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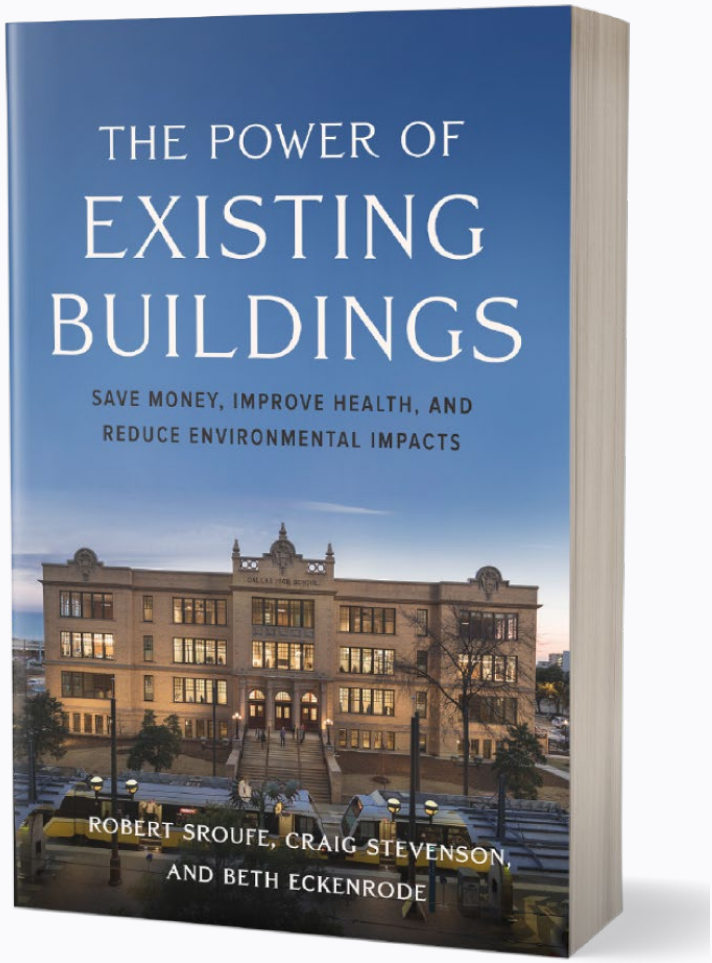
BUILDING PERFORMANCE. CONNECTED.

The Power of Existing Buildings



"High-performance buildings are key to achieving the UN's 2030 Agenda for Sustainable Development. Most of today's buildings will still be in use in 2050… as shown in this book, the capability to meet the challenge exists today."

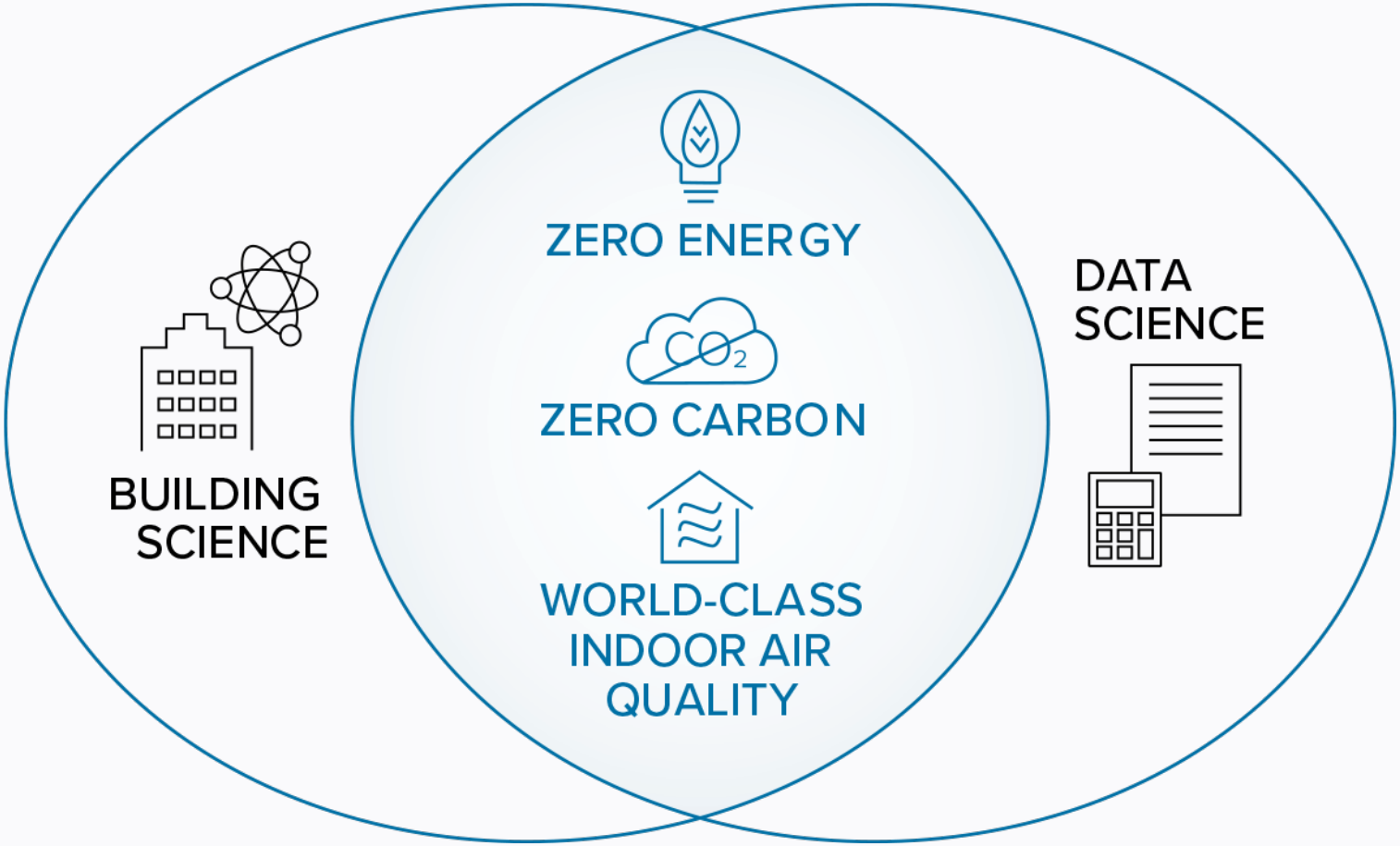
Scott Foster, Director, Sustainable Energy
United Nations Economic Commission for Europe (UNECE)

2022 "Environmental Book of the Year"

Academy of Management – Organizations and the Natural Environment Division

An Affordable Path to Zero Anything…

… requires both building science and data science



Natural Order of Sustainability

Strategies to cost-effectively drive to ultra-low energy consumption

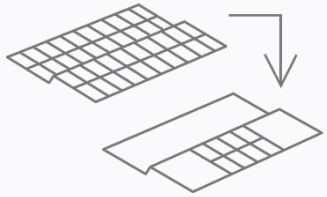
Efficiency Follows an Order of Operations

Optimize passive performance

Passive first

Reduce size of active systems

Active second



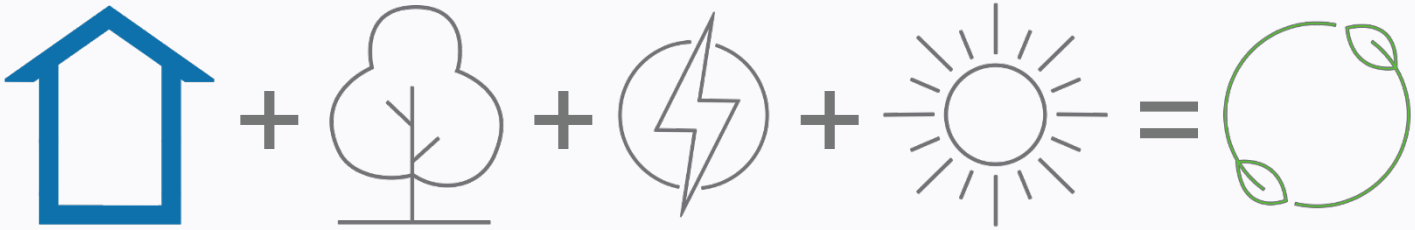
Minimize costs for renewable energy

Renewables last

Natural Order of Decarbonization…

… must begin with efficiency

New Building



Passive House + Low Embodied Carbon + Electrify Everything + Clean Energy = Zero Carbon Building

Existing Building

Establish the Optimum Decarbonization Potential (Passive House—EnerPHit + Low Embodied Carbon) + Electrify Everything + Clean Energy = Zero Carbon Building

Source: Passive House Accelerator

When is Enough, Enough?

Problem Statement

“I will be renovating my building, and my company has goals for energy and/or carbon, but I don’t know how to optimize performance gains against costs expended. How do I achieve as much as possible for as little as possible?”

When the juice is no longer worth the squeeze.

Steps to Decarbonize an Existing Building

How Buildings are commonly decarbonized

1. Compare Current Performance to Historical Energy Performance (Maybe only 1 year)

2. Compare Current Performance to Similar Buildings

Issues with this approach:

- Change / Difference in Occupancy
- Annual Weather Difference

Why not compare the current performance with how the building was designed to perform?

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Steps to Decarbonize an Existing Building

1. Gather Information
   - Metric-based goals and targets for building performance
   - Hourly energy consumption or utility bills
   - MEP systems inventory
   - Smart Building Infrastructure assessment
   - Systems & equipment triggers & sequences
2. Create an Operational Model
   - Calibrated physics-based performance model
3. Create an Optimum Model
   - Test ECM's using the Operational Model to identify the whole-building decarbonization potential
4. Create The Decarbonization Plan (Step Models)
   - Select ECMs respecting building goals, construction costs, and triggers & sequences and create phased models for deployment
5. Operationalize the Performance Models
   - Connect building science to data science

Project Example

- 500,000 ft^2 / 4 Story Office Building

- Facing potential regulatory fines (BERDO – Massachusetts)

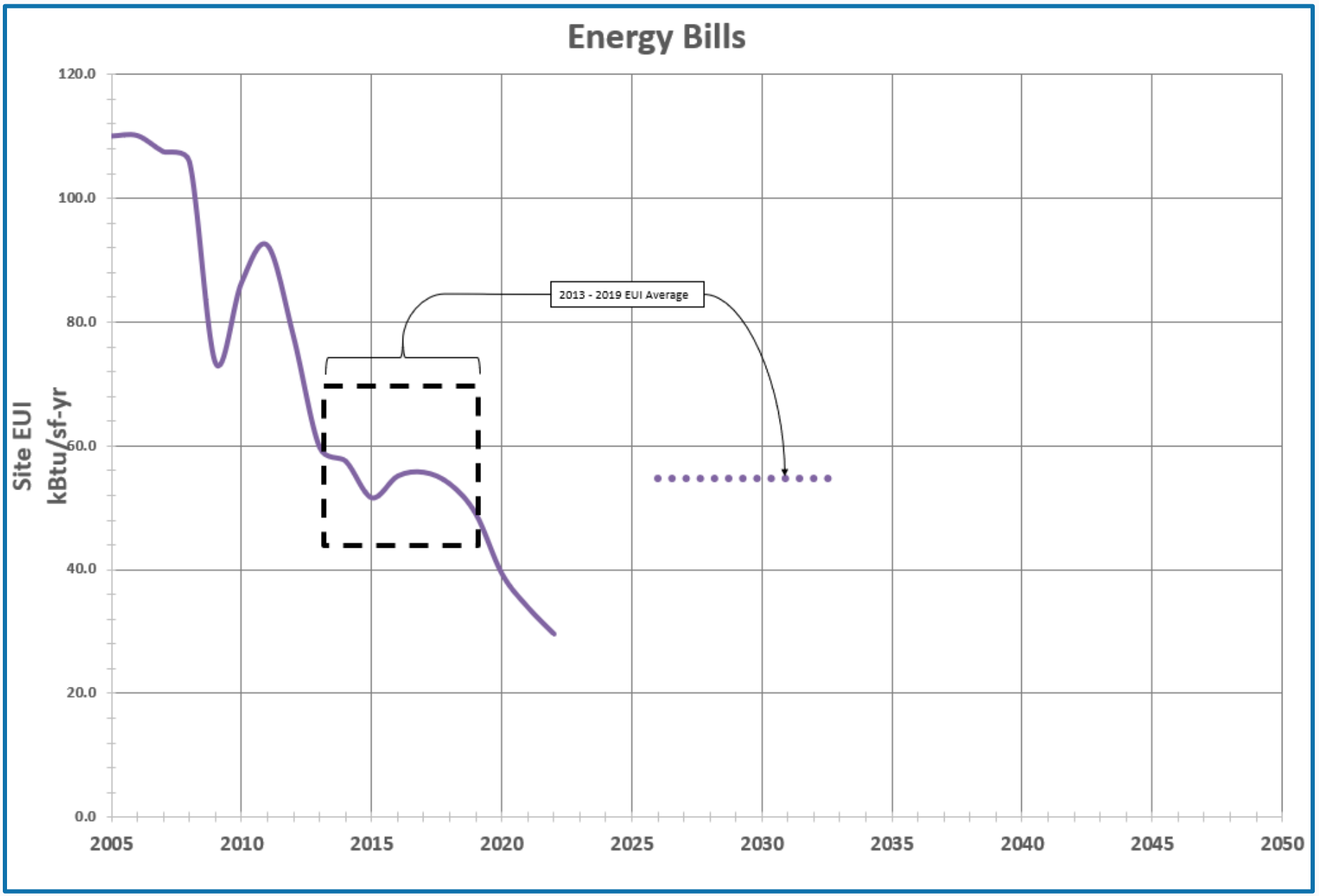
- 3 current tenant spaces / one is unoccupied

- Mechanicals are at End of Life

- Goals of project are to merge natural triggers and avoid any fines

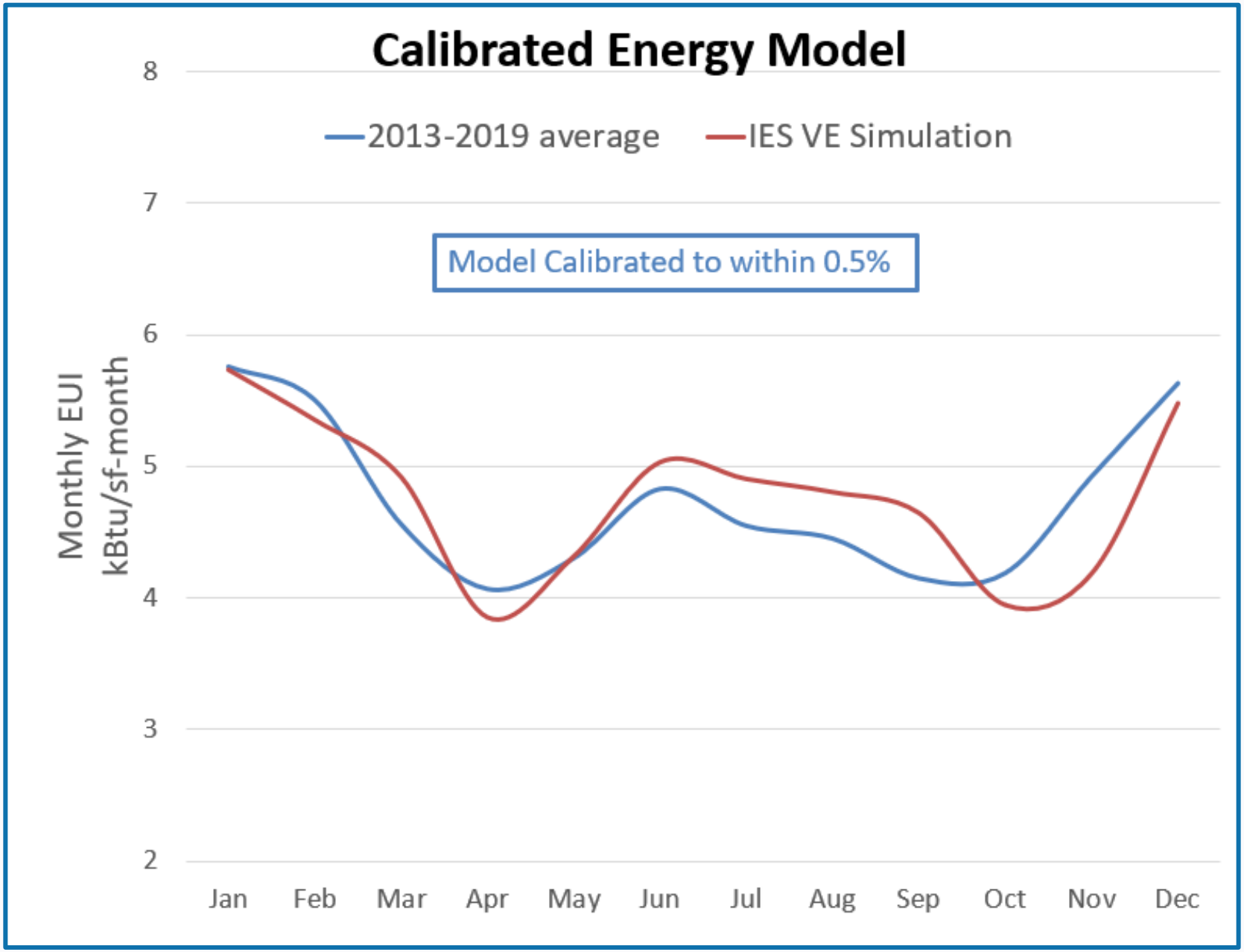
Gather Utility Information

Find an average (normalize vacancy)



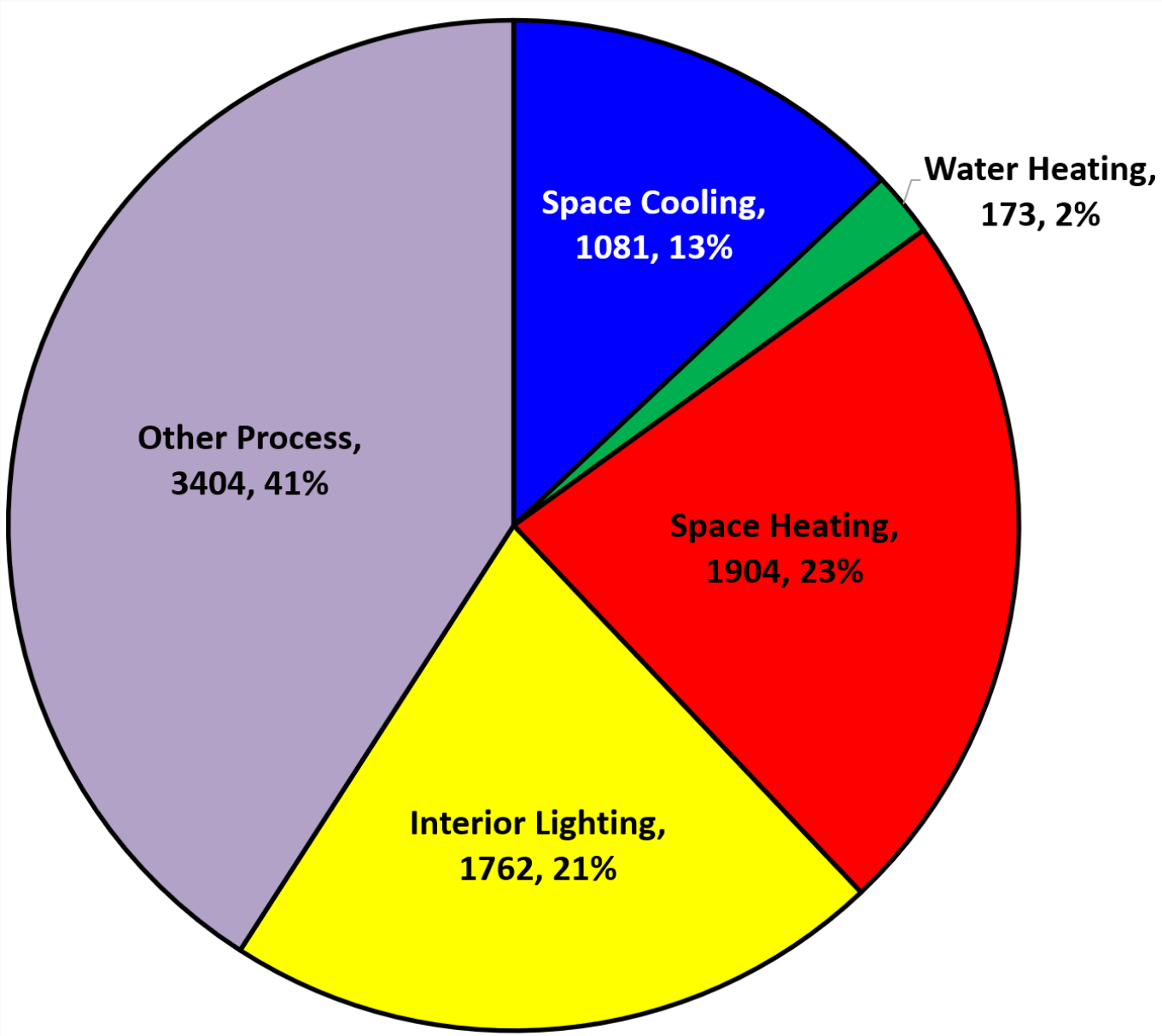
Calibrate the Physics-based Performance Model

Strive to calibrate the model to < 1%



Test ECMs and Bundles of ECMs

Passive First – Active Second – Renewables Last



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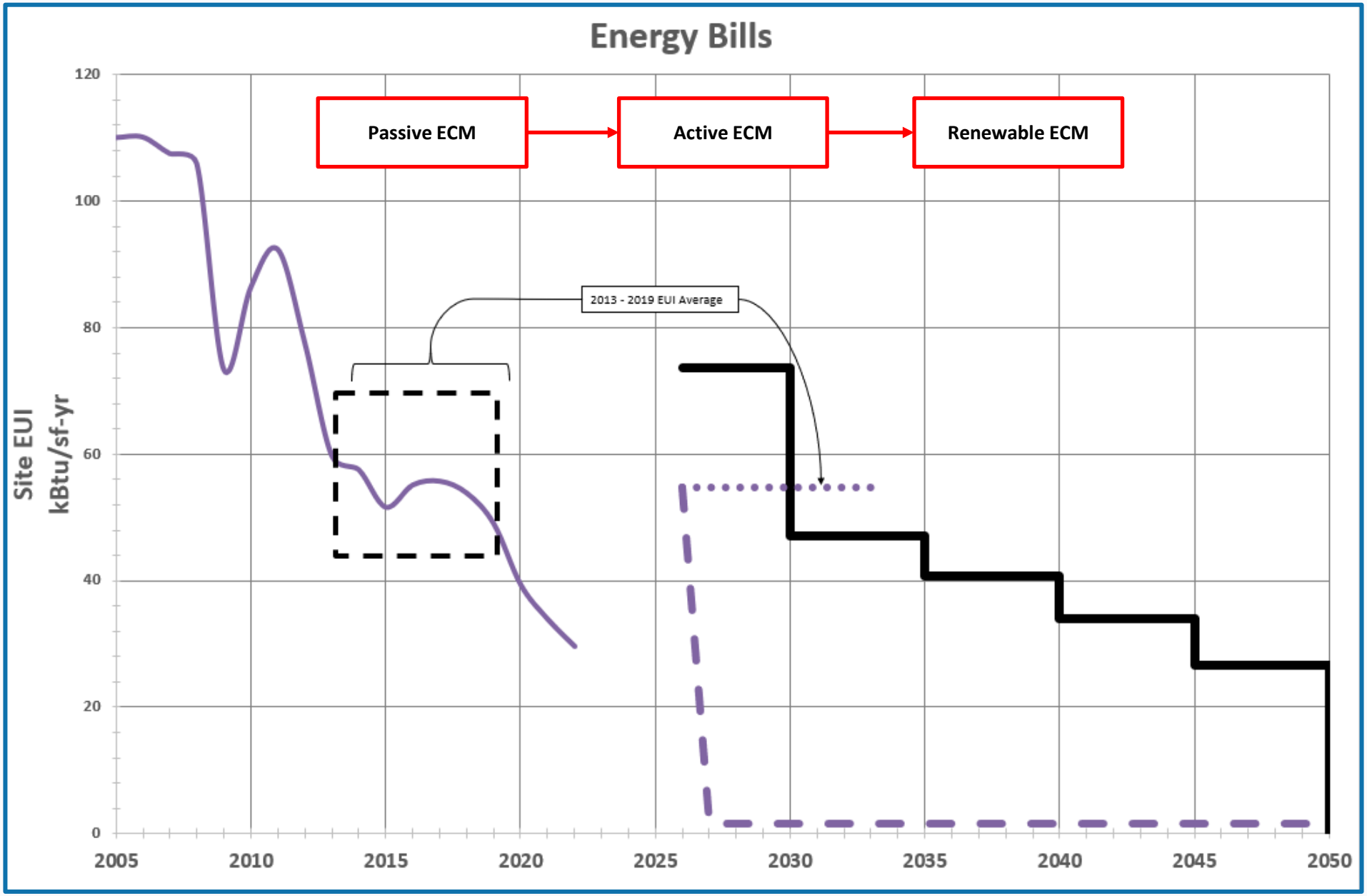
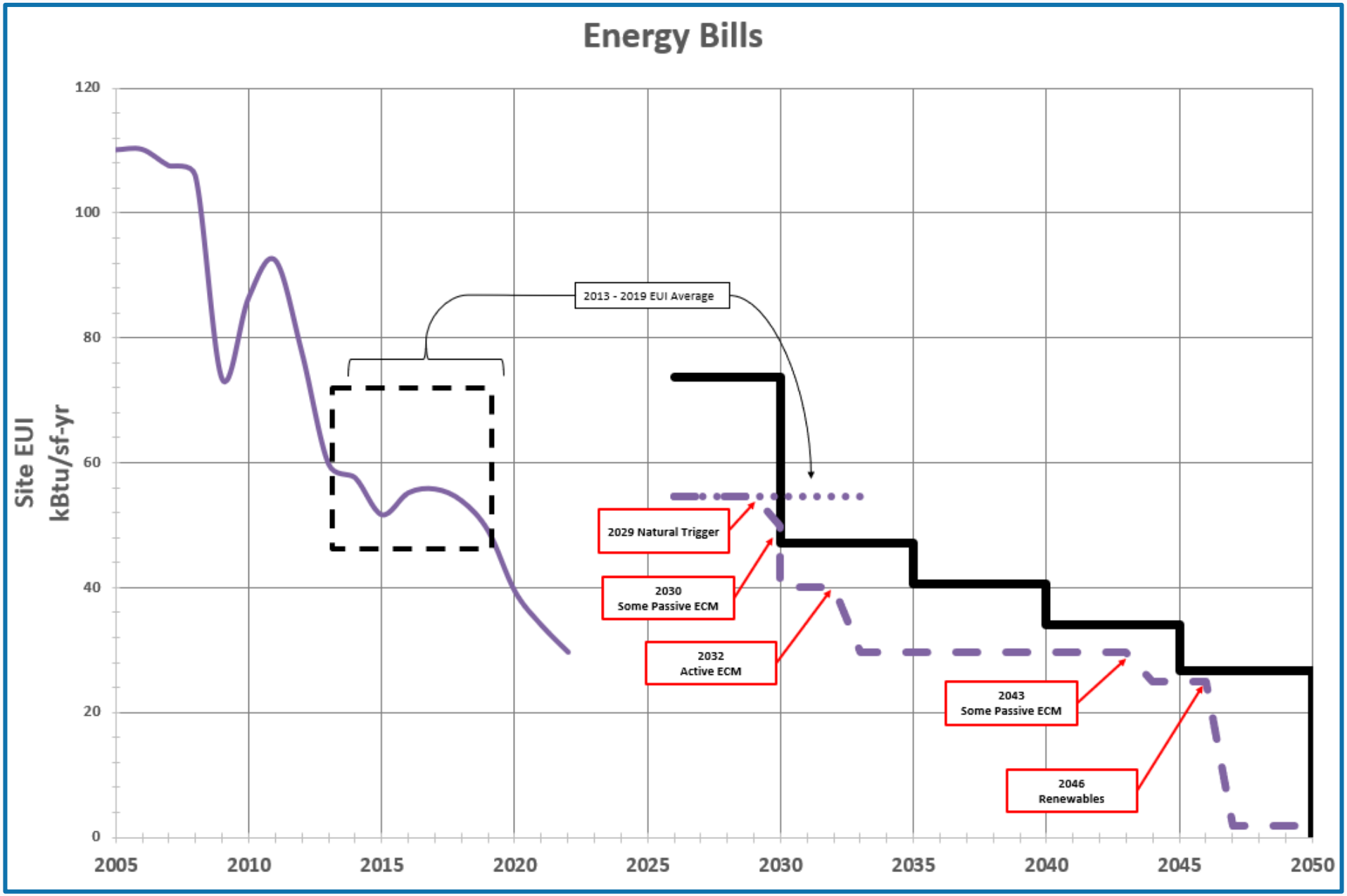


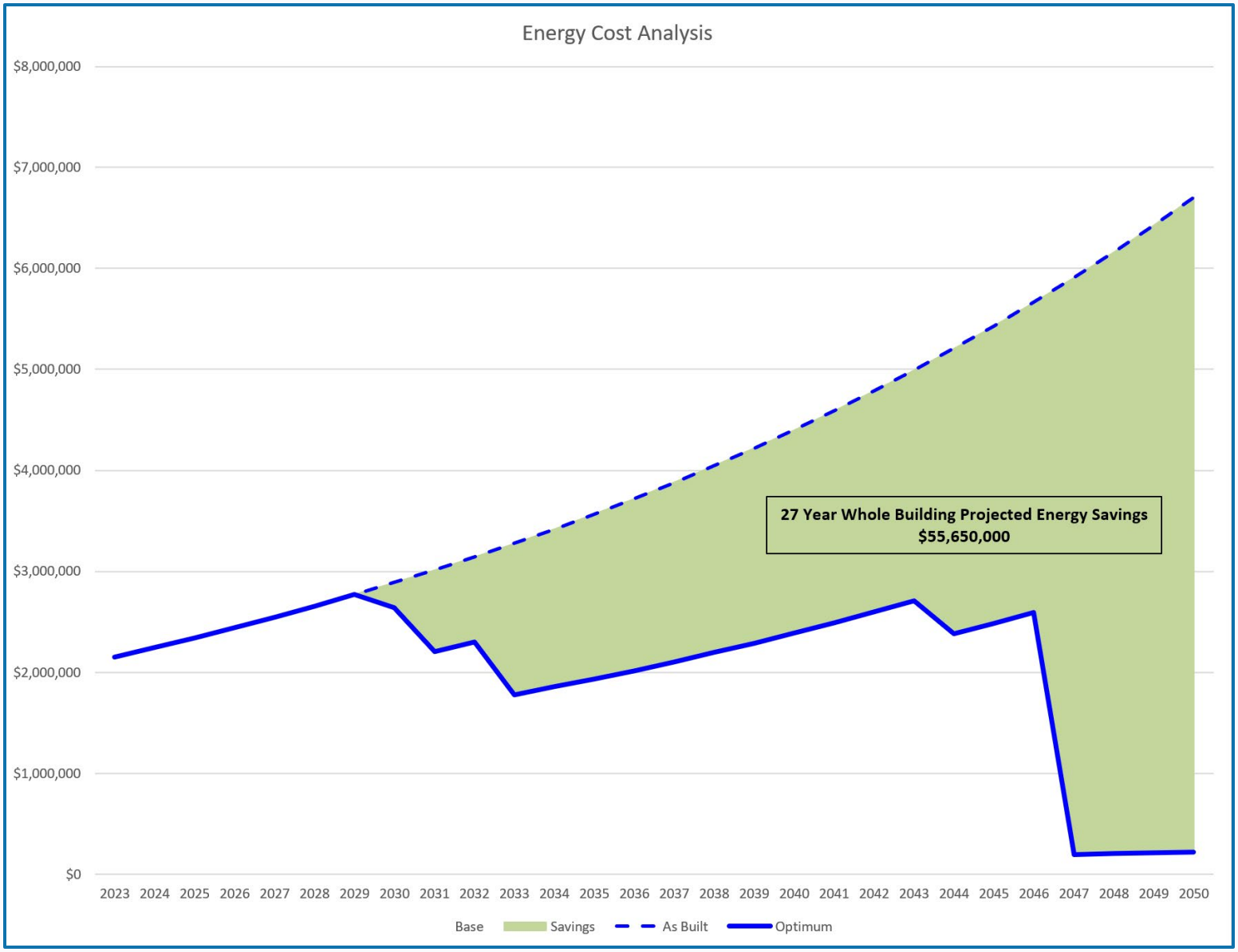
Visualize Whole-Building Performance

Against the context of building goals & targets and governmental regulations



Visualize Whole-Building Performance

Assess potential financial savings with relationship to step approach



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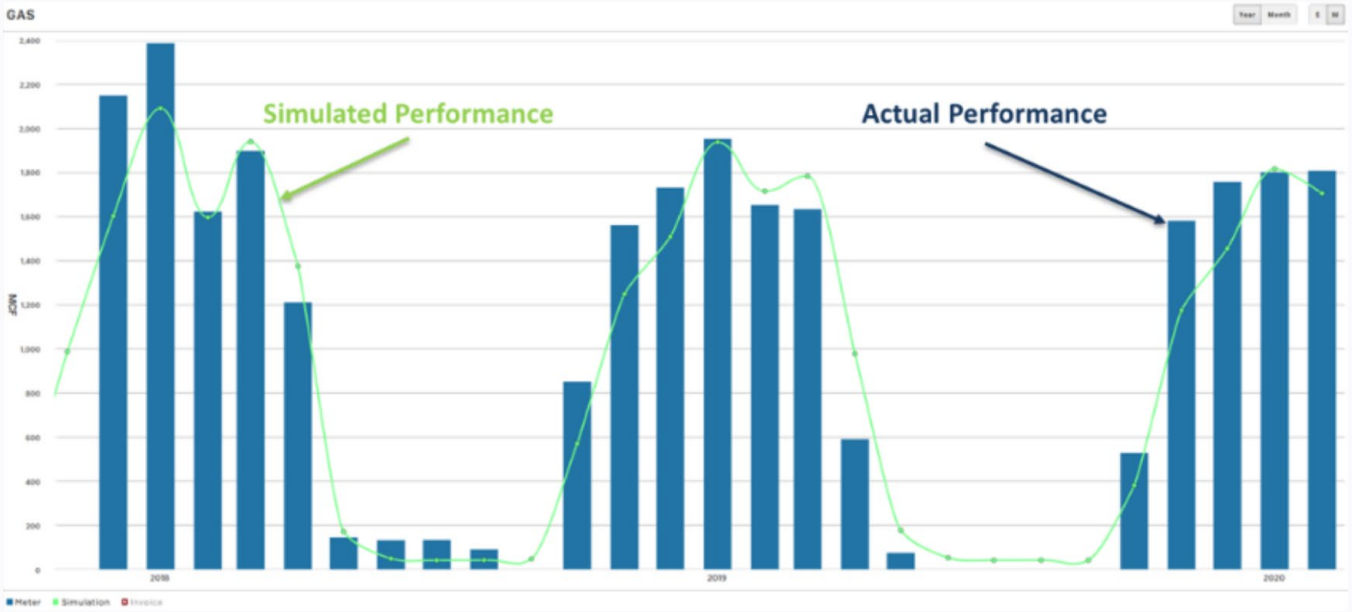
Integrated Simulation

Integrated Digital Twin

Physics-based simulation provides predicted performance context for trended data



Building owners want to know: “Did I get what I paid for?”

Q&A

AUROS Group

Craig Stevenson

412-506-6777

craig.stevenson@aurosgroup.com

linkedIn.com/in/craigestevenson

AUROS Group

Matt Bowers

412-506-6777

matthew.bowers@aurosgroup.com

linkedin.com/in/matthew-t-bowers

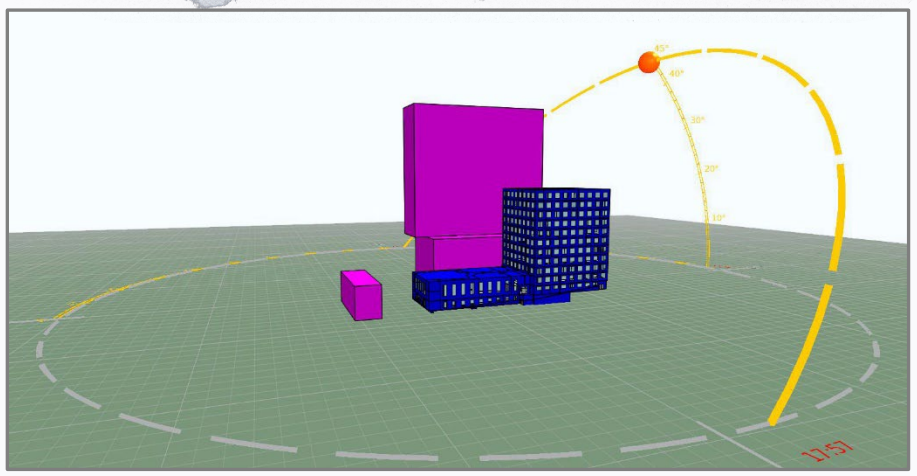
Metrics, Not Narratives

What will owners measure in operations? What defines success?

Change the Process

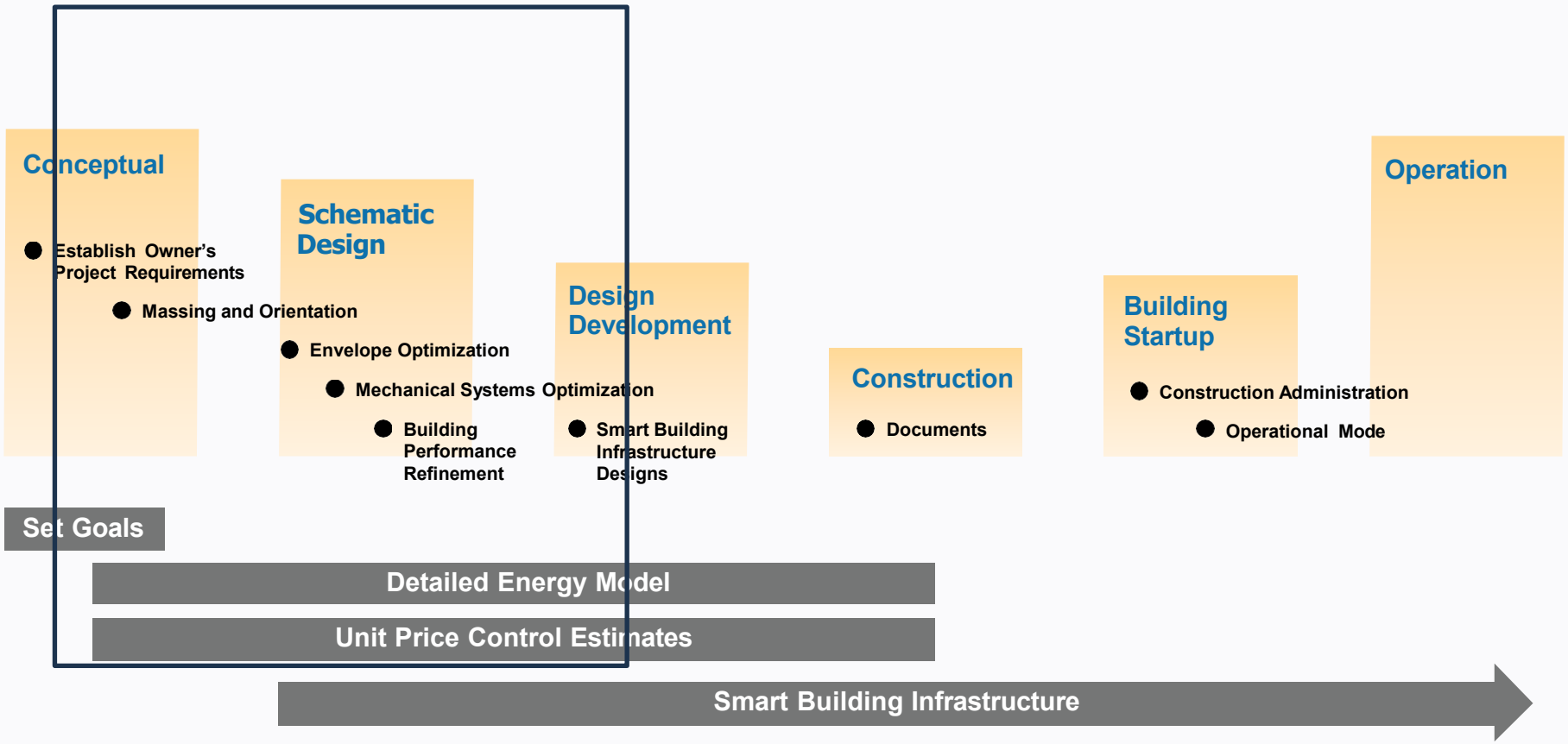
- Set metrics-based goals
- Align team to goals
- Open-source simulation to spin scenarios until we reach the highest performance at the lowest cost.

SUSTAINABILITY CERTIFICATION PROGRAM GOALS `	Evidence-based goals *[Select your programs]*
ENERGY	
Site Energy Use Intensity (EUI)	14 kBtu/sf/yr
Gas v. Electrification Balance	
Renewables	Offset annual energy consumption to Zero Energy
Building Envelope Infiltration	0.05 cfm/gross sf shell @50Pa
INDOOR AIR QUALITY	
Particulate Matter 2.5 (PM2.5)	< 12 µg/m3
Total Volatile Organic Compound (TVOC)	< 0.4 mg/m3 (< 400 µg/m3)
Carbon Dioxide (CO2)	< 600 ppm
Temperature	Monitored
Humidity	Monitored
Carbon Monoxide (CO)	< 9 ppm
Ozone (O3)	< 51 ppb
Particulate Matter 10 (PM10)	< 50 µg/m3
Radon	< 0.148 Bq/L [4 pCi/L] in the lowest occupied level
Ventilation Rate:	PH Compliance



Zero Energy/Zero Carbon

Low/No cost solutions come during SD/DD using simulation



Summary

Energy – In every California climate tested, Passive House squeezes out additional consumption.

Renewables – the path to zero is easier and cheaper with Passive House certification.

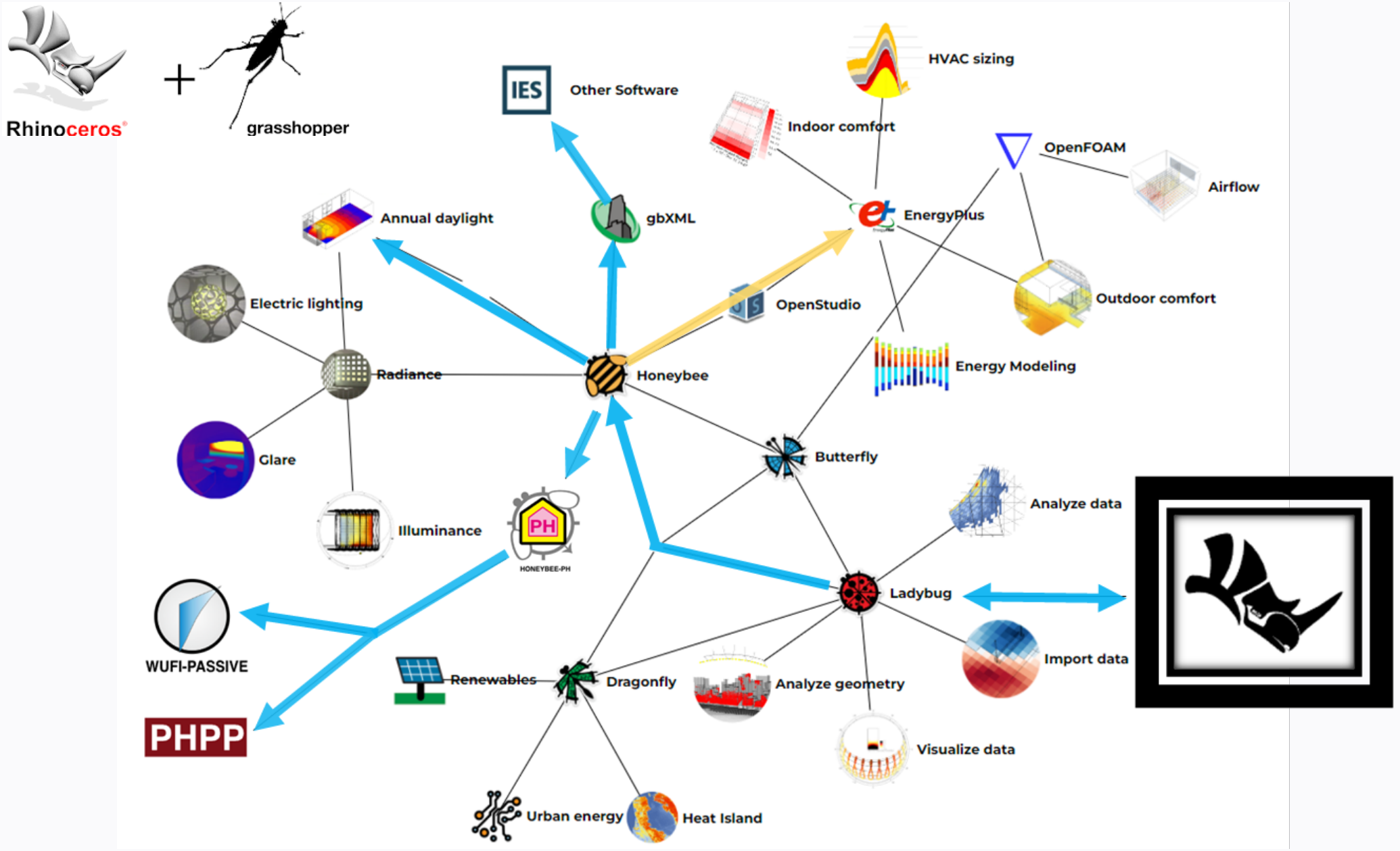
Thermal Comfort -- Passive House is also a comfort standard.

Balanced Ventilation
- Indoor Air Quality
- Odor Control
- Occupant Comfort

Air Tightness
- Long term building assembly durability
- Should not cost more, it is mainly craftsmanship
- Systems work better
- Consistent temperatures
- Dramatically improved acoustics
- Smoke tight building

Create the Physics-based Performance Model

Work Smarter, Not Harder



Minimum Viable Product

Control Your Building Data

Generate Data

Power Meter

Natural Gas Meter

Potable Water Meter

Aggregate Data

JACE Devices

Manage Data

Time-Series Data Intake & Normalization

Data Storage Historian

Unified User Interface

-Visualization & GIS

Use Cases

Data Analytics

-Decarbonization & CO2e Accounting

Operationalize Physics-based Simulation

-Monitoring-based Commissioning

-Whole-Building Decarbonization Plan

-Fault Detection & Diagnostics

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The Operational Value

Integrated Digital Twin

- Monitoring-based Commissioning
- Interrogation-base Commissioning
- Advanced Analytics Testing
- Independent and Proprietary Data Layer Agnostic

Building Performance During Building Life-cycle