

Review of ASHRAE 90.1 for B.C.: Compliance & LEED Implications

Vancouver LEED User's Group

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Presentation Overview

- 1) ASHRAE 90.1 Overview
- 2) Background – B.C. Experience
 - ✓ “Life-Cycle Economic Assessment of ASHRAE 90.1 Applied to British Columbia” and follow-on studies
- 3) Energy Standards Summary Comparison & Review
 - ✓ ASHRAE 90.1 versions & MNECB
 - ✓ LEED Implications

Review of **ASHRAE 90.1** for British Columbia

ASHRAE 90.1 Overview

ASHRAE 90.1 Background

- ANSI/ASHRAE/IESNA Standard 90.1
 - ✓ 3-Year Update Cycle since 2001 version
- Widely Recognized in North America
 - ✓ Cities of Vancouver and Toronto
 - ✓ Ontario references in OBC (1989 & 2004)
 - ✓ U.S. – adopted and federally legislated since July 2004
 - ✓ Referenced by designers and manufacturers
 - ✓ Basis for LEED™ EA Prerequisite 2 & Credit 1
 - Canada: 1999, 2007 versions
 - U.S.: 2004, 2007 versions

ASHRAE 90.1 Structure

■ Key sections:

- ✓ Administration, definitions, scope, enforcement, etc.
- ✓ Envelope, HVAC, SWH, Power, Lighting, Other Equipment (motors)
- ✓ ECB (Simulation) Method
- ✓ Appendices and References

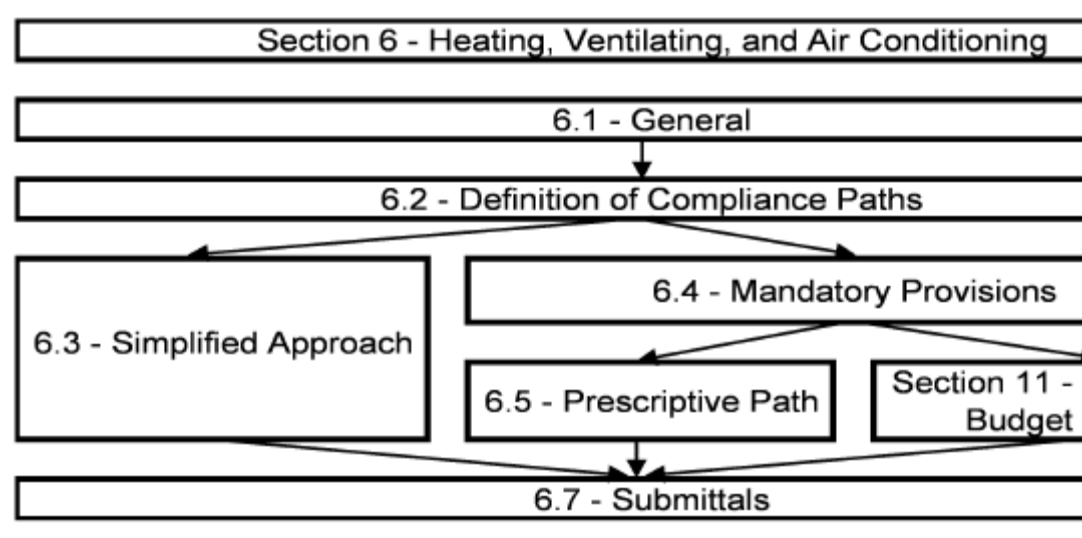
■ Requirements:

- ✓ 135 mandatory and prescriptive (*2001)
- ✓ Over 370 equipment efficiency and lighting power allowances (*2001)

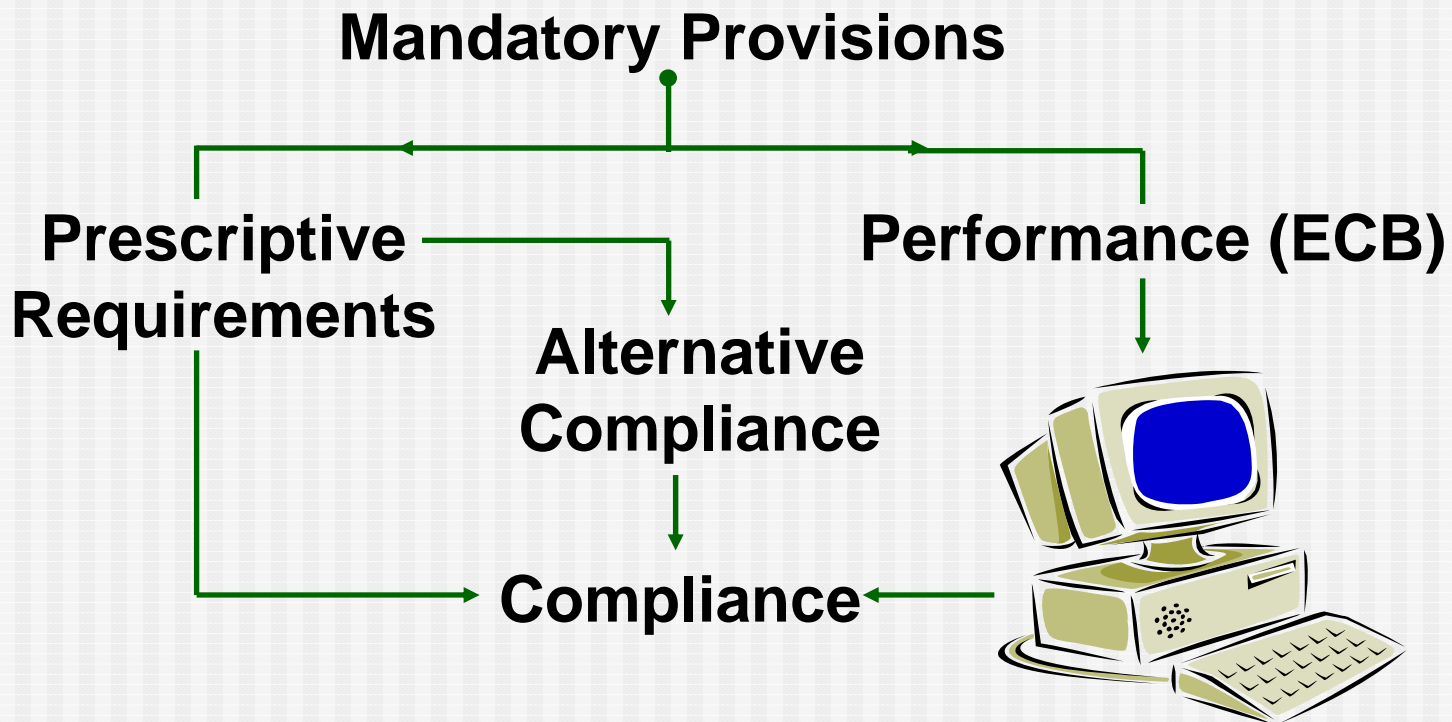
ASHRAE 90.1-2004/2007 Structural Changes vs 1999/2001

■ Reformatted for “ease of use”

- ✓ New Section [x].2 – Definition
- ✓ New Section [x].3 – Simplified Approach
(HVAC only)
- ✓ ECB req'ts tables
- ✓ App. G



ASHRAE 90.1 Compliance



- Prescriptive Path Most Widely Used
- Appendix G adds a procedure for building performance ratings (e.g., LEED 2009)

ASHRAE 90.1 Prescriptive Path

- Requirements defined in subsection 5 (x.5)
 - ✓ Restructured from 2001
- Envelope criteria tables condensed to 8 from 26 in 2004 vs 2001
 - ✓ About the same in stringency

TABLE 6.8.1F Gas- and Oil-Fired Boilers—Minimum Efficiency Requirements

Equipment Type ^a	Size Category (Input)	Subcategory or Rating Condition	Minimum Efficiency
Boilers, Gas-Fired	<300,000 Btu/h	Hot Water	80% AFUE
		Steam	75% AFUE
	≥300,000 Btu/h and ≤2,500,000 Btu/h	Maximum Capacity ^d	75% E_t^b
	>2,500,000 Btu/h ^a	Hot Water	80% E_c

TABLE 5.5-5 Building Envelope Requirements For Climate Zone 5 (A,B)

Opaque Elements	Nonresidential		Residential	
	Assembly Maximum	Insulation Min. R-Value	Assembly Maximum	Insulation Min. R-Value
<i>Roofs</i>				
Insulation Entirely above Deck	U-0.063	R-15.0 ci	U-0.063	R-15.0 ci
Metal Building	U-0.065	R-19.0	U-0.065	R-19.0
Attic and Other	U-0.034	R-30.0	U-0.027	R-38.0
<i>Walls, Above-Grade</i>				
Mass	U-0.123	R-7.6 ci	U-0.090	R-11.4 ci
Metal Building	U-0.113	R-13.0	U-0.057	R-13.0 + R-13.0
Steel-Framed	U-0.084	R-13.0 + R-3.8 ci	U-0.064	R-13.0 + R-7.5 ci
Wood-Framed and Other	U-0.089	R-13.0	U-0.089	R-13.0
<i>Wall, Below-Grade</i>				

ASHRAE 90.1 Alternative Compliance Paths

- Building Envelope Trade-Off (EnvStd, [COMCheck](#))
- Lighting Trade-Off Approach
- Simplified HVAC Approach
 - ✓ Intended for simple, small buildings

The screenshot shows two overlapping windows. The top window is 'EnvStd Project Explorer' showing a tree view of a project named 'Typical New High Rise_MURB'. The bottom window is 'example-90_1-2004.cck - COMcheck 3.5.3' showing a table of building components and their properties.

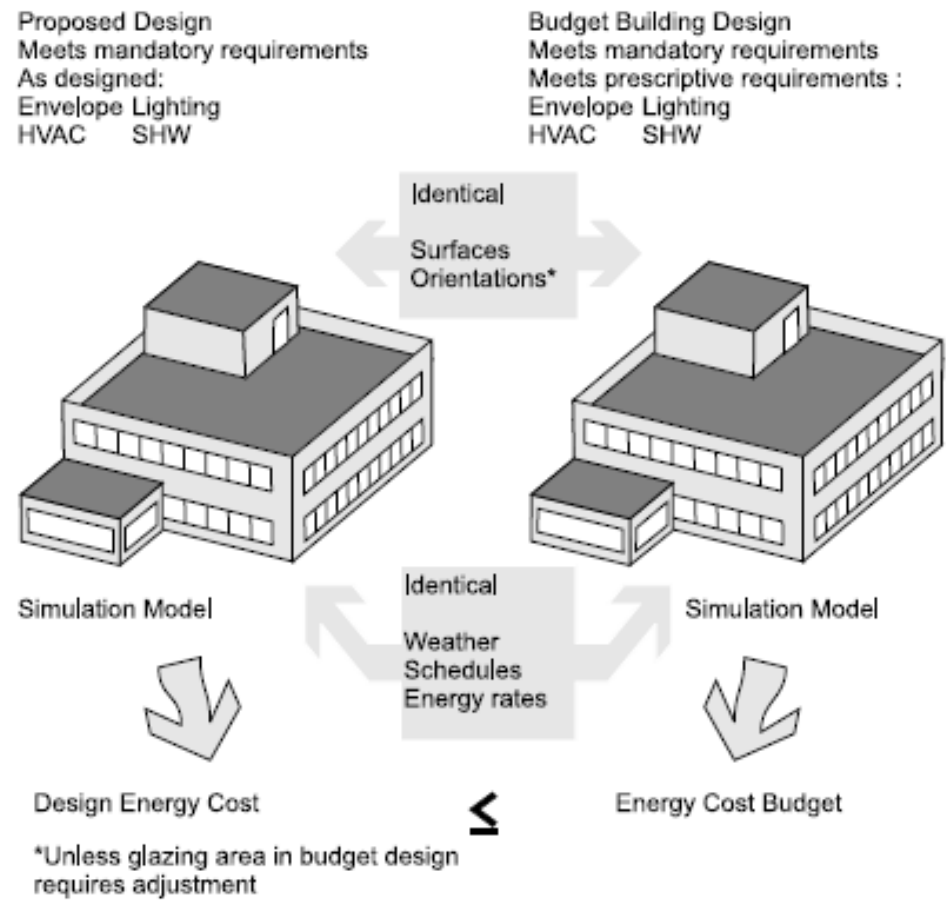
Component	Assembly	Concrete Density	Construction Details	Gross Area	Cavity Insulation R-Value	Continuous Insulation R-Value	U-Factor	SHGC
Building								
1	Roof 1	Non-Wood Joist/Rafter/T...		6112 ft2	0.0	26.1	0.037	
2	Skylight 1	Metal Frame, Double Pane	Glazing: Ti...	112 ft2			0.500	0.80
3	Exterior Wall 1	Steel-Framed, 24" o.c.		6000 ft2	22.0	0.0	0.087	
4	Door 1	Glass	Glazing: Cl...	42 ft2			0.700	0.58
5	Window 1	Metal Frame, Double Pan...	Glazing: Ti...	1500 ft2			0.600	0.63
6	Window 2	Metal Frame, Double Pane	Glazing: Cl...	56 ft2			0.700	0.72
7	Door 2	Insulated Metal	Swinging	288 ft2			0.700	
8	Interior Wall 2	Metal Frame, 16" o.c.		812 ft2	22.0	0.0	0.100	
9	Basement Wall 1	Solid Concrete:6" Thickness	Normal ...	2000 ft2			10.8	0.083
10	Floor 1	Slab-On-Grade:Unheated	Insulation:...	160 ft			10.8	

U.S. Only; Web version:
<http://energycode.pnl.gov/COMcheckWeb/>

Envelope PASSES: Design 4% better than Code
 Envelope +4% Interior Lighting +1% Exterior Lighting TBD

ASHRAE 90.1 Energy Cost Budget (ECB) Modelling Path

- Energy Performance Simulation for End-Use Trade-Offs
 - ✓ With prescriptive requirements applied to proposed design
 - ✓ Mandatory requirements still apply
- Compliance = Design Energy Cost \leq Energy Cost Budget



*from Figure 11-A of 90.1-2004 User's Manual

Review of ASHRAE 90.1 for British Columbia

**B.C. Experience
with ASHRAE 90.1**

BC History with ASHRAE 90.1

- 1991: LCC Analysis of 90.1-1989
 - ✓ Demonstrated 90.1 was cost-effective
- 1991: Vancouver Energy Utilization By-Law based on 1989 version
 - ✓ With some modifications and alternative approaches
- 2004: LCC Analysis of 90.1-2001
 - ✓ Demonstrated cost-effectiveness for all but a few stipulations
- 2004: Vancouver By-Law update referencing 90.1-2001, incl. all addenda, with modifications
- 2007: LCC Update to 2004 study for 90.1-2004
- 2008: 90.1-2007 review & comparison; City of Vancouver adopts

90.1-2001 Background & Context

- 2004 Study on “Life-Cycle Economic Assessment of ASHRAE 90.1 Applied to British Columbia”
- Working group formed for the Review of Energy Performance Measures for Buildings
 - ✓ Recommendation to Ministry based on ASHRAE 90.1-2001 and MNECB
 - ✓ Required justification based on cost-effectiveness of ASHRAE 90.1
- Relevant to 2004 version with only minor changes from 2001
 - ✓ Note: 2001 Addendum g on lighting adopted in 90.1-2004, significantly increasing LPD requirements

90.1-2001 LCC Study: Approach

- Detailed Review of ASHRAE 90.1-2001
 - ✓ Mandatory requirements
 - ✓ Prescriptive requirements
- Three Weather Region Perspective
 - ✓ Coastal (B-18) - Vancouver
 - ✓ Southern Interior (B-17) - Summerland
 - ✓ Northern Interior (B-22) – Prince George
- Focus on Prescriptive Compliance
 - ✓ Followed by vast majority of projects
 - Particularly using envelope and lighting trade-offs

90.1-2001 LCC Study: Approach

- Identified Key “Trouble Spots”
 - ✓ Most stipulations already standard practice
 - ✓ Focused on areas of concern, likely to be met with some resistance
- Qualitative Assessment
 - ✓ Market barriers
 - ✓ Poor design/construction practice
- Energy Analysis
 - ✓ Hourly modelling of critical stipulations
 - ✓ Typical building configurations
 - ✓ Not applied to all identified trouble spots

90.1-2001 LCC Study: Economic Criteria

■ Life-Cycle Cost Scenarios

- ✓ Medium scenario: 8% discount, -1.0% fossil and +2.0% electricity avg. price escalations
- ✓ Low scenario: 4% discount, +2.3% fossil fuel and +3.5% electricity avg. price escalations
- ✓ High scenario: 12% discount, -1.9% fossil and +1.7% electricity avg. price escalations

■ 25-Year LCC Analysis

- ✓ Incremental net capital costs and maintenance costs
- ✓ Applicable January 2004 rate tariffs

90.1-2001 LCC Study: Analysis

- Scope of Assessment
 - ✓ 100s of stipulations
 - ✓ Only 20 identified areas of concern
 - Over 40 energy analysis scenarios
 - 8 representative LCC case studies
- Categorized Based on NPV Savings
 - ✓ **Passed:** + savings for all LCC scenarios
 - ✓ **Marginal:** – savings for 1-2 LCC scenarios
 - ✓ **Failed:** – savings for all LCC scenarios

90.1-2001 LCC Study: Results Overview

- All Passed LCC Tests Except 7
 - ✓ Only 5 Failed, 2 Marginal
 - ✓ Across all 3 weather regions
- Possible Exemptions
 - ✓ Including design/market barriers
 - Fenestration accreditation
 - Vestibules
 - Optimum start and shut-off damper controls
- High-rise MURBs with High Glazing (i.e., > ~65%) Problematic
 - ✓ Parallel City of Vancouver By-Law Assessment

LCC Study: ASHRAE 90.1-2001 Stipulations (Coastal Region)

	ASHRAE 90.1 Stipulation	LCC Savings (\$/m ²)
PASS	Exhaust Heat Recovery (6.3.6.1)	\$35.17 med. \$20.51 to 90.31
	Glazing, Residential (5.3.2)	\$4.87 med. \$0.69 to 10.89
	Wall R-value requirements, residential steel frame construction (5.3.1.2)	\$1.85 med. \$0.63 to 3.61
	Condenser Heat Recovery for Service Water (6.3.6.2)	N/A - see Appendix A
MARGIN-AL	Mass wall R-value requirements (5.3.1.2)	\$8.12 med. -\$12.10 to 75.02
	Glazing, Commercial (5.3.2)	-\$3.94 med. -\$5.98 to 3.51
FAIL	Mandatory Automatic lighting shut-off (9.2.1.1)	-\$0.19 med. -\$0.44 to -1.08
	Water-source heat pumps must have two-position valve interlock (6.3.2.2)	-\$0.57 med. -\$0.87 to -0.57

LCC Study: ASHRAE 90.1-2001 Stipulations (Southern Interior)

	ASHRAE 90.1 Stipulation	LCC Savings (\$/m ²)
PASS	Exhaust Heat Recovery (6.3.6.1)	\$38.34 med. \$23.13 to 95.31
	Mass wall R-value requirements (5.3.1.2)	\$27.91 med. \$2.45 to 106.03
	Glazing, Commercial (5.3.2)	\$4.91 med. \$1.66 to 13.12
	Glazing, Residential (5.3.2)	\$4.74 med. \$1.31 to 9.68
	Wall R-value requirements, commercial steel frame construction (5.3.1.2)	\$3.32 med. \$1.66 to 8.85
	Mandatory Automatic lighting shut-off (9.2.1.1)	\$1.59 med. \$0.82 to 1.53
	Wall R-value requirements, residential steel frame construction (5.3.1.2)	\$1.22 med. \$0.19 to 2.71
	Condenser Heat Recovery for Service Water (6.3.6.2)	N/A - see Appendix A
FAIL	Water-source heat pumps must have two-position valve interlock (6.3.2.2)	-\$0.20 med. -\$0.61 to -0.01

LCC Study: ASHRAE 90.1-2001 Stipulations (Northern Interior)

	ASHRAE 90.1 Stipulation	LCC Savings (\$/m ²)
PASS	Exhaust Heat Recovery (6.3.6.1)	\$60.05 med. \$38.26 to 140.51
	Mass wall R-value requirements (5.3.1.2)	\$51.02 med. \$17.74 to 161.02
	Glazing, Residential (5.3.2)	\$7.52 med. \$3.09 to 14.36
	Wall R-value requirements, commercial steel frame construction (5.3.1.2)	\$4.49 med. \$2.39 to 11.82
	Glazing, Commercial (5.3.2)	\$3.98 med. \$1.19 to 12.03
	Wall R-value requirements, residential steel frame construction (5.3.1.2)	\$3.83 med. \$1.87 to 7.60
FAIL	Mandatory Automatic lighting shut-off (9.2.1.1)	-\$0.61 med. -\$0.73 to -1.89
	Wall R-value requirements, residential wood frame construction (5.3.1.2)	-\$6.94 med. -\$8.10 to -2.83

LCC Study: Overall Estimated Market Impacts

	Total (2005)	Cumulative	
		5-Year	15-Year
25-Yr NPV Savings (\$ millions)			
Medium Scenario	\$13.7	\$68.7	\$206.2
Low Scenario	\$51.3	\$256.4	\$769.2
High Scenario	\$1.8	\$8.9	\$26.8
Annual Energy Use Savings			
Electricity (GWh)	11.0	165.6	1,324.5
Fossil Fuel (TJ)	304	4,564	36,509
Total (TJ)	344	5,160	41,277
Annual Energy Cost Savings (\$ millions)			
Electricity	\$0.68	\$10.21	\$81.71
Fossil Fuel	\$2.93	\$43.88	\$351.05
Total	\$3.61	\$54.10	\$432.76
Incremental Net Costs (\$ millions)			
Capital	\$25.7	\$128.6	\$385.7
Annual Maintenance	\$0.049	\$0.738	\$5.901
Annual Emission Savings (thousand metric tonnes)			
Total CO ₂	19.3	289.5	2,315.8

90.1-2004 Follow-up Studies

- 2007 “Analysis of Energy Efficiency Standards for Buildings” for BC Hydro
 - ✓ Stantec reviewed 2001 amendments and 2004 envelope tables
 - ✓ Updated economic criteria and cost data
 - ✓ Effectively confirmed LCC findings still applicable & recommended adoption
- 2008 Comparative Assessment Review
 - ✓ Estimated relative energy cost savings between MNECB and ASHRAE 90.1 versions
 - Included ASHRAE 90.1-2007

Review of ASHRAE 90.1 for British Columbia

**Energy Standards Summary
Comparison & Highlights**

Model National Energy Code of Canada for Buildings (MNECB)

■ Background and Status

- ✓ Released in 1997 by NRC and stakeholders
- ✓ Based on ASHRAE 90.1-1989
- ✓ Derived using Canadian conditions & standards
- ✓ Basis for ecoEnergy (CBIP) and LEED™ Canada
- ✓ Presently under revision; targeted 2011 - 2012 deadline

■ Administrative Weather Regions

- ✓ 5 Regions for B.C. based on weather and utility service

■ Similar in Structure to ASHRAE 90.1

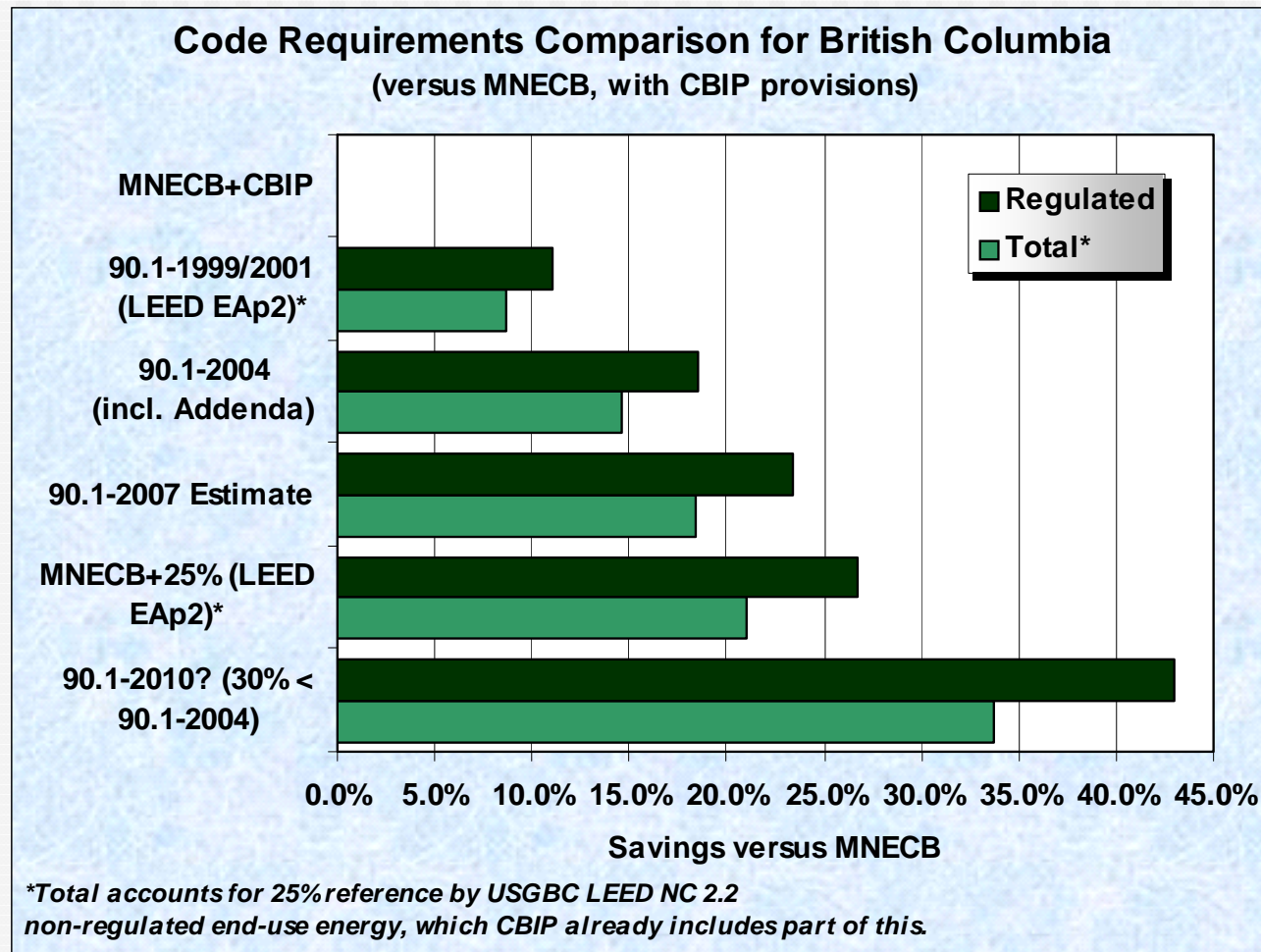


B-BG = BC Gas, Region B
B-PG = Pacific Northwest Gas, Region B

ANSI/ASHRAE/IESNA Standard 90.1

- 90.1-1989 – Basis for MNECB
- 90.1-1999 – LEED 2.1 and LEED Canada
- **90.1-2001** – Relatively minor changes to 1999 version
 - ✓ except Addendum g for lighting
 - ✓ Addendum e for performance rating
- **90.1-2004** – BC Building Code
 - ✓ U.S. LEED 2.2, LEED-CI
- **90.1-2007** – LEED 2009
 - ✓ Adopted by City of Vancouver
- 90.1-2010 – 30% goal over 90.1-2004

Standards Comparison



Standard Comparisons are Problematic

- ✓ Differing approaches & classifications
- ✓ End-uses & equipment covered is inconsistent (i.e., “non-regulated end-uses”)

ASHRAE 90.1-2004 vs MNECB: Shell Requirements



- Opaque Envelope: MNECB Generally More Stringent if Electrically Heated
 - ✓ Mass walls and floors, below grade walls and skylights usually more stringent for MNECB (except coldest climate)



- Glazing *less stringent*
 - ✓ Except for around 40-50% glass in most cases
 - ✓ MNECB has no requirements for SHGC



- Walls generally more stringent
 - ✓ **Curtainwall & high-rise MURB construction problematic**



- Roof generally more stringent
 - ✓ Except for attic and parallel-chord



- Exposed floor generally less stringent

ASHRAE 90.1-2004/07 vs MNECB: Lighting

- Lighting Typically Much Lower
 - ✓ Offices 40% lower
 - ✓ Schools 32% lower
 - ✓ Retail 46% lower, depending on exempted display lighting
 - ✓ Health care ~30% - 35% lower
 - ✓ Hotel/motel 28% lower
 - ✓ Residential 16% lower
 - ✓ Warehouse 44% *higher*
- Automatic Lighting Shut-Off Controls Required in Some Cases

ASHRAE 90.1-2004/07 vs MNECB: HVAC & DHW

- HVAC Equipment More Efficient for 90.1
 - ✓ MNECB mandatories reference ASHRAE 90.1 efficiency ratings, however
 - ✓ Improved controls (DCV), equipment staging
 - ✓ Fan energy typically lower (VSDs and better fan curves)
 - ✓ Pump energy typically lower
- Exhaust Heat Recovery More Stringent for 90.1
 - ✓ Many exceptions apply

ASHRAE 90.1-2004/07 vs 1999/2001: Envelope & Weather

- Fewer Climate Zones than 90.1-2001
 - ✓ 26 zones reduced to 8 (4 apply to BC)
 - Still generally based on degree-days
 - Further division based on 'moist', 'dry', and 'marine' conditions
 - ✓ Usually, a bit more stringent (e.g., Vancouver)
 - ✓ Sometimes less stringent (e.g., Fort St. John)

ASHRAE 90.1-2004 vs 1999/ 2001: Vancouver Envelope Req'ts

- Residential Attics: R-38 vs R-30
- Steel-framed Nonresidential Walls:
 - ✓ R-13+3.8ci vs R-13
 - ✓ Overall R_o -11.9 vs R_o -8.1
- Concrete Floors:
 - ✓ Nonresidential: R-8.3ci vs 6.3ci
 - ✓ Residential: R-10.4ci vs 8.3ci

ASHRAE 90.1-2007 vs 2004: Shell Requirements Increased

- Roof generally more stringent
 - ✓ R-15 to R-20 for flat roofs; increased for semi-heated
- Walls significantly more stringent:
 - ✓ Continuous insulation requirements
 - ✓ semi-heated requirements
- Glazing more stringent, but mixed
 - ✓ Prescriptive tables only apply to <40% glass
 - ✓ High performance double pane for curtain wall
 - ✓ *Punched metal frame and doors basically unchanged*
- Slab-on-grade insulation
 - ✓ Residential now requires insulation in Climate Zone 5
- Envelope Trade-Off method significantly less generous on daylighting credit

ASHRAE 90.1-2004 vs 1999/ 2001: Vancouver Glazing Req'ts

- **Windows - Lowered SHGC:**
 - ✓ <10% glazing – SHGC-0.49 vs 0.64 on north
 - ✓ 10-40% glazing – SHGC-0.39 vs 0.49 on all but north
 - ✓ 40-50% glazing – SHGC-0.26 vs 0.36, except for non-residential north SHGC-0.36 vs 0.49
- **Skylights - Lowered SHGC:**
 - ✓ Reduced by about 20 – 28% for most

ASHRAE 90.1-2004 vs 1999/2001: Lighting

- Lighting Significantly More Stringent
 - ✓ Same as 90.1-2001 addendum g (summer 2003)
- Building Area Method LPDs nearly all Lower (except for a couple categories)
 - ✓ E.g., Office – 1.0 vs. 1.3 W/ft²; School – 1.2 vs. 1.5 W/ft²
- Space-by-Space Method Generally Lower
 - ✓ Office – 1.1 vs. 1.3-1.5 W/ft²
 - ✓ Classroom – 1.4 vs. 1.5 W/ft²
 - ✓ Corridors for above – 0.5 vs. 0.7 W/ft²

ASHRAE 90.1-2004/07 vs 1999/2001: HVAC

- New Mechanical Equipment Labelling Requirements
 - ✓ May not be followed in Canada
- Basis for Some Controls Now Reference “Climate Zone”
 - ✓ Economizer based on climate zone instead of annual run hours between 8am – 4pm and cooling wetbulb temperature
 - ✓ Damper leakage allowance
 - ✓ Water loop heat pump cooling tower shut-off
- Time Clock Required for Systems Over 15,000 Btuh Instead of 65,000 Btuh

ASHRAE 90.1-2004/07 vs 1999/ 2001: HVAC & SWH

- HVAC Equipment with Further Improvements in Efficiency
 - ✓ Air cooled AC Units: Split at 10 vs. 12 SEER, Packaged at 9.7 vs 12 SEER
 - ✓ Air cooled HP Units: 7.1-7.4 vs. 6.6-6.8 HSPF (differs for split vs. packaged)
 - ✓ Boilers, furnaces and chillers the same
 - ✓ 2007 version phased in small cooling efficiency increases & lowered fan hp req'ts
- VSDs Required on VAV Fans ≥ 15 hp instead of 30 hp
- Heat Pump Pool Heaters Added – 4 COP

ASHRAE 90.1-2004/07 vs 1999/2001: Performance Path(s)

- Energy Cost Budget Method
 - ✓ Restructured but nearly the same
- New Performance Rating Method (Appendix G)
 - ✓ Introduced with 90.1-2001 addendum e
 - ✓ Not for compliance but for gauging energy efficiency
 - ✓ LEED EAp2 & EAc1: USGBC NC-2.2, -3.0; CaGBC 2009 (2.0)

90.1-2007 Performance Rating Method vs. ECB Method

- Schedule Modifications Allowed
 - ✓ e.g., demand controlled ventilation, lighting controls, natural ventilation
- Baseline Averaged from 4 Simulations at 90° Rotations
 - ✓ Possible exceptions allowed by Addendum r
- Envelope Types Fixed for PRM
 - ✓ Except glazing
- 40% Maximum Glazing vs. 50%

90.1-2007 Performance Rating Method vs. ECB Method (cont.)

- All Miscellaneous Loads Included for PRM
 - ✓ e.g., elevators, parking loads, cooking
 - ✓ ECB excludes if no contribution to systems considered for trade-off
 - ✓ Inconsistency on default percent between US and CaGBC LEED versions
- Credit for Lighting Controls Added
 - ✓ Programmable timer: 0 – 10% - *disallowed for CaGBC LEED 2009*
 - ✓ Occupancy Sensor: 10 – 15% - *CaGBC LEED 2009 revised to be consistent with MNECB 30% allowance*

90.1-2007 Performance Rating Method vs. ECB Method (cont.)

- HVAC System Types Reduced
 - ✓ Distinguished by building type and size
- Supply Fan Power Fixed
 - ✓ Based on flow instead of setting a maximum limit
- Mechanical Sizing Maximums Specified
 - ✓ Proposed case always modelled with cooling - *CaGBC LEED 2009 revised to be equivalent levels of cooling*
- LEED Canada 2009: *Supplementary Energy Modelling Guidelines*

ASHRAE 90.1-2004/07 “Trouble Spots”

- Vestibules – required if entrance to >3000 ft² space for building over 4 storeys; somewhat more stringent for 2007
- **Continuous wall insulation**
 - ✓ Steel-framed walls, including curtainwall systems
 - ✓ Mass walls
 - ✓ Residential wood frame walls (especially 2007)
 - ✓ BC Building Code addition (Section 9.25.2): *“All walls, ceilings and floors separating heated space from unheated space, the exterior air or the exterior soil shall be provided with sufficient thermal insulation to prevent moisture condensation on their room side during the winter and to ensure comfortable conditions for the occupants.”*

90.1-2004/07 "Trouble Spots" (cont.)

■ Window Performance

- ✓ 40-50% prescriptive glazing maximum allowance
- ✓ Low-e if over 40% glazing
- ✓ High performance curtain wall for 2007
- ✓ Tinted glass implications

■ Lighting

- ✓ Some difficulty attaining LPAs reported
- ✓ Mandatory automatic lighting shut-off controls
 - Time-of-day operated control device (DDC)
 - Occupancy sensors in some circumstances

90.1-2004/07 BC "Trouble Spots" (cont.)

- Heating, Ventilation and Air Conditioning
 - ✓ Water-source heat pumps with two-position valve interlock (systems > 10 hp pumping)
 - ✓ Exhaust heat recovery if over 70% O/A and 5000 cfm
 - Exception if no exhaust source > 75% of S/A
 - ✓ Mandatory ventilation controls for high occupancy areas (i.e., demand controlled ventilation)
 - ✓ Optimum start and shut-off damper controls
- SWH: Pool Cover Mandatory Req't
 - ✓ Effectively same as previous Standards

Conclusion

- ASHRAE 90.1 Provides Minimum Level of Energy Efficiency
 - ✓ Widely adopted and referenced
 - ✓ Already mostly standard practice in B.C.
- LCC Study – Few Exemptions Required
 - ✓ Only a few key stipulations uneconomical
- 90.1 Standard is Technically Viable although a Few Significant Barriers Exist for the BC Market
 - ✓ But 90.1-2010, 189.1?

Thank you!