



UNIVERSITY OF NORTH CAROLINA
CHARLOTTE

Tools for High-Performance Building Design

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What is a High-Performance Building?

ANSI/ASHRAE/ICC/USGBC/IES Standard 189.1-2020

(Supersedes ANSI/ASHRAE/ICC/USGBC/IES Standard 189.1-2017)
Includes ANSI/ASHRAE/ICC/USGBC/IES addenda listed in Appendix M

Standard for the Design of High-Performance Green Buildings

Except Low-Rise
Residential Buildings

The Complete Technical Content of the International Green Construction Code®

See Appendix M for approval dates by the ASHRAE Standards Committee, the ASHRAE Board of Directors, the International Code Council, U.S. Green Building Council, the Illuminating Engineering Society, and the American National Standards Institute.

This Standard is under continuous maintenance by a Standing Standard Project Committee (SSPC) for which the Standards Committee has established a documented program for regular publication of addenda or revisions, including procedures for timely, documented, consensus action on requests for change to any part of the Standard. Instructions for how to submit a change can be found on the ASHRAE® website (<https://www.ashrae.org/continuous-maintenance>).

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CONTENTS

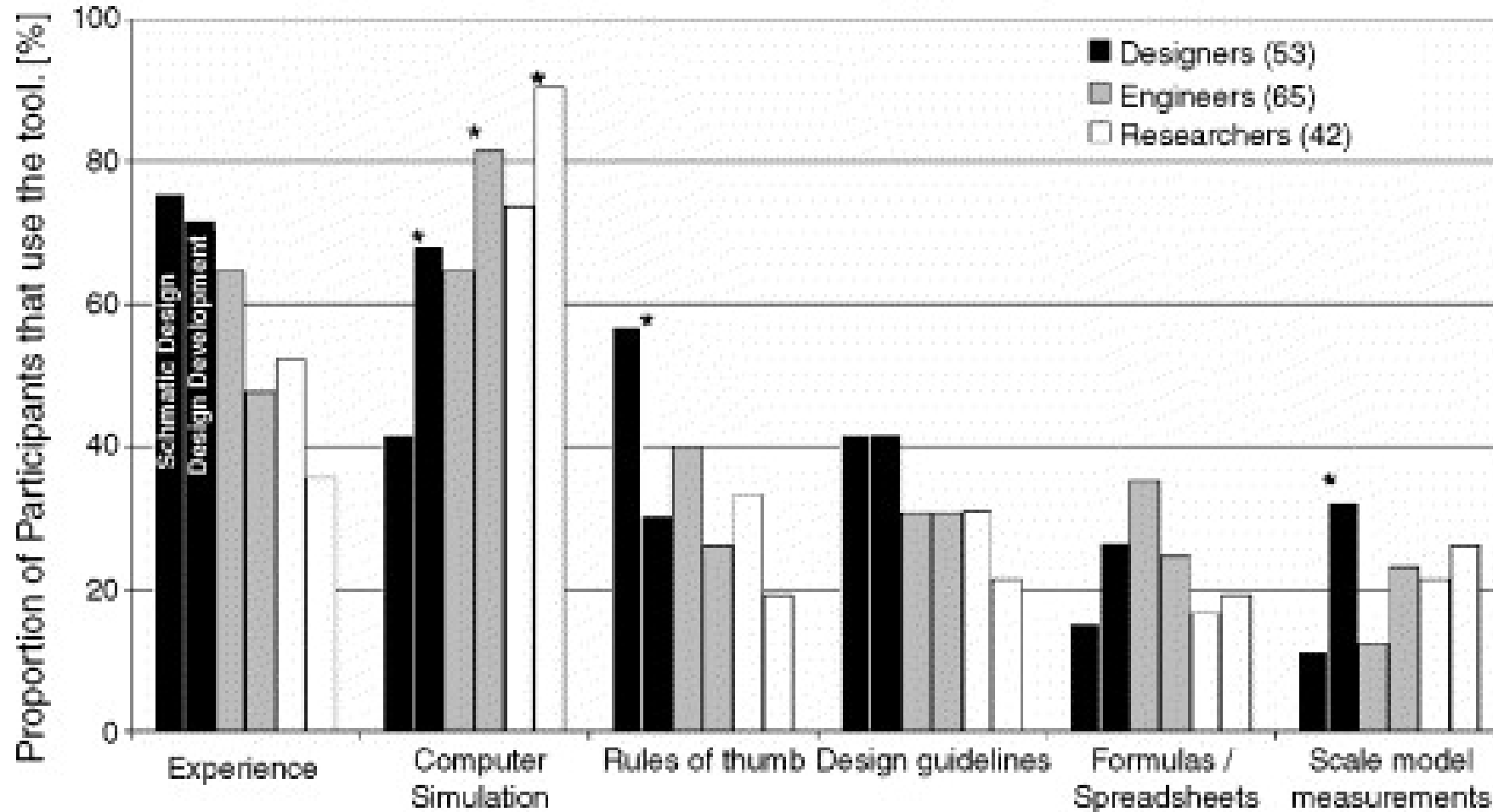
ANSI/ASHRAE/ICC/USGBC/IES Standard 189.1-2020
Standard for the Design of High-Performance Green Buildings
Except Low-Rise Residential Buildings

SECTION	PAGE
Foreword	2
1 Purpose	4
2 Scope	4
3 Definitions, Abbreviations, and Acronyms	4
4 Administration and Enforcement	18
5 Site Sustainability	18
6 Water Use Efficiency	26
7 Energy Efficiency	34
8 Indoor Environmental Quality (IEQ)	62
9 Materials and Resources	80
10 Construction and Plans for Operation	84
11 Normative References	96
Normative Appendix A: Prescriptive Building Envelope Tables	108
Normative Appendix B: Prescriptive Equipment Efficiency Tables for the Alternate Reduced Renewables and Increased Equipment Efficiency Approach in Section 7.4.1.1	109
Normative Appendix C: Performance Option for Energy Efficiency	135
Normative Appendix D: Building Concentrations	140
Informative Appendix E: Building Envelope Tables	141
Informative Appendix F: Integrated Design	160
Informative Appendix G: Informative References	162
Informative Appendix H: Option for Energy Efficiency Using the IECC Prescriptive Compliance Path	166
Informative Appendix I: zEPI Conversion Methodology	172
Informative Appendix J: Derivation of Source Energy Conversion Factors and CO ₂ e Emission Factors	173
Informative Appendix K: Additional Guidance for Functional Performance Testing (FPT) and the Commissioning (Cx) Process	178
Informative Appendix L: Requirements that Overlap with Core Elements of the LEED Rating System	182
Informative Appendix M: Addenda Description Information	184

<https://www.ashrae.org/technical-resources/standards-and-guidelines/read-only-versions-of-ashrae-standards>

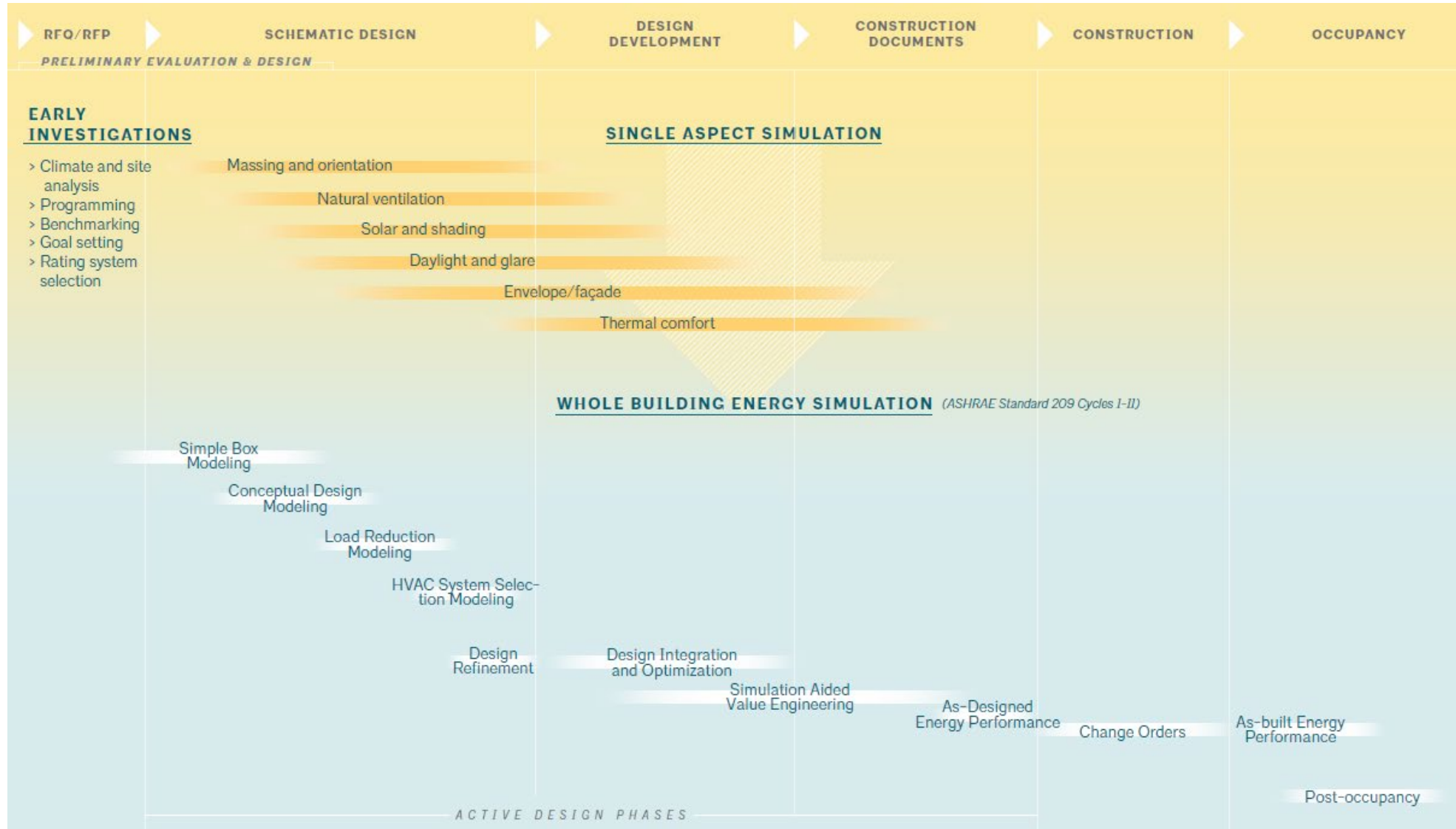
Tools for High-Performance Building Design

What kind of daylight prediction tools do you use to estimate or calculate daylighting during (a) schematic design (b) design development?



Source: Reinhart, C. and Fitz, A., 2006. Findings from a survey on the current use of daylight simulations in building design. *Energy and buildings*, 38(7), pp.824-835.

Architect's Role in Building Performance Simulation



Building Performance Simulation Software Directory

ibpsa.us/best-directory-list/



Find Software

Capabilities

- Air Flow Simulation
- Building Automation
- Building Energy Auditing
- Building Energy Benchmarking
- Building Energy Monitoring
- Code Compliance
- Energy Conservation Measures
- HVAC System Selection and Sizing
- Life Cycle Analysis
- Lighting Simulation
- Load Calculations
- Other
- Parametrics and Optimization
- Ratings and Certificates
- Solar and Photovoltaic Analysis
- Support Services
- Training Services
- Utility Bill and Meter Data Analysis
- Weather
- Weather Data and Climate Analysis
- Whole Building Energy Simulation

Building Type

- Commercial
- District Scale
- Industrial
- Multi Family
- Portfolio Scale
- Residential
- Subsystem Level
- Urban Scale

Tools Potentially Useful for the Workshop

- Climate Analysis

- Climate Consultant (<https://www.sbse.org/resources/climate-consultant>)
- CBE Clima Tool (<https://clima.cbe.berkeley.edu/>)

- Energy, Solar Radiation, and Daylighting Analysis

- Revit + Insight (<https://www.autodesk.com/education/students>)

- Thermal Comfort

- CBE Thermal Comfort Tool (<https://comfort.cbe.berkeley.edu/>)

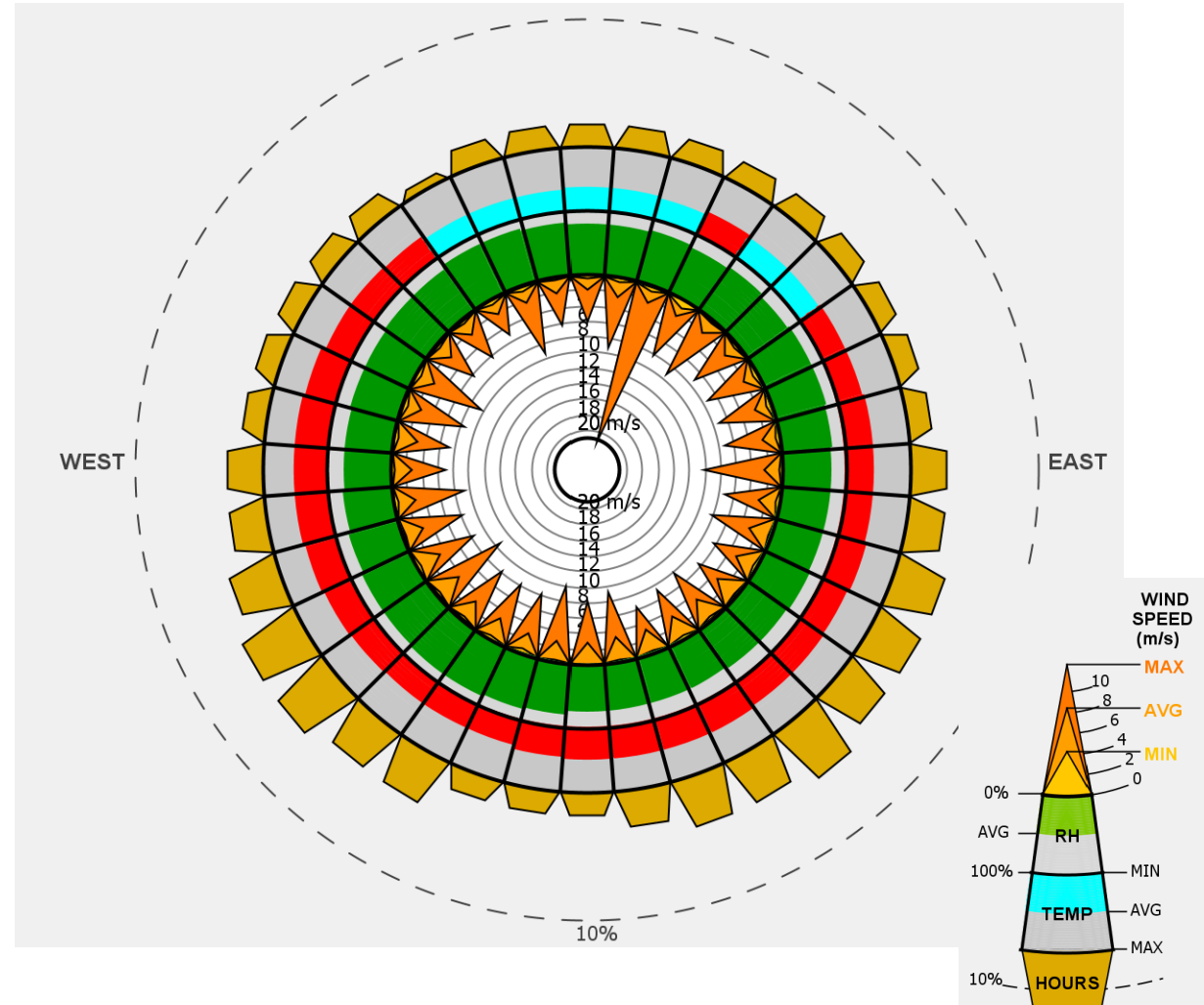
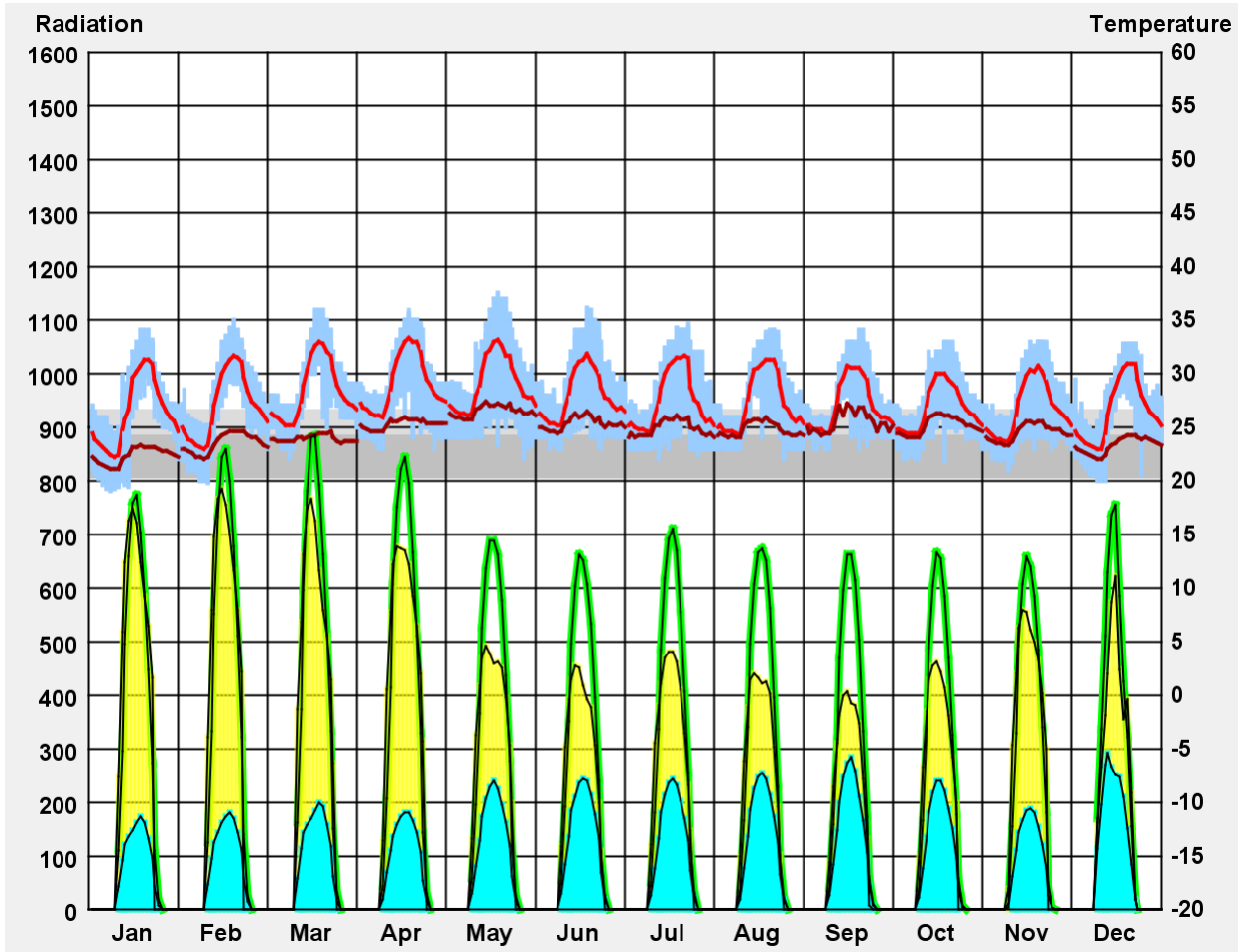
- Life-Cycle Assessment

- BEES (<https://ws680.nist.gov/bees2>)
- Athena Impact Estimator (<http://www.athenasmi.org/our-software-data/overview/>)

Climate Analysis Tools

- Climate data for building design
- Climate data files (<https://climate.onebuilding.org/default.html>)
- Climate Consultant Demo

Example Outputs of Climate Consultant



Energy Analysis with Revit and Insight

- Is based on Building Information Modeling
- Can be used in very early stage of design without detailed information
- Support design exploration and optimization
- Use Cloud computing
- Can generate and export the EnergyPlus model

References:

- <https://www.youtube.com/watch?v=1nkK4yjqCfQ>
- <https://www.youtube.com/watch?v=7CrG6hw1Wdo>

Key Steps of Energy Analysis with Revit and Insight

1. Create a Revit model using conceptual masses, building elements, or both
2. Set the project location
3. Review Revit energy settings
4. Generate the energy analytical model
5. Create and run energy models with different design options
6. Launch Insight for interactive project exploration, optimization & reporting

Email Notifications on Cloud Computing Progress

 AUTODESK[®] INSIGHT

Hi Weimin Wang,

Your model has been received. You will receive an email when the analysis is complete and you can access your results.

[Get Support](#)

Thanks for using Insight!
Autodesk Insight Team

 AUTODESK[®] INSIGHT

Hi Weimin Wang,

Your Analysis is complete. You can access the results on Insight.

Project details:

Model: Project4

Location: 78 Đường Lê Thánh Tôn, Ho Chi Minh City, Ho Chi Minh City

[VIEW INSIGHT](#)

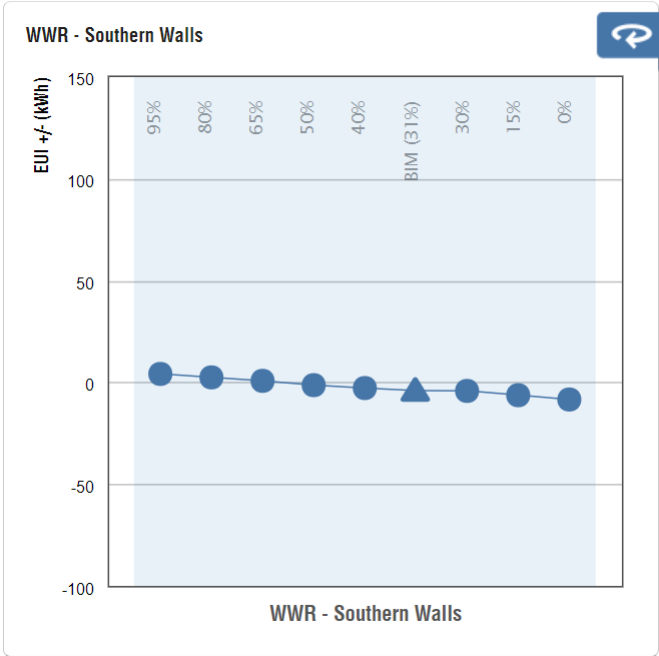
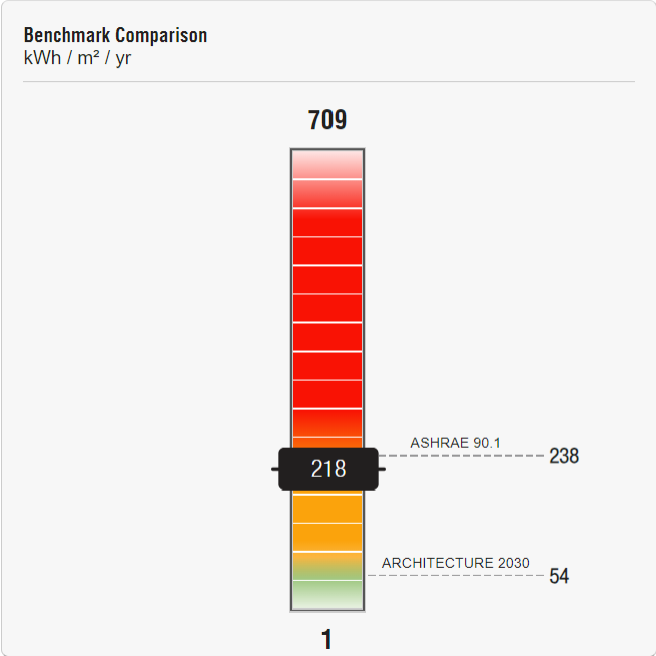
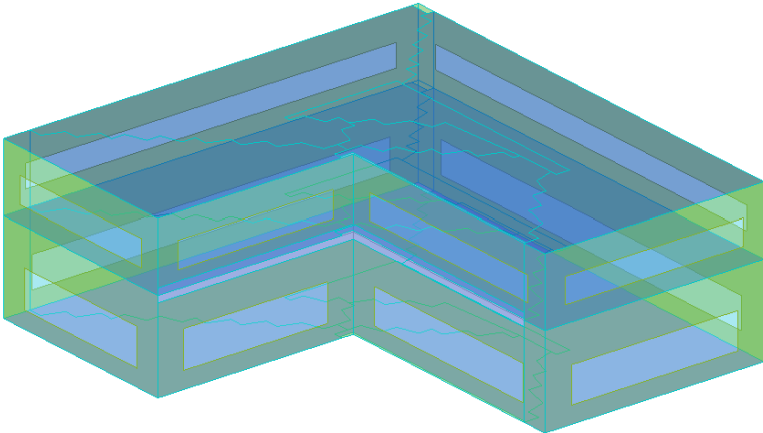
If the above link not working, please copy the following link and paste it into your browser:

<https://insight.autodesk.com/OneEnergy/Model/446247>

[Get Support](#)

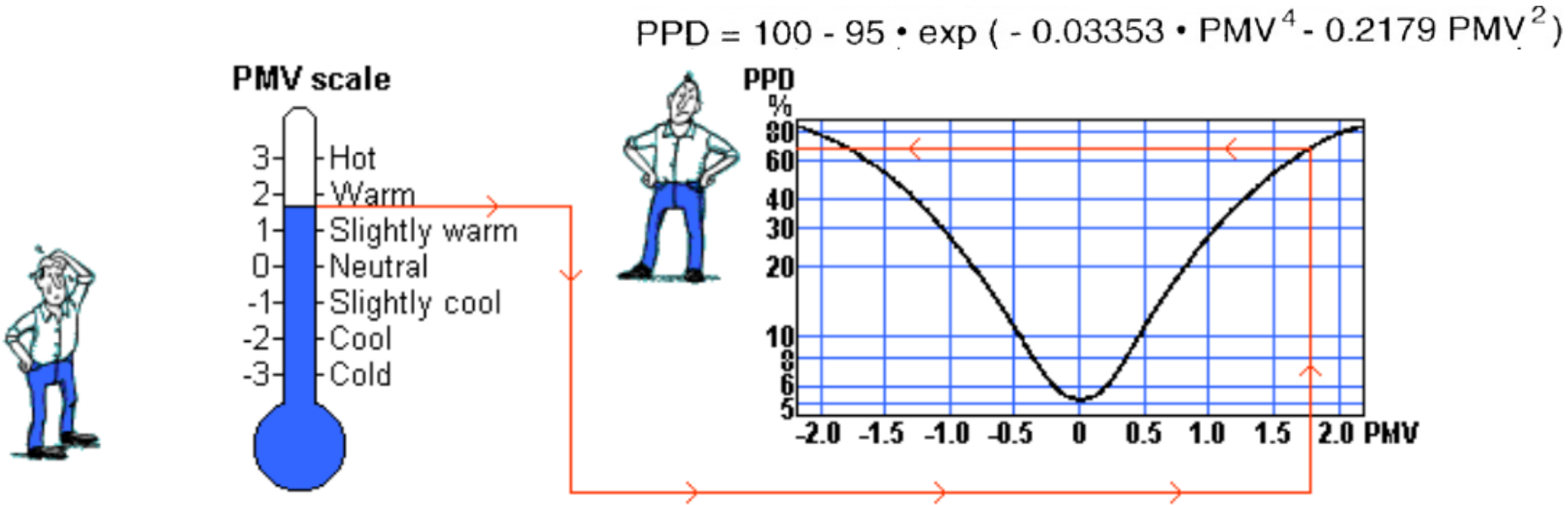
Thanks for using Insight!
Autodesk Insight Team

Revit + Insight Demo



Thermal Comfort Tutorial

- Environmental factors: air temperature, mean radiant temperature, relative humidity, and air velocity
- Personal factors: clothing insulation, metabolic heat
- Metrics and models



References:

https://www.ripcordengineering.com/files/tech_notes/Thermal%20Comfort_An%20Introduction.pdf

ASHRAE Standard 55: <https://www.ashrae.org/technical-resources/standards-and-guidelines/read-only-versions-of-ashrae-standards>

Different Applications

- Indoor built environment
 - Mechanically air-conditioned
 - Naturally air-conditioned
 - Heavily studied
 - ASHRAE Standard 55, ISO 7730, and EN-16798
- Outdoor environment
 - Urban planning, tourism attraction, weather information
 - Examples: street canyons, recreation parks, microclimate design
 - Fewer studies but draws increasing attention
- Semi-outdoor environment
 - Transitional spaces (e.g., passenger stations, stadiums, atriums)
 - Fewer studies but draws increasing attention

CBE Thermal Comfort Tool

<https://comfort.cbe.berkeley.edu>

CBE CBE Thermal Comfort Tool
CENTER FOR THE BUILT ENVIRONMENT

ASHRAE-55 EN-16798 Compare Ranges Upload Fans & Heat PHS

Help Other CBE tools

Inputs

Select method: PMV method

Operative temperature: 25 °C

Air speed: 0.1 m/s No local control

Relative humidity: 50 % Relative humidity

Metabolic rate: 1 met Seated, quiet: 1.0

Clothing level: 0.61 clo Trousers, long-sleeve s

Create custom ensemble
Dynamic predictive clothing
Solar gain on occupants
Set pressure SI/IP
Local discomfort
Reset Save Reload Share
Documentation

✓ Complies with ASHRAE Standard 55-2020

PMV = -0.16 Sensation = Neutral PPD = 6 % SET = 24.8 °C

Psychrometric (operative temperature)

t_{db}	0.0 °C
rh	0.0 %
W_a	0.0 g w/kg a_a
t_{wb}	0.0 °C
t_{ap}	0.0 °C
h	0.0 kJ/kg

Humidity Ratio [g_w / kg_{d,a}]

Operative Temperature [°C]

NOTE: In this psychrometric chart the abscissa is the operative temperature and for each point dry-bulb temperature equals mean radiant temperature (DBT = MRT). The comfort zone represents the combination of conditions with the same DBT and MRT for which the PMV is between -0.5 and +0.5, according to the standard.

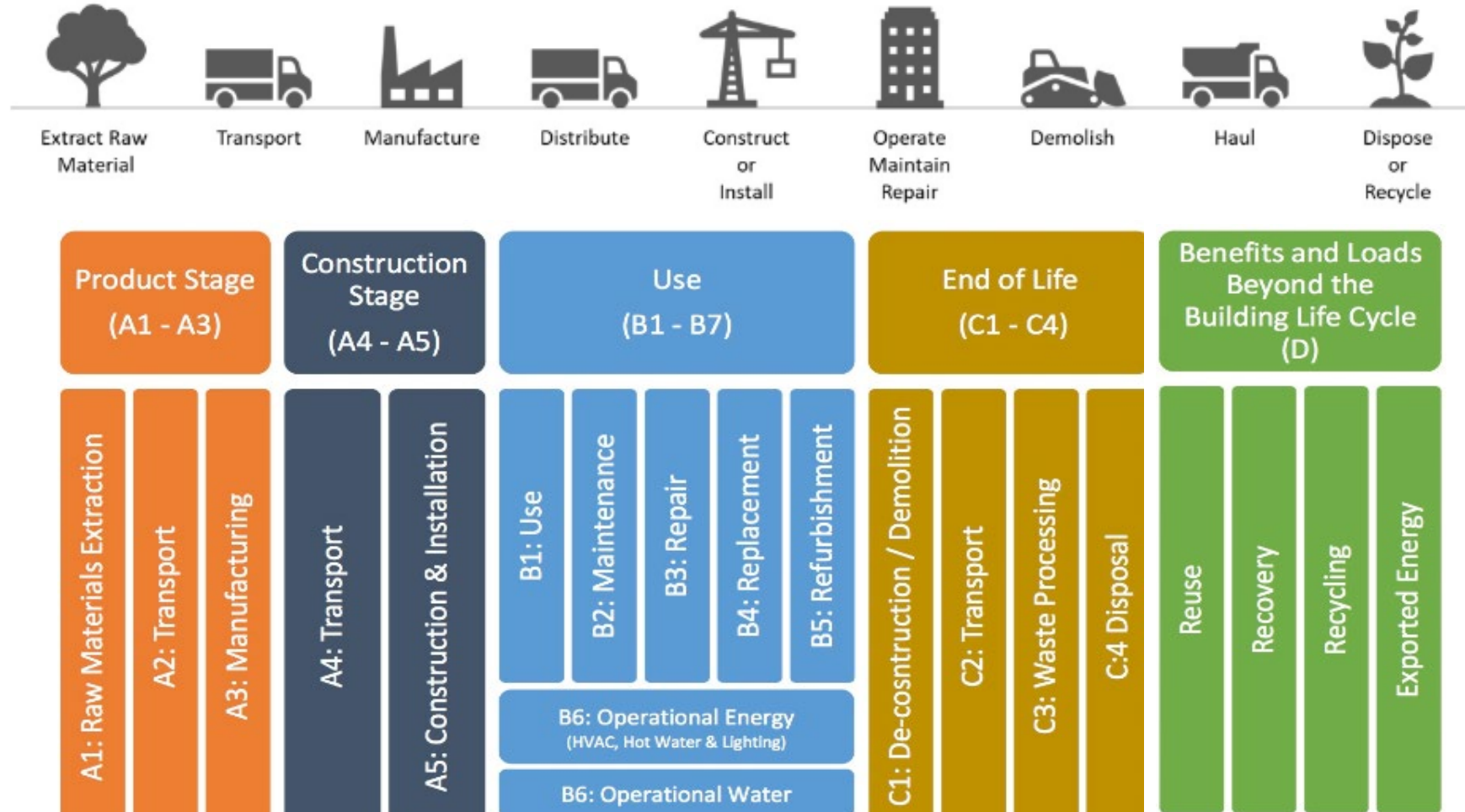
Limits of Applicability: This standard is only applicable to healthy individuals. This standard does not apply to occupants: a) whose clothing insulation exceed 1.5 clo; b) whose clothing is highly impermeable; or c) who are sleeping, reclining in contact with bedding, or able to adjust blankets or bedding.

The CBE comfort tools automatically calculates the relative air speed and the dynamic clothing insulation .

Building Life-Cycle Assessment (LCA)

- LCA basics
- Athena Impact Estimator demo

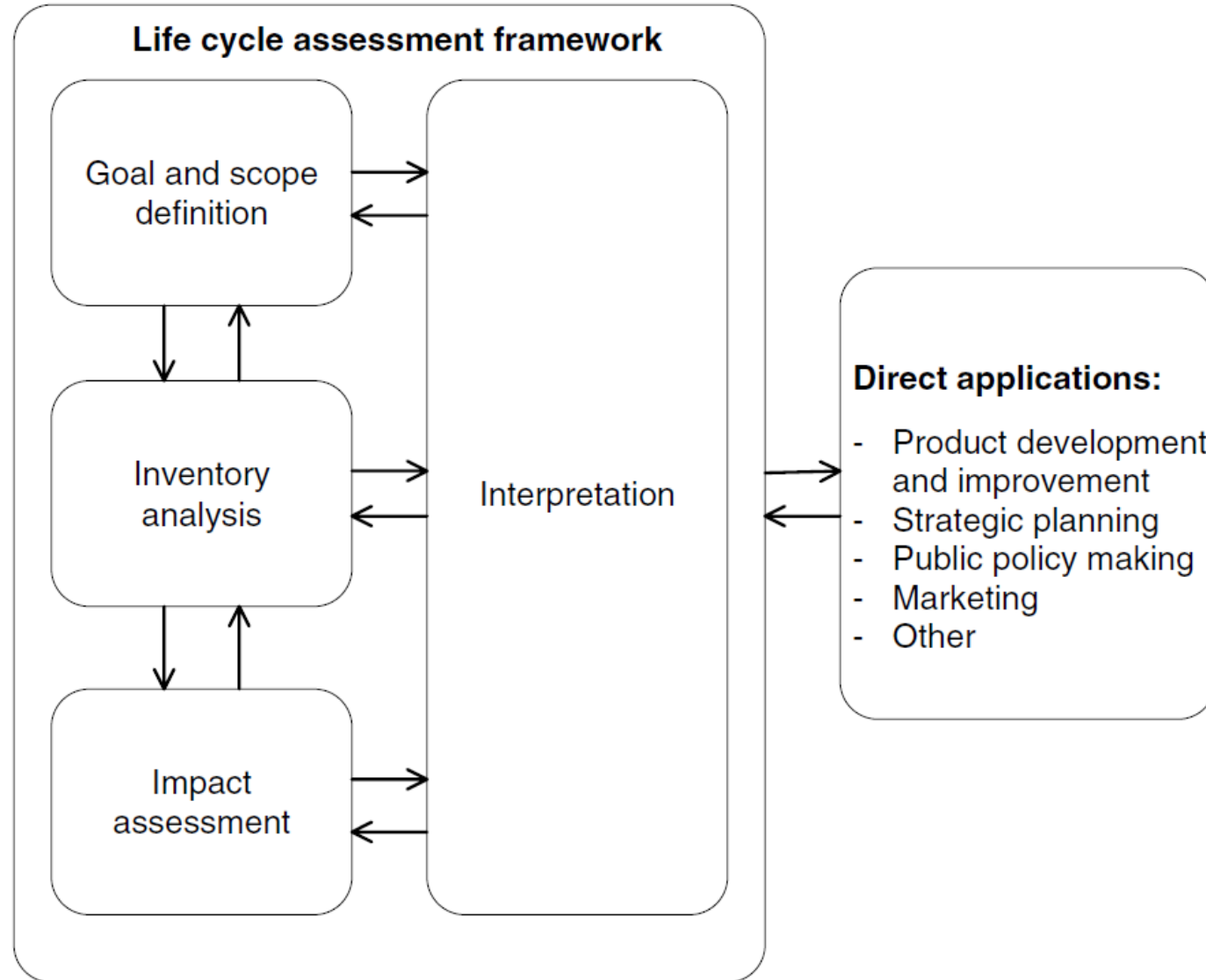
Building Life Cycle Stages



Sources:

- European Standard EN 15978:2011
- U.S. General Service Administration, <https://sftool.gov/plan/399/life-cycle-perspective-life-cycle-thinking>

LCA Components



Source: ISO 14040 (2006)

Impact Assessment

Evaluate the potential human health and environmental impacts of the inputs & output identified from the life-cycle inventory analysis.

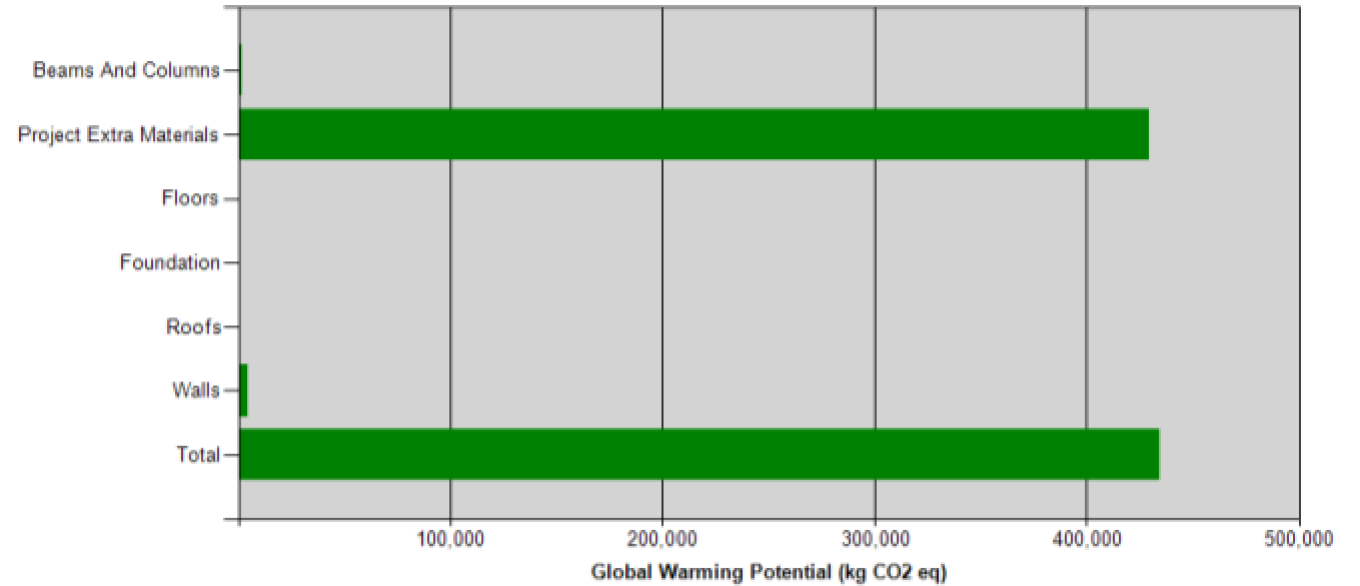
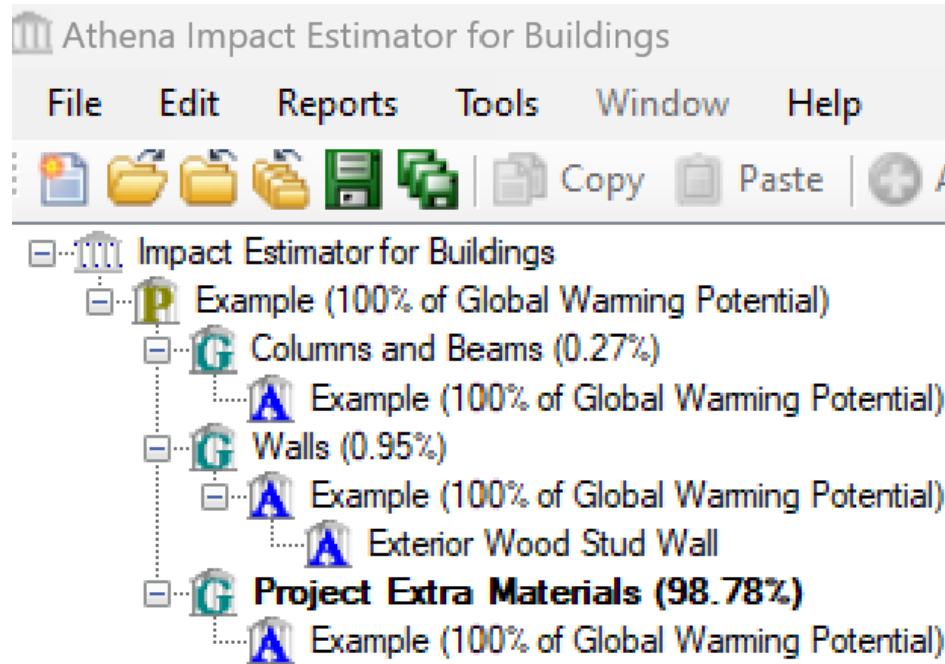
- Select and define impact categories
- Classification
- Characterization
- Normalization (optional)
- Grouping (optional)
- Weighting (optional)

Impact Categories

Commonly used impact categories include:

- Global Warming
- Ozone Depletion
- Acidification
- Eutrophication
- Smog Formation
- Human Health
- Ecotoxicity
- Fossil Fuel Use
- Land Use
- Water Use

Athena Impact Estimator Demo



LCA Measures	Unit	PRODUCT (A1 to A3)	CONSTRUCTION PROCESS (A4 & A5)	USE (B2, B4 & B6)		END OF LIFE (C1 to C4)	BEYOND BUILDING LIFE (D)	TOTAL EFFECTS		
				Replacement Total	Operational Energy Use Total			A to C	A to D	
Global Warming Potential	kg CO2 eq	3.41E+05	7.80E+04	1.54E+03	1.66E+06	1.67E+06	1.46E+04	-6.29E+03	2.10E+06	2.09E+06
Acidification Potential	kg SO2 eq	1.19E+03	4.98E+02	1.36E+01	1.12E+04	1.12E+04	1.79E+02	-8.01E-01	1.31E+04	1.31E+04
HH Particulate	kg PM2.5 eq	4.78E+02	8.09E+01	4.11E+00	1.99E+03	2.00E+03	6.25E+00	-3.51E-01	2.56E+03	2.56E+03
Eutrophication Potential	kg N eq	4.72E+02	9.06E+01	6.85E-01	5.30E+02	5.30E+02	1.12E+01	-4.12E-02	1.10E+03	1.10E+03
Ozone Depletion Potential	kg CFC-11 eq	9.26E-03	1.34E-03	4.45E-05	3.95E-02	3.96E-02	5.81E-07	0.00E+00	5.02E-02	5.02E-02
Smog Potential	kg O3 eq	2.17E+04	1.38E+04	1.69E+02	3.63E+04	3.65E+04	5.85E+03	-8.10E+00	7.78E+04	7.78E+04
Total Primary Energy	MJ	2.92E+06	8.31E+05	2.20E+04	2.88E+07	2.88E+07	2.15E+05	-1.60E+03	3.27E+07	3.27E+07
Non-Renewable Energy	MJ	2.76E+06	8.10E+05	1.74E+04	2.86E+07	2.86E+07	2.15E+05	-1.60E+03	3.24E+07	3.24E+07

Thank You!

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