

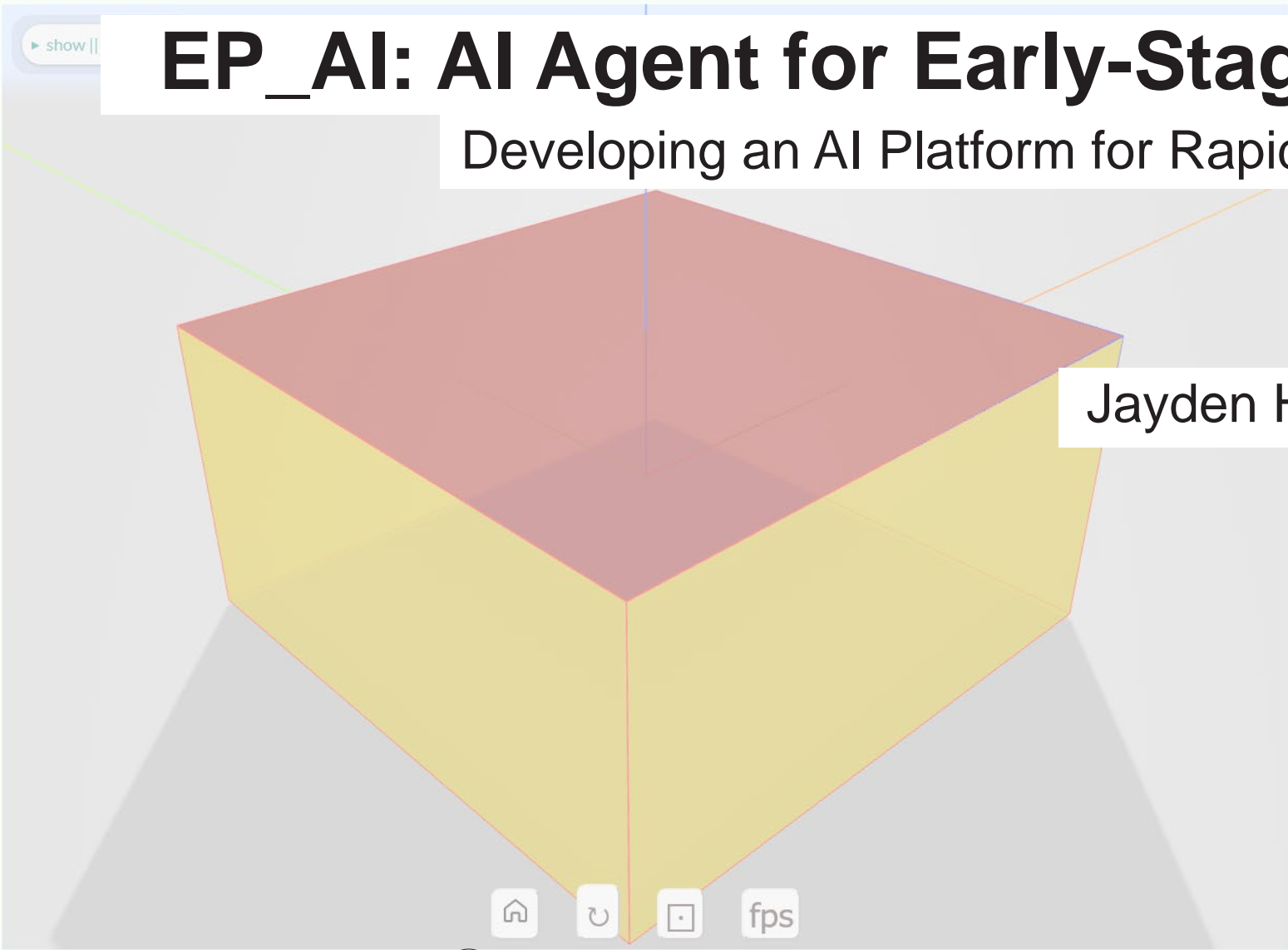
EP_AI: Submit a Prompt

Prompt: Square shaped, tall commercial building with many windows in New York, constructed with a steel frame and using a VAV chiller with PFP boxes

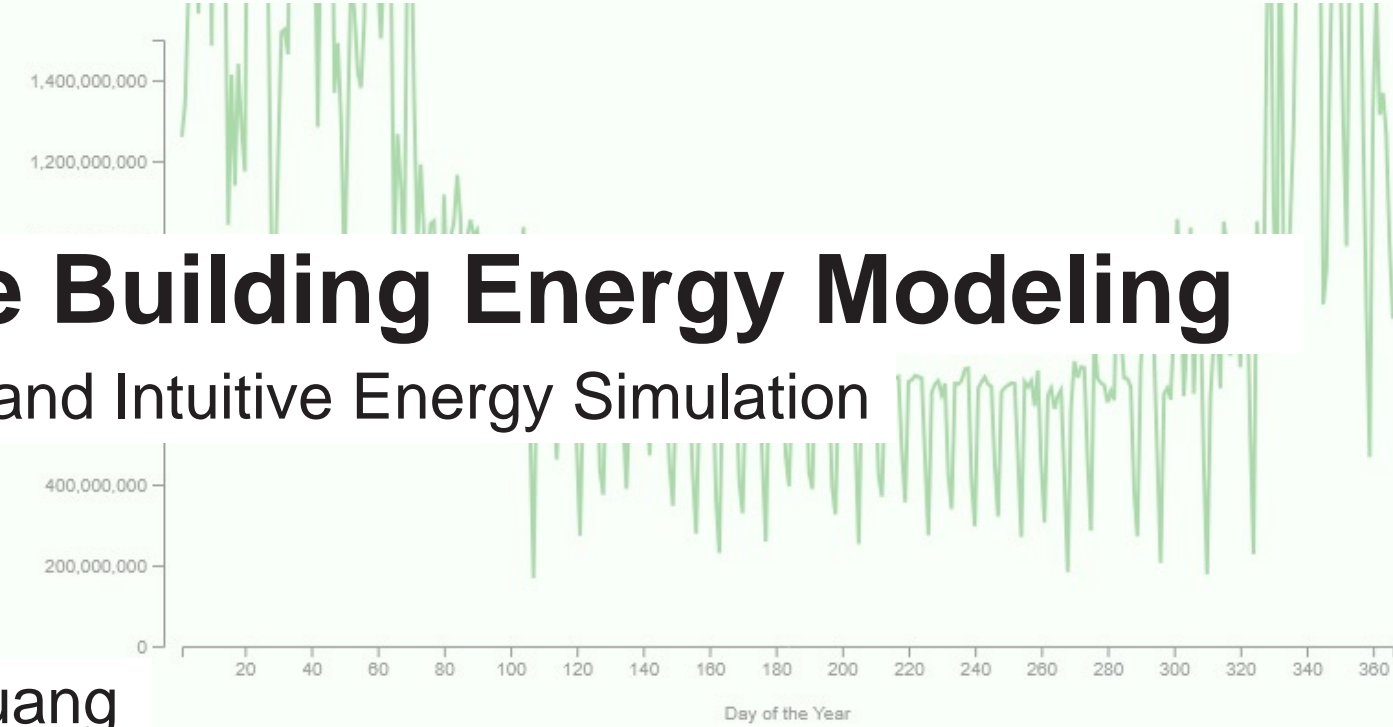
Run Simulation

Simulation completed successfully!

Model Viewer



Solution Result



EP_AI: AI Agent for Early-Stage Building Energy Modeling

Developing an AI Platform for Rapid and Intuitive Energy Simulation

Jayden Huang

Program Version:EnergyPlus, Version 23.2.0-7636e6b3e9, YMD=2025.04.28 22:15

Tabular Output Report in Format: HTML

Building: **unnamed**

Environment: RUN PERIOD 1 ** New York Laguardia Arpt NY USA TMY3 WMO#=725030

Simulation Timestamp: 2025-04-28 22:15:22

Report: **Annual Building Utility Performance Summary**

For: **Entire Facility**

Timestamp: 2025-04-28 22:15:22

Values gathered over 8760.00 hours

Site and Source Energy

	Total Energy [GJ]	Energy Per Total Building Area [MJ/m2]	Energy Per Conditioned Building Area [MJ/m2]
Total Site Energy	780.11	1950.28	1950.28
Net Site Energy	780.11	1950.28	1950.28
Total Source Energy	1550.65	3876.63	3876.63
Net Source Energy	1550.65	3876.63	3876.63

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Research Overview

Topic: AI for Early-Stage Building Energy Modeling

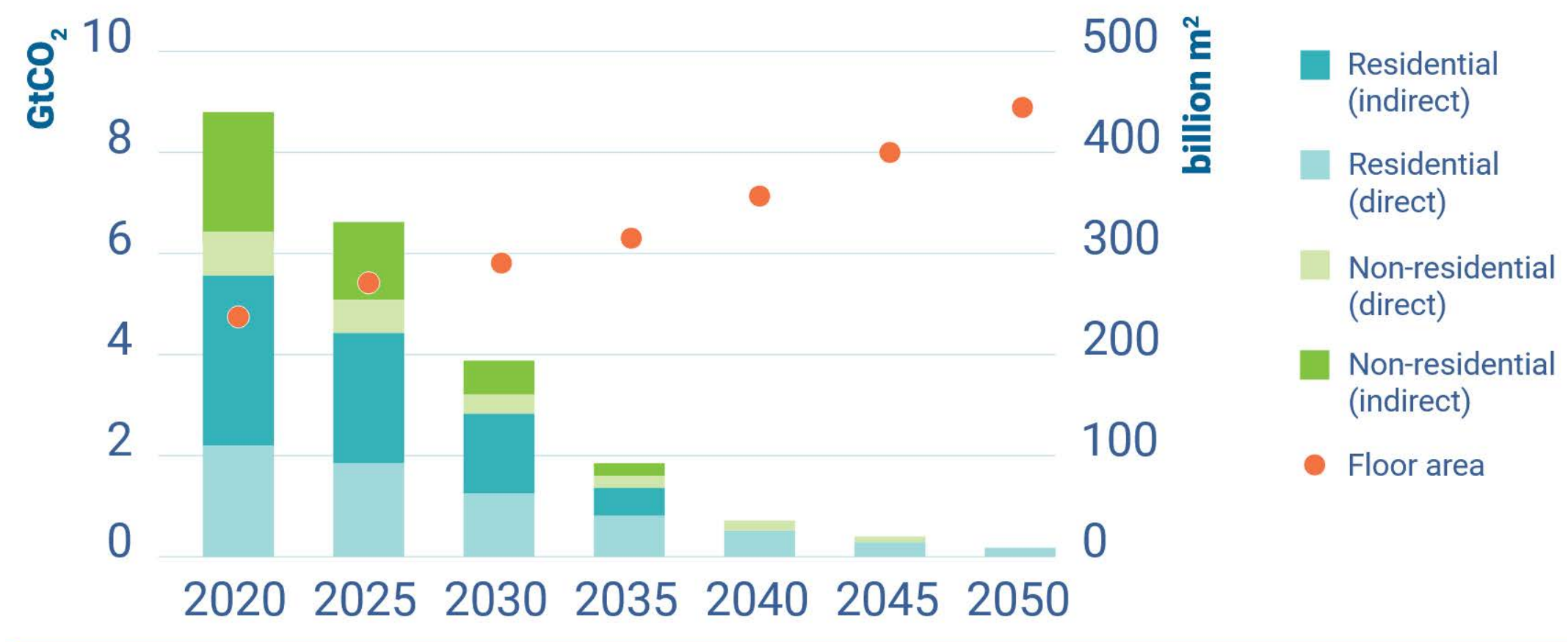
Question: How can AI reduce the complexity of energy modeling to make it more accessible?

Significance: Accessible energy modeling allows architects, engineers, and clients to make informed, energy-efficient decisions at the speed of design.

The Problem: Buildings need to reduce their energy usage

The building industry makes up for over a third of global emissions. To mitigate this, there must be radical changes in how we design and occupy buildings. Currently, operational energy of buildings accounts for 75% of building emissions, making it a major target for change.¹ Governments worldwide are setting sustainability goals to lower these values², and design tools will be required to do so.

How will we build more and use less?



Source: IEA 2021. All rights reserved. Adapted from "Tracking Clean Energy Progress" (IEA 2021c).

1: Cdb, Penrose. "2022 GLOBAL STATUS REPORT FOR BUILDINGS AND CONSTRUCTION," 2022.
2: Hoffman, Emily. "Local Law 97." NYC DOB. Accessed January 31, 2025. <https://www.nyc.gov/assets/buildings/pdf/presentations/2023bsls/ll97.pdf>.

Building Energy Modeling (BEM)

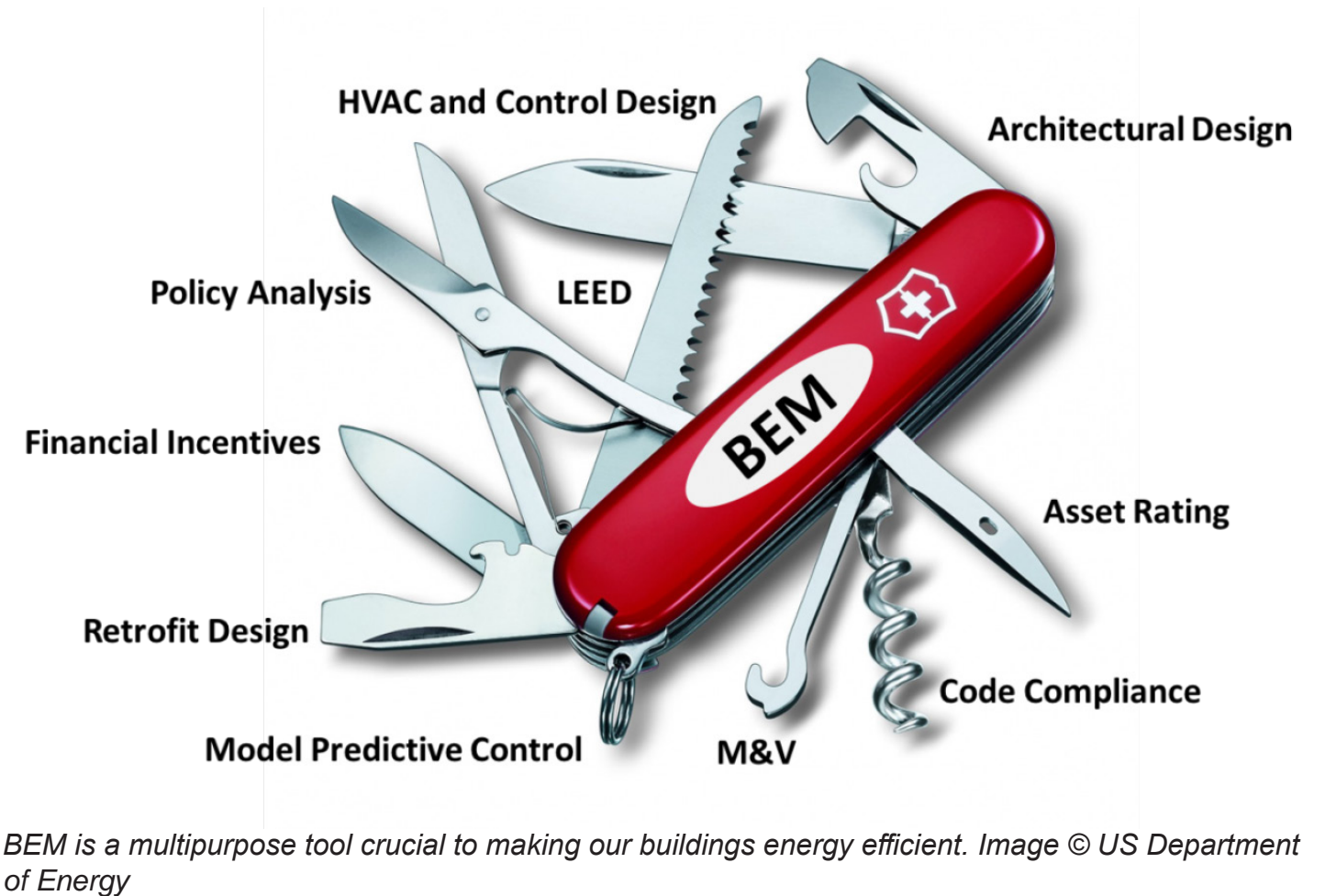
What is it?

BEM simulates a building to predict its energy use. This provides useful metrics that help inform design to be more energy conscious.¹

Why do we do it?

- Design Optimization
- Code Compliance
- Cost Reduction

As architects, we already consider these factors in the design process, building off intuition and general rules of thumb. BEM builds off of this, providing real measurement to our design sense.



1: Roth, Amir. "Building Energy Modeling." Energy.gov, August 28, 2014. <https://www.energy.gov/eere/buildings/building-energy-modeling>.

How do we energy model?

Energy modeling is predominately based on EnergyPlus, an application developed by the Department of Energy.¹ It is a powerful but complex way of simulating a building and its energy performance.

The workflow consists of four major steps:

Create Geometry: Building surfaces/window surfaces

Assign Attributes: Materials, HVAC, equipment, weather, etc.

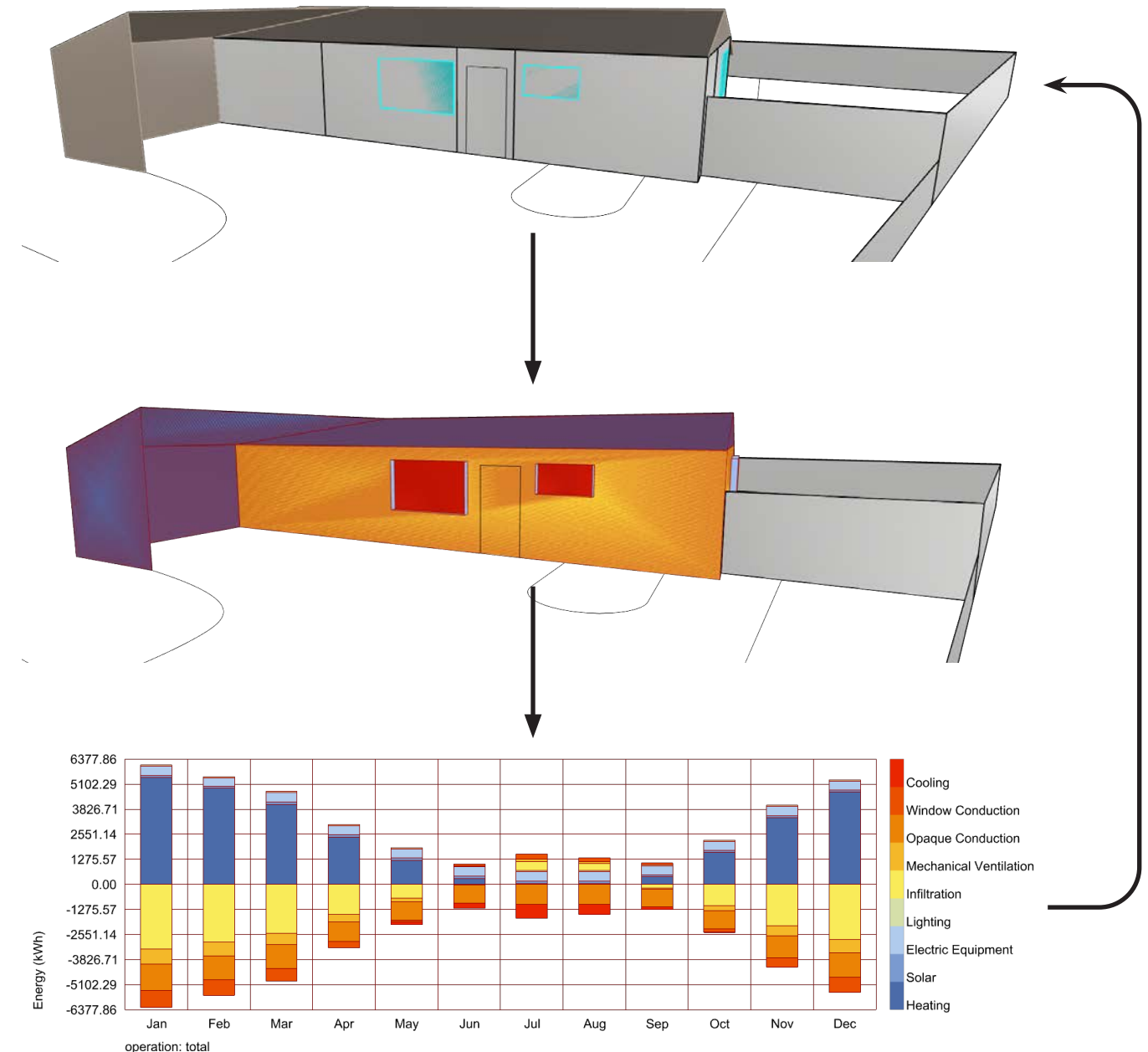
Analyze Results: Process simulation, extract relevant data

Repeat: An effective energy model is never made in one shot

Programs like Ladybug and OpenStudio provide interfaces for EnergyPlus, creating input files to be ran through the EnergyPlus calculation engine. They are easier to use and understand, and integrate readily with BIM software.

If energy modeling is an established practice, and there are tools to simplify it, what's the problem?

1: <https://www.youtube.com/watch?v=w-yVgOvcQaA&list=PLRW2KXkdSVUdY2iQ6yjohNT5E5EILVIhU>



ingProperty:Reflectance,
ngle_Family_Window_4_dfe14ae9_OutBorder0, !- Shading Surface Name
35,
35,
ing:Zone:Detailed,
ngle_Family_Window_4_dfe14ae9_OutBorder1, !- Name
om_1_a873ecb1..Face2, !- Base Surface Name

	A	B	C	D	E
1 Date/Time	Environment:Site Outdc SOUTH PERIMETER:Zone EAST PERIMETER:Zone F NORTH PERIMETER:Zo				
2 January		-4.644438844	3.036827957	1.380376344	3.03682795
3 February		-2.52358631	3.067559524	1.394345238	3.06755952
4 March		3.824327957	3.169892473	1.440860215	3.16989247
5 April		9.94625	2.891319444	1.314236111	2.89131944
6 May		15.30540995	3.169892473	1.440860215	3.16989247
7 June		21.10947917	3.138055556	1.426388889	3.13805555
8 July		24.1328461	2.931115591	1.332325269	2.93111559
9 August		21.77617608	3.169892473	1.440860215	3.16989247
10 September		18.13696181	3.028819444	1.376736111	
11 October		10.98168683	3.036827957	1.380376344	
12 November		4.73453125	3.138055556	1.426388889	
13 December		-3.681518817	2.931115591	1.332325269	

38279397324586, -6.68123886368444, 2.6, !- X,Y,Z Vertex 1 {m}
.0151367106420475, -9.10730353781098, 2.6, !- X,Y,Z Vertex 2 {m}
158153623224134, -9.20715572951726, 2.6, !- X,Y,Z Vertex 3 {m}
55608430711204, -6.78109105539072, 2.6; !- X,Y,Z Vertex 4 {m}

ingProperty:Reflectance,
ngle_Family_Window_4_dfe14ae9_OutBorder2, !- Shading Surface Name
35,
35,
C:\Users\jayde\simulation\unnamed\openstudio\run\EPTEMP-00000001>IF EXIST EPObjec
unnamed\openstudio\run\in.expidf"+EPObjecst
C:\Users\jayde\simulation\unnamed\openstudio\run\EPTEMP-00000001>IF EXIST EPObjecst.txt D
C:\Users\jayde\simulation\unnamed\openstudio\run\EPTEMP-00000001>IF EXIST "C:\Users\jayde
run\in.slab" COPY "C:\Users\jayde\simulation\unnamed\openstudio\run\in.slab" SLABSurfaceT
C:\Users\jayde\simulation\unnamed\openstudio\run\EPTEMP-00000001>IF EXIST GHTIn.idf DEL S
C:\Users\jayde\simulation\unnamed\openstudio\run\EPTEMP-00000001>IF NOT EXIST GHTIn.idf G
C:\Users\jayde\simulation\unnamed\openstudio\run\EPTEMP-00000001>IF EXIST SLABSurfaceTemp
mps.TXT in.idf /B
C:\Users\jayde\simulation\unnamed\openstudio\run\EPTEMP-00000001>IF EXIST SLABSurfaceTemp
lation\unnamed\openstudio\run\in.expidf"+SLABSurfaceTemps.TXT "C:\Users\jayde\simulation\
f" /B
C:\Users\jayde\simulation\unnamed\openstudio\run\EPTEMP-00000001>IF EXIST SLABSurfaceTemp
C:\Users\jayde\simulation\unnamed\openstudio\run\EPTEMP-00000001>"C:\EnergyPlusV24-2-0\En
EnergyPlus Starting
EnergyPlus, Version 24.2.0-94a887817b, YMD=2025.02.21 00:25

21 01/01 20: 1221822 885405.4 3099949 0 1122974 0 604248.7 0 604986.8 0 483951.4 0 630630.6 0 213067.4 0 630773.2 0 647306.2 -1007600 -796301 -1423300 -804101 -1233040 -2016900	22 01/01 21: 1221822 885405.4 3099949 0 1122974 0 604248.7 0 604986.8 0 483951.4 0 630630.6 0 213067.4 0 630773.2 0 647306.2 -1007600 -796301 -1423300 -804101 -1233040 -2016900	23 01/01 22: 1404393 608716.2 2960626 0 1123486 0 605384.4 0 606109.7 0 484375.8 0 634977.7 0 207765.5 0 636678.9 0 636278.9 -1005983 -808589 -1453403 -761889 -1165499 -1978454	24 01/01 23: 1404393 332027 2472993 0 1155032 0 621209.9 0 622179.5 0 497059.2 0 665982.9 0 216462.2 0 663423.6 0 658617.6 -984671 -795437 -1430088 -764758 -1005137 -1963299	25 01/01 24: 1404393 138344.6 2020192 0 1174789 0 628766.3 0 629998.3 0 503129 0 684254.2 0 221832 0 680899.2 0 677108.9 -983700 -800159 -1438002 -780210 -863223 -1979758	26 01/02 01: 1404393 55337.84 1567390 0 1240243 0 663321.9 0 664622.7 0 530779.9 0 722118.4 0 234030.3 0 718557.9 0 714389.9 -985391 -808882 -1450337 -795998 -705177 -2021729	27 01/02 02: 1404393 55337.84 1428066 0 1257210 0 673747.9 0 675019.2 0 539118 0 730897.2 0 237118 0 727444.4 0 723493.2 -1019722 -844344 -1511885 -835766 -624576 -2112003	28 01/02 03: 1404393 55337.84 1384050 0 1251258 0 670556.7 0 671836.9 0 536565.8 0 727840.1 0 236128.1 0 724386.6 0 720700.7 -1052566 -875127 -1565869 -869442 -601051 -2105074	29 01/02 04: 1404393 55337.84 1323574 0 1232542 0 660324.4 0 661542.7 0 528374.2 0 715909 0 232291.3 0 712651.5 0 707968.8 -1073748 -895040 -1600716 -891710 -599957 -2108534	30 01/02 05: 1404393 166013.5 1323574 0 1177621 0 633458.2 0 634506.9 0 506865.2 0 680707.5 0 221308.7 0 677983.5 0 674127.3 -1096277 -914176 -1635292 -912726 -675454 -2059131	31 01/02 06: 1404393 359695.9 1497728 0 1148984 0 618893.7 0 619874.8 0 495207.3 0 661506 0 214836.7 0 657829.5 0 656698.9 -1100575 -913927 -1636544 -914127 -802992 -1969770	32 01/02 07: 1404393 387364.9 1880868 0 1116258 0 602065 0 602909.1 0 481731.5 0 641459.8 0 208895.4 0 634429.9 0 634475.2 -1084818 -896900 -1608288 -898274 -922643 -1934373
--	--	--	---	--	--	---	---	---	---	---	---

Class List

W\allInterzone

Floor

CeilingAdiabatic

CeilingInterzone

FloorGroundContact

FloorAdiabatic

FloorInterzone

0.0001 ExternalSurfaceDetailed

Window

Door

GlazedDoor

WindowInterzone

DoorInterzone

GlazedDoorInterzone

WindowShadingControl

WindowPropertyFrameAndDivider

WindowPropertyAirflowControl

WindowPropertyStormWindow

Comments from IDF

Explanation of Object and Current Field

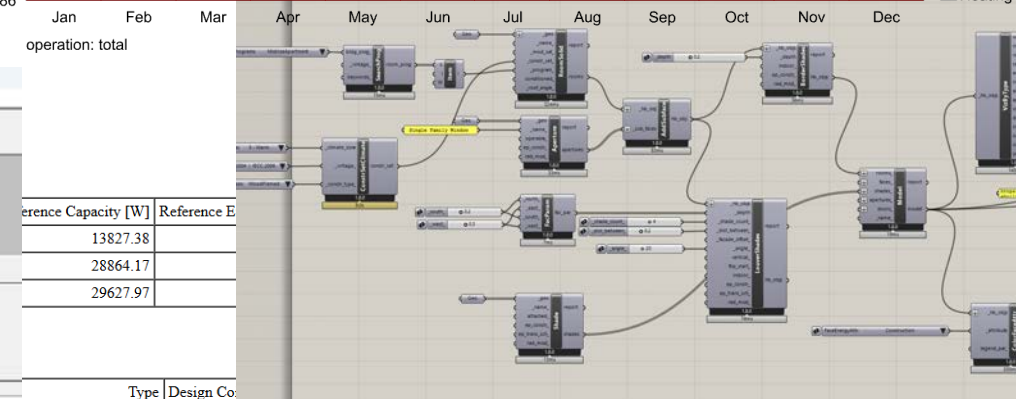
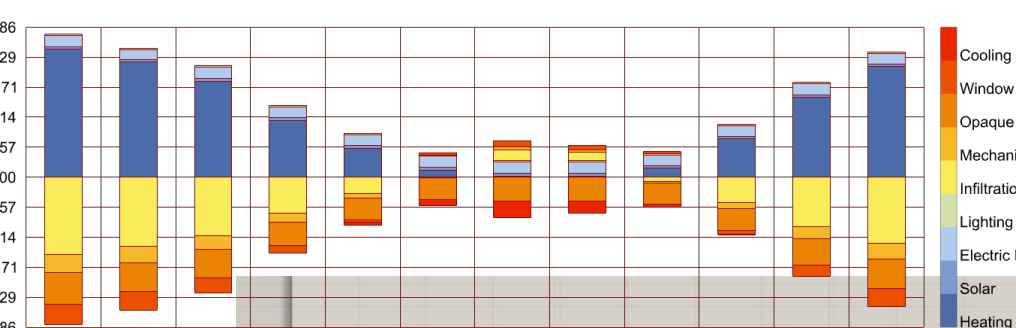
Object Description: Allows for detailed entry of sub-surfaces (windows, doors, glass doors, tubular daylighting devices).

Field Description: ID: A1 Enter an alphanumeric value This field is required.

Field	Units	Obj1	Obj2	Obj3	Obj4	Obj5	Obj6
Name		W/F-1	D/F-1	W/B-1	W/B-1	D/B-1	W/L-1

OVERLOAD

Vertex 4 X-coordinate	m	16.8	23.8	30.5	13.7	7	0
Vertex 4 Y-coordinate	m	0	0	11.4	15.2	15.2	3.0
Vertex 4 Z-coordinate	m	2.1	2.4	2.1	2.1	2.1	2.1
2/19/2025 1:02 PM	ESO File	6,393 KB					
2/19/2025 1:02 PM	MDD File	8 KB					
2/19/2025 1:02 PM	MTD File	15 KB					
2/19/2025 1:02 PM	RDD File	50 KB					
2/19/2025 1:02 PM	SHD File	49 KB					
2/19/2025 1:02 PM	SQL Source File	7,572 KB					
2/19/2025 1:02 PM	Microsoft Edge H...	503 KB					
2/19/2025 1:02 PM	Microsoft Excel C...	33 KB					
2/19/2025 1:02 PM	Task Scheduler Ta...	1 KB					
2/19/2025 1:04 PM	AUDIT File	2 KB					
2/19/2025 1:02 PM	Windows Batch File	1 KB					
2/19/2025 1:04 PM	BND File	10 KB					
2/19/2025 1:04 PM	Microsoft Excel C...	4,506 KB					
2/19/2025 1:04 PM	EIO File	26 KB					
2/19/2025 1:04 PM	ERR File	9 KB					
2/19/2025 1:04 PM	ESO File	6,243 KB					



ingling-Water	28864.17	31422.48	20775.70	10646.78
ngleSpeed		6752.09	4733.78	2018.31
supply air fan heat and electric power NOT accounted for.				
il Type [1]	Standard Rating Net Cooling Capacity [W][2]	Standard Rating Net COP [W/W][2]	EER [Btu/W-h][2]	SEER User [Btu/W-h][2,3]
ngleSpeed	6540.7	2.66	9.07	9.63
electric power.				
d as per AHRI Standard 210/240-2017.				
Btu/hv (39565 W) - calculated as per AHRI Standard 340/360-2007.				
Btu/hr (73268 W) - calculated as per AHRI Standard 365-2009 - Ratings not yet supported in EnergyPlus.				

DX Cooling Coil Standard Ratings 2023

	Cooling Coil Type [1]	Standard Rating Net Cooling Capacity [W][2]	Standard Rating Net COP2 [W/W][2,4]	EER2 [Btu/W-h][2,4]	SEER2 User [Btu/W-h]
AIRHANDLE COOLING COIL	Coil:Cooling-DX:SingleSpeed	6496.9	2.59	8.85	

ANSI/AHRI ratings account for supply air fan heat and electric power.

1 - EnergyPlus object type.

2 - Capacity less than 65K Btu/h (19050 W) - calculated as per AHRI Standard 210/240-2023.

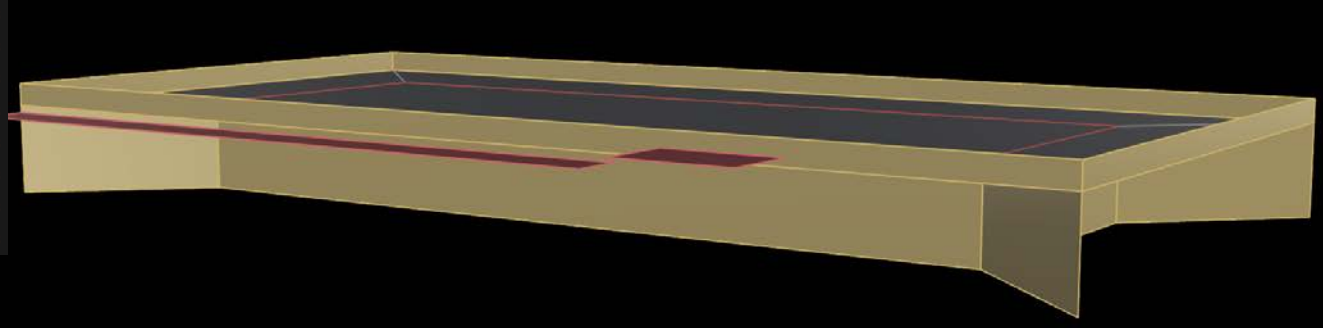
Capacity of 65K Btu/h (19050 W) to less than 135K Btu/h (39565 W) - calculated as per AHRI Standard 340/360-2022.

Capacity from 135K (39565 W) to 250K Btu/hr (73268 W) - calculated as per AHRI Standard 365-2009 - Ratings not yet supported in EnergyPlus.

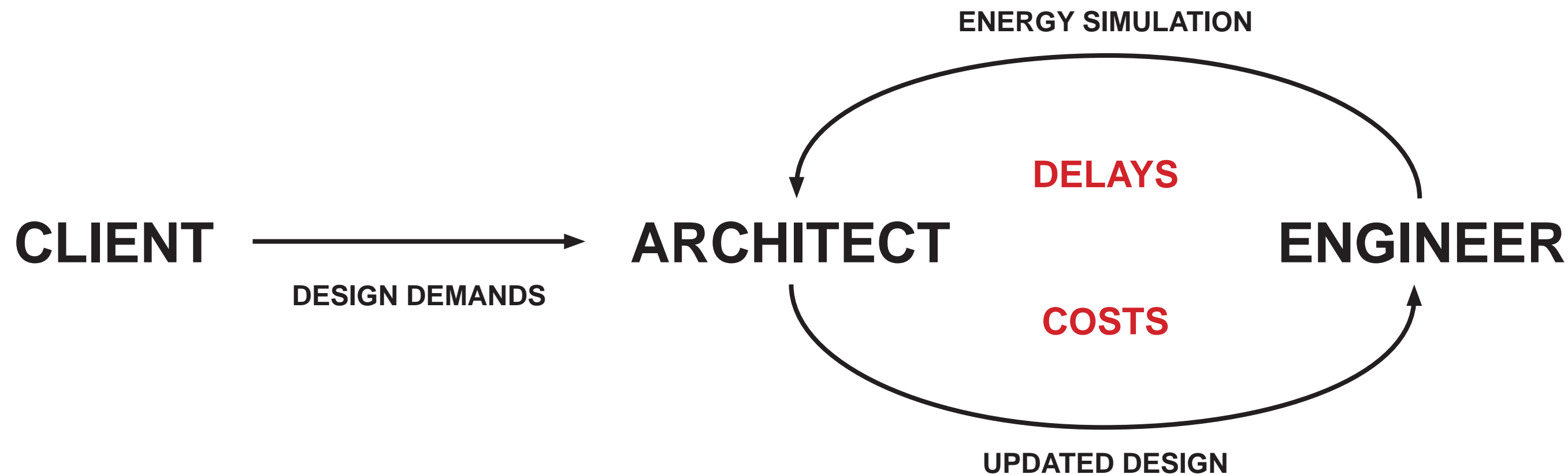
3 - SEER2 (User) is calculated using user-input PLF curve and cooling coefficient of degradation.

SEER2 (Standard) is calculated using the default PLF curve and cooling coefficient of degradationfrom the appropriate AHRI standard.

4 - Value for the Full Speed of the coil.



BEM in Practice



Due to complexity, BEM is typically outsourced to specialists. The added costs and delays limit BEM to projects with specific energy targets, rather than being employed more broadly.¹

1: Credit, Kevin, Qian Xiao, Jack Lehane, Juan Vazquez, Dan Liu, and Leo De Figueiredo. "LuminLab: An AI-Powered Building Retrofit and Energy Modelling Platform." arXiv, April 14, 2024. <https://doi.org/10.48550/arXiv.2404.16057>.

Finding a Research Problem

Buildings account for 30% of global energy use, resulting in high carbon emissions.¹



Energy modeling can help address this, yet remains underutilized.² The workflow relies on complex software and script-based tools, resulting in high costs and low accessibility.³



How do we simplify energy modeling?

1: Delmastro, Chiara, and Olivia Chen. "Buildings - Energy System." IEA. Accessed February 21, 2025. <https://www.iea.org/energy-system/buildings#tracking>.

2: Roth, Amir. "Building Energy Modeling." Energy.gov, August 28, 2014. <https://www.energy.gov/eere/buildings/building-energy-modeling>.

3: Credit, Kevin, Qian Xiao, Jack Lehane, Juan Vazquez, Dan Liu, and Leo De Figueiredo. "LuminLab: An AI-Powered Building Retrofit and Energy Modelling Platform." arXiv, April 14, 2024. <https://doi.org/10.48550/arXiv.2404.16057>.

State of the Art

EnergyPlus remains at the heart of energy modeling for its reputation as a reliable, proven energy calculator. Simplifying energy modeling involves alternate methods of generating inputs for calculation.

Ladybug and OpenStudio: Existing, industry-standard methods for energy modeling.

Benefits: Programming-oriented interface of EnergyPlus is replaced with visual workflows that integrate directly with BIM software.

Drawbacks: Remains manually-intensive, requires expertise in buildings and energy systems.

EPlus-LLM: User-friendly AI interface that translates human input into files for simulation and output of results.¹

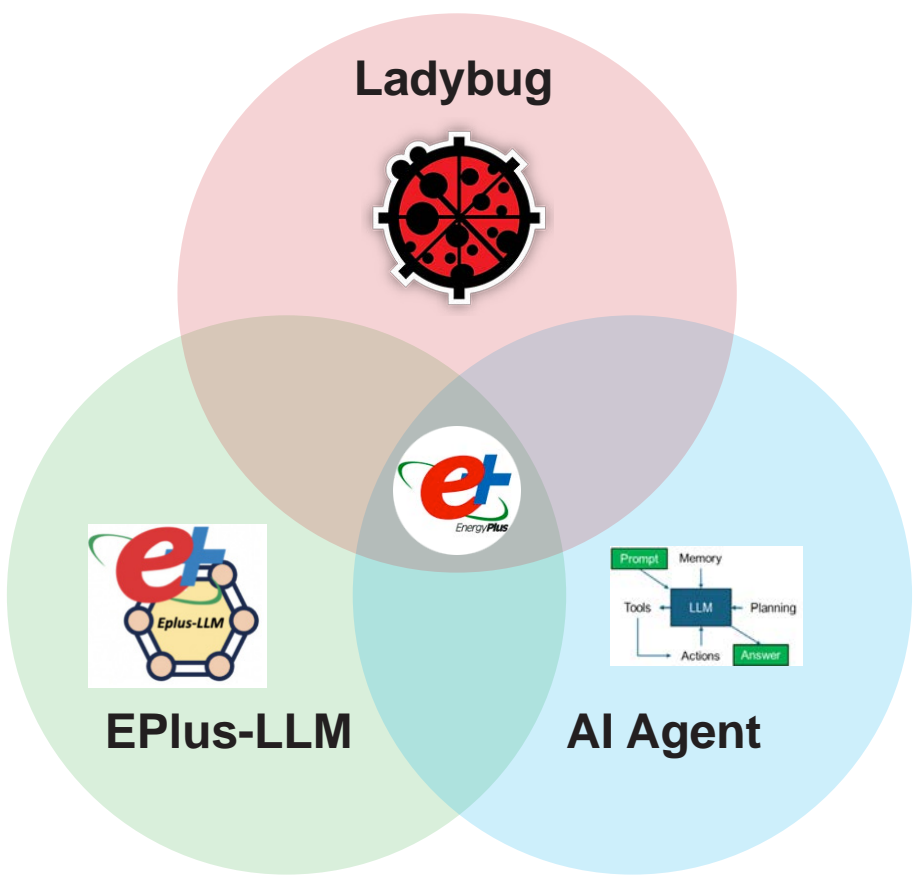
Benefits: Works with natural language, **opening energy modeling to non-energy professionals.**

Drawbacks: Limited prompt types don't allow for quick iteration.

Agentic Workflow: Agentic AI (structured decision-making and reasoning) creates IDF files and debugs them through a routine of sub-steps.²

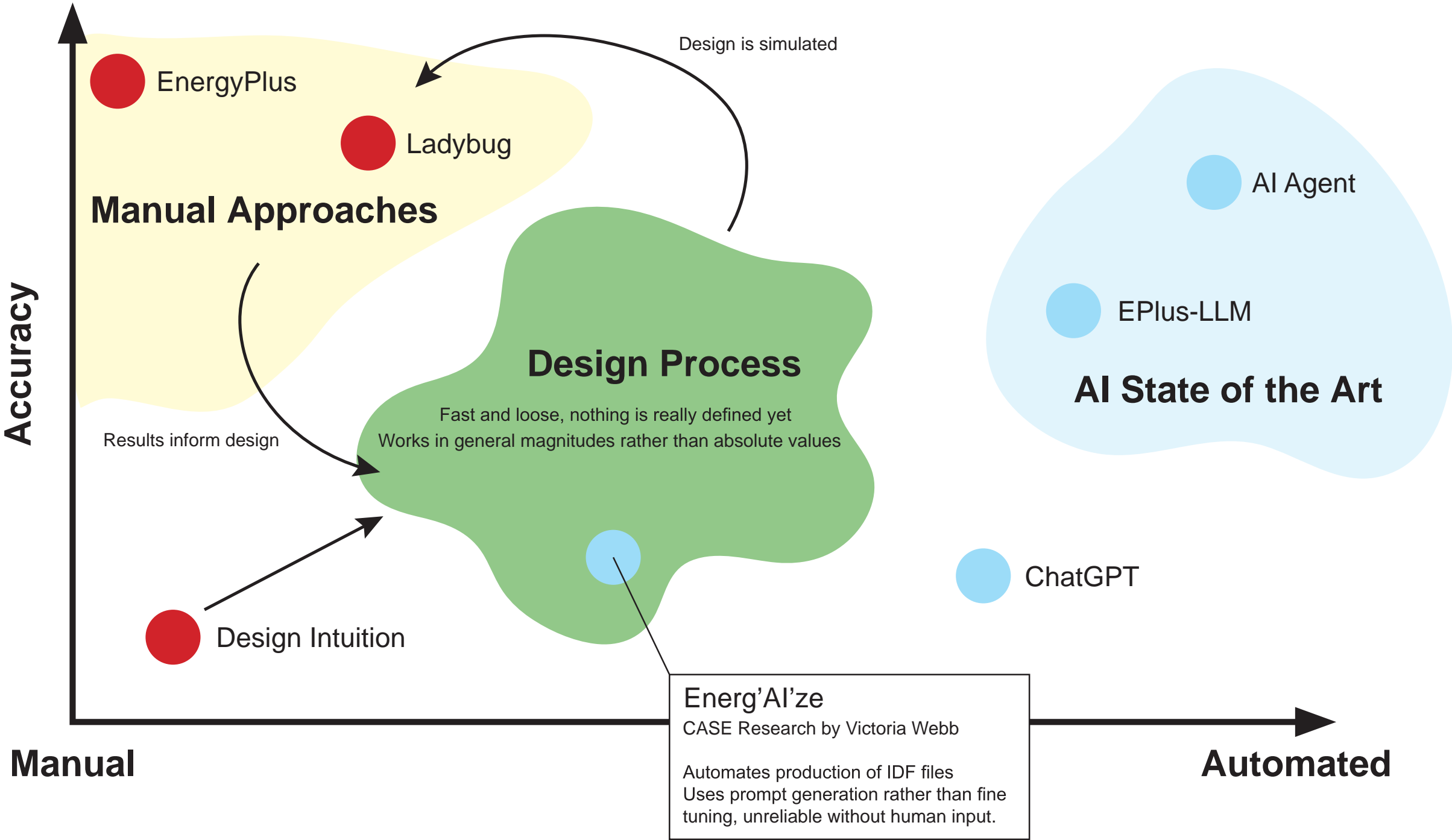
Benefits: Follows a sequence of logic to produce highly accurate models.

Drawbacks: Relies on iterative processes that are expensive and resource-intensive.



1: Jiang, Gang, Zhihao Ma, Liang Zhang, and Jianli Chen. "EPlus-LLM: A Large Language Model-Based Computing Platform for Automated Building Energy Modeling." Applied Energy 367 (August 1, 2024): 123431. <https://doi.org/10.1016/j.apenergy.2024.123431>.
2: Zhang, Liang, Vitaly Ford, Zhelun Chen, and Jianli Chen. "Automatic Building Energy Model Development and Debugging Using Large Language Models Agentic Workflow." Energy and Buildings 327 (January 15, 2025): 115116. <https://doi.org/10.1016/j.enbuild.2024.115116>.

The Gap



Research Hypothesis

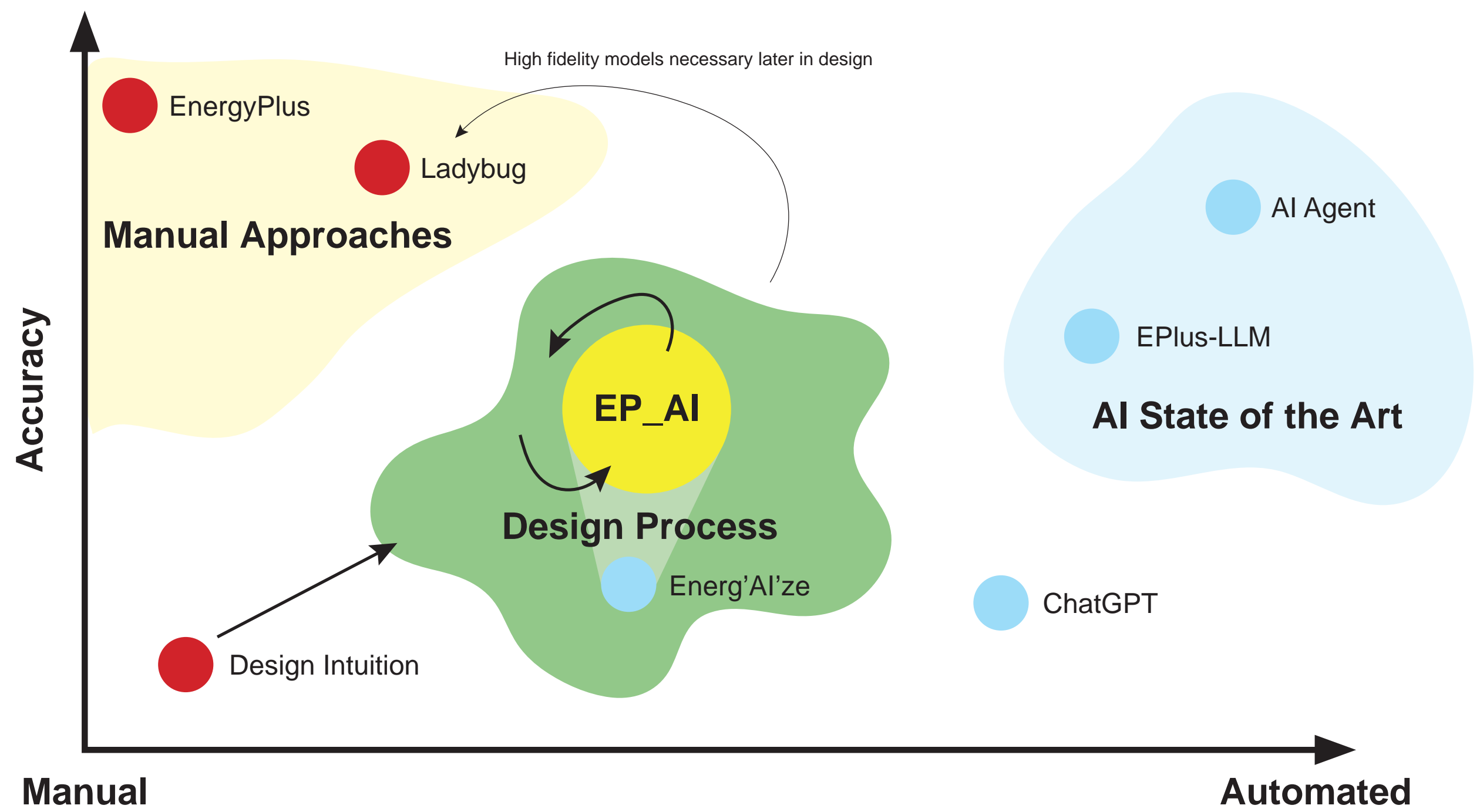
BEM allows architects and engineers to simulate performance and modify design.

BEM workflows are costly and time-consuming, requiring specialized knowledge and complex, manual processes. In practice, this requires outsourcing to specialists, adding costs and delays.

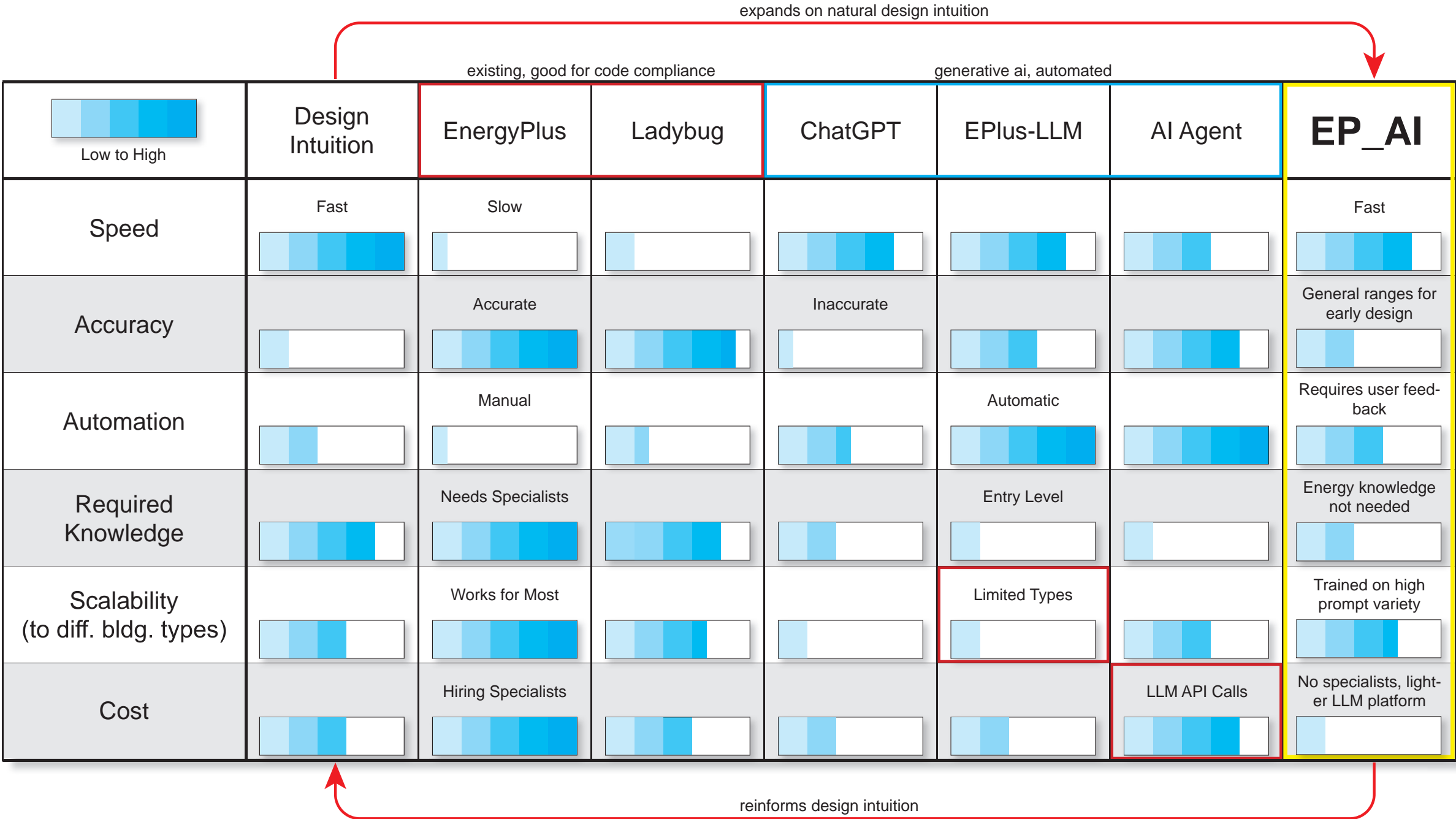
Current research like EPlus-LLM or agentic workflows, involve large language models (LLMs) to automate BEM, reducing the barrier to entry as fast, accessible, and comparatively accurate alternatives. However, these projects **prioritize reliability and accuracy, requiring a degree of specificity and heavy computation that are excessive for loose, early-stage design applications.**

If an AI is instead trained on a broader range of data, then it can perform as a design tool to match the speed of design and its fluidity.

Bridging The Gap



Where does this research stand?



EP_AI: Submit a Prompt

Prompt:

high rise T shaped building in arizona with few windows

Simulation completed successfully

“High rise T shaped building in Arizona with few windows”

Model Viewer

show || hide menu

Spider IDF Viewer v-2020-10-09

file menu

data menu

Home

Refresh

Fullscreen

fps

Solution Result

Phoenix Sky Harbor Intl Ap, AZ, USA

☒ Select All

☒ GENVOL_7326A5C0:Zone Lights Electricity Energy [J](Daily)

☒ GENVOL_7326A5C0:Zone Electric Equipment Electricity Energy [J](Daily)

☒ Whole Building:Facility Net Purchased Electricity Energy [J](Daily)

☒ Whole Building:Facility Total Produced Electricity Energy [J](Daily)

☒ 1 ZONE VAV FAN:Fan Electricity Energy [J](Daily)

☒ 90.1-2019 WATERCOOLED ROTARY SCREW CHILLER 0 25TONS 0.8KW/TON:Chiller Electricity Energy [J](Daily)

☒ PROPELLER OR AXIAL VARIABLE SPEED FAN OPEN COOLING TOWER 40.2 GPM/HP:Cooling Tower Fan Electricity Energy [J](Daily)

☒ 90.1-2019 BOILER 359KBTU/HR 0.8 THERMAL EFF:Boiler NaturalGas Energy [J](Daily)

☒ CHILLED WATER LOOP SECONDARY PUMP:Pump Electricity Energy [J](Daily)

☒ HOT WATER LOOP PUMP:Pump Electricity Energy [J](Daily)

☒ CHILLED WATER LOOP PRIMARY PUMP:Pump Electricity Energy [J](Daily)

☒ CONDENSER WATER LOOP CONSTANT PUMP:Pump Electricity Energy [J](Daily)

Environment: PHOENIX SKY HARBOR INTL AP ANN HUM_N 99.6% CONDNS DP=>MCDB HVAC Sizing Pass 1 ** Phoenix Sky Harbor Intl Ap AZ USA TMY3 WMO#=722780

Simulation Timestamp: 2025-04-30 12:20:07

Report: Annual Building Utility Performance Summary

For: Entire Facility

Timestamp: 2025-04-30 12:20:07

Values gathered over 8760.00 hours

Table of Contents

Site and Source Energy

	Total Energy [GJ]	Energy Per Total Building Area [MJ/m2]	Energy Per Conditioned Building Area [MJ/m2]
Total Site Energy	358.78	896.95	896.95
Net Site Energy	358.78	896.95	896.95
Total Source Energy	1025.05	2562.61	2562.61
Net Source Energy	1025.05	2562.61	2562.61

Site to Source Energy Conversion Factors

Site=>Source Conversion Factor

EP_AI: Submit a Prompt

Prompt:

high rise T shaped building in arizona with few windows with VAV air-cooled chiller with central air source heat pump reheat

Simulation completed successfully

“High rise T shaped building in Arizona with few windows with VAV air-cooled chiller with central air source heat pump reheat”

Model Viewer

show || hide menu

Spider IDF Viewer v-2020-10-09

file menu

data menu

Home

Refresh

Fullscreen

fps

Solution Result

☒ Select All

☒ GENVOL_D06C55DA:Zone Lights Electricity Energy [J](Daily)

☒ GENVOL_D06C55DA:Zone Electric Equipment Electricity Energy [J](Daily)

☒ EMS:Hot_Water_Loop_Central_Air_Source_Heat_Pump Electricity Consumption [J](Daily)

☒ Whole Building:Facility Net Purchased Electricity Energy [J](Daily)

☒ Whole Building:Facility Total Produced Electricity Energy [J](Daily)

☒ 1_ZONE VAV FAN:Fan Electricity Energy [J](Daily)

☒ 90.1-2019 CHILLER 0 25TONS 1.2KW/TON:Chiller Electricity Energy [J](Daily)

☒ CHILLED WATER LOOP PUMP:Pump Electricity Energy [J](Daily)

☒ HOT WATER LOOP PUMP:Pump Electricity Energy [J](Daily)

Environment: RUN PERIOD 1 ** Phoenix Sky Harbor Intl Ap AZ USA TMY3 WMO#=722780

Simulation Timestamp: 2025-04-30 12:34:44

Report: Annual Building Utility Performance Summary [Table of Contents](#)

For: Entire Facility

Timestamp: 2025-04-30 12:34:44

Values gathered over 8760.00 hours

Site and Source Energy

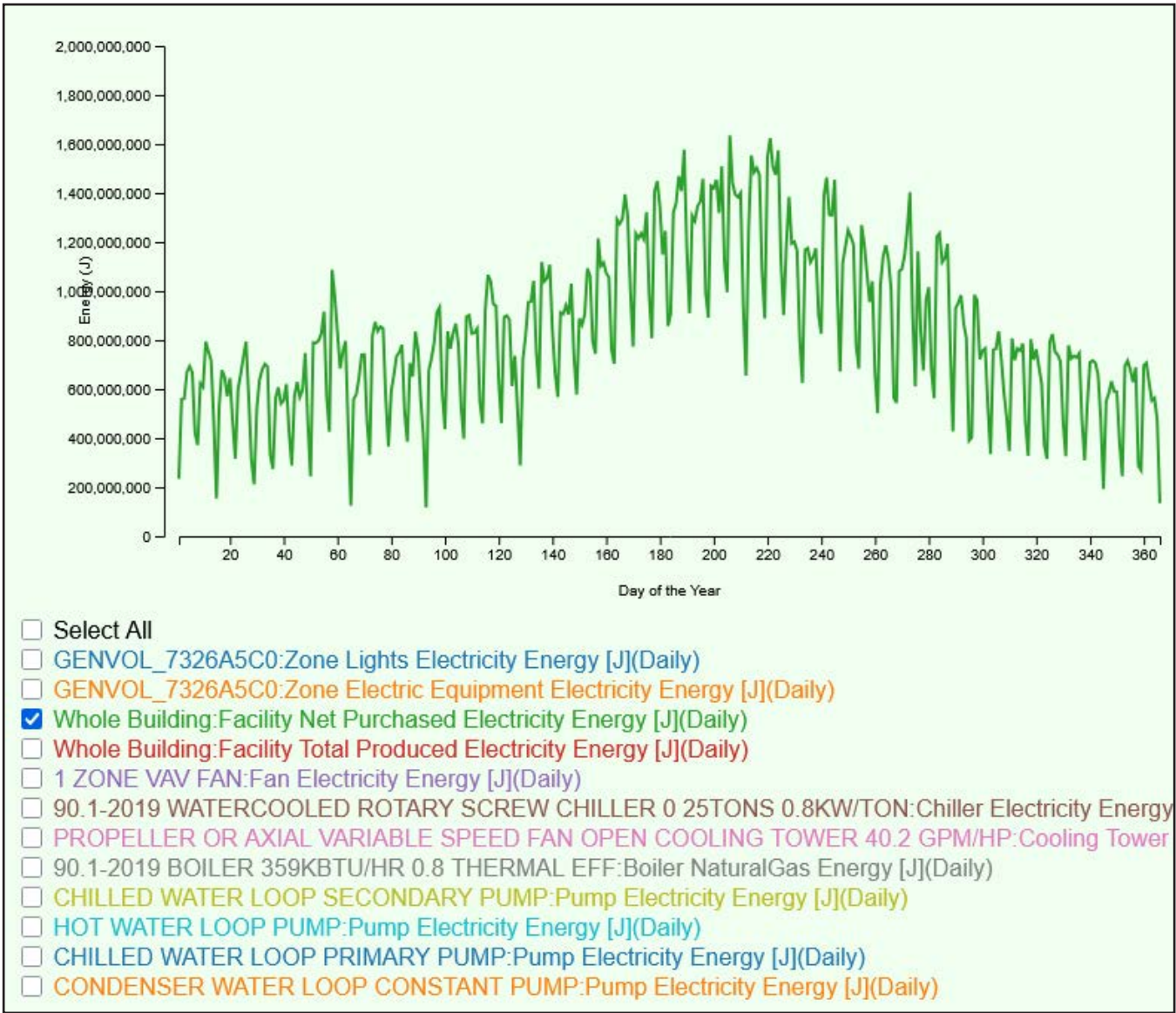
	Total Energy [GJ]	Energy Per Total Building Area [MJ/m2]	Energy Per Conditioned Building Area [MJ/m2]
Total Site Energy	341.91	854.77	854.77
Net Site Energy	341.91	854.77	854.77
Total Source Energy	1082.82	2707.06	2707.06
Net Source Energy	1082.82	2707.06	2707.06

Site to Source Energy Conversion Factors

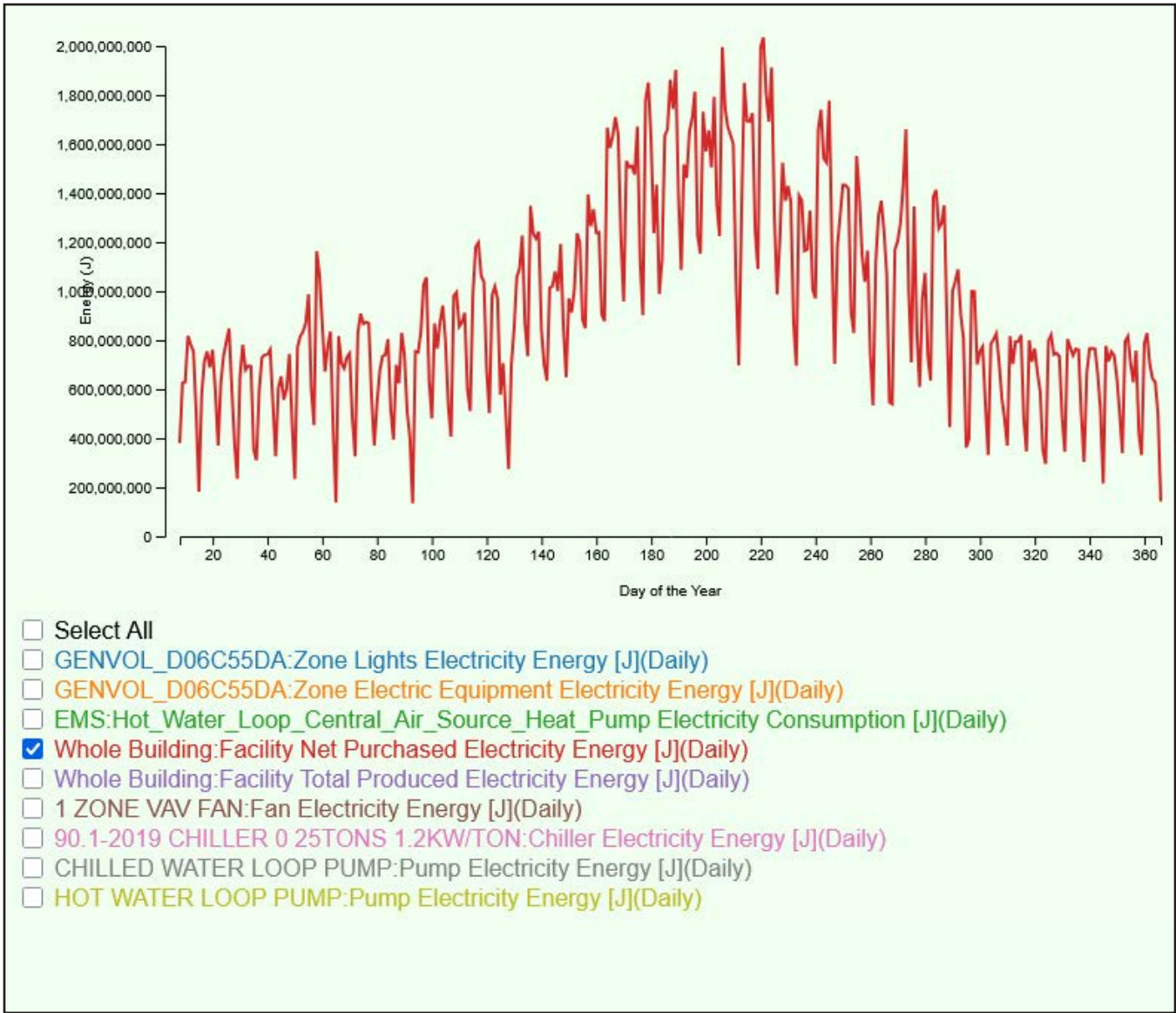
	Site=>Source Conversion Factor
Electricity	3.167

EP_AI contd.

Rapid iteration allows the user to quickly visualize what effect design changes can have on energy consumption.

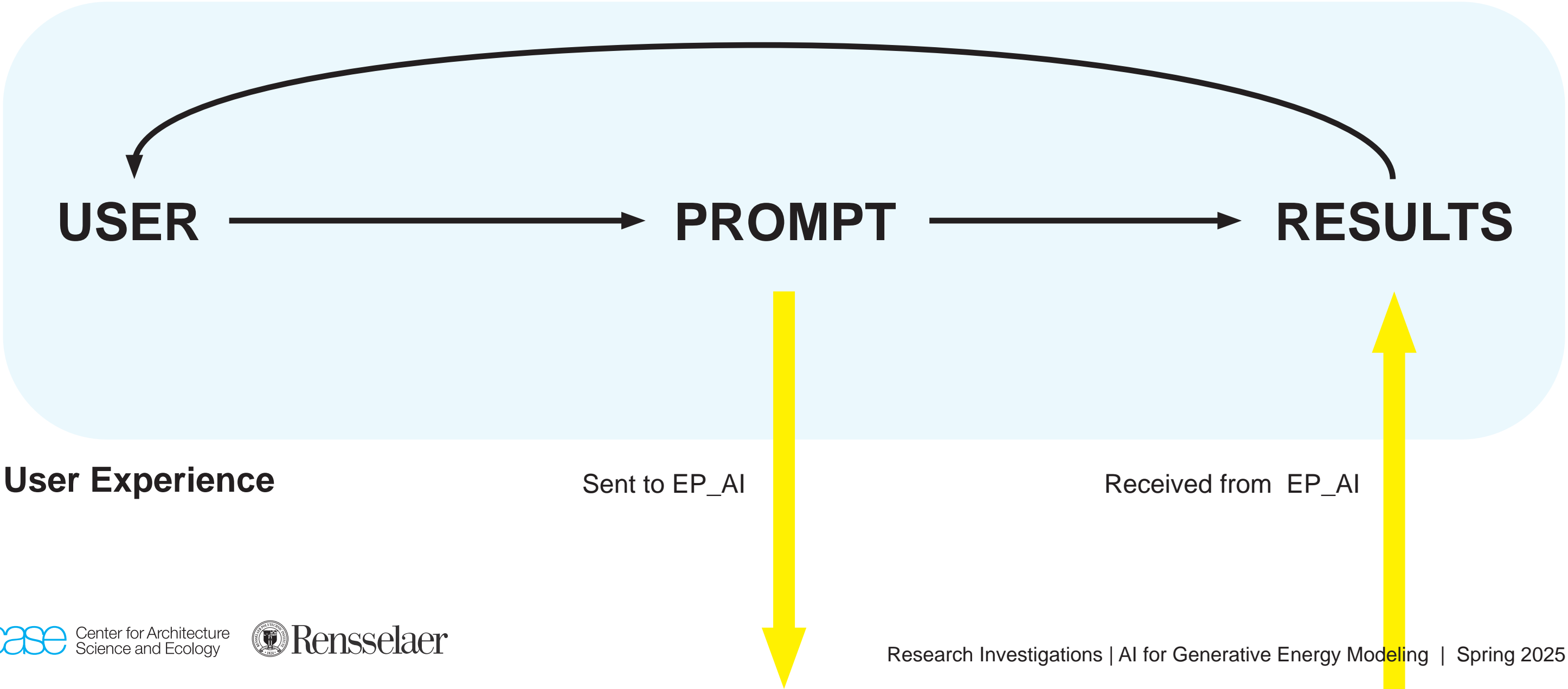


Example 1 (standard gas boiler)

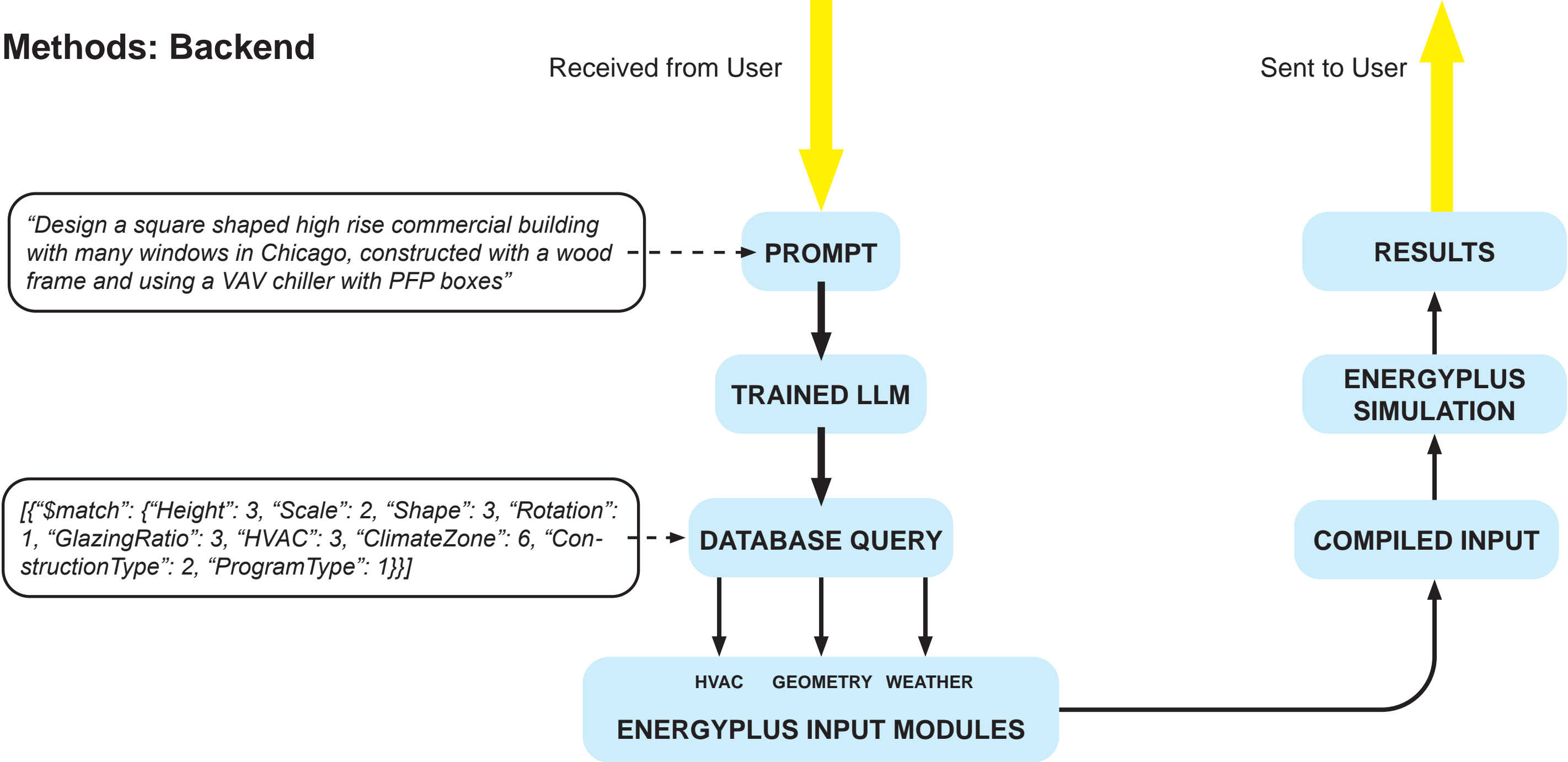


Example 2 (VAV chiller with central air heat pump)

Methods: Frontend

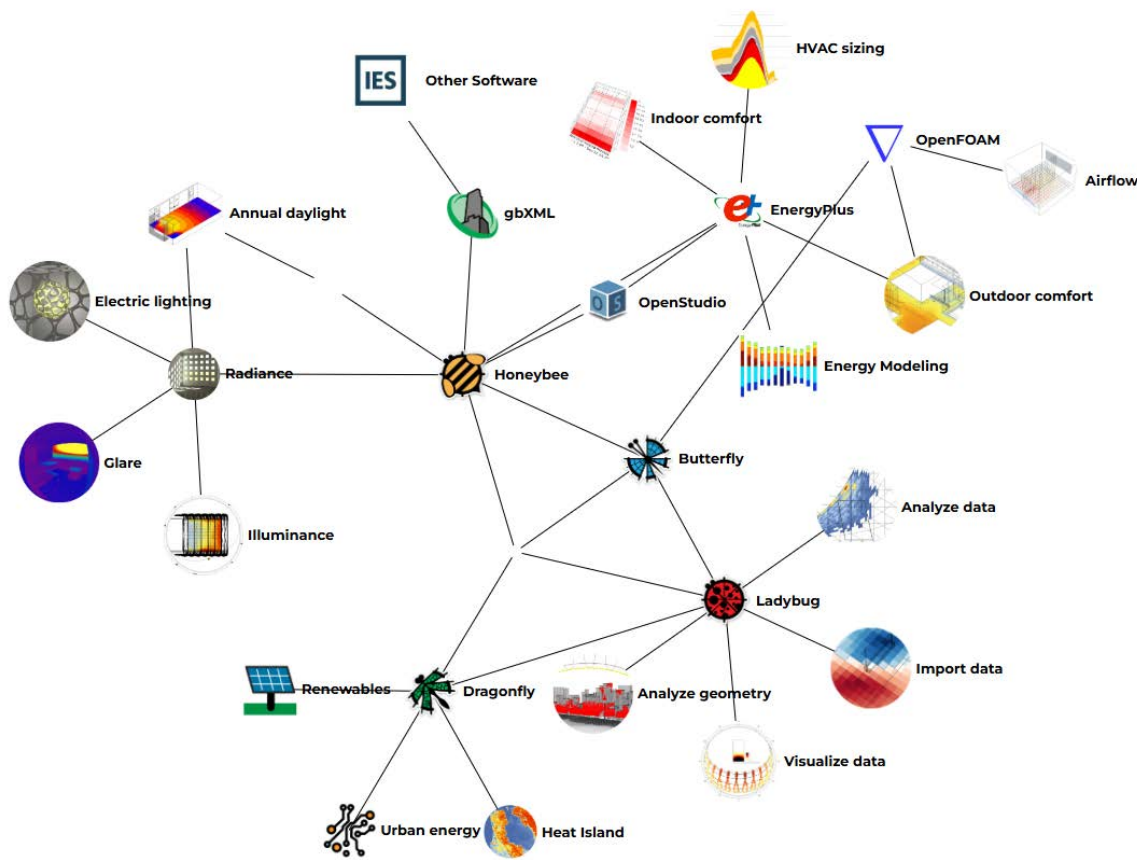


Methods: Backend

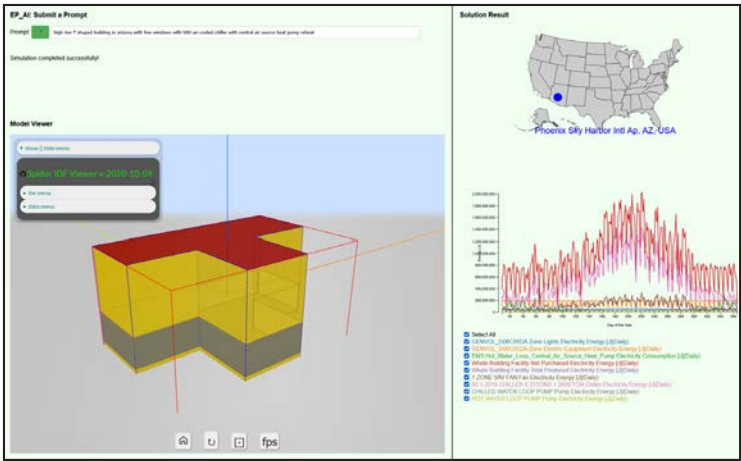
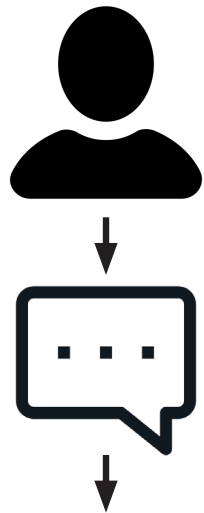


Why does this matter?

The user experience is simplified from the chaos of creating an energy model to a simple prompt-result interaction. By accelerating and simplifying a typically hours-long process, non-energy professionals have the opportunity to practice energy-conscious decision making.



NORMATIVE



PROPOSED

Conclusion and Looking Ahead

Buildings account for 30% of global energy use, resulting in high carbon emissions. Energy modeling can help design more efficient buildings that use less energy, but is underutilized due to complexity.

By simplifying building energy modeling,

- It can be done faster and earlier in the design process
- Non-professionals have access to it

This project uses AI to accelerate BEM by translating descriptive design language into performance-oriented results, allowing energy modeling to be not just a late-stage compliance check, but an early-stage design driver.