motor just to be sure that it is big enough. This practice should be discouraged. As mentioned above, the savings possible from properly sizing a motor can offset any additional costs associated with an increased efficiency. Since cost is an issue with motors, the likelihood of success is higher in the renovation scenario. Because of the high savings potential, the need for program was set at 3 for both scenarios.

	Retrofit	Renovation
Likelihood of Success	2.0	2.5
Need for Program	3.0	3.0

Improved Motor Rewind Practices

Each year hundreds of large industrial motors are rewound for continued use. Recently developed national shop standards and training for quality, energy efficient motor rewinds offer opportunities to increase energy savings in large, high-load-hour motors. NEEP is considering options for regional action to promote and establish these practices in the Northeast.[xxvii]

In their paper, Nadel and Suozzo give high quality motor repair practices a 3 on their likelihood of success scale.[xxviii] This is a renovation issue only.

Likelihood of Success	2.0
Need for Program	4.0

Variable Speed Drives

The Electric Power Research Institute (EPRI) has developed the software program called ASDMaster. ASDMaster helps a person designing and purchasing an electronic AC adjustable speed drive to choose and specify the best ASD for their application. System effects are analyzed with the program.[xxix]

In addition to the potential for energy savings, the use of a VSD may allow better control of the process.

The use of VSDs has become more common, although their first cost still is high.

	Retrofit	Renovation
Likelihood of Success	1.5	2.5
Need for Program	4.0	2.5

Process Support

The study of a process can result in energy savings at low capital expenditures if the process can be improved through minor adjustments. If properly adjusted, increased reliability, increased productivity, and decreased energy usage are all possible.

	Retrofit	Renovation
Likelihood of Success	2.0	2.5
Need for Program	4.0	3.5

Process Overhaul

A more complete study and evaluation of an industrial process has the possibility of producing greater benefits than a minor adjustment. However, the costs associated with the overhaul can be high, and the system might need to be taken down for a time.

	Retrofit	Renovation
Likelihood of Success	1.5	2.0
Need for Program	3.5	3.0

Compressed Air Systems

The mission of the Compressed Air Challenge (CAC) is to develop and provide resources that educate industry on the opportunities to increase net profits through compressed air system optimization. An efficient compressed air system can increase productivity and ensure better product quality. A more reliable compressed air system, translates into more cost effective product production as well as on-time delivery and increased customer satisfaction.[xxx]

National and regional research has identified repair and optimization of industrial compressed air systems as a major opportunity for cost-effective energy efficiency. The development of a national compressed air initiative now offers opportunities for action in the Northeast. NEEP is considering options for coordinated regional efforts to promote such practices.[xxxi]

Air compressors are an expensive item to purchase and install. It is sometimes necessary to make major building modifications to allow installation.

Misconceptions about how to decrease the energy and power used by a compressed air system are common. Books have been written for decades that say that using colder air for the intake air to an air compressor will decrease the power consumption. This has recently been found to be not true, although under certain conditions user colder intake air will decrease the energy consumption.[xxxii]

In their paper, Nadel and Suozzo give industrial air compressors a 3 on their likelihood of success scale.[xxxiii]

	Retrofit	Renovation
Likelihood of Success	2.0	3.0
Need for Program	3.0	3.0

LED Traffic Lights

In their paper, Nadel and Suozzo give red only traffic lights a 5 and red/green lights a 4 on their likelihood of success scale.[xxxiv]

LED traffic lights are becoming more common, but they are still more expensive than incandescent traffic lights, and have problems with not being able to be seen clearly in bright sunlight. As with many technologies, the likelihood for success is higher under the renovation assumption. Because these lights have high operating hours, the need for program is high under both assumptions.

	Retrofit	Renovation
Likelihood of Success	2.0	2.5
Need for Program	4.0	3.5

Commercial Refrigeration Doors

These are the plastic strip curtains or other similar devices that you put on open refrigeration cases or cooler doors that are open all the time or loading dock doors for refrigerated warehouses to keep the heat out. They do not restrict access to the inside, however some reluctance was reported by store owners when they first came out for fear that it would dissuade people for making purchases. They are becoming more common, and are less expensive than a solid door.[xxxv]

	Retrofit	Renovation
Likelihood of Success	2.0	3.0
Need for Program	2.0	2.0

High Efficiency Hot Water Heaters

Gas and Electric

In their paper, Nadel and Suozzo give both high efficiency gas storage water heaters and high efficiency electric water heating a 5 on their likelihood of success scale.[xxxvi]

The incremental costs associated with purchasing and installing a higher efficiency hot water heater (instead of a standard efficiency unit) are relatively small. The savings mechanisms are generally understood.

	Retrofit	Renovation
Likelihood of Success	3.0	4.5
Need for Program	2.5	2.0

Heat Pump Water Heaters

Heat pump water heaters are more expensive than natural gas water heaters. If not ducted to the outside, they can increase heating loads in the space, though this may be considered a cooling "bonus" in certain building types with large, localized cooling loads such as restaurants.

In their paper, Nadel and Suozzo give heat pump water heaters a 2 on their likelihood of success scale.[xxxvii]

	Retrofit	Renovation
Likelihood of Success	1.0	1.5
Need for Program	3.5	3.0

Low Flow Fixtures

In many commercial and industrial facilities there is not much water usage. In looking at catalogs for faucets and shower heads, no high water usage products were available.[xxxviii] For the program to have an impact, it would have to get customers who were not planning on installing new fixtures to replace them. This seems unlikely, unless the rebate was for the entire cost (including installation).

	Retrofit	Renovation
Likelihood of Success	3.0	4.5
Need for Program	2.0	1.0

Window Film

Window film not only helps to keep cooling energy costs down, it reduces glare and can help minimize fading of carpet and furniture, thereby delaying the need to replace these items.[xxxix]

In a study prepared for Pacific Gas and Electric, XENERGY and others found that the likelihood of success for commercial window film was a 3.[xl]

	Retrofit	Renovation
Likelihood of Success	2.5	3.0
Need for Program	3.0	2.5

EMS

Energy management systems are sometimes considered as items that can be cut from the building budget. However, they may prove cost effective by ensuring that the systems are all running properly, e.g., thermostats setback during unoccupied periods and lights are off when they should be, etc.

	Retrofit	Renovation
Likelihood of Success	2.0	2.5
Need for Program	4.0	3.5

New Construction

It makes more sense to build an efficient building, instead of having to go back and retrofit it as soon as the building is opened.

The incremental costs for energy efficiency are lower when a building is being built. However, the costs associated with building any building are high, and the need to control budgets may prevent comprehensive consideration and installation of energy efficiency measures, particularly if the building is not owner occupied.

Likelihood of Success	3.0
Need for Program	3.5

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[i] *NEW JERSEY 2000 - 2004 Energy Efficiency Four Year Plan: Commercial & Industrial Electric and Gas Energy Efficiency Programs.* Energy Efficient C&I Construction Program.

[ii] Nadel, Steven and Margaret Suozzo. "Selecting Technologies and Practices for New Market Transformation Initiatives." *Proceedings from the 1998 ACEEE Summer Study on Energy Efficiency in Buildings*. Pg 7.237-7.251.

[iii] I*bid.*

[iv] I*bid.*

[v] I*bid.*

[vi] I*bid.*

[vii] I*bid.*

[viii] http:\\www.neep.org\

[ix] Calwell, Chris, Danielle Dowers, and Doug Johnson. "How Far Have We Come? Remaining Opportunities for Upgrading Fluorescent Ballasts and Lamps." May, 1998. http:\\www.Esource.com.

[x] Nadel, Steven and Margaret Suozzo. "Selecting Technologies and Practices for New Market Transformation Initiatives."

[xi] *Ibid.*

[xii] Sardinsky, Robert and Sue Hawthorne. "LED Exit Signs: Improved Technology Leads the Way to Energy Savings." April, 1994. http:\\www.esource.com

[xiii] EPA. "Selecting and Specifying Energy-Efficient Exit Signs." EPA 430-F-98-008. January, 1998.

[xiv] Nadel, Steven and Margaret Suozzo. "Selecting Technologies and Practices for New Market Transformation Initiatives."

[xv] Nadel, Steven and Margaret Suozzo. "Selecting Technologies and Practices for New Market Transformation Initiatives."

[xvi] *Ibid.*

[xvii] Iowa State University. Conference documentation: "Building Lighting and Air Distribution Systems" Ames, IA. May 20,1991.

[xviii] Grainger. *Catalog no. 389.* 1998-1999. Pg 955-965.

[xix] Iowa State University. Conference documentation: "Building Lighting and Air Distribution Systems" Ames, IA. May 20,1991.

[xx] Grainger. *Catalog no. 389.* 1998-1999. Pg 955-965.

[xxi] http:\\www.neep.org\

[xxii] Nadel, Steven and Margaret Suozzo. "Selecting Technologies and Practices for New Market Transformation Initiatives."

[xxiii] http:\\www.neep.org\

[xxiv] *Atlantic City Electric Company's Demand Side Management (DSM) Programs in NJ*. DRAFT. 2/19/99

[xxv] http:\\www.motor.doe.gov\

[xxvi] Nadel, Steven and Margaret Suozzo. "Selecting Technologies and Practices for New Market Transformation Initiatives."

[xxvii] http:\\www.neep.org\

[xxviii] Nadel, Steven and Margaret Suozzo. "Selecting Technologies and Practices for New Market Transformation Initiatives."

[xxix] http:\\www.motor.doe.gov\

[xxx] http:\\www.knowpressure.org\

[xxxi] http:\\www.neep.org\

[xxxii] Smith, Karen and Howard Shapiro. "Energy Savings Opportunities for Positive Displacement Air Compressors", Proceedings of the ASHRAE Summer Conference, 1996.

[xxxiii] Nadel, Steven and Margaret Suozzo. "Selecting Technologies and Practices for New Market Transformation Initiatives."

[xxxiv] *Ibid.*

[xxxv] Research conducted by Abou-Seido, Ehab I. for Ph.D. Dissertation. 1996.

[xxxvi] Nadel, Steven and Margaret Suozzo. "Selecting Technologies and Practices for New Market Transformation Initiatives."

[xxxvii] *Ibid.*

[xxxviii] Grainger. *Catalog no. 389.* 1998-1999. Pg 3044-3048.

[xxxix] http://www.tri-statewindowtint.com/html/about.html

[xl] American Council for An Energy-Efficient Economy, XENERGY Inc. and E-Source. *Volume 1: Selecting Targets for New Market Transformation Initiatives, Phase II*, March, 1998. Pg 10.

R1 RENEWABLE DISTRIBUTED GENERATION

R RENEWABLE DISTRIBUTED GENERATION

R.1 TECHNOLOGY: SOLAR PHOTOVOLTAIC

R.1.1 Characterization of PV Technology

Solar photovoltaic (PV) modules are large-area solid-state semiconductor devices that convert solar energy directly into electrical energy. Individual PV modules produce direct current (dc) electricity, and are available in sizes from 10 W to 300 W. The modules can be used in a variety of applications including customer sited grid-tied and non-grid-tied applications and large-scale applications. The actual power output depends on the intensity of sunlight, the operating temperature of the module, and other factors. PV modules are designed and sized to produce the desired magnitude of electrical output. The addition of electrical power conditioning components (electrical switches, diode protection circuits, dc-to-ac inverters, etc.) are required to interface the PV output with the electrical load. The resulting assembly of components is known as a 'PV system'.

PV generating systems are easily scaled to meet demand and can be constructed using one or more modules, producing from a few tens of watts to multiple megawatts. Customer sited systems (for residential and small commercial use) are generally just a few kW in size, while the large-scale systems can range up to several MW.

Both customer sited and large-scale applications provide distributed benefits. Customer sited applications reduce customer demand for grid power and may feed power into the grid at low-load or other times. Larger scale systems can be used by generating companies to add capacity incrementally. PV systems are characterized by low operations and maintenance costs because they have few moving parts.

Customer-sited, grid-tied PV systems are expected to be a substantial early market for PV systems because they take maximum economical advantage of the technology's attributes. The unique advantages of PV, (i.e. modularity, low O&M costs, good match to many diurnal load patterns) are important factors for an early cost-effective application.

The legislation refers to "electric energy produced from solar technologies" along with photovoltaic technologies in the definition of Class 1 Renewables. Solar thermal power technology is discussed in the Appendix on Advanced and Other Renewable Technologies.

R.1.2 PV Technology Potential

Based on the analysis that is highlighted in this section, the technical potential for residential rooftop PV in New Jersey is estimated to be approximately 420 MW. To calculate the technical potential, the number of single-family owner-occupied homes in the state was estimated. Then, based on a study by the National Roofing Contractor's Association,[1] these homes were categorized by roofing type. An installation, shading, and orientation factor was then applied to each roofing type. The installation factor, ranging between 0 and 1, represents the ease of installation of a PV system on certain type of roof. For example, asphalt shingles receive a value of 1 because of the relative ease of installation. The shading factor limits the number of homes where PV systems will be suitable based on the presence of large, mature trees. Based on the assumption that New Jersey will have a relatively high presence of tall, mature trees, the shading factor eliminates 75% of all homes. The orientation factor then makes assumptions about the percent of homes that will have suitable space for 4 kW, 3 kW, 2 kW, and 1 kW systems[2]. These assumptions lead to an estimate that there is a technical potential for approximately 168,000 residential PV systems, which represents systems on 16% of NJ owner-occupied single-family dwellings. These sites would supply a total of 422 MW, or over 554 million kWh of power per year.

The following summarizes the calculation of residential technical potential:

Total Kilowatts for Area for Roof Type =

$$H \text{ x } IF \text{ x } SF \text{ X } [(O \text{ x } kW)_4 + (O \text{ x } kW)_3 + (O \text{ x } kW)_2 + (O \text{ x } kW)_1]\text{, where}$$

H = Households in area with give roof type
IF = Ease if installation factor
SF = Shading factor for area
O_i = Percent of homes properly oriented with (i x 100) available square feet of roof space
KW_i = Number of kilowatts (i) the roof can accommodate.

The market potential can be estimated by identifying the households that are potentially "in the market", after estimating that just over 30 percent of households would be less likely to look at a high capital cost investment due to poverty, ages over 65 and frequent moves between dwellings. Then, 50% of the remaining households is an indication of the potential market based on the existence of alternative, substitute onsite generating technologies (including PV) as well as the choice of power supply from the grid. This approach reduced the potential residential rooftop PV capacity from over 400 MW to a market potential in the range of 60 MW.

The installation of commercial and large-scale applications would be incremental, above the potential in the residential market. One study estimates that the technical potential of PV in commercial markets in the U.S. is between 3,000 and 5,000 MW based on the fact that 50 square kilometers of roof space are added each year in the commercial building sector.[3] A rough

[1] National Roofing Contractor's Association, Annual Survey 1994-95.

[2] For further detail on this methodology, refer to "Wenger, H., Hoff, T. and J. Pepper. (1996). Photovoltaic Economics and Markets: The Sacramento Municipal Utility District as a Case Study, September.

[3] Perez, R., Wenger, H., and C. Herig. (1998). Valuation of Demand-Side Commercial PV Systems in the United States.

estimate of the market potential for PV at commercial locations would be 12 MW based on estimating New Jersey's share of this national potential and then assuming that the market potential would be about 20 percent of that.

Finally, the technical potential for centrally-located PV generating stations is essentially unconstrained, given the substantial acreage that could theoretically be used. As a result, a technical potential figure may not be meaningful. However, we also estimated the magnitude of the potential "green power" market in NJ in Section __ of this Assessment, and an estimate of near to mid-term market potential for PV generation not serving on-site customer loads could be based on meeting a range of 2% to 10% of that demand with PV capacity.[4] Although PV carries a higher cost than other green power supplies, it is appealing to customers as a small part of the generation portfolio. A 5% share of the overall green power market portfolio would represent approximately 40 MW. While these categories may overlap to some extent, we do not assume any such overlap in view of the conservatism of the component assumptions. The total of the residential and commercial rooftop market potential and the green market PV potential is 112 MW.. Given the uncertainties implicit in this approach, the PV market potential should be considered as a range, between 70 MW and 170 MW as of 2012.

R.1.3 PV Cost

Photovoltaic (PV) systems have traditionally been economical in certain niche markets, consisting primarily of remote applications. Most common examples include; wireless and cellular communication systems, off-grid homes, recreational vehicles and boats, power for offshore oil rigs, and highway sign lighting and call boxes. Water pumping, vaccine refrigeration, and water purification have all been important roles for PV in developing countries.

For remote locations, PV is likely to be the most inexpensive renewable power generation option. If the extension of utility lines is a major cost factor for generating electricity, PV will provide a cheaper solution. The cost for extending utility lines to remote locations in the US can range from $10,000 to nearly $100,000 per mile. [5]The cost of the grid extension is now often borne by the customer. PV becomes cost effective when the power location is not on the transmission grid.

The costs of many other applications, including grid-tied customer-sited and power station-scale projects, have declined greatly in recent years, but are not cost-effective yet. For customer sited systems, the installed cost of a PV system is currently between $6 and $8 per watt. System costs have declined at a rate of approximately 5.5% per year since 1984, representing a real decline in

[4] PV could also be sited at locations on the T&D system, as part of plans to avoid or defer T&D investment. There is no basis at present to estimate the incremental capacity which might result from this approach above the estimates presented above.

[5] Solar Energy Industries Association, "Powerful Solutions for Residential and Commercial PV Applications." (see www.seia.org/pvapps.html

PV prices of 9% in the absence of inflation. If it is assumed that every doubling in cumulative worldwide PV sales volume leads to an 18% decrease in PV module and that PV module prices continue to constitute half of the PV system price, prices will be halved every eight years in real terms.[6] Therefore, based on 1997 system prices of $6,000 and $8,000 per kW, they will be halved to between $3,000 and $4,000 per kW by 2005. Another analysis suggests that installed costs will reach $4,500 per kW by 2005 and $2,000 per kW by 2015.[7] A study conducted by the National Renewable Energy Laboratory estimates that the break-even cost for residential PV systems in New Jersey is between $3000 and $4000 per kilowatt and several studies indicate that there is a significant market for PV at $3,000 per kW installed. [8] If system costs decline as they are projected to, then PV systems will be affordable to the early adopters in New Jersey around the year 2010, without subsidies. With subsidies, this market may be accelerated.

It is important to note that these estimated costs do not indicate that PV systems will be competitive on a purely economic basis. Instead, PV systems may become affordable in this time frame for niche markets of households and businesses that are motivated by other factors such as environmental benefits, a desire for greater independence, status or image, and emergency power supply following natural disasters.

Projected Cost for Customer-Sited PV Systems[9]

	1997	2000	2005	2010	2020	2030
Installed cost ($/watt)	7.86	6.30	4.74	3.58	2.08	1.21

Large-scale PV system costs are projected to decline at a higher rate than customer-sited systems. The installed cost is expected to decline from a current cost of $7.50 per watt to less than $1.00 per watt in 2030 in 1997 dollars.

Projected Cost for Large- Scale PV Systems[10]

	1997	2000	2005	2010	2020	2030
Installed cost ($/watt)	7.50	4.30	2.30	1.20	0.91	0.72

The cost of energy for various PV applications currently varies widely, but all applications are expected to have a levelized cost of energy of approximately 6.0 cents/kWh by 2030.[11]

6 "Wenger, H., Hoff, T. and J. Pepper. (1996). Photovoltaic Economics and Markets: The Sacramento Municipal Utility District as a Case Study, September.

7 Delmonaco, John, PSE&G Energy Technologies, telephone conversation 16 August 1999.

8 Wenger, H., Herig, C., Taylor, R., Eiffert-Taylot, P., and R. Perez. (1996). Niche Markets for Grid-Connected Photovoltaics. Golden, CO: National Renewable Energy Laboratory. May.

9 Electric Power Research Institute. (1997) Renewable Energy Technology Characterizations. EPRI Topical Report No. TR-109496, December.

10 Electric Power Research Institute. (1997) Renewable Energy Technology Characterizations. EPRI Topical Report No. TR-109496, December.

Currently, the levelized cost of energy for utility-owned residential PV systems is 37 cents/kWh in constant 1997 dollars, while the cost for utility scale applications ranges between 49 and 52 cents/kWh. [12]

Levelized Unit Cost of PV Generation (constant 1997 cents/kWh) [13]

	1997	2000	2010	2020	2030
Utility-Owned Residential	37.0	29.7	17.0	10.2	6.2
Utility Scale Flat-Plate Thin Film	51.7	29.0	8.1	6.2	5.0
Utility Scale Concentrators	49.1	24.4	9.4	6.5	5.3

[11] This is the cost to generate the kWh when the sun is out, not considering the cost of supplemental power for the rest of the time and the rest of the customer load

[12] Electric Power Research Institute. (1997) Renewable Energy Technology Characterizations. EPRI Topical Report No. TR-109496, December.

[13] Electric Power Research Institute. (1997) Renewable Energy Technology Characterizations. EPRI Topical Report No. TR-109496, December.

R.2 TECHNOLOGY: FUEL CELLS

R.2.1 Characterization of Fuel Cell Technology

Fuel cell (FC) power generation units provide an option for utilities and end-users as environmentally-benign, highly efficient sources of electricity and power for residential, commercial, and industrial market applications. No other fuel-based electric generation technology comes close to matching the extremely low emission level. Potential applications range from small, micro-cogeneration units for single-family and multi-family residences and small commercial applications to large industrial and utility power plant applications. Their low emissions and quiet operation allow fuel cells to be installed close to the end user, eliminating the need for transmission and distribution lines.[1]

It must be acknowledged, however, that only one fuel cell manufacturer has a product commercially available at this time. Several others are promising new products using alternative technologies and for different applications within the next few years, but these products are still in the research, development or demonstration phase.

Physically a fuel cell plant consists of three parts: 1) some type of fuel processor that removes fuel impurities and may increase the concentration of hydrogen in the fuel; 2) the fuel cell itself which consists of a set of stacks containing catalytic electrodes; this component generates the electricity; 3) a power conditioner that transforms the direct current produced by the FC into the alternating current used in most electrical applications.

Of the energy stored in the fuel, fuel cells can convert between 40 to 60 percent into electricity. If the heat (thermal energy) released in the process is captured and used, then FCs can achieve efficiencies of 85 to 90 percent, making this technology more attractive than gas turbines and internal combustion engines, which are unable to achieve electrical efficiencies above 40 percent and combined electrical and thermal efficiencies above 60 percent.[2]

How it Works

Fuel cells are electrochemical devices that convert chemical energy into usable electricity and heat without combustion as an intermediate step. Fuel cells are similar to batteries in that both produce a DC current by using an electrochemical process. Two electrodes, an anode and a cathode, are separated by an electrolyte. Like batteries, fuel cells are combined into groups, called stacks, to obtain a usable voltage and power output.

Unlike batteries, however, fuel cells do not release energy stored in the cell, running down when the energy is gone. Instead, they convert the energy in a hydrogen-rich fuel directly into electricity and will operate as long as they are supplied with fuel. Fuel cells emit almost none of the sulfur and nitrogen compounds released by conventional generating methods. The primary fuel source for the fuel cell is hydrogen, which can be obtained from natural gas, coal-derived gas, methanol, landfill gas, and other fuels containing hydrocarbons. Due to this fuel flexibility, power generation can be assured even when a primary fuel source is unavailable.[3]

Types of Fuel Cells

From its start in the U.S. space program, the recognition of fuel cell benefits has led to several RD&D programs involving a variety of fuel cell technologies. The four major fuel cell types are: 1) phosphoric acid, 2) carbonate, 3) proton exchange membrane, and 4) solid oxide.

Fuel cell systems are categorized by the type of electrode used, which gives each its name as well as by operating temperature. These include:

Phosphoric Acid Fuel Cell (PAFC): These fuel cells use phosphoric acid liquid electrolyte. Complete PAFC systems have been demonstrated at customer sites as commercial cogeneration units, and ONSI Corporation produces the only commercially available fuel cell, a 200 kW unit called the PC 25.

Molten carbonate fuel Cell (MCFC): MCFCs use a lithium/potassium carbonate electrolyte mixture, and are being tested in full-scale demonstration. These fuel cells also offer higher fuel-to-electricity efficiencies, approaching 60 percent, and operate at higher temperatures, making them candidates for combined-cycle applications in which the exhaust heat is used to generate additional electricity. When the waste heat is used for cogeneration, total thermal efficiencies can approach 85 percent.

Proton exchange membrane fuel cell (PEMFC): This fuel cell is based upon an ion exchange membrane electrolyte, which is an excellent proton conductor. PEM fuel cells are generally considered the most promising FC technology for transportation use, and have received funding support from both the U.S. and Canadian governments recently. These PEMFC's have been demonstrated (using hydrogen) in several vehicle development programs, including the Ballard bus and the Mercedes Benz minivan demonstrations. Ballard is the leading manufacturer of PEMFCs and has already installed a 10 kW demonstration natural gas-powered FC. Most current designs, including that of Ballard, are carbon-based with associated high fabrication costs, utilize expensive membranes, and require platinum and rare earth catalysts in the stack design. Currently PEMFCs are highly sensitive to fuel inputs, which translates to high fuel reformation costs. The technology essentially requires an almost pure hydrogen fuel. While this drives up the costs, it does allow these fuel cells to produce virtually no emissions. Of course the same could be said for any FC technology when it is run on pure hydrogen, and this raises the question of what are the "upstream" emissions caused by the production of the hydrogen.[4]

Solid Oxide Fuel Cell (SOFC): The SOFC uses a gas-impermeable ceramic electrolyte that conducts oxygen ions (an oxygen atom with two extra electrons and thus having an electrical charge) in much the same way that metals conduct electrons. The ceramic electrolye is coated on one surface with a porous electrode material that is stable in air and on the opposite surface with a porous electrode material that is stable in the fuel gas. High-temperature operation, up to 1,000C (1,800F), allows more flexibility in the choice of fuels and can produce very good performance in combined-cycle applications. Like MCFCs, SOFCs approach 60 percent electrical efficiency in the simple cycle system, and 85 percent total thermal efficiency in co-generation applications. They also have the advantage of not requiring a reformer. SOFCs are currently being demonstrated in a 100-kilowatt plant.[4]

Fuel Cell Type	Select Applications	Commercialization Status
Phosphoric Acid Fuel Cell (PAFC)	Stationary power and buses/larger vehicles	Commercially available (ONSI PC-25 200 kW unit) but not cost-competitive compared to alternatives in most applications.
Molten carbonate fuel Cell (MCFC)	Stationary power and small utility	Full-scale models are in field tests. --MC Power 250 kW demonstration at Miramar Base in San Diego
Proton exchange membrane fuel cell (PEMFC)	Specialty Power, transportation and appliance	Field units on demonstration --H Power Residential and small business commercialization targeted for 2001-2002 by GE Fuel Cell Systems
Solid Oxide Fuel Cell (SOFC)	Stationary power and transportation	Currently in demonstration (100 kW)

R.2.2 Fuel Cell Technology Potential

Because the technology is in the earliest stages of commercialization and there are several competing technologies that are also evolving, assessing the market potential of fuel cells involves a high degree of uncertainty. In addition to market and technological uncertainty, RD&D support of fuel cell technologies is unknown over the SBC funding period. Given this uncertainty, it is still possible to provide a reasonable range of the market potential of fuel cells based on current technology status of fuel cells, information on the New Jersey electric market and current expectations of future technological and market developments. This section assesses the market potential for large and small stationary applications for the years 2003 and 2012.

Large Stationary Applications (Commercial, Industrial, Institutional and Military)

The market for large stationary fuel cells (200 kW) is currently limited to a small niche of those customers seeking a premium, uninterruptible power supply. As the technology evolves and prices decline, the market size is expected to increase, but by most projections fuel cells are not expected to become cost competitive with grid-based power supply by 2012 without subsidization.

As discussed earlier in this section, there is currently one manufacturer producing commercially available fuel cells: ONSI. Production capacity of large stationary application fuel cells (ONSI's 200 kW unit) is currently limited to less than 20 MW per year worldwide with a maximum capacity through 2003 of 40 MW, should demand reach that level. This year ONSI will produce 21 to 24 units, roughly 5 MWs of capacity.[14] The production capacity is not expected to increase beyond 40 MW, since commercialization of other fuel cell models is not expected until after 2003 and ONSI would have to build another manufacturing facility which would take at least 18 months. Consequently, in the short term, the market potential may be limited by production capacity.

Given the production capacity limitations and the unfavorable economics of fuel cells for most applications (see next section on generation cost), we expect a relatively small number of installations by 2003. We do not expect more than 5 to 50 fuel cell installations by 2003 in New Jersey, which equates to 1 to 10 MW of generating capacity.

A starting point for assessing the long run market potential of fuel cells is to identify the number of customers in New Jersey that would be most likely to purchase a fuel cell. Generally, those most likely to purchase a fuel cell are willing to pay more for a premium, uninterruptible power supply.

For most applications, fuel cell customers will rely on natural gas for fuel. As a reference point the number of gas customers in New Jersey as of 1997 is displayed in the table below.

Utility	Commercial	Industrial
New Jersey Natural Gas	25,906	61
NUI	17,791	391
Public Service Electric & Gas	163,664	16,856
South Jersey Gas	19,353	316
Total	**226,714**	**17,624**

Of these nonresidential gas customers some small share place a significant premium on high quality, reliable power. These target customers represent good candidates to purchase a fuel cell, although it is not expected that all or even a large share of the businesses within these segments will actually do so in the period through 2012. The types of businesses that place a high premium on high quality power span many industries, but generally include:

- computer and data centers
- banking institutions

[14] Personal correspondence on August 10, 1999 with Donald Stein, ONSI Corporation.

- medical facilities (hospitals, laboratories, nursing homes)
- high tech manufacturers
- critical infrastructure (airports, sewage/water treatment)

In addition, a premium target is the military which is supported through the Department of Defense's Fuel Cell development program. To identify the number of customers in New Jersey that fall under these categories, XENERGY used iMarket's MarketPlace database. Selecting several four digit SIC industries with over 50 employees (we assume that small business are least likely to purchase a 200 kW fuel cell), we were able to generate a rough estimate of the number of customers that fall in this premium power segment. The number of businesses by 4 digit SIC is displayed in the table below.

The 1,257 customers in the premium power segment , provides a rough proxy for the number of customers we expect to pay a significant premium for high quality, reliable power. Fuel cells face significant competition from Uniterruptible Power Sources (UPS) which are more available in the marketplace, so we expect that a significant share of the premium power load will be served by UPSs. Given the high level of uncertainty regarding the future of fuel cells, we speculate that the number in the above table represents an upper bound on the number of customers that will purchase a fuel cell in 2012. Consequently, a reasonable range of installations is 50 to 1,250 fuel cells, or 10 to 250 MWs, assuming the standard unit size of 200 kW. As a point of reference, the Rhode Island and Massachusetts study estimated an upper limit of 100 MWs of generating capacity in 2017.

SIC 4 Code	Description	Number of Businesses
9711	National security	39
8734	Testing laboratories	28
8093	Specialty outpatient clinics	52
8092	Kidney dialysis centers	3
8082	Home health care services	79
8071	Medical laboratories	25
8069	Specialty hospitals, except psychiatric	14
8063	Psychiatric hospitals	14
8062	General medical and surgical hospitals	109
8059	Nursing and personal care	39
8052	Intermediate care facilities	9
8051	Skilled nursing care facilities	237
7382	Security systems services	28
7379	Computer related services	81
7378	Computer maintenance and repair	29
7377	Computer rental and leasing	9
7376	Computer facilities management	1
7375	Information retrieval services	11
7374	Data processing and preparation	84
7373	Computer integrated systems design	48
7372	Prepackaged software	30
7371	Custom computer programming services	94
6022	State commercial banks	23
6021	National commercial banks	35
4959	Sanitary services	8
4953	Refuse systems	58
4952	Sewerage systems	15
4911	Electric services	41
4581	Airports, flying fields, and services	14
	Total	**1,257**

Small Stationary Applications (Residential/Small Business)

The short term potential of fuel cells among residential and small commercial customers in New Jersey is limited by commercial availability of the product. Currently, there are no commercially available models, although there are several demonstration models in use. Recent developments point to short-term commercialization prospects:

- In February 1999 Plug Power and GE Power Systems formed GE Fuel Cell Systems, a joint venture that will sell, install and service Plug Power-designed and manufactured systems worldwide. The company expects to begin selling residential-sized systems in 2001 and small business-sized units by 2002. Retail prices for the residential system will be $7,500-$10,000 in 2001, but are expected to fall to less than $4,000 by 2003. The company broke ground in June 1999 on a 50,000 square foot manufacturing facility in Latham, NY, and expects to begin mass production there in 2003 following a testing phase from 1999 to 2000.[15]
- In July 1998, H Power was awarded a $748,000 contract by the New Jersey Department of Transportation to provide 65 PEM subwatt fuel cells that will power Variable Message (VM) signs. H Power, of Belleville, NJ, considers it the first commercialization of PEM fuel cells - the secured contract includes a warranty, company profit, and was secured in open competition.[16]

Although there are expectations among manufacturers that the commercialization of small scale fuel cell products will occur over the next few years, it is unlikely that a significant number of New Jersey consumers will participate in this market. As a result, we do not expect the market for small scale applications to exceed 1 MW by 2003. Rather, we expect that residential and small commercial applications in 2003 will be included in demonstration projects.

The potential for fuel cells in residential applications after 2003 and through 2012 will be affected by the response of homeowners to the following factors:

- the total capital outlay required (after any rebates and mortgage-financing assistance),
- uncertainty as to the level of confidence to place in estimates of costs and savings in the "sales pitch" (after the information which may be distributed by any utility or government educational initiatives),
- the degree to which transition charges (e.g., CTC or stranded cost charges) exist that can be avoided through net metering or other means,
- the value placed in power quality for home office or other electronics,
- concerns about loss of power from storms or other outages, together with the value placed on reliability from the combination of an on-site power source plus backup from the utility grid,

[15] "GE Fuel Cell Systems and New Jersey Resources Partner to Market Fuel Cells in New Jersey," PR Newswire, April 13, 1999.

[16] Personal correspondence on August 10, 1999 with Rene DuBois, H Power Corporation.

- each consumer's degree of comfort with the idea of generating power by a new type of device (e.g., a space heating/cooling appliance akin to a gas furnace or boiler),
- the potential for use of the thermal energy (e.g., CHP or cogeneration),
- each consumer's reaction to the use of hydrogen at their home,
- each consumer's degree of environmental commitment, offset by the lower visibility of fuel cell consumer's commitment to green power (compared with having a prominent solar PV system on the roof), and
- the long lives and slow turnover of furnaces and boilers, and the resulting infrequency of "equipment replacement" opportunities which reduce the capital cost "chargeable" to power generation.

While some of these factors will tend to be positive for the penetration of fuel cells in key residential niche markets (e.g., green consumers, home offices), it can be expected that the newness of this type of technology will cause its market to begin growing quite slowly. Until residential fuel cells become generally familiar to the consumer and the cost becomes attractive, sales will likely be limited for several years to early adopters in the green and home office markets. Their share of the residential market will likely be driven more by demands for reliable and quality power than by environmental values, in contrast to solar PV technology which will appeal primarily to green consumers and which may be a somewhat more familiar or comfortable purchase decision for many such homeowners.

The market potential for small stationary applications in 2012 is subject to a high degree of uncertainty. Since the technology is still in the development stage, the potential is highly dependent upon how rapidly it evolves and what the resulting economics are. To place a rough frame around the market potential, the table below displays the number of residential gas customers in New Jersey. Although it is highly speculative, we estimate that the upper limit for small scale fuel cells in 2012 is 5,000 to 10,000 installations amounting to 25 to 50 MW of generating capacity, assuming an average unit size of 5 kW.[17]

Utility	Commercial
New Jersey Natural Gas	349,622
NUI	226,032
Public Service Electric & Gas	1,363,051
South Jersey Gas	254,924
Total	**2,193,629**

[17] As a point of comparison, a higher level of potential is assumed in the Rhode Island and Massachusetts study, which estimated an upper bound of 250 MW by 2017.

R.2.3 Fuel Cell Cost

The lifecycle cost for fuel cells is driven primarily by capital costs, fuel costs and stack replacement costs. As with the market potential, the projections of generation costs are highly uncertain given the early stages of the technology's evolution, the conflicting expectations of industry participants regarding the prospects for dramatic reductions in capital costs, and the existence of competing technologies.

Large Stationary Applications

We conducted a simplified generation cost analysis to determine the generation cost of large stationary fuel cells in 2003. All of the assumptions have some level of uncertainty associated with them, but represent, based on a variety of sources, our best guess. The result of the cost analysis was a set of estimates ranging from $.11 to $.18/kWh. This variation was primarily attributable to a range of capital cost assumptions between $3,500 and $5,000/kW.

	2003
Cost for 200 kW fuel cell	11 - 18 ¢/kWh

Currently, costs for fully installed 200 kW ONSI units range from $700,000 to $1,000,000 or $3,500 to $5,000 per kW. Due to a slow down in orders and reduced production in 1999, costs have increased from 1997 levels, when the cost was roughly $3,500 per kW.

The variation between our high and low estimates is wider than a recent estimate prepared as part of the Massachusetts/Rhode Island study ($.13/kWh for 2002), but the midpoint of our range for 2003 is only 2 cents/kWh higher.

Small Stationary Applications

We conducted a similar financial analysis to assess the appropriate range of estimates of generation cost for small PEM fuel cells which may become commercially available by 2003 for residential applications. Our estimates cover a wide range from $.08 to $.24/kWh, primarily to span some of the positive expectations of vendors as well as the more skeptical expectations of other industry observers that it may take many more years to bring capital costs down as low as many hope.

	2003
Cost for ~3 kW PEM fuel cell	8 - 24 ¢/kWh

This variation was attributable to a range of capital cost assumptions between $1,500 and $4,000/kW, as well as variation in capacity factors (35% - 65%), electrical generating efficiency (30% to 45%) as well as stack replacement costs and equity return expectations on the part of the end use customers and/or their fuel cell vendors or developers. This range illustrates the high degree of uncertainty which we assign to forecasts of cost reduction given the limited experience to date with actual commercialization of complete fuel cell systems, especially at the smaller sizes. The midpoint of our cost range for 2003 is 3 cents/kWh higher that the estimate for the Massachusetts/Rhode Island study ($.14/kWh for 2002).

R.3 BARRIERS FOR CUSTOMER SITED RENEWABLE DISTRIBUTED GENERATION TECHNOLOGIES

R.3.1 Regulatory Barriers

An overall barrier to the development of distributed generation capacity, including renewable installations at customer sites, is the uncertainty concerning the ratemaking and regulatory principles and framework(s) which may apply to regulated and competitive activities in the area of distributed generation by both regulated distribution companies and competitive suppliers. One specific barrier in this area is uncertainty as to whether existing or potential new backup, standby and other rates accurately reflect the costs and benefits of customer generating facilities and send the proper pricing signals to the market.

In addition, when customer-sited generators are interconnected to the distribution network, they become a safety concern for utilities because they may upset the coordination of protective devices or accidentally energize a dead circuit. Other issues will small generator interconnections include power quality, service reliability, equipment protection, and metering arrangements. There are national standards to address these issues, and new standards are under consideration through IEEE as well as in New York, California and other states, but utilities have the discretion to establish their own criteria and guidelines based on such standards. Therefore, interconnection criteria vary widely and present barriers to customers and equipment manufacturers because individual installations may be subject to requirements for custom engineering designs or expensive equipment which can impair project economics. A set of uniform interconnection standards will be needed to achieve consistency between utilities within New Jersey and in other states.

Most customer-sited (DG) technologies experience little difficulty in siting due to minimal or nonexistent pollution and noise levels, compact technology size, and ease in selecting an appropriate location for the technology (either indoors or outdoors for fuel cells or on the rooftop or integrated into the building skin for PV technology). In fact, natural gas fuel cell power plants have been exempt from many environmental regulations in California [8] and have also been exempt from permitting in Massachusetts. Larger scale grid-connected DG applications also face few problems as siting PV arrays is much easier than siting a conventional power plant, and large or small scale fuel cells realize little difference in siting. Small wind technology experiences greater siting difficulties due to limited availability of windy sites in New Jersey, noise and environmental concerns.

R.3.2 Information Barriers

General awareness for DG technologies, their availability and their associated benefits is relatively low, although this awareness may be slightly higher for PV technologies. Even as awareness increases, skepticism remains about the technologies performance as promised

When consumers understand the connection between electric generation and environmental problems (such as global warming and air pollution) they are more inclined to make environmentally friendly energy choices. Education is a vital requirement in order to turn this preference into personal action. This preference is easier to actuate in buying green power, however, than in buying, installing, and operating customer sited generation. Even for the niche market of customers who will buy and install on-site systems there is also a need for the distribution of information about: 1) how these systems work, 2) what the system 's costs are, and 3) whom to call to get started.

Another kind of information barrier is the lack of fully developed methodologies for electric utility use for planning and acquisition of distributed generation resources to increase capacity or reduce costs on T&D systems. In addition, the information about the capacity, loading and other conditions of distribution circuits, feeders and substations may need to be improved to provide real-time data which can be used for valuing or pricing the output from distributed generation facilities for billing and/or operating purposes.

R.3.3 Infrastructure Barriers

Customer-sited technologies in the U.S. appear at different points on the infrastructure development curve. Currently, a significant infrastructure for manufacturing, distribution and service of fuel cells does not yet exist in the U.S. or worldwide. In contrast, PV technology infrastructure is relatively well developed.

For all of the technologies, however, improvements in the sales, installation, and service infrastructure are necessary to create a viable and properly functioning market in New Jersey. For example, grid-connected PV rooftop applications are still relatively uncommon, and few contractors have experience with proper PV installation. In addition, few utility engineers and building/electrical inspectors have the necessary expertise to determine whether or not a PV system has been installed safely and properly.

Though the financial and economic barriers are the most significant, development of market infrastructure is a priority as well. The following illustrates current developments in customer-sited infrastructure:

- ONSI Corporation is currently the only company in the U.S. that manufactures and sells fuel cells commercially though other manufacturers have developed demonstration units.

- GE Fuel Cell Systems, a joint venture between GE Power Systems and Plug Power, expects to start mass production of residential fuel cells in 2003, following a testing phase at its new manufacturing facility in Latham, New York.
- Several U.S. PV manufacturers have recently or are currently expanding their facilities. Shipments totaling over 46 peak MW were reported by 21 manufacturers in 1997.[18]

R.3.4 Technology Barriers

Distributed generation technologies have undergone significant research and development since the 1970's and 1980's, and are generally technically proven and in some cases, are commercially available. Performance risk is not a significant barrier as all of the technologies have been proven reliable. While there are needs for improved efficiencies, most barriers facing distributed generation are not technical in nature.

PV technology has become a commercially-viable, mature technology with a 20-year track record in commercial applications, and the majority have proven their potential in grid-connected field applications. For fuel cell technology, ONSI Corporation produces the only commercially available fuel cell (Phosphoric Acid type), while the technology for all other fuel cell types has been proven and is in demonstration or field tests at select locations. Developing a commercially viable manufacturing capability will take time, however. Furthermore, some fuel cell technologies may not be appropriate for small scale applications. For example, the molten carbonate fuel cell will likely be for large applications, such as utility bulk power, rather than for customer sited applications, and the solid oxide fuel cell operates at very high temperatures that make it inappropriate for customer-sited applications.

R.3.5 Financial Barriers

Customer sited technologies face financial barriers in the high capital costs involved for consumers, and in scaling up to economies of scale in production. These difficulties include:

- Obtaining loans with favorable terms for new and unfamiliar technologies because of risks associated with performance, maintenance, and other factors.
- Inability of residential consumers to pay the full cost of the technology up front, and the lack of low-cost, long-term financing, particularly with PV technology. Fuel cell technology will face the same barrier when residential commercialization occurs in 2003.

[18] *Renewable Energy Annual 1998*, Energy Information Administration, December 1998.

- Risks of scaling up to the production level needed to bring acquisition costs in line with other electricity sources.

- Sensitivity of lender to risks for the next few years despite the potential for market penetration that may assist these companies in securing bank loans.

In the fuel cell market, a number of companies with deep pockets—including GE and others—have entered the race to fuel cell commercialization in various applications and presumably have sufficient capital to finance production and assume financial risks. However, smaller, start-up companies will have difficulty in commercialization on the scale required to bring acquisition costs to a level consumers are willing to pay without subsidies.

For PV technology, other than the high capital cost, the lack of low-cost, long-term financing is perceived to be the most significant barrier facing PV technologies today. Access to low-interest financing will provide purchase opportunities to a wider range of consumers with varying income levels.

R.3.6 Economic Barriers

High capital cost is a significant barrier to market transformation in customer sited technologies, including PV, wind and fuel cell technologies.

Widespread introduction of grid-connected PV faces high up-front capital costs, with system costs of over $6 per watt - twice what the current market will bear. PV system costs have decreased significantly in recent years and are expected to reach a level of $3 per watt in or around 2010.

Likewise, despite operating costs on average 25 to 40 percent below those of nonrenewable energy, the high capital cost of fuel cells represents a barrier for commercial, industrial or residential customers. For large commercial operation fuel cells, the capital cost of $4,250/kW is well above the $1,500 to $2,000/kW considered viable for general commercial acceptance, and is slightly above the ceiling for premium power, estimated at $4,000/kW.[19] While residential and small business applications are not expected to be available commercially until at least 2003, acquisition cost is likely to be high for some time and may continue to deter interested customers.

[19] Fuel Cells Edge Toward Commercial Use," Achema Daily, June 12, 1997.

R.4 CUSTOMER SITED RENEWABLE DISTRIBUTED GENERATION TECHNOLOGIES: POTENTIAL FOR MARKET TRANSFORMATION

R.4.1 Market Transformation Strategies to Address Regulatory Barriers

Though siting represents little problem, some fuel cell manufacturers have experienced difficulty from the red tape involved in the actual permitting process. To address this relatively minor barrier, California and Massachusetts exempted fuel cells from air emission permitting requirements.

Renewable and other small-scale resources face regulatory barriers in terms of interconnection requirements that can be uncertain or onerous. This problem is already being addressed through standardized interconnection standards developed in conjunction with the IEEE, but they will need to be accepted and adopted by the individual utilities. Some interconnection and related rate issues may warrant appropriate review in the regulatory process.

R.4.2 Market Transformation Strategies to Address Information Barriers

Consumers, sometimes even including large electricity users, lack information about on-site generating technologies. These information needs may be met relatively easily with appropriate brochures, web sites, etc., and include:

- How to get started on a project
- Where to go for design and specification help
- How to evaluate and select particular products
- What type of performance and reliability to expect
- Who will service and maintain on-site maintenance
- How to judge the reasonableness of offered prices

Education programs need to target those customers who are mostly likely to be interested in on-site generation. This includes people with off-grid needs, uninterruptible power supply, premium power quality, and environmental motivations.

It may be valuable to undertake an initiative to address the barrier of undeveloped data and methodologies for planning and acquisition of distributed generation resources on T&D systems. This could be done in conjunction with discussion of ratemaking and other issues concerning the regulation of utility activities in the area of distributed generation.

R.4.3 Market Transformation Strategies to Address Infrastructure Barriers

Limited infrastructure capacity is an issue with small scale, distributed generators, especially customer-owned systems. With a sustained, orderly growth in the market demand for distributed generation, however, it should be possible to build up the infrastructure with a technical and economic development strategy. For example, this strategy might include:

- Training and certification programs for installers and service companies
- Development of standards and training for financial institutions to encourage customer credit and appropriate valuation of systems

Architectural and engineering design, and builder training and technical assistance to increase specification of these systems and integration in particular with new construction.

R.4.4 Market Transformation Strategies to Address Technology Barriers

Limited technology experience is a deterrent with customers, specifiers and financiers. Education and infrastructure support mentioned above would help overcome this barrier, but support for demonstration projects and case studies need to be highlighted to encourage customers to request, designers to accept the liability, and financiers to assume the risk of a new and uncertain (to them) technology. If necessary, part of a strategy could include providing liability insurance to designers, or providing performance guarantees to financiers to encourage them to allow and finance customer-sited technologies.

R.4.5 Market Transformation Strategies to Address Financial Barriers

Financial institutions routinely deal with customer credit-worthiness, but are less knowledgeable and willing to include the added value of the systems to the value of the building, or to credit the operating costs savings to the customer's ability to pay. The same strategies mentioned above for infrastructure, education and training, and increasing technology experience, should help to overcome financial barriers. To be successful, they should be done in a coordinated way so that institutions (as well as customers and others involved in the design and build process) do not receive conflicting information within the same market region.

R.4.6 Market Transformation Strategies to Address Economic Barriers

Economic barriers remain among the most serious for customer-sited technologies. This issue is less one of competitiveness of the energy generated (as it is with bulk power generation) than it is an issue of affordability. Customers will perceive benefits to on–site generation other than simply the electricity, which may include reliability, power quality, independence, status, environmental stewardship, among others. In some cases, customers will be willing to pay more than the competitive electricity price, but this is a niche market of people or businesses who will buy for reasons other than economic alone.

One of the goals of renewable programs is generally to achieve sufficient self-sustaining market transformation so that the program can be phased out over an acceptable period of time. For most renewable technologies, the key to achieving a sustainable presence in a market or a market niche is to bring down capital costs through economies of scale in manufacturing (which may not respond to the action of any single state) and in the entire design, development and installation process (which may be more responsive to state and regional programs).

Financial incentives will be important to achieve market transformation and to make the technologies more affordable, especially given the high initial cost to individuals and businesses. This would help reduce capital costs and increase demand, while a steady and reliable increase in demand should lead to scale economies of manufacturing more units, whether of fuel cells, PV or small wind turbines. For example, national and state buy down programs for PV and fuel cell systems place the technology at a price the market will bear and eliminate one of the single most important barriers facing customer sited technologies.

In addition, the competitive price for these technologies is not the wholesale price of bulk power, but the total retail price of delivered energy. Thus, net metering policies will play an important role in overcoming the economic barriers.

R2

GREEN POWER SUPPLY

R GREEN POWER SUPPLY

R.1 TECHNOLOGY: WIND POWER

R.1.1 Characterization of Wind Technology

Wind power is produced using wind turbines which convert the wind flow field into electric power. This is accomplished through the employment of aerodynamic surfaces configured as propellers.[1] The power produced by these systems varies with wind speed and is therefore considered to be an intermittent energy source. Due to the constant variation in power production, this technology has been traditionally used to supplement existing electric grid systems or in a hybrid type system.

There are three different types of applications for this technology. The first is wind farms, which employ the use of large (750 kW and larger) wind turbines. Wind farms are typically comprised of a number of the large scale wind turbines. For example a 50 MW wind farm utilizing 500 kW turbines would consist of 100 wind turbines. These wind farm arrays are often difficult to locate and are designed to be connected to a grid system. This is the scale of project which is discussed in detail in this section, and is represented as "Wind Power (>500 kW)" in the assessment tables in Section 5.

The use of wind as a method to produce energy for commercial use is generally thought of on a large scale basis (i.e. wind farms). However, it is also possible for this technology to be employed in smaller scale applications for on-site use. Therefore, the second category is comprised of much smaller wind turbines with a typical power rating of 10kW or less. These systems are often used to power ranches, villages or other remote sites. Depending on the circumstance they may or may not be connected with a larger grid system. This is the scale which would be appropriate for most residential installations. This is the scale of installation which is represented as "Wind: Small" under "Renewable Distributed Generation (Customer Sited)" in the assessment tables in Section 5.

A third category consists of clusters of wind turbines. These clusters consist of 2-10 and could employ either the large or small scale wind turbines. Because the siting of this type of system is far easier than the wind farms this category is most likely to be of use in the state of New Jersey.[2]

The wind industry is expanding dramatically in the United States. In the last year the wind industry has installed a total of more than 1073 MW of new, wind generated, installed capacity.

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[1] Scoping Study of Renewable Electric Resources for Rhode Island and Massachusetts, C.T. Donovan Associates, Inc., November 1997

[2] Scoping Study of Renewable Electric Resources for Rhode Island and Massachusetts, C.T. Donovan Associates, Inc., November 1997

This record level of capacity growth was driven by a combination of state renewable energy incentives and the July 1999 deadline under the federal production tax credit (PTC).[3]There is currently an extension to the PTC in Congress which is expected to gain approval by the House and Senate later this week. The Congressional tax package would extend the PTC through June 30, 2003, applying the credit retroactively to June 30 of this year, the date it expired. The PTC provides a credit of 1.5 cents per kilowatt-hour (adjusted for inflation) for electricity produced using wind resources. It therefore rewards actual electricity generation, rather than equipment installation, and is an important factor in setting the price of long-term wind energy contracts.[4]

The U.S. Department of Energy (DOE) has released details on 10 wind projects that it intends to fund with a total of $1.2 million in cost-sharing grants as part of the Wind Powering America campaign. The grants are being distributed under two programs, the Small Wind Turbine Field Verification program and the State Energy Program Special Projects Initiative. The DOE Small Wind Turbine Field Verification Grants will be cost-shared with industry and the final funding figures are still to be determined. Under this program, DOE will provide cost-sharing and technical support for projects to test and evaluate the field performance of small wind turbines in a variety of settings. The cost-share grants, which could total as much $1 million, will include up to $175,519 for the installation of four small wind turbines on four sites in New York and New Jersey by AWS Scientific, Inc., (including a farm, Liberty State Park in New Jersey, and a beach and an agricultural project on Long Island). AWS Scientific is based in Albany, N.Y. [5]

R.1.2 Wind Technology Potential

One of the reasons that wind power has developed so rapidly is because of the versatility of the technology. The potential for wind power in any given area is determined by the average speed of the wind. Depending on the average wind speeds, areas are classified into 7 different wind classes. With current technology it is possible to generate power with large scale wind turbines utilizing winds of class three or higher. These turbines can be sited in large wind farms or small clusters depending on siting requirements and land availability. Small wind turbines can be used for onsite generation to produce electricity at any wind speed. However, a majority of the wind power that could potentially be created in New Jersey would come from large scale wind

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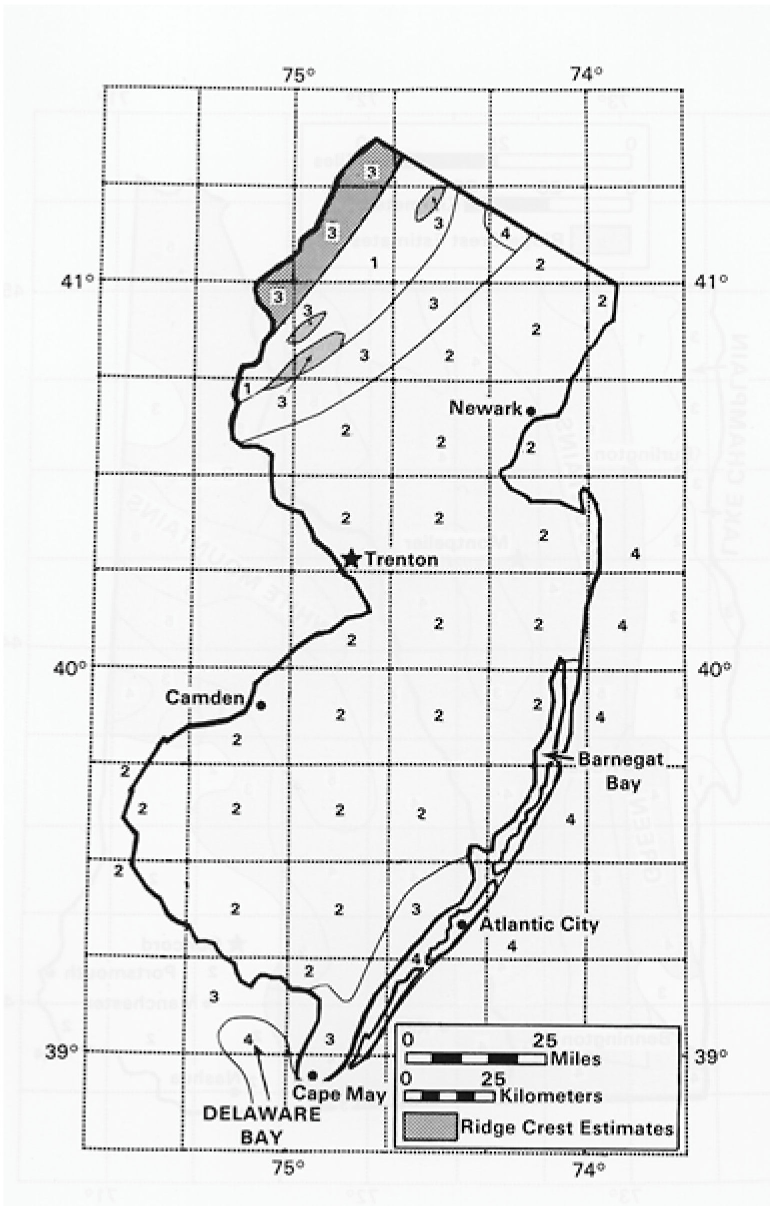
[3] New Jersey Board of Public Utilities Comprehensive Resource Analysis Proceeding, American Wind Energy Association, August 1999

[4] Wind Energy Tax Credit Extension Contained in Congressional Tax Plan, AWEA News Releases, August 1999

[5] Additional small wind projects include up to $163,087 for Endless Energy Corp.'s Maine Coast Winds project. This project will support the installation of up to four wind turbines at separate locations (including a shipyard, a blueberry processor, a farm and a maritime academy) along Maine's coastline. The project will test and evaluate the performance of each turbine and develop recommendations for future use of wind turbines for power generation in the state. Endless Energy is based in New Gloucester, Me. In addition, up to $248,270 is to be provided for the installation of five small wind turbines on Block Island, R.I., by Offshore Services of Block Island. The island has one of the nation's highest electric utility power costs. The wind turbines will be used to generate power for a number of residential, commercial and municipal government customers.

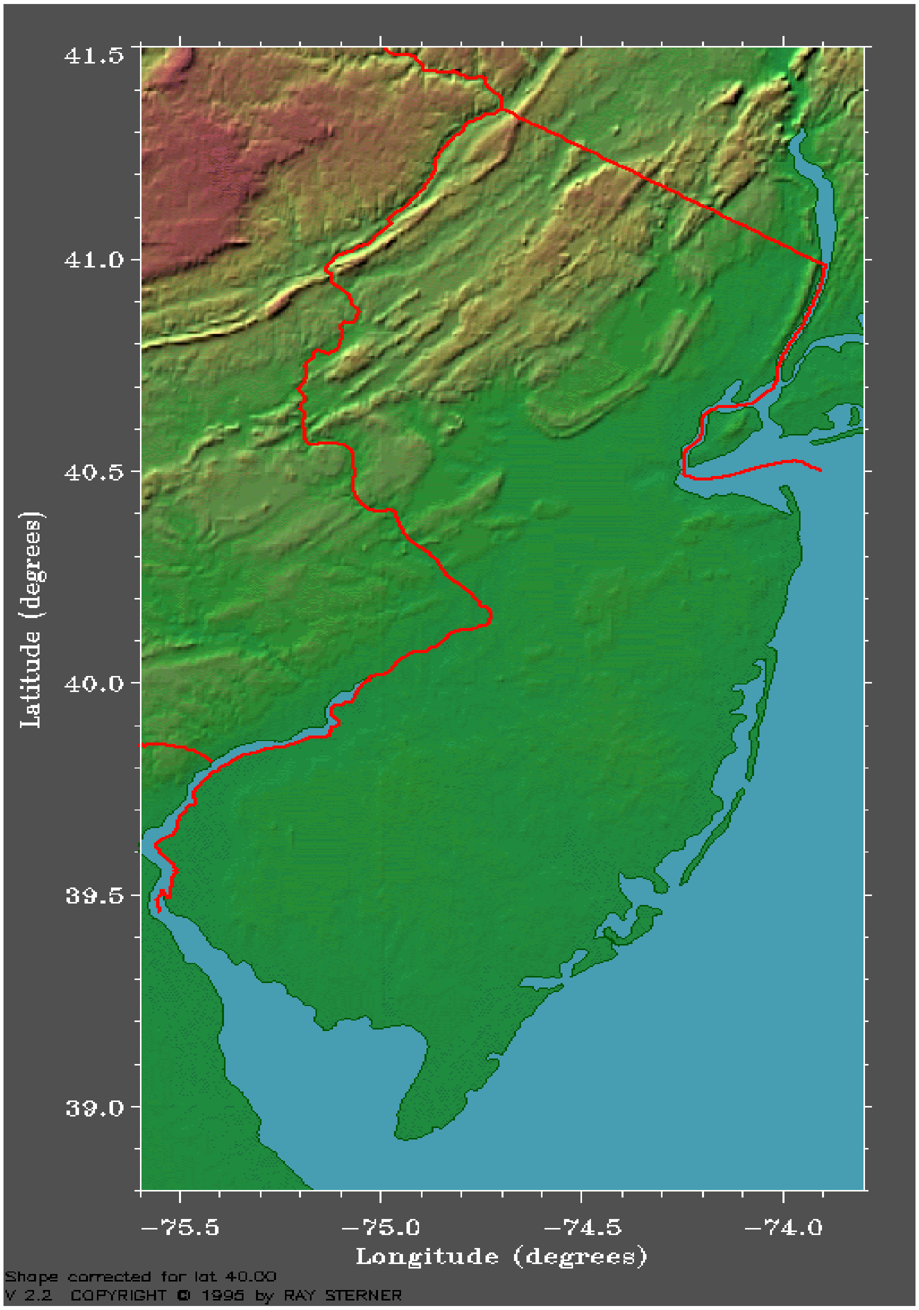
projects. Please see included maps which highlight where wind farms may possibly be located in New Jersey.

Figure 1
New Jersey annual average wind power



(from http://rredc.nrel.gov)

Figure 2
Shaded Relief Map of New Jersey



(from http://fermi.jhuapl.edu/states/maps1/nj.gif)

The U.S. Department of Energy estimates the if all the available land in New Jersey with a wind power class of 3 and higher, were developed with utility scale wind turbines they could produce approximately 19% of the state's electricity consumption. This estimate takes into consideration urban development, environmentally sensitive areas, as well as land use conflicts. The wind turbines necessary to produce this much electricity would be located on approximately 8% of the land in the state of New Jersey. The turbines themselves would occupy 10% of that area, while the remaining area could continue to be used for compatible purposes. The Department of Energy estimates that the power produced each year would be equal to 13,000,000 MWh, approximately 19% of the state's energy consumption.[6]

The American Wind Energy Association estimates that after accounting for reasonable environmental and land use exclusions, over 1140 square kilometers of land (6% of state) has wind energy development potential. If fully developed this resource could sustain an installed wind generation capacity of 4800 MW, enough to meet 17% of the state's electric need.[7]

R.1.3 Wind Market Potential

Large Scale Wind Projects for Green Power Supply

In the near term, commercial scale wind generation in NJ will consist of turbines in the 0.5 to 1.5 peak capacity range, grouped in small clusters. In the near term, constraints to significant wind development center around land use compatibility, land availability, local acceptance, aesthetics, avian issues, local zoning, and the lack of experience with siting and permitting. In general, for sites that might be developed by 2003, transmission availability is less of an issue. Wind projects take 2 to 3 years or longer to develop under ideal conditions, including the period necessary to gather wind data necessary for financing. In New Jersey, there is no experience siting wind facilities, suggesting that the process may not move quickly. Preliminary wind data (based on the Wind Energy Resource Atlas of the United States, –see http://rredc.nrel.gov and maps above) suggests that given today's technology (typically installed in wind class 4 or 5, and in rare cases in class 3), development attention by 2003 would be limited to a few potential on-shore sites, or along the ridgeline traversing the northwest portion of the state. It is unlikely that by 2003 more than a handful of small wind developments will be successfully developed. In coming to this conclusion, it was assumed that only a small fraction of the available NE-SW ridgeline in the northwestern part of the state could be developed, as well as perhaps a few scattered on-shore turbines.

[6] New Jersey Wind Resources, http://www.eren.doe.gov/state_energy

[7] New Jersey Board of Public Utilities Comprehensive Resource Analysis Proceeding, American Wind Energy Association, August 1999

In the longer term (2012), greater potential may result from a significant offshore wind resource (indicated as class 4 in existing studies[8]). Europe is just getting experience with commercial-scale off-shore development, with much larger developments slated for the near-future. By 2012, some of this experience is sure to be transferred to the US. Resolution of potential avian issues, which may be significant in the windier southern New Jersey off-shore areas, will be necessary for significant development to ensue. Off-shore projects must be larger in scale (at least 25-40 MW) to justify constructing the transmission facilities necessary to get the power to market. Development in shallow water areas (20-30 ft depth) off southern New Jersey might ultimately amount to the development of a few such projects. In addition, as technology improves, previously marginal wind sites will become commercially exploitable. Therefore, by 2012 the types of sites which received attention in the 2003 timeframe, less constrained by the need for the highest wind speeds, may be developed at a marginally higher rate.

Wind is also constrained by potential demand. Despite its relatively low cost (in large windfarms in the Western and Central US) wind is not expected to compete directly with commodity electricity between now and 2012. Nonetheless, there is arguably some small demand for wind even at today's costs, which is expected to increase as wind costs approach parity with conventional electricity generation sources. A portion of the demand for wind is likely to come from windier out of state areas (such as PA, WV, NY), as allowed by NJ's disclosure and RPS (draft) regulations. However, green power demand will be at least partially driven by the desire for local resources, and the presence of an SBC-funded program lowering the cost-differential will pull some portion of wind demand from NJ-based resources. By 2012, it was assumed that roughly half of the wind demand is served by in-state resources.

Small Distributed Wind Generation Installations

The potential for small distributed wind generation, considered to fall in the 10-50 kW size range, is expected to be fairly limited. Costs are not much lower than PV on a ¢/kwh basis. Sites are fairly limited by the need for strong winds and distance from neighbors (smaller machines spin at high RPS, and require some setback due to noise potential). By 2003, the potential short term market is estimated to consist of 1 to 4 dozen small wind installations, averaging roughly 20 kW each, for a total of 250 kW – 1 MW. By 2012, the rate of new installations may start to saturate. It is difficult to imagine a density exceeding 10 to 20 average turbines per town in perhaps 20 to 30 towns with sufficient wind. The resulting 2012 penetration is estimated to be in the 10 MW range.

[8] Wind Energy Resource Atlas of the United States, –see http://rredc.nrel.gov/wind/pubs/atlas/

R.1.4 Wind Cost

Large Scale Wind Projects for Green Power Supply

Due to the experience gained in the last 20 years, significant advancements have been made in the development of the wind power technology, including design, siting, operational practices and advancements in research and development. These factors have greatly contributed to the advancement of the industry, making the technology more cost effective and increasing consumer awareness and acceptance.

Wind energy production costs for 10-20 MW farms are likely to be at least twice the wholesale market price. Sites in New Jersey (class 3 wind regimes) would generate power at a cost of about 6-8 cents/kWh, with installed capital costs of about $1000/kW. Costs are expected to decline substantially in the next 10 years due to expected improvements in turbine design and increased production volume.[9] The cost of wind energy varies widely depending on the wind class and type of technology utilized for the project.

Levelized Cost of Energy Produced by Advanced Horizontal Axis Turbines (constant 1997 cents/kWh) [10]

	1997	2000	2010	2020	2030
Class 4 Wind Regime	6.4	4.3	3.1	2.9	2.8
Class 6 Wind Regime	5.0	3.4	2.5	2.4	2.3

Small Distributed Wind Generation Installations

End users considering buying a wind system for on-site use, generally in rural or remote locations, may be more likely to assess the affordability of the system, in terms of its total installed cost, than to compare the wind costs on a per-kWh basis with the market price of generation. The costs of buying and installing the wind turbine and associated equipment in 2003 are estimated to range from $3,500/kW to $5,000/kW, although costs of any particular project could be outside this range, depending on the size and design of the system and many other factors. Such factors include whether homeowners undertake some or all of the installation work and whether multiple systems are purchased and developed in an area, perhaps through a utility program.

The cost of generation from small wind systems will vary widely. The Rhode Island/Massachusetts study estimated 2002 costs at $.31/kWh for a coordinated purchase of 850 Watt wind microturbines, and at $.51/kWh for an individual purchase of a smaller machine (150

[9] New Jersey Board of Public Utilities Comprehensive Resource Analysis Proceeding, American Wind Energy Association, August 1999

[10] Electric Power Research Institute. (1997) Renewable Energy Technology Characterizations. EPRI Topical Report No. TR-109496, December.

kW). Generation cost estimates for 2003 range from over $.12/kWh to over $.30/kWh based on variation of assumptions over the following ranges: capital cost (installed) from $2,500 to $5,000/kW; capacity factors from 23% to 28%; O&M costs from 3 mils/kWh to $.013/kWh; and capital recovery factors from 10% to 12%. The midpoint of this range is $.215/kWh.

R.2 TECHNOLOGY: BIOMASS POWER

R.2.1 Characterization of Biomass Technology

Biomass refers to any plant or animal waste including wood and wood waste from forests, industrial and processing residues, agricultural residues, short rotation woody crops and herbaceous plants.

In New Jersey, Class I renewables include energy from biomass facilities, provided that the biomass is cultivated and harvested in a sustainable manner. As long as the resource is managed sustainably, biomass may be used in several different technologies, but here they are described briefly as of two types. *Direct combustion* refers to systems in which all phases of combustion (heating and drying, pyrolysis, gas phase pyrolysis and oxidation, and char oxidation) take place in a single vessel such as a furnace or boiler. During direct combustion, chemical energy contained in biomass fuels is converted to thermal energy. The thermal energy may be used directly to fire a boiler and create steam, which in turn generates electricity.

Direct combustion technology differs from *gasification* technology, in which combustion occurs in two distinct units, such as a gasifier and a gas turbine engine. In gasification, a biomass material is heated so that volatile gases and moisture are vaporized. This gas, referred to as ‘producer gas,” is treated or cleaned up and may be used as fuel in direct combustion equipment (such as boilers), internal combustion engines, gas turbine engines or fuel cells. Most RD&D and commercialization activities for medium to large biomass gasification systems focus on using the producer gas in gas turbine engines to produce electric energy, with waste heat in the exhaust gases captured in heat recovery boilers and converted to electricity through the steam cycle. The benefits of thermal gasification include an increase in overall system efficiency if used in a gas turbine combined cycle system, or a decrease in the emission of compounds that cause corrosion or erosion in biomass boilers.[11]

Direct combustion is by far the more common approach today, while gasification is still in demonstration phases funded in part by the federal government.

According to the U.S. Department of Energy, grid-connected biomass electricity capacity is nearly 7 GW, which is 1 percent of all generating capacity and about 8 percent of non-utility generation capacity. Much of this capacity is in combined heat and power facilities in the industrial sector, using wood products waste in direct combustion. The next most viable sector for biomass power applications includes stand-alone capacity dedicated solely to electric power generation. These facilities are typically fueled with non-captive residues drawn from urban

[11] C.T. Donovan Associates, Inc. Scoping Study of Renewable Electric Resources for Rhode Island and Massachusetts, Volume 1: Technology Assessments. November 1997.

living, and smaller or seasonal sources that generate residues such as orchards, food processing, and building construction and demolition.

Stand alone power producers often play an integral role in the management of residue and waste flows in a region, accepting clean materials that otherwise would be landfilled. As a consequence, the fuel cost to the generating plant is often only that of transporting these materials. This added dimension of waste and residue management is at the core of sustainability issues for New Jersey. Many people recognize that using dedicated biomass crops for electricity production offers a closed-loop carbon cycle. However, few recognize that the current use of biomass waste and residues for power production closes many other loops by capturing and using material and energy that might otherwise be lost or wasted.[12]

Whether "sustainable biomass" for New Jersey will include biomass waste and residue, or will be limited to dedicated energy crops, will be a significant determinant in the future of biomass in the state. It is also not clear whether biomass gasification, by itself, will qualify as "sustainable biomass," although it does offer high efficiencies and very low emissions when connected to advanced power systems.

The advanced power systems for large-scale power generation in a utility or industrial setting involve use of gas turbines and combined cycles. DOE has supported development of two types of biomass gasifiers: one a low-pressure type and another a high-pressure gasifier. Each of these gasifiers has been demonstrated at both a pilot scale (10 to 20 tons of biomass per day capacity) and has been validated at an intermediate scale (100 to 200 tons per day capacity) in a scale-up demonstration. Each has the capability of combining with advanced power systems, and represents a major advance over existing gasifier technology.

One of the scale-up demonstrations was in Hawaii and completed operation in 1998, while the other is in Vermont and began operation in 1998. The Hawaii Gasifier project demonstrated a high-pressure gasifier using bagasse—residues from sugar cane processing—for fuel obtained from a neighboring sugar mill in Maui, Hawaii. The Vermont Gasifier project is demonstrating a low-pressure, indirect biomass gasifier connected to the McNeil Generating Station in Burlington, Vermont.

According to feasibility studies sponsored by DOE's Biomass Power Program, three types of gasifiers—fixed-bed, fluidized-bed, and entrained-flow gasifiers—make economic sense when used in conjunction with gas turbine-generators. They are used in a direct-fired mode in which air or oxygen is fed directly to the gasifier, or in an indirect mode in which externally supplied heat is used to gasify the biomass.

Gasification with air produces a low-Btu gas, with a heating value about one-fifth that of natural gas. Indirectly heated gasification and oxygen-blown gasification produces a medium-Btu gas,

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[12] U.S. Department of Energy. DOE Biomass Power Program Strategic Plan, 1996—2015. DOE/GO-10096-345; December 1996.

with heating values as much as one-half that of natural gas. The product gas is suitable for fueling advanced power systems that require clean, gaseous fuels.

As mentioned, gasifiers have a number of advantages for use in advanced biomass power systems, including reduced emissions, increased efficiencies, and flexibility for use with a variety of biomass feedstocks. Emissions from advanced power systems, such as gas turbines and fuel cells, are extremely low compared with conventional power systems.

Furthermore, these systems can achieve high efficiencies. Replacing less efficient conventional boilers with advanced biomass gasifier or gas turbines can increase the amount of electricity produced from biomass by 50 percent or more. For even higher efficiency, the gas-turbine cycle can be combined with the steam cycle in either an integrated gasifier combined-cycle or steam-injected gas turbine.

Gasification can take advantage of biomass feedstocks unsuitable for direct burning. When biomass fuels are burned in conventional boilers, the inorganic materials that do not burn stick to boiler walls and reduce efficiency. Many fast-growing, desirable energy crops and residues have high proportions of these inorganic compounds. Inorganic compounds are removed during gasification as part of the cleanup process. The filtered by-products can then be recycled back to croplands.

R.2.2 Biomass Market Potential

The market potential of biomass in New Jersey depends more heavily upon the definition what biomass qualifies as Class I Renewable, than upon the total amount of biomass feedstock available or the construction of dedicated biomass direct combustion or gasification generation facilities. This is due in part to the presence of significant existing fossil-fueled capacity in which biomass could be co-fired as a small proportion of the fuel input. Although a literal read of the definition of Class I Renewables could lead to an interpretation that biomass must be gasified *and* cultivated and harvested in a sustainable manner, it has been interpreted herein as limited only by the requirement to harvest and cultivate in a sustainable manner.

The biomass market potential will be constrained by the availability of sustainable biomass fuel. A sustainability criteria clearly excludes certain types of biomass feedstock, such as site-conversion (land clearing) wood waste. At its narrowest, sustainable biomass would be limited to the sum of dedicated energy crops (such as plantation of willow, poplar or other short-rotation woody crops) and forestry wood harvested from forests in a sustainable manner. Whether, and how, the concept of “sustainable biomass” can be effectively applied to many other conventional biomass feedstocks -- including agricultural wastes, mill residue and other waste produced by the primary and secondary wood products industry, and urban wood waste (pallets, construction debris wood, etc.) – is likely to be the subject of protracted debate. It is assumed that none of these sources are considered sustainable by 2003, and only 25% by 2012. These non-sustainable fuel sources encompass a majority of the less expensive feedstocks[13], so their exclusion will also depress biomass market potential on economic grounds. In any event, NJ does not have a very large primary wood products industry (as would be expected from the state with the highest population density), so these sources will not be as significant as in many other states.

Further constraining the short-term market potential is the lack of infrastructure in place today to certify sustainable cultivation and harvesting. Sustainable certification of forest practices is a fairly new innovation, not yet widely practiced, and driven primarily by the demand for furniture products from sustainably harvested hardwoods. There are early, ongoing efforts to develop such standards for broader application to energy crops, and attempts at the forestry industry to preemptively develop their own sustainability standards.

Class I biomass market potential will also be constrained by economics and demand. In general, biomass is not expected to compete directly with commodity electricity between now and 2012. This will be exacerbated by the probability that the lower-cost fuel feed-stocks are the least likely to be considered sustainable, as discussed above. Thus, the demand will be largely influenced by demand to serve the green power and RPS markets. Biomass is among the lower cost and more significant scale renewable sources available to meet these demands. As the only dispatchable renewable source, there will be some degree of additional demand driven by the need to offset the intermittent nature of other renewable sources, and provide some flexibility in the delivery system for renewable kilowatt hours.

If supported by SBC-funded programs, a fair proportion of demand may be met by in-state biomass generation, overcoming any small cost advantages held by out-of-state generation of similar technology and scale. If co-fired in existing coal plants, the green power demand will be more limited, as many consumers and environmental advocates may resist considering such generation as "green". Nonetheless, the possibility of such co-firing presents a low-cost potential source. Green market demand pull for biomass is expected to be lukewarm compared to zero-emission resources at the same cost, based on the relative "willingness to pay" expressed in numerous consumer surveys, and a poor understanding by the general public of the benefits of a fuel that is burned.

The assumed capacity available in 2003 was based on the assumption that little can be done regarding constructing new greenfield biomass generation capacity between now and then, given the immature nature of the industry and limited infrastructure for sustainable biomass certification. In addition, the economics of greenfield development may be difficult to justify without a long-term contract. A fossil-to-biomass repowering or partial front-end gasification plant constructed to feed an existing fossil plant is more feasible in this timeframe, of roughly 15-25 MW scale. While it is uncertain whether sufficient sustainable forestry wood might be available in sufficient quantities to fuel such a plant in 2003, we have assumed for purposes of estimating short term market potential that such sources would be available. In addition, it was

[13] Many biomass plants consume free or low-cost construction debris or other wood or agricultural waste fuel, as an alternative to landfilling the fuel as waste.

assumed that a pilot scale willow plantation, covering 1000 acres of open space near an existing coal-fired power plant, will be ready for its first full harvest (3 years)[14] and will be co-fired at an existing NJ coal plant. Such a pilot would yield the equivalent of about 1.5 MW of co-fired biomass capacity.

By 2012, it was assumed that biomass would come from 3 sources: sustainable forest wood, short-rotation woody crops, and a 25% fraction of the "other" sources which have been deemed to be "sustainable", as discussed above. For forest wood and short-rotation woody crops, the projection of biomass capacity was made by adjusting the sum of biomass direct combustion and gasification projected for Massachusetts[15] in "Scoping Study of Renewable Electric Resources for Rhode Island and Massachusetts"[16] by the New Jersey to Massachusetts ratios of forested land and Class III crop/pastureland, respectively[17]. For the mill residue and urban wood waste, the NJ "sustainable" capacity was assumed to be 25% of the Massachusetts total capacity from these sources, from the same study. This figure was increased by 5% to reflect an assumption that some fraction of the biomass would be co-fired at greater efficiency than in a direct combustion dedicated biomass facility.[18] This approach yields an estimate of market potential capacity for 2012 in the range of 100 to 140 MW. Biomass facilities can generate more electricity per kW of capacity than some other renewable technologies -- particularly PV and wind -- due to the potential for baseload operation. Assuming a 75% capacity factor, which would allow for some of the biomass capacity being subject to dispatch (or being operated under acceptable market price conditions), the annual generation ranges from approximately 660 to 920 gWh. This is the second largest market potential, with only landfill gas technology having a greater potential generation market in 2012.

R.2.3 Biomass Cost

The legislature placed a strong emphasis on the requirement that "the biomass is cultivated and harvested in a sustainable manner" in order to be eligible for treatment as a Class I renewable

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14 This pilot would be similar in scale similar to the pilot-scale program being pursued in New York for co-firing at the Niagara Mohawk Dunkirk coal plant, see "Willow Biomass News", SUNY College of Environmental Science & Forestry, Vol. 1, No. 1, 1997)

15 There was very little difference in the Massachusetts upper limit projections of biomass generation between 2002 and 2017 in referenced study, therefore the 2017 figure was used as a proxy for 2012.

16 Vol. 1: Technology Assessments, C.T. Donovan & Associates, Inc., et al, November 1997, pp. 8-12 and 9-8. All other embedded assumptions regarding fuel usage, plant efficiency and the relative split between direct combustion and gasification were implicitly adopted from this study.

17 It was assumed that sustainable silviculture occurs in a portion of land classified as forested (which covers 42% of NJ), and a portion of the Class III marginal cropland/pastureland is converted to closed-loop willow or other short-rotation woody crops (SRWC) farming. In the RI/MA Study. P. 8-16, it was assumed that only marginal or low-quality farmland would be appropriately placed in use for SRWC farming. C.T. Donovan used "Class III cropland & pastureland" as a proxy, and assumed 25% of cropland & pastureland is available for Short Rotation Woody Crops by 2017.

18 This methodology also captures the market potential for small, distributed biomass gasification applications, which are implicitly included in the Rhode Island/Massachusetts study.

resource. Since these sustainable practices are to some extent under development at present, additional information will be needed to better understand the costs and infrastructure needs for sustainable cultivation, collection and transportation of biomass fuels.

The costs of the electricity generation systems are reasonably well-known, for both combustion and gasification equipment. The source of cost estimates which is most relevant for New Jersey is the recent study for Massachusetts and Rhode Island, which projects costs for the year 2002 of $.06/kWh for a gasification plant sized at 7.5 MW, including a market based cost for biomass fuel. The cost is estimated to be one cent/kWh higher for a direct combustion facility, even with the additional economies of scale associated with a 32 MW plant. In view of the constraint that "the biomass is cultivated and harvested in a sustainable manner," and the possible incremental biomass fuel costs that could result, it would be reasonable to increase the cost expectation, although the impact is very uncertain. In addition, there is some prospect that if the development activity for biomass power plants becomes significant, the environmental requirements for emission control equipment and other plant and operational characteristics could become more stringent. Biomass is more subject to this kind of environmental cost risk than the Class 1 renewables that have little or no air emissions. Therefore, to account for these potential costs and risks, it is reasonable to assume a that costs for a plant going online in 2003 would fall in the range of $.06 to $.09/kWh.

R.3 TECHNOLOGY: POWER FROM LANDFILL GAS

R.3.1 Characterization of Landfill Gas Technology

Landfill gas (LFG) is produced when wastes that have been stored in landfills start to decompose. This gas is about 50 percent methane (CH4), also known as natural gas, and 45 percent carbon dioxide (CO2). Small amounts of other gasses may also be trapped along with the methane and carbon dioxide. Rather than allowing LFG to escape into the air, this gas can be captured, converted, and utilized as an efficient energy source for many municipalities. Using the stored gas helps to minimize odors and other potential hazards associated with LFG emissions, and it helps prevent methane from migrating into the atmosphere and contributing to global climate change as well as local air pollution problems. LFG is a readily attainable energy source that minimizes the need for non-renewable resources (i.e. coal, oil and gas). It is important to note that LFG is the only renewable energy source that, when used, removes pollution that would otherwise naturally be released into the air. [19]

Current Clean Air Act regulations require many landfill owner/operators to collect and combust landfill gas. To comply with existing regulations, landfill owner/operators can either burn the gas off (a process known as 'flaring'), or install a landfill gas-to-energy (LFGTE) system. LFGTE is the only technological option that offers landfill owner/operators the opportunity to reduce the costs associated with regulatory compliance by turning this landfill byproduct into a marketable resource.

The stored gas is collected using a system of trenches and wells constructed at a landfill. It can then be converted and used in many ways:

- Reciprocating Internal Combustion Engines
- Gas Turbines
- Rankine Cycle (Steam) Turbines
- Combined Cycle Engines (gas turbine and steam turbine)
- Gas delivery systems:
    - Sale as a Medium BTU Fuel
    - Sale as a High BTU Fuel
- Emerging Utilization Options (i.e. niche applications like fuel cells). [20]

Almost any waste disposal facility can use landfill gas for a variety of uses. However, more than 78 percent of the planned or currently operational landfill energy facilities generate electricity

[19] Landfill Methane Outreach Program, US Environmental Protection Agency, www.epa.gov, FAQ's sheet.

[20] For more specific information see 'Landfill Gas to Energy Project Opportunities: Background Information On Landfill Profiles", US EPA, January 1999.

(internal combustion engines connected to electric generators). It is the easiest and most cost-efficient method of using LFG. [21] The generating capacity of these generating facilities normally ranges between 0.5 and 4 MW, with the largest facility producing almost 50 MW. The total US installed electric capacity fired by landfill gas is roughly 520 MW.

There currently are a number of demonstration projects in use, which are exploring the combined use of LFG and fuel cell technology.[22] However, LFG-to-fuel cell technology is still prohibitive in cost, and is not an economically viable option in the present.

Of the approximate 6,000 landfills across the United States, there are only about 270 LFGTE projects currently in operation. 51 percent of LFG projects are located at publicly owned landfills and 43 percent are stationed at privately owned landfills. The remaining projects exist at landfills which are owned/operated by a joint public/private corporation.

The EPA estimates that more than 700 landfills could cost-effectively have their methane turned into an energy resource, producing enough electricity to power 3 million homes across the United States. It is important to remember, however, that not all landfills can be used for the purpose of producing energy.

The following 'rules-of-thumb' should be kept in mind when identifying which landfills may be candidates for successful alternative energy projects: [23]

- At least 2 million tons of municipal solid waste (MSW) should be stored in the landfill. If a landfill contains a high level of waste not traditionally classified as MSW (such as industrial waste which contains lower amounts of organic material) the gas output of the landfill will be reduced. [24]
- The total landfill area should cover a minimum of 30 acres. A large portion of this area should be close to the perimeter of the waste-site so that an on-site gas collection system can be constructed.
- The landfill should have a depth of at least 40 feet or higher. The mining of LFG from landfills with depths less than 40 feet becomes very difficult due to the presence of atmospheric influences.
- The landfill should be have been actively used for the storage of waste for a period of 5 to 10 years at minimum. The decomposition process which produces LFG requires this

[21] Landfill Methane Outreach Program, US Environmental Protection Agency, www.epa.gov, FAQ's sheet. 1999.

[22] Scoping Study of Renewable Electric Resources for Massachusetts and Rhode Island, C.T. Donovan Associates, Inc., November 1997.

[23] Scoping Study of Renewable Electric Resources for Massachusetts and Rhode Island, C.T. Donovan Associates, Inc., November 1997.

[24] The Environmental Protection Agency suggests that MSW landfills with more than 1 million tons of waste should be considered as potential project sites.

length of time to produce a cost-efficient quantity of recoverable LFG. Peak methane production occurs soon after a landfills closure.

- The landfill should be planned to remain operable for at least several years after the LFGTE system in constructed. The life of a LFGTE project will be longer if the landfill is scheduled to remain open for a number of years after the system is installed. Closed (or soon to be closed) landfills are less desirable since the timeframe over which recoverable LFG is produced will be less. [25]

Existing gas-to-electricity systems in the United States range in size from approximately 50 kW to 50 MW, and a typical gas-to-electricity project produces between 500 kW and 1MW. Most of the existing facilities are constructed by the landfill operators themselves, or by firms that specialize in the construction of LFG projects. It is estimated that 84.1 percent of the investment associated with LFTGE facilities comes from private investors. [26]Waste Management Inc., BFI, Air Products and Laidlaw are some of the major companies investing in this type of technology, but there are a great number of much smaller firms who have made major financial investments in LFG recovery systems.

When a site is being considered for use as a LFGTE project, it is necessary to prove that that a gas resources indeed exists prior to the construction of a power generating station. This is requires an on-site pumping trial and analysis to determine if the quantity of gas present is sufficient to adequately fuel the proposed project. If the analysis concludes that there is a sufficient level of LFG to proceed, then the following equipment needs to be acquired to maintain an operational LFGTE system: [27]

- A gas collection system, which consists of wells and trenches, as well as collection piping used to draw gas out of the landfill and convey it to a central point.
- Compressor*s* which are first used to create negative pressure in the gas collection system in order to draw out the gas. The same compressors are then used to create positive pressure to supply the gas to the energy conversion equipment.
- A gas cleanup system which will generally remove moisture from the gas and other contaminants prior to its use for energy creation. The type of the cleanup system is directly related to the purpose for which the gas is being collected.

[25] The EPA believes that landfills closed prior to 1993 are not good candidates. However, in talking w/ someone from the LMOP office, this is just general guidance. There are many landfills, however, that were closed prior to 1993 which are still producing an economically usable amount of LFG.

[26] Estimate for 1992. From 'Implementation Guide for Landfill Gas Recovery Projects in the Northeast', SCS Engineers, September 1994.

[27] Scoping Study of Renewable Electric Resources for Massachusetts and Rhode Island, C.T. Donovan Associates, Inc., November 1997.

- The energy conversion system, such as an internal combustion engine generator set, gas turbine engine set, direct combustion boiler and steam turbine generator set cogeneration unit, fuel cell, or other power conversion technologies.

Technology Efficiency

Efficiency and heat rates for three of the most common LFG energy systems are presented here.[28] Information on overall efficiency rates for a complete LFGTE system is not available. Total system efficiency would be less than overall efficiencies presented here due to the influence of numerous parasitic loads (such as the LFG compressor motor) included in the system.

Conversion Technology	Efficiency (%)	Heat Rate (Btu/KW)
Internal Combustion Engine/Generator	33	10,400
• Caterpillar 3516 SITA or Waukesha 7100 GL		
Gas Turbine Engine/Generator	28	12,200
• About 3 MW		
Fuel Cells		
• Phosphoric Acid	36	9,400
(International Fuel Cell 200 kW)		
• Molten Carbonate	50	6,800
(Energy Research Corp. 2,000 kW		

Commercialization Status

LFGTE projects that utilize internal combustion engines, gas turbine engines and boilers, are fully commercialized. According to data published by the U.S. Environmental Protection in January of 1999, there are approximately 270 LFGTE projects in operation. However, the EPA estimates that as many as 700 additional landfills could cost-effectively have their stored methane gas turned into a productive energy resource. This translates into enough energy to power approximately 3 million homes in the US. [29]

[28] Comparative Analysis of Landfill Gas utilization Technologies. Northeast Regional Biomass Program, CONEG policy Research Center, Inc. Revised March 1997. As cited in Scoping Study of Renewable Electric Resources for Massachusetts and Rhode Island, C.T. Donovan Associates, Inc., November 1997.

[29] Landfill Methane Outreach Program, US Environmental Protection Agency, www.epa.gov, FAQ's sheet. 1999.

Benefits of LFGTE Technology for New Jersey

The benefits of LFGTE projects for the State of New Jersey can be broken down in the following manner:

- Environmental Benefits - Direct and Indirect
- Energy Benefits
- Economic Benefits.

Environmental Benefits

The following direct environmental benefits can be achieved with LFGTE systems:

Direct:

- Reduces volatile organic compound (VOC) emissions
- Reduces risk of global warming
- Reduces odors associated with decaying material buried in landfills
- Landfill gas is the biggest source of methane emissions in the US - contributes almost 40 percent to total methane emissions.

EPA estimates of environmental benefits of LFGTE projects in New Jersey to be the following:

- *Total current methane reduction (tons/yr)* - 99,829 (from 14 current LFGTE projects) .
- *Total potential methane reduction (tons/yr)* - 289,856 (from 14 current LFGTE projects, 5 candidate projects, and 6 projects classified as 'other').
- *Total current CO2 Equivalent of CH4 Reduction (tons/yr)* - 2,096,407 (from 14 current LFGTE projects) .
- *Total potential CO2 Equivalent of CH4 Reduction (tons/yr)* - 6,086,980 (from 14 current LFGTE projects, 5 candidate projects, and 6 projects classified as 'other').

Indirect:

By generating electricity from LFG, fossil fuel use is displaced and emissions from fossil fuel (SO2 and CO2) are avoided. The EPA estimated the 'Potential New Jersey Emissions Avoided by Fossil Fuel Displacement' for both electricity generation projects and direct use project. [See 'Landfill Gas to Energy Project Opportunities: Landfill Profiles for the State of New Jersey', US EPA, January 1999 for more detailed information.]

- Total current CO_2 avoided emissions (from coal, oil and natural gas) by the 14 current projects in New Jersey for both electric generation projects and direct use projects as estimated by the EPA = 4,299,204 tons/yr.
- Calculating the avoided emissions from the 5 candidate projects in New Jersey, and adding this to the total above, the projected benefits jump to 4,673,724 tons/yr.
- Total current SO_2 avoided emissions (from coal, oil and natural gas) by the 14 current projects in New Jersey for both electric generation projects and direct use projects as estimated by the EPA = 22,738 tons/yr.
- Calculating the avoided emissions from the 5 candidate projects in New Jersey, and adding this to the total above, the projected benefits jump to 24,719 tons/yr.

Energy Benefits

Energy benefits from LFGTE projects can be summed up as follows:

- First, LFGTE facilities provide a constant source of fuel - A landfill (on average) that has 2 million tons of MSW produces about 1.8 mmscf/day of LFG and can generate 2.5 MW of electricity.
- Second, LFG has a variety of uses - electricity generation (most common use) and direct use by industry.
- Third, landfill energy adds to the communities fuel diversity.
- Fourth, facilities can provide important DG benefits of normal demand side management options.

Economic Benefits

The economic benefits associated with LFGTE projects can be grouped into two categories:

- First, LFG is a low cost source of renewable energy (relative to other forms of renewable energy).
- Second, LFGTE projects, indirectly, help create jobs (in the construction and maintenance sector).

R.3.2 Landfill Gas Technology Potential

According to the U.S. EPA, operational LFGTE projects have the combined capacity to produce roughly 520 MW. [30] The current state of LFG projects in New Jersey was documented in 1999 by the EPA as part of the agency's Landfill Methane Outreach Program (Landfill Gas-to-Energy Project Opportunities: Land Profiles for the State of New Jersey.)[31] This 1999 report presents information about MSW landfills specifically in the State of New Jersey and analyzes the state's potential for the growth of LFGTE projects. This report is composed of three specific parts:

- A summary of the state-specific potential for LFG utilization energy by landfill category.
- A summary of the emissions avoided by fossil fuel displacement for electricity generation and direct use projects.
- An index of the state-specific MSW landfills (referenced by category, landfill name and general characteristics).

According to this report, there are currently 14 operational LFGTE existing facilities or landfills with LFGTE projects under construction. These 14 facilities had a total estimated generating capacity of 135 MW. There are also 5 candidate projects in New Jersey, with the potential of generating an additional 12 MW. (Candidate projects are defined as 1) landfills with a potential or planned LFGTE utilization project; and 2) landfill is either currently operating (or closed after 1993 baseline) and has more than 1 million tons of stored MSW.

Summarized below are the 14 gas projects in the State of New Jersey that currently produce electricity from LFG.

Current Capacity in New Jersey - By Landfill

[30] From 'Landfill Gas to Energy Project Opportunities: Background Information On Landfill Profiles", US EPA, January 1999. Landfill Methane Outreach Program.

[31] From 'Landfill Gas to Energy Project Opportunities: Landfill Profiles for the state of New Jersey", US EPA, January 1999. Landfill Methane Outreach Program.

Landfill/ Location	Waste In Place as of 1998 (in million short tons)	Estimated Methane Generation millions of standard cubic feet per day (mmscf/d)	Electricity Generation Project (MW)
Balefill North Arlington, NJ	18.89	5.250	16.4
Cape May County SLF Woodbine, NJ	1.79	0.876	2.7
Dover Township LF NJ	N/A	N/A	N/A
Edgeboro Disposal MCUA II East Brunswick, NJ	48.80	12.901	40.3
Hamm's LF Lafeyette, NJ	1.70	0.853	2.7
HMDC 1-A LF Kearny, NJ	2.82	1.140	3.6
HMDC 1-C LF Kearny, NJ	13.86	3.964	12.4
ILR LF Edison, NJ	3.32	1.268	4
Kearny 1-D LF Kearny, NJ	5.25	1.761	5.5
Kingsland LF North Arlington, NJ	18.26	5.088	15.9
Kinsley LF Deptford, NJ	5.11	1.725	5.4
L & D LF Mount Holly, NJ	3.29	1.259	3.9
Monmouth County LF Tinton Falls, NJ	10.70	3.154	9.9
Ocean County LF Manchester, NJ	13.29	3.818	11.9

There currently exist 5 candidate projects in New Jersey, with the potential of generating an additional 12 MW. (Candidate projects are defined as: 1) a landfill with a potential or planned LFGTE utilization project; and 2) a landfill that is either currently operating (or closed after 1993 baseline) and has more than 1 million tons of stored MSW.)

Candidate Landfills

Landfill/ Location	Waste In Place as of 1998 (in million short tons)	Estimated Methane Generation millions of standard cubic feet per day (mmscf/d)	Electricity Generation Project (MW)
Burlington County SLF Mansfield, NJ	3.50	1.313	4.1
Cumberland County SLF Deerfield, NJ	1.93	0.911	2.8
Gloucester County SLF Woodbury, NJ	1.74	0.862	2.7
Sussex County LF 1-E Lafayette, NJ	1.01	0.676	2.1
Towanda Electric Facility NJ	N/A	N/A	N/A

In additional to these 5 candidate landfills, the EPA estimates that there may be an additional 10 MW of new capacity available from 6 additional landfills that are currently deemed too small or too old to maintain a LFGTE project. Further analysis will need to be performed to determine if and when these 6 additional landfills could be used as LFGTE facilities. The six potentially usable landfills in New Jersey are [32]:

- Edison Township SLF
- Salem County SLF
- Galloway Township LF
- Pineland Park LF
- Linden City SLF
- Pennsauken LF.

Hence, in New Jersey, according to the EPA, there is the potential to develop an additional 22 MW (above the estimated 135 MW of capacity already in place), resulting in an overall potential capacity of 157 MW.

R.3.3 Landfill Gas Market Potential

While the EPA estimates that there may be only an additional 22 MW of LFG power available in New Jersey, it is possible that this estimate is too much conservative. It is a fact that electricity

[32] From 'Landfill Gas to Energy Project Opportunities: Landfill Profiles for the state of New Jersey", US EPA, January 1999. Landfill Methane Outreach Program.

production from an existing, capped landfill project degrades over time. However, as new garbage is added to existing landfills and the production of methane increased due to this increased garbage disposal, it is expected that the methane supply will grow. Similarly, as regulatory demands (to reduce methane emissions) on landfill owners/operators grow, the incentive for owners and operators to efficiently tap into this renewable source increases.

The projection for future landfill methane generation capacity involves calculating a net increase which accounts for new production offset in part by a degree of production attrition at existing facilities. The projection of future landfill methane production takes into account several factors:

Additional landfill methane at existing landfills that becomes economic to capture and convert to electricity at higher electricity prices resulting from RPS demand, green power demand, and the presence of SBC-funded programs. It was assumed that:

- the (inflation adjusted) sales price increases by roughly 1.5 ¢/kWh between 1999 and 2012 due to these factors, and the lack of lower-priced renewable substitutes;
- incremental capacity from increased efficiency of new generation, reflecting an evolution over time from internal combustion (diesel) technology today towards higher efficiency fuel-cells by 2012;
- additional waste disposed of in each year at NJ landfills (about 4.2%/yr, lagged by 2 years); and
- production attrition at landfill with existing production facilities (about 5% per year of existing production).

Based on the above information concerning future waste disposal in New Jersey and the likelihood that additional landfills will become economical sources of LFG (above and beyond EPA's estimates), the projected total LFG capacity may likely be as high as 267 MW by 2012. This corresponds to a 132 MW projected incremental capacity (to 2012) above the 1999 baseline of 135 MW. It is reasonable to expect the incremental capacity to fall in the range of 110 to 155 MW as of 2012. With the high capacity factors of most power facilities burning landfill gas, this capacity could generate from 870 to 1,220 gWh/year.

R.3.4 Landfill Gas Cost

Economically justified emissions reductions -- reductions that can be reached at a profit to a landfill owner/operators if a host of barriers were removed -- are highly dependent upon the market value of the energy produced from the LFGTE system. For example, at an electricity price of $0.05 per kWh, about 50 to 60 percent of landfill methane emissions could be recovered for a profit. At a price of $0.06 per kWh, profitable emissions reductions increase to 60 to 80 percent. At a price of $0.04 per kWh, it is profitable to recover only about 15 to 25 percent of emissions.

In the year 2000, it is estimated that about 750 landfills of the over 6,000 existing landfills could recover 6.7 Tg of methane and produce about 4,000 MW of electric generating capacity if the electricity price were $0.05 kWh. For the same year, at a price of $0.04 per kWh, only about 60 landfills would recover 1.5 Tg. At a price of $0.06, however, about 1,400 landfills could profitably recover 8.2 Tg and produce about 5,000 MW of electric generating capacity. Currently in New Jersey, the estimated electricity revenue for LFG projects is about $0.045 and is estimated to be about $0.055 in 2012.

There exists a wide range of overall capital costs associated with LFGTE projects.[33] Capital costs for a small 700 kW LFG project can be as low as $970,000 (in 1997 dollars). This translates into an installed cost of $1,074/kW. Larger projects often can easily cost more than $5 million. This translates into an installed cost in the following range - $1,800/kW to $3,100/kW depending upon the specific technology that is being used.

Annual O&M costs are based on an industry rule of thumb of $0.015/kWh. This number is based on experience designing and tracking the performance of these facilities. Research into costs associated with LFG projects have assumed annual O&M costs of $50,000. The annual capacity factor for LFGTE systems is relatively high - typically around 95%. This is largely because internal combustion engines and gas turbine engines are very reliable (in producing a steady stream of power) and have established performance records.

[33] For more information see ‘Landfill Gas to Energy Project Opportunities: Landfill Profiles for the state of New Jersey”, US EPA, January 1999. Landfill Methane Outreach Program.

R.4 BARRIERS FOR GREEN POWER SUPPLY TECHNOLOGIES

R.4.1 Regulatory Barriers

Bulk power generation technologies such as wind, biomass, and landfill gas face several types of regulatory barriers, some which only affect certain technologies and others that affect bulk power generation in general. Environmental, siting and permitting issues effect all bulk power generation technologies. For wind, permitting processes are uncertain at the current time and are likely to be lengthy at least initially. Concerns regarding avian interaction, and acoustic and aesthetic impacts are likely to draw local opposition. Local opposition to the siting location could increase the length of the permitting process dramatically.

Because of the intermittent nature of wind, large wind projects designed for the grid face a regulatory or market barrier in terms of access to transmission, and various difficulties under ISO dispatch and scheduling rules. Transmission pricing is usually based on a capacity reservation, so wind has to buy space on the transmission line whether or not the wind is blowing. Also, dispatch and scheduling rules are generally designed for generating plants which can control the level and timing of their output; therefore significant penalties for failing to generate to schedule can add significantly to the total cost of delivering wind to retail load.. These issues are not well addressed by a system benefits charge, but need to be addressed in ISO or power pool rules.

For biomass, a regulatory barrier may be uncertainty about what qualifies, that is, proving that the resource is cultivated and harvested in a sustainable manner. Proponents of different biomass projects with different resource feedstocks will likely argue their case for sustainability. Resolution of this question may require rulings by the BPU further defining sustainability.

Landfill gas recovery systems must comply with many layers of regulatory requirements (local, state, federal) that address environmental and zoning issues. The costs of complying with all of these regulations can be significant. Siting barriers would probably be site-specific - some communities may have a more effective/efficient zoning process which would make the development of these facilities much easier and time consuming. Similarly, some communities may have experience in attempting to site locally unwanted land uses. These communities would experience fewer siting barriers.

R.4.2 Information Barriers

While wind, biomass and landfill gas are viable electric power sources, many people are not educated as to the merits of these generation sources, or educated regarding the manner in which fossil fuels impact our environment. Most alternative/renewable energy technologies tend to be seen as high risk, and this will continue to act as a barrier for bulk power renewables projects despite their proven success. This perception of high risk can come from numerous sources including members of the surrounding community who may be fearful of these projects in their neighborhoods or public officials who may similarly not be aware of the success of existing renewables technologies. Education in both of these areas would intensify consumer support and increase consumer demand for the production of cleaner power.

R.4.3 Infrastructure Barriers

Green power generation faces market infrastructure barriers in New Jersey including a lack of market mechanisms to bring supply and demand together in the marketplace.[34] For example, although these technologies are best suited for the bulk power market and green power choice, green power demand grows in very small increments, while these technologies come in larger chunks. Wind comes in modules of 0.5 to 1.5 MW (although projects exceeding 5-10 MW are necessary for reasonable economies of scale), reasonably close to but still above demand increments; landfill gas is of a 1-8 MW scale, and biomass tends to be much larger, in tens of MW. Generally they are too big to add without risk, unless the market is growing steadily and the demand for green power has been proven. Although financing is not a serious barrier, the uncertainty about demand and fear about the project's output being uneconomic may increase financing costs. In addition to addressing the barrier with some form of financial incentive, it might be overcome by a form of insurance against loan default or against lack of green power demand.[35]

Sustainable biomass still faces some technology risk in that clean burning technologies such as gasification are not yet widely adopted. New Jersey cannot overcome this lack of experience by itself, but it might address the is need through either a performance guarantee or a financing guarantee, whichever is most needed to get a particular plant built. Sustainable biomass also means managing the resource inputs in a sustainable way. This will require defining, and perhaps also monitoring, what is a sustainable forestry or agricultural practice.

Other infrastructure barriers include a lack of trained installers and service capability. While there is certainly an infrastructure to support the development of the wind power industry, the local infrastructure in New Jersey is not yet in place. A large amount of business development and education regarding the operation and maintenance of the facilities would be necessary to have the industry thrive in this state. Because of the size of the facilities, developers generally bring engineering and other support services with them, but may train and use local labor for operation and maintenance. Enron, FPL, Micon, Vestas, etc. can move in and hire some local personnel and train them on the site.

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[34] One strategy to deal with these market infrastructure barriers is the development of a "Green Power Exchange;" see section 5.3 at the end of this Appendix for further details.

[35] See for example Means, Robert C., "Evaluation of a Proposal for Green Power Price Insurance." REPP Special Report (Washington, DC: Renewable Energy Policy Project, May 1999).

R.4.4 Technology Barriers

For the most part, bulk power renewable technologies do not face significant technology barriers. They have been commercially proven and are widely available technologies. For example, the landfill gas technology concept has been proven and is being demonstrated at landfills across the country. Technological barriers for the most common landfill gas to electricity projects appear to be fairly minimal. This is especially true for internal combustion engines using LFG. The technology has proven to be an effective method for reducing methane emissions (as mandated by the CAA) and producing a constant supply of energy for local facilities. [36] Only for some of the more cutting edge LFGTE technologies do there exist barriers - for example, the concept has not been proven and not demonstrated at any operational landfill.

However, the intermittent nature of wind technology does act as a technology barrier. Due to the nature of this power source, it can not be used alone as a sole source of power. The power produced by the wind has traditionally been supplied to the electric grid to supplement or replace the traditional fossil fuels burned. While we will soon have the ability to accurately predict the wind power generated at a particular site, we will still need to supplement or have the capability to store this power source when there is little or no wind.

Biomass gasification technology, as opposed to biomass direct combustion, still faces technology barriers as it is still in the demonstration stage and commercial power plants using this technology are not yet on-line.

R.4.5 Financial Barriers

Generally, I think of most of what is discussed in this category as economic issues/barriers. They cost more. Financial barriers, on the other hand, are the inability to get financing because of high risk or uncertainty (or perception of same) about the technology, or high financing costs because of same.

Renewable bulk power technologies face significant financial barriers. The major financial barrier to wind energy systems is due to the high initial equipment costs. There is also a high risk factor associated with wind energy due to the lack of reliable wind data in some regions. Currently there is little data to forecast the amount of energy produced through wind generation. The data necessary to accurately predict the energy produced at a particular site must be gathered over an extended period of time. While we currently have this type of data for wind farms currently generating electricity, there is always risk involved in predicting generation capabilities at new sites.

For landfill gas technology, if a gas collection system is already in place (as sometimes mandated by EPA regulations), then the only remaining cost is to install the electric power

[36] For a more detailed discussion of LFG technologies see 'Comparative Analysis of Landfill Gas Utilization Technologies' SCS Engineers, March 1997.

generation technology. It has been estimated that the generating equipment makes up about 65 percent of a projects capital costs. [37] Clearly, financial barriers are reduced for those landfills already collecting LFG (but not using it for energy production). However, for those landfills currently without a gas collection system, there exists a fairly high capital cost requirement (both the collection system and the power generation technology) which can act as a financial barrier.

In addition, there are several landfill gas technologies that carry larger price tags, and are currently not cost competitive. For example, attempting to combine LGF projects with the use of fuel cells is currently extremely cost prohibitive. A number of landfill owners/operators and project developers have considered fuel cells for landfill gas applications, but have not actually gone through with the idea. The costs (especially for some of the more cutting edge technologies like fuel cells) associated with less common forms of gas-to-electricity systems have the potential to deter landfill operators/owners who may own a facility that is ideal for a gas recovery system.[38]

Additional financial barriers arise in terms of markets for green power. The demand for green power is uncertain, making it difficult for developers and project financiers to justify new renewable development. The creation of a larger green power market made up of many individual customers provides a more statistically stable target market.

R.4.6 High Technology Cost

The greatest economic barrier that bulk power faces as a renewable energy source is that it is not generally not cost-competitive with the market price of power. For example, while the development of the wind energy industry and technology has decreased the cost of electricity significantly, it is still slightly higher than the traditional fossil fuels.

LFGTE technology, on the other hand, is generally price competitive with other sources of electricity. This is especially true for certain LFG utilization options such as internal combustion engines and gas turbines. Together, these two forms of electricity generation make up about 111 of the LFGTE projects in the United States. Landfill gas projects may be significantly cost efficient for the end user. For industrial end-users, a nearby landfill that is collecting its landfill gas can be an inexpensive source of fuel or steam.

[37] For more detailed information breaking down capital costs see 'Implementation Guide for Landfill Gas Recovery Projects in the Northeast', SCS Engineers, September 1994.

[38] For a more detailed discussion of LFG technologies see 'Comparative Analysis of Landfill Gas Utilization Technologies' SCS Engineers, March 1997.

R.5 GREEN POWER SUPPLY TECHNOLOGIES: POTENTIAL FOR MARKET TRANSFORMATION

Bulk power technologies for renewable energy (large wind, biomass and landfill gas) will depend to a great extent on the green market and customer choice.[39] Given this market niche or application, the main barriers facing these technologies are economic and a lack of information.

R.5.1 Market Transformation Strategies to Address Economic Barriers

First, all three bulk power renewable technologies are from one to a few cents above the market price of power, and this is critical because these plants must sell to the wholesale market. But this need can be addressed by a strategy to lower the cost. The system benefits charge fund could be used to address this need. Technologies would be competitive with a small subsidy. Technologies that are still moving down the cost curve fairly quickly (wind in particular meets this criterion) may very well reach a competitive cost level in four to eight years. If a technology is unlikely to drop further in cost, then the market for it cannot be said to have been transformed, but if a subsidy can make a technology competitive long enough for it to experience the decline (along with polices and programs taking place elsewhere in the country) then the prospects are good for market transformation.

One strategy to move bulk power renewables into the marketplace is the renewable production incentive which enables large-scale renewable energy projects to compete in the bulk power supply market by providing a subsidy based on the number of kWh actually produced. The incentive can be determined by regular auctions and paid to the generator.[40] The production incentive may be targeted to specific technologies to encourage projects that would be expected to have a hard time winning a cents per kWh bid, or to limit the incentive budget being allocated to the expected least expensive technology.

Bulk power cannot be omitted without losing certain technologies, especially large scale wind, biomass and landfill gas, and without these any comprehensive renewables program would be criticized. Production incentives are good for large scale, bulk power supply projects that are within a few cents of the wholesale power market price. Because competitive bidding is involved to establish the incentive level, large projects can more easily justify the cost of bid preparation and bid review.

[39] This may be least true for LFG which, because it is the cheapest new renewable resource, and may therefore be chosen to help meet renewable portfolio standard requirements. Nevertheless, landfill gas will also be used for green power products because it helps to reduce the average cost of a green power product.

[40] Another proposed program, the Green Power Purchase Incentive, would pay customers for their purchase of eligible green power kWh.

A second strategy to address economic barriers faced by bulk power renewables generation is the use of a Green Power Purchase Incentive (GPPI). A GGPI develops market pull for renewables by creating in each utility territory *long-term* green customers who will continue to buy green after end of subsidy. The objective is to encourage a significant proportion of the potential 15-30% (residential) green customers to become actual "green" customers. Based on evidence in other markets that customers who choose on a basis other than economics alone are less likely to switch for small savings, we can assume that many of theses customers will continue to purchase green power in the future after the subsidy is withdrawn.

GPPI can take the form of either direct payments to consumers who purchase electricity from eligible technologies to reduce the price premium, or (as is the case in California) payments to the retail sellers of green power so that they can reduce the premium charged to customers. Payments could be made on a cents per kWh basis, and/or could be directed on a fixed one-time or annual payment per customer. The level of credit could phase out over time according to a predefined schedule, so that the green customer will experience only a minor price dislocation when the green power price is no longer subsidized.

Experience from competitive retail states shows that there is significant market inertia to customer switching. Switching is low unless consumers have a good reason to participate in choice. Two primary motivators so far appear to be price and green power. Combining cost savings with environmental benefits may be the strongest magnet to draw consumers into the market. Market research also shows that a lot of people are likely to switch if they can combine green power with green savings. A customer incentive is also a powerful marketing hook.

In California, an annually declining credit is made available for all qualified purchases in each year of the program (so that a green customer signing up in year one would be eligible for 4 years of subsidy, versus a switcher in year four receiving subsidy for a year), based on a fixed budget. An alternative approach would pay each customer a fixed but declining per-kWh payment for a similar time frame (i.e. the shorter of 3 years or the length of time on a qualifying green product). The difficulty with both of these approaches is that they either do not provide the retailer/customer with a predictable payment stream (if payments not fixed), or make it difficult to budget (if payment fixed but number of participating customers are unknown). This type of strategy only pays for success. (If available to retailers), those most effective at gaining and retaining customers with qualified product offerings will be rewarded.

R.5.2 Market Transformation Strategies to Address Information Barriers

The second need to make the customer choice market work for bulk power renewables is better information and education for consumers. All three bulk power technologies suffer to one degree or another from customer ignorance or misinformation. For example, most people are not even aware what biomass is, and when they do understand it that it is renewable, they may be confused about how a fuel that is burned can be considered clean. There are similar reactions to landfill gas, despite its environmental benefits. In fact, market research into consumer preferences as to how their power is generated consistently show solar and wind as high, but biomass or landfill gas in a distant middle or lower. This may be due to informed opinion or it may be due to a lack of understanding. In either event, education programs explaining the environmental benefits of biomass and landfill gas, and just familiarity with the terms, should go a long way to helping these technologies into the green power market.

This general lack of knowledge about renewable energy technologies and their future potential in the marketplace, along with a lack of companies who are able and/or willing install and maintain these types of technologies can be addressed using a variety of strategies. These strategies can include increasing consumer awareness, Increasing producer/supplier awareness, facilitating informed decision making by consumers and producers/suppliers, and providing a credible and objective source of information.

There are already existing DSM programs in place that look to promote energy efficiency policies. These programs include: Residential and Commercial New Construction programs, Consumer Education programs, and School Education programs. Expansion of these types of existing programs incorporating specific education and outreach programs for renewable technologies would help lead to market transformation for renewable energy technologies.

Utility companies may find it useful to conduct a series of focus groups with members of the community (possibly targeting community leaders) in the beginning stages of the planning process. The information gathered during the course of these focus groups may assist the individual utilities in understanding what consumers want from an informational/educational program.

Similarly, utility companies may find it effective to work with existing community based organizations (i.e. grassroots groups and environmental groups). This will allow utilities to take advantage of existing networks, relationships and connections already present in local communities. It is likely to be a very cost-effective method of disseminating information about renewables. The hallmark of teaming up with the grassroots approach is broad-based, community wide involvement in the promotion and purchase of renewable power.

In addition to creating new informational/educational programs, existing programs could be expanded to include information about renewable energy. For example, expanding the scope of the School Energy Conservation Program to include information about renewables in the already established curriculum would prevent the creation of an entirely separate (and probably over lapping) program. Similarly, the existing Customer / Trade Ally Support infrastructure could be expanded upon to include workshops and forums targeted at certain renewable technologies.

Education and information strategies include use of educational programs that give students the opportunity to see, touch and understand how renewable technologies work. Children have a tremendous ability to learn through the use of hands on activities. One option is Involving local educational institutions and training organizations to bring these systems to individual schools where teachers and students could incorporate the use of PV, fuel cells and wind power into their science, social studies, math and reading curricula. The use of the WWW to share information around the country and the world is just one example of the types of interdisciplinary learning that can be encouraged through an educational program.

Public education and marketing campaigns are other types of strategies that can be implemented to raise awareness about the opportunities offered by renewable technologies. Well informed citizens are much more likely to make rational decisions what it comes to their use of energy, whether it be in their homes or businesses. It is essential to effectively communicate to the public what renewable energy is and how it is relevant to their lives. If campaigns are adequately directed toward renewable energy, the buying power of consumers could drive a significant expansion in our use of renewable resources, and contribute to a cleaner environment.

Although wind is a generally preferred source of renewable energy, it can also be opposed for its visual or aesthetic impacts in specific siting applications. Again, the perception may be worse than the reality, and education about what it would look like in the context of site surroundings can be helpful. Some education can be useful after the first wind turbines are installed. When people can see them and hear them, in some cases their objections disappear. This can be part of the education process and should be able to be easily accomplished both to reduce siting barriers and to increasing credibility of the resource as being environmentally friendly.

Because these technologies may be a significant component of green power sales from the grid, consumers need education about green power generally. Some of these needs include the basics such as:

- How can you send green kWh over the same lines as undifferentiated energy?
- Are separate poles and wires or meters needed?
- Is the green power actually delivered to my house?
- Will I still get electricity even when the wind is not blowing?
- How will I know I am getting the green power I pay for?
- How will I get the environmental benefits I was promised?

These questions are very much amenable to an education program, which can be accomplished early on in a renewables program. In addition, these needs may be met in part by providing information as required by legislative policy in disclosure rules or electricity labels.

A further strategy to combat the lack of information for financiers, potential customers and the general public is the demonstration project. For some technologies, like PV and fuel cells, working prototypes are available, but market forces do not yet allow full commercialization. With this criteria, and where consumers awareness of the technology remains limited or non-existent, demonstrations of the technology in action helps build awareness, interest, demand, and assist in the ultimate goal of technology acceptance.

R.5.3 Market Transformation Strategies to Address Regulatory and Other Barriers

Although economic barriers and a lack of information are the main issues that need to be addressed, green bulk power resources do face other barriers that must be addressed. In particular, bulk power technologies face barriers in the form of the institutional arrangements which are not yet fully adapted to the needs of buyers and sellers of renewable power in the marketplace, as noted above. Regulatory proceedings may be needed at state and regional levels to develop more appropriate market procedures.

One strategy to deal with market infrastructure barriers is the development of a "Green Power Exchange. A "green power exchange" designed as a market in which willing buyers and sellers can exchange renewable power at a market price, can support both a viable green power market and the cost-effective compliance with renewable portfolio requirements. Green power markets can in principle be set up as an adjunct to an ISO-integrated power exchange, or can be operated by one or more independent third parties. In California, for example, the Automated Power Exchange (APX) has set up (as a subset of its overall activities) the APX Green Power Market for these purposes, creating a week-ahead forward market in California Energy Commission-defined green power. It provides a service that brings the aforementioned benefits to the California.

Any power exchange requires critical mass, a large enough market, enough qualifying energy, willing buyers and sellers in a viable market atmosphere, to justify startup costs. Because green power represents just a small fraction of all power traded today, this situation is particularly acute for a green power exchange. Any exchange would require a much larger green market to justify a free-standing green power exchange than it would to add a green power market onto an existing exchange infrastructure for the same market.

A "green power exchange" can lower transaction costs for market participants associated with procuring and selling green power; ease administration, settlement and credit issues; facilitate compliance with disclosure and RPS requirements; facilitate the offering of green power products; and allow for the creation of visible prices and market information. It can serve as a backup market outlet for the surplus supply of generators, retail and wholesale marketers in which they can seek prices above the commodity value of electricity. Finally, it can serve as a backup source for retailers to mitigate the intermittent nature of much renewable generation.

R3 ADVANCED AND OTHER RENEWABLE TECHNOLOGIES

R ADVANCED AND OTHER RENEWABLE TECHNOLOGIES

R.1 TECHNOLOGY: TIDAL POWER

R.1.1 Characterization of Tidal Power Technology

Tidal Range

Changes in sea levels caused by movements in the tides can be used to generate electricity by building a dam across a coastal bay or estuary. In the simplest of terms, tidal gates are opened when the tide is rising. They are then closed at high tide, which traps the water in the pool behind the dam as the tide begins to go out. When the ocean level outside the trapped pool of water has fallen to about mid-tide range, the trapped water is released back into the ocean through conventional low-head hydroelectric turbines. It is also feasible to pass water both ways through the turbines, so power is generated as the tide flows in either direction. Both of these systems are proven technologies and are being used in several small tidal power facilities in China, France, Canada and Russia.

A number of other concepts for capturing the power of tides have been developed, but have not yet been demonstrated. A Connecticut company called Tidal Electric Inc. is attempting to demonstrate the commercial use of off-shore tidal pools, which help to eliminate the severe environmental side-effects of traditional tidal power facilities. However, these off-shore tidal pools require such a large tidal range, that they are not being actively pursued for use in the United States. Instead, Tidal Electric Inc. is targeting areas with large tidal ranges, especially in areas that currently are in high demand for reliable energy sources.

Tidal energy projects that involve the use of pools to hold the detained water behind a dam (referred to as a barrage) offer good prospects in the short to medium term at sites having high tidal ranges. But again, this is not the case along the coast of New Jersey. Most of the components are commercially available, and the best locations around the world for the use of this technology have already been identified. On the basis of current experience, tidal range power may be regarded as a technically proven, dependable and long-sustained source of power. Its largest problem to date has been its cost relative to other forms of electrical generation. An average tidal range of 5 meters or larger is considered necessary for effective tidal range power generation. In the United States, tidal ranges of this magnitude only occur in remote locations of Maine and Alaska.

Tidal Currents

Tidal currents can also be used to generate power. Submerged Darrieus type motors can be installed in areas with strong tidal currents without blocking local bays or estuaries (as tidal range facilities would do). Water that passes through the mounted rotors in either direction will cause the rotors to turn in a constant direction. Power generation is possible when the water flows 1m/s or higher. Optimal currents are 2-3 m/s3.

Scale of the Technology

The technology for utilizing tidal power is in commercial operation with proven success at a limited number of sites in France, China, Russia and Canada. The world's largest tidal power plant is a 240 MW grid-connection project on the coast of France which has been in use since 1967. Similarly, a 1 MW station has been operating in Russia since 1969 and a 20 MW unit has been operating in Nova Scotia (Bay of Fundy) since 1985. In the future, it is expected that tidal current and tidal range plants could produce on the order of 500 MW or more of power on a global basis, to be fed into national/regional supply grids.

Technology Efficiency

The efficiencies of tidal range technology and complete electric generating facilities using tidal energy are similar to those for hydropower.

The technology for making use of tidal current power is still in the pre-commercialization stage. Pilot demonstrations have been implemented in recent years, and developers are trying to influence investors and governments to initiate projects in suitable locations. Projects have been suggested, but none have actually been implemented, and the extent to which this technology could supply power in the long run is still unclear. Major drawback of this technology - its cost in relation to other means of producing power. With some financial/infrastructure support, this technology might contain some potential for future use in some areas of the world. New Jersey is likely not one of them.

Regulatory and Environmental Concerns

The primary environmental impacts of tidal range power projects are:

- Blocked navigation
- Blocked fish migration and fish/wildlife can be killed in the installed systems
- Impaired commercial fishing
- The location/nature of the intertidal zone can be drastically altered (i.e. flooding, erosion and sediment collection)
- "Tidal regime" can be changed downstream
- A drastically altered coastal landscape

The environmental impacts of tidal current systems are estimated to be less harmful and intrusive. The visual impacts of projects would be fairly low because most of the hardware for this technology is below the water line. However, there still would still need to be transformer stations and lines in the local area.

R.1.2 Tidal Power Potential

About 300 megawatts of tidal energy capacity are in place throughout the world. Some studies have estimated that there are up to 4,500 MW of capacity available in Maine and Alaska. There are currently no projects in New Jersey that utilize tidal power. This region of the East Coast cannot feasibly support tidal power because of the lack of a sufficient tidal range.

Tidal Range

For tidal range technology, the maximum market potential for siting in New Jersey is assessed to be negligible. Tidal power is generally thought to require a tidal range in excess of 15 feet. No such tidal range is experienced along the New Jersey coast. Therefore, there is no basis to identify any market potential for tidal power for New Jersey's energy future.

Tidal Current

Additional information in the form of an in-depth study of the New Jersey coastline (to detect areas with currents fast enough to sustain tidal current projects) would be needed to determine if this technology could be utilized in New Jersey. If suitable locations are found, it could be technologically feasible to generate power. . However, considering the fact that other states along the Atlantic coast do not use this technology, it is highly unlikely that New Jersey would be able to draw any considerable amount of power from this renewable resource.

R.1.3 Tidal Power Cost

For both tidal range and tidal current technology, there is very little basis for making cost estimates. For tidal current projects, some developers have suggested optimistic figures - $.04kWh and $600/kW. However these figures are highly speculative and extremely optimistic.

Other more realistic assumptions about tidal power place the cost on the order of $1,500/kW. As tidal current technology is not readily available for commercial use today, the current costs (for pilot projects) could easily reach $15,000/kW. [1] The capital cost of building tidal current stations (tidal range) is the primary economic barrier for tidal technology. O&M costs are relatively low (estimated to be 5% of capital costs), but the overall cost for the power produced is still cost prohibitive.

[1] For additional information see From 'Scoping Study of renewable Electric Resources for MA and RI', C.T. Donovan Associates, July 1997.

Cost Analysis for Tidal Technologies [2]

Energy System	Installed Cost ($.kW) 1997
Tidal Range	$5,800
Tidal Current	$15,000

R.2 TECHNOLOGY: WAVE POWER

R.2.1 Characterization of Wave Power Technology

Wave energy conversion takes advantage of the ocean waves which are caused primarily by interaction of winds with the ocean surface. The power in waves is dependent on both the wave height and the wave frequency. To capture energy from waves, it is necessary to intercept the waves with a structure that can respond appropriately to the forces applied to it by the waves. While the structure is fixed, some part of the device must be allowed to move with respect to the structure and thus convert the wave energy into mechanical energy. The energy produced by the waves is an oscillating low frequency energy source that must be converted to a 60 Hertz frequency before being added to the power grid.[3]

Currently there are 5 different types of wave energy systems: oscillating water column, surge devices, pitching devices, heaving floats, and heaving and pitching floats. Some of these systems extract energy from waves on the surface of the ocean, others extract energy from changes in pressure below the surface of the water.[4]

Nowhere in the world is wave power in common use for the production of electricity. Several countries, however, currently have prototype wave power systems in operation. The majority of these systems are of the oscillating water column (OWC) type. This technology utilizes an air chamber that pierces the water surface. The contained air is then repeatedly forced into and out of the chamber by the wave crests and troughs. The air moving into and out of the chamber is forced through an air turbine generator and the result is electricity.

While this technology is very promising, field tests and prototypes have not established wave power as a reliable commercial technology. Many of the prototypes have been rendered inoperable by the very environment whose energy they are designed to capture. Many

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[2] For additional information see From 'Scoping Study of renewable Electric Resources for MA and RI', C.T. Donovan Associates, July 1997.

[3] Scoping Study of Renewable Electric Resources for Rhode Island and Massachusetts, C.T. Donovan Associates, Inc., November 1997

[4] Scoping Study of Renewable Electric Resources for Rhode Island and Massachusetts, C.T. Donovan Associates, Inc., November 1997

developmental goals still remain to be achieved, including cost reduction, efficiency and improvements in reliability.[5]

R.2.2 Ware Power Potential

There is currently no wave power capacity in operation in the United States. Worldwide there are several prototype projects with an estimated capacity of approximately 685 kW.[6]
The wave power resources along the east coast of the United States are estimated to be in the range of 4-9 kW per meter of coastline.[7] While this capacity is below the potential capacity found in the most favorable sites around the world, with research and development of the technology it could prove feasible in the short term future.

R.2.3 Wave Power Cost

It is estimated that the installed cost for a wave power project built in 2002 in New Jersey would be approximately $3000/kW with life cycle costs estimated to be between $0.04 and $0.05 kWh. This estimate takes into account advancements in the current technology, and the available wave power resources off the cost of New Jersey.

R.3 TECHNOLOGY: GEOTHERMAL POWER

R.3.1 Characterization of Geothermal Power Technology

Geothermal energy is heat contained within the Earth that can be recovered and put to use generating electricity or heating homes and industry. Low- to moderate-temperature (20°C to 150°C [68°F to 302°F]) geothermal resources in the United States are widespread and are used to provide direct heat for homes and industry while high-temperature (above 150°C [302°F]) geothermal resources in the United States. Most types of geothermal resources result from concentration of Earth's thermal energy within certain discrete regions of the subsurface.

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[5] Scoping Study of Renewable Electric Resources for Rhode Island and Massachusetts, C.T. Donovan Associates, Inc., November 1997

[6] Scoping Study of Renewable Electric Resources for Rhode Island and Massachusetts, C.T. Donovan Associates, Inc., November 1997. An additional 300 kW has been announced with a A$750,000 demonstration project in Australia, using a new design. “Australian Support for Renewables,” CADDETT Renewable Energy Newsletter, July 1999.

[7] Estimated from Duckers, L., “Wave Energy: Prospects and Prototypes”, Proceedings of the 2nd World Renewable Energy Congress, Reading, UK, September 1992

Geothermal electricity is clean, reliable, and cost effective, and represents an abundant, secure source of energy within specific geographical areas where the resource is available. In addition, hydrothermal power plants with emissions controls have minimal impact on the environment as they release little or no carbon dioxide.

Types of Geothermal Resources

Geothermal resources are in five forms: hydrothermal fluids, hot dry rock, geopressured brines, magma, and ambient ground heat. Of these five, only hydrothermal fluids have been developed commercially for power generation.

Hydrothermal resources are reservoirs of steam or hot water, which are formed by water seeping into the earth and collecting in, and being heated by fractured or porous hot rock. These reservoirs are tapped by drilling wells to deliver hot water to the surface for generation of electricity or direct use. Hot water resources exist in abundance around the world, and in the western U.S., Alaska and Hawaii. Technologies to tap hydrothermal resources are proven and in are currently in commercialization.

Hot dry rock resources occur at depths of 5 to 10 miles everywhere beneath the Earth's surface, and at shallower depths in certain areas. Access to these resources involves injecting cold water down one well, circulating it through hot fractured rock, and drawing off the now hot water from another well. This technology has been proven feasible, but no commercial applications are in use at this time. When technology is developed to make hot dry rock resources commercially viable, they are sufficiently large to supply a significant fraction of U.S. electric power needs for centuries. The strategic approach of national geothermal R&D initiatives in the U.S. has been to try to lower costs in the hydrothermal commercial area, and by so doing, to improve generic geothermal technology enough to make HDR exploitation economically feasible in the no-too-distant future.

Geopressured resources are deeply buried waters at moderate temperature that contain dissolved methane. While technologies are available to tap geopressured resources, they are not currently economically competitive. In the United States, this resource base is located in the Gulf coast regions of Texas and Louisiana.

Geopressured brines—hot, pressurized, methane-rich waters found in sedimentary basins 10,000 to 20,000 feet below the surface—and magma—molten or partially molten rock within the Earth's crust—may also someday provide electricity. However, at this time, technology has not advanced to the point where geopressured brines and magma can be cost effectively exploited. The U.S. Department of Energy (DOE) conducted research into the extraction of energy from the geopressured (very high pressured) brines in the Gulf Coast area of Texas and Louisiana, and concluded that even the extraction of methane as a byproduct did not make this energy source economic.

Magma (or molten rock) resources offer extremely high-temperature geothermal opportunities, but existing technology does not allow recovery of heat from these resources.[8]

Location of Geothermal Resources

Known geothermal resource areas in the U.S. with resource conditions sufficient to generate electricity occur in the Western United States and Hawaii.[9] Current U.S. geothermal electric power generation totals approximately 2200 MW.[10]

R.3.2 Geothermal Power Potential

There is no commercially developable geothermal electricity generation resource in New Jersey in the near-term or foreseeable long-term.

R.3.3 Geothermal Power Cost

It is anticipated that as technology improves, the cost of generating geothermal energy will decrease. Today's cost of electricity from typical geothermal systems where resources exist ranges from \$0.05-\$0.08/kWh. [11] However, as noted above, such resources are not available in New Jersey.

R.4 TECHNOLOGY: SOLAR THERMAL POWER

R.4.1 Characterization of Solar Thermal Power Technology

Solar thermal power systems use tracking solar reflectors to concentrate sunlight onto a receiver. The receiver absorbs the reflected solar radiation in a high temperature working fluid which is used to drive one or more electricity producing generators. Concentrating devices can effectively use only the direct component of solar radiation (not the diffuse), restricting the

[8] "Consumer Energy Fact Sheet: Geothermal Energy," Energy Efficiency and Renewable Energy Network, Department of Energy, 1997.

[9] "Management of Known Geothermal Resource Areas," *Renewable Energy Annual*, Energy Information Administration, Department of Energy, 1996.

[10] "What is Geothermal Heat Center,

[11] "Geothermal Electricity Production," U.S. Department of Energy, available at [http://www.eren.doe.gov/geothermal/gep.html]. Accessed on August 12, 1999.

geographic location at which they can operate over any reasonable fraction of the year to those with relatively clear atmospheres.

The minimum limiting direct normal radiation considered necessary for economically operating concentrating solar thermal power systems is 2,000 kWh/square meter per year. The best location for this technology is Southwestern U.S. while the northeastern U.S. receives at best about 75% of this minimum. Direct solar radiation resource is not sufficiently available in New Jersey for the present and expected near-term future level of technology development.

Types of Solar Thermal Systems

Three main types of solar thermal power systems are currently in development by U.S. industry: parabolic troughs, power towers, and dish/engine systems.

Parabolic Trough systems use parabolic trough-shaped mirrors to focus sunlight on thermally efficient receiver tubes that contain a heat transfer fluid. This fluid is then heated to 390 degrees Celsius and pumped through a series of heat exchangers to produce superheated steam which powers a conventional turbine generator to produce electricity. Nine trough systems, built in the mid to late 1980's are currently generating 354 MW in Southern California. These systems, sized between 14 and 80 MW, are hybridized with up to 25 percent natural gas in order to provide dispatchable power when solar energy is not available. This system is the most mature solar thermal technology currently available and the technology most likely to be used for near-term deployment. This is the only solar thermal system currently in commercialization.

Power Tower systems use a circular field array of heliostats (large individually tracking mirrors) to focus sunlight onto a central receiver mounted on top of a tower. The first power tower, Solar One, which was built in Southern California and operated in the mid-1980's, used a water/steam system to generate 10 MW of power. In 1992 a consortium of U.S. utilities banded together to retrofit Solar One to demonstrate a molten-salt receiver and thermal storage system.

The addition of this thermal storage capability makes power towers unique among solar technologies by promising dispatchable power at load factors of up to 65 percent. In this system molten-salt is pumped from a "cold" tank at 288 degrees Celsius and cycled through the receiver where it is heated to 565 degrees Celsius and returned to a "hot" tank. The hot salt can then be used to generate electricity when needed.

Dish/Engine systems use an array of parabolic dish-shaped mirrors (stretched membrane or flat glass facets) to focus solar energy onto a receiver located at the focal point of the dish. Fluid in the receiver is heated to 750 degrees Celsius and used to generate electricity in a small engine attached to the receiver. Engines currently under consideration include Stirling and Brayton cycle engines. Several prototype dish/engine systems, ranging in size from 7 to 25 kW, have been deployed in various locations in the U.S. and abroad.

High optical efficiency and low startup losses make dish/engine systems the most efficient (29.4 percent record solar to electricity conversion[12]) of all solar technologies. In addition, the modular design of a dish/engine system makes it a good match for both remote power needs in the kilowatt range as well as hybrid end-of-the-line grid-connected utility applications in the megawatt range. If field validation of these systems is successful in 1998 and 1999, commercial sales could commence as early as 2000.

R.4.2 Solar Thermal Power Potential

Even with strong support, it is highly unlikely that this technology would develop into a viable energy source in New Jersey in the next two decades as there is an insufficient level of the direct component of solar radiation available in the geographic area. It is possible that with future developments in solar concentrator technology, particularly with respect to mirror costs and conversion technology improvements, this technology might become competitive with other power generation technologies. However, this would still be a long ways off, even in the southwest U.S. where conditions are optimum for use of direct solar radiation.[13]

R.4.3 Solar Thermal Power Cost

The following table shows a rough calculation of solar thermal costs per kW based on the limited number of units operating in the southwestern U.S.[14]

	1997 Installed Cost ($/kW)	
Energy System	1997	2002
Parabolic Troughs	$18,000	$15,000
Central Receivers	$15,000	$12,000
Dish/Stirling	$10,000	$7,000

It is important to note that the technology cost and the eventual cost of electricity generated will be significantly influenced by factors considered external to the technology itself. For example, for troughs and power towers, small stand-alone projects will be very expensive. In order to reduce the technology costs to competitive levels, the projects must be scaled up to larger plant sizes and to develop solar power parks containing multiple projects. In addition, since these technologies replace conventional fuel with capital equipment, the cost of capital and taxation issues related to capital intensive technologies will have a strong effect on their competitiveness.

12 "Overview of Solar Thermal Technologies," Energy Efficiency and Renewable Energy Network, Department of Energy.

13 Ibid.

14 "Scoping Study of Renewable Electric Resources for Rhode Island and Massachusetts," C.T. Donovan Associates, Inc., 1997.

R.5 BARRIERS FOR ADVANCED RENEWABLE TECHNOLOGIES

R.5.1 Regulatory / Information / Infrastructure Barriers

These advanced technologies suffer from many of the customer sited (DG) barriers as described above. Due to the fact that these advanced technologies have not yet been implemented in any substantial size in the United States or New Jersey, and probably won't be within the next 10 to 15 years, it is very difficult to hypothesize what the regulatory, information or infrastructure barriers may be. These barriers will only become apparent once the technologies are far enough along to be considered a viable source of power for New Jersey. One important feature to note here is that New Jersey simply is not geographically positioned to take advantage of the potential associated with a couple of these technologies - geothermal and tidal power.

There are, however, some very clear financial, economic and technology barriers for these advanced technologies. These are discussed below.

R.5.2 Economic Barriers

All of these technologies are not price competitive with other sources of power in New Jersey. In almost all respects, projects including these advanced forms of technology in New Jersey would be highly inefficient for the end user.

R.5.3 Financial Barriers

These technologies posses extremely high capital costs and are commonly perceived as extremely risky technologies. Finding financial support for technology development and demonstration projects is bound to be very difficult. Additionally, with some of these technologies, some of the capital costs are so uncertain that potential market players are again deterred.

R.5.4 Technology Barriers

For most of the advanced technologies described in this report, the technology is still in the development stage, and there are many questions about the issue of reliability and dependability. (i.e. high performance risk). Additionally, even if some of these technologies were fully developed (i.e. geothermal and tidal), the geographic location of New Jersey would prevent any utilization.

R.6 ADVANCED RENEWABLE TECHNOLOGIES: POTENTIAL FOR MARKET TRANSFORMATION

Almost all of these advanced renewable technologies are still in the early development stages. Only with very strong financial support could these technologies hold some potential for New Jersey. This support (in the form of research and development) may be best directed at wave and tidal current technologies, which at least posses some (although quite small) for New Jersey. Specifically, resources could be used to sponsor small demonstration projects (for tidal current and wave power) within the state. Similarly, resources could be directed towards in-state educational programs (i.e. Princeton's Center for Energy and Environmental Studies) that may assist in the development of these technologies for use by the State of New Jersey.

R.7 CONCLUSIONS

There are substantial barriers facing these advanced renewable technologies, and there are limited strategies to address most of them. Some of the technologies discussed in this appendix are not available or feasible in NJ. For tidal current and wave, there is no reason for them not to be eligible for rebates or incentives available to other "green power supply" technologies. It is possible that economic barriers can be offset to the point where these renewable technologies will be able to compete in some segments of the green power market, but the time frame is very uncertain, and probably well beyond the year 2012. Until the technologies are further commercialized, it is unlikely that significant financing would be available to bring these technologies into use in New Jersey, given the existing multiple risks and uncertainties. It may be possible to accelerate the introduction of these technologies into the NJ market somewhat by devoting a small portion of the available funding to establish or support appropriate technical or business institutions in the state which may be able to attract some federal or private RD&D funding in these areas. Similarly, a small portion of the available funding could be made available to attract new ventures with relevant capabilities and plans.

NEW JERSEY UTILITIES WORKING GROUP

SCOPE OF WORK

MARKET ASSESSMENT TO CHARACTERIZE THE OPPORTUNITIES FOR ENERGY EFFICIENCY AND RENEWABLE ENERGY IN NEW JERSEY

July 7, 1999

I. INTRODUCTION AND OVERVIEW

On February 9, 1999, the "Electric Discount and Energy Competition Act" (the Act) was signed into law. Section 12, subsection a (3) of the Act requires that the Board of Public Utilities initiate a proceeding and cause to be undertaken a Comprehensive Resource Analysis (CRA) of energy resources in New Jersey. Consistent with the requirements of the Act, the NJ Board of Public Utilities on June 9, 1999 established an Energy Efficiency and Renewables Proceeding and established a deadline of August 23, 1999 for a Comprehensive Resource Analysis and Energy Programs filing applicable to New Jersey's seven gas and electric public utilities (Public Service Electric and Gas Company, Elizabethtown Gas Company, South Jersey Gas Company, New Jersey Natural Gas Company, Rockland Electric Company, Atlantic Electric Company/Conectiv, and Jersey Central Power and Light Company, d/b/a GPU-Energy. Each of these seven utilities is required to make a filing with the BPU, either individually or as part of a joint filing with other parties. All submissions must be accompanied by prefiled testimony. The seven utilities have agreed to work together on a number of parts of their submissions, including conducting a market assessment. To accomplish this, the seven utilities have formed a working group (the “Working Group”).

The Working Group is seeking one or more qualified Contractors to characterize the New Jersey market so as to identify opportunities to enhance the deployment and market pull of energy efficiency and renewable energy technologies. The project will have two main objectives:

1. The first is to identify markets suitable to address with energy efficiency programs.
2. The second is to identify opportunities to encourage the development of Class I renewable energy sources.

This assessment should be considered as having two discrete parts - energy efficiency and Class I renewables. The Working Group may decide to separate the work into two phases and engage two different contractors to do the work.

In view of the tight timeframe, a formal Request for Proposal is not being developed, but contractors interested in performing this work are being asked to detail how they will approach the project. Work will be paid for on a time and materials basis, with a final report delivery deadline of 8/14. Informal interim reports on findings are to be provided on a weekly basis.

The following market segments will be examined:

- Residential (new construction, existing construction, low income)

- Commercial (new construction, existing construction)
- Industrial

The market assessment for energy efficiency and renewables should focus on:

- Technology penetration (sales, market share, number of installations, etc.),
- Industry practices,
- Market potential,
- Infrastructure (supporting technology supply, installation, and maintenance), and
- Barriers to market based development of resources and market “transformability”.
- Rough energy savings potential based on synthesis of load data and prior research should be uses to characterize market potential.
- Identification of key strategic opportunities which may argue for specific markets or program priorities (e.g., economic development, environmental, equity).

II. Definitions

BPU - The New Jersey Board of Public Utilities.

"Class I renewable energy" means electric energy produced from solar technologies, photovoltaic technologies, wind energy, fuel cells, geothermal technologies, wave or tidal action and methane gas from landfills or a biomass facility, provided that the biomass is cultivated and harvested in a sustainable manner.

"Comprehensive resource analysis" means an analysis including, but not limited to, an assessment of existing market barriers to the implementation of energy efficiency and renewable technologies that are not or cannot be delivered to customers through a competitive marketplace.

"Customer" means any person that is an end user and is connected to any part of the transmission and distribution system within an electric public utility's service territory or a gas public utility's service territory within the state.

"Demand-side management" means the management of customer demand for energy service through the implementation of cost-effective energy efficiency technologies, including, but not limited to, installed conservation, load management and energy efficiency measures on and in the residential, commercial, industrial, institutional and governmental premises and facilities in New Jersey.

"Electric related service" means a service that is directly related to the consumption of electricity by an end user, including, but not limited to, the installation of demand side management measures at the end user's premises, the maintenance, repair or replacement of appliances or other energy-consuming devices at the end user's premises, and the provision of energy consumption measurement and billing services.

"Gas related service" means a service that is directly related to the consumption of gas by an end user, including, but not limited to, the installation of demand-side management measures at the end users' premises, the maintenance, repair or replacement of appliances or other energy-consuming devices at the end user's premises, and the provision of energy consumption measurement and billing services.

"Social program" means a program implemented with board approval to provide assistance to a group of disadvantaged customers, to provide protection to consumers, or to accomplish a particular societal goal, and includes, but is not limited to, the winter moratorium program, utility practices concerning "bad debt" customers, low income assistance, deferred payment plans, weatherization programs, and late payment and deposit policies, but does not include any demand side management program or any environmental requirements or controls.

III. Scope of Work

A. Project Objectives

The principal objective of the project is to identify and characterize market opportunities for publicly funded energy efficiency and renewable programs using quantified and documented support to the maximum extent practicable.

This project will inform the utilities and support the submissions that must be completed by August 23, 1999, specifically with respect to the following questions (italicized text is provided to highlight the context of questions - project scope is indicated by bold face text):

- **The following questions should be applied to a) Class I Renewables, b) Residential Energy Efficiency Markets, c) Commercial/Industrial Energy Efficiency Markets***, d) New Energy Efficiency Programs:*
  1. **What resources and opportunities are available?**
  2. **What is the size and status of each potential resource and opportunity in New Jersey?**
  3. **What are the barriers to market-based development of each resource or opportunity?**
  4. **What information is still needed concerning each resource or opportunity?**
  5. **What are the costs and benefits of pursuing a particular resource or opportunity?**
  6. **What technologies need assistance?**

- *What methodology/approach should be employed to select/prioritize and allocate funds to Class I renewable projects/programs?*
    - *a. To what extent should there be even distribution of funds to Class I solar, photovoltaic, fuel cells, biomass facilities, methane gas, geothermal technologies and any other class I renewable energy programs.*
    - **b. What are the current pending federal renewable programs which are only partially funded by the federal government and thus need further funding?**
    - **c. What are the current federal programs for renewables in New Jersey, which are currently fully funded?**
    - **d. What new federal renewable programs are on the horizon and how are they expected to be funded?**
    - **e. What renewable programs are currently being implemented in other states?**
    - *f. Should funding for renewable programs be uniform across utilities or industries (i.e. gas and electric)?*

B. Market Assessment

The market assessment for energy efficiency and renewable technologies should support answering the questions above by characterizing:

- Technology penetration (sales, market share, number of installations, installed capacity, etc.),
- Industry practices (assessment of market values, installation & maintenance practices, and resources and opportunities)
- Market potential (what are the costs and benefits of pursuing a particular resource or opportunity without program support?)
- Infrastructure (number of agents supporting technology supply, installation, and maintenance, maturity of industry, quality assurance practices, industry organizations, etc.) and
- Barriers to market based development of resources and market "transformability" (including recommended metrics).

For each assessment, identify information still needed concerning each resource or opportunity.

The characterization (using the four classifications above) should address the following energy efficiency technologies for the residential and commercial/industrial markets:

Residential	Commercial and Industrial	Class I Renewable Technologies
• HVAC • Controls/home automation • Lighting • Appliances • Thermal envelope • Water heating • Education/information	• Lighting • Space conditioning • Motors/drives • Water heating • Process technologies • Facilities operations • New construction • Thermal Envelope • Commissioning	• Solar thermal • Photovoltaic • Wind Energy • Fuel Cells • Geothermal Technology • Wave or Tidal Action • Landfill Methane Gas • Biomass, provided biomass is cultivated or harvested in a sustainable manner

C. Additional Questions

In addition to the general questions to be answered above these specific questions should be addressed:

- What are the current pending federal renewable programs which are only partially funded by the federal government and thus need further funding?
- What are the current federal programs for renewables in New Jersey, which are currently fully funded?
- What new federal renewable programs are on the horizon and how are they expected to be funded?
- What renewable programs are currently being implemented in other states?
- What are other states doing to promote energy efficiency programs, core performance based, renewable forms of energy efficiency and other?

IV. Responsibilities of the Parties

A. The Working Group

The utilities will provide background materials, including resource assessments, market studies and market segmentation analysis. Although there is significant market research available, it is far from comprehensive. The utilities will provide substantial input and review for the project. Primary contact with the Working Group will be Fred Lynk, Manager- DSM Marketing, PSEG Marketing, 499 Thornall Street, 9th Floor, Edison 08837-2235. Phone 732-635-3643; fax 732-452-9190; e-mail frederick.lynk@pseg.com.

B. The Contractor

In view of the importance of this study and its state-wide implications, the Working Group would like to see and indication that senior personnel will work on the synthesis of market data, and be available to direct organize and write on a short notice. It may also be necessary to testify in support of the findings.