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Ressources naturelles
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C E T C

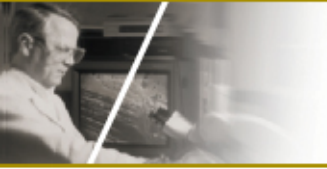
CANMET ENERGY TECHNOLOGY CENTRE

The Green Dream is Already Here

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Sustainable Buildings and Communities Group
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Canada 





Agenda



Photo: Lyse Tremblay architecte

- Articulating “The Dream”;
- Whose Dream?;
- Drivers;
- Realizing the Dream;
- What does this mean for building envelopes?
 - Case Study: Selecting Fenestration-to-wall Ratio;



Preparing for the Millennium

- 1983 UN General Assembly, Resolution 38/161:
 - "Process of preparation of the Environmental Perspective to the Year 2000 and Beyond"
- Brundtland Commission: Our Common Future:
 - Published 1987
- Definition of "Sustainable Development" that:
- "...meets the needs of the present without compromising the ability of future generations to meet their own needs".



1989: The Natural Step

- **System Condition 1:** Materials from the earth's crust must not be allowed to systematically increase in nature.
- **System Condition 2:** Persistent substances produced by society must not systematically increase in nature.
- **System Condition 3:** The physical basis for the earth's productive natural cycles and biological diversity must not be systematically deteriorated.
- **System Condition 4:** There must be fair and efficient use of resources with respect to meeting human needs.
- The Natural Step, founded in 1989 by Swedish Oncologist Dr. Karl-Henrik Robèrt. www.naturalstep.org



1992 Earth Summit, Rio de Janeiro



Photo: NASA

- Rio Declaration on Environment and Development;
- Agenda 21;
- Convention on Biological Diversity;
- Forest Principles;
- Framework Convention on Climate Change.





1997: Factor 10

- Social equity argument from the Wuppertal Institute, Germany, addressing world population growth and the resource intensity of Western standards of living;
- If everyone on the planet is going to equitably share its resources, Western society must reduce its energy intensity by an order of magnitude (a factor of 10).
- “Within one generation, nations can achieve a ten-fold increase in the efficiency with which they use energy, natural resources and other materials.”

Source: Factor 10 Club, 1997 Carnoules Statement to Government and Business Leaders



2002: UN WSSD Johannesburg



Photo: UN, WSSD Moderator Mr. Jan Pronk

- World Summit on Sustainable Development.
- UN Secretary General Kofi Annan sets discussion on “WEHAB.”
 - Conservation of **Water**
 - Conservation of **Energy**
 - Protection of **Health**
 - Protection of **Agriculture**
 - Support for **Biodiversity**
- Source: Dr. Stephen Peake, reporting in ISES REFocus, Nov/Dec 2002.



Sustainable Building Definition 2003

Greg Allen, Allen Kani & Associates, ed. SFP

- Use renewable energy only to construct and operate;
- Eliminate pollutant, toxic and waste discharges;
- Enhance natural hydrology and water quality;
- Use materials that regenerate biologically or are reusable and extracted such that bioproductivity is undiminished;
- Increase habitat for biodiversity and build bioregional integrity;
- Provide health improving environments for occupants that support equity and contributive livelihoods.





Dream Articulations: Summary

- World Scope: Universal demand for equity balancing population with resources;
- Multi-focused, addressing:
 - Energy;
 - Water;
 - Material use;
 - Natural capacity to support human activity without diminishing resources.
- No explicitly actionable suggestions;
- No reference to economic rationalizations;
- **All presuming that the impact of inhabitation is measurable.**



Whose Dream?

- Different engagement with the dream comes with project scale and entry point to a community:
 - Manufacturers;
 - Materials trade and distribution;
 - Consumers;
 - Conservation Associations;
 - Local Authorities;
 - Provincial / Federal Authorities.
- Short-term vs. long-term?
- Social Justice vs. market domination and presence.
- Building Designers and Specifiers:
 - Focus on building benchmarking and performance;
 - Can't answer all of the challenge areas with building alone.
 - Can provide a connection between building performance and social issues.





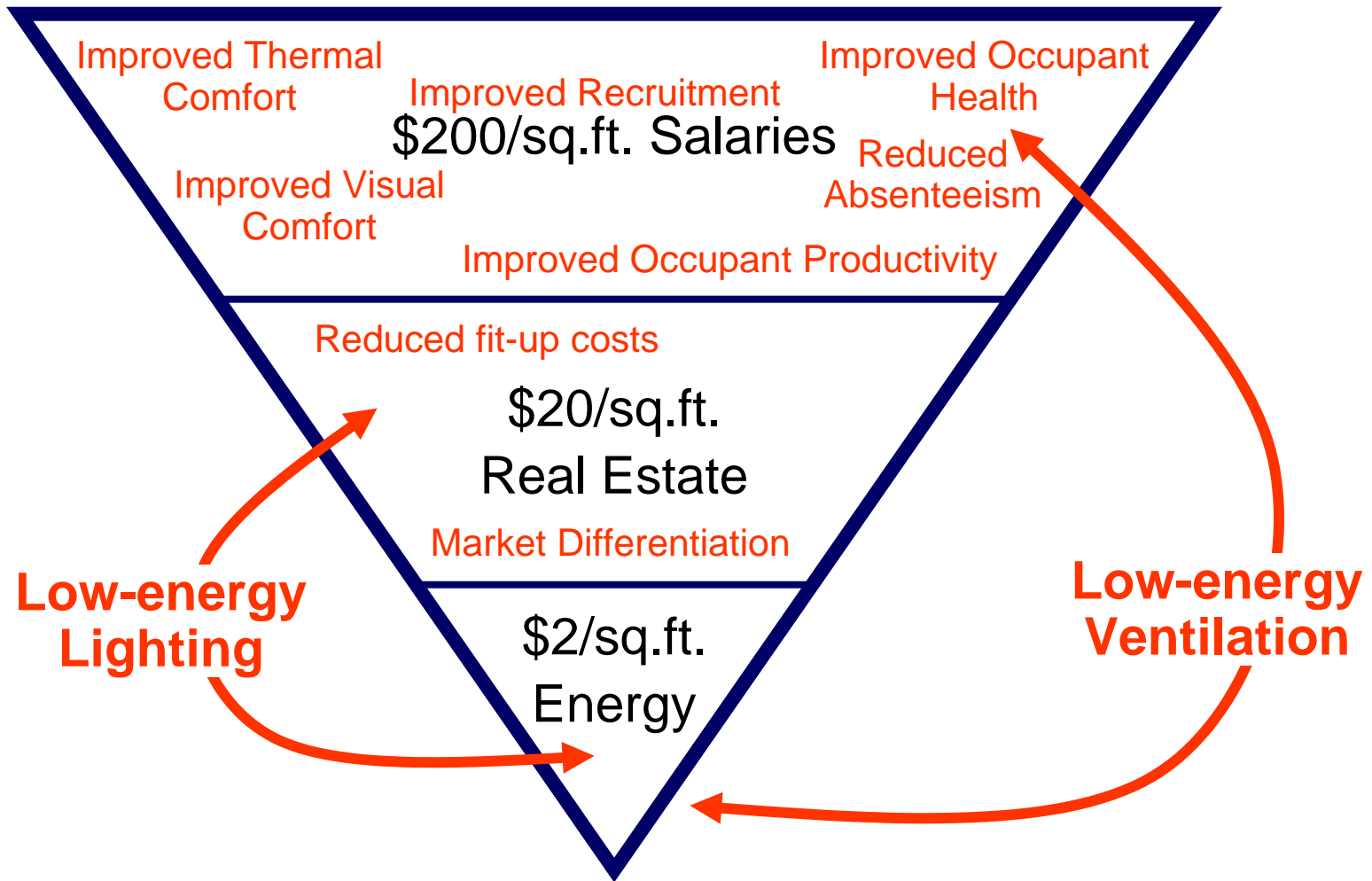
Whose Dream? (Who's Paying?)

- **Owners:**
 - More durable building;
 - Higher asset value;
 - Higher return on gross revenue;
 - Lower recapitalization costs over time;
 - Less tenant churn;
 - Savings sharing for operational efficiencies.
 - Higher rents.
- **Developers:**
 - Municipal approvals benefits;
 - Green financing benefits;
 - Faster pre-sales;
 - Market differentiation.
- **Occupants:**
 - Occupant thermal comfort;
 - Occupant visual comfort;
 - Occupant acoustic comfort;
 - Occupant productivity;
 - Occupant health.
- **Corporate Tenants:**
 - Lower operating costs;
 - Better control over operating costs;
 - Access to special green services;
 - Lower health plan expenses;
 - Lower attraction and retention costs;
 - Savings sharing for operational efficiencies.





The Drivers for Buildings are Soft





Green Dream Business Drivers

- Cost-effective / reliable power services for remote or developing communities;
- Business identity;
 - A position of international standing and scope;
 - Improve corporate reputation;
 - Brand enhancement;
 - Image cleansing.
- Attraction and retention of motivated staff:
 - Highest quality space;
 - A “no regrets” performance target.
- Social marketing.
 - Corporate Social Responsibility



Green Business Planning

- Green goes nowhere without a committed owner;
- Owners explore how a high performance facility contributes to their business:
 - Business plans must engage facility performance;
 - Set operating cost targets with performance targets for energy and water consumption;
 - Explore revenue opportunities for on-site energy generation, including sale of carbon credits;
 - Confirm contributions from utility incentive programs.
- Value of high performance facility is established in pre-design to inform equipment purchase decisions in design.
- Facility operations performance targets are set in the pre-design phase of an integrated design process;



Green Building Budget Setting

- Don't blame the Cost Consultant:
 - Lack of specific building information at pre-design;
 - Detailed historical cost information does not predict the future;
 - Risk can change substantially with changes in market conditions.
- Can't build budgets using the same methods as costing working drawings;
- Complete the Program of Use first;
 - Use scenario planning approaches if facility program can't be completed.
- Set budgets based on an explicit reference building;
 - What would the speculative building industry provide?
 - Give cost consultants as much information as possible as early as possible;
 - "Straw-man" or generic design gives real detail, but needs verification against a final program.





Energy and Economic References

- As soon as the gross floor area is known, start developing the energy and economic references:
- **Energy Reference Building**
 - Developed from MNECB or ASHRAE Standard 90.1 Energy Cost Budget Method;
 - Outline building specification developed using NRCan Screening Tool.
 - Energy reference permits life-cycle operating cost comparisons.
- **Economic Reference Building:**
 - Prepare outline specifications for “code-built” project, assuming simple plan, and bare minimum services;
 - Use MNECB default materials to generate outline specification for reference building systems and materials;
 - Critique the economic reference by comparison to the Program, and adjust program if costs are out.



Realizing the Dream



Photo: Bunting Coady Architects Ltd.

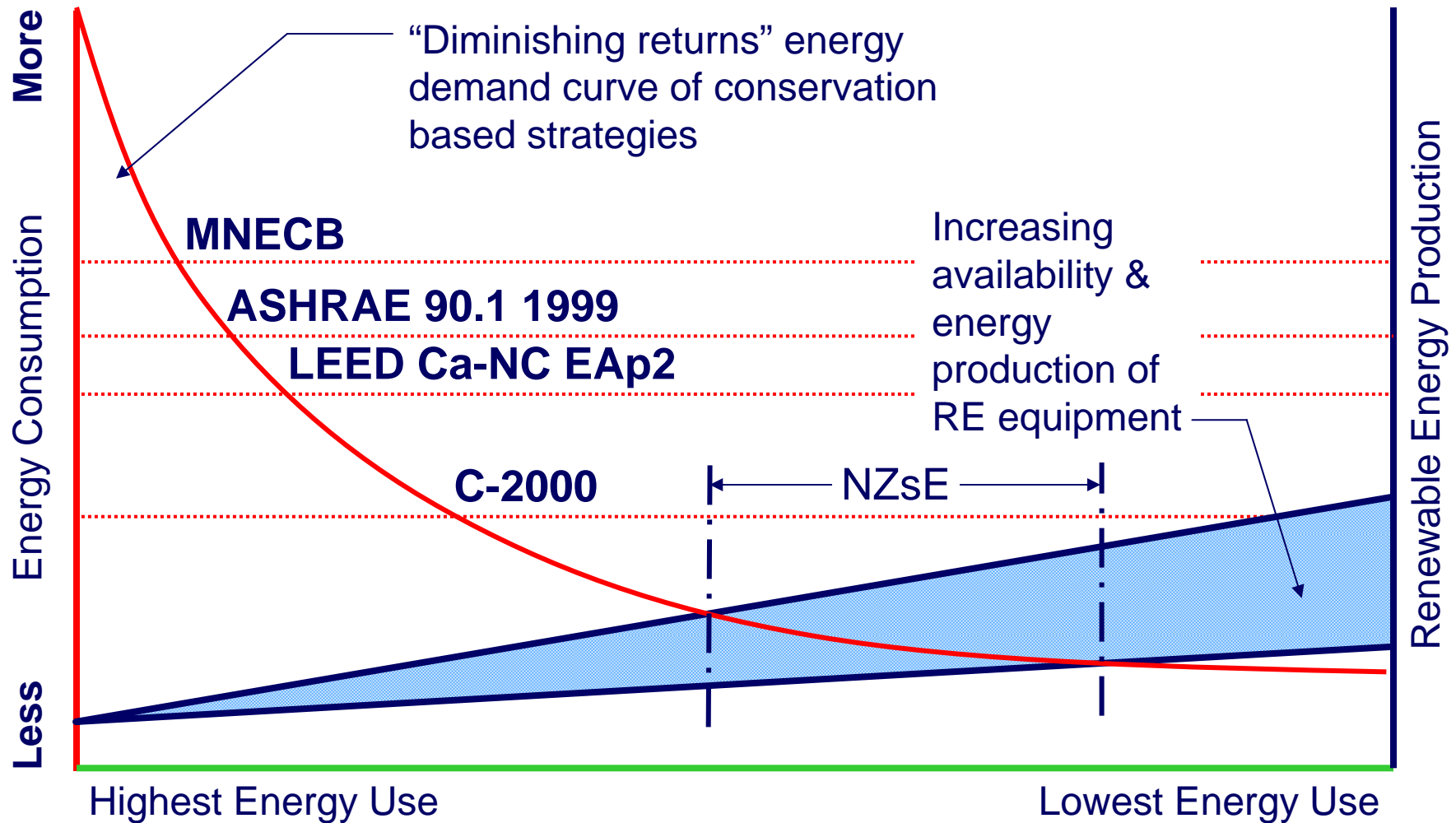
- Top level assessment system performance:
 - Green Globes – 5 Globes;
 - LEED Platinum.
- 2030 Challenge;
- Net Zero Buildings;
- Living Building Challenge;

- Third party measuring systems assist owner/designer focus on individual building performance.



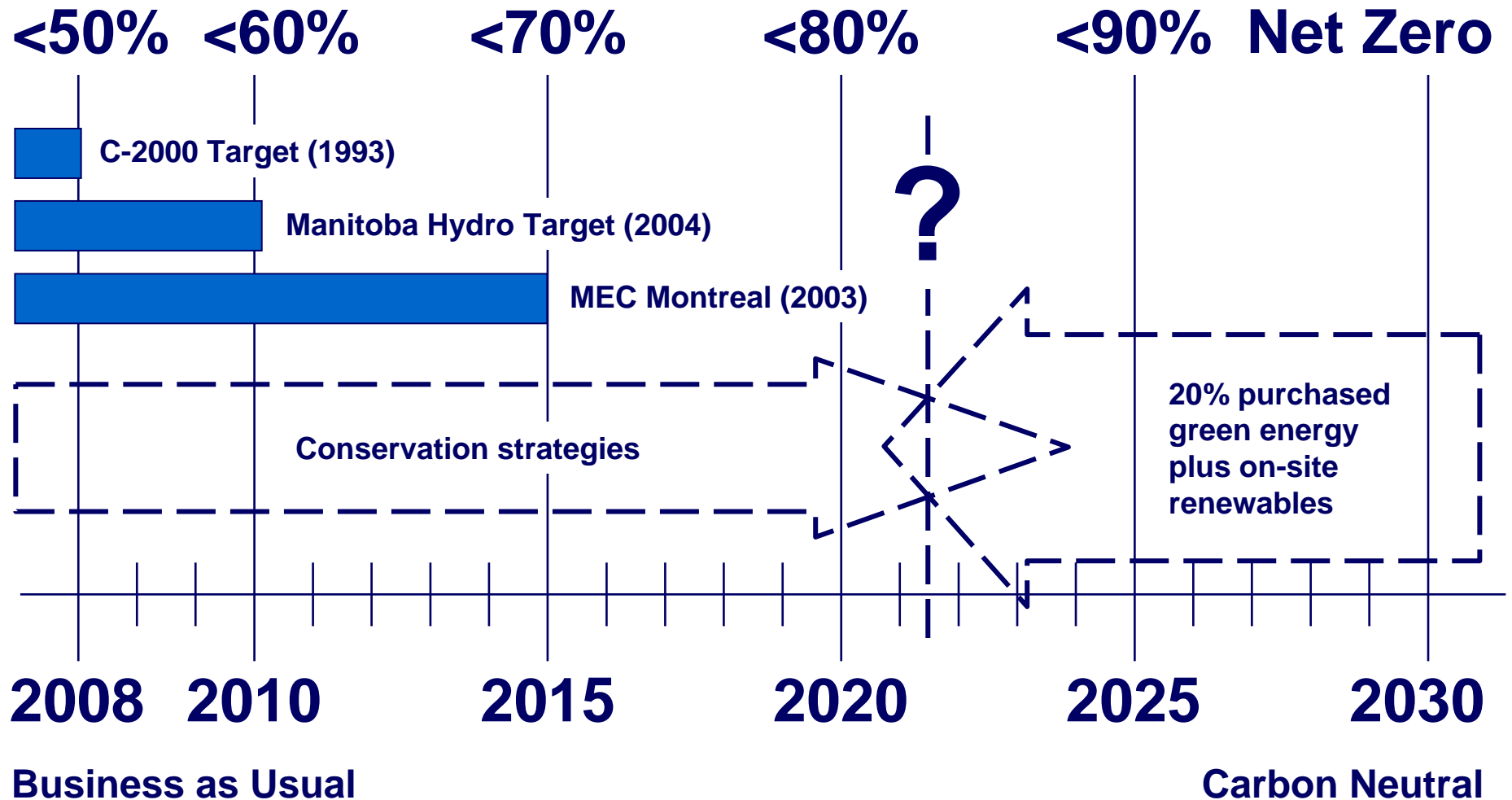


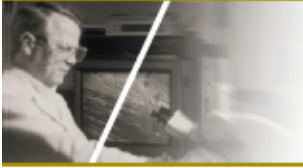
Energy Efficiency & Renewables





2030 Challenge Timelines & Performance





Net-Zero Energy: The Dream is Here

- Off-grid Houses, cottage or new homestead;
 - Bill Kemp: author and green advocate;
 - Equilibrium: CMHC competition – government sponsored single family homes;
 - Solar Decathlon: University / Industry sponsored mobile home/offices.
- Industrial buildings with self operated hydro or other generated electrical power;
- NRCan Built Environment Strategic Roadmap (BESR)
 - Net-zero energy study for technical feasibility:
 - Big box retail;
 - Warehouses;
 - “Near Zero” may be just as useful.



BESR Performance Targets

- 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 1997;
 - Level 2 (2020): 60% energy consumption reduction below MNECB 1997;
 - 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 2007

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. Building	Electric load satisfied %	26	26	25	29	32	32	25	24
	Heating load satisfied %	Yes	Yes	Yes	Yes	Yes	Yes	Yes	61



Renewable Energy Inputs - BESR

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



NZsE target: the RE Platform

- In order to maximize the ability of PV to provide building electricity, approach for 60% target cannot be used;
- Heating energy still largest annual requirement, but solar thermal energy easier to collect;
- Heat pumps use less overall electricity consumption for heating and cooling than conventional designs...
 - BUT too much for effective renewable supply;
- Design approach requires optimizing use of solar thermal and aggressive reduction of electricity consumption.





Office Electricity Use Comparison

Building Type: (Toronto)		Electricity Consumption (kWh/yr)	Percent < MNECB
Small Office	<60%: GSHP Plant	390,000	< 60.0%
	REP: Nat Gas FPFC	250,000	< 60.9%
Large Office	<60%: GSHP Plant	2,300,000	< 60.1%
	REP: Nat Gas FPFC	1,840,000	< 51.8%



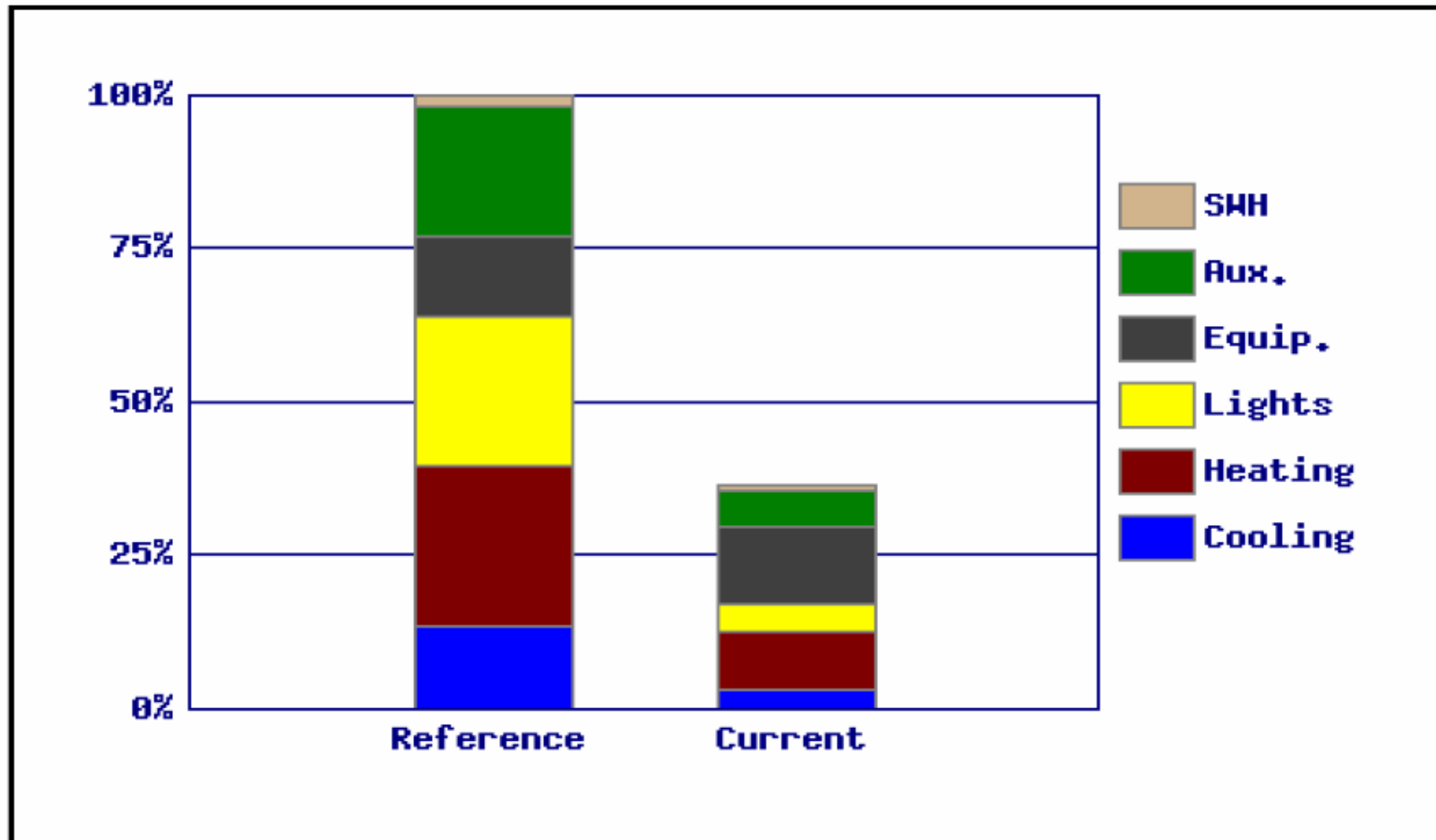


BESR Net-zero Details

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



Small Office 63.4% < MNECB

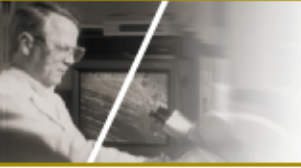




An extreme carbon neutral example

- Small office in Toronto – MNECB reference:
 - Natural Gas for space heat and ventilation: 393,055 ekWh;
 - Electricity for lights, fans, pumps, and equipment: 617,164 kWh;
 - All in, energy consumption: 1,010,219 ekWh.
- Small Office with BESR type reconfiguration:
 - Fan coil system with electric perimeter heat, plus balance of small office approaches for Renewable Energy Platform versions w/o renewables;
 - Total energy consumption: 317,430 kWh.
- Purchase ALL energy from Bullfrog Power:
 - Reference building utility costs: \$61,166.
 - Proposed building utility costs (all electricity) with Bullfrog premium:\$46,000.





Setting Fenestration-to-Wall Ratio



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

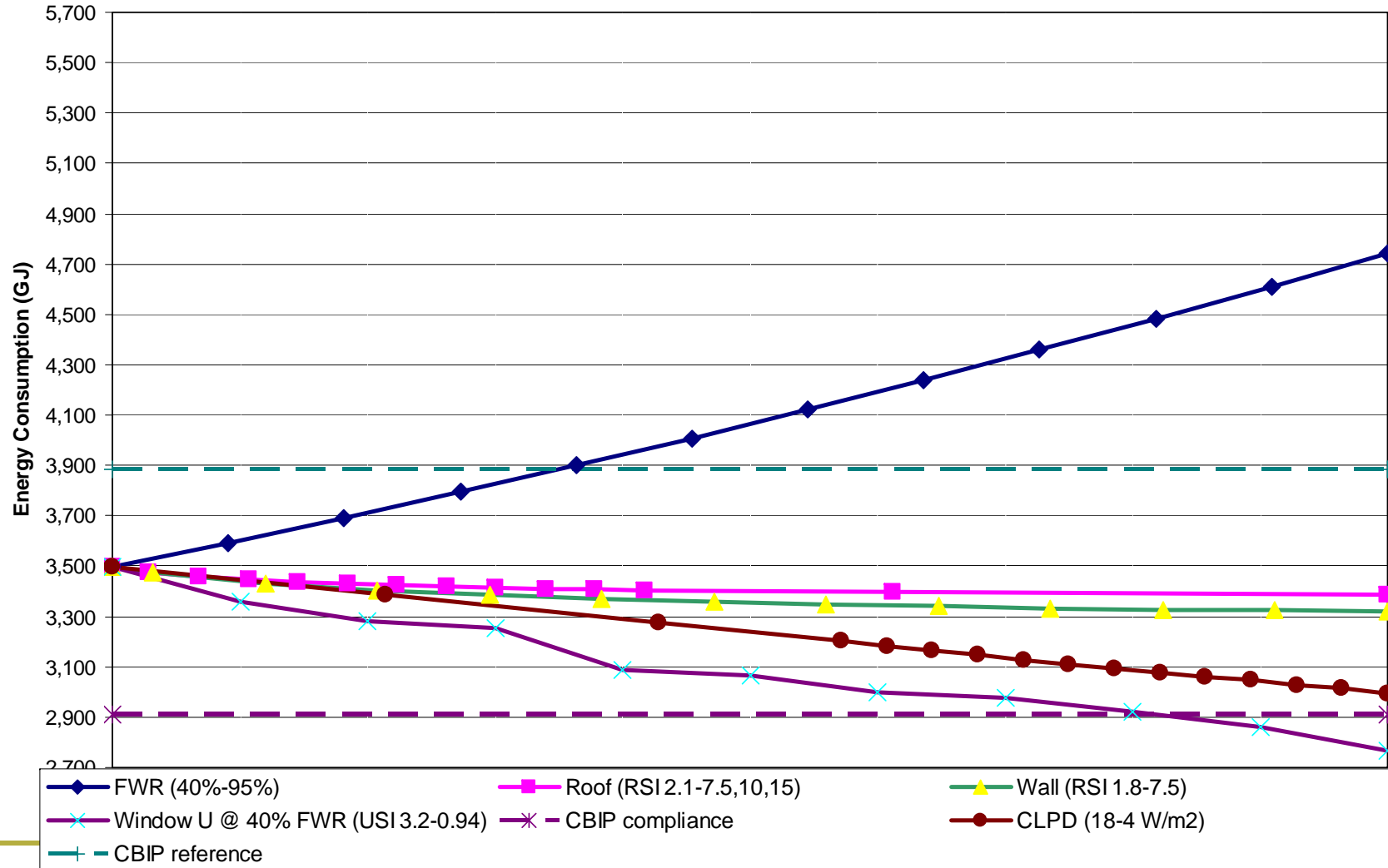
- Most important envelope related question;
- Confusion arises from examples of successful green buildings with high FWR ratios;
- Multi-system impacts need to be investigated;
- Designers need to be conscious of trade-offs.



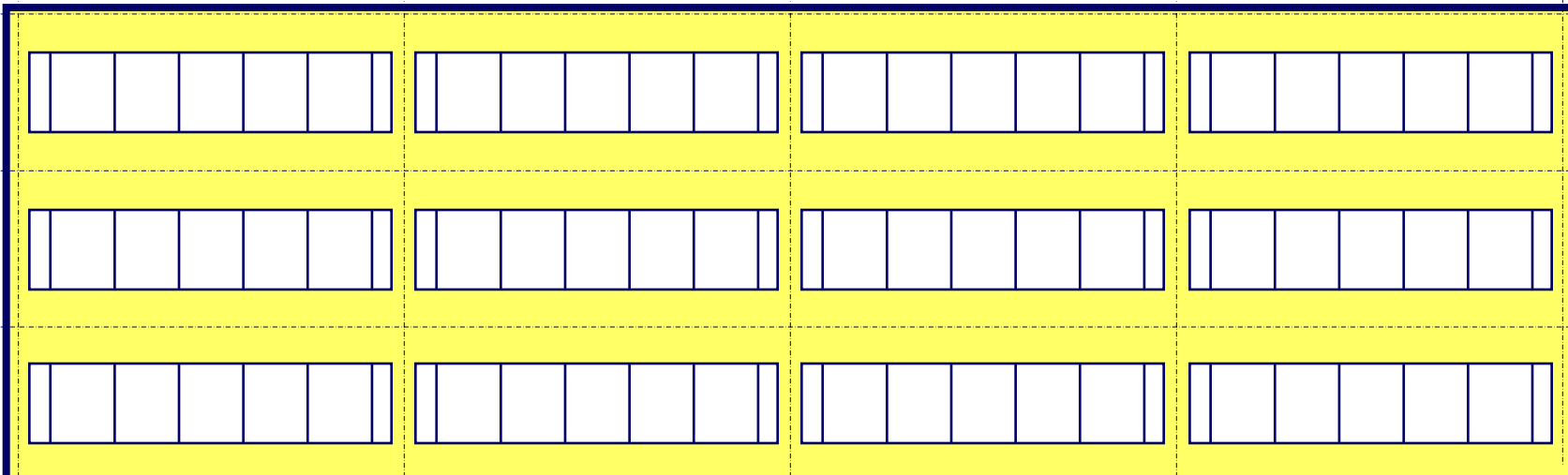


Simulate to identify system impacts:

CBIP Archetype Small Office in Ottawa w/ 4PFC - Envelope & Lighting



40% Fenestration-to-Wall Ratio (FWR)



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



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	-4	-8	-12	-16	-20	-25	-30	-35	-40	-46	-51
DG / U2.79 / SC 0.61	6	3	-1	-5	-8	-13	-17	-21	-26	-31	-36	-41
DG / U2.55 / SC 0.59	8	5	2	-2	-6	-9	-13	-18	-22	-26	-31	-36
DG / U2.45 / SC 0.59	9	6	3	-1	-5	-8	-12	-16	-21	-25	-30	-35
DG / U1.89 / SC 0.56	13	11	8	5	1	-2	-5	-9	-13	-17	-21	-25
DG / U1.82 / SC 0.56	14	11	8	5	2	-1	-5	-8	-12	-16	-20	-24
DG / U1.68 / SC 0.41	18	15	13	10	7	4	0	-3	-7	-10	-14	-18
DG / U1.62 / SC 0.41	18	16	13	10	7	4	1	-3	-6	-9	-13	-17
TG / U1.30 / SC 0.50	18	16	13	11	8	5	2	-1	-5	-8	-12	-15
TG / U1.10 / SC 0.46	20	18	16	13	10	8	5	2	-1	-5	-8	-12
TG / U0.94 / SC 0.31	24	22	20	17	15	12	10	7	4	1	-2	-6

Percent energy reduction from MNECB

- Expansion of FWR delivers performance benefits
- Expansion of FWR delivers benefits with reasonable 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



Impact of Other Systems

- MNECB Reference System AHU2 is a central VAV that tends to overcool spaces and make good with zone reheat;
- Heat loss through weak building envelope aggravates the initial weakness of the central system;
- Separation of ventilation from space heating is one of the first measures to be considered in green building design;
- Variable volume and air temperature delivery of ventilation air provides an adequate vehicle for trimming space temperatures IFF the envelope can neutralize thermal swings in the perimeter zone.



FWR for Small Office & FPFC

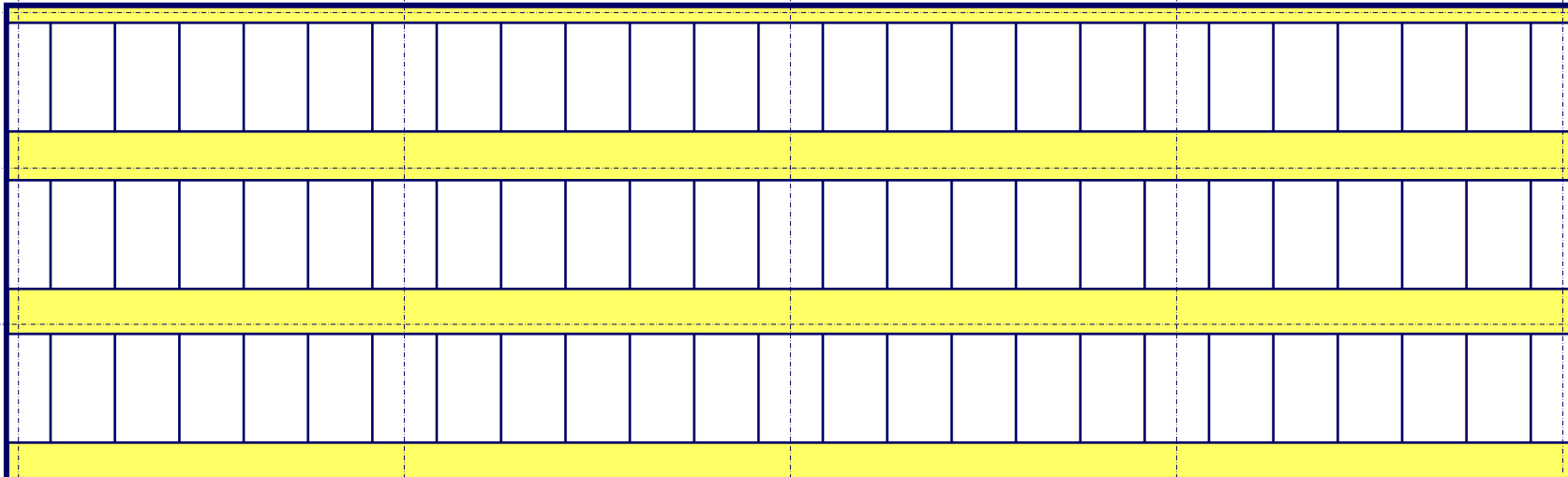
Window / FWR	40%	45%	50%	55%	60%	65%	70%	75%	80%	85%	90%	95%
DG / U3.2 / SC 0.74	9	6	3	0	-3	-6	-9	-13	-16	-18	-22	-26
DG / U2.79 / SC 0.61	14	12	9	6	3	0	-3	-6	-9	-13	-17	-20
DG / U2.55 / SC 0.59	16	14	11	9	6	3	0	-3	-6	-10	-13	-17
DG / U2.45 / SC 0.59	17	15	12	10	7	4	1	-2	-5	-8	-12	-15
DG / U1.89 / SC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

Percent energy reduction from MNECB

- Fenestration + 1 measure delivers LEED Ca-NC EAp2
- Expansion of FWR delivers performance benefits
- Expansion of FWR delivers benefits with reasonable 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



70% FWR



- Small Office Archetype: 4,010 m²: 1,337 m² floor plate: 3.65 m Flr Hght;
- Sill Height 0.85 m AFF
- Head Height 3.4 m AFF (underside of slab);
- Daylight Zone depth 5.1 m,





3 Measures for LEED Ca-NC EAp2

1. Separated ventilation air supply 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;
3. Mid efficiency modulating space heating boiler.



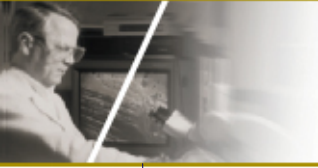


FWR for Small Office: Typical EAp2

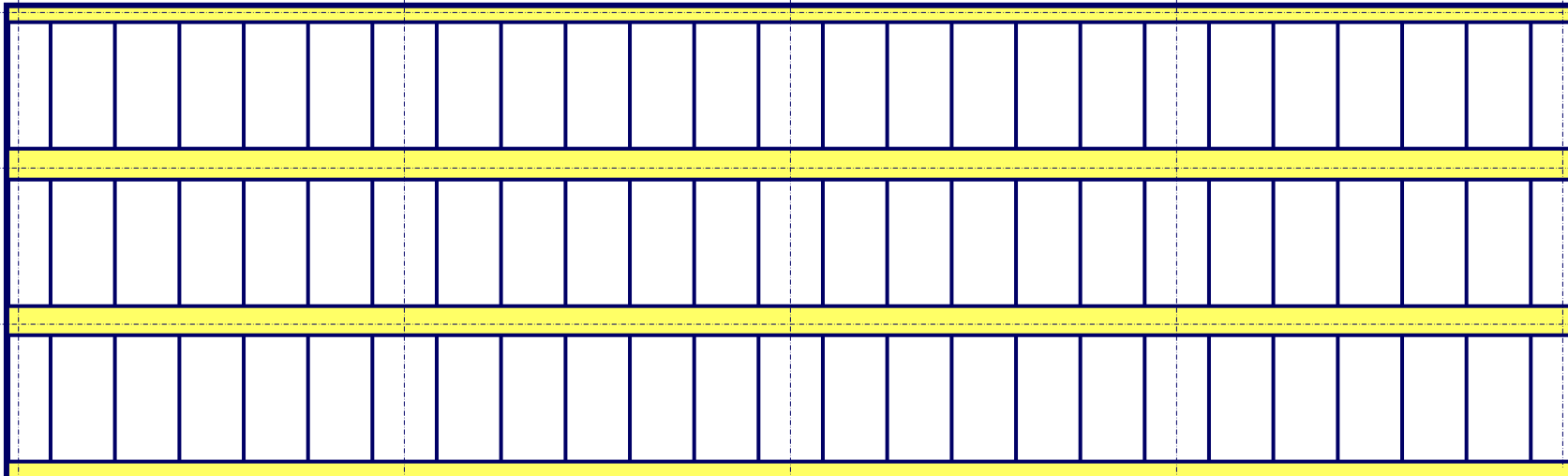
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DG / U2.79 / SC 0.61	29	27	24	21	18	15	12	9	6	2	-2	-5
DG / U2.55 / SC 0.59	31	29	27	24	21	18	15	12	9	6	2	-2
DG / U2.45 / SC 0.59	32	30	28	25	22	19	17	13	10	7	4	0
DG / U1.89 / SC 0.56	37	35	33	30	28	26	23	20	18	15	12	9
DG / U1.82 / SC 0.56	38	35	33	31	29	26	24	21	19	16	13	10
DG / U1.68 / SC 0.41	39	37	34	32	30	27	25	22	20	17	14	11
DG / U1.62 / SC 0.41	39	37	35	33	31	28	26	23	21	18	15	12
TG / U1.30 / SC 0.50	42	40	38	36	34	32	29	27	25	22	20	17
TG / U1.10 / SC 0.46	43	41	39	38	36	34	32	29	27	25	22	20
TG / U0.94 / SC 0.31	44	43	41	39	37	35	33	31	29	27	24	22

Percent energy reduction from MNECB

- Fenestration + 3 measures delivers LEED Ca-NC EAp2
- Expansion of FWR delivers benefits with reasonable 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



80% FWR



- High Performance Office – same geometry as Archetype;
- Sill Height 0.46 m AFF (level with raised floor);
- Head Height 3.4 m AFF (U/S slab);
- Daylight Zone 5.1 m.



High Performance Small Office

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



High Performance Small Office FWR

Window / FWR	40%	45%	50%	55%	60%	65%	70%	75%	80%	85%	90%	95%
DG / U3.2 / SC 0.74	44	42	40	38	36	33	31	28	25	23	19	16
DG / U2.79 / SC 0.61	46	45	43	41	39	36	34	32	29	26	23	20
DG / U2.55 / SC 0.59	48	46	44	43	41	39	36	34	32	29	26	24
DG / U2.45 / SC 0.59	48	47	45	43	41	39	37	35	33	30	28	25
DG / U1.89 / SC 0.56	52	50	49	47	46	44	42	41	39	37	35	32
DG / U1.82 / SC 0.56	52	51	49	48	46	45	43	41	39	37	35	33
DG / U1.68 / SC 0.41	53	52	50	49	48	46	44	42	41	39	37	35
DG / U1.62 / SC 0.41	53	52	51	50	48	47	45	43	41	40	38	35
TG / U1.30 / SC 0.50	55	54	52	51	50	49	47	46	45	43	41	40
TG / U1.10 / SC 0.46	56	55	54	53	52	50	49	48	47	45	44	42
TG / U0.94 / SC 0.31	57	56	56	54	53	52	51	50	49	47	46	44

Percent energy reduction from MNECB

2030 Challenge target zone for 2008-2010

6-7 points EAc1

- Fenestration + 8 measures delivers LEED Ca-NC EAp2
- Expansion of FWR delivers benefits with reasonable 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

- High-performance plant, HVAC delivery, lighting, and controls, overshadow envelope performance;
- Poor envelope performance can restrict access to daylighting benefits or squander benefits of high-performance systems;
- In concert with other building systems, envelope performance needs to target a minimum of LEED Ca-NC EAp2 performance to support green buildings;
- FWR greater than 70% require special trade-offs for advanced performance targets – spandrel performance is still important;
- TG not necessarily required for successful green building applications, but allow full benefits of other advances to be harvested.



Thank You



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