



# 5th Experts Meeting, Annex 46

"Holistic Assessment Tool-kit on Energy Efficient Retrofit Measures for Government Buildings, EnERGo"

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## Effects of single & multiple ERM on the energy consumption of Office Buildings

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# Outline

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1. Representative government office buildings pre 1975 and post 1975
2. ERM vs. Energy consumption
3. Comparative analyses of single vs. multiple ERM
4. Concluding remarks



# Representative Gov.Office Buildings

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- Construction date / Energy standard/best practice
  - 1950 – 1975 / ASHVE (1939) & ASHRAE (1961)
  - Post 1975 / ASHRAE (1977) & MNECB (1997)
- Size of building
  - 24,150 m<sup>2</sup> (260,000 ft<sup>2</sup>), Floor height = 3.5 m
  - 4,200 m<sup>2</sup> (45,000 ft<sup>2</sup>), Floor height = 3.5 m
- Location –
  - Ottawa
  - Edmonton
  - Vancouver



# #1 - Large size building, Concrete BE

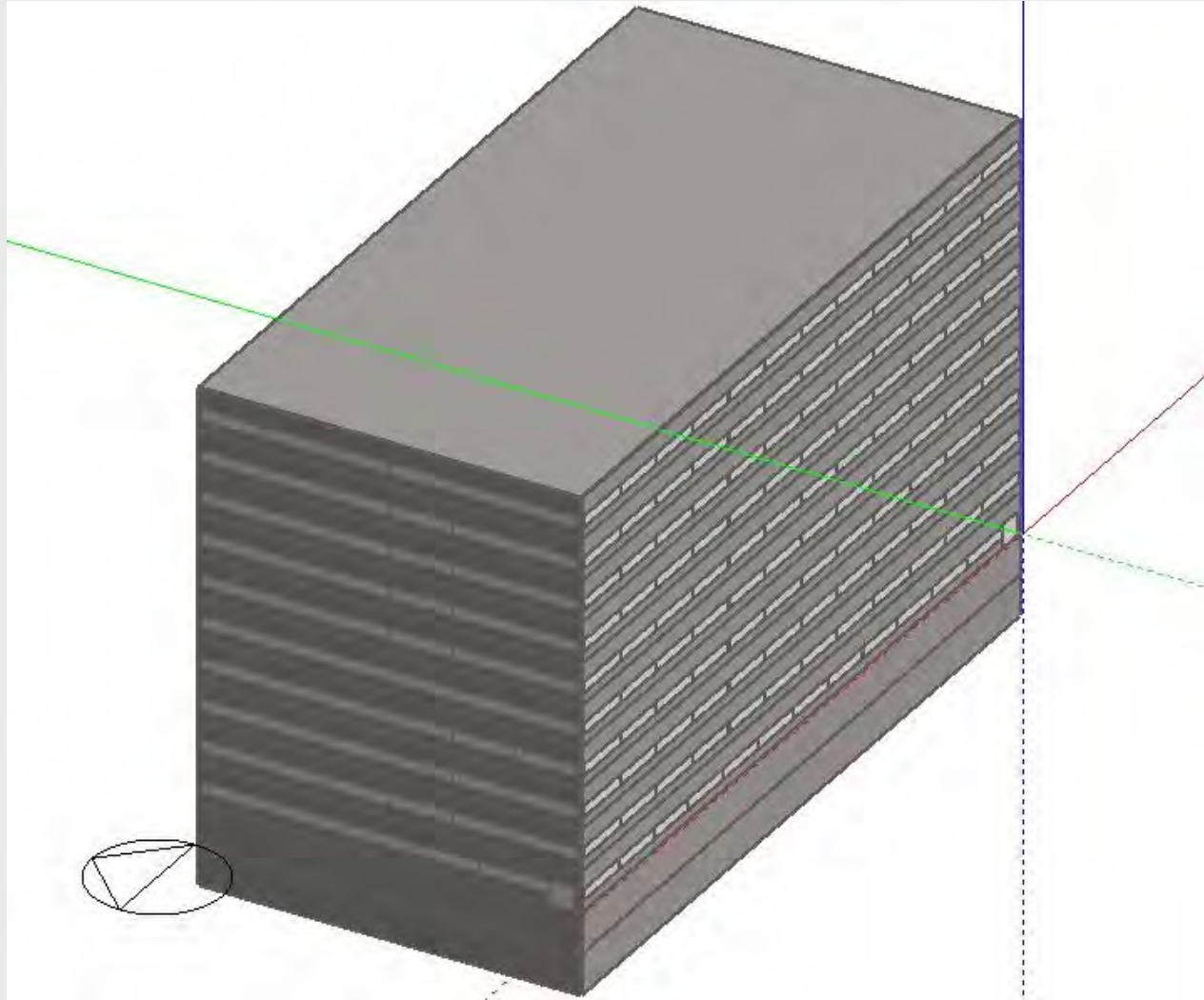
	Archetype #1	Archetype #2	Archetype #3
<b>General Description</b>			
<b>Vintage</b>	Pre 1950	1950 - 1975	Post 1975
<b>No. Floors</b>	10 + 2 Below ground	10 + 2 Below ground	10 + 2 Below ground
<b>Area, Volume</b>	24,150 (m <sup>2</sup> ), 72,450 (m <sup>3</sup> )	24,150 (m <sup>2</sup> ), 72,450 (m <sup>3</sup> )	24,150 (m <sup>2</sup> ), 72,450 (m <sup>3</sup> )
<b>Envelope</b>			
<b>Wall Type</b>	Brick on Concrete	Brick on Concrete	Brick on Concrete
<b>U-Value</b>	1.21	1.21	1.16
<b>Roof Type</b>	Built-up roofing on Metal Deck	Built-up roofing on Metal Deck	Built-up roofing on Metal Deck
<b>U-Value</b>	1.41	0.74	0.64
<b>Window Type</b>	Single Glazed	Double glazed	Double glazed
<b>U-Value</b>	6.42	4.50	3.40
<b>% to Wall</b>	30	40	50
<b>Distribution System Type</b>			
<b>Description</b>	CAV Combination AHU and Pumps	CAV Combination AHU and Pumps	VAV Combination AHU and Pumps

# #1 - Large size building, Concrete BE

	Archetype #1	Archetype #2	Archetype #3
<b>Electrical Systems</b>			
Lighting (W/m <sup>2</sup> )	26	17.8	17.8
Equipment Loads (W/m <sup>2</sup> )	10	20	30
Chiller Type COP	Chilled Water 1.8	Chilled Water 2.5	Chilled Water 5.2
<b>Secondary Fuel Systems</b>			
Boiler Fuel Capacity Efficiency	Natural Gas Hot Water 75%	Natural Gas Hot Water 75%	Natural gas Hot Water 75%
<b>Miscellaneous</b>			
SHW Fuel	Electricity	Natural Gas	Electricity



# #1 - Large size building, Concrete BE



# Building #1 (1975) - Single ERM

Starting at 1950 - 1975	Ottawa		Edmonton		Vancouver	
	Electricity	Natural Gas	Electricity	Natural Gas	Electricity	Natural Gas
Single Changes to Post 1975 Level						
Base Model	1.00	1.00	1.00	1.00	1.00	1.00
RET Appliance Load 20 to 30	1.17	0.82	1.18	0.83	1.07	0.70
RET Chiller COP 2.5 to 5.2	0.93	1.00	0.94	1.00	0.95	1.00
RET HVAC CAV to VAV (0.3)	0.72	1.08	0.72	1.04	0.82	1.22
RET Infiltration 0.75 to 0.5	0.99	0.64	1.00	0.65	0.89	0.51
RET Occupancy 25 to 20	1.01	1.06	1.01	1.05	1.03	1.07
RET Roof 0.74 to 0.64	0.99	1.00	0.99	1.00	1.00	1.00
RET Wall 1.21 to 1.16	1.00	0.99	1.00	0.99	1.00	0.99
RET Windows 40 to 50 percent	1.04	0.88	1.05	0.88	1.00	0.83
RET Windows from 4.50 to 3.4	0.92	0.92	0.92	0.91	0.92	0.91



# Building #1 (1975) – Ottawa - Multiple ERM

Multiple Changes to Post 1975 Level	Electricity	Natural Gas
Base Model	1.00	1.00
RET Appliance Load 20 to 30	1.17	0.82
RET HVAC CAV to VAV (0.3)	0.72	1.08
RET Windows 40 to 50 percent	1.04	0.88
RET Infiltration 0.75 to 0.5	0.99	0.64
RET (Appliance Load 30 + VAV(0.3))	0.86	0.99
RET (Appliance Load 30 + Infiltration 0.5)	1.16	<b>0.47</b>
RET (Appliance Load 30 + VAV(0.3) + Infiltration 0.5)	0.87	0.70
RET (Appliance Load 30 + Windows 50 Percent)	<b>1.21</b>	0.83
RET (Appliance Load 30 + VAV(0.3) + Windows 50 Percent)	0.88	1.02
RET (Appliance Load 30 + Infiltration 0.5 + Windows 50 Percent)	1.20	<b>0.49</b>
RET (Appliance Load 30 + VAV (0.3) + Infiltration 0.5 + Windows 50%)	0.89	0.73
Post 1975 - Base Model	0.81	0.74

# Building #1 (1975) – Ottawa - Multiple ERM

	Ottawa	
	Electricity	Natural Gas
Base Model	1.00	1.00
RET HVAC CAV to VAV (0.3)	0.72	1.08
RET Windows 40 to 50 percent	1.04	0.88
RET Infiltration 0.75 to 0.5	0.99	0.64
RET (VAV(0.3) + Infiltration 0.5)	0.72	0.81
RET (VAV(0.3) + Windows 50 Percent)	0.74	1.11
RET (VAV(0.3) + Infiltration 0.5 + Windows 50%)	0.75	0.84
Post 1975 - Base Model	0.81	0.74

# Building #1 (1975) – Ottawa - Multiple ERM

	Electricity	Natural Gas
Base Model	1.00	1.00
RET Infiltration 0.75 to 0.5	0.99	0.64
RET Windows 40 to 50 percent	1.04	0.88
RET (Infiltration 0.5 + Windows 50 Percent)	1.03	<b>0.65</b>
Post 1975 - Base Model	0.81	0.74



# Electrical/Bldg #1 (Post 1975) -Single ERM

Starting at Post 1975 Single Changes to Retrofit Level	<i>Normalized Electrical consumption</i>		
	Ottawa	Edmonton	Vancouver
Base Model	1.00	1.00	1.00
RET 60 Heat Recovery	0.99	0.99	0.96
RET Heating Efficiency to 0.95 + Eco-PreHeat	0.96	0.96	0.90
RET Improved Walls U 1.16 to 0.55	0.99	0.99	0.97
RET Lighting 17.8 to 10	0.84	0.84	0.92
RET Lighting Linear Light Dimming	0.88	0.87	0.92
RET Occupancy 20 to 18	1.00	1.00	1.02
RET Roof U 0.64 to 0.47	0.99	1.00	0.99
RET Windows U Value 3.4 to 1.8	0.99	0.99	0.94

# Gas/Bldg #1 (Post 1975) -Single ERM

Starting at Post 1975			
Single Changes to Retrofit Level	Ottawa	Edmonton	Vancouver
Base Model	1.00	1.00	1.00
RET 60 Heat Recovery	0.85	0.87	0.79
RET Heating Efficiency to 0.95 + Eco-PreHeat	0.79	0.71	1.21
RET Improved Walls U 1.16 to 0.55	0.90	0.90	0.86
RET Lighting 17.8 to 10	1.12	1.12	1.27
RET Lighting Linear Light Dimming	1.06	1.06	1.12
RET Occupancy 20 to 18	1.05	1.04	1.07
RET Roof U 0.64 to 0.47	0.99	0.99	0.99
RET Windows U Value 3.4 to 1.8	0.84	0.83	0.77



# Electrical/Bldg #1 (Post 1975)–Multiple ERM

Multiple Changes to Post 1975 Level	Ottawa	Edmonton	Vancouver
Base Model	1.00	1.00	1.00
RET Heating Efficiency to 0.95 + Eco-PreHeat	0.96	0.96	0.90
RET Improved Walls U 1.16 to 0.55	0.99	0.99	0.97
RET Lighting Linear Light Dimming	0.88	0.87	0.92
RET Lighting 17.8 to 10	0.84	0.84	0.92
RET (Boiler Eff. 0.95 + Wall U Value 0.55)	0.95	0.95	0.87
RET (Boiler Eff. 0.95 + Lighting Load 10)	0.81	0.81	0.81
RET (Boiler Eff. 0.95 + Window U-Value 1.8)	0.94	0.94	0.85
RET (Boiler Eff. 0.95 + Daylighting)	0.84	0.83	0.83
RET (Boiler Eff. 0.95 + Wall U Value 0.55 + Lighting Load 10)	0.80	0.80	0.79
RET (Boiler Eff. 0.95 + Wall U Value 0.55 + Daylighting)	0.83	0.82	0.80
RET (Boiler Eff. 0.95 + Wall U Value 0.55 + Window U-Value 1.8)	0.93	0.93	0.82
RET (Boiler Eff. 0.95 + Lighting Load 10 + Daylighting)	0.76	0.75	0.78
RET (Boiler Eff. 0.95 + Lighting Load 10 + Window U-Value 1.8)	0.80	0.79	0.77
RET (Boiler Eff. 0.95 + Daylighting + Window U-Value 1.8)	0.83	0.82	0.79

# Gas/Bldg #1 (Post 1975)–Multiple ERM

Multiple Changes to Post 1975 Level	Ottawa	Edmonton	Vancouver
Base Model	1.00	1.00	1.00
RET Heating Efficiency to 0.95 + Eco-PreHeat	0.79	0.71	1.21
RET Improved Walls U 1.16 to 0.55	0.90	0.90	0.86
RET Lighting 17.8 to 10	1.12	1.12	1.27
RET Lighting Linear Light Dimming	1.06	1.06	1.12
RET Windows U Value 3.4 to 1.8	0.84	0.83	0.77
RET Improved Walls U 1.16 to 0.55	0.90	0.90	0.86
RET (Boiler Eff. 0.95 + Wall U Value 0.55 + Lighting Load 10)	0.79	0.72	1.22
RET (Boiler Eff. 0.95 + Wall U Value 0.55 + Daylighting)	0.76	0.69	1.14
RET (Boiler Eff. 0.95 + Wall U Value 0.55 + Window U-Value 1.8)	0.57	0.50	0.89
RET (Boiler Eff. 0.95 + Wall U Value 0.55)	0.71	0.63	1.09
RET (Boiler Eff. 0.95 + Lighting Load 10 + Daylighting)	0.88	0.81	1.36
RET (Boiler Eff. 0.95 + Lighting Load 10 + Window U-Value 1.8)	0.73	0.66	1.15
RET (Boiler Eff. 0.95 + Lighting Load 10)	0.86	0.79	1.33
RET (Boiler Eff. 0.95 + Daylighting + Window U-Value 1.8)	0.71	0.64	1.07
RET (Boiler Eff. 0.95 + Daylighting)	0.84	0.77	1.26
RET (Boiler Eff. 0.95 + Window U-Value 1.8)	0.66	0.58	1.02



# Electrical/Bldg #1 (Post 1975)–Multiple ERM

Multiple Changes to Post 1975 Level	Ottawa	Edmonton	Vancouver
Base Model	1.00	1.00	1.00
RET Lighting 17.8 to 10	0.84	0.84	0.92
RET Lighting Linear Light Dimming	0.88	0.87	0.92
RET Windows U Value 3.4 to 1.8	0.99	0.99	0.94
RET (Lighting Load 10 + Daylighting + Window U-Value 1.8)	0.77	0.77	0.83
RET (Lighting Load 10 + Daylighting)	0.79	0.78	0.88
RET (Lighting Load 10 + Window U-Value 1.8)	0.83	0.83	0.87
RET (Daylighting + Window U-Value 1.8)	0.87	0.86	0.88

# Concluding Remarks

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1. Single ERM has varying effect, positive and negative, on the electrical and natural gas consumption of office buildings
2. Multiple ERM leads to improvement in the energy consumption but their effects are not additive.
3. Use of some ERM is found to yield higher energy consumption when compared to the original energy consumption.

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## Questions?

