

# High Performance Based Design for the Building Envelope

Mechanical Committee

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

# Demand Models

## for CBR Protection

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

# Demand Models for Thermal Loads

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

# Demand Models

## for Whole Building Energy Utilization

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



# Demand Models

## for Environmental Footprint

| Demand   | Characteristics   |
|--|---|
| <i>Equivalent CO<sub>2</sub> Emission (CO<sub>2</sub>e) from Whole Building Energy Utilization</i> | <ul style="list-style-type: none"><li>• <b>Calculated (i.e., not measurable) from the regional mix of non-renewable site energy resources and the Energy Utilization Intensity (EUI).</b></li></ul> |
| <i>Percentage of CO<sub>2</sub>e Attributable to the Building Envelope</i>                         | <ul style="list-style-type: none"><li>• <b>Calculated by the same method as for the percentage of energy utilization attributable to the building envelope.</b></li></ul>                           |

# Demand Models

## for Renewable Resource Opportunities

| Demand                                 | Characteristics  |
|--|--|
| <i>On-Site Energy Use /Application</i> | <ul style="list-style-type: none"><li>• <b><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></b></li></ul>  |
| <i>On-Site-Energy Production</i>       | <ul style="list-style-type: none"><li>• <b><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></b></li><li>• <b><i>Availability and reliability of renewable energy sources are dependent on regional conditions.</i></b></li></ul> |



# 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 <b>designed in compliance with ASHRAE Standard 90.1-2004.</b></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: <b>(30% below ASHRAE Standard 90.1-2004).</b></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 <b>(50% below ASHRAE Standard 90.1-2004).</b></i> | <i>The expected annual site EUI and percentage attributable to the envelope when the building is <b>designed in compliance with goal to achieve zero-net-energy (ZNE) as defined in EISA-2007.</b></i> |

# Benchmarks-Metrics for the Environmental Footprint

| Baseline Performance Target  | Improved Performance Target (P+)   | Enhanced Performance Target (P++)   | Future/High Performance Target   |
|--|--|---|--|
| <i>The <u>calculated</u> value of CO<sub>2</sub>e and percentage attributable to the envelope when the building is <b>designed in compliance with ASHRAE Standard 90.1-2004</b> and <u>assumed fuel mix</u>.</i> | <i>The <u>calculated</u> value of CO<sub>2</sub>e and percentage attributable to the envelope when the building is <b>designed in compliance with ASHRAE Standard 90.1-2010</b> and <u>assumed fuel mix</u>.</i> | <i>The <u>calculated</u> value of CO<sub>2</sub>e and percentage attributable to the envelope when the building is <b>designed in compliance with the ASHRAE <u>Advanced Energy Design Guide</u></b> and <u>assumed fuel mix</u>.</i> | <i>The <u>calculated</u> value of CO<sub>2</sub>e and percentage attributable to the envelope when the building is <b>designed in compliance with goal to achieve ZNE as defined by EISA-2007</b>.</i> |

# Benchmarks-Metrics


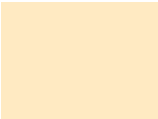

## for Renewable Resource Opportunities

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

# Outcomes-Standards

## Matrix of Levels of Performance – System ID

| Energy<br>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                        |  |
| <b>Baseline (System 1)</b> | 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>                     |
| <b>P+ (System 6)</b>       | 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>              |
| <b>P++ (System 11)</b>     | 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>   |
| <b>F/HP (System 16)</b>    | 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/<br>Env. Footprint<br>LOP | Energy Utilization Intensity<br>(EUI) |                  | Environmental Footprint<br>(CO <sub>2</sub> e) |                  |
|----------------------------------|---------------------------------------|------------------|--|------------------|
|                                  | kBtu/GSF/yr                           | % to<br>Envelope | Lb/GSF/yr                                      | % to<br>Envelope |
| <b>Baseline<br/>(System 1)</b>   | 46 – 70                               | 4 – 23           | 9 – 25   | < 1 – 6          |
| <b>P+ (System 2)</b>             | 31 – 43                               | 1 – 24           | 6 – 15   | < 1 – 3          |
| <b>P++ (System 3)</b>            | 23 – 31                               | 6 – 30           | 4 – 11   | < 1 – 3          |
| <b>F/HP (System 4)</b>           | 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   |
| <b>Baseline (System 1a)</b>   | 0.4 – 0.6                 | 30  | 43 - 65 |
| <b>P+ (System 2a)</b>         | 0.2 – 0.4                 | 20  | 47 - 66 |
| <b>P++ (System 3a)</b>        | 0.2 – 0.3                 | 16  | 51 - 68 |
| <b>F/HP (System 4a - ZNE)</b> | 0.3 – 0.5                 | 20 - 29                                     | 100     |

# Discussion

