Building Envelopes for the 2030 Challenge:

An early discussion

BC Building Envelope Council 2008
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26Sep08

Agenda

MEC Montreal. Photo Lyse Tremblay

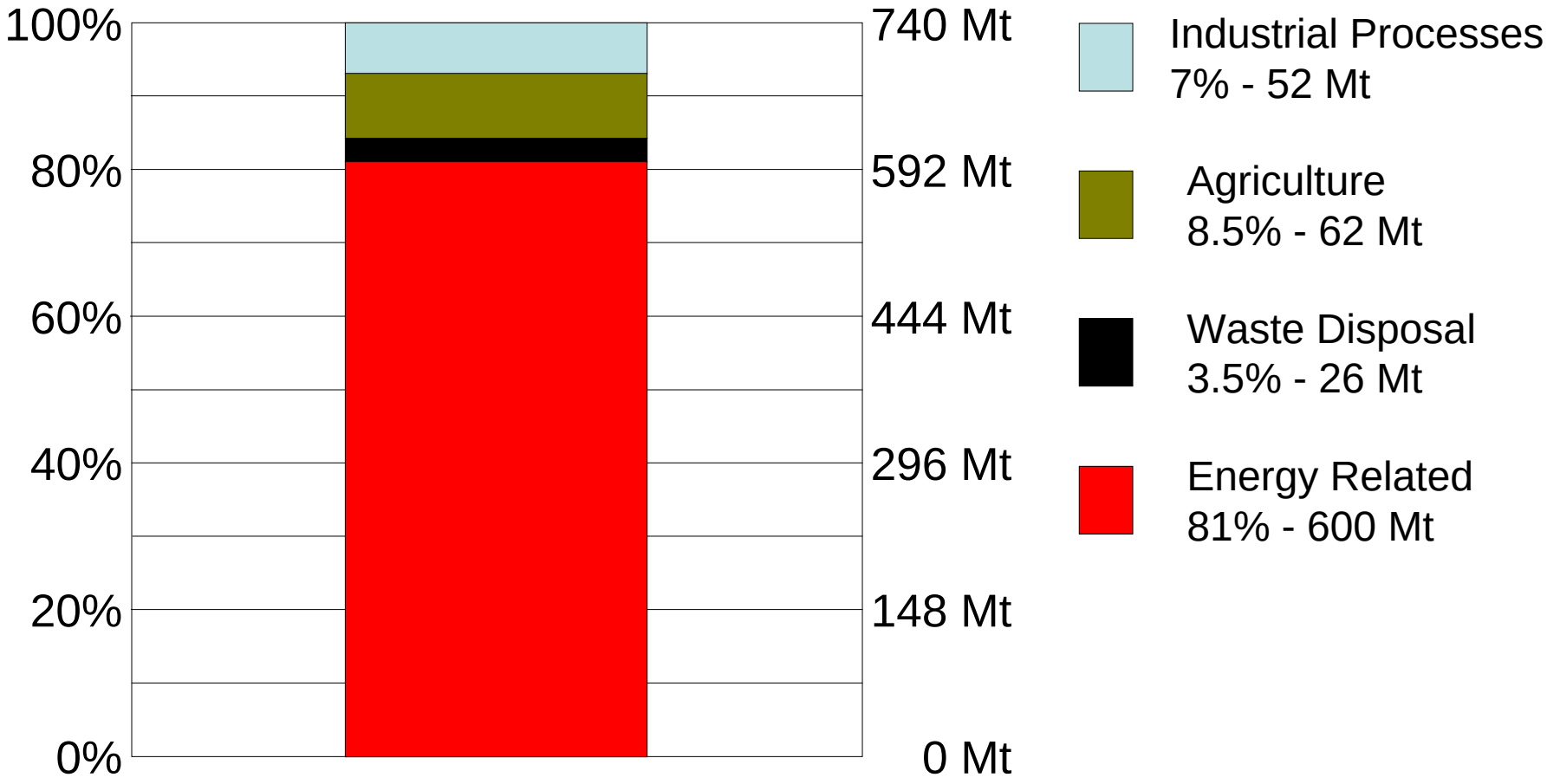
- Canadian consumption habits;
- 2030 Challenge instructions;
- General strategies for 2030;
- Designing for conservation;
- BESR 2007 (net-zero energy);
- Selecting Fenestration-to-wall Ratio (FWR);
- Comparative studies of FWR and Window performance values;
- Wrap-up.

Energy and Carbon

Photo Stephen Pope

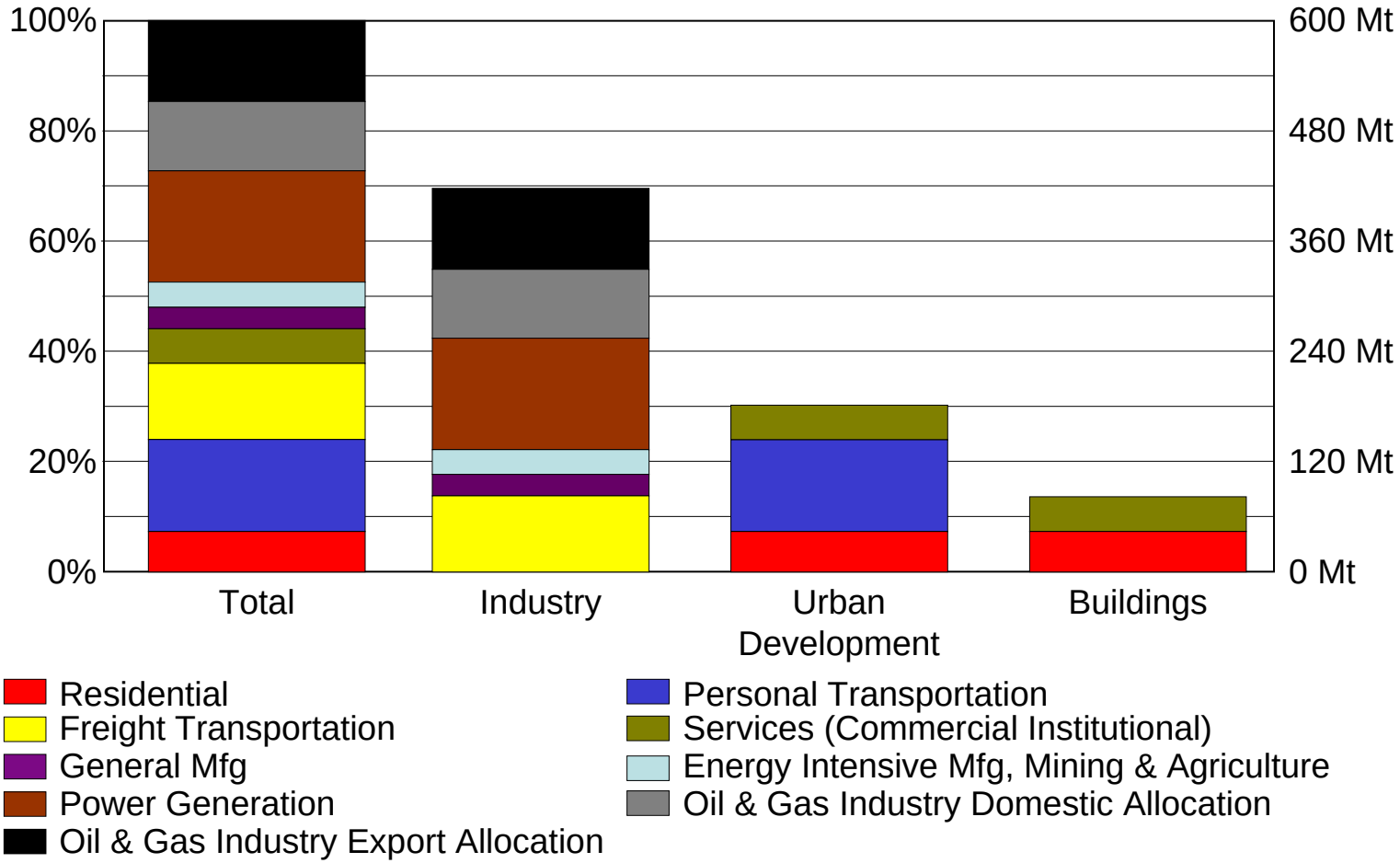
- Historical focus on energy consumption or cost;
- Energy consumption and carbon emissions are loosely related;
  - Hydro Provinces vs. Fossil and Mixed Fuel Provinces.
- Exergy bias against space heating with electricity;
  - Even for ultra-low energy buildings?
- Aggressive low-energy design changes understanding of energy requirements;
- Must look to integrated whole environments;
  - Buildings, groups of buildings, AND transportation.

Canadian GHG Emissions – 2003



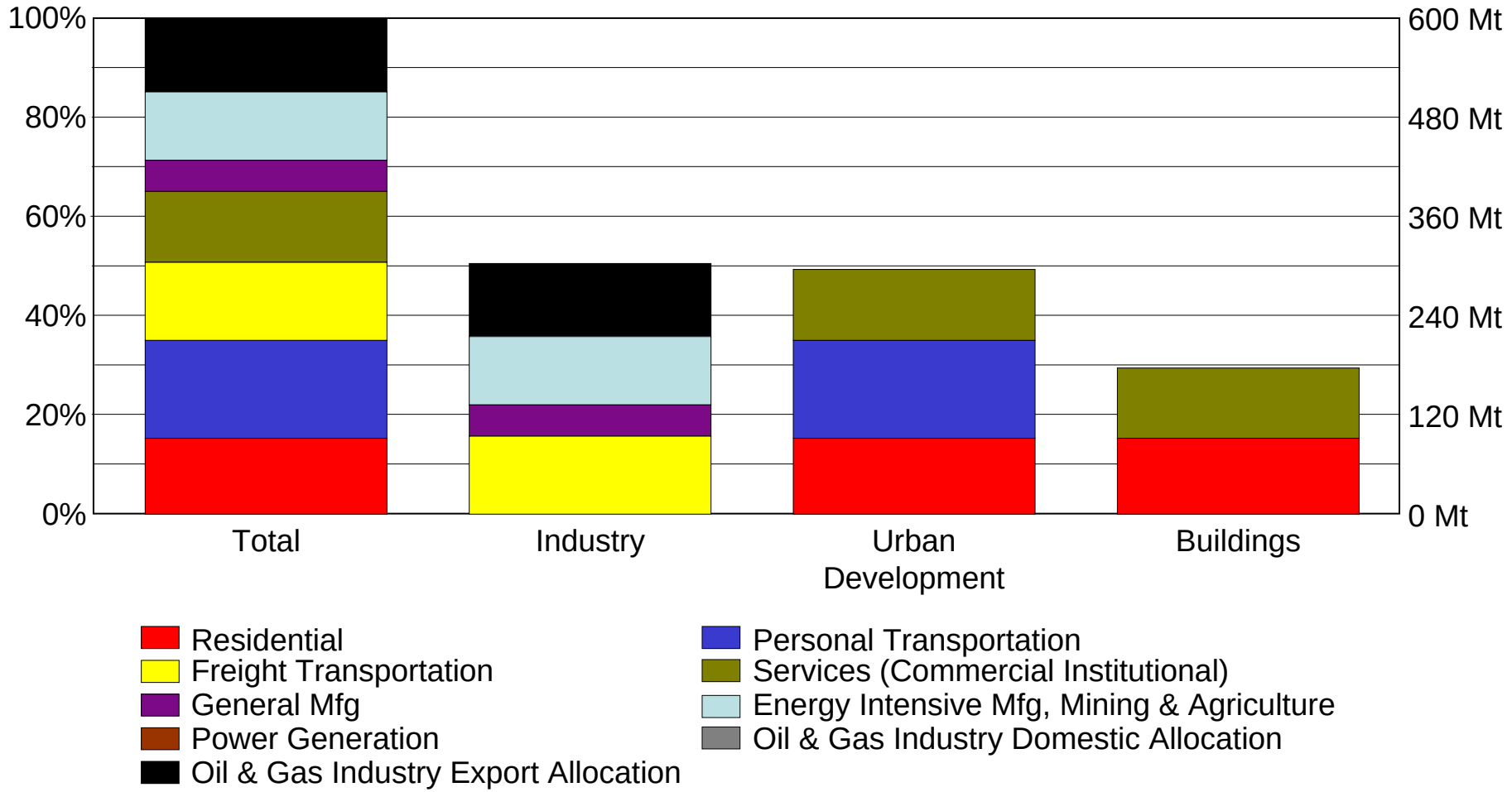
Source: NRTEE, Energy Related Greenhouse Gas Emissions in Canada in 2050, Appendix A Table A-9

Energy Related Greenhouse Gas Emissions in Canada in 2003 by Sector and **Source** Allocation



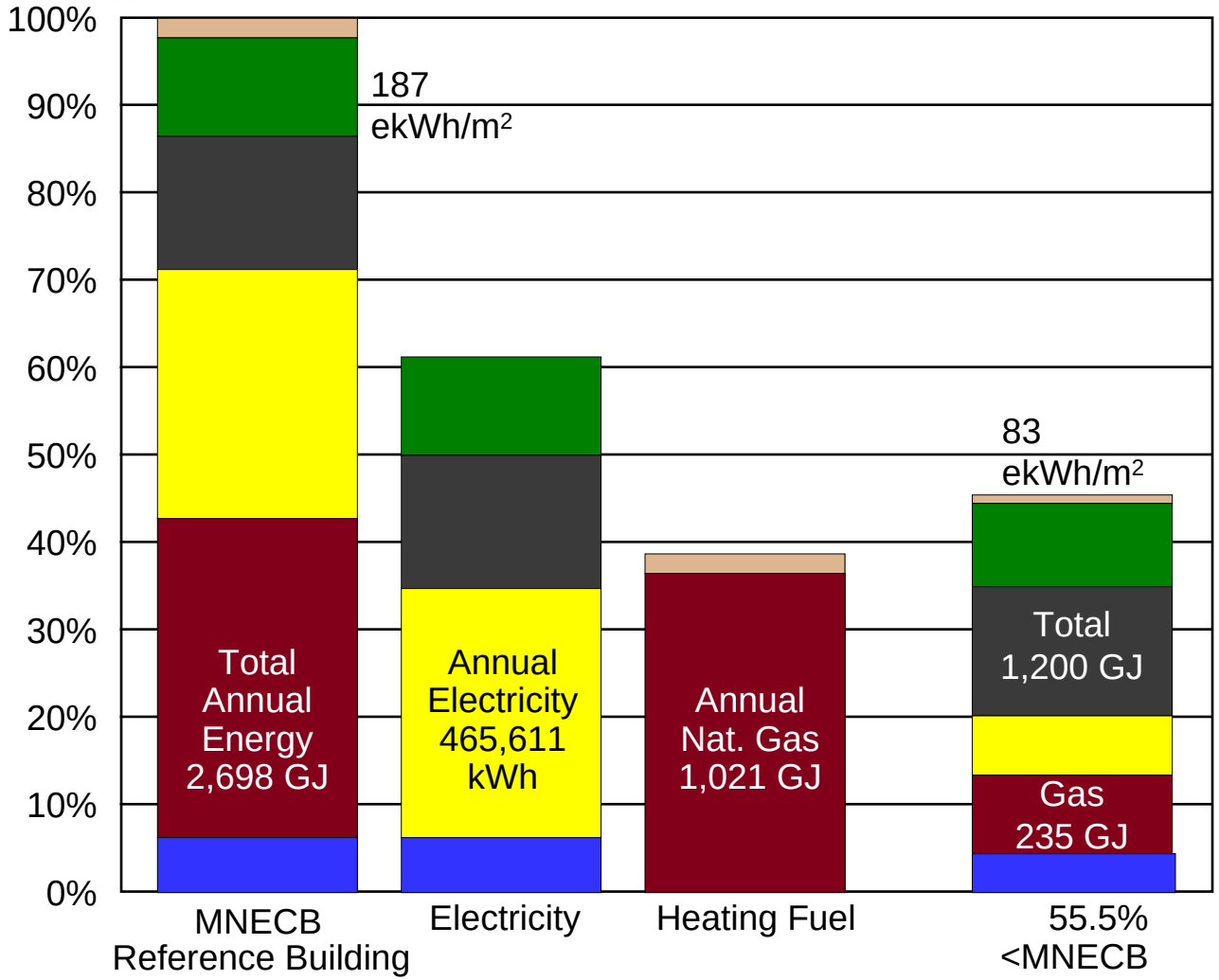
Source: NRTEE, Energy Related Greenhouse Gas Emissions in Canada in 2050, Figure 3-4

Energy Related Greenhouse Gas Emissions in Canada in 2003 by Sector and **End Use** Allocation



Source: NRTEE, Energy Related Greenhouse Gas Emissions in Canada in 2050, Figure 3-4

Vancouver Small Office Archetype



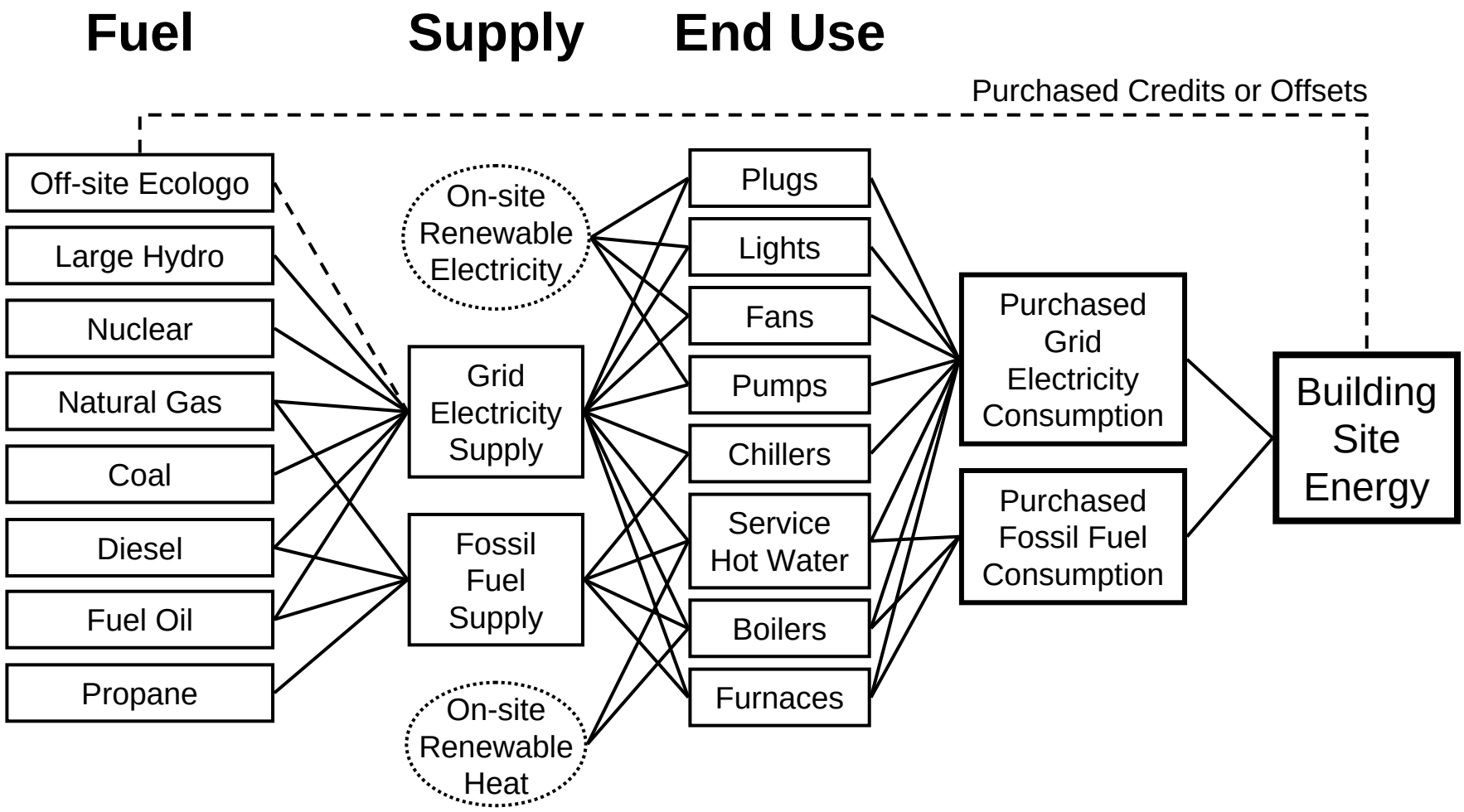
- Service Hot Water
- Fans & Pumps
- Plugs
- Lights
- Space & Vent Air Heat
- Cooling

Small Office Archetype:

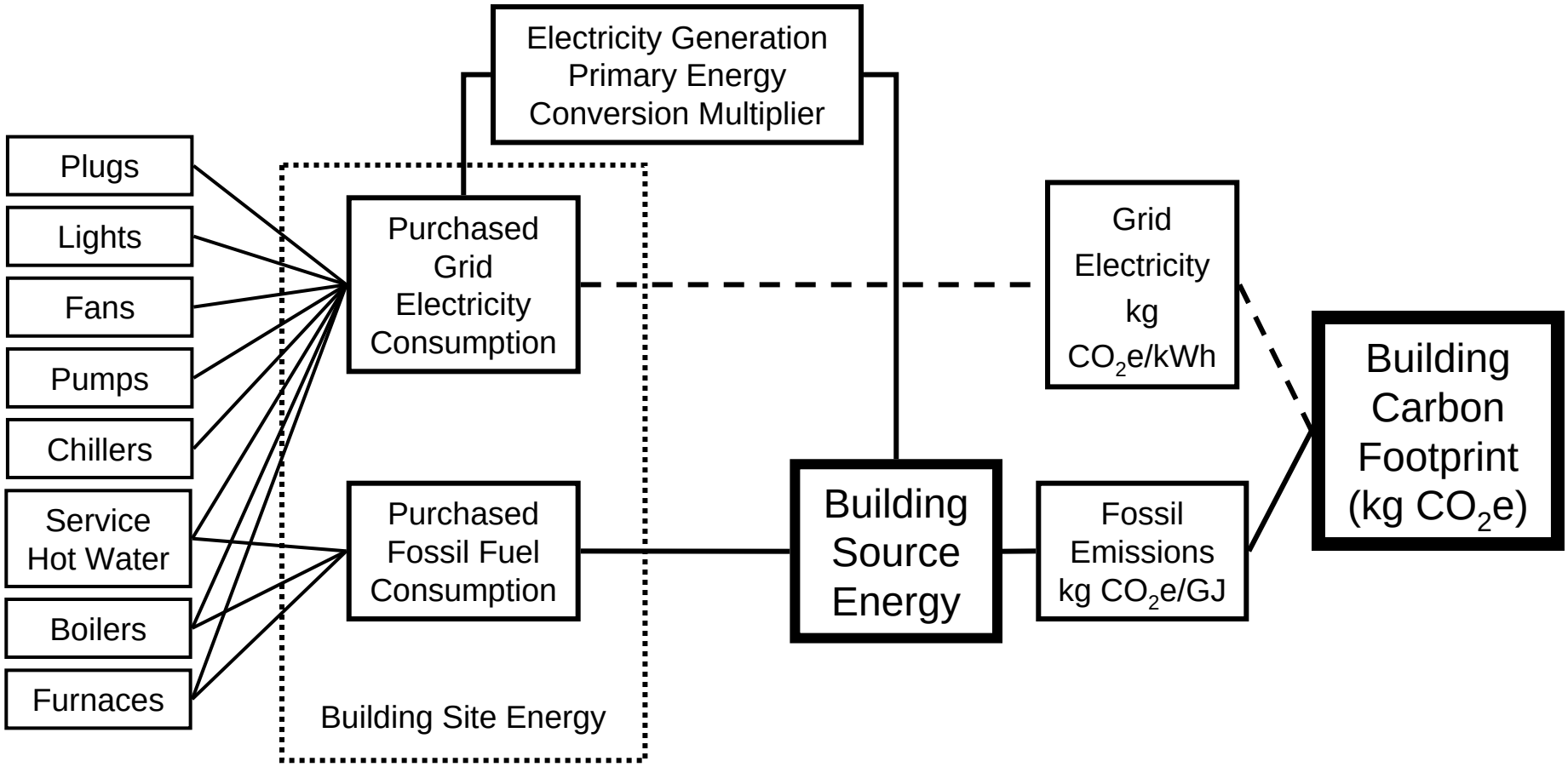
4010m^2 conditioned floor area; 3 storey height, 3.65m floor-to-floor; 1,337m^2 roof/floor plate area; 1,604m^2 gross wall area.

Natural gas fired boilers provide heat for space, DHW, and ventilation air heating. Electricity provides cooling, lights, fans and pumps.

Operations (Site) Energy



Source Energy & Carbon Footprint



GHG Emissions from Electricity

Province	Grid electricity: kg CO_2e / kWh
Newfoundland and Labrador	0.19
Prince Edward Island	0.546
Nova Scotia	0.78
New Brunswick	0.546
Quebec	0.0014
Ontario	0.18
Manitoba	0.011
Saskatchewan	0.862
Alberta	0.991
British Columbia	0.02
Yukon, NWT, NU	Depends on local grid source.

Source: Voluntary Challenge Registry (VCR) Complete Guide 1999, pg 34.

VCR Source: Canadian Electricity Association 1997 Provincial averages

CO_2e contribution from boilers

Fuel	CO_2	CH_4	N_2O	kg CO_2e/ekWh
GWP	1	21	310	
Natural Gas	1,880 g/m^3	0.048 g/m^3 (industrial)	0.02 g/m^3	0.18 (commercial)
		0.043 g/m^3 (commercial)		
Light Oil (Distillate)	2,830 g/L	0.006 g/L (industrial)	0.013 g/L	0.26 (commercial)
		0.026 g/L (commercial)		
Heavy Oil (Residual)	3,090 g/L	0.12 g/L (industrial)	0.013 g/L	0.27 (commercial)
		0.06 g/L (commercial)		

Source: Voluntary Challenge Registry (VCR) Complete Guide 1999, pg 31, 32.

kg CO_2e/ekWh calculations by author.

VCR Source: Canada's Greenhouse Gas Inventory, 1997 Emissions and Removals with Trends F.Neitzert, K.Olsen, P.Collas, Pollution Data Branch, Air Pollution Prevention Directorate, Environment Canada, 1999.

2030 Challenge Drivers

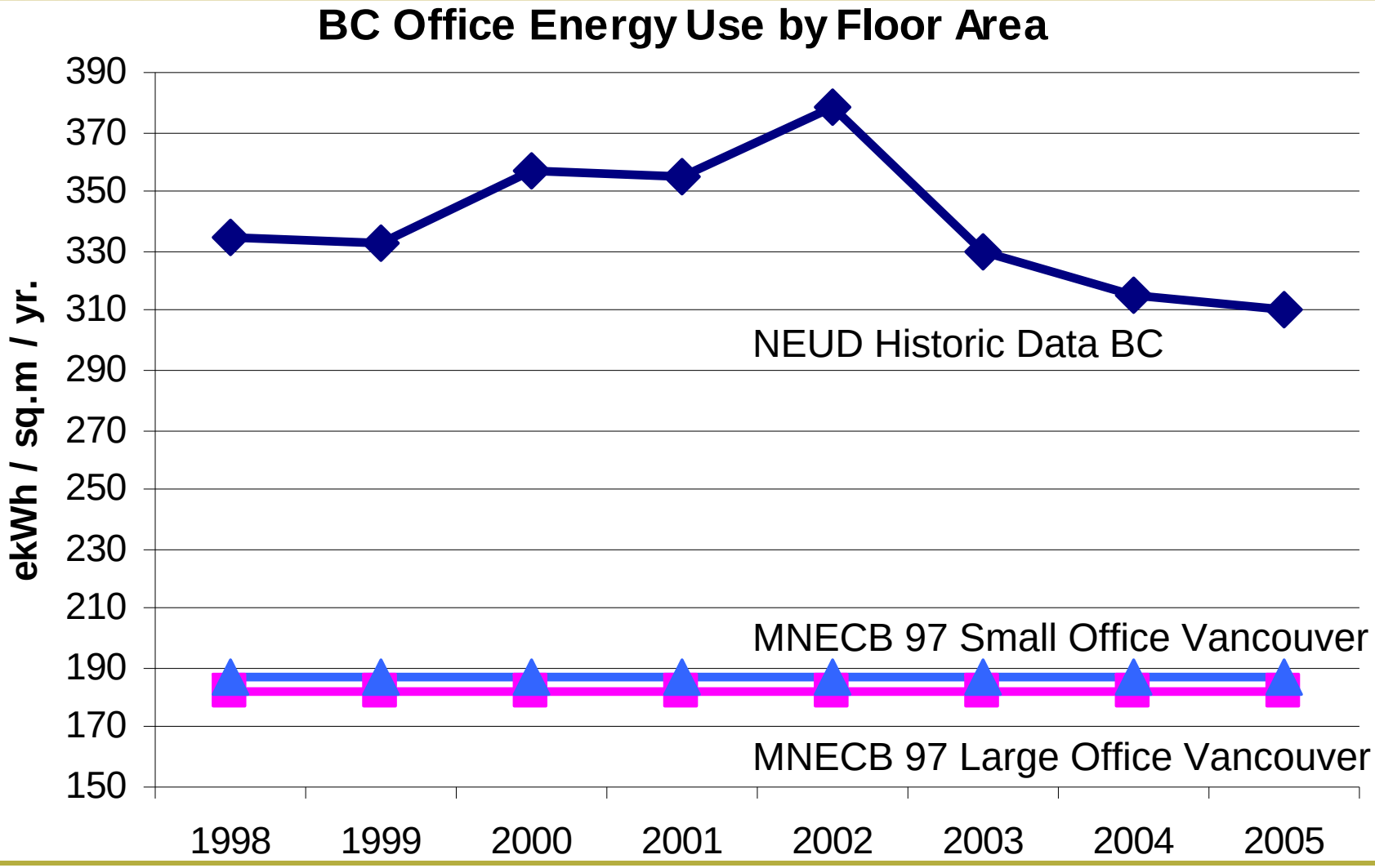
- Predicted 10 year window to stabilize atmospheric CO_2 to prevent catastrophic climate change;
- Buildings are a significant contributor to GHG emissions;
- Improving buildings operations to reduce GHG emissions has significant spin-off benefits for:
  - Occupant health and productivity;
  - Corporate economic health.

New York City under 3.0 m and 5.0 m sea level rise. Credit: Architecture 2030

2030 Challenge details

- www.architecture2030.org/2030_challenge/
- New buildings, and major renovations reduce fossil fuel consumption by 50% **from regional average by type**;
- Equal area of existing building renovated annually reducing fossil fuel consumption by 50% as per new;
- Fossil fuel reduction requirement for all new buildings shall be increased to:
  - 60% in 2010; 70% in 2015; 80% in 2020; 90% in 2025;
  - Carbon-neutral in 2030 (no GHG emissions for operations).
- Targets achieved through conservation, on-site renewable generation, offsets, and/or purchasing (20% maximum) renewable energy.

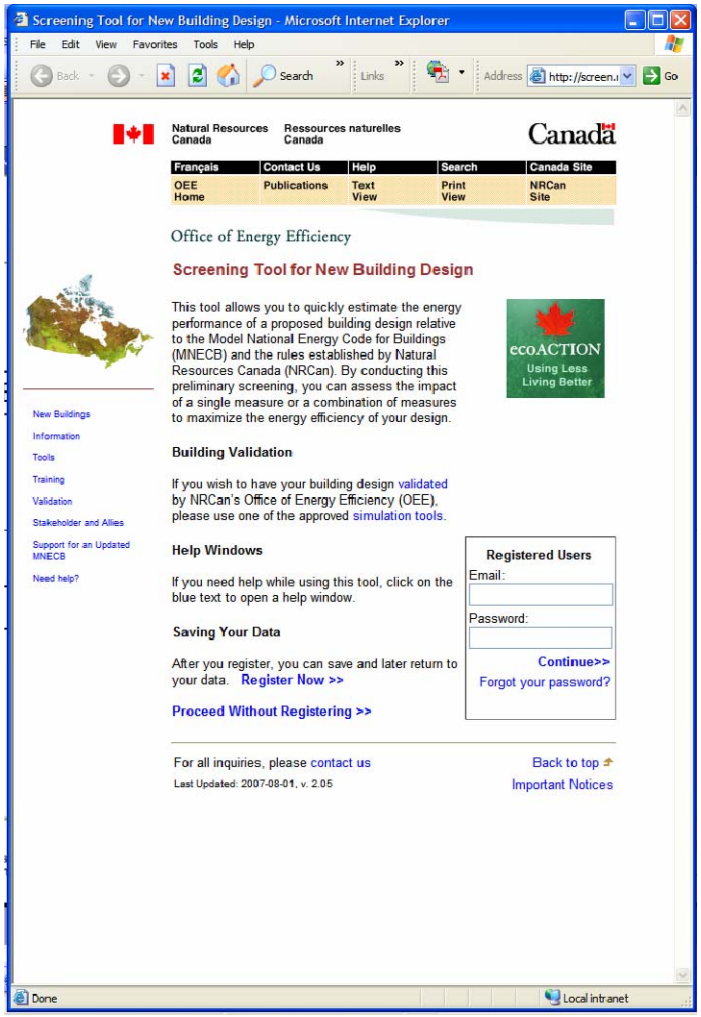
So… what's the "average"?



Three References for “average”

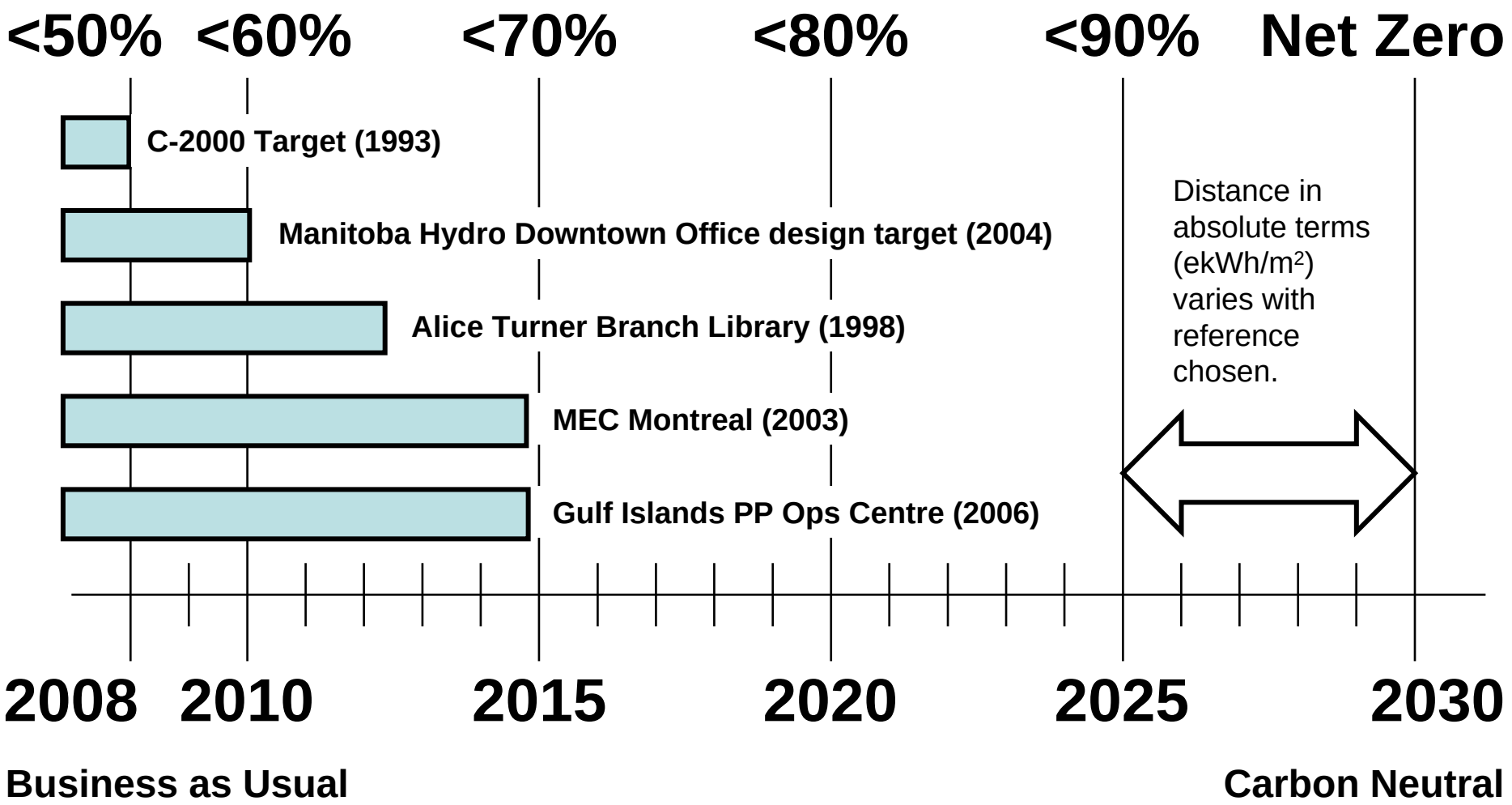
- US EPA Energy Star “Target Finder”;
  - http://www.energystar.gov/index.cfm?fuseaction=target_finder
  - US 2030 Challenge benchmarks – no MURBs.
- Canadian Energy Use Surveys:
  - National (Comprehensive) End-Use Database (NEUD / CEUD);
  - http://oee.nrcan.gc.ca/corporate/statistics/neud/dpa/comprehensive_tables/index.cfm?attr=0
  - Commercial and Institutional Consumption of Energy Survey 2005 (CICES);
  - http://oee.nrcan.gc.ca/corporate/statistics/neud/dpa/data_e/publications.cfm?attr=0#c
  - Survey of Household Energy Use 2003 (SHEU);
  - http://oee.nrcan.gc.ca/corporate/statistics/neud/dpa/data_e/publications.cfm?attr=0#c
- Model National Energy Code for Buildings, Part 8:
  - Former CBIP tools and guides (EE4, Screening Tool).

Whole Building Energy Simulation

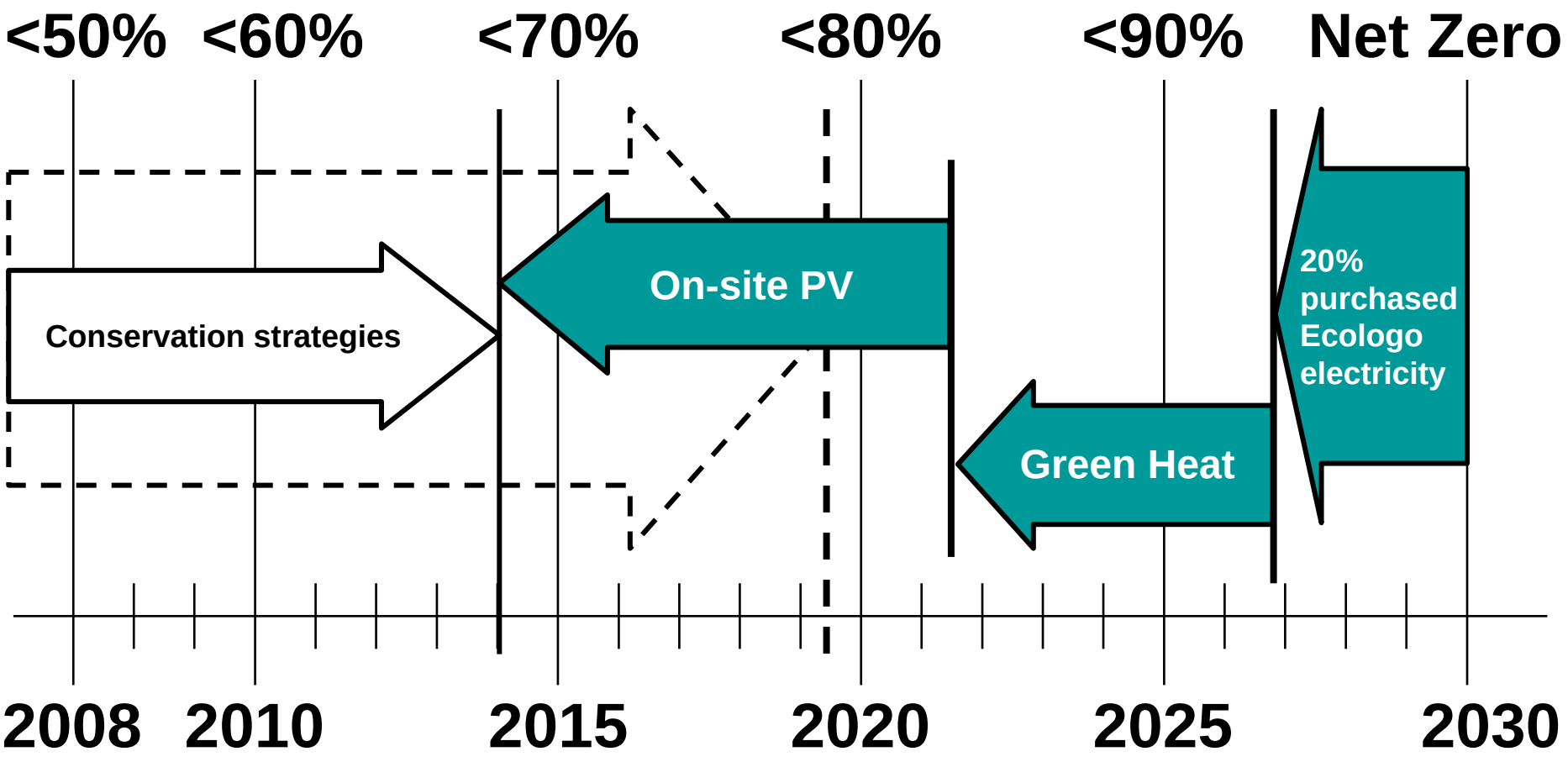


- NRCan Screening Tool for New Building Design;
- Parametric editor based on over 100,000 DOE 2.1e runs;
- 28-32 data entry points;
- Follows MNECB Part 8 + CBIP rules;
- Selection of building archetypes available;
- Selection of mechanical systems available.
- http://screen.nrcan.gc.ca/

Timelines and Performance



A General 2030 Challenge Strategy

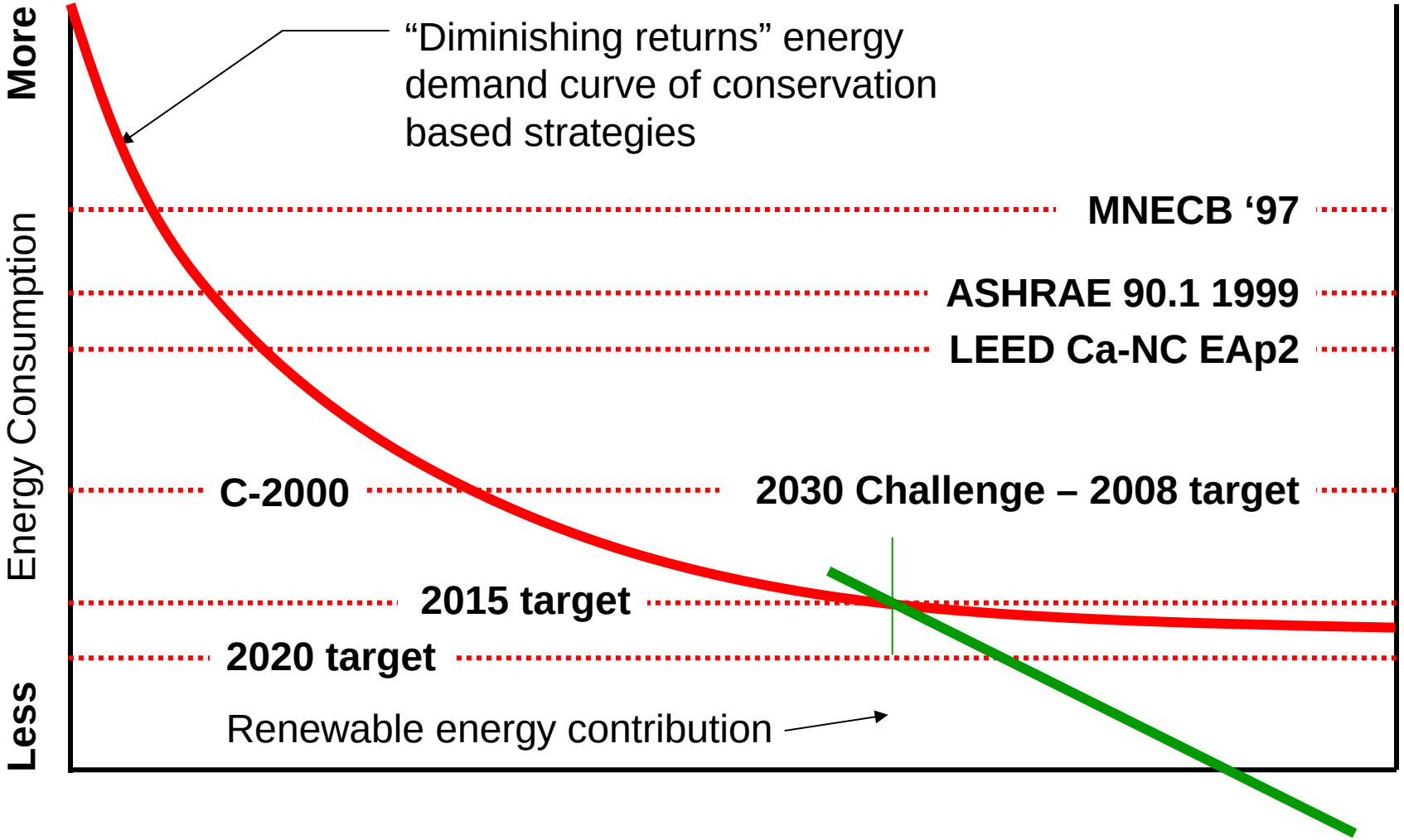


Design Tactics for Conservation

1. Control fenestration-to-wall ratio (FWR);
2. Reduce connected lighting power densities;
   a) Occupancy and daylighting dimming controls for light fixtures;
3. Improve window performance values (highest U-value affordable);
4. Separate of ventilation air supply from heating and cooling;
   a) Adopt low-energy hydronic heating and cooling;
5. Use heat recovery on exhaust or relief air;
6. Use demand controlled ventilation;
7. Use condensing space heating boilers;
8. Improve chiller efficiency – recover heat;
9. Increase wall and roof insulation (MNECB + RSI 3.5 max);
10. Reduce domestic hot water flow.

Order adjusted for MNECB BC Region A

Energy Efficiency & Renewables



NRCan BESR – Commercial Buildings

- Seven building types:
  - Large Offices; Small Offices; Big Box Retail; Warehouses; Schools; Extended Care Homes; MURBs.
- Eight Canadian cities:
  - Halifax, Montreal, Toronto, Winnipeg, Regina, Calgary, Vancouver, Whitehorse.
- Three levels of target reviewed:
  - Level 1 (2012): 35% energy consumption reduction below MNECB ‘97;
  - Level 2 (2020): 60% energy consumption reduction below MNECB ‘97;
  - Level 3 (2030): Net Zero site Energy (NZsE).
- Analysis is for technical feasibility. Costing not explicitly incorporated but influenced scenario development;
- Performance may vary considerably – general feasibility only discussed.

Net-Zero Site Energy: BESR Study '07

Building Type	/ City	H	M	T	Wi	R	C	V	Wh
Large Office	Electric load satisfied %	0	0	0	0	0	0	0	0
	Heating load satisfied %	88	78	Yes	83	78	94	Yes	48
Small Office	Electric load satisfied %	64	60	59	69	80	77	55	62
	Heating load satisfied %	Yes	Yes	Yes	Yes	Yes	Yes	Yes	62
Big Box Retail	Electric load satisfied %	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
	Heating load satisfied %	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Warehouse	Electric load satisfied %	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
	Heating load satisfied %	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
School	Electric load satisfied %	41	40	38	46	53	50	38	40
	Heating load satisfied %	Yes	Yes	Yes	Yes	Yes	Yes	Yes	68
Extended Care	Electric load satisfied %	26	25	22	24	33	27	21	21
Home	Heating load satisfied %	Yes	Yes	Yes	Yes	Yes	Yes	Yes	66
Multi-unit Res.	Electric load satisfied %	26	26	25	29	32	32	25	24
Building	Heating load satisfied %	Yes	Yes	Yes	Yes	Yes	Yes	Yes	61

BESR Renewable Energy Inputs

Renewable Energy Equipment	Large Office	Small Office *	Big Box Retail	Warehouse	School *	Extended Care *	MURB *
PV (% roof area)	0%	53%	44%	13%	53%	23%	53%
Area (m^2)	**0**	**845**	1,849	701	**2,546**	**717**	**510**
Total Capacity (kWp)	**0**	**107**	235	89	**323**	**91**	**65**
# Panels	**0**	**1,066**	2,330	883	**3,208**	**904**	**643**
SWH (% roof area)	75%	23%	16%	13%	23%	53%	23%
Total Area (m^2)	**1,002**	301	621	581	1,046	1,221	219
Capacity (kW_{th})	**522**	157	323	303	545	636	114
# Panels	**346**	104	214	200	361	421	75
SVAH (wall mount)							
Area (m^2)	**578**	0	171	0	0	0	130

* Annual heating load matched in all sites except Whitehorse.

“Efficiency” vs. Net Zero

- In order to maximize the ability of PV to provide building electricity, approach used for BESR 60% target (central ground-source heat pumps) cannot be used;
- Heating energy still largest single annual requirement, but solar thermal energy easiest (and least cost) to collect;
- Ground source heat pumps use less overall electricity consumption for heating and cooling than conventional designs…
  - BUT too much for effective renewable supply;
  - Conservation limit around 70% reduction from MNECB (2015).
- Design approach requires optimizing use of solar thermal and aggressive reduction of electricity consumption.

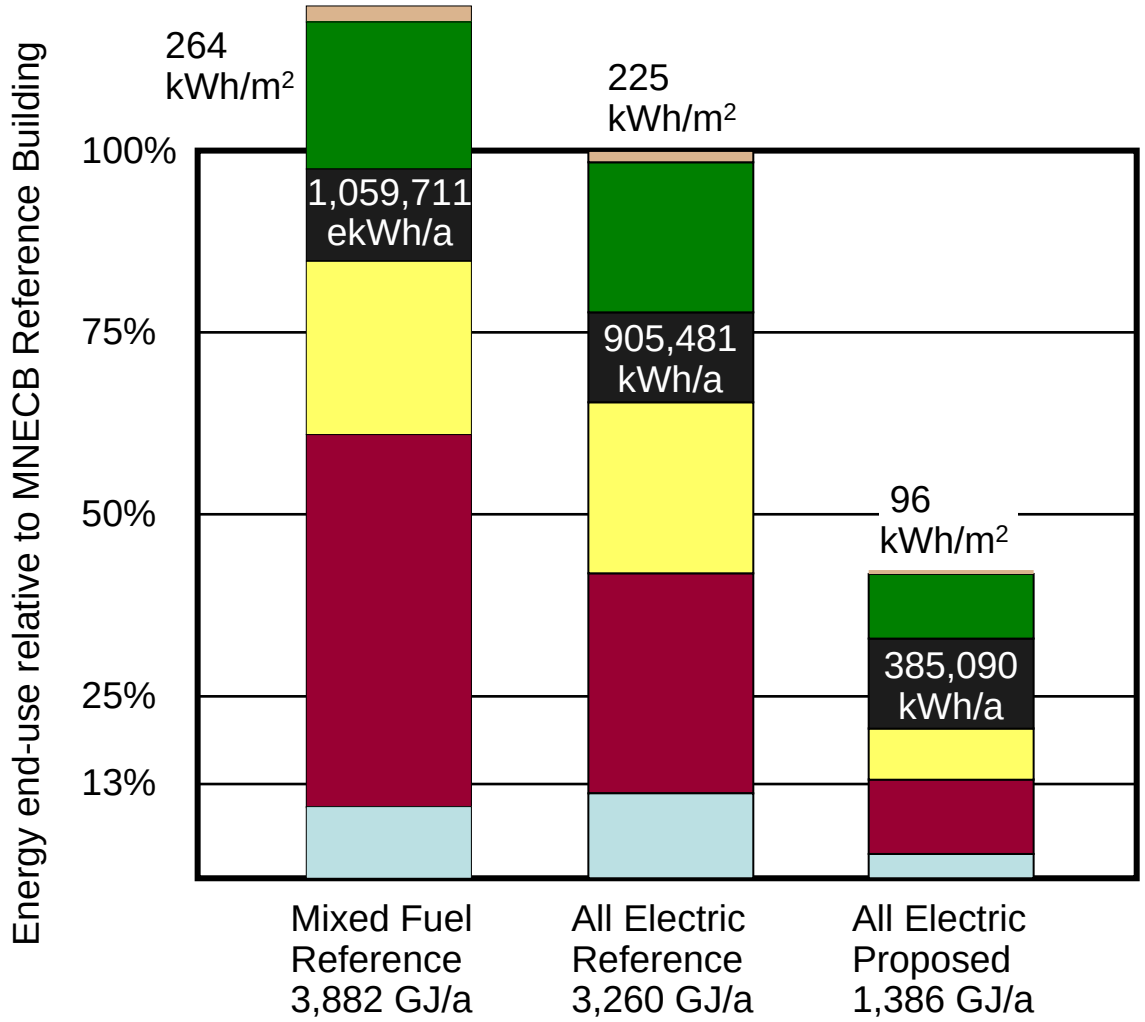
Office Electricity Use Comparison

Building Type: (Vancouver)		Electricity Consumption (kWh/yr)	Percent < MNECB
Small Office (4,010 m^2)	<60%: GSHP Plant	283,750	< 60.5%
	REP: Nat Gas FPFC	160,500	< 58.7%
Large Office (28,040 m^2)	<60%: GSHP Plant	1,751,400	< 60.0%
	REP: Nat Gas FPFC	1,604,000	< 50.7%

A carbon neutral “cheater”

- Small office in Ottawa – MNECB reference:
  - Natural Gas for space heat, ventilation & hot water: **451,390 ekWh**;
  - Electricity for lights, fans, pumps, and equipment: **608,321 kWh**;
  - All in, energy consumption: **1,059,711 ekWh** (site energy).
- Switch principal heating fuel to electricity;
  - Total reference energy consumption **905,481 kWh** (14.5% energy savings).
- Electric Small Office with high performance configuration:
  - Fan coil system with electric perimeter heat & hot water;
  - Plus balance of small office design tactics for conservation;
  - Total annual energy consumption: **385,090 kWh** (57.5% energy savings).
- Purchase ALL proposed bldg. energy from Bullfrog Power:
  - **Reference** building, all **utility costs** (0.05$/kWh): **$71,218**.
  - **Proposed** building **utility costs** (all electricity) with Bullfrog Power electricity @ 0.09$/kWh: **$55,435**.
- **Carbon neutral with $15,783.00 savings/year!!!**

Ottawa Small Office Test



Proposed Building is 57.5% below the MNECB (Electric) Reference. Mixed fuel reference provided for comparison.

Fenestration-to-Wall Ratio (FWR)

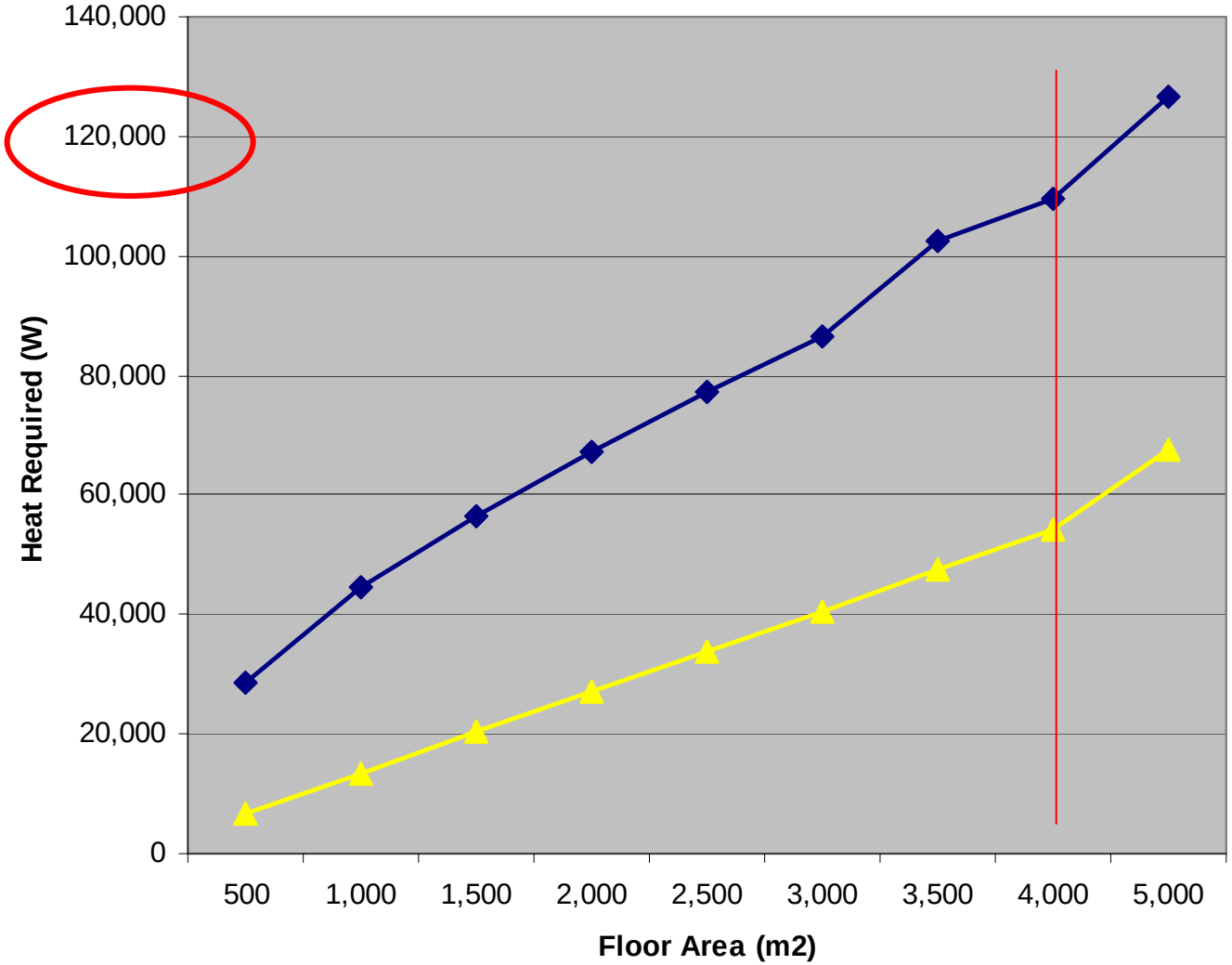
Photo: Smith Carter Arch's & Eng's Ltd.

- Most important envelope related question;
- Confusion caused by buildings with high FWRs claiming high performance values;
- Investigate multi-system impacts;
- Be conscious of trade-offs.

Envelope Performance Context

- Identify the proportions of the heating load taken by skin and ventilation;
- Identify the building systems immediately impacted by envelope performance:
  - Lighting;
  - Ventilation;
  - Perimeter heating and cooling.
- Assess envelope in the context of whole building annual energy consumption;
- Assess envelope performance in the context of room-by-room comfort.

Skin Heat Loss vs. Ventilation 1

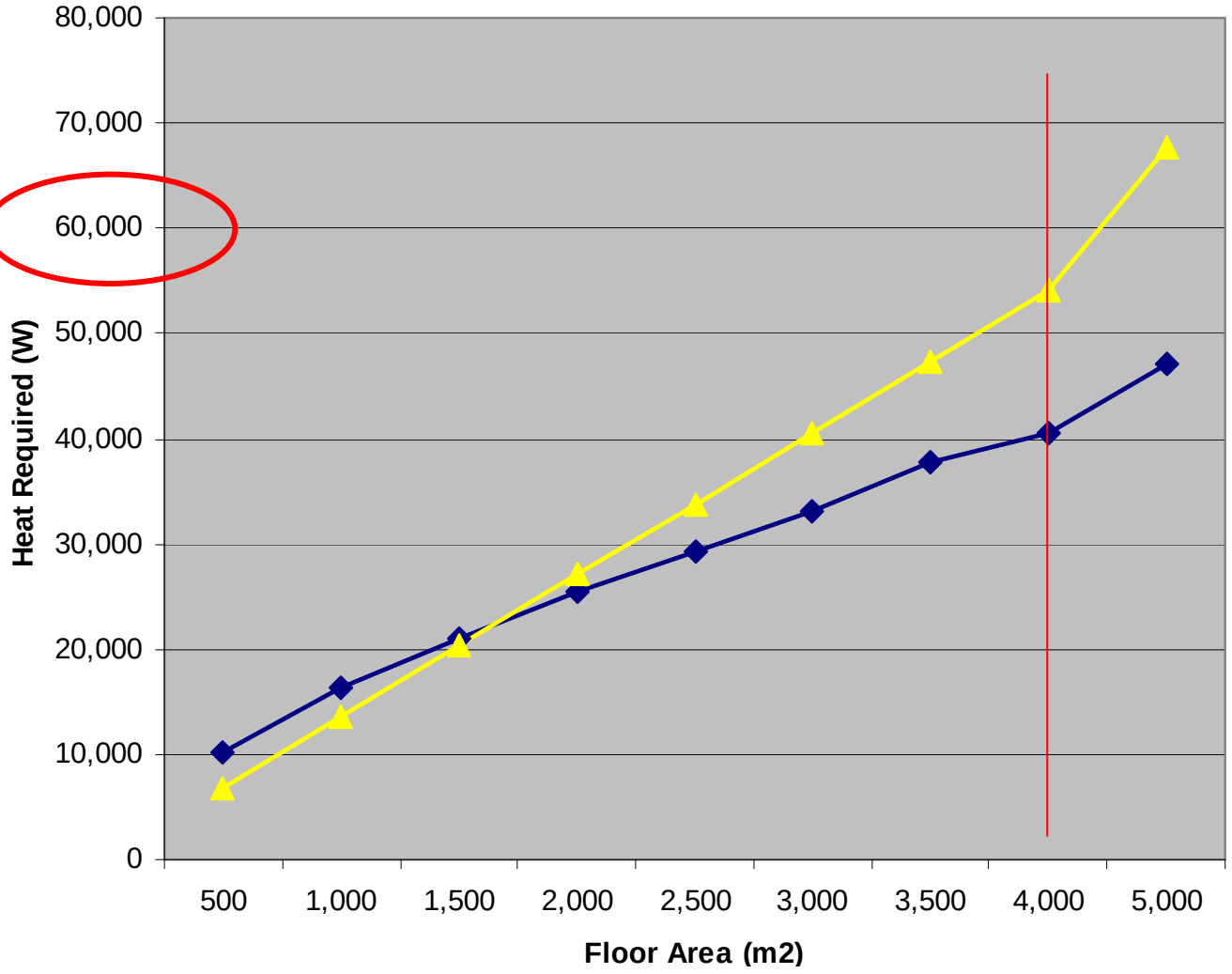


Base Case: MNECB Reference Building for BC Region A

3 Storey Small Office
Gas Heat
VAV Distribution
FWR 40%
RSI 2.1 Roof
RSI 1.2 Walls
RSI 0.3 Windows

Winter design day skin loss is 67% of total heating load for 4,000 m^2 office.

Skin Heat Loss vs. Ventilation 2

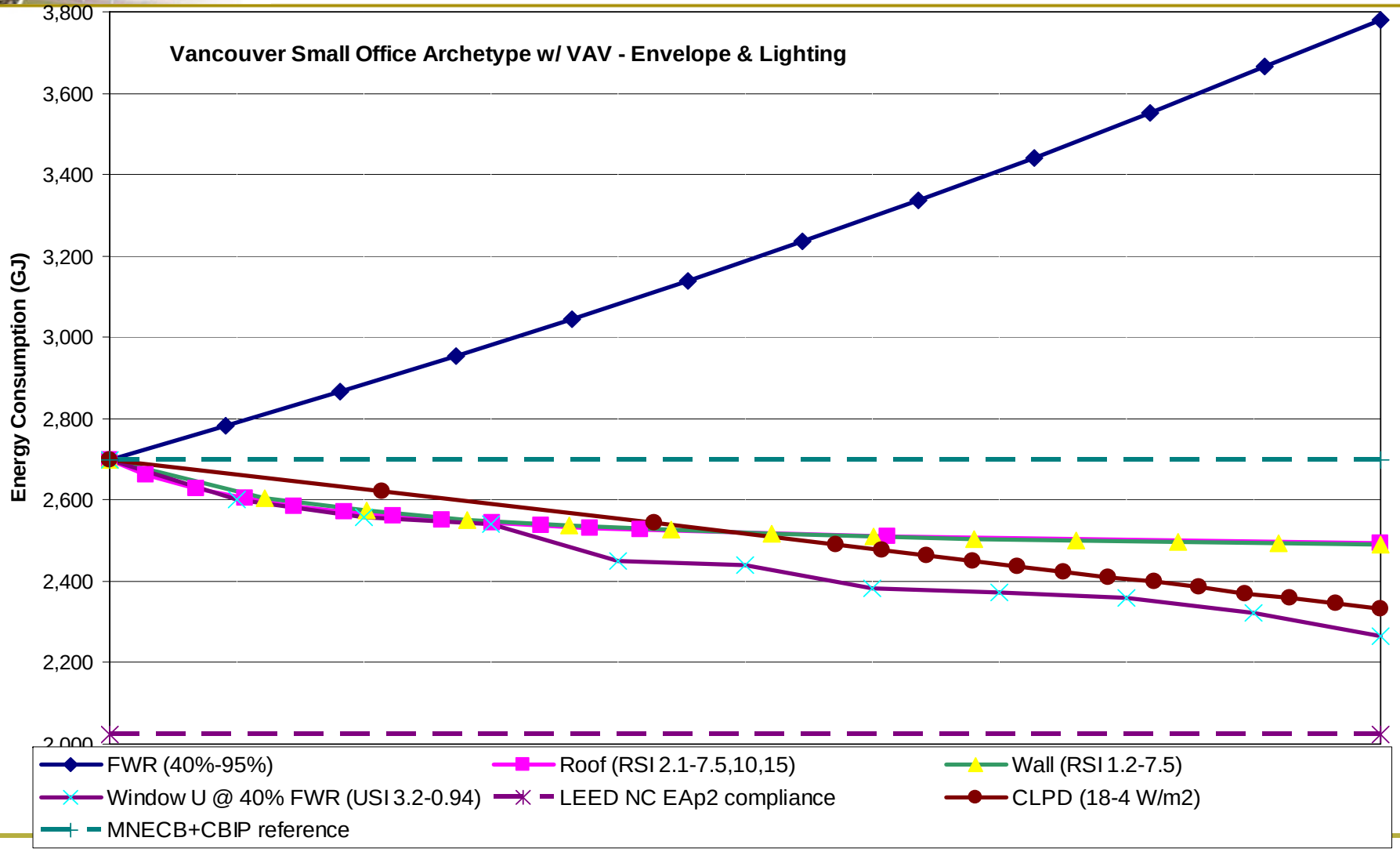


Advanced Case:
MNECB Proposed Building for BC Region A

3 Storey Small Office
Gas Heat
VAV Distribution
FWR 40%
RSI 4.0 Roof
RSI 3.0 Walls
RSI 1.0 Windows

Winter design day skin loss is 41% of total heating load for 4,000 m^2 office.

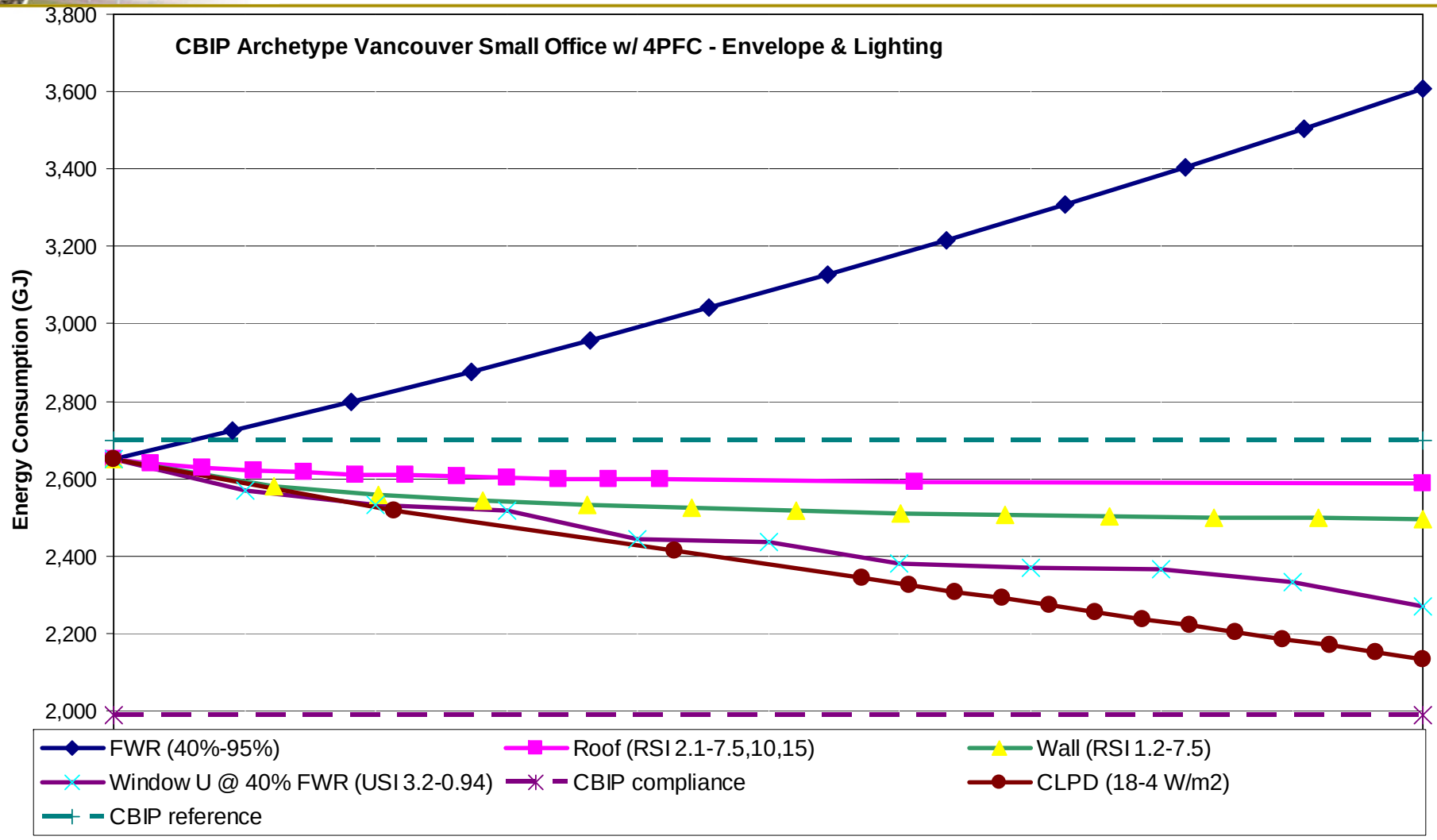
Identify EE measure limits



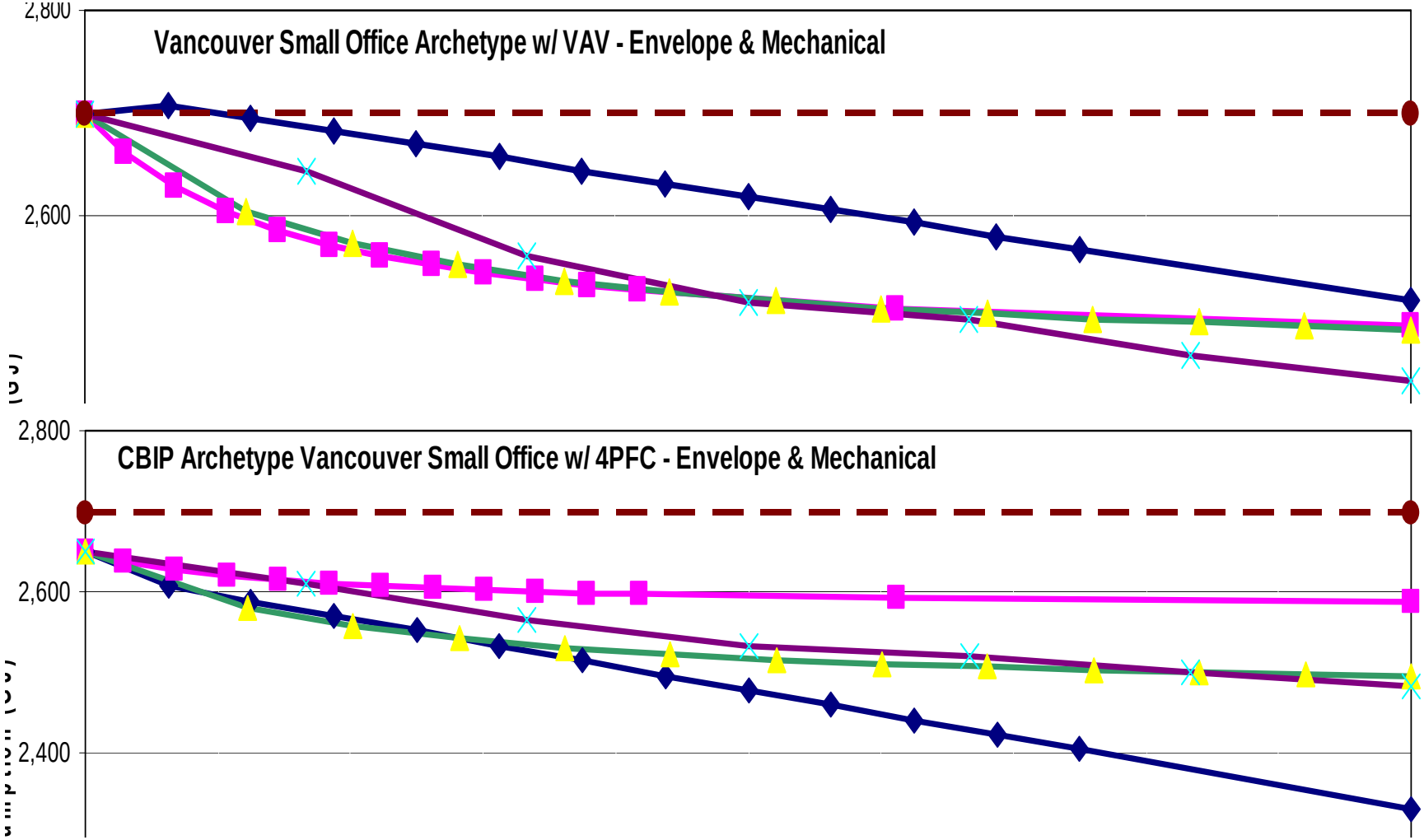
Impact of Ventilation Systems

- Multi-zone MNECB Reference System is a central VAV that overcools spaces and makes good by zone reheat;
  - Heat loss through weak building envelope aggravates the initial weakness of the central system;
- Separating ventilation from space heating and cooling:
  - Reduces volume of air required for tempering and transporting;
  - Enhances the performance of heat recovery and demand controlled ventilation approaches;
- Variable air temperature delivery can trim space temperatures IFF the envelope can neutralize thermal swings in the perimeter zone;

VAV vs. DOAS


CBIP Archetype Vancouver Small Office w/ 4PFC - Envelope & Lighting
Energy Consumption (GJ)
3,800
3,600
3,400
3,200
3,000
2,800
2,600
2,400
2,200
2,000
FWR (40%-95%)
Roof (RSI 2.1-7.5,10,15)
Wall (RSI 1.2-7.5)
Window U @ 40% FWR (USI 3.2-0.94)
CBIP compliance
CLPD (18-4 W/m2)
CBIP reference

System Impacts

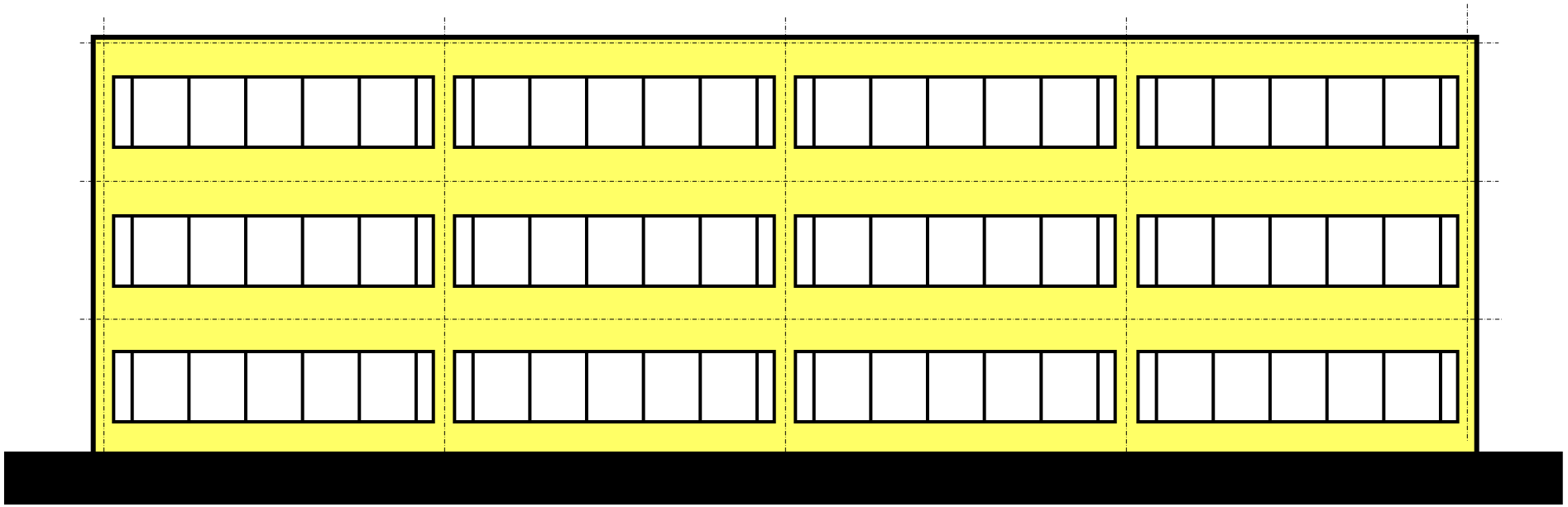


Fenestration Design

Greenstone Bldg, Yellowknife. Photo Mike Lubun

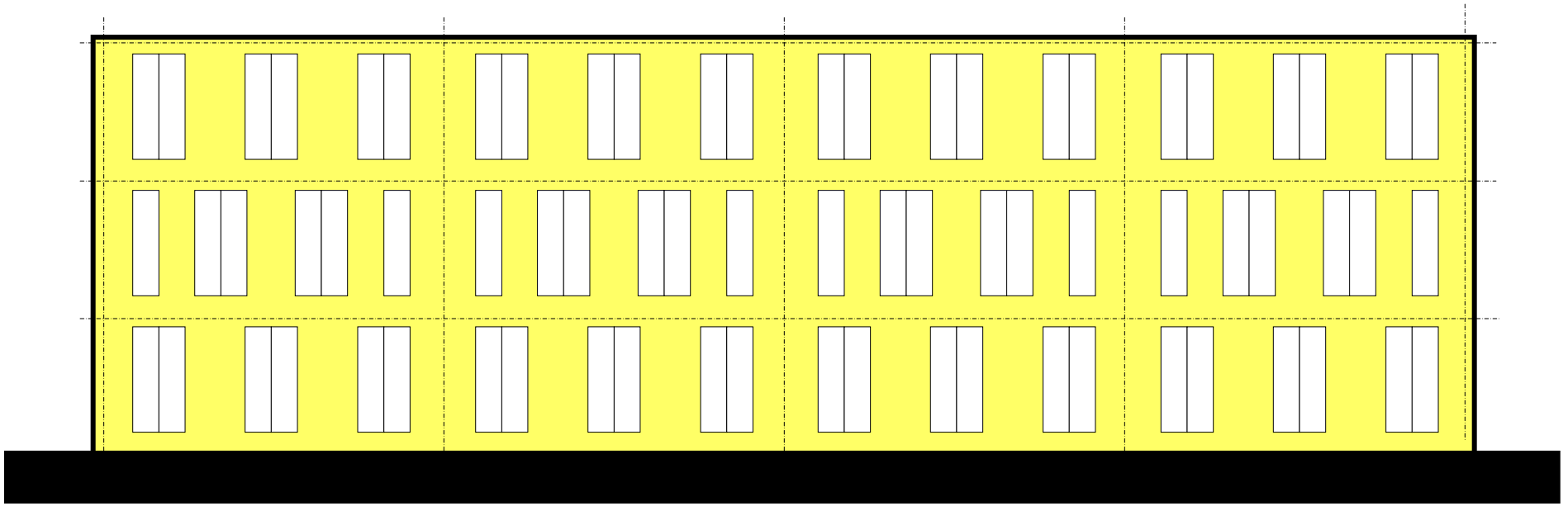
- Identify key elements with impact on other systems;
- Questions:
  - How much is enough?
  - Trade off a more expensive material for a faster installation schedule?
  - Panorama or framed views?
  - What should be the patterns when actual occupancy is unknown?

40% FWR



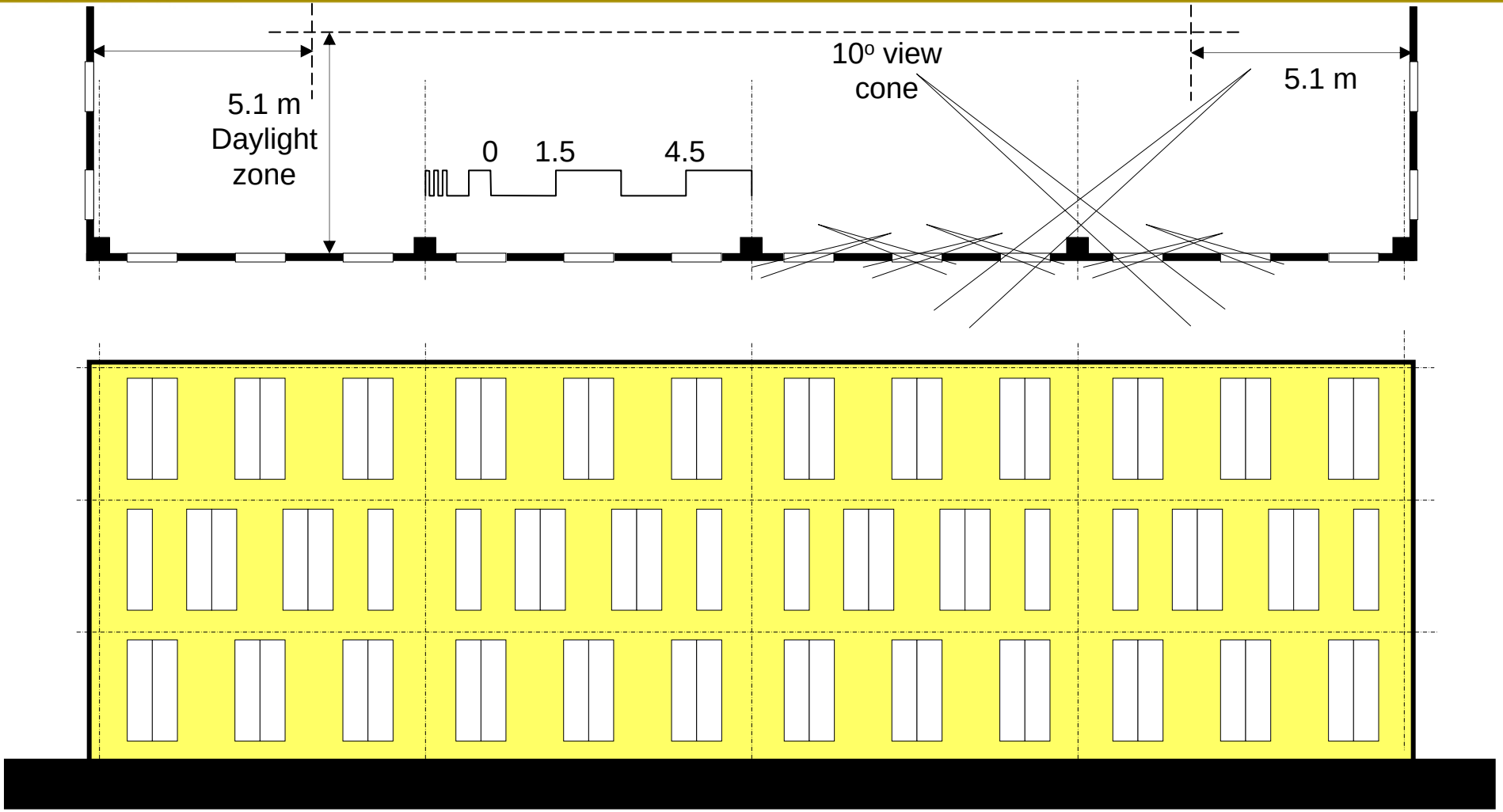
- MNECB Reference Building for Small Office Archetype:
- Sill height 0.85 m AFF;
- Head height 2.45 mm AFF
- Daylight Zone depth 3.675 m (1.5 x Head Height)

Improved 40% FWR

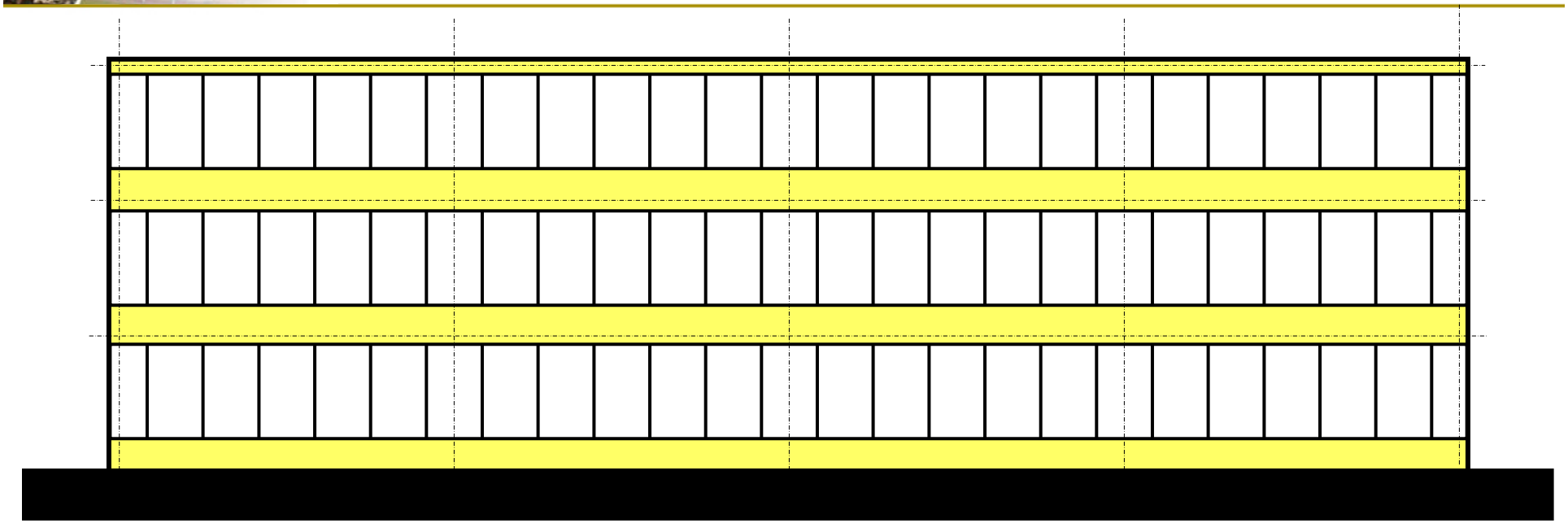


- Revised MNECB Reference for Small Office Archetype:
  - 40% FWR
- Sill height 0.61 m AFF;
- Head height 3.40 m AFF (underside of slab)
- Daylight Zone depth 5.1 m

Improved 40% FWR – Plan

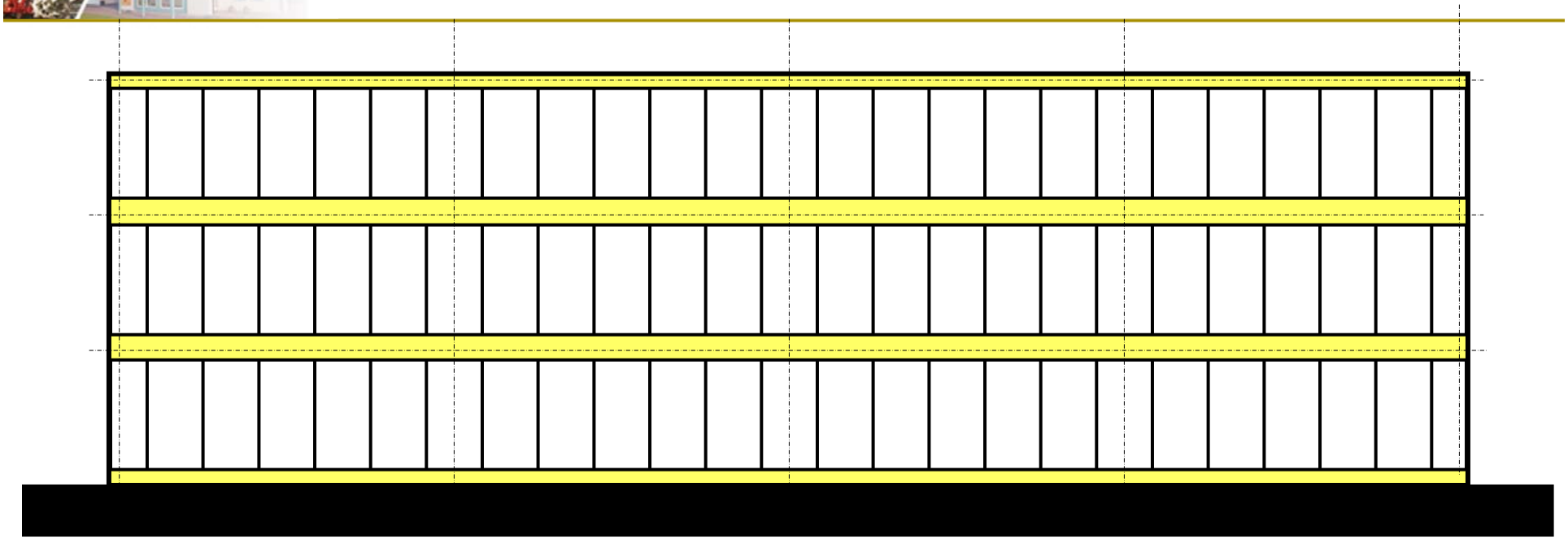


70% FWR



- Small Office Archetype;
- Window sill height 0.85 m AFF;
- Window head height 3.4 m AFF (underside of slab);
- Daylight Zone depth 5.1 m.

80% FWR



- High Performance Office – same geometry as Archetype;
- Sill height 0.46 m AFF (level with raised floor);
- Window head height 3.4 m above finished floor (U/S slab);
- Daylight Zone 5.1 m.
  - No change in perimeter zone depth from 70% FWR.

FWR for Small Office with VAV

Window / FWR	40%	45%	50%	55%	60%	65%	70%	75%	80%	85%	90%	95%
DG / U3.2 / SC 0.74	0	-3	-6	-9	-13	-16	-20	-24	-28	-32	-36	-40
DG / U2.79 / SC 0.61	4	1	-2	-5	-8	-11	-15	-18	-22	-26	-29	-33
DG / U2.55 / SC 0.59	5	3	0	-3	-6	-9	-12	-16	-19	-23	-27	-31
DG / U2.45 / SC 0.59	6	3	0	-2	-5	-8	-12	-15	-18	-22	-26	-29
DG / U1.89 / SC 0.56	9	7	4	2	-1	-4	-6	-10	-13	-17	-20	-23
DG / U1.82 / SC 0.56	10	7	5	2	-1	-4	-6	-10	-13	-16	-19	-23
DG / U1.68 / SC 0.41	12	9	7	4	2	-1	-4	-6	-9	-13	-16	-19
DG / U1.62 / SC 0.41	12	10	7	5	2	0	-3	-6	-9	-12	-15	-18
TG / U1.30 / SC 0.50	13	10	8	6	3	0	-2	-5	-8	-11	-14	-17
TG / U1.10 / SC 0.46	14	12	9	7	5	2	-1	-3	-6	-9	-12	-15
TG / U0.94 / SC 0.31	16	14	12	10	7	5	2	0	-3	-5	-8	-11

Percent energy reduction from MNECB

- Expansion of FWR provides performance benefits
- Expansion of FWR allows reasonable flexibility with trade-offs
- Expansion of FWR doesn't compromise benefits of other strategies
- Expansion of FWR compromises benefits of other strategies
- Expansion of FWR severely compromises energy efficiency goals

FWR for Small Office & 4PFC

Window / FWR	40%	45%	50%	55%	60%	65%	70%	75%	80%	85%	90%	95%
DG / U3.2 / SC 0.74	3	0	-4	-5	-8	-11	-14	-17	-21	-24	-28	-31
DG / U2.79 / SC 0.61	5	3	1	-2	-5	-7	-10	-13	-16	-20	-23	-26
DG / U2.55 / SC 0.59	7	5	2	0	-3	-6	-8	-11	-14	-17	-21	-24
DG / U2.45 / SC 0.59	8	5	3	0	-2	-5	-8	-11	-14	-17	-20	-23
DG / U1.89 / SC 0.56	11	8	6	4	1	-1	-4	-7	-9	-12	-15	-18
DG / U1.82 / SC 0.56	11	9	6	4	2	-1	-3	-6	-9	-12	-15	-18
DG / U1.68 / SC 0.41	13	11	8	6	4	2	-1	-4	-6	-9	-12	-15
DG / U1.62 / SC 0.41	13	11	9	7	4	2	-1	-3	-6	-8	-11	-14
TG / U1.30 / SC 0.50	14	12	9	7	5	3	0	-2	-5	-8	-11	-14
TG / U1.10 / SC 0.46	15	13	11	9	6	4	2	-1	-3	-6	-9	-12
TG / U0.94 / SC 0.31	17	15	13	11	9	7	5	2	0	-3	-5	-6

Percent energy reduction from MNECB

- Expansion of FWR provides performance benefits
- Expansion of FWR allows reasonable flexibility with trade-offs
- Expansion of FWR doesn't compromise benefits of other strategies
- Expansion of FWR compromises benefits of other strategies
- Expansion of FWR severely compromises energy efficiency goals

LEED® Ca-NC EAp2 in 4 Steps

1. Ventilation air supply separated from heating and cooling (fan coil HVAC system);
2. Reduced connected lighting power densities (9.0 W/m^2) with occupancy sensor and daylighting dimming controls for light fixtures over 30% of floor plate;
3. Condensing (92%) space heating boiler.
4. Occupancy sensor controlled DCV for all floor areas.

FWR & LEED™ Ca-NC EAp2

Window / FWR	40%	45%	50%	55%	60%	65%	70%	75%	80%	85%	90%	95%
DG / U3.2 / SC 0.74	25	23	21	18	16	13	11	8	5	2	-1	-4
DG / U2.79 / SC 0.61	28	26	24	21	19	17	14	12	9	6	3	0
DG / U2.55 / SC 0.59	29	27	25	23	21	18	16	13	11	8	5	3
DG / U2.45 / SC 0.59	30	28	26	24	21	19	17	14	12	9	6	4
DG / U1.89 / SC 0.56	33	31	29	27	25	23	21	18	16	14	11	9
DG / U1.82 / SC 0.56	33	31	29	28	25	23	21	19	16	14	11	9
DG / U1.68 / SC 0.41	34	33	31	29	27	25	23	21	18	16	14	11
DG / U1.62 / SC 0.41	35	33	31	29	27	25	23	21	19	16	14	12
TG / U1.30 / SC 0.50	36	34	32	31	29	27	25	22	20	18	16	13
TG / U1.10 / SC 0.46	37	35	34	32	31	29	26	24	22	19	17	15
TG / U0.94 / SC 0.31	38	37	35	34	32	30	28	26	24	22	20	17

Percent energy reduction from MNECB

- Expansion of FWR provides performance above CBIP average.
- Fenestration + 4 measures exceeds LEED™ Ca-NC EAp2
- Expansion of FWR allows reasonable flexibility with trade-offs
- Expansion of FWR doesn't compromise benefits of other strategies
- Expansion of FWR compromises benefits of other strategies
- Expansion of FWR severely compromises energy efficiency goals

High Performance Small Office

1. Concentrated Occupancy:
   a) Double MNECB Occupant Density (13m^2/occupant);
   b) Double MNECB receptacle power allowance (15 W/m^2)
2. Separated ventilation air supply from heating and cooling;
3. Low-energy hydronic radiant heating and cooling;
4. Reduced connected lighting power densities (9.0 W/m^2);
5. Occupancy and daylighting dimming controls for light fixtures;
6. Heat recovery on exhaust or relief air;
7. Demand controlled ventilation;
8. Condensing space heating boilers.
9. Improved window thermal performance values;

Note that the following chart has been recalibrated for higher percentages.

High Performance Office FWR

Window / FWR	40%	45%	50%	55%	60%	65%	70%	75%	80%	85%	90%	95%
DG / U3.2 / SC 0.74	41	39	36	34	32	29	27	24	21	18	15	11
DG / U2.79 / SC 0.61	43	41	39	37	35	32	30	27	25	22	19	16
DG / U2.55 / SC 0.59	43	42	40	38	36	34	31	29	26	24	21	18
DG / U2.45 / SC 0.59	44	42	40	38	36	34	32	30	27	25	22	19
DG / U1.89 / SC 0.56	44	42	40	38	36	34	32	30	27	24	22	19
DG / U1.82 / SC 0.56	46	44	43	41	39	37	35	33	31	29	27	24
DG / U1.68 / SC 0.41	47	46	42	41	39	37	35	33	31	29	26	24
DG / U1.62 / SC 0.41	47	46	45	43	42	40	38	36	34	32	30	28
TG / U1.30 / SC 0.50	47	46	45	43	42	40	38	37	35	33	31	29
TG / U1.10 / SC 0.46	48	47	45	44	43	41	40	38	36	34	33	31
TG / U0.94 / SC 0.31	50	49	48	46	45	44	42	41	39	38	36	34

Percent energy reduction from MNECB

- Fenestration + 8 measures delivers 2030 Challenge target for 2008-2010
- Expansion of FWR provides performance benefits
- Expansion of FWR allows reasonable flexibility with trade-offs
- Expansion of FWR doesn't compromise benefits of other strategies
- Expansion of FWR compromises benefits of other strategies
- Expansion of FWR severely compromises energy efficiency goals

Conclusions for FWR

- HVAC delivery, lighting and controls, and high-performance plant, deliver greater benefits than envelope performance alone;

….BUT….

- Small FWRs restrict access to daylighting benefits, increasing electrical consumption;
- Poor envelope performance squanders benefits of other high-performance measures and systems;

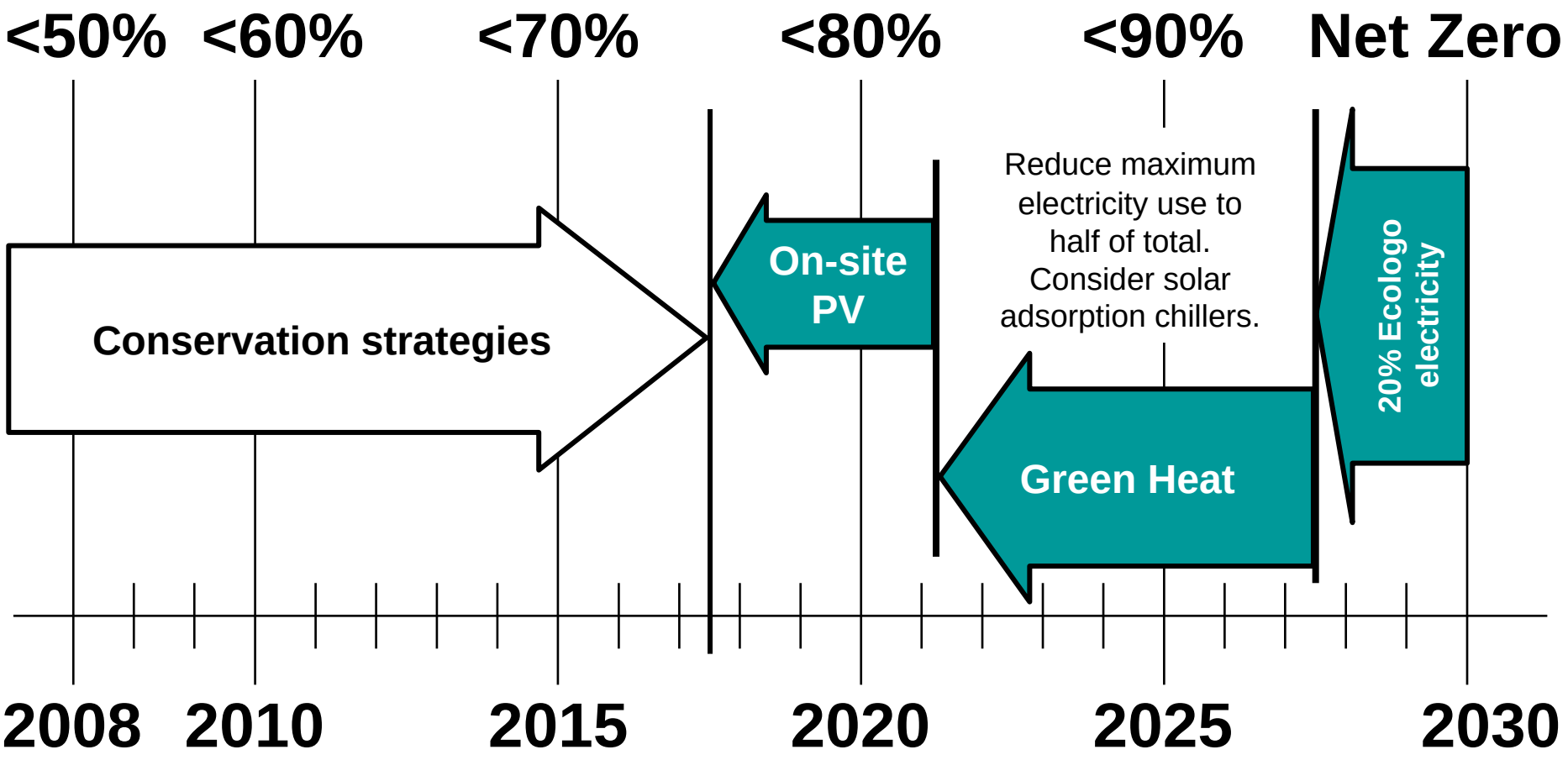
…THEREFORE…

- A wide range of FWR is available for high performance building;
- Envelope must support a minimum of LEED Ca-NC EAp2 performance to support 2030 Challenge objectives;
- Triple glazing not mandatory for successful green building applications.

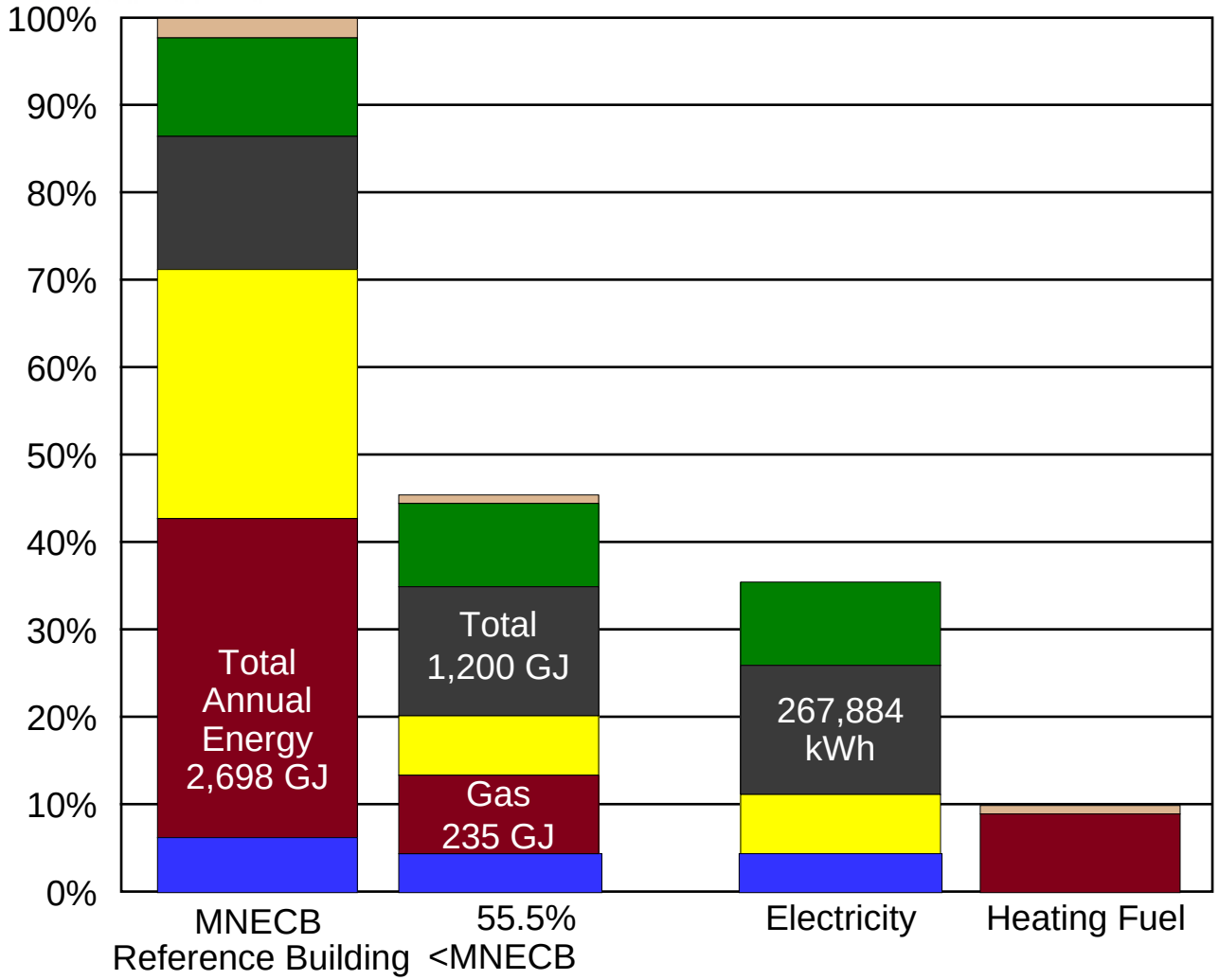
Pursuing the 2030 Challenge Goals

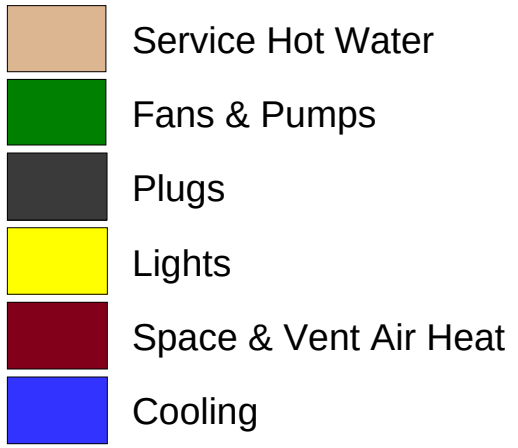
- Energy efficiency and carbon emission reductions are a design issue more than a technology issue;
- Building location and transportation factors cannot be ignored:
  - Remote locations may need advanced timelines.
- Heat is easier to collect from renewable sources than electricity:
  - Further R&D on storage needed;
  - Aggressive reductions to electricity consumption required.
- 2015 performance target is technically feasible NOW with off-the-shelf technology.

A Target Strategy for 2030



Vancouver Small Office Reprise



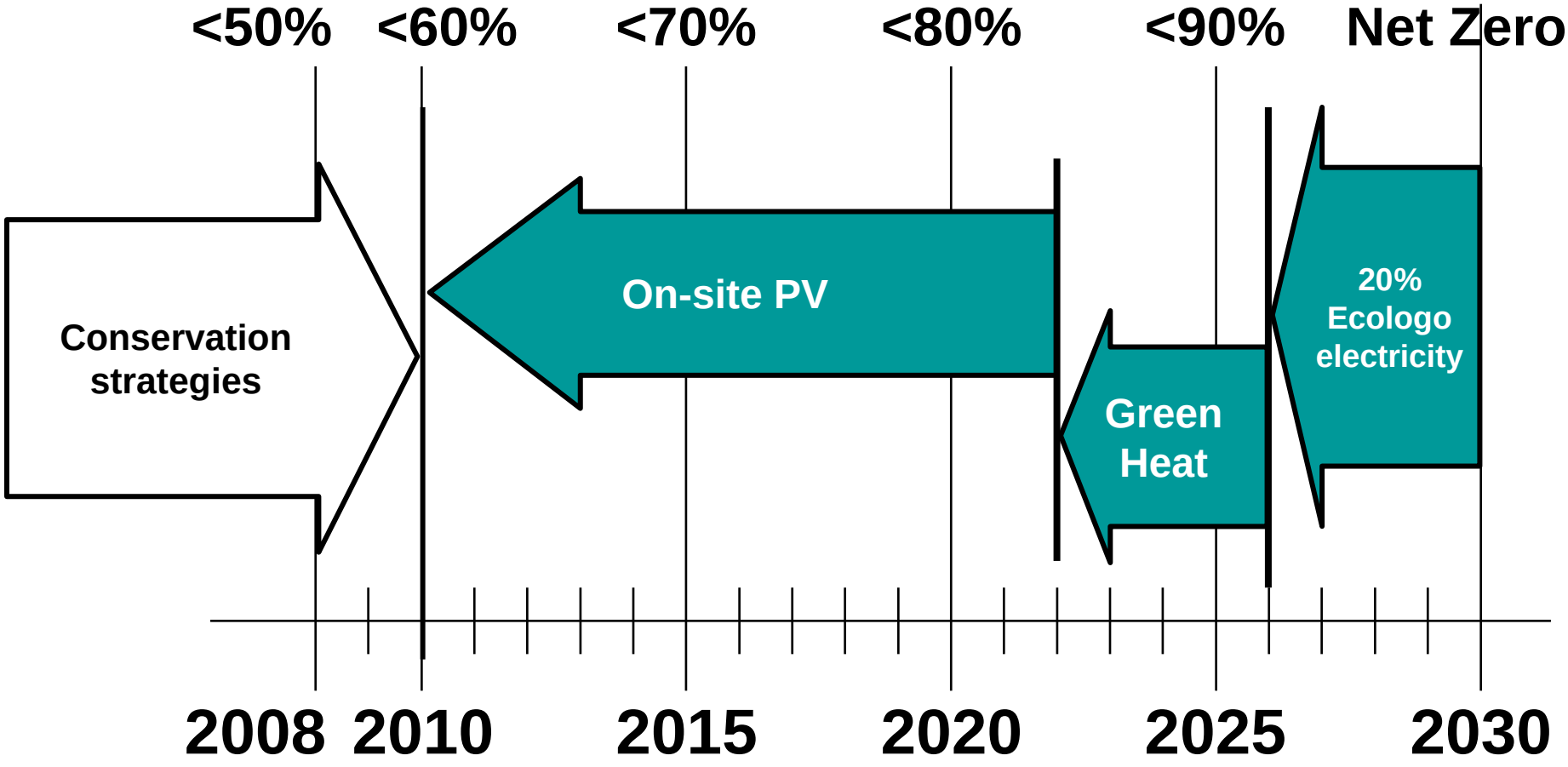


Small Office Archetype:

4010m^2 conditioned floor area; 3 storey height, 3.65m floor-to-floor; 1,337m^2 roof/floor plate area; 1,604m^2 gross wall area.

Natural gas fired boilers provide heat for space, DHW, and ventilation air heating. Electricity provides cooling, lights, fans and pumps.

Revised Strategy



Business as Usual

Carbon Neutral

Solar cooling investigation

- Solar heating and cooling:
  - Heating and cooling requirements can be satisfied;
  - Adsorption cooling is a well matched use for summer solar production and can reduce electricity consumption;
  - BUT cooling load is small once other measures in place;
  - Adsorption chiller COP <1.0.
- Replace solar cooling with high-performance chiller with heat recovery:
  - Good reduction in electrical demand, but;
  - Residual electricity demand cannot be satisfied by building mounted equipment
    - 60.5% of annual demand AFTER offset purchase of 20%.
- Central ground-source heat pumps?
  - Additional reductions in electricity use, but not enough.
- **Conclusion: Reduce electrical consumption.**

Beyond the model

- Quick tools have limits in available conservation options:
- Envelope:
  - No ability to tune fenestration performance by orientation;
  - No ability to describe window shading by overhangs or buildings;
  - No ability to describe more than one window type;
  - No scheduled exterior insulating shutters or blinds;
- Mechanical & Electrical:
  - No heat recovery from chillers;
  - No radiant slab heating and cooling;
  - No ECM motors and variable speed drives in zonal air handling units;
  - No ability to alter auxiliary system energy use or plug loads;
- Plug loads are now the second largest single end use.

Whole Building Research Areas

- Strategies and applications of the following technologies need to be proven in a whole building context:
- Electricity - (load reduction / demand response):
  - Plug loads and office equipment energy reductions.
  - Lighting (& daylighting), Equipment & Controls;
- Strategies for cost-effective exterior shading;
- Solar cooling:
  - Use of solar heat coincident with highest cooling load;
  - Absorption, adsorption, and desiccant-based cooling from solar thermal sources;
- Community energy networks:
  - Electrical;
  - Thermal (DES)
  - Distribution grid may be more important than fuel source.

Market Encouragement

- Adaptation of professional contracts and fee structures to support integrated design;
- Increased professional association recognition of building owners and managers that encourage green building design (and adopt the 2030 Challenge);
- Encouragement of Ecologo certified regional low-impact renewable small power producers and suppliers;
- Continued purchasing pressure on photovoltaic panel development and production;
  - Designers and owners need experience with PV behaviour.
- Continued pressure on utilities to improve access to grid for small renewable energy generators;

Thank You

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