New Jersey's Clean Energy Program Energy Impact Evaluation and Protocol Review

Summary Report

Prepared for New Jersey Board of Public Utilities

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1. Executive Summary

1.1 Introduction

KEMA was contracted by the New Jersey Board of Public Utilities' Office of Clean Energy (OCE) to perform an evaluation of energy impacts of New Jersey's Clean Energy Program's (NJCEP) energy efficiency and renewable programs. The results of this impact evaluation will assist OCE in determining the net and gross energy impacts of the programs. The results will also help the OCE update and modify the *Protocols to Measure Resource Savings* (Protocols)[1].

KEMA submitted the *New Jersey's Clean Energy Program Energy Impact Evaluation Final Work Plan* (Final Work Plan)[2] to OCE on October 8, 2007. The Final Work Plan as specified in the RFP mirrors the information provided in the bid proposal modified to reflect adjustments discussed at the kick-off meeting and subsequent discussions with OCE, the BPU Program Coordinator, the market managers and the utilities. The Final Work Plan presents individual research plans for the following six program areas.

1. Residential Electric and Gas HVAC Programs (Cool Advantage and Warm Advantage)
2. Residential New Construction Program
3. ENERGY STAR Products Program
4. Commercial and Industrial Program (SmartStart)[3]
5. Combined Heat and Power Program
6. Customer On-site Renewable Energy Program (CORE)[4]

[1] *New Jersey's Clean Energy Program, Protocols to Measure Resource Savings,* Revisions to September 2004 Protocols, December 2007.

[2] *New Jersey's Clean Energy Program Energy Impact Evaluation Final Work Plan.* Prepared by KEMA for New Jersey Board of Public Utilities, Office of Clean Energy. October 8, 2007.

[3] The SmartStart work plan was updated and approved by OCE in May 2008.
New Jersey's Clean Energy Program Energy Impact Evaluation Updated SmartStart Work Plan. Prepared by KEMA for New Jersey Board of Public Utilities, Office of Clean Energy. May 2, 2008.

[4] The comprehensive CORE work plan was updated and approved by OCE in November 2008.

1.2 Overview of Approach

The NJCEP energy impact evaluation had two broad objectives:

1. To revise the savings calculation Protocols so that going forward the calculations using these Protocols provide more accurate statements of savings accomplishments.

2. To provide a retrospective assessment of program accomplishment, as part of a due diligence review of past utility program effectiveness on behalf of ratepayers.

KEMA refers to the first of these objectives, review of savings protocols, as the Prospective Assessment. KEMA refers to the second objective, review of reported savings, as the Retrospective Assessment. The results of the impact evaluations were submitted in separate reports for each of the aforementioned program areas. KEMA presents the prospective and retrospective assessments in each report. Due to the complexity and scope of the SmartStart Protocol Review a separate report was prepared for the SmartStart retrospective and prospective analyses.

1.3 High Level Recommendations

This section presents high level recommendations from KEMA's energy impact evaluation of New Jersey's Clean Energy Program. High level recommendations are provided separately for the Prospective and Retrospective Assessments. These high level recommendations were selected because they fit one of the following criteria.

- KEMA deemed the recommendation to be of particular interest to policy makers;

- the recommendation is broad reaching, encompassing multiple program areas if not the entire program;

- the recommendation makes a large difference to estimated energy savings;

New Jersey's Clean Energy Program Energy Impact Evaluation CORE Work Plan. Prepared by KEMA for New Jersey Board of Public Utilities, Office of Clean Energy. November 14, 2008.

- the recommendation is based on a new kind of finding (i.e., CORE results reported by REIP eligibility); and
- the SmartStart prospective assessment recommendations are selected illustrative examples from the detailed list of findings for each technology group in the Protocols.

More technical readers should refer to the seven program area reports and the Summary of Recommendations Report[5] for more detailed findings and recommendations.

1.3.1 Prospective Assessment

The Protocols were developed to accurately and consistently determine energy and resource savings for measures supported by the NJCEP. The document is periodically updated as new programs are added, existing programs are modified, and new information becomes available. Prior to this evaluation the Protocols were most recently updated in December 2007.

In general, the Protocols provide the Program with consistent and reasonable methods for estimating gross energy savings. Many other jurisdictions are using New Jersey's Protocol document to develop similar documents for their energy efficiency and renewable programs. This review is part of an established process to continuously improve upon the document. KEMA conducted a detailed assessment of the Protocols and recommends several updates to the Protocols.

Table 1-1 provides KEMA's high level recommendations based on the Prospective Assessment.

Table 1-1 Prospective Assessment High Level Recommendations

Program Area	Technology	High Level Recommendation
Overall		Improve and expand the documentation, including the citations of secondary sources and primary data used to develop energy savings algorithms and inputs. All data used to develop Protocols should be available

[5] *New Jersey's Clean Energy Program Energy Impact Evaluation and Protocol Review, Summary of Recommendations,* Prepared by KEMA for New Jersey Board of Public Utilities, September 28, 2009.

Program Area	Technology	High Level Recommendation
		upon request.
Overall		Level of detail and use of energy savings terminology should be consistent across measures.
Overall		Periodic independent reviews, such as this evaluation, are important and add credibility to the document. Examples of expected changes overtime include: new calculation methods, new studies, new technologies, new applications of existing technologies, new baselines, new building codes, new levels of customer/market adoption of technologies, climate changes, etc.
Overall		Revise the current assumption that free ridership and spillover cancel each other out. Further research is needed for some program areas. OCE will need to decide the level of rigor and evaluation costs associated with measuring free ridership and spillover.
Overall		The program should develop a standard policy for the assignment of baseline efficiency levels for the purpose of calculating energy savings. It may be appropriate for this policy to vary by technology and program area. Key considerations to be addressed in the policy include but are not limited to: 1.) whether a measure is assumed to be natural replacement, retrofit, or short-term acceleration (i.e. deferred free ridership); 2.) associated incremental cost assumptions; 3.) the net-to-gross treatment for short-term acceleration; 4.) the magnitude of the change in calculated savings under alternative baseline assumptions; 5.) costs associated with collecting additional baseline

Program Area	Technology	High Level Recommendation
		data from participants and the marketplace; 6.) cost to evaluate; and 7.) the level of evaluation rigor OCE is willing to accept.
Residential HVAC	AC and Furnaces	The analysis indicates that the existing estimate of Equivalent Full Load Hours (EFLH is the total time the unit runs in a year) is too high. Cooling EFLH is reduced from 600 to 501 hours, while heating EFLH is reduced from 965 to 727. EFLH drives the calculation of savings for both technologies.
Residential HVAC	AC	Quality Installation Verification and proper sizing offer potential savings in addition to increases in unit efficiency. This analysis focused on energy efficiency related savings, but the analysis results do indicate the importance of fully evaluating the additional efforts related to proper installation and sizing.
Residential HVAC	AC	kW impacts at system peak are a key measurement for the CoolAdvantage program. Additional study is required to adjust the coincidence factors used for this program.
Residential New Construction	Residential New Construction	Update the energy savings algorithm baseline from New Jersey's Building Code to 2006 ENERGY STAR standards.
ENERGY STAR Products - CFLs	CFL	Update the following energy savings algorithm input values: delta watts to 48.5; hours of use to 2.8 hours/day; in-service rate to 83.4 percent; and coincidence factor to 9.9 percent.
SmartStart Buildings	Performance Lighting	Revise algorithm inputs for Equivalent Full Load Hours, Coincidence Factor, and Interactive Factor and adjust savings for lights controlled by a technology other than a simple switch. Use a standard table to estimate wattages by technology and eliminate cooling savings

Program Area	Technology	High Level Recommendation
		for installations in unconditioned spaces.
SmartStart Buildings	Prescriptive Lighting	Update the values for Equivalent Full Load Hours and Coincidence Factor to match Performance Lighting and include an Interactive Factor in the calculation. Use a standard table to estimate wattages by technology and adjust savings for lights controlled by a technology other than a simple switch.
SmartStart Buildings	Lighting Controls	Update the values for Equivalent Full Load Hours, Coincidence Factor, and Interactive Factor to match Performance Lighting and Prescriptive Lighting. Coordinate the savings estimates with those two measure groups to avoid double-counting savings.
SmartStart Buildings	Motors	Conduct research to gather motor operating hours by climate zone and by sector. Base savings calculations on the horsepower of the qualifying unit and change the algorithms to explicitly account for Load Factor and Duty Cycle. Coordinate the savings estimates with Variable Frequency Drives to avoid double-counting savings.
SmartStart Buildings	Electric HVAC	Adjust the baseline efficiency values to fit those provided by CEE Tier 1 and consider including a factor to account for equipment over-sizing in the calculation. Consider allowing variation in Coincidence Factor and Equivalent Full Load Hours by climate zone based on future research.
SmartStart Buildings	Electric Chillers	Use the Integrated Part Load Value for efficiency in the calculation and use a custom calculation approach for very large chillers. Conduct research into the chillers currently installed in New Jersey and investigate more accurate values for Equivalent Full Load Hours and Coincidence Factor.
SmartStart Buildings	Variable Frequency	Conduct a study to determine accurate values for Demand Savings Factor and Energy Savings Factor

Program Area	Technology	High Level Recommendation
	Drives	that are specific to the New Jersey climate. Develop a lookup table for DSF and ESF by fan or pump application.
SmartStart Buildings	Air Compressors w/ Variable Frequency Drives	Limit the prescriptive measure to facilities with a single compressor and determine savings from multiple-compressor systems using a custom calculation. Changes the Protocol terms and assumptions were provided in the report.
SmartStart Buildings	Gas Chillers (Absorption Chillers)	Perform custom calculations to determine energy savings resulting from gas absorption chiller installation.
SmartStart Buildings	Gas Fired Desiccants	Perform custom calculations to determine energy savings resulting from gas fired desiccant installation.
SmartStart Buildings	Gas Booster Water Heaters	Perform custom calculations to determine energy savings resulting from the installation of gas booster water heaters. Conduct research into typical dishwasher operation and use the data to create a prescriptive calculation.
SmartStart Buildings	Gas Water Heaters	Use an algorithm based on the energy use density by building type to determine energy savings. Use Energy Factor as the equipment efficiency for small water heaters and Thermal Efficiency as the equipment efficiency for large water heaters.
SmartStart Buildings	Furnaces and Boilers	Use an algorithm based on the heating degree days from the four New Jersey climate zones.
SmartStart Buildings	Compressed Air System Optimization	Require auditors providing a Compressed Air System Analysis to first complete the DOE Compressed Air Challenge training. Promote a systems approach for multiple compressor systems even under the Pay for Performance option.
SmartStart Buildings	Time Period	Conduct research to determine Time Period Allocation Factors for Lighting Controls, VFD Air Compressors,

Program Area	Technology	High Level Recommendation
	Allocation Factors	and Water Heaters. Use HVAC Time Period Allocations for Motors measures and Gas Fired Desiccant measures.
SmartStart Buildings	Custom Projects	Develop a standard method for handling energy savings calculations and measurements from various sources. Establish a standard method for determining whether a project is an early or natural replacement installation.
Combined Heat & Power	CHP	Due to the variety in the types of CHP projects installed, energy savings estimates should continue to be performed on an individual basis. However information collected during the post-installation visit should be used rather than the application data.
CORE	PV	KEMA recommends the Program continue its use of PVWatts to calculate energy production and discontinue its deemed value method for purposes of reporting energy production to the BPU. The required input to the PVWatts model is already collected for each installed PV system by the CORE Program through its customer application technical worksheet and on-site inspection documentation.
CORE	PV	KEMA recommends two changes to the PVWatts calculation methodology: 1.) perform separate PVWatts calculations for arrays at same site with different tilt angles, orientations, or shading levels; and 2.) incorporate a shading factor.
CORE	PV	Several recommendations were made with regards to the calculation of peak demand (kW).

1.3.2 Retrospective Assessment

KEMA employed a variety of impact analysis methods in the retrospective assessment of reported energy savings. The methods varied by program area as a result of the suitability of the methods and the allocation of evaluation budget afforded to each program area. Methods included: on-site measurement and verification, engineering review of energy savings calculations, use of KEMA's proprietary models, secondary research, analysis of past studies and third party data, billing analysis, surveys with program participants and customers, and ratio estimation techniques to expand sample results to the population of participants.

Table 1-2 provides KEMA's high level recommendations based on the Retrospective Assessment.

Table 1-2 Retrospective Assessment High Level Recommendations

Program Area	High Level Recommendation
Overall	Improved tracking is critical. KEMA understands the program has developed a statewide database following the period covered by this evaluation (2001-2006). The statewide tracking database should be reviewed by an independent party as soon as possible.
Overall	OCE should consider conducting an impact evaluation covering first three years of program under market manager model.
Residential HVAC	Lower Heating Equivalent Full Load Hours drive a lower gross savings estimate for gas furnaces. The result is an average 25 percent drop in gross heating savings from expected savings from the Protocols.
Residential HVAC	Lower Cooling Equivalent Full Load Hours drive a lower gross savings estimate for air conditioners. The result is a 17 percent drop in gross cooling savings from the expected savings from the Protocols.
Residential HVAC	Free ridership and spillover results indicate that these two effects are not equal and thus do not cancel each other out. The results indicate a net free ridership between 32 and 43 percent for these two programs.
Residential New Construction	The evaluation demonstrates that the ENERGY STAR Homes are meeting the electric and gas usage projections established by the REM/Rate™ model.

Program Area	High Level Recommendation
ENERGY STAR Products	Results of the ex post impact evaluation were used to update the delta watts and in-service rate Protocol input values to 48.5 and 83.4 percent, respectively.
SmartStart Buildings	Program should consider implementing electronic database and hard-copy (custom projects) quality assurance procedures to ensure the newly created statewide tracking database is being used to its full potential.
SmartStart Buildings	The Program's calculation tool failed to apply Coincidence Factor (CF) for all prescriptive lighting and unitary HVAC measures. The Program should consider reviewing the prescriptive savings calculation spreadsheets to ensure the Protocol calculation methods are being used correctly.
Combined Heat & Power	KEMA supports the following two program updates that occurred subsequent to the evaluation period (2001-2006): 1.) post-installation inspections with all CHP installations; and 2.) require participants, as part of the participation agreement, to provide the program with key information about the system design and operation after installation.
CORE	The tracking database should be used to track gross kW and kWh. The tracking database should contain all data required for the calculations outlined in the Protocols.
CORE	There were some significant differences between REIP Eligible and REIP Ineligible customers' program attribution results (energy savings that would not have occurred if the program did not exist). REIP Eligible customers are reporting higher levels of program attribution than REIP Ineligible customers. Nonresidential REIP Ineligible customers, systems larger than 50 kW attribute savings to the Program at half the rate of their REIP eligible counterparts.

2. Introduction

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[6] *New Jersey's Clean Energy Program, Protocols to Measure Resource Savings,* Revisions to September 2004 Protocols, December 2007.

[7] *New Jersey's Clean Energy Program Energy Impact Evaluation Final Work Plan.* Prepared by KEMA for New Jersey Board of Public Utilities, Office of Clean Energy. October 8, 2007.

[8] The SmartStart work plan was updated and approved by OCE in May 2008.
New Jersey's Clean Energy Program Energy Impact Evaluation Updated SmartStart Work Plan. Prepared by KEMA for New Jersey Board of Public Utilities, Office of Clean Energy. May 2, 2008.

[9] The comprehensive CORE work plan was updated and approved by OCE in November 2008.
New Jersey's Clean Energy Program Energy Impact Evaluation CORE Work Plan. Prepared by KEMA for New Jersey Board of Public Utilities, Office of Clean Energy. November 14, 2008.

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The NJCEP energy impact evaluation had two broad objectives:

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2.2 Organization of Report

The purpose of the Summary of Report is to provide OCE with a succinct summary of the seven program area reports. Summaries of the following reports are provided herein:

1. Residential Electric and Gas HVAC Programs (Cool Advantage and Warm Advantage[10])

2. Residential New Construction Program[11]

3. ENERGY STAR Products Program[12]

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[10] *New Jersey's Clean Energy Program Residential HVAC Impact Evaluation and Protocol Review,* Prepared by KEMA for New Jersey Board of Public Utilities, *WarmAdvantage™ and CoolAdvantage Programs™, June 11, 2009.*

[11] *New Jersey's Clean Energy Program*, Prepared by KEMA for New Jersey Board of Utilities, *Residential New Construction Program Impact Evaluation,* September 4, 2009.

4. Commercial and Industrial Program (SmartStart) – Prospective Assessment[13]
5. Commercial and Industrial Program (SmartStart) – Retrospective Assessment[14]
6. Combined Heat and Power Program[15]
7. Customer On-site Renewable Energy Program (CORE)[16]

KEMA advises the reader to reference the program area reports for more detailed information.

[12] *New Jersey's Clean Energy Program Residential CFL Impact Evaluation and Protocol Review*, Prepared by KEMA for New Jersey Board of Public Utilities, *ENERGY STAR® Products Program – Lighting,* September 28, 2009.

[13] *New Jersey's Clean Energy Program Energy Impact Evaluation and Protocol Review,* Prepared by KEMA for New Jersey Board of Public Utilities, *SmartStart Program Protocol Review,* July 10, 2009.

[14] *New Jersey's Clean Energy Program Energy Impact Evaluation,* Prepared by KEMA for New Jersey Board of Public Utilities, *SmartStart Program Impact Evaluation,* September 17, 2009.

[15] *Combined Heat & Power (CHP) Program Impact Evaluation,* Prepared by KEMA for New Jersey Board of Public Utilities, *Final Report,* June 10, 2009.

[16] *New Jersey's Clean Energy Program Energy Impact Evaluation,* Prepared by KEMA for New Jersey Board of Public Utilities, *Customer On-Site Renewable Energy Program (CORE),* September 4, 2009.

3. Residential Electric and Gas HVAC Programs (WarmAdvantage™ and CoolAdvantage Programs™)

This section presents a summary of KEMA's impact evaluation of the CoolAdvantage and WarmAdvantage Programs.[17]

The billing analysis performed for this evaluation provides the retrospective assessment of the key program measures. It also provides an empirical basis for recommendations for the most important Protocol equation inputs.

3.1 Protocol Review

This report provides a review of the savings algorithms for Warm- and CoolAdvantage Programs. The review assesses the appropriateness of the savings equations and the input parameters provided in the 2007 Protocols. The review draws on findings on operational parameters from the billing analysis conducted for this evaluation on recent program participants, as well as using additional secondary source research.

Key recommendations include:

- Adopt the impact evaluation estimates of Equivalent Full Load Hours (EFLH) for heating and cooling, 727 and 501 hours, respectively.
- Re-evaluate the 2007 Protocol proper sizing and QIV factors. Going forward, these factors will determine the majority of program cooling related savings. The billing analysis supports a maximum energy savings factor (combined proper sizing and quality installation verification) of 9.2 percent of installed usage. Installation-related demand savings cannot be estimated from the billing analysis. However, Demand savings

[17] *New Jersey's Clean Energy Program Residential HVAC Impact Evaluation and Protocol Review,* Prepared by KEMA for New Jersey Board of Public Utilities, *WarmAdvantage™ and CoolAdvantage Programs™,* June 11, 2009.

should not be greater than energy savings. In the absence of better evidence, the demand savings factor should also be set at 9.2 percent of installed demand.

- Adjust installation-related factors (proper sizing, QIV or duct sealing) to properly calculate savings from the estimated unit usage. Savings percentages from research are measured with respect to units without quality installation verification. Percentages need to be adjusted to get the proper savings from the usage estimated by the Protocol algorithms which include the effects of these quality installation improvements.
- Further research the coincidence factor of participant units. Proper sizing and QIV can have mixed effects on peak loads at extreme temperatures. The program coincidence factor should accurately reflect the coincidence factor of CoolAdvantage units at peak temperatures.
- Replace typical furnace or boiler output capacity (91,000 Btu) with individual qualifying unit output capacity in the heating savings equation.
- Continue to update the typical replacement heating equipment AFUE values using previous methodology. Include information on market share of unit types, if possible.
- Lower baseline water heater usage in the water heating saving equation from 212 therms to 180 based on regional estimates of average water heating usage.
- The Warm- and CoolAdvantage rebate applications are designed well to collect the necessary data for program tracking and evaluation purposes. The challenge with collecting tracking data is getting the data recorded accurately in the field and then transferring it successfully into a well-designed database that captures all of the necessary program data. The Warm- and CoolAdvantage programs can improve substantially in this respect. Of particular importance is the capturing of QIV and right-sizing activity that takes place.
- QIV and right-sizing activity by contractors needs to be validated by the program.

3.2 Ex-post Impact Evaluation

The ex-post impact evaluation provides a retrospective assessment of program accomplishment using participant billing records to assess the estimates of savings produced by the Protocol algorithms. The outcomes include estimates of measure level usage and savings for the major measures. In addition, the impact evaluation provides useful information related to the first purpose of the report, recommendations toward the revision of the Protocols. The data provided by the utilities did not allow us to determine participant counts, measure counts or measure savings to compare to numbers published in annual reports. Thus, the due diligence review focuses on comparison of gross impact evaluation results with savings as defined by the 2007 Protocol savings equations.

3.2.1 Gross Impact Estimates

Table 3-1 presents the per-unit gross impacts for the primary heating and cooling measures from the Cool-and WarmAdvantage Programs. Cool-Advantage provides electric savings only. WarmAdvantage generates some electric savings through efficient furnace fans but this evaluation addresses only gas savings.

Table 3-1:
2005-2006 Cool- and WarmAdvantage Ex-Post Per-Unit Gross Impacts

Program	Fuel	Measures	Source of Energy Savings	Impact
CoolAdvantage	Electric	Central air conditioning and heat pumps	Efficency, sizing and Installation	456 kWh
Warm Advantage	Gas	Furnaces and boilers	Efficiency	100 Therms

The gross cooling impact estimate includes both efficiency-related improvements as well as savings related to proper sizing and quality installation verification services required of contractors. The 456 kWh savings level reflects the standard-efficiency baseline SEER in effect at the time the installations took place (SEER 11). Also reflected in this savings value are a new recommended cooling EFLH and a new recommended level of installation-related savings, based on the findings of this evaluation.

The gross heating impact estimate is confined to efficiency-related improvements. The 100 therm savings level reflects two recommendations. There is a new heating EFLH estimate, and the new unit capacity is used for the baseline case rather than the, Protocol-defined “typical” unit capacity.

3.2.2 Cooling impact Estimates

The gross cooling impact estimates produced by this analysis are lower than the gross estimate indicated by the Protocols. In this case, we are applying the 2007 Protocols but assuming a baseline SEER of 11 as was the case during 2005-2006. The reduction in impacts has two different sources:

- The billing analysis found lower usage levels (and lower EFLH) among participants than assumed by the Protocols. This 17 percent reduction in estimated usage lowers the efficiency-related savings by 17 percent when the efficiency-related Protocol equations are applied.
- A combination of the billing analysis and secondary research indicate that expected savings due to Quality Installation Verification and proper sizing, as indicated by the Protocols, is inflated. The billing analysis evidence supports a more conservative level of savings for QIV/proper sizing of 8.4 percent. This is compared to the Protocol combined savings of 19.25 percent[18].

These two different sources of reduction result in an estimated gross cooling impact that is 41 percent lower than indicated by the Protocols. Table 3-2 compares the impact estimates derived from the Protocols to those developed for this impact evaluation. The table includes a range of possible QIV/proper sizing savings percentages. The final value for the impact evaluation was the middle savings percentage, 8.4 percent[19].

[18] Both estimates of QIV and proper sizing assume both actions took place for all participating units where appropriate. QIV and proper sizing, however, are difficult program measures to confirm, leaving the possibility that less than full program QIV and proper sizing takes place. Sources close to the program indicate that QIV and proper sizing were an active part of the program during the 2005-2006 period. They also indicate that the program's ability to confirm the activities was limited. It's worth noting that, going forward, additional steps have been added to the program implementation process to better confirm the results of QIV and proper sizing.

[19] QIV/Sizing savings percentages vs. Savings as a percentage of Usage are explained in program area report.

Table 3-2:
Gross 2005/2006 CoolAdvantage Ex-Post Per-Unit Impact Estimates Baseline SEER=11

Source for Hour (EFLH) Estimate	Post-Program Cooling Usage (kWh)	Effective Full Load Hours (EFLH)	EFLH Confidence Interval (+/-, 90%)	Impact of Efficiency Improvement (kWh)	Combined QIV/Sizing Savings Percentage	QIV/Sizing Savings as Percentage of Usage	Impact of Proper Sizing and QIV (kWh)	Total CAC or Heat Pump Cooling savings (kWh)
Protocols	1,500	600		409	19.3%	23.8%	358	767
Impact Evaluation	1,252	501	17	341	0.0%	0.0%	0	341
					8.4%	9.2%	115	456
					19.3%	23.8%	298	640

Table 3-3 provides the program-level cooling impacts for central air conditioners and heat pumps. The gross per unit impact savings are the same as in Table 3-2 above except expressed in MWs. The program-level gross impacts for both the Protocol and ex-post impact evaluation reflect counts of units from the tracking data received from the utilities.

Table 3-3:
Electric Impacts from Cooling Measures, Protocol Vs. Impact Evaluation

Source	Year	Per-Unit Impact (MWh)	Tracking Data Number of units*	Gross Impact (MWh)	(-) Free Ridership (MWh)	(+) Spillover (MWh)	Percentage of Gross Savings		Net Impact (MWh)
							Free Ridership	Spillover	
Protocol	2005	0.767	9,141	7,011					7,011
	2006		9,821	7,533					7,533
Impact Evaluation	2005	0.456	9,141	4,168	1,981	194	48%	5%	2,381
	2006		9,821	4,478	2,129	218		5%	2,567

* Count of units is from the tracking data provided to the evaluation by the utilities.

Table 3-3 also includes the effects of free ridership and spillover on program-level savings. The Protocols do not indicate individual free ridership and spillover levels, but do state that they have a net effect of zero[20]. For the Protocols, then, net impact equals gross impact. This impact evaluation produced independent estimates of free ridership and spillover. Free ridership and spillover estimates are more difficult and controversial than gross impact estimates. The relatively simple, self-report-based free ridership and spillover estimates derived for this evaluation indicate a much higher level of free ridership than spillover. If these estimates are

[20] "the net of free riders and free drivers are assumed to be zero in the counting of units from direct program participation." p. 2. Protocols to Measure Resource Savings, December 2007

incorporated into the program-level results, the net program impacts are further reduced relative to the Protocol estimate of net savings. It may be appropriate to use the estimates of free ridership and spillover developed in this study rather than the pre-existing Protocol assumption of 100 percent net-to-gross value.

The impact evaluation indicates a total reduction in estimated impacts of approximately 66 percent. The change in the QIV/proper sizing factor explains a 32 percent reduction relative to the gross Protocol impact estimate. The change in EFLH accounts for a 9 percent reduction. The combined free ridership/spillover estimate accounts for a 25 percent reduction. Thus, the largest piece of the reduction in cooling-related impacts is due to the change in the QIV/proper sizing factor. The combination of free-ridership and spillover also explains a large part of the reduction.

It's important to note that all of the results reported in this section assume a standard baseline of SEER 11 rather than the new Federal standard of SEER 13. Estimates for savings under the new Federal standards are reported in the program area report.

3.2.3 Heating impact Estimates

The gross heating impact estimates produced by this analysis are lower than the gross estimate indicated by the Protocols. The reduction in gross per-unit impact from 235 therms to 100 therms is caused by two factors:

- The existing Protocol equation artificially inflates savings by overstating the baseline unit capacity. The impact evaluation uses the more standard assumption of no change in unit capacity[21].
- A lower estimate of heating usage and Equivalent Full Load Hours (EFLH). The EFLH used to estimate heating impacts was derived from the billing analysis and is more consistent with secondary sources than the existing Protocol value.

[21] The program area report includes a discussion of the equations used to estimate heating savings.

Table 3-4:
Gross WarmAdvantage Per-Unit Impacts, Protocol vs. Impact Evaluation

Source for Hour (EFLH) Estimate	Post-Program Usage (Therms)	Equivalent Full Load Hours (EFLH)	EFLH Confidence Interval (+/-, 90%, Hours)	Baseline Capacity	Impact Relative to Standard (Therms)
Protocols	860	965		91,000	235
Impact Evaluation	648	727	13	82,449	100

Table 3-5 provides the program-level heating impacts for furnaces and boilers. The gross per-unit impacts are the Table 3-4 values reported in MWs. The gross results for both the Protocol and the ex-post impact evaluation reflect counts of units from the tracking data received from the utilities. As with the cooling measures, the Protocols have net free ridership and spillover of zero.

Table 3-5:
Gas Impacts from Heating Measures, Protocol Vs. Impact Evaluation

Source	Year	Per-Unit Impact (1000 therms)	Tracking Data Number of units*	Gross Impact (1000 therms)	(-) Free Ridership (1000 therms)	(+) Spillover (1000 therms)	Percentage of Gross		Net Impact (1000 therms)
							Free Ridership	Spillover	
Protocol	2005	0.235	9,658	2,270					2,270
	2006		11,363	2,670					2,670
Impact Evaluation	2005	0.100	9,658	966	434	122	45%	13%	654
	2006		11,363	1,136	511	136		12%	762

* Count of units is from the tracking data provided to the evaluation by the utilities.

As with the cooling measures, this impact evaluation produced independent estimates of free ridership and spillover. Free ridership and spillover estimates are more difficult and controversial than gross impact estimates. The relatively simple, self-report-based free ridership and spillover estimates derived for this evaluation indicate a much higher level of free ridership than spillover. If these estimates are incorporated into the program-level results the net program impacts are further reduced relative to the Protocol estimate of net savings. It may be appropriate to use the estimates of free ridership and spillover developed in this study rather than the pre-existing Protocol assumption of 100 percent net-to-gross value.

For 2006, the impact evaluation indicates a total reduction in estimated impacts of approximately 71 percent. The change in heating savings equation accounts for a 44 percent reduction relative to the gross Protocol impact estimate. The change in EFLH and the free ridership adjustment both account for a 14 percent reduction. Thus, the majority of the reduction in heating-related impacts is due to the correction of the faulty equation rather than analysis results produced by this evaluation.

4. Residential New Construction Program

This section presents a summary of the impact evaluation of the Residential New Construction Program.[22]

New Jersey's Clean Energy Program (NJCEP) promotes energy efficiency and the use of clean, renewable sources of energy. The Residential Construction Program, known as the New Jersey ENERGY STAR Homes Program, furnishes technical assistance and financial incentives to builders who commit to construct new homes to the standards established by the ENERGY STAR Homes Program. The purpose of this report is to present the findings from the ENERGY STAR Homes Program Impact Evaluation.

4.1 Evaluation Goals

The purpose of the evaluation is to assess the performance of the New Jersey ENERGY STAR Homes Program in terms of energy and demand savings.

- **Program Accomplishments** – The study presents a retrospective assessment of program accomplishments from 2001 through 2006 based on the findings from the program impact evaluation research.
- **New Jersey Clean Energy Program Protocols** – The study makes recommendations for the savings calculation Protocols so that they can furnish accurate statements of energy and demand savings accomplishments.

4.2 Evaluation Design Approach

The design for this Impact Study focused resources on the research activities that furnished the greatest amount of information for program managers and the BPU. The approach included:

- **Database Analysis** – Development of statistics on ENERGY STAR Builders, Projects, and Homes using the program administration databases.

[22] *New Jersey's Clean Energy Program*, Prepared by KEMA for New Jersey Board of Utilities, *Residential New Construction Program Impact Evaluation,* September 4, 2009.

- **Sample Frames** – Development of Sample Frames for ENERGY STAR Homes and Nonparticipating Homes.
- **Matched Sample** – Selection of matching samples of ENERGY STAR and Nonparticipating builders, projects, and homes.
- **Mail Survey** – Administration of a mail survey to owners of ENERGY STAR and nonparticipating new homes.
- **Utility Usage Data** – Retrieval of electric and gas usage data for CY 2007 for survey respondents who signed authorization forms.
- **REM/Rate™ Data** – Retrieval of REM/Rate™ data (i.e., information on energy specifications and rating data) for ENERGY STAR Homes.
- **Analysis** – Multivariate analysis of available data to assess the performance of the homes constructed with ENERGY STAR Homes incentives, compared to other groups of homes, including: those constructed without incentives by ENERGY STAR Builders and those constructed by nonparticipating builders.

The evaluation focused on those market segments that account for most of the projected savings from the ENERGY STAR Homes Program.

- **Housing Unit Type** – The analysis focused on single family and townhouse units; those homes represent 95% of ENERGY STAR Homes.
- **Production Homes** – The analysis focused on Production Homes; those homes represent 93% of ENERGY STAR Homes.
- **Homes Certified in 2005 and 2006** – The analysis focused on homes certified in 2005 and 2006 to facilitate development of the comparison home sample. Half of all NJ ENERGY STAR Homes were certified in 2005 and 2006.

With the available data, the Impact Evaluation was able to address most of the targeted information goals for the study. However, due to resource limitations, the study was not able to develop information on freeridership and spillover.

4.2.1 Key Evaluation Terms and Concepts

There are a number of evaluation terms and concepts throughout the report. For easy reference, a discussion of those terms and concepts is provided in Table 4-1.

Table 4-1: Key Terms and Concepts

Key Terms & Concepts	Definition
HERS Rating	A home energy rating involves an analysis of a home's construction plans and onsite inspections to project energy usage and generate a HERS Index score for the home.
REM/Rate™	This energy analysis software is used by a HERS Raters in New Jersey to generate a HERS rating and projected energy savings for an ENERGY STAR home.
Reference Home	A reference home is a *hypothetical* home constructed using the minimum energy efficiency standards specified by the building code in a jurisdiction. The energy analysis software uses the reference home to project the expected consumption of a standard home.
Production Homes	These are homes that are built using stock plans on land that is owned by the building firm. Such homes may be customized by selecting from a variety of predetermined options.
New Jersey Clean Energy Program Protocols	The Protocols were developed by the Office of Clean Energy to accurately and consistently determine energy and resource savings from measures supported by the New Jersey Clean Energy Program.
Gross Program Impact	For the ENERGY STAR Homes program, the gross program impact is the *measured* energy and demand savings that result from building a new home that meet program standards rather than the energy efficiency standards specified in the New Jersey building code. Since we can only measure the energy consumption for the home as built, gross program savings are measured by comparing actual energy consumption for an ENERGY STAR Home to the energy consumption that it was projected to use by the REM/Rate™ software prior to inclusion of energy efficiency measures.
Gross Realization Rate	The gross realization rate is the share of *projected* energy savings documented by measuring energy consumption for ENERGY STAR Homes. If the Reference Home is projected to use 1,200 therms of gas and the ENERGY STAR Home is projected to use 900 therms of gas, the projected energy savings is 300 therms. If the ENERGY STAR Home actually uses 870 therms of gas, the gross realization rate is 110% (330 therms actual savings / 300 therms projected savings). A gross realization rate greater than 100% means that the program exceeds expectations; a rate less than 100% means that the program is falling short of expectations.
Net Program Impact	To compute net program impacts, gross program impacts are adjusted for freeridership and program spillover (see below).
Freeriders	In the ENERGY STAR Homes program, freeriders are the builders who receive program incentives, but would have included energy efficiency measures in their homes without the incentives.
Spillover	In the ENERGY STAR Homes program, spillover is the energy savings that are realized because builders of nonparticipating homes adopt some or all of the energy efficiency measures installed in ENERGY STAR Homes. One reason that they may install those measures is to compete with ENERGY STAR Homes.
Mean	The mean is a measure of central tendency that is computed by summing values and dividing by the number of observations. For example, the mean square footage of 50 homes is computed by summing the square footage for the 50 homes and dividing the sum by 50.
Median	The median is a measure of central tendency that represents a value where one half of the observations have a higher value and one half of the observations have a lower value. When working with a small number of observations, the median is sometimes a more reliable measure because it is not affected by one or two extremely high or extremely low values.

4.3 Program Evaluation Findings

The data collected in the evaluation allow us to directly measure the electric and gas usage in ENERGY STAR Homes. In 2005, ENERGY STAR Homes were projected to use at least 30% less energy than the benchmark home built to the existing building code. In 2006, because of the implementation of new building codes and appliance efficiency standards, ENERGY STAR Homes were projected to use at least 15% less energy than the benchmark home built to the existing building code. The REM/Rate™ projections for the ENERGY STAR homes in our sample estimated that the homes would use about 25% less gas and about 60% less electricity for air conditioning than the benchmark home.

Gross Realization Rates

The first purpose of the analysis was to measure the energy savings resulting from the ENERGY STAR Homes program. The New Jersey Clean Energy Program Protocols define program impacts as the amount of energy saved by building a home to ENERGY STAR Home standards (i.e., the difference between the usage of the Reference Home and the usage of the ENERGY STAR Home). In this evaluation, we compared actual energy savings in ENERGY STAR Homes to the REM/Rate™ projected energy savings to see if the homes met program expectations. The *Gross Realization Rate* is defined as the ratio of measured savings to projected savings; a rate of 100% means that the homes are meeting program expectations; a rate greater than 100% means that the homes are exceeding expectations; and a rate less than 100% means that the homes are falling short of expectations.

Table 4-2 presents the findings. Averaged over all ENERGY STAR Homes, the *Gross Realization Rate* for gas (therm) savings was just over 100%, indicating that the program is meeting expectations. In age-restricted housing units, the realization rates were lower than 100%, but in nonage-restricted units the realization rates were higher than 100%.

Averaged over all ENERGY STAR Homes, the mean *gross realization rate* for electric air conditioning was about 60%, indicating that the program achieved about 60% of the expected savings. For three of the housing unit groups, the rate was about 70%, but for the Townhome group, the *gross realization rate* was only 10%.

Table 4-2: Summary of ENERGY STAR Homes Gross Realization Rates
By Housing Unit Type and Fuel

Gross Realization Rate	Age-Restricted Two-Story	Age-Restricted One-Story	Other Single Family	Other Townhomes	All ENERGY STAR Homes
Mean Therms	92%	74%	112%	132%	101%
Mean kWh	71%	66%	75%	10%	57%

Performance of the REM/Rate™ Model

The second purpose of the analysis was to assess the performance of the REM/Rate™ model in terms of modeling different types of housing units. With respect to gas usage, we found that the ratio of measured gas usage to projected gas usage varied from about 0.5 to 1.5. Using a regression analysis, we found a number of factors that appeared to be systematically related to variations in the ratio, including:

- Energy Behaviors – Households that report setting their thermostat above 70 degrees have higher usage and those that report using winter setback have lower usage. There is no way for the REM/Rate™ model to account for those household behaviors.
- Housing Unit Features – Those homes where it was reported that there was a multistory entryway, sunroom, or basement had statistically significant factors in the regression. It may be difficult for the REM/Rate™ model to account for such features.
- HERS Rating – For homes with higher HERS ratings, we found that measured usage was consistently less than projected usage. The implication of the finding is that higher HERS ratings are yielding better results than is projected.[23]

We did not find that a regression analysis helped us to assess factors that affected the ratio of measured air conditioning usage to projected air conditioning usage.

[23] For the rating system used by New Jersey in 2005 and 2006, a higher HERS score was given to housing units that were projected to have lower energy consumption.

Net Program Impacts

The third purpose of our analysis was to compare usage for homes that received ENERGY STAR incentives to those that are not receiving incentives. For each housing unit type, we compared the survey data to ensure that the homes were similar. In general, our comparison homes matched our ENERGY STAR homes in terms of the most important household and housing unit characteristics. We then compared the 2007 measured usage of the ENERGY STAR homes to the usage for the Comparison Homes.

Table 4-3 shows the findings for the gas usage analysis. On average, the gross impact of the ENERGY STAR program was to reduce gas usage by about 18% compared to the Reference Home. However, we found that the Comparison Homes also used less than the Reference Home, presumably because nonparticipating builders were exceeding the required energy standards in the New Jersey building codes. As a result, the net impact of the program was to reduce gas usage by about 9% lower than the Comparison Homes.

Table 4-3: Summary of ENERGY STAR Homes Gross and Net Percentage Impacts on Gas Usage By Housing Unit Type

Gas Impacts	Age-Restricted Two-Story	Age-Restricted One-Story	Other Single Family	Other Townhomes	All ENERGY STAR Homes
Gross Mean Therms	24%	17%	18%	41%	18%
Net Mean Therms	0%	10%	10%	11%	9%

We also conducted a regression analysis to control for more factors. The findings from that analysis include:

- **Net Impact of ENERGY STAR** - ENERGY STAR Homes use less energy than homes that did not receive ENERGY STAR program incentives. Each HERS point appears to be associated with a 2.8% reduction in the energy usage per square foot.
- **Comparison Homes Energy Performance** - Comparison homes appear to be built to higher standards than the REM/Rate™ Reference Home. The average Comparison Home uses about 7% more per square foot than the average ENERGY STAR Home.
- **ENERGY STAR Builders** – The Comparison Homes built by ENERGY STAR builders did not perform better than those built by non-ENERGY STAR builders.

Table 4-4 shows the findings for the electric air conditioning usage analysis. On average, the gross impact of the ENERGY STAR program was to reduce electric air conditioning usage by about 33% compared to the Reference Home. However, we found that the Comparison Homes also used less than the Reference Home, presumably because nonparticipating builders were exceeding the required energy standards in the New Jersey building codes. As a result, the net impact of the program was to reduce electric air conditioning usage by about 10%.

Table 4-4: Summary of ENERGY STAR Homes Gross and Net Percentage Impacts on Electric Air Conditioning Usage By Housing Unit Type

Gas Impacts	Age-Restricted Two-Story	Age-Restricted One-Story	Other Single Family	Other Townhomes	All ENERGY STAR Homes
Gross Mean kWh	42%	39%	43%	5%	33%
Net Mean kWh	7%	-7%	33%	8%	10%

The regression analysis for electric air conditioning usage found no difference between air conditioning electric usage for the ENERGY STAR Homes and the Comparison Homes.

4.4 Findings and Recommendations

The purpose of this evaluation is to assess the performance of the New Jersey ENERGY STAR Homes Program in terms of energy and demand savings, including a retrospective assessment of program accomplishments and recommendations for updates to the New Jersey Clean Energy Protocols. In general terms, this evaluation finds that ENERGY STAR Homes achieve the gas energy savings that are projected by the REM/Rate™ model and achieve about three-fourths of the air conditioning electric savings that are projected by the REM/Rate™ model. However, the net program impacts for the 2005 and 2006 ENERGY STAR Homes are considerably smaller than the gross program impacts. While ENERGY STAR Homes use considerably less gas and electricity than the REM/Rate™ Reference Homes, the differences between ENERGY STAR Homes and Comparison Homes that are built without ENERGY STAR incentives are considerably smaller than the differences projected by the REM/Rate™ model.

Based on the findings from the evaluation, we make the following recommendations with respect to the New Jersey ENERGY STAR Homes Program.

- **Program Accomplishments** – The evaluation demonstrates that the ENERGY STAR Homes are achieving the electric and gas usage savings established by the REM/Rate™ model. Until additional information is available on freerider and spillover effects, it is appropriate to leave the program accomplishments as stated in previous New Jersey Clean Energy Program Reports.
- **Protocol Revisions** – It appears that the new homes market in New Jersey has been transformed so that all new homes in the current ENERGY STAR Homes market segments are constructed to the minimum ENERGY STAR standards in place prior to the 2007 upgrades. From that perspective, homes being constructed with incentives from the ENERGY STAR Homes Program should be using the 2006 ENERGY STAR standards as the "Reference Home,"
- **Program Incentives** – ENERGY STAR Homes Program incentives should be focused on encouraging higher levels of savings in the existing market segments. Alternatively, it might be appropriate to allocate resources to market segments that have not yet been addressed by the ENERGY STAR Homes Program.
- **REM/Rate™ Revisions** – It may be appropriate to examine how well the REM/Rate™ model is performing with respect to certain housing unit features and to change the final ratings for home that include features that detract from a home's energy performance.

Table 4-5 presents the specific recommendations with respect to the New Jersey Clean Energy Program Protocols.

Table 4-5: ENERGY STAR Homes Protocol Findings and Recommendations

Issue	Findings	Recommendation
Validate Clean Energy Program Protocols for 2001-2006.	2005 and 2006 ENERGY STAR Homes achieved the Therm and kWh savings projected by the Protocols.	Confirm that the 2001-2006 Therm and kWh savings were achieved by the ENERGY STAR Homes Program.
	No new information was developed on demand impacts of the program.	Continue to use the 2001-2006 KW savings unless additional information is developed.
Assess whether freerider and spillover adjustments to the Clean Energy Program Protocols are appropriate.	Freerider and spillover research was not funded. The study found that nonparticipating homes are more efficient than the "reference home." This finding could indicate that ENERGY STAR homes are freeriders or that there is substantial spillover to the non-participants.	Continue to make the assumption that the net to gross ratio for the ENERGY STAR Homes Program is 1.0. Consider funding research on freeridership and spillover.
Propose Clean Energy Program Protocols for 2007 and later.	A matching sample of nonparticipating homes was as efficient as the homes that met the minimum ENERGY STAR Standard.	Make the reference home in the REM/Rate™ equal to the ENERGY STAR home. Since important program revisions were implemented in 2006, consider funding research on the performance of ENERGY STAR Homes built in 2007 and later.

5. ENERGY STAR Products Program – CFL Only

This section presents a summary of KEMA's impact evaluation of the ENERGY STAR Product Program's CFL component.[24]

Administered through NJCEP, the ENERGY STAR® Products Programs[25] provided incentives for four types of consumer products: compact fluorescent lamps (CFLs; 2003-2005), Room Air Conditioners (2003-2006), Clothes Washers (2005), and a Programmable Thermostat Pilot (2005). To calculate savings for these installations, the Programs use the "New Jersey Clean Energy Program Protocols to Measure Resource Savings" (Protocols)[26].

KEMA was contracted to conduct a New Jersey residential CFL impact evaluation and a review of the energy savings calculation protocols used for assessing CFL installations. The KEMA evaluation covers program years 2003-2005. The CFL ENERGY STAR Products Program component, which accounts for 6.7 percent of total NJCEP tracked savings and 1.4 percent of committed expenditures[27], involved a buy down of retailer purchase costs from CFL suppliers (through an RFP issued to manufacturers). Because the program incentives were delivered upstream (that is, to suppliers rather than directly to consumers), program records include information on the total number of program-discounted CFLs purchased by the major retailers participating in the program. There is however, no information on how many bulbs were actually sold by each retailer and no information on to whom the bulbs were sold.

This report has two primary functions:

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[24] *New Jersey's Clean Energy Program Residential CFL Impact Evaluation and Protocol Review*, Prepared by KEMA for New Jersey Board of Public Utilities, *ENERGY STAR® Products Program – Lighting,* September 28, 2009.

[25] During the evaluation period (2001-2006) this program changed names several times (e.g. ENERGY STAR Products, Residential ENERGY STAR Lighting Program). This evaluation report focuses on NJCEP's upstream CFL initiative.

[26] *New Jersey's Clean Energy Program, Protocols to Measure Resource Savings,* Revisions to September 2004 Protocols, December 2007.

[27] Percents based on program year 2005 activities reported in the NJCEP annual financial report.

1. To offer recommendations for revisions to the savings calculation Protocols so that going forward, the calculations using these Protocols provide more accurate statements of savings accomplishments; and

2. To provide a retrospective assessment of program accomplishment as part of a due-diligence review of past utility program effectiveness on behalf of ratepayers.

The second function is addressed with an ex-post impact evaluation. The ex-post impact evaluation was designed to support potential Protocol revisions as mandated by the first function. The impact evaluation focuses on the measures that generated the majority of the savings for the programs. The results produced by this impact evaluation provide key revisions to important Protocol equations. In addition to the direct impact evaluation input, KEMA engineers performed a review of Protocol equations and the recommended inputs.

5.1 Protocol Review

The ENERGY STAR CFLs measure is a subset of the Residential ENERGY STAR Lighting Program. The Residential CFL Protocol is related to the Protocol for the Residential Low Income Program's Efficient Lighting measure. The two measures use the same algorithm, though the values entered are different. Upon evaluating the Protocols used to calculate savings from installation of screw-in ENERGY STAR CFLs, it was apparent that some of the original assumptions and variable terms used could be improved to reflect more accurate statements of savings accomplishments.

The existing Protocols, equations and input variables, are shown below.

$$\textit{Electricity Impact (kWh)} = \left(\frac{CFL_{watts}}{1000}\right) * CFL_{hours} * 365 * ISR_{CFL}$$

$$\textit{Peak Demand Impact (kW)} = (CFL_{watts}) * \textit{Light CF}$$

Where:

CFL_{watts} = Average difference in watts between baseline and ENERGY STAR CFL
CFL_{hours} = Average hours of use per day per CFL
ISR_{CFL} = In-service rate
Light CF = Coincidence Factor for lighting.

Table 5-1: Original Algorithm Input Values

Variable	Type	Value
CFL_{watts}	Fixed	48.7[28]
CFL_{hours}	Fixed	3.4[29]
ISR_{CFL}	Fixed	84%[30]
Light CF	Fixed	5%[31]

Upon conducting a review of other program protocols and CFL studies used by other programs, we recommend changes that will:

- Create consistency between this current evaluation and past studies;
- Simplify comparisons between measures reducing confusion; and
- Update algorithmic inputs to reflect more accurate data and therefore more accurate assumptions about energy usage.

Our recommendations are as follows:

1. Change the terms “Energy Impact” to “kWh Savings,” “Peak Demand Impact” to “kW Savings,” “Light CF” to “CF,” and “CFL_{watts}” to “ΔW” to remain consistent with the rest of New Jersey Protocols;

2. Correct the error in the algorithm for kW Savings (Peak Demand Impact) by dividing by 1000 to convert Watts to kilo-Watts (kW).

[28] Market Research, “Impact Evaluation of the Massachusetts, Rhode Island and Vermont 2003 Residential Lighting Programs”, Final Report, October 1, 2004, p. 43 (Table 4-9)

[29] Ibid., p. 104 (Table 9-7). This table adjusts for differences between logged sample and the much larger telephone survey sample and should, therefore, have less bias.

[30] Ibid., p. 42 (Table 4-7). These values reflect both actual installations and the % of units planned to be installed within a year from the logged sample. The logged % is used because the adjusted values (i.e. to account for differences between logging and telephone survey samples) were not available for both installs and planned installs. However, this seems appropriate because the % actual installed in the logged sample from this table is essentially identical to the % after adjusting for differences between the logged group and the telephone sample (p. 100, Table 9-3).

[31] RLW Analytics, “Development of Common Demand Impacts for Energy Efficiency Measures/Programs for the ISO Forward Capacity Market (FCM)”, prepared for the New England State Program Working Group (SPWG), March 25, 2007, p. IV.

3. Compare the variables ΔW *(CFL_{watts}), ISR_{CFL},* and CF to other, more recent studies and updated appropriately, while the variable CFL_{hours} should be revised based on metered data from more recent studies.

4. Use the ΔW values from the most recent New Jersey study, as they align with industry trends in other states and are derived from New Jersey data.

5. Use CF value based on the 2007 New England Study[32] and adjusted for the New Jersey peak period.

Given these recommendations, the algorithms and their inputs are updated as follows:

$$kWh\ Savings = \left(\frac{\Delta W}{1000}\right) * CFL_{hours} * 365 * ISR_{CFL}$$

$$kW\ Savings = \left(\frac{\Delta W}{1000}\right) * CF$$

<u>Where:</u>

ΔW = Average difference in watts between baseline and ENERGY STAR CFL
CFL_{hours} = Average hours of use per day per CFL
ISR_{CFL} = In-service rate
CF = Coincidence Factor.

Table 5-2: Updated Algorithm Input Values

Variable	Type	Value	Source
ΔW	Fixed	48.5	2009 New Jersey CFL Study
CFL_{hours}	Fixed	2.8	2009 New England Study
ISR_{CFL}	Fixed	83.4%	2009 New Jersey CFL Study
CF	Fixed	9.9%	2007 New England Metering Study

[32] Ibid.

5.2 Ex-Post Impact Evaluation

The methodology used to conduct the ex-post impact evaluation involved a number of interdependent tasks including calculating gross energy and peak demand savings (gross impacts); upstream measurements of free ridership; an examination of potential spillover effects; and measurements of net savings. Using the revised algorithm inputs and assumptions described above, these measurements relied upon primary and secondary data including New Jersey consumer telephone surveys, program and non-program sales data elicited from retail and manufacturer through telephone surveys, CFL Program tracking data, reliable and applicable proxy meter data from a previous study (2009 New England Study), and Protocol algorithm values consistent with past studies from residential CFL programs in other states.

Among purchasers, the CFL customer survey was tailored to estimate gross and net program impacts as well as understand New Jersey resident CFL awareness, purchasing incidence and behavior, and non-purchaser behavior. Additionally, the survey examined future CFL purchase potential and barriers, tracked CFL purchase locations and installation by room-type, and explored incidences of stockpiling and storage, and CFL installation expansion potential and barriers.

Gross impact calculations involved:

a) Determination of the number of 2003-2005 ENERGY STAR Products Program CFLs;

b) Calculation of displaced wattage;

c) Determination of estimated installed Program CFL usage per day; and

d) Estimation of Program CFL in-service rate.

Free ridership[33] estimates were based on telephone interviews conducted with retailers and manufacturers regarding their program and non-program sales. A free ridership fraction for each manufacturer was given a weight according to the volume of 2004-2005 program CFLs sold

[33] Program attribution is another term used to describe the influence of the program on a program participant's decision to make energy efficiency improvements. In this report program attribution would be calculated as 1 – Free Ridership.

through the program by each participating retailer and a weighted average free ridership fraction computed.

Spillover was qualitatively assessed to capture potential dynamics associated with the market. Finally, program-level net savings were calculated by averaging chain-level free ridership estimates, weighting these estimates by the volume of program-discounted CFLs sold by each retailer, and combining 2004 and 2005 annual free ridership estimates. A program-level net-to-gross ratio was determined using the following formula:

1 – Program-Level Free ridership = Net-to-Gross Ratio

5.3 Results

5.3.1 Surveys and Interviews

Evaluators conducted interviews with manufacturers and retail chain representatives representing more than 90 percent of total program CFL sales in New Jersey between 2004 and 2005. Evaluators successfully completed a total of 409 consumer surveys, of which at least 100 consumers purchased CFLs between 2003 and 2005. Additionally, we also conducted 112 surveys of consumers who had purchased CFLs that were not subsidized by New Jersey's Change-a-Light program.

5.3.2 Gross Impacts

We estimated annual gross energy and demand savings for 2004 and 2005 (Table 5-3). As shown in the table below, we estimated gross energy savings for the two-year program at about 129,000 MWh and gross peak demand savings at 12.5 MW. Data sources for the key impact parameters are shown in Table 5-4.

Table 5-3: Gross Energy and Peak Demand Savings, 2004-2005

Gross Savings	Program Year		Overall
	2004	2005	
Energy (MWh)	78,175	51,230	**129,405**
Peak Demand (MW)	7.6	5.0	**12.5**

Table 5-4: Key Impact Parameters and Sources

Parameter	Source
1. Number of CFLs	Program records
2. Displaced Wattage (Watts)	Computer-Assisted Telephone Interviewing (CATI) Surveys with residential customers
3. Hours of Use per Day	2009 New England Study
4. CFL In-Service Rate (installation rate)	CATI Surveys with residential customers

5.3.3 Spillover

The following are general observations made by manufacturers in the “Change-a-Light” program. They qualitatively reflect program spillover.

- Almost all manufacturers mentioned observing an increasing variety of CFLs widely available in stores and that consumers and retailers have grown more accustomed to the types that were discounted by the program. This is especially true in the Hardware, “Do It Yourself” (DIY) and Big Box retail channels, but greater variety is also seen in nontraditional CFL markets in the last two years, such as convenience stores.
- New Jersey’s Change-a-Light program is given credit for helping to expand the market for CFLs to newer market channels. Several manufacturers explained that as sales growth from traditional outlets is slowing, they have begun expanding into nontraditional outlets such as supermarkets, drug stores and ethnic markets. Sales representatives are finding it easier to move into these channels and credit this program with having educated the retail buyers, making them more receptive to increasing the range and exposure of CFLs in their stores.
- Manufacturers that sell to discount stores (such as dollar stores) report that they see zero spillover – dollar stores will only stock CFLs that they can sell for a dollar (which is currently possible only when there is a discount). Similar effects are reported by other manufacturers that sell to the low-end retailers. One respondent said that rather than market transformation or spillover, he perceived only robust price elasticity for CFLs that has remained unchanged among consumers over the last few years. That is, this representative indicated that consumers weren’t changing their behavior, rather they were simply responding to price.

5.3.4 Free ridership

Free ridership results are shown in Table 5-5. As shown, the overall program-level freeridership estimate is 15.4 percent.

Table 5-5: Freeridership Estimate (Weighted by Number of Program CFLs), 2004 and 2005

Program Year	Weighted Results	
	Estimated Freeridership	**Std Err**
2004	14.4%	±5.3%
2005	16.4%	±5.0%
Overall	**15.4%**	**±5.5%**

5.3.5 Net Impacts

After applying annual free ridership estimates to the annual gross savings estimates for 2004 and 2005 separately and adding the resultant savings across program years, net energy savings for the two-year program are approximately 110,000 MWh and net peak demand savings are 10.6 MW, as shown in Table 5-6.

Table 5-6: Gross and Net Energy and Peak Demand Savings, 2004-2005

(does not include Spillover)

Gross Savings	Program Year		Overall
	2004	**2005**	
Energy (MWh)	78,175	51,230	**129,405**
Peak Demand (MW)	7.6	5.0	**12.5**
Net Savings			
Energy (MWh)	66,918	42,829	**109,746**
Peak Demand (MW)	6.5	4.1	**10.6**

6. SmartStart Program Protocol Review (Prospective Assessment)

This section presents a summary of KEMA's review of the Protocols pertaining to the SmartStart Program.[34] KEMA's retrospective assessment of energy savings reported by the SmartStart Program was provided in a separate document[35] and summarized in Section 7.

6.1 Overview of Approach

The Protocols were developed to accurately and consistently determine energy and resource savings for measures supported by the NJCEP. The document is periodically updated as new programs are added, existing programs are modified, and new information becomes available. The Protocols were most recently updated in December 2007. KEMA conducted a detailed assessment of the Protocols and recommends updates to the Protocols based on:

- a review of the December 2007 version;
- a review of sources and data cited in the protocols;
- a review of similar "deemed savings" documents prepared in other jurisdictions and other secondary sources;
- knowledge gained from the retrospective review of track savings currently underway; and
- application of these data and sources to the measures supported by NJCEP.

6.2 Summary of Findings and Recommendations

This section presents KEMA's key findings and recommendations for the Protocol Review, Protocol use of Time Period Allocation Factors, a process for estimating savings for custom projects, an on-going process for updating the Protocols, and tracking data and hard-copy documentation.

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[34] *New Jersey's Clean Energy Program Energy Impact Evaluation and Protocol Review,* Prepared by KEMA for New Jersey Board of Public Utilities, *SmartStart Program Protocol Review,* July 10, 2009.

[35] *New Jersey's Clean Energy Program Energy Impact Evaluation SmartStart Program Impact Evaluation.* Prepared by KEMA for New Jersey Board of Public Utilities, Office of Clean Energy. July 10, 2009.

6.2.1 Protocol Review

This report provides a review of the savings algorithms for the SmartStart Program. The review assesses the appropriateness of the savings equations and the input parameters provided in the 2007 Protocols. A detailed review of the following Protocols is included in this report:

- Lighting Equipment
  - Performance Lighting
  - Prescriptive Lighting
- Lighting Controls
- Motors
- Electric HVAC Systems
- Electric Chillers
- Variable Frequency Drives
- Air Compressors with Variable Frequency Drives
- Gas Chillers (Absorption Chillers)
- Gas Fired Desiccants
- Gas Booster Water Heaters
- Gas Water Heaters
- Furnaces and Boilers
- Compressed Air System Optimization

First, we address the use of key terms used in the Protocols. Then we provide a table containing KEMA's key recommendations for each SmartStart protocol.

6.2.1.1 Key Protocol Terms

Key variables (e.g., Coincidence Factor, Equivalent Full Load Hours, kW savings) in the Protocols are defined differently, depending on the Protocol. To remove confusion regarding these definitions, KEMA provides a Glossary of Key Terms and Variables as they are used in this report. KEMA recommends consistent use of key terms in the Protocols.

6.2.1.2 Key Protocol Recommendations

Table 6-1 presents a summary of KEMA's key recommendations for each of the fourteen Protocols reviewed. This summary of recommendations is provided at a high and general level; for a more detailed explanation of each recommendation refer to the full body of the report.

Table 6-1
Summary of Protocol Recommendations

Protocol	Number	Page	Recommendation
Performance Lighting	PL-1	3-15	Revise algorithm inputs for Equivalent Full Load Hours (EFLH), Coincidence Factor (CF), and Interactive Factor (IF) based on the values provided, which are based on secondary sources and are differentiated by building type.
	PL-3	3-18	Record lighting control type on the application. When lighting is controlled by something other than a simple switch, use savings factors provided in the Lighting Controls section to adjust for savings based on those controls.
	PL-4	3-18	Provide a list of building types, space types, and a standard lighting wattage table either on the application or on a separate downloadable document.
	PL-5	3-18	Clarify whether the wattage data from the application is used in savings calculations, or whether the wattages are based on a standard wattage table. We recommend that a standard wattage table be used, and have provided California's Standard Performance Contract (SPC) table for that purpose.
	PL-6	3-18	Record on the application information on which building spaces are conditioned and which are not, so that interactive savings are not claimed for unconditioned spaces.
	PL-7	3-18	In calculating energy savings, use all building spaces, even if the lighting densities from some spaces do not meet the qualifying requirements for the program. This will provide a more accurate estimate of energy savings.
Prescriptive Lighting	PrL-1	3-21	Replace the existing wattages from the Prescriptive Lighting Savings Table with updated wattages from California's Standard Performance Contract (SPC) table.
	PrL-2	3-21	Use the same inputs for CF, EFLH, and IF as provided in the Performance Lighting protocol review.
	PrL-3	3-21	Account for interactive energy savings realized under this protocol by including Interactive Factor (IF) in the savings calculation.
	PrL-4	3-21	Record lighting control type on the application. When lighting is controlled by something other than a simple switch, use savings factors provided in the Lighting Controls section to adjust savings based on those controls.
Lighting Controls	LC-1	3-24	Coordinate this measure with Performance and Prescriptive Lighting, such that savings are not double-counted for customers who apply for Lighting Controls and one of the other lighting measures.

Protocol	Number	Page	Recommendation
	LC-2	3-24	Use the same values for EFLH, CF, and IF as are recommended for Performance Lighting.
Motors	M-1	3-34	Base energy savings calculations on the horsepower of the qualifying unit, rather than on both the qualifying and replaced unit.
	M-2	3-34	Fully articulate the algorithms such that commonly used factors as Load Factor and Duty Cycle are apparent in the algorithm, rather than subsumed under the Rated Load Factor, a term that is not commonly used in the industry.
	M-3	3-34	Include in the algorithm a factor to account for the interaction motor between two sometimes concurrent measures: Motors and Variable Frequency Drives (VFDs).
	M-4	3-34	Conduct a survey to gather motor operating hours by climate zone and by sector. Until that has been completed, base operating hours on those provided.
	M-5	3-34	Include in the protocols the provided tables which establish baseline and qualifying premium motor efficiencies.
Electric HVAC System	ES-1	3-47	Adjust the baseline energy efficiency values to fit those provided by the Consortium of Energy Efficiency (CEE) Tier 1.
	ES-2	3-47	Consider including a factor in the algorithm to account for over sizing of equipment.
	ES-3	3-48	Consider allowing variation in CF and EFLH based on building type, building vintage, and climate zone. Further research is warranted to determine these values. The variation could be estimated by adjusting variability information for California for the New Jersey climate, or by carrying out rigorous DOE 2 (computer based) building simulation.
Electric Chillers	EC-1	3-58	Use IPLV (Integrated Part Load Value) for efficiency in the algorithm rather than full load efficiency, which is currently used.
	EC-2	3-59	Adjust baseline efficiency values based on equipment type and size as provided in the full body of the report.
	EC-3	3-59	Limit qualifying equipment such that the qualifying chiller must be at least 5% more efficient than the baseline chiller. A list of qualifying efficiencies is provided.
	EC-4	3-59	Use a custom approach for very large chillers.
	EC-5	3-59	Conduct market research into the installed baseline of chillers in New Jersey, including size, age, efficiency, and operational hours, which will help determine the importance of this measure and establish appropriate benchmarks.

Protocol	Number	Page	Recommendation
	EC-6	3-59	Investigate and provide more accurate values for EFLH and CF.
Variable Frequency Drives	VFD-1	3-70	Undertake a metering study to determine accurate values for Demand Savings Factor (DSF) and Energy Savings Factor (ESF). Since HVAC motors are highly dependent upon weather, it will be important to use data that are collected within New Jersey.
	VFD-2	3-70	Create a lookup table of DSF and ESF values based on the type of fan or pump application. This will require updating the application to collect this information from the customer.
	VFD-3	3-70	Until a metering study is complete, use values for DSF and ESF based on those used by Connecticut Light and Power, as provided.
Air Compressors with Variable Frequency Drives	ACVFD-1	3-77	Proceed conservatively with the promotion of VFDs on air compressors unless there is confidence that the compressor regularly operates at 30%-70% load. Within that window, VFDs can provide significant savings, but for compressors which typically operate outside that window, savings will be minimal or negative.
	ACVFD-2	3-77	Limit this prescriptive measure to facilities with a single operating compressor who are either replacing their existing compressor with a new single compressor of the same size, or are installing a retrofit VFD on the existing compressor. For multiple-compressor systems, it is much more difficult to determine whether a VFD would save energy, and the customer and program may receive greater benefit by treating multiple-compressor systems as a custom measure.
	ACVFD-3	3-77	Fully articulate in the protocol the algorithms provided for Yearly, Peak, and Maximum kW/HP savings and their inputs, as provided.
	ACVFD-4	3-77	Change and expand values used for key variables in the protocol based on secondary sources and our engineering review, as provided.
Gas Chillers (Absorption Chillers)	GC-1	3-82	Treat Gas Chillers as a custom measure. Gas absorption chiller energy use is extremely site-specific.
	GC-2	3-82	In the custom calculation, we suggest using a temperature bin calculation method both for the baseline chiller and for the new proposed chiller. At minimum, the load profile must be based on operating hours during peak times and operating hours during off-peak times. As an alternative, SmartStart may create a complete building simulation using energy modeling software. Various simulation tools like DOE-2, HAP, Trace and e-Quest have in built performance simulation modules for gas absorption chillers.
Gas Fired Desiccants	GFD-1	3-87	Treat Gas Fired Desiccants as a custom measure. Energy savings are highly variable based on many factors, including the design and efficiency of the existing cooling equipment.
	GFD-2	3-87	One possible approach to determine savings for gas fired desiccants is to use existing modeling software. There are several models that

Protocol	Number	Page	Recommendation
			are currently available, including TRACE, DOE-2, and DesiCalc. Another option is to conduct further research by measurement and verification of SmartStart customers who are installing the technology.
Gas Booster Water Heaters	GBWH-1	3-96	Consider treating Gas Booster Water Heaters as a custom measure. Booster heater energy use will vary greatly, depending upon whether they are installed on commercial dishwashers or elsewhere. Even amongst commercial dishwasher installations, energy use variability is considerable based on dishwasher type.
	GBWH-2	3-96	KEMA provides a prescriptive methodology for booster heater installations on a great majority of commercial dishwashers. The following recommendations apply to these installations. a.) Use the provided algorithms, which are based on the sensible heat equation, rather than estimating EFLH. b.) Ask for the racks of dishes washed per day on the application and obtain gallons per rack from the provided lookup table. The values are used in the algorithm to estimate the amount of water heated. c.) Use the values provided for other algorithm variables.
	GBWH-3	3-97	Conduct further research into dishwasher use with respect to time and typical booster water heater input temperatures.
Gas Water Heaters	GWH-1	3-103	Use the algorithm provided, which is based on energy use density by building type, rather than a fixed value for baseline energy usage. The fixed baseline is currently based on residential water heating energy, not commercial.
	GWH-2	3-103	Require that the application collect the square footage served by the water heater and use the value with the appropriate energy use density to determine hot water energy use.
	GWH-3	3-103	Use Energy Factor (EF) for efficiency values for small water heaters (less than 50 gallons or 75,000 BtuH). Use Thermal Efficiency (TE) for efficiency values for larger water heaters.
Furnaces and Boilers	FB-1	3-114	Use the provided algorithm to calculate energy savings. It is based on heating degree days from four New Jersey climate zones and twelve building types, rather than on a single fixed value for EFLH.
Compressed Air System Optimization	CASO-1	3-103	Take advantage of the DOE Compressed Air Challenge (CAC), which provides training and other services regarding compressed air systems. Following CAC guidelines will help to provide a more thorough and standardized approach to compressed air systems and give more confidence and authority to the SmartStart Program's energy savings recommendations.
	CASO-2	3-103	Maintain both options for rebates under Compressed Air System Optimization: Compressed Air System Analysis and Pay for Performance. Below we discuss recommendations for these measures separately.
	Compressed Air		

Protocol	Number	Page	Recommendation
	System Analysis Recommendations		
	CASO-3	3-119	Require any auditor providing this analysis to have attended the CAC two-part training series and not be under the employ of a company which also sells compressed air products.
	CASO-4	3-119	Refer to the main body of the report for an extensive list of potential compressed air system improvements.
	Pay for Performance Recommendations		
	CASO-5	3-121	Make sure not to offer this option to a customer who has already begun installation of a product. This type of project would have occurred without the program and program dollars could be better spent elsewhere.
	CASO-6	3-121	Promote the systems approach to air compressor energy savings for multiple-compressor systems, even under the Pay for Performance option.
	CASO-7	3-121	Encourage customers to take CAC training.
	CASO-8	3-121	Continue to require that Measurement and Verification (M&V) plans follow the International Performance Measurement and Verification Protocol (IPMVP). This protocol offers two options and we recommend that the program generally promote Option B, the system-wide M&V approach. We recommend that the program also consider the Compressed Air Supply Efficiency method as promoted by California as a simple standardized M&V method.
	CASO-9	3-122	Rebate ultrasonic leak detectors or create a tool library where customers can borrow ultrasonic leak detectors. Ultrasonic leak detectors are an essential tool for checking leaks in air lines.

6.2.2 Time Period Allocation Factors

Time Period Allocation Factors are an important component of determining the cost-effectiveness of program measures from a utility perspective.

The time periods are defined as follows:

- Electricity (kWh) savings across summer peak, summer off-peak, winter peak, and winter off-peak

- Gas (therm) savings across summer and winter periods

KEMA does not recommend changes to the Time Period Allocation Factors for electricity most measures. However for several technologies, including control measures that save energy at specific times, rather than over the normal course of equipment operations KEMA recommends additional research. In such cases, the measure savings shape (energy savings) is expected to be different from the end use load shape (energy consumption). Unfortunately, most load shape research to date has focused on end use load shapes.

Table 6-2 below summarizes the recommendations for improving Time Period Allocation Factors for electric measures.

Table 6-2
Summary of Recommendations (Electric Measures)

Measure	Recommendations
Lighting Equipment	No changes currently recommended.
Lighting Controls	Use current Time Period Allocation Factors until additional research and possible on-site metering surveys yield more appropriate data on measure shape of lighting controls.
High Efficiency Motors	Time Period Allocations should utilize the specific end-use load shapes. Since most motor applications are for HVAC systems, the HVAC system Time Period allocation Factors should suffice.
High Efficiency HVAC	No changes currently recommended.
High Efficiency Chillers	No changes currently recommended.
VFDs	Use equipment specific Time Period Allocation Factors, per Efficiency Vermont Technical Reference User Manual (TRC) No. 2005-37.
VFD air compressors	Use current Time Period Allocation Factors until additional analysis of business and application types inform more appropriate hours of operation.

Gas efficiency measures only have Time Period Allocation Factors associated with summer and winter use. The Protocols stipulate that the summer and winter periods are six months each. Therefore, for any efficiency measure to operate at a constant rate year round, the Time Period Allocation Factor is expected to be roughly 50/50 for summer and winter periods.

Some of the measures in the C&I Gas Protocols result primarily in electric savings, rather than gas savings. Although they are being recommended as custom savings measures, estimated Time Period Allocation Factors for gas chillers and gas fired desiccants have been provided in this analysis. Table 6-3 summarizes the Time Period Allocation Factor recommendations for measures in the Gas Protocols.

Table 6-3
Summary of Recommendations (Gas Protocols)

Measure	Recommendations
Gas Chillers	Revise Time Period Allocation Factors to reflect zero electric savings in the winter, and zero gas savings in the summer.
Gas Fired Desiccants	Use HVAC system Time Period Allocation Factors for electric savings. No gas savings are associated with this measure.
Gas Booster Water Heaters	No changes currently recommended.
Water Heaters	Use current Time Period Allocation Factors until additional research on seasonal variation in water delivery temperature can be completed.
Furnaces and Boilers	Minor changes to the Time Period Allocation Factors are recommended, based on climate zone.

6.2.3 Estimating Savings for Custom Projects

Custom measures allow customers to qualify for and receive an incentive for energy efficiency measures that are not on the Prescriptive Equipment incentive list. Custom measures are site and end-use specific, and require a detailed analysis to qualify for incentives. The following is a brief synopsis of key considerations and recommendations for estimating savings for custom projects. For a more complete discussion of these topics, please refer to the program area report.

6.2.3.1 Key Questions and Concerns

The following is a summary of general issues and recommendations regarding custom savings calculations.

- KEMA recommends SmartStart develop a standard method for handling energy savings calculations and measurements from various sources. We recommend that the program carefully review all calculations. For calculations provided by manufacturers, vendors, or contractors, we recommend that the program perform separate calculations using standard methods for comparison.
- KEMA recommends that the program establish a standard method for determining whether a project is an early or natural replacement installation. This distinction determines which baseline condition is used and can have a significant impact on the energy savings calculated. We recommend that the program ask for the reason equipment is being replaced on the application and use the answer to make this

determination. If the answer is not clear or it is otherwise difficult to determine, we recommend that the program assume natural replacement as the default

- SmartStart currently accounts for interactive effects for some prescriptive lighting measures. KEMA recommends that the program develop a standard regarding whether interactive effects should be considered for custom projects. Since interactive effects are often difficult to determine and verify, we recommend that the program, by default, excludes interactive effects from custom projects. Exceptions can be made for unusual projects.

6.2.3.2 Methods for Determining Savings

Savings for custom measures may be determined by:

Engineering Estimates. This is the most common method for determining savings. It involves applying well-established engineering algorithms to estimate baseline and qualifying energy use.

Building or Process Simulation Modeling. For measures that have building-wide impacts or impacts across a number of systems, building or process simulation modeling using public domain software may be acceptable to document savings.

Metering. Whole-building metering may be used to determine savings if savings are a significant fraction of the total monthly or annual energy usage. When measures are installed that affect a large and distinct system, sub-metering may be the best way to document the savings. The program may wish to require metering for measurement and verification (M&V) in order for a project to qualify for an incentive, or to gain a greater understanding of energy savings for planning purposes. In such cases, the International Performance Measurement and Verification Protocol[36] (IPMVP) should be followed to develop an M&V plan. Documentation of the method used and assumptions made should be a program requirement.

6.2.4 Tracking Data and Hard-Copy Documentation

Consistent and complete program tracking data is a fundamental requirement for a statewide energy efficiency program such as SmartStart. Program tracking data can be used for program

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[36] 1.2.3 International Performance Measurement and Verification Protocol (IPMVP) - Efficiency Valuation Organization, April 2007

operations, program planning, and reporting and verification of accomplishments. KEMA understands that OCE has implemented a statewide tracking database and process for archiving hard-copy project documentation subsequent to the time period covered by this evaluation (2001-2006).

6.2.4.1 Electronic Data

During the period under review (2001-2006), the program relied on policies and procedures to ensure consistency and quality control. The application, technical information, savings and incentive calculations, and supporting documents were reviewed upon receipt to verify eligibility. However the data was not collected and stored in a consistent electronic format across the state. Statewide energy efficiency and renewable programs, such as SmartStart, should have an electronic tracking database to facilitate consistent and accurate measure level energy savings calculations and therefore reporting of overall program impacts. The database should contain the following categories: customer information, contractor/vendor information, measure and project-specific data.

The database should contain measure specific energy and demand savings values. These values should be hand entered (with supporting hard-copy documentation or electronic PDFs) for custom projects and officially calculated by the database for non-custom projects.

The database should be as detailed as possible. All measure specific information on the program application should be entered into the database. Electronic tracking of this information will enable the OCE greater flexibility in monitoring and researching its programs. It will also minimize demands on the program for data requests for program impact evaluations, benefit-cost studies, and other research studies. The accuracy of these studies will also improve with better program tracking data.

KEMA understands that OCE has created a statewide database subsequent to the time period covered by this impact evaluation (2001-2006).

6.2.4.2 Hard-Copy Documentation

Following data entry into the program tracking database, all project application and supporting documentation should be filed in a dedicated location for the program. Each file should consist of:

- Application form
- Invoices, or other information submitted by the customer or their contractor

- Supporting calculations (e.g. prescriptive lighting worksheet, lighting controls worksheet, etc.)
- Any internal procedural application processing forms (e.g. payment release forms, internal check-in forms, etc.)

6.2.5 On-going Protocol Updates

The Protocols to Measure Resource Savings (Protocols) is updated and modified periodically in order to ensure that the savings calculation methodologies are accurate and relevant. KEMA recommends that OCE update the Protocol document on an annual basis to coincide with the annual program planning process. The Protocol update process should also include the results and recommendations of any independent third-party program evaluations of the SmartStart program. Table 6-4 shows a selection of regulations, federal and state policies, and studies which may inform updates to the Protocol.

Table 6-4
Selection of Sources for Protocol Updates

Source	Description
Federal policy	Federal policies such as the EISA 2007 will set new federal efficiency standards for certain motors and lighting
New Jersey building codes	New commercial buildings are required to show compliance to ASHRAE 90.1-2004.
NJCEP Impact Evaluations	Third party evaluations of the SmartStart program can provide important data on the accuracy of key assumptions used in the Protocols.
Regional or New Jersey specific metering studies	Other metering studies may provide improved values for operating hours and equivalent full load hours, across different business types.
Other industry studies	The results and findings of other industry studies may also inform revisions to New Jersey operating hours and savings calculations.

7. SmartStart Program Impact Evaluation (Retrospective Assessment)

This section presents a summary of KEMA's retrospective review the SmartStart Program's reported energy savings for program year 2006.[37] KEMA's review of the *Protocols to Measure Resource Savings* for measures supported by SmartStart was provided in a separate document[38] and summarized in Section 6.

7.1 Overview of Approach

KEMA used the statistical procedure of ratio estimation to develop estimates of evaluation verified gross and net impacts. There are two basic steps to the process.

- **Verify energy savings in a sample of participating customers.** For a sample of 63 customers that installed energy efficient equipment during the 2006 program year, KEMA estimated actual energy savings under current conditions. A telephone interview was delivered to another sample of 299 customers to collect information on measure installation and program attribution.

- **Expand sample results to the population of customers.** The sample results obtained in Step 1 were expanded to the population by calculating the ratios of verified-to-tracked savings (gross savings adjustment factor) and attributable-to-verified savings (attribution factor) for the sample.

The adjustment factors estimated from the data collection and analysis tasks include:

- **Gross savings adjustment factor:** This factor adjusts tracked gross savings for installation rate and changes based on the engineering review. Applying the gross savings adjustment factor to tracked gross savings produces the estimate of verified gross savings.

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[37] *New Jersey's Clean Energy Program Energy Impact Evaluation,* Prepared by KEMA for New Jersey Board of Public Utilities, *SmartStart Program Impact Evaluation,* September 17, 2009.
[38] *New Jersey's Clean Energy Program Energy Impact Evaluation SmartStart Program Protocol Review.* Prepared by KEMA for New Jersey Board of Public Utilities, Office of Clean Energy. July 10, 2009.

- **Attribution factor:** This factor adjusts verified gross savings for program attribution. That is, the fraction of verified gross savings that occurred because of the Program.
- **Realization rate:** This factor combines the gross savings adjustment factor and the attribution factor. It is the ratio of net savings to tracked gross savings, or the fraction of tracked gross savings that occurred because of the Program.

The gross savings adjustment factor is computed as the product of the installation rate[39] and the engineering adjustment factor. The engineering adjustment factor was determined through a review of the program's tracked gross savings estimate for a sample of measures installed in 2006. Measures were reviewed to verify that the program's gross savings estimates were a reasonable estimation of the energy savings that could be achieved with that measure. For custom measures, every aspect of the project and calculation was reviewed. For prescriptive measures, only the proper application of the prescriptive algorithm(s) and input values was reviewed. One on-site visit was conducted for a large custom project to verify installation and reported energy savings.

A telephone survey was delivered to a sample of participants to collect information for estimation of program attribution. Respondents verified whether or not the project was installed and answered questions about the influence of the program on the quantity, efficiency, and timing of the project installed. The attribution factor can range between zero and one. Zero indicates the Program had no effect on the quantity, efficiency, or timing of the project installed; one indicates the project would not have been installed without the assistance of the Program.

7.2 Impact Evaluation Results Summary

This section presents KEMA's retrospective assessment of energy savings reported by the SmartStart Program. Adjustment factors are provided for each energy unit (kW, kWh, and therms) and sector (Retrofit, New Construction, and Schools)[40].

[39] Installation rate is based on the results of telephone survey.

[40] Due to small sample sizes the sub-population estimates should be viewed with caution. Measures of statistical precision (e.g.: sample size, relative error, and 90% confidence interval) are provided in the report.

7.2.1 Adjustment Factors

Overall, the Program achieved realization rates of 49 percent, 39 percent, and 13 percent for kWh, kW, and therms respectively. Based on the data provided for our evaluation, the total net savings achieved during the 2006 program year were 24,059,607 kWh; 4,531 kW; and 178,986 therms[41].

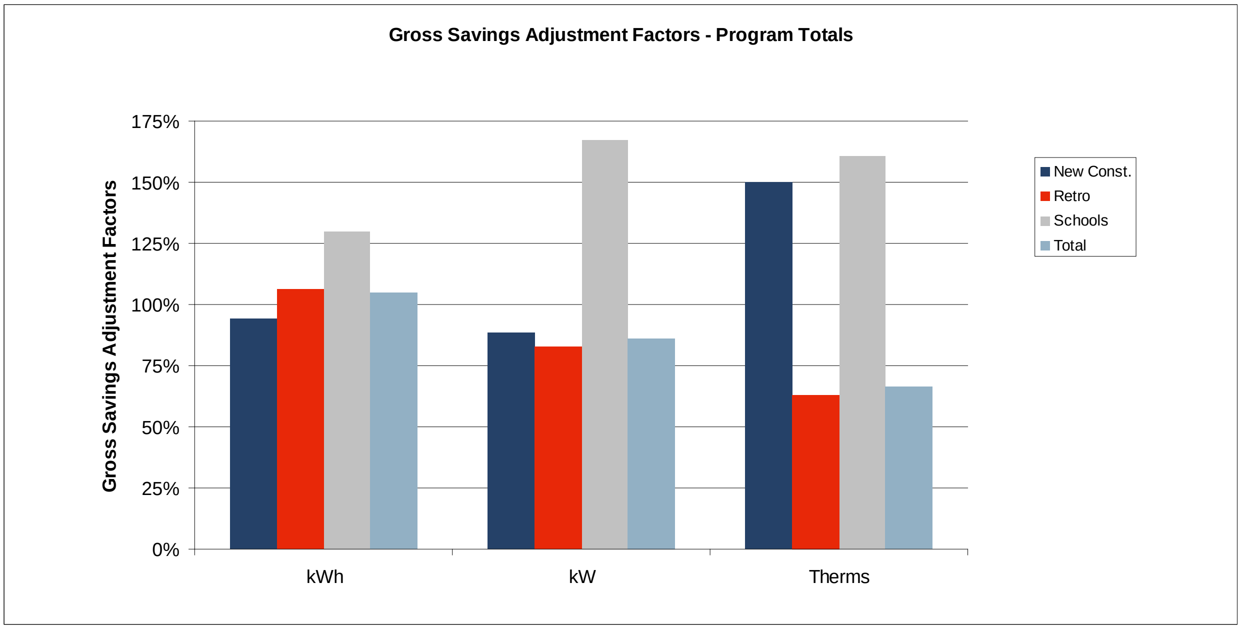
Figure 7-1 shows the gross savings adjustment factors for the SmartStart Program by sector and overall (Total). Overall gross savings adjustment factors were 105 percent, 86 percent, and 66 percent for kWh, kW, and therms, respectively. These are good results for kWh and kW. The difference between the two electric energy savings values is due to a consistent misapplication of the prescriptive savings formulas for kW savings in prescriptive lighting and unitary HVAC measures. For these measures, coincidence factor was omitted. The kWh formulas for these measures were applied correctly.

The lower therms value was due to the Program's overestimation of therm savings for one large project[42]. This project accounted for 75 percent of program reported natural gas savings in 2006. Large projects can have a significant effect on the results because of the large fraction of energy savings they represent.

[41] These energy savings totals are based on the program tracking data KEMA was provided by each of the seven electric and natural gas utilities.

[42] This project's engineering reviewing incorporated an on-site visit. The review also resulted in additional untracked savings of 40,284 kWh.

Figure 7-1: Gross Savings Adjustment Factors by Sector



The high gross savings adjustment factors for Schools are a result of underestimated savings for two large schools projects. The dramatically high results for Schools is included in the overall results, however the impact of a project on the adjustment factors for the overall program (total bars in the charts) is determined by the size of the project relative to all projects in the population. This is why the overall results tend to mirror the Retrofit sector that accounts for the vast majority of SmartStart tracking gross energy savings.

Figure 7-2 shows attribution adjustment factors for the SmartStart Program by sector and overall. Overall attribution rates were 47 percent, 45 percent, and 19 percent for kWh, kW, and therms. Some level of free ridership should be expected for most programs; however the overall attribution results for SmartStart are low relative to other large scale nonresidential programs. It is important to note that this is the first time net energy savings have been addressed by NJCEP. These estimates would be expected to improve with program designs with the clear objective of minimizing free ridership.

Attribution results for the Schools and New Construction sectors are not very informative due to the small sample sizes which were in turn due to the small percentage of program-reported savings represented by these sectors. This is also true for therms projects, which represent a small fraction of the total number of projects. The sample was exhausted in our efforts to achieve the target number of completes and only a small number of Schools and New Construction participants agreed to participant in the study.

The therms adjustment factor for Schools is zero. This result is based on only three projects. The Schools sector had low program participation relative to the other sectors and therefore received a small allocation of sample. That is, Schools accounted for a very small fraction of program savings relative to Retrofit and New Construction so KEMA reviewed a small number of Schools projects compared to the other sectors.

Figure 7-2: Attribution Factors by Sector

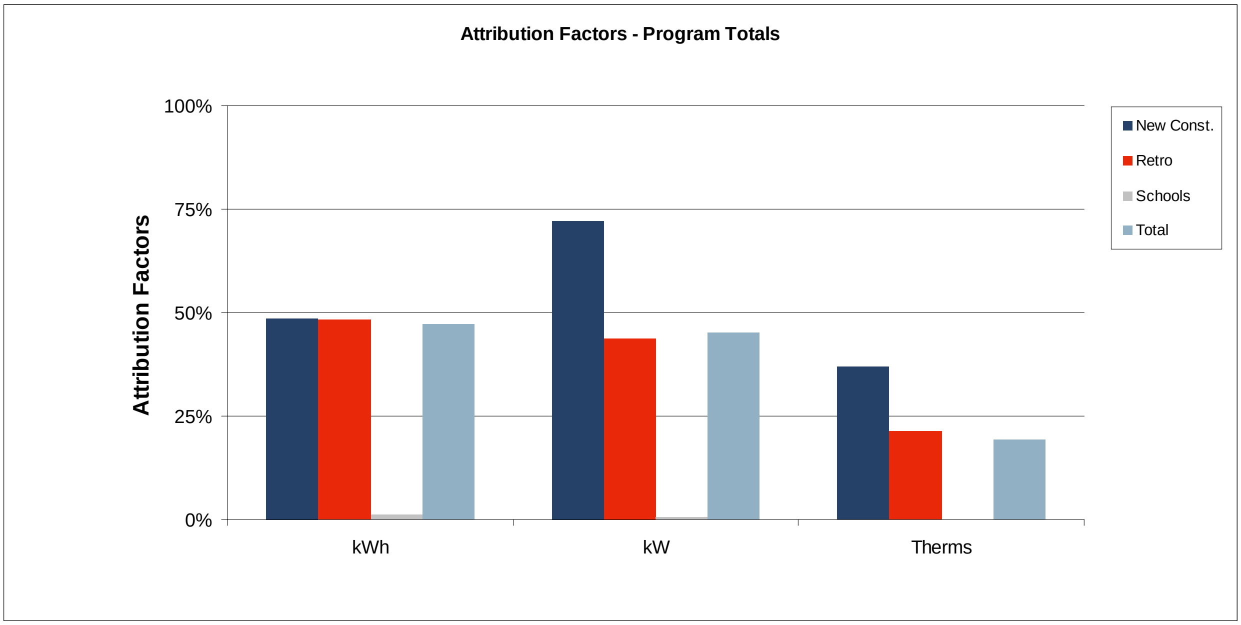
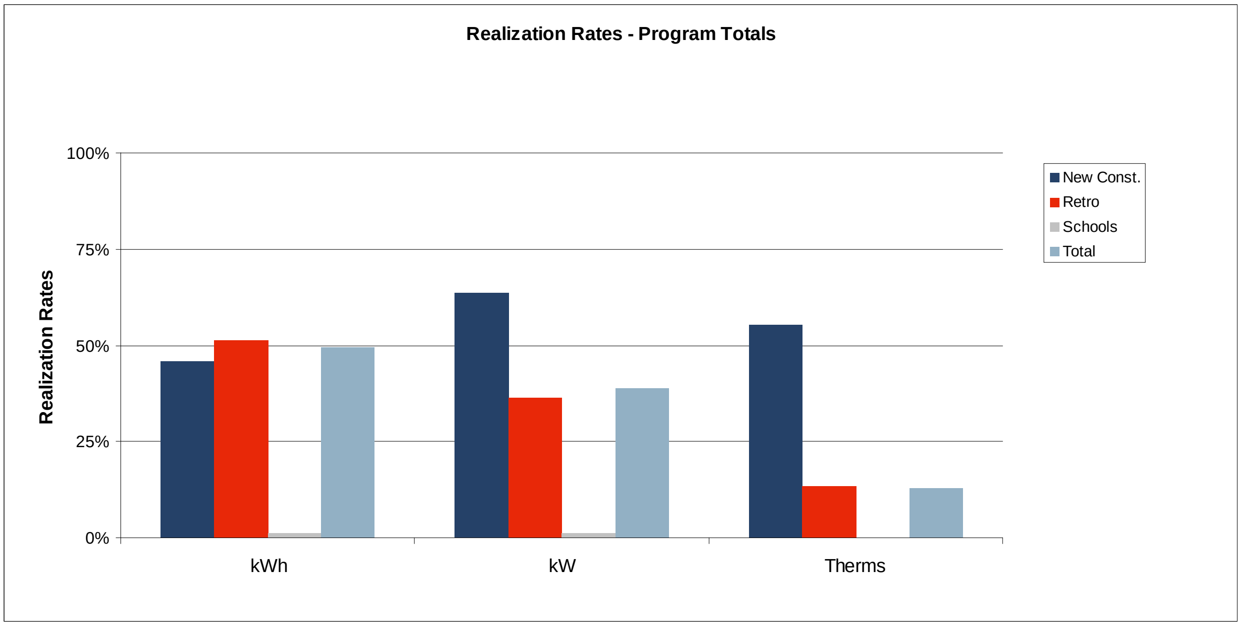


Figure 7-3 shows Realization Rates for the SmartStart Program. The Realization Rate is the combined effect of the gross savings adjustment factor and the attribution factor.

Figure 7-3: Realization Rates by Sector



7.2.2 Sampling

The sample frame was created by compiling the individual program tracking databases provided to KEMA by the seven participating electric and natural gas utilities. The samples were designed to produce the best possible statewide estimates of gross and net energy savings for kWh, kW and therms for the program overall. The sample was stratified by:

- Energy unit (kWh, kW and therms),
- Sector (New Construction, Retrofit, Schools),
- Measure type (prescriptive and custom projects), and
- Measure size (incentive amount).

Figure 7-4 shows the distribution of total program reported activity by the number of projects, total incentive dollars, and kWh savings. The figure represents the distribution of projects for only the data that was available and is separated by sector. This figure shows that in terms of number of projects, total incentives dollars, and kWh savings the 2006 program was dominated by Retrofit measures.

Figure 7-4: Sample Frame by Sector

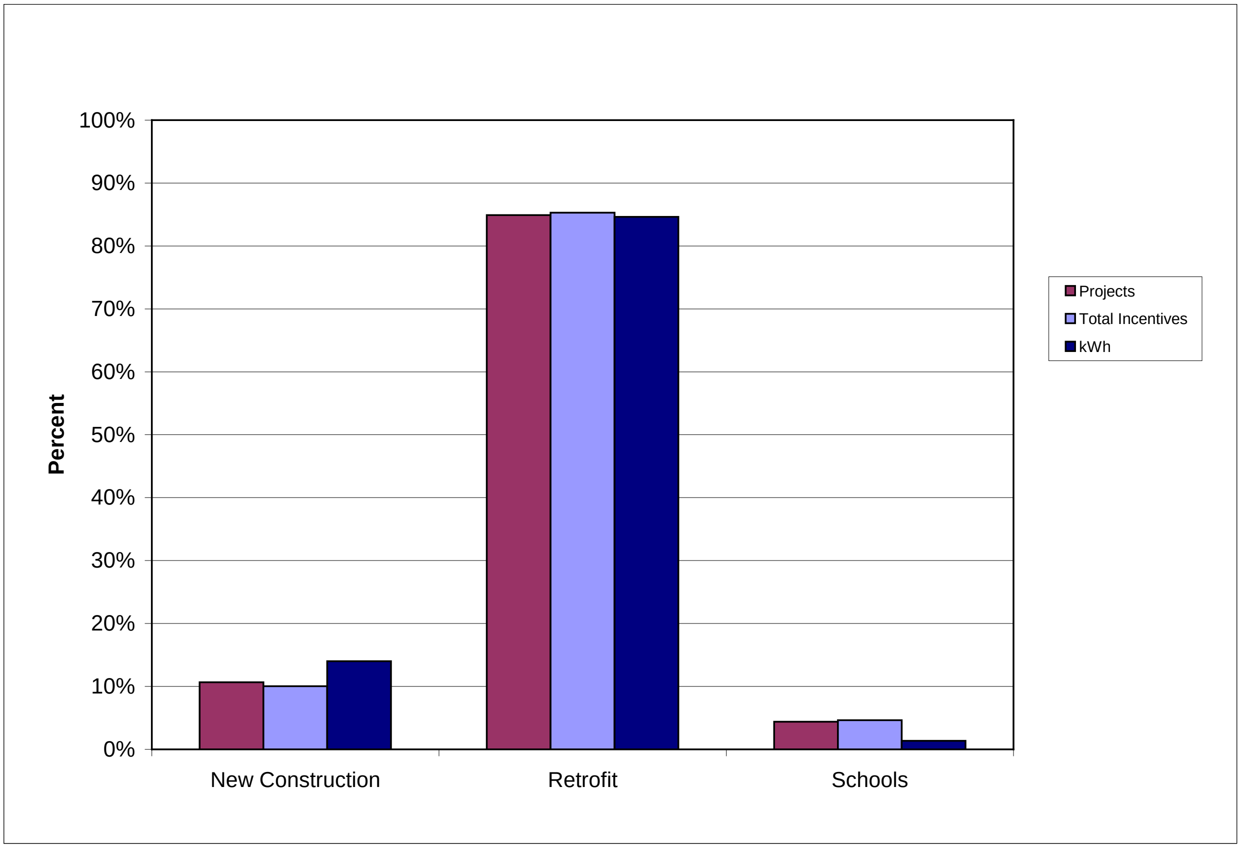


Figure 7-5 shows the distribution of total program reported activity by the number of projects, total incentive dollars, and kWh savings. The figure represents the distribution of projects for only the data that was available and is separated by measure type. This figure shows that in terms of number of projects, total incentives dollars, and kWh savings the 2006 program was dominated by Prescriptive measures.

Figure 7-5: Sample Frame by Measure Type

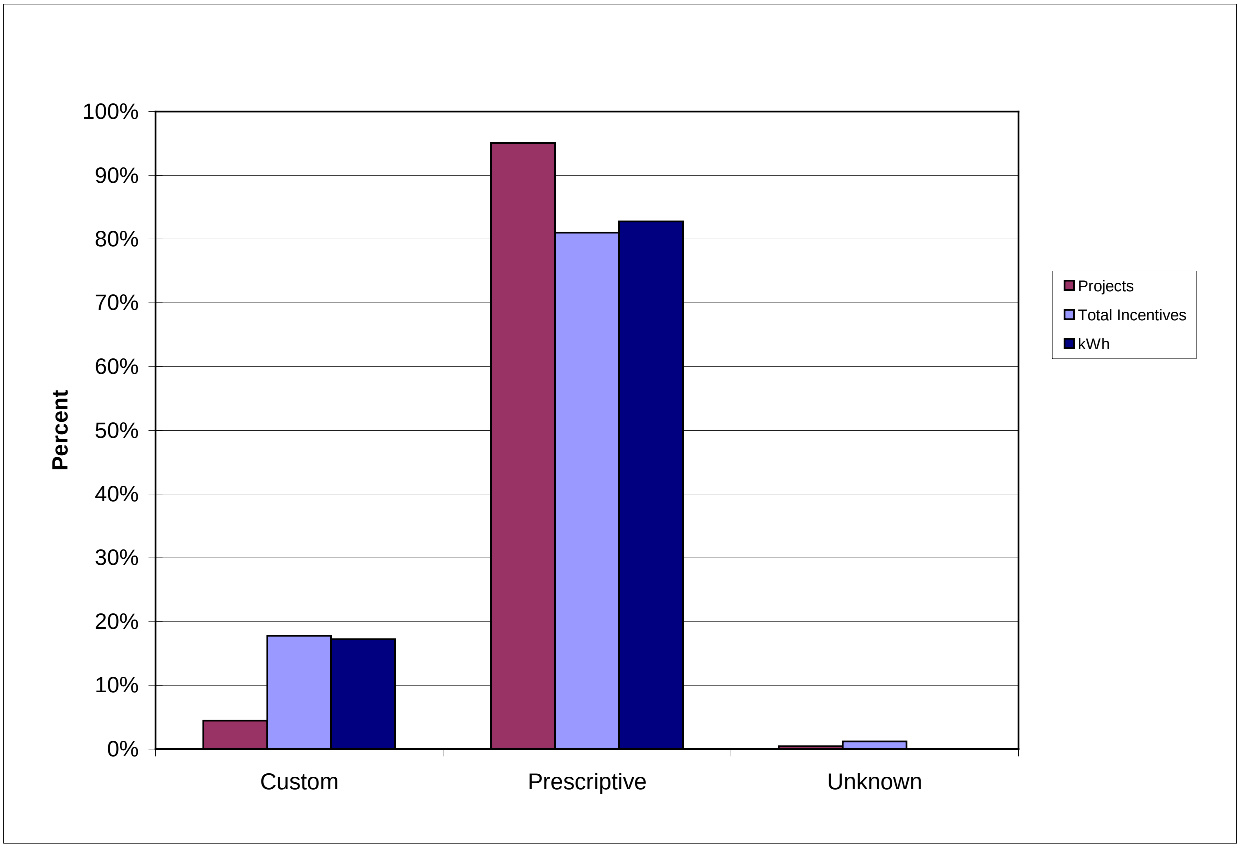


Table 7-1 and Table 7-2 show the fractions of sample frame energy savings included in the engineering review sample and the CATI sample (installation and attribution). Twelve percent and 26 percent of kWh energy savings reported by the Program are included in the engineering and CATI samples, respectively. Consistent with the distribution of sample frame measures, Retrofit and Prescriptive projects comprise the majority of the samples. Natural gas measures account for a small percentage of the sample because the 2006 program was dominated by electric measures. Only 121 measures of a total of 1,565 measures installed in 2006 had natural gas energy savings.

Table 7-1: Fraction of Sample Frame Energy Savings in the Engineering Sample

	kWh				kW				Therms			
		Reported Energy Savings				Reported Energy Savings				Reported Energy Savings		
Sector	n	Sample	Sample Frame	% of Sample Frame	n	Sample	Sample Frame	% of Sample Frame	n	Sample	Sample Frame	% of Sample Frame
Retrofit	38	3,776,163	41,189,535	9%	38	788	10,160	8%	4	1,273,634	1,335,803	95%
NC	9	2,091,869	6,828,544	31%	8	186	1,228	15%	2	705	37,839	2%
Schools	4	37,110	656,219	6%	4	29	253	11%	2	6,877	23,428	29%
Total	51	5,905,142	48,674,298	12%	50	1,002	11,641	9%	8	1,281,216	1,397,070	92%

Table 7-2: Fraction of Sample Frame Energy Savings in the CATI Sample

	kWh				kW				Therms			
		Reported Energy Savings				Reported Energy Savings				Reported Energy Savings		
Sector	n	Sample	Sample Frame	% of Sample Frame	n	Sample	Sample Frame	% of Sample Frame	n	Sample	Sample Frame	% of Sample Frame
Retrofit	185	10,498,503	41,189,535	25%	179	3,039	10,160	30%	20	260,168	1,342,261	19%
NC	21	2,092,795	6,828,544	31%	18	375	1,228	31%	4	6,748	37,839	18%
Schools	8	101,858	656,219	16%	9	46	253	18%	3	6,767	23,428	29%
Total	214	12,693,156	48,674,298	26%	206	3,461	11,641	30%	27	273,683	1,403,528	19%

The size of a project, in terms of energy savings, determines the influence the project will have on the estimates of gross and net energy savings. Therefore KEMA sampled large projects with certainty. That is, per the sample design, we attempted to include all participants that installed largest projects (incentive greater than $100,000). Furthermore, the sample design included a census on 21 of the 31 sampling stratum.[43] KEMA ended up performing a census on the 10 non-census strata in its effort to achieve the target number of completes. One limiting factor to the precision of estimates with finite populations is the inability of researchers to force respondents to participate in the research study. If program participants that installed large projects refuse or are unable to participate in the study, the precision of the estimates decreases because a large fraction of energy savings is not included in the sample.

7.2.3 Engineering Review

As mentioned above, a detailed engineering review of reported energy savings was performed for measures in the engineering sample. Table 7-3 shows the number of measures for which the verified gross installed (VGI) savings were different from the program-reported savings, and the degree of this difference. The VGI savings were greater than the program-reported savings for the majority of kWh and therm reviews. For kW, however, the opposite is true.

VGI savings was less than reported savings for 26 of 34 kW measures reviewed. Sixteen of the 26 were adjusted between 20 and 30 percent. The large number of adjustments is due to a consistent calculation error for prescriptive lighting and unitary HVAC projects. The program's calculation tool failed to apply Coincidence Factor (CF) for all prescriptive lighting and unitary HVAC measures.

For kWh and therms savings, adjustments were made for a number of different reasons including correcting faulty calculation methods, creating new calculation methods when existing

[43] Refer to Section 4.2 for more detailed sample information.

calculations were not available, correcting size and efficiency values based on manufacturer documentation, and other reasons.

Table 7-3: Numbers of Measures Adjusted

Percent Change (by number of measures)	kWh			kW			Therms		
	V>R	V<R	Total	V>R	V<R	Total	V>R	V<R	Total
10% to 20%	2	0	2	0	5	5	0	0	0
20% to 30%	2	2	4	0	16	16	0	0	0
30% to 50%	0	1	1	0	4	4	0	0	0
50% to 100%	7	0	7	1	1	2	2	1	3
100% or Greater	0	0	0	2	0	2	1	0	1
Verified shows savings (+ or -) where reported = 0	4	1	5	5	0	5	0	0	0
Total Measures Adjusted	15	4	19	8	26	34	3	1	4
Notes: V = Verified; R=Reported									

Roughly half of all measures reviewed were adjusted, with kW adjustments being the most common. Most adjustments, both positive and negative, were due to calculation errors and misapplication of prescriptive savings formulas. Program documentation was lacking for some custom projects. In these cases, evaluation was forced to start from scratch with a new calculation method and was unable to meaningfully review the specific calculations used by the program.

7.3 Recommendations

This section contains KEMA's recommendations to the Program based on the results of the impact evaluation. These recommendations are based on a retrospective assessment of program year 2006 accomplishments. KEMA understands that since 2006 the management of the SmartStart Program has been transferred from the utilities to the third-party Market Managers. Evaluation of the current programs was beyond the scope of this evaluation; however lessons learned from the program year 2006 impact evaluation may be useful to increase program effectiveness and energy savings impacts going-forward.

Recommendation #1

KEMA recommends that the Program consider using attribution factors based on evaluation research to determine net energy impacts rather than the existing assumption that attribution is 100 percent. In light of the transition of the Program from the seven electric and natural gas utilities to the statewide Market Managers in April 2007, we do not recommend the exclusive use of the adjustment factors developed for this retrospective look at program year 2006 accomplishments. For the purposes of program planning it would be appropriate for the Program to develop estimates of attribution based on:

1. this report's retrospective look at program year 2006 accomplishments,
2. current Program procedures, and
3. comparisons with attribution results for similar comprehensive statewide business programs.

Recommendation #2

KEMA recommends NJCEP conduct an impact evaluation covering the first three years (April 2007 through December 2009) of program performance under the Market Manager model. The results of this future evaluation should be used to assess the net achievements of the current program and be used for program planning to mitigate the effects of free ridership. An impact evaluation covering the first three years of program performance would also provide OCE and the Program with baseline data to measure improvements in gross and net energy impacts.

Recommendation #3

If OCE decides to include program attribution in its assessment of net energy impacts of the Program, KEMA recommends the Program consider incorporating strategies into the program design to mitigate the effects of free ridership. Potential strategies the Program could consider include:

1. Increase promotion of the next generation of high efficiency equipment;
2. Decrease promotion of market accepted high efficiency equipment;
3. Limit repeat program participation (by the same customer) for the same technology; and
4. Pre-screen customers for potential free ridership.

KEMA acknowledges that some of these strategies are likely part of the Market Manager's current program design.

Recommendation #4

Consistent and complete program tracking data is a fundamental requirement for a statewide energy efficiency program such as SmartStart. Program tracking data can be used for program operations, program planning, and reporting and verification of accomplishments. KEMA understands that OCE has implemented a statewide tracking database and process for archiving hard-copy project documentation subsequent to the time period covered by this evaluation (program year 2006).

KEMA recommends the Program consider implementing electronic database and hard-copy (custom projects) quality assurance procedures to ensure the newly created database is being used to its full potential. Simple data entry errors can have significant effects on the claimed energy savings, particularly for large projects. For example, one missing zero at the end of an energy savings database entry could be the difference between 1,000,000 kWh and 100,000 kWh of energy savings attributable to the Program.

Recommendation #5

KEMA recommends the Program consider reviewing the prescriptive savings calculation spreadsheets to ensure the Protocol calculation methods are being used correctly. These calculations could also be incorporated into the statewide tracking database to further reduce the potential for errors.

8. Combined Heat and Power Program

This section presents a summary of KEMA's impact evaluation of the Combined Heat and Power Program.[44]

8.1 Program Overview

New Jersey's Clean Energy Program (NJCEP) provides financial incentives for the purchase and installation of Combined Heat & Power (CHP) systems. The Combined Heat and Power Program (CHP Program) began in 2004 and it continues to serve the same purpose today. According to the New Jersey's Clean Energy Program filing submitted on December 7, 2007, the objectives of the program include:

- Reducing the overall system peak demand,
- Encouraging the use of emerging technologies,
- Using energy more efficiently and reduce emissions, and
- Using distributed generation to provide reliability solutions for New Jersey.

CHP systems pair on-site power generation with heat recovery. This combination improves the overall efficiency of the energy system when meeting a facility's electrical and thermal demands. In addition to the benefits listed above, this overall efficiency gain can provide societal benefits such as emission reductions as well as energy savings and cost savings for the end user. The State of New Jersey included CHP in the Clean Energy Program and offered financial incentives to encourage the adoption of CHP technologies. This report summarizes KEMA's energy impact evaluation of the CHP projects that were installed with assistance from the CHP Program and, using available data, evaluates the effectiveness of the NJCEP CHP Program.

8.2 Approach

KEMA used a well-defined methodology to examine each of the installed CHP systems and then the program itself. The evaluation process couples our proprietary CHP feasibility model, a

[44] *Combined Heat & Power (CHP) Program Impact Evaluation,* Prepared by KEMA for New Jersey Board of Public Utilities, *Final Report,* June 10, 2009.

survey of the end users regarding the CHP Program process, and then site visits of selected facilities. Though the census of installed projects was small, conclusions and recommendations were drawn from the results of all the data collected. However, as the census size was only four projects, results may not be indicative of future CHP Program installations.

Utility billing data was provided by the utilities for some of these participants. Actual recorded performance information was not provided by the end users. However, the CHP model allowed KEMA to make estimates about system operation, using available utility data and expert knowledge. KEMA also compared model estimates to program applications. The comparison helped KEMA form the survey questionnaire and target areas for the survey. Utilizing the tools possessed by KEMA and data provided by the CHP Program, the utilities, and the participants our evaluation process was conducted in the following manner:

a. Obtained information on each of the four installed projects from the NJCEP grant applications and utility provided usage data

b. Inputted the data into the KEMA feasibility model to estimate project impacts

c. Conducted a phone survey to confirm installation, discuss equipment operation, investigate the project process, and assess overall satisfaction with the program and CHP installations

d. Conducted selected site visits to confirm information in the grant applications

e. Finalized the estimated models to perform calculations on estimated generation and energy and emissions savings

f. Compiled the information from the collected data to provide feedback and recommendations on the NJCEP CHP Program

8.3 Summary of Findings

8.3.1 CHP Installations

According to New Jersey's Clean Energy Program Report, submitted March 28, 2006, applications for ten CHP projects were approved in 2005. During the evaluation period, four projects were completed and running. To protect participant confidentiality, these projects are referenced according to case studies as Cases 1 through 4. A general description of the cases is provided below:

- Case 1: Nursing home facility
- Case 2: Large industrial company
- Case 3: Commercial food processor
- Case 4: Recreational/athletic center

KEMA compiled CHP system characteristics for each project through a review of project application data, provided utility billing data, telephone interviews with all four program participants and two site visits to review the system in operation. KEMA found that two of the installations differed from those specified in the applications. In both cases, the actual installed system was of greater total capacity. In one case a cleaner (lower emissions) system was installed. According to the applications the plan for Case 1 was to install two 60 kW UTC/Capstone microturbines but two 70 kW Ingersoll-Rand microturbines were actually installed. The plan for Case 3 was to install a 260 kW BluePoint Energy gas engine but five 60 kW Capstone Microturbines were actually installed. The ratio of total installed kW capacity to total planned kW capacity is 106 percent. That is, in total, the CHP Program installed more capacity than planned (documented in the project applications). Details regarding the actual type of equipment that was utilized in each of the cases are listed in Table 8-1.

Table 8-1: CHP System Characteristics

	Case 1: Nursing Home Facility	Case 2: Large Industrial Company	Case 3: Commercial Food Processor	Case 4: Recreational/Athletic Center
Equipment Type	Microturbine	Backpressure Steam Turbine	Microturbine	Reciprocating Gas Engine
Equipment #	2	1	5	2
Per Unit Capacity	70kW	509kW	60kW	75kW
Equipment Cost	$357,000	$654,701	$750,000	$515,500
Incentive Amount	$107,000	$196,410	$225,000	$150,000
Displaced Thermal Loads	- Heating - Service HW	NA	- Chiller - Service HW - Process HW	- Service HW - Pool
Operation	Roughly full-time	Roughly full-time	Roughly full-time	Engine 1: 100% all yr; Engine 2: 100% for ½ yr

Notes: "NA" = Not applicable, "Roughly full-time" means operators were not baseloading operation in the past, and "HW" = hot water applications

8.3.2 Generation, Energy and Emissions Savings

Table 8-2 lists KEMA's estimate of energy and emissions savings from the four projects. It also lists estimates of CHP electricity production (kWh), installed capacity (kW) and peak output (kW), which are reported as distributed generation rather than savings. The savings and distributed generation estimates represent average yearly estimates. In each of the cases, KEMA assumed that the generation devices were running as a baseload device. The differences in generation over each time period represents different power output for the generators (particularly in the case of microturbines), and the fact that the peak period is defined as Monday-Friday from 8:00AM to 8:00PM. For the microturbine, the peak output is slightly less during the summer months because of the device's degradation that occurs with hotter temperatures.

KEMA estimates total annual CHP electricity generation is 86 percent of planned. Planned generation was not provided in the project application documentation for all cases. Therefore, where data were not available, KEMA calculated the percent of total CHP electricity generation as the ratio of *estimated* planned generation to total generation from the model. KEMA estimated planned generation using information provided in the project application files and two scenarios. The first scenario assumes similar load profiles to modeled profiles and the second scenario assumes systems were baseloaded with 85 percent availability. Estimated planned savings used to calculate the difference between actual and planned is the average of the two scenarios. KEMA also estimates that there are no electricity savings. In particular, no facilities displaced electric cooling with cooling that uses recaptured heat from the CHP systems.[45]

Table 8-2: Summary of Estimated Generation, Energy & Emission Savings

	Case 1: Nursing Home Facility	Case 2: Large Industrial Company	Case 3: Commercial Food Processor	Case 4: Recreational/ Athletic Center
Equipment Type	Microturbine	Backpressure Steam Turbine	Microturbine	Gas IC Engine
CHP Installed Capacity (kW)	140	509	300	150
Total CHP Production (kWh)	888,615	1,460,927	1,151,800	930,635
CHP Thermal Offset (MMBtu)	5,850	0	9,915	7,600
CHP Production by Period				
Peak Summer (kWh)	165,668	73,302	276,458	196,862
Peak Winter (kWh)	235,307	114,652	398,679	221,253
Off-Peak Summer (kWh)	223,141	496,459	198,621	277,987
Off-Peak Winter (kWh)	264,500	776,513	278,043	234,533
CHP Peak Output (kW)	125	509	278	150
Emissions Reductions (lbs)				
Carbon Dioxide	858,288	2,220,608	1,128,654	956,342
Sulfur Dioxide	5,776	9,496	7,487	6,049
Nitric Oxide	2,446	4,091	3,172	2,567

[45] According to the *Protocols to Measure Resource Savings*, electricity savings should only be reported where recaptured thermal energy from a CHP system is used to drive an absorption chiller that displaces electricity previously consumed for cooling.

8.3.3 Protocols

The *Protocols to Measure Resource Savings* (Protocols) were developed to accurately and consistently determine energy and resource savings for measures supported by the NJCEP. The document is periodically updated as new programs are added, existing programs are modified, and new information becomes available. The Protocols were most recently updated in December 2007.

According to the Protocols the measurement of energy and demand savings for CHP systems is based on the characteristics of the individual CHP systems. The majority of the inputs used in the savings estimates are based on information provided on the project applications. The variety in the types of CHP projects installed makes it appropriate to base calculations on individual installations. **However, KEMA recommends that calculations use information from the post-installation design and operation of the CHP systems rather than application data.**

The CHP Program did not conduct post-installation reviews for the projects KEMA reviewed. Beginning in 2008, the CHP Program will perform post-installation inspections on 100 percent of installed projects and has the authority to request additional project information and documentation to ensure the installed system meets the requirements as detailed in the project application. In addition, a new requirement of the program included in the 2008 Program & Budget Filing[46] is that applicants must provide twelve months of operational data. KEMA supports these program improvements.

The Protocols for CHP systems also provide formulas for estimating emissions reductions. The emission savings are generated from the overall gain in efficiency of the unit. For example, the efficiency of a CHP system (typically above 70%) is used as the main factor in determining the emission savings. The approach is satisfactory for calculating emissions.

Alternative approaches are seen in the EPA Emission calculator. This approach starts with the fuel input (in MMbtus) and calculates the emissions from the CHP system, the displaced emissions from the thermal that is being generated, and measures that total against the

[46] New Jersey's Clean Energy Program 2008 Program Description and Budget, Commercial & Industrial Energy Efficiency Program managed by TRC as C&I Program Manager, December 7, 2007.

displaced grid emissions. By examining the emission savings based on the fuel input may provide the opportunity to take into account individual variances of facilities.

8.3.4 Persistence of Energy Savings

The installed systems are very likely to continue to accrue savings. Based on the participant interviews and site visits there is no indication that participants are having technical problems with the CHP systems or plan to remove or shut them down. More specifically, three of the four participants responded that they were happy with the performance of their CHP systems. Additional comments from the one participant dissatisfied with the CHP system indicate that the facility will likely keep the system operating. For this case, the participant noted that the dissatisfaction was not due to the use of CHP systems as much as initial equipment issues, and that the system is currently operating. Furthermore, the four CHP systems were installed in what are typically very favorable facility types. Generally, the electricity load profiles compliment the thermal usages.

CHP systems typically last approximately ten years in length. Hence, it is expected that the savings should persist throughout this time. For microturbines, high-level maintenance typically occurs after about 40,000 hours, or five years of operation. For reciprocating engineers, high-level maintenance typically occurs after about 20,000 hours, or two-and-a-half years of operation.

Economics can heavily influence the decision to maintain operation of a CHP system. In particular, where fuel input costs add to operation and maintenance costs, the spark spread (the difference between gas and electricity rates) can influence whether the economics are favorable for a CHP system. Because the backpressure steam turbine installation (Case 2) requires no additional fuel input costs, the economics are quite favorable. The savings generated by the steam turbine are likely to persist throughout the life of the project. Other installations may be impacted by the spark spread over time.

KEMA learned from the interviews that some of the facilities did not seem to be focusing on economics and were not tracking their overall savings via benchmarking. This indicates that there may have been other motivations for installing the system other than project economics. For example, the economics may have been exclusive of some additional benefits that could be gained from an installation of a CHP system, such as back-up power or energy security. KEMA still expects these projects to accrue savings for the full lifetimes of the systems.

8.3.5 Free Ridership

KEMA used the interviews with participants to explore what affect the program had on the participants' decision to install the CHP system at the time it was installed. Participants who would have installed the same equipment at the same point in time in the absence of the program are considered to be free riders. The CHP Program should consider whether it is in the best interest of the program and the State of New Jersey to offer assistance and financial incentives for projects that would have been installed without assistance or financial incentives.

KEMA cannot establish free ridership trends based on only four cases. These four cases may not be indicative of future installations or participants. However, the four cases can provide insight for future program efforts. KEMA classified each of the four cases, noting where participants were more or less likely to be free riders. Based on the preponderance of evidence, KEMA determined that two of the cases were likely not free riders. The program should be credited full net saving credit for these projects. One survey respondent was "very likely" to install the project without the program's assistance, indicating full free ridership and the program should receive zero net savings for this CHP installation. Another respondent was "somewhat likely", indicating a high probability of partial free ridership. The program should receive a fraction (25-50 percent) of the savings for this CHP installation. KEMA estimates that the free ridership rate for the four installed systems is 46 to 52 percent of the total energy savings. That is, 46 to 52 percent of the total energy savings would have occurred in the absence of the program.

KEMA is bound by evaluation research ethics to protect respondent confidentiality. The small number of participants in the CHP Program makes it difficult for KEMA to balance respondent confidentiality with the need to provide the program with actionable research. Overall, responses to the surveys indicate that free ridership is associated with this program. It is noted that in each case, the grant shortens the simple payback by approximately three years. This research supports that theory that CHP system free ridership is positively correlated with the size of the customer. Explanations for the higher free ridership rates in large customers relative to small customers include:

- In general, the economics of larger customers tend to be greater. The reason for this is that larger facilities tend to be 24 hours – 7 day operations, running three shifts with a solid baseload of electrical and thermal usage. Hence, every kWh or btu generated by the CHP is captured for savings, thermal usage is high, and the system provides both energy savings and a hedge against gas prices. In addition, larger facilities tend to have their own maintenance and engineering staff and are able to handle and maintain the CHP system on their own without the need of employing outside assistance.

- For smaller facilities, the same two factors can run against the operator. Typically, smaller facilities do not run 24 hours or 7 days a week. An office building is an excellent example of this case where at most, the building operates six days a week and its thermal load and electrical load drop dramatically between the hours of midnight to 5 AM. Similar load profiles are seen for small industrial facilities. In addition, smaller facilities sometimes do not maintain the staff that can operate the system and tend to rely on the project developer to maintain the system. This causes increased cost to the project and in some cases an increased "hassle factor" to consider when adopting and implementing CHP.

8.3.6 Program Operation and Procedures

In addition to considering program impacts, KEMA examined program operation. KEMA noted the following key points from the evaluation:

- Program projects are meeting the goals set by the CHP Program on encouraging the use of emerging energy technologies and achieving energy and emissions savings from the adoption of CHP systems.
- Satisfaction with the CHP Program and installations are generally high. However, some applicants noted potential for improved turn-around times on application approval and rebate issuance.
- Improvements can be made in follow-up of the projects as equipment changes or project changes appeared to have been made after the applications were approved.
- In general, participants could use additional help with education and outreach to help them better assess the paybacks of their projects, acquire information from independent sources, and optimize the operation of the units.

8.4 Recommendations

This section provides KEMA's recommendation for improving the accuracy of project impact estimates and supplemental recommendations based on the participant interviews.

Recommendation 1: Assistance with Project Feasibility

The program should consider providing participants with project feasibility studies, including a brief assessment of project financials. KEMA's analysis showed project paybacks on the applications that were longer than indicated in the grant applications, and participants relying solely on contractors for economic insights. If projects do not perform as initially projected and reported on the application, it may lead to dissatisfaction with the CHP system and the program.

Recommendation 2: Follow-Up with Applicants

KEMA recommends that the program conduct post-installation inspections with all CHP installations. While none of the installations surveyed for this evaluation received on-site inspections, KEMA recognizes that inspections are now part of the program going forward. KEMA recommends that the inspections occur as soon after installation as possible, be a part of the participation agreement and actively integrate information and guidance for facility managers.

KEMA recommends the Protocols be updated to require that the measurement of generation and energy savings of CHP systems be based on data and information from the post-installation inspections rather than data from the project applications.

Recommendation 3: Access to Operation Information

KEMA encountered some difficulty in accessing information about CHP system characteristics and performance. KEMA believes that the program should require participants, as part of the participation agreement, to provide the program with key information about the system design and operation after installation. KEMA is aware that new program procedures require that participants:

1. submit pre-installation applications;
2. allow the facility manager to monitor the facility's energy use;
3. provide the program with twelve months of operational data; and
4. fully document any changes between proposed and installed systems.

KEMA believes that these provisions will benefit both the program and the participants. KEMA also encourages the program to ensure that the information it collects as part of the post-installation follow-up include not only changes in system characteristics but also notable changes to system operation and to operation and maintenance costs.

Recommendation 4: Better Outreach on CHP Information Center

The Program should consider an education and training component of the program. While all participants noted doing background research on CHP Systems, the majority reported not having received information from the Program. The majority noted that contractors had a large influence on their model selection. Furthermore, while information sources were not discussed in depth during the surveys, the sources cited by many of the participants appear to be limited in scope in that they do not provide detailed information on system selection, installation and operation. KEMA recommends the Program facilitate further, in-depth learning about CHP by providing references to links where participants can find detailed information and guidance on system selection, installation and operation. There are many tools for these purposes accessible through a number of organizations and websites. For example, the Environmental Protection Agency's (EPA) CHP Partnership website, www.epa.gov/chp, contains a number of CHP resources including tools related to qualification, feasibility analysis, procurement, and operations and maintenance.

Recommendation 5: Shorter Approval Turn-Around

The Program should investigate ways to minimize the wait-time for project approvals, whether by amending existing procedures or implementing a rolling admissions process, as recommended by one participant.

Recommendation 6: Shorter Rebate Turn-Around

The Program should be sure to monitor this process to ensure that such delays do not grow to a perceived barrier to program participation by applicants. Two of the applicants cited this as an issue in their project implementation and installation.

9. Customer On-Site Renewable Energy Program

This section presents a summary of KEMA's impact evaluation of the Customer On-Site Renewable Energy Program's photovoltaic component.[47]

9.1 Program Overview

New Jersey's Clean Energy Program (NJCEP) offers support to help implement renewable energy generation technologies and systems. Through the Customer On-Site Renewable Energy Program (CORE)[48], the NJCEP offered rebates to New Jersey residents, commercial, public and non-profit entities for the installation of qualified clean energy generation systems in New Jersey. The CORE Program supports a variety of technologies, such as solar, wind, and biopower. The impact evaluation was limited to the photovoltaic (PV) component of the CORE Program, covering residential and non-residential participants from program years 2001 to 2006.

The CORE Program closed to new applicants on December 31, 2008. A new program, Renewable Energy Incentive Program (REIP), offers incentives and support services needed for participants to build on-site renewable energy projects using solar, wind, and biopower technologies. The most dramatic change pertains to upfront incentive eligibility. Under the new program' eligibility rules, residential systems larger than 10 kW[49] and commercial systems larger than 50 kW are no longer eligible for upfront incentives. These larger systems are still eligible to participate in the Solar Renewable Energy Certificate Program (SREC). These changes had not occurred during the program period included in the CORE impact evaluation and therefore any effects of these changes were beyond the scope of this report. However, KEMA's report addresses these changes in several places.

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[47] *New Jersey's Clean Energy Program Energy Impact Evaluation,* Prepared by KEMA for New Jersey Board of Public Utilities, *Customer On-Site Renewable Energy Program (CORE),* September 4, 2009.

[48] Customer On-site Renewable Energy Program is also referred to in this report as the "Program" and "CORE Program."

[49] The first 10 kW of residential systems is eligible for a rebate. For example, a 12 kW residential system is eligible for a rebate for 10 kW.

9.2 Approach

KEMA's comprehensive evaluation approach incorporated primary data collection (telephone surveys and on-site visits), engineering analysis, and ratio estimation techniques to accomplish the objectives of the Retrospective Impact Analysis.

The objective of the Prospective Analysis, recommended updates to the current energy savings calculation methods described in the Protocols, was accomplished based on an engineering review of Protocols and the incorporation of the Retrospective Impact Analysis results. Because the results from the Retrospective Impact analysis are used in the Prospective Analysis, we present the Retrospective Impact Analysis first.

9.3 Retrospective Impact Analysis

9.3.1 Overview of Approach

KEMA used the statistical procedure of ratio estimation to develop estimates of evaluation verified gross and net impacts. There are two basic steps to the process.

1. **Verify energy savings in a sample of participants.** For a sample of participants that installed PV systems during program years 2001 through 2006[50], KEMA estimated actual energy output under current conditions. KEMA collected information for this estimation from a combination of telephone interviews and on-site visits. The telephone interview confirmed system installation and collected information about program attribution, satisfaction, and other process issues. The on-site visits were conducted by trained engineers that confirmed system installation, assessed the quality of the installation, obtained inverter readings, and took other measurements required to calculate system output.

2. **Expand sample results to the population of participants.** The sample results obtained in Step 1 were expanded to the population by calculating the ratios of verified-

[50] KEMA developed a stratified random sample of Program participants based on their sector (residential, commercial, school, or other), program year, and the size of their system. KEMA completed a total of 400 phone interviews and 73 on-site visits.

to-tracked (gross generation adjustment factor) and attributable-to-verified (attribution factor) for the sample.

The adjustment factors estimated from the data collection and analysis tasks include:

- **Gross savings adjustment factor:** This factor adjusts tracking gross savings for installation and changes based on the engineering review. Applying the gross savings adjustment factor to tracking gross savings produces the estimate of verified gross savings.
- **Attribution factors:** This factor adjusts verified gross savings for program attribution. That is, the fraction of verified gross savings that occurred because of the Program.
- **Realization rate:** This factor combines the gross savings adjustment factor and the attribution factor. (It is the ratio of net savings to tracking gross savings.) That is, the fraction of tracking gross savings that occurred because of the Program.

9.3.2 Summary of Findings

This section presents the results of the Retrospective Impact analysis. Evaluation verified gross and net savings estimates are provided for kW and kWh for the overall program and broken out by REIP eligibility status. The REIP breakouts provide a method of using the results of the CORE Program Retrospective Impact Analysis to make meaningful inferences about the structure of the new program (REIP).

9.3.2.1 Gross Adjustment Factors

Table 9-1, provides the gross generation adjustment factors for kWh and kW for the CORE Program overall and broken out by REIP eligibility. Overall, the CORE Program has done a good job estimating gross generation.

The gross adjustment factors represent how accurately the Program estimated energy (kWh) and capacity (kW) of the installed systems. A gross adjustment factor of 100 percent would mean that the Program's estimate was perfect. Gross adjustment factors less than 100 percent mean that the Program over-estimated. In contrast, gross adjustment factors greater than 100 percent indicate that the program under-estimated.

At the portfolio level, KEMA found that the energy produced per year is 95.6 percent (between 90.3 percent and 100.9 percent) of the estimate from the tracking database (rated system kW times 1200 hours/year). The estimate of actually-installed capacity is 99.7 percent of the capacity recorded in the tracking database (90 percent confidence interval is ±1.5 percent). The lower Gross Adjustment for kWh is not completely attributable to errors in tracked installed capacity of the panels, but due to other factors such as downtime, shading, and system efficiency.

Table 9-1: Gross Adjustment Factors for kWh and kW[51]

Gross Energy (kWh) Adjustment Factor					
	90% Confidence Interval				
Customer Segment	**N**	**Gross Adjustment Factor**	**SE**	**Lower Bound**	**Upper Bound**
All	**73**	**95.6%**	**3.2%**	**90.3%**	**100.9%**
Res REIP Eligible	24	**88.6%**	3.8%	82.0%	95.1%
Res REIP Ineligible	21	**88.7%**	1.8%	85.6%	91.8%
Nonres REIP Eligible	17	**83.6%**	8.7%	68.3%	98.8%
Nonres REIP Ineligible	11	**105.6%**	3.1%	100.0%	111.2%

Gross Capacity (kW) Adjustment Factor					
	90% Confidence Interval				
Customer Segment	**N**	**Gross Adjustment Factor**	**SE**	**Lower Bound**	**Upper Bound**
All	**73**	**99.7%**	**0.9%**	**98.2%**	**101.2%**
Res REIP Eligible	24	**100.1%**	0.4%	99.4%	100.7%
Res REIP Ineligible	21	**100.1%**	0.1%	100.0%	100.2%
Nonres REIP Eligible	17	**93.2%**	8.0%	79.2%	107.2%
Nonres REIP Ineligible	11	**100.6%**	1.1%	98.7%	102.5%

9.3.2.2 Attribution Adjustment Factor

The attribution factor is the theoretical proportion of the total energy that would be generated in a system's lifetime, or of total capacity, that is attributable to the Program. "Attributable to the program" means that this generation would not have occurred without the program. If an installation would have occurred entirely without the program, attribution is zero. If an installation would not have occurred at all without the program, attribution is 100 percent. In other words, attribution is 100 percent minus the rate of free ridership.

[51] SE = Standard error of the estimate.

Table 9-2 shows the attribution adjustment factor, the ratio of program-attributed generation to evaluation verified gross generation, for the Program overall and by customer eligibility for REIP. As mentioned above, the REIP breakouts provide a method of using the results of the CORE Program Retrospective Impact Analysis to make meaningful inferences about the structure of the new program (REIP). The results of the attribution analysis are particularly striking and supportive of the new program design.

The overall attribution rate is 71 percent for annualized energy generation, and 70 percent for generating capacity. These are good results for a comprehensive PV program that serves residential and non-residential customers with the installation of systems of all sizes.

A closer look at the data shows some significant differences between REIP Eligible and REIP Ineligible customers. REIP Eligible customers are reporting higher levels of program attribution than REIP Ineligible customers. Nonresidential REIP Ineligible customers, systems larger than 50 kW attribute savings to the Program at half the rate of their REIP eligible counterparts. This difference is significant at the 99.5 percent level (p-value < 0.005). For residential customers, kWh attribution is 93.7 percent and 89.9 percent, and kW attribution is 89.4 percent and 83.6 percent for REIP Eligible and REIP Ineligible, respectively.

Table 9-2: Attribution Adjustment Factors by REIP Eligibility for kWh and kW

Attribution (kWh) Adjustment Factor					
	90% Confidence Interval				
Customer Segment	**N**	**Attribution Factor**	**SE**	**Lower Bound**	**Upper Bound**
All	**375**	**71.0%**	**9.3%**	**55.7%**	**86.3%**
Res REIP Eligible	247	**93.7%**	1.7%	90.8%	96.5%
Res REIP Ineligible	55	**89.9%**	4.0%	83.2%	96.6%
Nonres REIP Eligible	55	**96.2%**	3.7%	90.1%	102.4%
Nonres REIP Ineligible	18	**45.6%**	14.9%	19.7%	71.6%

Attribution (kW) Adjustment Factor					
	90% Confidence Interval				
Customer Segment	**N**	**Attribution Factor**	**SE**	**Lower Bound**	**Upper Bound**
All	**375**	**70.0%**	**8.2%**	**56.4%**	**83.5%**
Res REIP Eligible	247	**89.4%**	1.6%	86.8%	92.1%
Res REIP Ineligible	55	**83.6%**	3.5%	77.7%	89.4%
Nonres REIP Eligible	55	**90.8%**	3.3%	85.2%	96.4%
Nonres REIP Ineligible	18	**47.0%**	14.4%	21.9%	72.1%

9.3.2.3 Realization Rates

The Realization Rates are shown in Table 9-3. The realization rate is simply the product of the gross savings and attribution factor

Table 9-3: Realization Rates for kWh and kW, by REIP Eligibility

Realization Rate (kWh)					
	90% Confidence Interval				
Customer Segment	**N**	**Realization Rate**	**SE**	**Lower Bound**	**Upper Bound**
All	**375**	**67.9%**	**0.1%**	**67.8%**	**67.9%**
Res REIP Eligible	247	**82.9%**	0.2%	82.7%	83.2%
Res REIP Ineligible	55	**79.7%**	0.1%	79.5%	79.9%
Nonres REIP Eligible	55	**80.4%**	0.5%	79.5%	81.3%
Nonres REIP Ineligible	18	**48.2%**	0.9%	46.6%	49.7%

Realization Rate (kW)					
	90% Confidence Interval				
Customer Segment	**N**	**Realization Rate**	**SE***	**Lower Bound**	**Upper Bound**
All	**375**	**69.8%**	**0.0%**	**69.7%**	**69.8%**
Res REIP Eligible	247	**89.5%**	0.0%	89.5%	89.5%
Res REIP Ineligible	55	**83.6%**	0.1%	83.5%	83.7%
Nonres REIP Eligible	55	**84.6%**	0.5%	83.9%	85.4%
Nonres REIP Ineligible	18	**47.3%**	0.8%	45.9%	48.7%

* A 0.0% SE means that the standard error was less than 0.1% (but greater than 0%).

9.3.2.4 Application of Adjustment Factors

Table 9-4 summarizes the gross tracked, evaluation verified gross, and evaluation verified net generation and capacity for the Program. The tracking database reports that all of the systems installed during the period 2001-2006 together generate about 30.8 GWh/year. KEMA estimates that about 29.8 GWh/year are actually generated and 20.2 GWh/year are directly attributable to the Program[52]. The tracking database predicts that all of the systems installed between 2001 and 2006 have about 25.7 MW of capacity. KEMA estimates that the actual capacity is 25.6 MW and 17.9 MW are directly attributable to the program.

[52] The sector level adjustment factors were used to produce these results.

Table 9-4: Evaluation Verified Gross and Net Energy Impact

Sector	Gross Tracked MWh	Evaluation Verified Gross MWh	Evaluation Verified Net MWh	Gross Tracked kW	Evaluation Verified Gross kW	Evaluation Verified Net kW
Res REIP Eligible	10,933	9,683	9,069	9,111	9,118	8,156
Res REIP Ineligible	2,304	2,044	1,837	1,920	1,921	1,605
Nonres REIP Eligible	2,411	2,015	1,939	2,009	1,873	1,700
Nonres REIP Ineligible	15,190	16,040	7,317	12,659	12,735	5,989
Total	**30,838**	**29,781**	**20,161**	**25,698**	**25,648**	**17,451**

9.3.3 Recommendations

This section contains KEMA's recommendations to the Program based on the results of the Retrospective Impact Analysis. Note, these recommendations are limited because the CORE Program is closed to new applicant and there are fundamental differences between CORE and REIP (e.g.: eligibility).

Recommendation #1

KEMA recommends the Program consider using the attribution factors found in this evaluation to determine net impacts rather than the existing assumption that attribution is 100 percent. Furthermore, the Program could use the attribution factors for each of the separate REIP eligibility categories. Going forward, the BPU, OCE or the Program Coordinator could calculate estimated net impacts at any time by multiplying the program gross tracked savings estimate from the database by the attribution factors reported in this document.

Recommendation #2

The tracking database should be used to track gross kW and kWh. The tracking database should contain all data required for the calculations outlined in the Protocols. For example, the Protocols require an estimate for peak kW impact for summer and winter, but the tracking database did not provide these estimates. The tracking database should also include an estimate of annual energy (kWh) generated by each system. In addition, the program should make sure that the tracking database is kept up to date.

Tracked kW and kWh in the database should use information from follow-up site inspections by the REIP program team. In a few instances, KEMA learned during the on-site visits that the installed equipment was not always the same as the equipment recorded in the tracking database. This was not a systemic issue but something to consider as part of routine quality control measures.

9.4 Prospective Analysis

The results of the Retrospective Impact Analysis and a detailed engineering review of the kW and kWh calculations in the existing Protocols were used to recommend updates to the Protocols.

9.4.1 Overview of Approach

The Protocol review included an assessment of how the Program estimates annual solar energy (Energy Production (kWh)) and a review of the peak hour impact (Peak Demand (kW)) using equations established in the Protocols.

9.4.1.1 Energy Production (kWh)

The CORE Program has two methods for estimating annual solar energy delivered from a PV system to the electrical grid. The first method, Method 1,[53] relies on an engineered calculation using parameters relevant to each site (PVWatts). According to conversations with CORE staff[54] this method of estimation is used to assess projected individual system performance by the Clean Power Markets (CPM) (recently transferred to PJM GATS). The second method, Method 2, uses an empirically based deemed value. This deemed value is multiplied by the total kW_{STC} of PV systems installed to estimate annual solar energy. This value is used by the Market Managers to derive the Program's annual energy savings from all PV installations[55].

In order to assess the accuracy of Method 1 and Method 2, KEMA calculated several intermediate values. First, we calculated the amount of energy that would be expected if using the PVWats estimate (Method 1). Second, we calculated the amount of energy that would be expected if using the deemed value estimate (Method 2). Next, we annualized the kWh measurements we obtained from the on-site visits. Finally, we computed two System

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[53] The terms Method 1 and Method 2 were created by KEMA for explanatory purposes.

[54] Telephone conversation with Mark Loeser, CORE Account Manager, NJCEP, 12/17/08.

[55] Email communication with Charlie Garrison, NJCEP Renewable Energy Market Manager, Honeywell, 01/20/09.

Performance ratios (one for Method 1 and one for Method 2) to verify the accuracy of the different methods.

9.4.1.2 Peak Demand (kW)

Although the Protocols require an estimate for peak kW impact for summer and winter, the tracking database did not include these estimates. We calculated a verified summer peak kW and a winter peak kW impact for the Program based on data gathered from the site visits and the Protocols. We then compared the verified peak kW impacts to the peak kW impacts calculated based on information from the database and the Program Protocols.

9.4.2 Summary of Findings

The results of the Protocol review first address energy production (kWh) followed by peak demand (kW).

9.4.2.1 Energy Production (kWh)

In order to assess the Protocols' methodology to estimate energy production for PV systems, we compared the Method 1 (PVWatts) and Method 2 (Deemed Value) estimates to the actual value measured during the on-site visit.

Table 9-5 shows the System Performance (SP) Ratio for Method 1 and Method 2 as compared to the measured value. The SP Ratio is shown for all systems and by the REIP eligibility category. SP Ratios greater than 1.0 indicate that the actual measured kWh is greater than the estimate provided by Method 1 or Method 2. In other words the Protocol estimate is lower than the measured value. SP Ratios less than 1.0 denotes that the actual measured kWh value is less than the calculated estimate. In other words the Protocols estimate is higher than actual.

Table 9-5: Method 1 and Method 2 Comparison

System Size	Sample Size	Method 1 (PVWatts)		Method 2 (Deemed)	
		SP Ratio	90% confidence interval	SP Ratio	90% confidence interval
All Systems	73	1.06	1.01 – 1.11	0.96	0.90 – 1.01
Res REIP Eligible	24	1.01	0.95 – 1.06	0.89	0.82 – 0.95
Res REIP Ineligible	21	0.99	0.95 – 1.02	0.89	0.86 – 0.92
Nonres REIP Eligible	17	1.01	0.94 – 1.07	0.84	0.69 – 0.98
Nonres REIP Ineligible	11	1.12	1.05 – 1.19	1.06	1.01 – 1.11

It can be seen from Table 9-1 that both methods provided a fairly close estimate of the actual kWh measurements for systems overall. The Method 1 (PVWatts) SP Ratio for all systems of 1.06 indicates that Method 1 underestimated production by 6.0 percent. The Method 2 (Deemed Value) SP Ratio for all systems of 0.96 indicates that Method 2 (Deemed Value) overestimated production by 4.0 percent.[56]

When broken down by system size and type, for systems 50 kW or less (REIP Eligible), Method 1 (PVWatts) provided quite accurate estimates of energy production, whereas Method 2 (Deemed Value) did not. Conversely, for Nonresidential REIP Ineligible PV systems Method 2 provided a closer estimate to actual kWh measurements, although both methods predicted lower kWh values than actual. It is these larger (>50 kW) nonresidential systems which tend to skew energy production estimates lower (resulting higher SP ratios) for All Systems.

9.4.2.2 Peak Demand (kW)

In addition to installed capacity and annual electrical production, the Protocol requires an estimate of peak demand impact based on research conducted by Richard Perez of SUNY Albany for the New Jersey Board of Public Utilities. The peak demand impact is a measure of the likely reduction in the utility peak due to the installation of photovoltaic systems. As the demand for electricity delivery through aging infrastructure grows, reduction in peak demand will

[56] This is equivalent to the kWh Gross Savings Adjustment Factor reported in the Retrospective Impact Analysis because the Retrospective Impact Analysis uses the Method 2 (Deemed Value) estimates recorded in the Program tracking database.

be increasingly important to prevent rolling blackouts or other power system problems related to utility peaks.

The effective load carrying capacity indicates the potential portion of the system rated output that will be available during a utility peak. Perez et al developed the effective load carrying capacity factors through research and sophisticated analytical methods.[57,58] In simple terms, Perez et al determined when the utility peak occurred, estimated the solar irradiance during the utility peak, and estimated the probable portion of rated capacity that would be available during peak.

KEMA identified the following three issues the Program should consider with regards to its use of the Effective Load Carrying Capacity (ELCC) to estimate peak impact for summer.

1. The ELCC was estimated based on time of the existing utility peak. Rate structures and Programs that discourage electrical use during the peak period may cause the utility peak to shift over time thereby changing the ELCC.

2. The ELCC factor that is used is too high.

3. Estimating the peak impact based on the ELCC is inconsistent with the approach used in the rest of the Protocols.

KEMA also identified the following two issues the Program should consider with regards to its use of the Winter Effective Load Carrying Capacity (WELCC) to estimate winter peak impact.

1. The Protocols state that the summer and winter peak impacts are based on research by Richard Perez. We were unable to find research supporting the WELCC. In addition, the Protocols state that WELCC is estimated based on "monitored system data from White Plains NY". We were unable to find additional information on this source. As a result, we are unable to assess the validity of the WELCC value used in the Protocols.

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[57] Perez, Richard, *Determination of Photovoltaic Effective Capacity for New Jersey*, Project Manager: Cassandra Kling, BPU found at http://www.clean-power.com/research/capacityvaluation/ELCC_New_Jersey.pdf (accessed 24 June 2009)

[58] Perez, R., R. Margolis, M. Kmiecik, M. Schwab, and M. Perez, *Update Effective Load-Carrying Capability of Photovoltaics in the United States*, Conference paper NREL CP-620-40068, June 2006

2. The Protocols indicate that coincident peak demand savings in winter are not applicable and no time periods are provided defining the winter peak. Therefore, we were unable to use a time period defined by the Protocol to estimate the winter peak impact.

9.4.3 Recommendations

This section contains KEMA's Energy Production (kWh) and Peak Demand (kW) recommendations to the Program based on the Prospective Analysis.

9.4.3.1 Energy Production (kWh)

Recommendation #1

KEMA recommends the Program continue its use of PVWatts to calculate energy production and discontinue its deemed value method for purposes of reporting energy production to the BPU. The required input to the PVWatts model is already collected for each installed PV system by the CORE Program though its customer application technical worksheet and on-site inspection documentation. More specifically, KEMA is recommending the Program calculate energy production system-by-system with the data already collected during the Program's site inspections. The increase in accuracy from the system-by-system calculation approach should require minimal additional cost.

The NJCEP has issued a guidebook which contains the present processes and procedures by which the Renewable Energy Incentive Program (REIP) is administered by the Renewable Energy Market Managers.[59] It should be noted that the REIP is currently in transition from Clean Power Markets platform to the Generation Attributes Tracking System (GATS) operated by PJM. In the guidebook, PVWatts continues to be the calculation method by which kWh production for systems less than 10 kW is estimated for the purposes of issuing Solar Renewable Energy Certificates (SRECs). Systems larger than 10 kW are awarded SRECs on the basis of self reported or electronically reported PV energy production.

[59] Renewable Energy Incentive Program Guidebook, January 2009 version 1.0. New Jersey's Clean Energy Program, New Jersey Board of Public Utilities.

Recommendation #2

KEMA recommends the Program consider two changes to the PVWatts calculation methodology.

1.) In instances where arrays of panels at a site are at different tilt angles, orientations, or have different shading, the PVWatts calculations should be performed separately for each array and then added for the total system.

2.) Incorporation of a shade factor. Shading was found to be significant at many of the sites visited. On average shading decreased the solar radiation reaching the PV systems by 6.3 percent. To arrive at an overall system derate factor, the base derate factor should be multiplied by a factor for shading. This factor is not currently included in the base derate factor, but it is collected by the CORE Program. The calculation is performed as follows:

System derate factor = Base derate factor x Shade factor

Where:

System derate factor	=	Value entered into the PVWatts calculator to derate PV panel DC rating to an AC rating.
Base derate factor	=	Derate factor = 0.77 (default value).
Shade factor	=	100 percent minus percent shading (decimal value).

9.4.3.2 Peak Demand (kW)

Recommendation #1

The Program should consider periodically reviewing the load curves for the New Jersey utilities. If the peak load shifts substantially, the ELCC should be recalculated based on the new peak.

Recommendation #2

KEMA recommends the ELCC be reduced from 65 percent to 50 percent to more accurately reflect the types of systems installed.

Recommendation #3

KEMA recommends the Program revise the Protocols to include the average kW over the peak. This metric offers program planners a definition that is consistent with the rest of the Program kW metrics. However, since the ELCC method is useful for utilities, we also recommend that the Program continue to track peak kW impact based on this method with the revised ELCC factor.

Recommendation #4

KEMA recommends the Program document the basis for the WELCC. The documentation should be available for independent review and analysis. In the absence of documentation, revise the Protocols to include the average kW over the winter peak. This metric offers program planners a definition that is consistent with the rest of the Program kW metrics.