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bim2sim: A Python Framework for Automated Generation of Multi-Domain Building Simulation Models from IFC Data

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Software

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Summary

Building Information Modeling (BIM) offers comprehensive data about buildings, but transforming this information into domain-specific simulation models remains challenging. **bim2sim** addresses this gap by providing a Python framework that transforms Industry Foundation Classes (IFC) models into simulation models for multiple domains. This open-source framework implements a two-stage approach with a uniform meta-structure for IFC data extraction and domain-specific plugins for simulation model generation. The framework focuses on Building Energy Performance Simulation (BEPS) and Heating, Ventilation, and Air Conditioning (HVAC) simulations, with support for Computational Fluid Dynamics (CFD) and Life Cycle Assessment (LCA).

Statement of Need

Energy-efficient building design and operation heavily rely on BEPS, but creating these simulation models manually is time-consuming, error-prone, and requires specialized expertise. While BIM provides rich building data, direct use for simulation faces several challenges:

1. **Geometric Discrepancies**: Architectural BIM models employ geometric representations that differ from simulation requirements
2. **Semantic Gaps**: Critical simulation parameters are often missing in BIM models
3. **Topological Gaps**: HVAC simulation requires accurate component connections often missing in BIM files
4. **Data Format Incompatibilities**: Simulation domains demand specific input formats different from BIM exports

Creating simulation models manually can take days to weeks for complex buildings, creating a major bottleneck in the design process.

bim2sim addresses these needs by:

1. Automating transformation from IFC to simulation models, reducing creation time from days to under an hour
2. Providing a flexible Python framework extensible to new simulation tools
3. Supporting multiple domains through specialized plugins
4. Handling imperfect IFC data through repair algorithms
5. Maintaining OpenBIM compatibility with minimal dependencies

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The framework enables efficient incorporation of building performance simulation into workflows, supporting better-informed decisions.

Architecture and Implementation

bim2sim is implemented in Python with a two-stage architecture illustrated in Figure 1.

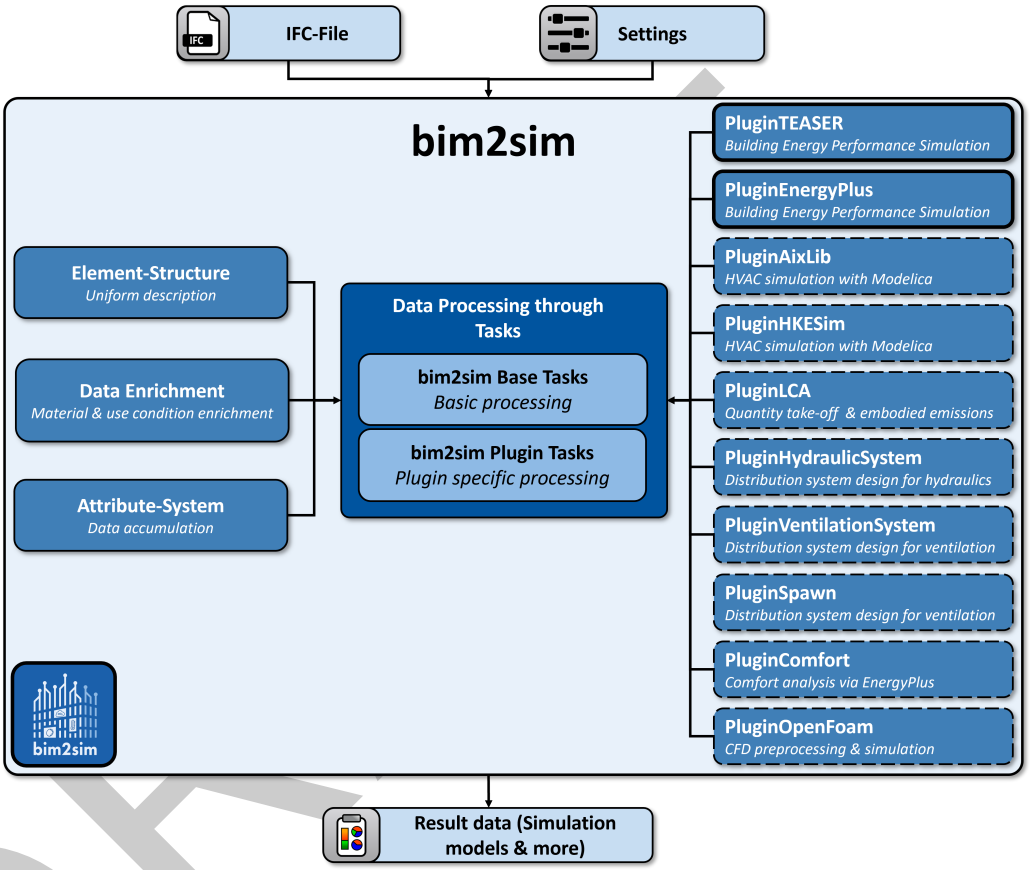

Figure 1: bim2sim framework structure and plugins. Dashed plugins are still under heavy active development.

1. **Base Framework**: Transforms IFC data into a uniform meta-structure
2. **Domain-Specific Plugins**: Convert the meta-structure into simulation-ready models

Core Components of Base Framework

- **Elements**: Domain-specific meta-structure for building component classes
- **Tasks**: Modular processing steps sequenced into workflows
- **Playground**: Task execution environment managing transformations
- **Simulation Settings**: Configuration system for customizing parameters
- **Plugins**: Domain-specific extensions for different simulation targets

Key Features

- IFC parser utilizing IfcOpenShell (Krijnen, 2018)
- Decision management for handling ambiguities
- Enrichment processes for adding missing information

- Algorithms to correct Space Boundary (SB) information
- HVAC system simplification for Modelica simulations
- Exporters for different simulation platforms

Available Plugins

bim2sim currently includes the following plugins:

1. **TEASER**: Modelica based BEPS simulation using TEASER (Remmen et al., 2018)
2. **EnergyPlus**: BEPS Simulation using EnergyPlus (Crawley et al., 2001)
3. **AixLib**: Modelica-based HVAC simulation with AixLib library (Maier et al., 2023)
4. **HKESim**: Modelica-based HVAC simulation (Modelica library itself is not public available)
5. **LCA**: Life cycle assessment via quantity takeoff
6. **Comfort**: Thermal comfort analysis using EnergyPlus

The following plugins are currently in development and exist only in feature branches, pending public release:

7. **Ventilation & Hydraulic System**: Automatic design of ventilation and hydraulic distribution systems
8. **PluginSpawn**: Dynamic coupled simulations of building and HVAC via SpawnOfEnergyPlus (Wetter et al., 2024)
9. **OpenFOAM**: CFD simulation (under development, open-source available in fall 2025)

Existing Publications on Methodology

- The methodology for **TEASER** and **EnergyPlus** plugins will be published in Jansen et al. (Jansen et al., 2025)
- Implementation of **AixLib** and **HKESim** plugins are documented in Jansen et al. (Jansen et al., 2023)
- Algorithms for handling SBs are presented in Richter et al. (V. Richter et al., 2021)
- The **Comfort** plugin framework is presented in Richter et al. (V. Richter et al., 2023) and evaluated in Richter et al. (V. E. Richter et al., 2023)
- The methodology of **OpenFOAM** plugin has been presented by Richter et al. (V. E. Richter et al., 2024) and extended by Hochberger et al. (Hochberger & Richter, 2024)

Comparison with Similar Tools

bim2sim addresses the challenge of leveraging BIM data for building energy simulations, a field with several existing approaches. In our paper (Jansen et al., 2025) (currently under review), we conducted a comprehensive analysis of these BIM-to-simulation tools. Table 1 presents an abbreviated comparative overview of these tools. The complete analysis in the to-be-published paper considers additional dimensions such as IFC version support, space and surface boundary handling, and data enrichment methods. In the abbreviated version shown here, we focus on the most important aspects: simulation domains (BEPS, HVAC), modular architecture, open-source availability, and implementation technologies.

Table 1: IFC-based approaches from related research (chronologically ordered) as analyzed in (Jansen et al., 2025). P: Partially, Y: Yes, -: No/not applicable, EP: EnergyPlus, Mod: Modelica, OS: Open-source, Mod.: Modularity, Impl.: Implementation language/framework.

Reference	Name	BEPS	HVAC	Mod.	OS	Impl.
(Bazjanac, 2008)		EP	-	Y	-	-
(O'Donnell et al., 2011)	Sim-Model	EP	-	Y	-	XML

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Reference	Name	BEPS	HVAC	Mod.	OS	Impl.
(Emira El Asmi et al., 2015)		COMETH	COMETH	-	-	-
(G. I. Giannakis et al., 2015)		EP, TRNSYS	-	-	-	Matlab
(Cao, 2018)	SimModel+	Mod	Mod	Y	-	Py, C++
(Andriamamonjy et al., 2018)	Ifc2Modelica	Mod	Mod	P	-	Py, IFC
(Nytsch-Geusen et al., 2017, 2019)	CoTeTo	Mod	-	-	Y	Py, JModelica
(G. Giannakis et al., 2019)		SimModel, EP	-	-	-	-
(Ramaji et al., 2020)	OsmSerializer	OS/EP	-	-	Y	Java
(W. Chen et al., 2021)		EP, eQuest	Y	-	-	Java
(*SIM-VICUS - NEXT LEVEL BUILDING SIMULATION*, 2023)	SIM-VICUS	Nandrad, EP	district	Y	Y	C++
(Z. Chen et al., 2023)	AutoBPS-BIM	EP	EP	-	-	-
(Mediavilla et al., 2023)		EP (not run)	-	-	-	-
bim2sim	bim2sim	EP, Mod	Mod	Y	Y	Py, IFC

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