Applied Public Policy Research
APPRISE
Institute for Study and Evaluation

MEMO

DATE: June 27, 2014

TO: NJ CP Utility Working Group

FROM: Jackie Berger

SUBJECT: NJ Comfort Partners Energy Saving Protocols and Engineering Estimates

This memo provides a review of the NJ Comfort Partners Energy Saving Protocols, recommends changes to the protocols and additional protocols for measures not included, and calculates Engineering Estimates for those proposed energy savings formulas.

I. Introduction

NJ Comfort Partner's Energy Saving Protocols are an important aspect of the program, as they are used to estimate program savings. The protocols are used to assess program impacts and calculate energy and resource savings for the following purposes.

- Report to the Board on program performance.
- Inputs for planning and cost-effectiveness calculations.
- Calculation of lost margin revenue recovery (as approved by the BPU).
- Determination of eligibility for administrative performance incentives.[1]
- Assessment of the environmental benefits of program implementation.

In this memo, we utilize findings from the evaluation to make recommendations for updating the protocols. The following research and analyses are summarized in this document.

1. Review of the calculations made with the current protocols using data in NJ CP database. The purpose of this review is to ensure that Protocol Savings Estimates are calculated in accordance with the procedures that are currently in place.

2. Recommend changes for existing protocols that can be refined to take additional information into account or to more accurately estimate savings.

3. Recommend additional protocols for measures that do not have protocols or are being considered for addition to the program.

4. Provide engineering estimates for new and recommended changes to protocols.

[1] To the extent that such incentives are approved by the BPU.

This memo provides recommendations based on research and review of the literature. An additional memo will provide details on a variety of protocols used in other programs and source documentation for those protocols.

II. Review of Energy Saving Protocol Calculations

We reviewed the current protocols and checked the calculations in the NJ CP database to ensure that savings are calculated correctly.

A. Baseload

All baseload protocols were calculated in accordance with the formulas summarized below.

Savings = Δ Watts/1000 * Hours Used * 365 Days

1. *CFLs*

   Fixed Values
   - Δ Watts = 42
   - Hours = 2.5

   Projected savings = 38.33 kWh

2. *Fixtures*

   Fixed Values
   - Δ Watts = 110
   - Hours = 3.5

   Projected savings = 140.52 kWh

3. *Lamp*

   Fixed Values
   - Δ Watts = 245
   - Hours = 3.5

   Projected savings = 312.99 kWh

B. Hot Water

All hot water protocols were calculated in accordance with the formulas summarized below.

1. *Electric*

   Average package of domestic hot water measures
   Projected savings = 178 kWh

2. *Gas*

   Average package of domestic hot water measures

<u>Projected savings</u> = 1.01 MMBTU = 9.85 ccf

C. Refrigerators

The refrigerator and freezer protocols were calculated in accordance with the formulas summarized below. However, no savings were calculated for additional refrigerator or freezer removal without replacement.

Savings = Baseline Refrigerator kWh – New Refrigerator kWh

The baseline refrigerator kWh is based upon the contractor metering or refrigerator usage lookups. Contractors provided a table of rated values of replacement refrigerator usage for inclusion in the calculation.

D. Space Conditioning

The following space conditioning Energy Saving protocols were reviewed.

1. *Air Sealing*

All air sealing protocols were calculated in accordance with the formulas summarized below. In most cases, the gas seasonal use was estimated by subtracting 300 ccf from gas usage as shown below. However, in a few cases, the seasonal gas usage was included in the database and used in the calculation.

- Electricity Savings = Pre-Treatment Electric Space Consumption * .05
- Gas Savings = Pre-Treatment Gas Space Consumption * .05

Pre-Treatment Gas Space Consumption = Pre Gas Consumption – 300 ccf (if seasonal use is not available.)

2. *Furnace/Boiler Replacement*

The furnace/boiler savings calculated in accordance with the formula below do not match the protocol savings reported in the NJ CP database.

Savings = [(Capyq/AFUELI) – (Capyq/ AFUEq)] * EFLH / 100,000 BTUs/therm

- Capyq = Output capacity of qualifying unit output in BTUs/hour
- AFUELI = Annual Fuel Utilization Efficiency of the Low Income Program replaced furnace or boiler.
- AFUEq = Annual Fuel Utilization Efficiency of the qualifying baseline furnace or boiler.
- EFLH = Equivalent full load hours of operation for the average unit. This value is fixed at 965 for heating and 600 for cooling hours.

3. *Duct Sealing and Repair with Central Air Conditioning*

All duct sealing and repair with central air conditioning protocols were calculated in accordance with the formulas summarized below. In most cases, the gas seasonal use was estimated by subtracting 300 ccf from gas usage as shown below. However, in a few cases, the seasonal gas usage was included in the database and used in the calculation.

- Electricity Savings = Pre-Treatment Electric Space Consumption * .10

- Gas Savings = Pre-Treatment Gas Space Consumption * .0.02

  Pre-Treatment Gas Space Consumption = Pre Gas Consumption – 300 ccf (if seasonal use is not available.)

4. *Duct Sealing and Repair without Central Air Conditioning*
   All duct sealing and repair without central air conditioning protocols were calculated in accordance with the formulas summarized below. In most cases, the gas seasonal use was estimated by subtracting 300 ccf from gas usage as shown below. However, in a few cases, the seasonal gas usage was included in the database and used in the calculation.

   - Electricity Savings = Pre-Treatment Electric Space Consumption * .02
   - Gas Savings = Pre-Treatment Gas Space Consumption * .02

     Pre-Treatment Gas Space Consumption = Pre Gas Consumption – 300 ccf (if seasonal use is not available.)

5. *Insulation Upgrades*
   All insulation protocols were calculated in accordance with the formulas summarized below. In most cases, the gas seasonal use was estimated by subtracting 300 ccf from gas usage as shown below. However, in a few cases, the seasonal gas usage was included in the database and used in the calculation.

   - Electricity Savings = Pre-Treatment Electric Space Consumption * .08
   - Gas Savings = Pre-Treatment Gas Space Consumption * .13

     Pre-Treatment Gas Space Consumption = Pre Gas Consumption – 300 ccf (if seasonal use is not available.)

6. *Thermostat Replacement*
   All thermostat replacement protocols were calculated in accordance with the formulas summarized below. In most cases, the gas seasonal use was estimated by subtracting 300 ccf from gas usage as shown below. However, in a few cases, the seasonal gas usage was included in the database and used in the calculation.

   - Electricity Savings = Pre-Treatment Electric Space Consumption * .03
   - Gas Savings = Pre-Treatment Gas Space Consumption * .03

     Pre-Treatment Gas Space Consumption = Pre Gas Consumption – 300 ccf (if seasonal use is not available.)

7. *Heating and Cooling Equipment Maintenance Repair/Replacement*
   All electric replacement protocols were calculated in accordance with the formulas summarized below.

   - Electricity Savings = Pre-Treatment Electric Space Consumption * .17
   - Gas Savings – No protocol provided

III. Recommended Changes to Current Protocols

We recommend the following changes to existing protocols.

- *Refrigerator Removal* – Refrigerator removal savings are not included in the NJ Comfort Partners Energy Saving Protocols. The refrigerator removal savings should be estimated as the annual metered usage of the refrigerator that was removed. NJ Comfort Partners should encourage extra refrigerator removal or two-for-one swaps and take credit for the savings from these removals.

- *Hot Water Measures* – Currently a fixed kWh or ccf savings amount is applied for a "standard package" of hot water measures. We recommend instead that separate savings are applied for each of the following measures as specified in the following section.

  - Hot Water Heater Replacement
  - Hot Water Tank Wrap
  - Hot Water Pipe Insulation
  - Aerators
  - Showerheads

- *Shell Measures* – The protocols currently apply the following thresholds for spending on air sealing, duct sealing, insulation, and HVAC before the percentage savings is applied.

  - Air Sealing - $100
  - Duct Sealing - $100
  - Insulation - $100
  - HVAC (electric) - $100
  - HVAC (gas) - $2,000

  The utilities asked APPRISE to review these thresholds. Below we provide an analysis and recommendations.

  <u>Air Sealing</u>
  Tables III-1A and III-1B display the relationship between spending on air sealing, mean protocol saving estimates, and total job savings from the usage impact analysis. Table III-1A shows that for gas jobs, the protocol savings estimates from air sealing are greater than the home's total usage impact savings for jobs with spending on air sealing of less than $200, and the protocol savings are almost equal to total gas savings from the usage impact analysis for jobs with spending between $200 and $300. Therefore, we recommend a spending threshold of at least $300 on air sealing for gas heating jobs before the five percent savings is applied to gas space consumption.

  Table III-1B displays similar results for air sealing on electric heating jobs. A less detailed analysis is presented here because there are a smaller number of these jobs. However, these results also suggest that a $300 or $400 threshold should be applied.

Table III-1A
Air Sealing Spending and Savings – Gas Heating Jobs

Air Sealing Spending	# Obs.	Mean Protocol Gas Savings (ccf)	Mean Total Gas Savings from Usage Impact Analysis (ccf)
≤$100	3	20	9
$101-$200	263	28	18
$201-$300	305	31	34
$301-$400	287	33	61
$401-$500	262	37	34
$501-$600	224	38	71
$600+	1,576	48	86
Total	**2,920**	**41**	**68**

Table III-1B
Air Sealing Spending and Savings – Electric Heating Jobs

Air Sealing Spending	# Obs.	Mean Protocol Electric Savings (kWh)	Mean Total Electric Savings from Usage Impact Analysis (kWh)
≤ $200	42	321	203
$201-$400	57	406	1,479
$401-$600	44	336	1,399
$601-$800	31	373	821
$801+	130	443	2,115
Total	**304**	**396**	**1,538**

Duct Sealing

Table III-2 displays the relationship between spending on duct sealing, mean protocol saving estimates, and total job savings from the usage impact analysis for gas heating jobs. The table also shows the percent of these jobs that had air sealing and insulation work and the average dollars spent on these other measures. This analysis is not provided for electric heating jobs, as there were many fewer electric heating jobs in total, and only 56 electric heating jobs with data on this measure.

The table shows that mean protocol gas savings for duct sealing range from 15 ccf for jobs that had $101 to $150 in spending on duct sealing to 19 ccf for jobs that had over $400 spent on duct sealing. It appears that $100 is a good threshold to use for spending before the percentage savings is applied. However, given that most of these jobs had air sealing and about half had significant insulation work as well, the two percent of gas space consumption savings for duct sealing may be too high of an estimate.

Table III-2
Duct Sealing Spending and Savings – Gas Heating Jobs

Duct Sealing Spending	# Obs.	Mean Protocol Gas Savings (ccf)	Mean Total Gas Savings from Usage Impact Analysis (ccf)	Percent with Air Sealing	Mean Air Sealing Spending	Percent with Insulation	Mean Insulation Spending
≤$100	0	-	-				
$101-$150	213	15	48	90%	$907	51%	$1,355
$151-$200	163	15	91	88%	$1,139	55%	$1,437
$201-$250	104	16	58	96%	$1,011	54%	$1,774
$251-$300	66	14	46	92%	$1,092	58%	$1,399
$301-$350	42	16	101	100%	$1,150	55%	$1,379
$351-$400	38	17	66	97%	$971	63%	$1,913
$401+	132	19	125	91%	$1,318	61%	$2,185
Total	758	16	75	92%	$1,075	55%	$1,626

Insulation

Table III-3 displays the relationship between spending on insulation, mean protocol saving estimates, and total job savings from the usage impact analysis for gas heating jobs. This analysis is not provided for electric heating jobs, as there were many fewer electric heating jobs in total, and only 187 electric heating jobs with data on this measure.

Table III-3 shows that for gas jobs, the protocol savings estimates from insulation are greater than the home's total usage impact savings for all jobs with spending on insulation of less than $900 with the current protocol of 13 percent of gas space heating consumption.

We propose that a lower percentage savings be applied for this measure. For illustration purposes, we divide the protocol savings by 3, for an approximate percentage of 4.33 percent of gas heating consumption saved. If a lower percentage around this level is applied, we recommend applying this percentage savings to jobs with at least $300 in spending on insulation.

Table III-3
Insulation and Savings – Gas Heating Jobs

Insulation Spending	# Obs.	Mean Protocol Gas Savings (ccf)		Mean Total Gas Savings from Usage Impact Analysis (ccf)
		Current (13%)	Proposed (4.33%)	
≤$100	0	-		-
$101-$200	56	85	28	9
$201-$300	78	94	31	59
$301-$400	60	88	29	59
$401-$500	53	87	29	83
$501-$600	59	103	34	56

Insulation Spending	# Obs.	Mean Protocol Gas Savings (ccf)		Mean Total Gas Savings from Usage Impact Analysis (ccf)
		Current (13%)	Proposed (4.33%)	
$601-$700	79	97	32	35
$701-$800	63	109	36	74
$801-$900	66	109	36	58
$901-$1,000	70	107	36	127
$1,001+	947	134	45	134
Total	1,531	120	40	109

<u>HVAC</u>
The current spending thresholds for HVAC measures are as follows and are much higher for gas than for electric to aim to separate installations of new systems from repairs.

- HVAC (electric) - $100
- HVAC (gas) - $2,000

We recommend that the separate replacement protocol is used for replacement rather than the repair, as shown in the following section of this memo. The NJ CP Protocols did not provide savings protocols for gas heating repairs. Following this change, the lower spending threshold for gas HVAC repairs can be implemented. The energy saving factor shown below is five percent, but may need to be adjusted depending on the type and amount of repair work that is performed.

- *Gas Usage Disaggregation* – Under the current protocols, baseload gas usage is assumed to be 300 ccf in most cases. The system should be programmed to disaggregate both gas and electric usage. This information can increase the accuracy of the Protocol Savings estimates. More importantly, the information should be provided to the contractors to help them diagnose energy usage issues in the home. Once the disaggregation is done by the system, the system can also calculate seasonal spending guidelines for the contractors.

IV. Additional Protocols

This section provides recommendations for additional protocols for the measures that do not have protocols or are being considered for addition to the program. Some of these measures have protocols in the NJ Clean Energy Program, but not for the Comfort Partners program. Where this happens, both the NJ Clean Energy Program protocol and an alternate protocol are provided in this section.

A. Combined Gas Boiler and Water Heater

These units have become common to replace both a gas boiler and water heater where there were previously two separate units. However, there are no existing protocol savings formulas for this measure as they were not considered when the protocols were developed.

There is not currently a separate measure code for combination units in the CP System, so this code should be added if this protocol is adopted.

The formula below is from Connecticut's 2012 program savings document.[2]

$$ACCF = ACCF_H + ACCF_w$$

$$ACCF_H = \frac{ABTU_H}{102{,}900}$$

$$ABTU_H = SF \times HF \times \left(\frac{1}{AFUE_E} - \frac{1}{AFEU_I}\right)$$

$$ACCF_W = \frac{ABTU_W}{102{,}900}$$

$$ABTU_W = ADHW \times \left(\frac{1}{AFUE_E} - \frac{1}{AFEU_I}\right)$$

$$ADHW = GPY \times 8.3 \times (T_{dhw} - T_{aiw})$$

Table IV-1
Definitions and Values for Combined Boiler and Water Heater Protocol

Term	Definition	Value
ACCF	Annual natural gas savings (Ccf/year)	
$ACCF_H$	Annual natural gas savings – heating (Ccf/year)	
$ACCF_W$	Annual natural gas savings – water heating (Ccf/year)	
$ABTU_H$	Annual Btu savings – heating (Btu/year)	
SF	Heated area served by boiler (square feet)	
HF	Heating factor based on age of home (Btu/ft^2/year)	See Table IV-2
$AFUE_E$	Annual fuel utilization efficiency, existing	See Table IV-3
$AFUE_I$	Annual fuel utilization efficiency, installed	83%
ADHW	annual domestic water heating load (Btu)	11,197,132 Btu
GPY	Annual domestic home water usage (gallons)	19,839 gallons
T_{dhw}	Domestic hot water heater set point	125°F
T_{aiw}	Average annual incoming water temperature	57°F
102,900	Conversion factor: Btu per ccf natural gas	
8.3	Conversion factor: density of water	

Table IV-2
Heating Factor (HF) Based on Home Age

Year Built (YRh)	HF (Btu/ft^2/year)
Before 1940	45,000
1940 to 1949	41,400

[2]Connecticut Light and Power and United Illuminating. "Connecticut Program Savings Document, 8th Edition for 2013 Program Year." October 30, 2012. Pages 143-148, 241-242.

Year Built (YRh)	HF (Btu/ft^2/year)
1950 to 1959	38,700
1960 to 1969	36,000
1970 to 1979	33,300
1980 to 1989	30,600
1990 to 1999	27,900
2000 to present	26,100

Table IV-3
Existing Boiler AFUE Based on Boiler Age

Year Boiler Installed (YRe)	Gas AFUE
Before 1960	60%
1960 to 1969	60%
1970 to 1974	65%
1975 to 1983	65%
1984 to 1987	70%
1988 to 1991	77%
1992 to present (baseline)	80%

B. HVAC Repair – Gas Savings

While the protocols included electric savings for HVAC repairs, they did not include gas savings. The formula below is for gas savings from New York's 2010 Technical Resource Manual.[3]

$$\Delta therms = units \times \left(\frac{kBtuh_{in}}{unit}\right) \times \left(\frac{EFLH}{100}\right) \times ESF$$

$$EFLH_{heat} = \frac{Annual\ Heating\ Energy}{Nameplate\ capacity}$$

Table IV-4
Definitions and Values for Gas HVAC Repairs

Term	Definition	Value
Δtherms	Gross annual gas savings	
Units	Number of units repaired	
kBtuh/unit	Nominal heating input capacity in kBtu/hour	
$EFLH_{heat}$	heating equivalent full-load hours (relative to nameplate)	
ESF	Energy savings factor	0.05

[3] "New York Standard Approach for Estimating Energy Savings from Energy Efficiency Programs (Technical Resource Manual – TRM) Record of Revision." November 26, 2013. Page 68.

C. Hot Water Heater Replacements

The gas savings for hot water heater replacements is calculated in the NJ Clean Energy Protocols as follows.

$$\text{Gas Savings} = [(EF_q - EF_b)/EF_q] * DHW_{use}$$

Table IV-5
Definitions and Values for Hot Water Gas Heater Replacements

Term	Definition	Value
EF_q	Energy factor of qualifying water heater	If not rated: 41,0942/(41,094/TE + Volume*SLratio*24hours)
TE	Thermal efficiency of the unit	
Volume	Volume of water heater in gallons	
SLratio	Average ratio of rated standby losses	9.73
EB_q	Energy factor of baseline heater	.67 – (.0019*Gallons of Capacity)
DHW_{use}	Annual baseline water heater usage	180 Therms

Savings for hot water heater replacements from New York's 2013 Technical Resource Manual are as follows[4,5]

$$\Delta kW_s = units \times \left[\frac{(UA_{base} - UA_{ee}) \times \Delta T_s}{3{,}413}\right] \times DF_s \times CF_s$$

$$\Delta kWh = units \times \left(\frac{GPD \times 365 \times 8.33 \times \overline{\Delta T_w}}{3{,}413}\right) \times \left(\frac{1}{EF_{base}} - \frac{1}{EF_{ee}}\right)$$

$$\Delta therm = units \times \left(\frac{GPD \times 365 \times 8.33 \times \overline{\Delta T_w}}{100{,}000}\right) \times \left(\frac{1}{EF_{base}} - \frac{1}{EF_{ee}}\right)$$

Table IV-6
Definitions and Values for Hot Water Heater Replacements

Term	Definition
ΔkW_s	Gross coincident demand savings
ΔkWh	Gross annual energy savings
$\Delta therm$	Gross annual gas savings
Units	Number of high efficiency water heaters installed under program
UA_{base}	Overall heat loss coefficient of base water heater (Btu/hour-°F)
UA_{ee}	Overall heat loss coefficient of efficient water heater (Btu/hour-°F)
ΔT_s	Temperature difference between the stored hot water and the surrounding air (°F)

[4] New York Evaluation Advisory Contractor Team and TecMarket Works. "New York Standard Approach for Estimating Energy Savings from Energy Efficiency Programs; Residential, Multi-Family, and Commercial/Industrial Measures." October 15, 2010. Page 79.

[5] "New York Standard Approach for Estimating Energy Savings from Energy Efficiency Programs (Technical Resource Manual – TRM) Record of Revision." November 26, 2013. Page 12.

Term	Definition
GPD	Average daily water consumption (gallons/day)
ΔT_w	Average difference between cold inlet temperature and hot water temperature (°F)
EF_{base}	Baseline water heater energy factor
EF_{ee}	Efficient water heater energy factor
365	Conversion factor: days per year
8.33	Conversion factor: Btu per gallon-°F
3,413	Conversion factor: Btu per kWh
100,000	Conversion factor: Btu per therm

Table IV-7
Average Annual Incoming Water Temperature in New York

City	Average Annual Outdoor Temperature (°F)	Temperature of Water Mains (°F)
Albany	48.2	54.2
Binghamton	46.9	52.9
Buffalo	48.3	54.3
Massena	44.7	50.7
Syracuse	48.6	54.6
Upstate Average	47.3	53.3
New York City	56.5	62.5

D. Drain Water Heat Recovery System (GFX) Installation

Contractors have not installed this measure, as it is difficult to find opportunities. However, the utilities would like to encourage contractors to install GFX.

The New Jersey Clean Energy Program has assumed a constant savings per installed drain water heat recovery unit in a household with an electric water heater and a percentage savings for drain water heat recovery installation in a home with a gas hot water heater.

- Electric Savings = 1,457 kWh
- Gas Savings = Baseline gas water heater usage * .30

The formula below is from the Minnesota Technical Reference Manual from 2014.[6]

$$\frac{Unit\ kWh\ savings}{year} = \left(\frac{Energy\ to\ heat\ water}{Eff}\right) \times \left(\frac{Savings\ factor}{Conversion\ factor}\right)$$

[6]Minnesota Department of Commerce. "State of Minnesota Technical Reference Manual for Energy Conservation Improvement Programs Version 1.0." Effective January 1-December 31, 2014. Pages 212-213. Savings factor – Drain pipe heat exchange savings estimates are based on study findings reported in a communication from J. J. Tomlinson, Oak Ridge Buildings Technology Center, to Marc LaFrance, DOE Appliance and Emerging Technology Center, DOE, August 24, 2000, suggesting 25 to 30% of water heating consumption savings potential. The lower end of the savings scale was chosen for this report, assuming ideal installation for the study. From: Minnesota Department of Commerce. "State of Minnesota Technical Reference Manual for Energy Conservation Improvement Programs Version 1.0." Effective January 1-December 31, 2014. Page 214.

$$\frac{Unit\ Dth\ savings}{year} = \left(\frac{Energy\ to\ heat\ water}{Eff}\right) \times \left(\frac{Savings\ factor}{Conversion\ factor}\right)$$

$$Energy\ to\ heat\ water = Specific\ heat \times Density \times \frac{Gal}{Day} \times \frac{365.25\ Days}{Year} \times (T_{set} - T_{cold})$$

Table IV-8
Definitions and Values for GFX Installation

Term	Definition
Gal/day	Average gallons per day of hot water (Table IV-9)
T_{set}	Water heater temperature setting
T_{cold}	Average groundwater temperature
0.25	Savings factor
Eff	Energy factor of water heater
1.0	Conversion factor: specific heat of water (Btu/lb.-°F)
8.34	Conversion factor: density of water (lbs./gallon)
365.25	Conversion factor: days per year
3,412	Conversion factor (electric) Btu per kWh
1,000,000	Conversion factor (gas) Btu per Dth

Table IV-9
Daily Hot Water Usage by Building Type

Building Type	Daily Gal/Person*	Number of People**	Total Daily Hot Water Use (Gal/day)
Single-family	20.4	2.59	52.7
Multi-family	18.7	2.17	40.5

*Interpolated values from Table 38, Ohio Technical Reference Manual. October 15, 2009. Page 52.
**U.S. Census Bureau, *Selected Housing Characteristics 2010 American Community Survey 1-Year Estimates* for the state of Minnesota.

E. Heat Pump Water Heaters[7]

The New Jersey Clean Energy Program has assumed a constant savings per installed heat pump water heater.

- Electric Savings = 2,662 kWh

[7]Assumption taken from: Residential Water Heaters Technical Support Document for the January 17, 2001, Finale Rule Table 9.3.9, pp. 9-34, http://www1.eere.energy.gov/buildings/appliance_standards/residential/pdfs/09.pdf. Consistent with FEMP study: Field Testing of Pre-Production Prototype Residential Heat Pump Water Heaters, http://www1.eere.energy.gov/femp/pdfs/tir_heatpump.pdf.

Savings from New York's 2013 Technical Resource Manual are as follows[8,9]

$$\Delta kWh = units \times \left(\frac{GPD \times 365 \times 8.33 \times \overline{\Delta T_w}}{3{,}413}\right) \times \left(\frac{1}{EF_{base}} - \frac{1}{EF_{ee}}\right)$$

For electric water heaters:

$$EF_{base} = 0.93 - (0.00132 \times Volume)$$

For gas water heaters:

$$EF_{base} = 0.62 - (0.0019 \times Volume)$$

Table IV-10
Definitions and Values for Heat Pump Water Heaters

Term	Definition	Value
ΔkWh	Gross annual energy savings	
GPD	Gallons hot water per day	78 (see Table IV-11)
Units	Number of high efficiency water heaters installed under the program	
ΔT_w	Average difference between cold inlet temperature and hot water delivery temperature (T_{set} – T_{main}) (°F)	65°F
T_{set}	Hot water delivery temperature (°F)	130°F
T_{main}	Water mains temperature (cold inlet) (°F)	65°F (see Table IV-12)
EF_{base}	Baseline water heater energy factor	
EF_{ee}	Efficient water heater energy factor	2.2
365	Conversion factor: days per year	
8.33	Conversion factor: Btu per gallon-°F	
3,413	Conversion factor: Btu per kWH	

*Default value for family of four.
**Default value.

Table IV-11
Hot Water Use by Family Size in New York[10]

Number of people	Gal/person-day	Gal/day-household
1	29.4	29
2	22.8	46
3	20.6	62

[8] New York Evaluation Advisory Contractor Team and TecMarket Works. "New York Standard Approach for Estimating Energy Savings from Energy Efficiency Programs; Residential, Multi-Family, and Commercial/Industrial Measures." October 15, 2010. Pages 89-91.
[9] "New York Standard Approach for Estimating Energy Savings from Energy Efficiency Programs (Technical Resource Manual – TRM) Record of Revision." November 26, 2013. Pages 17-18.
[10] Average hot water use per person were taken from: Lutz, James D., Liu, Xiaomin, McMahan, James E., Dunham, Camilla, Shown, Leslie J., McCure, Quandra T; "Modeling patterns of hot water use in households;" LBL-37805 Rev. Lawrence Berkeley Laboratory, 1996.

Number of people	Gal/person-day	Gal/day-household
4	19.5	78
5	18.9	94
6	18.5	111

Table IV-12
Average Annual Incoming Water Temperature in New York[11,12]

City	Annual average outdoor temperature (°F)*	T mains (°F)**
Albany	48.2	54.2
Binghamton	46.9	52.9
Buffalo	48.3	54.3
Massena	44.7	50.7
Syracuse	48.6	54.6
Upstate average	47.3	53.5
NYC	56.5	62.5
Cold water entering temperatures (T mains) are approximately equal to the annual average outdoor temperature plus 6°F.		
Water heater set point for residential buildings is usually in the range of 120°F to 140°F.		

*Average annual outdoor temperatures were taken from the National Renewable Energy Laboratory TMY 3 long-term average weather data sets, processed with the DOE 2.2 weather data statistics package. www.nrel.gov
**Water mains temperatures were estimated from annual average temperature taken from: Burch, Jay and Craig Christensen; "Towards Development of an Algorithm for Mains Water Temperature." National Renewable Energy Laboratory.

F. Indirect Hot Water Heater

Savings from Wisconsin's 2013 Focus on Energy Deemed Savings are as follows.[13]

$$\Delta Therm = Therm_{Std} - Therm_{Eff}$$

$$Therm_{Out} = EF_{Std} \times Therm_{StdTank}$$

$$Therm_{Std} = Standby_{Std} \times 8{,}760 \times 1/100{,}000/AFUE_{Std} + Therm_{Out} \times 1/AFUE_{std}$$

$$Therm_{Eff} = Standby_{Eff} \times 8{,}760 \times 1/100{,}000/AFUE_{Eff} + Therm_{Out} \times 1/AFUE_{Eff}$$

$$Standby_{Std} = Vol_{Std} \times \left(\frac{°\mathrm{F}}{hr_{Std}}\right) \times 8.33$$

$$Standby_{Eff} = Vol_{Eff} \times \left(\frac{°\mathrm{F}}{hr_{Eff}}\right) \times 8.33$$

[11] Average annual outdoor temperatures were taken from the National Renewable Energy Laboratory TMY 3 long-term average weather data sets, processed with the DOE 2.2 weather data statistics package. www.nrel.gov
[12] Water mains temperatures were estimated from annual average temperature taken from: Burch, Jay and Craig Christensen; "Towards Development of an Algorithm for Mains Water Temperature." National Renewable Energy Laboratory.
[13] The Cadmus Group, Inc. "Final Report Focus on Energy Evaluated Deemed Savings Changes." *Prepared for the Public Service Commission of Wisconsin.* November 26, 2013. Pages 15-16.

Table IV-13
Definitions and Values for Indirect Hot Water Heaters

Term	Definition	Value
∆Therm	Gas Savings	
$Therm_{Std}$	Calculated therms standard tank	206
$Therm_{Eff}$	Calculated therms replacement tank	177.52
$Therm_{Out}$		
EF_{Std}	Federal standard energy factor	(.67 – (.0019xvolume))=.58
$Therm_{StdTank}$	Therms used by standard tank	223
$Standby_{Std}$	Standby loss from standard water heater	434 BTU/hr*
$AFUE_{Std}$	Efficiency (AFUE) of standard water heater	80%
$Standby_{Eff}$	Standby loss from efficient water heater	397 BTU/hr**
$AFUE_{Eff}$	Efficiency (AFUE) of efficient water heater	93%
Vol_{Std}	Volume of standard water heater (gallons)	63.50
Vol_{Eff}	Volume of efficient water heater (gallons)	51.20
$°F/hr_{Std}$	Heat lost per hour from standard water heater tank	0.8
$°F/hr_{Eff}$	Heat lost per hour from efficient water heater tank	0.93
	Conversion factor: density of water (lbs./gallon)	8.33

*AHRI Database. **Data model look-ups of AHRI Certifications.

G. Solar Hot Water Heater

The New Jersey Clean Energy Program has assumed a constant savings per installed solar hot water heater augmenting electric resistance DHW.

- Electric Savings = 3,100 kWh

The Pennsylvania calculation from Pennsylvania Public Utilities Commission's 2013 Technical Reference Manual is as follows.[14]

$$\Delta kWh = \frac{\left\{\left(\frac{1}{EF_{base}} - \frac{1}{EF_{proposed}}\right) \times [HW \times 365 \times 8.3 \times 1 \times (T_{hot} - T_{cold})]\right\}}{3{,}413}$$

Table IV-14
Definitions and Values for Solar Hot Water Heaters

Term	Definition	Value
EF_{Base}	Energy factor of baseline water heater	.904
$EF_{Proposed}$	Energy factor of proposed solar water heater	1.84
HW	Gallons of hot water used per day	50 gallons/day

[14]Pennsylvania Public Utility Commission. "Technical Reference Manual, State of Pennsylvania." June 2013. Pages 60-62.

Term	Definition	Value
T_{hot}	Hot water temperature	
T_{cold}	Cold water temperature	*55°F*
	Days per year	365
	Water density	8.3
	Specific heat of water (Btu/lb.*°F)	1
	Btu/kWh	3,413

H. Water Heater Pipe Insulation

The formula below is from Connecticut's 2012 program savings document.[15]

$$AKWH_W = AKW_W \times L$$

$$ACCF = ACCF_W \times L$$

Table IV-15
Definitions and Values for Water Heater Pipe Insulation

Term	Definition	Value
$AKWH_W$	Annual electric domestic hot water savings	
AKW_W	Annual electric savings per linear foot of heating	See Table IV-16
ACCF	Annual gas domestic hot water savings	
$ACCF_W$	Annual gas savings per linear foot of heating pipe insulation	See Table IV-16
L	Length of heating pipe insulation	

Table IV-16
Pipe Diameter and Energy Savings

Pipe Diameter	AKW_H (kWh/ft)	$ACCF_W$ (Ccf/ft)
0.50	10.4	0.55
0.75	15.9	0.85

I. Water Heater Tank Wrap

The formula below for electric water heaters is from Delaware's 2012 program savings document.[16]

$$\Delta kWh = KWH_{base} \times \left(\frac{EF_{new} - EF_{base}}{EF_{new}}\right)$$

[15] Connecticut Light and Power and United Illuminating. "Connecticut Program Savings Document, 8th Edition for 2013 Program Year." October 30, 2012. Pages 143-148, 241-242.
[16] Opinion Dynamics Corporation. "Delaware Technical Resource Manual, An Update to the Mid Atlantic TRM." April 30, 2012. Page 79-80.

Table IV-17
Definitions and Values for Electric Water Heater Tank Wrap

Term	Definition	Value
KWH_{base}	Average kWh consumption of electric domestic hot water tank[i]	3,460 kWh
EF_{new}	Assumed efficiency of electric tank with tank wrap installed**	0.88
EF_{base}	Assumed efficiency of electric tank without tank wrap installed**	0.86
ΔkWh	Change in kWh from installed measure	79 kWh

**The Oak Ride study predicted that wrapping a 40 gallon water heater would increase Energy Factor of a 0.86 electric DHW tank by 0.02 (to 0.88).

The formula below for electric water heaters is from Connecticut's 2012 program savings document.[17] We apply this formula to gas savings using the parameters shown in Table IV-18.

$$ABTU_W = ADHW \times \left(\frac{1}{EF_B} - \frac{1}{EF_I}\right)$$

$$ADHW = GPY \times 8.3 \times (T_{dhw} - T_{aiw})$$

Table IV-18
Definitions and Values for Gas Water Heater Tank Wrap

Term	Definition	Value
ADHW	Annual domestic hot water load	
$ABTU_W$	Annual Btu savings – water heating	
EF_B	Energy factor – baseline	0.54*
EF_I	Energy factor – insulated unit	0.56*
GPY	Annual domestic hot water usage in gallons	19,839
T_{dhw}	Domestic hot water heater set point	
T_{aiw}	Average annual incoming water temperature	
8.3	Conversion factor: lbs. per gallon of water	
ABTUw/100,000	Conversion factor to therms	

*Oak Ridge National Laboratory. "Meeting the Challenge: The Prospect of Achieving 30 Percent Energy Savings Through the Weatherization Assistance Program," May 2002. Page 25.

J. Showerheads

The following protocol is from the Ohio 2010 Technical Reference Manual.[18]

$$\Delta kWh = ISR \times (GPM_{base} - GPM_{low}) \times \left(\frac{kWh}{GPM_{reduced}}\right)$$

[17] Connecticut Light and Power and United Illuminating. "Connecticut Program Savings Document, 8th Edition for 2013 Program Year." October 30, 2012. Pages 143-148, 241-242.

[18] Vermont Energy Investment Corporation. "State of Ohio Energy Efficiency Technical Reference Manual, Including Predetermined Savings Values and Protocols for Determining Energy and Demand Savings." August 6, 2010. Pages 93-96.

$$\Delta MMBtu = ISR \times (GPM_{base} - GPM_{low}) \times \left(\frac{MMBtu}{GPM_{reduced}}\right)$$

Table IV-19
Definitions and Values for Showerheads

Term	Definition	Value
ISR	In Service Rate – Fraction of Units Installed	1.0
GPM_{base}	Gallons Per Minute of baseline showerhead	2.87
GPM_{low}	Gallons Per Minute of low flow showerhead	1.75
$kWh/GPM_{reduced}$	Assumed kWh savings per GPM reduction	149
MMBtu/GPM Reduced	Assumed MMBtu savings per GPM of reduction	0.66

K. Aerators

The following protocols are from the New York 2010 Technical Reference Manual.[19]

$$kWh\ savings = \frac{\left[water\ savings \times (temp\ faucet - temp\ to\ heater) \times \left(\frac{8.3}{3{,}413}\right)\right]}{water\ heater\ efficiency_{elec}}$$

$$therm\ savings = \frac{\left[water\ savings \times (temp\ faucet - temp\ to\ heater) \times \left(\frac{8.3}{100{,}000}\right)\right]}{water\ heater\ efficiency_{gas}}$$

$$Water\ savings = (Std_{aero} - LF_{aero}) \times \frac{duration}{use} \times \frac{\#\ uses}{day} \times \frac{days}{year}$$

Table IV-20
Definitions and Values for Aerators

Term	Definition	Value
Std_{aero}	Standard aerator GPM	2.2
LF_{aero}	Low flow aerator GPM	1.5
	Duration/use	0.5 minutes
	# uses/day	30
	Days/year	365
	Temp faucet	80°F
	Temp to heater	variable
8.3	Conversion factor: lbs. per gallon	
3,413	Conversion factor (electric): Btu per kWh	
100,000	Conversion factor (gas): Btu per Therm	

[19] New York Evaluation Advisory Contractor Team and TecMarket Works. "New York Standard Approach for Estimating Energy Savings from Energy Efficiency Programs; Residential, Multi-Family, and Commercial/Industrial Measures." October 15, 2010. Pages 94-96..

Term	Definition	Value
	Water heater $efficiency_{elec}$	0.97
	Water heater efficiencygas	0.75

L. Window Air Conditioners

The New Jersey Clean Energy Program has assumed a constant savings per replaced window air conditioner.

- Electric Savings = 56.4 kWh

The formula below is from Connecticut's 2012 program savings document.[20]

$$AKWH_{C,Retire} = EFLH \times CAP_{C,e} \times \frac{\left(\frac{1}{EER_e} - \frac{1}{EER_b}\right)}{1{,}000}$$

Table IV-21
Definitions and Values for Window Air Conditioners

Term	Definition	Value
$AKWH_{C, Retire}$	Annual electric energy savings from retiring a room a/c unit	
EFLH	Annual equivalent full load hours	272
$CAP_{C, e}$	Rated cooling capacity of (old) existing unit	
EER_e	Energy efficiency ratio of existing unit	
EER_b	Energy efficiency ratio, representing baseline NEW model	
1,000	Conversion factor: watts per KW	

M. LED Lighting (Replacement of Incandescent)

The savings from LED replacements would follow the same formula as the CFL replacement, with a different assumption for LED wattage.

Project Savings = Δ Watts/1,000 * Hours/day *365

Fixed Values
- Δ Watts = 52
- Hours/day = 2.5

Projected savings = 47.45 kWh

N. LED Night Light

The savings from LED replacements would follow the same formula as the CFL replacement, with a different assumption for LED wattage and hours of use.

Project Savings = Δ Watts/1,000 * Hours/day *365

[20] Connecticut Light and Power and United Illuminating. "Connecticut Program Savings Document, 8th Edition for 2013 Program Year." October 30, 2012. Pages 143-148, 241-242.

Fixed Values

- Standard night light = 7 watts
- LED night light = .25 watts
- Δ Watts = 6.75
- Hours/day = 24

Projected savings = 59.13 kWh

O. Smart Strips

The New Jersey Clean Energy Program has assumed a constant savings per replaced smart strip.

- Electric Savings = 102.8 kWh

The formula below is from Pennsylvania's 2013 Technical Reference Manual.[21]

$$\Delta kWh = \frac{\left[\left(kW_{comp} \times Hr_{comp}\right) + \left(kW_{TV} \times Hr_{TV}\right)\right]}{2} \times 365$$

Table IV-22
Definitions and Values for Smart Strips

Term	Definition
kW_{comp}	Idle kW of computer system
Hr_{comp}	Daily hours of computer idle time
kW_{TV}	Idle kW of TV system
Hr_{TV}	Daily hours of TV idle time

P. Solar Panels

The NJ Clean Energy Program formerly used a deemed value method for estimating savings from solar panels. This deemed value was approximately 1200 kWh/year per kW of installed capacity.

While solar photovoltaic (PV) manufacturers provide ratings for direct current (DC) power production, installers and program evaluators rely on modeling software and online calculators to provide production estimates for solar PV technology. A list of models used to estimate energy production is available in the report "Models Used to Assess the Performance of Photovoltaic Systems," by Geoffrey Klise and Joshua Stein.[22] These models include National Renewable Energy Laboratory's (NREL) PVWatts calculator[23] and RETScreen International's software suite[24].

[21] Pennsylvania Public Utility Commission. "Technical Reference Manual, State of Pennsylvania." June 2013. Pages 58-59

[22] Klise, Geoffrey T. and Joshua S. Stein. "Models Used to Assess the Performance of Photovoltaic Systems." December 2009.

[23] National Renewable Energy Laboratory. "PVWatts." 18 November 2013. Web. 14 February 2014. http://www.nrel.gov/rredc/pvwatts/.

[24] RETScreen International. "RETScreen International Home." 23 May 2014. http://www.retscreen.net/ang/home.php.

The NJ Clean Energy Program uses PVWATTS Version 1 to estimate the energy generated by photovoltaic systems. PVWATTS v.1 is available at: http://rredc.nrel.gov/solar/calculators/PVWATTS/version1/

$$Summer\ Peak\ Impact\ (kW) = Rating \times ELCC$$

$$Winter\ Peak\ Impact\ (kW) = Rating \times WELCC$$

Table IV-23
Definitions and Values for Solar Panels

Term	Definition	Value
Rating	System rated output (AC output based on DC output at Standard Rating Conditions and default DC/AC ratings)	
ELCC*	Summer effective load carrying capacity	65%
WELCC**	Winter effective load carrying capacity	8%

*Summer and winter peak impacts in PVWATTS v.1 are based on research conducted by Richard Perez of SUNY Albany (http://www.nrel.gov/ncpv/documents/pv_util.html). The estimated summer effective load carrying capacity (ELCC) for New Jersey is 60% to 70%. A value of 65% was adopted in New Jersey's protocols.
** WELCC = 8% is from monitored system data from White Plains, NY.

Data is collected for the following:

- Fixed, single or double axis tracking
- Array tilt angle (for fixed axis only)
- Array azimuth (for fixed axis only)
- Weather Data – based on closest weather station data for v.1. Four sites are used:
  1. Wilkes Barre, PA
  2. Newark, NJ
  3. Philadelphia, PA
  4. Atlantic City, NJ

The following protocol is from the National American Board of Certified Energy Practitioners.[25]

$$\frac{Production}{Year} = \frac{Peak\ Sun\ Hours}{Year} \times Total\ STC\ Rating \times System\ Factor$$

$$\frac{Peak\ Sun\ Hours}{Year} \equiv Annual\ Solar\ Irradiation$$

$$Annual\ Solar\ Irradiation = Avg.Daily\ Irradiation \times 365$$

$$Total\ STC\ Rating = \frac{W_{STC} \times Modules}{1{,}000}$$

[25]National American Board of Certified Energy Practitioners. "Photovoltaic (PV) Installer Resource Guide." March 2012. http://www.nabcep.org/wp-content/uploads/2012/08/NABCEP-PV-Installer-Resource-Guide-August-2012-v.5.3.pdf

Table IV-24
Definitions and Values for Solar Panels

Term	Definition
Peak Sun Hours	Equivalent number of hours producing power of 1,000W/m
Average Daily Irradiation	Amount of solar irradiation on panel in average day
W_{STC}	Maximum power rating of module in Watts
365	Conversion factor: days/year
1,000	Conversion factor: W/kW
System Factor	Adjustments made to the energy produced due to system

Q. Cool Roofs

An EPA article regarding cool roof technology recommends online calculators to estimate savings from this technology. The two calculators mentioned in this article are an Energy Star® Calculator and a calculator developed by the Oak Ridge National Laboratory (ORNL). Inputs for the ORNL calculator include building location, roof insulation, solar reflectance and thermal emittance.[26]

This technology was mentioned in technical reference manuals for New York, Ohio and Connecticut, but detailed equations for savings estimates were not included. A very basic equation found in New York's technical reference manual is shown below along with actual savings estimates from this manual's appendix.[27]

$$\Delta kWh = kSF_{coolroof} \times \left(\frac{\Delta kWh}{kSF}\right)$$

$$\Delta therm = kSF_{coolroof} \times \left(\frac{\Delta therm}{kSF}\right)$$

Table IV-25
Definitions and Values for Cool Roofs

Term	Definition
ΔkWh	Gross annual energy savings
kSF cool roof	Thousand square feet of cool roof installed over a cooled space
ΔkWh/kSF	Electricity consumption savings per square foot of cool roof
Δtherm/kSF	Gas consumption impact per thousand square foot of cool roof

[26] U.S. Environmental Protection Agency. "Reducing Urban Heat Islands: Compendium of Strategies, Cool Roofs." October 2008. Pages 22-24.
[27] New York Evaluation Advisory Contractor Team and TecMarket Works. "New York Standard Approach for Estimating Energy Savings from Energy Efficiency Programs; Residential, Multi-Family, and Commercial/Industrial Measures." October 15, 2010. Pages 127-128.

Table IV-26
Savings Estimates for a Small Office Building in New York State

City	kWh/1000 Sq ft. Roof	kW/unit	Therm/unit
Albany	151	0.128	12.0
Binghamton	128	0.128	11.5
Buffalo	130	0.128	11.0
Massena	152	0.128	14.0
NYC	169	0.128	8.0
Poughkeepsie	164	0.128	10.0
Syracuse	157	0.128	14.0

V. Engineering Estimates

This section provides engineering estimates for new protocols when participants have implemented these measures and input data are available.

Table V-1
Engineering Estimates for Electric Savings

Measure	Observations	NJ Protocol Savings	Other Protocol Savings
Hot Water Heater Replacement*	59	--	1,001 kWh
GFX**	0	1,457 kWh	817 kWh
Heat Pump Water Heater***	0	2,662 kWh	2,943 kWh
Solar Water Heater****	0	3,100 kWh	1,748 kWh
Water Heater Pipe Insulation[#]	84	--	73 kWh
Water Heater Tank Wrap	53	--	79 kWh
Showerheads	125	--	167 kWh
Aerators[##]	7	--	168 kWh
Window Air Conditioners[###]	28	56 kWh	68 kWh
LED Lighting	0	--	47 kWh
LED Night Lights	0	--	59 kWh
Smart Strips	0	--	--
Solar Panels	0	--	--

Measure	Observations	NJ Protocol Savings	Other Protocol Savings
Cool Roofs	0	--	--

*Hot Water Heater Replacement Efficiency fixed at 95%, hot water temperature fixed at 130° F, cold water temperature fixed at 62.5° F. (NYC water main temperature from Table IV-7). GPD fixed at 78 (per table IV-11)
**GFX: GPD calculated as 0.7*(Single Family Value) + 0.3*(Multi Family Value) = 46.6 (per table IV-9) 70% of treatment group was Single Family. Energy Factor of Water Heater fixed at 0.904
***Heat Pump Water Heater: Baseline Water Heater Energy Factor fixed at 0.904.
****Solar Water Heater: hot water temperature fixed at 130° F.
#Water Heater Pipe Insulation: averaged electric savings per foot of pipe insulation between values for pipe diameter of 0.5 and 0.75 inches. Feet of insulation installed capped at 6 feet.
##Aerator: temp to heater fixed at 62.5° F (NYC water main temperature from Table IV-7)
###Window AC: EER of old unit fixed at 8 & EER of new unit fixed at 10. Capacity fixed at 10,000 Btu

Table V-2
Engineering Estimates for Gas Savings

Measure	Observations	NJ Protocol Savings	Other Protocol Savings
Combined Gas Boiler and Water Heater*	0	--	25.94 therms
HVAC Repairs	2	--	0.56 therms
Hot Water Heater Replacement**	315	8.55 therms	12.63 therms
GFX***	0	--	31.51 therms
Indirect Water Heater	0	--	32 therms
Water Heater Pipe Insulation#	1,032	--	3.88 therms
Water Heater Tank Wrap##	492	--	7.35 therms
Showerheads	1,036	--	7.39 therms
Aerators###	19	--	7.42 therms
Solar Panels	0	--	--
Cool Roofs	0	--	--

*Combined Gas Boiler & Water Heater: SF fixed at median for treatment group square footage (1,200). HF fixed at 38,700, based on median home age of 55. Existing efficiency fixed at 80%.
**Hot Water Heater Replacement Efficiency fixed at 65%. Maximum of 65% efficiency imposed for old unit. Hot water temperature fixed at 130° F. Cold water temperature fixed at 62.5° F. (NYC water main temperature from Table IV-7). GPD fixed at 78 (per table IV-11).
***GFX: GPD calculated as 0.7*(Single Family Value) + 0.3*(Multi Family Value) = 46.6 (per table IV-9). 70% of treatment group was Single Family. Energy Factor of Water Heater fixed at 0.8.
****Water Heater Pipe Insulation: averaged gas savings per foot of pipe insulation between values for pipe diameter of 0.5 and 0.75 inches
#Water Heater Pipe Insulation: Feet of insulation installed capped at 6.
##Hot Water Heater Tank Wrap: hot water temperature fixed at 130° F. Cold water temperature fixed at 62.5° F. (NYC water main temperature from Table IV-7)
###Aerator: temp to heater fixed at 62.5° F (NYC water main temperature from Table IV-7).

VI. Summary

This memo provided an analysis of current NJ Comfort Partners Energy Saving Protocols, made recommendations for changes to some of the protocols, and provided additional protocols for measures that are not currently included or are being considered for addition.

Checks of the Energy Saving Protocol calculations found that almost all of the savings data in the NJ CP Tracking database matched the specifications provided in the documentation. The one exception was the furnace and boiler replacements.

The following key changes were recommended.

- Refrigerator Removal – The savings from additional refrigerator removal should be calculated.

- Hot Water Measures – The savings from individual measures should be calculated rather than including savings for a standard package of measures.

- Shell Measures – The spending thresholds for applying percentage savings should be increased for air sealing and insulation. The percentage savings applied should be lowered for duct sealing and insulation.

- HVAC Replacement and Repairs – Savings for replacement and repairs should be calculated separately.

Additional protocols were recommended for the following measures.

- Combined Gas Boiler and Water Heater
- Gas Heating System Repair
- Hot Water Heater Replacements
- Drain Water Heat Recovery System (GFX)
- Heat Pump Water Heaters
- Indirect Hot Water Heaters
- Solar Hot Water Heaters
- Water Heater Pipe Insulation
- Water Heater Tank Wrap
- Showerheads
- Aerators
- Window Air Conditioners
- LED Lighting (Incandescent Replacement)
- LED Night Lights
- Smart Strips
- Solar Panels
- Cool Roofs

Engineering estimates were provided for these protocols where input data were available or default values could be used.