

High Performance Based Design for the Building Envelope

Mechanical Committee

Members:

James E. Woods, Ph.D., P.E.

Kenneth Schram, P.E.

Overview

Objective:

Support development of performance requirements that:

- “Guarantee” blast and CBR resistances are included as a key elements in HPB *Attributes* and *Benchmarks*;
- Allow for selection of best combination of *Envelope System Attributes* that balance owner’s need for the project:
 - Safety
 - Security
 - Energy
 - Environment Footprint
 - Sustainability

Approach:

Address interactive performance metrics for:

- HPB Envelope Sub-Attributes:
 - CBR Protection from external releases
 - Energy and Environmental Footprint Percentages attributable to the envelope
- HPB HVAC Attributes:
 - Pressurization Control
 - Filtration Control
 - Sensing/Monitoring and Control
 - Renewable Energy Use w/o Greenhouse Gases

Attributes and Sub Attributes

for Evaluation of CBR Protection, and its Impact on Energy Use and Environmental Footprint

Attribute	Sub-Attribute
Security	<ul style="list-style-type: none">• CBR Protection from external releases of Manmade Hazards
Energy	<ul style="list-style-type: none">• Thermal Loads from sensible and latent heat transfer through the building envelope.• Whole-Building Energy Utilization rates from which percentages can be attributed to building envelopes.
Environment	<ul style="list-style-type: none">• Environmental Footprint calculated from the whole-building energy utilization rates and from which percentages can be attributed to building envelopes
Sustainability	<ul style="list-style-type: none">• Renewable Energy Opportunities for alternative methods of energy production, which can be associated with building envelopes.

Demand Models

for CBR Protection

Demand	Characteristics
<i>Release Location:</i>	<ul style="list-style-type: none"> • Remote: outside of the property boundaries (off-site) • On-site: within the property boundaries • Proximate: near the building envelope, including fenestrations and make-up intake locations
<i>Threat Level:</i>	<ul style="list-style-type: none"> • Qualitative: Low, Moderate, High.
<i>Agent:</i>	<p>Chemical, Biological or Radiological substances that are intentionally released to cause harm.</p>
<i>Exposure:</i>	<p>The product of airborne concentration of the agent and the duration of release at its location:</p> <ul style="list-style-type: none"> • Qualitative: Low, Moderate, High.

Demand Models for Thermal Loads

Demand	Characteristics
<i>Envelope Sensible and Latent Heat Gain and Loss Rates</i>	<i>Instantaneous heat transfer rates through opaque and glazed assemblies:</i> <ul style="list-style-type: none">• With and without natural ventilation• With and without solar radiation.
<i>Envelope Thermal Loads</i>	<i>Sensible heat gain and loss rates, modified by:</i> <ul style="list-style-type: none">• <i>Time lags</i> due to thermal mass of the envelope assemblies and furnishings within the building;• <i>Absorption and dissipation</i> of radiant heat gains at interior surfaces; and• <i>Latent heat gain and loss rates.</i>
<i>Envelope Mass Transfer Rates</i>	<i>Potentially contaminated air and water vapor transfer through opaque and fenestration assemblies by:</i> <ul style="list-style-type: none">• <i>Infiltration;</i>• <i>Permeation;</i>• <i>Natural ventilation.</i>

Demand Models

for Whole Building Energy Utilization

Demand	Characteristics
<p><i>Site-Energy Mix, Availability, Reliability, and Redundancy</i></p>	<ul style="list-style-type: none"> • <i>Dependent on regional conditions and owner requirements.</i>
<p><i>Site-Energy Costs and Demand Charges</i></p>	<ul style="list-style-type: none"> • <i>Dependent on regional conditions and policies of the utility providers.</i>
<p><i>Percentage of Whole-Building Energy Utilization Attributable to the Building Envelope</i></p>	<ul style="list-style-type: none"> • <i>The thermal loads from the building envelope are directly affected by treatments for blast and CBR resistance.</i> • <i>The envelope thermal loads affect energy utilization:</i> <ul style="list-style-type: none"> • Adiabatically mixed with other thermal loads and transferred to heat exchangers within the HVAC system. • Energy from renewable and fossil-fuel resources is consumed to establish thermal balances required for the building performance. • <i>After the whole-building energy utilization rate is estimated (or measured), the percentage attributed to the building envelope can be calculated.</i>

Demand Models

for Environmental Footprint

Demand	Characteristics
<i>Equivalent CO₂ Emission (CO₂e) from Whole Building Energy Utilization</i>	<ul style="list-style-type: none">• <i>Calculated (i.e., not measurable) from the regional mix of non-renewable site energy resources and the Energy Utilization Intensity (EUI).</i>
<i>Percentage of CO₂e Attributable to the Building Envelope</i>	<ul style="list-style-type: none">• <i>Calculated by the same method as for the percentage of energy utilization attributable to the building envelope.</i>

Demand Models

for Renewable Resource Opportunities

Demand	Characteristics
<i>On-Site Energy Use /Application</i>	<ul style="list-style-type: none">• <i>Applications (e.g., electricity, water heating, space heating, other) will directly affect the choice of types and capacities of renewable energy devices (e.g., solar photovoltaic panels, solar thermal panels, wind turbines).</i>
<i>On-Site-Energy Production</i>	<ul style="list-style-type: none">• <i>Selection of "economically viable" (i.e., per EISA 2007) production capacities of on-site renewable energy sub-systems will directly affect the expected reductions in whole-building energy utilization targets through the types of renewable energy devices that can be interfaced with the building envelope.</i>• <i>Availability and reliability of renewable energy sources are dependent on regional conditions.</i>

Benchmarks-Metrics

for CBR Protection

Baseline Performance	Improved Performance (P+)	Enhanced Performance (P++)	Future/High Performance
<i>Minimum or Low Level of Protection is <u>acceptable</u>.</i>	<i>Moderate Level of Protection is <u>acceptable</u>.</i>	<i>High Level of Protection is <u>required</u>.</i>	<i>Very High Level of Protection is <u>required</u>.</i>

Benchmarks-Metrics

for Whole Building Energy Utilization

Baseline Performance Target	Improved Performance Target (P+)	Enhanced Performance Target (P++)	Future/High Performance Target
<i>The expected annual site EUI and percentage attributable to the envelope when the building is designed in compliance with ASHRAE Standard 90.1-2004.</i>	<i>The expected annual site EUI and percentage attributable to the envelope when the building is designed in compliance with ASHRAE Standard 90.1-2010: (30% below ASHRAE Standard 90.1-2004).</i>	<i>The expected annual site EUI and percentage attributable to the envelope when the building is designed in compliance with the ASHRAE Advanced Energy Design Guide (50% below ASHRAE Standard 90.1-2004).</i>	<i>The expected annual site EUI and percentage attributable to the envelope when the building is designed in compliance with goal to achieve zero-net-energy (ZNE) as defined in EISA-2007.</i>

Benchmarks-Metrics for the Environmental Footprint

Baseline Performance Target	Improved Performance Target (P+)	Enhanced Performance Target (P++)	Future/High Performance Target
<p>The <u>calculated</u> value of CO₂e and percentage attributable to the envelope when the building is designed in compliance with ASHRAE Standard 90.1-2004 and assumed fuel mix.</p>	<p>The <u>calculated</u> value of CO₂e and percentage attributable to the envelope when the building is designed in compliance with ASHRAE Standard 90.1-2010 and assumed fuel mix.</p>	<p>The <u>calculated</u> value of CO₂e and percentage attributable to the envelope when the building is designed in compliance with the ASHRAE <u>Advanced Energy Design Guide</u> and assumed fuel mix.</p>	<p>The <u>calculated</u> value of CO₂e and percentage attributable to the envelope when the building is designed in compliance with goal to achieve ZNE as defined by EISA-2007.</p>

Benchmarks-Metrics

for Renewable Resource Opportunities

Baseline Performance Target	Improved Performance Target (P+)	Enhanced Performance Target (P++)	Future/High Performance Target
<p><i>The expected value of the photovoltaic (PV) plate area (SF) to GSF ratio for Lighting and Plug Loads when the building is designed in compliance with ASHRAE Standard 90.1-2004.</i></p>	<p><i>The expected value of the PV plate area (SF) to GSF ratio for Lighting and Plug Loads when the building is designed in compliance with ASHRAE Standard 90.1-2010.</i></p>	<p><i>The expected value of the PV plate area (SF) to GSF ratio for Lighting and Plug Loads when the building is designed in compliance with the ASHRAE Advanced Energy Design Guide.</i></p>	<p><i>The expected value of the PV-plate area (SF) to GSF ratio for all of the residual EUI when the building is designed in compliance with goal to achieve ZNE as defined in EISA-2007.</i></p>

Outcomes-Standards

Matrix of Levels of Performance – System ID

Energy CBR	Baseline		P+		P++		Future/HP	
	NO PV	PV	NO PV	PV	No PV	PV	No PV	PV
Baseline	1	1a	2	2a	3	3a	4	4a
P+	5	5a	6	6a	7	7a	8	8a
P++	9	9a	10	10a	11	11a	12	12a
Future/HP	13	13a	14	14a	15	15a	16	16a

	<i>Systems, with and without PV, at Baseline levels of performance for both CBR Protection <u>and</u> Energy Target.</i>
	<i>Systems, with and without PV, at Baseline level for CBR <u>but</u> Benchmark (P+, P++, Future/HP) levels of performance for Energy Target.</i>
	<i>Systems, with and without PV, at Benchmark levels of performance for both CBR Protection <u>and</u> Energy Target.</i>

Outcomes-Standards

CBR Protection

CBR LOP	Envelope Integrity	HVAC/OA System Components			Expected Outcome
		Part. Filter	Chem. Filter	Perimeter Pressure	
Baseline (System 1)	ASHRAE 90.1-2004	MERV 8-13	None	None	<i>Major disruption or system failure; significant impact on health/safety (<u>high vulnerability</u>)</i>
P+ (System 6)	ASHRAE 90.1-2010	MERV 9-13	30-60%	$\Delta 10\%$ supply-exhaust diff.	<i>Significant disruption in system performance; some impact on health/safety (<u>moderate vulnerability</u>)</i>
P++ (System 11)	ASHRAE 50% AEDG	MERV 13-17 w/ DOAVS	60-95% w/ DOAVS	$\Delta P > 0.05$ in.w.g. across envelope	<i>Some disruption in system performance; negligible impact on health/safety, some discomfort (<u>low vulnerability</u>)</i>
F/HP (System 16)	Zero-Net-Energy (ZNE) per EISA-2007	MERV > 17 (HEPA) w/ DOAVS	> 95% w/ DOAVS	$\Delta P > 0.05$ in.w.g. across envelope	<i>Negligible disruption in system performance; negligible impact on health/safety/comfort (<u>very low vulnerability</u>)</i>

Outcomes-Standards

Energy and Environmental Footprint Targets

Energy/ Env. Footprint LOP	Energy Utilization Intensity (EUI)		Environmental Footprint (CO ₂ e)	
	kBtu/GSF/yr	% to Envelope	Lb/GSF/yr	% to Envelope
Baseline (System 1)	46 – 70	4 – 23	9 – 25	< 1 – 6
P+ (System 2)	31 – 43	1 – 24	6 – 15	< 1 – 3
P++ (System 3)	23 – 31	6 – 30	4 – 11	< 1 – 3
F/HP (System 4)	20 – 29	6 – 30	3 - 10	< 1 – 3

Outcomes-Standards

Renewable Resource Opportunities

Solar PV Alternatives	Plate Area Ratio (SF/GSF)	Target Reduction in Non-renewable Resources	
		kBtu/GSF/yr	% EUI
Baseline (System 1a)	0.4 – 0.6	30	43 - 65
P+ (System 2a)	0.2 – 0.4	20	47 - 66
P++ (System 3a)	0.2 – 0.3	16	51 - 68
F/HP (System 4a - ZNE)	0.3 – 0.5	20 - 29	100

Discussion

