# II. Residential Market Sector

## Residential ENERGY STAR Compact Fluorescent Lamp (CFL) (Time of Sale)

**Official Measure Code (Measure Number: X-X-X-X (Efficient Products, Lighting End Use)**

**Description**
A low wattage ENERGY STAR qualified compact fluorescent screw-in bulb (CFL) is purchased through a retail outlet in place of an incandescent screw-in bulb. The incremental cost of the CFL compared to the incandescent light bulb is offset via either rebate coupons or via upstream markdowns. Assumptions are based on a time of sale purchase, not as a retrofit or direct install installation.
This characterization assumes that the CFL is installed in a residential location. Where the implementation strategy does not allow for the installation location to be known and absent verifiable evaluation data to support an appropriate residential v commercial split, it is recommended to use this residential characterization for all purchases to be appropriately conservative in savings assumptions.

**Definition of Efficient Equipment**
In order for this characterization to apply, the high-efficiency equipment must be a standard ENERGY STAR qualified compact fluorescent lamp.

**Definition of Baseline Equipment**
In order for this characterization to apply, the baseline equipment is assumed to be an incandescent light bulb.

**Deemed Calculation for this Measure**

Annual kWh Savings $= (CFL_{Watts} * 3.25) * 0.957$

Summer Coincident Peak kW Savings $= (CFL_{Watts} * 3.25) * 0.000114$

Annual MMBtu Increase $= (CFL_{Watts} * 3.25) * 0.001908$

Note: the delta watts multiplier of 3.25 will be adjusted in accordance with table presented below:

| CFL Wattage | Delta Watts Multiplier[2] | | | |
|---|---|---|---|---|
| | 2009 - 2011 | 2012 | 2013 | 2014 and Beyond |
| 15 or less | 3.25 | 3.25 | 3.25 | 2.05 |
| 16-20 | 3.25 | 3.25 | 2.00 | 2.00 |
| 21W+ | 3.25 | 2.06 | 2.06 | 2.06 |

Adjustment to annual savings within life of measure:

| CFL Wattage | Savings as Percentage of Base Year Savings | | | |
|---|---|---|---|---|
| | 2009 - 2011 | 2012 | 2013 | 2014 and Beyond |
| 15 or less | 100% | 100% | 100% | 63% |

[2] Calculated by finding the new delta watts after incandescent bulb wattage reduced (from 100W to 72W in 2012, 75W to 53W in 2013 and 60W to 43W in 2014).

| CFL Wattage | Savings as Percentage of Base Year Savings | | | |
|---|---|---|---|---|
| | 2009 - 2011 | 2012 | 2013 | 2014 and Beyond |
| 16-20 | 100% | 100% | 62% | 62% |
| 21W+ | 100% | 63% | 63% | 63% |

**Deemed Lifetime of Efficient Equipment**
The expected lifetime of the measure is 9.18 years[3].

**Deemed Measure Cost**
The incremental cost for this measure is assumed to be $3[4].

**Deemed O&M Cost Adjustments**
The calculated net present value of the baseline replacement costs for CFL type and installation year are presented below:

| | NPV of baseline Replacement Costs | | | |
|---|---|---|---|---|
| CFL wattage | 2010 | 2011 | 2012 | 2013 on |
| 21W+ | $4.48 | $4.28 | $4.28 | $4.28 |
| 16-20W | $3.57 | $4.48 | $4.28 | $4.28 |
| 15W and less | $3.81 | $3.57 | $4.48 | $4.28 |

**Coincidence Factor**
The summer peak coincidence factor for this measure is 0.11[5].

## REFERENCE SECTION

**Calculation of Savings**

**Energy Savings**

$$\Delta kWh = ((\Delta Watts) / 1000) * ISR * HOURS * WHFe$$

Where:

$\Delta Watts$ = Compact Fluorescent Watts * 3.25[6]

[3] Calculated using average rated life of compact fluorescent bulbs of 8000 hours (8000/1011 = 8 years), based on average for Energy Star CFLs (http://www.energystar.gov/index.cfm?c=cfls.pr_crit_cfls), plus assuming 57% of the 20% not installed in the first year replace CFLs (based on 32 out of 56 respondents purchased as spares; Nexus Market Research, RLW Analytics, October 2004; "Impact Evaluation of the Massachusetts, Rhode Island, and Vermont 2003 Residential Lighting Programs", table 6-4). Measure life is therefore calculated as 8 + (8 * 0.57 * (0.2/0.77)) = 9.18. Note, a provision in the Energy Independence and Security Act of 2007 requires that by January 1, 2020, all lamps meet efficiency criteria of at least 45 lumens per watt, in essence making the CFL baseline. Therefore after 2011 the measure life will have to be reduced each year to account for the number of years remaining to 2020.
[4] Based on review of TRM assumptions from Vermont, New York, New Jersey and Connecticut.
[5] Nexus Market Research, RLW Analytics and GDS Associates study; "New England Residential Lighting Markdown Impact Evaluation, January 20, 2009"
[6] Average wattage of compact fluorescent from Duke Energy, June 2010; "Ohio Residential Smart Saver CFL Program" study was 15.47W, and the replacement incandescent bulb was 65.8W (note only data from responses who reported both wattage removed and wattage replaced are used). This is a ratio of 4.25 to 1, and so the delta watts is equal to the compact fluorescent bulb multiplied by 3.25.

Note: The multiplier should be adjusted according to the table below to account for the change in baseline stemming from the Energy Independence and Security Act of 2007 discussed below:

| CFL Wattage | Delta Watts Multiplier[7] | | | |
|---|---|---|---|---|
| | 2009 - 2011 | 2012 | 2013 | 2014 and Beyond |
| 15 or less | 3.25 | 3.25 | 3.25 | 2.05 |
| 16-20 | 3.25 | 3.25 | 2.00 | 2.00 |
| 21W+ | 3.25 | 2.06 | 2.06 | 2.06 |

ISR = In Service Rate or percentage of units rebated that get installed.
= 0.86[8]

HOURS = Average hours of use per year
= 1040 (2.85 hrs per day)[9]

WHFe = Waste Heat Factor for Energy to account for cooling savings from efficient lighting.
= 1.07[10]

For example, a 20watt CFL bulb installed in 2010:

$$\Delta kWh = ((20 * 3.25)/1000) * 0.86 * 1040 * 1.07$$

$$= 62.2 \text{ kWh}$$

**Baseline Adjustment**

Federal legislation stemming from the Energy Independence and Security Act of 2007 will require all general-purpose light bulbs between 40 and 100W to be approximately 30% more energy efficient than current incandescent bulbs, in essence beginning the phase out of standard incandescent bulbs[11]. In 2012 100W incandescents will no longer be manufactured, followed by restrictions on 75W in 2013 and 60W in 2014. The baseline for this measure will therefore become bulbs (improved incandescent or halogen) that meet the new standard.

To account for these new standards, the first year annual savings for this measure must be reduced for 100W equivalent bulbs (21W+ CFLs) in 2012, for 75W equivalent bulbs (16-20W CFLs) in 2013 and for 60 and 40W equivalent bulbs (15W or less CFLs) in 2014. To account for this adjustment the delta watt

[7] Calculated by finding the new delta watts after incandescent bulb wattage reduced (from 100W to 72W in 2012, 75W to 53W in 2013 and 60W to 43W in 2014).

[8] Starting with a first year ISR of 0.77 and a lifetime ISR of 0.97 from Nexus Market Research, RLW Analytics and GDS Associates study; "New England Residential Lighting Markdown Impact Evaluation. January 20, 2009", and assuming 43% of the remaining 20% not installed in the first year replace incandescents (24 out of 56 respondents not purchased as spares; Nexus Market Research, RLW Analytics, October 2004; "Impact Evaluation of the Massachusetts, Rhode Island, and Vermont 2003 Residential Lighting Programs", table 6-4). ISR is therefore calculated as 0.77 + (0.43*0.2) = 0.86.

[9] Based on weighted average daylength adjusted hours from Duke Energy, June 2010; "Ohio Residential Smart Saver CFL Program"

[10] Waste heat factor for energy to account for cooling savings from efficient lighting. The value is estimated at 1.07 (calculated as 1 + (0.64*(0.35 / 3.1)). Based on cooling loads decreasing by 35% of the lighting savings (average result from REMRate modeling of several different configurations and OH locations of homes), assuming typical cooling system operating efficiency of 3.1 COP (starting from standard assumption of SEER 11 central AC unit, converted to 10.5 EER using algorithm EER = (SEER * 0.37) + 6.43 (based on Roberts and Salcido, Architectural Energy Corporation, Feb 2008; "Peak Electric Demand Calculations in the REM/Rate Home Energy Rating Software and REM/Design Home Energy Analysis Software"), converted to COP = EER/3.412 = 3.1COP) and assuming 64% of homes have central cooling (East North Central census division from Energy Information Administration, 2005 Residential Energy Consumption Survey; http://www.eia.doe.gov/emeu/recs/recs2005/hc2005_tables/hc6airconditioningchar/pdf/tablehc12.6.pdf).

[11] http://www.gpo.gov/fdsys/pkg/BILLS-110hr6enr/pdf/BILLS-110hr6enr.pdf

multiplier is adjusted as shown above. In addition, since during the lifetime of a CFL, the baseline incandescent bulb will be replaced multiple times, the annual savings claim must be reduced within the life of the measure. For example, for 100W equivalent bulbs (21W+ CFLs) installed in 2010, the full savings (as calculated above in the Algorithm) should be claimed for the first two years, but a reduced annual savings claimed for the remainder of the measure life.

The appropriate adjustments as a percentage of the base year savings for each CFL range are provided below[12]:

| CFL Wattage | Savings as Percentage of Base Year Savings | | | |
|---|---|---|---|---|
| | 2009 - 2011 | 2012 | 2013 | 2014 and Beyond |
| 15 or less | 100% | 100% | 100% | 63% |
| 16-20 | 100% | 100% | 62% | 62% |
| 21W+ | 100% | 63% | 63% | 63% |

**Summer Coincident Peak Demand Savings**

$$\Delta kW = ((\Delta Watts)/1000) * ISR * WHFd * CF$$

Where:

WHFd = Waste Heat Factor for Demand to account for cooling savings from efficient lighting
= 1.21 [13]

CF = Summer Peak Coincidence Factor for measure
= 0.11

For example, a 20watt CFL bulb installed in 2010:

$$\Delta kW = ((20*3.25) / 1000) * 0.86 * 1.21 * 0.11$$

$$= 0.0074 \text{ kW}$$

**Fossil Fuel Impact Descriptions and Calculation**

$$\Delta MMBTU_{WH} = (((\Delta Watts)/1000) * ISR * HOURS * 0.003413 * HF) / \eta Heat$$

Where:

$\Delta MMBTU_{WH}$ = gross customer annual heating MMBTU fuel increased usage for the measure from the reduction in lighting heat.

0.003413 = conversion from kWh to MMBTU

HF = Heating Factor or percentage of light savings that must be heated

---

[12] Calculated by finding the percentage reduction in change of delta watts, for example change in 100W bulb: (72-23.5)/(100-23.5) = 63.4%

[13] Waste heat factor for demand to account for cooling savings from efficient lighting. The value is estimated at 1.21 (calculated as 1 + (0.64 / 3.1)). Based on typical cooling system operating efficiency of 3.1 COP (starting from standard assumption of SEER 11 central AC unit, converted to 10.5 EER using algorithm EER = (SEER * 0.37) + 6.43 (based on Roberts and Salcido, Architectural Energy Corporation, Feb 2008; "Peak Electric Demand Calculations in the REM/Rate Home Energy Rating Software and REM/Design Home Energy Analysis Software"), converted to COP = EER/3.412 = 3.1COP), and 64% of homes having central cooling (East North Central census division from Energy Information Administration, 2005 Residential Energy Consumption Survey).

= 0.45[14]

ηHeat = average heating system efficiency
= 0.72 [15]

For example, a 20watt CFL bulb installed in 2010:

$$\Delta MMBTU_{WH} = (((20 * 3.25)/1000) * 0.86 * 1040 * 0.003413 * 0.45) / 0.72$$

$$= 0.12 \text{ MMBtu}$$

**Deemed O&M Cost Adjustment Calculation**
In order to account for the shift in baseline due to the Federal Legislation discussed above, the levelized baseline replacement cost over the lifetime of the CFL is calculated (see CFL baseline savings shift.xls). The key assumptions used in this calculation are documented below:

| | Standard Incandescent | Efficient Incandescent |
|---|---|---|
| Replacement Cost | $0.50 | $2.00 |
| Component Life (years) (based on lamp life / assumed annual run hours) | 1[16] | 3[17] |

The calculated net present value of the baseline replacement costs for CFL type and installation year are presented below:

| CFL wattage | NPV of baseline Replacement Costs | | | |
|---|---|---|---|---|
| | 2010 | 2011 | 2012 | 2013 on |
| 21W+ | $4.48 | $4.28 | $4.28 | $4.28 |
| 16-20W | $3.57 | $4.48 | $4.28 | $4.28 |
| 15W and less | $3.81 | $3.57 | $4.48 | $4.28 |

**Version Date & Revision History**
Draft: Portfolio #
Effective date: Date TRM will become effective
End date: Date TRM will cease to be effective (or TBD)

**Referenced Documents:**
On the following page is an embedded Excel worksheet showing the calculation for the levelized annual replacement cost savings. Double click on the worksheet to open the file and review the calculations.

[14] I.e. heating loads increase by 45% of the lighting savings (average result from REMRate modeling of several different configurations and OH locations of homes).
[15] This has been estimated assuming that natural gas central furnace heating is typical for Ohio residences (65% of East North Central census division has a Natural Gas Furnace (based on Energy Information Administration, 2005 Residential Energy Consumption Survey:
http://www.eia.doe.gov/emeu/recs/recs2005/hc2005_tables/hc4spaceheating/pdf/tablehc12.4.pdf))
In 2000, 40% of furnaces purchased in Ohio were condensing (based on data from GAMA, provided to Department of Energy during the federal standard setting process for residential heating equipment). Furnaces tend to last up to 20 years and so units purchased 10 years ago provide a reasonable proxy for the current mix of furnaces in the State. Assuming typical efficiencies for condensing and non condensing furnaces and duct losses, the average heating system efficiency is estimated as follows:
$(0.4*0.92) + (0.6*0.8) * (1-0.15) = 0.72$
[16] Assumes rated life of incandescent bulb of approximately 1000 hours.
[17] VEIC best estimate of future technology.

## Calculation of O&M Impact for Baseline

| | |
|---|---|
| Measure Life | 9 |
| Real Discount Rate (RDR) | 5.00% |

| | Bulb Assumptions | |
|---|---|---|
| | Inc | Halogen |
| Component 1 Life (years) | 1 | 3 |
| Component 1 Replacement Cost | $0.50 | $2.00 |

**2010**

| | | NPV | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 21W+ | Baseline Replacement Costs | $5.21 | $0.00 | $0.50 | $2.00 | $0.00 | $0.00 | $2.00 | $0.00 | $0.00 | $2.00 |
| 16-20W | Baseline Replacement Costs | $4.15 | $0.00 | $0.50 | $0.50 | $2.00 | $0.00 | $0.00 | $2.00 | $0.00 | $0.00 |
| 15W and less | Baseline Replacement Costs | $4.43 | $0.00 | $0.50 | $0.50 | $0.50 | $2.00 | $0.00 | $0.00 | $2.00 | $0.00 |

**2011**

| | | NPV | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 21W+ | Baseline Replacement Costs | $4.97 | $0.00 | $2.00 | $0.00 | $0.00 | $2.00 | $0.00 | $0.00 | $2.00 | $0.00 |
| 16-20W | Baseline Replacement Costs | $5.21 | $0.00 | $0.50 | $2.00 | $0.00 | $0.00 | $2.00 | $0.00 | $0.00 | $2.00 |
| 15W and less | Baseline Replacement Costs | $4.15 | $0.00 | $0.50 | $0.50 | $2.00 | $0.00 | $0.00 | $2.00 | $0.00 | $0.00 |

**2012**

| | | NPV | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 21W+ | Baseline Replacement Costs | $4.97 | $0.00 | $2.00 | $0.00 | $0.00 | $2.00 | $0.00 | $0.00 | $2.00 | $0.00 |
| 16-20W | Baseline Replacement Costs | $4.97 | $0.00 | $2.00 | $0.00 | $0.00 | $2.00 | $0.00 | $0.00 | $2.00 | $0.00 |
| 15W and less | Baseline Replacement Costs | $5.21 | $0.00 | $0.50 | $2.00 | $0.00 | $0.00 | $2.00 | $0.00 | $0.00 | $2.00 |

| | NPV of baseline Replacement Costs | | | |
|---|---|---|---|---|
| CFL wattage | 2010 | 2011 | 2012 | 2013 on |
| 21W+ | $5.21 | $4.97 | $4.97 | $4.97 |
| 16-20W | $4.15 | $5.21 | $4.97 | $4.97 |
| 15W and less | $4.43 | $4.15 | $5.21 | $4.97 |

**Multiply by 0.86 ISR**

| | NPV of baseline Replacement Costs | | | |
|---|---|---|---|---|
| CFL wattage | 2010 | 2011 | 2012 | 2013 on |
| 21W+ | $4.48 | $4.28 | $4.28 | $4.28 |
| 16-20W | $3.57 | $4.48 | $4.28 | $4.28 |
| 15W and less | $3.81 | $3.57 | $4.48 | $4.28 |

# Residential Direct Install - ENERGY STAR Compact Fluorescent Lamp (CFL) (Early Replacement)

**Official Measure Code (Measure Number: X-X-X-X (Existing Homes, Lighting End Use)**

**Description**
A low wattage ENERGY STAR qualified compact fluorescent screw-in bulb is installed by an auditor, contractor or member of utility staff, in a residential location in place of an existing incandescent screw-in bulb through a Direct Install program. The characterization assumes protocols are implemented that guide installation of the bulb in to high use locations in the home. The CFL is provided at no cost to the end user.

**Definition of Efficient Equipment**
In order for this characterization to apply, the high-efficiency equipment must be an ENERGY STAR qualified compact fluorescent lamp.

**Definition of Baseline Equipment**
In order for this characterization to apply, the existing baseline equipment is assumed to be an incandescent light bulb.

**Deemed Calculation for this Measure**

Annual kWh Savings = $(CFL_{Watts} * 3.25) * 0.901$

Summer Coincident Peak kW Savings = $(CFL_{Watts} * 3.25) * 0.000108$

Annual MMBtu Increase = $(CFL_{Watts} * 3.25) * 0.0018$

Note: the delta watts multiplier of 3.25 will be adjusted in accordance with table presented below:

| CFL Wattage | Delta Watts Multiplier[18] | | | |
|---|---|---|---|---|
| | 2009 - 2011 | 2012 | 2013 | 2014 and Beyond |
| 15 or less | 3.25 | 3.25 | 3.25 | 2.05 |
| 16-20 | 3.25 | 3.25 | 2.00 | 2.00 |
| 21W+ | 3.25 | 2.06 | 2.06 | 2.06 |

Adjustment to annual savings within life of measure:

| CFL Wattage | Savings as Percentage of Base Year Savings | | | |
|---|---|---|---|---|
| | 2009 - 2011 | 2012 | 2013 | 2014 and Beyond |
| 15 or less | 100% | 100% | 100% | 63% |
| 16-20 | 100% | 100% | 62% | 62% |
| 21W+ | 100% | 63% | 63% | 63% |

**Deemed Lifetime of Efficient Equipment**
The expected lifetime of the measure is 8 years[19].

[18] Calculated by finding the new delta watts after incandescent bulb wattage reduced (from 100W to 72W in 2012, 75W to 53W in 2013 and 60W to 43W in 2014).
[19] Calculated using average rated life of compact fluorescent bulbs of 8000 hours (8000/1011 = 8 years), based on average for Energy Star CFLs (http://www.energystar.gov/index.cfm?c=cfls.pr_crit_cfls).

**Deemed Measure Cost**

The full cost for this measure should be equal to the actual cost for implementation and installation (i.e. the cost of product and the labor for its installation).

**Deemed O&M Cost Adjustments**

The calculated levelized annual replacement cost savings for CFL type and installation year are presented below:

| CFL wattage | NPV of baseline Replacement Costs | | | |
|---|---|---|---|---|
| | 2010 | 2011 | 2012 | 2013 on |
| 21W+ | $3.12 | $4.03 | $4.03 | $4.03 |
| 16-20W | $3.36 | $3.12 | $4.03 | $4.03 |
| 15W and less | $3.59 | $3.36 | $3.12 | $4.03 |

**Coincidence Factor**

The summer peak coincidence factor for this measure is 0.11[20].

**REFERENCE SECTION**

**Calculation of Savings**

**Energy Savings**

$$\Delta kWh = ((\Delta Watts) / 1000) * ISR * HOURS * WHFe$$

Where:

ΔWatts = Compact Fluorescent Watts * 3.25[21]

Note: The multiplier should be adjusted according to the table below to account for the change in baseline stemming from the Energy Independence and Security Act of 2007 discussed below:

| CFL Wattage | Delta Watts Multiplier[22] | | | |
|---|---|---|---|---|
| | 2009 - 2011 | 2012 | 2013 | 2014 and Beyond |
| 15 or less | 3.25 | 3.25 | 3.25 | 2.05 |
| 16-20 | 3.25 | 3.25 | 2.00 | 2.00 |
| 21W+ | 3.25 | 2.06 | 2.06 | 2.06 |

ISR = In Service Rate or percentage of units rebated that get installed.
= 0.81 [23]

---

Note, a provision in the Energy Independence and Security Act of 2007 requires that by January 1, 2020, all lamps meet efficiency criteria of at least 45 lumens per watt, in essence making the CFL baseline. Therefore after 2014 the measure life will have to be reduced each year to account for the number of years remaining to 2020.

[20] Nexus Market Research, RLW Analytics and GDS Associates study; "New England Residential Lighting Markdown Impact Evaluation, January 20, 2009"

[21] Average wattage of compact fluorescent from Duke Energy, June 2010; "Ohio Residential Smart Saver CFL Program" study was 15.47W, and the replacement incandescent bulb was 65.8W (note only data from responses who reported both wattage removed and wattage replaced are used). This is a ratio of 4.25 to 1, and so the delta watts is equal to the compact fluorescent bulb multiplied by 3.25.

[22] Calculated by finding the new delta watts after incandescent bulb wattage reduced (from 100W to 72W in 2012, 75W to 53W in 2013 and 60W to 43W in 2014).

HOURS = Average hours of use per year
= 1040 (2.85 hrs per day)[24]

WHFe = Waste Heat Factor for Energy to account for cooling savings from efficient lighting.
= 1.07 [25]

For example, a 20watt CFL bulb installed in 2010:

$$\Delta kWh = ((20 * 3.25) / 1000) * 0.81 * 1040 * 1.07$$

$$= 58.6 \text{ kWh}$$

**Baseline Adjustment**

Federal legislation stemming from the Energy Independence and Security Act of 2007 will require all general-purpose light bulbs between 40 and 100W to be approximately 30% more energy efficient than current incandescent bulbs, in essence beginning the phase out of standard incandescent bulbs[26]. In 2012 100W incandescents will no longer be manufactured, followed by restrictions on 75W in 2013 and 60W in 2014. The baseline for this measure will therefore become bulbs (improved incandescent or halogen) that meet the new standard.

To account for these new standards, the first year annual savings for this measure must be reduced for 100W equivalent bulbs (21W+ CFLs) in 2012, for 75W equivalent bulbs (16-20W CFLs) in 2013 and for 60 and 40W equivalent bulbs (15W or less CFLs) in 2014. To account for this adjustment the delta watt multiplier is adjusted as shown above. In addition, since during the lifetime of a CFL, the baseline incandescent bulb will be replaced multiple times, the annual savings claim must be reduced within the life of the measure. For example, for 100W equivalent bulbs (21W+ CFLs) installed in 2010, the full savings (as calculated above in the Algorithm) should be claimed for the first two years, but a reduced annual savings claimed for the remainder of the measure life.

The appropriate adjustments as a percentage of the base year savings for each CFL range are provided below[27]:

| CFL Wattage | Savings as Percentage of Base Year Savings | | | |
|---|---|---|---|---|
| | 2009 - 2011 | 2012 | 2013 | 2014 and Beyond |
| 15 or less | 100% | 100% | 100% | 63% |
| 16-20 | 100% | 100% | 62% | 62% |

---

[23] Megdal & Associates, 2003; "2002/2003 Impact Evaluation of LIPA's Clean Energy Initiative REAP Program". Note this is not adjusted upwards since those people removing bulbs after being installed in Direct Install program are likely to do so because they dislike them, not to use as replacements.

[24] Based on weighted average daylength adjusted hours from Duke Energy, June 2010; "Ohio Residential Smart Saver CFL Program"

[25] Waste heat factor for energy to account for cooling savings from efficient lighting. The value is estimated at 1.07 (calculated as 1 + (0.64*(0.35 / 3.1)). Based on cooling loads decreasing by 35% of the lighting savings (average result from REMRate modeling of several different configurations and OH locations of homes), assuming typical cooling system operating efficiency of 3.1 COP (starting from standard assumption of SEER 11 central AC unit, converted to 10.5 EER using algorithm EER = (SEER * 0.37) + 6.43 (based on Roberts and Salcido, Architectural Energy Corporation, Feb 2008; "Peak Electric Demand Calculations in the REM/Rate Home Energy Rating Software and REM/Design Home Energy Analysis Software"), converted to COP = EER/3.412 = 3.1COP) and assuming 64% of homes have central cooling (East North Central census division from Energy Information Administration, 2005 Residential Energy Consumption Survey;
http://www.eia.doe.gov/emeu/recs/recs2005/hc2005_tables/hc6airconditioningchar/pdf/tablehc12.6.pdf).

[26] http://www.gpo.gov/fdsys/pkg/BILLS-110hr6enr/pdf/BILLS-110hr6enr.pdf

[27] Calculated by finding the percentage reduction in change of delta watts, for example change in 100W bulb: (72-23.5)/(100-23.5) = 63.4%

| CFL Wattage | Savings as Percentage of Base Year Savings | | | |
|---|---|---|---|---|
| | 2009 - 2011 | 2012 | 2013 | 2014 and Beyond |
| 21W+ | 100% | 63% | 63% | 63% |

**Summer Coincident Peak Demand Savings**

$\Delta kW = ((\Delta Watts) / 1000) * ISR * WHFd * CF$

Where:

WHFd = Waste Heat Factor for Demand to account for cooling savings from efficient lighting
= 1.21 [28]

CF = Summer Peak Coincidence Factor for measure
= 0.11

For example, a 20watt CFL bulb, installed in 2010:

$\Delta kW = ((20 * 3.25) / 1000) * 0.81 * 1.21 * 0.11$

$= 0.0070\ kW$

**Fossil Fuel Impact Descriptions and Calculation**

$\Delta MMBTU_{WH} = (((\Delta Watts) / 1000) * ISR * HOURS * 0.003413 * HF) / \eta Heat$

Where:

$\Delta MMBTU_{WH}$ = gross customer annual heating MMBTU fuel increased usage for the measure from the reduction in lighting heat.

0.003413 = conversion from kWh to MMBTU

HF = Heating Factor or percentage of light savings that must be heated
= 0.45[29]

ηHeat = average heating system efficiency
= 0.72 [30]

For example, a 20watt CFL bulb, installed in 2010:

---

[28] Waste heat factor for demand to account for cooling savings from efficient lighting. The value is estimated at 1.21 (calculated as 1 + (0.64 / 3.1)). Based on typical cooling system operating efficiency of 3.1 COP (starting from standard assumption of SEER 11 central AC unit, converted to 10.5 EER using algorithm EER = (SEER * 0.37) + 6.43 (based on Roberts and Salcido, Architectural Energy Corporation, Feb 2008; "Peak Electric Demand Calculations in the REM/Rate Home Energy Rating Software and REM/Design Home Energy Analysis Software"), converted to COP = EER/3.412 = 3.1COP), and 64% of homes having central cooling (East North Central census division from Energy Information Administration, 2005 Residential Energy Consumption Survey).

[29] I.e. heating loads increase by 45% of the lighting savings (average result from REMRate modeling of several different configurations and OH locations of homes).

[30] This has been estimated assuming that natural gas central furnace heating is typical for Ohio residences (65% of East North Central census division has a Natural Gas Furnace (based on Energy Information Administration, 2005 Residential Energy Consumption Survey: http://www.eia.doe.gov/emeu/recs/recs2005/hc2005_tables/hc4spaceheating/pdf/tablehc12.4.pdf))
In 2000, 40% of furnaces purchased in Ohio were condensing (based on data from GAMA, provided to Department of Energy during the federal standard setting process). Assuming typical efficiencies for condensing and non condensing furnace and duct losses, the average heating system efficiency is estimated as follows:
(0.4*0.92) + (0.6*0.8) * (1-0.15) = 0.72

$$\Delta MMBTU_{WH} = (((20 * 3.25)/1000) * 0.81 * 1040 * 0.003413 * 0.45) / 0.72$$

$$= 0.12 \text{ MMBtu}$$

**Deemed O&M Cost Adjustment Calculation**
In order to account for the shift in baseline due to the Federal Legislation discussed above, the levelized baseline replacement cost over the lifetime of the CFL is calculated (see CFL baseline savings shift.xls). The key assumptions used in this calculation are documented below:

| | Standard Incandescent | Efficient Incandescent |
|---|---|---|
| Replacement Cost | $0.50 | $2.00 |
| Component Life (years) (based on lamp life / assumed annual run hours) | 1[31] | 3[32] |

The calculated net present value of the baseline replacement costs for CFL type and installation year are presented below:

| CFL wattage | NPV of baseline Replacement Costs | | | |
|---|---|---|---|---|
| | 2010 | 2011 | 2012 | 2013 on |
| 21W+ | $3.12 | $4.03 | $4.03 | $4.03 |
| 16-20W | $3.36 | $3.12 | $4.03 | $4.03 |
| 15W and less | $3.59 | $3.36 | $3.12 | $4.03 |

**Version Date & Revision History**
Draft: Portfolio #
Effective date: Date TRM will become effective
End date: Date TRM will cease to be effective (or TBD)

**Referenced Documents:**
On the following page is an embedded Excel worksheet showing the calculation for the levelized annual replacement cost savings. Double click on the worksheet to open the file and review the calculations.

[31] Assumes rated life of incandescent bulb of approximately 1000 hours.
[32] VEIC best estimate of future technology.

# Calculation of O&M Impact for Baseline

| | |
|---|---|
| Measure Life | 8 |
| Real Discount Rate (RDR) | 5.00% |

| Bulb Assumptions | Inc | Halogen |
|---|---|---|
| Component 1 Life (years) | 1 | 3 |
| Component 1 Replacement Cost | $0.50 | $2.00 |

**2010**

| | | NPV | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 |
|---|---|---|---|---|---|---|---|---|---|---|
| 21W+ | Baseline Replacement Costs | $3.86 | $0.00 | $0.50 | $2.00 | $0.00 | $0.00 | $2.00 | $0.00 | $0.00 |
| 16-20W | Baseline Replacement Costs | $4.15 | $0.00 | $0.50 | $0.50 | $2.00 | $0.00 | $0.00 | $2.00 | $0.00 |
| 15W and less | Baseline Replacement Costs | $4.43 | $0.00 | $0.50 | $0.50 | $0.50 | $2.00 | $0.00 | $0.00 | $2.00 |

**2011**

| | | NPV | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 |
|---|---|---|---|---|---|---|---|---|---|---|
| 21W+ | Baseline Replacement Costs | $4.97 | $0.00 | $2.00 | $0.00 | $0.00 | $2.00 | $0.00 | $0.00 | $2.00 |
| 16-20W | Baseline Replacement Costs | $3.86 | $0.00 | $0.50 | $2.00 | $0.00 | $0.00 | $2.00 | $0.00 | $0.00 |
| 15W and less | Baseline Replacement Costs | $4.15 | $0.00 | $0.50 | $0.50 | $2.00 | $0.00 | $0.00 | $2.00 | $0.00 |

**2012**

| | | NPV | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 |
|---|---|---|---|---|---|---|---|---|---|---|
| 21W+ | Baseline Replacement Costs | $4.97 | $0.00 | $2.00 | $0.00 | $0.00 | $2.00 | $0.00 | $0.00 | $2.00 |
| 16-20W | Baseline Replacement Costs | $4.97 | $0.00 | $2.00 | $0.00 | $0.00 | $2.00 | $0.00 | $0.00 | $2.00 |
| 15W and less | Baseline Replacement Costs | $3.86 | $0.00 | $0.50 | $2.00 | $0.00 | $0.00 | $2.00 | $0.00 | $0.00 |

| | NPV of baseline Replacement Costs | | | |
|---|---|---|---|---|
| CFL wattage | 2010 | 2011 | 2012 | 2013 on |
| 21W+ | $3.86 | $4.97 | $4.97 | $4.97 |
| 16-20W | $4.15 | $3.86 | $4.97 | $4.97 |
| 15W and less | $4.43 | $4.15 | $3.86 | $4.97 |

Multiply by 0.81 ISR

| | NPV of baseline Replacement Costs | | | |
|---|---|---|---|---|
| CFL wattage | 2010 | 2011 | 2012 | 2013 on |
| 21W+ | $3.12 | $4.03 | $4.03 | $4.03 |
| 16-20W | $3.36 | $3.12 | $4.03 | $4.03 |
| 15W and less | $3.59 | $3.36 | $3.12 | $4.03 |

# Refrigerator and/or Freezer Retirement (Early Retirement)

**Official Measure Code (Measure Number: X-X-X-X (Program name, End Use)**

**Description**
This measure involves the removal of an existing inefficient refrigerator or freezer from service, prior to its natural end of life (early retirement)[33]. The program should target units with an age greater than 10 years, though it is expected that the average age will be greater than 20 years based on other similar program performance. Savings are calculated for the estimated energy consumption during the remaining life of the existing unit.

**Definition of Efficient Equipment**
n/a

**Definition of Baseline Equipment**
In order for this characterization to apply, the existing inefficient unit must be in working order and be removed from service.

**Deemed Savings for this Measure**

| | Average Annual KWH Savings per unit | Average Summer Coincident Peak kW Savings per unit | Average Annual Fossil Fuel heating fuel increased usage (MMBTU) per unit | Average Annual Water savings per unit |
|---|---|---|---|---|
| Refrigerator | 1376 | 0.22 | n/a | n/a |
| Freezer | 1244 | 0.20 | n/a | n/a |

**Deemed Measure Life**
The remaining useful life of the retired unit is assumed to be 8 Years [34].

**Deemed Measure Cost**
The incremental cost for this measure will be the actual cost associated with the removal and recyling of the retired unit.

**Deemed O&M Cost Adjustments**
n/a

**Coincidence Factor**
A coincidence factor is not used to calculate peak demand savings for this measure. See discussion below.

## REFERENCE SECTION

**Calculation of Savings**

[33] This measure assumes a mix of primary and secondary units will be replaced (and the savings are reduced accordingly). By definition, the refrigerator in a household's kitchen that satisfies the majority of the household's demand for refrigeration is the primary refrigerator. One or more additional refrigerators in the household that satisfy supplemental needs for refrigeration are referred to as secondary refrigerators.
[34] KEMA "Residential refrigerator recycling ninth year retention study", 2004

**Energy Savings**

$\Delta kWh = UEC_{retired} * ISAF$

Where:

$UEC_{retired}$ = Average in situ Unit Energy Consumption of retired unit, adjusted for part use
Refrigerator = 1,619 kWh [35]
Freezer = 1,464 kWh [36]

ISAF = In Situ Adjustment Factor
= 0.85[37]

Refrigerator $\Delta kWh = 1619 * 0.85$

$= 1376$ kWh

Freezer $\Delta kWh = 1464 * 0.85$

$= 1244$ kWh

**Summer Coincident Peak Demand Savings**

$\Delta kW = (\Delta kWh/8760) * TAF * LSAF$

Where:

TAF = Temperature Adjustment Factor
= 1.30 [38]

LSAF = Load Shape Adjustment Factor
= 1.074 [39]

Refrigerator $\Delta kW = 1376/8760 * 1.30 * 1.074$

$= 0.22$ kW

Freezer $\Delta kW = 1244/8760 * 1.30 * 1.074$

$= 0.20$ kW

---

[35] Based on regression-based savings estimates and incorporating the part-use factors, from Navigant Consulting, "AEP Ohio Energy Efficiency/Demand Response Plan Year 1 (1/1/2009-12/31/2009) Program Year Evaluation Report: Appliance Recycling Program", March 9, 2010.

[36] Ibid.

[37] A recent California study suggests that in situ energy consumption of refrigerators is lower than the DOE test procedure would suggest (The Cadmus Group et al., "Residential Retrofit High Impact Measure Evaluation Report", prepared for the California Public Utilities Commission, February 8, 2010). The magnitude of the difference – estimated as 6% lower for one California utility, 11% lower for a second, and 16% lower for a third – was a function of whether the recycled appliance was a primary or secondary unit, the size of the household and climate (warmer climates show a small difference between DOE test procedure estimated consumption and actual consumption; cooler climates had lower in situ consumption levels). Ideally, such an adjustment for Ohio should be computed using Ohio program participant data. However, such a calculation has not yet been performed for Ohio. In the absence of such a calculation, a 15% downward adjustment, which is near the high end of the range found in California, is assumed to be reasonable for Ohio given its cooler climate (relative to California).

[38] Temperature adjustment factor based on Blasnik, Michael, "Measurement and Verification of Residential Refrigerator Energy Use, Final Report, 2003-2004 Metering Study", July 29, 2004 (p. 47). It assumes 64% of Ohio homes have central air conditioning.

[39] Daily load shape adjustment factor also based on Blasnik, Michael, "Measurement and Verification of Residential Refrigerator Energy Use, Final Report, 2003-2004 Metering Study", July 29, 2004 (p. 48, using the average Existing Units Summer Profile for hours ending 16 through 18)

**Fossil Fuel Impact Descriptions and Calculation**
n/a

**Water Impact Descriptions and Calculation**
n/a

**Deemed O&M Cost Adjustment Calculation**
n/a

**Version Date & Revision History**

| | |
|---|---|
| Draft: | Portfolio # |
| Effective date: | Date TRM will become effective |
| End date: | Date TRM will cease to be effective (or TBD) |

## Residential HVAC Maintenance/Tune Up (Retrofit)

**Official Measure Code (Measure Number: X-X-X-X (Program name, End Use)**

**Description**
This measure involves the measurement of refrigerant charge levels and airflow over the central air conditioning or heat pump unit coil, correction of any problems found and post-treatment re-measurement. Measurements must be performed with standard industry tools and the results tracked by the efficiency program.
Savings from this measure are developed using a reputable Wisconsin study. It is recommended that future evaluation be conducted in Ohio to generate a more locally appropriate characterization.

**Definition of Efficient Equipment**
n/a

**Definition of Baseline Equipment**
This measure assumes that the existing unit being maintained is either a residential central air conditioning unit or an air source heat pump.

**Deemed Calculation for this Measure**

Annual kWh Savings (central air conditioning) $= FLHcool * BtuH * (1/SEER_{CAC}) * 5 * 10^{-5}$

Annual kWh Savings (air source heat pump) $= (FLHcool * BtuH * (1/SEER_{ASHP}) * 5 * 10^{-5}) + (FLHheat * BtuH * (1/HSPF_{ASHP})) * 5 * 10^{-5})$

Summer Coincident Peak kW Savings $= BtuH * (1/EER)) * 1.0 * 10^{-5}$

**Deemed Lifetime of Efficient Equipment**
The measure life is assumed to be 5 years[40].

**Deemed Measure Cost**
If the implementation mechanism involves delivering and paying for the tune up service, the actual cost should be used. If however the customer is provided a rebate and the program relies on private contractors performing the work, the measure cost should be assumed to be $175[41].

**Deemed O&M Cost Adjustments**
n/a

**Coincidence Factor**
The summer peak coincidence factor for this measure is assumed to be 0.5[42].

---

[40] Measure Life Report, Residential and Commercial/Industrial Lighting and HVAC Measures, GDS Associates, June 2007.
http://www.ctsavesenergy.org/files/Measure%20Life%20Report%202007.pdf
[41] Based on personal communication with HVAC efficiency program consultant Buck Taylor or Roltay Inc., 6/21/10, who estimated the cost of tune up at $125 to $225, depending on the market and the implementation details.
[42] Based on Energy Center of Wisconsin, May 2008 metering study; "Central Air Conditioning in Wisconsin, A Compilation of Recent Field Research", p32

## REFERENCE SECTION

### Calculation of Savings

**Energy Savings**

$\Delta kWh_{Central\ AC}$ = (FLHcool * BtuH * (1/$SEER_{CAC}$))/1000 * MFe

$\Delta kWh_{Air\ Source\ Heat\ Pump}$ = ((FLHcool * BtuH * (1/$SEER_{ASHP}$))/1000 * MFe) + (FLHheat * BtuH * (1/$HSPF_{ASHP}$))/1000 * MFe)

Where:

FLHcool = Full load cooling hours
Dependent on location as below:

| Location | Run Hours[43] |
|---|---|
| Akron | 476 |
| Cincinnati | 664 |
| Cleveland | 426 |
| Columbus | 552 |
| Dayton | 631 |
| Mansfield | 474 |
| Toledo | 433 |
| Youngstown | 369 |

BtuH = Size of equipment in Btuh (note 1 ton = 12,000Btuh)
= Actual

$SEER_{CAC}$ = SEER Efficiency of existing central air conditioning unit receiving maintenence
= Actual[44]

MFe = Maintenance energy savings factor
= 0.05[45]

$SEER_{ASHP}$ = SEER Efficiency of existing air source heat pump unit receiving maintenence
= Actual [46]

FLHheat = Full load heating hours
Dependent on location as below:

| Location | Run Hours[47] |
|---|---|
| Akron | 1576 |
| Cincinnati | 1394 |
| Cleveland | 1567 |
| Columbus | 1272 |
| Dayton | 1438 |

[43] Based on Full Load Hour assumptions taken from the ENERGY STAR calculator (http://www.energystar.gov/ia/business/bulk_purchasing/bpsavings_calc/Calc_CAC.xls) and reduced by 33% due to assumption that the average air conditioning is oversized by 50% (Neme, Proctor, Nadal, 1999; "National Energy Savings Potential From Addressing Residential HVAC Installation Problems"). Note this approach results in full load hour estimates within 10% of measured estimates from the Energy Center of Wisconsin, May 2008 study; "Central Air Conditioning in Wisconsin, A Compilation of Recent Field Research."

[44] Use actual SEER rating where it is possible to measure or reasonably estimate. When unknown use SEER 10 (VEIC estimate of existing unit efficiency, based on minimum federal standard between the years of 1992 and 2006)

[45] Energy Center of Wisconsin, May 2008; "Central Air Conditioning in Wisconsin, A Compilation of Recent Field Research."

[46] Use actual SEER rating where it is possible to measure or reasonably estimate. When unknown use SEER 10 (VEIC estimate of existing unit efficiency, based on minimum federal standard between the years of 1992 and 2006)

[47] Heating EFLH extracted from simulations conducted for Duke Energy, OH Joint Utility TRM, October 2009; "Technical Reference Manual (TRM) for Ohio Senate Bill 221Energy Efficiency and Conservation Program and 09-512-GE-UNC"

| Location | Run Hours[47] |
|---|---|
| Mansfield | 1391 |
| Toledo | 1628 |

HSPFbase = Heating Season Performance Factor of existing air source heat pump unit receiving maintenence
= Actual[48]

For example, maintenance of a 3-ton, SEER 10 air conditioning unit in Cincinnati:

$\Delta kWh_{CAC}$ = (657 * 36000 * (1/10))/1000 * 0.05

= 118.3 kWh

For example, maintenance of a 3-ton, SEER 10, HSPF 6.8 air source heat pump unit in Cincinnati:

$\Delta kWh_{ASHP}$ = ((657 * 36000 * (1/10))/1000 * 0.05) + (1394 * 36000 * (1/6.8))/1000 * 0.05)

= 487.3 kWh

**Summer Coincident Peak Demand Savings**

ΔkW = BtuH * (1/EER)/1000 * MFd * CF

Where:

EER = EER Efficiency of existing unit receiving maintenence
= Calculate using Actual SEER
= (SEER * 0.9)[49]

MFd = Maintenance demand savings factor
= 0.02[50]

CF = Summer Peak Coincidence Factor for measure
= 0.5[51]

For example, maintenance of 3-ton, SEER 10 (equals EER 9.0) unit:

ΔkW = 36000 * (1/(9.0)/1000 * 0.02 * 0.5

= 0.04 kW

**Fossil Fuel Impact Descriptions and Calculation**
n/a

**Water Impact Descriptions and Calculation**
n/a

**Deemed O&M Cost Adjustment Calculation**
Conservatively not included

---

48 Use actual HSPF rating where it is possible to measure or reasonably estimate. When unknown use HSPF 6.8 (Minimum Federal Standard between 1992 and 2006).
49 If SEER is unknown, default EER would be (10 * 0.9) = 9.0. Calculation based on prior VEIC assessment of industry equipment efficiency ratings.
50 Based on June 2010 personal conversation with Scott Pigg, author of Energy Center of Wisconsin, May 2008; "Central Air Conditioning in Wisconsin, A Compilation of Recent Field Research" suggesting the average WI unit system draw of 2.8kW under peak conditions, and average peak savings of 50W.
51 Based on Energy Center of Wisconsin, May 2008 metering study; "Central Air Conditioning in Wisconsin, A Compilation of Recent Field Research", p32

**Version Date & Revision History**

| | |
|---|---|
| **Draft:** | Portfolio # |
| **Effective date:** | Date TRM will become effective |
| **End date:** | Date TRM will cease to be effective (or TBD) |

## Central Air Conditioning (Time of Sale)

**Official Measure Code (Measure Number: X-X-X-X (Program name, End Use)**

**Description**
This measure relates to the installation of a new Central Air Conditioning ducted split system meeting ENERGY STAR efficiency standards presented below. This measure could relate to the replacing of an existing unit at the end of its useful life, or the installation of a new system in an existing home (i.e. time of sale).

**Definition of Efficient Equipment**
In order for this characterization to apply, the efficient equipment is assumed to be a ducted split central air conditioning unit meeting the minimum ENERGY STAR efficiency level standards; 14.5 SEER and 12 EER.

**Definition of Baseline Equipment**
In order for this characterization to apply, the baseline equipment is assumed to be a ducted split central air conditioning unit meeting the Federal Standard efficiency level; 13 SEER and 11 EER.

**Deemed Calculation for this Measure**

Annual kWh Savings = (Hours * BtuH * (1/13 - 1/SEERee))/1000

Summer Coincident Peak kW Savings = (BtuH * (1/11 - 1/EERee))/1000 * 0.5

**Deemed Lifetime of Efficient Equipment**
The expected measure life is assumed to be 18 years [52].

**Deemed Measure Cost**
The incremental capital cost for this measure is provided below[53].

| Efficiency Level | Cost per Ton |
|---|---|
| SEER 14 | $119 |
| SEER 15 | $238 |
| SEER 16 | $357 |
| SEER 17 | $476 |
| SEER 18 | $596 |
| SEER 19 | $715 |
| SEER 20 | $834 |
| SEER 21 | $908 |

**Deemed O&M Cost Adjustments**
n/a

**Coincidence Factor**
The summer peak coincidence factor for this measure is assumed to be 0.5[54].

---

[52] Measure Life Report, Residential and Commercial/Industrial Lighting and HVAC Measures, GDS Associates, June 2007.
http://www.ctsavesenergy.org/files/Measure%20Life%20Report%202007.pdf
[53] DEER 2008 Database Technology and Measure Cost Data (www.deeresources.com)

## REFERENCE SECTION

**Calculation of Savings**

**Energy Savings**

ΔkWH = (FLHcool * BtuH * (1/SEERbase - 1/SEERee))/1000

Where:

FLHcool = Full load cooling hours
Dependent on location as below:

| Location | Run Hours[55] |
|---|---|
| Akron | 476 |
| Cincinnati | 664 |
| Cleveland | 426 |
| Columbus | 552 |
| Dayton | 631 |
| Mansfield | 474 |
| Toledo | 433 |
| Youngstown | 369 |

BtuH = Size of equipment in Btuh (note 1 ton = 12,000Btuh)
= Actual installed

SEERbase = SEER Efficiency of baseline unit
= 13 [56]

SEERee = SEER Efficiency of ENERGY STAR unit
= Actual installed

For example, a 3 ton unit with SEER rating of 14.5, in Dayton:

ΔkWH = (631 * 36000 * (1/13 – 1/14.5)) / 1000

= 180.8 kWh

**Summer Coincident Peak Demand Savings**

ΔkW = (BtuH * (1/EERbase - 1/EERee))/1000 * CF

Where:

EERbase = EER Efficiency of baseline unit
= 11 [57]

EERee = EER Efficiency of ENERGY STAR unit
= Actual installed

CF = Summer Peak Coincidence Factor for measure

[54] Based on Energy Center of Wisconsin, May 2008 metering study; "Central Air Conditioning in Wisconsin, A Compilation of Recent Field Research", p32

[55] Based on Full Load Hour assumptions taken from the ENERGY STAR calculator (http://www.energystar.gov/ia/business/bulk_purchasing/bpsavings_calc/Calc_CAC.xls) and reduced by 33% due to assumption that the average air conditioning is oversized by 50% (Neme, Proctor, Nadal, 1999; "National Energy Savings Potential From Addressing Residential HVAC Installation Problems"). Note this approach results in full load hour estimates within 10% of measured estimates from the Energy Center of Wisconsin, May 2008 study; "Central Air Conditioning in Wisconsin, A Compilation of Recent Field Research."..

[56] Minimum Federal Standard

[57] Minimum Federal Standard

$= 0.5$ [58]

For example, a 3 ton unit with EER rating of 12:

$$\Delta kW = (36000 * (1/11 - 1/12)) / 1000 * 0.5$$

$$= 0.14 \text{ kW}$$

**Fossil Fuel Impact Descriptions and Calculation**
n/a

**Water Impact Descriptions and Calculation**
n/a

**Deemed O&M Cost Adjustment Calculation**
n/a

**Version Date & Revision History**
Draft: Portfolio #
Effective date: Date TRM will become effective
End date: Date TRM will cease to be effective (or TBD)

[58] Based on Energy Center of Wisconsin, May 2008 metering study; "Central Air Conditioning in Wisconsin, A Compilation of Recent Field Research", p32

## Air Source Heat Pump (Time of Sale)

**Official Measure Code (Measure Number: X-X-X-X (Program name, End Use)**

**Description**
This measure relates to the installation of a new Air Source Heat Pump system meeting ENERGY STAR efficiency standards presented below. This measure could relate to the replacing of an existing unit at the end of its useful life, or the installation of a new system in an existing home (i.e. time of sale).

**Definition of Efficient Equipment**
In order for this characterization to apply, the efficient equipment is assumed to be an Air Source Heat Pump unit meeting the minimum ENERGY STAR efficiency level standards; 14.5 SEER, 12 EER and 8.2 HSPF.

**Definition of Baseline Equipment**
In order for this characterization to apply, the baseline equipment is assumed to be an Air Source Heat Pump unit meeting the Federal Standard efficiency level; 13 SEER and 11 EER.

**Deemed Calculation for this Measure**

Annual kWh Savings = (FLHcool * BtuH * (1/13 - 1/SEERee))/1000 + (FLHheat * BtuH * (1/7.7 – 1/HSPFee))/1000

Summer Coincident Peak kW Savings = (BtuH * (1/11 - 1/EERee))/1000 * 0.5

**Deemed Lifetime of Efficient Equipment**
The expected measure life is assumed to be 18 years [59].

**Deemed Measure Cost**
The incremental capital cost for this measure is provided below[60].

| Efficiency Level | Cost per Ton |
|---|---|
| SEER 14 | $137 |
| SEER 15 | $274 |
| SEER 16 | $411 |
| SEER 17 | $548 |
| SEER 18 | $685 |

**Deemed O&M Cost Adjustments**
n/a

**Coincidence Factor**
The summer peak coincidence factor for this measure is assumed to be 0.5[61].

---

[59] Measure Life Report, Residential and Commercial/Industrial Lighting and HVAC Measures, GDS Associates, June 2007.
http://www.ctsavesenergy.org/files/Measure%20Life%20Report%202007.pdf
[60] DEER 2008 Database Technology and Measure Cost Data (www.deeresources.com)
[61] Based on Energy Center of Wisconsin, May 2008 metering study; "Central Air Conditioning in Wisconsin, A Compilation of Recent Field Research", p32

## REFERENCE SECTION

### Calculation of Savings

**Energy Savings**

$$\Delta kWH = (FLHcool * BtuH * (1/SEERbase - 1/SEERee))/1000 + (FLHheat * BtuH * (1/HSPFbase - 1/HSPFee))/1000$$

Where:

FLHcool = Full load cooling hours

Dependent on location as below:

| Location | Run Hours[62] |
|---|---|
| Akron | 476 |
| Cincinnati | 664 |
| Cleveland | 426 |
| Columbus | 552 |
| Dayton | 631 |
| Mansfield | 474 |
| Toledo | 433 |
| Youngstown | 369 |

BtuH = Size of equipment in Btuh (note 1 ton = 12,000Btuh)
= Actual installed

SEERbase = SEER Efficiency of baseline unit
= 13 [63]

SEERee = SEER Efficiency of ENERGY STAR unit
= Actual installed

FLHheat = Full load heating hours

Dependent on location as below:

| Location | Run Hours[64] |
|---|---|
| Akron | 1576 |
| Cincinnati | 1394 |
| Cleveland | 1567 |
| Columbus | 1272 |
| Dayton | 1438 |
| Mansfield | 1391 |
| Toledo | 1628 |

HSPFbase = Heating Season Performance Factor for baseline unit
= 7.7[65]

---

[62] Based on Full Load Hour assumptions taken from the ENERGY STAR calculator (http://www.energystar.gov/ia/business/bulk_purchasing/bpsavings_calc/Calc_CAC.xls) and reduced by 33% due to assumption that the average air conditioning is oversized by 50% (Neme, Proctor, Nadal, 1999; "National Energy Savings Potential From Addressing Residential HVAC Installation Problems"). Note this approach results in full load hour estimates within 10% of measured estimates from the Energy Center of Wisconsin, May 2008 study; "Central Air Conditioning in Wisconsin, A Compilation of Recent Field Research.".

[63] Minimum Federal Standard; Federal Register, Vol. 66, No. 14, Monday, January 22, 2001/Rules and Regulations, p. 7170-7200.

[64] Heating EFLH extracted from simulations conducted for Duke Energy, OH Joint Utility TRM, October 2009; "Technical Reference Manual (TRM) for Ohio Senate Bill 221Energy Efficiency and Conservation Program and 09-512-GE-UNC"

[65] Minimum Federal Standard; Federal Register, Vol. 66, No. 14, Monday, January 22, 2001/Rules and Regulations, p. 7170-7200.

HSPFee = Heating Season Performance Factor for efficient unit
= Actual Installed

For example, a 3 ton unit with SEER rating of 14.5 and HSPF of 8.2 in Dayton:

$$\Delta kWH = (631 * 36000 * (1/13 - 1/14.5)) / 1000 + (1438 * 36000 * (1/7.7 - 1/8.2)) / 1000$$

$$= 590.7 \text{ kWh}$$

**Summer Coincident Peak Demand Savings**

$$\Delta kW = BtuH * (1/EERbase - 1/EERee))/1000 * CF$$

Where:

EERbase = EER Efficiency of baseline unit
= 11 [66]

EERee = EER Efficiency of ENERGY STAR unit
= Actual installed

CF = Summer Peak Coincidence Factor for measure
= 0.5 [67]

For example, a 3 ton unit with EER rating of 12:

$$\Delta kW = (36000 * (1/11 - 1/12)) / 1000 * 0.5$$

$$= 0.14 \text{ kW}$$

**Fossil Fuel Impact Descriptions and Calculation**
n/a

**Water Impact Descriptions and Calculation**
n/a

**Deemed O&M Cost Adjustment Calculation**
n/a

**Version Date & Revision History**

Draft: Portfolio #
Effective date: Date TRM will become effective
End date: Date TRM will cease to be effective (or TBD)

[66] Minimum Federal Standard
[67] Based on Energy Center of Wisconsin, May 2008 metering study; "Central Air Conditioning in Wisconsin, A Compilation of Recent Field Research", p32

## Attic/Roof/Ceiling Insulation (Retrofit)

**Official Measure Code** (Measure Number: X-X-X-X (Program name, End Use)

**Description**
This measure characterization is for the installation of new additional insulation in the attic/roof/ceiling of a residential building. The measure assumes that an auditor, contractor or utility staff member is on location, and will measure and record the existing and new insulation depth and type (to calculate R-values), the surface area of insulation added, and the efficiency of the heating system used in the home.

**Definition of Efficient Equipment**
The new insulation should meet any qualification criteria required for participation in the program. The new insulation R-value should include the total attic floor /roof assembly and include any existing insulation that is left in situ.

**Definition of Baseline Equipment**
The existing insulation R-value should include the total attic floor / roof assembly. An R-value of 5 should be assumed for the roof assembly plus the R-value of any existing insulation[68].

**Deemed Calculation for this Measure**

Air conditioning Savings

Annual kWh Savings = ((1/Rexist – 1/Rnew) * CDH * 0.75 * Area) / 1000 / ηCool

Summer Coincident Peak kW Savings = ΔkWh / FLHcool * 0.5

Space Heating Savings:

MMBTU Savings (fossil fuel heating)
= ((1/Rexist – 1/Rnew) * HDD * 24 * Area) / 1,000,000 / ηHeat

Annual kWh Savings (electric heating)
= (((1/Rexist – 1/Rnew) * HDD * 24 * Area) / 1,000,000 / ηHeat) * 293.1

**Deemed Lifetime of Efficient Equipment**
The measure life is assumed to be 25 years[69].

**Deemed Measure Cost**
The actual insulation installation measure cost should be used.

**Deemed O&M Cost Adjustments**
n/a

**Coincidence Factor**
The summer peak coincidence factor for this measure is assumed to be 0.5[70].

---

[68] The R-5 assumption for roof assembly is based on J.Neymark & Associates and National Renewable Energy Laboratory, June 2009; "BESTEST-EX Interim Test Procedure" p27. The attic floor and roof should be modeled as a system including solar gains and attic ventilation, and R-5 is the standard assumption for the thermal resistance of the whole attic/roof system.

[69] Measure Life Report, Residential and Commercial/Industrial Lighting and HVAC Measures, GDS Associates, June 2007.
http://www.ctsavesenergy.org/files/Measure%20Life%20Report%202007.pdf

[70] Based on Energy Center of Wisconsin, May 2008 metering study; "Central Air Conditioning in Wisconsin, A Compilation of Recent Field Research", p32

## REFERENCE SECTION

### Calculation of Savings

**Energy Savings**

ΔkWh = ((1/Rexist – 1/Rnew) * CDH * DUA * Area) / 1000 / ηCool

Where:

Rexist = existing effective whole-assembly thermal resistance value or R-value[71]
= actual recorded

Rnew = new total effective whole-assembly thermal resistance value or R-value[72]
= actual recorded

CDH = Cooling Degree Hours[73].
Dependent on location:

| Location | Cooling Degree Hours (75°F set point) |
|---|---|
| Akron | 3,986 |
| Cincinnati | 7,711 |
| Cleveland | 5,817 |
| Columbus | 4,367 |
| Dayton | 5,934 |
| Toledo | 4,401 |
| Youngtown | 3,689 |

DUA = Discretionary Use Adjustment to account for the fact that people do not always operate their air conditioning system when the outside temperature is greater than 75°F
= 0.75 [74]

Area = Square footage of insulated area
= actual recorded

ηCool = Efficiency of Air Conditioning equipment
= actual recorded

For example, insulating 1000 square feet of an attic floor from R-5 to R-30, in a Cincinnati home with AC SEER 10:

ΔkWh = ((1/Rexist – 1/Rnew) * CDH * DUA * Area) / 1000 / ηCool

= ((1/5 – 1/30) * 7711 * 0.75 * 1000) / 1000 / 10

= 96 kWh

**Summer Coincident Peak Demand Savings**

ΔkW = ΔkWh / FLHcool *CF

Where:

FLHcool = Full load cooling hours

---

[71] If uninsulated assembly assume R-5.
[72] Include the R-value for the assembly and any existing insulation remaining.
[73] Derived by summing the delta between the average outdoor temperature and the base set point of 75 degrees (above which cooling is assumed to be used) each hour of the year. Hourly temperature data obtained from TMY3 data (http://rredc.nrel.gov/solar/)
[74] Based on Energy Center of Wisconsin, May 2008 metering study; "Central Air Conditioning in Wisconsin, A Compilation of Recent Field Research", p31

Dependent on location as below:

| Location | Run Hours[75] |
|---|---|
| Akron | 476 |
| Cincinnati | 664 |
| Cleveland | 426 |
| Columbus | 552 |
| Dayton | 631 |
| Mansfield | 474 |
| Toledo | 433 |
| Youngstown | 369 |

CF = Summer Peak Coincidence Factor for measure
= 0.5 [76]

For example, insulating 1000 square feet of an attic floor from R-5 to R-30, in a Cincinnati home with AC SEER 10:

ΔkW = ΔkWh / FLHcool *CF

= 129 / 657 * 0.5

= 0.1 kW

**Space Heating Savings Calculation**

ΔMMBTU = ((1/Rexist – 1/Rnew) * HDD * 24 * Area) / 1,000,000 / ηHeat

Where:

HDD = Heating Degree Days (60° base temperature) for location[77]

| Location | Heating Degree Days (60°F base temperature) |
|---|---|
| Akron | 4,848 |
| Cincinnati | 3,853 |
| Cleveland | 4,626 |
| Columbus | 4,100 |
| Dayton | 4,430 |
| Toledo | 4,482 |
| Youngstown | 4,887 |

ηHeat = Average Net Heating System Efficiency (Equipment Efficiency * Distribution Efficiency) [78]

[75] Based on Full Load Hour assumptions taken from the ENERGY STAR calculator (http://www.energystar.gov/ia/business/bulk_purchasing/bpsavings_calc/Calc_CAC.xls) and reduced by 33% due to assumption that the average air conditioning is oversized by 50% (Neme, Proctor, Nadal, 1999; "National Energy Savings Potential From Addressing Residential HVAC Installation Problems"). Note this approach results in full load hour estimates within 10% of measured estimates from the Energy Center of Wisconsin, May 2008 study; "Central Air Conditioning in Wisconsin, A Compilation of Recent Field Research."

[76] Based on Energy Center of Wisconsin, May 2008 metering study; "Central Air Conditioning in Wisconsin, A Compilation of Recent Field Research", p32

[77] The 10 year average annual heating degree day value, using a balance point for heating equipment use of 60 degrees was calculated for each location based on data obtained from http://www.engr.udayton.edu/weather/. The 60 degree balance point is used based on personal communication with Michael Blasnik, consultant to Columbia gas in May 2010, and derived from a billing analysis of approximately 600,000 Columbia Gas residential single family customers in Ohio.

[78] The System Efficiency can be obtained either by recording the AFUE of the unit, or performing a steady state efficiency test. The Distribution Efficiency can be estimated via a visual inspection and by referring to a look up table

= actual recorded

**Note for homes with electric heat (resistance or heat pump), follow the MMBTU formula above and convert to kWh by multiplying by 293.1. For heat pumps the equipment efficiency used in the above algorithm should be the Coefficient Of Performance or COP (i.e., divide HSPF by 3.412; e.g., HSPF 7.7 is COP of 2.26).**

For example, insulating 1000 square feet of an attic floor from R-5 to R-30, in a Cincinnati home with a gas heating system with efficiency of 70%:

ΔMMBTU = ((1/Rexist – 1/Rnew) * HDD * 24 * Area) / 1,000,000 / ηHeat

= ((1/5 – 1/30) * 3,853 * 24 * 1,000) / 1,000,000 / 0.7

= 22 MMBtu

**Water Impact Descriptions and Calculation**
n/a

**Deemed O&M Cost Adjustment Calculation**
n/a

**Version Date & Revision History**
Draft: Portfolio #
Effective date: Date TRM will become effective
End date: Date TRM will cease to be effective (or TBD)

---

such as that provided by the Building Performance Institute: (http://www.bpi.org/files/pdf/DistributionEfficiencyTable-BlueSheet.pdf) or by performing duct blaster testing.
If there are more than one heating systems, the weighted (by consumption) average efficiency should be used.
If the heating system or distribution is being upgraded within a package of measures together with the insulation upgrade, the new average heating system efficiency should be used.

## ENERGY STAR Torchiere (Time of Sale)

**Official Measure Code (Measure Number: X-X-X-X (Program name, End Use)**

**Description**
A high efficiency ENERGY STAR fluorescent torchiere is purchased in place of a baseline mix of halogen and incandescent torchieres and installed in a residential setting. Assumptions are based on a time of sale purchase, not as a retrofit or direct install installation.

**Definition of Efficient Equipment**
To qualify for this measure the fluorescent torchiere must meet ENERGY STAR efficiency standards.

**Definition of Baseline Equipment**
The baseline is based on a mix of halogen and incandescent torchieres.

**Deemed Savings for this Measure**

| | Average Annual KWH Savings per unit | Average Summer Coincident Peak kW Savings per unit | Average Annual Fossil Fuel heating fuel savings (MMBTU) per unit | Average Annual Water savings per unit |
|---|---|---|---|---|
| Residential | 128.9 | 0.015 | - 0.257 | n/a |

**Deemed Lifetime of Efficient Equipment**
The lifetime of the measure is assumed to be 8 years[79].

**Deemed Measure Cost**
The incremental cost for this measure is assumed to be $5.00[80].

**Deemed O&M Cost Adjustments**
The annual O&M Cost Adjustment savings is calculated as $2.52.

**Coincidence Factor**
The summer peak coincidence factor for this measure is 0.11[81].

---

**REFERENCE SECTION**

---

**Calculation of Savings**

**Energy Savings**

$$\Delta kWH = ((\Delta Watts_{Torch} / 1000) * ISR * HOURS * WHFe$$

Where:

$\Delta Watts_{Torch}$ = Average delta watts per purchased ENERGY STAR torchiere
= 115.8 [82]

[79] Measure Life Report, Residential and Commercial/Industrial Lighting and HVAC Measures, GDS Associates, June 2007.
[80] DEER 2008 Database Technology and Measure Cost Data (www.deeresources.com) and consistent with Efficiency Vermont TRM.
[81] Nexus Market Research, RLW Analytics and GDS Associates study; "New England Residential Lighting Markdown Impact Evaluation, January 20, 2009"

ISR = In Service Rate or percentage of units rebated that get installed.
= 0.95 [83]

HOURS = Average hours of use per year
= 1095 (3.0 hrs per day)[84]

WHFe = Waste Heat Factor for Energy to account for cooling savings from efficient lighting.
= 1.07 [85]

$\Delta kWH$ = (115.8 /1000) * 0.95 * 1095 * 1.07

= 128.9 kWh

**Summer Coincident Peak Demand Savings**

$\Delta kW = (\Delta\ Watts_{Torch} / 1000) * ISR * WHFd * CF$

Where:

WHFd = Waste Heat Factor for Demand to account for cooling savings from efficient lighting
= 1.21 [86]

CF = Summer Peak Coincidence Factor for measure
= 0.11[87]

$\Delta kW$ = (115.8 /1000) * 0.95 * 1.21 * 0.11

= 0.015 kW

**Fossil Fuel Impact Descriptions and Calculation**

$\Delta MMBTU_{WH} = ((\Delta Watts_{Torch} / 1000) * ISR * HOURS * 0.003413 * HF) / \eta Heat$

---

[82] Nexus 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)

[83] Nexus Market Research, RLW Analytics "Impact Evaluation of the Massachusetts, Rhode Island, and Vermont 2003 Residential Lighting Programs" table 6-3 on p63 indicates that 86% torchieres were installed and a further 9% were to be installed. Table6-7 on p67 shows that none are purchased as spares so we assume that all are installed in first year. (http://publicservice.vermont.gov/energy/ee_files/efficiency/eval/marivtreportfinal100104.pdf)

[84] Nexus Market Research, "Impact Evaluation of the Massachusetts, Rhode Island and Vermont 2003 Residential Lighting Programs", Final Report, October 1, 2004, p. 104 (Table 9-7)

[85] Waste heat factor for energy to account for cooling savings from efficient lighting. The value is estimated at 1.07 (calculated as 1 + (0.64*(0.35 / 3.1)). Based on cooling loads decreasing by 35% of the lighting savings (average result from REMRate modeling of several different configurations and OH locations of homes), assuming typical cooling system operating efficiency of 3.1 COP (starting from standard assumption of SEER 11 central AC unit, converted to 10.5 EER using algorithm EER = (SEER * 0.37) + 6.43 (based on Roberts and Salcido, Architectural Energy Corporation, Feb 2008; "Peak Electric Demand Calculations in the REM/Rate Home Energy Rating Software and REM/Design Home Energy Analysis Software"), converted to COP = EER/3.412 = 3.1COP) and assuming 64% of homes have central cooling (East North Central census division from Energy Information Administration, 2005 Residential Energy Consumption Survey; http://www.eia.doe.gov/emeu/recs/recs2005/hc2005_tables/hc6airconditioningchar/pdf/tablehc12.6.pdf).

[86] Waste heat factor for demand to account for cooling savings from efficient lighting. The value is estimated at 1.21 (calculated as 1 + (0.64 / 3.1)). Based on typical cooling system operating efficiency of 3.1 COP (starting from standard assumption of SEER 11 central AC unit, converted to 10.5 EER using algorithm EER = (SEER * 0.37) + 6.43 (based on Roberts and Salcido, Architectural Energy Corporation, Feb 2008; "Peak Electric Demand Calculations in the REM/Rate Home Energy Rating Software and REM/Design Home Energy Analysis Software"), converted to COP = EER/3.412 = 3.1COP), and 64% of homes having central cooling (East North Central census division from Energy Information Administration, 2005 Residential Energy Consumption Survey).

[87] Nexus Market Research, RLW Analytics and GDS Associates study; "New England Residential Lighting Markdown Impact Evaluation, January 20, 2009"

Where:

$\Delta MMBTU_{WH}$ = gross customer annual heating MMBTU fuel increased usage for the measure from the reduction in lighting heat.

0.003413 = conversion from kWh to MMBTU

HF = Heating Factor or percentage of light savings that must be heated
= 0.45[88]

ηHeat = average heating system efficiency
= 0.72 [89]

$\Delta MMBTU_{WH}$ = ((115.8/1000) * 0.95 * 1095 * 0.003413 * 0.45) / 0.72

= 0.257 MMBtu

**Water Impact Descriptions and Calculation**
n/a

**Deemed O&M Cost Adjustment Calculation**
The annual O&M Cost Adjustment savings is calculated as $2.52, based on the following component costs and lifetimes[90]

| | Efficient Measure | | Baseline Measures | |
|---|---|---|---|---|
| Component | Cost | Life (yrs) | Cost | Life (yrs) |
| Lamp | $7.50 | 8.87 years[91] | $6.00 | 1.83 years[92] |

**Version Date & Revision History**
Draft: Portfolio #
Effective date: Date TRM will become effective
End date: Date TRM will cease to be effective (or TBD)

---

[88] I.e. heating loads increase by 45% of the lighting savings (average result from REMRate modeling of several different configurations and OH locations of homes),

[89] This has been estimated assuming that natural gas central furnace heating is typical for Ohio residences (65% of East North Central census division has a Natural Gas Furnace (based on Energy Information Administration, 2005 Residential Energy Consumption Survey:
http://www.eia.doe.gov/emeu/recs/recs2005/hc2005_tables/hc4spaceheating/pdf/tablehc12.4.pdf))
In 2000, 40% of furnaces purchased in Ohio were condensing (based on data from GAMA, provided to Department of Energy during the federal standard setting process). Assuming typical efficiencies for condensing and non condensing furnace and duct losses, the average heating system efficiency is estimated as follows:
(0.4*0.92) + (0.6*0.8) * (1-0.15) = 0.72

[90] Cost data derived from Efficiency Vermont TRM.

[91] Calculated using assumed average rated life of Energy Star compact fluorescent torchiere bulbs of 9710 hours (9710/1095= 8.87 years) (http://downloads.energystar.gov/bi/qplist/fixtures_prod_list.xls).

[92] Based on VEIC assumption of baseline bulb (mix of incandescent and halogen) average rated life of 2000 hours.

# Dedicated Pin Based Compact Fluorescent Lamp (CFL) Table Lamp (Time of Sale)

**Official Measure Code** (Measure Number: X-X-X-X (Efficient Products, Lighting End Use)

**Description**
A dedicated pin based low wattage compact fluorescent (CFL) table lamp is purchased through a retail outlet in place of an equivalent incandescent bulb lamp. The incremental cost of the CFL lamp compared to an incandescent lamp is offset via either rebate coupons or via upstream markdowns. Assumptions are based on a time of sale purchase, not as a retrofit or direct install installation.
This characterization assumes that the CFL is installed in a residential location.

**Definition of Efficient Equipment**
In order for this characterization to apply, the high-efficiency equipment must be dedicated pin based low wattage compact fluorescent (CFL) table lamp.

**Definition of Baseline Equipment**
The baseline equipment is an incandescent table lamp.

**Deemed Savings for this Measure**

| | Average Annual KWH Savings per unit | Average Summer Coincident Peak kW Savings per unit | Average Annual Fossil Fuel heating fuel savings (MMBTU) per unit | Average Annual Water savings per unit |
|---|---|---|---|---|
| Residential | 42.5 | 0.0061 | - 0.085 | n/a |

Adjustment to annual savings within life of measure:

| CFL Wattage | Savings as Percentage of Base Year Savings | | | |
|---|---|---|---|---|
| | 2009 - 2011 | 2012 | 2013 | 2014 and Beyond |
| 15 or less | 100% | 100% | 100% | 63% |
| 16-20 | 100% | 100% | 62% | 62% |
| 21W+ | 100% | 63% | 63% | 63% |

**Deemed Lifetime of Efficient Equipment**
The expected lifetime of the measure is 8 years[93].

**Deemed Measure Cost**
The incremental cost for this measure is assumed to be $8[94].

**Deemed O&M Cost Adjustments**
The calculated levelized annual replacement cost savings for CFL type and installation year are presented below:

[93] Measure Life Report, Residential and Commercial/Industrial Lighting and HVAC Measures, GDS Associates, June 2007.
http://www.ctsavesenergy.org/files/Measure%20Life%20Report%202007.pdf
[94] Average table lamp measure in DEER 2008 Database Technology and Measure Cost Data (www.deeresources.com).

| CFL wattage | NPV of baseline Replacement Costs | | | |
|---|---|---|---|---|
| | 2010 | 2011 | 2012 | 2013 on |
| 21W+ | $3.86 | $4.97 | $4.97 | $4.97 |
| 16-20W | $4.15 | $3.86 | $4.97 | $4.97 |
| 15W and less | $4.43 | $4.15 | $3.86 | $4.97 |

**Coincidence Factor**

The summer peak coincidence factor for this measure is 0.11[95].

## REFERENCE SECTION

**Calculation of Savings**

**Energy Savings**

$\Delta$kWh = (($\Delta$Watts) /1000) * ISR * HOURS * WHFe

Where:

$\Delta$Watts = Difference in wattage between CFL and incandescent bulb
= 45.7 [96]

ISR = In Service Rate or percentage of units rebated that get installed.
= 1.0 [97]

HOURS = Average hours of use per year
= 869 [98]

WHFe = Waste Heat Factor for Energy to account for cooling savings from efficient lighting.
= 1.07 [99]

$\Delta$kWh = (45.7 / 1000) * 1.0 * 869 * 1.07

= 42.5 kWh

**Summer Coincident Peak Demand Savings**

$\Delta$kW = (($\Delta$Watts) /1000) * ISR * WHFd * CF

Where:

[95] Nexus Market Research, RLW Analytics and GDS Associates study; "New England Residential Lighting Markdown Impact Evaluation, January 20, 2009"

[96] Based on RLW Analytics, New England Residential Lighting Markdown Impact Evaluation, January 20, 2009.

[97] VEIC is not aware of any evaluations that evaluate In Service Rates of table lamps, but feel it is appropriate to assume that those people purchasing a table lamp will install and use it.

[98] Nexus Market Research, RLW Analytics and GDS Associates study; "New England Residential Lighting Markdown Impact Evaluation, January 20, 2009", p50.

[99] Waste heat factor for energy to account for cooling savings from efficient lighting. The value is estimated at 1.07 (calculated as 1 + (0.64*(0.35 / 3.1)). Based on cooling loads decreasing by 35% of the lighting savings (average result from REMRate modeling of several different configurations and OH locations of homes), assuming typical cooling system operating efficiency of 3.1 COP (starting from standard assumption of SEER 11 central AC unit, converted to 10.5 EER using algorithm EER = (SEER * 0.37) + 6.43 (based on Roberts and Salcido, Architectural Energy Corporation, Feb 2008; "Peak Electric Demand Calculations in the REM/Rate Home Energy Rating Software and REM/Design Home Energy Analysis Software"), converted to COP = EER/3.412 = 3.1COP) and assuming 64% of homes have central cooling (East North Central census division from Energy Information Administration, 2005 Residential Energy Consumption Survey; http://www.eia.doe.gov/emeu/recs/recs2005/hc2005_tables/hc6airconditioningchar/pdf/tablehc12.6.pdf).

WHFd = Waste Heat Factor for Demand to account for cooling savings from efficient lighting
= 1.21 [100]

CF = Summer Peak Coincidence Factor for measure
= 0.11

$$\Delta kW = (45.7 / 1000) * 1.0 * 1.21 * 0.11$$

$$= 0.0061 \text{ kW}$$

**Baseline Adjustment**

Federal legislation stemming from the Energy Independence and Security Act of 2007 will require all general-purpose light bulbs between 40 and 100W to be approximately 30% more energy efficient than current incandescent bulbs, in essence beginning the phase out of standard incandescent bulbs[101]. In 2012 100W incandescents will no longer be manufactured, followed by restrictions on 75W in 2013 and 60W in 2014. The baseline for this measure will therefore become bulbs (improved incandescent or halogen) that meet the new standard.

To account for these new standards, the first year annual savings for this measure must be reduced for 100W equivalent bulbs (21W+ CFLs) in 2012, for 75W equivalent bulbs (16-20W CFLs) in 2013 and for 60 and 40W equivalent bulbs (15W or less CFLs) in 2014. To account for this adjustment the delta watt multiplier is adjusted as shown above. In addition, since during the lifetime of a CFL, the baseline incandescent bulb will be replaced multiple times, the annual savings claim must be reduced within the life of the measure. For example, for 100W equivalent bulbs (21W+ CFLs) installed in 2010, the full savings (as calculated above in the Algorithm) should be claimed for the first two years, but a reduced annual savings claimed for the remainder of the measure life.

The appropriate adjustments as a percentage of the base year savings for each CFL range are provided below[102]:

| CFL Wattage | Savings as Percentage of Base Year Savings | | | |
|---|---|---|---|---|
| | 2009 - 2011 | 2012 | 2013 | 2014 and Beyond |
| 15 or less | 100% | 100% | 100% | 63% |
| 16-20 | 100% | 100% | 62% | 62% |
| 21W+ | 100% | 63% | 63% | 63% |

**Fossil Fuel Impact Descriptions and Calculation**

$$\Delta MMBTU_{WH} = (((\Delta Watts) / 1000) * ISR * HOURS * 0.003413 * HF) / \eta Heat$$

Where:

$\Delta MMBTU_{WH}$ = gross customer annual heating MMBTU fuel increased usage for the measure from the reduction in lighting heat.

[100] Waste heat factor for demand to account for cooling savings from efficient lighting. The value is estimated at 1.21 (calculated as 1 + (0.64 / 3.1)). Based on typical cooling system operating efficiency of 3.1 COP (starting from standard assumption of SEER 11 central AC unit, converted to 10.5 EER using algorithm EER = (SEER * 0.37) + 6.43 (based on Roberts and Salcido, Architectural Energy Corporation, Feb 2008; "Peak Electric Demand Calculations in the REM/Rate Home Energy Rating Software and REM/Design Home Energy Analysis Software"), converted to COP = EER/3.412 = 3.1COP), and 64% of homes having central cooling (East North Central census division from Energy Information Administration, 2005 Residential Energy Consumption Survey).

[101] http://www.gpo.gov/fdsys/pkg/BILLS-110hr6enr/pdf/BILLS-110hr6enr.pdf

[102] Calculated by finding the percentage reduction in change of delta watts, for example change in 100W bulb: (72-23.5)/(100-23.5) = 63.4%