Deep Design Data Portal (D3P) and BEMcyclopedia

Deep Design Data Portal

BEMcyclopedia

LBNL, with Sustainable IQ and Model Efficiency
Cindy Regnier, P.E., Program Manager 4
CMRegnier@lbl.gov

Project Summary

Timeline:

Start date: Oct 1, 2019

Planned end date: TBD

Key Milestones

1. Develop initial data schema for Deep Design Data portal; 5/31/2021
2. Develop 2 educational trainings for BEMcyclopedia; 6/30/2021

Budget:

Total Project $ to Date: $780k

- DOE: $680k
- Cost Share: $100k

Total Project $: $1,380k

- DOE: $1,180k
- Cost Share: $200k

Key Partners:

Sustainable IQ	LBNL
Model Efficiency	Arup
IBPSA-USA	EYP
Atelier Ten	Perkins Eastman
WSP	DLR Group

Project Outcome:

The Deep Design Data Portal (D3P) enables the largest A/E firms to leverage their collective design detail data to support design decision making to deepen carbon and energy savings, enabling analysis by building type, climate, end use, and EEMs and demonstrating the value of different simulation tools.

The BEMcyclopedia fills an educational niche by providing free, online learning resources to support professional development of new and advanced modelers in a range of topics spanning building physics to advanced modeling techniques.

Challenge

Deep Design Data Portal (D3P) problem:

A/E firms do not currently have a detailed, and easily accessible, benchmarking (e.g., fuel source, end-use, carbon or measure-level) dataset to compare project designs with other low energy/carbon designs, to inform and motivate better design decisions and improved performance at the project and portfolio level as well

D3P will provide a large and diverse design energy performance dataset that:

- Enables benchmarking and comparison at the fuel source, carbon, end-use and EEM levels of individual projects and entire project portfolios, improving project and firm performance
- Educates firms on the value of Deep Design Data, including how this data can be utilized for other low-carbon initiatives, saving time, money and resources.
- Complements the AIA 2030 Commitment DDx with additional (voluntary) data submission and deeper analytics

BEMcyclopedia problem:

- A tiny fraction of A/E designers receive formal training in BEM during school
- No go-to source to learn on the job
- As a result, it is not always applied effectively to inform design decisions
- Inconsistent quality - limits both the effectiveness and value proposition of using BEM to inform design

BEMcyclopedia provides:

- Fundamental knowledge on building science
- How to construct quality BEM models
- How, when, and why to apply BEM to specific design tasks
- How to present results effectively to decision makers.

Team

Cindy Regnier, P.E., LBNL

- Project management, advising and stakeholder coordination

D3P:

Kevin Settlemyre, Sustainable IQ

- Large firm collaboration lead, D3P design lead
- Dataset assembly and analysis

BEMcyclopedia:

Dimitri Contoyannis, Model Efficiency

- Site development lead, content development

IBPSA-USA

- Outreach, stakeholder engagement

Erik Kolderup, Kolderup Consulting

- Content development

Approach - Deep Design Data Portal (D3P)

Collaborate with large firms (Large Firm Round Table (LFRT), top 60 firms by design floor area) to:

- Identify analyses of interest and project data that support them
- Collect initial firm dataset to assess the level of D3 being collected and analyze dataset
- Provide input on design of portal, and feedback to firms on analysis findings and discoveries

Collaborate with BEM software vendors to:

- Automate reporting of key project data to support deep project and portfolio design analysis

D3P provides firms:

– A comparison and benchmarking tool for projects and entire portfolios with analytics at the EEM and end-use level

– A structure to organize internal data collection, and interest in BEM vendor automated approach

BEM Design Design Data Portal (D3P) provides DOE:

– A dataset that quantifies the value of BEM in design

Impact - D3P

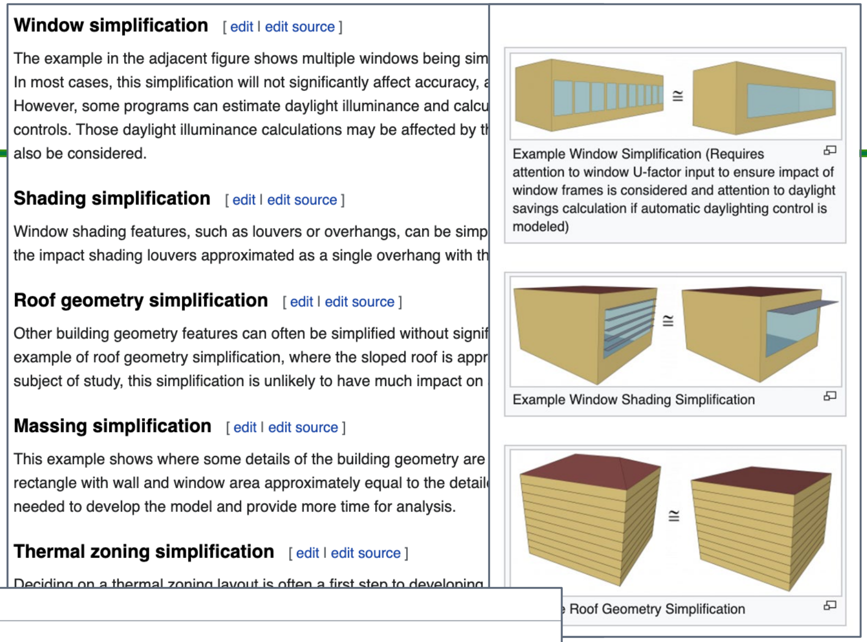
- **Support for DOE Program Goals:**
  - BEM RDO Topic 6 – **“Need to establish longitudinal correlations between BEM and project performance and cost”**
- **Unique advantages:**
  - Large firms represent a large fraction of design square footage
  - Large firms can influence BEM vendors to automate reporting
- **Differentiators:**
  - Tracks energy use by end-use and fuel type, tracks carbon metrics
  - Tracks design variables for individual EEMs in addition to whole-building
  - TAG consists of broader BEM stakeholder community (A, E, and modeling consultants) to identify use cases for the data driven design process
  - An open-source approach allows incorporation with third party tools and platforms
- **Impact milestones:**
  - Number of firms and projects using D3P
  - D3P features adopted by AIA for 2030 Commitment DDx

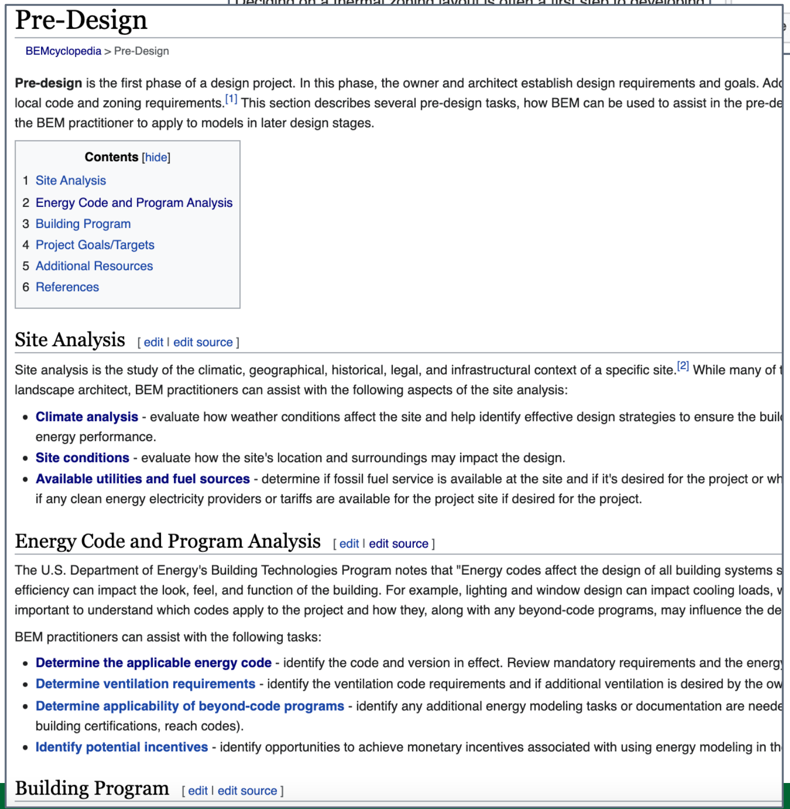
Progress – D3P

- **Project stage:** early
- **Accomplishments:**
  - Diverse TAG (10 large firms - architect, engineering, and consultants)
  - TAG consensus on "data anonymization" approach, analyses, and BEM data ask
  - Collection and on-going analysis of the initial data from 7 of 10 TAG firms
  - Over **2,050 projects** have been shared, or **~688 MGSF**
  - Findings so far:
    - **D3P collection method** varies by firm (manual vs script use). However, all are interested in learning how it can be better automated (e.g. through BEM software).
    - **Varying degrees of data currently collected -** some work needed to standardize how firms can and will collect data.
    - **Carbon reduction measures and reporting are key drivers -** Zero carbon initiatives at project and city levels are increasingly driving design and project requirements.
  - **Conducting initial analysis of firm dataset**

Approach - BEMcyclopedia

- **BEMcyclopedia will provide wiki based training modules on fundamental concepts** including building physics, HVAC systems, and different model types.
  - Step-by-step modules - how to create models and where to get appropriate input data.
  - Complements existing training from software vendors
- **BEMcyclopedia provides clear connections between design tasks, and how modelers can provide input on the decision making process**
  - Specific guidance is given, organized by design phase
  - How to understand the design team’s goals,
  - How to perform meaningful analysis to provide insight on the design decision, and
  - How to effectively present results.
- Initial content seeded by DOE-funded contractors.
- Long-term goal is to crowdsource content, in partnership with industry experts from IBPSA-USA, and diverse stakeholder groups represented by TAG



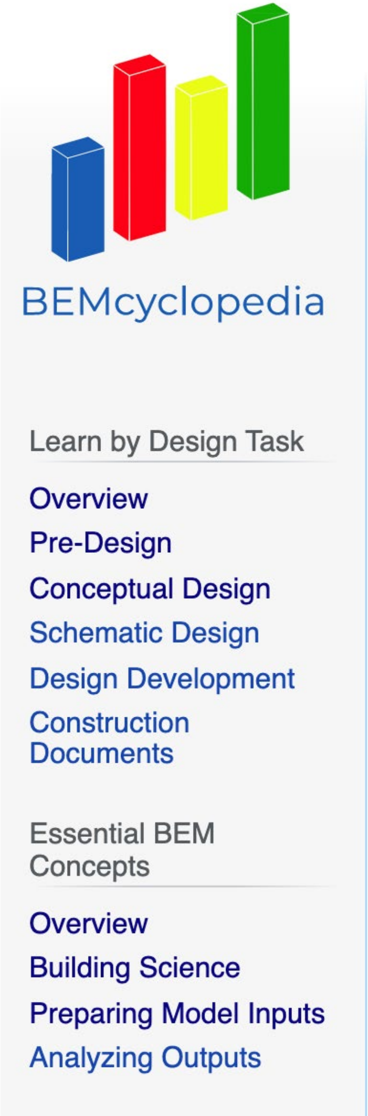


Impact - BEMcyclopedia

- **Support for DOE Program Goals:**
  - BEM RDO, Topic 5 **"BTO should support the development of tool-neutral educational and training materials"**
- **Unique advantages:**
  - No-cost option for training
  - Fills many identified gaps in training offerings – fundamentals of building science, fundamentals in design process, effective application of BEM in the design process
  - Focus on practitioners of all skill levels
- **Differentiators:**
  - Not limited to "how to build models" but also provides background on how the design process works, and how BEM can be used to inform decisions along the way
  - Not limited to specific software tools but detailed enough so that content can be applied consistently to many tools
- **Impact milestones:**
  - Beta release this fall
  - Inviting TAG to review/edit/create new content
  - Will set goals for number of contributors, and number of visitors to measure impacts, and number of attendees at webinars

Progress – BEMcyclopedia

- **Project stage:** early
- **Accomplishments:**
  - Website (beta) is live with over 40 pages of detailed educational content
  - Content created so far falls under several main categories:
    - How BEM can support decisions in the design process,
      - initial focus on early-stage (pre-design and conceptual design)
    - Description of different model types, how and when to use them
    - How to prepare BEM inputs (starting with simple box models)
    - Navigation pages
  - Assembled a TAG with broad stakeholder representation. TAG provided development priorities on early stage analysis.
  - Partnership with IBPSA-USA to leverage subject matter expertise for content development, and test the "crowdsourced content" approach.
  - Project has met all milestones on budget.



Stakeholder Engagement

D3P:

- LFRT TAG Assembled in 2020
  - 10 Large Practitioner Firms (A, E, & Energy Modeling Consultants)
- TAG provides development priorities, project data
- Interaction with TAG on-going, and next meeting in fall
- Coordinating with major BEM developers for future phases

EYP/ PERKINS EASTMAN nbbj wsp atelier ten ARUP DLR Group HKS

BEMcyclopedia:

- TAG Assembled in 2020 - a broad group of “interested stakeholders”
  - Practitioners (A&E)
  - Universities
  - BEM Trainers
  - Software Developers
  - Emerging Professionals
- Large group deemed important due to crowdsourced nature of wikis.
- TAG provides development priorities, content review and future development
- Next TAG Meeting in early fall

Berkeley UNIVERSITY OF CALIFORNIA EYP/ AUTODESK. ASU Arizona State University SMITHGROUP Ladybug Tools

Remaining Project Work

D3P:

- FY21
  - Analyzing firm dataset, iterating on analysis use cases, developing MVP requirements, on-going TAG engagement
- FY22
  - Development of MVP
    - Develop clickable prototype to demonstrate capabilities and workflows of MVP
    - On-going (and expanding) TAG engagement: review and feedback loop
  - Developer selection process, on-boarding, and implementation
  - Software Vendor engagement

BEMcyclopedia:

- FY21
  - Beta Testing (Q4)
- FY22
  - Ongoing Content Development
    - “Early stage analysis” v1 complete
    - Consolidation of lookup table data
  - Rollout and Promotion
    - Coordination with user groups - teachers, BEM professionals, early practitioners
    - IBPSA promotion

BEMcyclopedia

Thank You

LBNL, with Sustainable IQ and Model Efficiency
Cindy Regnier, P.E., Program Manager 4 LBNL
CMRegnier@lbl.gov

REFERENCE SLIDES

Project Budget

Project Budget: The project initiated in FY20 with early scoping of both activities and moved into data collection and content development in FY21. IBPSA came on as a partner in FY20, and in an expanded role for development of BEMcyclopedia in FY21. In FY22 project budget will include scope for a web developer to develop the D3P.

Variances: N/A

Cost to Date: 378k

Additional Funding: N/A

Budget History					
FY 2020 (past)		FY 2021 (current)		FY 2022 – TBD (planned)	
DOE	Cost-share	DOE	Cost-share	DOE	Cost-share
$350k	$50k	$335k	$100k	$500k	$100k

Project Plan and Schedule

- Project original initiation date – Oct 1, 2019
- Project planned completion date - TBD
- Schedule and Milestones are per the attached project schedule
- Explanation for slipped milestones and slips in schedule
- Go/no-go decision points
- Current and future work

Project Plan and Schedule

Project Schedule		
Project Start: October 1, 2019	(blue)	Completed Work
Projected End: September 30, 2022	(dark blue)	Active Task (in progress work)
	◆ (red)	Milestone/Deliverable (Originally Planned)
	◆ (black)	Milestone/Deliverable (Actual)

	FY2020				FY2021				FY2022			
Task	Q1 (Oct-Dec)	Q2 (Jan-Mar)	Q3 (Apr-Jun)	Q4 (Jul-Sep)	Q1 (Oct-Dec)	Q2 (Jan-Mar)	Q3 (Apr-Jun)	Q4 (Jul-Sep)	Q1 (Oct-Dec)	Q2 (Jan-Mar)	Q3 (Apr-Jun)	Q4 (Jul-Sep)
Past Work												
Q1 Milestone: Data: Draft version of BEM D3P Framework Requirements					Completed ◆							
Q1 Milestone: Education: Draft internal version of education content portal					Completed ◆							
Q2 Milestone: Data: Define target data analysis needs, and the status of efforts with firms						Completed ◆						
Q2 Milestone: Draft internal version of the education content portal						Completed ◆						
Q2 Milestone: Development specification (report)						Completed ◆						

Project Plan and Schedule

Project Schedule		
Project Start: October 1, 2019		Completed Work
Projected End: September 30, 2022		Active Task (in progress work)
	◆	Milestone/Deliverable (Originally Planned)
	◆	Milestone/Deliverable (Actual)

Task	FY2020 Q1 (Oct-Dec)	FY2020 Q2 (Jan-Mar)	FY2020 Q3 (Apr-Jun)	FY2020 Q4 (Jul-Sep)	FY2021 Q1 (Oct-Dec)	FY2021 Q2 (Jan-Mar)	FY2021 Q3 (Apr-Jun)	FY2021 Q4 (Jul-Sep)	FY2022 Q1 (Oct-Dec)	FY2022 Q2 (Jan-Mar)	FY2022 Q3 (Apr-Jun)	FY2022 Q4 (Jul-Sep)
Past Work												
Q3 Milestone: Data: Memo summarizing dataset, data contribution guidelines and checks							◆					
Q3 Milestone: Education: Drafts of 2 educational resources							◆					
Q3 Go/No-Go: Education: A minimum of 2 tutorials approved by TAG for development							◆					
Current/Future Work												
Q4 Milestone: Education: Memo summarizing TAG feedback								◆				
Q4 Go/No-Go: Data: BEM D3P Framework Requirements Approved by TAG								◆				

Project Plan and Schedule

Project Schedule		
Project Start: October 1, 2019		Completed Work
Projected End: September 30, 2022		Active Task (in progress work)
		Milestone/Deliverable (Originally Planned)
		Milestone/Deliverable (Actual)

	FY2020				FY2021				FY2022			
Task	Q1 (Oct-Dec)	Q2 (Jan-Mar)	Q3 (Apr-Jun)	Q4 (Jul-Sep)	Q1 (Oct-Dec)	Q2 (Jan-Mar)	Q3 (Apr-Jun)	Q4 (Jul-Sep)	Q1 (Oct-Dec)	Q2 (Jan-Mar)	Q3 (Apr-Jun)	Q4 (Jul-Sep)
Current/Future Work												
Q4 Milestone: Data: Memo summarizing analysis findings from the first analysis of collected BEM deep design data												
Q4 Milestone: Data: Finalize version 1 requirements												
Q4 Milestone: Education: Finalize drafts of training content												

BEM D3P Architecture (Detail)

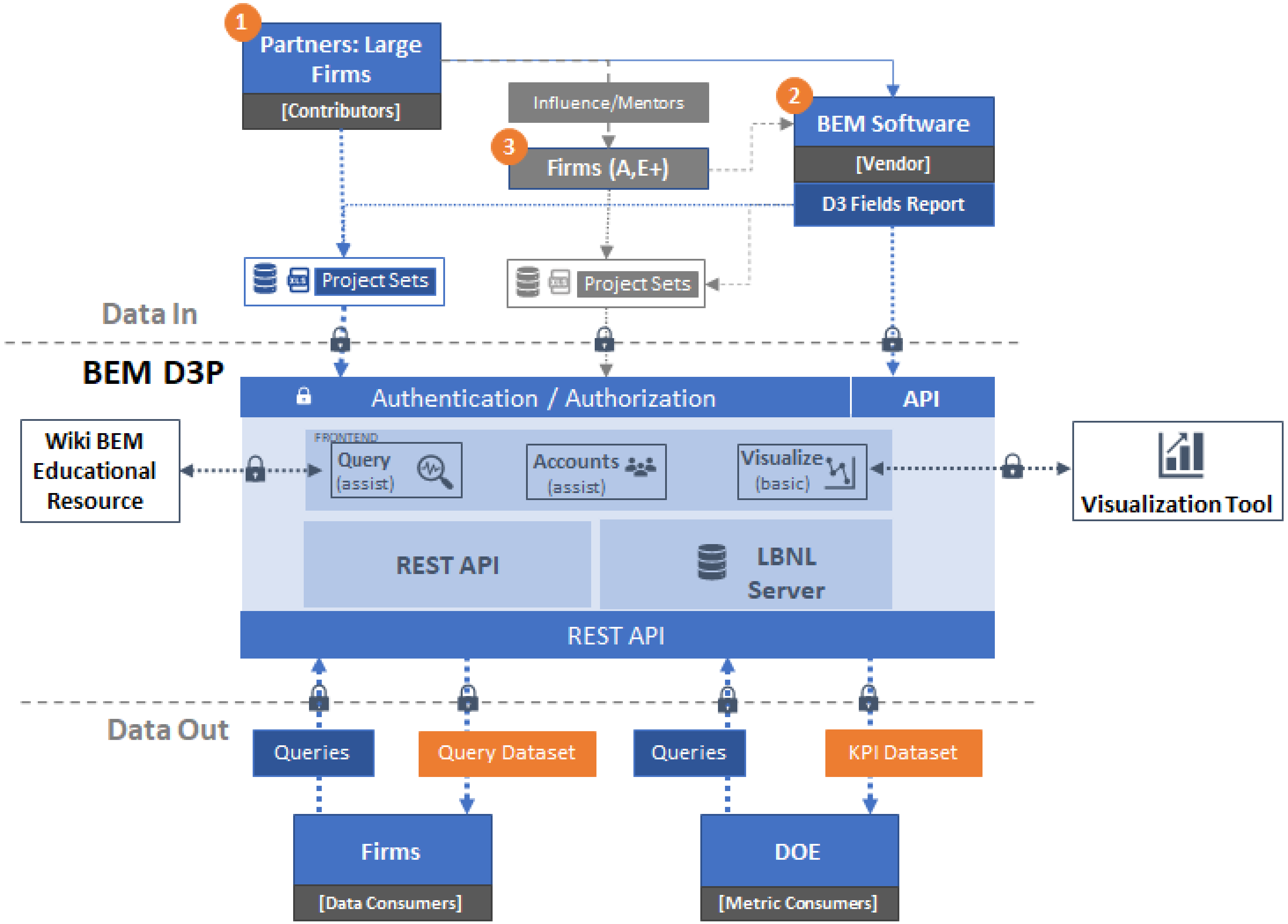
1- Firms (Multi-disciplinary) contribute project BEM data to D3P (initially and over time)

2 - Targeting EM Software output to directly contribute

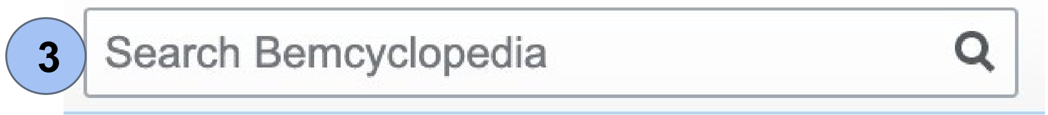
D3P provides the schema and framework for the dataset to continue to grow and increase in usefulness

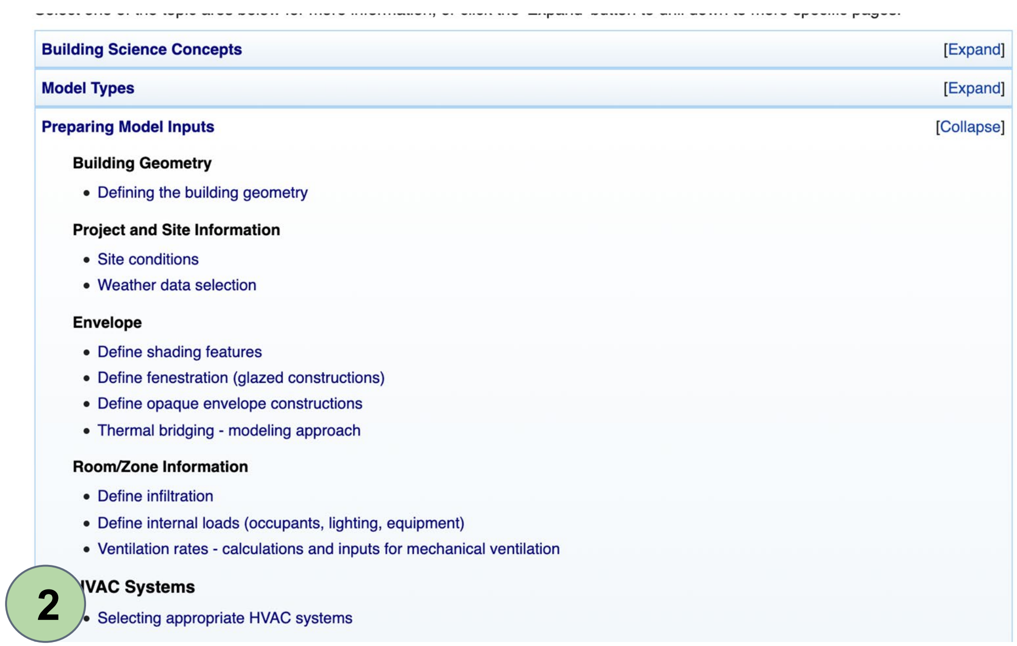
D3P data can be accessed by:

1) To benchmark projects and portfolios, as well as inform design decisions
2) DOE to **enable longitudinal correlations**



BEMcyclopedia Concept





3 main ways to navigate the site:

1. Learn by Design Task - tutorials by design timeline
2. BEM Essentials - general knowledge tutorials
3. Search - search the wiki

Navigation views are automatically generated/updated by “tagging” pages.

BEMcyclopedia Example Content Pages

Pre-Design

BEMcyclopedia > Pre-Design

Pre-design is the first phase of a design project. In this phase, the owner and architect establish design requirements and goals. Additionally, research is performed to analyze the site and local code and zoning requirements.[1] This section describes several pre-design tasks, how BEM can be used to assist in the pre-design decision-making, and data gathering activities for the BEM practitioner to apply to models in later design stages.

Contents [hide]

1 Site Analysis
2 Energy Code and Program Analysis
3 Building Program
4 Project Goals/Targets
5 Additional Resources
6 References

Site Analysis [edit | edit source]

Site analysis is the study of the climatic, geographical, historical, legal, and infrastructural context of a specific site.[2] While many of these activities are performed by an architect or landscape architect, BEM practitioners can assist with the following aspects of the site analysis:

- **Climate analysis** - evaluate how weather conditions affect the site and help identify effective design strategies to ensure the building will be comfortable and will achieve the desired energy performance.
- **Site conditions** - evaluate how the site's location and surroundings may impact the design.
- **Available utilities and fuel sources** - determine if fossil fuel service is available at the site and if it's desired for the project or whether an all-electric design will be pursued. Determine if any clean energy electricity providers or tariffs are available for the project site if desired for the project.

Energy Code and Program Analysis [edit | edit source]

The U.S. Department of Energy's Building Technologies Program notes that "Energy codes affect the design of all building systems separately and collectively. Designing for energy efficiency can impact the look, feel, and function of the building. For example, lighting and window design can impact cooling loads, windows can impact lighting, and so on."[3] It is important to understand which codes apply to the project and how they, along with any beyond-code programs, may influence the design.

BEM practitioners can assist with the following tasks:

- **Determine the applicable energy code** - identify the code and version in effect. Review mandatory requirements and the energy modeling procedures for the performance approach.
- **Determine ventilation requirements** - identify the ventilation code requirements and if additional ventilation is desired by the owner.
- **Determine applicability of beyond-code programs** - identify any additional energy modeling tasks or documentation are needed to comply with beyond-code programs (e.g. green building certifications, reach codes).
- **Identify potential incentives** - identify opportunities to achieve monetary incentives associated with using energy modeling in the project design process.

Building Program [edit | edit source]

The programming process defines how a building will be used by the occupants, including how much area will be designated for different space types.[4] Programming is typically not

Pre-design phase:

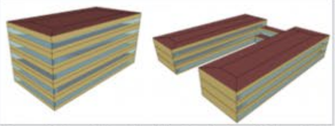
Linking BEM tasks to design objectives

BEMcyclopedia Example Content Pages

Simple Box Models

BEMcyclopedia > Simple Box Models

Simple box models are a type of whole building energy model used to inform early design. A simplified model is used to test the impact of fundamental design decisions on energy consumption and peak heating and cooling loads. The appropriate level of detail in the model depends on the state of the design. During pre-design, the model may look like a simple box. During conceptual design, the model will typically represent a simplified version of one or more design concepts.



Example Simple Box Models, Pre-design (left) and Conceptual Design Massing (right)

Contents [hide]

1 Common Use Cases for Simple Box Models
1.1 Architectural Design
1.1.1 Building form
1.1.2 Fenestration
1.1.3 Opaque envelope
1.1.4 Daylighting energy savings potential
1.1.5 Natural ventilation savings potential
1.1.6 Net zero energy or carbon emissions potential
1.1.7 Resilience - temperature response to loss of cooling or heating
1.2 End-use Breakdown
1.3 Performance Targets
1.4 HVAC System Options
2 Timing for Simple Box Modeling
2.1 Related Analysis Methods During Early Stage Design
2.1.1 Prototype Models
2.1.2 Shoebox Models
2.1.3 Conceptual Design Models
3 Team Responsibilities
4 Simple Box Modeling Approach
4.1 Determine initial design questions to be evaluated
4.2 Identify design constraints
4.3 Select energy modeling tool
4.3.1 Whole-building, annual simulation modeling tools
4.3.1.1 Useful whole building energy modeling tool features:
4.3.1.2 Other calculation methods
4.4 Identify model inputs
4.5 Develop a base case simple box model
4.6 Create alternative models
4.6.1 Selecting design options
4.6.2 Sensitivity analysis
4.6.3 Evaluating combined impacts of "measure packages"
4.7 Analyze the outputs
4.8 Present the results
4.9 Iterate
4.10 Transitioning to later modeling phases

Simple box models:

Tutorial

BEMcyclopedia Example Content Pages

Window simplification [edit | edit source]

The example in the adjacent figure shows multiple windows being simplified to a single window with the same area, orientation and tilt. In most cases, this simplification will not significantly affect accuracy, as long as the thermal impact of window frames is considered. However, some programs can estimate daylight illuminance and calculate electric lighting savings due to automatic daylighting controls. Those daylight illuminance calculations may be affected by the dimensions and location of windows, so that impact should also be considered.

Shading simplification [edit | edit source]

Window shading features, such as louvers or overhangs, can be simplified in some cases. The adjacent figure shows an example with the impact shading louvers approximated as a single overhang with the same projection factor.

Roof geometry simplification [edit | edit source]

Other building geometry features can often be simplified without significantly affecting the analysis. The adjacent figure shows an example of roof geometry simplification, where the sloped roof is approximated with a flat roof. Unless the roof design is a specific subject of study, this simplification is unlikely to have much impact on analysis of the relative performance of other design features.

Massing simplification [edit | edit source]

This example shows where some details of the building geometry are ignored and the building is represented instead as a simple rectangle with wall and window area approximately equal to the detailed model. This type of simplification might reduce the time needed to develop the model and provide more time for analysis.

Thermal zoning simplification [edit | edit source]

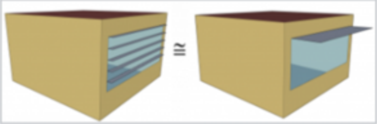
Deciding on a thermal zoning layout is often a first step to developing an energy model, and judgment is necessary at all stages. Even in detailed energy models, some simplification is typical, and multiple HVAC control zones are often combined into single thermal zones to reduce model complexity and simulation time.

At the time of a simple box model analysis, it will rarely be the case that HVAC control zones are already defined. Therefore, simplified perimeter/core thermal zoning is typically applied. Perimeter zones are defined that extend from exterior walls to a depth of 12 to 20 feet, and separate perimeter zones are defined for each orientation. Spaces more than 12 to 20 feet from the perimeter are defined as separate core zones.

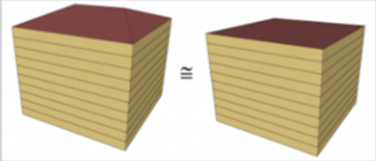
In the typical case for a simple box model, a rectangular building has 5 zones per floor: one for each of the four orientations and one for the core space as shown in the adjacent figure. For multi-story buildings, a separate set of zones should be defined for the ground floor and top floor because they experience different loads compared to middle floors due to additional ground floor heat transfer from the floor slab (or basement, or crawlspace) and top floor loads from the roof. Middle floors are all adjacent to spaces with similar temperatures so heat transfer between them is minimal. In some software tools, the middle floors can be represented by a single floor with a multiplier on results, and this approach is generally acceptable for simple box modeling.

In some cases, additional thermal zones beyond the simple perimeter/core configuration will be appropriate. If a conceptual design exists, then spaces may have been defined that have significantly different envelope conditions, internal loads or operating schedules. As an example, consider a school building, where the administrative offices operate on a different schedule and with different internal loads compared to classrooms or multipurpose rooms. In that case, it would generally be appropriate to create separate zones representing classrooms and the other space types. Some judgment is needed to determine if defining those spaces as separate zones is necessary based on the purpose of the simple box modeling exercise. In many cases, the simple perimeter/core zoning pattern is adequate for evaluating relative performance of alternatives.

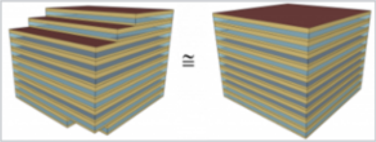
Example Window Simplification (Requires attention to window U-factor input to ensure impact of window frames is considered and attention to daylight savings calculation if automatic daylighting control is modeled)



Example Window Shading Simplification



Example Roof Geometry Simplification



Example Building Geometry Simplification

Simple box models:

Geometry simplification guidance