



Environmental Insights Explorer for Buildings

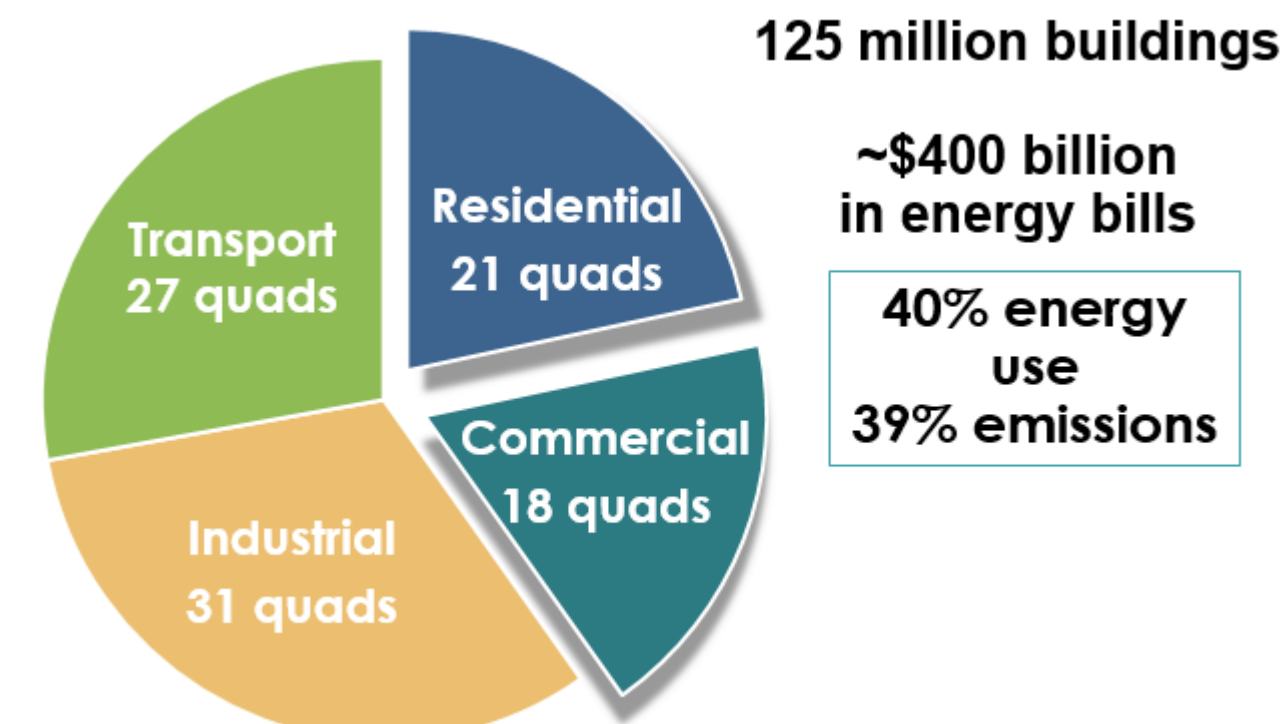
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INTRODUCTION

Motivation

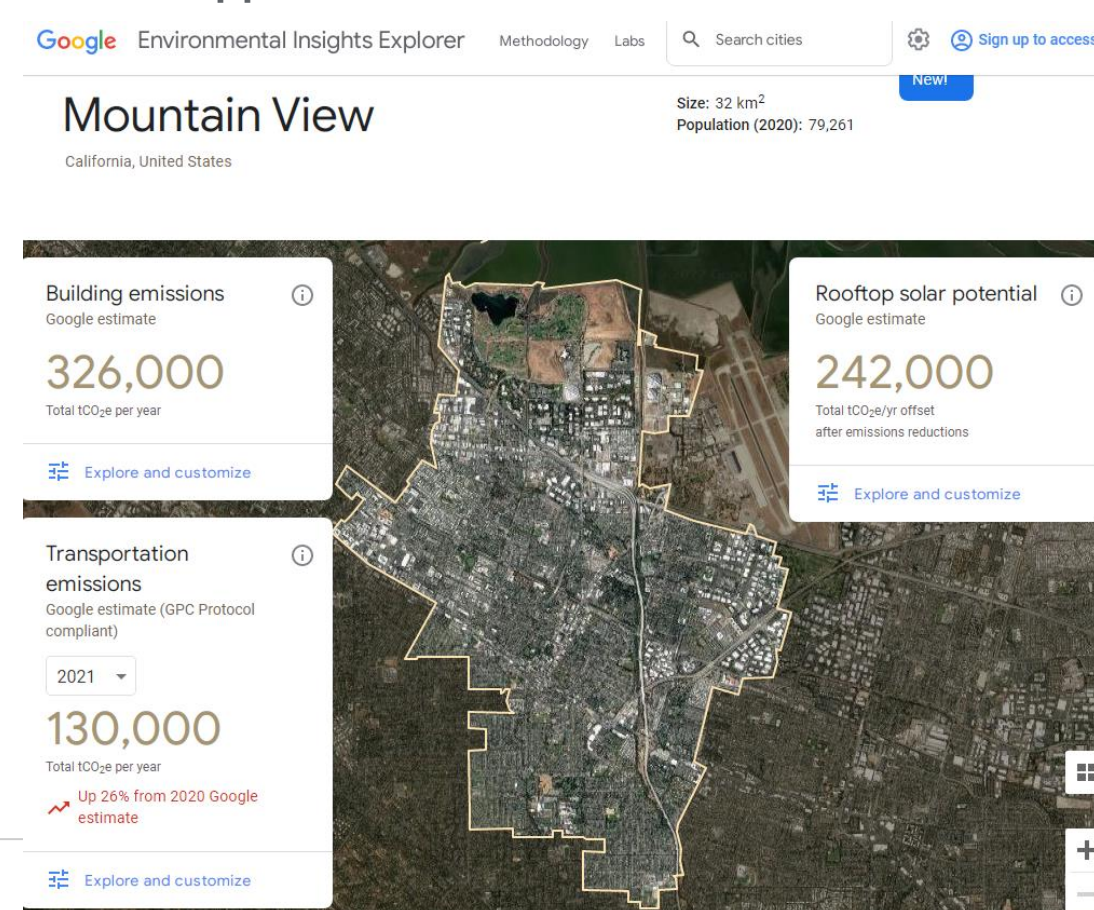
Residential and commercial buildings consume 35% of energy (55% of electricity) and contribute 38% of total emissions world-wide. While many cities have carbon reduction plans, and Google's Environmental Insights Explorer helps quantify carbon footprints for over 100 cities, our collaborative project between Google and Oak Ridge National Laboratory (ORNL) are better estimating building emissions and developing actionable carbon reduction opportunities for cities.



United States - 125M buildings, \$400B/yr in energy bills, 39% of emissions

What was our goal?

- Help create a sustainable built environment
- Provide useful information to government and industry
- Train Artificial Intelligence for scalable prediction
- Make data, models, software, and literature freely available for permissive commercial use.
- Rallying cry: "Simulate every U.S. building"
- Collect data to model digital twin of every U.S. building



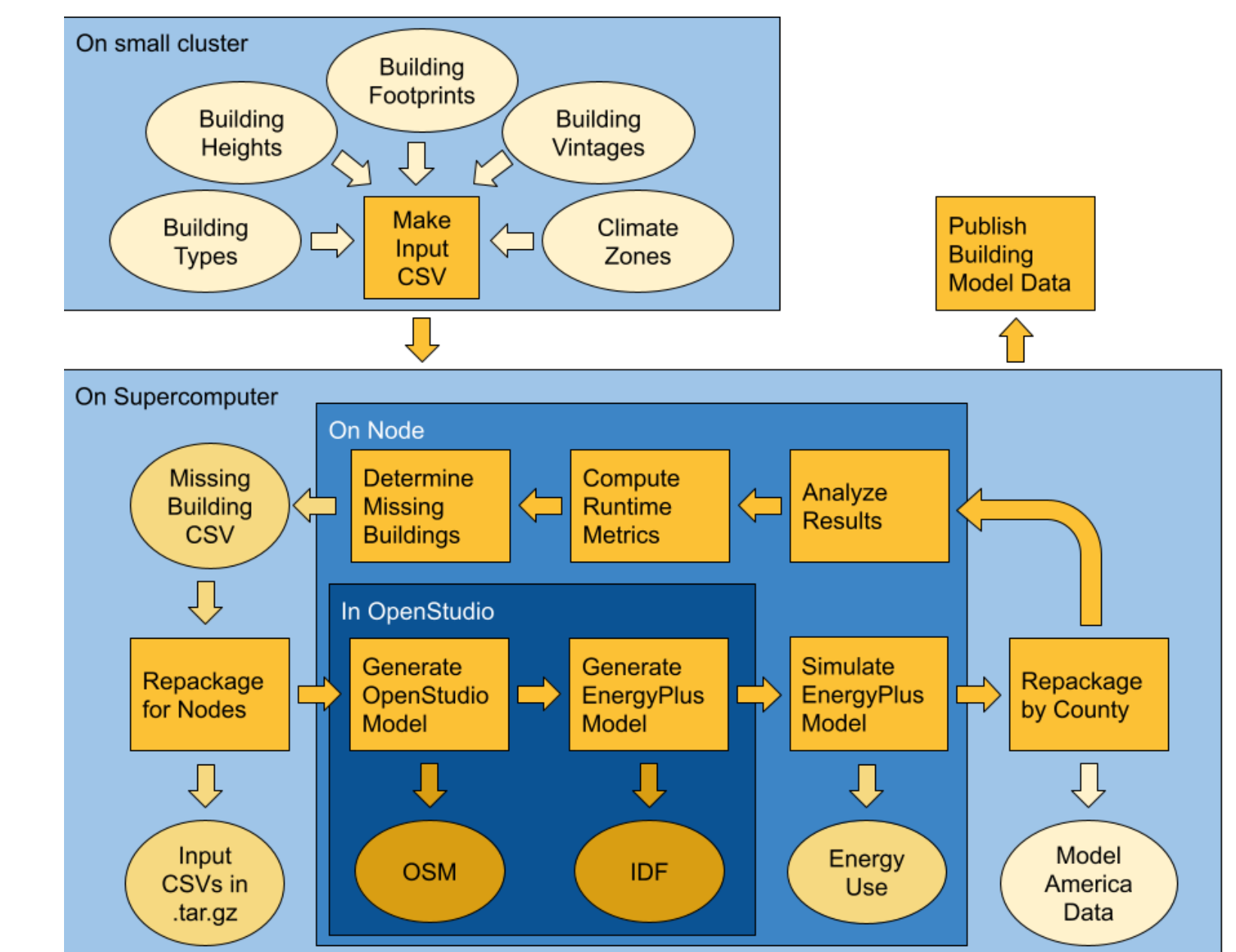
HOW I DID IT

Reach out to various industries to understand what is required for actionable decisions given industry trends and potential business models in the United States: architectural engineering and construction (\$17B/yr), utility energy efficiency and demand programs (\$11B/yr), and Energy Service Companies (\$7B/yr).

Step-by-step

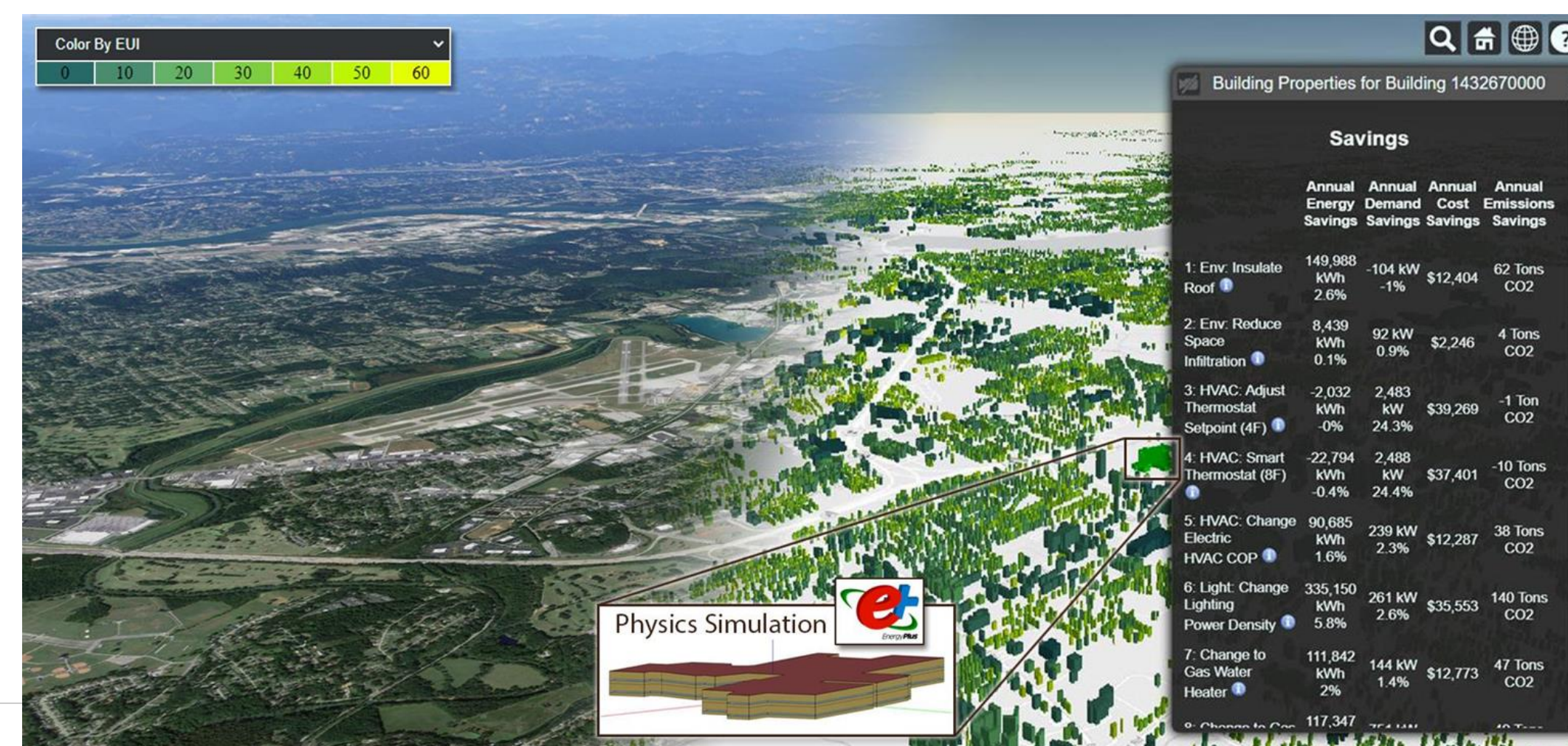
- Sensitivity analysis of up to 4,700 inputs per model
- Production-level scalability on 3 of the world's #1 fastest high performance computing resources
- 50+ data sources, resolution, accuracy, limitations, and which simulation input is represented
- Partner with companies that provide key data
- Extend AI algorithms to handle data at scale
- Generate and simulate buildings based on building codes for unknown characteristics
- Simulate buildings with dozens of technologies and under IPCC-defined climate change models
- Work with different industries to use these models

"What if we put \$4 billion into the county where you live? Could we make building changes, guarantee energy performance, and make \$10 billion profit in 17 years?"
 - CEO of an Energy Service Company



RESULTS

- Automatic Building Energy Modeling (AutoBEM) software
- Data consolidated for 125.7 million U.S. buildings.
- 122.9 million EnergyPlus and OpenStudio building energy models made freely available.
- Interactive, web-based visualization for estimating city-wide or building-specific energy, demand, emissions, and cost reductions for energy efficient technologies.



CONCLUSION

Lessons Learned

- AutoBEM models within 5% of publicly available measured building energy data for three modeled cities
- Models compare favorably to previous Google estimates
- AI trained on building energy simulation output allows for generalization to other cities

		Hartford		
		Electricity	Natural Gas	Total
EIE		31%	-47%	-26%
AutoBEM		70%	-27%	-1%

		Boulder		
		Electricity	Natural Gas	Total
EIE		4%	-73%	-41%
AutoBEM		0%	-2%	-1%

		DC		
		Electricity	Natural Gas	Total
EIE		-44%	-73%	-46%
AutoBEM		-9%	23%	5%

References

- Automatic Building Energy Modeling (AutoBEM) publications - bit.ly/AutoBEM
- Model of 122.9M U.S. buildings - bit.ly/ModelAmerica