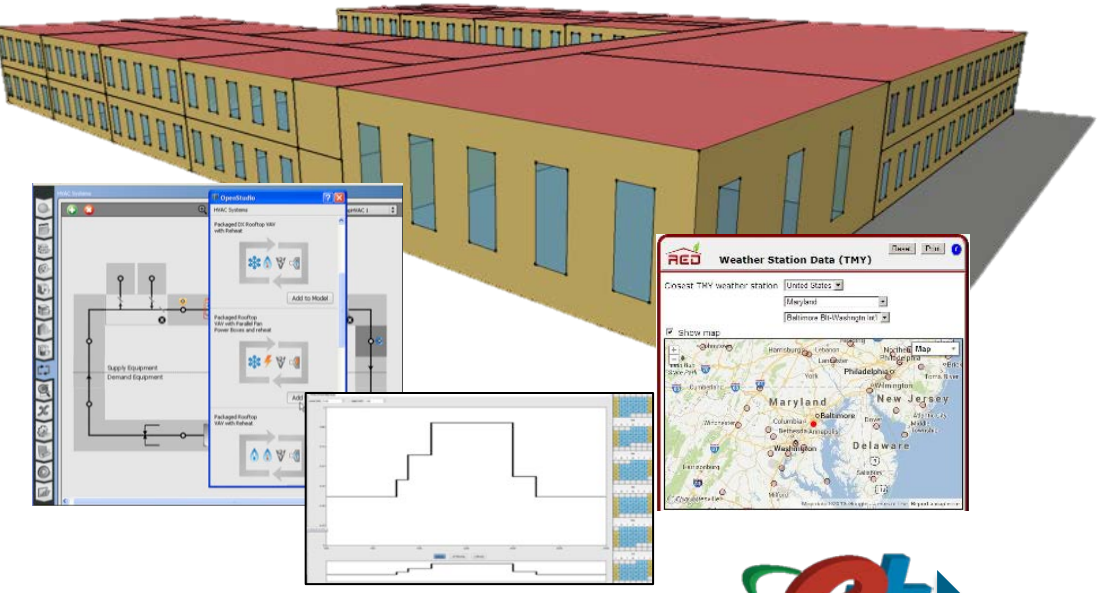
Building Energy Modeling: The Force Awakens

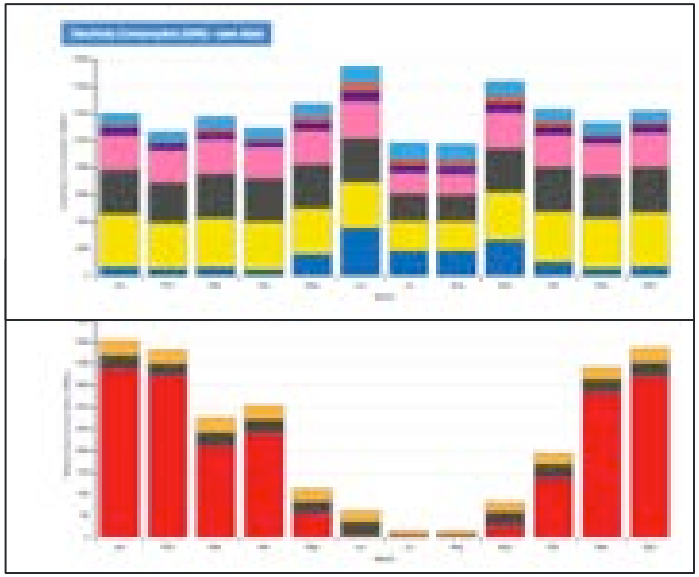
Better Buildings Summit

Tuesday, May 10th

2:00-3:15 PM

Ins and Outs of Building Energy Modeling





Information about building

- Geometry, constructions, systems
- Occupancy, loads, set-points
- Weather
- Measured data if you have it
- Detail helps but isn't necessary

Analytical view of building

- Where & when do kWh ($$) go?
- Where are savings opportunities?
- Can I improve occupant comfort?
- How far above (or below) code?
- Qualify for certificates or incentives?

Modeling Is Decision Tool

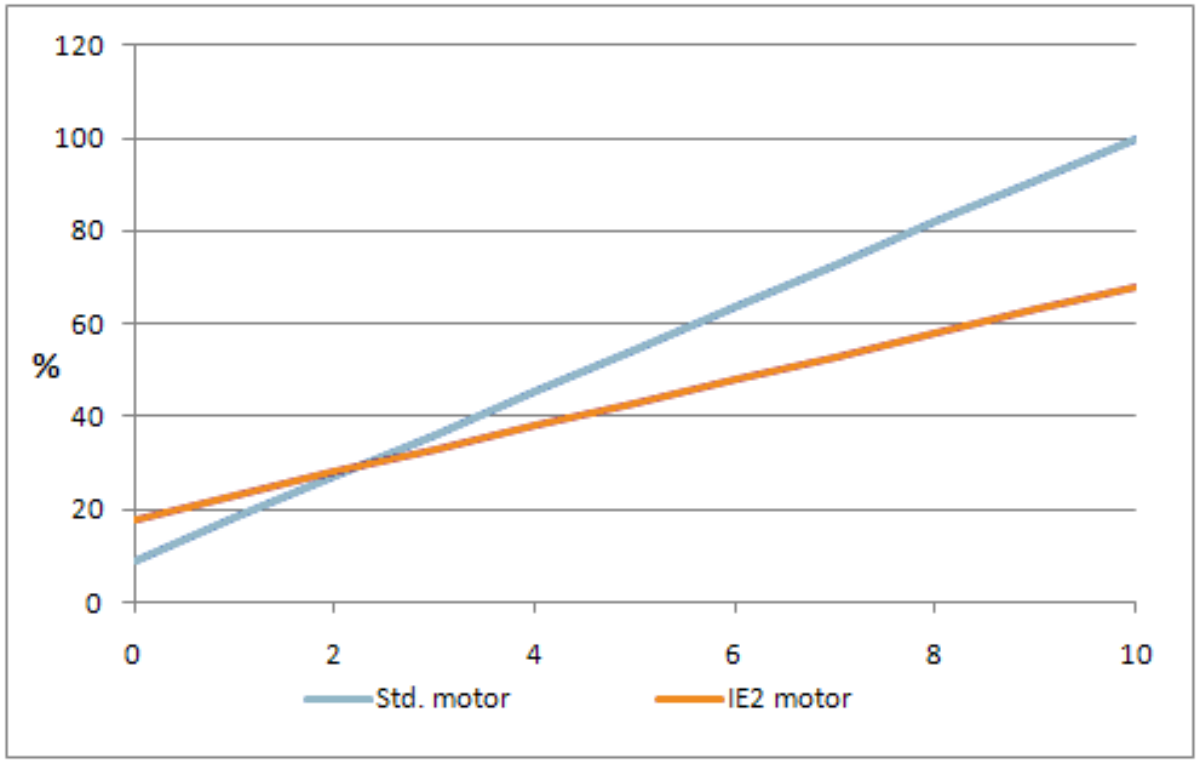
Complements benchmarking & measurement

- Benchmarking helps screen but doesn't give (good) specific insight & advice
- Measurement grounds analysis, but requires existing building & doesn't do "what if"
- Modeling is the key third tool for building energy management

Use it when making (important) energy decisions

- Early in a project ➔ big mistakes are hard to overcome later
- Comparative can rank alternatives even under uncertainty

Modeling as an ECM (Energy Conservation Measure)



Spend money up-front ➔ reap operational savings

- Standard ECM metrics: simple-payback, ROI, NPV

Modeling can have *immediate* payback

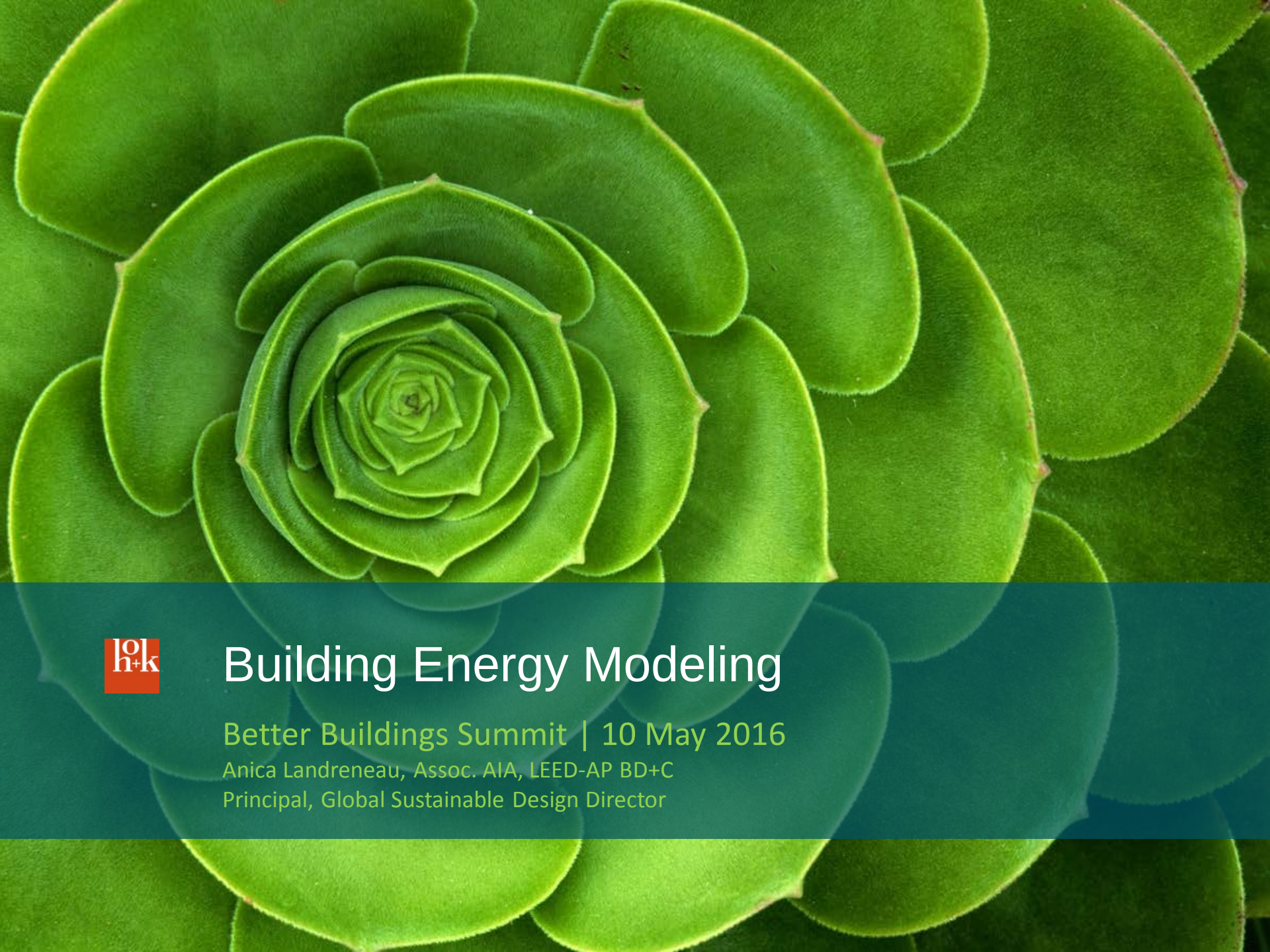
- Can show you where *not* to spend money

The ROI of Modeling

Anica Landreneau

HOK: Principal; Director of Sustainable Consulting, Global; Board of Directors

DC Green Building Advisory Council



Building Energy Modeling

Better Buildings Summit | 10 May 2016

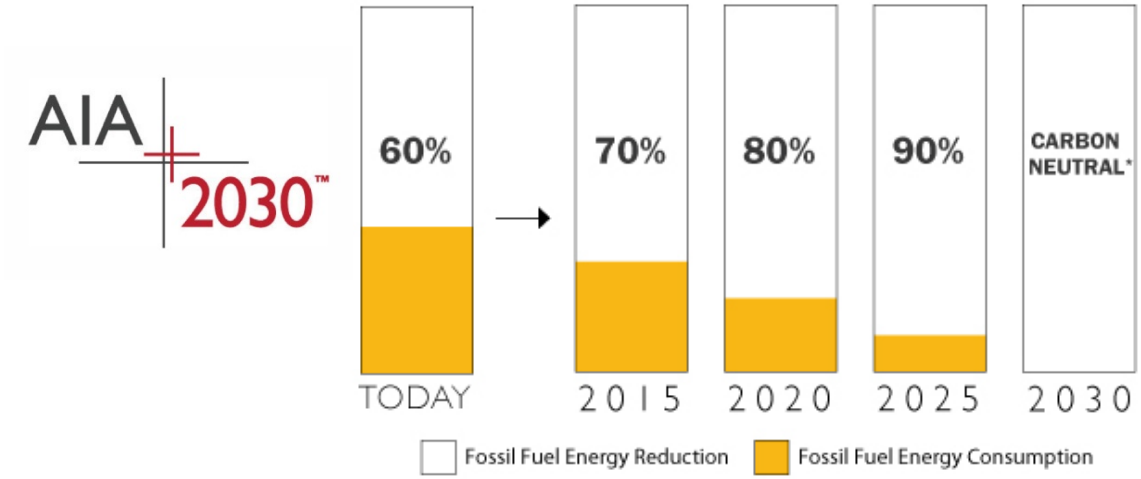
Anica Landreneau, Assoc. AIA, LEED-AP BD+C
Principal, Global Sustainable Design Director

Why do we do it?

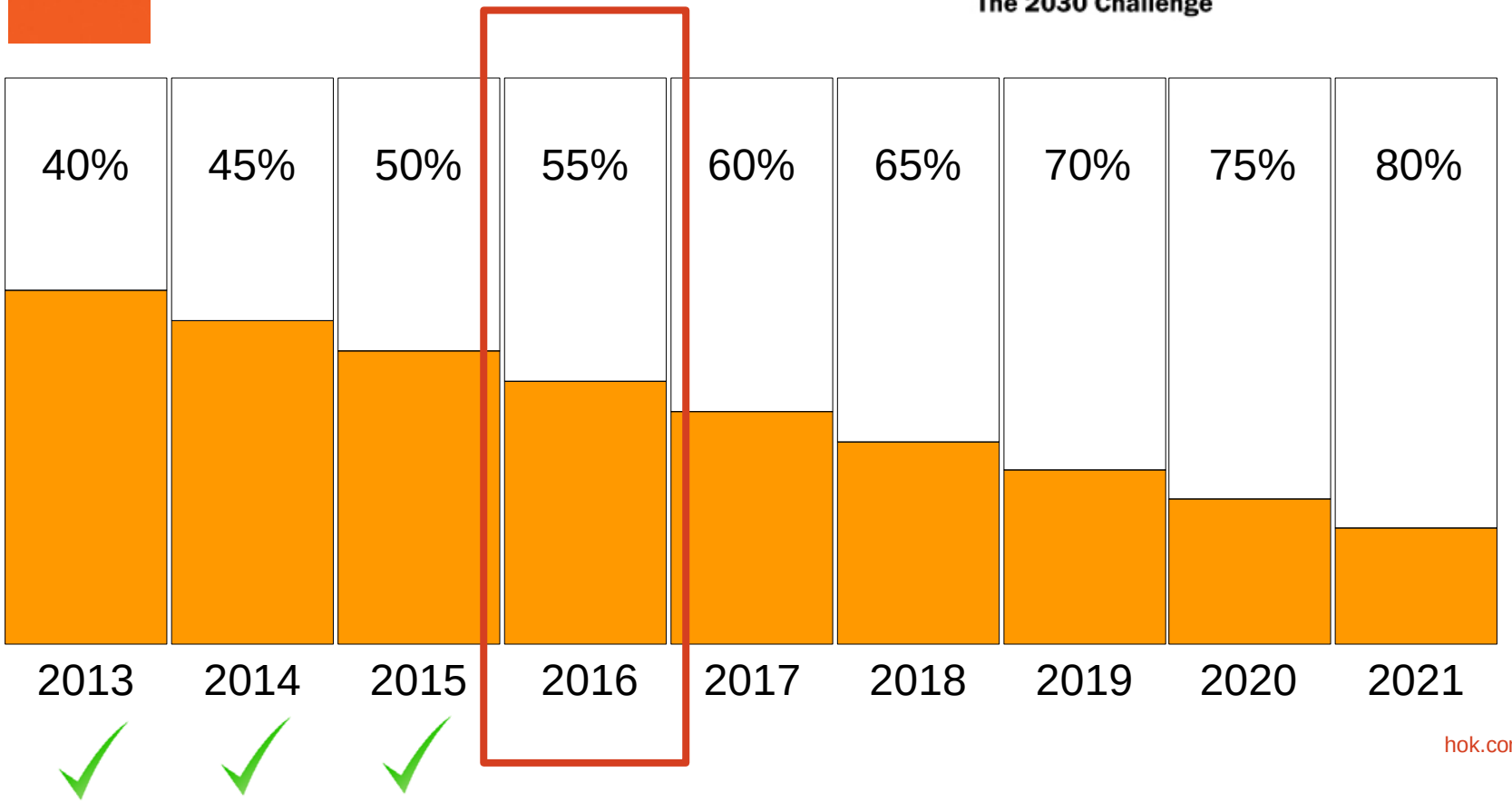
MODELING HAS IMMEDIATE PAYBACK

Project Name	% Modeling Fees vs Gross Fees	Annual Modeled Energy Cost Savings	Payback on Modeling Fees in MONTHS
Office Building	0.7%	$122,876	2
Office Building	0.5%	$306,692	1
Justice Center	0.8%	$350,000	3
Convention Hotel	0.6%	$233,791	1
Regional Hospital	2.4%	$3,300,000	1
Government Office Building	3.3%	$186,000	4
Government Building 20	1.1%	$224,276	2
Cancer & Critical Care Tower	0.6%	$853,013	3
Institutional Research Center	0.6%	$340,000	3
Energy Institute	2.5%	$169,432	7
Institutional Research Facility	1.0%	$302,169	1
Science Teaching and Research Facility	0.8%	$419,599	1
Corporate Headquarters	1.0%	$239,835	4

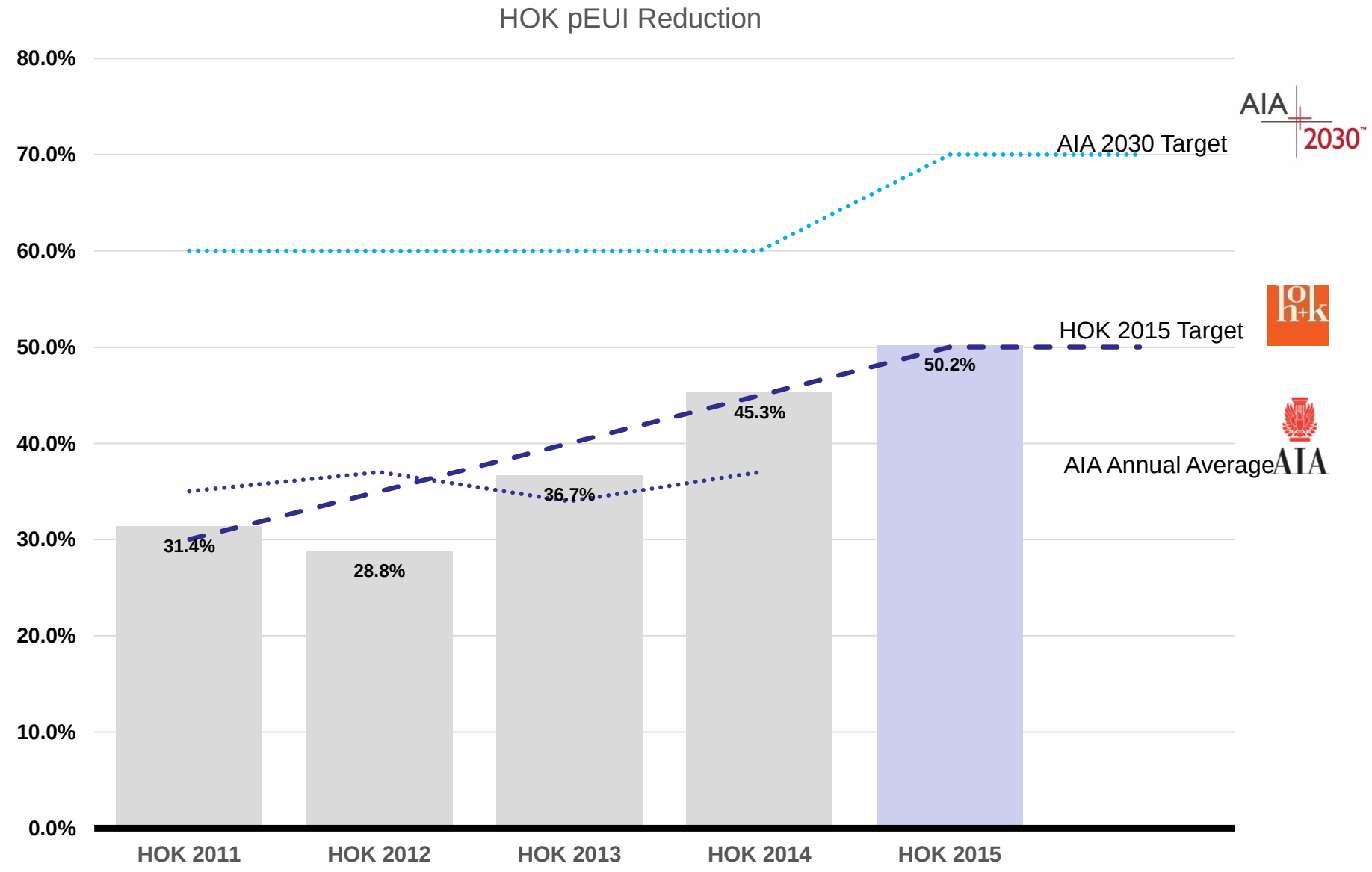
Internal study performed by HOK



The 2030 Challenge

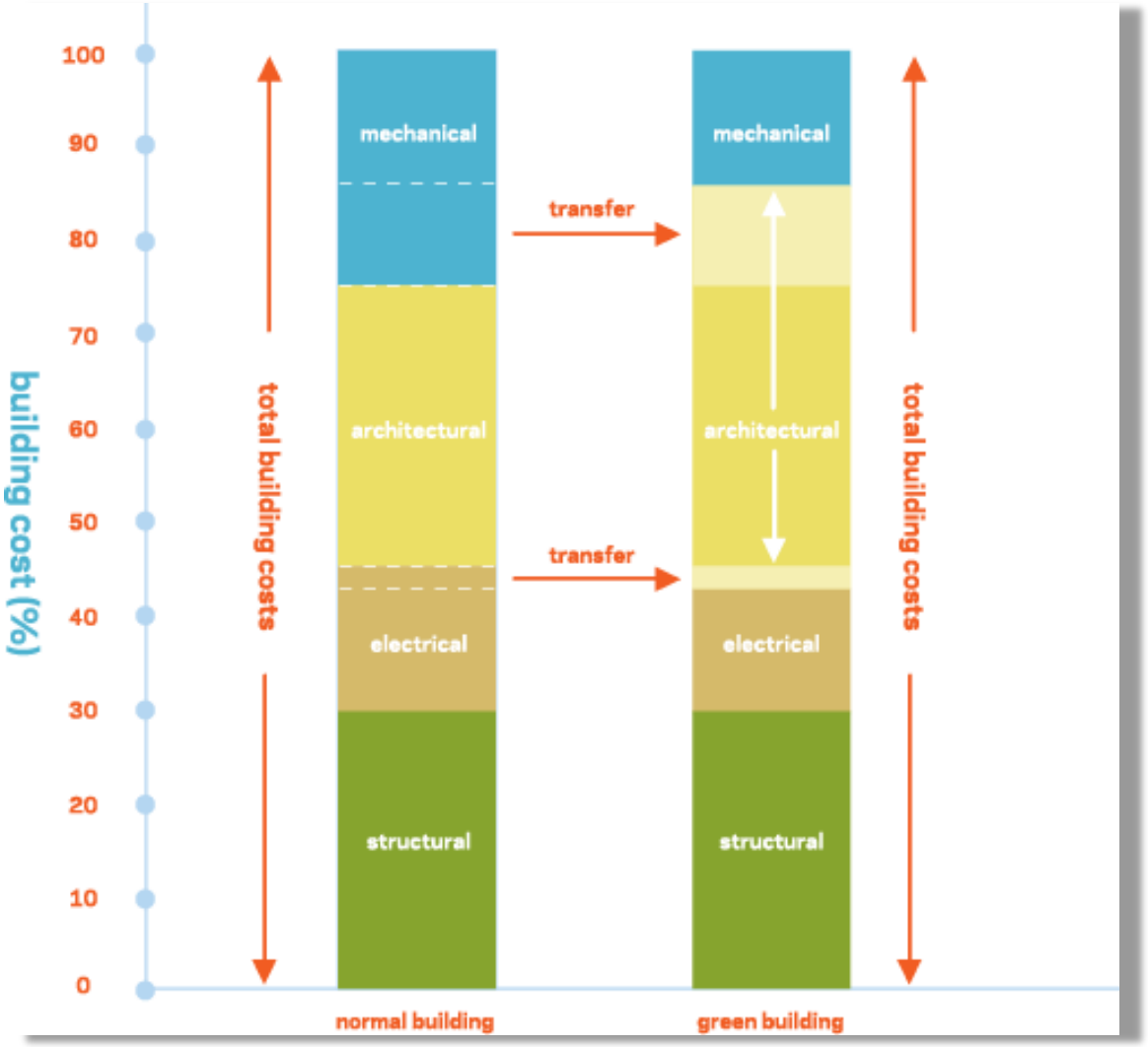


HOK Design Energy Use Intensity (pEUI) Reduction



Average percent reduction from CBECS/AIA 2030 baseline across HOK's global portfolio.

INTEGRATIVE DESIGN SHIFTS INVESTMENT



How do we do it?

EARLY GOAL SETTING

SUSTAINABLE ANALYSIS REPORT

OVERVIEW OF HOK

General Information

Project Number: 12.14023.00
Project Location: United_States,Kansas_City-Missouri
Coordinates: 39.12° N - 94.6° W

Building Type	Office - 10,001 sf to 100,000 sf
Energy Code	ASHRAE 90.1-2007
Certification Goal	LEED Platinum
Project Site Area (sf)	50,000
Gross Floor Area (sf)	30,000
Project Roof Area (sf)	15,000
Number of Full Time Occupants	180
Operational Days/Year	250
Year of Project Completion	2,017
Climate Zone	ASHRAE Climate Zone 4A
Weather File	Kansas City Downtown Ap - TMY3

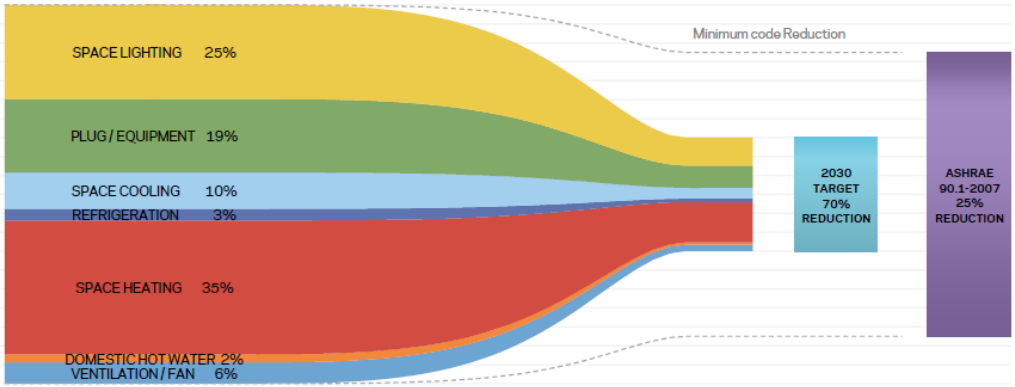
HOK's Six Step Process to Sustainability

1 DISCOVERY & DEFINITION	Define integrated sustainable process to establish the following: Team Roles and Responsibilities, Energy and Utility Benchmarks, Key Performance Indicators (KPIs) and metrics, Green Building Codes, Standards and available incentive programs.
2 CLIMATE & PLACE	Analyze Climate, Site and Cultural conditions to establish design constraints and opportunities. Identify design solutions that respond to local temperature, humidity, wind velocity, topography, ecology, adaptive comfort and building design / construction practices.
3 LOAD REDUCTION	Identify passive Architectural strategies that are best management practices for the building type and location . Analyze these strategies through iterative, early-stage analysis software / tools to help identify optimized solutions.
4 INTEGRATED SOLUTIONS	Identify Architectural and MEP strategies that allow the building to function as an efficient organism. Research and analyze the cumulative effects that result from envelope, mechanical, lighting and behavior design strategies. Perform continuous and iterative energy modeling to verify performance.
5 RENEWABLE SYSTEMS	Anticipate the incorporation of renewable systems during site planning, programming and architectural massing to maximize the efficiency of the system. Perform energy modeling analysis that incorporates local and federal incentives.
6 OCCUPANCY	Anticipate and design for human behavior as it relates to operational performance of the project. Ensure that systems selected will allow for ease of operations for facility staff. Consider design for optimal thermal comfort and system controls that encourage plug and lighting load reductions.

1 DISCOVERY & DEFINITION

Typical Energy Use Intensity (EUI) & Lighting Power Density (LPD)

Office - 10,001 sf to 100,000 sf



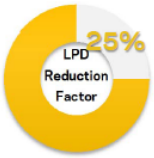
Weighted Averages EUI, CBECS
90.0
kBtu/Sf

2030 Target Value
27.0
kBtu/Sf

Code Min Reduction
67.5
kBtu/Sf

Required PV Projected Area to be Net Zero Energy (SF)
30,901 77,252

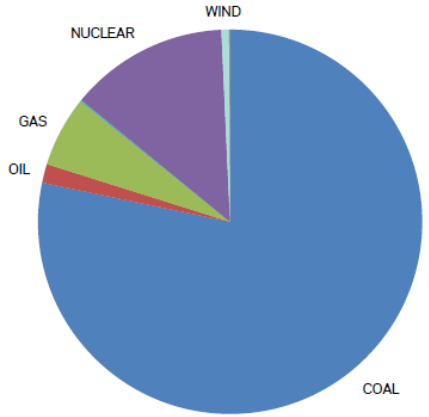
Code LPD (ASHRAE 90.1)
1.0
(W/SF)



Target LPD
0.75
(W/SF)

Electric Grid Carbon Emissions Mix

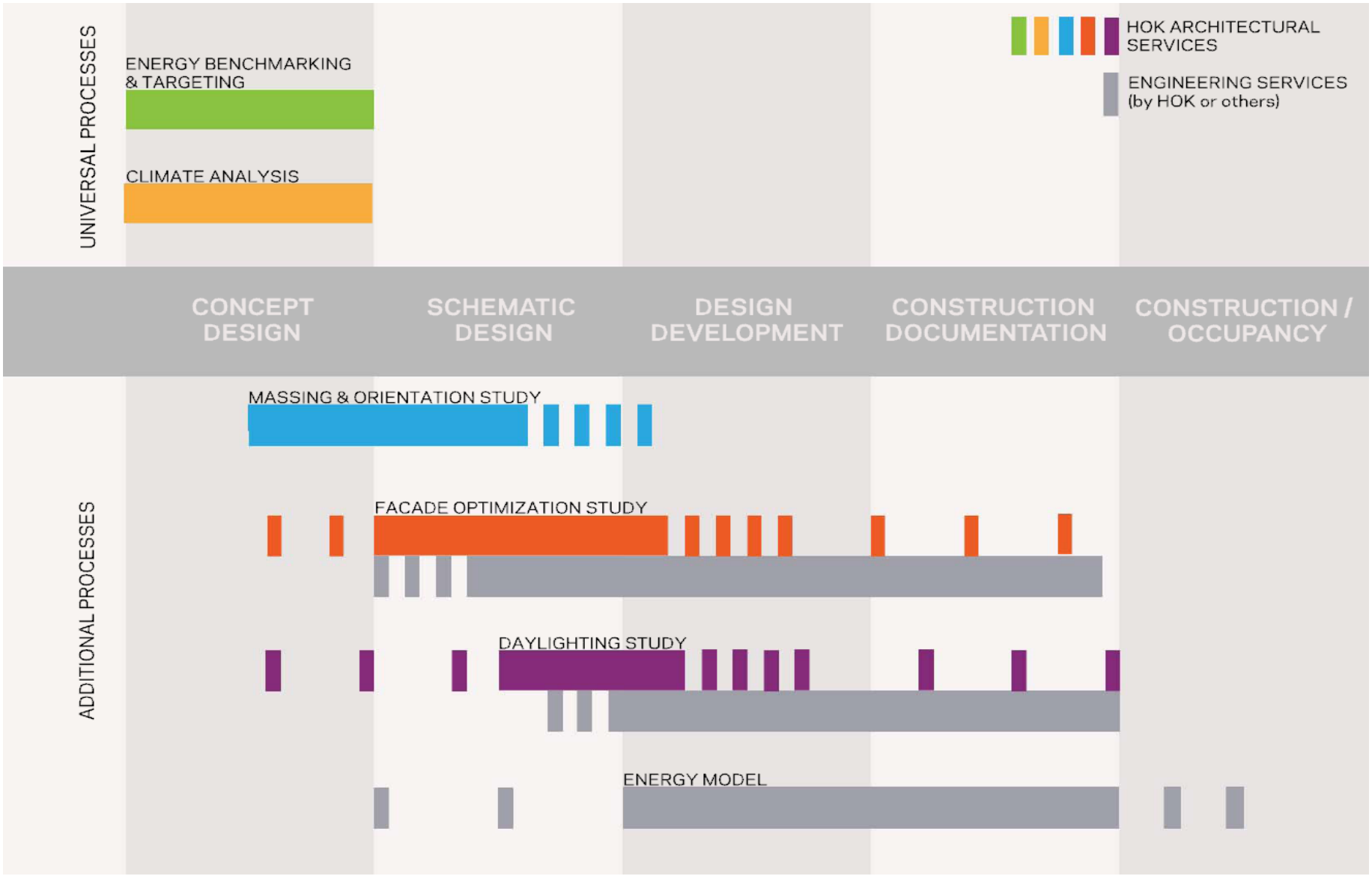
United States -SPNO



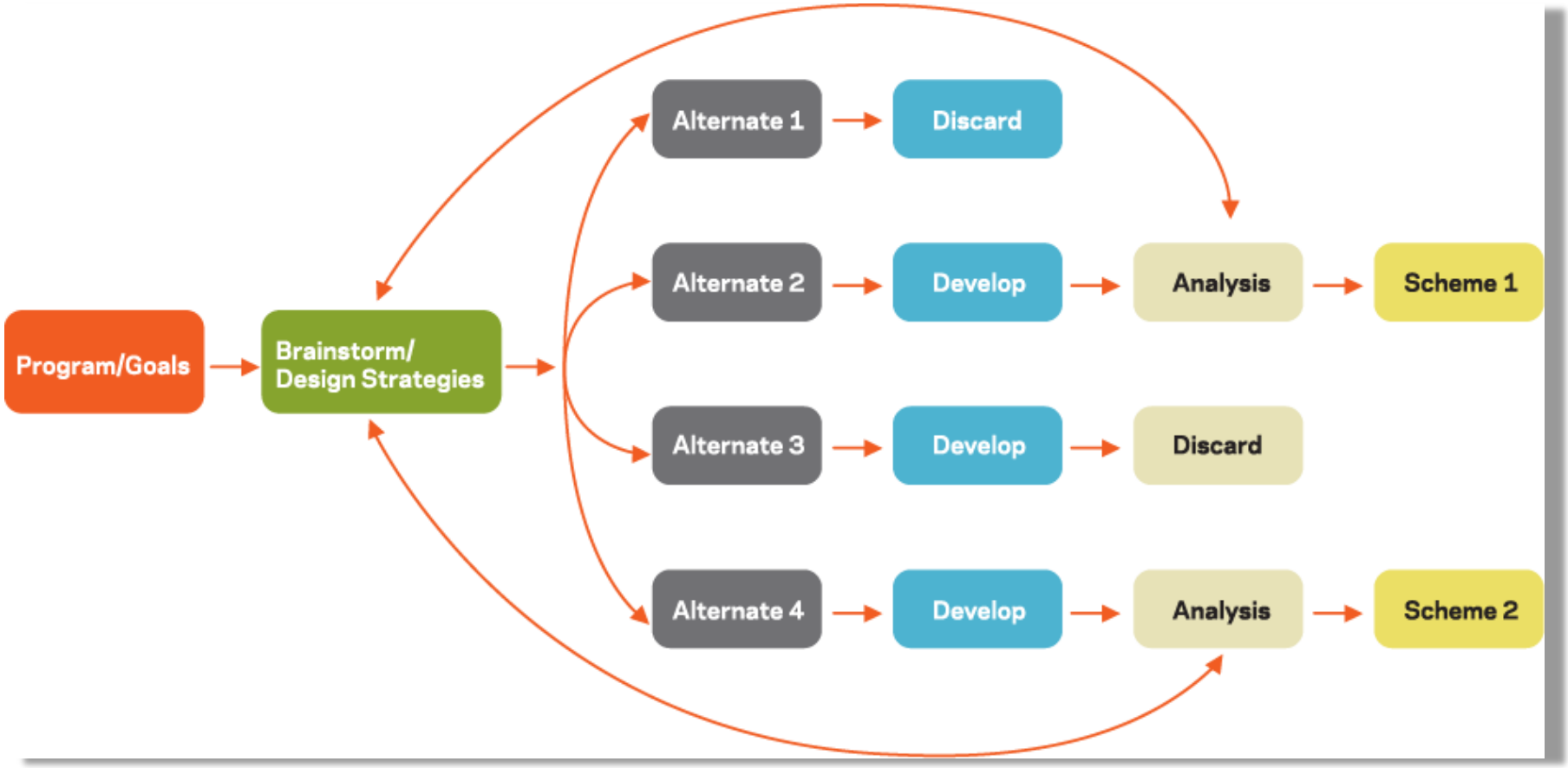
CO2 Emissions Rates
1960.9
(lbs/MWh)

Legend

Coal	78%		Wind	0.6%	
Oil	2%		Solar	0.0%	
Gas	6%		Geothermal	0.0%	
Hydro	0%		Other fossil	0.1%	
Nuclear	13%		Unknown	0.0%	
Biomass	0%				


UNIVERSAL PROCESSES
ENERGY BENCHMARKING & TARGETING
CLIMATE ANALYSIS
HOK ARCHITECTURAL SERVICES
ENGINEERING SERVICES (by HOK or others)
CONCEPT DESIGN
SCHEMATIC DESIGN
DESIGN DEVELOPMENT
CONSTRUCTION DOCUMENTATION
CONSTRUCTION / OCCUPANCY
ADDITIONAL PROCESSES
MASSING & ORIENTATION STUDY
FACADE OPTIMIZATION STUDY
DAYLIGHTING STUDY
ENERGY MODEL

ITERATIVE ANALYSIS INFORMS DESIGN

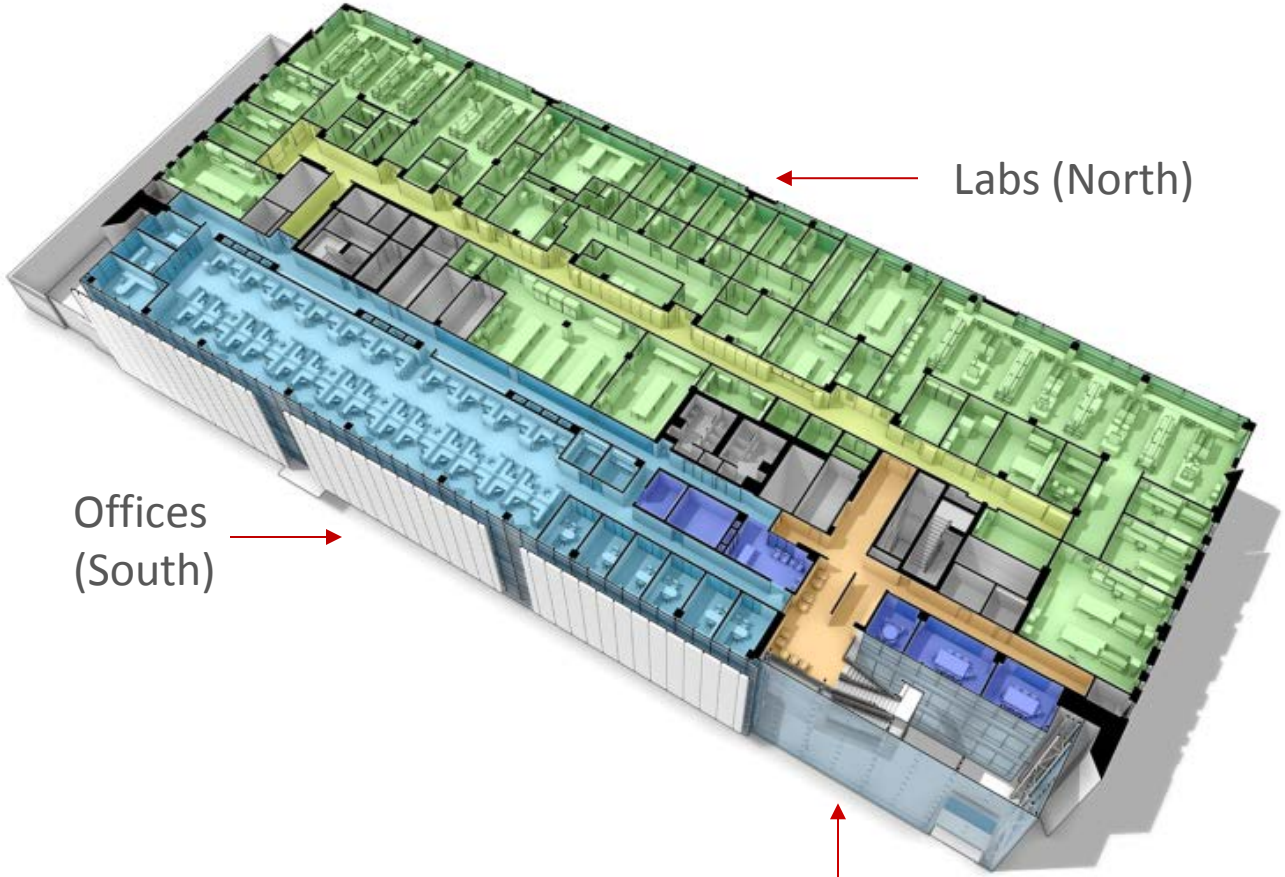


What does it look like?

DC Consolidated Forensic Lab

351,000 sf
Completed 2012
LEED Platinum *(Silver required)*
Annual EUI 184 kBtu/sf/yr
22.5% below ASHRAE 90.1-2004
60% Reduction against I^2SL baseline
17% under budget

ORGANIZATION

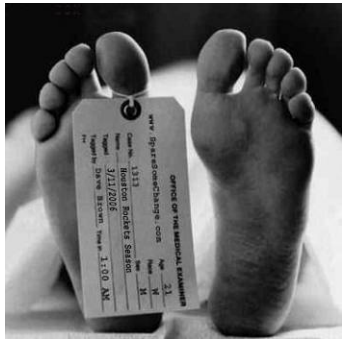


Metropolitan Police Department

Forensics Laboratory

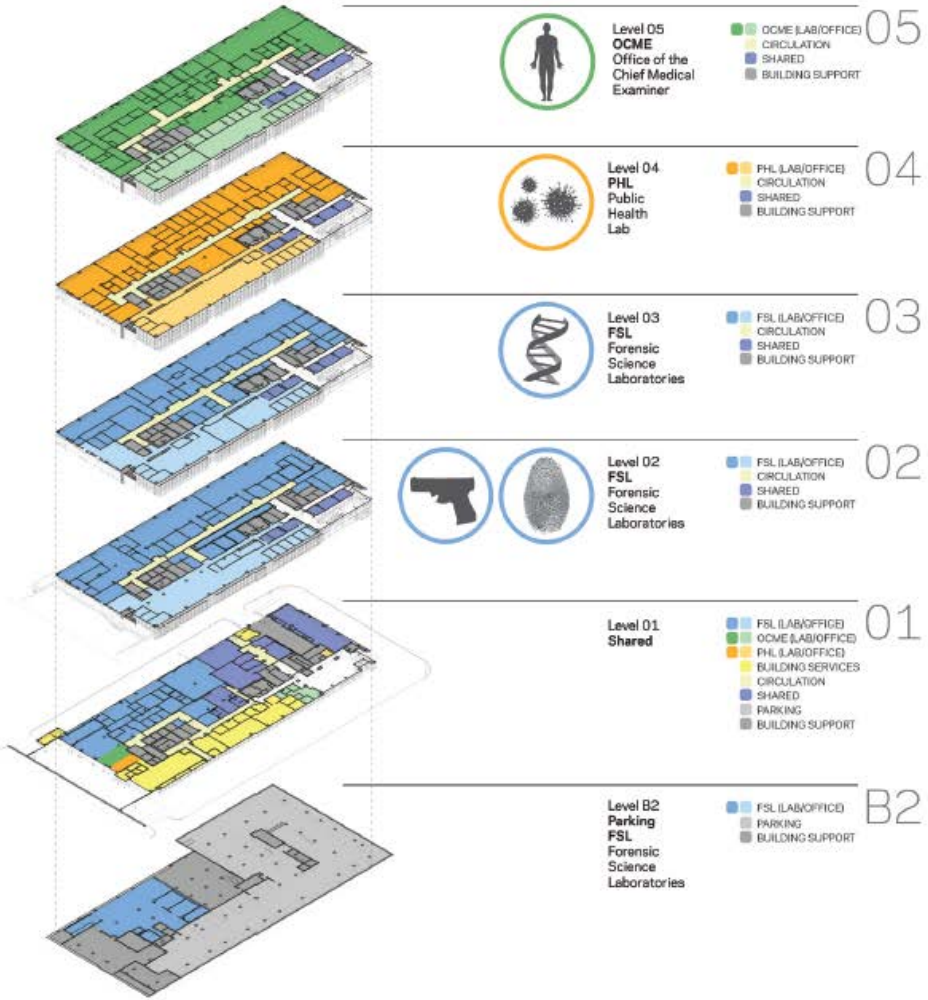
Department of Health

Public Health Laboratory



Office of the Chief Medical Examiner

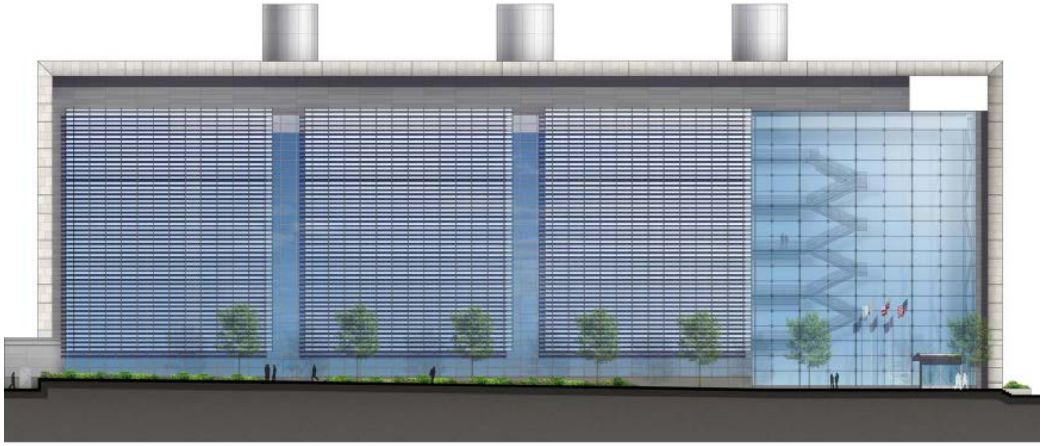
Morgue and Toxicology


Level 05
OCME
Office of the Chief Medical Examiner
OCME (LAB/OFFICE)
CIRCULATION
SHARED
BUILDING SUPPORT
05
Level 04
PHL
Public Health Lab
PHL (LAB/OFFICE)
CIRCULATION
SHARED
BUILDING SUPPORT
04
Level 03
FSL
Forensic Science Laboratories
FSL (LAB/OFFICE)
CIRCULATION
SHARED
BUILDING SUPPORT
03
Level 02
FSL
Forensic Science Laboratories
FSL (LAB/OFFICE)
CIRCULATION
SHARED
BUILDING SUPPORT
02
Level 01
Shared
FSL (LAB/OFFICE)
OCME (LAB/OFFICE)
PHL (LAB/OFFICE)
BUILDING SERVICES
CIRCULATION
SHARED
PARKING
BUILDING SUPPORT
01
Level B2
Parking
FSL
Forensic Science Laboratories
FSL (LAB/OFFICE)
PARKING
BUILDING SUPPORT
B2

ORIENTATION

NORTH ELEVATION

WEST ELEVATION

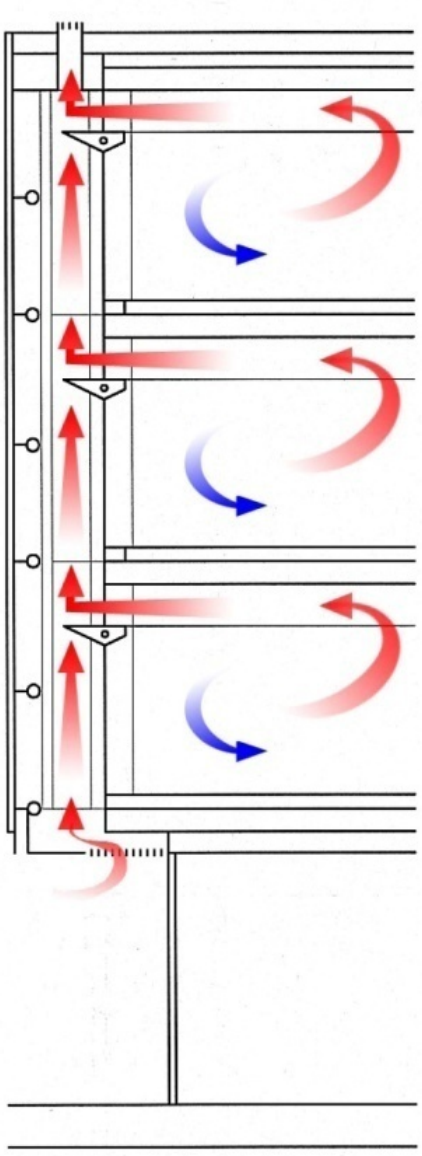


SOUTH ELEVATION

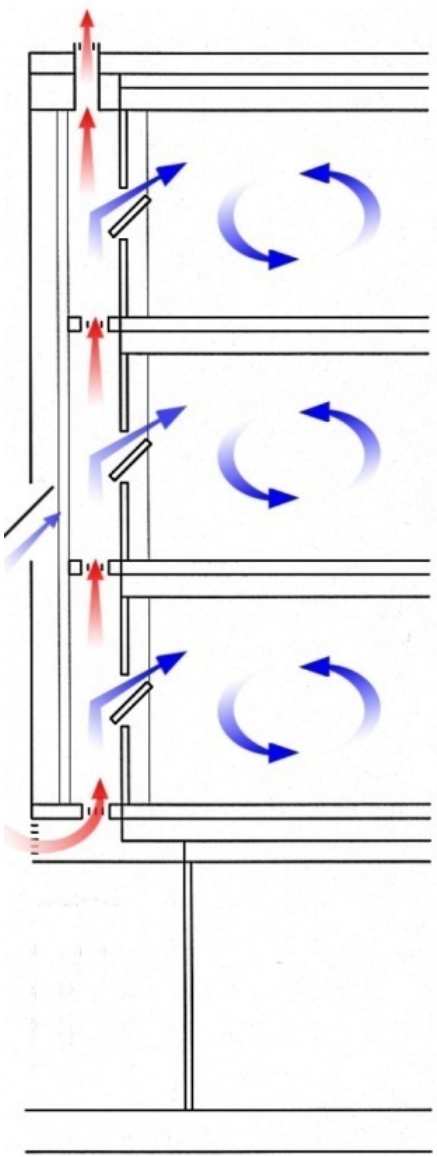
EAST ELEVATION

DOUBLE SKIN WALLS

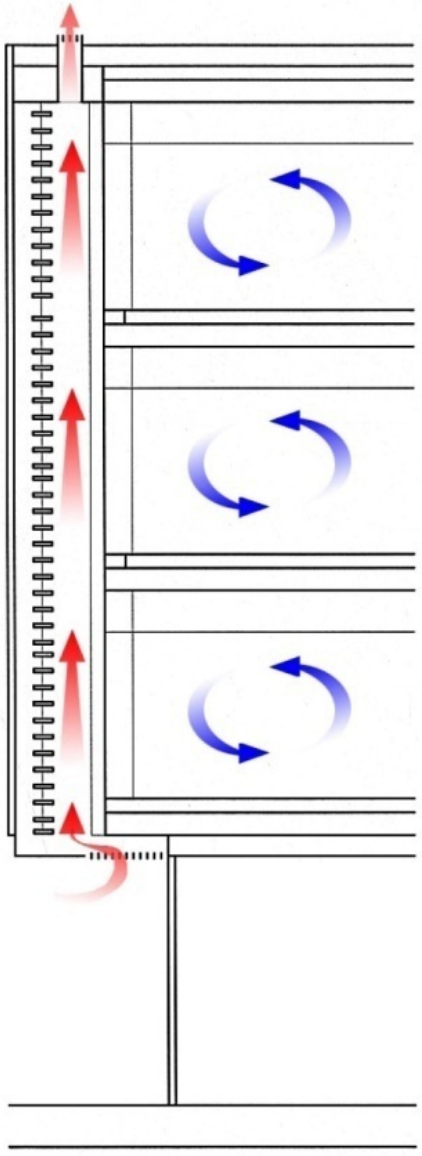
The Extract-Air Facade with Divided Air Space



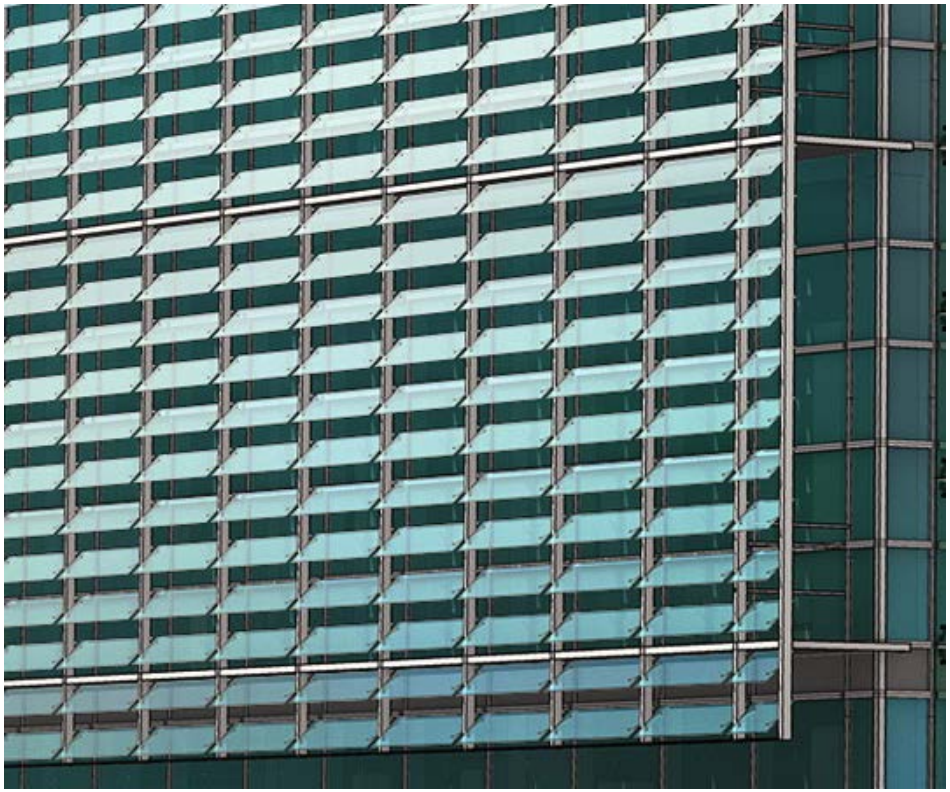
The Twin-Face Facade with Divided Air Space



The Buffer Facade with Undivided Air Space

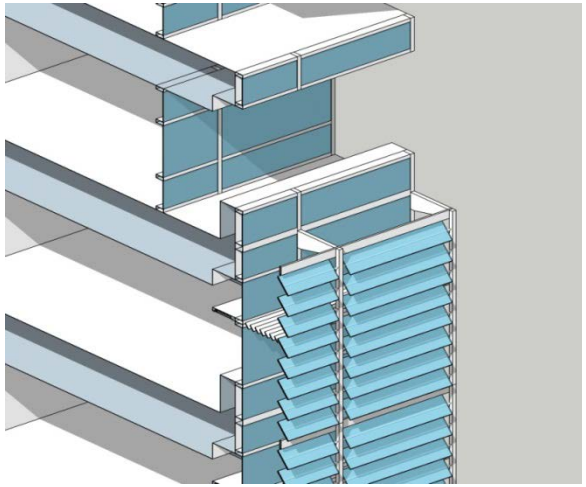


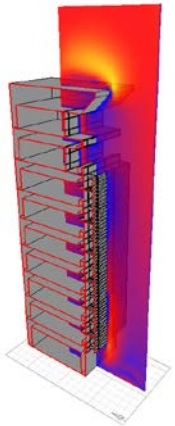
DYNAMIC FACADE

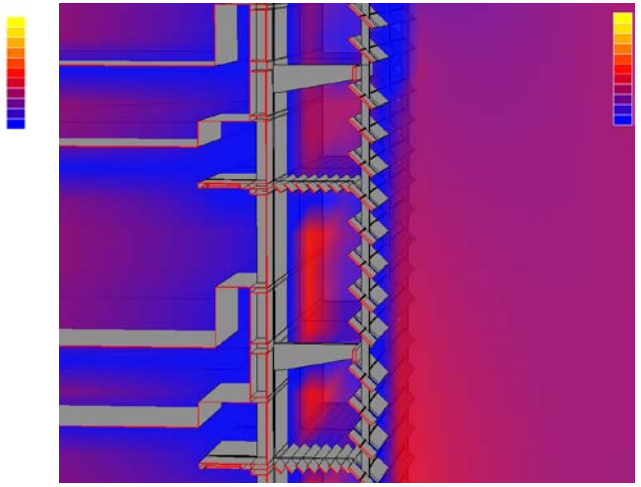


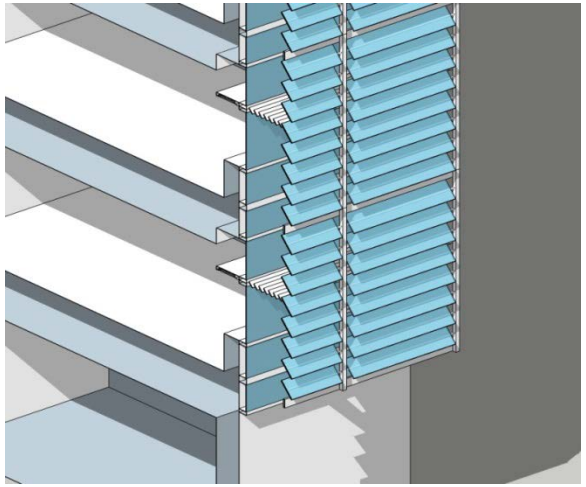
Buffer façade with operable louvers + 50% ceramic frit; not a true double skin wall

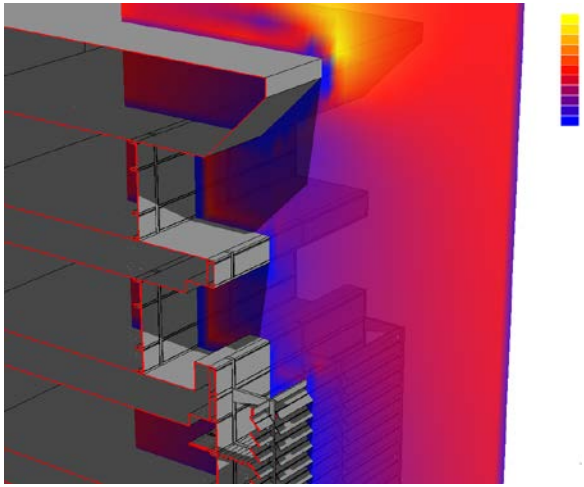
ANALYSIS

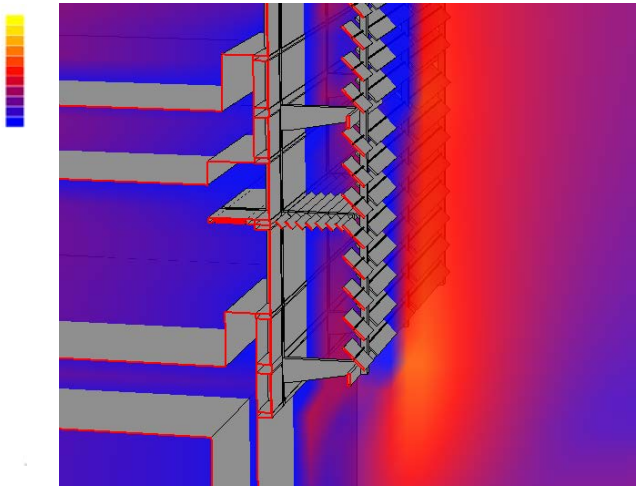






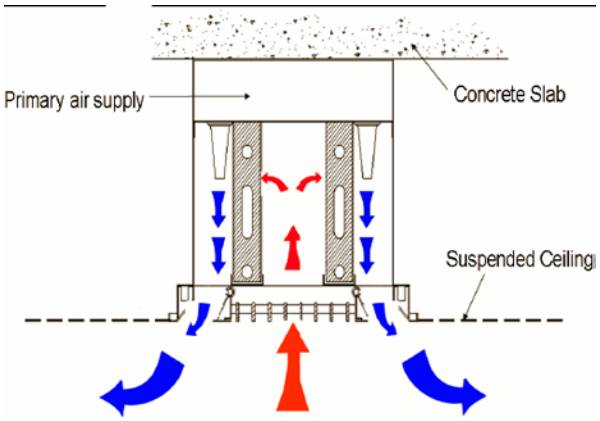


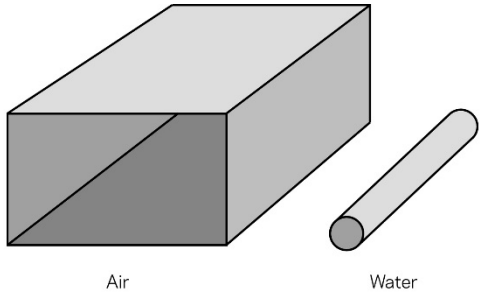




Computational fluid dynamics (CFD) model

ENERGY + THERMAL COMFORT: ACTIVE CHILLED BEAMS

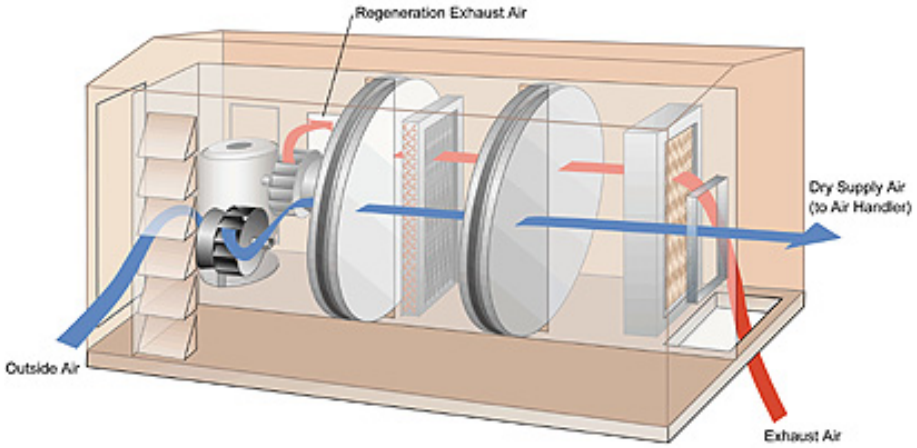




Area Required for Equivalent Amount of Cooling

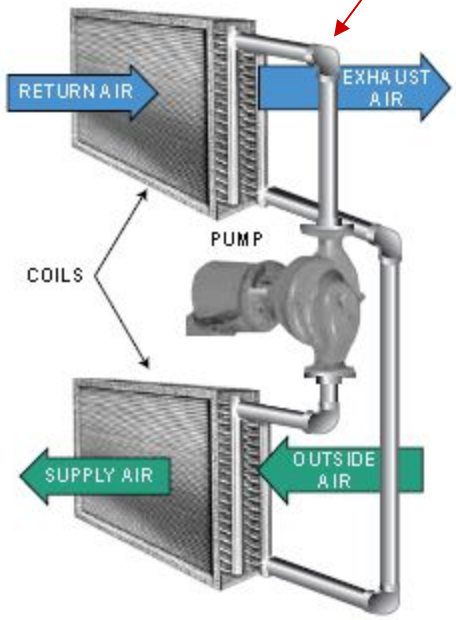
ENERGY + VENTILATION: 100% OUTSIDE AIR

General/
office exhaust



+ Enthalpy Wheel

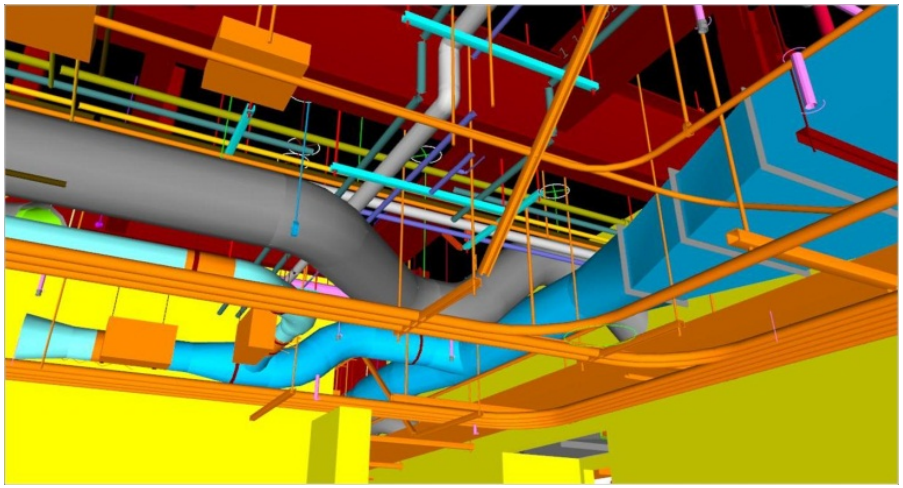
Lab/
fume hood
exhaust



+ Glycol Loop

+ Heat Shift Chiller

BIM



Energy Model Payback

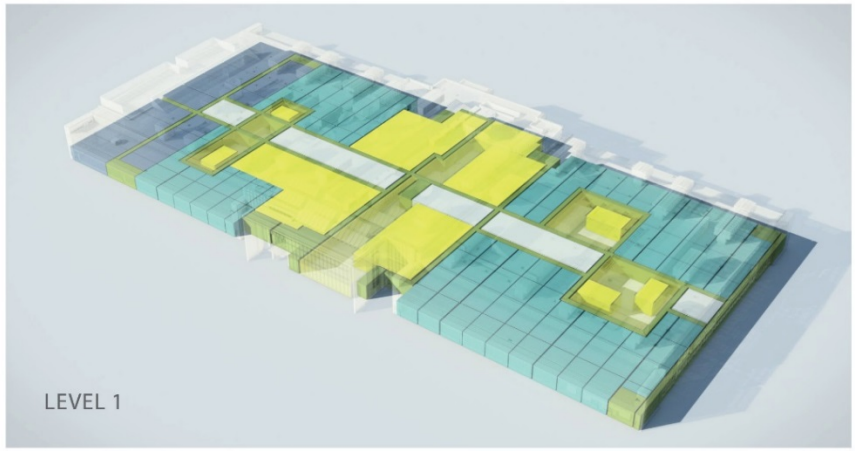
CFL Energy Model Payback	
annual energy savings (predicted)	$537,855
monthly energy savings (predicted)	$44,821
energy modeling costs	$60,000
months to payback energy model cost	1.3

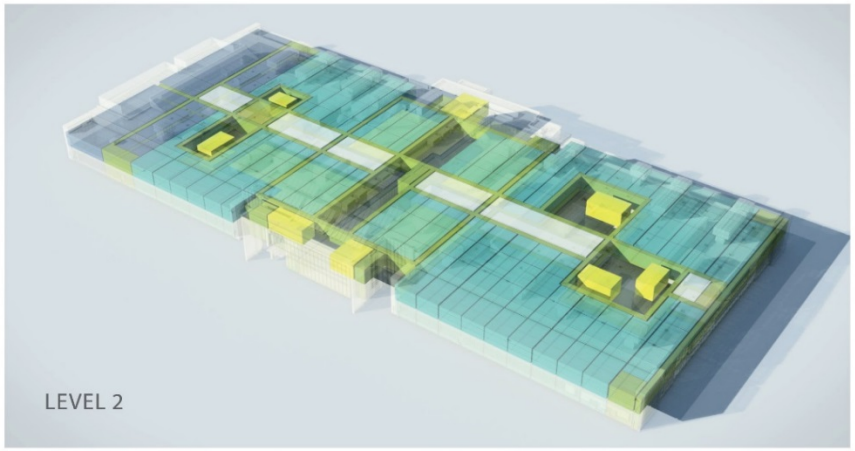
NOAA Daniel K. Inouye Regional Center

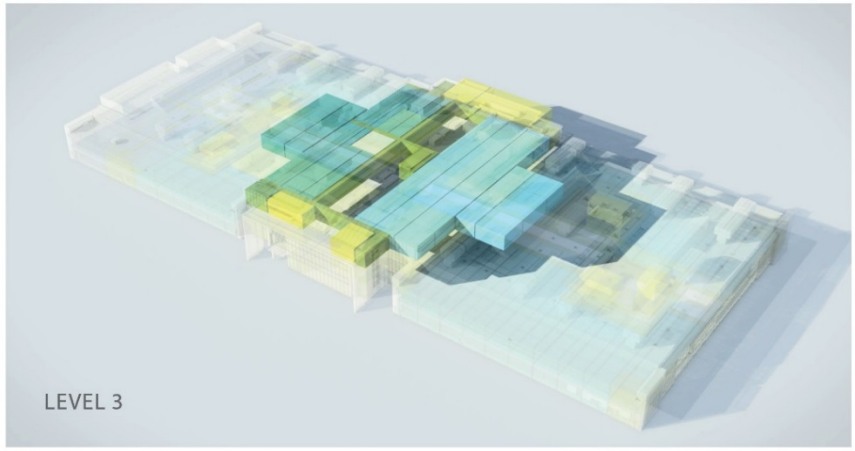
350,000 sf
Completed 2014
LEED Gold
32.7% below ASHRAE 90.1-2007
79% Reduction against CBECS baseline
Mechanical system solution under budget


NOAA
Inouye Regional Center

PROGRAM AREAS



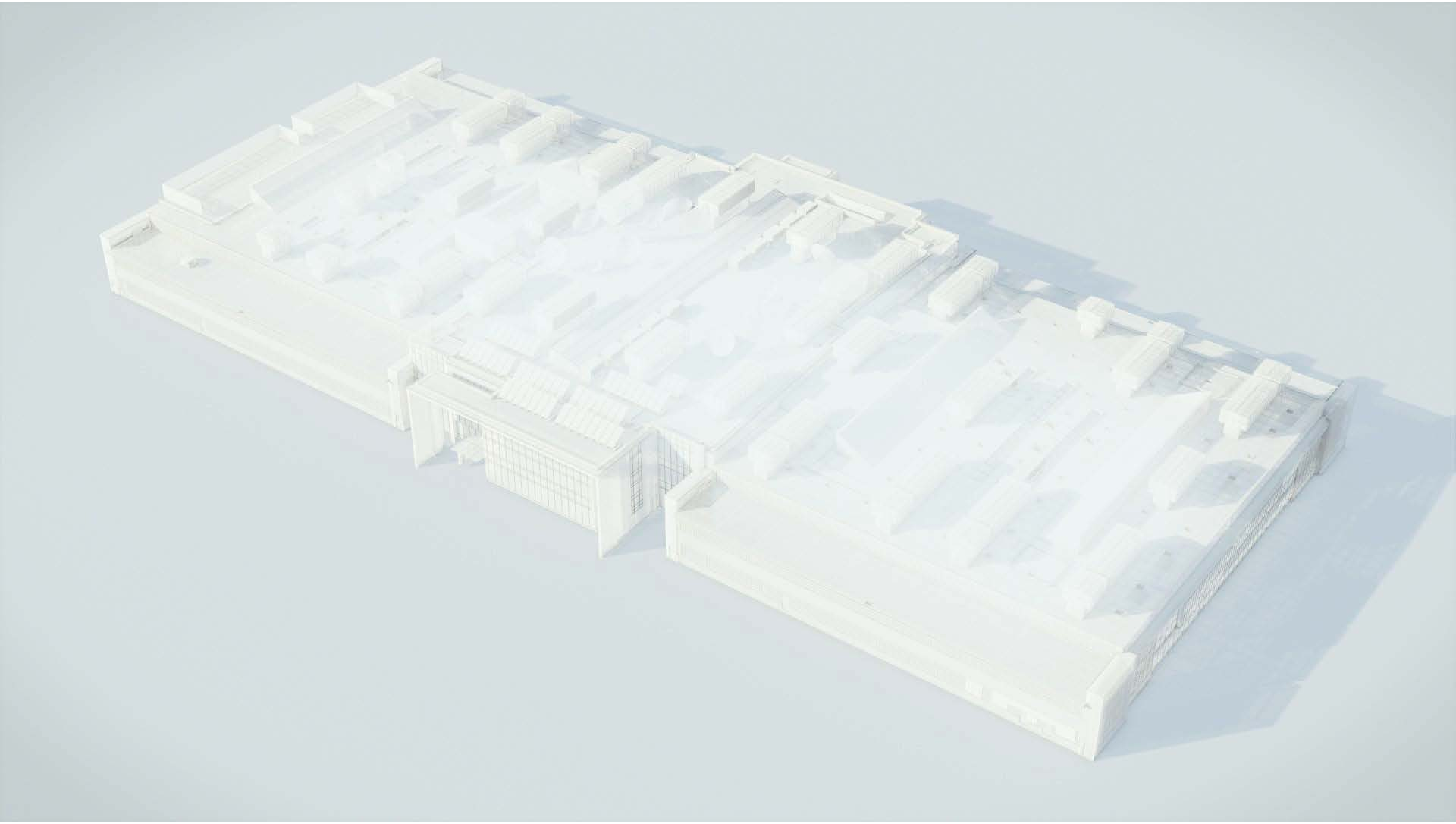


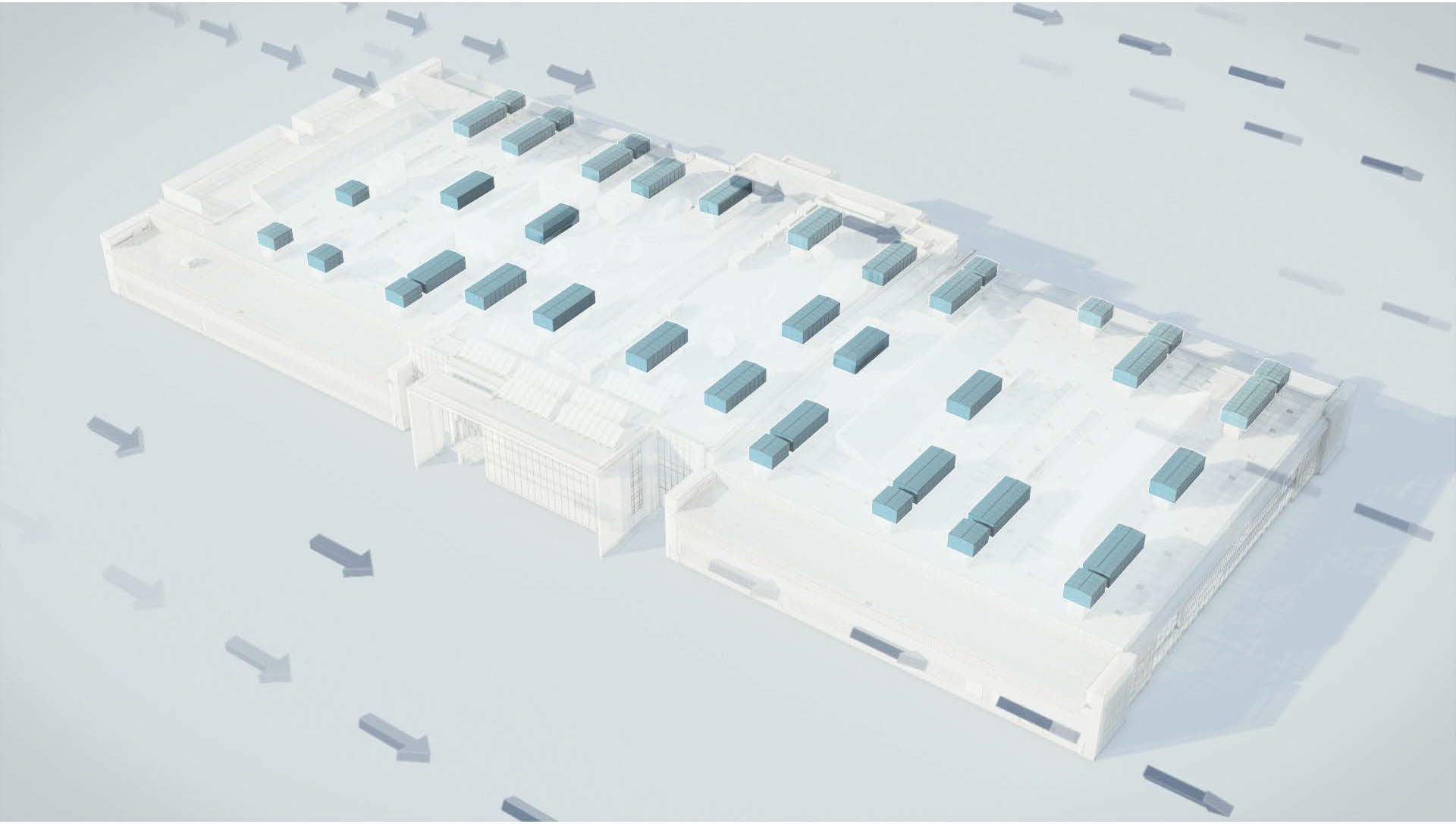


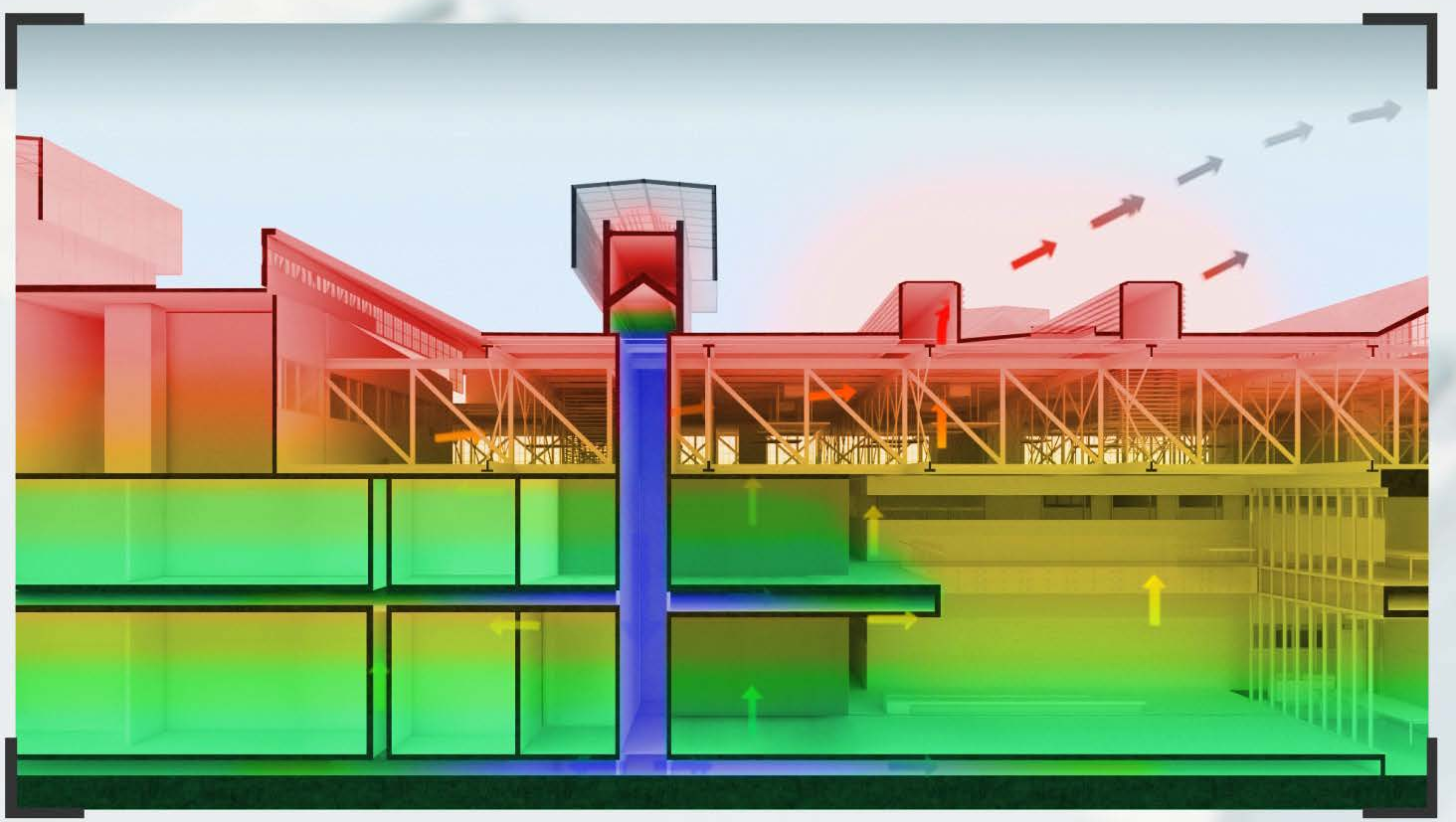
- CIRCULATION
- CORE
- SUPPORT
- SUPPORT
- LABORATORIES
- ADMINISTRATION

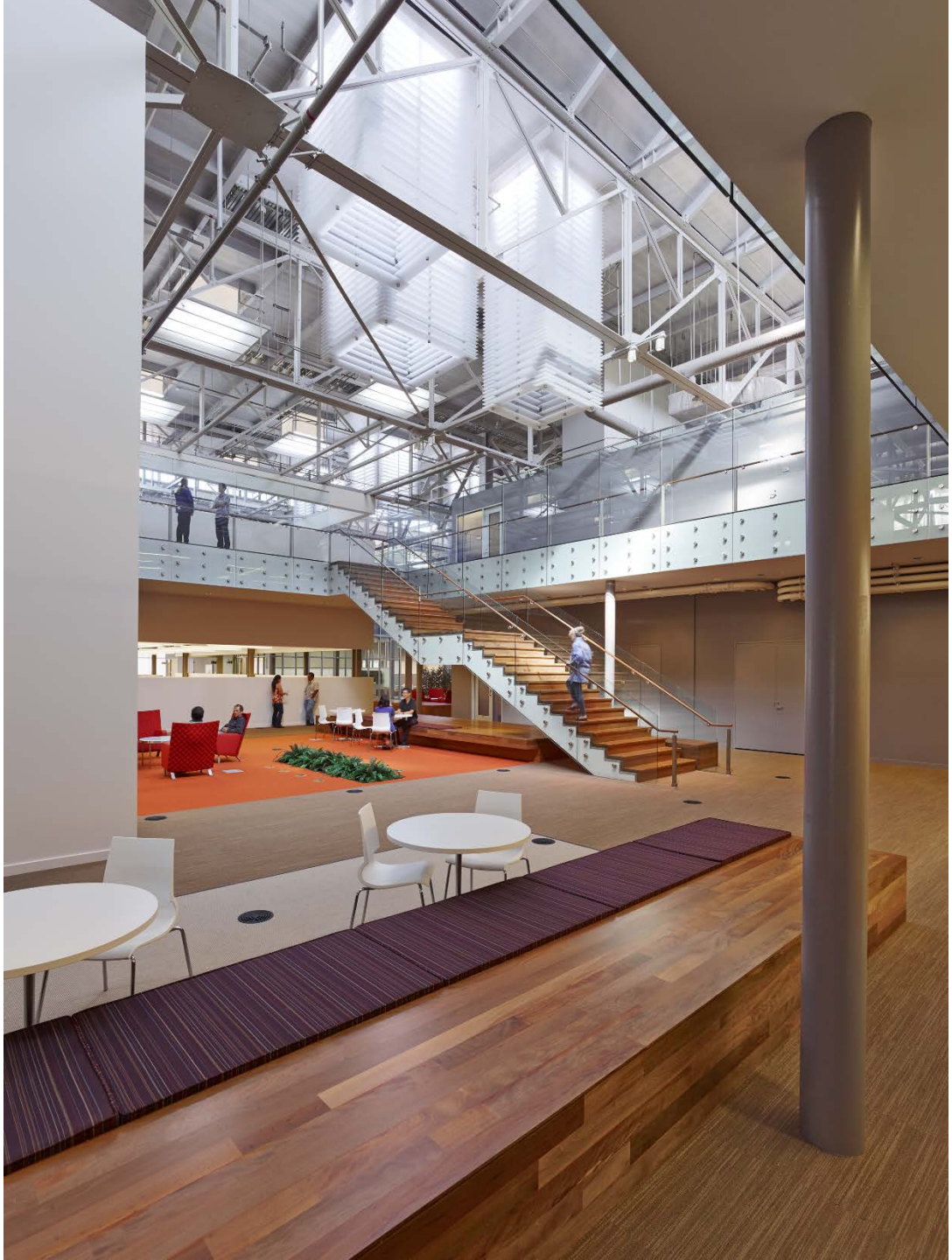
Hawaiian Monkey Pod Tree

Innovation Inspired
by Nature



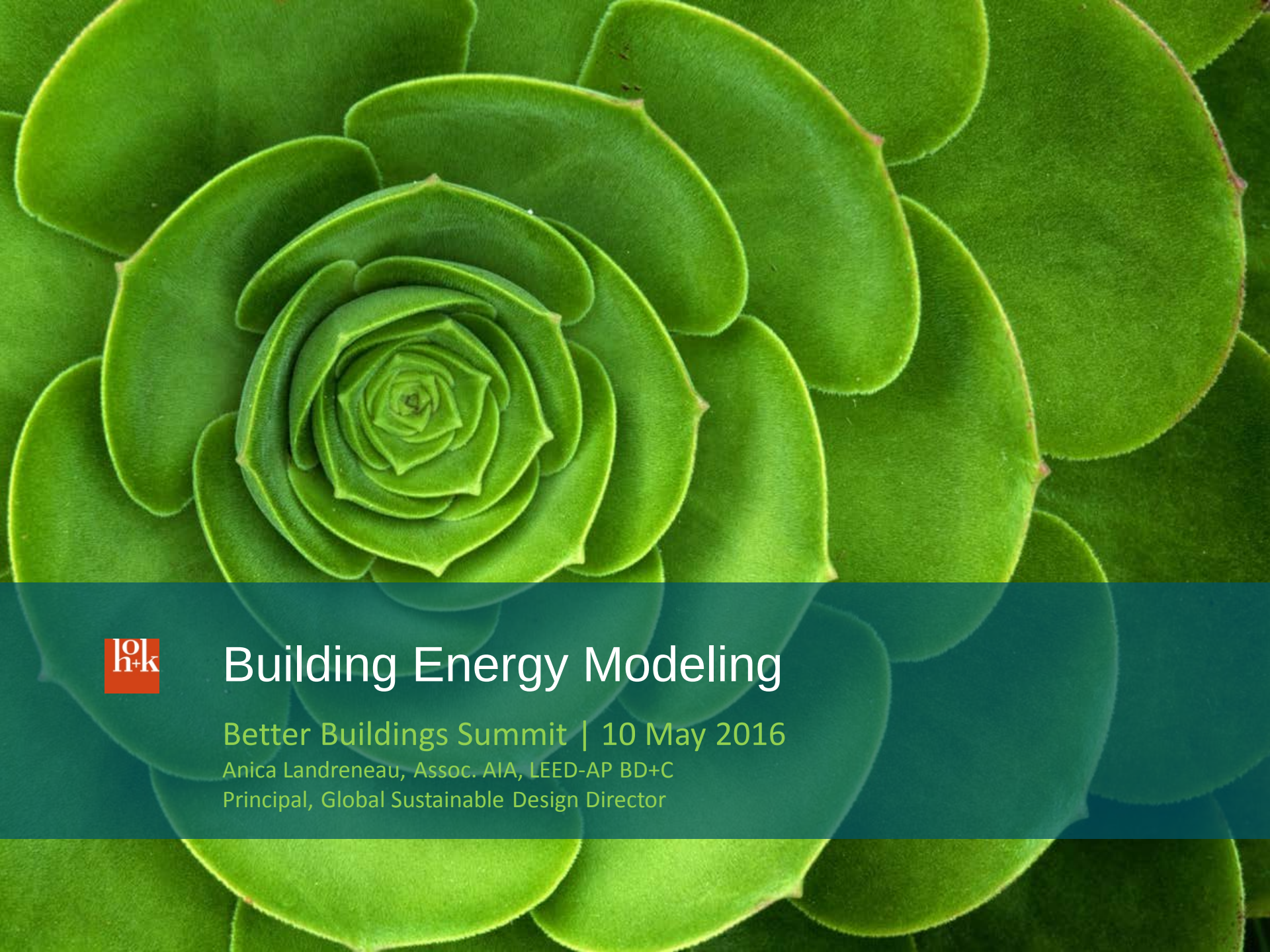






Energy Model Payback

NOAA HI Energy Model Payback	
annual energy savings (predicted)	$468,283
monthly energy savings (predicted)	$39,024
energy modeling costs	$40,000
months to payback energy model cost	1.0
energy + CFD + daylight model costs	$170,000
months to payback all model costs	4.4



Building Energy Modeling

Better Buildings Summit | 10 May 2016

Anica Landreneau, Assoc. AIA, LEED-AP BD+C
Principal, Global Sustainable Design Director

Leveraging Energy Models Beyond Design

Mark Chambers, RA|LEED AP

Sustainability + Energy Director

Government of the District of Columbia

Department of General Services

hello

DC DEPARTMENT OF GENERAL SERVICES

THE DISTRICT'S REAL ESTATE MANAGER

BEFORE : ENERGY MODELS PRIMARILY AS DESIGN TOOLS




New Construction Approach
Focused on:

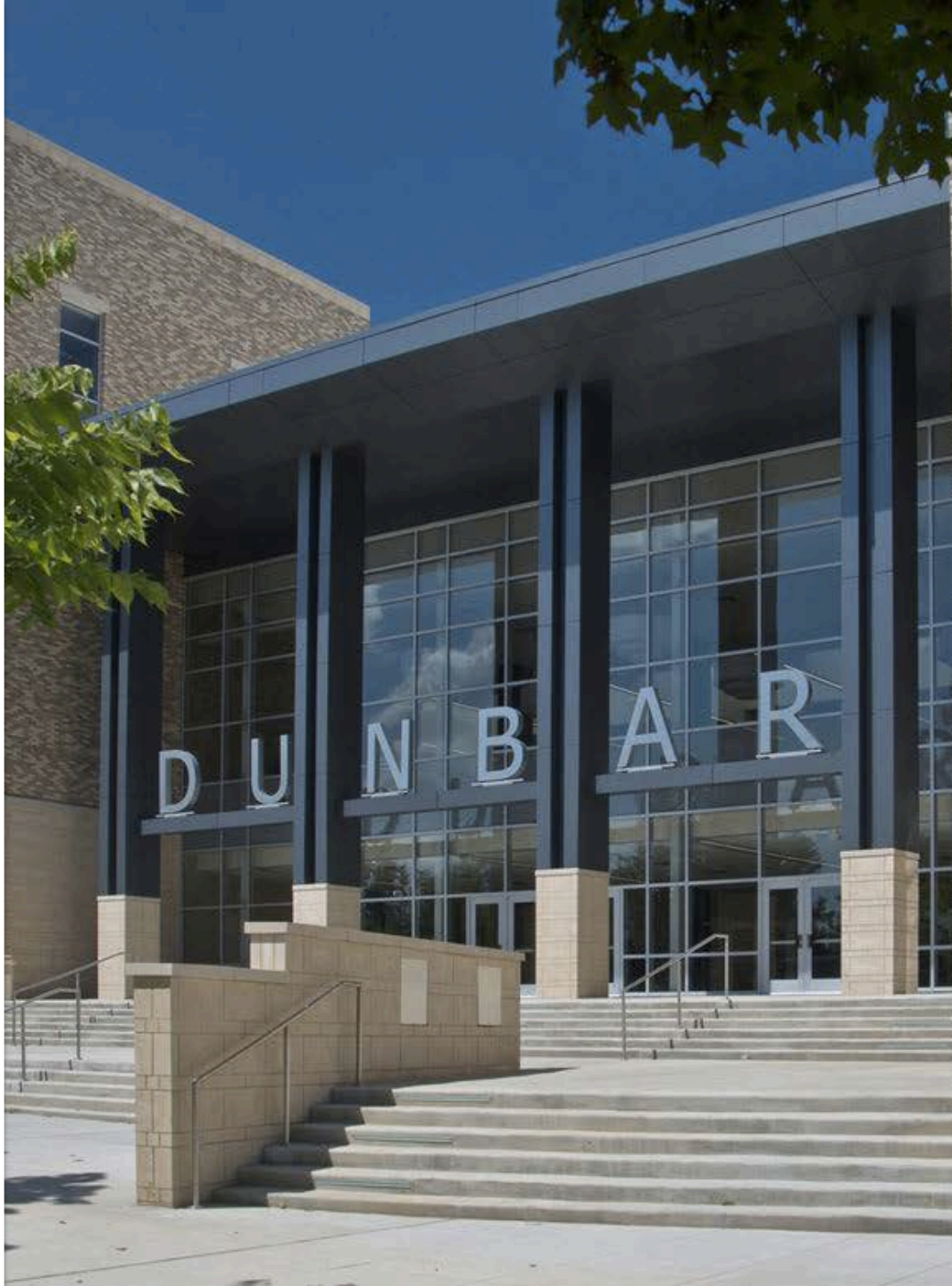
PERFORMANCE GOAL SETTING
DESIGN DEVELOPMENT
SYSTEMS INTEGRATION
INTEGRATED DESIGN MANAGEMENT
VALUE ENGINEERING
PRE-CONSTRUCTION
COMMISSIONING

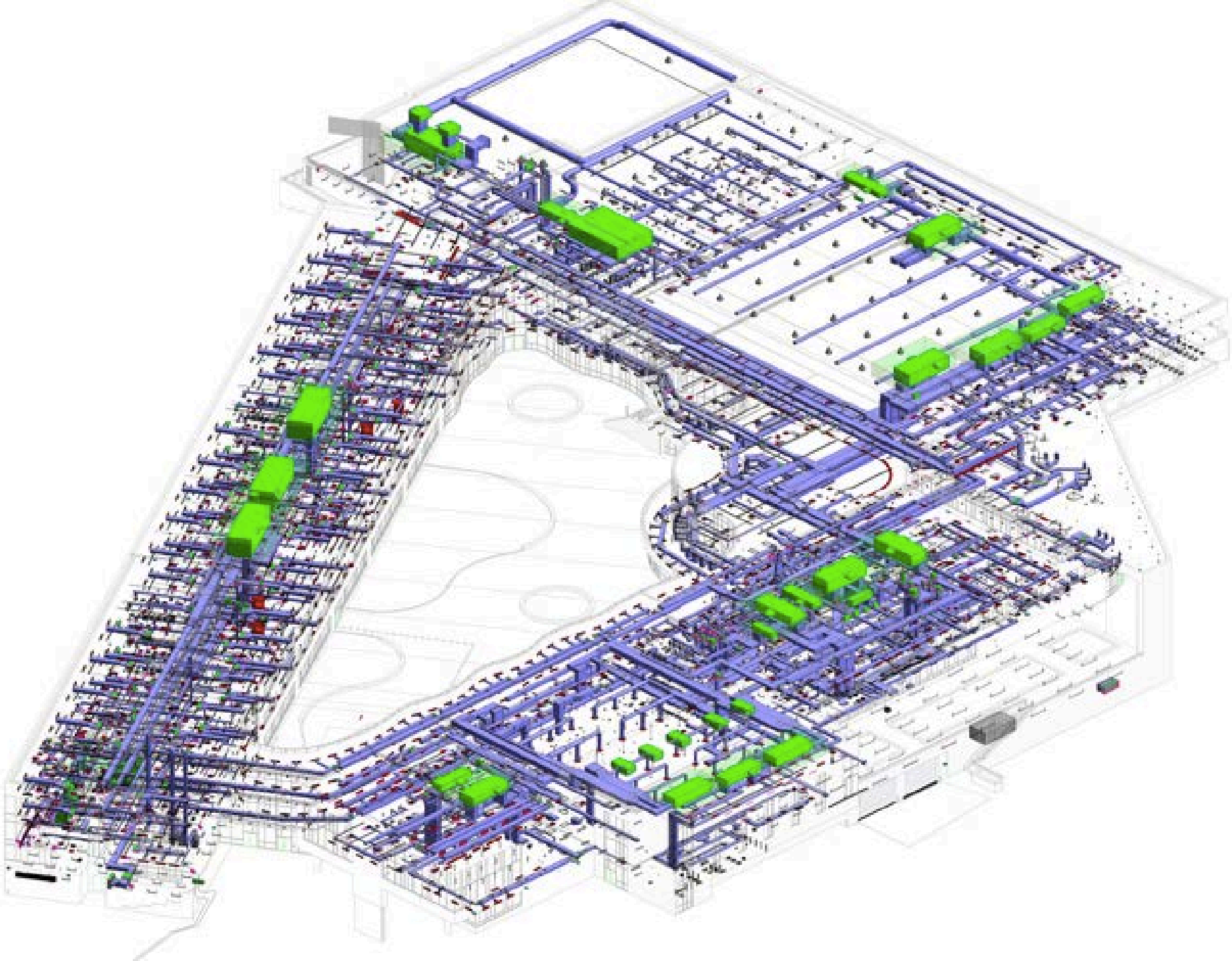

WORLD BOOK
discovery education


Anacostia Library


1872
Paul Laurence
DUNBAR
1906
playwright
poet
author


DUNBAR


DUNBAR




KING

NOW : ENERGY MODELS AS OPERATIONAL TOOLS




RetroCommissioning Approach

Focused on:

DESIGN INTENT

LOAD DISAGGREGATION

EQUIPMENT ASSUMPTIONS

SYSTEM FAULTS/REDUNDANCY

INSTALLATION VARIANCE

SYSTEM INTEROPERABILITY

UPDATING YOUR ENERGY MODEL ADDS VALUE POST DESIGN

+Interval Meter Data

- Portfolio-wide snapshots
- Quick Segmentation

+Building Automation System Data

- Granular data (e.g. equipment runtimes)
- Real-time feedback

Update the Energy Model

- Are there variances?
- Have usage patterns changed?
- Has hardware changed?
- Has design intent been lost?

Recommission (Building & Model)

Upgrade (Building & Model)

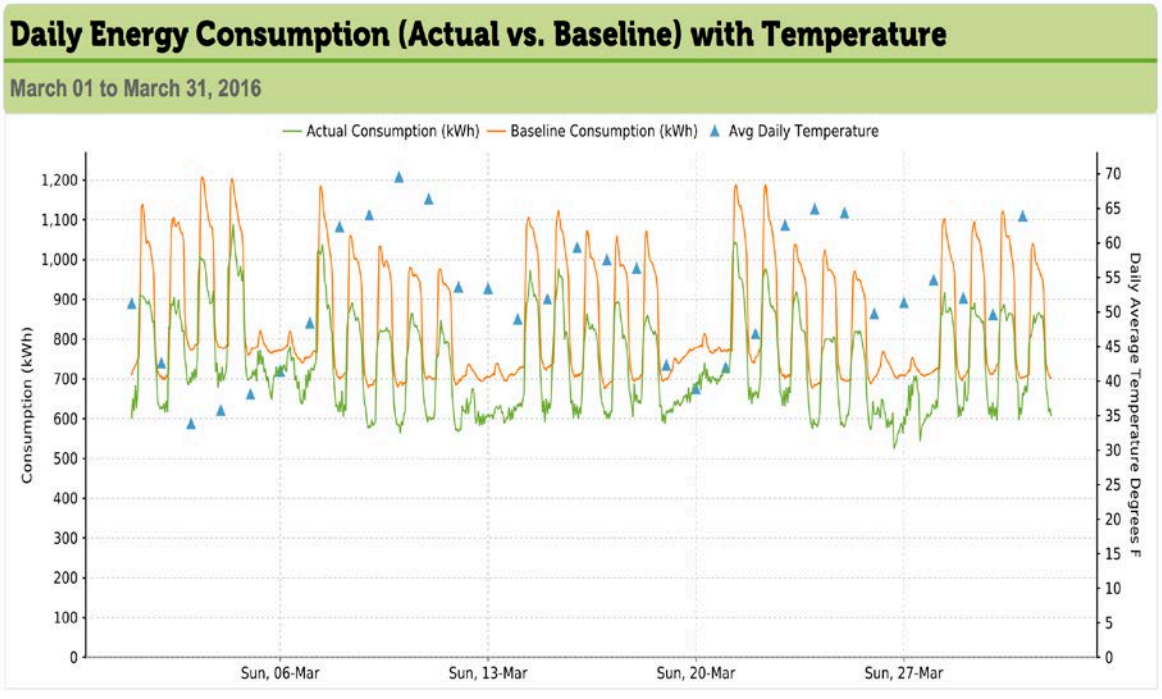
INTERVAL DATA IMPROVES BEM PREDICTIVE POWER

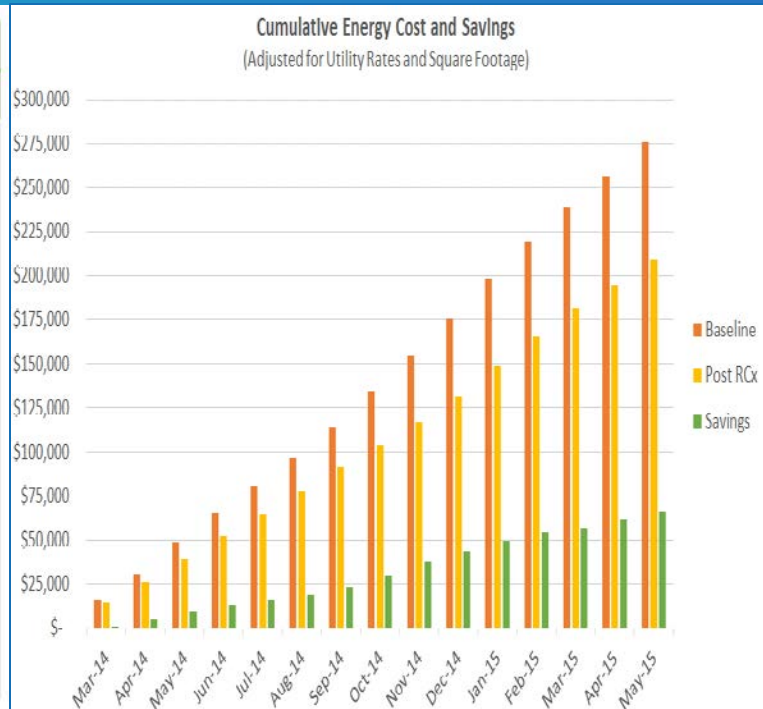
LBNL Used DGS DATA to Compare 10 Different Modeling Packages

- 12 Months of Data
- Average median error was ~1.2% → ALL MODELS ARE GOOD

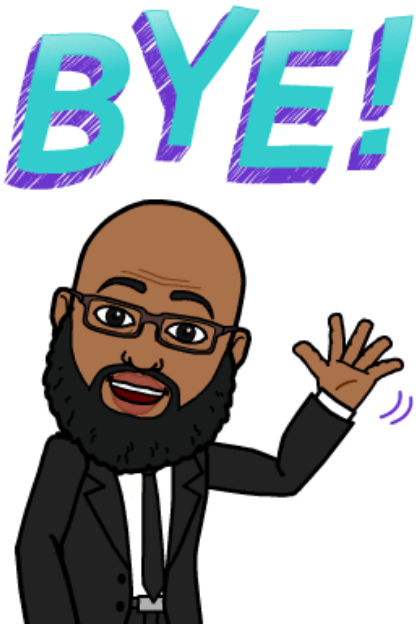
DOE Building Technologies Office Grant – DGS/Building IQ (3M ft$^{2)}$

- Building IQ system draws on open BAS data + weather & PJM pricing
- Fine tunes airside HVAC systems – maintains comfort while minimizing cost
- Learning mode to active mode → $10K in savings/mo. at leading site





Leveraging Energy Models Beyond Design



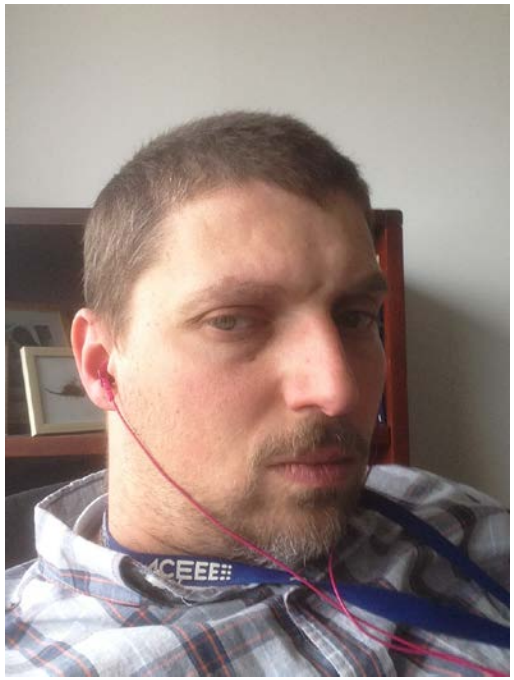
Mark Chambers, RA|LEED AP

Sustainability + Energy Director

Government of the District of Columbia

Department of General Services

Modeling Is Getting Better, Easier, Cheaper & ROIer!



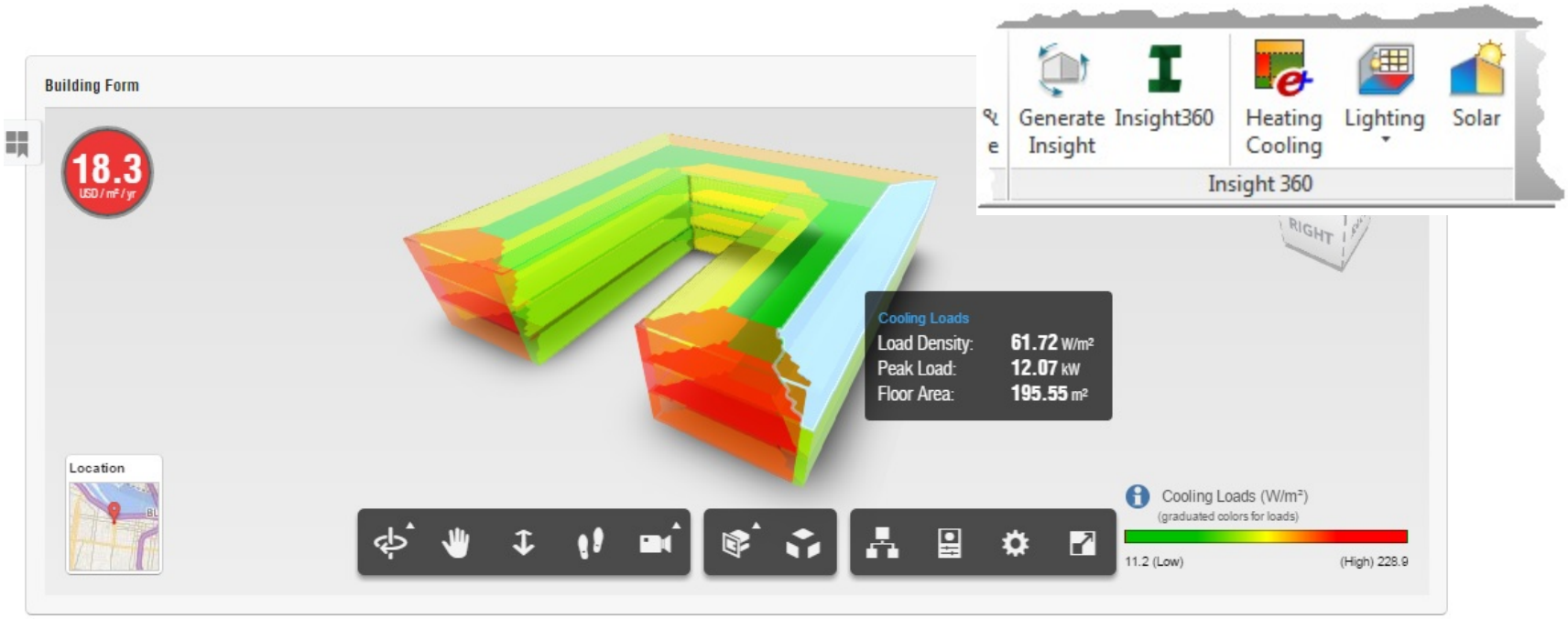
~~Kristin Field~~ Amir Roth, Ph.D.

Technology Manager, Building Energy Modeling, US DOE

Energy Modeling Is Starting To “Tip”

Multiple key developments ➔ ROI keeps improving

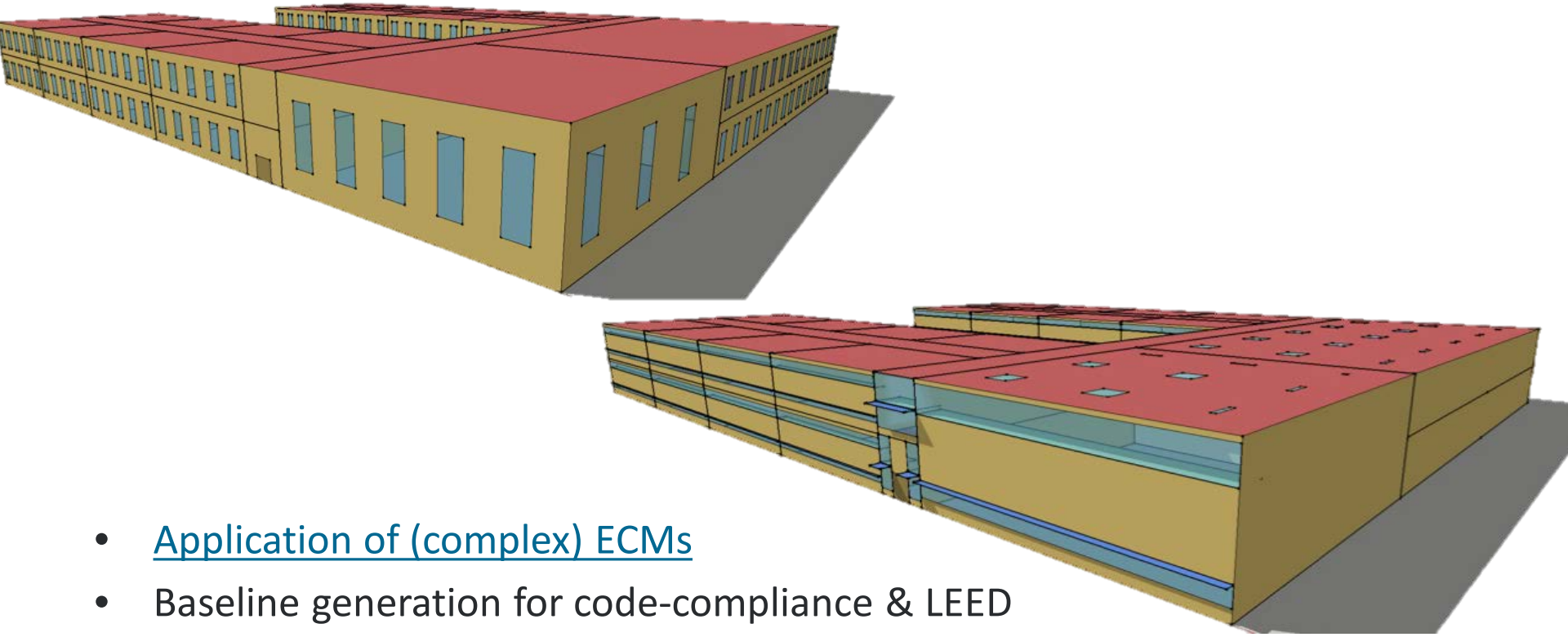
Development #1: Design-Workflow Integration



Modeling as a "button" on design app

- No "re-modelling" no data transcription effort & reduced error
- Autodesk Insight360 (Revit & FormIt)
- Sefaira Architecture (Revit & SketchUp)
- Honeybee & Ladybug (Rhino/Grasshopper & Dynamo)

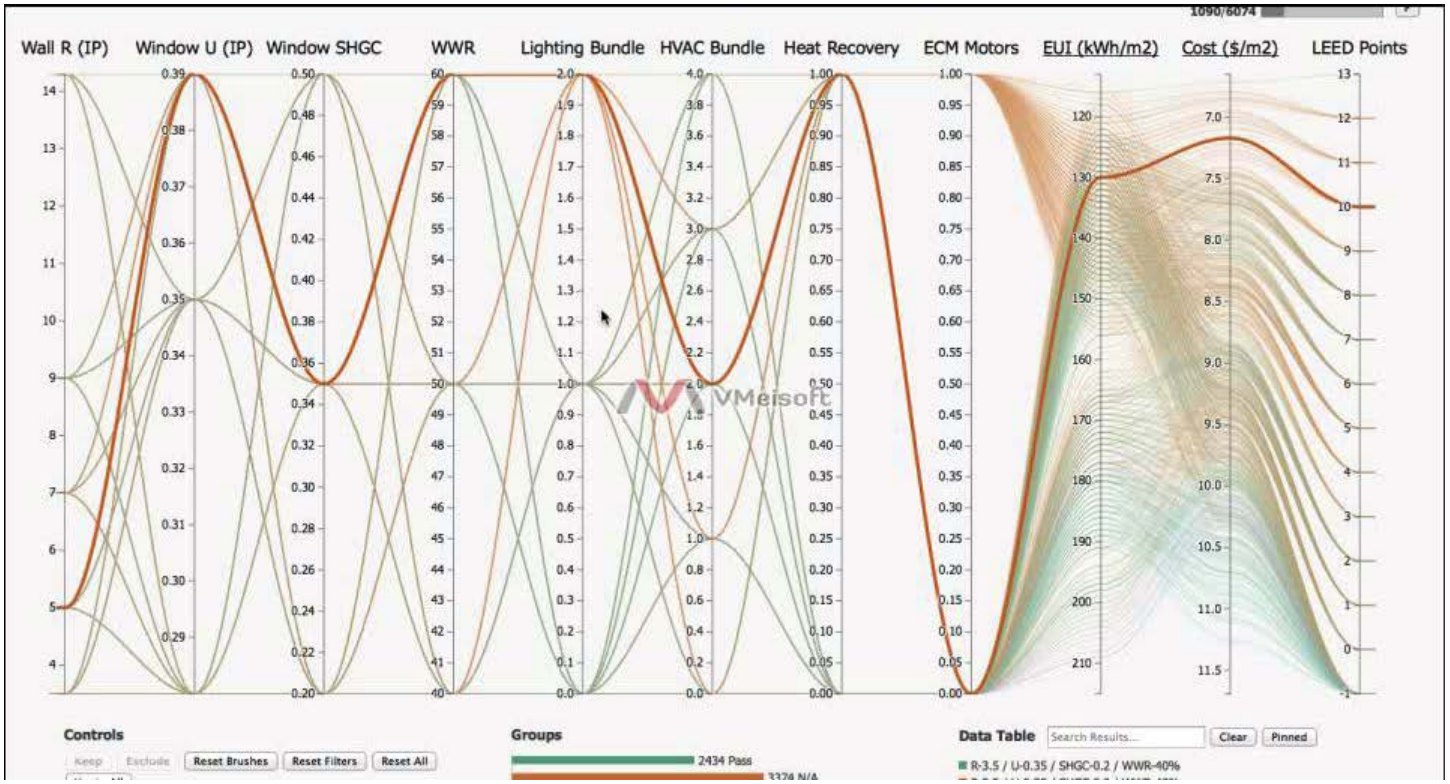
Development #2: Task Automation



- Application of (complex) ECMs
- Baseline generation for code-compliance & LEED
- QA/QC
- Custom reports & visualization
- Complex multi-tool workflows

Less time building models, more time analyzing performance

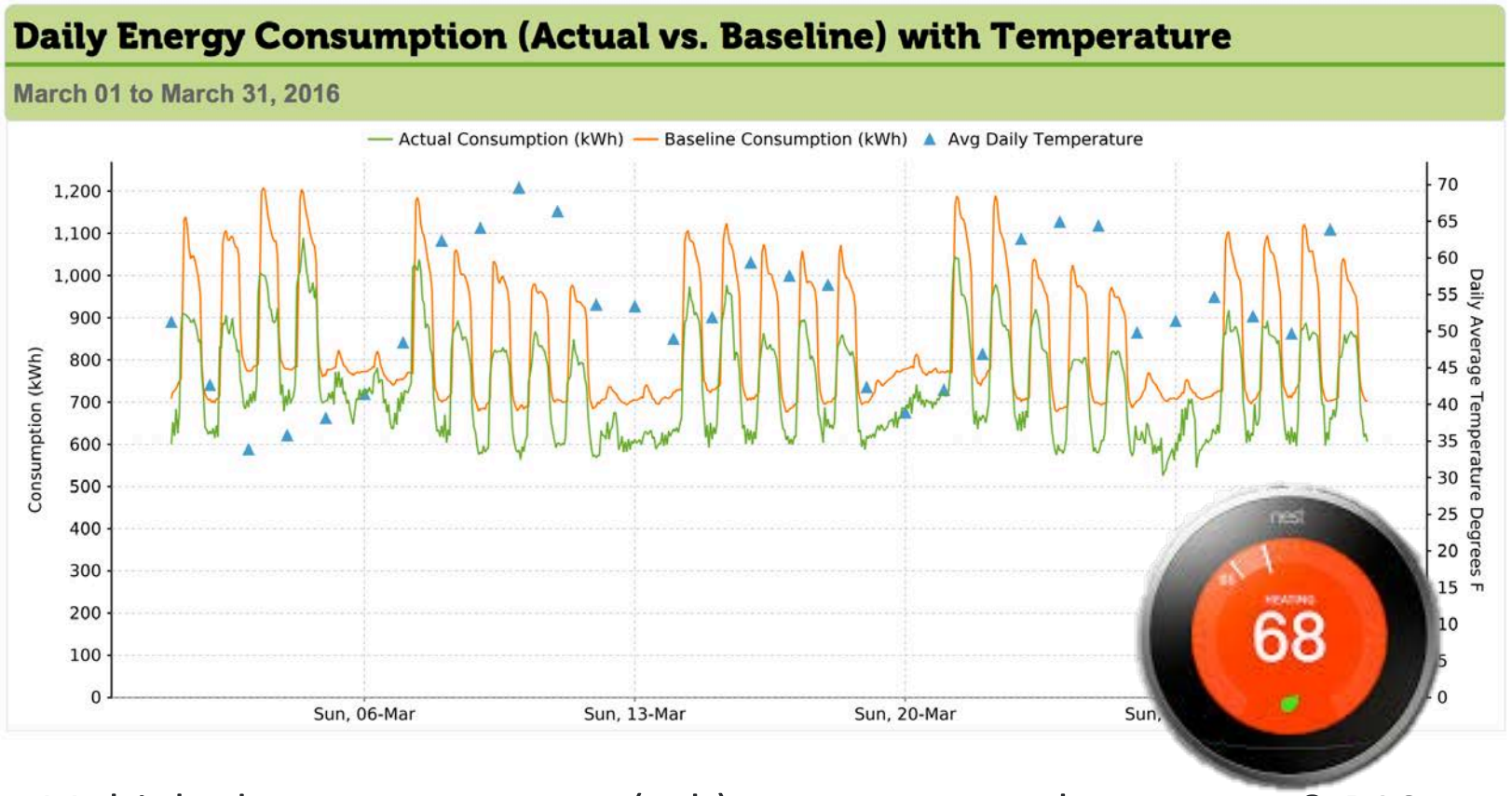
Development #3: Simulation on the Cloud



$0.01/EnergyPlus run

- Automated measure application ➔ design optimization
- Uncertainty analysis (ranges instead of point estimates)
- Input calibration for existing buildings

Development #4: Modeling for Existing Buildings



- Multiple data sources: smart (sub)-meters, smart thermostats & BAS
- New automated calibration tools (that cloud thing again)
- New “operational” uses – predictive control, continuous commissioning

Development #5: Modeling Standards

BSR/ASHRAE Standard 209P

Public Review Draft

Energy Simulation Aided Design for Buildings except Low-Rise Residential Buildings

First Public Review (March 2016)
(Draft Shows Complete Proposed New Standard)

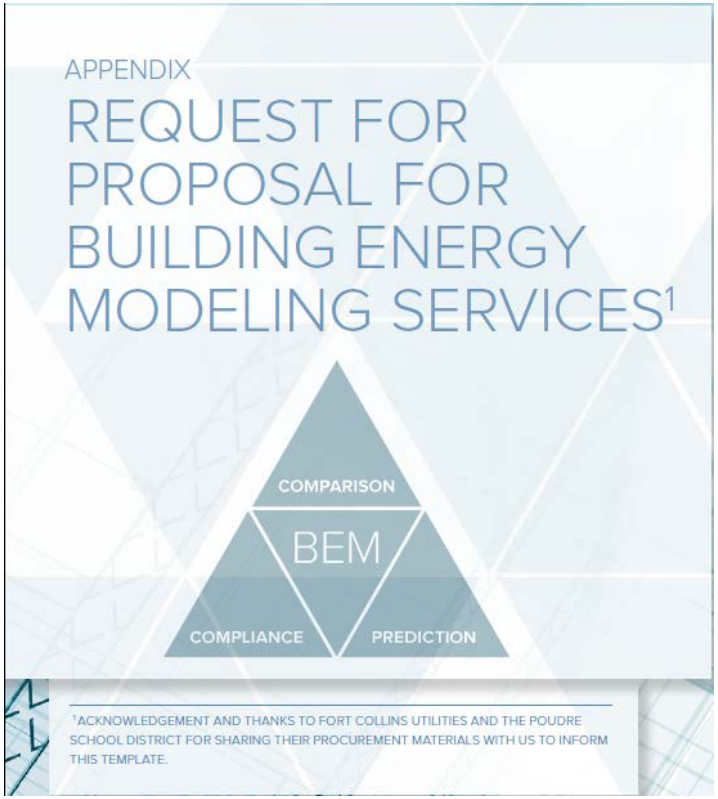
- Modeling requirements for multiple project stages ➔ know what to expect
- First public draft

Getting Started: "BEM Guide for Owners"

- Developed in 2013 by RMI, NREL & DOE
- Here it is!

BGfO: Soliciting BEM Services

- Example RFP (Request for Proposals)
- Items to communicate to proposers
- Items to look for in evaluating bids …



Modeler affiliation

- Architect, engineer, consultant?

Modeler credentials

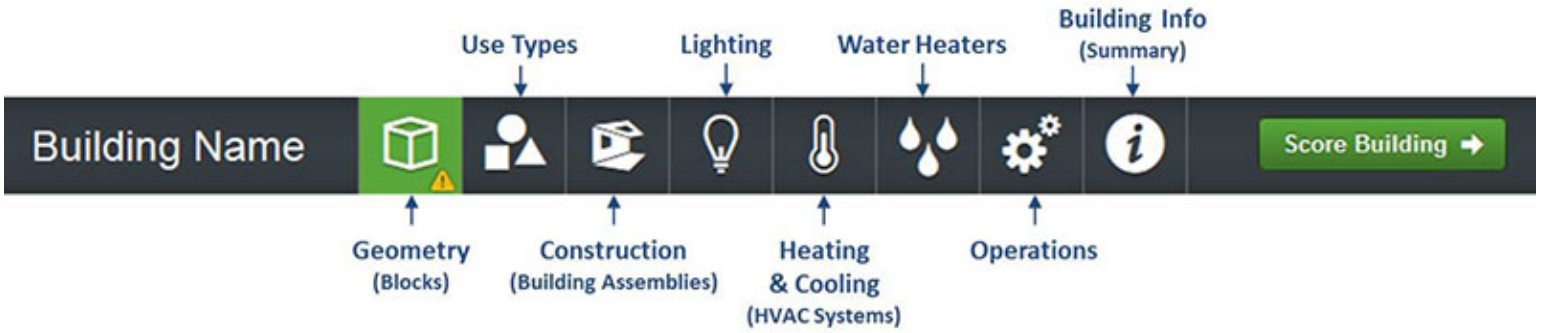
- ASHRAE BEMP, and/or AEE BESA
- Project experience

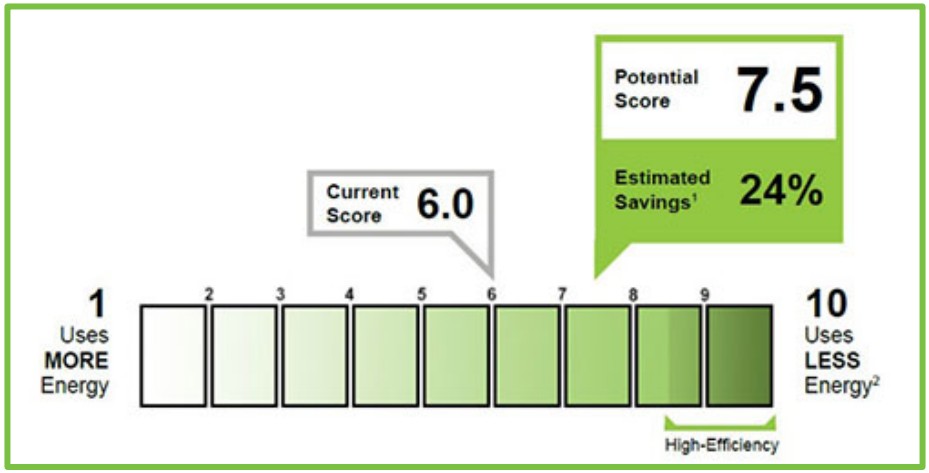
Modeling software

Contract-type

- May impact motivation and ability to meet performance targets
- Design-build v. design-bid-build v. construction management at-risk v. IPD

Development #6: New Gateways & Entry Points





- Energy Asset Score … and Asset Score Preview
- Audit Tools & BuildingSync
- SEED
- Easy to get rough models from tools you are already using

More Info & Follow-up?

Amir, BTO

amir.roth@ee.doe.gov

…/eere/buildings/building-energy-modeling/

Anica, HOK

anica.landrenau@hok.com

James, Houston Rockets

mark.chambers@dc.gov