2017 Annual Conference | Long Beach, CA

Seminar #29 Urban-Scale Building Energy Modeling, Part 5

Automatic Building Energy Model Creation (AutoBEM)

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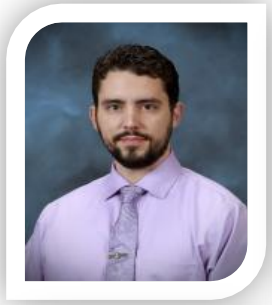
Learning Objectives

- Provide the amount of energy consumed by buildings and cities
- Provide a method to develop a customized building energy use baseline estimation tool by using a data-driven approach
- Describe how façade features could influence certain building energy use in a specific climate condition and a particular building geometry
- Demonstrate how district-scale energy retrofit analysis can be performed using existing urban modeling tools

Acknowledgements

- U.S. Department of Energy
- National Nuclear Security Administration
- Oak Ridge National Laboratory
- Building Technologies Office
- Office of Electricity
- Tunation, LLC











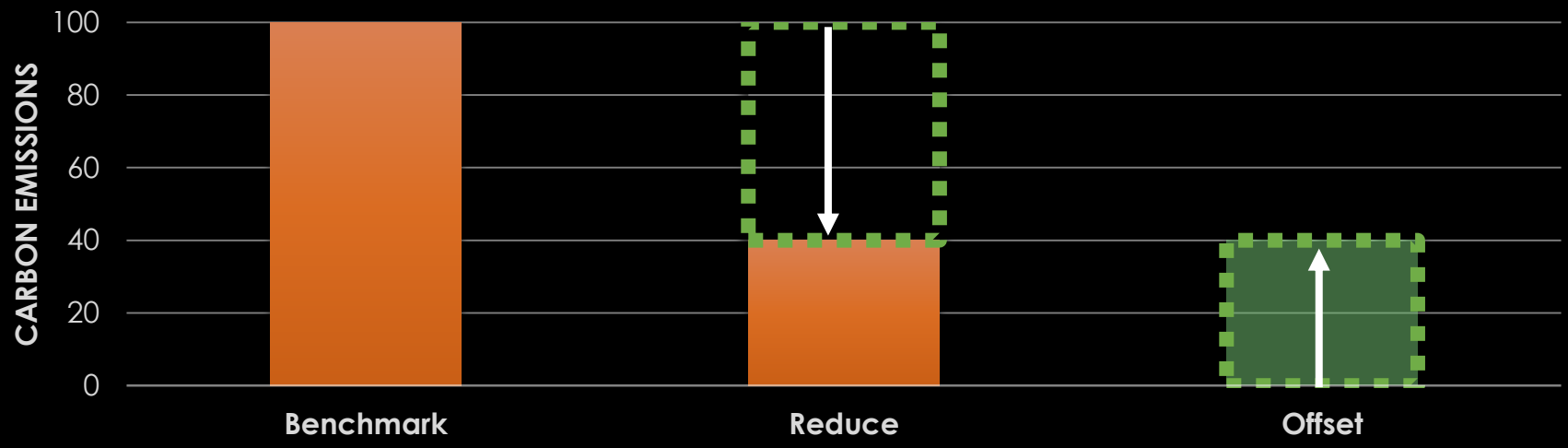


Sustainable Cities in three steps…

1) Benchmark – understanding existing energy consumption associated with existing and projected building infrastructure is an important first step to plan for retrofit reductions and offset measures.

2) Reduce – using expertise in existing building energy modeling, retrofit libraries are applied to prioritize energy conservation measures, leading to large-scale reductions in demand across the city, and phase strategies for more efficient energy supply.

3) Offset – for remaining carbon emissions, we apply strategic workflows and toolsets to evaluate new forms of energy generation.



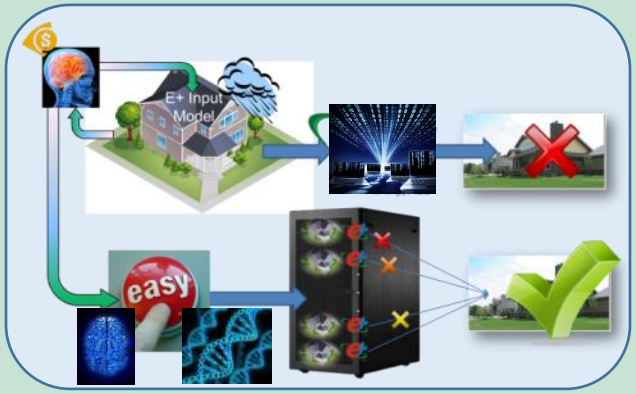
Automatic calibration of software to data

Calibration Performance – automated M&V

National HPC Resources → **Applied Research** → **Industry and building owners**

High Performance Computing

- Different calibration algorithms
- Machine learning – big data mining
- Large-scale calibration tests



Features

- Calibrate any model to data
- Calibrates to the data you have (monthly utility bills to submetering)
- Runs on a laptop and in the cloud

- 35+ Publications:
  `http://bit.ly/autotune_science`
- Open source (GitHub):
  `http://bit.ly/autotune_code`

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+ calibrations
(16 bldg types, 47-470 tuned inputs each)

Other error metrics

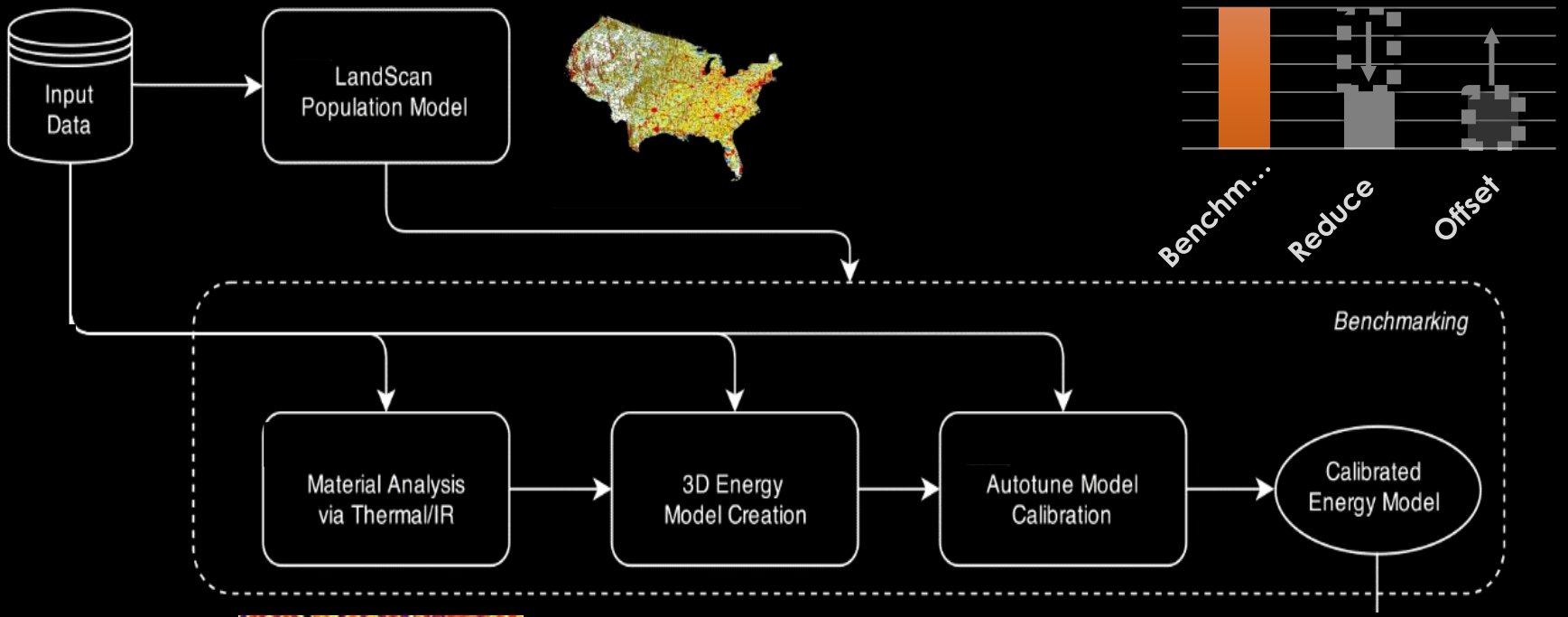
Residential home	Tuned input avg. error
Within 30¢/day (actual use $4.97/day)	Hourly – 8% Monthly – 15% 3 bldgs, 8-79 inputs

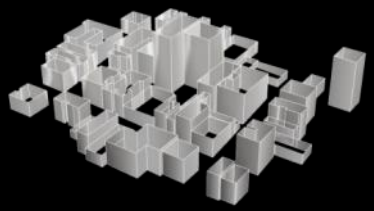
Leveraging HPC resources to calibrate models for optimized building efficiency decisions

Energy I-Corps/Lab-Corps

- 6-week training program, commercialization of calibration software
  - Scientific method applied to the business model canvas
  - 115 interviews
  - Customer Segments: ESCOs and Utilities
    - Key technical gap:
      Utilities need a building energy model for every building in their service area

Model America 2020 – calibrated BEM for every U.S. building



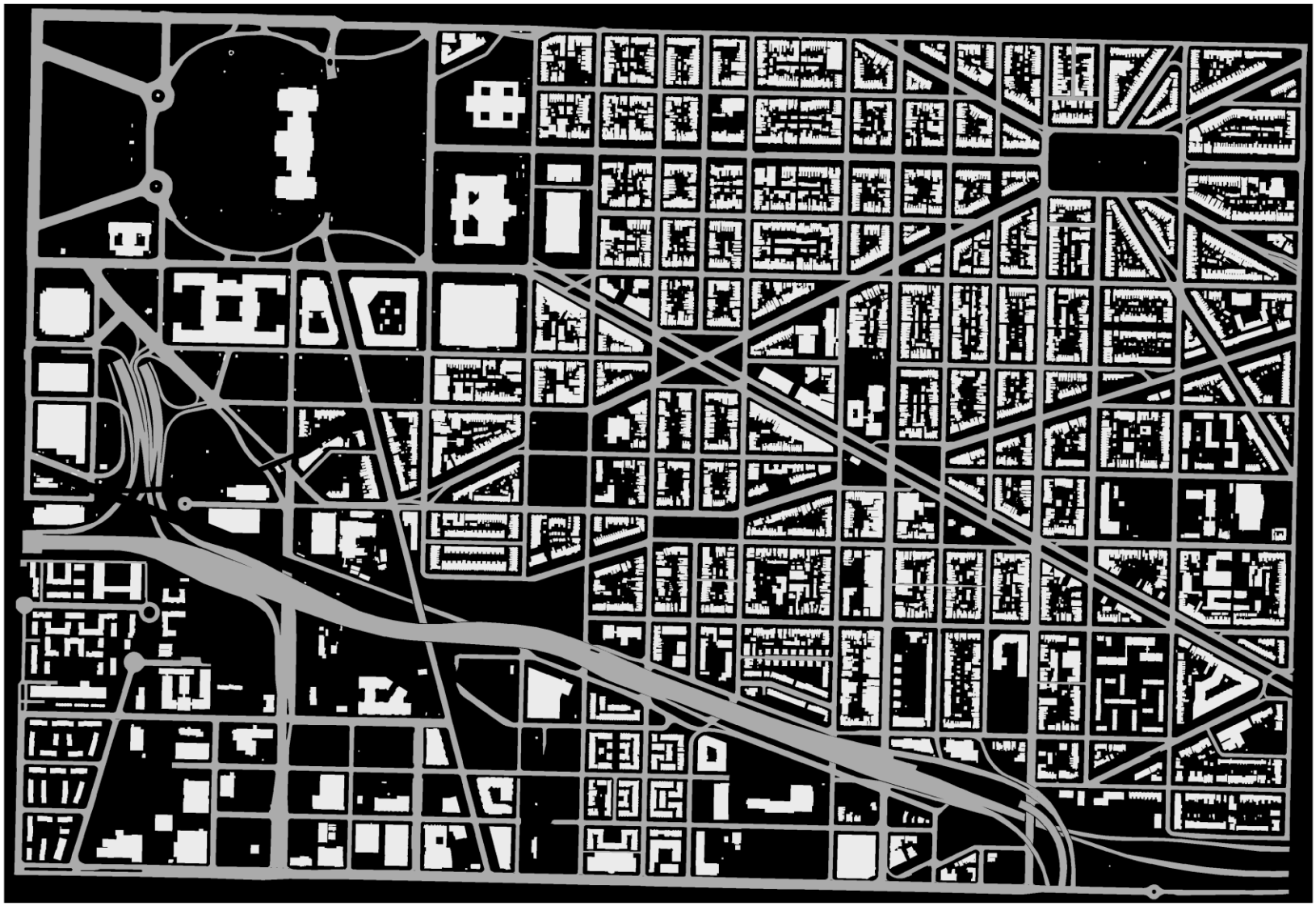


Data Sources

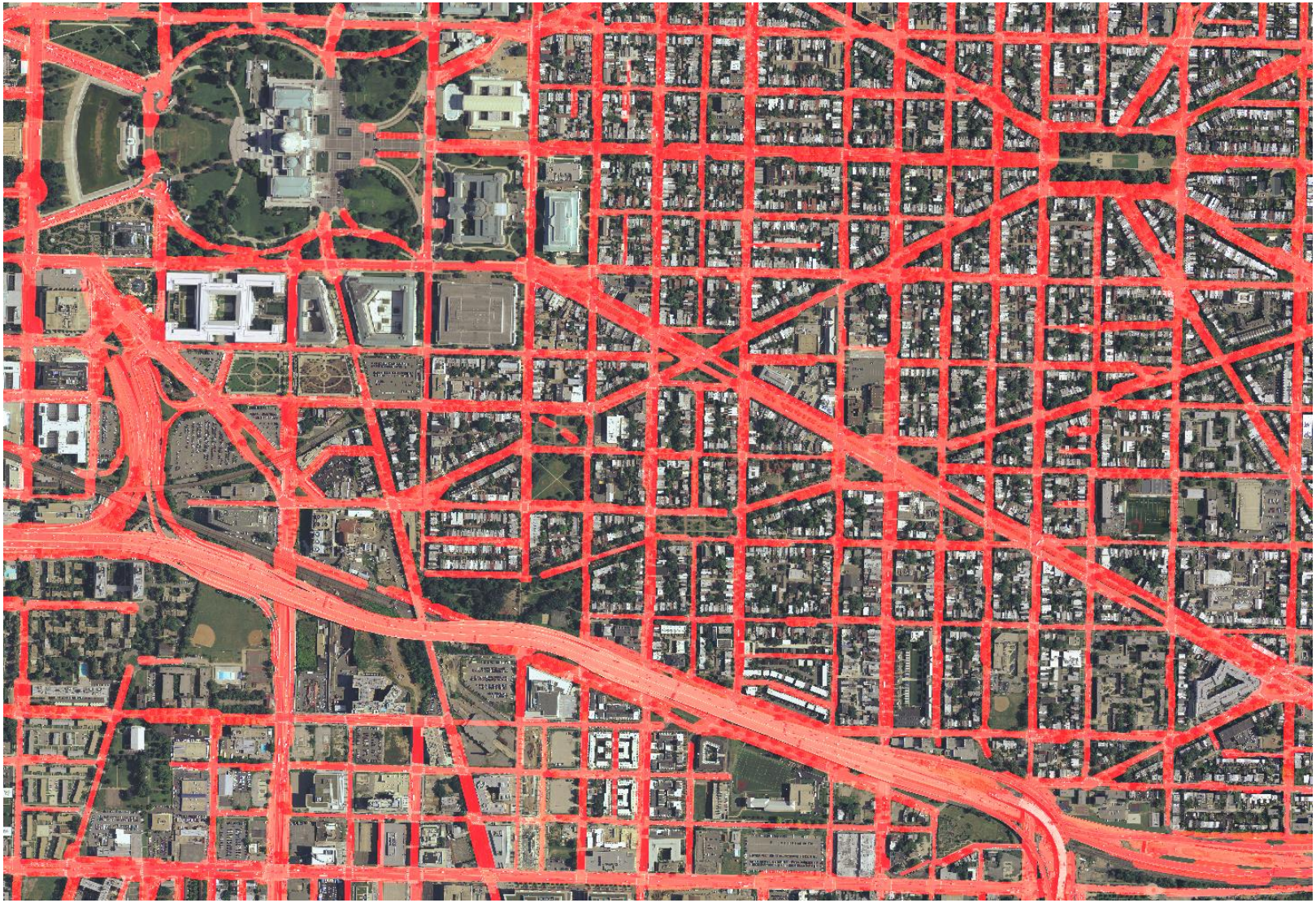
- Database and image sources for urban model generation
  - Satellite and airborne imagery
  - Cartographic data
  - Ground level images
  - Elevation data
  - Building information databases
  - 3D building model databases

	Short Title
Summary	Satellite imagery, including panchromatic and multispectral images
Data type	Image
Company	
Website	
Temporal resolution	Cities - 3-11 times per week
Spatial resolution	0.3 m
Measure accuracy	
Cost	$11 per sq. km
Format	GeoTiff
Mapping to building input variables	Building footprints
Mapping to area properties	Vegetated areas, road surface, buildings, parking lots
Mapping to material properties	Road pavement materials (e.g., concrete, asphalt), parking lots (e.g., gravel, soil)
Coverage of US	Over 10 million km^2 of coverage of the contiguous US
Orientation	Aerial
Existing internal software	N/A
Existing expertise	Remote sensing data analysis tool
Restrictions	N/A
Comments	

Manual Segmentation of DC



Automatic Road Extraction

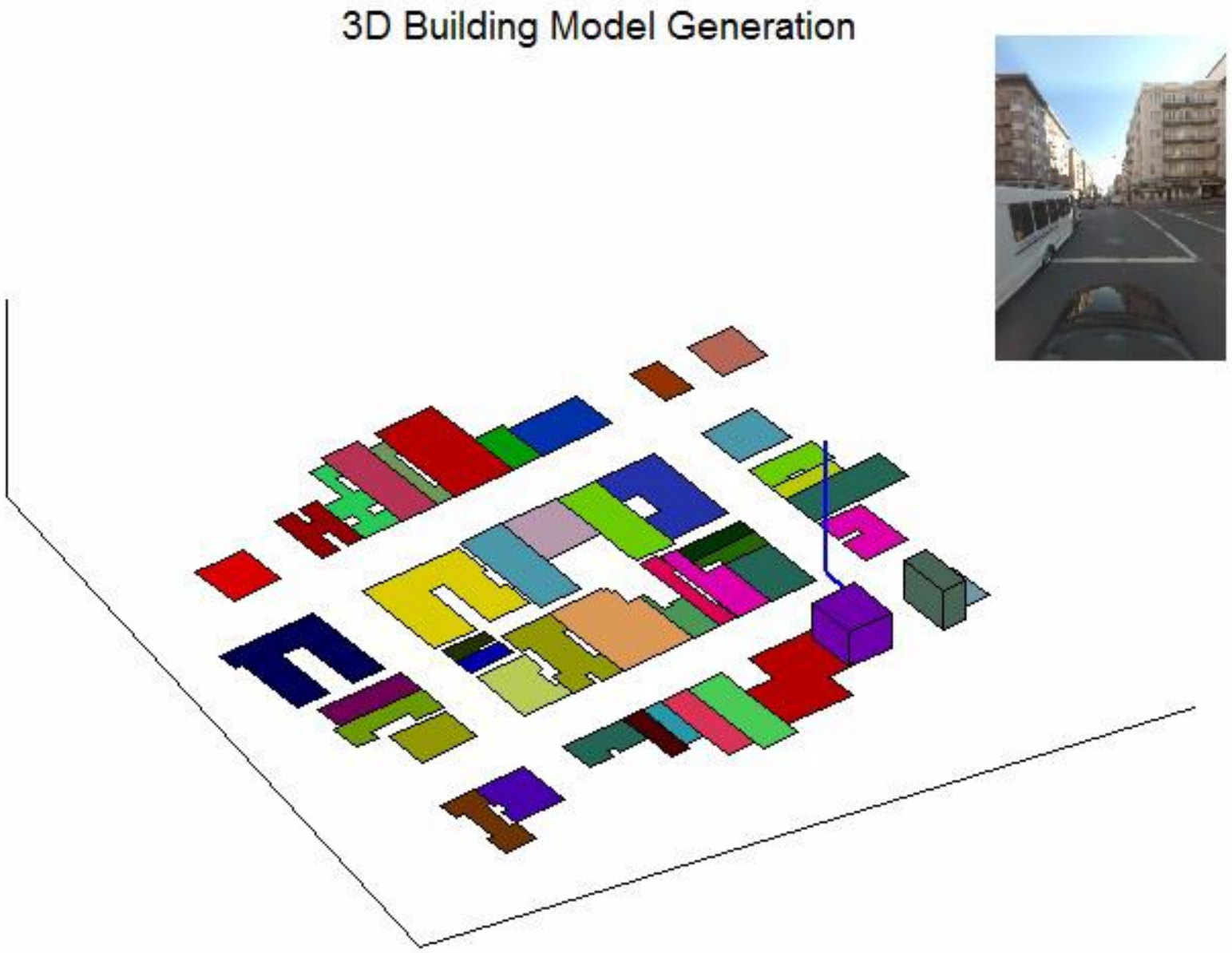


Automatic Building Footprint Extraction

Algorithm: Deep Learning extended and using GPUs for fast building footprint and area extraction over large geographical areas.

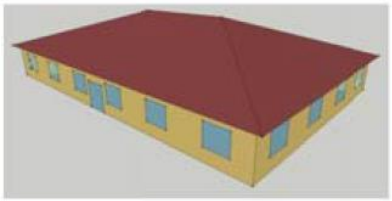
Multi-company Competition Precision/Recall – 30/35; Current Precision/Recall – 60+/60+

Processing Street-Level Imagery

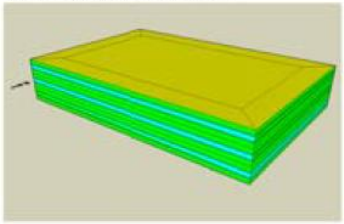


Prototype Buildings

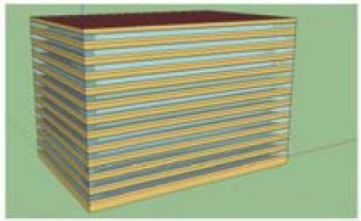
Small Office



Medium Office

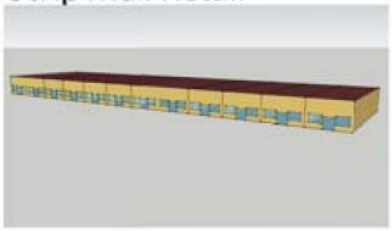


Large Office

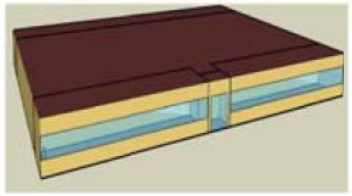


Warehouse

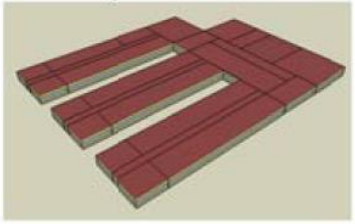
Strip Mall Retail



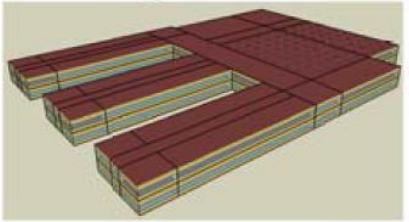
Standalone Retail



Primary School

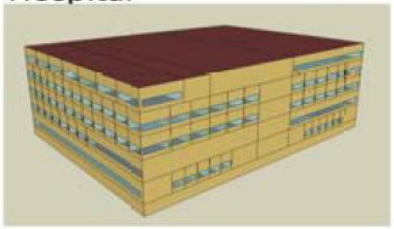


Secondary School



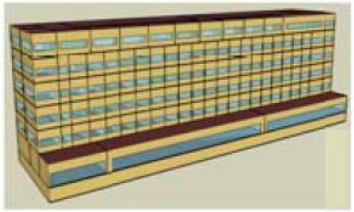
Outpatient Healthcare

Hospital

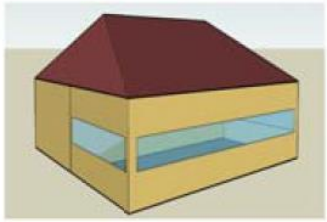


Small Hotel

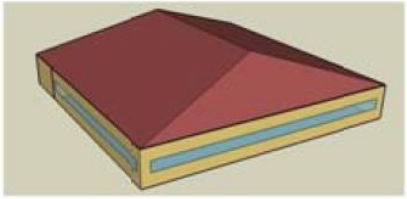
Large Hotel



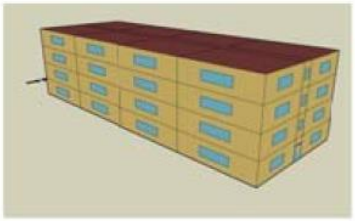
Quick-service Restaurant



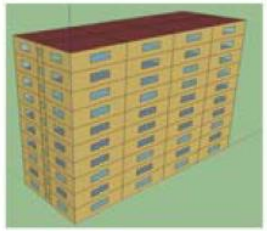
Full-service Restaurant



Mid-rise Apartment



High-rise Apartment



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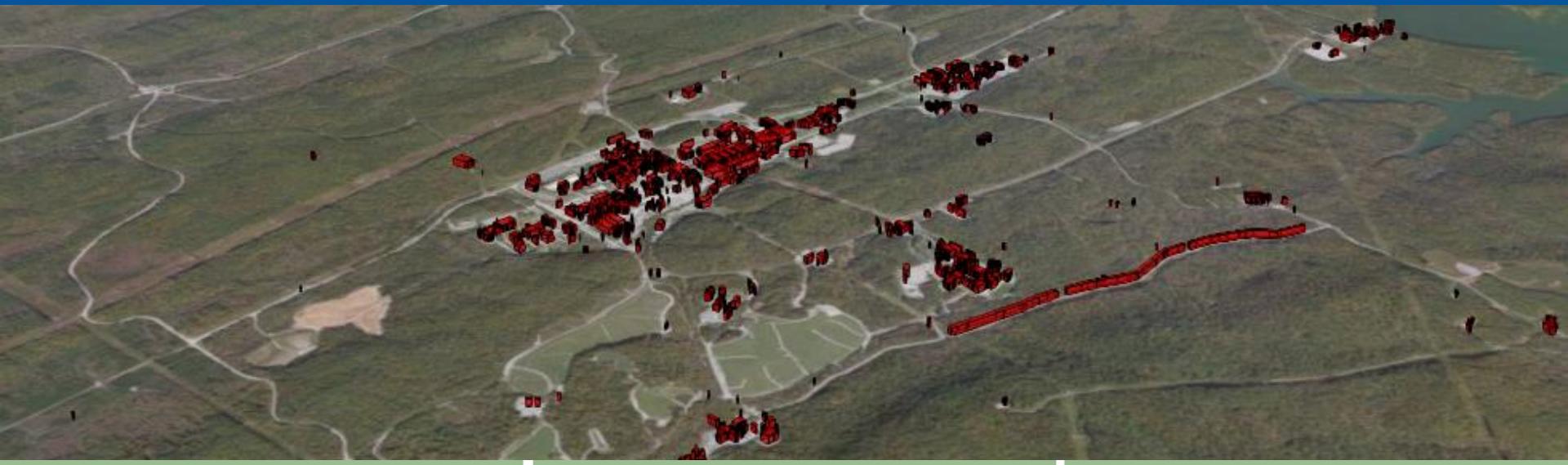

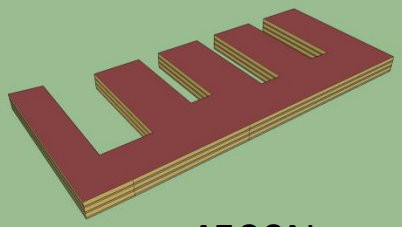

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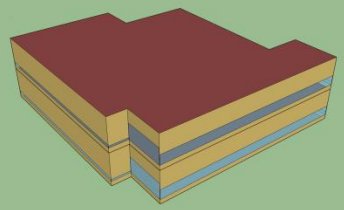

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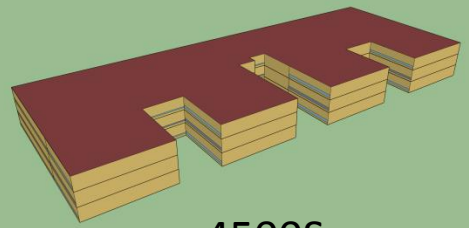

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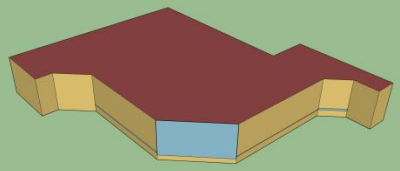

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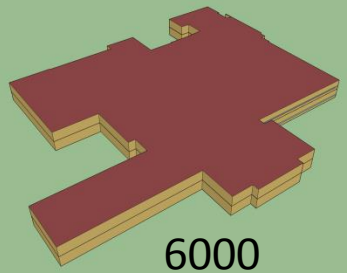

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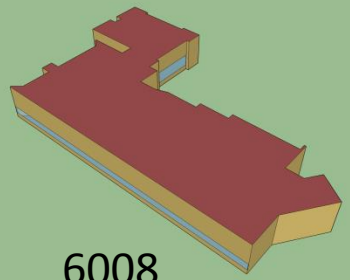

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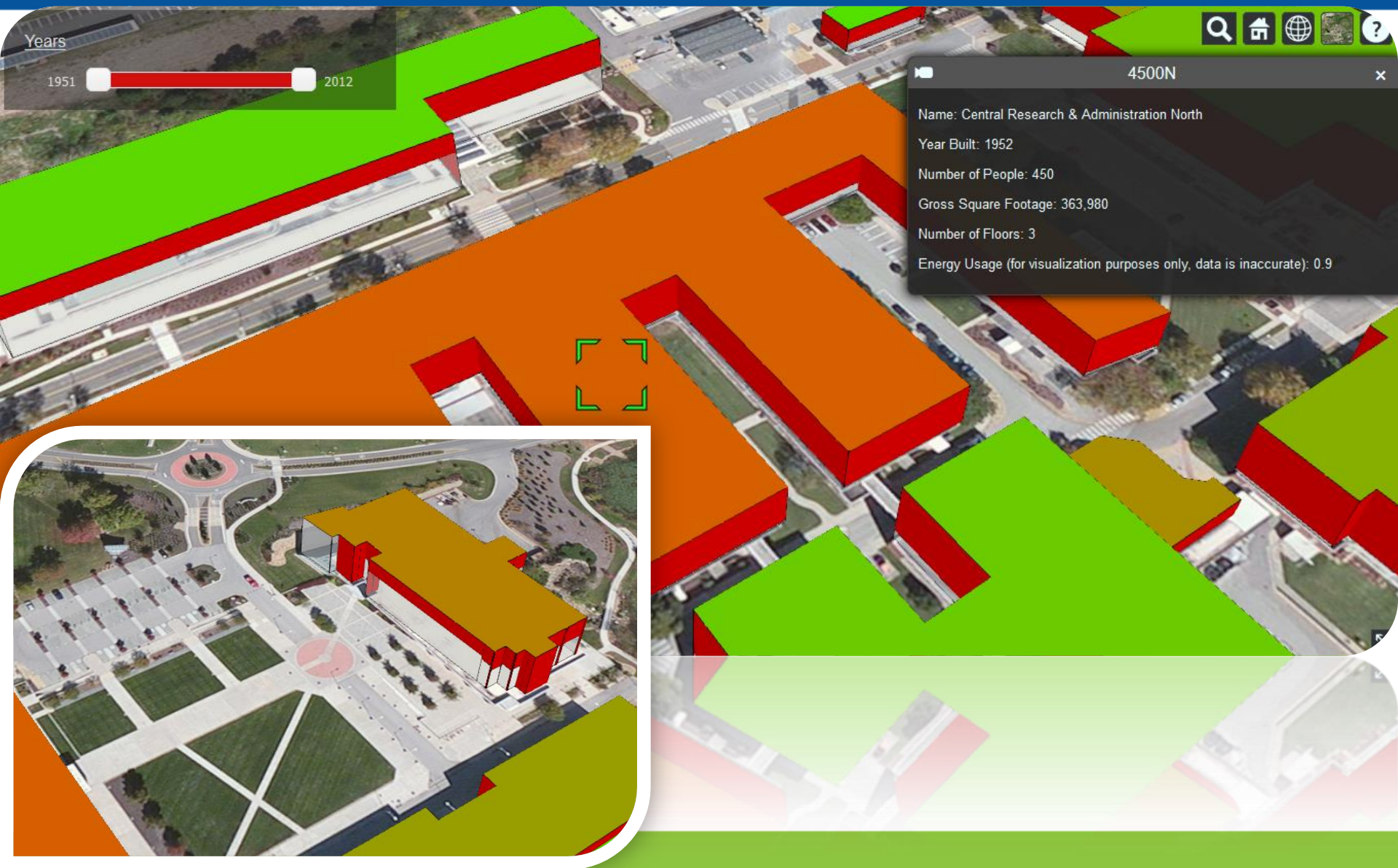
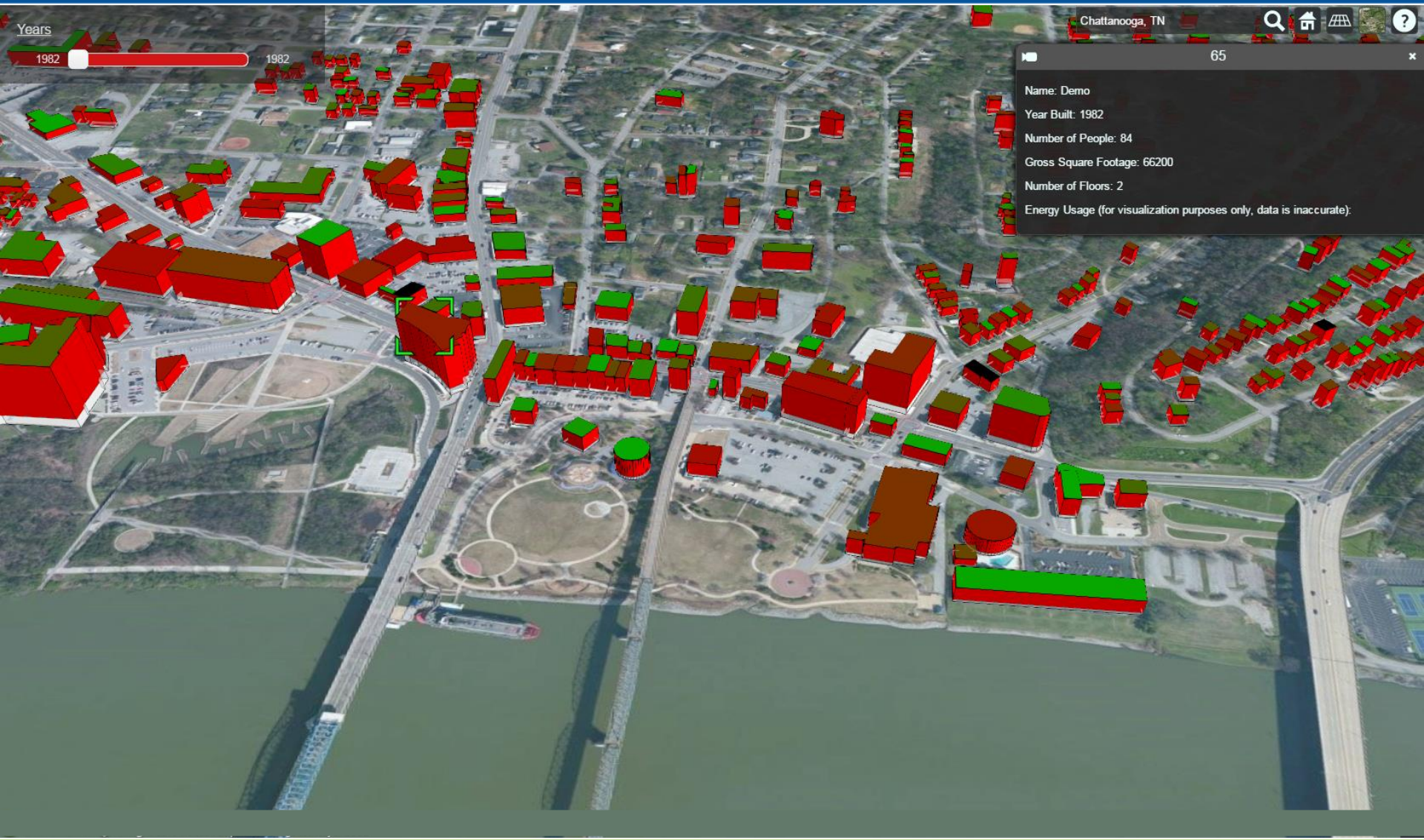


University Campus

Chattanooga, TN



Output: Grid Modernization Load Models, EE programs, Transactive Energy, Utility/Distributor Business Models (EaaS), Actionable Sustainability Plan, Carbon Neutrality

1) Demand-Side Building Efficiency

2) Supply-Side Infrastructure Enhancements

3) Responsible Renewables Implementation

QUESTIONS?

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