ONTARIO POWER AUTHORITY

2009 Commercial and Institutional Measures and Assumptions

Ontario Power Authority™

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INTRODUCTION

The 2009 OPA Measures and Assumptions List – Commercial & Institutional ("C&I List") is a collection of prescriptive input assumptions (PIAs) and quasi-prescriptive input assumptions (QPIAs) for electricity conservation measures specific to the commercial and institutional sector.

Free ridership rates and other adjustment factors are not included in any of the OPA Measures and Assumptions Lists. Adjustment factors are a function of the program design and delivery as well as the measure type and MUST be determined and maintained on a regular basis through program evaluation research. Prior lists may have included an Adjustment Factors template, but any rates or numbers contained therein should not be used as a substitute for conducting program evaluation research. Rather, broad adjustment factor assumptions may be utilized for planning and/or portfolio management purposes in the absence of better information.

Prescriptive Input Assumptions (PIAs)

PIAs are used to estimate the impacts (energy and demand savings) attributable to individual conservation measures as well as providing key inputs for assessing their cost-effectiveness. The PIAs are composed of per installation assumptions related to the following areas:

- Definition of the base case and efficient case
- Energy and peak demand savings (Appendix A describes the methodology used to estimate the peak demand savings for each measure)
- Other resource savings (e.g. natural gas, water)
- Seasonal energy savings patterns (8 time-of-use periods are considered – winter/summer peak, off-peak, and mid-peak, and shoulder mid-peak and off-peak)
- Incremental cost (cost difference between implementing high efficiency case and base case)
- Estimated useful life of the equipment

Quasi-Prescriptive Input Assumptions (PIAs)

QPIAs are used to estimate the impacts (energy and demand savings) attributable to individual conservation measures using key, project-specific inputs and a prescribed methodology for assessing their cost effectiveness. A common quasi-prescriptive methodology is to prescribe energy and demand savings for a measure on a scalable basis (such as per unit-of-capacity or per hour-of-operation). It may include equations requiring minimal inputs or lookup tables with pre-generated values.

QPIAs are composed of per installation assumptions related to areas similar to those listed under PIAs. In addition, the key participant inputs must be described

OPA MEASURES AND ASSUMPTIONS MAINTENANCE

The PIA and QPIA values for each measure in the List will undergo an annual cursory review (April/May) to determine if any changes have occurred in the market that would substantially alter the current assumption values (e.g. changes to codes, standards, or regulations / changes in product offerings, new research, etc.). Affected measures will undergo a more comprehensive review (which may include a primary research project) to update their assumptions. Updates for PIA values will also be informed by directed research and Evaluation, Measurement and Verification (EM&V) research on program results. Annual publishing of this List will occur in late August/early September of each year. These published values will remain fixed until the next publishing of the List in the following year. However, should there be some additions to the C&I measures, their substantiation will be inserted and properly coded in the original List.

The OPA is also accepting external party submissions for new measures, new measure ideas and/or revisions to existing measure values for consideration for inclusion in the List. New measures, new measure ideas or revisions to existing measure values may be submitted by any individual or group of individuals (e.g. company, organization, association).

Submissions for **new measures** and **revisions to existing measure values** must be accompanied by a completed Measures and Assumptions Substantiation Form containing the references and rationales behind all values that make up the set of assumptions for the new measure or behind all suggested revisions to values. The Form can be downloaded from the OPA website (www.powerauthority.on.ca) by clicking on the Conservation button and then the Evaluation, Measurement & Verification (EM&V) tab on the drop down menu. On the EM&V page, click on the OPA Measures and Assumptions List. The process for submitting new measures, new measure ideas and revisions to existing measure values is described on that page. Click on the Measures and Assumptions Substantiation Form[1]. A copy of the Form can also be found on Appendix B. The completed Substantiation Form can be sent by e-mail to New.Measures@powerauthority.on.ca.

New measure ideas submissions may have their assumptions developed internally by OPA or may be part of new measures research performed by an external party.

Based on the merits of the substantiation provided, submissions will be reviewed by the OPA and will either be 1) accepted, 2) modified and accepted, or 3) rejected. If information and references for the new measure or revisions to existing measure values are insufficient, the applicant may be asked to provide more information.

For the **new measure** or **revision to existing measure values** to be included on the OPA Measures and Assumptions List published every September, submissions must be

[1] http://www.powerauthority.on.ca/Storage/83/7862_Appendix_A1-New_Measure_Submission_Substantiation_Template_Final.doc.

received by the OPA prior to June 30. Submissions received after June 30 may be added to the “New Measures” list (after an OPA review), but will not appear on the List until the next publishing in the following year. Submissions on revisions to existing measure values received after June 30 may be incorporated into the List if the revision entails a significant impact; otherwise, the revision (after an OPA review) will be incorporated into the List the following year.

The descriptions and statuses of the submissions of **new measures, new measure ideas,** and **revisions to existing measure values** will be available online. This listing will allow for tracking and recording of proposed measures and revisions.

OPA Measures Substantiation Sheets

Space Cooling and Heating

Energy Star® Unitary and Room Air Conditioners

Revision #	Description/Comment	Date Revised
0	Created in Measures & Assumptions List	Oct. 31, 2008

Efficient Equipment and Technologies Description

Consortium of Energy Efficiency (CEE) Tier 1 or Tier 2 levels for Unitary Air Conditioning is chosen to represent the high efficiency case.[1]

Base Equipment and Technologies Description

CSA-C656-2005 for small (cooling capacity < 65,000Btu/h) three-phase air-cooled air-conditioners or heat pumps.[2]

CSA-C746-98 for large equipment (cooling capacity $\geq$ 65,000Btu/h), or CSA-C746-06, Level 1 if the efficiency for a certain classification of equipment is not defined in CSA-C746-98.[3,4]

CSA-C368.1-M90 for window-mounted (WM) and through the wall (TTW) air conditioners predominantly used in residential buildings.[5]

Codes, Standards and Regulations

- The current Energy Star levels are equal to the current regulated levels for many of the equipment described by this measure.[6] This is why CEE Tier 1 or Tier 2 is selected as the efficient equipment case.
- For the window-mounted and TTW AC, a product is rated Energy Star if its performance EER is 10% greater than the minimum level[7] and receives CEE Tier 1 level if the performance EER is 15% greater.[8]

Decision Type	Target Market(s)	Load Type
New / Replacement / Retrofit	Commercial & Institutional	OPA Commercial Space Cooling

Resource Savings Assumptions

Key Parameter Inputs

- Building Type

Office	School	Hotel/Motel
Restaurant	University	Health Facility
Retail Service	Warehouse	Grocery
Multi-unit Family Building		

- Cooling Capacity (Btu/hr or ton); 1 ton capacity is equal to 12,000 Btu/hr
- Energy Efficiency Ratio (EER) in Btu/Wh of the base and high efficiency air-conditioner
- Equipment Type (air-cooled or water and evaporatively cooled, split system or single package)
- Equivalent Full Load Hours (EFLH)[9] - taken from PG&E for commercial buildings and a Caneta Room AC analysis workpaper for multi-unit residential buildings, which was determined through simulation, building surveying and normalizing data. Actual EFLH could be higher or lower depending on operating conditions and would result in higher or lower energy savings, respectively.

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[1] CEE website. Accessed: November, 2007. http://www.cee1.org/com/hecac/hecac-tiers.pdf
[2] Canadian Standards Association. *CSA-C656-05: Performance Standard for Split-System and Single-Package Central Air Conditioners and Heat Pumps*. 2005.
[3] Canadian Standards Association. *CSA-C746-98: Performance Standard for Rating Large and Single Packaged Vertical Air Conditioners and Heat Pumps.* 1998.
[4] Canadian Standards Association. *CSA-C746-06: Performance Standard for Rating Large and Single Packaged Vertical Air Conditioners and Heat Pumps.* 2006
[5] http://www.oee.nrcan.gc.ca/publications/infosource/pub/energy_use/air-conditioning-home2004/regulations.cfm?text=N&printview=N
[6] Energy Star website. Accessed: November, 2007. http://www.oee.nrcan.gc.ca/energystar/
[7] http://www.oee.nrcan.gc.ca/publications/infosource/pub/energy_use/air-conditioning-home2004/regulations.cfm?text=N&printview=N
[8] http://www.cee1.org/resid/seha/rm-ac/rm-ac-main.php3
[9] PG&E Workpapers. June, 2005

Health Facility	1,900	Retail Service	800	Grocery	600
University	1,200	Hotel/Motel	700	School	500
Office	1,000	Multi-unit Family Building[10]	615	Warehouse	300
Restaurant	1,300				

Annual Energy Savings

Demand Savings (kW)

$$\text{Demand Savings} = (\text{Cooling Capacity} / EER_{Base\ Eff}) - (\text{Cooling Capacity} / EER_{High\ Eff})$$

Equipment Type	Size Category Btu/h (ton)	$EER_{Base\ Eff}$	$EER_{High\ Eff}$		kW Savings per Ton Cooling Capacity	
			CEE Tier 1	CEE Tier 2	CEE Tier 1	CEE Tier 2
Air-cooled, split system	< 65,000 (5.4)	13.0 (SEER) 11.4 (EER)	12.0	12.5	0.0526	0.0926
Air-cooled, single package		13.0 (SEER) 11.2 (EER)	11.6	12.0	0.0369	0.0714
Air-cooled, split system & single package	≥ 65,000 (5.4) and < 135,000 (11.25)	10.3	11.0	11.5	0.0741	0.1216
	≥ 135,000 (11.25) and < 240,000 (20)	9.7	10.8	11.5	0.1260	0.1936
	≥ 240,000 (20)	9.5	10.0	10.5	0.0632	0.1203
Water & evaporatively cooled, split system & single package	≥ 65,000 (5.4) and < 135,000 (11.25)	11.5	14.0	None	0.1863	None
	≥ 135,000 (11.25)	11.0	14.0	None	0.2338	None

Air conditioners that are single package and split system, single and three phase with rated capacity of less than 65,000 Btu/hr are currently regulated to a SEER of 13.0. If only the SEER is known for equipment under 65 kBtu/h, use the following relationships to estimate EER, based on the ARI database of this equipment.[11]

$$EER = SEER \times 0.685 + 2.487 \text{ for split-system AC}$$
$$EER = SEER \times 0.701 + 2.039 \text{ for single package AC}$$

Annual Energy Savings (kWh)

$$\text{Annual Energy Savings (kWh)} = \text{Demand Savings (kW per ton)} \times \text{ton capacity} \times EFLH$$

Peak Demand Savings

See Appendix A for the description of the methodology in determining peak demand savings using OPA end use load profiles for the commercial and institutional sector.

Other Resource Savings

Other Input Assumptions

Effective Useful Life (EUL)

For unitary air conditioners, the effective useful life is 15 years.[12]

Base & Conservation Measure Equipment and O&M Costs

The incremental cost for the high efficiency case will depend on the cooling capacity and increase in EER between base case and high efficiency cases. Example costs are provided in the following tables based on various sources:[13,14,15]

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[10] Caneta Research Inc. *Market and Benchmark Analysis for Central Air Conditioners and Heat Pumps.* September 2004.
[11] ARI Database of Certified Product Performance. http://www.aridirectory.org/
[12] American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc., *2007 ASHRAE Handbook: Heating, Ventilating and Air-Conditioning Applications*. 2007.

Unitary Air Conditioners

Classification	Size Range (Btu/h)	Example Size (kBtu/h)	Incremental Cost ($/ΔEER)
3 Phase, Split System	< 65,000	48	$295
3 Phase, Single Package	< 65,000	48	$325
Air-Cooled, Split System & Single Package	> 65,000 to < 135,000	90	$452
	>135,000 to < 240,000	180	$786
	> 240,000	400	$1,748

Room Air Conditioners

Classification	Example Size (Btu/hr)	Incremental Cost ($/ΔEER)
< 6,000 Btu/hr, WM	5,000	$5.50
6,000 Btu/hr to 7,999 Btu/hr, WM	7,000	$10.50
8,000 Btu/hr to 13,999 Btu/hr, WM	11,000	$23.50
14,000 Btu/hr to 19,999 Btu/hr, WM	17,000	$49.50
> 20,000 Btu/hr, WM	21,000	$92.50
< 8,000 Btu/hr, TTW	6,000	$113.00
> 8,000 Btu/hr, TTW	10,500	$181.00

WM – window mounted
TTW – through the wall

[13] U.S. Department of Energy. *Engineering Analysis: Cost Efficiency Curves – Commercial Unitary Air Conditioners and Air-Source Heat Pumps*. January, 2002.
[14] Caneta Research Inc. *Market and Benchmark Analysis for Central Air Conditioners and Heat Pumps.* September 2004.
[15] Caneta Report*, Potential Demand and Energy Savings in Air Conditioning End Uses in Canada,* March 2007.

Dual Enthalpy Economizer

Revision #	Description/Comment	Date Revised
0	Included in the OPA Measures and Assumptions List	Oct. 31, 2008

Efficient Equipment and Technologies Description

Economizer - consists of dampers, sensors, actuators, controls and links that work together to bring in outside air into a building. Accurate sensing of outdoor air conditions ensures that free cooling is used only when cost-effective.

Base Equipment and Technologies Description

Fixed damper, no economizer

Codes, Standards and Regulations

Decision Type	Target Market(s)	Load Type
Retrofit	Small to medium size commercial	OPA Commercial Space Cooling

Resource Savings Assumptions

Key Parameter Inputs

- Cooling capacity of equipment in tons; 1 ton = 12,000 Btu/hr
- Energy Efficiency Ratio (EER) - cooling energy efficiency ratio of the equipment (Btu/Wh); may be estimated as SEER/1.1.
- Savings Factor (SF) – annual kWh savings per ton of cooling equipment at an EER of 1.0. Based on a simulation modelling done for Burlington, Vermont, for units less than 5.4 tons, SF = 4,576 (assumes fixed damper baseline); for units 5.4 tons or more, SF = 3,318 (assumes dry bulb economizer baseline)[1].

Annual Energy Savings

Annual Energy Savings (kWh) = SF x Cooling capacity (tons) / EER

Peak Demand Savings

Peak demand savings are assumed to be 0 since it is assumed that during peak summer hours, the outside temperature is too warm to bring into the building.

Other Resource Savings

Other Input Assumptions

Effective Useful Life (EUL)

The effective useful life is reported to be 14 years from Efficiency Vermont[2]. The New England State Program Working Group (SPWG) uses a EUL of 7 years for a retrofit[3].

Base & Conservation Measure Equipment and O&M Costs

Efficiency Vermont assume the cost of an economizer to be $800[4]. However based on discussions with Ontario contractors, economizers can range between $1,500 to $3,000 for an RTU less than 5 tons.

Based on a $2,000 average cost, incremental cost = $400 per ton ($2,000 / 5 tons).

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[1] Efficiency Vermont Technical Reference Manual – Commercial Master, No. 2005-37
[2] Ibid.
[3] *GDS Associates,* Measure Life Report - Residential and Commercial/Industrial Lighting and HVAC Measures, Prepared for *The New England State Program Working Group (SPWG)*, June 2007
[4] Ibid.

Programmable Thermostat (Nighttime Setback)

Revision #	Description/Comment	Date Revised
0	Included in the OPA Measures and Assumptions List	Oct. 31, 2008

Efficient Equipment and Technologies Description

Nighttime Setback.

Base Equipment and Technologies Description

No nighttime setback strategy

Codes, Standards and Regulations

- ASHRAE 90.1, Section 6.4.3.2.2 states that heating controls capable of setback shall be installed.

Decision Type	Target Market(s)	Load Type
New / Retrofit	Commercial & Institutional	OPA Commercial Space Heating

Resource Savings Assumptions

Key Parameter Inputs

- Building type
- Floor area of the building (A)
- Number of hours of nighttime setback (n)
- Number of degree Celsius of nighttime setback
- Energy Saving Factor, ESF (Wh/m^2/ºC for 8 hours of setback)[1,2,3,4,5]:

Building Type	ESF	Building Type	ESF
Food service	13.95	C/I accommodation	3.57
Food retail	7.63	Non-food retail	3.18
Public assembly	5.10	Administration	3.03
Entertainment/Recreation	4.82	Health care	2.98
Shopping malls	4.34	Warehouse/Wholesale	2.78
Office	3.69	Education	2.18
Non-food service	3.63	Others	2.38

Annual Energy Savings

To generate the annual electricity savings (kWh):

$$\text{Annual Energy Savings (kWh)} = [\,(^n/_8) \times A \times \Delta T \times ESF\,] / 1{,}000$$

Peak Demand Savings

- See Appendix A for the description of the methodology in determining peak demand savings using OPA end use load profiles for the commercial and institutional sector.
- Demand may actually increase in the morning recovery period with a setback strategy. Demand is not expected to decrease during peak periods.

Other Resource Savings

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[1] Bullock, Charles E. (1978) "Energy Savings through Thermostat Setback with Residential Heat Pumps", ASHRAE Transactions, Volume 83, AL-78-1 (3): 352-361.
[2] Nelson, Lorne W. and J. Ward MacArthur (1978) "Energy Savings through Thermostat Setbacks", ASHRAE Transactions, Volume 83, AL-78-1 (1): 319-333.
[3] Plourde, Andre. Programmable Thermostats as Means of Generating Energy Savings: Some Pros and Cons. Canadian Building Energy End Use Data and Analysis Centre. March, 2003.
[4] EnerMark. Residential Energy Manual. Ontario Hydro, 1987.
[5] NRCan. Commercial and Institutional Building Energy Use: Detailed Statistical Report. December, 2002.

Other Input Assumptions

Effective Useful Life (EUL)
Programmable thermostats have the same effective useful life as the building.
Base & Conservation Measure Equipment and O&M Costs
Programmable thermostats cost $72.27[6,7], but since the Ontario Building Code already requires that programmable thermostats be installed, the actual incremental cost should be $0.

[6] RS Means. Mechanical Cost Data. 2006.
[7] California Energy Commission. "2001 DEER Update Study: Final Report". August, 2001

Cooling Thermal Storage to Reduce Space Cooling Load

Revision #	Description/Comment	Date Revised
0	Included in the OPA Measures and Assumptions List	Oct. 31, 2008

Efficient Equipment and Technologies Description

Thermal energy storage (TES) systems cool a storage medium and then use that cold medium to cool air at a later point in time. Using thermal storage can reduce the size and initial cost of cooling systems, lower energy costs, and reduce maintenance costs. If electricity costs more during the day than at night, thermal storage systems can reduce utility bills further.

Base Equipment and Technologies Description

Directly cool the space without thermal energy storage.

Codes, Standards and Regulations

Decision Type	Target Market(s)	Load Type
New	Commercial & Institutional	Custom

Resource Savings Assumptions

Key Parameter Inputs

- Thermal storage capacity - assume 2000 ton-hour to store the cooling energy produced at night for medium to large commercial buildings.
- Assume the thermal storage tank charging rate is equal to the thermal storage discharging rate = 4 hours
- Assume the typical cooling system efficiency including chillers, pump and cooling tower is 0.9 kWh / ton-hour during on-peak hours in day time and 1.1 kWh / ton-hour for charging the thermal storage tank during off-peak hours at night
- Thermal storage system operates during weekdays for 8 months a year, which is 347 hours for both on-peak and off-peak in both summer and shoulder months.

Annual Energy Savings

Reduction in On-peak Energy Consumption

- Daily on-peak electricity reduction through discharging the thermal storage equipment
  = 0.9 kWh/ton-hour x 2,000 ton-hours
  = 1,800 kWh
- Annual electricity avoided through discharging the thermal storage equipment
  = 1,800 kWh x 5 days x 52 weeks x 8 months / 12 months
  = 312 MWh
- On a per ton-hour basis, this is equal to 312 MWh / 2000 ton-hour = 156 kWh / ton-hour

Increase in Off-peak Energy Consumption

- Daily off-peak electricity consumption to charge the thermal storage
  = 1.1 kWh/ton-hour x 2,000 ton-hours
  = 2,200 kWh
- Daily increase in energy consumption due to thermal storage
  = 2,200 kWh (consumption during charging) – 1,800 kWh (reduced energy via discharging)
  = 400 kWh

Annual Increase in Energy Consumption Due to Thermal Storage

- Annual increase in energy consumption due to thermal storage
  = 400 kWh x 5 days x 52 weeks x 8 months / 12 months
  = 69,333 kWh
- On a per ton-hour basis, this is equal to 69,333 kWh / 2000 ton-hour = 34.7 kWh / ton-hour

Peak Demand Savings

- Reduced on-peak demand on a per ton-hour basis = 1,800 kWh / 4 hours / 2000 ton-hour = 0.225 kW / ton-hour for summer cooling.
- Since thermal storage is not in operation during winter season, winter peak demand reduction is zero.
- The load profile is constructed based on the load shifting nature of thermal storages assuming daily charging and discharging periods of 4 hours each, 8 months per year for both summer and shoulder months.

Other Resource Savings

Other Input Assumptions

Effective Useful Life (EUL)

The useful life of the TES system is 25 years. [1]

Base & Conservation Measure Equipment and O&M Costs

Because of the diverse options of customizing thermal energy storage for specific purposes, the cost of equipment cannot be reliably estimated. Project-specific costs (on a per ton-hour of thermal storage capacity) have to be defined by users.

[1] Modelling the potential of thermal storage for cooling under time-of-use electricity rates: An economic-engineering simulation approach, Lee and Miedema, International Journal of Energy Research, Vol.12 75-85 (1988)

Air Curtain

Revision #	Description/Comment	Date Revised
0	Included in the OPA Measures and Assumptions List	Oct. 31, 2008

Efficient Equipment and Technologies Description
Air curtains in retail, office and institutional buildings to reduce infiltration of cold outside air through doorway to reduce natural gas heating during heating season and reduce air conditioning usage due to infiltration of hot, humid air through doorway during summer season.
Base Equipment and Technologies Description
Retail, office and institutional buildings with non-air curtain doors.

Codes, Standards and Regulations

Decision Type	Target Market(s)	Load Type
Retrofit	Commercial	OPA Commercial Space Heating / OPA Commercial Space Cooling

Resource Savings Assumptions

Key Parameter Inputs

Electricity savings reflect reduced air-conditioning load given less outside air through doors to condition less incremental electricity use to operate air curtain. The following input assumptions can be made:

- Inside Temperature for heating season, T_{IH} = 68.00 ºF (20 ºC)
- Inside Temperature for cooling season, T_{IC} = 72.00 ºF (22 ºC)
- Average outside temperature for heating season T_{OH} = 29.27 ºF (- 2 ºC)
- Average outside temperature for cooling season T_{OC} = 77.00 ºF (25 ºC)
- Hours per day that door is open, HR = 1 hour
- Days per week that door is in use, DPW = 7 days
- Door Height, H = 8 ft
- Door Width, W = 6 ft
- Total horsepower of air curtain, HP = 0.5 hp
- Air curtain cfm at nozzle, Q_0 = 1,005 cfm
- Air curtain nozzle depth, NZ = 2.75 "
- Door coefficient, DC = 0.3
- Days per heating season, DPS_H = 120 days
- Days per cooling season, DPS_C = 100 days
- Average wind velocity for heating season V_{WH} = 10.0 mph
- Average wind velocity for cooling season V_{WC} = 8.3 mph
- Energy Efficiency Ratio for A/C Unit , EER = 12 Btu/Watt-hour

Annual Energy Savings

__Heating Season__

Doorway Calculations Without Air Curtain for Heating Season:

- Air entering doorway due to wind[1], $Q_W = V_{WH}$ x H x W x 88 fpm/mph x DC = 12,672 cfm
- Air entering doorway due to inside/outside temperature difference, QTD = [68.094+0.4256($T_i - T_{0H}$)] x H x W x $\sqrt{H(T_i - T_{0H})}/(T_i + 460)$ = 3,110 cfm
- Total air entering door way, $Q_T = Q_W + Q_{TD}$ = 15,782 cfm
- Heat lost at doorway without air curtain = 1.1 x Q_T x ($T_i - T_{0H}$) = 672,357 Btu/hr

[1] ASHRAE Handbook 2001 Fundamentals Ch.26

Doorway Calculations With Air Curtain for Heating Season:

- Total air flow rate at the door, $Q_E = 0.4704\ Q_0\ (\sqrt{H/NZ}) - Q_0$ = 1,788 cfm
- Heat lost at doorway using air curtain, $q_{AC} = 1.1 \times Q_E \times (T_i - T_{0H})$ = 76,183 Btu/hr

Heat Loss Prevented Per Year Using Air Curtain for Heating Season:

- qS = (qD - qAC) x HR x DPS_H x (DPW/7) = 77.50 MMBtu, which is equivalent to 2,191 m^3 natural gas.
- Electricity used = HP x 0.746 x DPS_H x (DPW/7) x HR = 48.49 kWh

Cooling Season

Doorway Calculations Without Air Curtain for Cooling Season:

- Air entering doorway due to wind[2], $Q_W = V_{WC}$ x H x W x 88 fpm/mph x DC = 10,492 cfm
- Air entering doorway due to inside/outside temperature difference, QTD = $[68.094+0.4256(T_{0C} - T_i)] \times H \times W \times \sqrt{H(T_{0C} - T_i)} / (T_i + 460)$ = 924 cfm
- Total air entering door way, $Q_T = Q_W + Q_{TD}$ = 11,417 cfm
- Sensible heat gain at doorway without air curtain = $1.1 \times Q_T \times (T_{0C} - T_i)$ = 62,792 Btu/hr

Doorway Calculations With Air Curtain for Cooling Season:

- Total air flow rate at the door, $Q_E = 0.4704\ Q_0\ (\sqrt{H/NZ}) - Q_0$ = 1,788 cfm
- Total air flow rate difference, $Q_{delta} = Q_T - Q_E$ = 9,628 cfm
- Latent heat gain at doorway to cool the space from 77ºF and 70% relative humidity to 72ºF and 60% relative humidity, $H_L = 0.68 \times Q_{delta}$ x humidity ratio difference = 0.68 x 9,628 cfm x (97.75 – 70.45) grain/lb = 178,743 Btu/hr
- Sensible heat gain at doorway using air curtain due to Q_{delta}, $H_s = 1.1 \times Q_{delta} \times (T_{0C} - T_i)$ = 52,957 Btu/hr

Heat Gain Prevented Per Year Using Air Curtain for Cooling Season:

- qS = (HL + Hs) x HR x DPSH x (DPW/7) = 23.17 MMBtu = 1,931 kWh
- Electricity used = HP x 0.746 x DPSH x (DPW/7) x HR = 37.30 kWh
- Total annual electricity saved = 1931- 37.30 – 48.49 = 1,845 kWh

Peak Demand Savings

See Appendix A for the description of the methodology in determining peak demand savings using OPA end use load profiles for the commercial and institutional sector.

Other Resource Savings

Annual saved natural gas is 77.5 MMBtu based on reduction in cool air entering doorway, which is equivalent to 2,191 m^3.

Other Input Assumptions

Effective Useful Life (EUL)

The effective useful life is reported as 15 years[3].

Base & Conservation Measure Equipment and O&M Costs

U.S. prices are about $1,800 equipment cost for air curtain, $200 installation cost.[4] Corresponding Canadian prices are estimated to be $2,000 initial cost and $400 installation cost.

[2] Ibid.
[3] SEED Program Guideline, Appendix J, Cost Effective Analysis, http://www.oregon.gov/ENERGY/CONS/SEED/docs/AppendixJ.pdf
[4] Berner International Study, Air Curtains: a Proven Alternative to Vestibule Design (October, 2008)

Lighting

Energy Star® Compact Fluorescent Lamps

Revision #	Description/Comment	Date Revised
0	Included in the OPA Measures and Assumptions List	Oct. 31, 2008

Efficient Equipment and Technologies Description
Energy Star® compact fluorescent lamps (screw-in or hardwired)
Base Equipment and Technologies Description
Incandescent bulbs (40W, 60W, 75W, 100W, or 150W)

Codes, Standards and Regulations

- The nominal selection of a CFL to replace an incandescent bulb is based on a nominal rating of 25% of incandescent lamp[1].
- CFLs use 75% less electricity to produce the same amount of light as an incandescent bulb and last up to 10 times longer[2]

Decision Type	Target Market(s)	Load Type
New / Replacement / Retrofit	Commercial & Institutional	OPA Commercial Lighting

Resource Savings Assumptions

Key Parameter Inputs

- Building Type

Office	School	Hotel/Motel
Restaurant	University	Health Facility
Retail Service	Warehouse	Grocery
Multi-unit Family Building		

- Wattages of incandescent bulbs and CFLs including ballast power

Equivalent CFL Wattages Replacement for Incandescent Bulbs[3]

Incandescent Bulb	CFL Equivalent
40 W	9-10 W
60 W	13-15 W
75 W	18 W
100 W	23-25 W
150 W	30-37 W

Ballast Powers for Hardwired CFLs (4-Pin)[4]

CFLs	Ballast Power
13 W	18 W
18 W	25 W
26 W	37 W

Notes:
Approximate ballast power increase is 28%. An increase of 28% to the power is therefore assumed for each specified CFL. No Ballast power is associated with screw-in CFLs.

- Number of fixtures
- Number of operating hours per fixture. The hours of operation vary for each building type and are based on indoor installation of CFLs. Outdoor lights would have a different operating schedule and depend on whether a photocell has been installed.

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[1] Seeline Group Inc., "Every KiloWatt Counts" TRC Assesment for The Summerhill Group (Ontario, October 2006) 2.
[2] Ontario Ministry of Energy, "Lighting Information" 2007, http://www.energy.gov.on.ca/index.cfm?fuseaction=conservation.lighting (August 15, 2007).

Annual Operating Hours of Selected Buildings[5]

Building Type	Annual Operating Hours	Building Type	Annual Operating Hours
Grocery store	5,800	Schools	2,150
Hotels/Motels	5,500	Multi-unit residential bldg (MURB)[6]	3,150
Large/Small retail (incl. restaurant)	4,450	MURB Apartment[7]	2,100
Hospital/Nursing home	4,400	MURB Corridor/Lobby[8]	5,100
Large/Small office	4,000	MURB Parking Garage	8,760
University	3,900		

Annual Energy Savings

$$\text{Annual Energy Savings (kWh)} = \sum_u \{ (\text{kW / Fixture x N x H})_{base} - (\text{kW / Fixture x N x H})_{efficient} \}$$

where:

kW/Fixture = lighting baseline demand per fixture for usage group *u*
N = quantity of affected fixtures for usage group *u*
H = number of operating hours per year for affected fixtures for usage group *u*

Note:

The demand and energy saving equations do not account for net energy savings associated with a reduced cooling load and increased heating load.

Peak Demand Savings

See Appendix A for the description of the methodology in determining peak demand savings using OPA end use load profiles for the commercial and institutional sector.

Other Resource Savings

Other Input Assumptions

Effective Useful Life (EUL)

- The useful life of the CFL fixtures varies between 6,000 to 12,000 hours. The hard-wired fluorescent lamps have a useful life of 8,000 hours and the magnetic ballasts 32,000 hours.[9]
- Incandescent bulbs have a useful life between 750 to 1,000 hours

Base & Conservation Measure Equipment and O&M Costs

- Base incandescent bulb = $0.50[10]
- Incremental costs are dependent on whether the fixture is hard-wired or screw in
- Hardwired fixed costs vary depending on power. Costs listed below are for a 13W hard-wired CFL.[11]

Screw in CFL:

Initial Cost = $3.50[12] → Incremental cost = $3.00 (The incremental cost is the difference between incandescent bulb and CFL, since this retrofit is likely done when the existing incandescent bulb burns out)

Hard-wired CFL Fixture: [13]
Initial bulb cost = $6.90
Magnetic Ballast = $5.00

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[3] http://www.energystar.gov/index.cfm?c=cfls.pr_cfls
[4] EE4, Energy Modeling Software.
[5] PG&E Workpapers, June 13, 2005.
[6] Caneta Research, *Base Case and Preliminary C-2000 Building Simulations*, 1993. These operating hours include corridor, parking garage, lobby, service rooms and apartments.
[7] EE4, Energy Modeling Software
[8] PG&E Workpapers, June 13, 2005.
[9] Ibid.
[10] http://www.energystar.gov/index.cfm?c=cfls.pr_cfls
[11] PG&E Workpapers, June 13, 2005
[12] http://www.energystar.gov/index.cfm?c=cfls.pr_cfls
[13] PG&E Workpapers, June 13, 2005

Fluorescent fixture = $37.00

Incremental cost = $48.90 (The incremental cost is the full cost for the CFL fixture, ballast and bulb because this type of retrofit is likely to occur prematurely – i.e. before the existing incandescent bulb is burnt out.)

Incremental costs do not include the life-cycle costs of the bulb. For example, assuming the life of a CFL is 10,000 hours, and the life of an incandescent bulb is 1,000 hours. The cost of installing additional 9 incandescent bulbs during the lifetime of the CFL has not been included in the incremental cost calculation.

High Performance T-8 Fixtures

Revision #	Description/Comment	Date Revised
0	Included in the OPA Measures and Assumptions List	Oct. 31, 2008

Efficient Equipment and Technologies Description

T12 fixtures can be replaced with standard performance T8 fixtures or high performance T8 fixtures. High performance T8 fixtures comply with the Consortium of Energy Efficiency (CEE)[1] and are simply T8 fixtures with lower ballast powers and higher luminosities. A list of eligible T8 high performance fixtures can be found on the CEE website. The medium ballast factor range data is listed below:

T8 Fixture (Standard)	Ballast Power (W)	Lumen/Fixture [2]
4' 32W – 4 Lamps	112	10,240
4' 32W – 3 Lamps	85	7,680
4' 32W – 2 Lamps	58	5,120
4' 32W – 1 Lamp	30	2,560
T8 Fixture (High Performance)	**Ballast Power (W)**	**Lumen/Fixture [3]**
4' 32W – 4 Lamps	109	11,800
4' 32W – 3 Lamps	85	8,850
4' 32W – 2 Lamps	55	5,900
4' 32W – 1 Lamp	28	2,950

Base Equipment and Technologies Description

Typical T12 Fixtures.

T12 Fixture	Ballast Power (W)	Lumen/Fixture (40W Non U-shaped[4], Others[5])
8' 95W – 2 Lamps (HO)	231	15,361
8' 75W – 2 Lamps (HO)	172	10,286
8' 60W – 2 Lamps (HO)	142	9400
4' 40W – 4 Lamps	175	9,160
4' 40W – 2 Lamps	88	4,580
4' 40W – 1 Lamp	51	2,290
4' 34W – 4 Lamps	149	8,791
4' 34W – 2 Lamps	81	4,779
4' 34W – 1 Lamp	47	2,775
40W U-Shaped 2 Lamps	93	4,418
34W U-Shaped 2 Lamps	81	5,038

HO – high output

Codes, Standards and Regulations

- High performance T8 fixtures comply with CEE standards[6]

Decision Type	Target Market(s)	Load Type
New / Replacement / Retrofit	Commercial & Institutional	OPA Commercial Lighting

[1] http://www.cee1.org/com/com-lt/com-lt-id.pdf
[2] Analysis and Potential Benefits and Costs of Adapting ASHRAE 90.1-1999 as a Commercial Building Energy Code in Michigan. Sept 2002. Completed by the Pacific Northwest National Laboratory for DOE
[3] http://www.cee1.org/com/com-lt/com-lt-main.php3
[4] Analysis and Potential Benefits and Costs of Adapting ASHRAE 90.1-1999 as a Commercial Building Energy Code in Michigan. Sept 2002. Completed by the Pacific Northwest National Laboratory for DOE
[5] Ontario Hydro Lighting Reference, 1992, Section 15.8 to 15.10
[6] http://www.cee1.org/com/com-lt/com-lt-id.pdf

Resource Savings Assumptions

Key Parameter Inputs

- Building Type

Office	School	Hotel/Motel
Restaurant	University	Health Facility
Retail Service	Warehouse	Grocery
Multi-unit Family Building		

- Wattages of the T12 and T8 fluorescent fixtures including ballast power for each fixture. The T8 ballast powers are different for each manufacturer and therefore average ballast power was used.
- Number of fixtures
- Number of operating hours per fixture. Operating hours may vary for each type of building, however the PG&E report was deemed to provide an acceptable estimate.

Annual Operating Hours of Selected Buildings[7]

Building Type	Annual Operating Hours	Building Type	Annual Operating Hours
Grocery store	5,800	Schools	2,150
Hotels/Motels	5,500	Multi-unit residential bldg (MURB)[8]	3,150
Large/Small retail (incl. restaurant)	4,450	MURB Apartment[9]	2,100
Hospital/Nursing home	4,400	MURB Corridor/Lobby[10]	5,100
Large/Small office	4,000	MURB Parking Garage	8,760
University	3,900		

Annual Energy Savings

$$\text{Annual Energy Savings (kWh)} = \sum_{u} \{ (\text{kW / Fixture x N x H})_{base} - (\text{kW / Fixture x N x H})_{efficient} \}$$

where:
- kW/Fixture = lighting baseline demand per fixture for usage group *u*
- N = quantity of affected fixtures for usage group *u*
- H = number of operating hours per year for affected fixtures for usage group *u*

Note:
The demand and energy saving equations do not account for net energy savings associated with a reduced cooling load and increased heating load.

Peak Demand Savings

See Appendix A for the description of the methodology in determining peak demand savings using OPA end use load profiles for the commercial and institutional sector.

Other Resource Savings

Other Input Assumptions

Effective Useful Life (EUL)

- The useful life of standard T8 and T12 ballasts are 16 years and the lamps are rated for 16,000 hours[11].
- High performance T8 ballasts have a useful life of 24 years[12]

Base & Conservation Measure Equipment and O&M Costs

A CEE study summarized the ballast costs in 2005 of a 2 lamp T12 fixture, a standard 2 lamp T8 fixture and a high performance 2 lamp T8 fixture[13]:

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[7] PG&E Workpapers, June 13, 2005.
[8] Caneta Research, *Base Case and Preliminary C-2000 Building Simulations*, 1993. These operating hours include corridor, parking garage, lobby, service rooms and apartments.
[9] EE4, Energy Modeling Software
[10] PG&E Workpapers, June 13, 2005.
[11] Ibid.
[12] http://www.cee1.org/com/com-lt/com-lt-main.php3
[13] http://www.cee1.org/com/com-lt/com-lt-id.pdf

Ballast	Ballast Cost
T12	$14
T8 (standard)	$20
T8 (high performance)	$26

Since the existing ballasts are already purchased the incremental cost would be the full cost of the T8 ballast.

T-8 Fixtures for Medium Bay Lighting

Revision #	Description/Comment	Date Revised
0	Included in the OPA Measures and Assumptions List	Oct. 31, 2008

Efficient Equipment and Technologies Description

T8 fixtures (standard and high performance 28 W) can be used to replace high intensity discharge (HID) lighting for medium bay applications where the fixture is mounted at a height of less than 25 feet.

Base Equipment and Technologies Description

295 W and 460 W ballasted power of metal halide fixtures.

Codes, Standards and Regulations

- High performance T8 fixtures comply with CEE standards[1]

Decision Type	Target Market(s)	Load Type
New / Replacement / Retrofit	Commercial & Institutional	OPA Commercial Lighting

Resource Savings Assumptions

Key Parameter Inputs

- Building Type

Office	School	Hotel/Motel
Restaurant	University	Health Facility
Retail Service	Warehouse	Grocery
Multi-unit Family Building		

- Wattages of the T8 fluorescent fixtures including ballast power for each fixture needed to replace 295 W and 460 W metal halides. The T8 ballast powers are different for each manufacturer and therefore average ballast power was used. Factors to be applied to the total wattage of each replacement are needed to produce the same lighting output:[2]

Metal Halide Wattages	Standard Performance T8	High Performance T8
295W MH	1.3 x 4-lamp T8 (145W) 6-lamp T8 (172W)	1.15 x 4-lamp T8 (125W)
460W MH	1.15 x 8-lamp T8 (263W)	1.35 x 6-lamp T8 (221W) 8-lamp T8 (218W)

- Number of fixtures
- Number of operating hours per fixture. Operating hours may vary for each type of building, however the PG&E report was deemed to provide an acceptable estimate.

Annual Operating Hours of Selected Buildings[3]

Building Type	Annual Operating Hours	Building Type	Annual Operating Hours
Grocery store	5,800	Schools	2,150
Hotels/Motels	5,500	Multi-unit residential bldg (MURB)[4]	3,150
Large/Small retail (incl. restaurant)	4,450	MURB Apartment[5]	2,100
Hospital/Nursing home	4,400	MURB Corridor/Lobby[6]	5,100
Large/Small office	4,000	MURB Parking Garage	8,760
University	3,900		

[1] http://www.cee1.org/com/com-lt/com-lt-id.pdf
[2] Marbek Resources Ltd., "ERIP Lighting Technology Review and Custom Lighting Calculation Methodology and Tool Development: Final Report", November 2008.
[3] PG&E Workpapers, June 13, 2005.

Annual Energy Savings

$$\text{Annual Energy Savings (kWh)} = \sum_{u} \{ (\text{kW / Fixture x N x H})_{base} - (\text{kW / Fixture x N x H})_{efficient} \}$$

where:
kW/Fixture = lighting baseline demand per fixture for usage group *u*
N = quantity of affected fixtures for usage group *u*
H = number of operating hours per year for affected fixtures for usage group *u*

Note:
The demand and energy saving equations do not account for net energy savings associated with a reduced cooling load and increased heating load.

Peak Demand Savings

See Appendix A for the description of the methodology in determining peak demand savings using OPA end use load profiles for the commercial and institutional sector.

Other Resource Savings

Other Input Assumptions

Effective Useful Life (EUL)

- The useful life of standard T8 ballasts is 16 years and the lamps are rated for 16,000 hours[7].
- High performance T8 ballasts have a useful life of 24 years[8]

Base & Conservation Measure Equipment and O&M Costs

Standard Performance T8

- The incremental cost of 1.3 4-lamp T8 fixtures complete with lamps and ballast is $234.
- The incremental cost of a 6-lamp T8 fixtures complete with lamps and ballast is $200.
- The incremental cost of 1.15 8-lamp T8 fixtures complete with lamps and ballast is $288.

High Performance T8

- The incremental cost of 1.15 4-lamp T8 fixtures complete with lamps and ballast is $230.
- The incremental cost of 1.35 6-lamp T8 fixtures complete with lamps and ballast is $325.
- The incremental cost of the 8-lamp T8 fixture complete with lamps and ballast is $300.

[4] Caneta Research, *Base Case and Preliminary C-2000 Building Simulations*, 1993. These operating hours include corridor, parking garage, lobby, service rooms and apartments.
[5] EE4, Energy Modeling Software
[6] PG&E Workpapers, June 13, 2005.
[7] Ibid.
[8] http://www.cee1.org/com/com-lt/com-lt-main.php3

T-5 High Output High Bay

Revision #	Description/Comment	Date Revised
0	Included in the OPA Measures and Assumptions List	Oct. 31, 2008

Efficient Equipment and Technologies Description

T5 High Output High Bay fixtures can be installed to replace metal halide or incandescent fixtures.

T5 Fixture	Ballast Power (W)	Luminosity
4 lamps F54T5HO	224 [1]	18,800
6 lamps F54T5HO	351 [2]	28,200

Base Equipment and Technologies Description

250W, 400W Metal Halide, Incandescent & Mercury Vapour > 400W

Fixture	Ballast Power (W)	Luminosity[3]
250W MH	295	13,700
400W MH	461	23,500

Codes, Standards and Regulations

Decision Type	Target Market(s)	Load Type
New / Replacement / Retrofit	Commercial & Institutional	OPA Commercial Lighting

Resource Savings Assumptions

Key Parameter Inputs

- Building Type
  - Grocery store
  - Industrial process
  - University gymnasium
  - Warehouse
  - School gymnasium
- Wattages of the metal halide and incandescent lamps including ballast power to be replaced per fixture
- Wattages of the T5 high output lamps including ballast power per fixture. Considering the equivalent lumen per fixture, it may be assumed that a 6 lamp-F54T5HO can replace a 400W metal halide and a 4-lamp F54T5HO can replace a 250W metal halide
- Number of fixtures
- Number of operating hours per fixture. Operating hours may vary for each type of building, however the PG&E report was deemed to provide an acceptable estimate. It was assumed school and university gymnasiums have an extended operating schedule from the rest of the school/university hours.

Annual Operating Hours of Selected Buildings[4]

Building Type	Annual Operating Hours
Grocery store	5,800
Industrial process	5,000
University gymnasium	3,900
Warehouse	3,550
School gymnasium	2,150
Arena[5]	2,880

- It is assumed that no occupancy sensors are installed prior to retrofit. Occupancy sensors would decrease the

[1] PG&E Workpapers, June 13, 2005.
[2] EE4, Energy Modeling Software
[3] http://www.lrc.rpi.edu/programs/nlpip/lightingAnswers/mwmhl/characteristics3.asp

number of operating hours, resulting in a decrease to the annual energy savings.

Annual Energy Savings

$$\text{Annual Energy Savings (kWh)} = \sum_{u} \{ (\text{kW / Fixture x N x H})_{base} - (\text{kW / Fixture x N x H})_{efficient} \}$$

where:
kW/Fixture = lighting baseline demand per fixture for usage group *u*
N = quantity of affected fixtures for usage group *u*
H = number of operating hours for affected fixtures for usage group *u*

Note:
The demand and energy saving equations do not account for net energy savings associated with a reduced cooling load and increased heating load.

Peak Demand Savings

See Appendix A for the description of the methodology in determining peak demand savings using OPA end use load profiles for the commercial and institutional sector.

Other Resource Savings

Other Input Assumptions

Effective Useful Life (EUL)

- The useful life of a T5 bulb is 20,000 hours.
- The useful life of a 250W MH bulb is 15,000 hours.
- The useful life of a 400W MH bulb is 20,000 hours.
- The useful life of a mercury vapour or incandescent bulb > 400W is 1,000 hours.

Base & Conservation Measure Equipment and O&M Costs

The 2001 DEER Update Study lists a 4-lamp T5HO fixture installed cost of $300.[6] This would be the incremental cost, since the other existing fixtures are replaced.

[4] PG&E Workpapers, June 13, 2005.
[5] NRCan, Reference Arena, http://cetc-ctec.nrcan-rncan.gc.ca/fichier.php/codectec/En/2003-066/2003-066-0f.pdf.
[6] California Energy Commission. “2001 DEER Update Study: Final Report”. August, 2001.

T-5 Fixtures

Revision #	Description/Comment	Date Revised
0	Included in the OPA Measures and Assumptions List	Oct. 31, 2008

Efficient Equipment and Technologies Description

T-5 High Output (HO) fixtures can replace two T-8 fixtures.

T5 Fixture (Standard)	Ballast Power (W)	Lumen/Fixture[1]
4' 28W – 3 Lamps	76	7,047
4' 28W – 2 Lamps	50	4,698
4' 28W – 1 Lamp	25	2,349
T5 Fixture (HO)	**Ballast Power (W)**	**Lumen/Fixture[2]**
4' 54W – 2 Lamps	117	9,400
4' 54W – 1 Lamp	59	4,700

Base Equipment and Technologies Description

Typical T12 Fixtures.

T8 Fixture (Standard)	Ballast Power (W)	Lumen/Fixture[3]
4' 32W – 4 Lamps	112	10,240
4' 32W – 3 Lamps	85	7,680
4' 32W – 2 Lamps	58	5,120
4' 32W – 1 Lamp	30	2,560

Codes, Standards and Regulations

- High performance T8 fixtures comply with CEE standards[4]

Decision Type	Target Market(s)	Load Type
New / Replacement / Retrofit	Commercial & Institutional	OPA Commercial Lighting

Resource Savings Assumptions

Key Parameter Inputs

- Building Type

Office	School	Hotel/Motel
Restaurant	University	Health Facility
Retail Service	Warehouse	Grocery
Multi-unit Family Building		

- Wattages of the T8 and T5 fixtures including ballast power per fixture. The T8 ballast powers are different for each manufacturer and therefore average ballast power was used. Considering the equivalent lumen per fixture, below are some of the possible replacement schemes

Reference T8 Fixture	T5 Fixture Installed
1-F32T8 (30W)	1-F28T5 (25W)
2-F32T8 (59W)	2-F28T5 (50W)
3-F32T8 (85W)	3-F38T5 (76W)
2-F32T8 (58W)	1-F54T5HO (59W)
4-F32T8 (112W)	2-F54T5HO (117W)

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[1] http://www.lrc.rpi.edu/programs/nlpip/lightingAnswers/lat5/pc7.asp
[2] Ibid.
[3] Analysis and Potential Benefits and Costs of Adapting ASHRAE 90.1-1999 as a Commercial Building Energy Code in Michigan. Sept 2002. Completed by the Pacific Northwest National Laboratory for DOE.
[4] http://www.cee1.org/com/com-lt/com-lt-id.pdf

- Number of fixtures
- Number of operating hours per fixture. Operating hours may vary for each type of building, however the PG&E report was deemed to provide an acceptable estimate.

Annual Operating Hours of Selected Buildings[5]

Building Type	Annual Operating Hours	Building Type	Annual Operating Hours
Grocery store	5,800	Schools	2,150
Hotels/Motels	5,500	Multi-unit residential bldg (MURB)[6]	3,150
Large/Small retail (incl. restaurant)	4,450	MURB Apartment[7]	2,100
Hospital/Nursing home	4,400	MURB Corridor/Lobby[8]	5,100
Large/Small office	4,000	MURB Parking Garage	8,760
University	3,900		

Annual Energy Savings

$$\text{Annual Energy Savings (kWh)} = \sum_{u} \{ (\text{kW / Fixture x N x H})_{base} - (\text{kW / Fixture x N x H})_{efficient} \}$$

where:
kW/Fixture = lighting baseline demand per fixture for usage group *u*
N = quantity of affected fixtures for usage group *u*
H = number of operating hours per year for affected fixtures for usage group *u*

Note:
The demand and energy saving equations do not account for net energy savings associated with a reduced cooling load and increased heating load. In some instances, using T5HO fixtures will not provide any energy savings, just a lower initial cost and maintenance cost because fewer bulbs are required.

Peak Demand Savings

See Appendix A for the description of the methodology in determining peak demand savings using OPA end use load profiles for the commercial and institutional sector.

Other Resource Savings

Other Input Assumptions

Effective Useful Life (EUL)

The useful life of a T5 bulb is 20,000 hours. [9]
The useful life for a T8 bulb is 16,000 hours. [10]

Base & Conservation Measure Equipment and O&M Costs

- The ballast cost for a T5, T5HO and T8 lamp is summarized below:

Ballast	Ballast Cost
T5[11]	$30
T5HO[12]	$30
T8 (Stand.)[13]	$20

- From the DEER Update Study in 2001[14], the T5 installed cost is $210. Since the existing T8 fixtures are being torn down, an incremental cost of $210 is incurred.

[5] PG&E Workpapers, June 13, 2005.
[6] Caneta Research, *Base Case and Preliminary C-2000 Building Simulations*, 1993. These operating hours include corridor, parking garage, lobby, service rooms and apartments.
[7] EE4, Energy Modeling Software
[8] PG&E Workpapers, June 13, 2005.
[9] http://www.lrc.rpi.edu/programs/nlpip/lightingAnswers/lat5/pc7.asp
[10] Ibid.
[11] http://www.naturallighting.com/web/shop.php?crn=753
[12] Ibid.
[13] http://www.cee1.org/com/com-lt/com-lt-id.pdf
[14] California Energy Commission. “2001 DEER Update Study: Final Report”. August, 2001

Metal Halide Ceramic (High Wattage)

Revision #	Description/Comment	Date Revised
0	Included in the OPA Measures and Assumptions List	Oct. 31, 2008

Efficient Equipment and Technologies Description

320W Metal Halide Ceramic Pulse Start – ballast power = 366W[1]

Base Equipment and Technologies Description

The following fixtures can be substituted with 320W metal halide ceramic.

- 350W or 400W Metal Halide Lamps [2]
  - 350W MH – Ballast Power = 395W[3]
  - 400W MH – Ballast Power = 450W[4]
- 1000W Incandescent fixture[5]

Codes, Standards and Regulations

Decision Type	Target Market(s)	Load Type
New / Replacement/ Retrofit	Commercial & Institutional	OPA Commercial Lighting

Resource Savings Assumptions

Key Parameter Inputs

- Building Type
  - Large/Small retail (incl. restaurant)
  - Large/Small office
  - Hospital/Nursing home
  - Hotel/Motel
  - Schools
  - University
  - Grocery
- Type of lamp replaced
- Ballast powers for the fixtures being replaced (kW / Fixture)
- Number of fixtures retrofitted for each usage group *u* (N)
- Number of operating hours per year for affected fixtures for usage group *u* (H)

Annual Operating Hours of Selected Buildings[6]

Building Type	Annual Operating Hours	Building Type	Annual Operating Hours
Grocery store	5,800	Schools	2,150
Hotels/Motels	5,500	Large/Small office	4,000
Hospital/Nursing home	4,400	University	3,900
Large/Small retail (incl. restaurant)	4,450		

Annual Energy Savings

$$\text{Annual Energy Savings (kWh)} = \sum_{u} \{ (\text{kW / Fixture x N x H})_{base} - (\text{kW / Fixture x N x H})_{efficient} \}$$

Note:

- Ballast powers may vary depending on the manufacturer. Venture lighting [7] published power inputs, so these values were used. Energy saved through a reduced cooling load has not been included.

[1] PG&E Workpapers, June 13, 2005.
[2] http://news.thomasnet.com/fullstory/462967
[3] http://www.venturelighting.com/VLPS/Opti-Wave400W.html
[4] Ibid.
[5] PG&E Workpapers, June 13, 2005.
[6] Ibid.
[7] http://www.venturelighting.com/VLPS/Opti-Wave400W.html

Peak Demand Savings
See Appendix A for the description of the methodology in determining peak demand savings using OPA end use load profiles for the commercial and institutional sector.
Other Resource Savings

Other Input Assumptions

Effective Useful Life (EUL)
The useful life of a 350W, 400W or 320W MH bulb is 16 years. The useful life of a 1,000W Incandescent is 1,000 hours[8]
Base & Conservation Measure Equipment and O&M Costs
The DEER Update Study[9] lists an installation cost of $287 for 50W to 400W MH fixtures. The incremental cost to replace a 400W MH with 320W Ceramic Pulse Start would be $287 since the existing fixtures are being replaced. The 320W MH requires a completely new fixture.

[8] NRCan Lighting Resources Guide, pg 44

[9] California Energy Commission. “2001 DEER Update Study: Final Report”. August, 2001.

Metal Halide Ceramic (Low Wattage)

Revision #	Description/Comment	Date Revised
0	Included in the OPA Measures and Assumptions List	Oct. 31, 2008

Efficient Equipment and Technologies Description

Ceramic Metal Halide (24W to 25W) – self ballasted

Base Equipment and Technologies Description

Halogen Bulb (50W to 120W)

Codes, Standards and Regulations

Decision Type	Target Market(s)	Load Type
New / Replacement/ Retrofit	Commercial & Institutional	OPA Commercial Lighting

Resource Savings Assumptions

Key Parameter Inputs

- Building Type
  - Large/Small retail (incl. restaurant)
  - Large/Small office
  - Hospital/Nursing home
  - Hotel/Motel
  - Schools
  - University
  - Grocery
- Type of lamp replaced
- Ballast powers for the fixtures being replaced (kW / Fixture)
- Number of fixtures retrofitted for each usage group *u* (N)
- Number of operating hours per year for affected fixtures for usage group *u* (H)

Annual Operating Hours of Selected Buildings[1]

Building Type	Annual Operating Hours	Building Type	Annual Operating Hours
Grocery store	5,800	Schools	2,150
Hotels/Motels	5,500	Large/Small office	4,000
Hospital/Nursing home	4,400	University	3,900
Large/Small retail (incl. restaurant)	4,450		

Annual Energy Savings

$$\text{Annual Energy Savings (kWh)} = \sum_u \{ (\text{kW / Fixture} \times N \times H)_{base} - (\text{kW / Fixture} \times N \times H)_{efficient} \}$$

Note:

- Ballast powers may vary depending on the manufacturer. Venture lighting [2] published power inputs, so these values were used. Energy saved through a reduced cooling load has not been included.

Peak Demand Savings

See Appendix A for the description of the methodology in determining peak demand savings using OPA end use load profiles for the commercial and institutional sector.

Other Resource Savings

[1] Ibid.

[2] http://www.venturelighting.com/VLPS/Opti-Wave400W.html

Other Input Assumptions

Effective Useful Life (EUL)
Metal halide ceramic with low wattages have a rated life of 8,000 to 10,500 hours.[3]
Base & Conservation Measure Equipment and O&M Costs
The incremental cost of the 24W to 25W ceramic MH is about $60.[4]

[3] http://ecmweb.com/images/710ecmSBLtable2.jpg
[4] Marbek Resources Ltd., “ERIP Lighting Technology Review and Custom Lighting Calculation Methodology and Tool Development: Final Report”, November 2008.

Lower Wattage High Intensity Discharge (HID) Lighting

Revision #	Description/Comment	Date Revised
0	Included in the OPA Measures and Assumptions List	Oct. 31, 2008

Efficient Equipment and Technologies Description
Lower wattage high intensity discharge lamps (400W MH, 175W MH, 250W HPS)
Base Equipment and Technologies Description
High wattage high intensity discharge lamps (360W MH, 150W MH, 225W HPS)

Codes, Standards and Regulations

Decision Type	Target Market(s)	Load Type
New / Replacement / Retrofit	Commercial & Institutional	OPA Commercial Lighting

Resource Savings Assumptions

Key Parameter Inputs

- Building Type
  - Office
  - Restaurant
  - Retail Service
  - Multi-unit Family Building
  - School
  - University
  - Warehouse
  - Hotel/Motel
  - Health Facility
  - Grocery
- Wattages of low and high wattage HID lamps

Equivalent Low and Wattage HID Lamps

High Wattage HID	Low Wattage HID
400 W MH	360 W MH
175 W MH	150 W MH
250 W HPS	225 W HPS

- Number of fixtures
- Number of operating hours per fixture. The hours of operation vary for each building type and are based on indoor installation of lighting. Outdoor lights would have a different operating schedule and depend on whether a photocell has been installed.

Annual Operating Hours of Selected Buildings[1]

Building Type	Annual Operating Hours	Building Type	Annual Operating Hours
Grocery store	5,800	Schools	2,150
Hotels/Motels	5,500	Multi-unit residential bldg (MURB)[2]	3,150
Large/Small retail (incl. restaurant)	4,450	MURB Apartment[3]	2,100
Hospital/Nursing home	4,400	MURB Corridor/Lobby[4]	5,100
Large/Small office	4,000	MURB Parking Garage	8,760
University	3,900		

[1] PG&E Workpapers, June 13, 2005.
[2] Caneta Research, *Base Case and Preliminary C-2000 Building Simulations*, 1993. These operating hours include corridor, parking garage, lobby, service rooms and apartments.
[3] EE4, Energy Modeling Software
[4] PG&E Workpapers, June 13, 2005.

Annual Energy Savings

$$\text{Annual Energy Savings (kWh)} = \sum_{\mathbf{u}} \{ (\text{kW / Fixture x N x H})_{base} - (\text{kW / Fixture x N x H})_{efficient} \}$$

where:

kW/Fixture = lighting baseline demand per fixture for usage group *u*
N = quantity of affected fixtures for usage group *u*
H = number of operating hours per year for affected fixtures for usage group *u*

Note:
The demand and energy saving equations do not account for net energy savings associated with a reduced cooling load and increased heating load.

Peak Demand Savings

See Appendix A for the description of the methodology in determining peak demand savings using OPA end use load profiles for the commercial and institutional sector.

Other Resource Savings

Other Input Assumptions

Effective Useful Life (EUL)

Metal halide lamps have a useful life ranging from 5,000 to 20,000 hours while high pressure sodium lamps have 16,000 to 24,000 hours.[5]

Base & Conservation Measure Equipment and O&M Costs

The incremental cost is around $12 for a 360W MH lamp, $8 for a 150W MH lamp, and $8 for a 225W HPS lamp, with minimal incremental labour costs since the fixture and ballast can remain in place.[6]

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[5] U.S. Department of Energy, http://apps1.eere.energy.gov/consumer/your_home/lighting_daylighting/index.cfm/mytopic=12080, accessed December 8, 2008.
[6] Marbek Resources Ltd., "ERIP Lighting Technology Review and Custom Lighting Calculation Methodology and Tool Development: Final Report", November 2008.

Halogen General Service Lamps

Revision #	Description/Comment	Date Revised
0	Included in the OPA Measures and Assumptions List	Oct. 31, 2008

Efficient Equipment and Technologies Description
Halogen General Service Lamps (40W, 50W, 70W)
Base Equipment and Technologies Description
Incandescent bulbs (60W, 75W, 100W)

Codes, Standards and Regulations

- Halogen General Service Lamps are approximately 50% more efficient and perform just as well as regular incandescent lamps in terms of dimming, power factor and color rendition index.[1]

Decision Type	Target Market(s)	Load Type
New / Replacement / Retrofit	Commercial & Institutional	OPA Commercial Lighting

Resource Savings Assumptions

Key Parameter Inputs

- Building Type
  - Office
  - Restaurant
  - Retail Service
  - Multi-unit Family Building
  - School
  - University
  - Warehouse
  - Hotel/Motel
  - Health Facility
  - Grocery
- Wattages of incandescent bulbs and halogens

Equivalent Halogen Wattages Replacement for Incandescent Bulbs

Incandescent Bulb	Halogen Equivalent
60 W	40 W
75 W	50 W
100 W	70 W

- Number of fixtures
- Number of operating hours per fixture. The hours of operation vary for each building type and are based on indoor installation of lighting. Outdoor lights would have a different operating schedule and depend on whether a photocell has been installed.

Annual Operating Hours of Selected Buildings[2]

Building Type	Annual Operating Hours	Building Type	Annual Operating Hours
Grocery store	5,800	Schools	2,150
Hotels/Motels	5,500	Multi-unit residential bldg (MURB)[3]	3,150
Large/Small retail (incl. restaurant)	4,450	MURB Apartment[4]	2,100
Hospital/Nursing home	4,400	MURB Corridor/Lobby[5]	5,100
Large/Small office	4,000	MURB Parking Garage	8,760
University	3,900		

[1] ERIP Lighting Technology Review and Custom Lighting Calculation Methodology and Tool Development: Final Report, Marbek Resource Consultants Ltd, November 2008.

Annual Energy Savings

$$\text{Annual Energy Savings (kWh)} = \sum_{u} \{ (\text{kW / Fixture x N x H})_{base} - (\text{kW / Fixture x N x H})_{efficient} \}$$

where:

kW/Fixture = lighting baseline demand per fixture for usage group *u*
N = quantity of affected fixtures for usage group *u*
H = number of operating hours per year for affected fixtures for usage group *u*

Note:
The demand and energy saving equations do not account for net energy savings associated with a reduced cooling load and increased heating load.

Peak Demand Savings

See Appendix A for the description of the methodology in determining peak demand savings using OPA end use load profiles for the commercial and institutional sector.

Other Resource Savings

Other Input Assumptions

Effective Useful Life (EUL)

- The useful life of halogen lamps is approximately 5,000 hours.
- Incandescent bulbs have a useful life between 750 to 1,000 hours

Base & Conservation Measure Equipment and O&M Costs

- The halogen GSL represents an incremental cost of approximate $7 over a standard incandescent bulb.[6]

[2] PG&E Workpapers, June 13, 2005.
[3] Caneta Research, *Base Case and Preliminary C-2000 Building Simulations*, 1993. These operating hours include corridor, parking garage, lobby, service rooms and apartments.
[4] EE4, Energy Modeling Software
[5] PG&E Workpapers, June 13, 2005.
[6] Marbek Resources Ltd., "ERIP Lighting Technology Review and Custom Lighting Calculation Methodology and Tool Development: Final Report", November 2008.

LED/Photoluminescent Exit Signs

Revision #	Description/Comment	Date Revised
0	Included in the OPA Measures and Assumptions List	Oct. 31, 2008

Efficient Equipment and Technologies Description

ENERGY STAR® Exit Signs 5 W - Photoluminescent

Base Equipment and Technologies Description

Existing Exit Sign 22 W

Codes, Standards and Regulations

- CSA 860 states exits signs must be 22W or lower (120V) and 27W or lower for (208V)[1].

Decision Type	Target Market(s)	Load Type
New / Replacement	Commercial & Institutional	OPA COM Baseload

Resource Savings Assumptions

Key Parameter Inputs

- Number of fixtures (exit signs) being replaced (N)
- Exit sign wattages (kW / Exit Sign)
- Number of operating hours per year = 8,760 (exit signs operate 24 hours a day and are not dependent on the building type)

Annual Energy Savings

$$\text{Annual Energy Savings (kWh)} = [\,(\text{kW / Exit Sign})_{base} - (\text{kW / Exit Sign})_{efficient}\,] \times N \times 8760$$

Assuming:

$(\text{kW / Exit Sign})_{base}$ = 0.022 kW

$(\text{kW / Exit Sign})_{efficient}$ = 0.005

Annual Energy Savings (kWh) = (0.022 – 0.005) x 8760

Annual Energy Savings (kWh) = 149 kWh per Exit Sign

Peak Demand Savings

See Appendix A for the description of the methodology in determining peak demand savings using OPA end use load profiles for the commercial and institutional sector.

Other Resource Savings

Other Input Assumptions

Effective Useful Life (EUL)

Energy Star requires that the exit signs have a minimum life of 5 years, however most LED exit signs have an effective useful life of 10 years.[2]

Base & Conservation Measure Equipment and O&M Costs

The incremental costs vary depending on the type of exit sign installed:

[1] http://www.theexitstore.com/CSA-860-Approved.htm

[2] http://www.energystar.gov/index.cfm?c=exit_signs.pr_exit_signs

- 3W LED exit sign – incremental cost = $96[3]
- Photoluminescent exit sign – incremental cost = $50[4]
- Energy Star lists a $57 incremental cost for an LED exit sign[5]
- Manitoba Hydro lists an incremental cost of $45/sign[6]

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3 http://www.conservationbureau.on.ca/Storage/14/1981_FINAL_TRC_Results_for_the_Low_Income_-_Social_Housing_Sector_V2.pdf

4 Ibid.

5 http://www.energystar.gov/index.cfm?c=exit_signs.pr_exit_signs

6 http://www.mansea.org/pdf/Hyrich-Power-Smart-for-Business.pdf

Lamps with Infrared Coating

Revision #	Description/Comment	Date Revised
0	Included in the OPA Measures and Assumptions List	Oct. 31, 2008

Efficient Equipment and Technologies Description
MR16, PAR30 & PAR38 lamps with infrared coating
Base Equipment and Technologies Description
MR16, PAR30 & PAR38 lamps without infrared coating

Codes, Standards and Regulations

Decision Type	Target Market(s)	Load Type
New / Replacement / Retrofit	Commercial & Institutional	OPA Commercial Lighting

Resource Savings Assumptions

Key Parameter Inputs

- Building Type

Office	School	Hotel/Motel
Restaurant	University	Health Facility
Retail Service	Warehouse	Grocery
Multi-unit Family Building		

- Wattages of base and efficient lamps with infrared coating[1]
  - 20W MR16 with infrared can replace a 35W standard MR16, or a 30 to 35W MR16 with infrared can replace a 50W standard MR16.
  - 60W PAR with infrared can replace a 75W standard PAR, or a 48W PAR with infrared can replace a 75W standard PAR.
- Number of fixtures
- Number of operating hours per fixture. The hours of operation vary for each building type and are based on indoor installation of lighting. Outdoor lights would have a different operating schedule and depend on whether a photocell has been installed.

Annual Operating Hours of Selected Buildings[2]

Building Type	Annual Operating Hours	Building Type	Annual Operating Hours
Grocery store	5,800	Schools	2,150
Hotels/Motels	5,500	Multi-unit residential bldg (MURB)[3]	3,150
Large/Small retail (incl. restaurant)	4,450	MURB Apartment[4]	2,100
Hospital/Nursing home	4,400	MURB Corridor/Lobby[5]	5,100
Large/Small office	4,000	MURB Parking Garage	8,760
University	3,900		

[1] Marbek Resources Ltd., "ERIP Lighting Technology Review and Custom Lighting Calculation Methodology and Tool Development: Final Report", November 2008.
[2] PG&E Workpapers, June 13, 2005.
[3] Caneta Research, *Base Case and Preliminary C-2000 Building Simulations*, 1993. These operating hours include corridor, parking garage, lobby, service rooms and apartments.
[4] EE4, Energy Modeling Software
[5] PG&E Workpapers, June 13, 2005.

Annual Energy Savings

$$\text{Annual Energy Savings (kWh)} = \sum_{u} \{ (\text{kW / Fixture x N x H})_{base} – (\text{kW / Fixture x N x H})_{efficient} \}$$

where:

kW/Fixture = lighting baseline demand per fixture for usage group *u*
N = quantity of affected fixtures for usage group *u*
H = number of operating hours per year for affected fixtures for usage group *u*

Note:

The demand and energy saving equations do not account for net energy savings associated with a reduced cooling load and increased heating load.

Peak Demand Savings

See Appendix A for the description of the methodology in determining peak demand savings using OPA end use load profiles for the commercial and institutional sector.

Other Resource Savings

Other Input Assumptions

Effective Useful Life (EUL)

The rated life for most infrared coated lamps is about 5,000 hours.[6]

Base & Conservation Measure Equipment and O&M Costs

- The incremental cost of a MR16 with infrared coating is approximately $4 per bulb while the incremental cost of a PAR with infrared coating is approximately $6 per bulb.[7]

[6] http://www.radiantenergy.com/TechnicalData/T-3-ProductDataSheet.pdf, accessed December 8, 2008.
[7] Marbek Resources Ltd., "ERIP Lighting Technology Review and Custom Lighting Calculation Methodology and Tool Development: Final Report", November 2008.

Occupancy Sensors

Revision #	Description/Comment	Date Revised
0	Included in the OPA Measures and Assumptions List	Oct. 31, 2008

Efficient Equipment and Technologies Description

Occupancy Sensor (for a controlled fixture wattage greater than 300W)

Base Equipment and Technologies Description

No Occupancy Sensor

Codes, Standards and Regulations

- The Ontario Building Code requires automatic lighting control (which may include occupancy sensors) to be installed in buildings with a floor area greater than 500 m^2.

Decision Type	Target Market(s)	Load Type
New	Commercial & Institutional	OPA Commercial Lighting

Resource Savings Assumptions

Key Parameter Inputs

- Building Type
- Total controlled lighting wattage (the controlled fixture wattage must be greater than 300W), kW
- Type of occupancy sensor (wall mounted – switch plate or ceiling mounted)
- Number of occupancy sensors to be installed
- Operating hours/year[1] and percentage (%) occupancy[2] based on the selected building type, H:

Building Type	Operating Hours/year	%Occupied	Notes
Large/Small Retail	4,450	60%	Predominantly Restrooms
Hospital/Nursing Home	4,400	60%	Predominantly Restrooms
Large/Small Office	4,000	65%	Incl. Conference Room & WC
Schools	2,150	57%	Classrooms & W/C
University	3,900	57%	Classrooms & WC
Hotels/Motels	5,500	35%	Meeting Rooms
Multi-Unit Residential Bldg (MURB)	5,100	70%	Common Areas

- Corridors were not included, however it has been estimated that they are occupied 20% to 70% of the time (average 45%)[3]
- The 30% Lighting Reduction was assumed for MURB[4] – no other information could be found.
- EE4 assumes a 30% lighting reduction (from ASHRAE-1999 Table 6-3) PG&E report assumed a 45% reduction for an office conference room[5]

Annual Energy Savings

Annual Energy Savings (kWh/system) = kW x (1 - % Occupied) x H

Note:
Energy savings are dependent on the quantity of occupancy controlled fixtures. This is a user input, which should be known. OPA has stated that the controlled fixture wattage must be at least 300W. This could be set as the default value if the controlled fixture wattage is unknown. It is highly unlikely that a large open office is unoccupied 35% of the time during an occupied period. Occupancy sensors installed in open offices would typically be used for

[1] PG&E Workpapers, June 13, 2005.
[2] http://www.p2pays.org/ref/32/31316.pdf
[3] Ibid.
[4] ASHRAE Standard 90.1, 1999, Table 6-3
[5] PG&E Workpapers, June 13, 2005.

night time control. The methodology is not very well suited for large open offices as the calculated electricity savings would be inflated.
Peak Demand Savings
See Appendix A for the description of the methodology in determining peak demand savings using OPA end use load profiles for the commercial and institutional sector.
Other Resource Savings

Other Input Assumptions

Effective Useful Life (EUL)
PG&E work papers[6] estimate an 8 year product life.
Base & Conservation Measure Equipment and O&M Costs
• Cost for manual switch or low-voltage switch is between $50 to $100 per circuit. • Cost for infrared or ultrasonic occupancy sensors is between $150 to $300. • Since this is a retrofit the incremental cost would be $300.

[6] PG&E Workpapers, June 13, 2005.

Commercial Refrigeration (Coolers & Freezers)

Energy Star® Qualified Refrigerator (Reach-In)

Revision #	Description/Comment	Date Revised
0	Included in the OPA Measures and Assumptions List	Oct. 31, 2008

Efficient Equipment and Technologies Description

Energy Star® Qualified Refrigerator (Reach-In)

Base Equipment and Technologies Description

Conventional Commercial Refrigerator (Reach-In)

Codes, Standards and Regulations

- Natural Resources Canada's (NRCan's) Office of Energy Efficiency amended Canada's Energy Efficiency Regulations to require dealers of self-contained, commercial refrigerators and freezers imported or shipped inter-provincially for sale or lease in Canada to comply with minimum energy performance standards[1].
- For units with doors or drawers: ANSI/ASHRAE Standard 117-1992, Method of Testing Closed Refrigerators
- The actual daily power consumed (in kWh/day) shall not exceed the amounts specified below:

Product	Type of Cabinet Door or Cabinet Drawer	Maximum Daily Energy Consumption (kWh)
Self-contained, commercial refrigerators	Solid/Opaque	Effective Jan. 1 to Dec. 31, 2007 E_{daily} = 0.00441V + 4.22 Effective Jan. 1, 2008 E_{daily} = 0.00441V + 2.76
	Transparent	Effective Jan. 1 to Dec. 31, 2007 E_{daily} = 0.00607V + 5.78 Effective Jan. 1, 2008 E_{daily} = 0.00607V + 4.77

Notes:

- V is the refrigerator volume measured in litres
- AV (adjusted volume, in litres) is equal to the refrigerator volume plus 1.63 times the freezer volume.

- Maximum daily energy use (kWh/day) for Energy Star® solid door refrigerators is computed by the following: 0.10 V + 2.04 where V is in cubic feet.

Decision Type	Target Market(s)	Load Type
New / Replacement	Hotels	OPA Commercial Electric Auxiliary

Resource Savings Assumptions

Key Parameter Inputs

- Type of refrigerator
- Unit internal volume of refrigerator, V (ft^3)
- No. of hours usage per year

Annual Energy Savings

$$\text{Annual Energy Savings (kWh)} = [\,(\text{kWh/day})_{base} - (\text{kWh/day})_{efficient}\,] \times \text{H (days/year)}$$

[1] NRCan, Office of Energy Efficiency, http://www.oee.nrcan.gc.ca/regulations/fridge-refrigerateur.cfm?Text=N&PrintView=N

For solid/opaque self-contained refrigerators:

$$\text{Annual Energy Savings (kWh)} = \{ [(0.00441 \times V \times 28.3168^{2}) + 2.76] \text{ base} – [(0.10 \times V) + 2.04] \} \times H$$

Simplifying:

$$\text{Annual Energy Savings (kWh)} = [(0.0249 \times V) + 0.72] \times H$$

Peak Demand Savings

See Appendix A for the description of the methodology in determining peak demand savings using OPA end use load profiles for the commercial and institutional sector.

Other Resource Savings

Other Input Assumptions

Effective Useful Life (EUL)

The EUL for Energy Star refrigeration is estimated to be 12 years based on Energy Star calculator[3]. Other jurisdictions have reported EUL between 9 and 12 years.

Base & Conservation Measure Equipment and O&M Costs

NYSERDA estimates an incremental cost of $300[4], while Energy Star calculator estimates a difference of $328. NCI proposes to use an incremental cost of $300.

[2] 1 cubic foot = 28.3168 liters
[3] Energy Star Calculator, http://www.energystar.gov/index.cfm?c=commer_refrig.pr_commercial_refrigerators
[4] NYSERDA

Energy Efficient Evaporator Fan Motors (Coolers/Freezers) incl. Walk-In Types

Revision #	Description/Comment	Date Revised
0	Included in the OPA Measures and Assumptions List	Oct. 31, 2008

Efficient Equipment and Technologies Description

- Case 1: Permanent split capacitor motors (PSC)
- Case 2: Electronically Commutated Motors (ECM).

Base Equipment and Technologies Description

Single-phase shaded pole (SP) motors.

Codes, Standards and Regulations

Decision Type	Target Market(s)	Load Type
New / Replacement	Commercial & Institutional	OPA Commercial Electric Auxiliary

Resource Savings Assumptions

Key Parameter Inputs

- Specifications for coolers/freezers:
  - Length of open display cases in feet (L)
  - Number of doors for closed display cases (n)
  - Coefficient of Performance (COP); if COP is unknown, default to 2, which is an average for low and medium temperature applications[1].
- Installed motor type (PSC or ECM)
- FMSF - Fan Motor Savings Factor/Cooling Load Savings Factor:
  - Display Case with no doors ($FMSF_A$) [2,3]
    Shaded Pole to PSC = 6.4 W/ft
    Shaded Pole to ECM = 8.1 W/ft
  - Reach-In Display w/ doors ($FMSF_B$)**Error! Bookmark not defined.**,**Error! Bookmark not defined.**
    Shaded Pole to PSC = 32.1 W/door
    Shaded Pole to ECM = 40.7 W/door
- EFLH – Equivalent Full Load Hours; 5,957 hours is assumed for compressor power**Error! Bookmark not defined.** and 8,760 hours for fan motor power

Annual Energy Savings

Demand Savings (kW)

$$\left[\frac{FMSF_A \times L}{COP \times 1000} + \frac{FMSF_A \times L}{1000}\right]_{PSCorECM} + \left[\frac{FMSF_B \times n}{COP \times 1000} + \frac{FMSF_B \times n}{1000}\right]_{PSCorECM}$$

Annual Energy Savings (kWh)

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[1] PG&E Workpapers, June 13, 2005.
[2] Evaporator fan power data from Hussmann (www.hussmann.com) and Tyler Refrigeration (www.tylerrefrigeration.com)
[3] Arthur D. Little, Inc. Energy Savings Potential for Commercial Refrigeration Equipment: Final Report. June, 1996.

$$\left[\frac{FMSF_A \times L \times 5{,}957}{COP \times 1000} + \frac{FMSF_A \times L \times 8760}{1000}\right]_{PSCorECM} + \left[\frac{FMSF_B \times n \times 5{,}957}{COP \times 1000} + \frac{FMSF_B \times n \times 8760}{1000}\right]_{PSCorECM}$$

Notes:

- The prescribed EFLH for compressors is an average for both low and medium temperature applications. Actual EFLH is dependent on several factors and will have an effect on overall energy savings.
- The Savings are based on an average fan power per foot for all types of display cases, based on data from two manufacturers. Actual fan power per foot will vary depending on the number and type of display cases and manufacturer.
- The “Class 1” type display cases can have upper and lower motors, increasing the W/ft of the display case, thus yielding more savings. These models were not taken into consideration when calculating the average savings, which leads to more conservative demand and energy saving estimates.

Peak Demand Savings

See Appendix A for the description of the methodology in determining peak demand savings using OPA end use load profiles for the commercial and institutional sector.

Other Resource Savings

Other Input Assumptions

Effective Useful Life (EUL)

The useful life is 16 years[Error! Bookmark not defined.].

Base & Conservation Measure Equipment and O&M Costs

The incremental cost was determined to be $25.20/motor incremental for PSC over SP[Error! Bookmark not defined.,4] and $41.36/motor incremental for ECM over SP[Error! Bookmark not defined.,4]

[4] RS Means. Mechanical Cost Data. 2006.

Floating Head Pressure Controls (Coolers/Freezers) incl. Walk-in Types

Revision #	Description/Comment	Date Revised
0	Included in the OPA Measures and Assumptions List	Oct. 31, 2008

Efficient Equipment and Technologies Description
Floating head pressure controls.
Base Equipment and Technologies Description
No floating head pressure controls.

Codes, Standards and Regulations

Decision Type	Target Market(s)	Load Type
New/Replacement/Retrofit		

Resource Savings Assumptions

Key Parameter Inputs

- Length of display cases in meter (L)
- Volume of cold rooms/walk-ins in cubic meter (V)
- Demand Savings Factor (DSF) – this is assumed to be 0.050 kW/m (display) or 0.0035 kW/m^3 (cold rooms/walk-ins)[1,2,3,4,5]
- Energy Savings Factor (ESF) – this is assumed to be 1.3 kWh/m/day (display) or 0.092 kWh/m^3/day (cold room/walk-ins) [1,2,3,4,5]

Annual Energy Savings

Demand Savings (kW) = (0.050 x L) + (DSF x V)

Annual Energy Savings (kWh) = (1.3 x L x 365) + (ESF x V x 365)

Note:
Savings are based on an average value for all display case types. Actual savings will vary depending on the number and type of display cases and walk-ins for each supermarket. Savings are based on percentage estimates from various sources. Actual savings will depend on the facility and mode of operation for this particular measure.

Peak Demand Savings

See Appendix A for the description of the methodology in determining peak demand savings using OPA end use load profiles for the commercial and institutional sector.

Other Resource Savings

[1] BC Hydro Website. Accessed October, 2007: http://www.bchydro.com/business/investigate/investigate6012.html
[2] NRCan Website. Accessed October 2007: http://www.oee.nrcan.gc.ca/industrial/equipment/commercial-refrigeration/savings.cfm?attr=24
[3] Arthur D. Little, Inc. Energy Savings Potential for Commercial Refrigeration Equipment: Final Report. June, 1996.
[4] Quebec Hydro. Technology Profile Report: Commercial Refrigeration System. July, 1996. Prepared by Innovation Technologique INTEK Inc, Quebec, Canada.
[5] Canadian Electricity Association: Capitalising on the Energy Savings Opportunities Presented by CFC and HCFC Phase-out in Non-Domestic Refrigeration: Volume 1. Prepared by AE Technology, UK.

Other Input Assumptions

Effective Useful Life (EUL)
The useful life is 14 years[6].
Base & Conservation Measure Equipment and O&M Costs
The incremental cost was determined to be $109/m of display case, $15.60/m3 of cold rooms/walk-ins[7,8].

[6] PG&E Workpapers, June 13, 2005.
[7] Quebec Hydro. Technology Profile Report: Commercial Refrigeration System. July, 1996. Prepared by Innovation Technologique INTEK Inc, Quebec, Canada.
[8] RSMEANS Mechanical Cost Data. 2006.

Humidistat Anti-Sweat Heater Controls (Coolers/Freezers) incl. Walk-in Types

Revision #	Description/Comment	Date Revised
0	Included in the OPA Measures and Assumptions List	Oct. 31, 2008

Efficient Equipment and Technologies Description
Pulse Modulation Anti-Sweat Heaters (ASH) controls.
Base Equipment and Technologies Description
ASH without controls (i.e. always on).

Codes, Standards and Regulations

Decision Type	Target Market(s)	Load Type
New / Replacement / Retrofit	Commercial & Institutional	OPA Commercial Electric Auxiliary

Resource Savings Assumptions

Key Parameter Inputs

- Average relative humidity (RH) of building (default to 45%).
- Number of cooler walk-in doors (n_1), average door area (A_{d1}).
- Number of freezer walk-in doors (n_2), average door area (A_{d2}).
- Number of display-case cooler doors (n_3), average area (A_{d3}).
- Number of display-case freezer doors (n_4), average area (A_{d4}).
- Compressor EER (Note: if this is unknown by user, assume 5.19 for low temperature applications and 8.51 for medium temperature[1])
- Cooling Load Savings Factors (CLSF)[2]
  - 35% RH – 1.34 Btu/Wh
  - 45% RH – 0.52 Btu/Wh
  - 55% RH – 0.009 Btu/Wh
- Anti-Sweat Heater Savings Factors (ASF)[3]:
  - 35% RH – 100% savings (i.e. no ASH power draw)
  - 45% RH – 53.6% savings
  - 55% RH – 0.55% savings
- For walk-in types; assume 3.0 W of ASH per sq ft for cooler door[4] and 7.1 W of ASH per sq ft for freezer door[5]
- $EFLH_{Compressor}$ – Equivalent Full Load Hours of Compressors use are 5,957 hours[6]
- $EFLH_{ASH}$ – Equivalent Full Load Hours of Anti-Sweat Heaters are 8760 hours

[1] PG&E Workpapers, June 13, 2005.
[2] Southern California Edison. Anti-sweat Control Technology Boosts Display Case Efficiency: Evaluating Pulse Modulation Controls and Polymer Doors. Accessed October, 2007. http://www.sce.com/RebatesandSavings/DesignandEngineer.htm
[3] Ibid.
[4] Draft of Federal Standards Legislative Language for Walk-In Coolers and Freezers (EPCA draft). July 18, 2007.
[5] Ibid.
[6] Arthur D. Little, Inc. Energy Savings Potential for Commercial Refrigeration Equipment: Final Report. June, 1996

Annual Energy Savings

Demand Savings (kW):

Demand Savings (kW) = Compressor Load Savings + ASH Load Savings

$$\text{Demand Savings (kW)} = \left[\frac{CLSF \times A_{d1} \times n_1}{EER \times 1000} + \frac{3.0\,{}^{W}\!/_{m^2} \times ASF \times A_{d1} \times n_1}{1000}\right] + \left[\frac{CLSF \times A_{d2} \times n_2}{EER \times 1000} + \frac{7.1\,{}^{W}\!/_{m^2} \times ASF \times A_{d2} \times n_2}{1000}\right] + \left[\frac{CLSF \times A_{d3} \times n_3}{EER \times 1000} + \frac{3.0\,{}^{W}\!/_{m^2} \times ASF \times A_{d3} \times n_3}{1000}\right] + \left[\frac{CLSF \times A_{d4} \times n_4}{EER \times 1000} + \frac{7.1\,{}^{W}\!/_{m^2} \times ASF \times A_{d4} \times n_4}{1000}\right]$$

Annual Energy Savings (kWh):

$$\text{Annual Energy Savings (kWh)} = \left[\frac{CLSF \times A_{d1} \times n_1 \times EFLH_{Comp}}{EER \times 1000} + \frac{3.0\,{}^{W}\!/_{m^2} \times ASF \times A_{d1} \times n_1 \times EFLH_{ASH}}{1000}\right] + \left[\frac{CLSF \times A_{d2} \times n_2 \times EFLH_{Comp}}{EER \times 1000} + \frac{7.1\,{}^{W}\!/_{m^2} \times ASF \times A_{d2} \times n_2 \times EFLH_{ASH}}{1000}\right] + \left[\frac{CLSF \times A_{d3} \times n_3 \times EFLH_{Comp}}{EER \times 1000} + \frac{3.0\,{}^{W}\!/_{m^2} \times ASF \times A_{d3} \times n_3 \times EFLH_{ASH}}{1000}\right] + \left[\frac{CLSF \times A_{d4} \times n_4 \times EFLH_{Comp}}{EER \times 1000} + \frac{7.1\,{}^{W}\!/_{m^2} \times ASF \times A_{d4} \times n_4 \times EFLH_{ASH}}{1000}\right]$$

Note:

- Uncertainty in the RH dependent cooling load savings is dependent on the accuracy of the Southern California Edison study[7]. Assumed ASH power intensity is based on a U.S. draft report for updating the EPCA. Actual power intensity for ASH will vary between manufacturers and subsequently impact both demand and energy savings.
- Refrigeration EFLH is an average value for low and medium temperature applications. Actual EFLH is dependent on several factors and could cause higher or lower energy savings.

Peak Demand Savings

See Appendix A for the description of the methodology in determining peak demand savings using OPA end use load profiles for the commercial and institutional sector.

Other Resource Savings

Other Input Assumptions

Effective Useful Life (EUL)

The useful life is 4 years for anti-sweat heaters[8]

Base & Conservation Measure Equipment and O&M Costs

The incremental cost was determined to be $8.72/sq ft of door area[8, 9]

[7] PG&E Workpapers, June 13, 2005.
[8] California Energy Commission. “2001 DEER Update Study: Final Report”. August, 2001.
[9] RSMeans. Mechanical Cost Data. 2006.

Installing Night Covers for Open Display Cases

Revision #	Description/Comment	Date Revised
0	Included in the OPA Measures and Assumptions List	Oct. 31, 2008

Efficient Equipment and Technologies Description
Install film or blanket type night covers on display cases
Base Equipment and Technologies Description
No night covers on display cases. The display cases are open to the ambient conditions for all hours of the day, resulting in a maximum heat gain through infiltration.

Codes, Standards and Regulations

Decision Type	Target Market(s)	Load Type
New		OPA Commercial Electric Auxiliary

Resource Savings Assumptions

Key Parameter Inputs

- Specifications of open display cases
  - Lv = Total length of vertical display cases (ft)
  - Lh = Total length of horizontal display cases (ft)
- Hours per year the walk-in doors are open (dependent on building type):[1]
  - Retail (average use) = 1,095 hrs
  - Retail (heavy use) = 1,725 hrs
  - Food Service = 1,095 hrs
  - Warehouse = 1,095 hrs
- Compressor efficiency (EER) – this is assumed to be 8.51 Btu/Wh for vertical display cases and 5.12 Btu/Wh for horizontal display cases
- The following values have been assumed in the derivation of the compressor demand and energy savings. These values were taken from an analysis by the Pacific Gas and Electric Company[2].

$Q_{cooling}$	Case Rating (Btu/hr/ft)	1,450 Btu/hr/ft
C_{inf}	% of cooling from infiltration	80%
K_{inf}	% of infiltration saving factor	70%
C_{rad}	% of cooling from radiation	10%
K_{rad}	% of radiation saving factor	50%
EFLH	Equivalent full load hours	5,700 hours/year
T	Time nigh hours covers are applied per day	6 hrs per day

Annual Energy Savings

The method for calculating the energy savings associated with implementing night covers is based on the procedure outlined in the PG&E report. The cooling savings, demand savings, and energy savings from implementing night covers were calculated separately for horizontal and vertical display cases using the following equations:

Cooling Savings, $Q_{coolingsvg}$ (Btu/hr/ft)

$$Q_{coolingsvg} = Q_{cooling} \times [(C_{inf} \times K_{inf}) + (C_{rad} \times K_{rad})]$$

[1] PG&E Workpapers, June 13, 2005
[2] Ibid.

Compressor Power Savings, CPSkW (kW/ft)

$$CPSkW = [Q_{coolingsvg}/EER]/1000$$

Annual Compressor Energy Savings, CPSkWh (kWh/ft)

$$CPSkWh = CPSkW \times EFLH \times (T / 24)$$

Based on these equations and the default values listed above, the annual compressor savings from implementing night covers on vertical display cases is 148 kWh/ft and 59 kWh/ft for horizontal display cases. Based on these, annual energy savings associated with implementing night covers is calculated as follows:

Annual Electricity Savings (kWh) = (148 kWh/ft x Lv) + (59 kWh/ft x Lh)

Peak Demand Savings

There is no peak demand savings associated with night covers because the savings occur during off-peak periods.

Other Resource Savings

Other Input Assumptions

Effective Useful Life (EUL)

The effective useful life was determined to be 5 years.[3]

Base & Conservation Measure Equipment and O&M Costs

The incremental capital cost of night covers is $9.25 per linear foot of display cases.[4]

[3] Ibid.
[4] Ibid.

Installing Strip Curtains for Walk-in Coolers/Freezers

Revision #	Description/Comment	Date Revised
0	Included in the OPA Measures and Assumptions List	Oct. 31, 2008

Efficient Equipment and Technologies Description
Install strip curtains in the walk-in freezer and cooler doorways to reduce the infiltration heat gain when the doors are opened.
Base Equipment and Technologies Description
No walk-in cooler/freezer doorway covering in base case. There is no barrier at the walk-in doorway to reduce the infiltration load when a door is opened.

Codes, Standards and Regulations

Decision Type	Target Market(s)	Load Type
New	Commercial	OPA Commercial Electric Auxiliary

Resource Savings Assumptions

Key Parameter Inputs

- Specifications of door areas
  - Ac = Total cooler door area (ft^2)
  - Af = Total freezer door area (ft^2)
- Hours per year the walk-in doors are open (dependent on building type):[1]
  - Retail (average use) = 1,095 hrs
  - Retail (heavy use) = 1,725 hrs
  - Food Service = 1,095 hrs
  - Warehouse = 1,095 hrs
- Compressor efficiency (EER) – this is assumed to be 1.6 kW/ton for walk-in cooler and 2.4 kW/ton for walk-in freezer[2]
- The following values have been assumed in the derivation of the compressor demand and energy savings. These values were taken from an analysis by the Pacific Gas and Electric Company[3] and from ASHRAE[4].

W	Walk-in doorway width	3 ft
H	Walk-in doorway height	7 ft
Q/A	Sensible heat load of infiltration air per square foot of doorway opening (tons/ft^2)	0.16 ton/ft^2 for coolers and 0.61 tons/ft^2 for freezers
R	Sensible heat ratio of the infiltration air heat gain	0.59 for coolers, and 0.63 for freezers
Dt	Doorway open time factor	1 hour
Df	Doorway flow factor	0.8
E	Effectiveness of doorway protection device	80% for strip curtains; 0% for no coverings

1 PG&E Workpapers, June 13, 2005
2 Ibid.
3 Ibid.
4 ASHRAE Refrigeration handbook 1994

Annual Energy Savings

The method for calculating the energy savings associated with implementing strip curtains is based on the equations presented in the ASHRAE refrigeration handbook and on an analysis by the Pacific Gas and Electric Company. The cooling savings, demand savings, and energy savings from implementing strip curtains were calculated separately for walk-in coolers and walk-in freezers using the following equations**:**

Average Heat Gain, Q_{gain} (Btu/h)

$$Q_{gain} = 3{,}790 \times W \times H^{1.5} \times (Q/A) \times (1/R) \times Dt \times Df \times (1-E)$$

Increase in Compressor Input, kW_{gain} (kW)

$$kW_{gain} = Q_{gain} \times EER / 12{,}000 \text{ Btu/ton}$$

Based on these equations and the default values assumed above, the increase in compressor input was calculated with and without strip curtains over a period of one hour. The compressor demand savings (non-coincident) from implementing strip curtains on an open door for one full hour is 0.221 kW per square foot of door area (walk-in coolers), and 1.243 kW per square foot of door area (walk-in freezers).

Annual Electricity Savings (kWh) = $[(0.221 \text{ kW/ft}^2 \times Ac) + (1.243 \text{ kW/ft}^2 \times Af)] \times T$

Note:
The majority of the uncertainty in the calculated energy savings comes from the estimates of the hours that the doors are open per year. For the retail (average use), food service and warehouse buildings, the annual hours were taken from the PG&E analysis[5]. For the retail (heavy use), the annual hours were increased in proportion to the infiltration loads taken from ASHRAE –1977[6]**Error! Bookmark not defined.**. Unfortunately, this input is highly variable, even between buildings of the same type.

Peak Demand Savings

There is no peak demand savings associated with night covers because the savings occur during off-peak periods.

Other Resource Savings

Other Input Assumptions

Effective Useful Life (EUL)

The effective useful life was determined to be 5 years.[7]

Base & Conservation Measure Equipment and O&M Costs

The incremental capital cost of night covers is $9.25 per linear foot of display cases.[8]

[5] PG&E Workpapers, June 13, 2005.
[6] ASHRAE Refrigeration handbook 1977
[7] PG&E Workpapers, June 13, 2005.
[8] Ibid.

Cleaning Condenser Coils (Coolers/Freezers) incl. Walk-in Types

Revision #	Description/Comment	Date Revised
0	Included in the OPA Measures and Assumptions List	Oct. 31, 2008

Efficient Equipment and Technologies Description
Proof of maintenance program that outlines periodic cleaning of condenser coils.
Base Equipment and Technologies Description
No condenser maintenance.

Codes, Standards and Regulations

Decision Type	Target Market(s)	Load Type
	Commercial & Institutional	OPA Commercial Electric Auxiliary

Resource Savings Assumptions

Key Parameter Inputs

- Length of display cases in meter (L)
- Volume of cold rooms/walk-ins in cubic meter (V)
- Compressor power savings is assumed to be 4.3%.[1]
- Equivalent Full Load Hours – assumed to be 5,957 hours[2]

Annual Energy Savings

Compressor Savings (kW)[3,4]

Compressor Savings = (0.6 x L) + (0.044 x V)

Annual Energy Savings (kWh):

Annual Energy Savings (kWh) = Compressor Savings (kW) x EFLH

Note:
Condenser fouling coverage is assumed to be 35%, although the actual value may vary. Increased fouling coverage would lead to greater savings when cleaned and decreased fouling coverage would lead to fewer saving.

Peak Demand Savings

See Appendix A for the description of the methodology in determining peak demand savings using OPA end use load profiles for the commercial and institutional sector.

Other Resource Savings

Other Input Assumptions

Effective Useful Life (EUL)

Maintenance should be performed annually.

[1] Breuker, M., Rossi, T. and Braun, J. Smart Maintenance For Rooftop Units. ASHRAE Journal, November, 2000.
[2] Arthur D. Little, Inc. Energy Savings Potential for Commercial Refrigeration Equipment: Final Report. June, 1996.
[3] Quebec Hydro. Technology Profile Report: Commercial Refrigeration System. July, 1996. Prepared by Innovation Technologique INTEK Inc, Quebec, Canada.
[4] Caneta Research. Potential Demand and Energy Savings in Refrigeration End Uses in Canada. 2007

Base & Conservation Measure Equipment and O&M Costs
The incremental cost was determined to be $79.87 annually[5,6].

[5] RS Means. Mechanical Cost Data. 2006
[6] RSMeans. Facilities Maintenance and Repair Cost Data. 1997.

Electric Auxiliary

Premium Efficiency Motors up to 200 HP

Revision #	Description/Comment	Date Revised
0	Included in the OPA Measures and Assumptions List	Oct. 31, 2008

Efficient Equipment and Technologies Description

NEMA premium efficiency for motors[1]

Base Equipment and Technologies Description

Minimum nominal efficiency for motors as listed in the Ontario Building Code[2]

Codes, Standards and Regulations

Decision Type	Target Market(s)	Load Type
New / Replacement / Retrofit	Commercial & Institutional	OPA Commercial Electric Auxiliary

Resource Savings Assumptions

Key Parameter Inputs

- Size of motors (hp)
- Motor applications (fans, heating pumps, cooling pumps)
- Building type
- Presence of variable speed drives. Motors with variable speed drives operate on average at approximately 50% load.[3,4]
- Demand Savings Factors (DSF):[5]

	Demand Savings per Motor (kW)					
	Open Motors			Enclosed Motors		
Poles	2	4	6	2	4	6
RPM	3600	1800	1200	3600	1800	1200
HP						
1	0.01	0.02	0.02	0.01	0.02	0.02
1.5	0.02	0.03	0.03	0.02	0.03	0.02
2	0.02	0.04	0.03	0.02	0.04	0.03
3	0.04	0.07	0.04	0.02	0.04	0.04
5	0.04	0.07	0.07	0.04	0.07	0.07
7.5	0.05	0.13	0.09	0.05	0.11	0.08
10	0.07	0.15	0.10	0.05	0.15	0.10
15	0.07	0.20	0.15	0.08	0.14	0.15
20	0.11	0.26	0.19	0.20	0.26	0.20
25	0.12	0.31	0.21	0.12	0.19	0.21
30	0.14	0.33	0.23	0.14	0.23	0.26
40	0.18	0.28	0.28	0.18	0.28	0.28

[1] NEMA website. Accessed November, 2007. http://www.nema.org/stds/complimentary-docs/upload/MG1premium.pdf
[2] 2007 Ontario Building Code.
[3] American Society of Heating, Refrigeration and Air Conditioning Engineers. *2004 ASHRAE Handbook: HVAC Systems and Equipment*. 2004.
[4] Hegberg, R.A. *Converting Constant-Speed Hydronic Pumping Systems to Variable-Speed Pumping*. ASHRAE Transactions, 1986.
[5] PG&E Workpapers, June 13, 2005.

60	0.23	0.53	0.34	0.23	0.53	0.34
75	0.29	0.42	0.43	0.29	0.61	0.43
100	0.39	0.81	0.56	0.32	0.56	0.56
125	0.40	0.70	0.70	0.39	0.70	0.70
150	0.48	0.74	0.84	0.47	0.74	0.74
200	0.62	0.98	1.12	0.49	1.47	0.98

- Operating hours, H:[6]

Facility Type	Fan Hours	Heating Pump Hours	Cooling Pump Hours
Office	3,900	2,600	1,300
Restaurant	6,032	4,021	2,010
Retail/Service	4,888	3,259	1,629
School	4,160	2,773	1,387
Warehouse	3,588	2,392	1,196
Hotel/Motel	8,760	5,840	2,920
MURB	8,760	5,840	2,920
Health	8,760	5,840	2,920
Athletics/Theatre	4,004	2,669	1,335

Annual Energy Savings

$$\text{Annual Energy Savings (kWh)} = \sum (DSF_i \times H_i)_{\text{No VSD}} + (0.5 \times DSF_i \times H_i)_{\text{with VSD}}$$

Note:
No coincident diversity factor (CDF) for coincident peak demand was used. PG&E cites a 0.74 CDF, however they do not provide an explanation or reference for such a number. It is assumed that the connected demand reduction is equal to the coincident peak demand reduction. Using a CDF would reduce demand savings. Operating hours were taken from MNECB schedules. An 8-month heating season and 4-month cooling season were assumed, with motors not operating during setback hours. An increase or decrease in actual motor operating hours would increase or decrease the energy savings.

Peak Demand Savings

See Appendix A for the description of the methodology in determining peak demand savings using OPA end use load profiles for the commercial and institutional sector.

Other Resource Savings

Other Input Assumptions

Effective Useful Life (EUL)

Dependent on motor size:[7]

- 1-5 hp: 17 years
- 6-20 hp: 19 years
- 21-50 hp: 22 years
- 51-200 hp: 28 years

Base & Conservation Measure Equipment and O&M Costs

Note: If there is no incremental cost indicated in the following table, it is cheaper to buy a premium efficiency motor than a minimum efficiency motor for that particular size and rpm.

[6] Canadian Commission on Building and Fire Codes. *Performance Compliance for Buildings*. May, 1999.
[7] ACEEE. *Impact of Proposed Increases to Motor Efficiency Performance Standards, Proposed Federal Motor Tax Incentives, and Suggested New Directions Forward*. June, 2007.

	Incremental Cost[8]					
	Open Motors			Enclosed Motors		
Poles	2	4	6	2	4	6
RPM	3600	1800	1200	3600	1800	1200
HP						
1	-	$16	$7	-	$59	$6
1.5	-	$40	$41	$57	$68	$103
2	-	$29	$31	$26	$78	$55
3	-	$39	$37	$64	$112	$77
5	$8	$55	$54	$25	$63	$61
7.5	$53	$107	-	$72	$133	$214
10	$73	$125	$83	$60	$131	$333
15	$114	$119	$96	$224	$205	$213
20	$60	$153	-	$167	$180	$532
25	$48	$255	$9	$243	$286	$508
30	$61	$211	$73	$516	$491	$698
40	$75	$208	$153	$583	$602	$580
50	$122	$130	$241	$954	$743	$672
60	$312	$255	$645	$929	$709	$499
75	$87	$163	$850	$617	$629	$1,329
100	$118	$483	-	$901	$738	$1,445
125	$223	$315	$74	$452	$734	$1,206
150	$196	$682	$668	$596	$727	$192
200	$689	$867	$1,721	$506	$710	$484

[8] Motor Database from "MotorMaster" software, Version 1.0.15, from the US Department of Energy.

Energy Star® Commercial Ice Machines

Revision #	Description/Comment	Date Revised
0	Included in the OPA Measures and Assumptions List	Oct. 31, 2008

Efficient Equipment and Technologies Description

Energy Star Ice Machine (Ice Making head unit – air cooled)

Base Equipment and Technologies Description

Conventional Ice Machine (Ice Making head unit – air cooled)

Codes, Standards and Regulations

NRCan's Office of Energy Efficiency technical requirements for Automatic Ice Makers[1] - this applies to factory-assembled automatic ice-makers that have a standard capacity rating of between 23 and 1000 kilograms per day (kg/d), including self-contained and split-system machines that produce cubed, flaked, crushed or fragmented ice, in either a batch or continuous process. Ice-makers installed in household refrigerators, refrigerator-freezers or freezers, automatic ice-dispensing machines and cold-plate drink dispensers are excluded. For air-cooled and water-cooled batch automatic ice-makers (cubers), below are the maximum energy input for each category:

Product Class (Capacity = kg/day)	Maximum Energy Input (kJ/kg)
Air-cooled	
23 ≤ capacity < 150 kg/d	1630 – 6.008 × capacity
150 ≤ capacity ≤ 1000 kg/d	807.2 – 0.5229 × capacity
Water-cooled	
23 ≤ capacity < 150 kg/d	1234 – 4.381 × capacity
150 ≤ capacity ≤ 1000 kg/d	621.8 – 0.2985 × capacity

Energy Star® and the Consortium for Energy Efficiency (CEE) have developed different tier specifications for ice making units. Listed below are the specifications for ice-making head units (the most commonly used machines) for both air and water cooled[2].

Harvest Rate (lbs ice/day)	Energy Use Limit (kWh/100 lbs ice)	
	Energy Star®	CEE Tier 1
Air-cooled		
< 450	9.23 – 0.0077H	10.26 – 0.0086H
≥ 450	6.20 – 0.0010H	6.89 - 0.0011H
Water-cooled		
< 500	-	7.80 – 0.0055H
≥ 500 and < 1436	-	5.58 – 0.0011H
≥ 1436	-	4.00

Decision Type	Target Market(s)	Load Type
New / Replacement	Hotel	OPA Commercial Electric Auxiliary

[1] NRCan, Office of Energy Efficiency, http://www.oee.nrcan.gc.ca/regulations/product/automatic_ice_makers.cfm?text=N&printview=N
[2] Packaged Commercial Refrigeration Equipment: A Briefing Report for Program Planners and Implementers, Steven Nadel, ACEEE, December 2002.

Resource Savings Assumptions

Key Parameter Inputs

- Volume of ice required per day, V_{ice}
- Number of days the ice machine is being operated, D (days per year)

Annual Energy Savings

$$\text{Annual Energy Savings (kWh)} = [\ (kWh/kg)_{base} - (kWh/kg)_{efficient}\ ] \times V_{ice} \times D$$

Unit Type and Capacity (lbs. of ice/24 hours)	Annual Energy Use of Average Base Case Model (kWh/year)	Annual Energy Use of Average Tier 1 Model (kWh/year)	Average Annual kWh Savings Relative to Base Case for Tier 1
Air-Cooled			
<200	2,021	1,887	134
200 to 400	3,680	3,243	437
401 to 600	4,906	4,480	427
> 600	6,531	5,870	661
Water-Cooled			
<200	1,620	1,412	208
200 to 400	2,835	2,546	289
401 to 600	4,077	3,465	612
> 600	5,381	4,572	809

- As referenced from the CEE table above, using a 200 to 400 lb of ice/day air cooled unit, 437 kWh/year savings can be expected for a Tier 1 Model.
- Energy Star Calculator reports an ice making head (water cooled) harvesting 200 lb/day of ice saves 568 kWh/year based on base model usage of 6,182 kWh/year and an Energy Star model of 5,614 kWh/year[3].

Peak Demand Savings

See Appendix A for the description of the methodology in determining peak demand savings using OPA end use load profiles for the commercial and institutional sector.

Other Resource Savings

Other Input Assumptions

Effective Useful Life (EUL)

The EUL for ice machine is reported to be 10 years for NYSERDA[4] and Northwest Power and Conservation Council[5] and 8 years by Energy Star Calculator[6] and Efficiency Vermont[7]. Navigant Consulting, Inc. estimates 8 years.

Base & Conservation Measure Equipment and O&M Costs

Incremental costs for an Energy Star unit vary between $45 to $300. Navigant Consulting, Inc used the most recent value published by Northwest Power and Conservation Council (2007)[8] of $60.

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[3] Energy Star Calculator, http://www.energystar.gov/ia/business/bulk_purchasing/bpsavings_calc/Calc_Ice_Machines.xls
[4] NYSERDA – New York Energy $mart Programs, Deemed Database
[5] Northwest Power and Conservation Council Deemed Calculator, www.nwcouncil.org/energy/rtf/meetings/2008/05/ComIceMakerCalcFY07v1_4.xls,
[6] Energy Star Calculator, http://www.energystar.gov/ia/business/bulk_purchasing/bpsavings_calc/Calc_Ice_Machines.xls
[7] Efficiency Vermont Commercial Master Technical Reference Manual, Reference Manual Number 2005-37
[8] Northwest Power and Conservation Council Deemed Calculator, www.nwcouncil.org/energy/rtf/meetings/2008/05/ComIceMakerCalcFY07v1_4.xls,

Energy Star® Softdrink Vending Machine

Revision #	Description/Comment	Date Revised
0	Included in the OPA Measures and Assumptions List	Oct. 31, 2008

Efficient Equipment and Technologies Description
Energy Star® Vending Machine
Base Equipment and Technologies Description
Conventional Vending Machine

Codes, Standards and Regulations

Canada's Energy Efficiency Regulations (the Regulations) were amended November 2, 2006 and published in the Canada Gazette, Part II on November 15, 2006 to require dealers of refrigerated bottled and canned vending machines imported or shipped interprovincially for sale or lease in Canada to comply with minimum energy performance standards[1].

Product		Maximum E_{daily} (kWh/day)	
	Number of discrete types of beverages displayed and dispensed	**January 1, 2007 – December 31, 2007**	**On or after January 1, 2008**
Refrigerated beverage vending machine	< 20	0.55 (8.66 + 0.009 × VC)	0.45 (8.66 + 0.009 × VC)
	$\geq$ 20	0.55 (8.66 + 0.009 × VC)	0.55 (8.66 + 0.009 × VC)
Snack and refrigerated beverage vending machines		0.55 (8.66 + 0.009 × VC)	0.55 (8.66 + 0.009 × VC)

Notes:

- "E_{daily}" means, the daily energy consumption of the product expressed in kilowatt hours per day.
- "VC" or "vendible capacity" means the maximum quantity of product that is recommended by the manufacturer to be dispensed from one full loading of the machine.
- All refrigerated beverage vending machines must be capable of operating in low power mode.

  "*low power mode*" means a mode – into which the machine automatically enters during a period of extended inactivity – that is capable of reducing the energy consumption of the machine by means of each of the following power states:

  (a) a lighting power state in which the machine's lights are turned off,
  (b) a refrigeration power state in which the average temperature of the refrigerated beverages is allowed to rise to 4.4°C, and
  (c) a machine power state in which the lighting and refrigeration power states are both in operation.

Decision Type	Target Market(s)	Load Type
New / Replacement	Hotel	OPA Commercial Electric Auxiliary

[1] NRCan, Office of Energy Efficiency, Refrigerated Beverage Vending Machines – Final, November 2006. http://www.oee.nrcan.gc.ca/regulations/refrigerated-beverage-vending-machines-nov2006.cfm?text=N&printview=N

Resource Savings Assumptions

Key Parameter Inputs

- Vending Capacity per one full loading of the machine
- Total number of days the vending machine is "on"

Annual Energy Savings

- Energy savings has been estimated from Energy Star Calculator[2] and summarized below for two cases: with and without a software enabling low energy lighting and refrigeration mode during periods of inactivity (night).

Can Capacity	Energy Consumption (kWh/year)			Savings (kWh/year)	
	Conventional	EStar without Software	EStar with Software	EStar without Software	EStar with Software
< 500	3,113	2,014	1,454	1,099	1,659
500	3,916	2,162	1,685	1,754	2,231
600	3,551	2,309	1,800	1,242	1,751
700	4,198	2,457	1,915	1,741	2,283
800+	3,318	2,605	2,030	713	1,288

- Using a typical 500 can capacity, and without the low energy software, savings are estimated to be 1,754 kWh/year.

Peak Demand Savings

See Appendix A for the description of the methodology in determining peak demand savings using OPA end use load profiles for the commercial and institutional sector.

Other Resource Savings

Other Input Assumptions

Effective Useful Life (EUL)

The EUL for vending machine is reported to be 14 years from the Energy Star Calculator[3]

Base & Conservation Measure Equipment and O&M Costs

Energy Star presentation reports retrofit cost from conventional vending machine to be $150 to $200[4]. Navigant Consulting, Inc. will assume the average incremental cost to be $175.

[2] Energy Star Calculator, Energy Star Vending Machines, http://www.energystar.gov/ia/business/bulk_purchasing/bpsavings_calc/Calc_Vend_Mach.xls
[3] Ibid.
[4] US EPA Energy Star Presentation, www.nwcouncil.org/energy/rtf/meetings/2006/2006_09/RTF%20091806%20-%20Vending%20Final-2.ppt

Heat Recovery

Installing Waste Water Heat Recovery

Revision #	Description/Comment	Date Revised
0	Included in the OPA Measures and Assumptions List	Oct. 31, 2008

Efficient Equipment and Technologies Description
Waste Water Heat Recovery installed
Base Equipment and Technologies Description
No Waste Water Heat Recovery

Codes, Standards and Regulations

Decision Type	Target Market(s)	Load Type
New	Commercial & Institutional	OPA Commercial Water Heating

Resource Savings Assumptions

Key Parameter Inputs

- Building type:
  a) Restaurant (full meal or fast food)
  b) Hair Salon (number of sinks)
- Average daily amount of water needed and hot water temperature requirements. Below are assumptions:

Building Type	Average Daily Flow	Hot Water Temperature Requirements
Restaurants (full meal)[1]	9.1 L/customer	55.0°C
Restaurants (fast food)[2]	2.6 L/customer	55.0°C
Hair salon day[3]	946 L/sink	40.6°C

- Average discharge temperature = 32°C[4]
- Average incoming water temperature = 9.5°C[5]
- Waste Water Heat Recovery effectiveness assumed to be 50% although the effectiveness can range from 40% to 60%[6].
- Density of water, ρ_{water} = 1 kg/L
- Specific Heat of Water, C_p = 4.186 kJ/kg°C
- Electric Boiler Efficiency = 95%
- The preheated water temperature calculation assumes the flow is balanced and all discharge water is drained through the waste water heat recovery system.

Annual Energy Savings

Annual Energy Savings (kWh) = Energy Savings Factor (kWh/L) x Daily Volume of Water Consumed (L/day) x No. of days per year

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[1] American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc. 2007 ASHRAE Handbook – HVAC Applications. 2007.
[2] Ibid.
[3] http://gfxtechnology.com/Salon.pdf
[4] Caneta Report, Opportunities for Electricity Savings Through Heat Recovery in Residential and Commercial Buildings, November 1991, page 7.
[5] Picard, Delisle, Bernier, On the combined Effect of Wastewater heat recovery and solar domestic hot water heating, 2006
[6] http://www.retherm.com/ProductsSpecs.htm#Specs

Energy Savings Factor, ESF (kWh/L):

$$ESF\ (kWh/L) = [\ \rho_{water}\ (kg/L) \times C_p\ (kJ/kg°C) \times \Delta T_{water}\ (°C)\ ] / 3600$$

where:

ΔT_{water} - the difference between the preheated water temperature (boiler inlet) and the required hot water temperature (boiler outlet). The preheated water temperature depends on the effectiveness of the waste water heat recovery equipment (assumed to be 50%) and is estimated as follows:

$$T_{pre\text{-}heated} = [\ Effectiveness \times (T_{discharge} - T_{raw\ water})\ ] + T_{raw\ water}$$
$$= [\ 0.5 \times (32 - 9.5)\ ] + 9.5$$
$$= 20.75°C$$

Hence, ΔT_{water} are as follows:

Restaurant = 55.00 – 20.75 = 34.25°C

Hair Salon = 40.60 – 20.75 = 19.85°C

Computing for the ESF (kWh/L):

Restaurant: ESF = (1.0 x 4.186 x 34.25) / 3600 = 0.0398 kWh/L

Hair Salon: ESF = (1.0 x 4.186 x 19.85) / 3600 = 0.023 kWh/L

Note:

- Energy savings could be higher or lower depending on the size and type of waste water heat recovery system.

Peak Demand Savings

See Appendix A for the description of the methodology in determining peak demand savings using OPA end use load profiles for the commercial and institutional sector.

Other Resource Savings

Other Input Assumptions

Effective Useful Life (EUL)

Waste Water Heat Recovery Systems have a useful life between 30 to 50 years[7].

Base & Conservation Measure Equipment and O&M Costs

The cost for a waste water heat recovery system ranges between $600 and $1,000 including installation costs. The system has no maintenance fees.[8]

[7] http://www.renewability.com/pdfs/powerpipe_bg_4.25.06.pdf

[8] Ibid.

Arena Refrigeration Heat Recovery with Advanced Refrigeration Control System

Revision #	Description/Comment	Date Revised
0	Included in the OPA Measures and Assumptions List	Oct. 31, 2008

Efficient Equipment and Technologies Description

Heat recovery from refrigeration system, integration of refrigeration system with heating, ventilation and dehumidification system, short-term heat storage, variable condensing temperature and pressure (floating head pressure).

Base Equipment and Technologies Description

No heat recovery from refrigeration system

Codes, Standards and Regulations

Decision Type	Target Market(s)	Load Type
Retrofit	Commercial	OPA Commercial Electric Auxiliary

Resource Savings Assumptions

Key Parameter Inputs

- Total area for rink and bleachers is assumed to be 4,140 m^2.
- Annual energy consumption is 1,560,000 kWh in 2003-2004.

Annual Energy Savings

- The following savings are based on a case study of the Colisee des Bois-Francs arena in Victoriaville (Quebec) based on a major retrofit of their refrigeration system[1].
- 14% electrical energy savings is assumed for 50% greater cooling capacity compared with previous system before retrofit.
- Energy savings is 275,294 kWh/year, which is 66.5 kWh/m^2.

Peak Demand Savings

See Appendix A for the description of the methodology in determining peak demand savings using OPA end use load profiles for the commercial and institutional sector.

Other Resource Savings

Other Input Assumptions

Effective Useful Life (EUL)

The effective useful life is reported as 40 years by a Sweden case study.[2]

Base & Conservation Measure Equipment and O&M Costs

Incremental cost per m^2 = \$693,300/4,140m^2 = \$167.5/m^2[2][3]

[1] NRCan, RAPB http://cetc-ctec.nrcan-rncan.gc.ca/fichier.php/codectec/En/2004-154/2004-154e.pdf
[2] A Swedish world unique invention for ice rink cooling www.scda.com/files/pm_ice_rink_.doc
[3] NRCan, RAPB http://cetc-ctec.nrcan-rncan.gc.ca/fichier.php/codectec/En/2004-154/2004-154e.pdf

Thermal Envelope

Arena Low Emissivity Ceiling

Revision #	Description/Comment	Date Revised
0	Included in the OPA Measures and Assumptions List	Oct. 31, 2008

Efficient Equipment and Technologies Description

The amount of heat radiated from the ceiling to the ice is directly proportional to the emissivity (EM) of the ceiling. Reducing the emissivity arena ceiling can have a large impact on the load on ice plant, reducing energy costs and providing better ice conditions. True Low Emissivity Ceiling materials have an EM of 0.05, or 5% or less.

Base Equipment and Technologies Description

Codes, Standards and Regulations

Decision Type	Target Market(s)	Load Type
New / Retrofit	Commercial & Institutional	OPA Commercial Electric Auxiliary

Resource Savings Assumptions

Key Parameter Inputs

- Building area in square meter
- Annual energy consumption in kWh

Annual Energy Savings

- Refrigeration system energy consumption is reduced by 93,000 kWh[1] a year, or 14% of the total refrigeration system consumption and nearly 7% saving of the total energy consumption.
- Building area is 3,000 m^2. Duration of operation: 9 months. [2]
- Energy savings on square meter basis: 31kWh/m^2.

Peak Demand Savings

See Appendix A for the description of the methodology in determining peak demand savings using OPA end use load profiles for the commercial and institutional sector.

Other Resource Savings

Other Input Assumptions

Effective Useful Life (EUL)

The effective useful life is reported as 20 years[3].

Base & Conservation Measure Equipment and O&M Costs

$35,000[4] for 3000 m^2, which is $11.67/$m^2$.

[1] NRCan, Technical Fact Sheets on the Impacts of New Energy Efficiency Technologies and Measures in Ice Rinks, Influence of the Type of Ice Rink Ceiling, http://cetc-ctec.nrcan-rncan.gc.ca/fichier.php/codectec/En/2003-066-1/2003-066-1e.pdf
[2] NRCan, Reference Arena, http://cetc-ctec.nrcan-rncan.gc.ca/fichier.php/codectec/En/2003-066/2003-066-0f.pdf
[3] NRCan, RETScreen Model: Energy Efficiency Project Analysis for Supermarkets and Arenas
[4] Ibid.

Water Heating

Pipe and Hot Water Tank Insulation

Revision #	Description/Comment	Date Revised
0	Included in the OPA Measures and Assumptions List	Oct. 31, 2008

Efficient Equipment and Technologies Description

Adding insulation to domestic hot water (DHW) pipes and storage tanks:

- Pipe diameter < 40mm = 12mm insulation required (k = 0.42W/mK)[1]
- Pipe diameter > 40mm = 25mm insulation required (k = 0.42W/mK)[1]

Tank Insulation must meet R-12 (RSI 2.2) (insulation thickness = 92.4mm)

Base Equipment and Technologies Description

No insulation

Codes, Standards and Regulations

Decision Type	Target Market(s)	Load Type
New / Retrofit		OPA Commercial Water Heating

Resource Savings Assumptions

Key Parameter Inputs

- Insulation thickness
- Building Type
  - a) Large/Small Retail
  - b) Hospital/Nursing Home
  - c) Large/Small Office/Warehouse
  - d) Schools/Universities
  - e) Hotels/Motels
- Piping (diameter, insulated pipe length)
- Storage tank volume, V (L)
- Domestic Hot Water Use:
  - ♦ If Pipe Diameter is < 40 mm, assume reference insulation thickness of 12 mm
  - ♦ If Pipe Diameter is > 40 mm, assume reference insulation thickness of 25 mm
- Annual DHW usage[2]:
  - ♦ Large/Small Retail 2,077hrs/year
  - ♦ Hospital/Nursing Home 7,862hrs/year
  - ♦ Large/Small Office/Warehouse 2,353hrs/year
  - ♦ Schools/Universities 2,522hrs/year
  - ♦ Hotels/Motels 3,931hrs/year
- Other assumed values
  - ♦ Thermal conductivity of the insulating material, k = 0.042W/m°K
  - ♦ T_{sur} = 21.1°C (surrounding air temperature)
  - ♦ T_{water} = 55°C (storage tank temperature)
  - ♦ Tank height, H = 1.6 m
  - ♦ Electric boiler efficiency = 95%

[1] OBC, 2007
[2] DHW peak load percentages taken from EE4

Annual Energy Savings

Pipe Insulation Annual Energy Savings:

$$\text{Annual Energy Savings (kWh/m)} = \frac{q'net \times AnnualDHWUsage}{1{,}000}$$

Pipe Diameter < 40 mm

$$q'net \text{ (W/m)} = 8.95 \times \left(\frac{1}{\ln(1 + 12/r_1)} - \frac{1}{\ln(1 + r_2/r_1)} \right)$$

Pipe Diameter $\geq$ 40mm

$$q'net \text{ (W/m)} = 8.95 \times \left(\frac{1}{\ln(1 + 25/r_1)} - \frac{1}{\ln(1 + r_2/r_1)} \right)$$

Pipe Insulation (per meter of pipe length)

$$q' \text{ (W/m)} = \frac{2\pi k \Delta T}{\ln(r_2/r_1)}$$

r_1 (mm) = Pipe diameter/2

r_2 (mm) = r_1 + insulation thickness

Storage Tank Insulation Annual Energy Savings:
(assuming cylindrical storage tank shape)

$$\text{Annual Energy Savings (kWh)} = \frac{q'net \times H \times 8760}{1000 \times EBE}$$

$$V = \pi r^2 H$$

$$r_1 = \sqrt{\frac{V}{1{,}000 \times H \times \pi}} \times 1{,}000 \text{ (mm)}$$

$$q'net \text{ (W/m)} = 8.95 \times \left(\frac{1}{\ln(1 + 92.4/r_1)} - \frac{1}{\ln(1 + r_2/r_1)} \right)$$

Note:

- The temperature of the water has a significant impact on the energy savings. If the domestic hot water temperature is increased, more energy savings would be expected.
- It is assumed that the pipe insulation is installed immediately downstream of the hot water storage tank where most of the heat loss would occur.
- The number of hours of domestic hot water usage per year is predominantly responsible for the energy savings. This usage was obtained from EE4 and deemed to be an accurate estimate for each building type.

Peak Demand Savings

See Appendix A for the description of the methodology in determining peak demand savings using OPA end use load profiles for the commercial and institutional sector.

Other Resource Savings

Other Input Assumptions

Effective Useful Life (EUL)

The useful life for pipe/tank insulation is 20 years[3].

Base & Conservation Measure Equipment and O&M Costs

The incremental cost for pipe wrap and tank insulation is \$0.36/ft^2 [4].

[3] http://www.oldhouseweb.com/stories/Detailed/10382.shtml

[4] PG&E Workpapers, June 13, 2005.

Efficient Water Use

Low Flow Faucet Aerators

Revision #	Description/Comment	Date Revised
0	Included in the OPA Measures and Assumptions List	Oct. 31, 2008

Efficient Equipment and Technologies Description

No Energy Star or CEE level exists, however low-flow aerators as low as 1.9 L/min (0.5 gpm) can be purchased.

Base Equipment and Technologies Description

Ontario Building Code maximum faucet flow rate is 8.3 L/min (2.2 gpm)[1].

Codes, Standards and Regulations

Decision Type	Target Market(s)	Load Type
New / Retrofit	Commercial & Institutional	OPA Commercial Water Heating

Resource Savings Assumptions

Key Parameter Inputs

In order to generate the savings, the building type and the number of rooms/people, number of faucets being changed and net flow of newly installed faucets must be determined.

- Hotel/Motel (includes restaurant):
  - ♦ 114 L/room/day[2] (includes restaurant)
    - 65% toward personal usage
    - 10% towards general cleaning
    - 25% towards cooking
  - ♦ 80% of personal use water is for showering[3]
  - ♦ 14.8L/room/day (washroom faucets)
- Nursing Home/Hospital:
  - ♦ 175.6L/resident/day[4] (personal use DHW only)
  - ♦ 80% of water is assumed for showering
  - ♦ 35.1L/resident/day (washroom faucets)
- Small/Large Office/Warehouse:
  - ♦ 3.8L/person/day[3] (does not include food service)
  - ♦ The use of showers are considered negligible
- Large/Small Retail (non food service):
  - ♦ 3.8L/customer/day[5] (no cafeteria or restaurant)
- School /University:
  - ♦ 2.3L/student/day [3] (no showers) (this includes cafeteria water usage)
  - ♦ 0.4L/student/day reported[5] in an Ottawa elementary school (no cafeteria, no showers)
  - ♦ 0.4L/student/day used for washroom faucets

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[1] OBC, 2007

[2] S.C. Carpenter and J.P. Kokko. *Estimating Hot Water Use in Existing Commercial Buildings*. ASHRAE Transactions Volume 94, Part 2. 1988.

[3] American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc. *2007 ASHRAE Handbook – HVAC Applications*. 2007.

[4] W.H. Thrasher and D.W. DeWerth. *New Hot-Water Use Data for Five Commercial Buildings (RP-600)*. ASHRAE Transactions Volume 100, Part 1. 1994.

[5] Caneta Report, *Commercial/Institutional Service Water Heating – A state-of-the-art and practice review*, pg 14

- Commercial Kitchens:
  - ♦ 10.5L/meal/day[3] (full service kitchen – primarily dishwashing)
  - ♦ 1.7L/meal/day[3] (quick service kitchen, no dishwasher, includes food prep, clean-up and washroom)
  - ♦ One Atlantic Canada restaurant indicated it saw 5% of its total hot water usage dedicated towards cooking[5]
  - ♦ 0.5L/meal/day was assumed

Other assumed parameters:

- Density of water, ρ_{water} = 1 kg/L
- Specific Heat of Water, C_p = 4.186 kJ/kg°C
- Electric Boiler Efficiency = 95%
- The average water temperature rise in the boiler is 44°C (storage tank temperature is assumed to be 55°C), ΔT_{water}

Annual Energy Savings

Hot Water Savings (L/day):

Total Hot Water Usage (minutes/day) = [Daily Specific Flow (L/N) x N] / [8.3 L/min x Total No. of Washroom Faucets Installed in Building)]

where N is equivalent to one of the following:

Hotel/Motel	Number of rooms
Nursing Home/Hospital	Number of residents/patients
Small/Large Office/Warehouse	Number of employees
Large/Small Retail (non-food service)	Number of customers
School/University	Number of students
Commercial Kitchens	Number of customers

Hot Water Savings (L/day) = [8.3 L/min – Efficient Flow Rate (L/min)] x Total Hot Water Usage per day per faucet (minutes/day) x Total Number of Washroom Faucets Changed

Annual Energy Savings (kWh):

Annual Energy Savings (kWh) = [(Hot Water Savings (L/day) x ρ_{water} (kg/L0 x C_p (kJ/kg-°C) x ΔT_{water} (°C)) / (0.95 x 3600 kWh/kJ)] x No. of days/year

Note:
The energy savings are dependent on the amount of hot water used. Some uncertainty exists in the energy savings calculation because it is difficult to estimate the amount of washroom faucet usage. ASHRAE[3] estimated typical total hot water usage in several building types, and there was a wide range of estimates for water usage from other case studies. Conservative values were used where various estimates were given, so the energy saving calculation may be underestimating the energy saving results.

Peak Demand Savings

See Appendix A for the description of the methodology in determining peak demand savings using OPA end use load profiles for the commercial and institutional sector.

Other Resource Savings

Other Input Assumptions

Effective Useful Life (EUL)

The useful life of a low-flow aerator has not been reported, but would be dependent on the concentration of dissolved minerals in the water and the amount of build-up in the faucet. Faucets typically last 10 to 15 years, so it can be assumed low-flow aerators will have the same life span[6].

Base & Conservation Measure Equipment and O&M Costs

A low-flow faucet aerator costs $0.50 to $5.00[7] (not including the installation cost). The installation cost is assumed to be negligible.

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[6] http://www.oldhouseweb.com/stories/Detailed/10382.shtml
[7] http://pubs.cas.psu.edu/FreePubs/pdfs/XH0004.pdf

Low Flow Rinse Nozzle (Commercial Kitchen)

Revision #	Description/Comment	Date Revised
0	Included in the OPA Measures and Assumptions List	Oct. 31, 2008

Efficient Equipment and Technologies Description

Low-Flow Rinse Nozzle with less than 1.6 gpm maximum flow rate. There are three US manufacturers of pre-rinse nozzles. Fisher Manufacturing is the leading manufacturer and promotes an ultra-low-flow rinse nozzle with a maximum flow rate of 1.15 gpm[1]

Base Equipment and Technologies Description

Natural Resources Canada has adopted the U.S. regulated level of 1.6 gpm (6.1 L/min)[2]

Codes, Standards and Regulations

- CEE has not defined a high efficiency level based on the current regulated level. In 2005, ENERGY STAR® identified that any nozzle with a flow less than or equal to 1.6 gpm would be classified as high-efficient[3]. ENERGY STAR® has not updated this level since then to meet the new regulated flow.

Decision Type	Target Market(s)	Load Type
New / Replacement / Retrofit	Commercial & Institutional	OPA Commercial Water Heating

Resource Savings Assumptions

Key Parameter Inputs

- Hours of usage for each kitchen type

Kitchen Type	Hours of Usage
Quick service kitchen/restaurant	2 hours per day
Full service kitchen/restaurant	1 minute per customer up to 4 hours/day[4]

- Hot water temperature rise (ΔT) is 44°C (Boiler tank temperature = 55°C)
- Density of water, ρ_{water} = 1 kg / L
- Specific Heat of Water, C_p = 4.186 kJ/kg-°C
- Electric boiler efficiency = 95%
-

Annual Energy Savings

Energy Savings (kWh/L):

Energy Savings (kWh/L) = [ρ_{water} (kg/L) x C_p (kJ/kg-°C) x ΔT_{water} (°C)] / (0.95 x 3,600 kJ/kWh)

Energy Savings (kWh/L) = 0.054

Annual Energy Savings (kWh):

Annual Energy Savings = [6.1 (L/min) – Efficient Flow (L/min)] x Energy Savings (kWh/L) x 60 min/hour x Hours of Usage/day x 365 days/year

1 http://www.fisher-mfg.com/
2 http://www.oee.nrcan.gc.ca/commercial/equipment/commercial-kitchen/warewashing/purchasing_tips.cfm?attr=24
3 http://www.energystar.gov/ia/partners/prod_development/new_specs/downloads/ SprayValveEligibility_Draft1.pdf
4 PG&E Workpapers, June 13, 2005.

Note:

- It was assumed quick service restaurants have a 2 hour/day low-flow rinse nozzle usage. This is associated with rinsing pots, food storage containers or any reusable plates. Some kitchens may use the pre-rinse nozzle less, others more. There may be some uncertainty with the calculated energy savings based on this assumed daily pre-rinse nozzle usage.
- For full service restaurants it was estimated that each customer would use three dishes and the low-flow rinse nozzle is used for 20 seconds on each dish for a total of one minute of use per customer. The PG&E report identified that the bulk of the restaurants are medium sized and that the pre-rinse nozzle is typically used for 4 hours per day, so the 1 min/customer use rate was limited to a maximum of 4 hours per day. The predicted energy savings may be an underestimate for larger restaurants with a higher water usage.
- It was assumed that each restaurant has only one low-flow rinse nozzle in constant use. Spray nozzles for pot washing would be inconsistent and difficult to estimate and therefore not included in the analysis. It is also assumed that the low-rinse nozzle is installed in the predominant rinse nozzle. If more than one low-rinse nozzle is installed and used, energy savings may be under-predicted by the energy saving equation.

Peak Demand Savings

See Appendix A for the description of the methodology in determining peak demand savings using OPA end use load profiles for the commercial and institutional sector.

Other Resource Savings

Other Input Assumptions

Effective Useful Life (EUL)

The estimated useful life of this product is 5 years[5].

Base & Conservation Measure Equipment and O&M Costs

A PG&E report estimates a conservative incremental cost of $5 for a low-flow pre-rinse nozzle[5].

5 http://www.cee1.org/com/com-kit/codes.pdf

Measures Under Review

Hotel Room PTAC Occupancy Sensor

Cooking Exhaust Fan Variable Frequency Drive

HID Electronic Ballast (Greenhouse)

Retail LED Lighting

Fans (18”, 20”, 32”, 48”, 54”)

High Volume, Low Speed Fans

Glossary

GLOSSARY

Avoided Costs	These are the marginal costs that are avoided by not producing and delivering the next unit of energy to the customer. They include energy, generation, and transmission and distribution costs. They measure the expected change in the system's total costs due to a decrease or increase in load and are calculated using either a short-run or long run perspective.
Adjustment Factors	These are behavior patterns of program participants that can affect the outcome of the programs i.e. the number of participants in a program asked to install compact fluorescent lamps (CFLs) versus the actual number of CFL installations.
Base Case	This defines the scenario of energy use that program participants would encounter without taking the actions promoted by the Energy Conservation program.
Base Load	The minimum level of continuous load required over a given period of time.

Demand Savings

Demand savings may be expressed in many different ways. Three common ways of expressing demand savings are described as follows:

1. Connected Demand Savings
2. Average Demand Savings, and
3. Coincident Peak Demand Savings

Connected Demand Savings, the simplest way of expressing demand savings, is the difference between the load required by an efficient (high efficiency case) device and that required by a standard efficiency (base case) device.

Average Demand Savings represents the difference between the load required by an efficient (high efficiency case) device and that required by a standard (base case) device - averaged over a specified period of time. This is also commonly known as non-coincident demand savings or simply demand, capacity or kW savings.

Coincident Peak Demand Savings is the demand savings that occurs during the system peak. This measure accounts for whether a device will be operating during the system peak and at what capacity level. They may be seasonally differentiated, indicating coincidence with a summer and/or winter peak. The relationship between the non-coincident and coincident peak demand savings is often represented by a coincidence factor.

See Appendix A for more details.

Conservation

Conservation programs intend to alter base case scenarios by reducing electricity consumption and demand. These actions are monitored by the OPA's Integrated Power System Planning (IPSP) according to the following four categories: energy efficiency, demand management/conservation behavior, fuel switching, and customer-based generation.

End Use An application of final use to which energy is applied. End-uses are the services of economic value to the users of energy and of which the Conservation programs concentrate efforts on. Examples of end use include: refrigeration, food service, heating, ventilating and air-conditioning (HVAC), appliances, envelop and lighting.

Energy Efficiency A form of conservation action aimed at reducing electricity consumption while maintaining at least the same level of end-use service. Energy efficiency is achieved by using more efficient appliances, equipment and buildings.

Energy Savings The reduction in use of energy from pre-program baseline to post-program energy use, once independent variables (i.e., weather and occupancy) have been adjusted for.

Effective Measure Life An estimate of the median number of years that the measures installed under a program will still be in place and operable. This is important when estimating the levelized cost or the total resource cost (TRC) of a program.

Equipment Life This represents the number of years that the more efficient equipment installed under a Conservation program is assumed to produce energy savings. The benefits from energy efficient equipment are assumed to persist for the life of the equipment. This is also commonly known as Effective Useful Life.

Evaluation An assessment of all activities associated with the measurement of a program's energy and peak demand saving, the verifying of installed measures, and the valuating of the program's benefits versus its costs alongside all external impacts.

Evaluation, Measurement & Verification (EM&V) The undertaking of studies and activities aimed at assessing and reporting the effects of a Conservation program on its participants and/or the market environment. Effectiveness is measured though energy efficiency and cost effectiveness.

Free-rider A free rider is a program participant who would have installed a measure on his own initiative without the influence of the Conservation program. This participant simply uses the program to offset the cost of installing or undertaking the energy efficient initiative.

Fuel Switching (Fuel Substitution) The substitution of one energy source for another, usually based on price and availability.

High Efficiency Case This defines the scenario of energy use that program participants would encounter by taking the actions promoted by the Conservation program. This usually involves the installation of equipment or technology that is considered more energy efficient then existing base case installations.

Incremental Cost The cost of undertaking a Conservation measure calculated from the price differential between energy-efficient equipment and standard baseline measure.

Load Shape The time-of-use pattern of customer or equipment energy use. Pattern can be over a day (24 hours) or over a year (8760 hours).

Load Shifting A load shape objective that involves moving loads from peak periods to off-peak periods.

Market Transformation Achieving a substantial and sustainable increase in the market share of energy efficient technologies, building and production processes though the removal of market barriers that slow the process of adapting more efficient measures.

Measure An action undertaken by a Conservation program which involves the application of a technology, type of equipment, or procedure used to replace another technology or type of equipment.

Measurement A component of EM&V that involves the collection of data to describe pre- and post- program conditions.

Net-to-Gross Ratio (NGR) This accounts for only those energy efficiency gains that are attributed to, and the direct result of, the energy efficiency program in question. It gives evaluators an estimate of savings achieved as a direct result of program expenditures by removing savings that would have occurred even in the absence of a Conservation program.

New (Decision-Type) A customer decision type targeted by energy efficiency measure that encourages builders and developers to install energy efficiency measures that go above and beyond building standards at the time of construction.

Ontario Energy Board (OEB) The OEB regulates all non-commodity electricity rates, sets electricity prices for low volume and designated customers and gives licence to the IESO and all market participants.

OEB Measures and Assumptions List Published in the OEB's Total Resource Cost Guide and serves as basis document for OPA's Measurements and Assumptions List.

OEB Total Resource Cost Guide A guide prepared by the OEB to assist local distribution companies (LDCs) in meeting filing requirements for intended Conservation plans approved by the OEB.

OPA Measures and Assumptions List These are prescriptive input assumptions used in determining reported energy, peak demand savings and cost-effectiveness; published and revised annually by the OPA.

OPA Conservation Cost Effectiveness Tests Guide A guide prepared by the OPA to assist Conservation stakeholders in cost effectiveness test analysis for Conservation programs.

Peak Demand The maximum level of metered demand during a specified period. Daily electricity peaks on weekdays occur in late afternoon and early evening. Annual peaks occur during hot temperate summer days.

Prescriptive A type of tracking and reporting method used to measure energy and peak demand savings attributed to Conservation program participation. Method is used to prescribe typical or average participant energy and peak demand savings on a gross level, excluding more detailed participant inputs.

Prescribed Inputs Implicit inputs embedded into the energy and demand savings equations, and evaluated based on key participant inputs. These can include default efficiencies for a type of equipment specified or annual operating hours for the type of building selected.

Program Participants The number of participants or installations expected for the program. Typically specified on an annual basis, this value is multiplied by the per unit impacts and the free ridership level to generate the total savings for the program.

Quasi-Prescriptive A type of tracking and reporting method used to measure energy and peak demand savings attributed to Conservation program participation. Method uses more key, project-specific inputs to estimate energy and peak demand savings for each program participant.

Replacement (Decision Type) A customer decision type targeted by energy efficiency measure that encourages customer to purchase and install efficient equipment instead of existing standard appliance which is either worn out or needs replacing.

Retrofit (Decision Type) A customer decision type targeted by energy efficiency measure that encourages customer to replace and dispose of old appliance with more efficient one, when existing appliance is working with several years of useful life remaining.

Retirement (Decision Type) A customer decision type targeted by energy efficiency measure that encourages customer to remove, but not replace existing fixture.

Verification A component of evaluation that involves the use of the measurement data to verify that anticipated energy and peak demand savings have occurred. Verified results are usually available at the end of the program.

Appendix A

Peak Demand Savings Methodology

APPENDIX A: Average Peak Demand Savings Methodology and Coincident Factors

INTRODUCTION

Demand savings may be expressed in many different ways. Three common ways of expressing demand savings are described in the following paragraphs:

1. Connected Demand Savings
2. Average Demand Savings, and
3. Coincident Peak Demand Savings.

1. Connected Demand Savings

The simplest way of expressing demand savings is the Connected Demand Savings which is the difference between the load required by an efficient (high efficiency case) device and that required by a standard efficiency (base case) device. For example, replacing a 100W incandescent bulb with a 20 W CFL would give a demand savings of 80 W, i.e., 100W – 20W. This method may be suitable for estimating demand savings when looking at a conservation measure in isolation (e.g. for a particular installation) but it does not give any consideration to when the demand savings will occur – which is often of primary interest.

2. Average Demand Savings

Average demand savings represents the difference between the load required by an efficient (high efficiency case) device and that required by a standard (base case) device averaged over a specified period of time. This accounts for the fact that the load required by most devices varies with time. When referred to simply as demand, capacity or kW savings, the data is most often referring to this average measure of demand savings. In other cases, the documentation may specifically refer to this calculation of demand savings as average or non-coincident demand savings.

3. Coincident Peak Demand Savings

Power system planners are most concerned with coincident peak demand savings - the demand savings that occurs during the system peak. This measure accounts for whether a device will be operating during the system peak and at what capacity level. Coincident peak demand savings may be seasonally differentiated, indicating coincidence with a summer and/or winter peak. The relationship between the non-coincident and coincident peak demand savings is often represented through a coincidence factor. The coincident factor is most commonly defined as the ratio of coincident peak demand to non-coincident demand savings.

AVERAGE PEAK DEMAND SAVINGS

The OPA has used the concept of average demand savings in the development of the average peak demand savings for the OPA Measures and Assumptions List. The average peak demand savings (ΔP_{avg}) attributed to the installation of a measure refers to the estimated difference in the load required by an efficient device (high-efficiency case) and that required by a standard device (base case technology) averaged over a specified "peak" period of time. To provide consistency between reported Conservation program results and the OPA's Integrated Power System Plan (IPSP), the average peak demand savings have been determined utilizing the summer and winter peak periods defined in the IPSP[1] (see Table 1).

Table 1 – Time-of-Use Periods (and hours in each period)

Time-of-Use	Winter (December – March)		Summer (June-September)		Shoulder (April, May, October, November)	
	Time Period	*Hours*	*Time Periods*	*Hours*	*Time Periods*	*Hours*
Peak	0700 - 1100 and 1700 - 2200 weekdays	602	1100 - 1700 weekdays	522	None	None
Mid-Peak	1100 - 1700 and 2000 - 2200 weekdays	688	700-1100 and 1700-2200 weekdays	783	0700 - 2200 weekdays	1305
Off-Peak	0000 - 0700 and 2200 - 2400 weekdays; all hours weekends and holidays	1614	0000 - 0700 and 2200 - 2400 weekdays; all hours weekends and holidays	1623	0000 - 0700 and 2200 - 2400 weekdays; all hours weekends and holidays	1623

Seasonal Energy Savings Patterns, which are the percentage of energy savings estimated to occur in each of time-of-use period, have been developed for a number of commercial and institutional end-uses (see Table 2) using the 8760 hour end-use load profiles that have been utilized in the load forecasting analysis conducted for the IPSP[2]. These end-use load profiles represent the aggregated end-use demand at the provincial level and thus have the diversity of individual end-use equipment already incorporated in the load profiles.

Table 2 – Seasonal Energy Savings Patterns

	End-Use Load Profile	Winter			Summer			Shoulder		
		Peak	Mid-Peak	Off Peak	Peak	Mid-Peak	Off Peak	Mid-Peak	Off Peak	
		602	688	1614	522	783	1623	1305	1623	**Hours**
1	OPA Com Space Heating	17.9%	16.5%	44.5%	0.4%	0.7%	1.8%	6.2%	12.1%	
2	OPA Com Space Cooling	0.5%	0.6%	1.5%	42.0%	30.9%	15.1%	6.9%	2.3%	
3	OPA Com Ventilation	7.4%	8.8%	21.9%	5.2%	7.7%	13.7%	15.9%	19.4%	
4	OPA Com Lighting	8.6%	10.5%	13.8%	7.1%	10.1%	14.8%	20.1%	15.1%	
5	OPA Com Electric Auxiliary	7.8%	9.8%	14.6%	6.7%	9.8%	16.2%	18.7%	16.3%	
6	OPA Com Water Heating	9.2%	10.8%	16.9%	5.6%	9.0%	14.7%	17.8%	16.0%	

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[1] Evaluating the Cost Effectiveness of the Conservation Resource, EB-2007-0707, Exhibit D, Tab4, Schedule 1, Attachment 3.

[2] IPSP Reference Forecast – Methodology, EB-2007-0707, Exhibit D, Tab 1, Schedule 1, Attachment 1.

Procedure for Estimating a Measure's Average Peak Demands Savings

1. The estimated annual energy savings (kWh) associated with the measure is apportioned into each time-of-use period identified in Table 1 using the appropriate Seasonal Energy Savings Pattern from Table 2.
2. The estimated energy savings (kWh) occurring in each of the time-of-use period is divided by the number of hours associated with that period to compute the average demand savings. Of particular interest are the average peak demand savings for the summer on-peak and winter on-peak periods.

Note: This method explicitly assumes the load profiles of the high efficiency case and base case will have similar shapes but different amplitudes. Therefore this method is not suited for use with load-shifting measures or for measures where it is expected that the load profiles of the high efficiency and base case technologies will be of significantly different shape.

COINCIDENT PEAK DEMAND SAVINGS

Ratios of the coincident peak savings (based on both the one hour system peak and top ten system peak hours) to the average peak demand savings for each end-use have been developed to estimate the coincident peak demand savings attributable to the installation of each conservation measure. These ratios are referred to as coincidence factors. The methodology behind the development of the coincident factors is as follows:

1. Identify the system peak hour and the top ten system peak hours using the system demand profile for both summer and winter (as defined in Table 1).
2. For each end use, determine the estimated demand at the system peak hour and the average demand for the top ten system peak hours for both summer and winter.
3. For each end use, divide the demand at the system peak hour and the average demand for the top ten system peak hours by the average demand over the summer and winter peak periods (as defined in Table 1) to determine the coincident factors.
    - CF1 – ratio of demand at system peak hour to average peak demand
    - CF2 - ratio of demand at top ten system peak hours to average peak demand

The coincident peak demand savings for a measure can be estimated by multiplying the average peak demand savings by the appropriate coincidence factor. Since the coincidence factor CF1 is based on the ratio of a single data point (the end use demand at the system peak) it is more susceptible to being skewed to extremes. It is therefore recommended that the coincidence factor CF2 (which is based on the average of ten data points) be used for determining the coincident peak demand savings.

The resulting coincidence factors for each end-use are shown in Table 3.

Table 3 – Coincidence Factors

End-Use Load Profile	CF1		CF2	
	Winter	Summer	Winter	Summer
OPA COM Space Heating	0.95	0.97	1.16	1.05
OPA COM Space Cooling	1.21	1.32	1.13	1.26
OPA COM Ventilation	1.20	0.92	1.13	0.99
OPA COM Lighting	1.30	0.93	1.15	1.00
OPA COM Electric Auxiliary	1.31	0.95	1.16	1.02
OPA COM Water heating	1.13	0.92	1.11	1.00

The coincident peak demand savings for a measure can be estimated by multiplying the average peak demand savings by the appropriate coincidence factor. Since the coincidence factor CF1 is based on the ratio of a single data point (the end use demand at the system peak) it is more susceptible to being skewed to extremes. It is therefore recommended that the coincidence factor CF2 (which is based on the average of ten data points) be used for determining the coincident peak demand savings.

The average demand savings methodology and use of coincident ratios is illustrated using an example of an ENERGY STAR® refrigerator measure

Example: Average Peak Demand Savings and Coincident Peak Demand Savings for an ENERGY STAR® Unitary Air-Conditioner

Step 1) Apportion the annual energy savings (say, 1000 kWh) to each of the time-of-use periods using the Seasonal Energy Savings Pattern for OPA Commercial Space Cooling (Table 2).

Seasonal Energy Savings Pattern for Unitary Air-Conditioner

Winter			Summer			Shoulder	
On- Peak	Mid-Peak	Off-Peak	On-Peak	Mid-Peak	Off-Peak	Mid-Peak	Off-Peak
0.52%	0.62%	1.54%	41.99%	30.92%	15.15%	6.94%	2.32%

Energy Savings (kWh) for Energy Star® Unitary Air-Conditioner

Winter			Summer			Shoulder	
On- Peak	Mid-Peak	Off-Peak	On-Peak	Mid-Peak	Off-Peak	Mid-Peak	Off-Peak
5.2	6.2	15.4	419.9	309.2	151.5	69.4	23.2

Step 2) Compute the average peak demand savings (summer and winter) using the energy savings apportioned to the summer on-peak period (419.9 kWh) and winter on-peak period (5.2 kWh) and the number of hours in the summer (522 hours) and winter (602 hours) periods.

$$\Delta P_{avg,summer} = \frac{419.9}{522} \quad \rightarrow \quad \Delta P_{avg,summer} = 0.8044kW$$

$$\Delta P_{avg,winter} = \frac{5.20}{602} \quad \rightarrow \quad \Delta P_{avg,winter} = 0.0086kW$$

Step 3) Compute the coincident peak demand savings (summer and winter) using the coincidence factor (CF2 in Table 3 for commercial space cooling) and the average peak demand savings.

$$\Delta P_{cp1,summer} = 0.8044 \times 1.26 \quad \rightarrow \quad \Delta P_{avg,summer} = 1.0135kW$$

$$\Delta P_{cp1,winter} = 0.0086 \times 1.13 \quad \rightarrow \quad \Delta P_{avg,winter} = 0.0097kW$$

Appendix B

OPA Measures & Assumptions Substantiation Submission Form

OPA Measure and Assumption Substantiation Submission Form

Name:	
Company / Organization:	
Email:	

Submission for (choose one):

1. New Measure	☐
2. New Measure Idea	☐
3. Revision to Existing Measure	☐

Measure Name

Efficient Equipment and Technologies Description
Description of Efficient Equipment (high-efficiency case) – specify the units of the equipment or technologies (e.g. single unit, package of 3, string of lights)
Base Equipment and Technologies Description
Description of Standard Equipment (base case) – specify the units of the equipment or technologies (e.g. single unit, package of 3, string of lights)

Codes, Standards, and Regulations

List any applicable codes, standards, and / or regulations governing the performance (i.e. energy consumption) of the equipment.

- Bulleted text

Decision Type	Target Market(s)	Load Type
State the decision type (e.g. New, Retrofit, Removal)	State the target market(s) for the measure (e.g. Residential / Small Commercial, New homes / Existing Homes, Single-Family / Multi-Family)	Indicate whether the measure is using an existing OPA load profile or custom load profile.

Resource Savings Table

	Electricity and Other Resource Savings			Equipment & O&M Costs of Conservation Measure	Equipment & O&M Costs of Base Measure	Peak Demand Savings	
Year (EUL=)	Electricity (kWh)	Natural Gas (m^3)	Water (L)	($)	($)	Summer Capacity (kW)	Winter Capacity (kW)
1							
2							
3							
4							
5							

6							
7							
8							
9							
10							
11							
12							
13							
14							
15							
16							
17							
18							
19							
20							
TOTALS							

Resource Savings Assumptions

Annual Electricity Savings

Provide the rationale and references for the per unit energy savings (kWh). All sources of information should be referenced.

Peak Demand Savings

If an OPA load profile is being utilized, the average demand savings can be determined using the Seasonal Energy Savings Pattern (refer to Appendix A of the OPA Measures and Assumptions List found on the OPA website) associated with the OPA load profile. The coincident peak demand savings are determined using the coincident factors associated with the OPA load profile.

If a custom load profile is being utilized the rationale and / or references on which the peak demand savings are based on must be provided and all sources of information should be referenced. The custom load profile should be documented in the space provided below.

Other Resource Savings

Other resource savings (e.g. natural gas, water) may be achieved coincident to the electricity savings. Provide the rationale and references on which the per unit resource savings (m3, L) are based on. All sources of information should be referenced.

Custom Load Profile (if used)

Description	Winter			Summer			Shoulder		
	On - Peak 602	Mid - Peak 688	Off Peak 1614	On - Peak 522	Mid - Peak 783	Off Peak 1623	Mid - Peak 1350	Off Peak 1623	Hrs
									%

If a custom load profile is being utilized all references should be documented. The custom load profile may be a blend of existing OPA load profile. In such cases, each OPA load profile used in the custom load profile as well as the method by which the OPA load profiles were blended should be clearly stated.

Other Input Assumptions

Effective Useful Life (EUL)

Provide the rationale and references for the effective useful life of the measure. All sources of information should be referenced.

Base & Conservation Measure Equipment and O&M Costs

Provide the rationale and references for the incremental cost of the measure. All sources of information should be referenced.

Measure Assumptions Used by Other Jurisdictions

<table>
<tr><th rowspan="2">Source</th><th rowspan="2">Annual Electricity Savings (kWh)</th><th colspan="2">On-Peak Demand Reduction</th><th rowspan="2">Effective Useful Life (yrs)</th><th rowspan="2">Incremental Cost ($)</th></tr>
<tr><th>Winter (kW)</th><th>Summer (kW)</th></tr>
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Put comments regarding the other measure assumptions here</td></tr>
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