U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

EnergyPlus: DOE's Next Generation Simulation Program

Building Technologies Program

February 16, 2010

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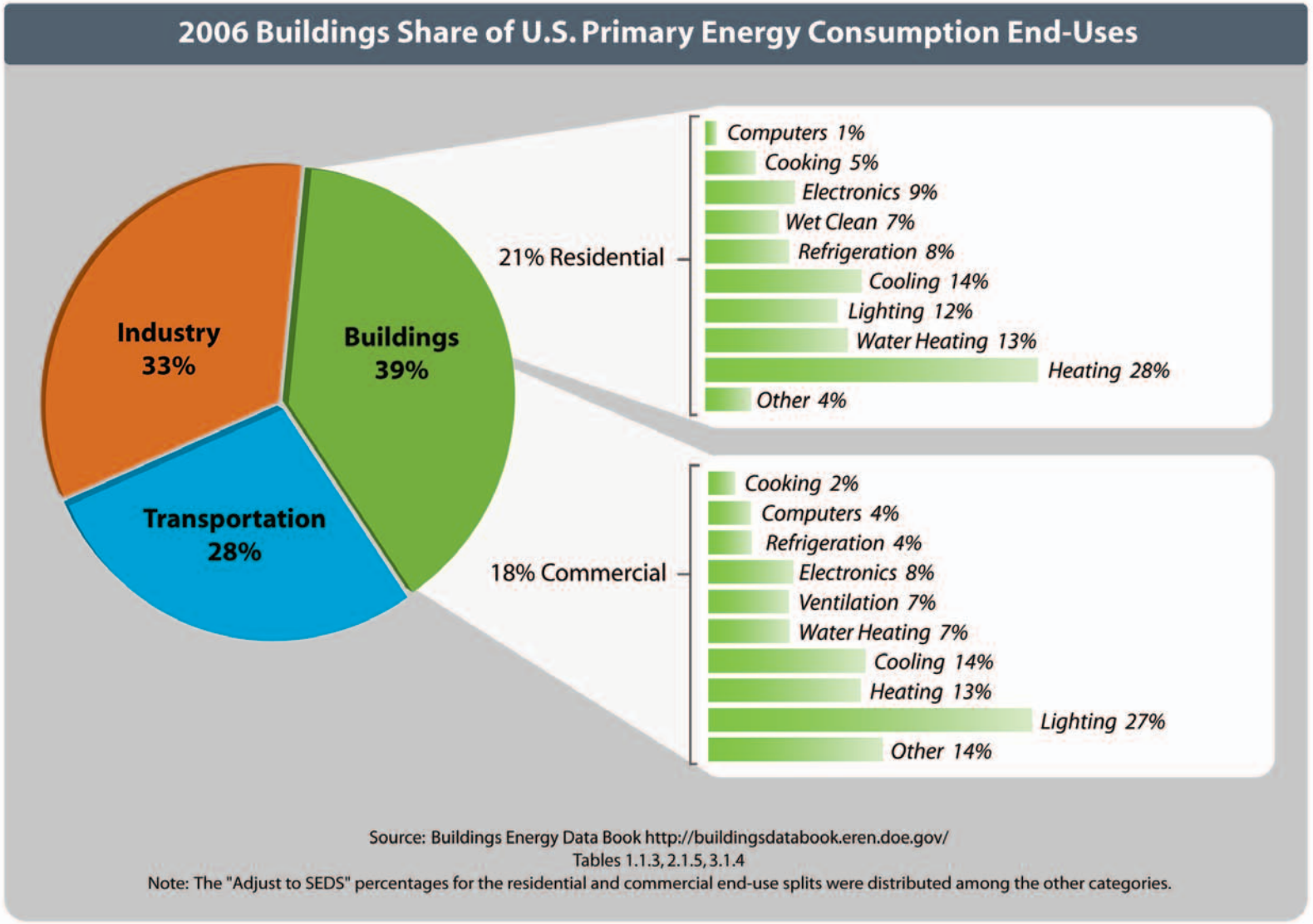
U.S. Department of Energy
Energy Efficiency and Renewable Energy

Buildings' Energy Use

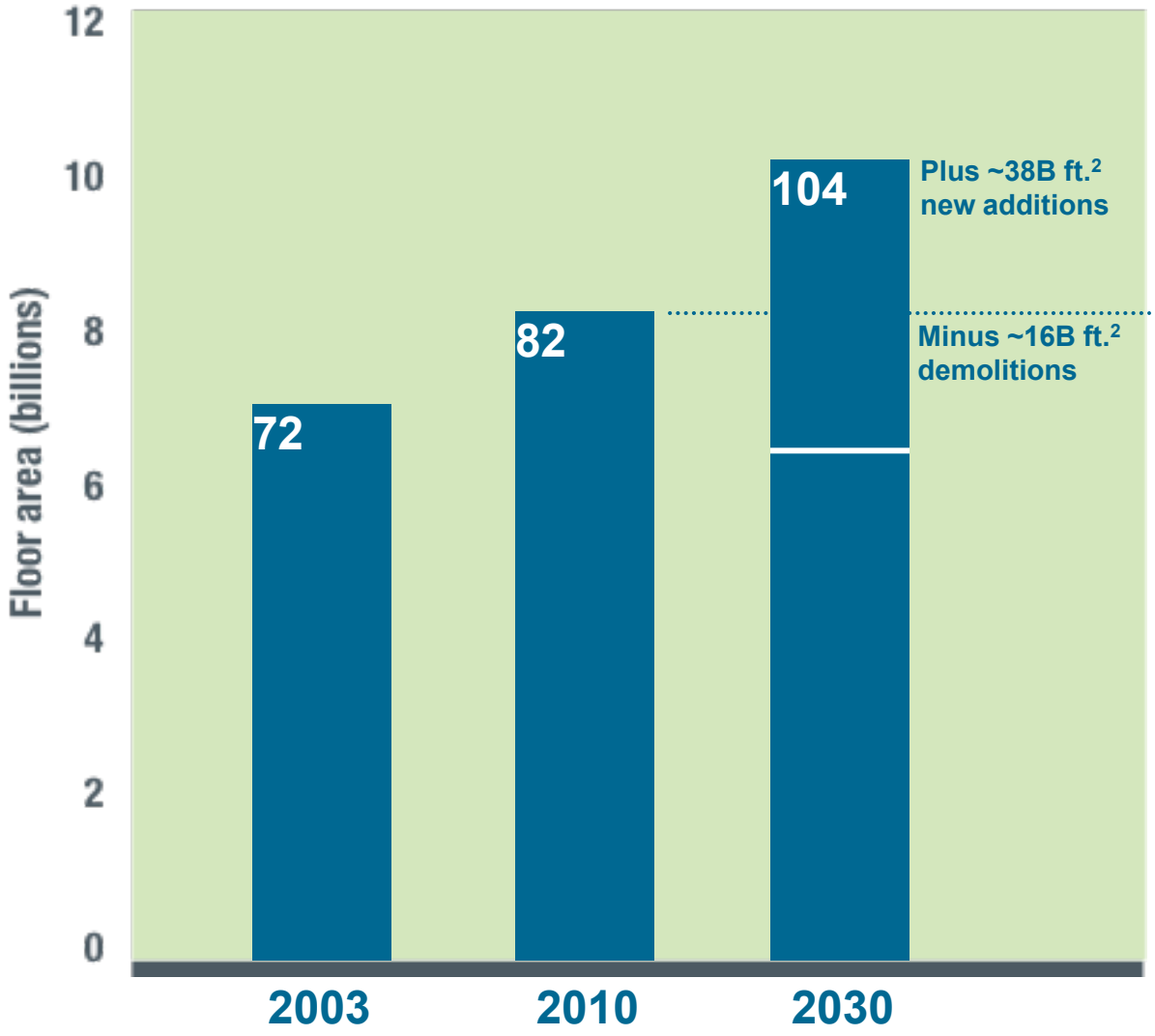


Commercial Buildings' Energy Share

Commercial buildings account for:

- 18% of U.S. energy
- 18% of greenhouse gas emissions (~1,000 MMT of CO_2e)
- slightly less than India's entire energy consumption and GHG emissions

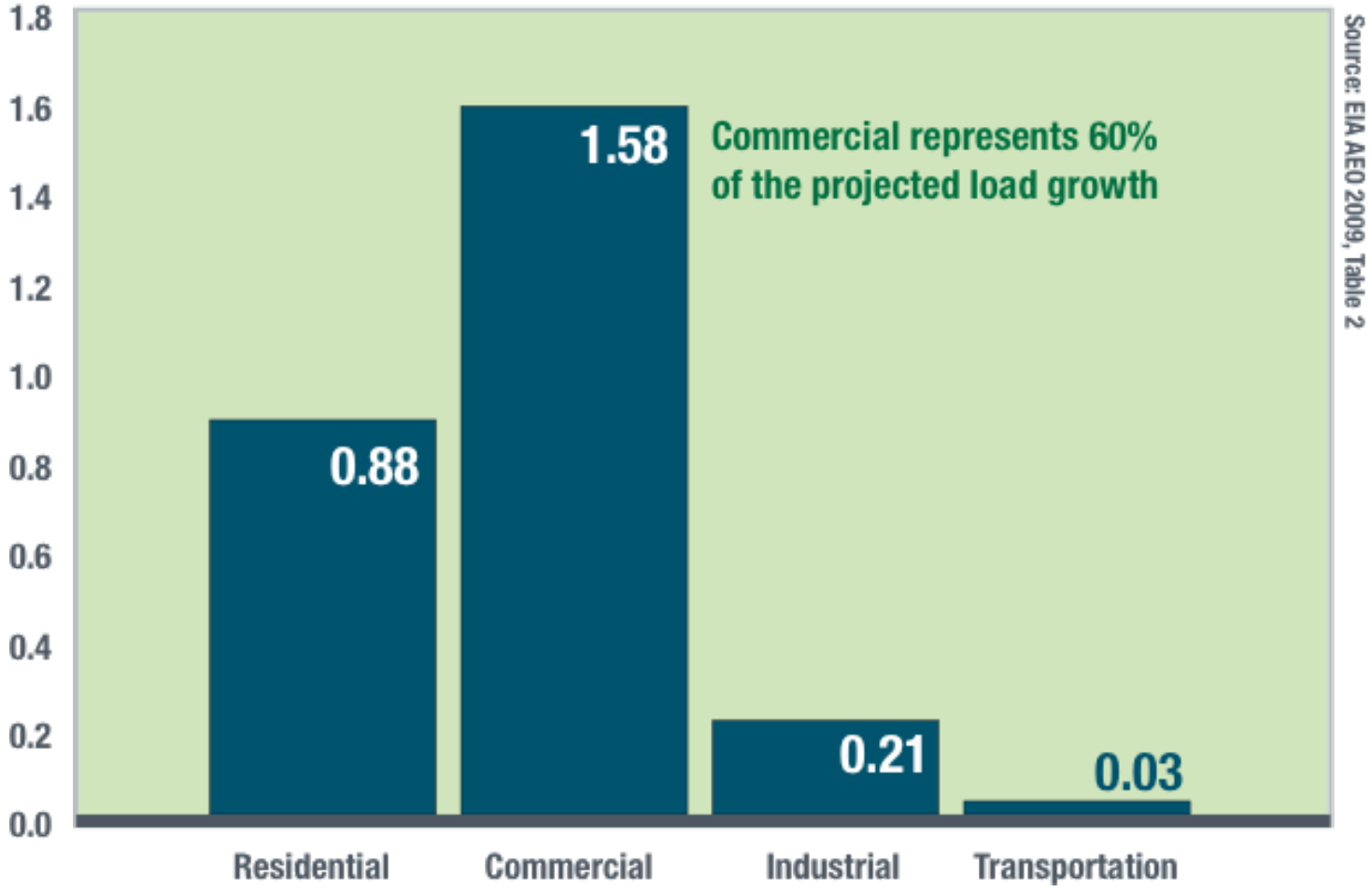
Commercial Square Footage Projections



Source: EIA's Annual Energy Outlook 2009, Table 5.

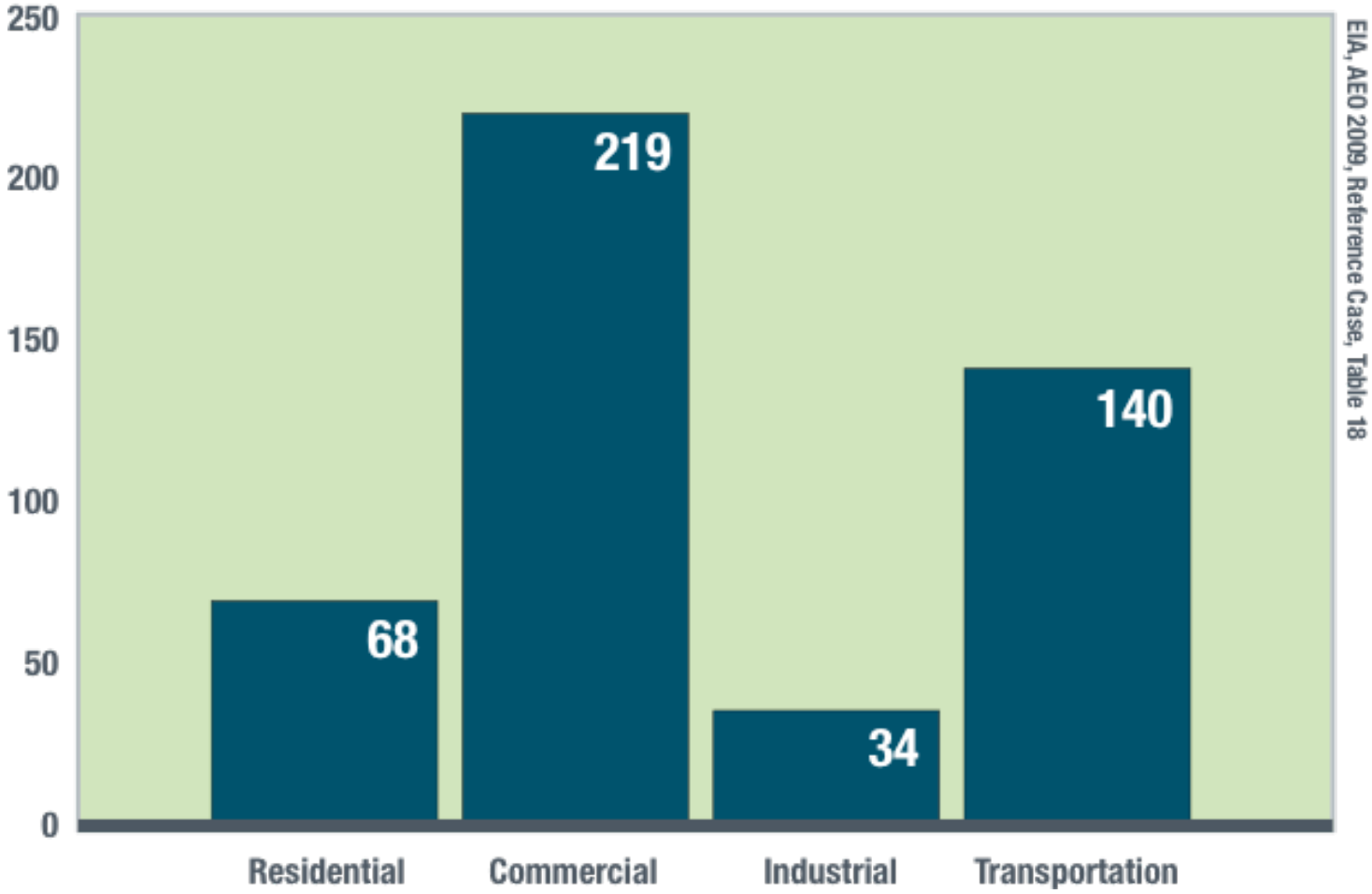
Projected Electricity Growth

2010 to 2030, by End-Use Sector *(site quad)*



Projected Increase in Carbon Dioxide Emissions

2008 to 2030, by End-Use Sector *(MMTCO$_2$-e)*



Goals for Commercial Buildings

2050

All commercial buildings are ZEB (EISA 2007)
83% reduction in U.S. GHGs by 2050 (Obama)

2040

50% of commercial building stock is ZEB (EISA 2007)

2039

All New are ZEB (EISA 2007)
Stock energy performance 50% better w.r.t. CBECS 2003 (CBI Performance Goal)

2025

Improve New 70% with 5-year payback or less (CBI Performance Goal)

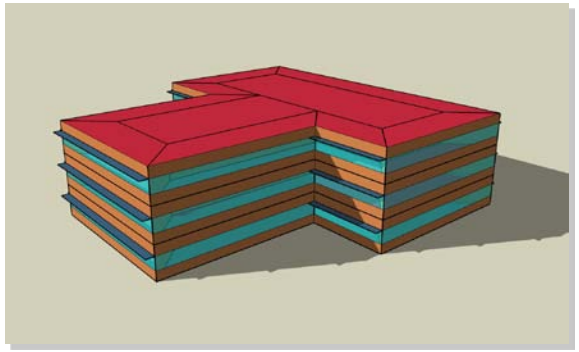
2020

17% reduction in GHGs rel. to 2005 (Senate Proposal)

2015

Improve New 50% (CBI Performance Goal)

EnergyPlus



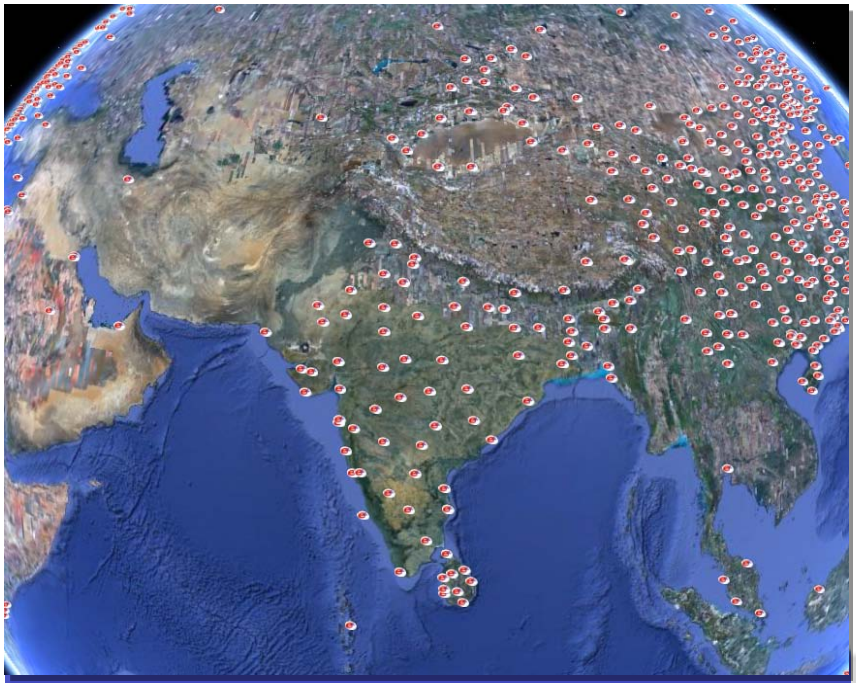
- Fully integrated building, envelope, HVAC, water, and renewables simulation program
- Available free at www.energyplus.gov
- Originally based on BLAST and DOE-2.1E, far exceeds their capabilities now

EnergyPlus *(cont.)*

- 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; twice yearly updates
- 100,000 copies downloaded to date
- Windows XP/Vista/7, Linux & Mac

EnergyPlus

- Designed for flexibility and expansion
- Many new low-energy technologies
- Sub-hourly calculations
- Many output metrics: energy, water, emissions
- 3,800 pages of documentation and testing/validation reports
- Weather data for more than 2,100 locations worldwide (Google Earth layer for weather data)



buildings.energy.gov/energyplus/download/energyplusweatherdata.kmz

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 *(cont.)*

San Francisco Federal Building

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

San Diego Supercomputer Center

- Thermal simulation
- Natural displacement ventilation analysis
- Climate analysis

"Every building is a forecast.
Every forecast is wrong."

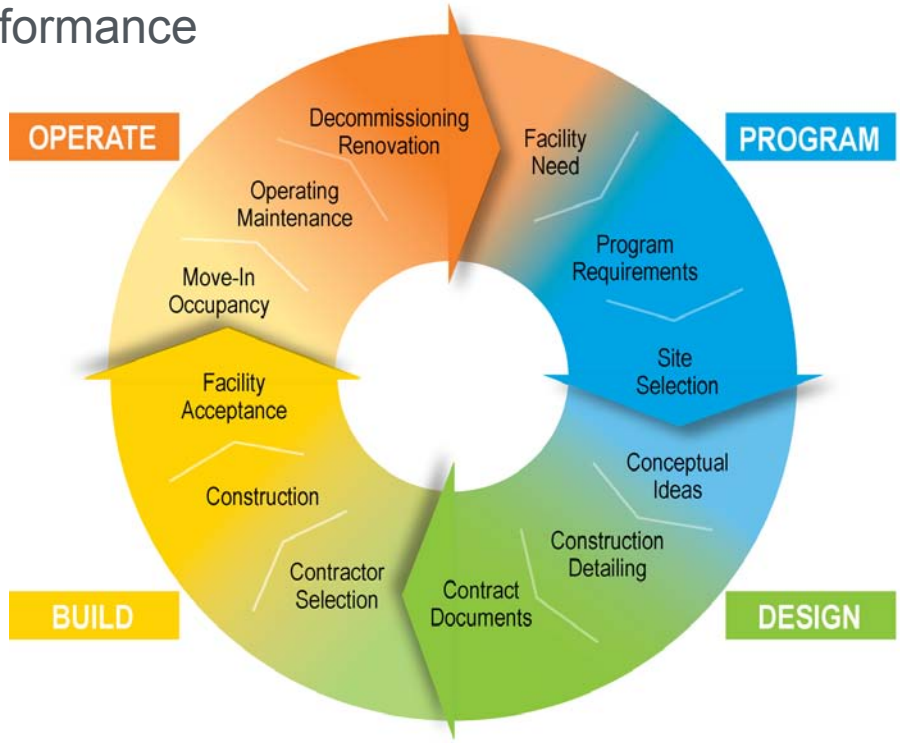
Stewart Brand

Simulation vs. Operating Energy

- In DOE's low-energy building research, simulation has been critical for designing and operating buildings to support decision-making
- BUT, compared to simulations, real buildings
  - use more energy
  - produce less power
  - have worse controls
  - have more occupant complaints
  - GIGO

Why Use Energy Simulation?

- Inform energy decisions from earliest phases of design through construction and into operation
- Help the design team and owner focus energy-use reduction efforts where they will be most effective
- Permit assessment of predicted performance with established benchmarks or project goals
- Size renewable energy systems and determine their likely % contribution
- Evaluate alternatives through programming, design, construction, operation—retrofit, too
- Simulation is cheaper than constructing the wrong building!



Using EnergyPlus for Simulation

EnergyPlus is an Integrated Simulation Manager

- Simultaneous simulation of loads, systems, and plant
- Air and water loops solved iteratively each time-step
- Provides tighter coupling between the air- and water-sides of the system and plant
- Allows capacity limits to be modeled more realistically
- Loads “not met” result in zone temperature and humidity changes
- Time-dependent conduction
  - conduction through building surfaces calculated with conduction transfer functions
  - heat storage and time lags
  - finite difference, with variable properties to model phase-change materials

EnergyPlus Version 4.0

- Released October 2009
- New features include
  - EnergyManagementSystem implemented, including EnergyPlus runtime language with numerous actuators. A separate application guide covers its use.
  - large horizontal openings added to AirflowNetwork for natural ventilation
  - plant and condenser HVAC loops merged with significant improvements throughout
  - walk-in refrigeration, refrigeration cascade condenser, and refrigeration secondary loop
  - evaporative fluid cooler

Private Sector User Interfaces

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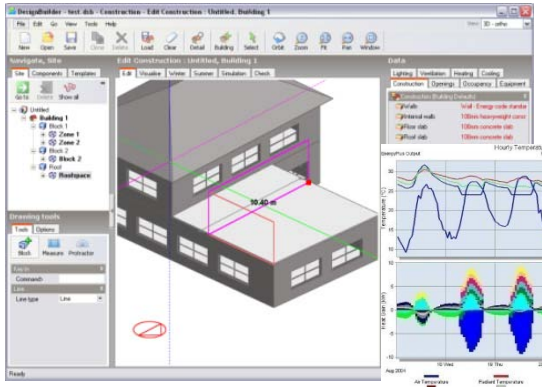
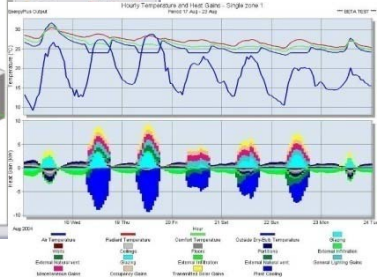
ENERGY-10

PV modeling by EnergyPlus

DesignBuilder SOFTWARE





HEVACOMP

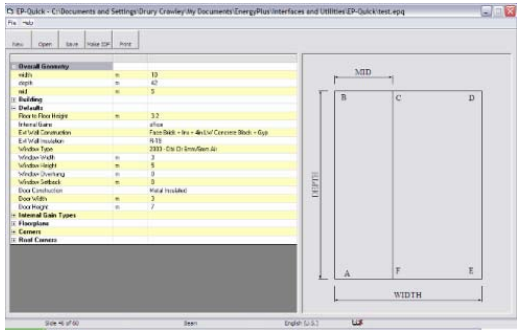
HLCP
HOURLY LOAD CALCULATION PROGRAM

ecotect

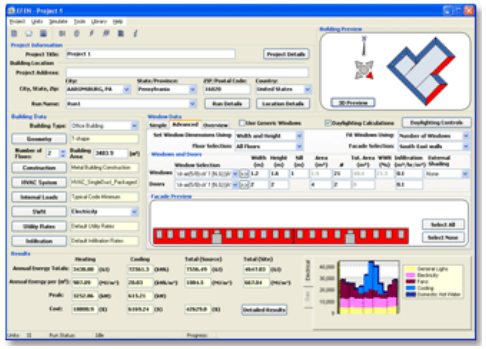
ECOTECT

EFEN

Easy Energyplus *(Chinese)*
COMFEN
EnergyGauge
TREAT Plus
ESP-r
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)

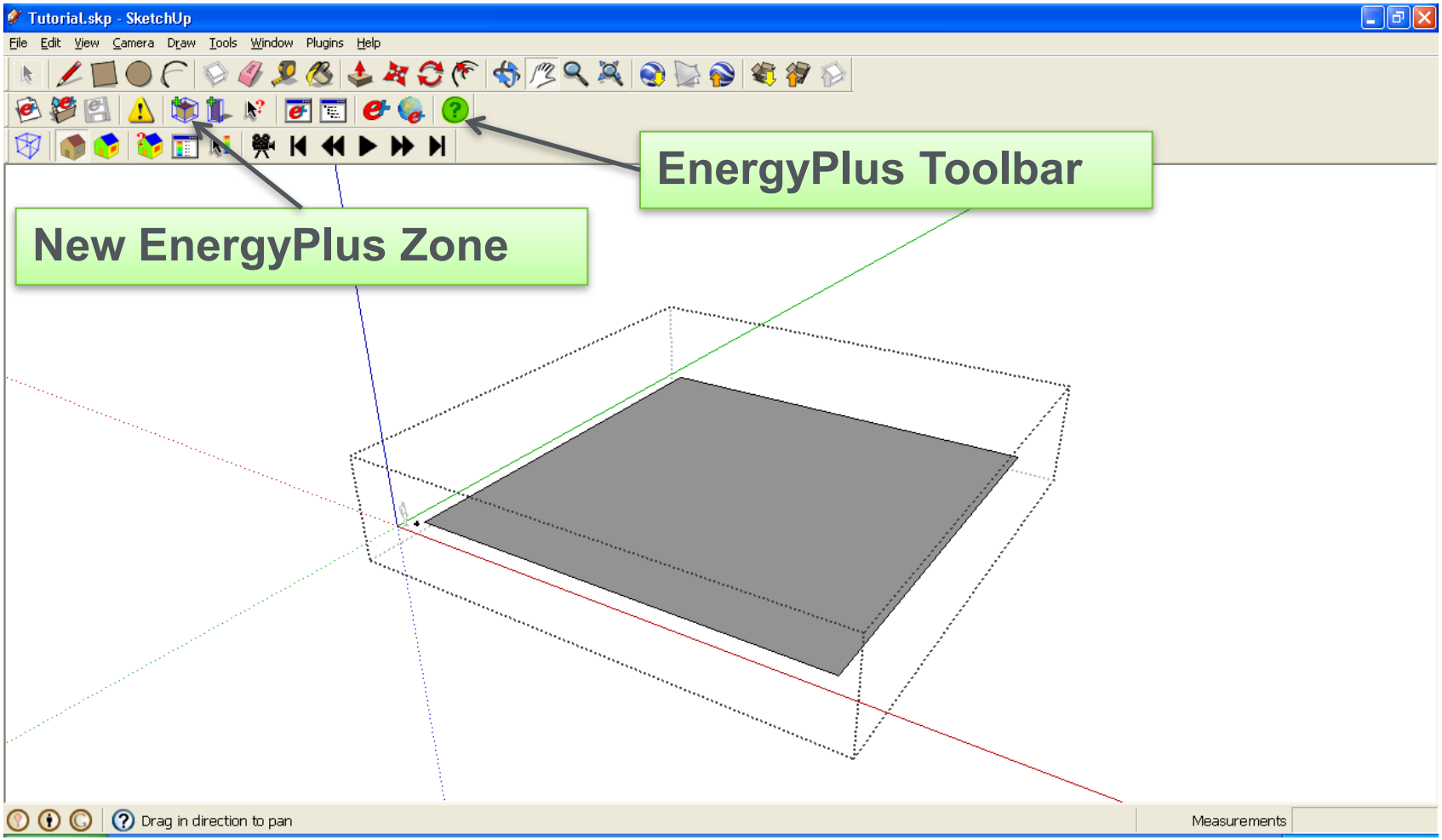
- Direct from CADD to EnergyPlus
  - Graphisoft adding direct export from ArchiCAD to EnergyPlus
  - Bentley recently purchased HEVACOMP and investigating direct link from Microstation

- Interoperability is key to getting energy simulation mainstream. Other drivers—zero-energy buildings and green building rating systems

Google SketchUp and OpenStudio

- Google SketchUp 3-D environment
  - intuitive, easy-to-use 3-D drawing software available from Google
  - popular with architects
  - powerful API using Ruby programming language
- OpenStudio
  - adds EnergyPlus functionality to Google SketchUp (Free and Pro versions)
  - available free at www.energyplus.gov
  - distributed under open source license (GPL)
  - provide feedback during the conceptual phase of the design process
  - geometry only—must have energy model in mind

Create Geometry from Scratch



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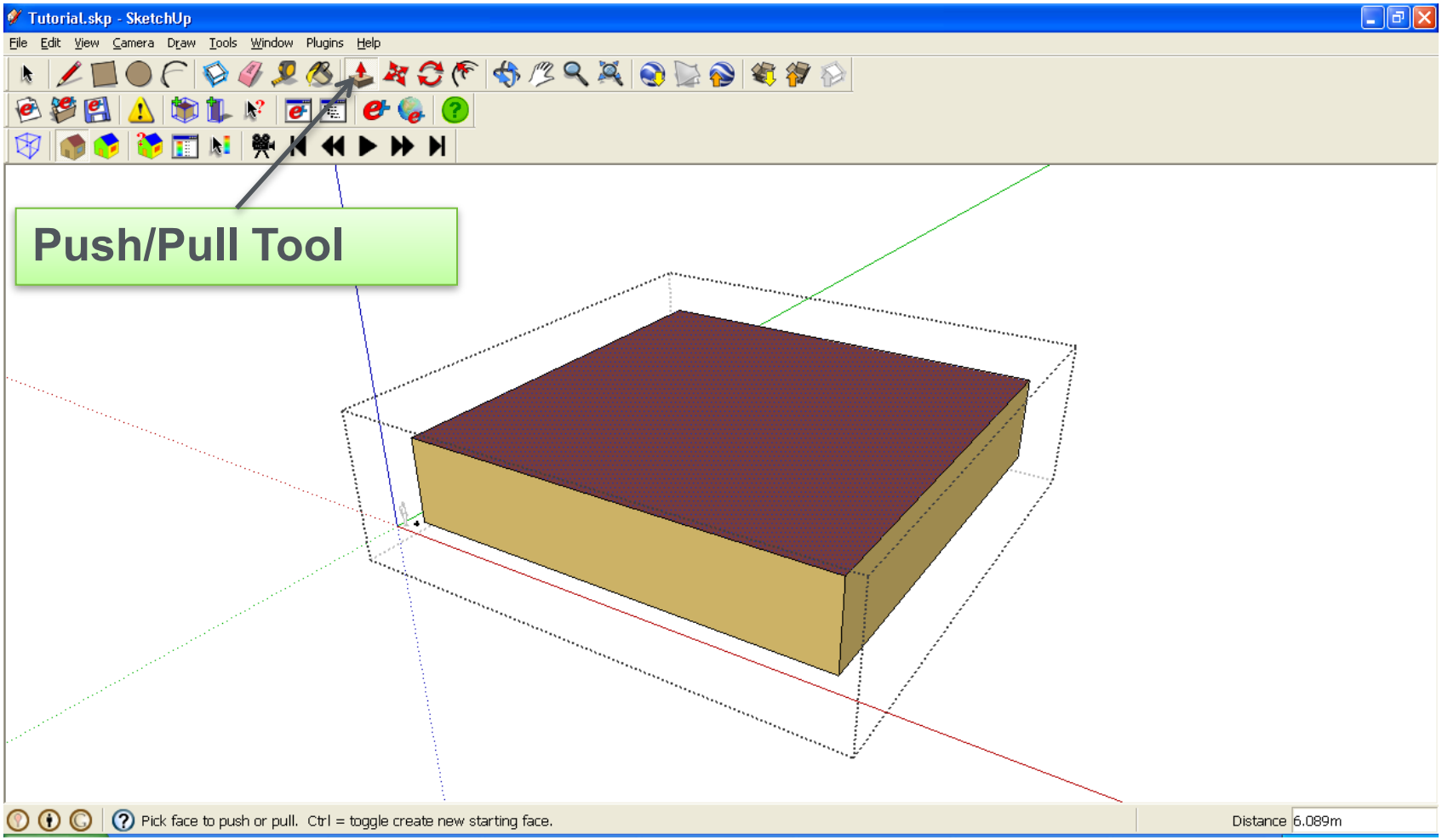

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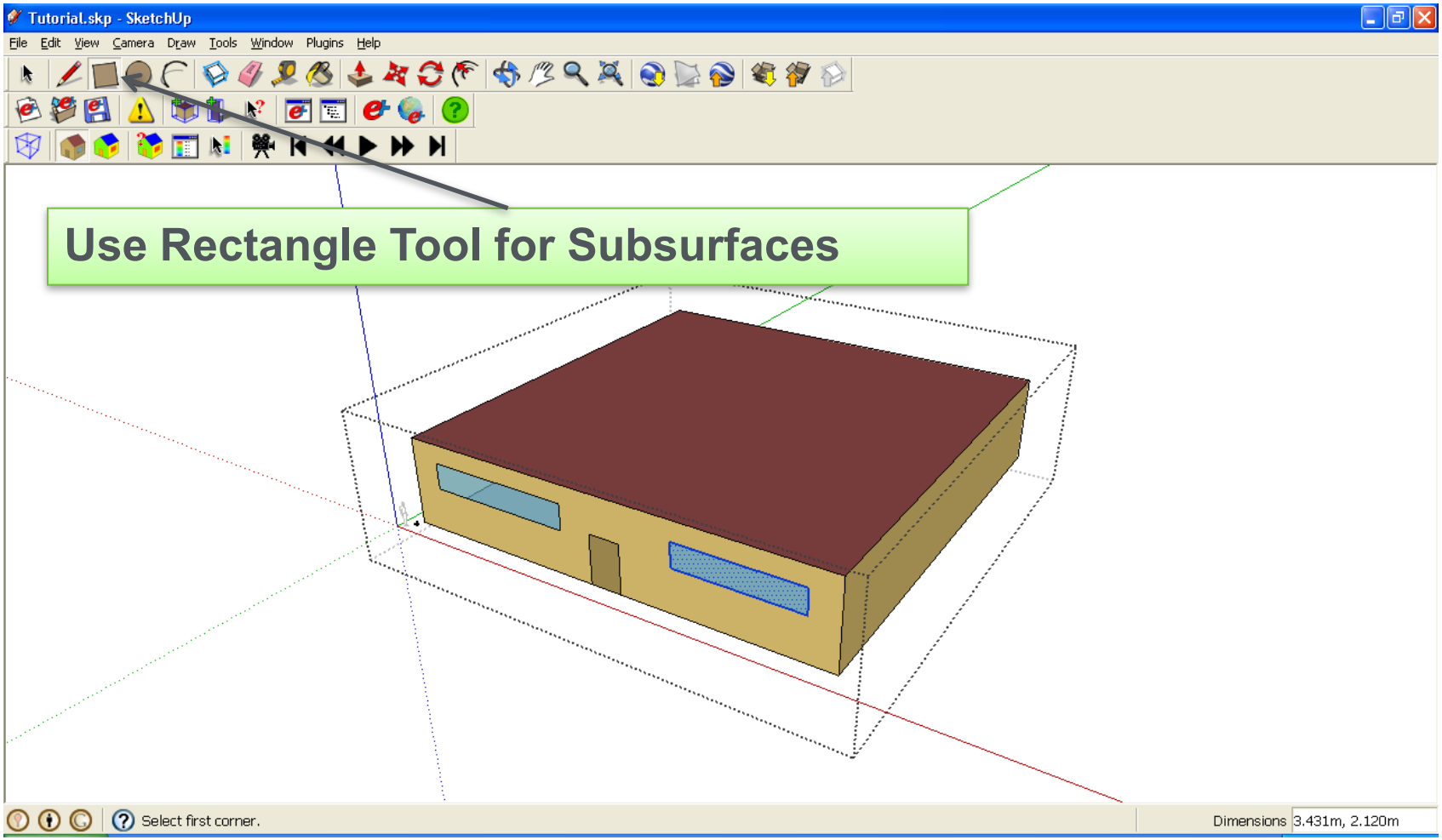
Create Geometry from Scratch



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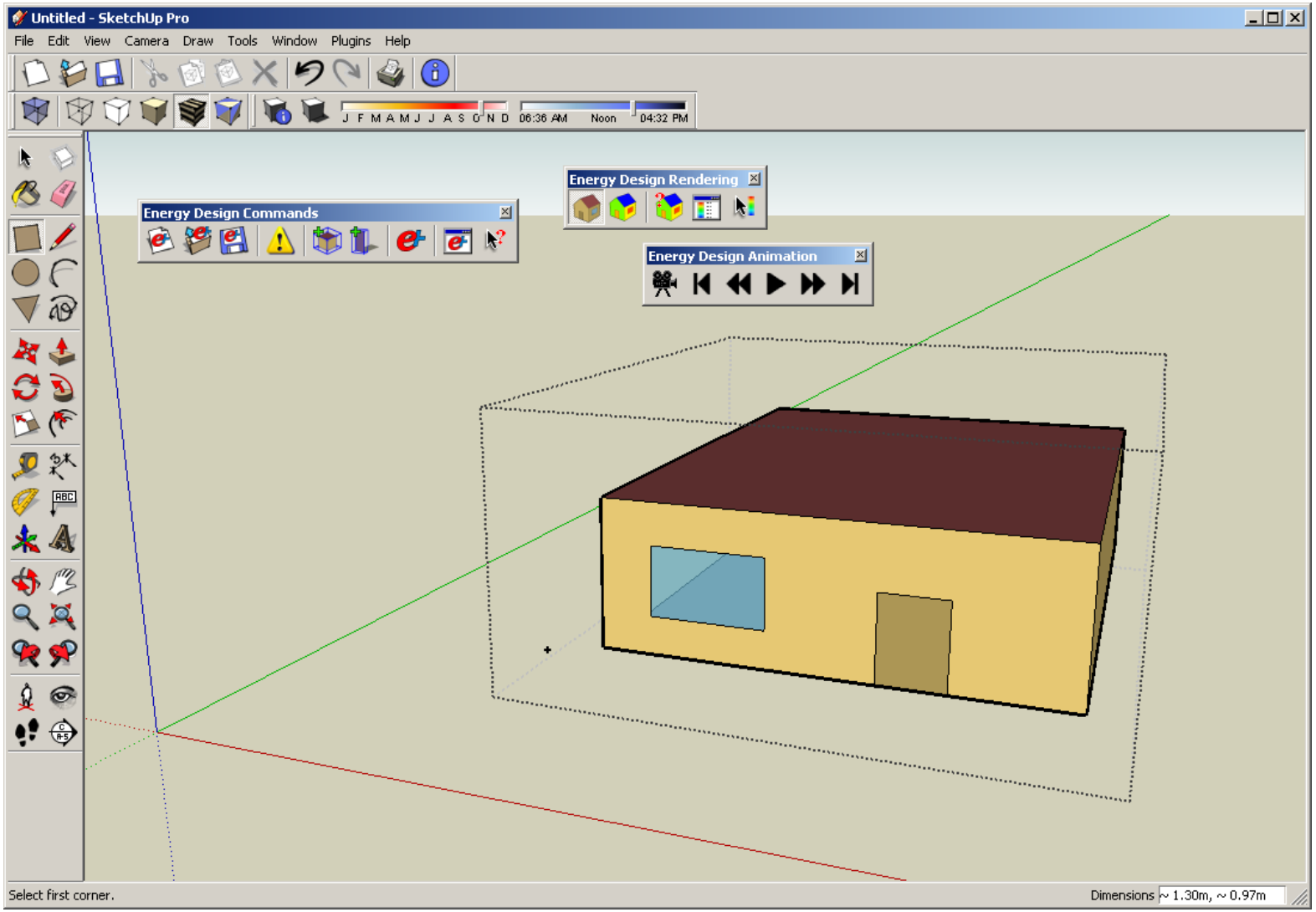
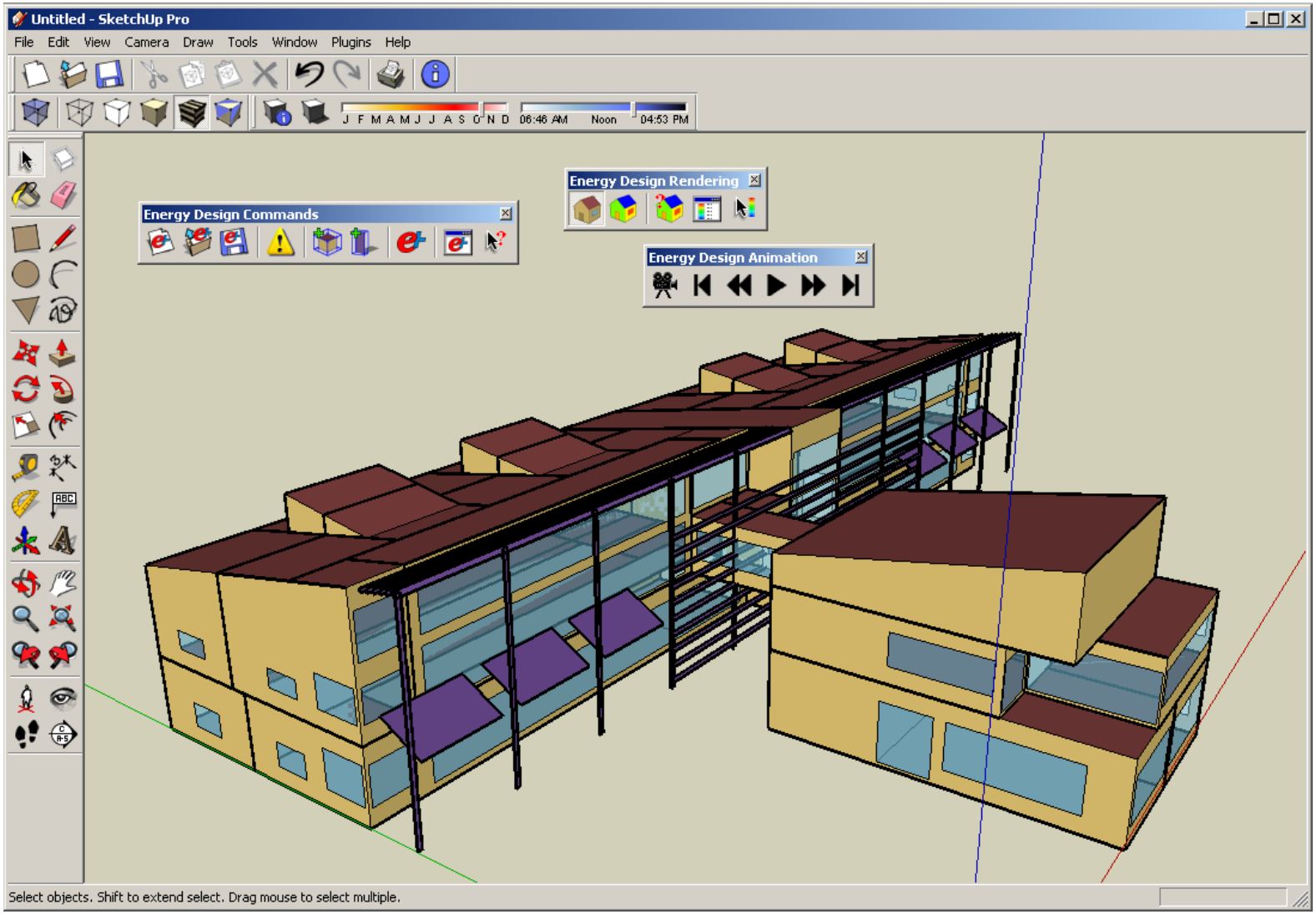
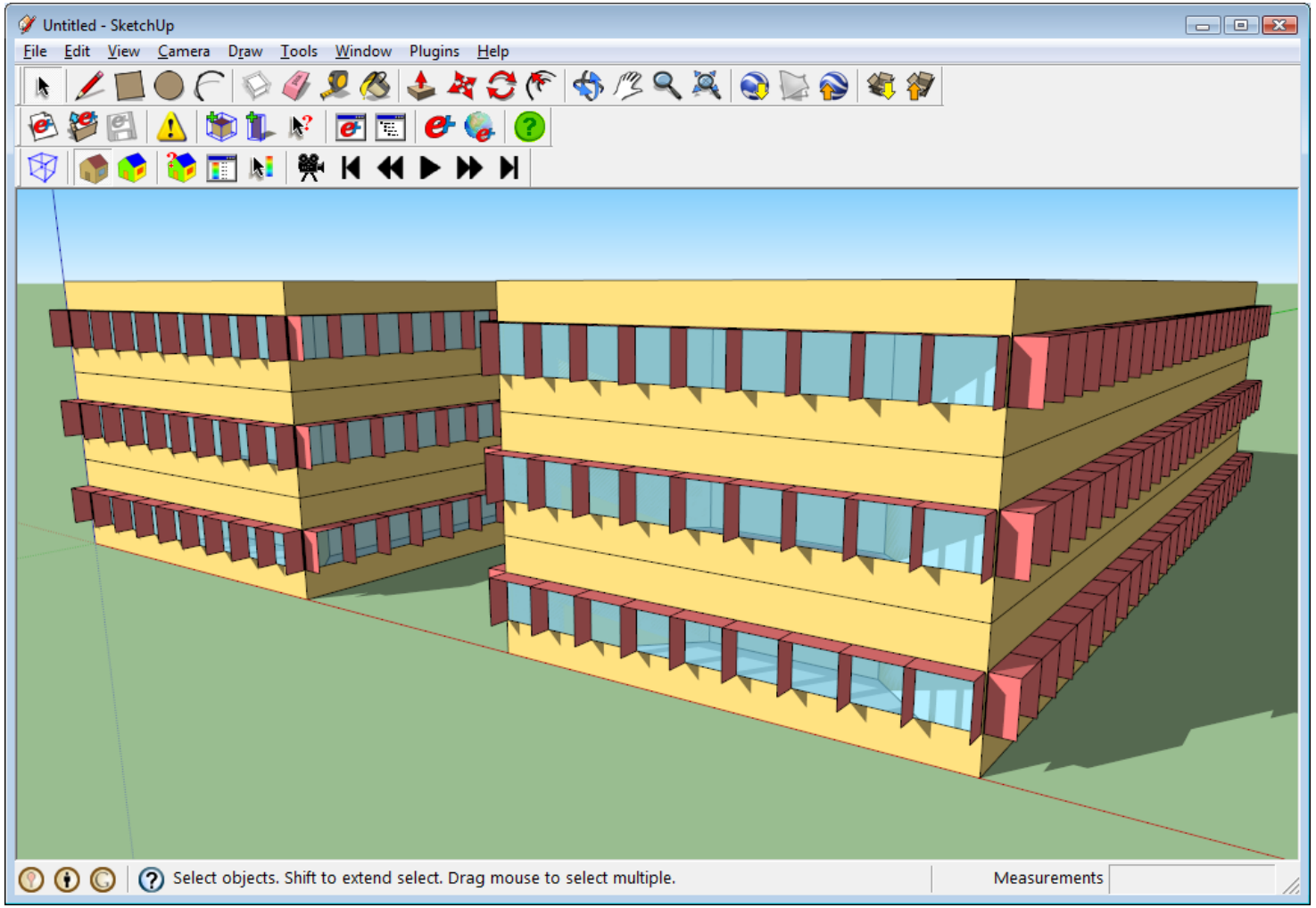


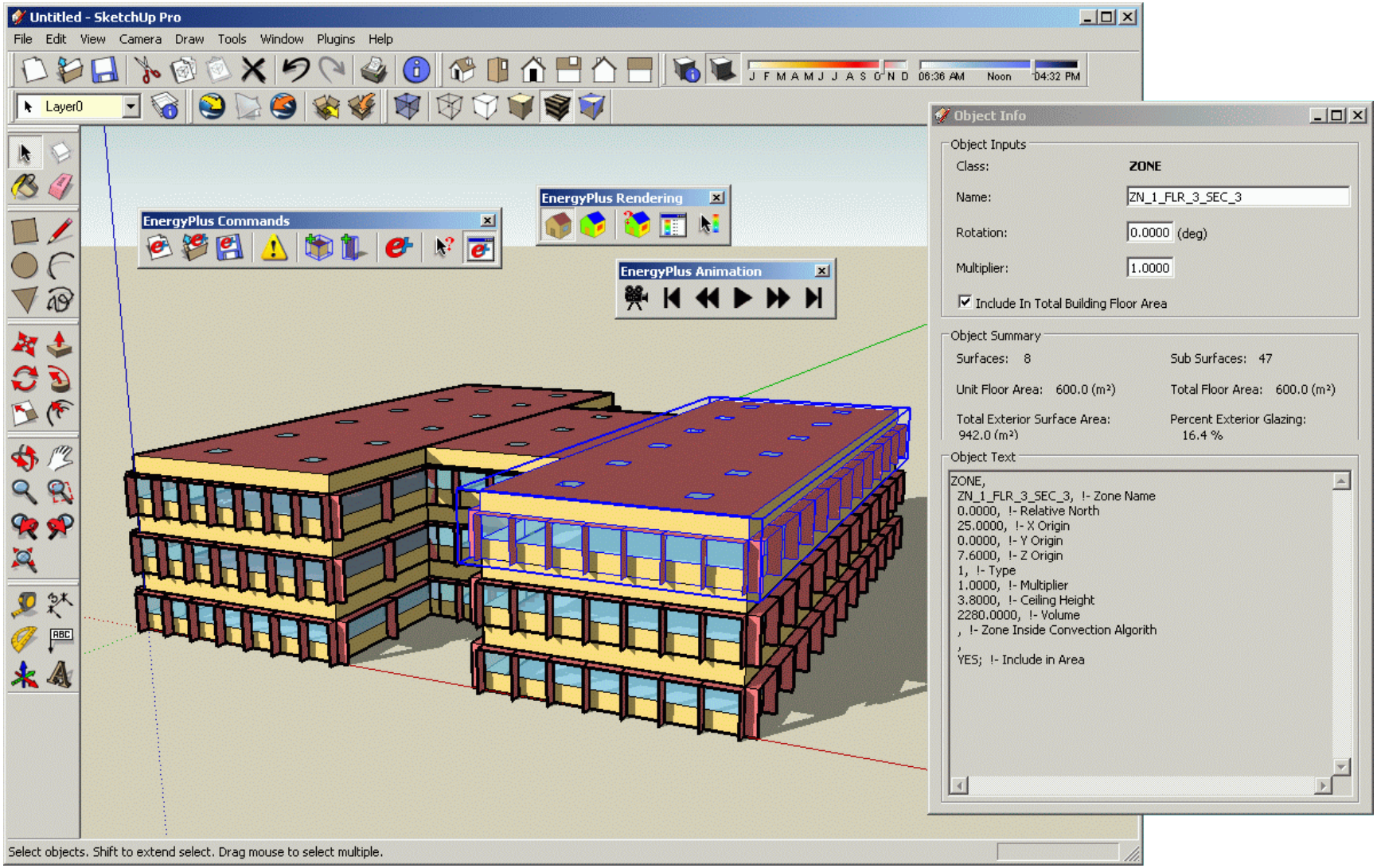
Open an Existing Input File



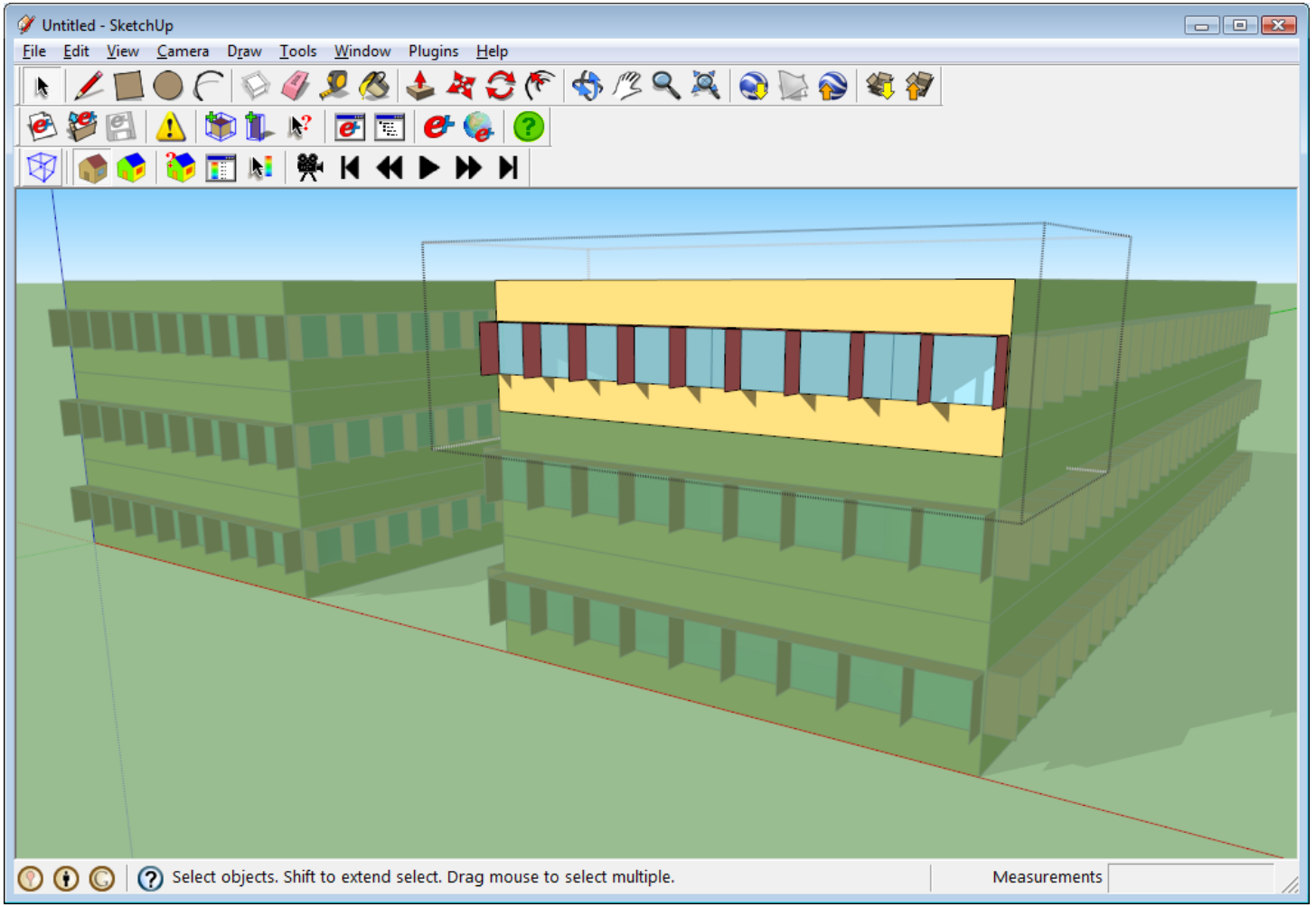
Open/Edit an Input File



Edit Zone Properties



Edit a Zone



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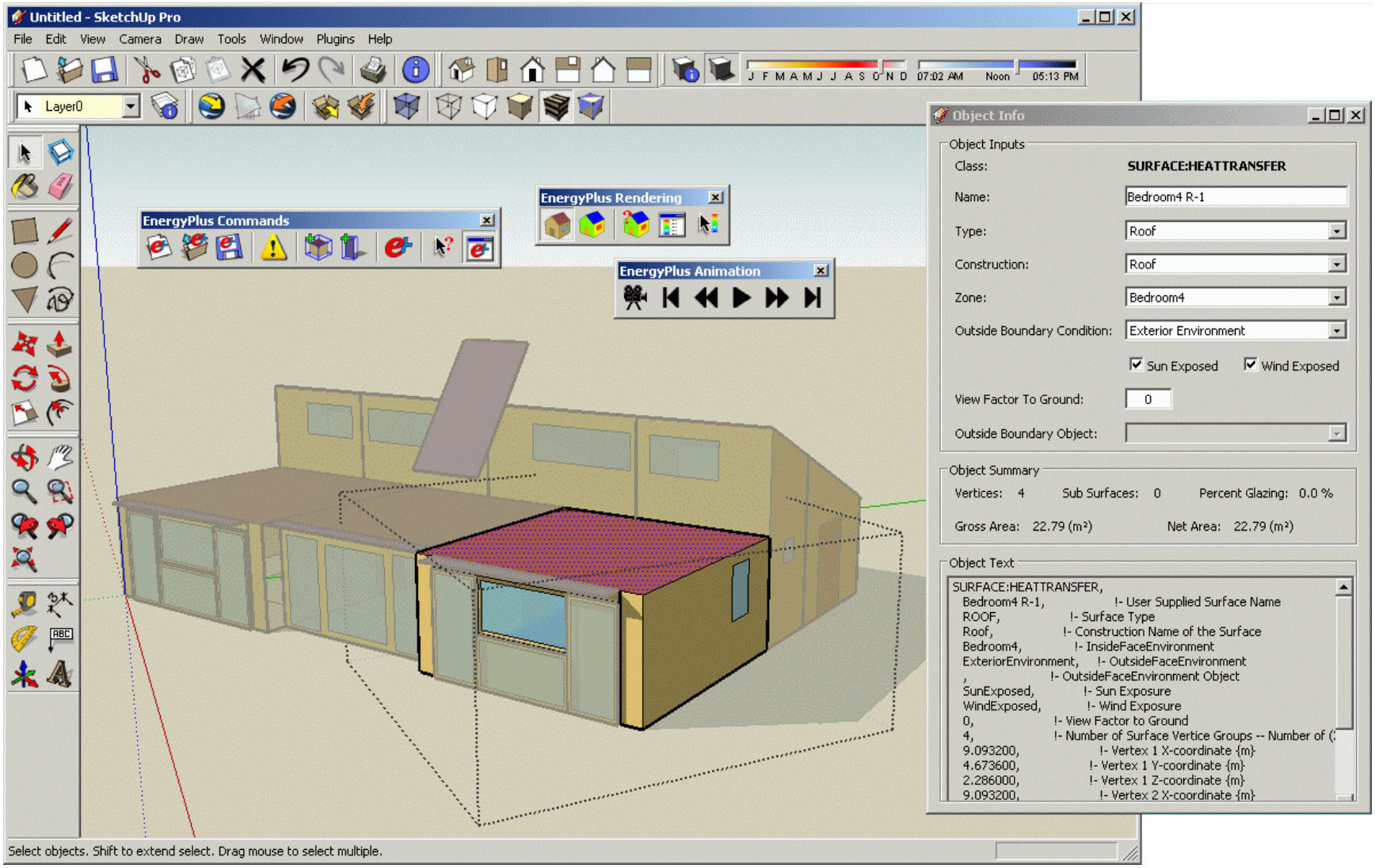
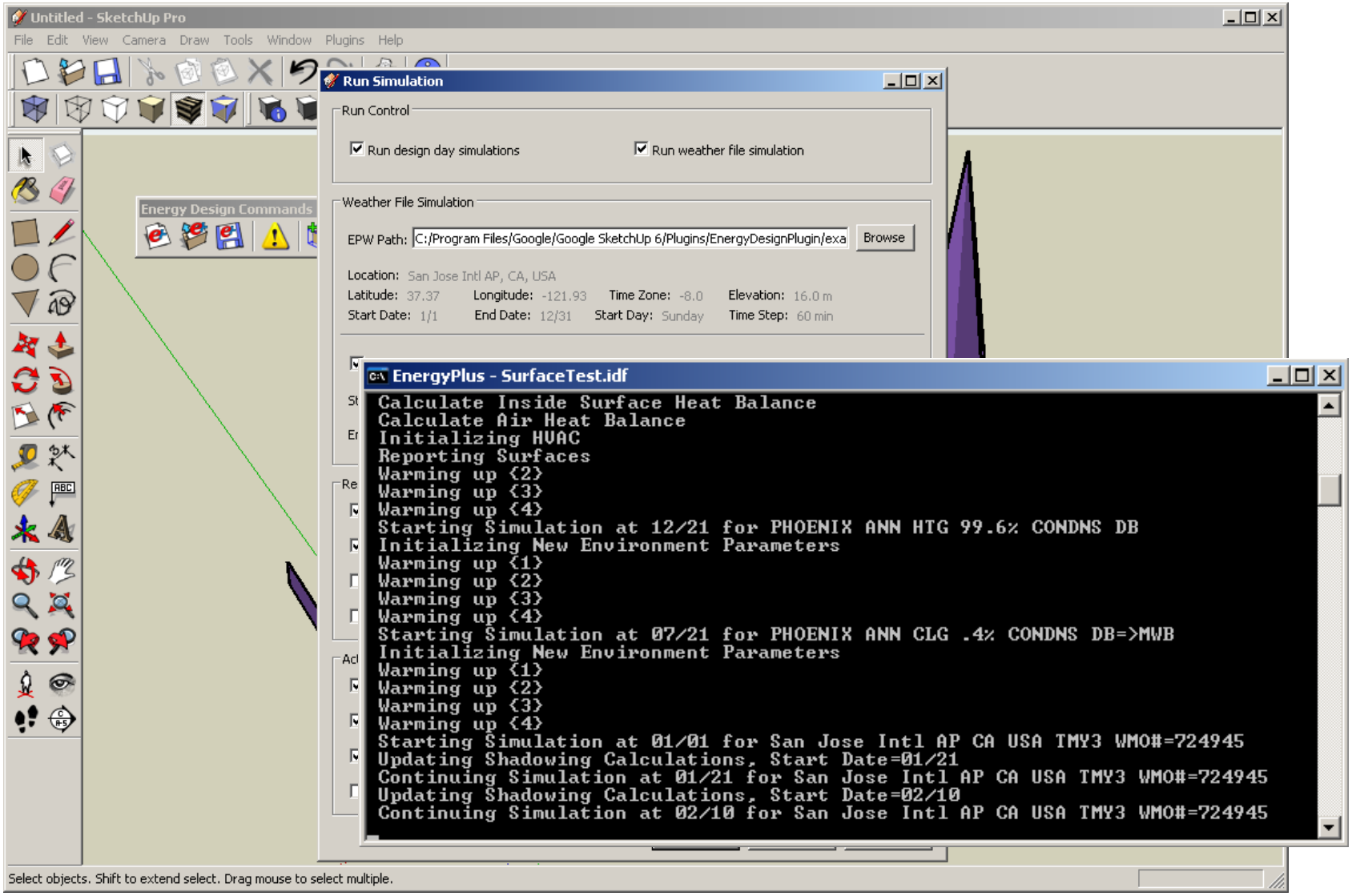
Edit Surface Properties



Run Simulation



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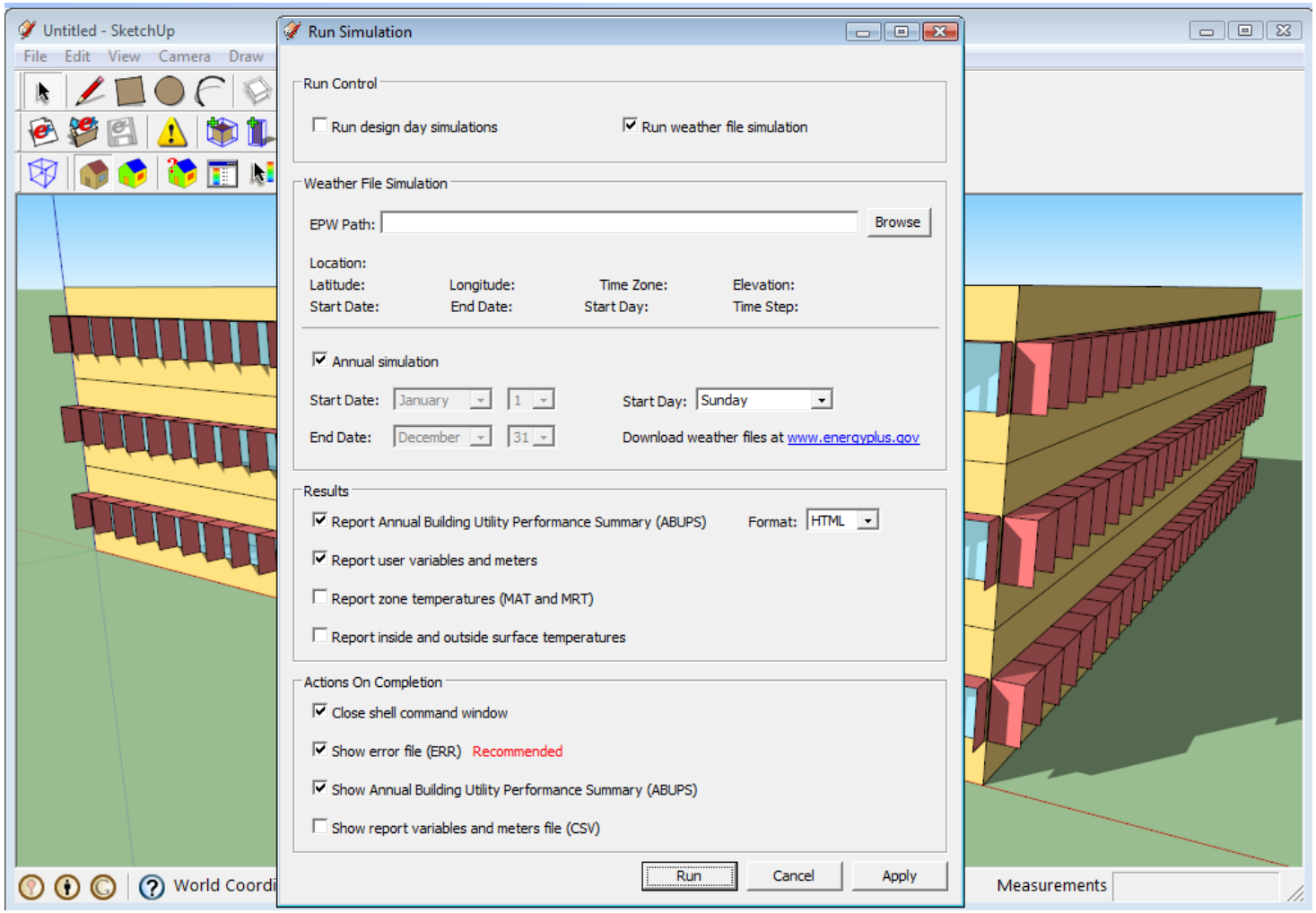

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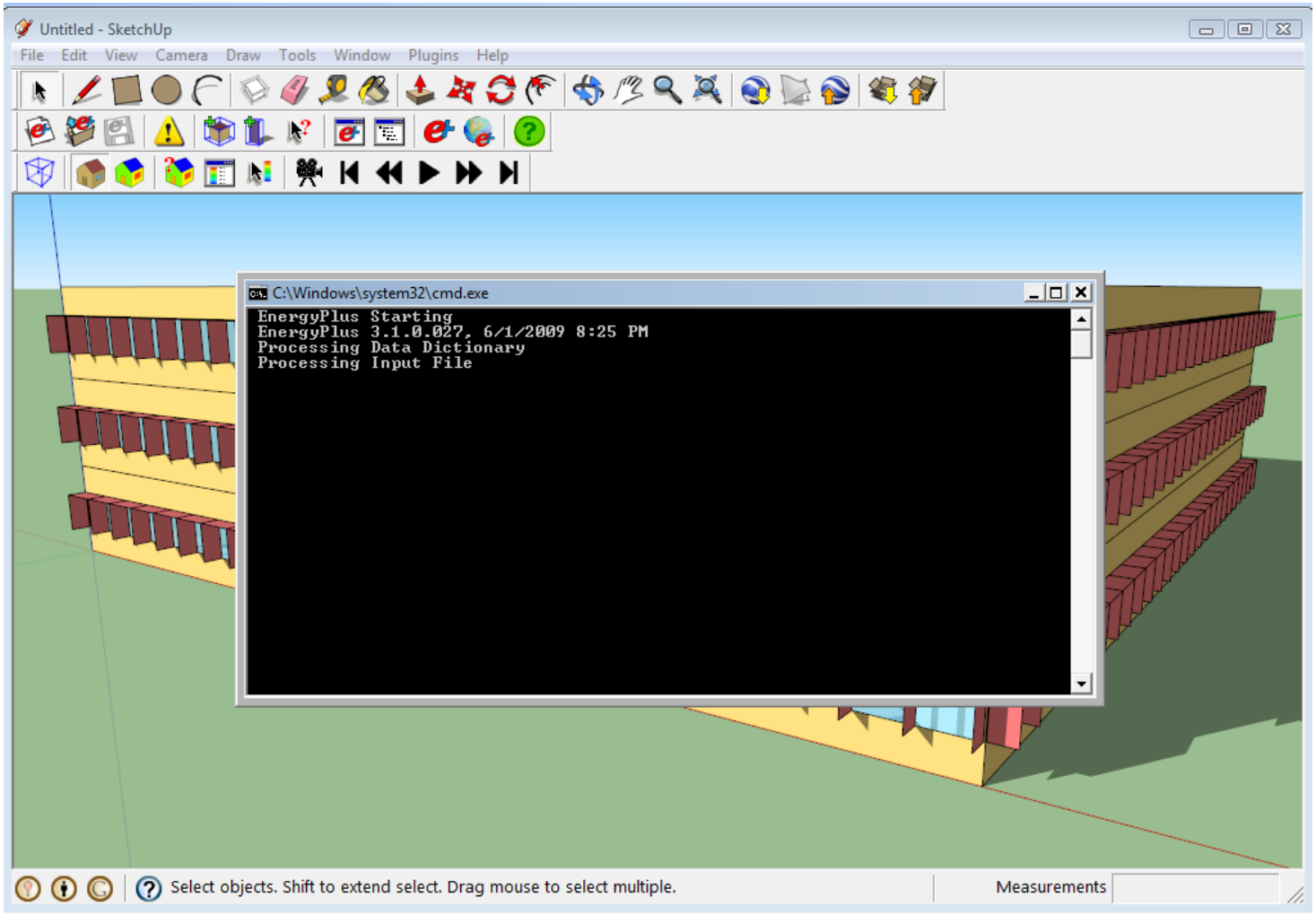

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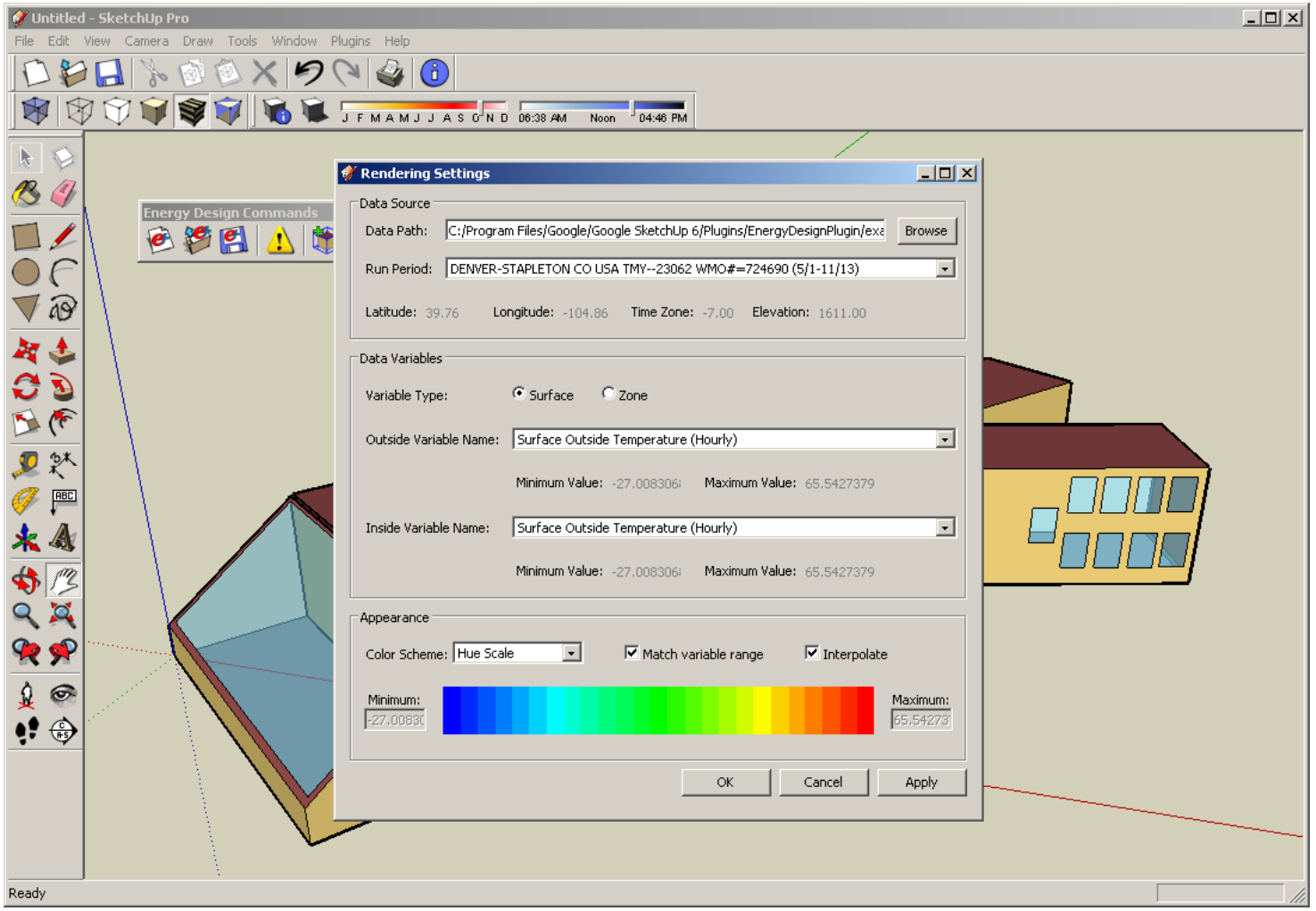
Data Visualization



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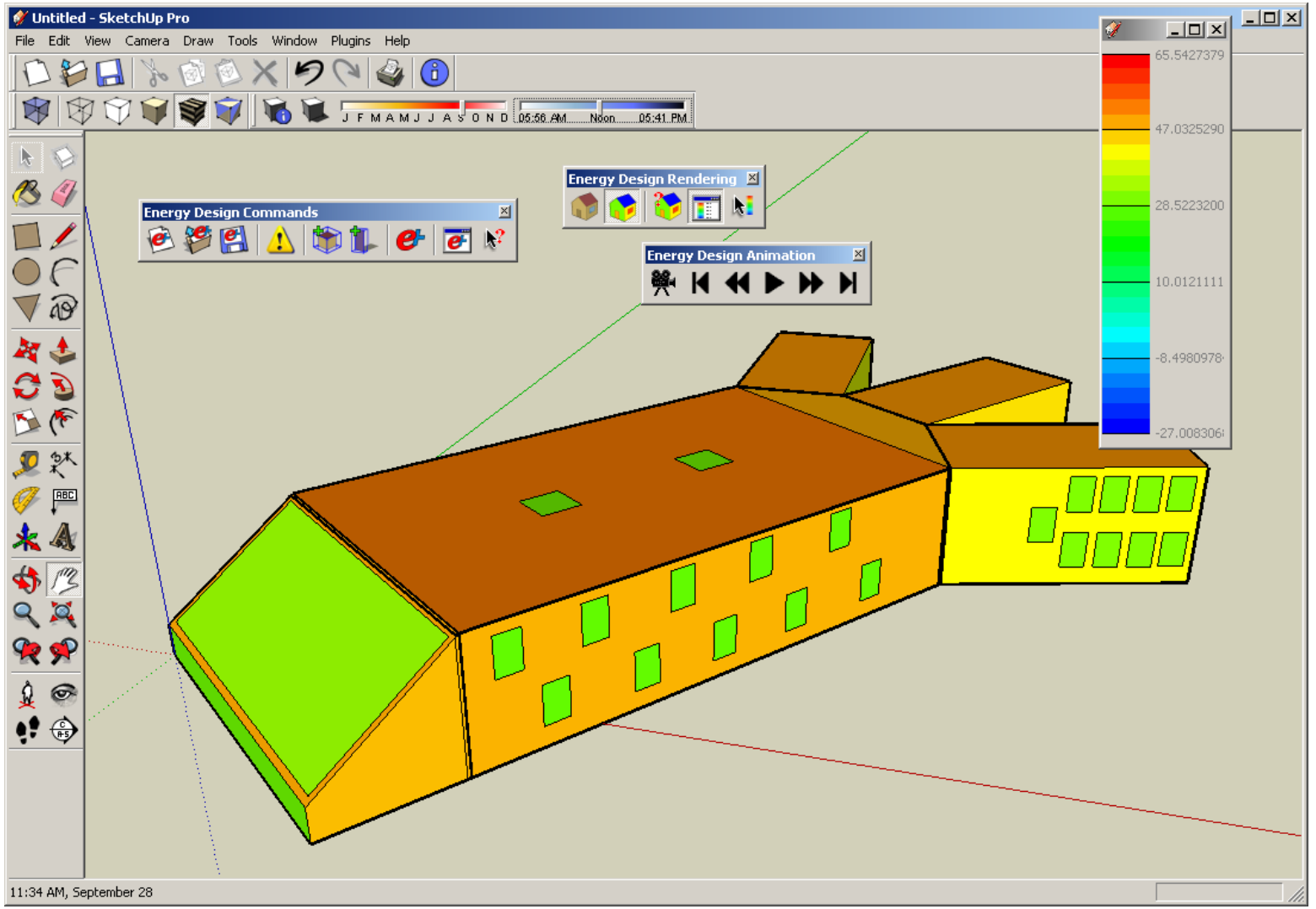
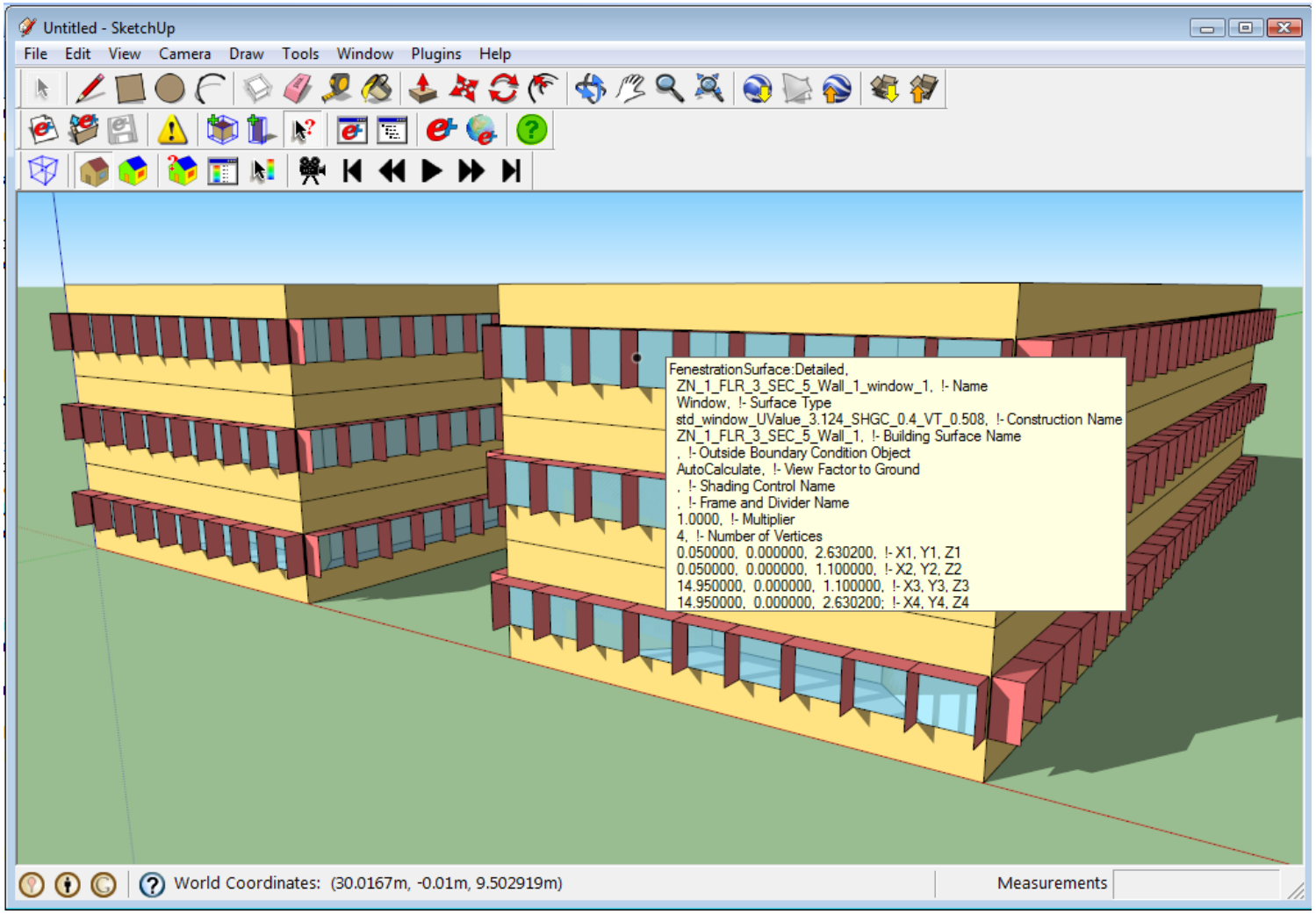


Info Tool



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OpenStudio License

- Developed by NREL
- Open source project
- Current version 1.0.4, October 2009
- Available for free at www.energyplus.gov
- Works with free and pro versions of SketchUp
- Available for Windows and Mac

OpenStudio in the Design Process

- Conceptual Phase:
  - Quickly create building form and massing
  - Changes based on simulation feedback
  - Present design proposals to client
  - Changes based on client feedback
- Design Development:
  - Export from SketchUp to CAD tool
  - Design refinement with CAD

Limitations of OpenStudio

- Not a full-featured interface for EnergyPlus
  - Geometry only
  - Must still be expert user and/or use other tools in conjunction
- Not a translator from SketchUp to EnergyPlus
  - Cannot automatically convert a model
  - Must have the energy model in mind from the beginning

What to watch out for in OpenStudio

- OpenStudio is still being developed
  - Make sure to “click into the zone” before adding surfaces/subsurfaces
  - Watch for extraneous objects in the IDF file (e.g., walls without zones, windows with no subsurface)
  - Undo may not work as expected
  - Synchronization between IDF and SKP files can fail (**make sure to save your IDF frequently**)
  - Assign other side surfaces

Support Resources

- **EnergyPlus Web site** (www.energyplus.gov)
  - free program download
  - documentation
  - weather data (more than 2,100 locations worldwide)
  - testing and validation reports
  - developer & commercial distribution licenses
- **User Support Helpdesk**
  - energyplus.helpserve.com
  - submit questions
    - via Web: energyplus.helpserve.com
    - via email: EnergyPlus-Support@gard.com
    - attach input files as needed

Support Resources *(cont.)*

- **EnergyPlus Yahoo Technical Group**
  - user-to-user forum
  - join EnergyPlus-Support Yahoo Group at http://groups.yahoo.com/group/EnergyPlus_Support
  - subscribe by sending email to EnergyPlus_Support-subscribe@yahoogroups.com
  - post messages by sending email to EnergyPlus_Support@yahoogroups.com

DOE Building Technologies Program
buildings.energy.gov

EnergyPlus and OpenStudio
energyplus.gov

Thanks!

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