0.003413	= conversion from kWh to MMBTU
HF	= Heating Factor or percentage of light savings that must be heated = 0.45[103]
ηHeat	= average heating system efficiency = 0.72 [104]

$\Delta MMBTU_{WH}$ = ((45.7 / 1000) * 1.0 * 869 * 0.003413 * 0.45) / 0.72

= 0.085 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 Table Lamp 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[105]	3[106]

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+	$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

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Referenced Documents:

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

[103] 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),

[104] 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

[105] Assumes rated life of incandescent bulb of approximately 1000 hours.

[106] VEIC best estimate of future technology.

Calculation of O&M Impact for Baseline

Measure Life	8
Real Discount Rate (RD	5.00%

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

2010		Year	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		Year	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		Year	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

Ceiling Fan with ENERGY STAR Light Fixture (Time of Sale)

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

Description
This measure describes the installation of an ENERGY STAR ceiling fan that uses a high efficiency motor and contains compact fluorescent bulbs in place of a standard fan with integral incandescent bulbs.

Definition of Efficient Equipment
The efficient equipment must be an ENERGY STAR certified ceiling fan with integral CFL bulbs.

Definition of Baseline Equipment
The baseline equipment is assumed to be a standard fan with integral incandescent bulbs.

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
2010 -2013	167	0.019	- 0.33	n/a
2014 on	97	0.012	- 0.19	n/a

Adjustment to annual savings within life of measure of 58% at 2014.

Deemed Lifetime of Efficient Equipment
The measure life is assumed to be 10 years[107].

Deemed Measure Cost
The incremental cost for the ENERGY STAR ceiling fan is $86[107].

Deemed O&M Cost Adjustments
The calculated net present value of the baseline replacement costs minus the CFL replacement cost for each installation year are presented below. Note this is per fan (i.e. 3 bulbs):

NPV of baseline Replacement Costs - CFL Replacement Costs			
2010	2011	2012	2013 on
$5.82	$8.85	$8.17	$7.45

Coincidence Factor
The summer peak coincidence factor for this measure is 0.11[108].

REFERENCE SECTION

Calculation of Savings

[107] ENERGY STAR Ceiling Fan Savings Calculator (http://www.energystar.gov/ia/business/bulk_purchasing/bpsavings_calc/Ceiling_Fan_Savings_Calculator_Consumer.xls)

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

Energy Savings

$$\Delta kWh = ((\%_{low} * (LowKW_{base} - LowKW_{ee}) + \%_{med} * (MedKW_{base} - MedKW_{ee}) + \%_{high} * (HighKW_{base} - HighKW_{ee})) * HOURS_{fan}) + ((IncKW - CFLKW) * HOURS_{light} * WHFe)$$

Where [109]:

$\%_{low}$	= Percent of time on Low Speed	= 40%
$\%_{med}$	= Percent of time on Medium Speed	= 40%
$\%_{high}$	= Percent of time on High Speed	= 20%
$LowWatt_{base}$	= Low speed baseline ceiling fan wattage	= 0.0152kW
$LowWatt_{ee}$	= Low speed ENERGY STAR ceiling fan wattage	= 0.0117kW
$MedWatt_{base}$	= Medium speed baseline ceiling fan wattage	= 0.0348kW
$MedWatt_{ee}$	= Medium speed ENERGY STAR ceiling fan wattage	= 0.0314kW
$HighWatt_{base}$	= High speed baseline ceiling fan wattage	= 0.0725kW
$HighWatt_{ee}$	= High speed ENERGY STAR ceiling fan wattage	= 0.0715kW
$HOURS_{fan}$	= Typical fan operating hours (2.8/day[110], 365 days per year)	= 1022 hours
IncWatt	= Incandescent bulb kW (assumes 3 * 60W bulb)	= 0.180kW
CFLWatt	= CFL bulb kW (assumes 3 * 20W bulb)	= 0.060kW
$HOURS_{light}$	= Typical lighting operating hours (3.5/day, 365 days per year)	= 1277.5 hours
WHFe	= Waste Heat Factor for Energy to account for cooling savings from efficient lighting.	= 1.07 [111]

$$\Delta kWh = ((0.4 * (0.0152 - 0.0117) + 0.4 * (0.0348 - 0.0314) + 0.2 * (0.0725 - 0.0715)) * 1022) + ((0.18 - 0.06) * 1277.5 * 1.07)$$

$$= 167 \text{ kWh}$$

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. 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, first year annual savings for this measure must be reduced beginning in 2014. This measure assumes 60W baseline bulbs, which in 2014 will become 43W and so the annual savings beginning in 2014 should therefore be:

$$\Delta kWh = ((0.4 * (0.0152 - 0.0117) + 0.4 * (0.0348 - 0.0314) + 0.2 * (0.0725 - 0.0715)) * 1022) + ((0.129 - 0.06) * 1277.5 * 1.07)$$

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[109] All data points (unless otherwise noted) come from the ENERGY STAR Ceiling Fan Savings Calculator (http://www.energystar.gov/ia/business/bulk_purchasing/bpsavings_calc/Ceiling_Fan_Savings_Calculator_Consumer.xls)

[110] For East North Central location.

[111] 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).

= 97 kWh

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. Therefore, for bulbs installed in 2010, the full savings (167kWh) should be claimed for the first four years, but the reduced annual savings (97kWh) claimed for the remainder of the measure life. The savings adjustment is therefore equal to 97/167 = 58%.

Summer Coincident Peak Demand Savings

$$\Delta kW = (\%_{low} * (LowKW_{base} - LowKW_{ee}) + \%_{med} * (MedKW_{base} - MedKW_{ee}) + \%_{high} * (HighKW_{base} - HighKW_{ee})) + ((IncKW - CFLKW) * WHFd) * CF$$

Where:

WHFd = Waste Heat Factor for Demand to account for cooling savings from efficient lighting
= 1.21 [112]

CF = Summer Peak Coincidence Factor for measure
= 0.11

$$\Delta kW = ((0.4 * (0.0152 - 0.0117) + 0.4 * (0.0348 - 0.0314) + 0.2 * (0.0725 - 0.0715)) + ((0.18 - 0.06) * 1.21) * 0.11$$

$$\Delta kW = 0.019kW$$

After 2014, this will be reduced to:

$$\Delta kW = ((0.4 * (0.0152 - 0.0117) + 0.4 * (0.0348 - 0.0314) + 0.2 * (0.0725 - 0.0715)) + ((0.129 - 0.06) * 1.21) * 0.11$$

$$\Delta kW = 0.012kW$$

Fossil Fuel Impact Descriptions and Calculation

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

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 [113]

ηHeat = average heating system efficiency
= 0.72 [114]

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[112] 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).

[113] 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),

[114] 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))

$MMBTU_{WH}$ = (((120/1000) * 1277.5 * 0.003413 * 0.45) / 0.72

= 0.33 MMBtu

After 2014, this will be reduced to:

$MMBTU_{WH}$ = (((69/1000) * 1277.5 * 0.003413 * 0.45) / 0.72

= 0.19 MMBtu

Water Impact Descriptions and Calculation
n/a

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 Ceiling Fan 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[115]	3[116]

The calculated net present value of the baseline replacement costs minus the CFL replacement cost for each installation year are presented below. Note this is per fan (i.e. 3 bulbs):

NPV of baseline Replacement Costs - CFL Replacement Costs			
2010	2011	2012	2013 on
$5.82	$8.85	$8.17	$7.45

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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.

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

[115] Assumes rated life of incandescent bulb of approximately 1000 hours.

[116] VEIC best estimate of future technology.

Calculation of O&M Impact for Baseline

Measure Life	10
Real Discount Rate (RD	5.00%

	Bulb Assumptions		
	Inc	Halogen	CFL
Component 1 Life (years)	1	3	8
Component 1 Replacement Cost	$0.50	$2.00	$3.50

2010	Year	NPV	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
60W	Baseline Replacement Costs	$4.43	$0.00	$0.50	$0.50	$0.50	$2.00	$0.00	$0.00	$2.00	$0.00	$0.00
	CFL Replacement Costs	$2.49	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$3.50	$0.00	$0.00
	Net replacement cost	$1.94										

2011	Year	NPV	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
60W	Baseline Replacement Costs	$5.44	$0.00	$0.50	$0.50	$2.00	$0.00	$0.00	$2.00	$0.00	$0.00	$2.00
	CFL Replacement Costs	$2.49	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$3.50	$0.00	$0.00
	Net replacement cost	$2.95										

2012	Year	NPV	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
60W	Baseline Replacement Costs	$5.21	$0.00	$0.50	$2.00	$0.00	$0.00	$2.00	$0.00	$0.00	$2.00	$0.00
	CFL Replacement Costs	$2.49	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$3.50	$0.00	$0.00
	Net replacement cost	$2.72										

2013	Year	NPV	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
60W	Baseline Replacement Costs	$4.97	$0.00	$2.00	$0.00	$0.00	$2.00	$0.00	$0.00	$2.00	$0.00	$0.00
	CFL Replacement Costs	$2.49	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$3.50	$0.00	$0.00
	Net replacement cost	$2.48										

NPV of baseline Replacement Costs - CFL Replacement Costs			
2010	2011	2012	2013 on
$1.94	$2.95	$2.72	$2.48

* 3 bulbs

NPV of baseline Replacement Costs - CFL Replacement Costs			
2010	2011	2012	2013 on
$5.82	$8.85	$8.17	$7.45

Efficient Refrigerator – ENERGY STAR and CEE TIER 2 (Time of Sale)

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

Description

This measure relates to the purchase and installation of a new refrigerator meeting either ENERGY STAR or CEE TIER 2 specifications (defined as requiring >= 20% or >= 25% less energy consumption than an equivalent unit meeting federal standard requirements respectively). This is a time of sale measure characterization.

Definition of Efficient Equipment

The efficient condition is a new refrigerator meeting either the ENERGY STAR or CEE TIER 2 efficiency standards.

Definition of Baseline Equipment

The baseline condition is a new refrigerator meeting the minimum federal efficiency standard for refrigerator efficiency.

Deemed Savings for this Measure

Efficiency Level	Refrigerator Configuration	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
ENERGY STAR	Bottom Freezer	119	0.021	n/a	n/a
	Top Freezer	100	0.018		
	Side by Side	142	0.025		
CEE TIER 2	Bottom Freezer	149	0.026	n/a	n/a
	Top Freezer	124	0.022		
	Side by Side	177	0.031		

Deemed Lifetime of Efficient Equipment

The measure life is assumed to be 17 Years [117].

Deemed Measure Cost

The incremental cost for this measure is assumed to be $30[118] for an ENERGY STAR unit and $140[119] for a CEE Tier 2 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.

[117] Consistent with Efficiency Vermont and New Jersey TRMs

[118] From ENERGY STAR calculator:
http://www.energystar.gov/ia/business/bulk_purchasing/bpsavings_calc/Consumer_Residential_Refrig_Sav_Calc.xls

[119] Based on weighted average of units participating in Efficiency Vermont program and retail cost data provided in Department of Energy, "TECHNICAL REPORT: Analysis of Amended Energy Conservation Standards for Residential Refrigerator-Freezers", October 2005;
http://www1.eere.energy.gov/buildings/appliance_standards/pdfs/refrigerator_report_1.pdf

REFERENCE SECTION

Calculation of Savings

Energy Savings

$$\Delta kWh = UEC_{BASE} - UEC_{EE}$$

Where:

UEC_{BASE} = Annual Unit Energy Consumption of baseline unit [120]
- Bottom Freezer = 596 kWh
- Top Freezer = 497 kWh
- Side by Side = 706 kWh

UEC_{EE} = Annual Unit Energy Consumption of ENERGY STAR unit (20% less)
- Bottom Freezer = 477 kWh
- Top Freezer = 397 kWh
- Side by Side = 564 kWh

Or = Annual energy consumption of CEE Tier 2 unit (25% less)
- Bottom Freezer = 447 kWh
- Top Freezer = 373 kWh
- Side by Side = 529 kWh

$\Delta kWH_{ENERGY\ STAR}$
- Bottom Freezer = 596 – 477 = 119 kWh
- Top Freezer = 497 – 397 = 100 kWh
- Side by Side = 706 – 564 = 142 kWh

$\Delta kWH_{CEE\ TIER\ 2}$
- Bottom Freezer = 596 – 447 = 149 kWh
- Top Freezer = 497 – 373 = 124 kWh
- Side by Side = 706 – 529 = 177 kWh

Summer Coincident Peak Demand Savings

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

Where:

TAF = Temperature Adjustment Factor = 1.30 [121]

LSAF = Load Shape Adjustment Factor = 1.18 [122]

[120] KWh assumptions for base condition are based on the average federal standard baseline usage for the range of efficient units purchased through the Efficiency Vermont's Residential Refrigerator program during 2009.

[121] 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.

[122] 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, extrapolated by taking the

$\Delta kW_{ENERGY\ STAR}$

Bottom Freezer	= 119/8760 * 1.3 * 1.18 = 0.021 kW
Top Freezer	= 100/8760 * 1.3 * 1.18 = 0.018 kW
Side by Side	= 142/8760 * 1.3 * 1.18 = 0.025 kW

$\Delta kW_{CEE\ TIER\ 2}$

Bottom Freezer	= 149/8760 * 1.3 * 1.18 = 0.026 kW
Top Freezer	= 124/8760 * 1.3 * 1.18 = 0.022 kW
Side by Side	= 177/8760 * 1.3 * 1.18 = 0.031 kW

Fossil Fuel Impact Descriptions and Calculation
n/a

Water Impact Descriptions and Calculation
n/a

Deemed O&M Cost Adjustment Calculation
n/a

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ratio of existing summer to existing annual profile for hours ending 16 through 18, and multiplying by new annual profile).

Refrigerator Replacement (Low Income, Early Replacement)

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

Description
This measure describes the early removal of an existing inefficient refrigerator from service, prior to its natural end of life, and replacement with a new ENERGY STAR qualifying unit. This measure is suitable for a Low Income or Home Performance program. Savings are calculated for the estimated energy consumption during the remaining life of the existing unit.

Definition of Efficient Equipment
The efficient condition is a new replacement refrigerator meeting the ENERGY STAR efficiency standard (defined as requiring >= 20% less energy consumption than an equivalent unit meeting federal standard requirements).

Definition of Baseline Equipment
The baseline condition is the existing inefficient refrigerator for the remaining assumed useful life of the unit, and then for the remainder of the measure life the baseline becomes a new refrigerator meeting the minimum federal efficiency standard.

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
Remaining life of existing unit (1st 8 years)	976	0.156	n/a	n/a
Remaining measure life (next 9 years)	100	0.018	n/a	n/a

Deemed Lifetime of Efficient Equipment
The measure life is assumed to be 17 Years [123].

Deemed Lifetime of Replaced (Existing) Equipment (for early replacement measures only)
The assumed remaining useful life of the existing refrigerator being replaced is 8 Years [124].

Deemed Measure Cost
The actual measure cost for removing the existing unit and installing the new should be used.

Deemed O&M Cost Adjustments
The net present value of the deferred replacement cost (the cost associated with the replacement of the existing unit with a standard unit that would have had to have occurred in 8 years, had the existing unit not been replaced) is calculated as $490.73[125].

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

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[123] Consistent with Efficiency Vermont and New Jersey TRMs
[124] KEMA "Residential refrigerator recycling ninth year retention study", 2004
[125] Determined by calculating the Net Present Value (with a 5% discount rate) of the annuity payments from years 9 to 17 of a deferred replacement of a standard efficiency unit costing $1150 (from ENERGY STAR calculator: http://www.energystar.gov/ia/business/bulk_purchasing/bpsavings_calc/Consumer_Residential_Refrig_Sav_Calc.xls).

REFERENCE SECTION

Calculation of Savings

Energy Savings

ΔkWh for remaining life of existing unit (1st 8 years) = $UEC_{existing} - UEC_{ES}$

ΔkWh for remaining measure life (next 9 years) = $UEC_{base} - UEC_{ES}$

Where:

$UEC_{existing}$ = Unit Energy Consumption of existing refrigerator
= 1,376 kWh [126]

UEC_{ES} = Unit Energy Consumption of new Energy Star refrigerator
= 400 kWh [127]

UEC_{base} = Unit Energy Consumption of new baseline refrigerator
= 500 kWh [128]

ΔkWh for remaining life of existing unit (1st 8 years) = 1376 – 400

= 976 kWh

ΔkWh for remaining measure life (next 9 years) = 500 – 400

= 100 kWh

To incorporate this baseline shift, multiply annual savings by a Savings Adjustment of 10% after 8 years.

Summer Coincident Peak Demand Savings

ΔkW = (ΔkWh/8760) * TAF * LSAF

Where:

TAF = Temperature Adjustment Factor
= 1.30 [129]

LSAFexist = Load Shape Adjustment Factor for existing unit
= 1.074 [130]

LSAFnew = Load Shape Adjustment Factor for new unit
= 1.18 [131]

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[126] 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, and multiplied by in situ factor of 0.85 as discussed in Refrigetarot Retirement measure.

[127] Approximate average consumption of typical ENERGY STAR refrigerator; http://www.energystar.gov/index.cfm?fuseaction=refrig.display_products_excel

[128] Approximate average consumption of typical baseline refrigerator at federal standard efficiency levels; http://www.energystar.gov/index.cfm?fuseaction=refrig.display_products_excel

[129] 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.

[130] 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)

[131] 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, extrapolated by taking the

ΔkW for remaining life of existing unit (1st 8 years)	= (1376/8760 * 1.3 * 1.074) – (400/8760 * 1.3 * 1.18)
	= 0.149 kW
ΔkW for remaining measure life (next 9 years)	= 100/8760 * 1.3 * 1.18
	= 0.018 kW

Fossil Fuel Impact Descriptions and Calculation
n/a

Water Impact Descriptions and Calculation
n/a

Deemed O&M Cost Adjustment Calculation
The net present value of the deferred replacement cost (the cost associated with the replacement of the existing unit with a standard unit that would have had to have occurred in 8 years, had the existing unit not been replaced) is calculated as $490.73[132].

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ratio of existing summer to existing annual profile for hours ending 16 through 18, and multiplying by new annual profile.

[132] Determined by calculating the Net Present Value (with a 5% discount rate) of the annuity payments from years 9 to 17 of a deferred replacement of a standard efficiency unit costing $1150 (from ENERGY STAR calculator: http://www.energystar.gov/ia/business/bulk_purchasing/bpsavings_calc/Consumer_Residential_Refrig_Sav_Calc.xls).

Clothes Washer – ENERGY STAR and CEE TIER 3 (Time of Sale)

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

Description

This measure relates to the purchase (time of sale) and installation of a clothes washer exceeding either the ENERGY STAR or CEE TIER 3 minimum qualifying efficiency standards presented below:

Efficiency Level	Modified Energy Factor (MEF)	Water Factor (WF)
Federal Standard	>= 1.26	No requirement
ENERGY STAR (as of Jan 1, 2011)	>= 2.0	<= 6.0
CEE TIER 3	>= 2.20	<= 4.5

The modified energy factor (MEF) measures energy consumption of the total laundry cycle (washing and drying). It indicates how many cubic feet of laundry can be washed and dried with one kWh of electricity; the higher the number, the greater the efficiency.

The Water Factor is the number of gallons needed for each cubic foot of laundry. A lower number indicates lower consumption and more efficient use of water.

Definition of Efficient Equipment
The efficient condition is a clothes washer meeting either the ENERGY STAR or CEE TIER 3 efficiency criteria presented above.

Definition of Baseline Equipment
The baseline condition is a clothes washer at the minimum federal baseline efficiency presented above.

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 (gal) per unit
ENERGY STAR	202	0.028	0.447 (NGas), 0.02 (Oil), 0.013 (LP)	6,265
CEE TIER 3	233	0.033	0.516 (NGas), 0.023 (Oil), 0.015 (LP)	7,160

Deemed Lifetime of Efficient Equipment
The measure life is assumed to be 11 years[133].

Deemed Measure Cost
The incremental cost for this measure is assumed to be $258[134] for an ENERGY STAR unit and $372 for a CEE TIER 3 unit[135].

Deemed O&M Cost Adjustments
n/a

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[133] ENERGY STAR calculator (http://www.energystar.gov/index.cfm?fuseaction=find_a_product.showProductGroup&pgw_code=CW)
[134] ENERGY STAR calculator (as above)
[135] Based on an Efficiency Vermont market field study of incremental clothes washer cost between non-energy star and Tier 3 units, finding an average incremental cost to Tier 3 of $371.63.

Coincidence Factor
The coincidence factor for this measure is assumed to be 0.045[136].

REFERENCE SECTION

Calculation of Savings

Energy Savings

Savings are determined using Modified Energy Factor assumptions, applying the proportion of consumption used for water heating, clothes washer and clothes dryer operation and then to the mix of domestic hot water heating fuels and dryer fuels. Savings from reduced water usage are also factored in.

For the full calculation see Clothes Washer Work Sheet, but the key assumptions and their sources are provided below:

Washer Volume	= 3.23 cubic feet [137]
Baseline MEF	= 1.26
ENERGY STAR MEF	= 2.0
CEE TIER 3 MEF	= 2.2
Number of cycles per year	= 320 [138]

% energy consumption for water heating, CW operation, Dryer operation
= 26%, 7%, 67% [139]

Water savings per load [140]
ENERGY STAR = 19.6 gallons
CEE TIER 3 = 22.4 gallons

Community/Municipal Water and Wastewater pump kWh savings per gallon water saved
= 0.0039kWh per gallon of water save[141]

Ohio DHW fuel mix[142]:

Fuel	% of Homes
Electric	27%
Natural Gas	63%
Oil	6%
Propane	4%

[136] Calculated from Itron eShapes, which is 8760 hourly data by end use for Upstate New York and adjusted for OH peak definitions.
[137] Average unit size from Efficiency Vermont program.
[138] Weighted average of 2005 Residential Energy Consumption Survey (RECS) for East North Central Census Division:
(http://www.eia.doe.gov/emeu/recs/recs2005/hc2005_tables/hc10homeappliaceindicators/pdf/tablehc12.10.pdf)
[139] Based on the Clothes Washer Technical Support Document, Chapter 4, Engineering Analysis, Table 4.1, Page 4-5
http://www.eere.energy.gov/buildings/appliance_standards/residential/pdfs/chapter_4_engineering.pdf
[140] Determined starting from gallons per load assumption from the ENERGY STAR calculator, dividing by water factor (gallons per cubic foot) to get cubic feet assumption and multiplying by each efficient case water factor.
[141] Efficiency Vermont analysis of Community/Municipal Water and Wastewater pump energy consumption showed 0.0024 kWh pump energy consumption per gallon of water supplied, and 0.0015 kWh consumption per gallon for waste water treatment.
[142] 2005 Residential Energy Consumption Survey (RECS) for East North Central Census Division:
(http://www.eia.doe.gov/emeu/recs/recs2005/hc2005_tables/hc8waterheating/pdf/tablehc12.8.pdf)

Ohio Dryer fuel mix[143]:

Fuel	% of Homes
Electric	66%
Natural Gas	34%

$\Delta kWH_{ENERGY\ STAR}$ = 202 kWh

$\Delta kWH_{CEE\ TIER\ 3}$ = 233 kWh

Summer Coincident Peak Demand Savings

$\Delta kW = \Delta kWh/Hours * CF$

Where:

Hours = Assumed Run hours of Clothes Washer
= 320 [144]

CF = Summer Peak Coincidence Factor for measure
= 0.033 [145]

$\Delta kW_{ENERGY\ STAR}$ = 202 / 320 * 0.045

= 0.028 kW

$\Delta kW_{CEE\ TIER\ 3}$ = 233 / 320 * 0.045

= 0.033 kW

Fossil Fuel Impact Descriptions and Calculation

For calculation see Clothes Washer Work Sheet. Savings are based on the mix of domestic hot water heating fuels and Dryer fuels.

ENERGY STAR unit:

MMBtu Savings Natural Gas	= 0.447 MMBtu
MMBtu Savings Oil	= 0.02 MMBtu
MMBtu Savings Propane	= 0.013 MMBtu

CEE TIER 3 unit:

MMBtu Savings Natural Gas	= 0.516 MMBtu
MMBtu Savings Oil	= 0.023 MMBtu
MMBtu Savings Propane	= 0.015 MMBtu

Water Impact Descriptions and Calculation

For calculation see Clothes Washer Work Sheet.

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[143] 2005 Residential Energy Consumption Survey (RECS) for East North Central Census Division: (http://www.eia.doe.gov/emeu/recs/recs2005/hc2005_tables/hc9homeappliance/pdf/tablehc12.9.pdf)

[144] Based on assumption of 1 hour average per cycle. # cycles based on weighted average of 2005 Residential Energy Consumption Survey (RECS) for East North Central Census Division (see CW Work Sheet). http://www.eia.doe.gov/emeu/recs/recs2005/hc2005_tables/hc10homeappliaceindicators/pdf/tablehc11.10.pdf

[145] Calculated from Itron eShapes, which is 8760 hourly data by end use for Upstate New York and adjusted for OH peak definitions.

ENERGY STAR unit:
Water Savings = 6,265 gallons

CEE TIER 3 unit:
Water Savings = 7,160 gallons

Deemed O&M Cost Adjustment Calculation
n/a

Reference Tables
On the following page is the embedded Clothes Washer calculation spreadsheet. Double click on the window to open the Excel worksheet and follow the formulae.

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Clothes Washer Work Sheet - ENERGY STAR and CEE TIER 3

1. Calculate kWh savings per year per machine:

kWh Savings per machine = Washer Volume* (1/BaseMEF - 1/EFFMEF) * # Cycles

ENERGY STAR	303.2
CEE TIER 3	350.1

Where:		Source:
Washer Volume	3.23	Average of Efficiency Vermont program
Base MEF	1.26	Federal Standard
ESTAR MEF	2	Energy Star minimum standard (as of Jan 1 2011)
CEE TIER 3 MEF	2.2	CEE Tier 3 Standard
# Cycles	320	Weighted average of 2005 Residential Energy Consumption Survey (RECS) for East North Central Census Division

http://www.eia.doe.gov/emeu/recs/recs2005/hc2005_tables/hc10homeappliancindicators/pdf/tablehc12.10.pdf

2. Divide savings by end use for washer and dryer operation:

Electricity Consumption by End Use for Washer/Dryer Operation	Electricity Consumption Percent by End Use	ENERGY STAR Electric	ENERGY STAR Gas	ENERGY STAR Oil	CEE TIER 3 Electric	CEE TIER 3 Gas	CEE TIER 3 Oil
Water Heating	26%	78.8	0.34	0.34	91.0	0.39	0.39
CW Machine Operation	7%	21.2	n/a	n/a	24.5	n/a	n/a
Dryer	67%	203.1	0.69	n/a	234.6	0.80	n/a
Total	100%	303.2			350.1		

Sources:
1.www.eere.energy.gov/buildings/appliance_standards/residential/clwash_0900_r.html
2.Chapter 4, Engineering Analysis, Table 4.1, Page 4-5
www.eere.energy.gov/buildings/appliance_standards/residential/pdfs/chapter_4_engineering.pdf

3. Calculate Water Pump Savings

	ENERGY STAR	CEE TIER 3		
Annual Water Savings/load	19.6	22.4	Gal	Calculated based on ENERGY STAR calculator (http://www.energystar.gov/ia/business/bulk_purchasing/bps
Annual Gallons saved	6265	7160	Gal	Calculated
Annual CCF	8.4	9.6	CCF	Calculated
Water Pump Savings	24.4	27.9	kWh	0.0039kWh savings per gallon saved - based on Efficiency Vermont analysis of community/municipal water s

4. Multiply savings by DHW and Dryer Fuel Mix

Ohio assumed DHW fuel mix

Electric	27%
Natural Gas	63%
Oil	6%
Propane	4%

Ohio assumed Dryer mix

Electric	66%
Natural Gas	34%

	ENERGY STAR	CEE TIER 3
kWh Savings	202.0	233.0
Natural Gas	0.447	0.516
Oil	0.020	0.023
LP	0.013	0.015

("other" fuel category is split proportionately between fuels)

http://www.eia.doe.gov/emeu/recs/recs2005/hc2005_tables/hc8waterheating/pdf/tablehc12.8.pdf
http://www.eia.doe.gov/emeu/recs/recs2005/hc2005_tables/hc9homeappliance/pdf/tablehc12.9.pdf

DHW Fuel	Million homes	% of homes
Electric	5.1	27%
Natural Gas	11.9	63%
Oil	1.1	6%
Propane	0.7	4%
	18.8	

Dryer Fuel	Million homes	% of homes
Electric	9.9	66%
Natural Gas	5	34%
	14.9	

ENERGY STAR Dehumidifier (Time of Sale)

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

Description
A dehumidifier meeting the minimum qualifying efficiency standard established by ENERGY STAR on 10/1/2006 is purchased and installed in a residential setting in place of a unit that meets the minimum federal standard efficiency.

Definition of Efficient Equipment
To qualify for this measure, the new dehumidifier must meet the ENERGY STAR standards as of 10/1/2006 as defined below:

Capacity (pints/day)	ENERGY STAR Criteria (L/kWh)
≤25	≥1.20
> 25 to ≤35	≥1.40
> 35 to ≤45	≥1.50
> 45 to ≤ 54	≥1.60
> 54 to ≤ 75	≥1.80
> 75 to ≤ 185	≥2.50

Definition of Baseline Equipment
The baseline for this measure is defined as a new dehumidifier that meets the Federal Standard efficiency standards as defined below:

Capacity (pints/day)	Federal Standard Criteria (L/kWh)
≤25	≥1.10
> 25 to ≤35	≥1.20
> 35 to ≤45	≥1.20
> 45 to ≤ 54	≥1.23
> 54 to ≤ 75	≥1.55
> 75 to ≤ 185	≥1.90

Deemed Savings for this Measure

Capacity Range (pints/day)	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
≤25	54	0.012	n/a	n/a
> 25 to ≤35	117	0.027		
> 35 to ≤45	213	0.048		
> 45 to ≤ 54	297	0.068		
> 54 to ≤ 75	185	0.042		
> 75 to ≤ 185	374	0.085		

Deemed Lifetime of Efficient Equipment
The assumed lifetime of the measure is 12 years[146]

Deemed Measure Cost
The assumed incremental capital cost for this measure is $45[147]

Deemed O&M Cost Adjustments
n/a

Coincidence Factor
The coincidence factor is assumed to be 0.37 [148]

REFERENCE SECTION

Calculation of Savings

Energy Savings

$$\Delta kWH = (Av\ Capacity * 0.473) / 24 * Hours / L/kWh$$

Where:

0.473 = Constant to convert Pints to Liters
Hours = Run hours per year
= 1620 [149]
L/kWh = Liters of water per kWh consumed
= As provided in tables above

Annual kWh calculation results for each capacity class presented below:

		Annual kWh		
Capacity Range	Pints/day used	ENERGY STAR	Federal Standard	Savings
≤25	22.4	596	650	54
> 25 to ≤35	30	684	802	117
> 35 to ≤45	40	851	1064	213
> 45 to ≤ 54	49.5	988	1285	297
> 54 to ≤ 75	64.5	1144	1329	185
> 75 to ≤ 185	92.8	1185	1559	374

Summer Coincident Peak Demand Savings

$$\Delta kW = \Delta kWh/Hours * CF$$

Where:

CF = Summer Peak Coincidence Factor for measure
= 0.37 [150]

[146] ENERGY STAR Dehumidifier Calculator
http://www.energystar.gov/ia/business/bulk_purchasing/bpsavings_calc/CalculatorConsumerDehumidifier.xls
[147] Based on available data from the Department of Energy's Life Cycle Cost analysis spreadsheet:
http://www1.eere.energy.gov/buildings/appliance_standards/residential/docs/lcc_dehumidifier.xls
[148] Assume usage is evenly distributed day vs night, weekend vs weekday and is used between April through the end of September (4392 possible hours). 1620 operating hours from ENERGY STAR Dehumidifier Calculator. Coincidence peak during summer peak is therefore 1620/4392 = 36.9%
[149] ENERGY STAR Dehumidifier Calculator
http://www.energystar.gov/ia/business/bulk_purchasing/bpsavings_calc/CalculatorConsumerDehumidifier.xls

Summer coincident peak demand calculation results for each capacity class presented below:

		Annual kW		
Capacity Range	Pints/day used	ENERGY STAR	Federal Standard	Savings
≤25	22.4	0.136	0.148	0.012
> 25 to ≤35	30	0.156	0.182	0.027
> 35 to ≤45	40	0.194	0.242	0.048
> 45 to ≤ 54	49.5	0.225	0.293	0.068
> 54 to ≤ 75	64.5	0.261	0.303	0.042
> 75 to ≤ 185	92.8	0.270	0.355	0.085

Fossil Fuel Impact Descriptions and Calculation
n/a

Water Impact Descriptions and Calculation
n/a

Deemed O&M Cost Adjustment Calculation
n/a

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[150] Assume usage is evenly distributed day vs night, weekend vs weekday and is used between April through the end of September (4392 possible hours). 1620 operating hours from ENERGY STAR Dehumidifier Calculator. Coincidence peak during summer peak is therefore 1620/4392 = 36.9%

ENERGY STAR Room Air Conditioner (Time of Sale)

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

Description
This measure relates to the purchase and installation of a room air conditioning unit that meets either the ENERGY STAR or CEE TIER 1 minimum qualifying efficiency specifications, in place of a baseline unit meeting minimum Federal Standard efficiency ratings presented below:

Product Class (BtuH)	Federal Standard (EER)	ENERGY STAR (EER)	CEE TIER 1 (EER)
8,000 to 13,999	>= 9.8	>= 10.8	>= 11.3

Definition of Efficient Equipment
To qualify for this measure the new room air conditioning unit must meet either the ENERGY STAR of CEE TIER 1 efficiency standards presented above.

Definition of Baseline Equipment
The baseline assumption is a new room air conditioning unit that meets the current minimum federal efficiency standards presented above.

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
ENERGY STAR	18.7	0.024	n/a	n/a
CEE TIER 1	26.8	0.035	n/a	n/a

Deemed Lifetime of Efficient Equipment
The measure life is assumed to be 12 years [151].

Deemed Measure Cost
The incremental cost for this measure is assumed to be $40 for an ENERGY STAR unit and $80 for a CEE TIER 1 unit [152].

Deemed O&M Cost Adjustments
n/a

Coincidence Factor
The coincidence factor for this measure is assumed to be 0.3[153].

REFERENCE SECTION

Calculation of Savings

[151] 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
[152] Based on field study conducted by Efficiency Vermont
[153] Consistent with coincidence factors found in:
RLW Report: Final Report Coincidence Factor Study Residential Room Air Conditioners, June 23, 2008 (http://www.puc.nh.gov/Electric/Monitoring%20and%20Evaluation%20Reports/National%20Grid/117_RLW_CF%20Res%20RAC.pdf)

Energy Savings

$$\Delta kWH = (Hours * BtuH * (1/EERbase - 1/EERee))/1000$$

Where:

Hours = Full Load Hours of room air conditioning unit
= 233[154]

BtuH = Average size of rebated unit
= 8500[155]

EERbase = Efficiency of baseline unit
= 9.8[156]

EERee = Efficiency of ENERGY STAR unit
= 10.8[157]

Or = Efficiency of CEE Tier 1 unit
= 11.3[158]

$\Delta kWH_{ENERGY\ STAR}$
= (233 * 8500 * (1/9.8 – 1/10.8)) / 1000
= 18.7 kWh

$\Delta kWH_{CEE\ TIER\ 1}$
= (233 * 8500 * (1/9.8 – 1/11.3)) / 1000
= 26.8 kWh

Summer Coincident Peak Demand Savings

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

Where:

CF = Summer Peak Coincidence Factor for measure
= 0.3[159]

$\Delta kW_{ENERGY\ STAR}$
= (8500 * (1/9.8 – 1/10.8)) / 1000 * 0.3
= 0.024 kW

$\Delta kW_{CEE\ TIER\ 1}$
= (8500 * (1/9.8 – 1/11.3)) / 1000 * 0.3
= 0.035 kW

Fossil Fuel Impact Descriptions and Calculation
n/a

Water Impact Descriptions and Calculation
n/a

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[154] The average ratio of FLH for Room AC (provided in RLW Report: Final Report Coincidence Factor Study Residential Room Air Conditioners, June 23, 2008: http://www.puc.nh.gov/Electric/Monitoring%20and%20Evaluation%20Reports/National%20Grid/117_RLW_CF%20Res%20RAC.pdf) to FLH for Central Cooling for the same location (provided by AHRI: http://www.energystar.gov/ia/business/bulk_purchasing/bpsavings_calc/Calc_CAC.xls) is 31%. This factor was applied to the FLH for Central Cooling provided for OH cities and averaged to come up with the assumption for FLH for Room AC.

[155] Based on maximum capacity average from the RLW Report: Final Report Coincidence Factor Study Residential Room Air Conditioners, June 23, 2008.

[156] Minimum Federal Standard for capacity range

[157] Minimum qualifying standard for ENERGY STAR.

[158] Minimum qualifying standard for CEE Tier 1.

[159] Consistent with coincidence factors found in:
RLW Report: Final Report Coincidence Factor Study Residential Room Air Conditioners, June 23, 2008
(http://www.puc.nh.gov/Electric/Monitoring%20and%20Evaluation%20Reports/National%20Grid/117_RLW_CF%20Res%20RAC.pdf)

Deemed O&M Cost Adjustment Calculation
n/a

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ENERGY STAR Room Air Conditioner Replacement (Low Income, Early Replacement)

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

Description
This measure describes the early removal of an existing inefficient Room Air Conditioner unit from service, prior to its natural end of life, and replacement with a new ENERGY STAR qualifying unit. This measure is suitable for a Low Income or a Home Performance program. Savings are calculated between existing unit and efficient unit consumption during the remaining life of the existing unit, and between new baseline unit and efficient unit consumption for the remainder of the measure life.

Definition of Efficient Equipment
The efficient condition is a new replacement room air conditioning unit meeting the ENERGY STAR efficiency standard (i.e. with an efficiency rating greater than or equal to 10.8EER).

Definition of Baseline Equipment
The baseline condition is the existing inefficient room air conditioning unit for the remaining assumed useful life of the unit, and then for the remainder of the measure life the baseline becomes a new replacement unit meeting the minimum federal efficiency standard (i.e. with an efficiency rating greater than or equal to 9.8EER).

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
Remaining useful life of existing unit (3 years)	73.8	0.095	n/a	n/a
Remaining Measure Life (next 9 years)	18.7	0.024	n/a	n/a

Deemed Lifetime of Efficient Equipment
The measure life is assumed to be 12 Years[160].

Deemed Lifetime of Replaced (Existing) Equipment (for early replacement measures only)
The assumed remaining useful life of the existing room air conditioning unit being replaced is 3 years[161].

Deemed Measure Cost
The actual measure cost for removing the existing unit and installing the new should be used.

Deemed O&M Cost Adjustments
The net present value of the deferred replacement cost (the cost associated with the replacement of the existing unit with a standard unit that would have had to have occurred in 3 years, had the existing unit not been

[160] 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
[161] Based on Connecticut TRM; Connecticut Energy Efficiency Fund; CL&P and UI Program Savings Documentation for 2008 Program Year

replaced) should be calculated as (Actual Cost of ENERGY STAR unit - $50 (incremental cost of ENERGY STAR unit over baseline unit[162]) * 69%[163].

Coincidence Factor
The coincidence factor for this measure is assumed to be 0.3[164].

REFERENCE SECTION

Calculation of Savings

Energy Savings

ΔkWh for remaining life of existing unit (1st 3 years)
= (Hours * BtuH * (1/EERexist - 1/EERee))/1000

ΔkWh for remaining measure life (next 9 years)
= (Hours * BtuH * (1/EERbase - 1/EERee))/1000

Where:

Hours	= Full Load Hours of room air conditioning unit = 233[165]
BtuH	= Average size of rebated unit = 8500[166]
EERexist	= Efficiency of baseline unit = 7.7[167]
EERbase	= Efficiency of baseline unit = 9.8[168]
EERee	= Efficiency of ENERGY STAR unit = 10.8[169]

ΔkWh for remaining life of existing unit (1st 3 years)
= (233 * 8500 * (1/7.7 – 1/10.8)) / 1000
= 73.8 kWh

ΔkWh for remaining measure life (next 9 years)
= (233 * 8500 * (1/9.8 – 1/10.8)) / 1000

[162] From ENERGY STAR calculator (ENERGY STAR - $220, Baseline - $170); http://www.energystar.gov/ia/business/bulk_purchasing/bpsavings_calc/CalculatorConsumerRoomAC.xls)
[163] 69% is the ratio of the Net Present Value (with a 5% discount rate) of the annuity payments from years 4 to 12 of a deferred replacement of a standard efficiency unit costing $170, divided by the standard efficiency unit cost ($170). The calculation is done in this way to allow the use of the known ENERGY STAR replacement cost to calculate an appropriate baseline replacement cost.
[164] Consistent with coincidence factors found in:
RLW Report: Final Report Coincidence Factor Study Residential Room Air Conditioners, June 23, 2008 (http://www.puc.nh.gov/Electric/Monitoring%20and%20Evaluation%20Reports/National%20Grid/117_RLW_CF%20Res%20RAC.pdf)
[165] The average ratio of FLH for Room AC (provided in RLW Report: Final Report Coincidence Factor Study Residential Room Air Conditioners, June 23, 2008: http://www.puc.nh.gov/Electric/Monitoring%20and%20Evaluation%20Reports/National%20Grid/117_RLW_CF%20Res%20RAC.pdf) to FLH for Central Cooling for the same location (provided by AHRI: http://www.energystar.gov/ia/business/bulk_purchasing/bpsavings_calc/Calc_CAC.xls) is 31%. This factor was applied to the FLH for Central Cooling provided for OH cities and averaged to come up with the assumption for FLH for Room AC.
[166] Based on maximum capacity average from the RLW Report; "Final Report Coincidence Factor Study Residential Room Air Conditioners, June 23, 2008."
[167] Based on Nexus Market Research Inc, RLW Analytics, December 2005; "Impact, Process, and Market Study of the Connecticut Appliance Retirement Program: Overall Report."
[168] Minimum Federal Standard for capacity range
[169] Minimum qualifying standard for ENERGY STAR

= 18.7 kWh

Summer Coincident Peak Demand Savings

ΔkW for remaining life of existing unit (1st 3 years)
= (BtuH * (1/EERexist - 1/EERee))/1000 * CF

ΔkW for remaining measure life (next 9 years)
= (BtuH * (1/EERbase - 1/EERee))/1000 * CF

Where:

CF = Summer Peak Coincidence Factor for measure
= 0.3[170]

ΔkW for remaining life of existing unit (1st 3 years)
= (8500 * (1/7.7 – 1/10.8)) / 1000 * 0.3
= 0.095 kW

ΔkW for remaining measure life (next 9 years)
= (8500 * (1/9.8 – 1/10.8)) / 1000 * 0.3
= 0.024 kW

Fossil Fuel Impact Descriptions and Calculation
n/a

Water Impact Descriptions and Calculation
n/a

Deemed O&M Cost Adjustment Calculation
The net present value of the deferred replacement cost (the cost associated with the replacement of the existing unit with a standard unit that would have had to have occurred in 3 years, had the existing unit not been replaced) should be calculated as (Actual Cost of ENERGY STAR unit - $50 (incremental cost of ENERGY STAR unit over baseline unit[171]) * 69%[172].

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[170] Consistent with coincidence factors found in:
RLW Report: Final Report Coincidence Factor Study Residential Room Air Conditioners, June 23, 2008
(http://www.puc.nh.gov/Electric/Monitoring%20and%20Evaluation%20Reports/National%20Grid/117_RLW_CF%20Res%20RAC.pdf)

[171] From ENERGY STAR calculator (ENERGY STAR - $220, Baseline - $170);
http://www.energystar.gov/ia/business/bulk_purchasing/bpsavings_calc/CalculatorConsumerRoomAC.xls)

[172] 69% is the ratio of the Net Present Value (with a 5% discount rate) of the annuity payments from years 4 to 12 of a deferred replacement of a standard efficiency unit costing $170, divided by the standard efficiency unit cost ($170). The calculation is done in this way to allow the use of the known ENERGY STAR replacement cost to calculate an appropriate baseline replacement cost.

ENERGY STAR Room Air Conditioner Recycling (Early Retirement)

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

Description
This measure describes the savings resulting from running a drop off service taking existing inefficient Room Air Conditioner units from service, prior to their natural end of life. This measure assumes that a percentage of these units will be replaced with a baseline standard efficiency unit (note that if it is actually replaced by a new ENERGY STAR qualifying unit, the savings increment between baseline and ENERGY STAR will be recorded in the Efficient Products program).

Definition of Efficient Equipment
n/a. This measure relates to the retiring of an existing inefficient unit.

Definition of Baseline Equipment
The baseline condition is the existing inefficient room air conditioning unit.

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
103.6	0.906	n/a	n/a

Deemed Lifetime of Replaced (Existing) Equipment (for early replacement measures only)
The assumed remaining useful life of the existing room air conditioning unit being retired is 3 Years.

Deemed Measure Cost
The actual implementation cost for recycling the existing unit plus the cost for the replacement of some of the units of $129[173].

Deemed O&M Cost Adjustments
The net present value of the deferred replacement cost (the cost associated with the replacement of those units that would be replaced, with a standard unit that would have had to have occurred in 3 years, had the existing unit not been replaced) is calculated as $89.36[174].

Coincidence Factor
The coincidence factor for this measure is assumed to be 0.3[175].

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[173] This is calculated by multiplying the percentage assumed to be replaced – 76% (from Based on Nexus Market Research Inc, RLW Analytics, December 2005; "Impact, Process, and Market Study of the Connecticut Appliance Retirement Program: Overall Report") by the assumed cost of a standard efficiency unit of $170 (ENERGY STAR calculator; http://www.energystar.gov/ia/business/bulk_purchasing/bpsavings_calc/CalculatorConsumerRoomAC.xls). 0.76 * 170 = $129.2.

[174] Determined by calculating the Net Present Value (with a 5% discount rate) of the annuity payments from years 4 to 12 of a deferred replacement of a standard efficiency unit costing $170 multiplied by the 76%, the percentage of units being replaced (i.e. 0.76 * $170 = $129.2. Baseline cost from ENERGY STAR calculator; http://www.energystar.gov/ia/business/bulk_purchasing/bpsavings_calc/CalculatorConsumerRoomAC.xls)

[175] Consistent with coincidence factors found in:
RLW Report: Final Report Coincidence Factor Study Residential Room Air Conditioners, June 23, 2008 (http://www.puc.nh.gov/Electric/Monitoring%20and%20Evaluation%20Reports/National%20Grid/117_RLW_CF%20Res%20RAC.pdf)

REFERENCE SECTION

Calculation of Savings

Energy Savings

$\Delta kWh = kWh_{exist} - (\%replaced * kWh_{newbase})$

$= ((Hours * BtuH * (1/EERexist))/1000) - (\%replaced * ((Hours * BtuH * (1/EERnewbase))/1000)$

Where:

Hours = Full Load Hours of room air conditioning unit
= 233[176]

BtuH = Average size of rebated unit
= 8500[177]

EERexist = Efficiency of baseline unit
= 7.7[178]

%replaced = Percentage of units dropped off that are replaced
= 76%[179]

EERbase = Efficiency of baseline unit
= 9.8[180]

$\Delta kWh = ((233 * 8500 * (1/7.7)) / 1000) - (0.76 * ((233 * 8500 * (1/9.8)) / 1000)$

$= 103.6\ kWh$

Summer Coincident Peak Demand Savings

$\Delta kW = (kW_{exist} - (\%replaced * kW_{newbase})) * CF$

$= ((BtuH * (1/EERexist))/1000) - (\%replaced * ((BtuH * (1/EERnewbase))/1000) * CF$

Where:

CF = Summer Peak Coincidence Factor for measure
= 0.3[181]

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[176] The average ratio of FLH for Room AC (provided in RLW Report: Final Report Coincidence Factor Study Residential Room Air Conditioners, June 23, 2008: http://www.puc.nh.gov/Electric/Monitoring%20and%20Evaluation%20Reports/National%20Grid/117_RLW_CF%20Res%20RAC.pdf) to FLH for Central Cooling for the same location (provided by AHRI: http://www.energystar.gov/ia/business/bulk_purchasing/bpsavings_calc/Calc_CAC.xls) is 31%. This factor was applied to the FLH for Central Cooling provided for OH cities and averaged to come up with the assumption for FLH for Room AC.

[177] Based on maximum capacity average from the RLW Report; "Final Report Coincidence Factor Study Residential Room Air Conditioners, June 23, 2008."

[178] Based on Nexus Market Research Inc, RLW Analytics, December 2005; "Impact, Process, and Market Study of the Connecticut Appliance Retirement Program: Overall Report."

[179] Based on Nexus Market Research Inc, RLW Analytics, December 2005; "Impact, Process, and Market Study of the Connecticut Appliance Retirement Program: Overall Report." Report states that 63% were replaced with ENERGY STAR units and 13% with non-ENERGY STAR. However this formula assumes all are non-ENERGY STAR since the increment of savings between baseline units and ENERGY STAR would be recorded by the Efficient Products program when the new unit is purchased.

[180] Minimum Federal Standard for capacity range

[181] Consistent with coincidence factors found in:
RLW Report: Final Report Coincidence Factor Study Residential Room Air Conditioners, June 23, 2008 (http://www.puc.nh.gov/Electric/Monitoring%20and%20Evaluation%20Reports/National%20Grid/117_RLW_CF%20Res%20RAC.pdf)

$$\Delta kW = ((8500 * (1/7.7)) / 1000) - (0.76 * ((8500 * (1/9.8)) / 1000) * 0.3$$

$$= 0.906 \text{ kW}$$

Fossil Fuel Impact Descriptions and Calculation
n/a

Water Impact Descriptions and Calculation
n/a

Deemed O&M Cost Adjustment Calculation
The net present value of the deferred replacement cost (the cost associated with the replacement of those units that would be replaced, with a standard unit that would have had to have occurred in 3 years, had the existing unit not been replaced) is calculated as $89.36[182].

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[182] Determined by calculating the Net Present Value (with a 5% discount rate) of the annuity payments from years 4 to 12 of a deferred replacement of a standard efficiency unit costing multiplied by the 76%, the percentage of units being replaced (i.e. 0.76 * $170 = $129.2. Baseline cost from ENERGY STAR calculator; http://www.energystar.gov/ia/business/bulk_purchasing/bpsavings_calc/CalculatorConsumerRoomAC.xls)

Smart Strip Power Strip (Time of Sale)

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

Description
This measure relates to Controlled Power Strips (or Smart Strips) which are multi-plug power strips with the ability to automatically disconnect specific connected loads depending upon the power draw of a control load, also plugged into the strip. Power is disconnected from the switched (controlled) outlets when the control load power draw is reduced below a certain adjustable threshold, thus turning off the appliances plugged into the switched outlets. By disconnecting, the standby load of the controlled devices, the overall load of a centralized group of equipment (i.e. entertainment centers and home office) can be reduced. Uncontrolled outlets are also provided that are not affected by the control device and so are always providing power to any device plugged into it. This measure characterization provides savings for a 5-plug strip and a 7-plug strip.

Definition of Efficient Equipment
The efficient case is the use of a 5 or 7-plug smart strip.

Definition of Baseline Equipment
The assumed baseline is a standard power strip that does not control connected loads.

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
5- Plug	56.5	0.0063	n/a	n/a
7- Plug	102.8	0.012	n/a	n/a

Deemed Lifetime of Efficient Equipment
The assumed lifetime of the smart strip is 4 years[183].

Deemed Measure Cost
The incremental cost of a smart strip over a standard power strip with surge protection is assumed to be $16 for a 5-plug and $26 for a 7-plug[184].

Deemed O&M Cost Adjustments
n/a

Coincidence Factor
The summer peak coincidence factor for this measure is assumed to be 0.8[185].

REFERENCE SECTION

Calculation of Savings

[183] David Rogers, Power Smart Engineering, October 2008; "Smart Strip electrical savings and usability", p22.
[184] Price survey performed in NYSERDA Measure Characterization for Advanced Power Strips, p4
[185] Efficiency Vermont coincidence factor for smart strip measure –in the absence of empirical evaluation data, this was based on assumptions of the typical run pattern for televisions and computers in homes.

Energy Savings [186]

$\Delta kWh_{5\text{-}Plug}$ = 56.5 kWh

$\Delta kWh_{7\text{-}Plug}$ = 102.8 kWh

Summer Coincident Peak Demand Savings

ΔkW = ΔkWh / Hours * CF

Where:

Hours = Annual number of hours during which the controlled standby loads are turned off by the Smart Strip.
= 7,129[187]

CF = Summer Peak Coincidence Factor for measure
= 0.8[188]

$\Delta kW_{5\text{-}Plug}$ = 56.5 / 7129 * 0.8

= 0.0063 kW

$\Delta kW_{7\text{-}Plug}$ = 102.8 / 7129 * 0.8

= 0.012 kW

Fossil Fuel Impact Descriptions and Calculation
n/a

Water Impact Descriptions and Calculation
n/a

Deemed O&M Cost Adjustment Calculation
n/a

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[186] Based on: NYSERDA Measure Characterization for Advanced Power Strips
[187] Average of hours for controlled TV and computer from; NYSERDA Measure Characterization for Advanced Power Strips
[188] Efficiency Vermont coincidence factor for smart strip measure –in the absence of empirical evaluation data, this was based on assumptions of the typical run pattern for televisions and computers in homes.

Central Air Conditioning (Early Replacement)

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

Description
This measure describes the early removal of an existing inefficient Central Air Conditioning unit from service, prior to its natural end of life, and replacement with a new ENERGY STAR qualifying unit. Savings are calculated between existing unit and efficient unit consumption during the remaining life of the existing unit, and between new baseline unit and efficient unit consumption for the remainder of the measure life.

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
The baseline condition is the existing inefficient central air conditioning unit for the remaining assumed useful life of the unit, and then for the remainder of the measure life the baseline becomes a new replacement unit meeting the minimum federal efficiency standard (i.e. 13 SEER and 11 EER).

Deemed Calculation for this Measure

Annual kWh Savings for remaining life of existing unit (1st 5 years)
= (FLHcool * BtuH * (1/SEERexist - 1/SEERee))/1000

Annual kWh Savings for remaining measure life (next 13 years)
= (FLHcool * BtuH * (1/13 - 1/SEERee))/1000

Summer Coincident Peak kW Savings for remaining life of existing unit (1st 5 years)
= (BtuH * (1/EERexist - 1/EERee))/1000 * 0.5

Summer Coincident Peak kW Savings for remaining measure life (next 13 years)
= (BtuH * (1/11 - 1/EERee))/1000 * 0.5

Deemed Lifetime of Efficient Equipment
The expected measure life is assumed to be 18 years [189].

Deemed Lifetime of Replaced (Existing) Equipment (for early replacement measures only)
The assumed remaining useful life of the existing central air conditioning unit being replaced is 5 years[190].

Deemed Measure Cost
The actual measure cost for removing the existing unit and installing the new should be used.

Deemed O&M Cost Adjustments
The net present value of the deferred replacement cost (the cost associated with the replacement of the existing unit with a standard unit that would have had to have occurred after 5 years, had the existing unit not been replaced) should be calculated as (Actual Cost of ENERGY STAR unit - incremental cost of ENERGY STAR unit over baseline unit from table below[191]) * 63%[192].

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[189] 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
[190] VEIC estimate
[191] DEER 2008 Database Technology and Measure Cost Data (www.deeresources.com).
[192] 63% is the ratio of the Net Present Value (with a 5% discount rate) of the annuity payments from years 6 to 18 of a deferred replacement of a standard efficiency unit costing $2857, divided by the standard efficiency unit cost ($2857). The

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

Coincidence Factor
The summer peak coincidence factor for this measure is assumed to be 0.5[193].

REFERENCE SECTION

Calculation of Savings

Energy Savings

ΔkWh for remaining life of existing unit (1st 5 years)
= (FLHcool * BtuH * (1/SEERexist - 1/SEERee))/1000

ΔkWh for remaining measure life (next 13 years)
= (FLHcool * BtuH * (1/SEERbase - 1/SEERee))/1000

Where:

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

Location	Run Hours[194]
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

calculation is done in this way to allow the use of the known ENERGY STAR replacement cost to calculate an appropriate baseline replacement cost. Standard unit cost from ENERGY STAR calculator; http://www.energystar.gov/ia/business/bulk_purchasing/bpsavings_calc/Calc_CAC.xls

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

[194] 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."..

SEERexist	= SEER Efficiency of existing unit = Actual[195]
SEERee	= SEER Efficiency of ENERGY STAR unit = Actual installed
SEERbase	= SEER Efficiency of baseline unit = 13[196]

For example, replacing a 3 ton SEER 10 unit with a new SEER 14.5 unit, in Dayton:

ΔkWh for remaining life of existing unit (1st 5 years)
= (631 * 36000 * (1/10 – 1/14.5)) / 1000

= 705 kWh

ΔkWh for remaining measure life (next 13 years)
= (631 * 36000 * (1/13 – 1/14.5)) / 1000

= 180.8 kWh

Summer Coincident Peak Demand Savings

ΔkW for remaining life of existing unit (1st 5 years)
= (BtuH * (1/EERexist - 1/EERee))/1000 * CF

ΔkW for remaining measure life (next 13 years)
= (BtuH * (1/EERbase - 1/EERee))/1000 * CF

Where:

EERexist	= EER Efficiency of existing unit = Calculate using Actual SEER = (SEER * 0.9)[197]
EERbase	= EER Efficiency of baseline unit = 11 [198]
EERee	= EER Efficiency of ENERGY STAR unit = Actual installed
CF	= Summer Peak Coincidence Factor for measure = 0.5 [199]

For example, replacing a 3 ton SEER 10 unit (EER 9)with a new SEER 14.5, EER 12 unit, in Dayton:

ΔkW for remaining life of existing unit (1st 5 years)
= (36000 * (1/9 – 1/12)) / 1000 * 0.5

= 0.5 kW

[195] 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)
[196] Minimum Federal Standard
[197] If SEER is unknown, default EER would be (10 * 0.9) = 9.0. Calculation based on prior VEIC assessment of industry equipment efficiency ratings.
[198] Minimum Federal Standard
[199] Based on Energy Center of Wisconsin, May 2008 metering study; "Central Air Conditioning in Wisconsin, A Compilation of Recent Field Research", p32

ΔkW for remaining measure life (next 13 years)
= (36000 * (1/11 – 1/12)) / 1000 * 0.5

= 0.14 kW

Fossil Fuel Impact Descriptions and Calculation
n/a

Water Impact Descriptions and Calculation
n/a

Deemed O&M Cost Adjustment Calculation
n/a

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Ground Source Heat Pumps (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 Ground Source Heat Pump system meeting ENERGY STAR efficiency standards presented below. This measure relates to the installation of a new system in an existing home (i.e. time of sale).

Tier 1 Requirements (Effective December 1, 2009)

Product Type	EER	COP
Water-to-air		
Closed Loop	14.1	3.3
Open Loop	16.2	3.6
Water-to-Water		
Closed Loop	15.1	3
Open Loop	19.1	3.4
DGX	15	3.5

Tier 2 Requirements (Effective January 1, 2011)

Product Type	EER	COP
Water-to-air		
Closed Loop	16.1	3.5
Open Loop	18.2	3.8
Water-to-Water		
Closed Loop	15.1	3
Open Loop	19.1	3.4
DGX	16	3.6

Tier 3 Requirements (Effective January 1, 2012)

Product Type	EER	COP
Water-to-air		
Closed Loop	17.1	3.6
Open Loop	21.1	4.1
Water-to-Water		
Closed Loop	16.1	3.1
Open Loop	20.1	3.5
DGX	16	3.6

Definition of Efficient Equipment
In order for this characterization to apply, the efficient equipment must be a Ground Source Heat Pump unit meeting the minimum ENERGY STAR efficiency level standards effective at the time of installation as detailed above.

Definition of Baseline Equipment
The baseline equipment is assumed to be an Air Source Heat Pump meeting the Federal Standard efficiency level; 13 SEER and 11 EER.

Deemed Calculation for this Measure

Annual kWh Savings = (FLHcool * BtuH * (1/13 – (1/(EERee * 1.02))/ + (FLHheat * BtuH * (1/7.7 – (1/COPee * 3.412))/1000

Summer Coincident Peak kW Savings = BtuH * (1/11 - 1/(((EERee * 1.02) * 0.37) + 6.43))/ 1000 * 0.5

Deemed Lifetime of Efficient Equipment
The expected measure life is assumed to be 18 years [200].

Deemed Measure Cost
The actual installed cost of the Ground Source Heat Pump should be used, minus the assumed installation cost of a 3 ton standard baseline Air Source Heat Pump of $3,609[201].

Deemed O&M Cost Adjustments
n/a

Coincidence Factor
The summer peak coincidence factor for this measure is assumed to be 0.5[202].

REFERENCE SECTION

Calculation of Savings

Energy Savings

$$\Delta kWH = (FLHcool * BtuH * (1/SEERbase – (1/(EERee * 1.02))/1000 + (FLHheat * BtuH * (1/HSPFbase – (1/COPee * 3.412))/1000$$

Where:

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

Location	Run Hours[203]
Akron	476

[200] 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
[201] Based on DEER 2008 Database Technology and Measure Cost Data (www.deeresources.com). Material cost of 13 SEER AC is $796 per ton, and labor cost of $407 per ton. For a 3 ton unit this would be (796+407) *3 = $3609.
[202] Based on Energy Center of Wisconsin, May 2008 metering study; "Central Air Conditioning in Wisconsin, A Compilation of Recent Field Research", p32
[203] 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 Wisconsin study.

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 [204]

EERee = EER Efficiency of efficient unit
= Actual installed

1.02 = Constant used to estimate the SEER based on the efficient unit's EER[205].

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

Location	Run Hours[206]
Akron	1576
Cincinnati	1394
Cleveland	1567
Columbus	1272
Dayton	1438
Mansfield	1391
Toledo	1628

HSPFbase =Heating Season Performance Factor for baseline unit
=7.7[207]

COPee = Coefficient of Performance of efficient unit
= Actual Installed

3.413 = Constant to convert the COP of the unit to the Heating Season Performance Factor HSPF).

For example, a 3 ton unit with EER rating of 16 and COP of 3.5 in Dayton:

$$\Delta kWH = (FLHcool * BtuH * (1/SEERbase - (1/(EERee * 1.02))/1000 + (FLHheat * BtuH * (1/HSPFbase - (1/COPee * 3.412))/1000$$

$$\Delta kWH = (631 * 36000 * (1/13 - 1/(16*1.02))) / 1000 + (1438 * 36000 * (1/7.7 - 1/(3.5*3.412)) / 1000$$

$$= 2744 \text{ kWh}$$

Summer Coincident Peak Demand Savings

$$\Delta kW = BtuH * (1/EERbase - 1/(((EERee * 1.02) * 0.37) + 6.43))/1000 * CF$$

[204] Minimum Federal Standard; Federal Register, Vol. 66, No. 14, Monday, January 22, 2001/Rules and Regulations, p. 7170-7200.
[205] Note that EERs of GSHPs are measured differently than EERs of air source heat pumps (focusing on entering water temperatures rather than ambient air temperatures). The equivalent SEER of a GSHP can be estimated by multiplying EER by 1.02, based on VEIC extrapolation of manufacturer data.
[206] 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"
[207] Minimum Federal Standard; Federal Register, Vol. 66, No. 14, Monday, January 22, 2001/Rules and Regulations, p. 7170-7200.

Where:

EERbase	= EER Efficiency of baseline unit = 11 [208]
EERee	= EER Efficiency of ENERGY STAR unit = Actual installed
1.02	= Constant used to estimate the unit's equivalent air conditioning SEER based on the GSHP unit's EER[209]. This is then converted to the unit's equivalent air conditioning EER to enable comparisons to the baseline unit using the following algorithm: EERac = (SEER * 0.37) + 6.43[210]
CF	= Summer Peak Coincidence Factor for measure = 0.5[211]

For example, a 3 ton unit with EER rating of 16:

$$\Delta kW = (36000 * (1/11 - 1/(((16 * 1.02) * 0.37) + 6.43)) / 1000 * 0.5$$

$$= 0.2 \text{ kW}$$

Fossil Fuel Impact Descriptions and Calculation
n/a

Water Impact Descriptions and Calculation
n/a

Deemed O&M Cost Adjustment Calculation
n/a

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[208] Minimum Federal Standard; as above.
[209] Note that EERs of GSHPs are measured differently than EERs of air source heat pumps (focusing on entering water temperatures rather than ambient air temperatures). The equivalent SEER of a GSHP can be estimated by multiplying EER by 1.02, based on VEIC extrapolation of manufacturer data.
[210] 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". This formulaic relationship was derived from 1861 unique combinations of data, from nearly 200,000 ARI-rated residential central air conditioners.
[211] Based on Energy Center of Wisconsin, May 2008 metering study; "Central Air Conditioning in Wisconsin, A Compilation of Recent Field Research", p32