
EnergyPlus: DOE's Next Generation Simulation Program

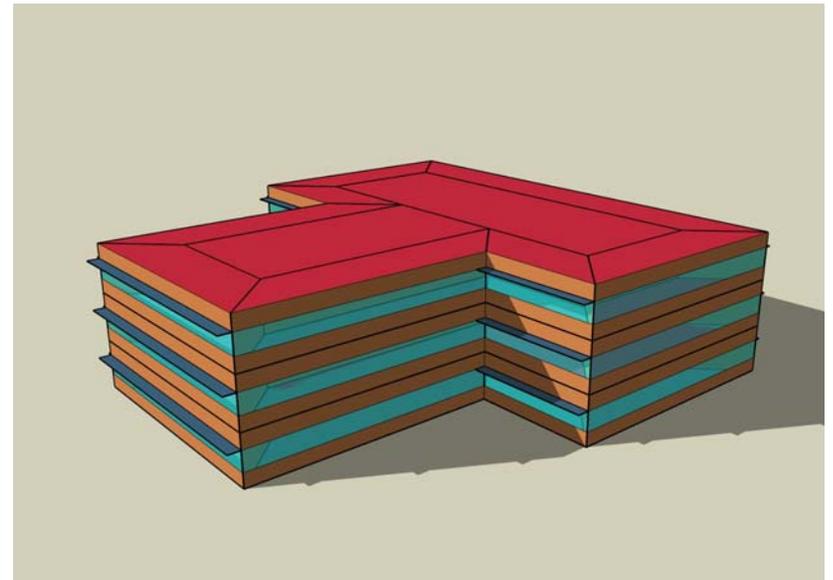
Drury B. Crawley
U S Department of Energy



Energy Efficiency and Renewable Energy

EnergyPlus

- Fully integrated building, envelope, HVAC and renewables simulation program
- Originally based on BLAST and DOE-2.1E, now far exceeds their capabilities
- One of the most robust simulation tools available in the world today
- Enables integrated energy performance analysis of low-energy technologies in commercial and residential buildings including on-site generation and renewable energy sources
- Interfaces available from private sector developers as well as web interface
- Version 1.0 Launched April 2001
- Windows 2000/XP, Linux & Mac



Current Version Status

- Current version 2.2.0.023, April 2008
 - Dual-setpoint humidistat
 - Enhanced economizer controls
 - Greater flexibility in specifying internal gains (i.e., people, lights, equipment) and ventilation/infiltration
 - Microturbine electric generator model, and
 - Lots of new HVAC capabilities and data sets.
- Twice yearly updates—April and October
- Upcoming features (October 2008 and beyond):
 - VRV
 - Controls – EMS & Strategies
 - Lots more low-energy building, HVAC and other technologies

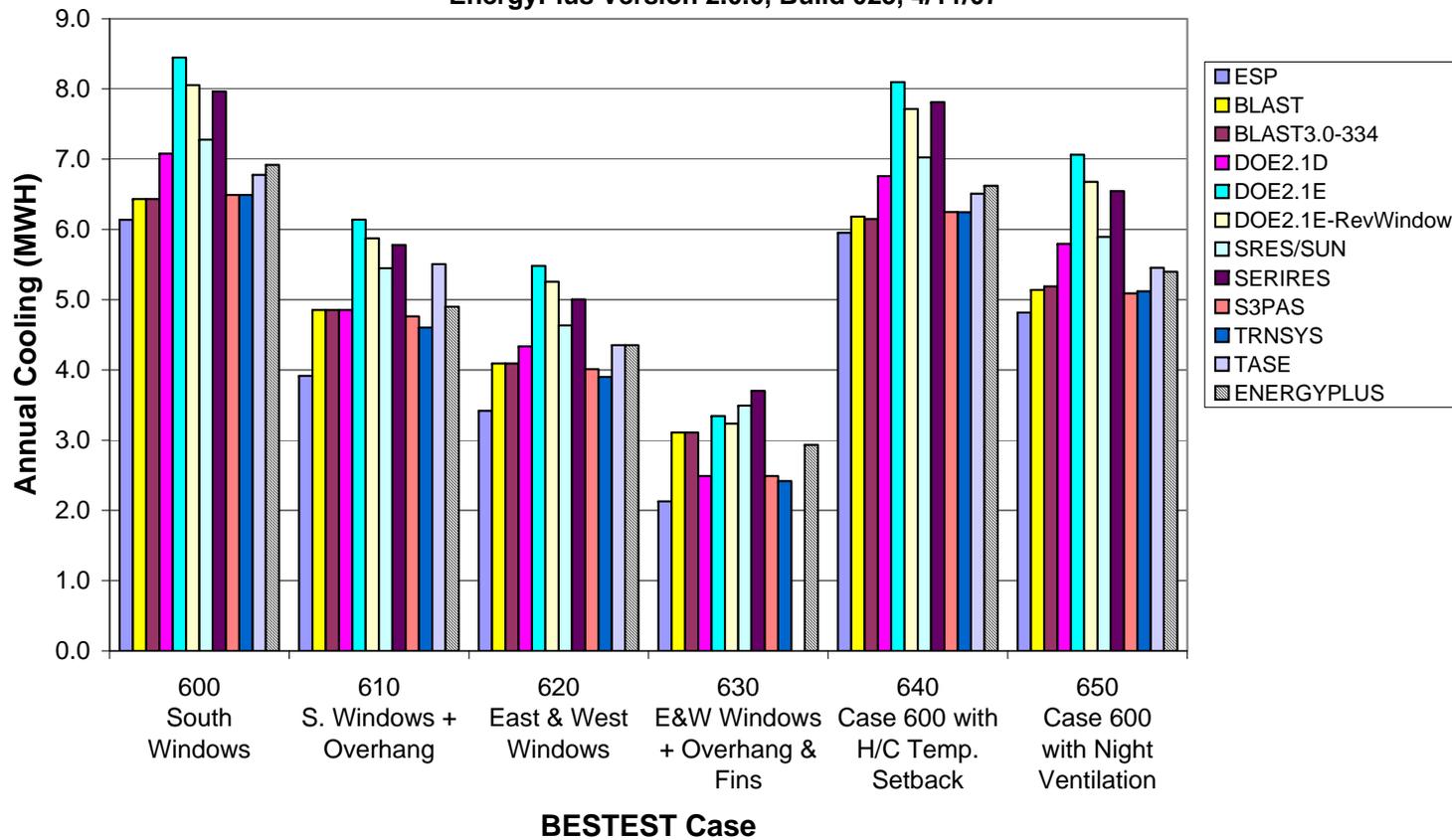
Testing and Validation

- Regression test suite run for every build
 - Hundreds of examples and test cases checked to ensure no changes in results (bugs) are introduced
- Standardized test suites run for every major build and before release
 - ASHRAE
 - Standard 140 (envelope loads BESTEST)
 - 1052-RP (building fabric analytical load calculations)
 - IEA BESTEST
 - HVAC E100/200 (unitary space cooling equipment)
 - HVAC E300/400/500 (unitary cooling with outside air)
 - HVAC Furnace (fuel-fired furnaces)
 - Ground-Coupling (heat transfer from slab on grade)
- Updated reports available on the EnergyPlus web site soon after each release

ASHRAE Standard 140 Test Results

BESTEST Comparison Low Mass Building Annual Cooling

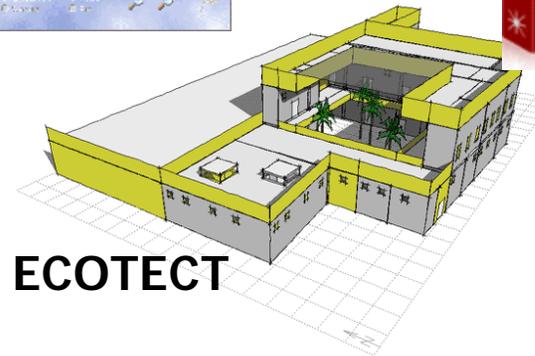
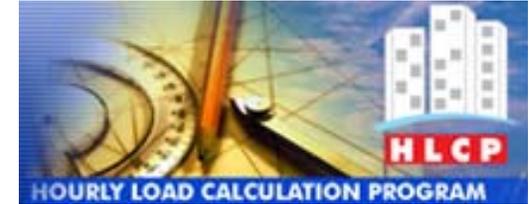
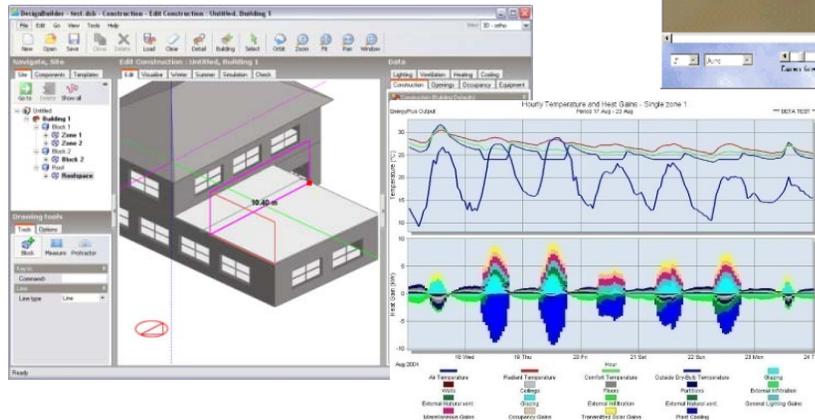
EnergyPlus Version 2.0.0, Build 025, 4/11/07



Private Sector User Interfaces



PV modeling by EnergyPlus

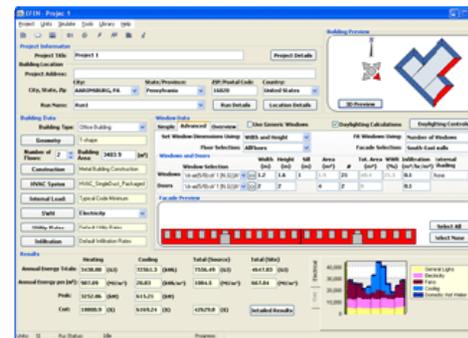
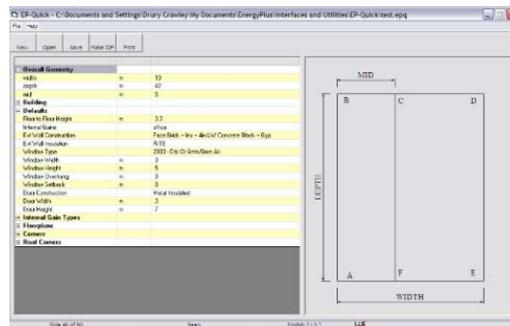


ECOTECT

EFEN

BEE (Chinese)
TREAT Plus
COMFEN
ESP-r
EnergyGauge
EPlusInterface
HVAC Energy
SolarShoeBox
xEsoView
others,

EP-Quick



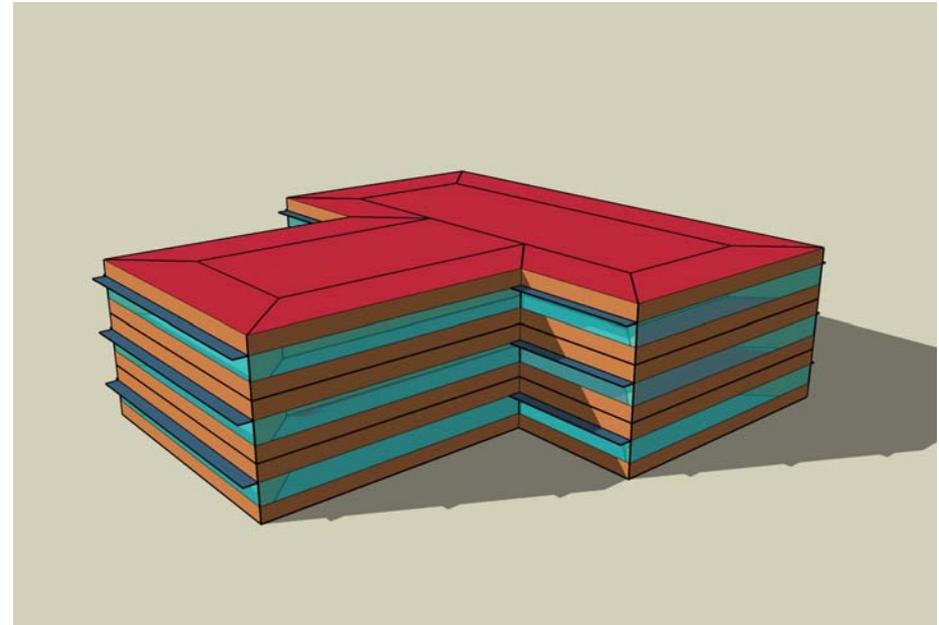
CADD to EnergyPlus

- Translate CADD to EnergyPlus
 - International Alliance for Interoperability
 - Any CADD software that supports interoperability.
 - Available since 2001
 - Limited to what CADD tools export—typically only geometry
 - Green Building Studio (now part of AutoDesk)
 - Web-based conversion of major CADD formats to energy simulation inputs
 - Limited coverage
 - Requires users to create their CADD drawings in structured way (may not follow designer regular methods)
- Direct from CADD to EnergyPlus
 - Graphisoft adding direct export from ArchiCAD to EnergyPlus, later in 2008
 - Bentley recently purchased HEVACOMP and investigating direct link from Microstation
- Interoperability is a key to getting energy simulation mainstream. Other key drivers are zero-energy buildings and green building rating systems.



Web Interface

- Web interface for simple buildings
- Select:
 - Location
 - Standard (currently 90.1-1999, 2001, 2004, 2007 and AEDGs)
 - Building types
 - Floor area
 - Number of floors
 - Internal loads
 - Shape/Aspect ratios
 - Glazing percentage
 - HVAC equipment/systems



Geometry Configuration: [Help](#)

Rectangle
 Courtyard
 L-Shape
 H-Shape
 T-Shape
 U-Shape

Geometry Parameters: [Help](#)

Exterior Equipment	0.00	0.00
Fans	206.12	0.00
Pumps	0.00	0.00
Heat Rejection	0.00	0.00
Humidification	0.00	0.00
Heat Recovery	0.00	0.00
Water Systems	0.00	0.00
Refrigeration	0.00	0.00
Generators	0.00	0.00
Total End Uses	1103.37	463.94

SketchUp

- Intuitive, easy-to-use 3-D drawing software
- Available from Google as free or pro versions
- Popular among architects
- Powerful API using Ruby programming language for plugins



Energy Design Plugin

Adds EnergyPlus functionality
to the SketchUp 3-D environment

- Create/Edit EnergyPlus Input Files
- Run EnergyPlus and view results
- Automatically create building models

Energy Design Plugin

- Developed by NREL
- Still in development
- Beta version released early April – now more than 2000 downloads
- Available for **free** at www.energyplus.gov
- Works with free and pro versions of SketchUp
- Available for Windows initially (Mac later)

SketchUp in the Design Process

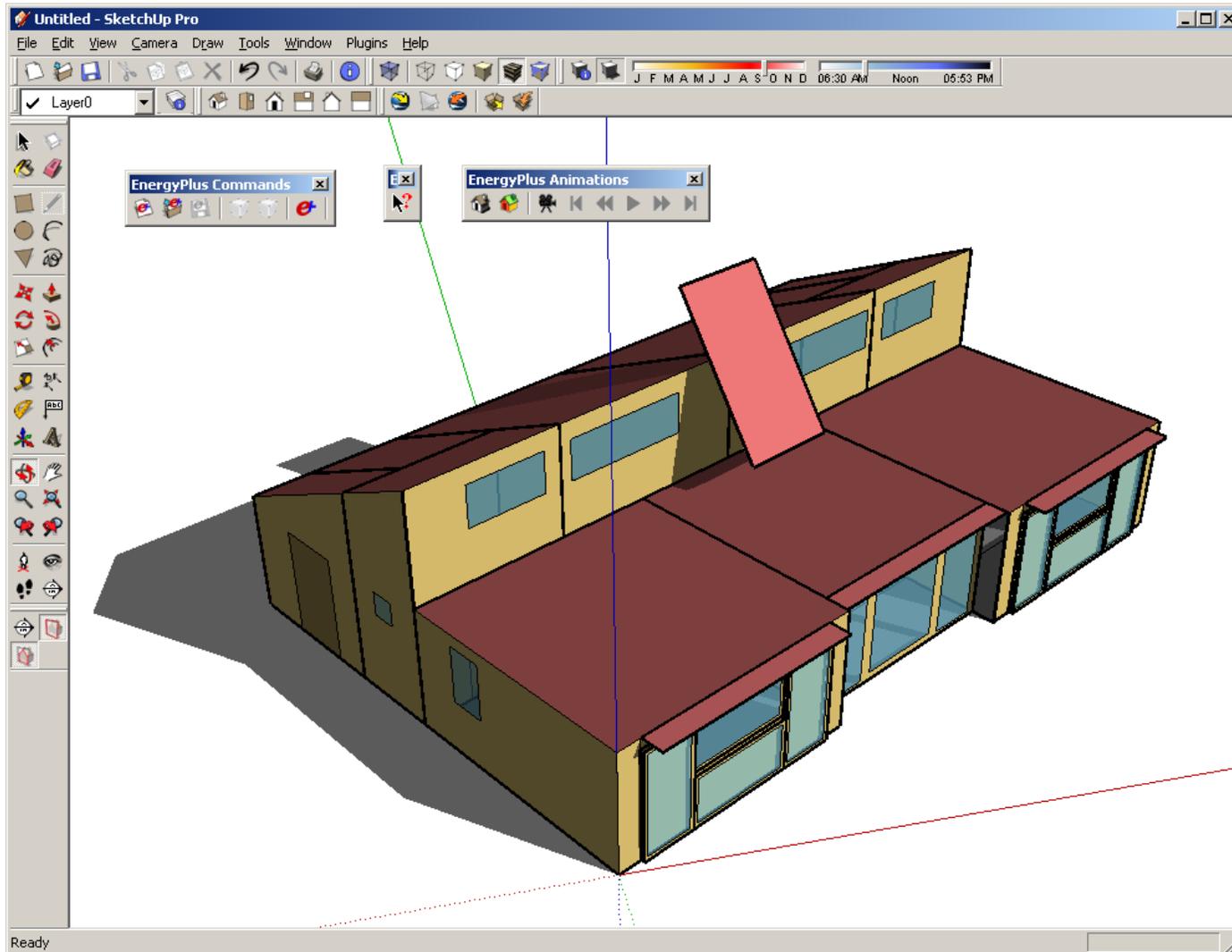
- Conceptual Phase:
 - Quickly create building form and massing
 - Present design proposals to client
 - Changes based on client feedback

- Design Development:
 - Export from SketchUp to CAD tool
 - Design refinement with CAD

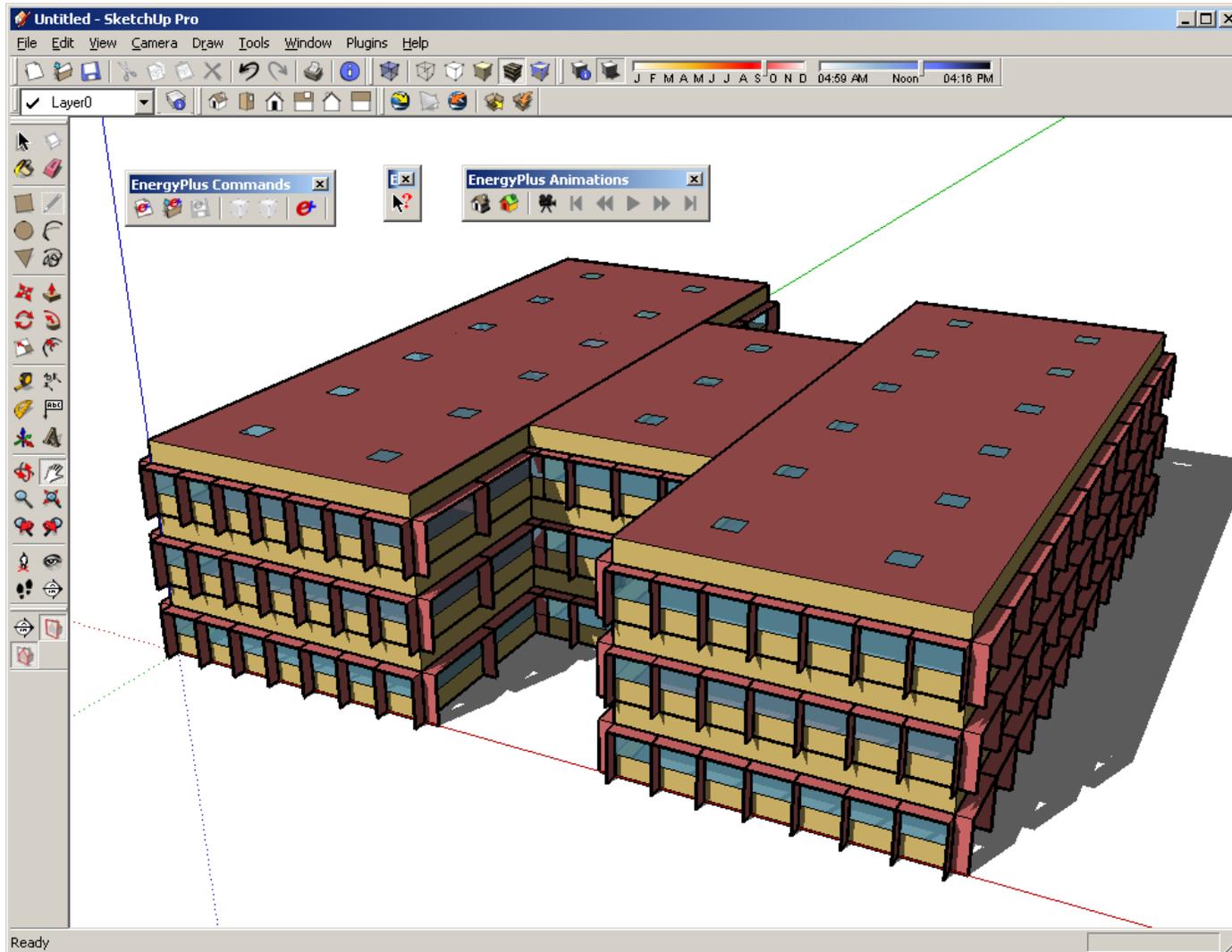
SketchUp in the Design Process

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 - Changes based on simulation feedback ←
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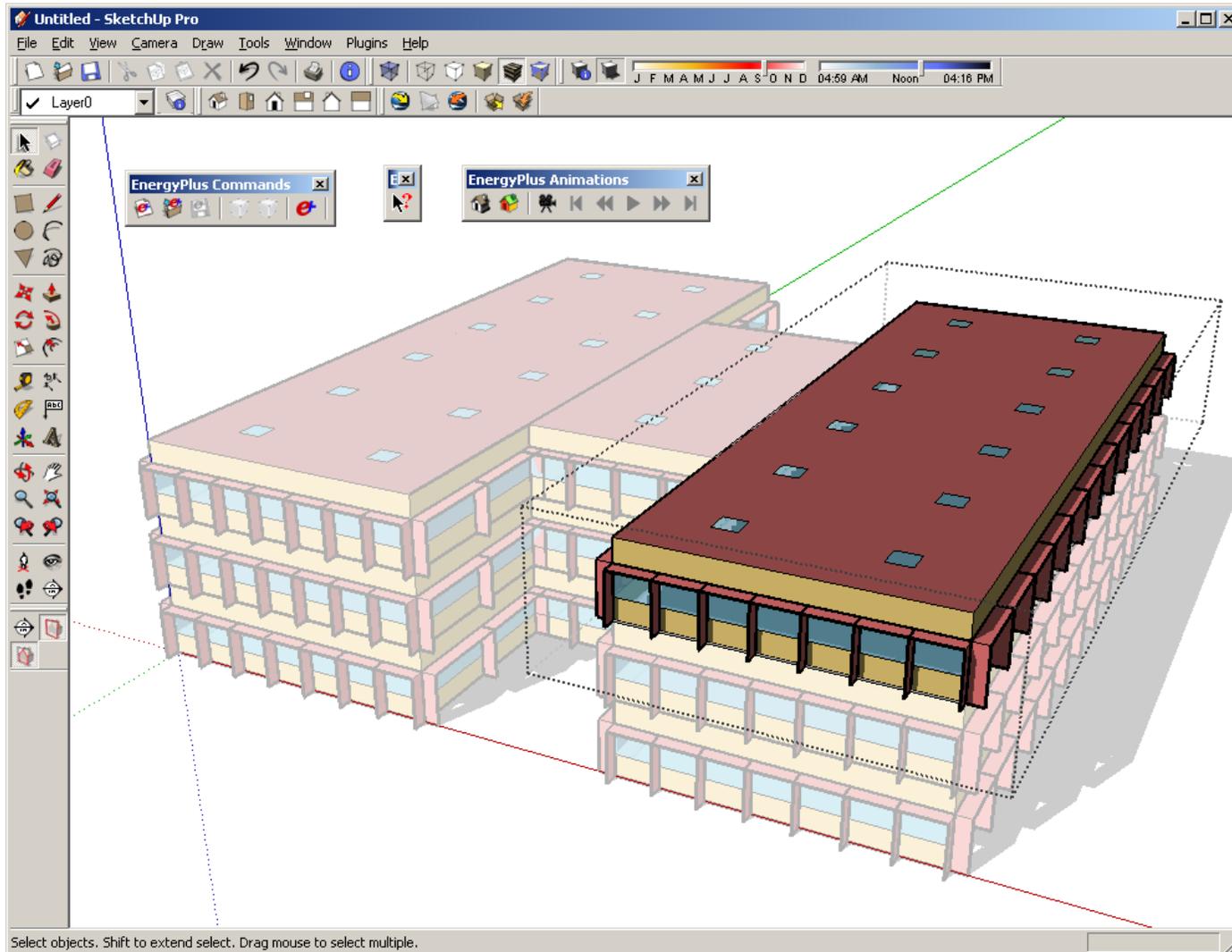
Open/Edit an Input File



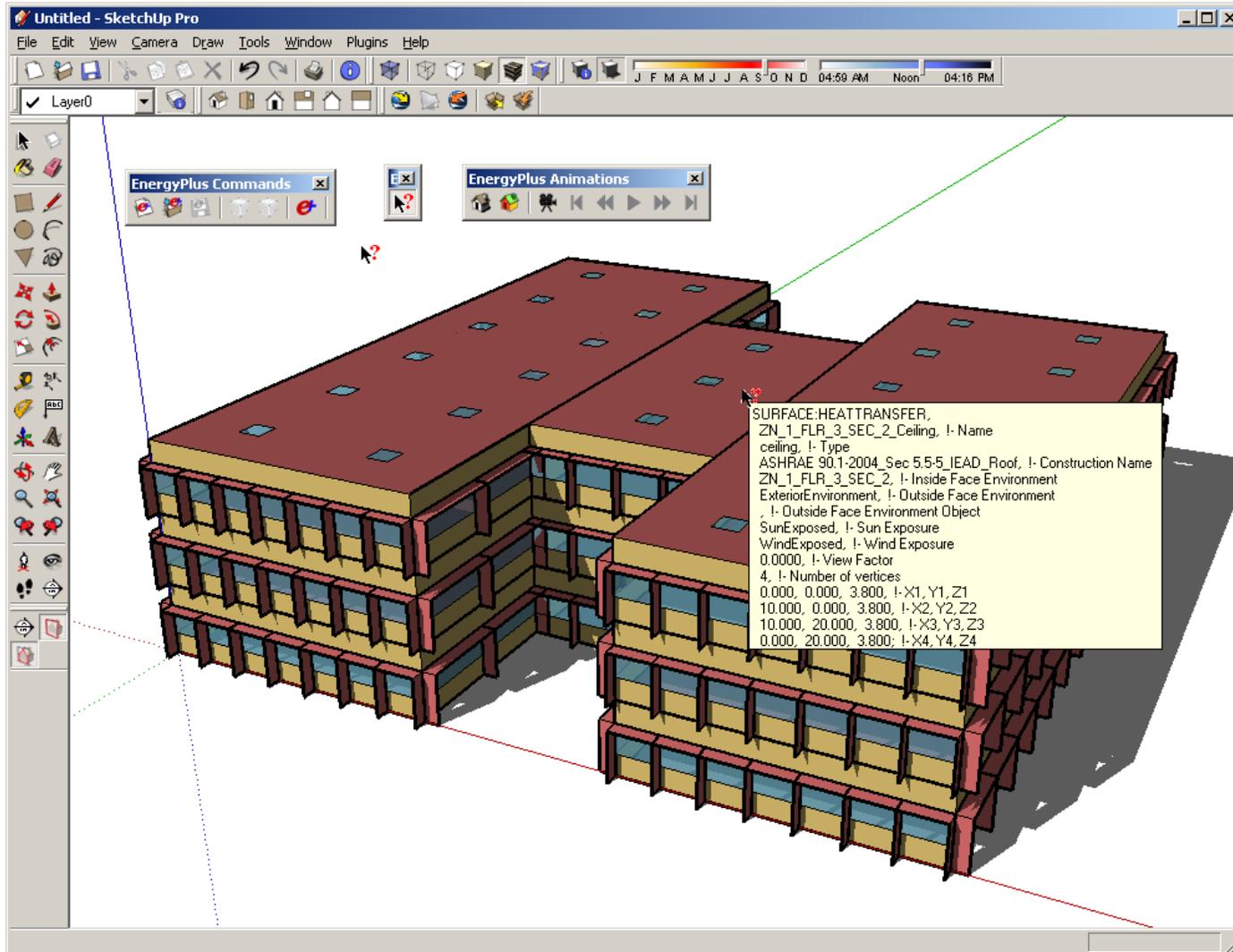
Open/Edit an Input File



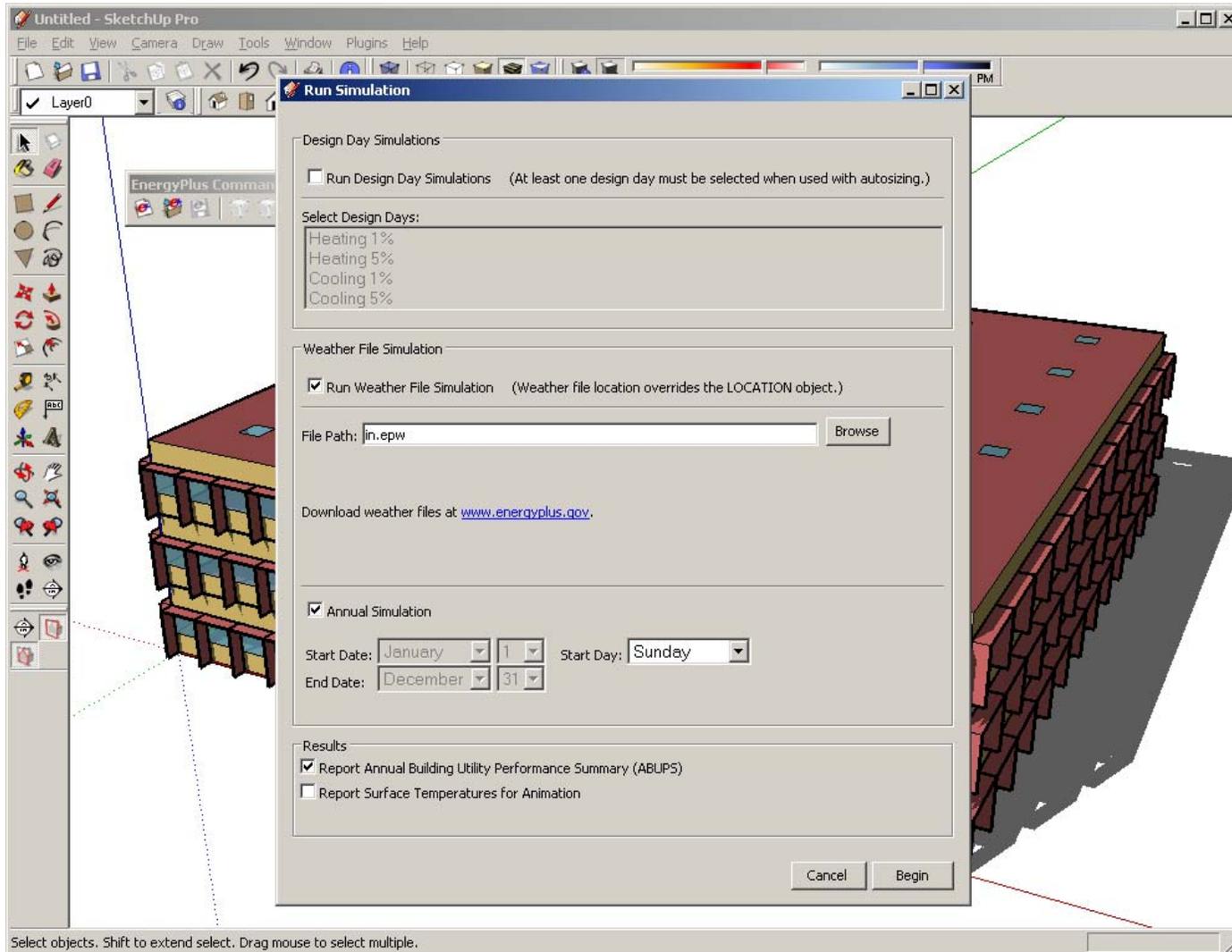
Edit a Zone



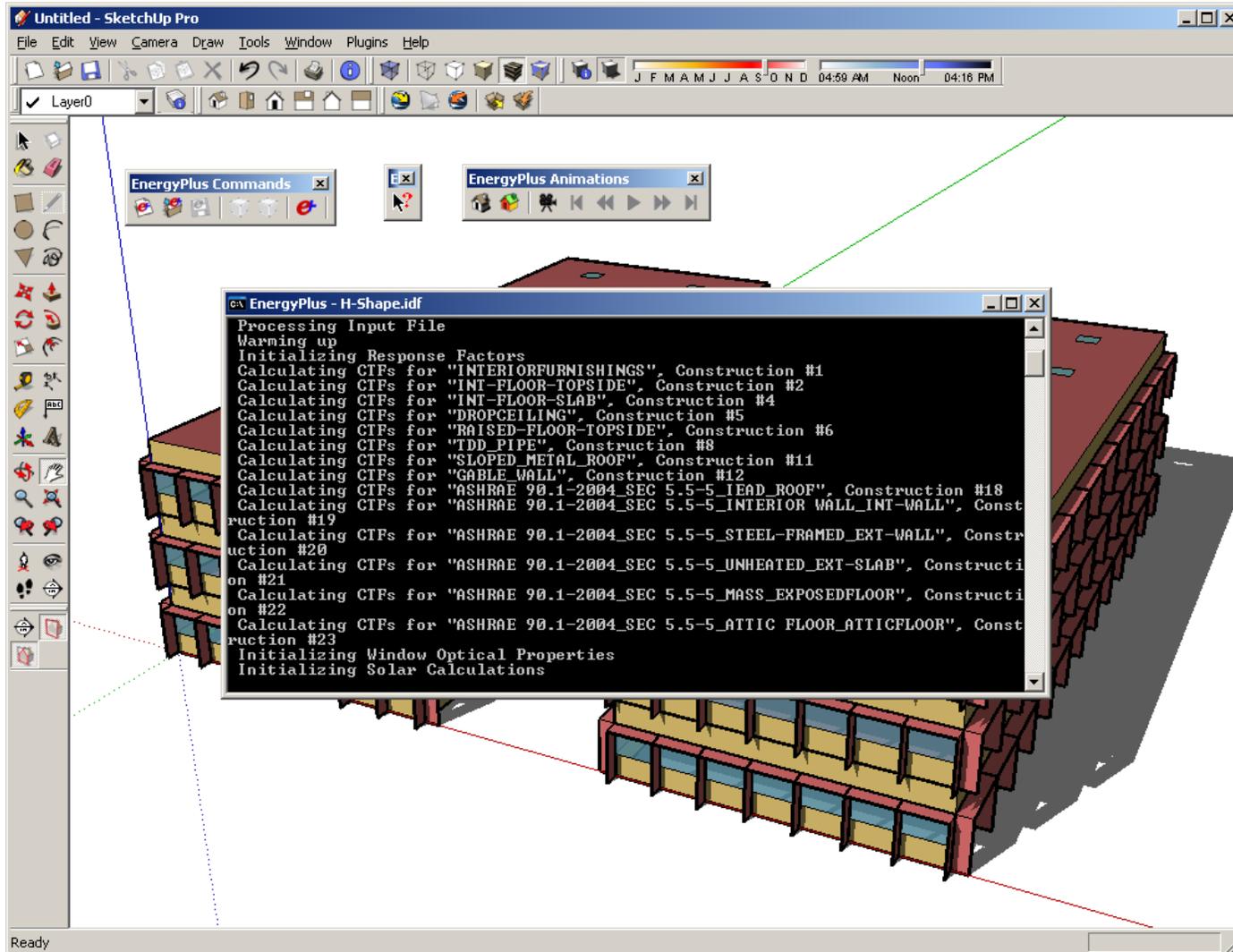
Info Tool



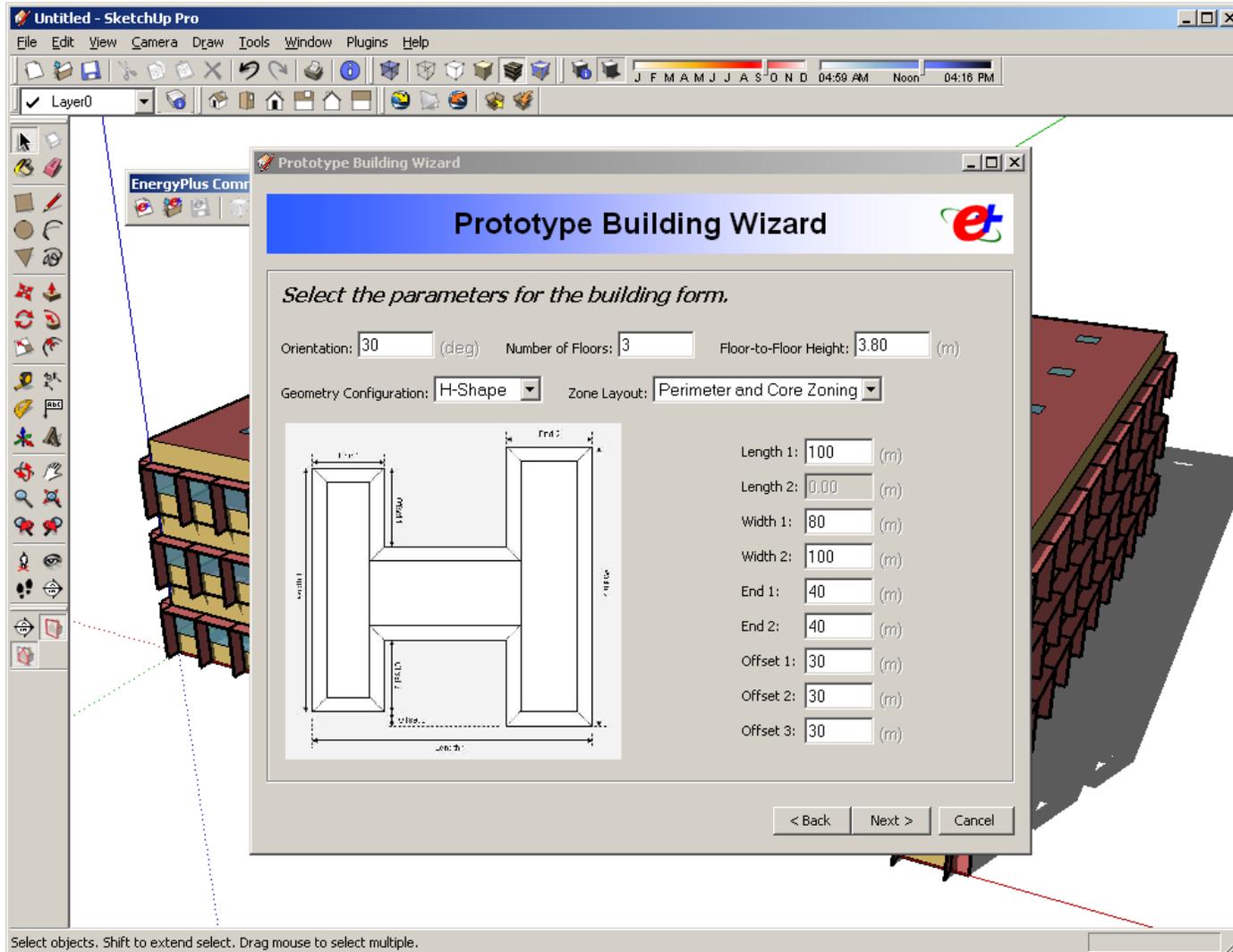
Run Simulation



Run Simulation



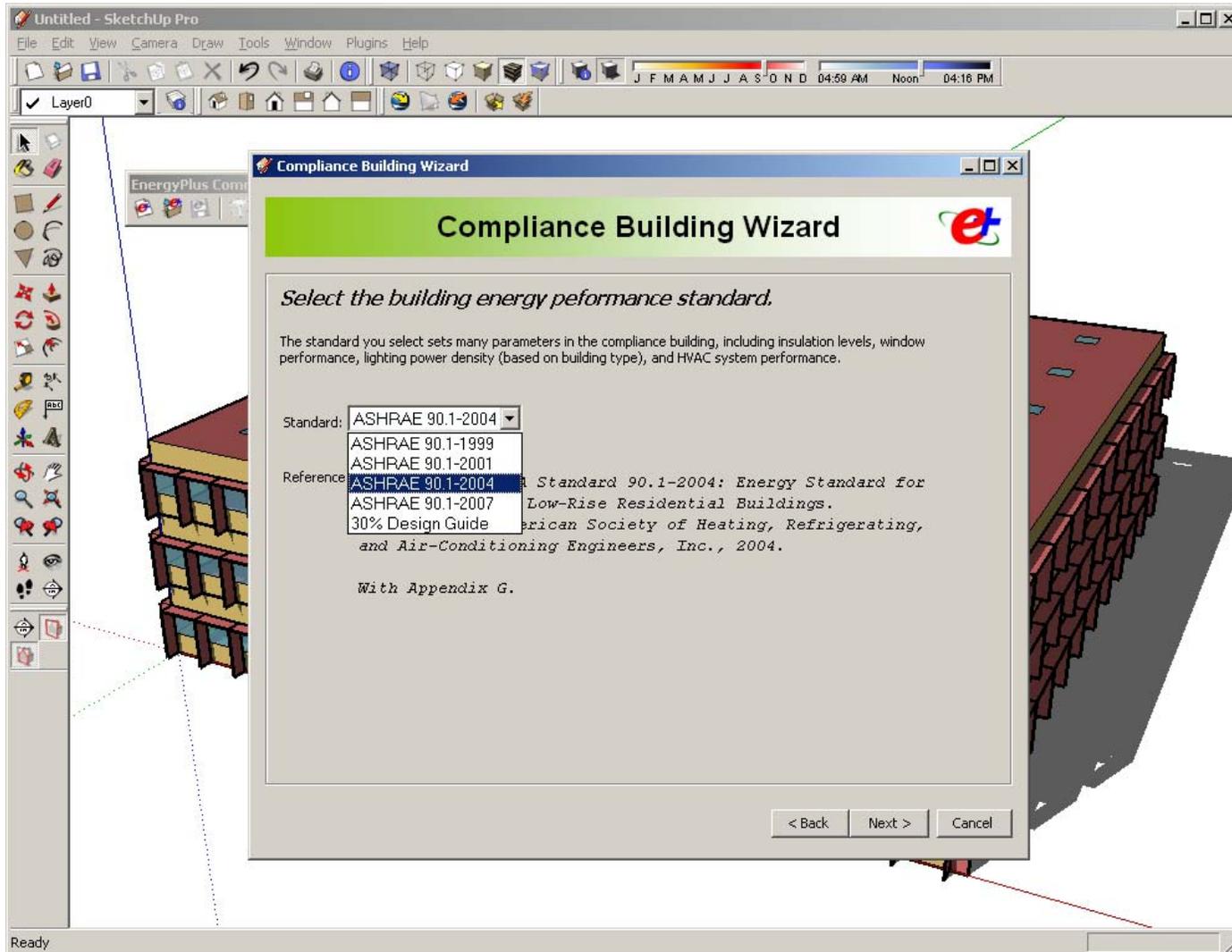
Prototype Building Wizard



Prototype Building Wizard

- Input
 - Code standard
 - Location
 - Construction type
 - Building type
 - Total floor area
 - Building shape: Rect, H, L, U, T, Courtyard
 - Other: Window fractions, daylighting, overhangs, fins, HVAC system type, service hot water, PV
- Output
 - EnergyPlus input file of prototype “starter” model

Compliance Building Wizard



Compliance Building Wizard

- Input
 - Code standard
 - Location
 - Construction type
 - Building type
- Output
 - EnergyPlus input file of compliance model

Compliance Building Wizard

- What changes:
 - Insulation levels
 - Window performance
 - Window-to-wall ratio
 - Lighting power density
 - HVAC system
- What does not change:
 - Building form/geometry
 - People and equipment loads (optional)

EnergyPlus Plugin, Version 1.0

- Goals
 - Make entering 3-D geometry easy
 - Automatic prototype or compliance models
- Audience
 - Current E+ users
 - Prospective E+ adopters

EnergyPlus Plugin, Version 2.0

- Goals
 - Manage and edit most simulation inputs
- Audience
 - Simulation experts
 - Brave architects

EnergyPlus Plugin, Version X.X

- Goals
 - “Simulation for everyone”
 - Appeal similar to Energy-10
- Audience
 - Engineers
 - Architects
 - Homeowners

- SketchUp / Energy Design Plugin Demo

Who's Using EnergyPlus?

- 68,000+ copies downloaded since Version 1.0 in April 2001 (all releases).
- 8,000+ copies per twice-yearly release.
- Nearly 15,000 in last 12 months alone.
- More than 120 countries.
- 1700 people on EnergyPlus_Support email list.
- And a few buildings where EnergyPlus was used...

Buildings Designed Using EnergyPlus

- San Diego Supercomputer Center

- Thermal simulation
- Natural displacement ventilation analysis
- Climate analysis



- San Francisco Federal Building

- Natural cross ventilation system
- No mechanical cooling in high-rise portion
- Building management controls



Buildings Designed Using EnergyPlus

- Freedom Tower

- Building energy simulation of alternatives
- Aggressive energy and environmental goals
- Code compliance



- New York Times

- Building energy simulation of alternatives
- Controls, peak demand, energy use impacts



Buildings Designed Using EnergyPlus

- Evergreen Valley College Arts Center, San Jose, California
 - Low energy cooling including natural ventilation and radiant floor systems
- Heritage Middle School, Minnesota
 - 173,000 ft² new school
 - Load calculation and evaluation of energy efficiency measures



EnergyPlus

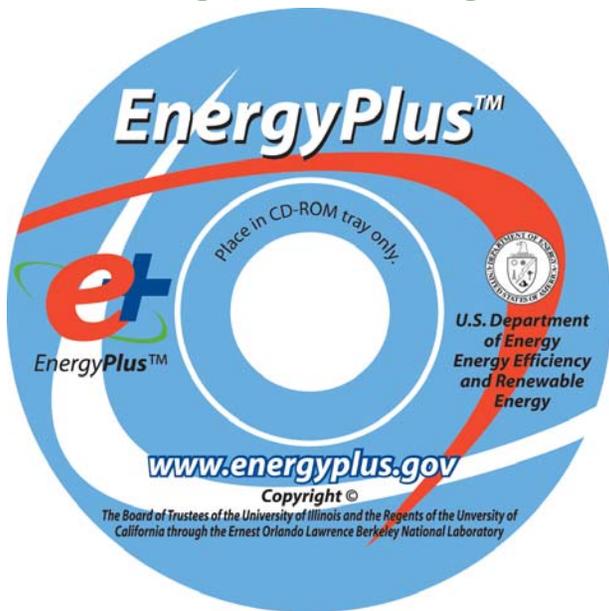
- Designed for flexibility and expansion
- Many new low-energy technologies
- Sub-hourly calculations
- Many output metrics: energy, water, emissions.
- Interfaces available including web file generator and SketchUp plugin
- Web site: energyplus.gov
 - Free download.
 - 3500 pages of documentation and testing/validation reports.
 - Weather data for 1300 locations worldwide (Google Earth layer for the weather data)

DOE Building Technologies Program

buildings.energy.gov

EnergyPlus

energyplus.gov



Thanks!

Drury.Crawley@ee.doe.gov