Generating Energy Models of Existing Buildings Using Open Data

Seminar 9: Modeling Existing Buildings I

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The Building Energy Smart Technologies (BEST) Center

Background

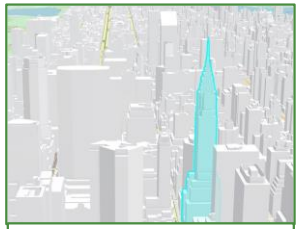
- Facility-specific building energy models (BEM) are needed for retrofits to achieve decarbonization targets
- Open data sources are becoming available to automate the generation of energy models
  - Geometry though LiDAR scans
  - Building attributes through energy audits
  - Energy consumption from benchmarking
- OpenStudio / EnergyPlus platform allows for scripted commands
- Bulk generation of models should be possible at scale with actual facility attributes
  - NREL Comstock or ORNL AutoBEM models use generalized attributes

Project Objectives

- Generate and calibrate BEMs in automated or semi-automated fashion, using publicly available or private building data collected via energy audits or other purposes (e.g., geometry, system info, operation schedules, property attributes)
- Produce a prototype BEM workflow and evaluate it holistically in the context of running and calibrating BEMs for a large portfolio of buildings
- Leverage open-source BEM software tools and public data sources
- Help transform 8,760-hour BEMs to an asset management tool, not simply for code compliance
- Partner with NYC agencies to facilitate data access
  - NYC Department of Citywide Administrative Services (DCAS) Division of Energy Management (DEM) to gather additional information not necessarily in public domain (e.g., below grade data, floor area, number of floors)
  - NYC Mayor's Office of Climate and Environmental Justice for access to audit data in BuildingSync XML (BSXML) format (.csv files available as open data)

Workflow Overview

Geometry Data Source



ESRI Multipatch: Publicly available whole-city mesh geometry dataset.

BEM Geometry Setup Tools

ArcGIS: Query and export specific buildings from native format to CAD.

Ladybug Tools (Rhino/Grasshopper: Troubleshoot geometry, add floors, & translate to BEM-compatible geometry.

BEM Systems Data Setup Tool

AutoGenerate BEM Tools: Use a BEM SDK (in Ruby) to translate audit information from BSXML to BEM objects.

Building System Data Source

BuildingSyncXML: Standardized file format used to store audit data for use with other applications.

Audit Template: Source of ASHRAE Level 2 audit data for NYC buildings.

BEM Simulation Application

OpenStudio: Wrap E+ (simulation engine) objects, allowing for BEM simulation, manipulation & calibration

BEM Calibration Tool

OpenStudio Parametric Analysis Tool: Set up algorithmic BEM calibration for cloud analyses

OpenStudio Server

Utility Data

Monthly or sub-hourly consumption &/or demand

Workflow Steps

Step 1 – Extract Building Models from NYC Building Portfolio

Step 2 – Generate BEM, Including Geometry Data

Step 3 – Apply BEM Inputs from Building and Systems Data with AutoGenerateBEM Tool

Step 4 – Calibrate BEM to Utility Data and Calibration Criteria

Step 1 – Geometry Workflow

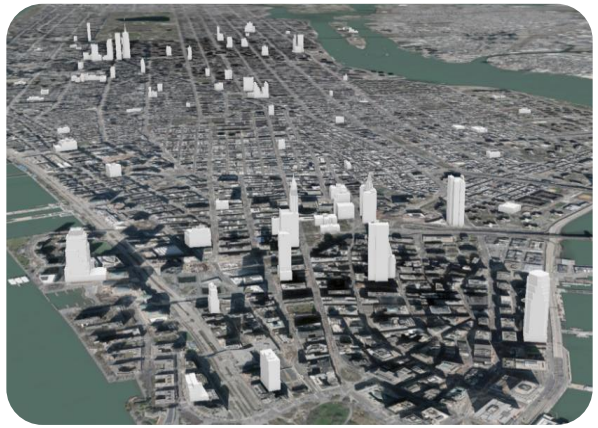
- Used GIS software and code to query 3D building Multipatch data. Filter is based on buildings with Audit Template BSXML files using NYC Building Identification Number (**BIN**) to match files.
- Exported 3D files to .DWG files for individual building geometry. Geometry represents the exterior surface of the building.

Input

GIS Geo >1 Million 3D Multipatch Buildings

Match and filter buildings

CSV



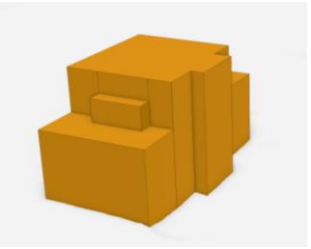
876 NYC municipal 3D Multipatch Buildings

Export to CAD

DWG

Output

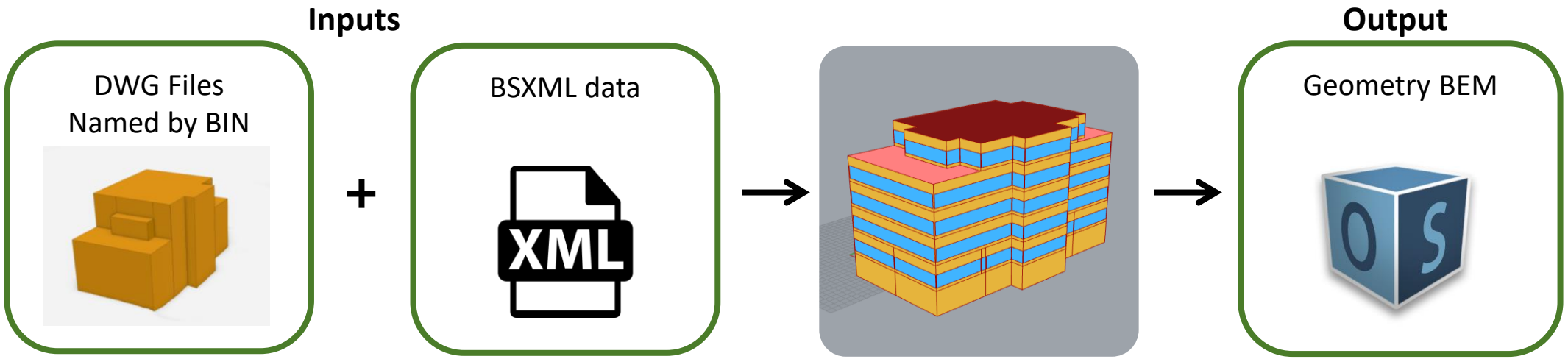
DWG Files Named by BIN



Automated with command line tools

Step 2 – Generate BEM

Used visual programming to validate input geometry and compile additional building characteristic data from a DEM dataset that included **gross floor area, number of floors, basement size, and other baseline attributes.**



Automated with command line tools

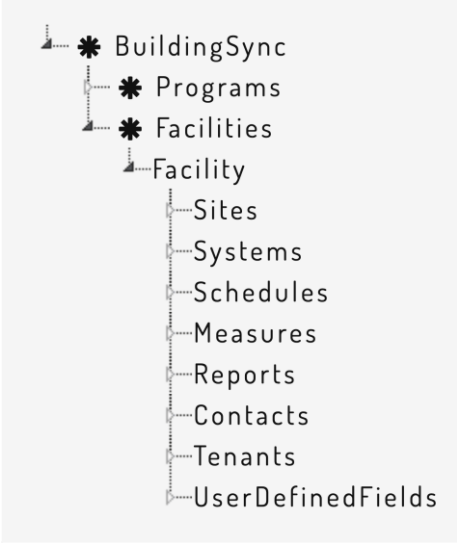
Step 3 – Building and System Data

Audit Template (AT):

- Web-tool for inserting, storing & sharing Level II audit data for a building.
- Allows you to fill pre-determined fields.
- Follows ASHRAE Standard 211 and supports data export to BSXML, level of definition (LOD) 200

BSXML:

- Standardized schema (Building Sync) for describing building data, systems data, consumption data, recommended efficiency measures, etc.



Tree structure in BSXML Schema

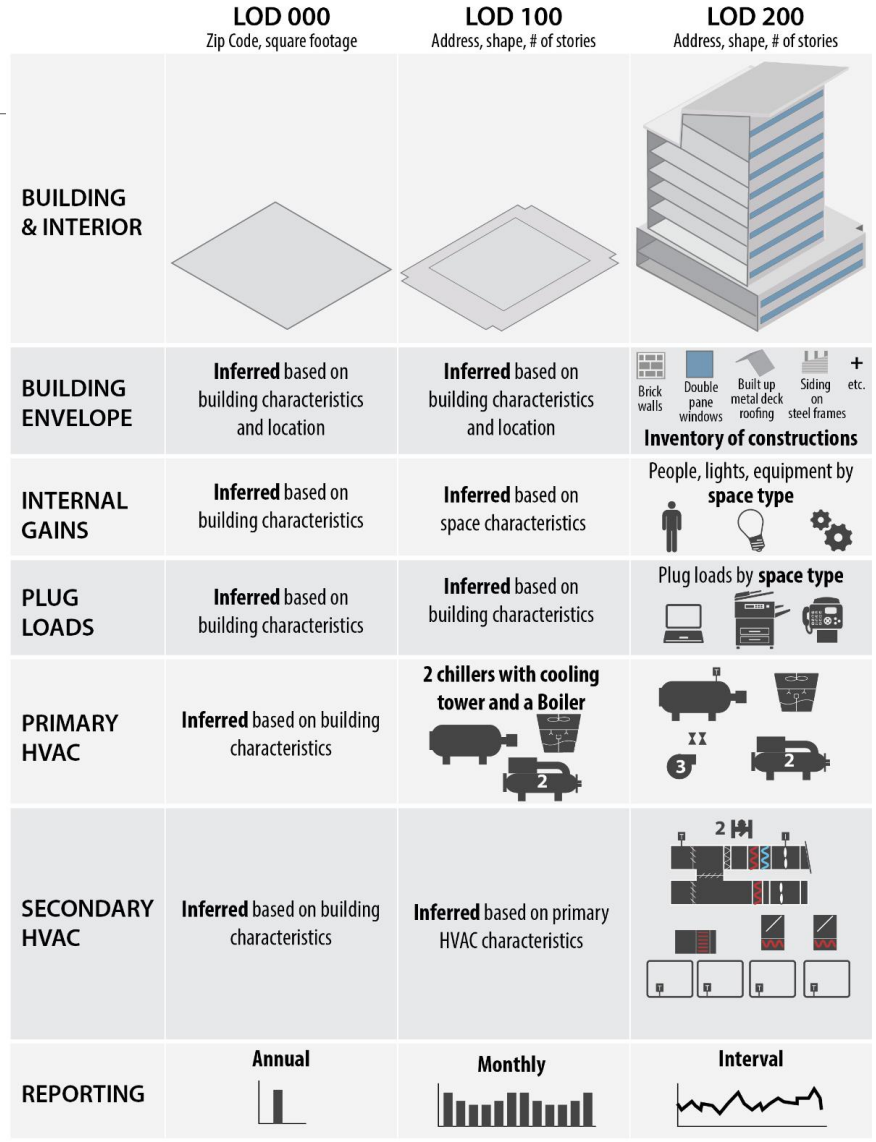
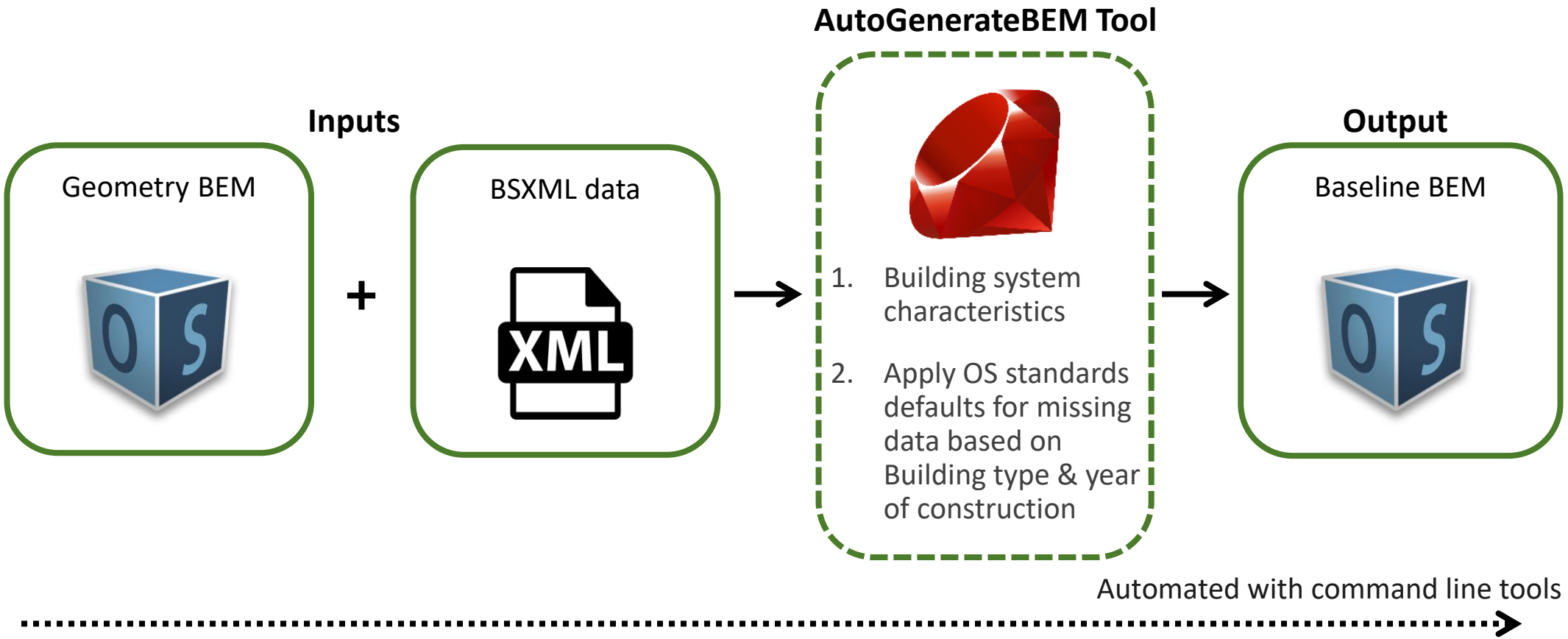


Image curtesy of Building Sync, by Marjorie Schott

Step 3 – AutogenerateBEM Tool

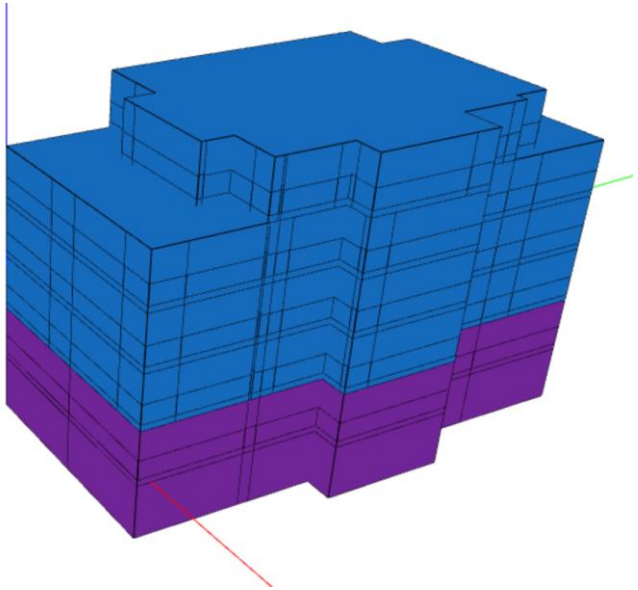
Additional functionalities were coded into NREL's BuildingSync Gem to create a separate library, AutoGenerateBEM Tool enabling import, translation and incorporation of energy data into BEM.



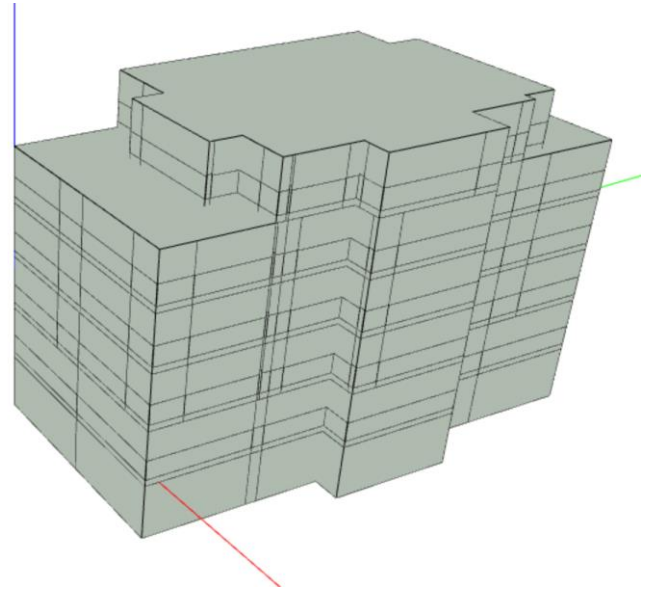
Step 3 – AutogenerateBEM Tool

Building and System Characteristics

1. Building uses: the collection of building uses and their ratio of building area are used to create a blended space type for the final BEM.



Retail + Office

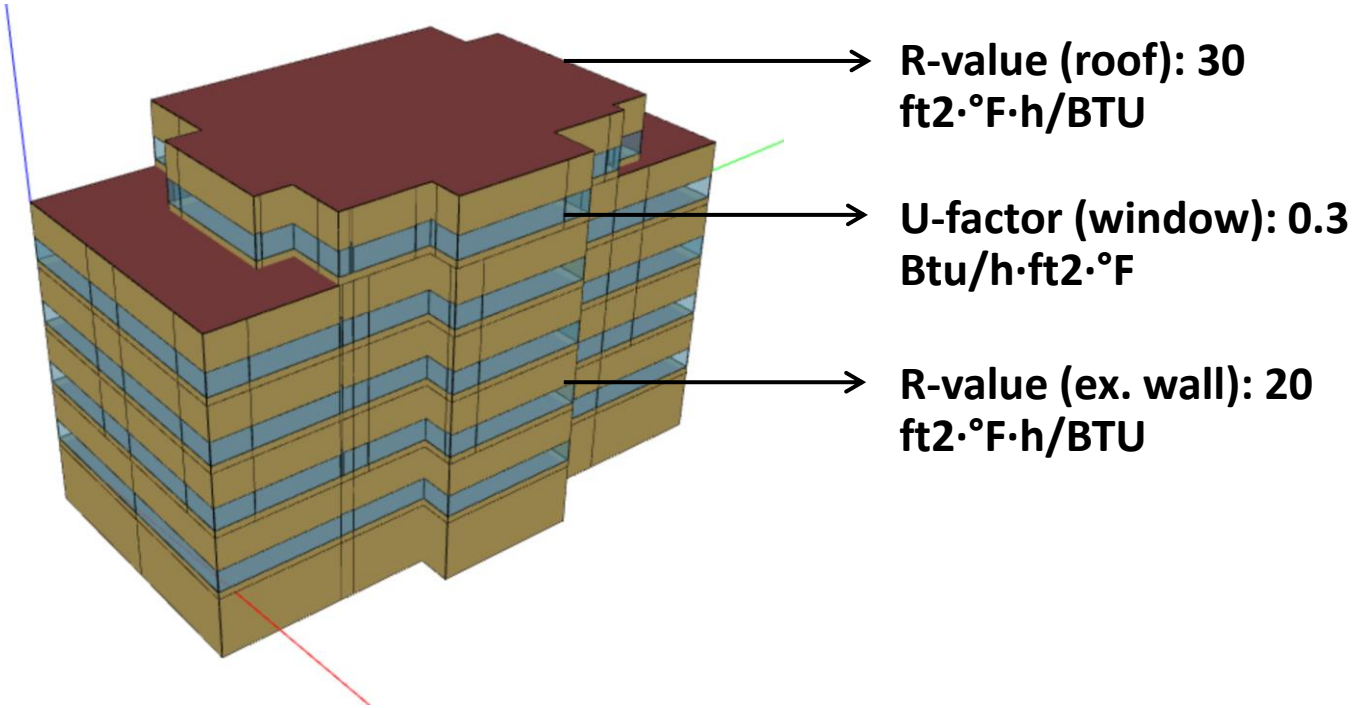


Single blended space type

Step 3 – AutogenerateBEM Tool

Building and System Characteristics

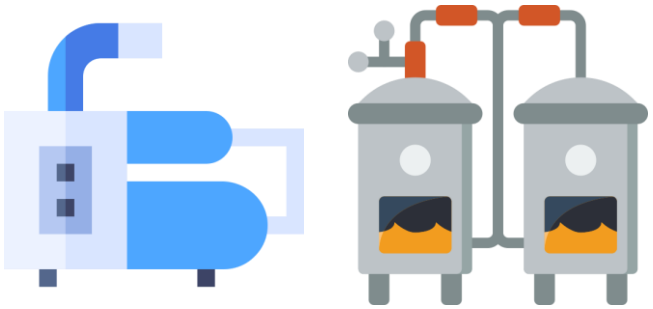
2. <u>Envelope properties</u>: the specific thermal properties and descriptions for roofs, walls, etc. are used as reported in BSXML to create BEM constructions.



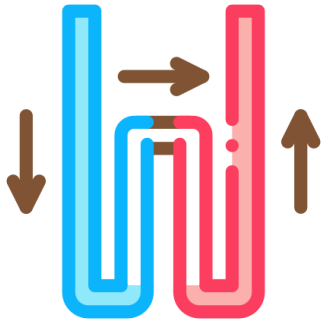
Step 3 – AutogenerateBEM Tool

Building and System Characteristics

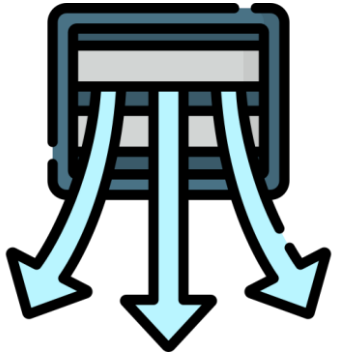
3. HVAC: individual components and their attributes are read from BSXML (e.g., boilers, deliveries, coils, etc.) and constructed in BEM then assembled into a system with granularity.



Plant components



Heating & Cooling components



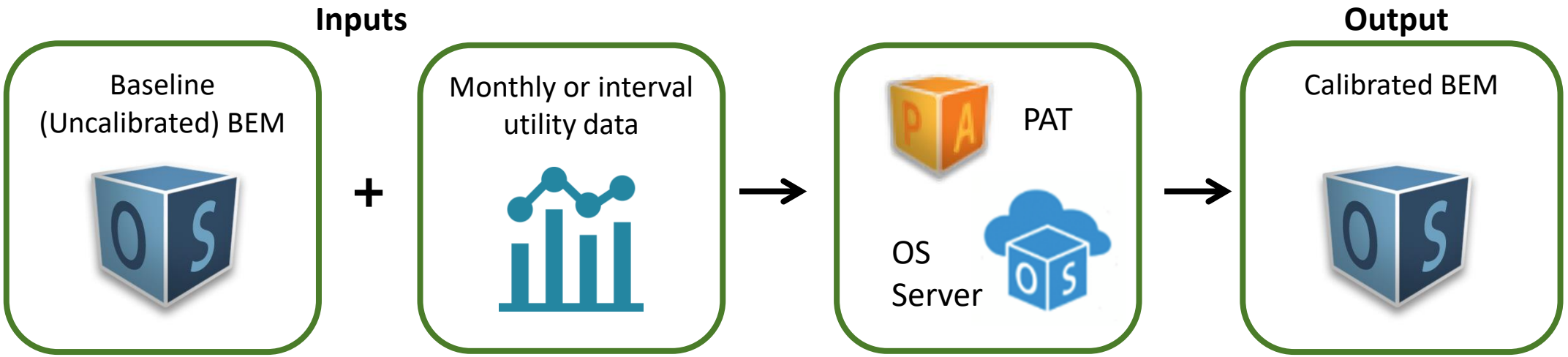
Distribution equipment

Limitations and Challenges

- Information in typical “energy audit” BSXML file isn’t 100% of what is needed to generate BEMs
  - BSXML schema has fields, but they aren’t part of DOE Audit Template inputs
  - Relying on standard efficiency values and preset construction dataset for missing data
  - Building thermal zoning and detailed association to HVAC
  - Detailed system information such as efficiency values and envelope parameters such as R-values
- Provides a whole building model with 1 thermal zone/floor, currently requires expert intervention for model refinement

Next Steps (Step 4) – Test Calibration on OS-Server

Algorithmic analysis setup with Parametric Analysis Tool (PAT), use Nondominated Sorting Genetic Algorithm 2 to calibrate energy consumption to ASHRAE Guideline 14-2014 standard for utility data



Not yet automated for a portfolio of buildings

Conclusion

- Developed an enhanced workflow to generate BEMs at scale, accounting for actual facility attributes utilizing open data sources

- Developed an improved workflow to construct HVAC systems in bottom-up fashion that accounts for individual components (plants, coils, deliveries, etc.)

- Identified the need for a more standardized schema for energy audit data (Building Sync) and building thermal zoning

Further Enhancements

- Accounting for the impact of adjacent buildings (shading)
- 3D geometry validation using iterative Grasshopper programming to ensure building shell and volume accuracy
- Develop methodology to increase capability to model thermal zones to more reasonably represent building specific layouts/space types
- Develop calibration workflow using audit specific calibration measure and OSW JSON

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Questions?