Energy Modeling for Early Design Support

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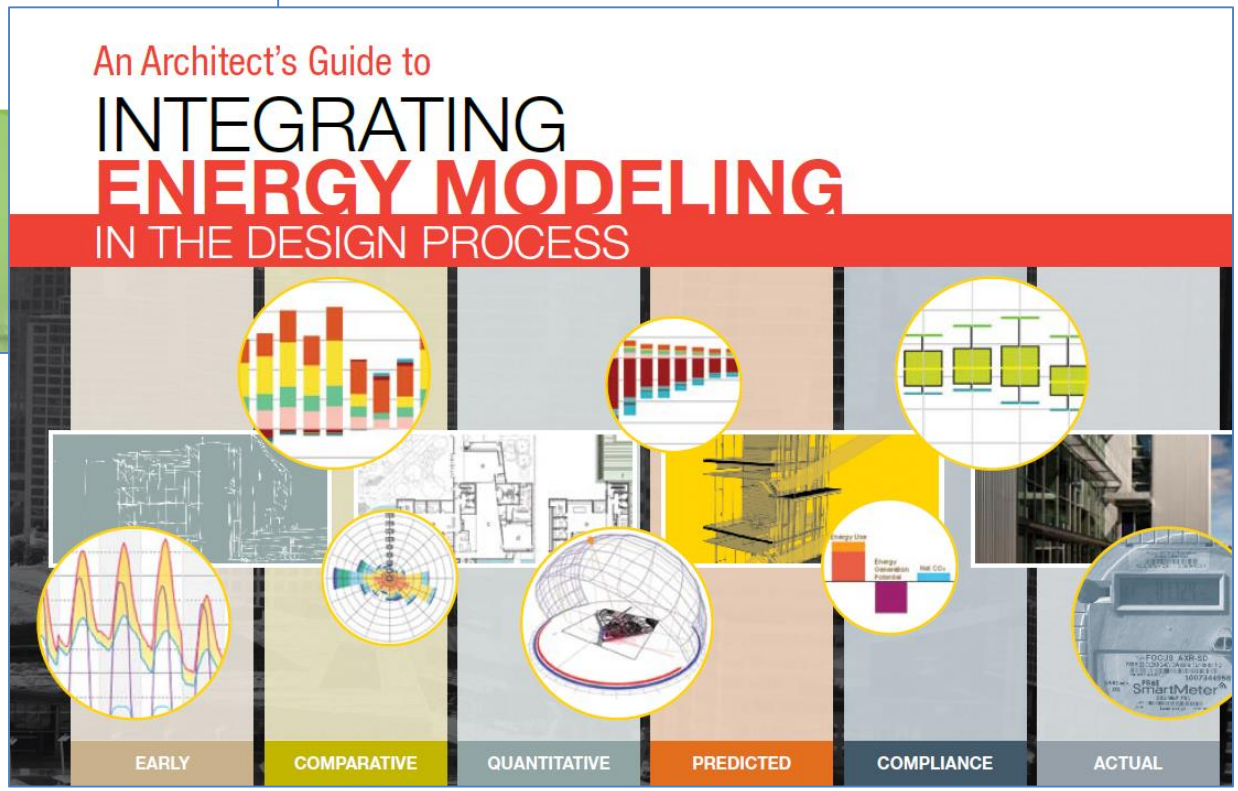
energize CONNECTICUT CT℠

Empowering you to make smart energy choices

EVERSOURCE ENERGY

UI SCG CNG

Key Resources



http://www.aia.org/aiaucmp/groups/aia/documents/pdf/aiab107447.pdf
http://aiad8.prod.acquia-sites.com/sites/default/files/2016-04/Energy-Modeling-Design-Process-Guide.pdf

The AIA 2030 Commitment
2014 Progress Report - Takeaways

"…… A standout finding from 2015 is the **critical role of energy modeling** in improving building design. Modeling **early in the process** helps ensure that there is greater interplay in the decision making between efficiency and aesthetics from the initial stages of a project. This negates the need to either undo design decisions that have already been made in exchange for improved performance, or altogether forgo those options because the project is too far down the road."

What is Energy Modeling?

In its simplest form, an energy model is…

a set of inputs and default variables

(Building geometry/ massing/form, system type, operation schedules, etc.)

a calculation engine

(DOE-2, EnergyPlus, Apache, etc.)

the results or output the program delivers

(Performance comparison graphs, compliance reports, etc.)

Energy Modeling at Different Design Stages

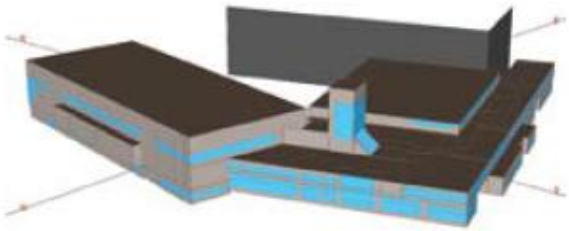
	CONCEPT DESIGN	SCHEMATIC DESIGN	DESIGN DEVELOPMENT	CONSTRUCTION DOCUMENTS	CONSTRUCTION/ POST-OCCUPANCY
TEAM GOALS	Use early Design Performance Modeling to help define the goals of the project (NOTE: Design Performance modeling could be with either component modeling tools or a basic building energy model, but should at this stage address other performance parameters in addition to energy.) Define the project requirements, as informed by modeling results	Review financial and performance energy information from model to guide design decisions	Review design alternatives based on initial goals, as informed by modeling results Create baseline and alternatives to choose from	Create documentation needed to accompany energy model results for code compliance Create documentation needed to accompany energy model results for commissioning and metering/ monitoring validation	Use results of the as-built model for commissioning Compare results of the as-built model against metered data to look for operating problems
ENERGY MODELING GOALS	Experiment with building siting and orientation Determine effective envelope constructions Assess the effects of daylighting and other passive strategies Explore ways to reduce loads	Create a rough baseline energy model Test energy efficiency measures to determine the lowest possible energy use Set up thermal zones and HVAC options	Create proposed models with system alternatives to choose from Refine, add detail, and modify the models, as needed Provide annual energy use charts and other performance metrics for baseline vs proposed Evaluate specific products for project Test control strategies Do quality control check on the models	Complete the final design model Do quality control check on the models Create final results documentation needed to submit for code compliance	Complete the as-built model with installed component cut-sheet performance values Collect metered operating data to create a calibrated model to share with outcome-based database
BENEFITS TO CLIENT	Get entire design team united around project goals Use modeling results to make design decisions informed by integrated system performance	Test different options before implementing them Determine the most efficient and cost effective solutions	Determine the most efficient and cost effective solutions Size mechanical equipment correctly	Use energy model as part of LEED or other sustainable design certification application Provide ability to better predict energy use in the building	Provide ability to refine operations to meet reduced energy use goals in the built project

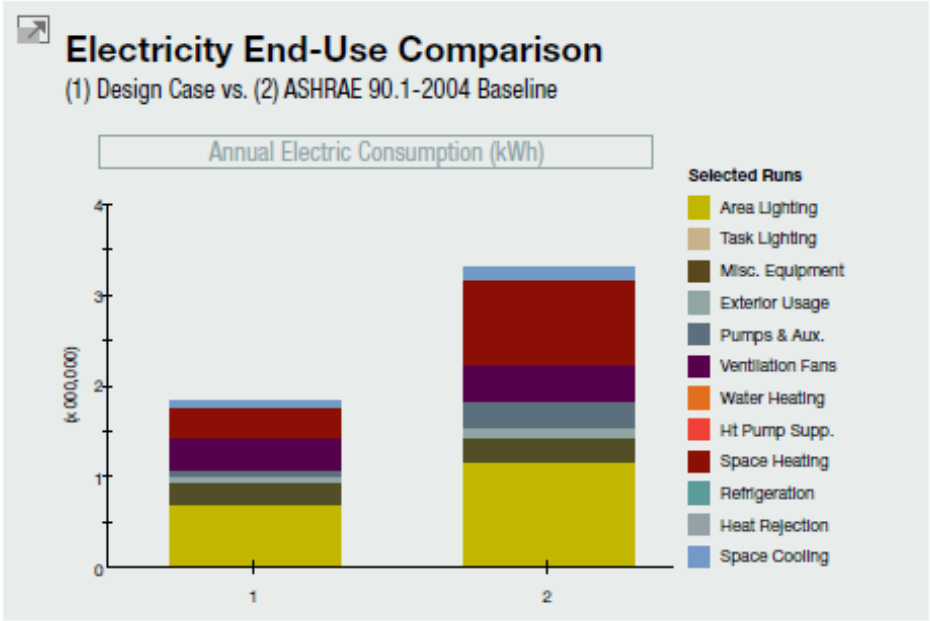
An Architect's Guide to Integrating Energy Modeling in the Design Process

Comparative Analysis of Alternatives

An Example of Energy Model Output and Results

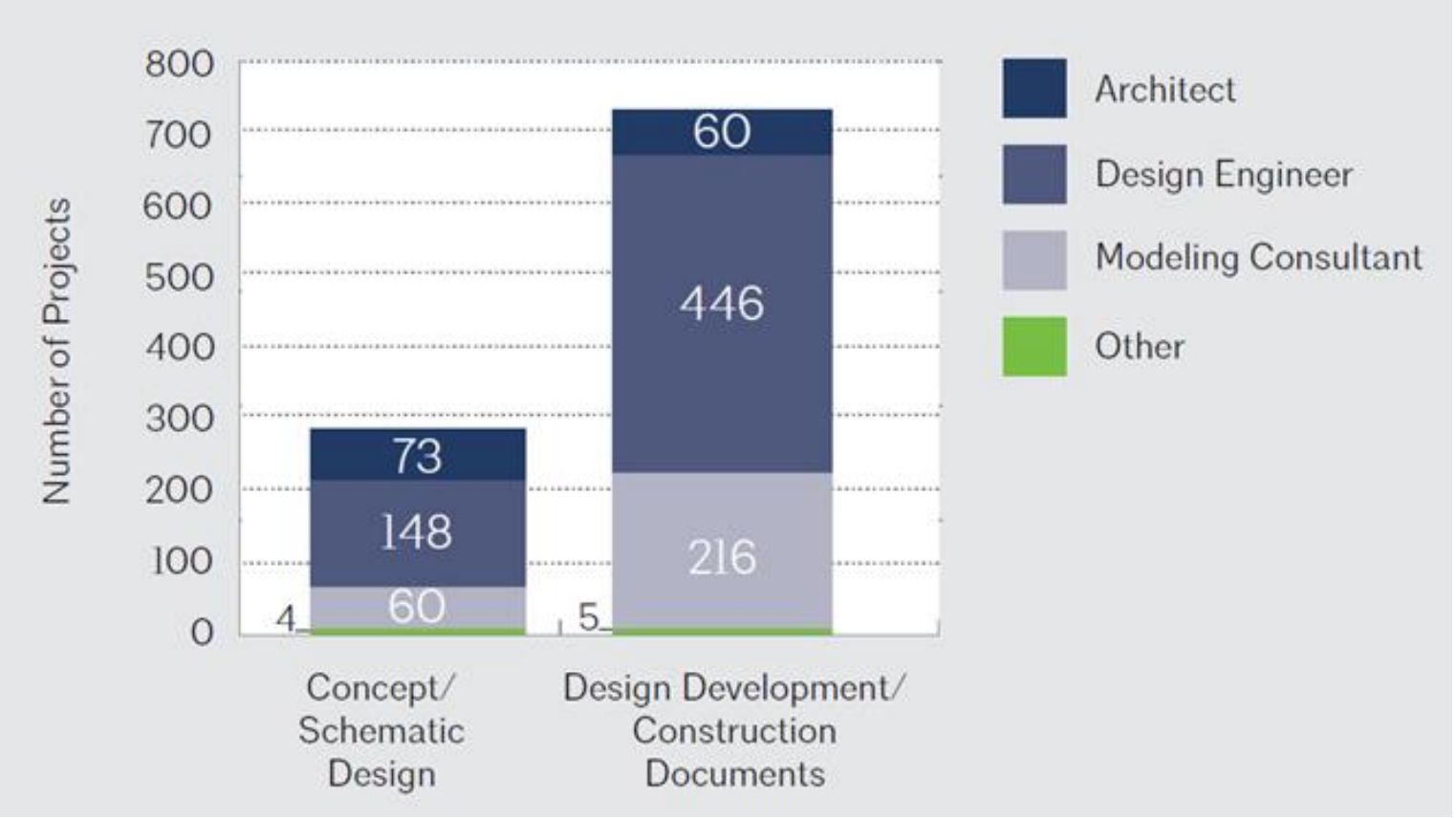
SIMULATION RUN	ELECTRICITY USE (kWh x 10^6)	NATURAL GAS USE (MBtu x 10^3)	ENERGY USE INTENSITY (KBtu x 10^3)	ENERGY SAVINGS (%)
Baseline Building	34	39	114	–
ECM#1-LPD=0.8	22	45	90	21
ECM#2-Add Wall Insul.	34	39	114	0
ECM#3-Add Roof Insul.	34	39	114	0.2
ECM#4-Improved Glazing	33	30	106	7.5



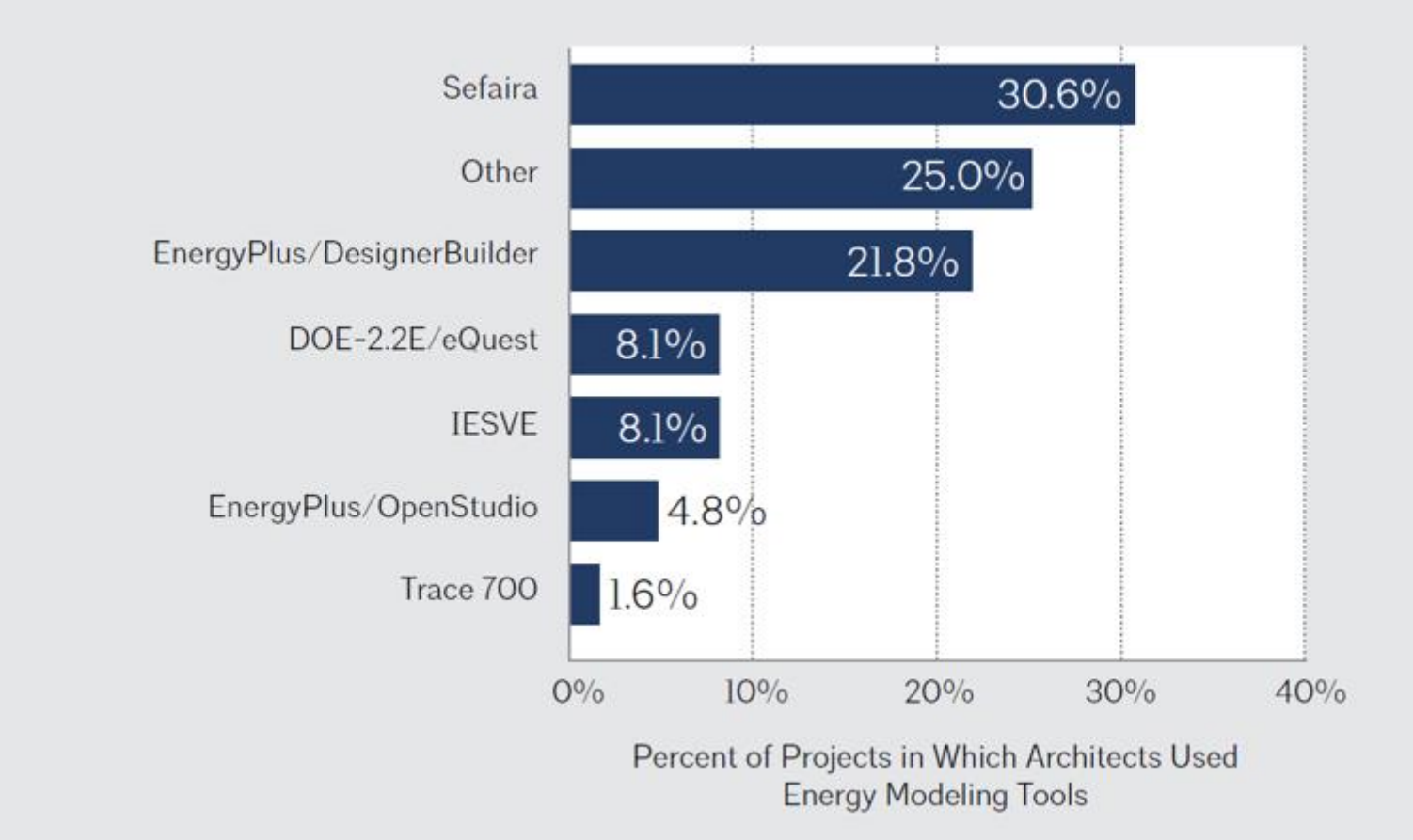


An eQuest model output that demonstrates where major consumption occurs in a building. Baseline and design cases will vary, depending on project parameters.

Team Members Responsible for Energy Simulation by Design Phase



Simulation Tools Used by Architects



Building Energy Modeling Tools

MODELING TOOL	CALCULATION ENGINE	GRAPHIC INTERFACE FOR FRONT-END INPUT	GRAPHIC RESULTS PROVIDED	APPROPRIATE FOR EARLY DESIGN PHASE	APPROVED FOR CODE COMPLIANCE MODELING	FREEWARE
COMFEN (RESFEN – residential)	EnergyPlus	Yes	Yes	Yes	No	Yes
DesignBuilder	EnergyPlus	Yes	Limited	Yes	Yes	No
Ecotect	CIBSE Admittance Method	Yes	Yes	Yes	No	No
EMIT1.2	None (spread-sheet)	No	Not specifically, (but s/s capability)	Yes	No	Yes
EnergyPro	DOE-2.1E	No	No(auto-generates compliance report)	No	Yes (easiest to use)	No
eQUEST®	DOE-2.2	Yes	No	Must be far enough along to input HVAC	Yes (most popular)	Yes
Green Building Studio / Vasari	DOE-2.2	Yes	Yes	Yes	No	No
Hourly Analysis Program (HAP)	Transfer Function Method	Limited	No	No	Yes	No
IES Virtual Environment	Apache	Yes	Yes	Gaia + Toolkit Yes Pro requires input of HVAC	Yes	No
OpenStudio	EnergyPlus	Yes (similar to SketchUp)	Yes	Must be far enough along to input HVAC	Yes	Yes
Sefaira Concept	Sefaira	Yes	Yes	Yes	No	No
Simergy	EnergyPlus	Yes	Limited	Not yet	Yes	Yes
TAS	TAS	Yes	Yes	Yes	Yes	No
TRACE® 700	TRACE	No	Limited	Must be far enough along to input HVAC	Yes	No
TRNSYS	TRNSYS	Yes	No	No	No	No

Simulation Tool Cost Comparison

Tool	Cost
eQuest	FREE
DesignBuilder v5	$1,599 /license
OpenStudio	FREE
IES Virtual Environment	$3,142 /3 years per license $4,450 /3 years network license
TRACE 700	$1,995 /license $3,990 /site
Sefaira Concept	$5,000 /year per firm

Check vendor websites for up-to-date prices and purchase options!

- The credit affects:
  - **Energy Related Systems**, AND
  - Water Related Systems

- Develop a preliminary “simple box” energy model to explore energy reduction and related sustainability strategies

- Document how the analysis informed design decisions on
  - Building and Site Program
  - Form and Geometry
  - Envelope and Façade Treatment
  - Sizing of Building Systems (HVAC, Lighting, Controls, Exterior Finishes)
  - Other Systems

Real Project Example: Compare HVAC Options for a Major Renovation of a High School

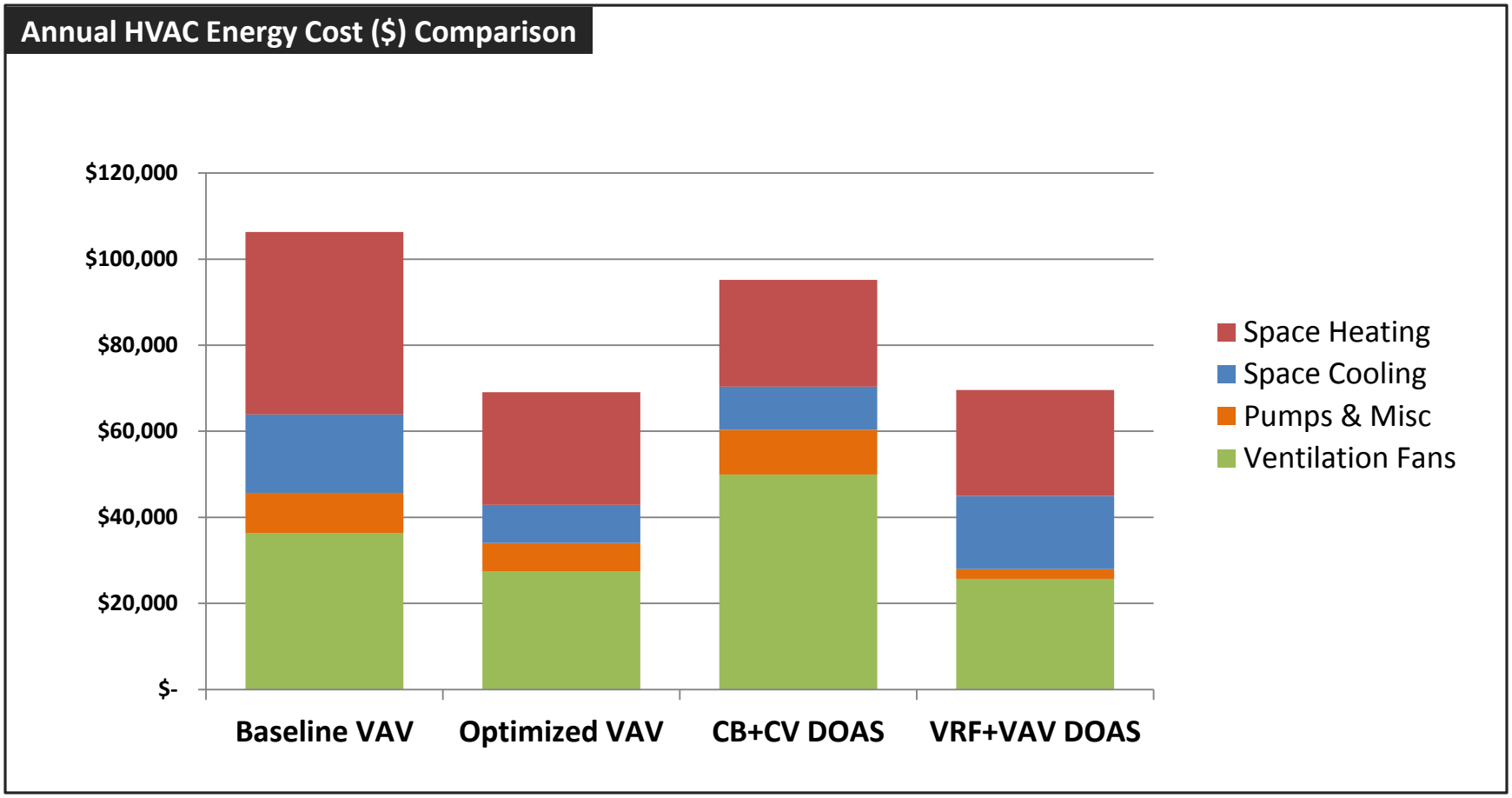
- **Baseline VAV**: Variable Air Volume (VAV) air handlers, water cooled chillers and conventional hot water (HW) boilers

- **Optimized VAV**: VAV with HW condensing boilers and air-cooled, magnetic bearing chillers, & improved controls

- **CB + DOAS**: Chilled beams (CB) with condensing boilers and air-cooled magnetic bearing chillers, a constant volume (CV) dedicated outdoor air system (DOAS)

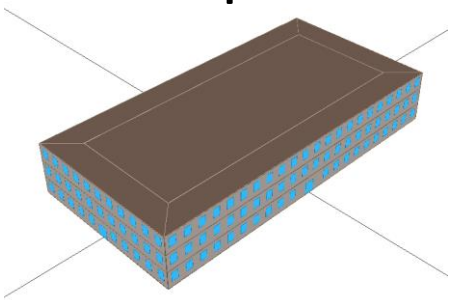
- **VRF + DOAS**: Variable refrigerant flow (VRF) heat pumps and a variable volume (VAV) DOAS

RESULTS


Annual HVAC Energy Cost ($) Comparison
$120,000
$100,000
$80,000
$60,000
$40,000
$20,000
$-
Baseline VAV
Optimized VAV
CB+CV DOAS
VRF+VAV DOAS
Space Heating
Space Cooling
Pumps & Misc
Ventilation Fans

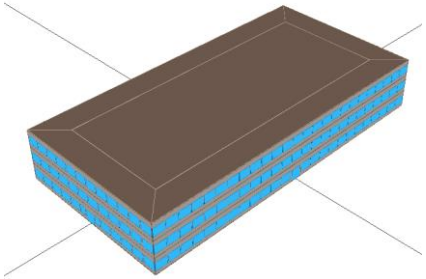
Live eQUEST Demo: Early Design Support

- Program calls for a 50,000 square foot office building
- Concept stage explores different options for building shape and window to wall ratio



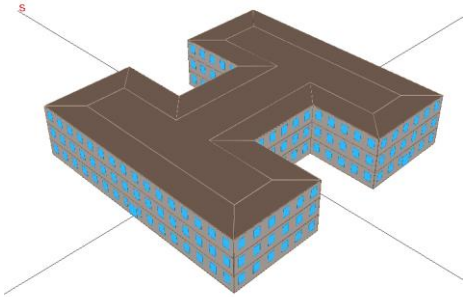
Base Case:

- Rectangular footprint
- 3 story
- 2:1 aspect ratio
- 25% window to wall ratio (WWR)
- daylight dimming control



Alternative 1:

- Same as base case, but 55% WWR



Alternative 2:

- Same as Alt 1, but H-Shape