



# Distribution of potential savings from urban-scale energy modeling of a utility

Speaker:

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#### Motivation

- Utility+ Urban-scale energy modeling is now scalable to utilitysized or larger geographic regions
- BEM for utilities How can BEM inform utility energy efficiency programs and use cases?
- Distribution of savings What are ranges of savings across every building in city-sized areas?
- Best practices Develop case studies that can validate and inform best practices for urban-scale building energy modeling



HPC Tools for Modeling and Simulation apturing building energy consumption

#### **Beyond Urban-scale Modeling**

1. Quantitatively rank most important building inputs

Inputs	Small Outy Office 458 3 Strip Re Mall		t Large Offic t 1072		e Medium Office		Hospita 1955	Wa	ehous e 33	Small Hotel			Large hotel 887 Primary School	
			tail	Qu R	Quick Service Restaurant		Full Service Restaurant		Hig	High Rise Apt		Secondary School		
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Sensitivity Analysis

2. Time on world's #1 fastest high-performance machines



Supercomputers

3. Identify and compare data sources for important inputs

	Shert Title
Summary	Satellite imagery, including panchromatic and multispectral images
Data type	Image
Company	
Website	
Temporal resolution	Cities - 3-11 times per week
Spatial resolution	0.5 m
Measure accuracy	
Cest	\$11 per sa lem
Format	GeoTiff
Mapping to building input variables	Building from ents
Marging to area properties	Vegetated areas, road surface, buildings, parking lots
Marging to moterial properties	Read conversent materials (e.e., concrete, aspiralt), parking lots (e.g., gravel, acel
Coverage of US	Over 10 million km <sup>2</sup> of coverage of the contiguous US
Operation	Arnal
Existing internal software	N/A
Existing experies	Remote serving data applyin tool
Restoctions	N/A
Competes	

**Comparison Matrix** 



4. Establish partnerships and APIs for scalable data retrieval



5. Algorithms to extract building properties



6. Create OpenStudio & EnergyPlus models





Demonstrate and stimulate opportunities toward a sustainable built environment

RIDG

7. Make models freely available

Download BEM via street address Use cases:

- · Utility-scale energy and program impacts
- City-scale emissions reductions
- Simulation-informed analysis during siting & design
- Resilience and Adaptation to Climate Change
- Sales/marketing leads
- · Automated financing
- · Business model evaluation

#### Key Innovations

- AutoBEM (Automatic Building Energy Modeling; <u>bit.ly/AutoBEM</u>) software suite developed to synthesize multiple data sources, generate building energy models, simulate, and statistically summarize simulation results for large geographical regions.
- High Performance Computing Theta, world's 39<sup>th</sup> most powerful supercomputer, used to perform over 2 million annual simulations.
- Distribution of energy efficiency (EE, kWh) of 4 technologies for all buildings in a utility's service area.
- Distribution of demand flexibility (DF, kW) of 4 technologies for all buildings in a utility's service area.



#### Virtual EPB – utility serving Chattanooga, TN, USA

- 178k building, 8-county, 1400 km<sup>2</sup> service area at boundary of TN, GA, and AL
- 15-minute whole-building electricity use from each building
- Building type assigned by: utility rate class, tax assessor data, and 15-min energy use intensity for a year (EUI<sub>15</sub>) of actual vs type+vintage combinations

<ul> <li>8 technologies</li> </ul>	#	Description	Category	Value	Source
C	1	Insulate Roof	Envelope	R-16.12 to R-28.57	IECC-2012
$P_{\rm Look}$ optical $k M/b/tt^2$	2	Reduce Space Infiltration	Envelope	Reduce 25% from vintage	EnergyStar
Black – actual KWN/II <sup>2</sup>	3	Smart Thermostat (2.2°C)	HVAC	2.2°C 2 hours prior to peak	EPB
Reu – Residential EUI <sub>15</sub>	4	Smart Thermostat (4.4°C)	HVAC	4.4°C 4 hours prior to peak	EPB
Blue – Small Office $EOI_{15}$	5	Change Electric HVAC COP	HVAC	COP to 3.55 (heating) 3.2 (cooling)	IECC-2012
A A A A A A A A A A A A A A A A A A A	6	Change Lighting Power Density	Lighting	LPD 0.85 W/ft <sup>2</sup>	IECC-2012
Mark Markey and a state design of a state of the	7	Change to Gas Water Heater	Water	Efficiency 80% (assumes electric)	IECC-2012
	8	Change to Gas HVAC	HVAC	Efficiency 80% (assumes electric)	IECC-2012



#### Results (kWh)

#### Greatest savings: lighting in warehouses, strip malls, and retail





### Results (kWh)

 Old buildings save more

 HVAC is most consistent





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Annual Electricity Savings by vintage

### Results (kW)

- 0-75% DF
- PV: 300-750 GWh/month

Maxiumum PV Generation



Jur.

AP' MOH

AUS GOR OC

1 30 NON Dec



Annual Demand Savings



105 600 200

### Results (kW)

- 2.2°C pre-conditioning avg 22% kW savings but varies 0-93% per month by building
- Fuel-switching to natural gas for heating shows significant electric demand savings during winter months



Smart Thermostat (4F Degree Offset)



#### Energy, Demand, Emissions, and \$avings at building-level

Virtual EPB: 178,368 building energy models; validated against 15-minute electricity

- Results
  - Energy (kWh)
  - Demand (kW)
  - Emissions (CO<sub>2-eq</sub>)
  - Cost (\$USD)
- Publicly available:
   <u>bit.ly/virtual\_epb</u>







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**Questions and Comments** 

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