



Building Energy Simulation

Introduction to EnergyPlus

Lecture 5

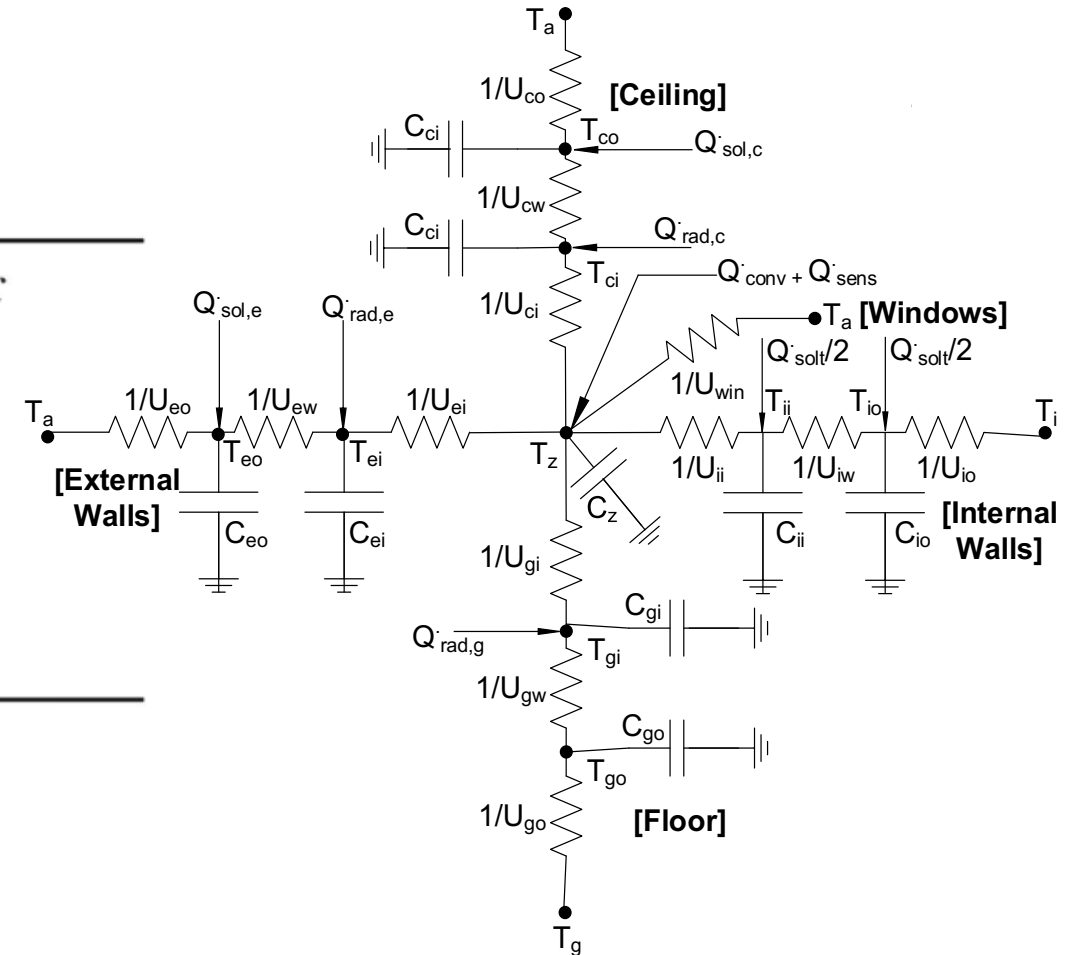
Principles of Modeling for Cyber-Physical Systems

Instructor: Madhur Behl

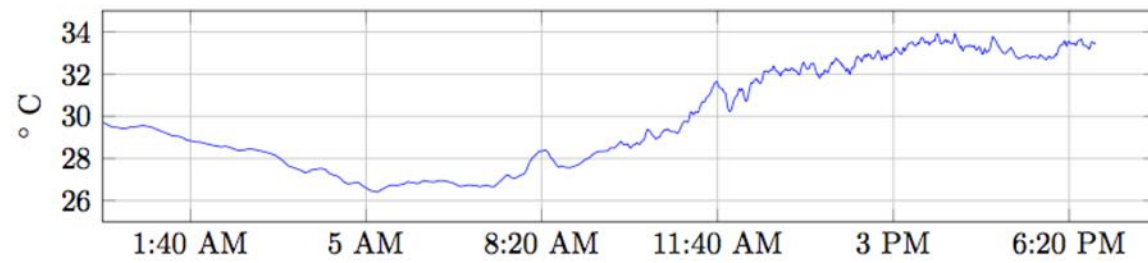
Previously..

How to find the values of the parameters ?

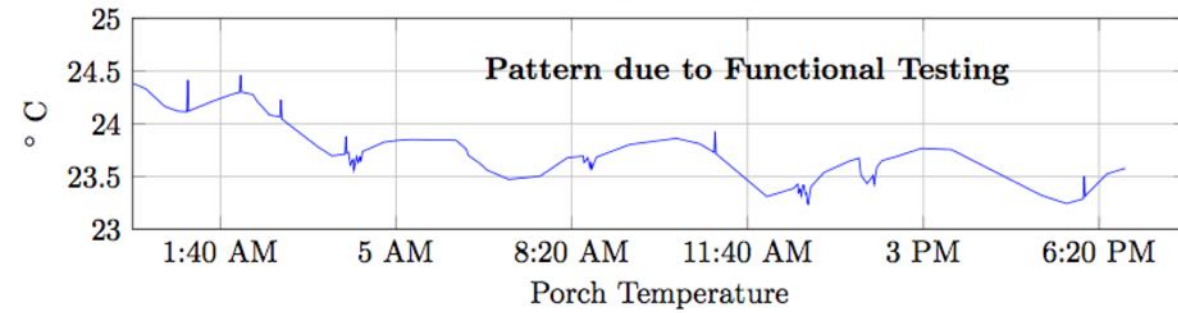
U_{*o}	convection coefficient between the wall and outside air
U_{*w}	conduction coefficient of the wall
U_{*i}	convection coefficient between the wall and zone air
U_{win}	conduction coefficient of the window
C_{**}	thermal capacitance of the wall
C_z	thermal capacity of zone z_i
g : floor; e : external wall; c : ceiling; i : internal wall	



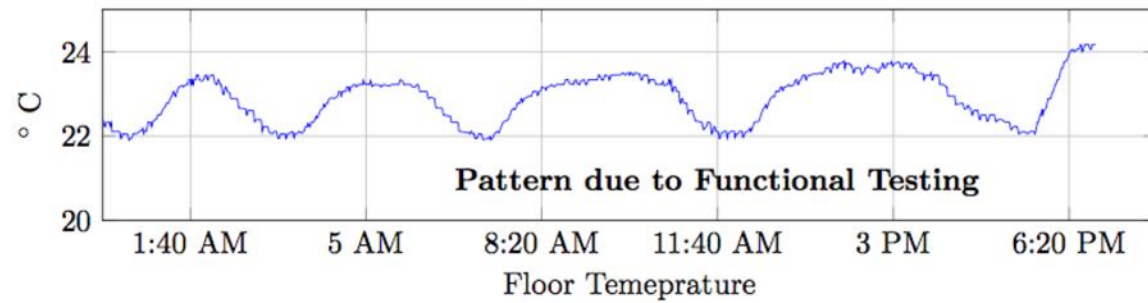
Ambient temperature



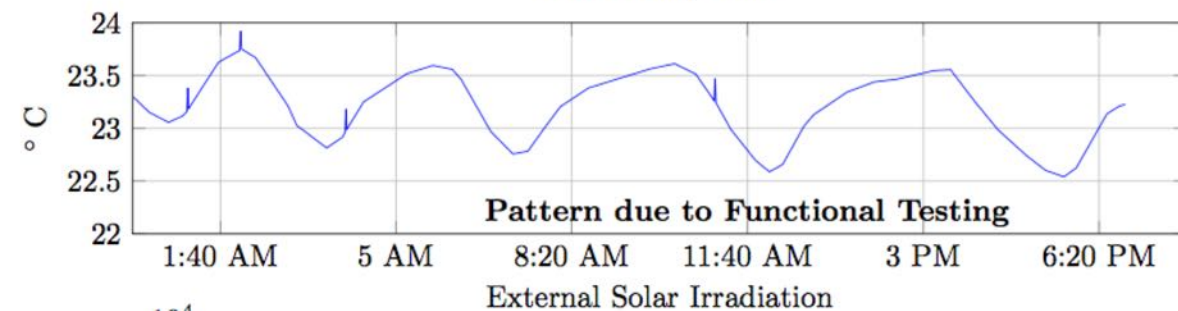
Ceiling temperature



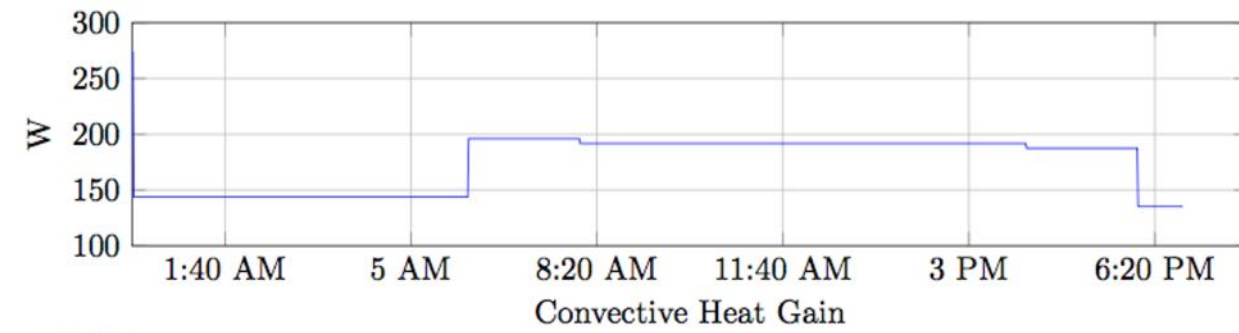
Porch Temperature



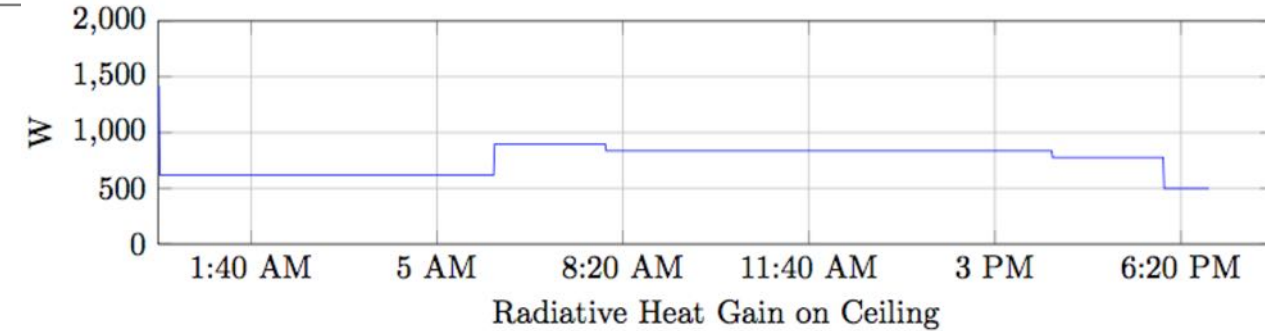
Floor Temperature



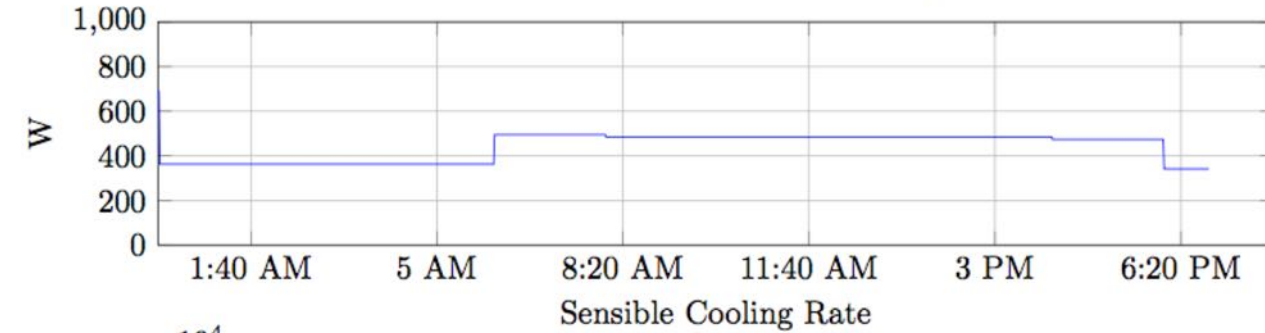
External Solar Irradiation



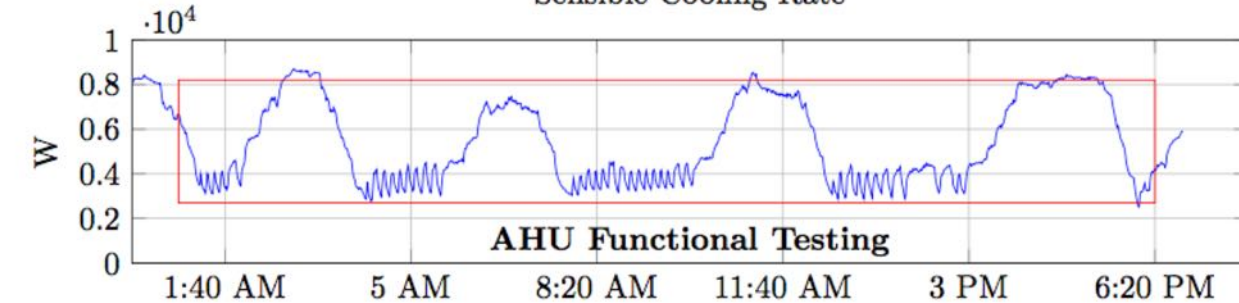
Convective Heat Gain



Radiative Heat Gain on Ceiling

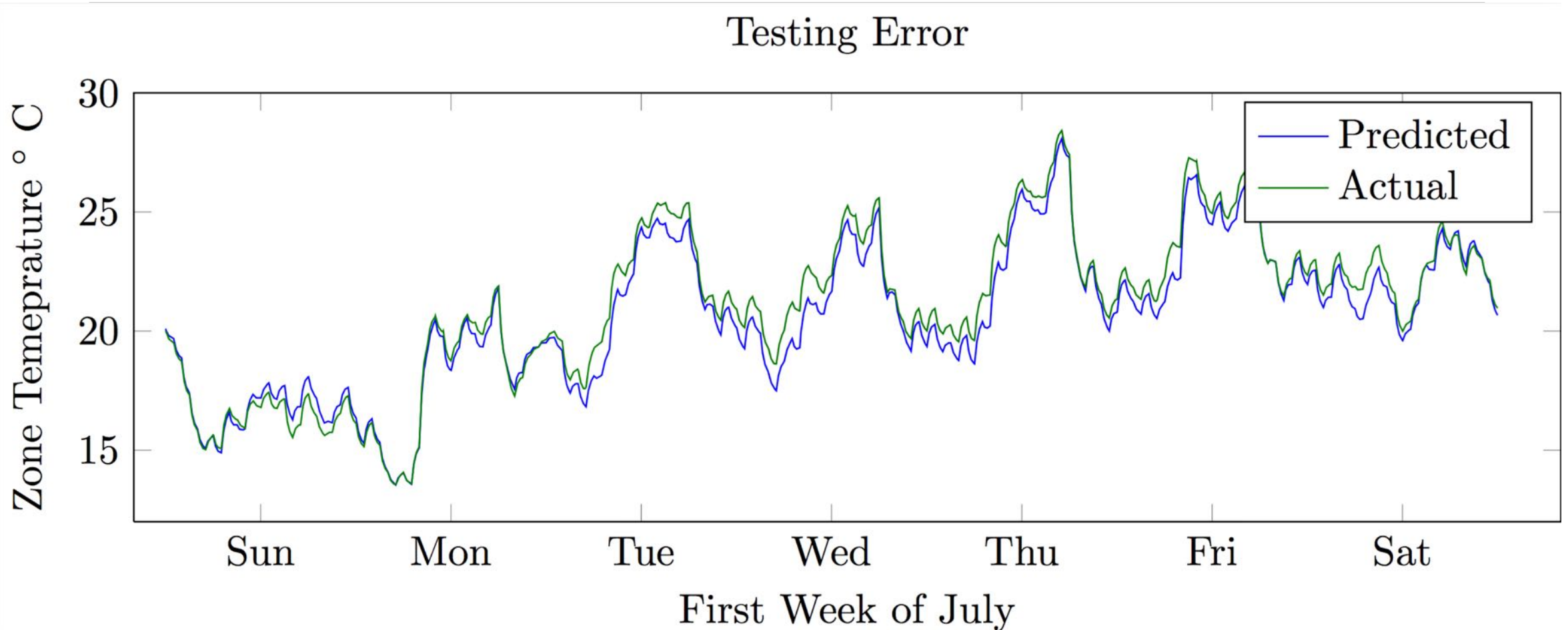


Sensible Cooling Rate



AHU Functional Testing

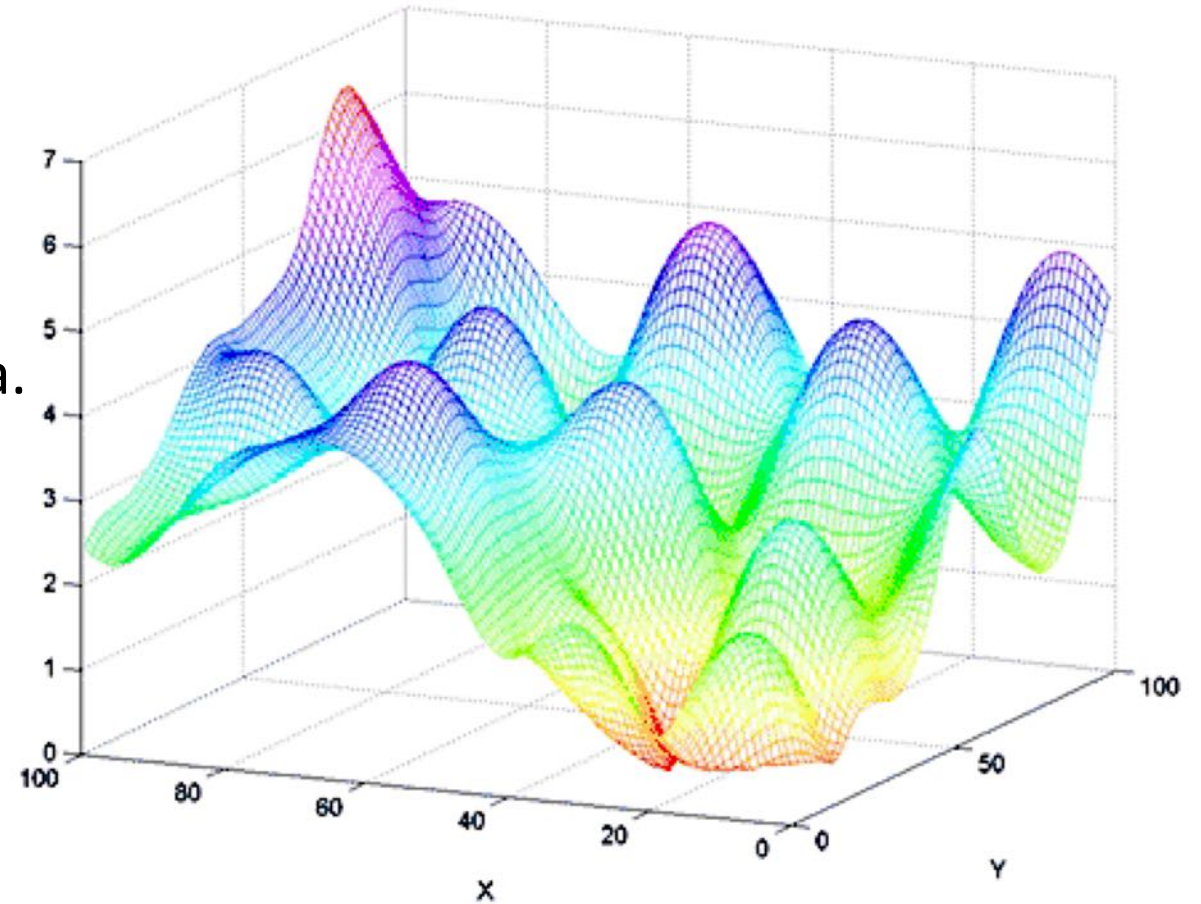
Given the disturbances and inputs, the model should predict the zone temperature.



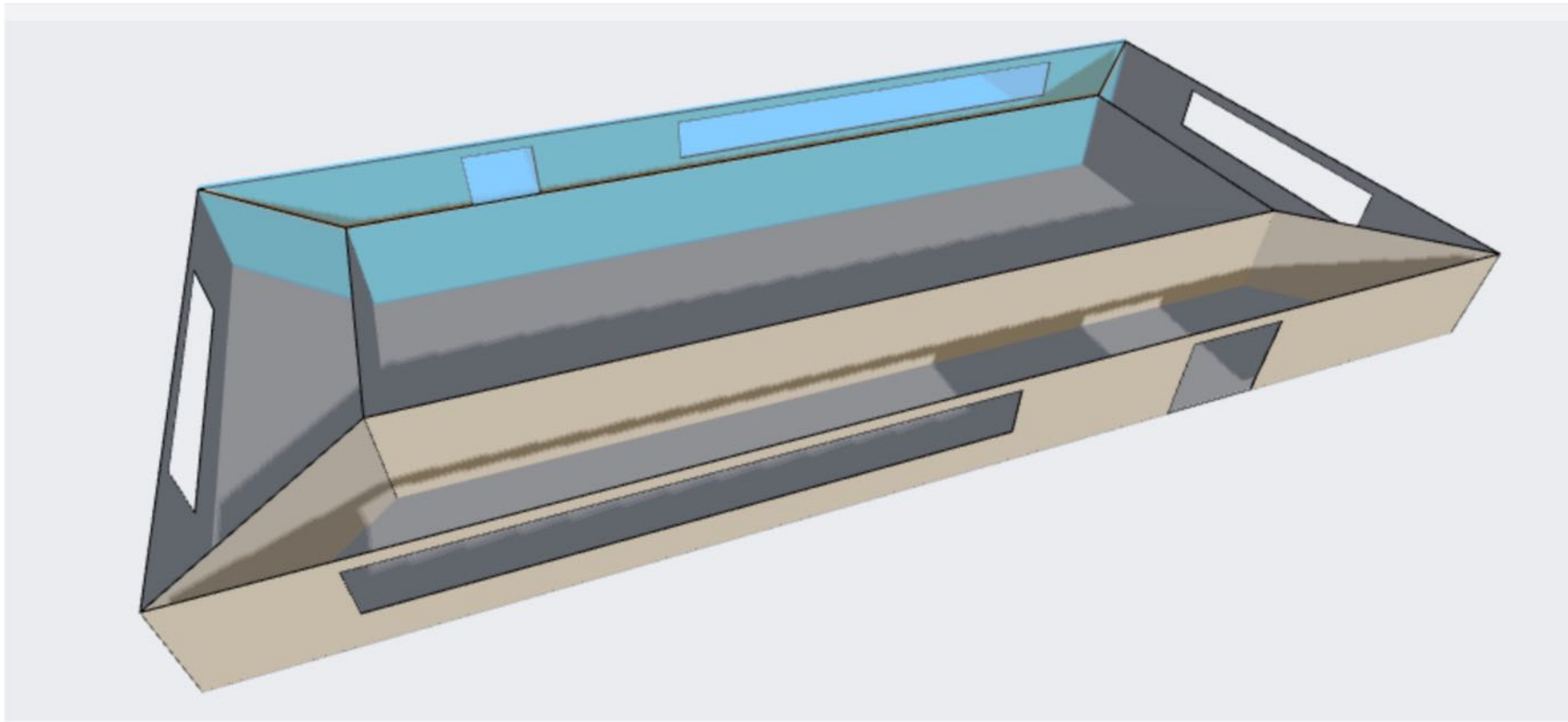
Parameter estimation is a search

Need a good starting point to avoid local minima.

Compute **nominal values** of the parameters.

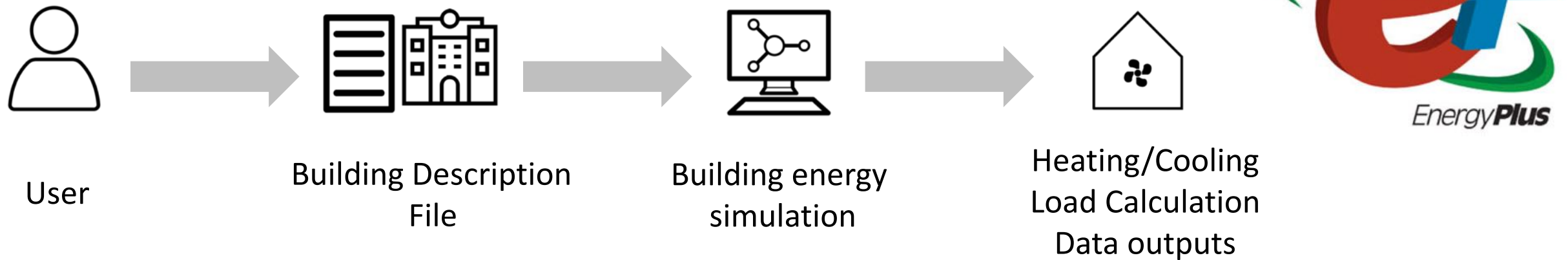


For our model:
EnergyPlus == A real building



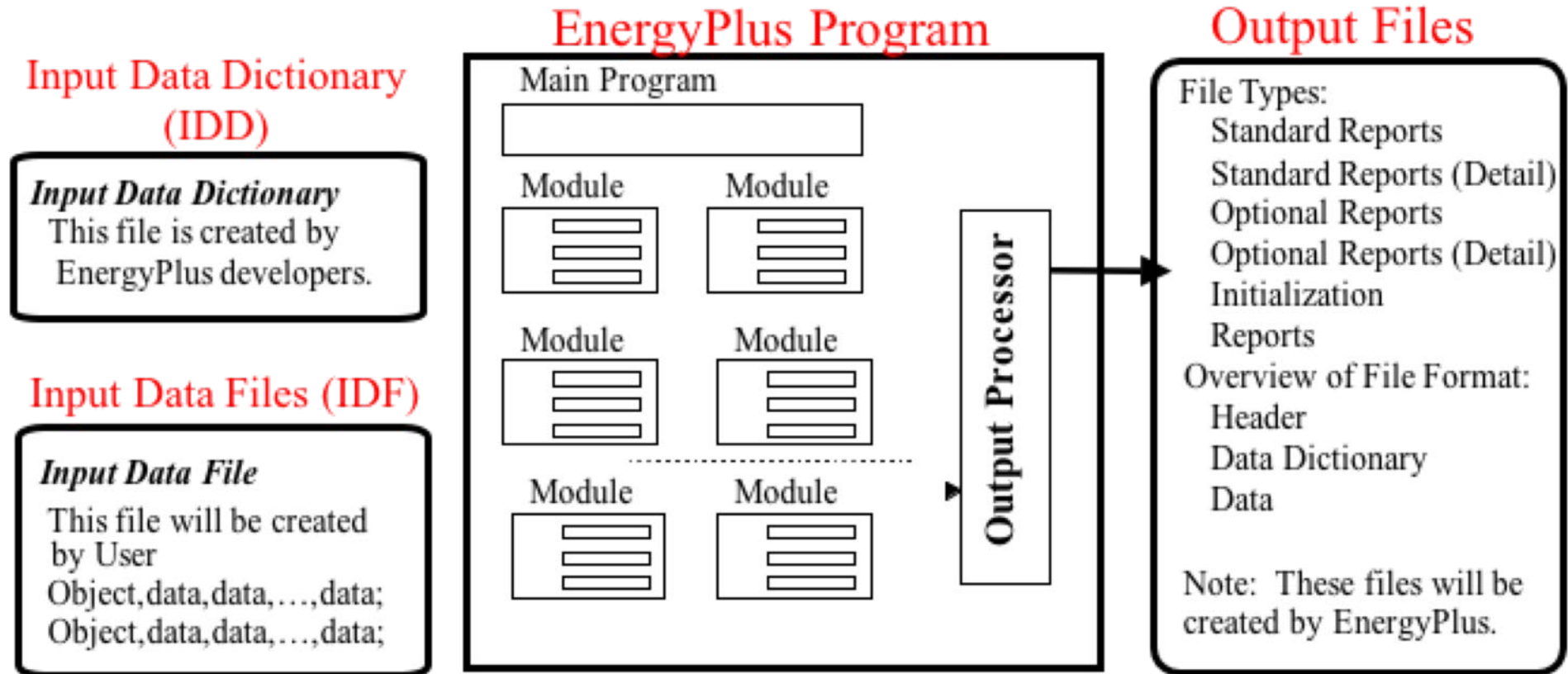
What is EnergyPlus ?

EnergyPlus is an energy analysis and thermal load simulation program



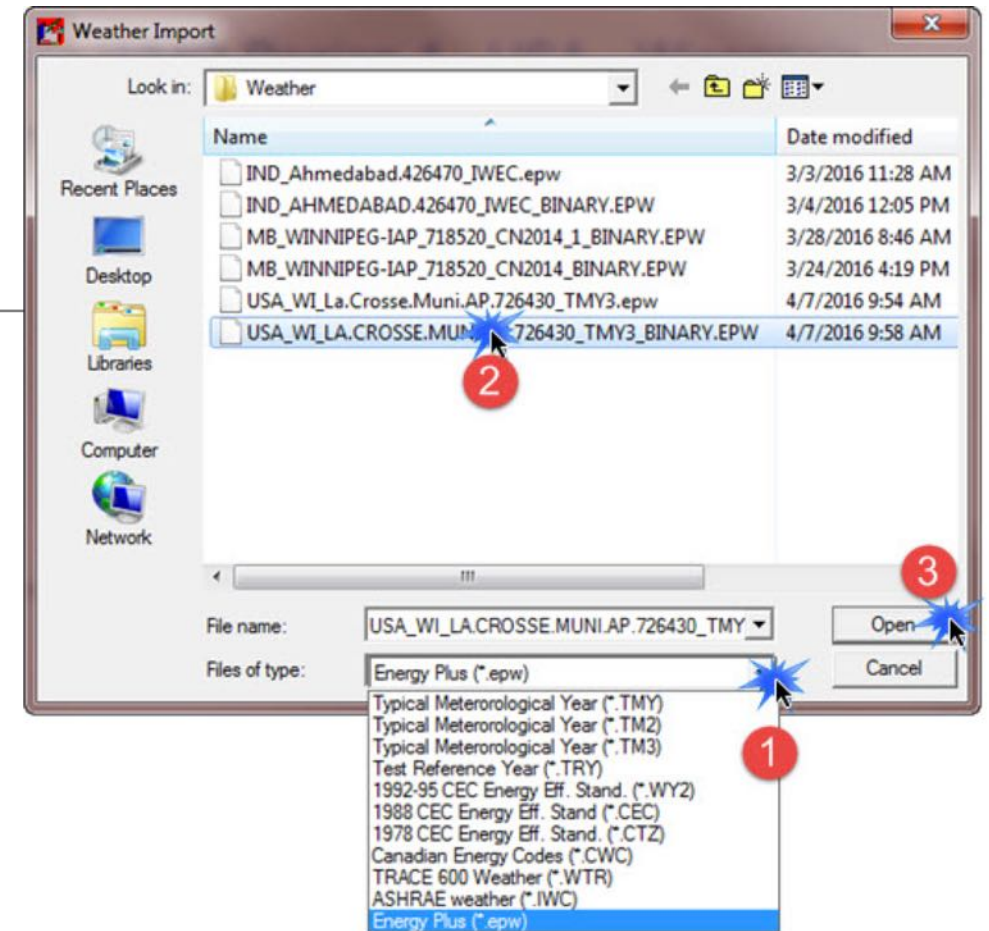
<https://github.com/NREL/EnergyPlus>

io files



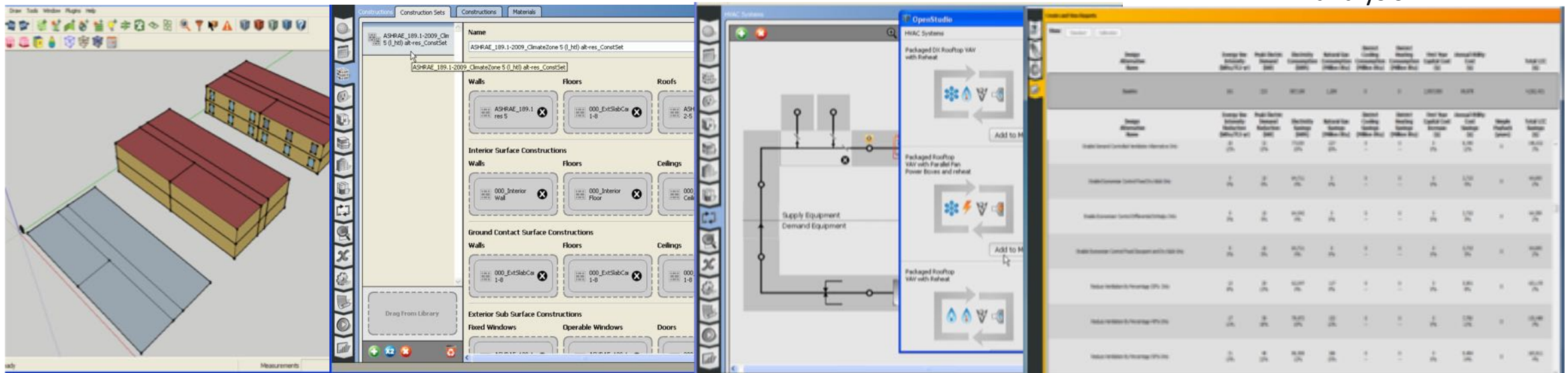
Weather data

- Data include
 - temperature,
 - humidity,
 - solar,
 - wind,
 - rain, and
 - snow flags, etc.
- Hourly data typical, can be sub-hourly
 - Interpolated for EnergyPlus time steps

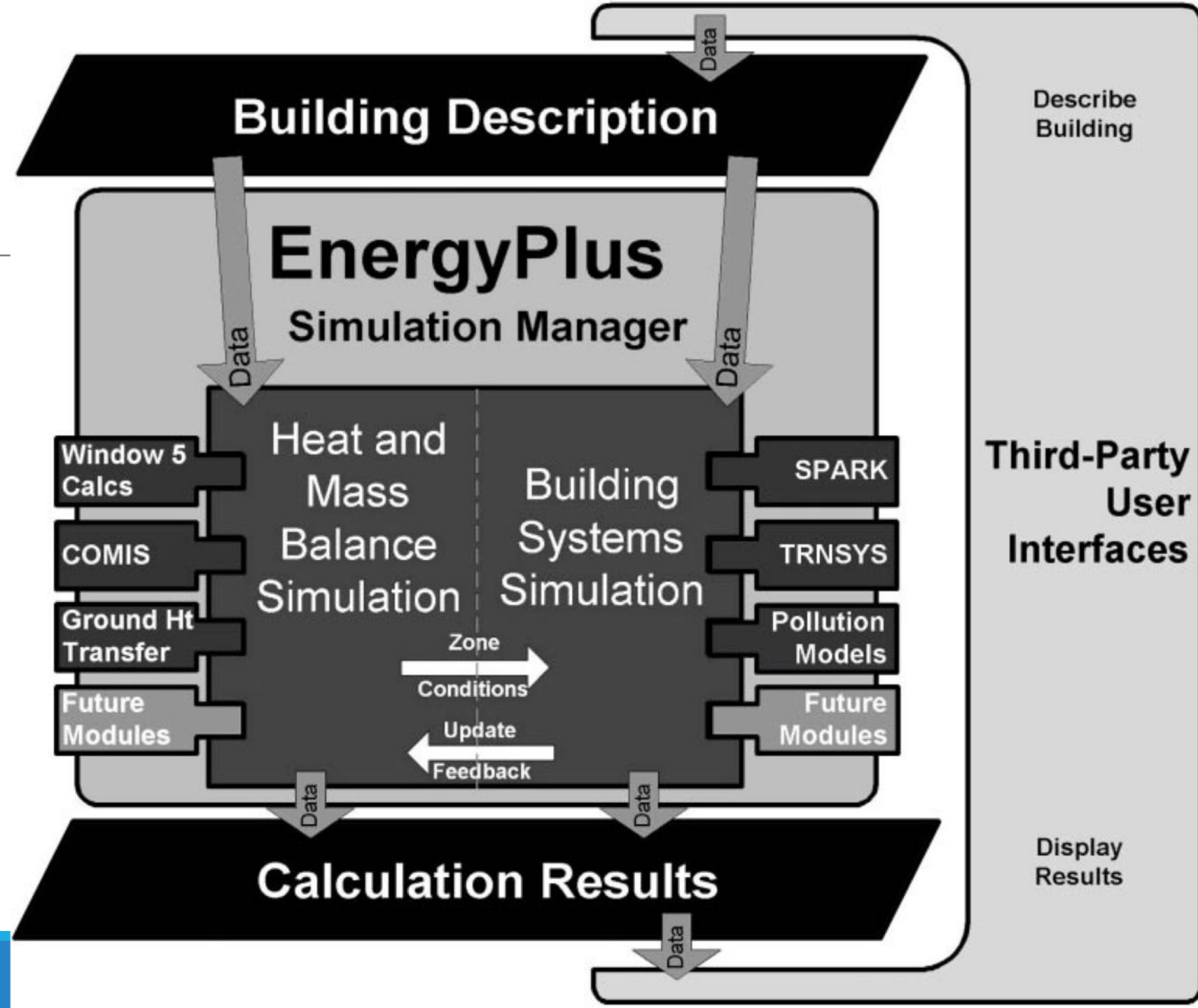


TMY: Typical Meteorological Year data

10

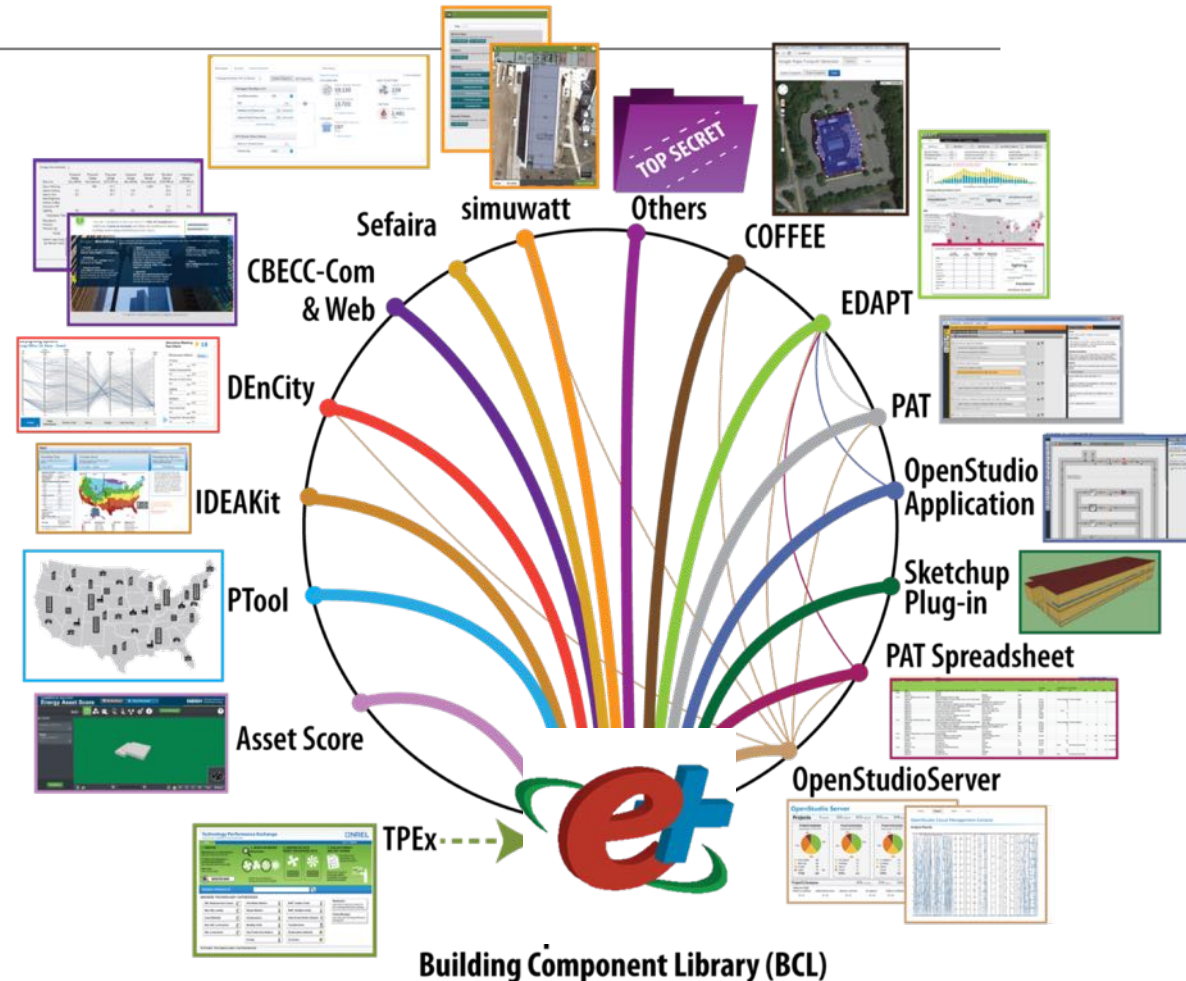


EnergyPlus – Simulation Architecture

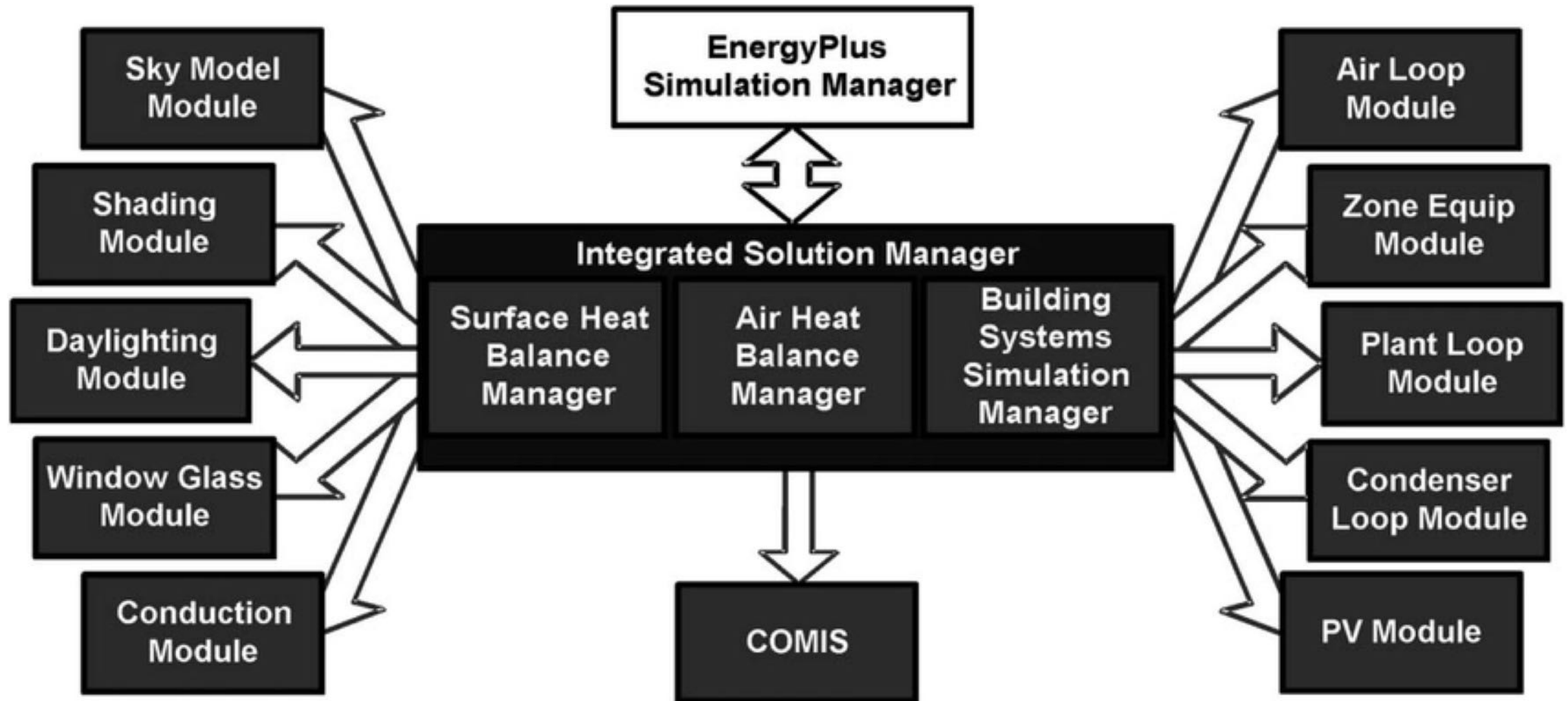


More than an engine or a single tool

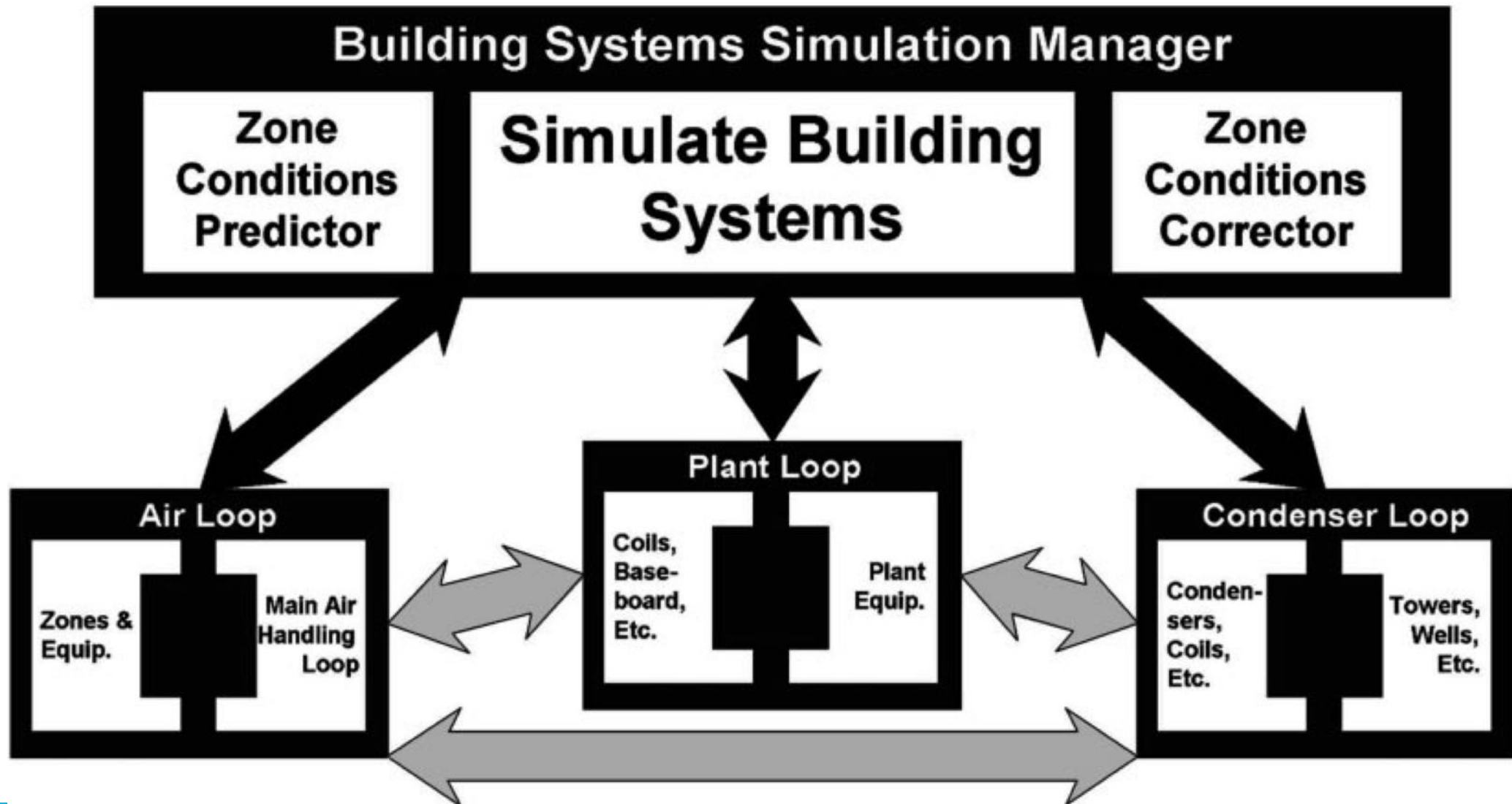
- Whole building energy simulation.
- Peak load calculation and equipment design.
- Sub-hourly, user-definable time steps.
- Advanced fenestration models.
- Illuminance and glare calculations.
- Component-based HVAC.
- Built-in HVAC and lighting control strategies.
- Functional Mockup Interface.
- Standard summary and detailed output reports.



Integrated simulation manager

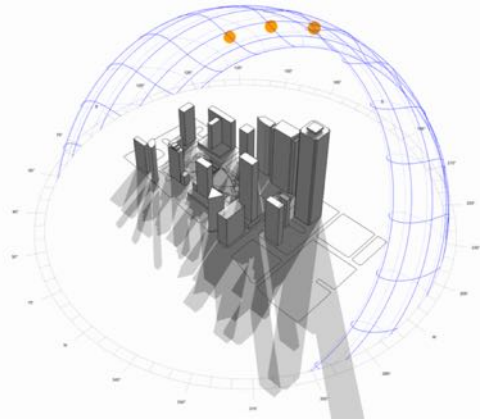


Building systems simulation manager



Authoring tools: Third party interfaces

OpenStudio



Zone and Air System Integration

$$C_z \frac{dT_z}{dt} = \sum_{i=1}^{N_{sl}} \dot{Q}_i + \sum_{i=1}^{N_{surfaces}} h_i A_i (T_{si} - T_z) + \sum_{i=1}^{N_{zones}} \dot{m}_i C_p (T_{zi} - T_z) + \dot{m}_{inf} C_p (T_{\infty} - T_z) + \dot{m}_{sys} C_p (T_{sup} - T_z)$$

Sum of convective internal loads

Convective heat transfer from zone surfaces

Infiltration of outside air

Inter zone air mixing

HVAC air system

Building envelope hierarchy

Site

>> Building

>> Zones

>> Surfaces

>> Constructions

>> Materials

Energy Plus Demo