Data Analytics and Modeling for Building Energy Efficiency

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Oak Ridge, Tennessee
April 8, 2015

ORNL is managed by UT-Battelle
for the US Department of Energy

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Source of Input Data

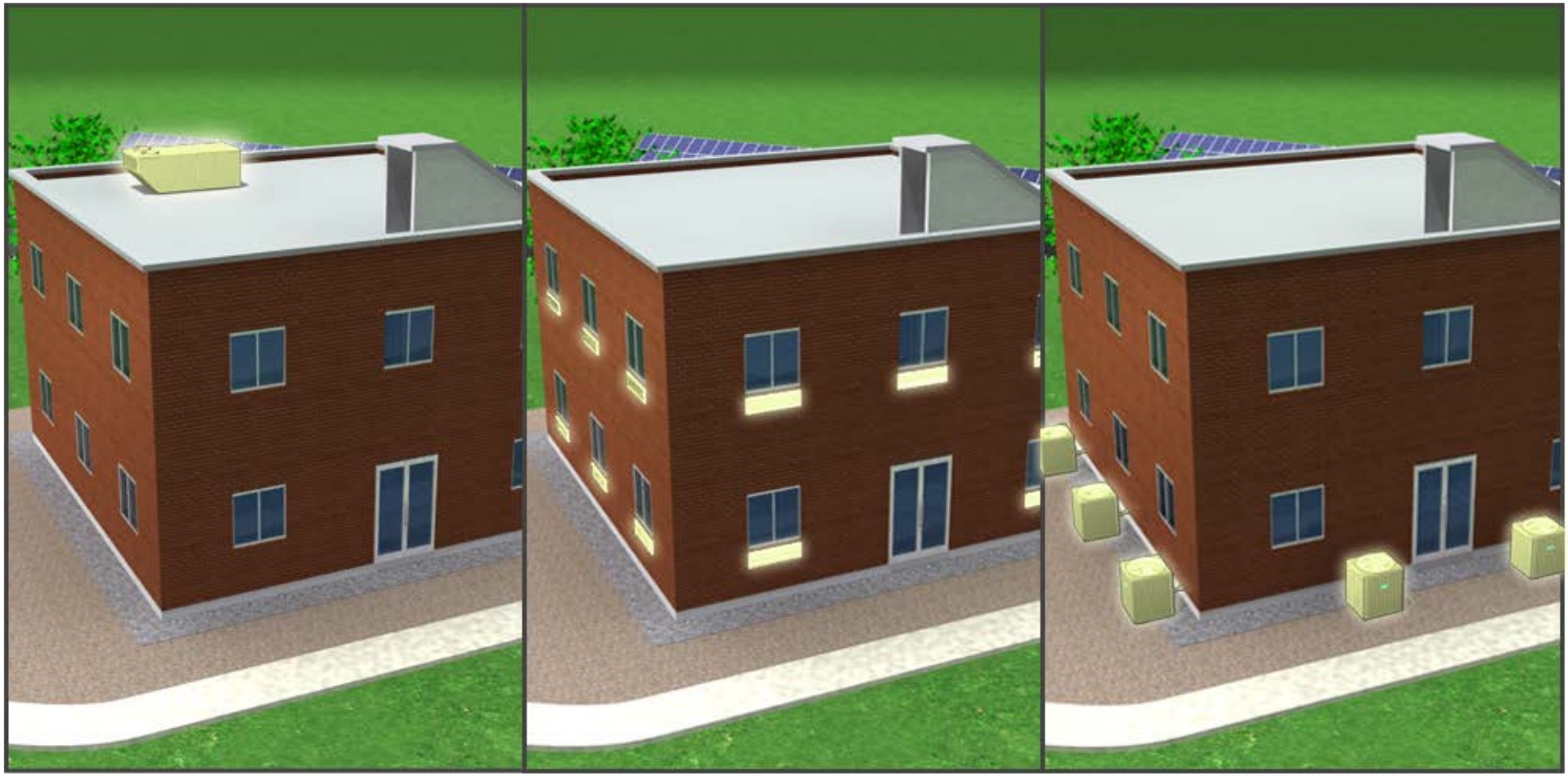
- Residential (~15 min. data)
  - Yarnell (37 sensors)
  - Wolf Creek (4x 356 sensors/building)
  - Campbell Creek (3x 144 sensors/bldg.)
    - Temperatures
    - Plugs
    - Lights
    - Range
    - Washer
    - Radiated heat
    - Dryer
    - Refrigerator
    - Dishwasher
    - Heat pump air flow
    - Shower water flow
    - Etc.

Permanent Research Platforms

MAXLAB Building

MAXLAB Project

Multiple multi-zone HVAC systems installed



HVAC system A

HVAC system B

HVAC system C

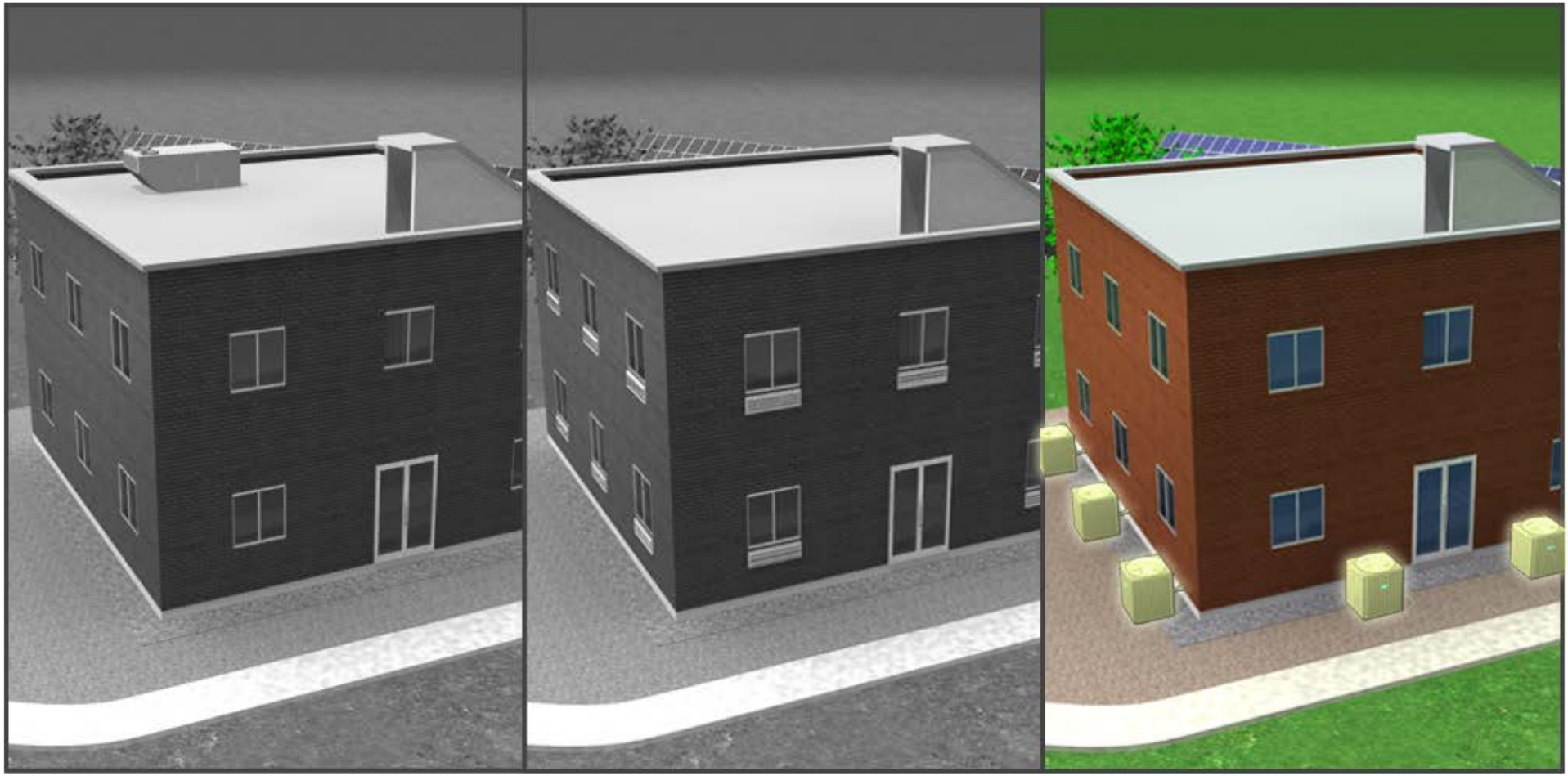
Operate HVAC System A

HVAC system A HVAC system B HVAC system C

Operate HVAC System B

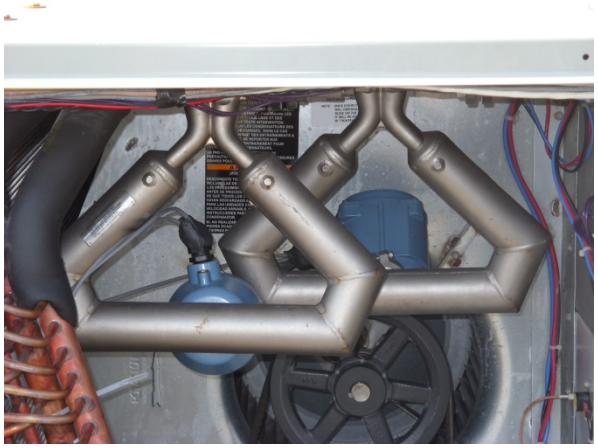
HVAC system A HVAC system B HVAC system C

Operate HVAC System C



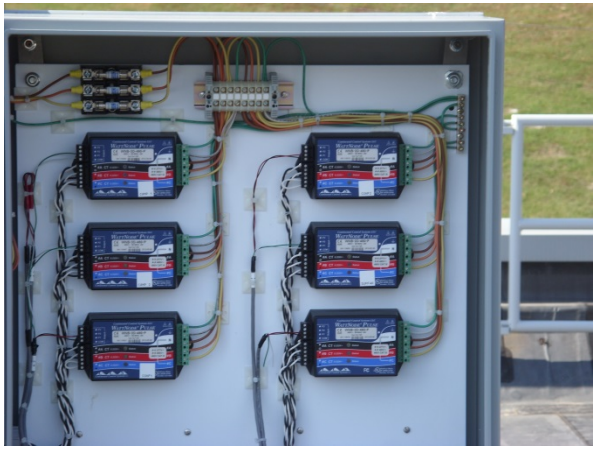
HVAC system A HVAC system B HVAC system C

FRP2 Sensors

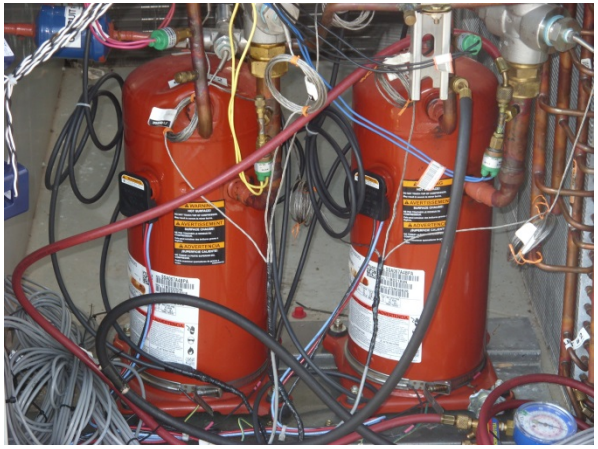


Refrigerant Mass Flow

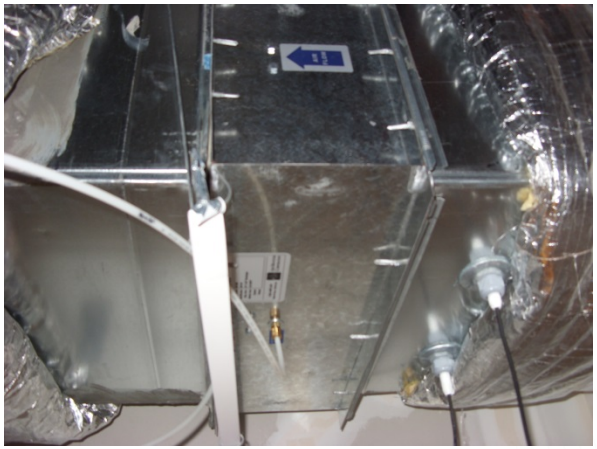
Natural Gas Flow



Electrical Power



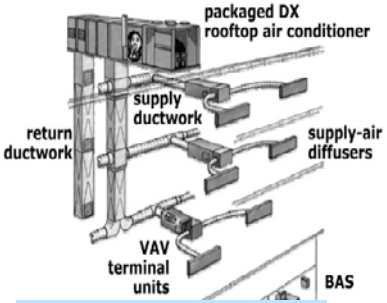
Refrigerant Temp and Press



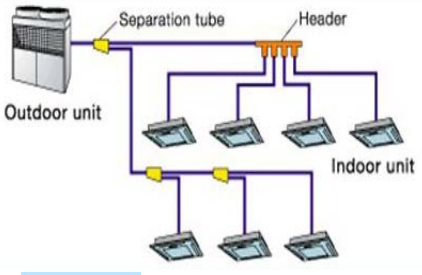
Airflow

Air Temp And RH

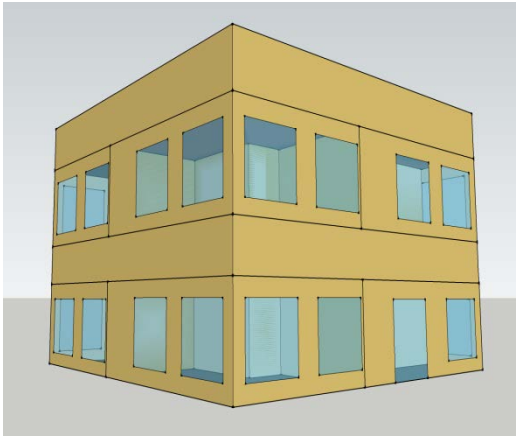
Measured performance of multiple HVACs
(same building, occupancy, weather)

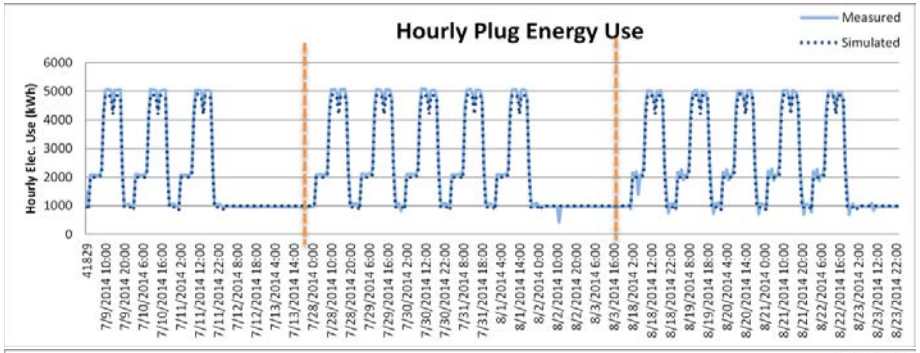


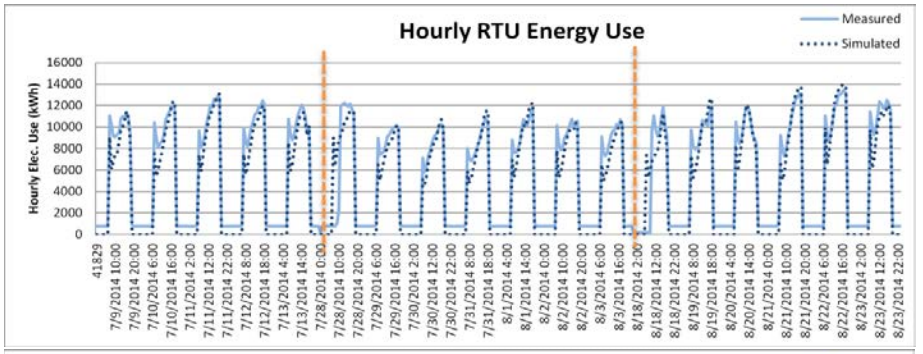
RTU/VAV

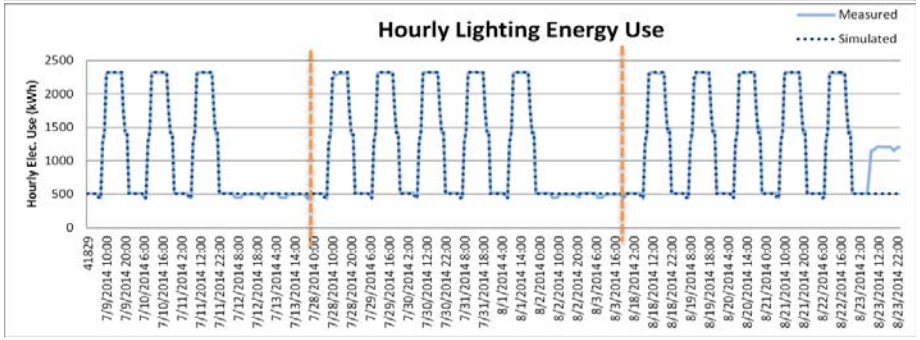


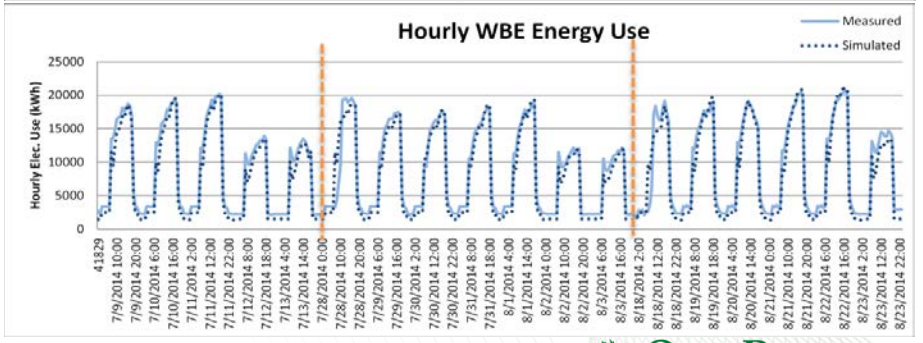
VRF











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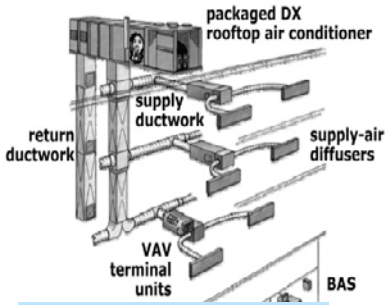
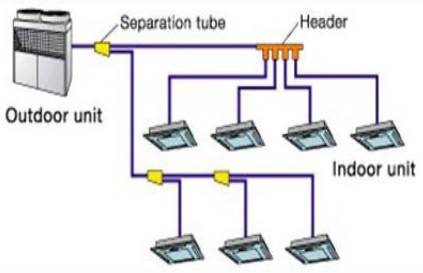
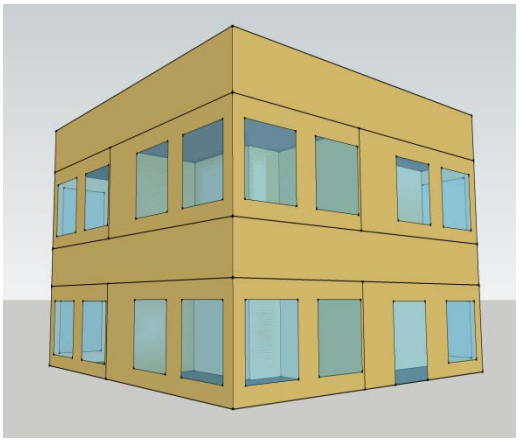
Measured performance of multiple HVACs
(same building, occupancy, weather)



RTU/VAV



VRF

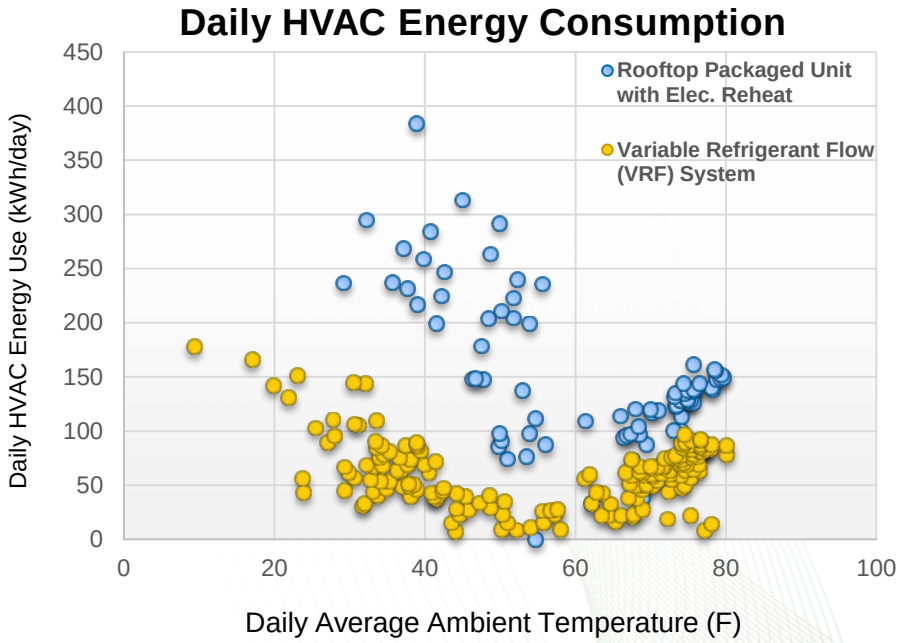


Cooling Season HVAC Energy Comparison (RTU vs. VRF)

	RTU	VRF
Total Energy Use (kWh)	5,635	4,517
% Difference (vs. RTU)	-	20%

Heating Season HVAC Energy Comparison (RTU vs. VRF)

	RTU	VRF
Total Energy Use (kWh)	31,104	7,715
% Difference (vs. RTU)	-	75%



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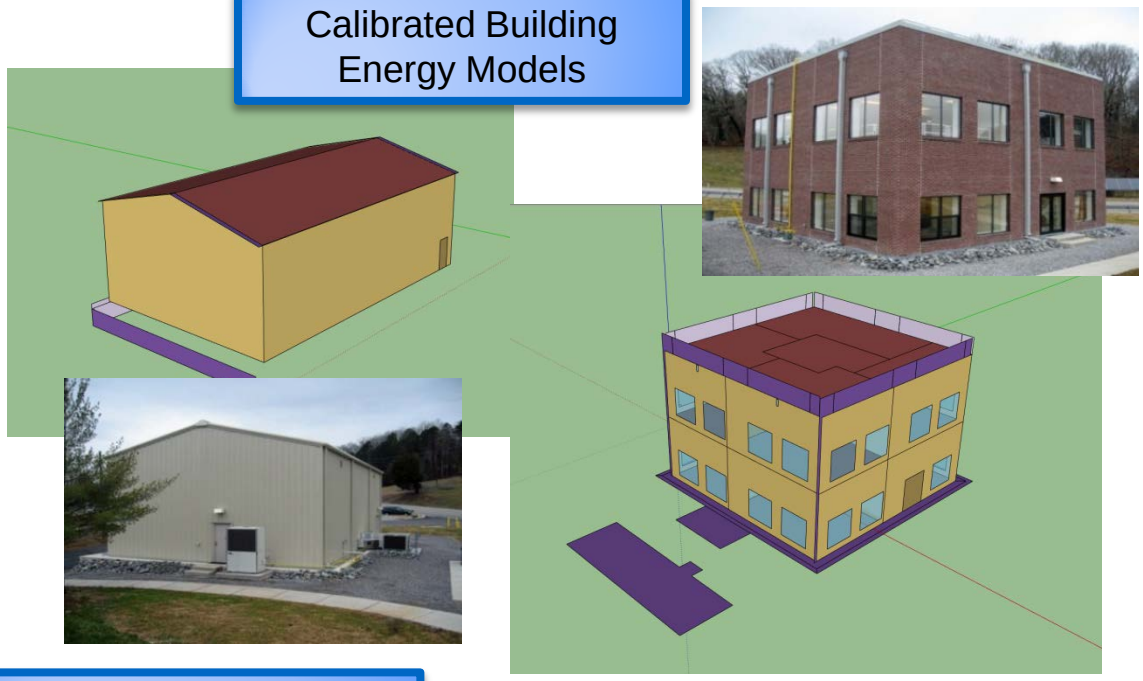
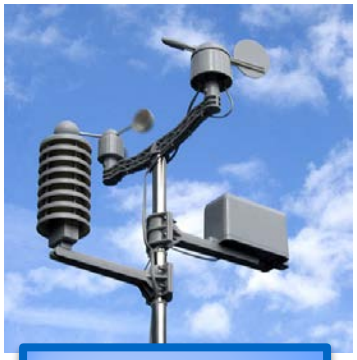
Energy Modeling for Generalizing Results

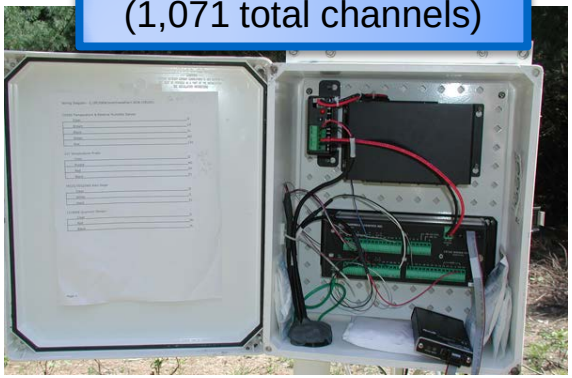
Calibrated Building Energy Models

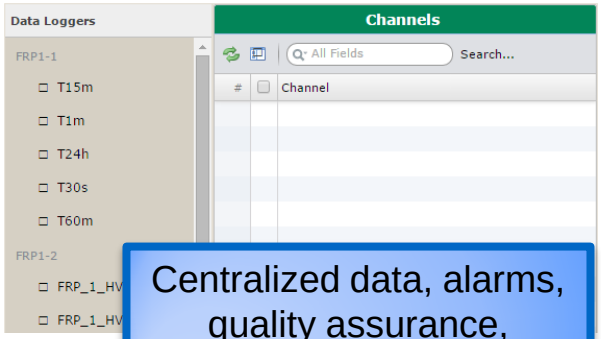




Real weather file from FRP2 weather station

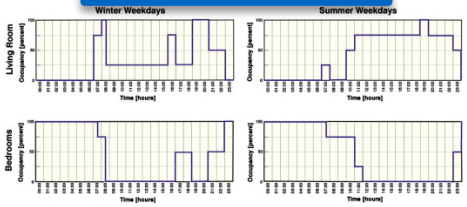
30 sec Data Measurements (1,071 total channels)





Centralized data, alarms, quality assurance, dashboard, analytics

Emulated Occupancy



Software-controlled rotation among HVAC systems

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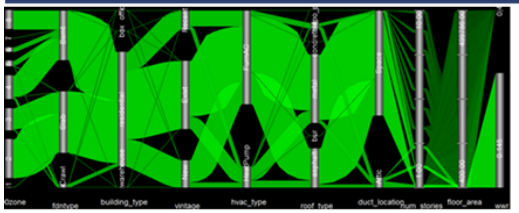
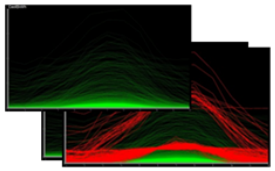
Visual Analytics for DOE's Roof Calculator

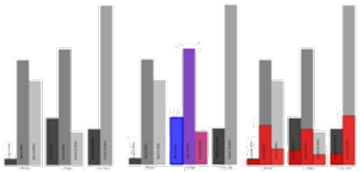
Multivariate Visualization of Large-Scale Parameter Sweeps



Parallel Coordinates Plots

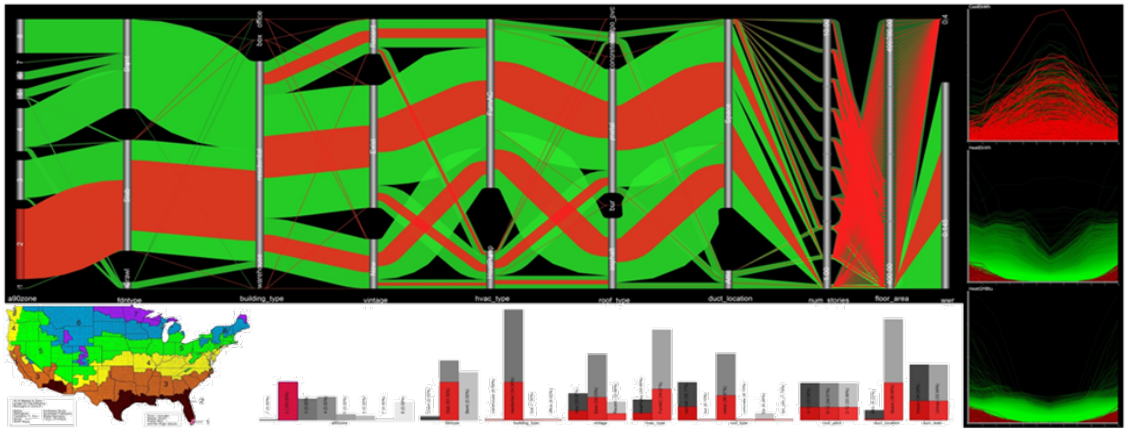


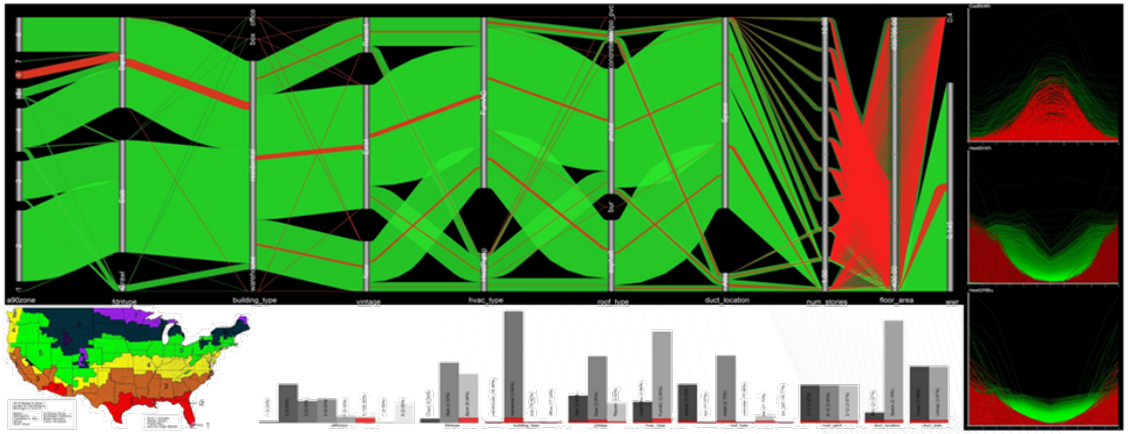
Time-variant Function Plots



Category Charts

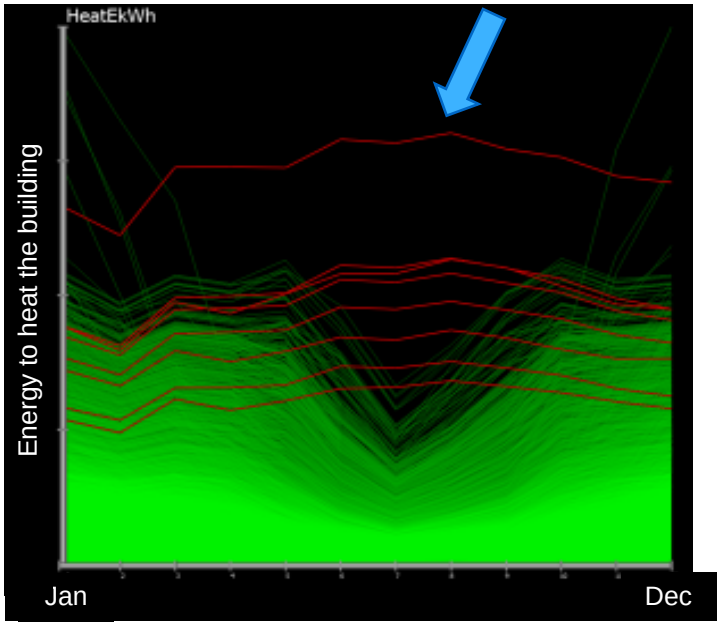
Climate Zone Map

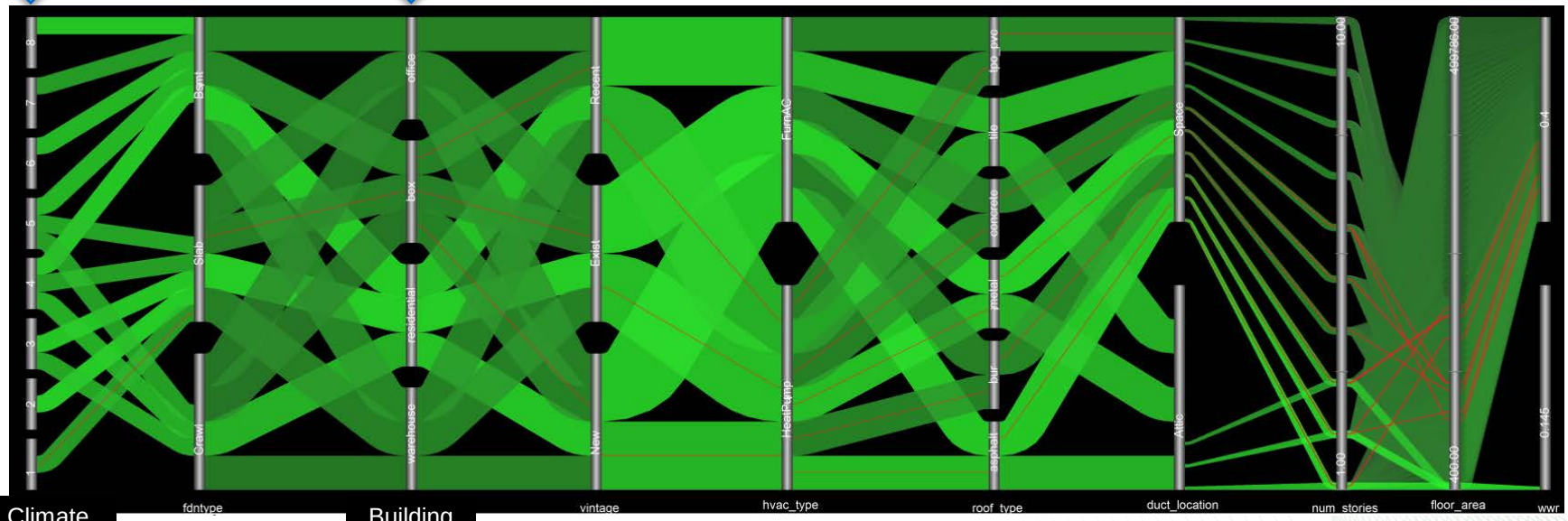




RSC Debug

- Selection of heating outliers
- All have box building type and in Miami, FL





From Visual Analytics and Simulations To Actualized Energy Savings in the Marketplace

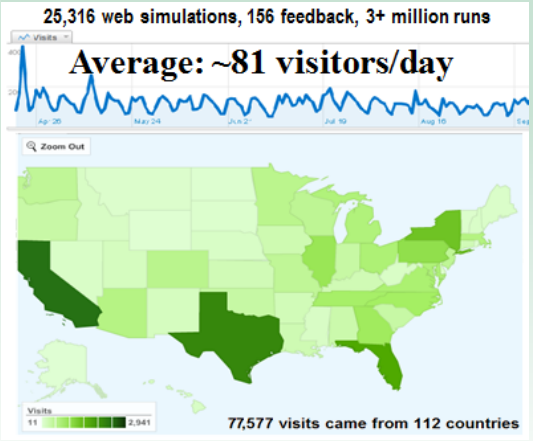
DOE: Office of Science | **CEC & DOE EERE: BTO** | **Industry & Building Owners**

Engine (AtticSim/DOE-2) debugged using HPC Science assets enabling visual analytics on $3x(10)^6$ simulations

Roof Savings Calculator (RSC) web site/service developed (estimates energy and cost savings from roof and attic technologies)

CentiMark
Innovative Roofing and Flooring Solutions

CentiMark, the largest nation-wide roofing contractor (installs 2500 roofs/mo), is integrating RSC into their proposal generating system



20+ companies interested

Leveraging HPC & Vis resources to facilitate deployment of building energy efficiency technologies

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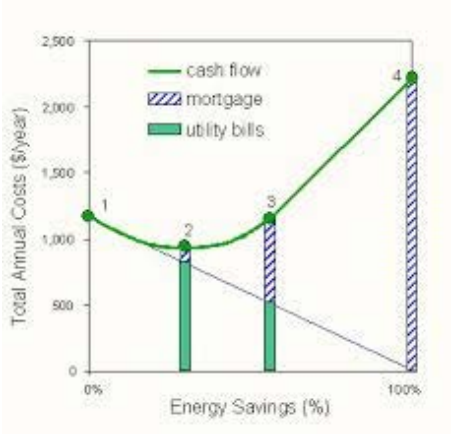
Existing tools for retrofit optimization



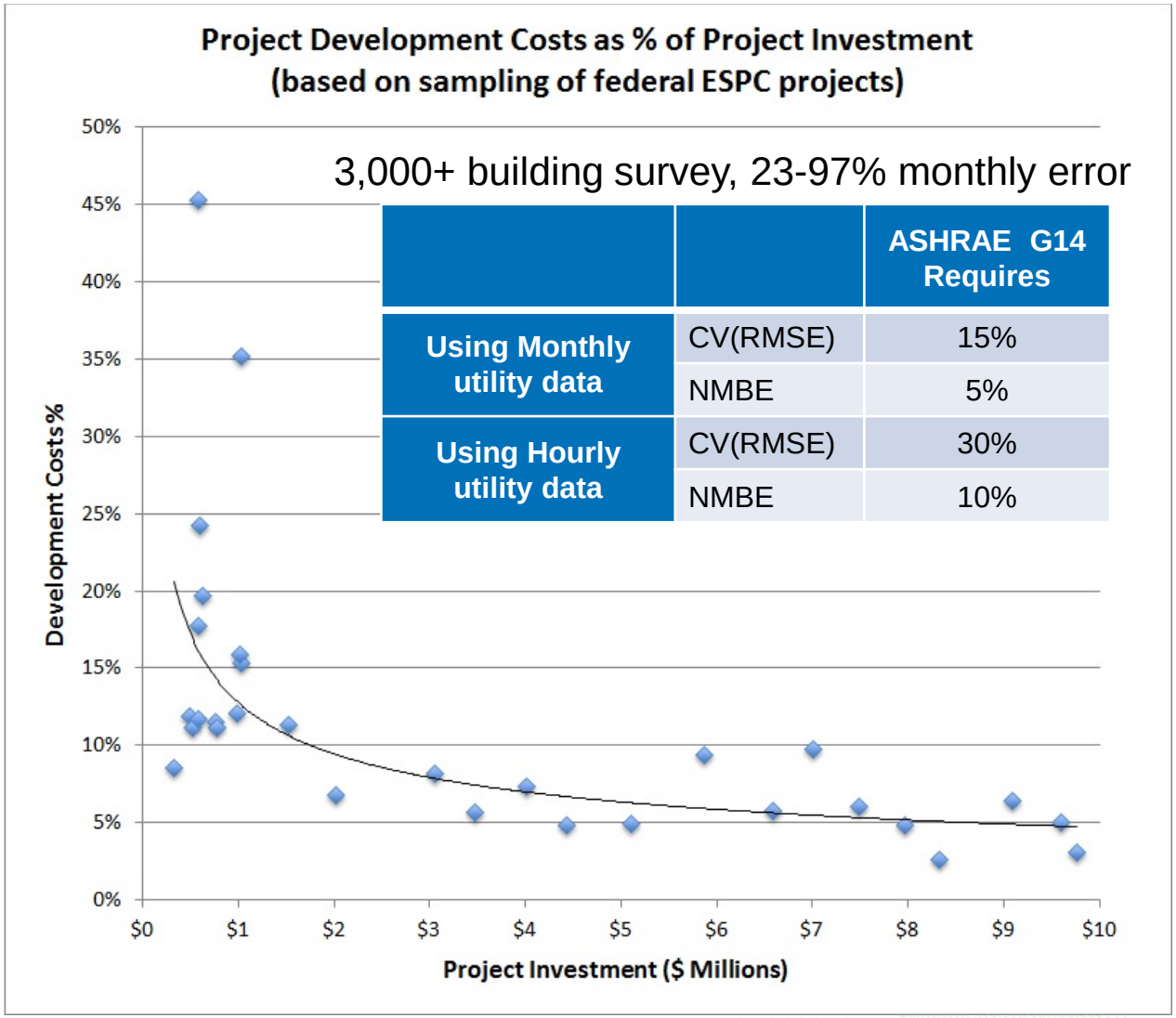
API

OpenStudio

Simulation Engine

DOE–$65M (1995–?)

EnergyPlus



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From Visual Analytics and Simulations To Actualized Energy Savings in the Marketplace

- Titan is the world's #1 fastest buildings energy model simulator
- 500,000+ EnergyPlus building simulations in less than an hour
- 125.1 million U.S. buildings could be simulated in 2 weeks
- 8 million simulations for DOE ref. buildings

Autotune
Automatic Calibration of Simulation to Data

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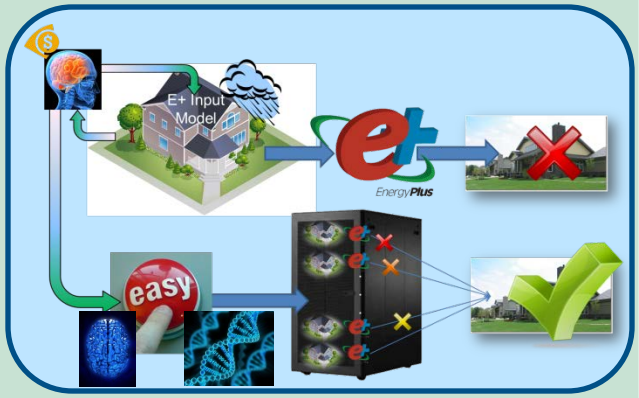
Autotune Calibrates Building Energy Models

DOE Office of Science → **DOE-EERE: BTO** → **Industry and building owners**



Features:

- Calibrate any model to data
- EnergyPlus calibrated in 1 hour (web service) or 6 hours (laptop)
- Calibrates to the data you have (monthly utility bills to submetering)

Results

		ASHRAE G14 Requires	Autotune Results
Monthly utility data	CVR	15%	1.20%
	NMBE	5%	0.35%
Hourly utility data	CVR	30%	3.65%
	NMBE	10%	0.35%

Results of 20,000+ Autotune calibrations
(15 types, 47-282 tuned inputs each)

Residential home	Tuned input avg. error
Within 30¢/day (actual use $4.97/day)	Hourly – 8% Monthly – 15%

15+ organizations interested

Leveraging HPC resources to calibrate models for optimized building efficiency decisions

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Discussion

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