Trends in Buildings and Energy Simulation

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Buildings in 2050

- Envelope
  - Organic, dynamic skin (like human skin)
- Ventilation
  - Dynamic, pers
  - Decoupled fro
- Materials
  - Organic compo
  - 'plug-n-play'
  - Waste materia
- Lighting
  - Solid state sou
  - Dynamic level
- Thermal condit
  - Micro-scale so
    individual control

- Energy Resources
  - Distributed, site level (PV, fuel cells, CHP)

gical integrated with
neering
discharge

-sensors, personalized
ing controls, metering,
ess controls
rtdust'

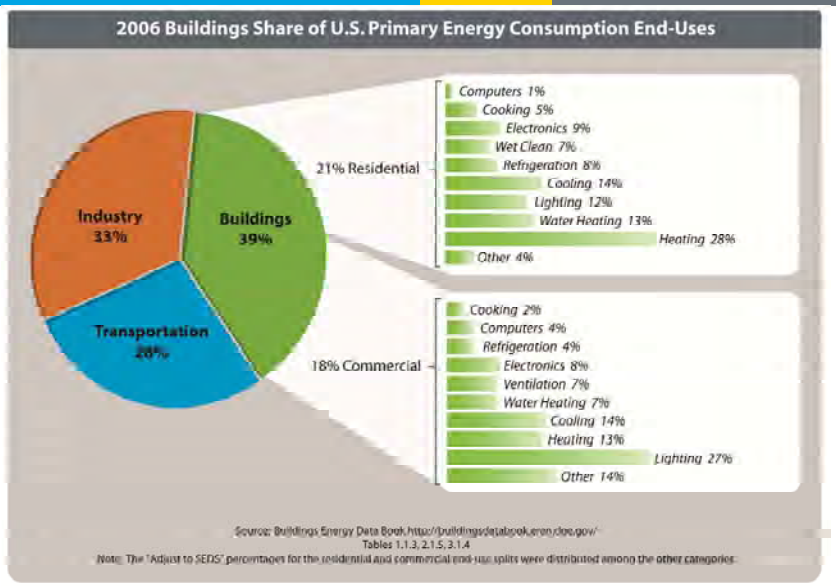
ortation/Land Use
building ≈ no building

e/Economics
  - Service focus–not products
  - Long-term, life-cycle costs

Recent Trends in Buildings Industry

- Centralization of Ownership (large chains, owners)
- Worker Health / Productivity / Comfort
- Continuous commissioning, ESCOs, utility programs
- Price shocks, energy deregulation
- Bioterrorism?
- Green buildings
- ZEB
- Climate change? → Carbon regulation?
  (probably not at this time)

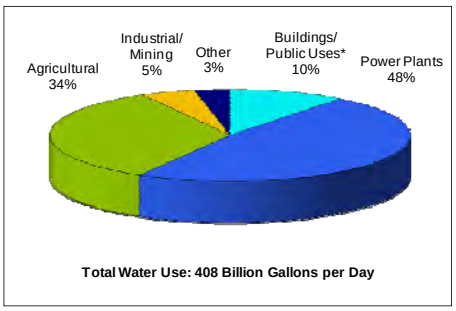
Buildings' Energy Use



Buildings Water Use is Significant

Including electric generation, buildings account for 45 percent of U.S. water use

- Not including electricity, per capita use is **100 gallons per day for domestic use**.
- Approximately **140 billion gallons of water per day** is used to provide **electricity to buildings**



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Projected Increase in Carbon Dioxide Emissions

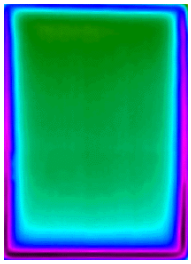
2008 to 2030, by End-Use Sector *(MMTCO$_2$-e)*

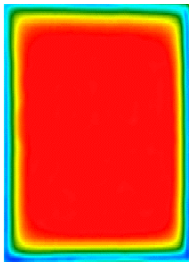
Policy Drivers – Buildings *Will* Be Getting Better

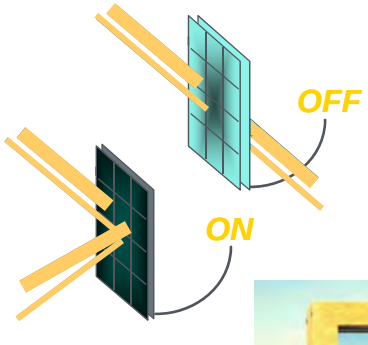
- Economic and environmental drivers
- Mandatory performance metrics: national and local codes ... but are they enforced?
- Voluntary performance metrics (LEED, 90.1, 189.1, BREEAM, BEPAC, many others)
- National and international policy
  - Climate Change?
    - Kyoto Protocol
    - EU building performance mandatory labeling in 2009 ...
  - US energy policy – voluntary approach

New Technologies: Already or Nearly Available

Electro-
Photo-chromic Windows
Thermo-







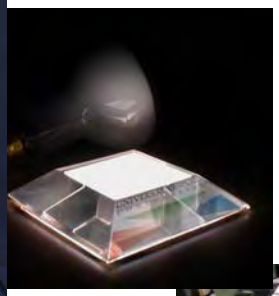
Super Envelopes

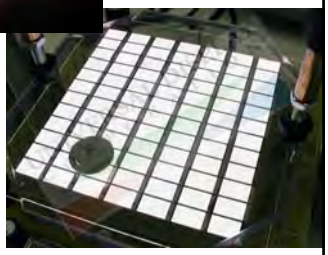
Lighting: Moving from incandescent and fluorescent to LED and OLED

LED Lighting Sources

Subcompact Fluorescent Lighting

SSL and OLED





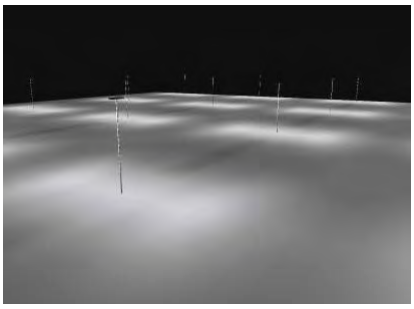

Lunch Meat
Cheese


INDIVIDUALLY WRAPPED

Why LEDs?

- Potential for impressive energy-efficiency improvements and large savings on maintenance
- Directional control and uniformity
- Fully dimmable
- Reduced glare, long life and durability projections

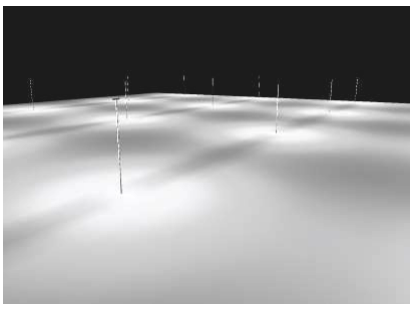
Metal Halide Parking Lot



Average: 3.5
Maximum: 9.0
Minimum: 0.9
Max : Min: 10.0

455 W MH

LED Parking Lot



Average: 2.8
Maximum: 5.2
Minimum: 1.2
Max : Min: 4.3

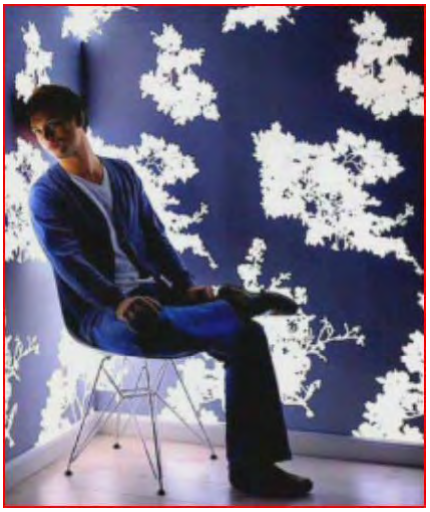
218 W LED

What it looks like

SUPERVALU

Tradition, excellence and future promise.

Next for OLEDs?



Prototype OLED Wallpaper

Controls

Photovoltaic Power

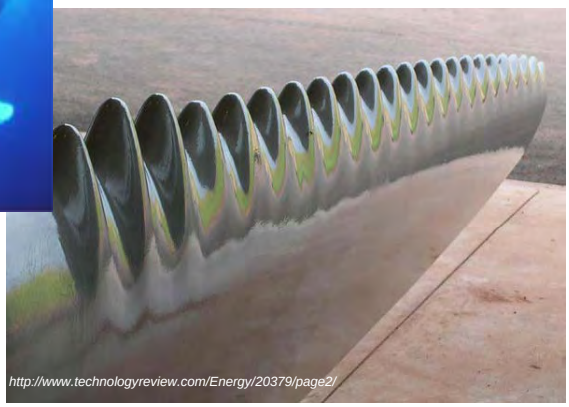
Fuel Cells, Microturbines, DHCP, DC







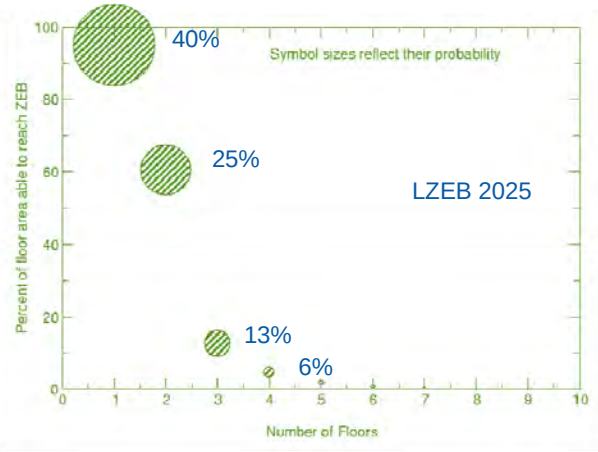
Mimicking Nature

Can we get to Net-Zero Energy?

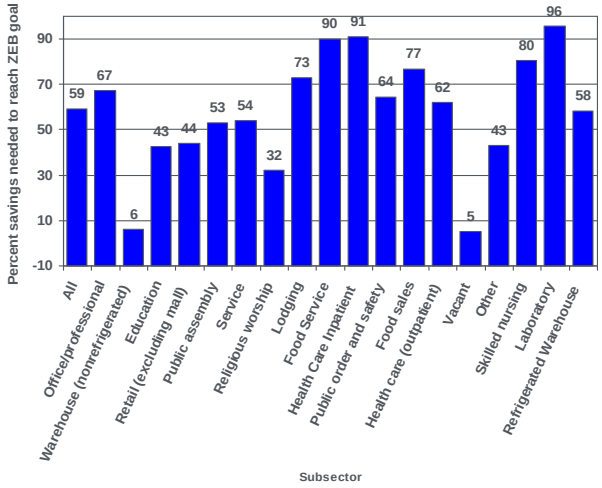
ZEB Characteristics

- Number of floors impacts ability to reach ZEB goal
- Roof area
- Daylighting



Energy Efficiency

Need 60% to 70% decrease in energy consumption of commercial buildings



Database of Net-Zero Energy Buildings

http://commercialbuildings.energy.gov/

Building	Location	Floor Area, ft² (m²)	Annual Purchased Energy (kBtu/m²)
Aldo Leopold Legacy Center	Baraboo, WI	11,300 (1,050)	-6.627
Audubon Center at Debs Park	Los Angeles, CA	5,020 (465)	
Challengers Tennis Club	Los Angeles, CA	3,500 (325)	-0.3133
Environmental Tech. Center, Sonoma State	Rohnert Park, CA	2,200 (205)	-4.822
Hawaii Gateway Energy Center	Kailua-Kona, HI	3,600 (335)	-11.351
IDeAs Z2 Design Facility	San Jose, CA	6,560 (610)	-0.0017
Oberlin College Lewis Center	Oberlin, OH	13,600 (1,265)	-13.877
Science House	St. Paul, MN	1,530 (145)	0

Building Simulation: Key to Improving Building Performance

Simulation Drivers/Trends

- Simulation is still more art than science
- Major Issues:
  - Building data maintenance/storage throughout building life-cycle
  - Training...must train users in simulation methods not tools!
  - Tools must enable and encourage new technologies--too many technologies/systems that various tools cannot simulate
- Code Compliance
- Points for Green Building Ratings
- Qualify for Utility or Government Rebates/Incentives
- Green/sustainable design and policy are driving simulation more than energy costs (LEED, EPDB)

Simulation Trends

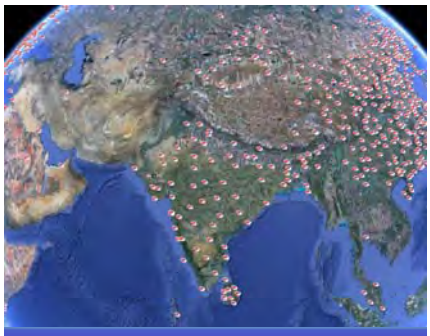
- New tools/capabilities in established tools
  - Interoperability—IAI IFC, XML, BIM Standards
  - Visualization/VR
  - Integration—thermal, CFD, electrical, IEQ, visual
  - Risk assessment (insurance)
  - Embodied energy, LCI/LCA, toxicity of built environment
  - Emissions
- More tools, not fewer, customized to user needs
- Users continue to want more at lower effort

EnergyPlus

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

EnergyPlus

- Designed for flexibility and expansion
- Many new low-energy technologies
- Sub-hourly calculations
- Many output metrics: energy, water, emissions
- 4000+ pages of documentation and testing/validation reports
- Weather data for more than 2100 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

“Every building is a forecast. Every forecast is wrong.”

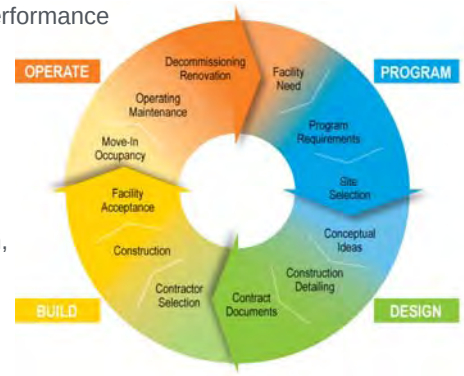
Stewart Brand

Simulation vs. Operating Energy

- In 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!

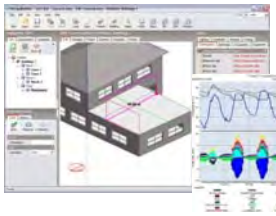


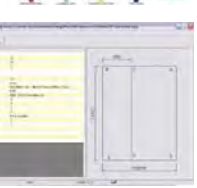
Private Sector User Interfaces

ENERGY-10

PV modeling by EnergyPlus

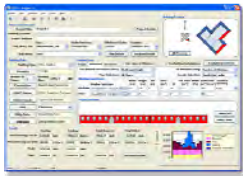
DesignBuilder SOFTWARE





HEVACOMP

EFEN



ECOTECT

Easy Energyplus *(Chinese)*
COMFEN
EnergyGauge
TREAT Plus
ESP-r
EPlusInterface
HVAC Energy
SolarShoeBox
xEsoView
others....

EP-Quick

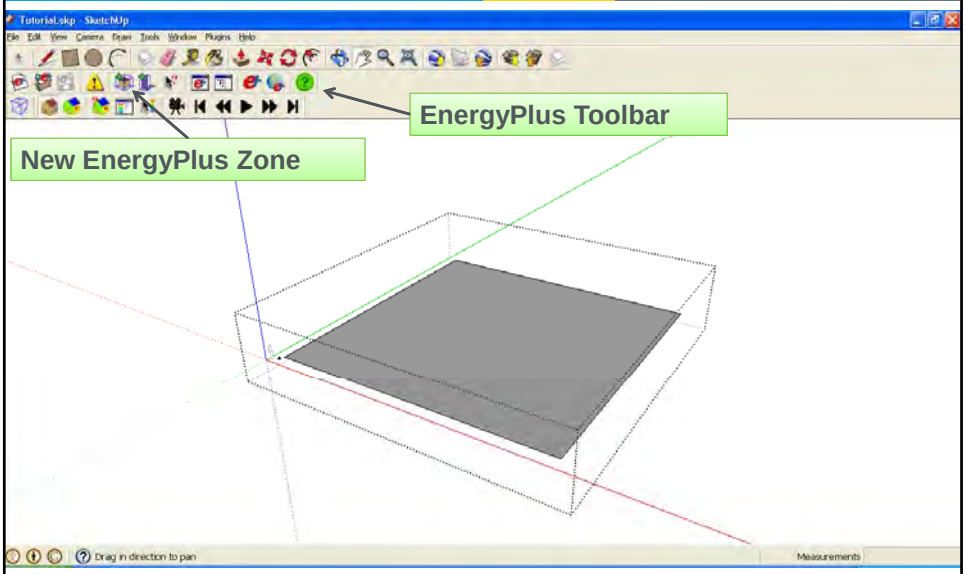
CADD to EnergyPlus

- 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 direct link in Hevacomp and AECOsim Energy Simulator from Revit, AutoCAD, Microstation, and ArchiCAD.
- Interoperability is key to getting energy simulation mainstream. Other drivers—zero-energy buildings and green building rating systems

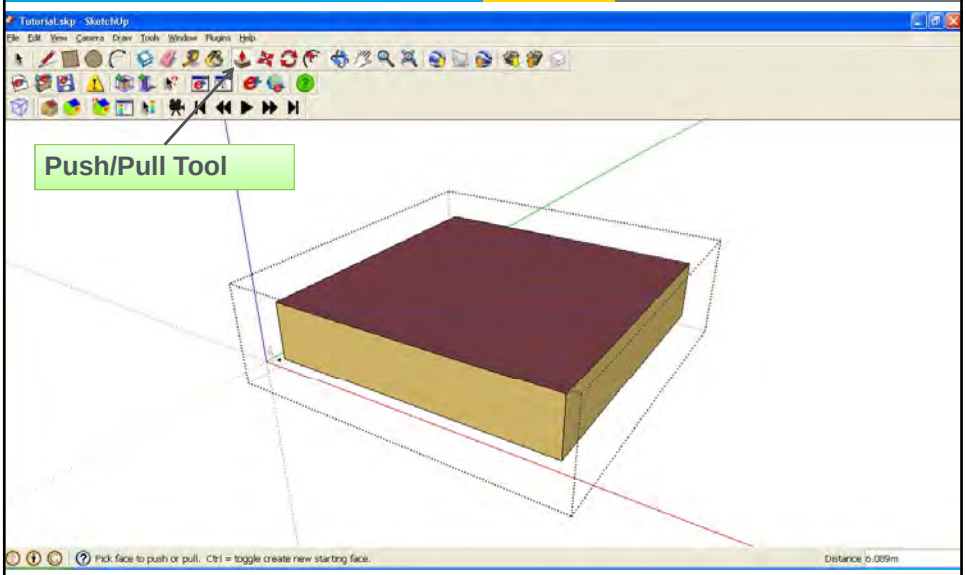
Google SketchUp and OpenStudio

- 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

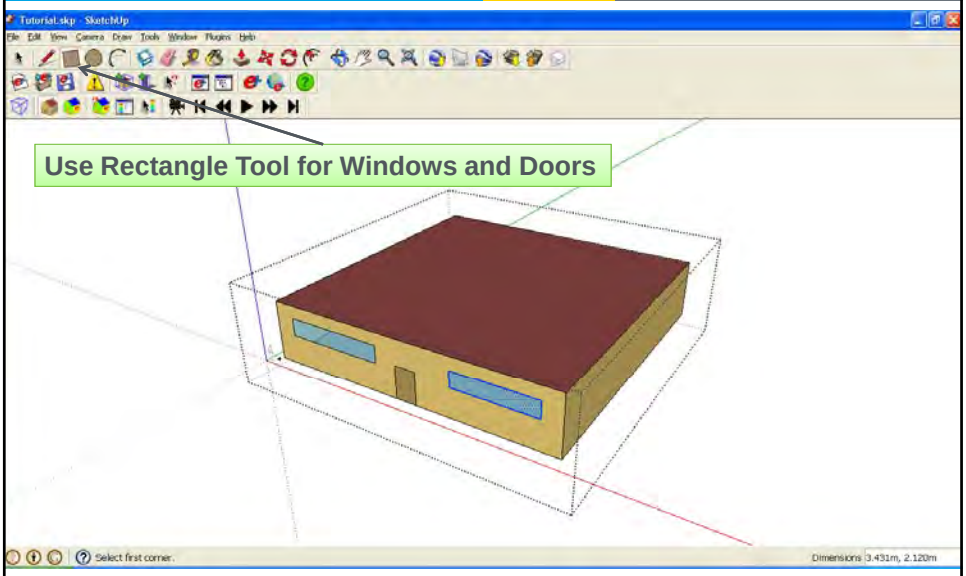
Create Geometry from Scratch



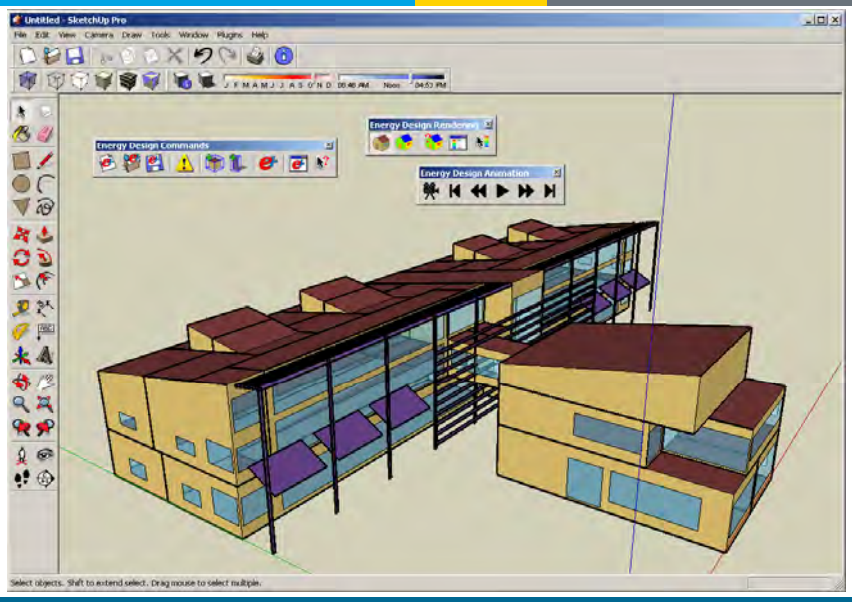
Create Geometry from Scratch



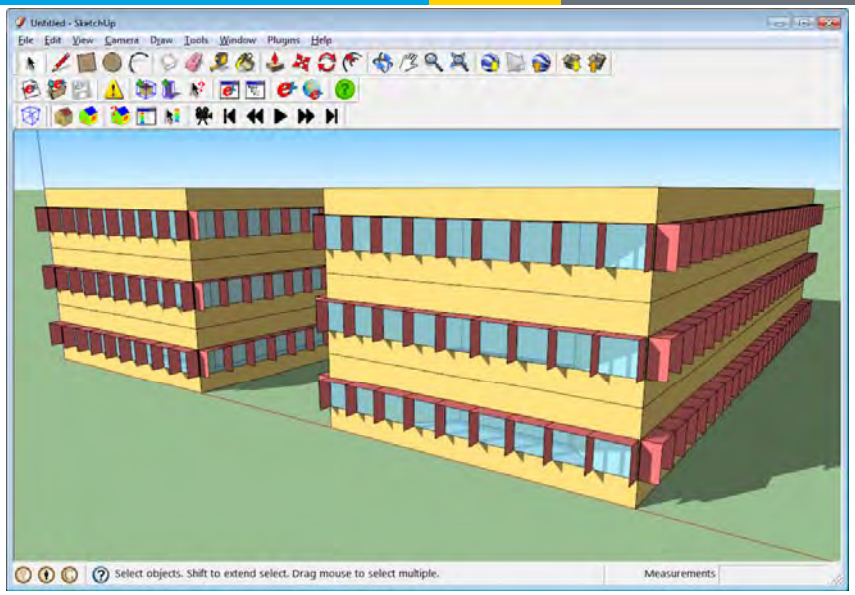
Create Geometry from Scratch



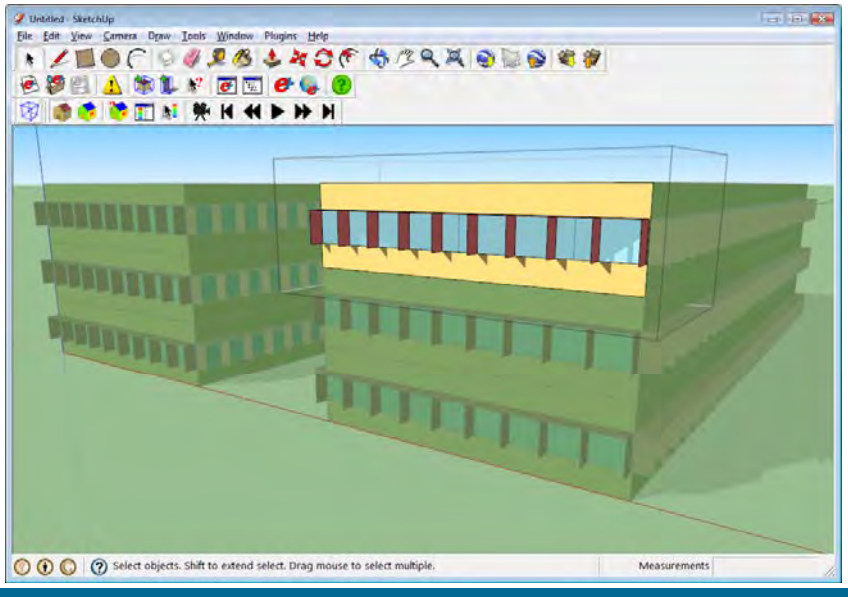
Open an Existing EnergyPlus Input File



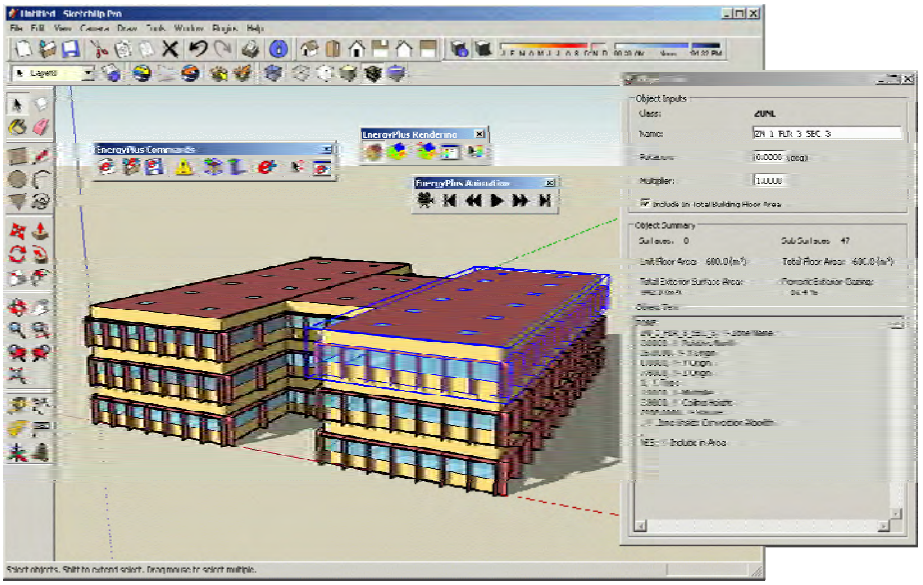
Open/Edit an Input File



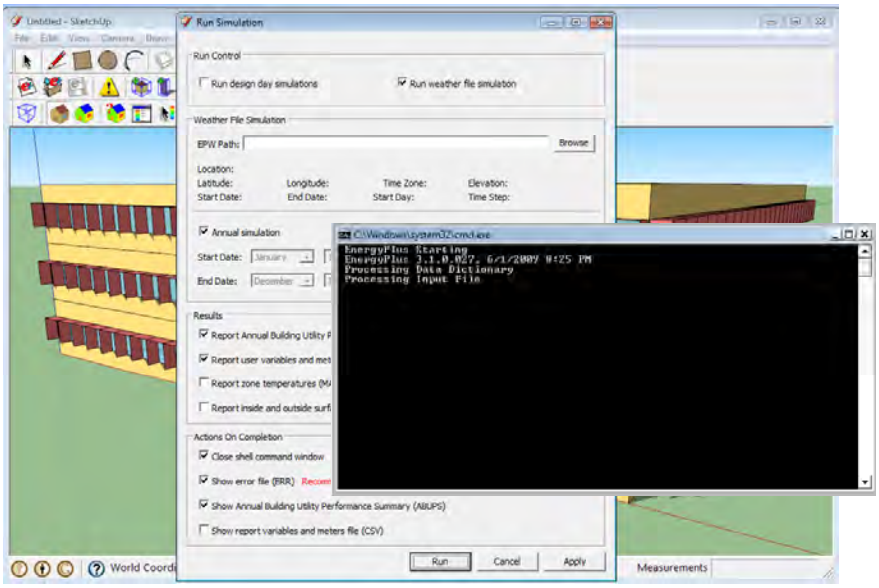
Edit a Zone



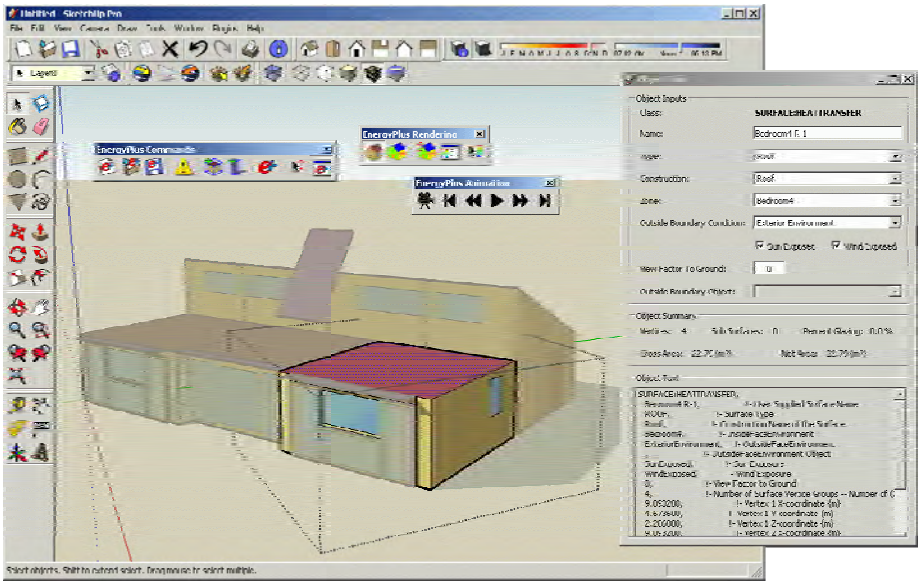
Edit Zone Properties



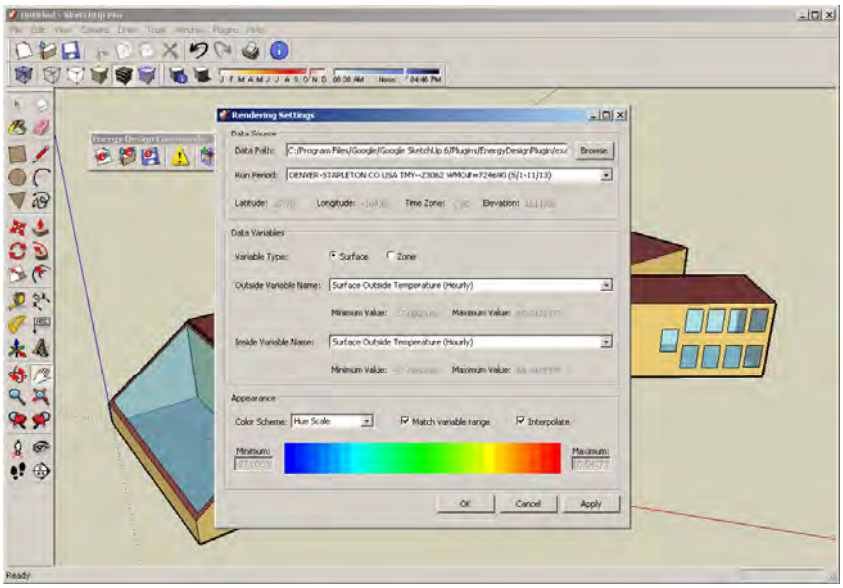
Run Simulation



Edit Surface Properties



Data Visualization



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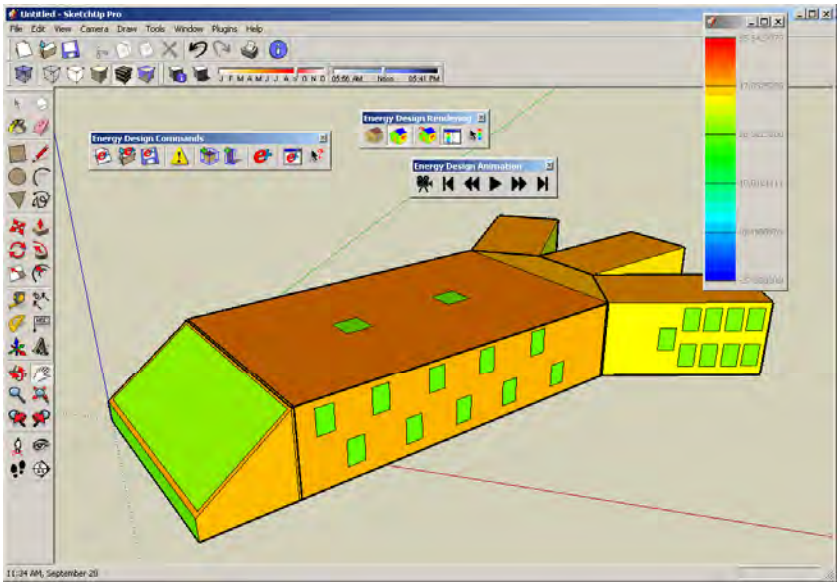
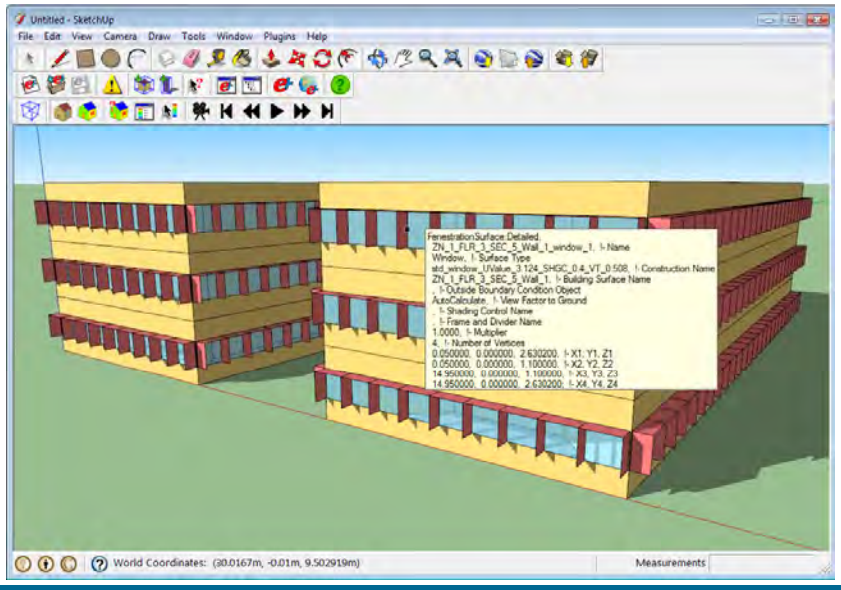


Info Tool



So, Is This the Building of Tomorrow?

More Likely We Will See More Like These—Simulation Required!

Architecture: Blanz & Necks, DE

"The future has already arrived,
it's just not widely distributed."

William Gibson

Summary

- Changes in building technologies over the next several decades will be significant—driven by:
  - Policies (labeling, energy standards, EPC, carbon regulation)
  - Demand for better buildings from building owners and occupants
- It is possible to create low-energy buildings today but it requires integrated building design and performance simulation.
- Simulation is critical to support decision-making to achieve low- and zero-energy buildings.
- But the information coming from simulation is only as good as the data entered: GIGO
- No one tool can simulate everything—smart users have a suite of software that can support their work.

Think about Metrics

Energy

Demand

Cost

Water

IEQ

Carbon

Business
(student, occupied room, sales)

Thanks!

Questions?

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