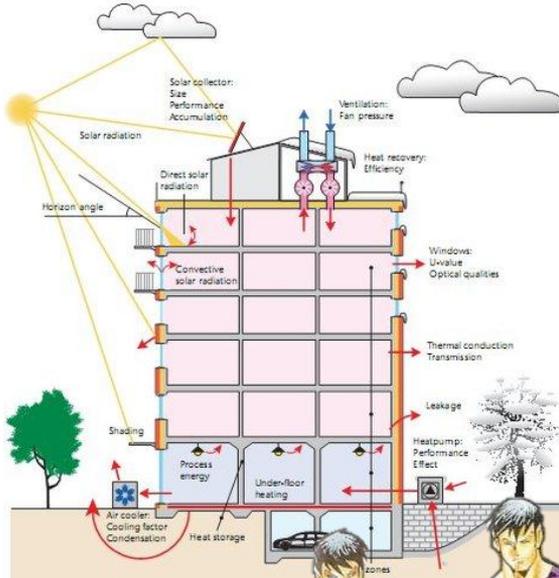


# Building Energy Modeling (BEM) Overview

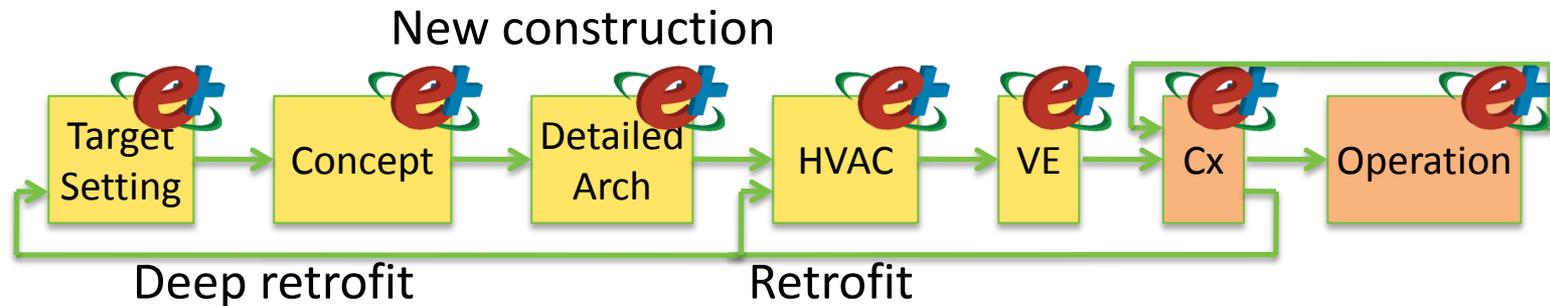
2014 Building Technologies Office Peer Review



# BEM is a Fundamental Energy-Efficiency Technology

## BEM calculates energy use from description of assets & operations

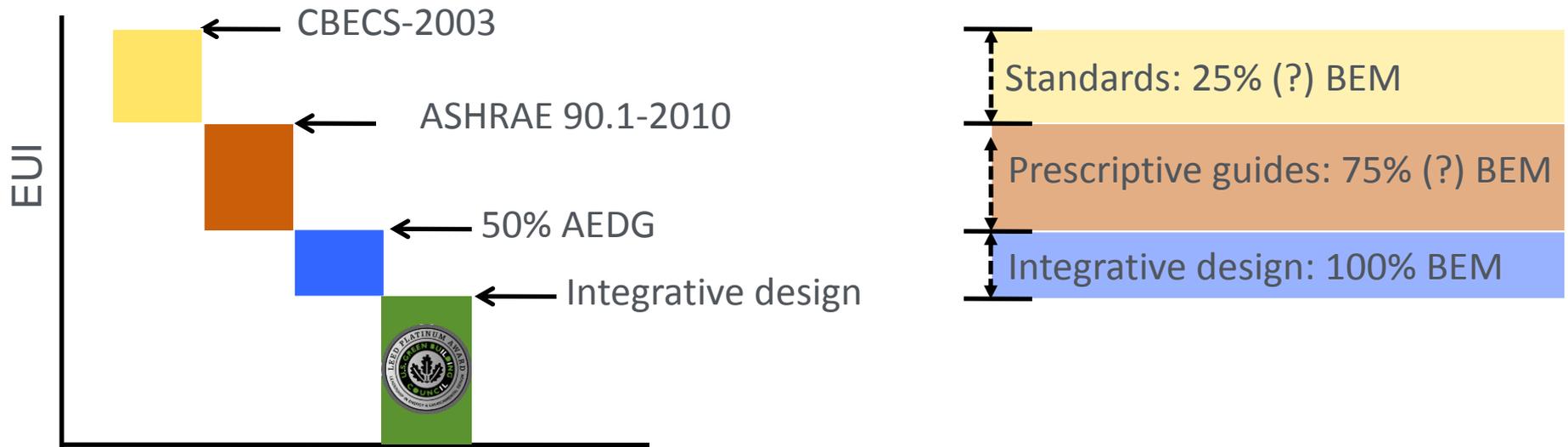
- Predictive if all major inputs are certain; comparative when they are not
- Complements measured data: isolates effects, supports optimization & “what if”



## BEM has multiple use cases, both established and emerging

- **Design:** architecture, HVAC system selection & sizing
- **Operations:** HVAC fault diagnosis, dynamic control & demand response
- **Market:** code development & compliance, ratings, incentives, M&V, policy, etc.

# Measuring Impact—BEM on Buildings, BTO on BEM



## Uber-metric: energy savings in actual buildings

- Easiest to attribute “integrative design” savings to BEM
  - Holistic optimization (30-50% savings) vs. individual ECMs (5-20% savings)
  - 600 TBTU / year by 2030 [BTO p-tool] [Ed: this is a conservative estimate]
  - Will track integrated design & simulation use via AIA+2030 Commitment
- What about standards? And emerging operational use cases?

## Taxi-metric: number of third-party applications & services

- Slightly less meaningful than number of users & easier to get

# Logic Model—BTO Role in BEM Ecosystem

## BEM differs from windows, heat pumps & sensors

- Information technology with no “unit” cost → DOE *can* build it
- An evaluation tool → transparency & impartiality matter → DOE *should* build it

## Ground rules for BTO (BEM) software

- State-of-the-art capabilities + commercial-friendly open-source licensing
- No end-user applications ... except in special circumstances
- **“20 application vendors, not 20,000 end-users”**



# Portfolio—PR&E: Products, Research & Ecosystems

## Products: state-of-the-art & industrial strength, not toys!

- EnergyPlus engine: established & “foundational” [2013 BTO review]
- OpenStudio middleware: newer, market-facing & “foundational” [2014 BTO review]

## Research: directly supports products

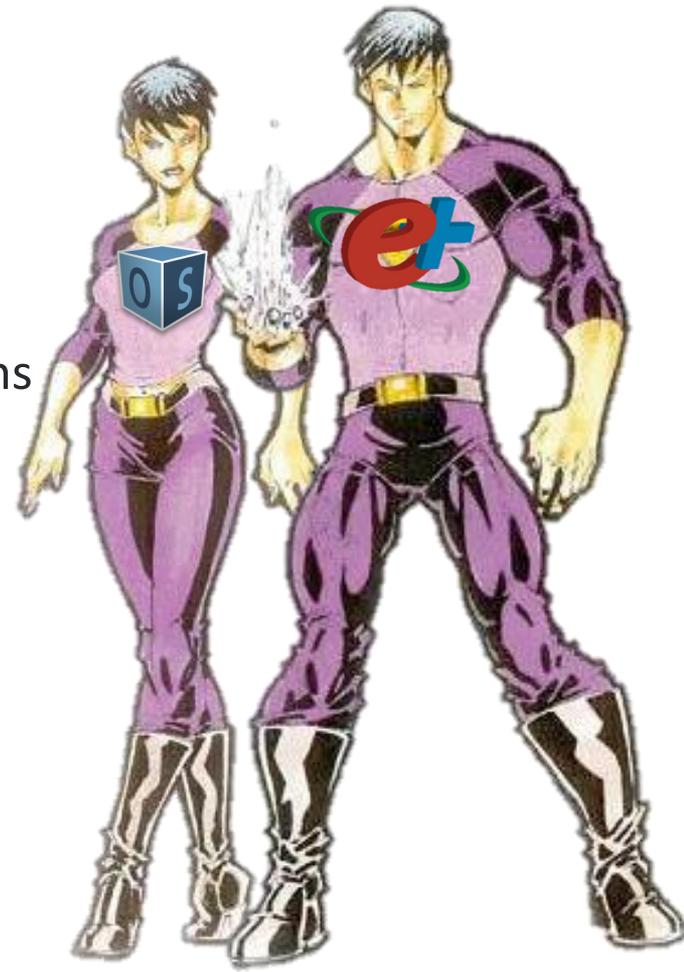
- Testing & validation
- New simulation frameworks & directions

## Ecosystems: for developers & end-users

- Partner with companies & professional organizations

## Cross-cutting portfolio

- Emerging technologies (ET): \$3,500,000
- Commercial buildings (CBI): \$2,200,000
- Increasing co-ordination with residential & codes
- Many other related projects



# Emerging Technologies (ET) Projects

## Best-in-class simulation engines

- EnergyPlus whole-building energy simulation
- Radiance lighting

## Testing & validation

- ASHRAE Standard 140: “Method of test ...”
- FLEXLAB & Annex 58: validation-grade experiments

## Targeted research & advanced development

- Modelica Buildings Library & IEA Annex 60
  - Modelica + Functional Mockup Interface
  - Will form the basis of “Spawn-of-EnergyPlus”
    - Modelica for HVAC & controls
    - More modularity, easier interface to other engines
    - Easier prototyping & sharing of component models
    - Control simulation, optimization & code generation

MODELICA



# Commercial Buildings (CBI) Projects

## Best-in-class simulation middleware

- **OpenStudio middleware & Software Development Kit (SDK)**
  - Application accelerator: **“20 lines of Ruby, not 20,000 lines of E+”**
- Code-compliance, input-calibration, UQ, QA/QC, **inter-operability (PSU CBEI)**, etc.

## Impact tracking & outreach

- **AIA+2030 Commitment Reporting**

## Education, training & support

- BEM Library → IBPSA
  - SimBuild conference
  - AEC hackathon
  - Online publishing of lectures
  - “UnmetHours” peer-driven Q&A site
  - BEMBook wiki

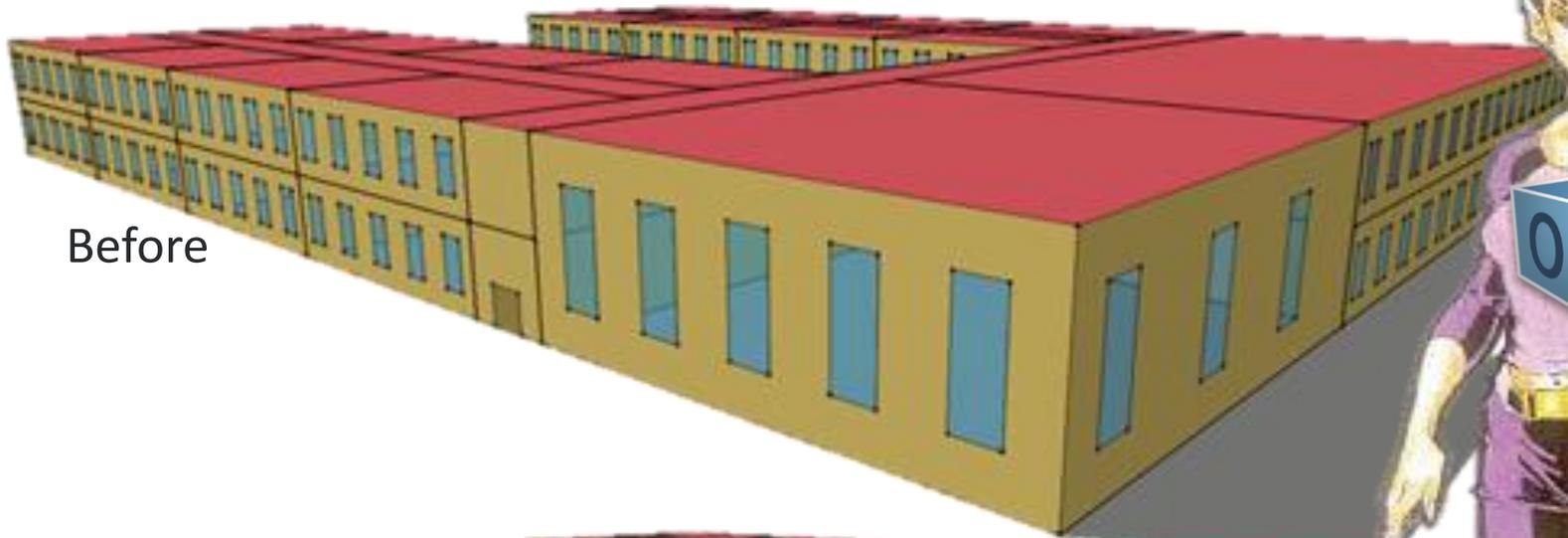


```
VirtualPULSE_run.rb
1 require 'openstudio'
2 require 'VirtualPULSEModel'
3
4 #create a new model
5 model = VirtualPULSEModel.new
6
7 #add geometry (in this case a simple multi-story core/perimeter building)
8 model.add_geometry({"length" => 100,
9 #add windows at a given window-to-wall ratio
10 model.add_windows({"wwr" => 0.4,
11 #add HVAC - Packaged VAV w/ Reheat - DX Cooling, Hot Water heat and reheat
12 model.add_hvac({"fan_eff" => 0.5,
13 #add thermostats
14 model.add_thermostats({"heating_setpoint" => 24,
15 #assign constructions from a local library to the walls/windows/etc. in the model
16 model.add_constructions({"construction_library_path" => "#{Dir.pwd}/VirtualPULSE_default_constr
17
18 #add space type from a remote library (BCL) to the model
19 model.add_space_type({"NREL_reference_building_vintage" => "ASHRAE_90.1-2004",
20 #add design days to the model
21 model.add_design_days()
22
23 #save the OpenStudio model (.osm)
24 model.save_openstudio_osm({"osm_save_directory" => Dir.pwd,
25 #translate the OpenStudio model (.osm) to an EnergyPlus model (.idf)
26 model.translate_to_energyplus_and_save_idf({"idf_save_directory" => Dir.pwd,
27 #run the EnergyPlus model (.idf)
28 VirtualPULSEModel.run_energyplus_simulation({"idf_directory" => Dir.pwd,
29
```

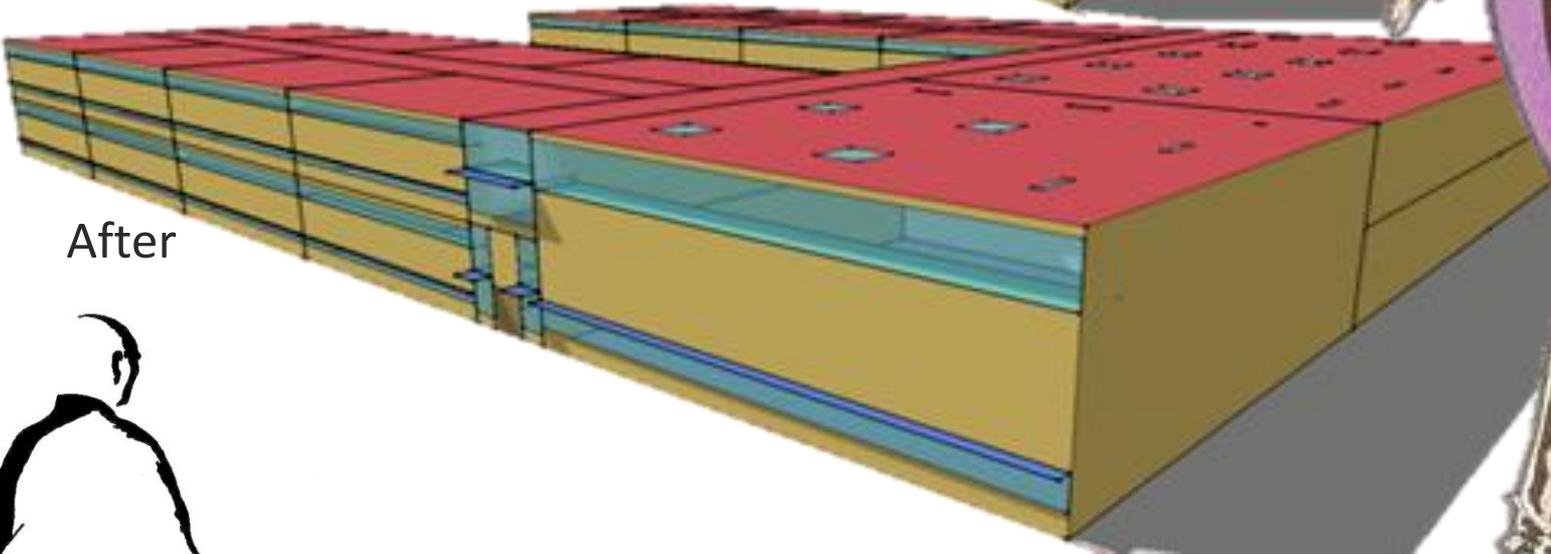


# A Moment of Zen

Before



After



# Other Projects

## BTO

- **ET: CERC occupant/operator behavior & IEA Annex 66**
- **ET: CBERD Simergy**
- ET: just made three phase I SBIR/STTR awards in energy simulation!
- **ET: THERM/WINDOW thermal/optical envelope, WUFI hygrothermal envelope**
- **CBI: Commercial Building Energy Asset Score**
- **RBI: BEopt**
- CBI: 30% & 50% Advanced Energy Design & Retrofit Guides

## Elsewhere

- CEC: CBECC-Com commercial building energy code compliance
- CEC: Commercial Building Energy Saver for small and medium buildings
- **Concept3D: Simuwatt mobile audit tool**
- **Xcel: EDAPT (Energy Design Assistance Program Tracker)**
- NationalGrid: COFEE (Customer Optimization for Energy Efficiency)
- Bentley: AECOSim, DesignBuilder, GreenSpaceLive: gEnergy, Sefaira: Concept
- Others that we can't talk about | don't know about

# Program Redux

## **We have an explicit, consistent & appropriate position in ecosystem**

- Organizations are quickly learning how to work with us—and around us

## **We are more consistent, streamlined & efficient at product delivery**

- Better quality & more responsiveness → organizations want to work with us

## **We have a more cohesive portfolio with complementary projects**

- Clear deployment channels, no “bridges to nowhere”, well-integrated in BTO

## **We have many partners & we listen to them**

- “Give people what they want” ... actually “give people what they need”

