

Urban Systems Research

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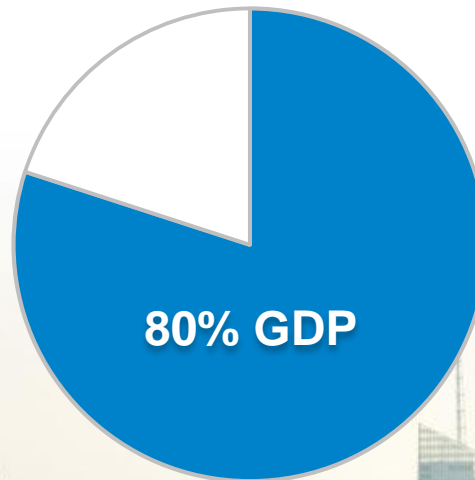
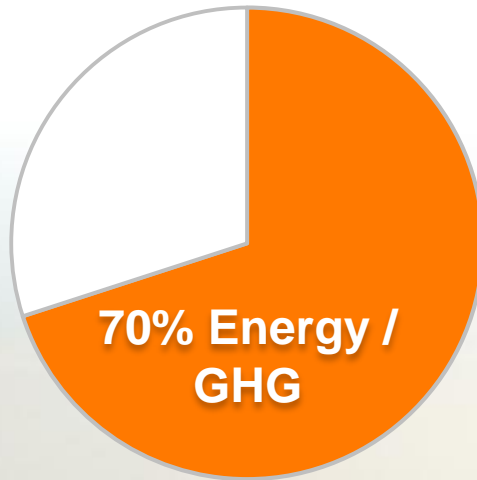
Speaker: Han Li

Building Technology and Urban Systems Division

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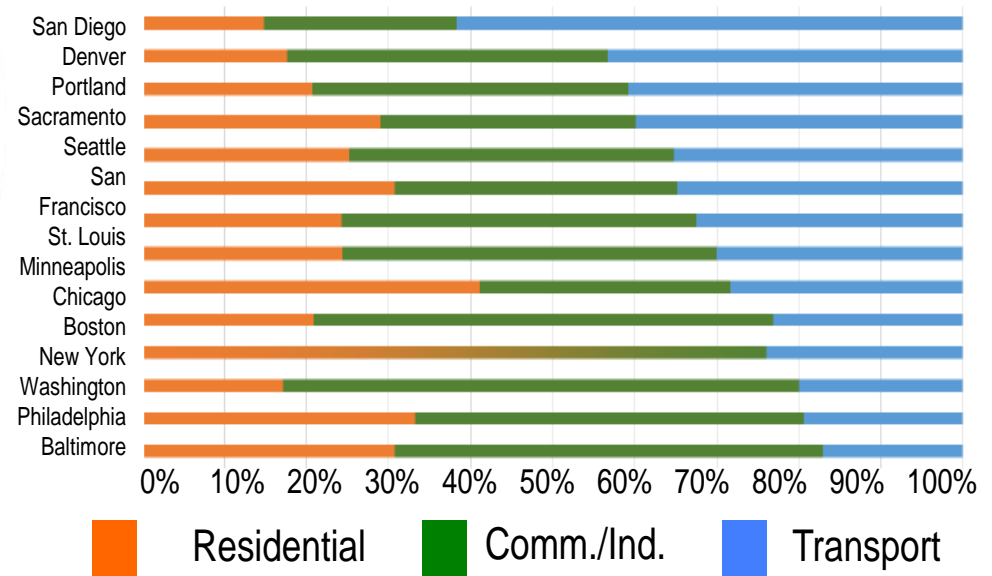
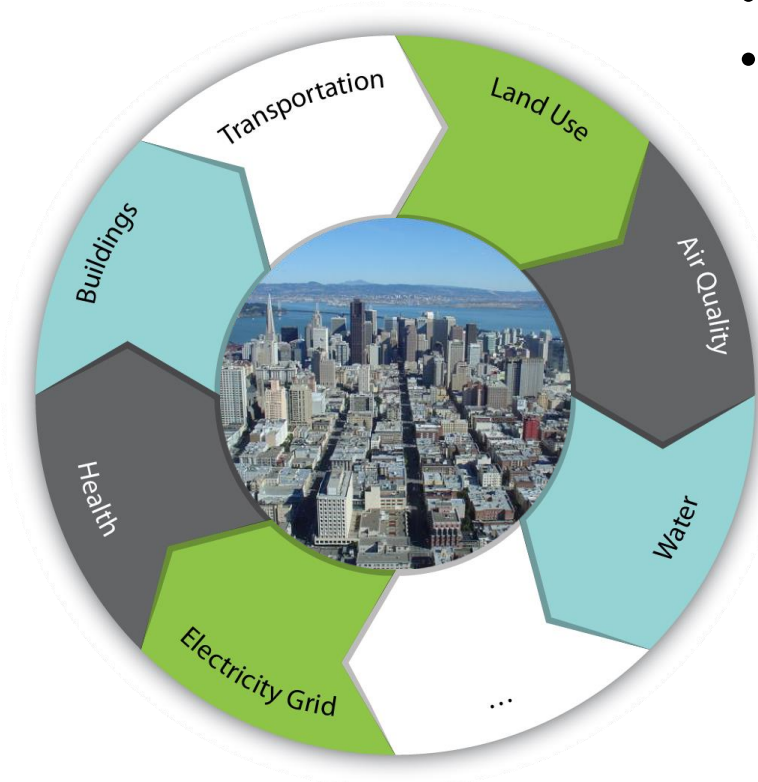
Transforming Cities

Cities drive our economy and dominate energy and environmental challenges



How to reduce 50% energy use in city building stock?

- Buildings in cities consume 30-70% of the primary energy
- Cities have different building energy use profiles
- The building sector has the most potential to save energy



City Energy Profiles

Imagine a City...

...that consumes 50% less total energy per person while improving economic vitality and quality of life and increasing resilience and sustainability

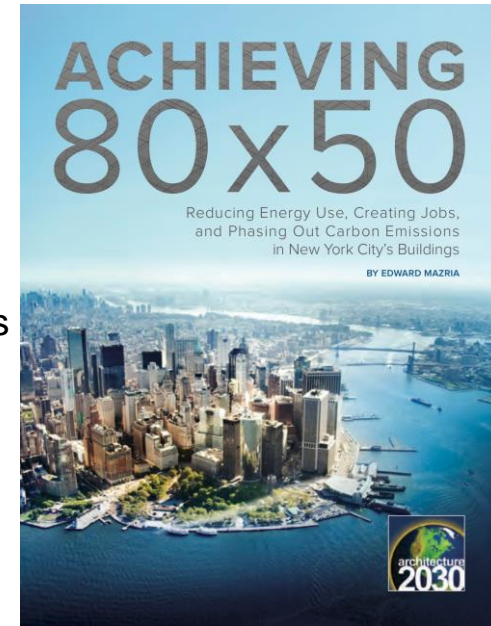


Support cities on decision making for meeting the 80 X 50 goal

- ❑ Support building energy disclosure ordinance: building energy visualization and benchmarking
- ❑ Prioritize building retrofit investment: quantitative modeling and analysis
- ❑ Track and report building performance (energy use and GHG emissions)
- ❑ Inform policy and evaluation: incentives/rebates, climate change, heat waves
- ❑ Guide urban energy planning: ZNE communities, smart energy districts

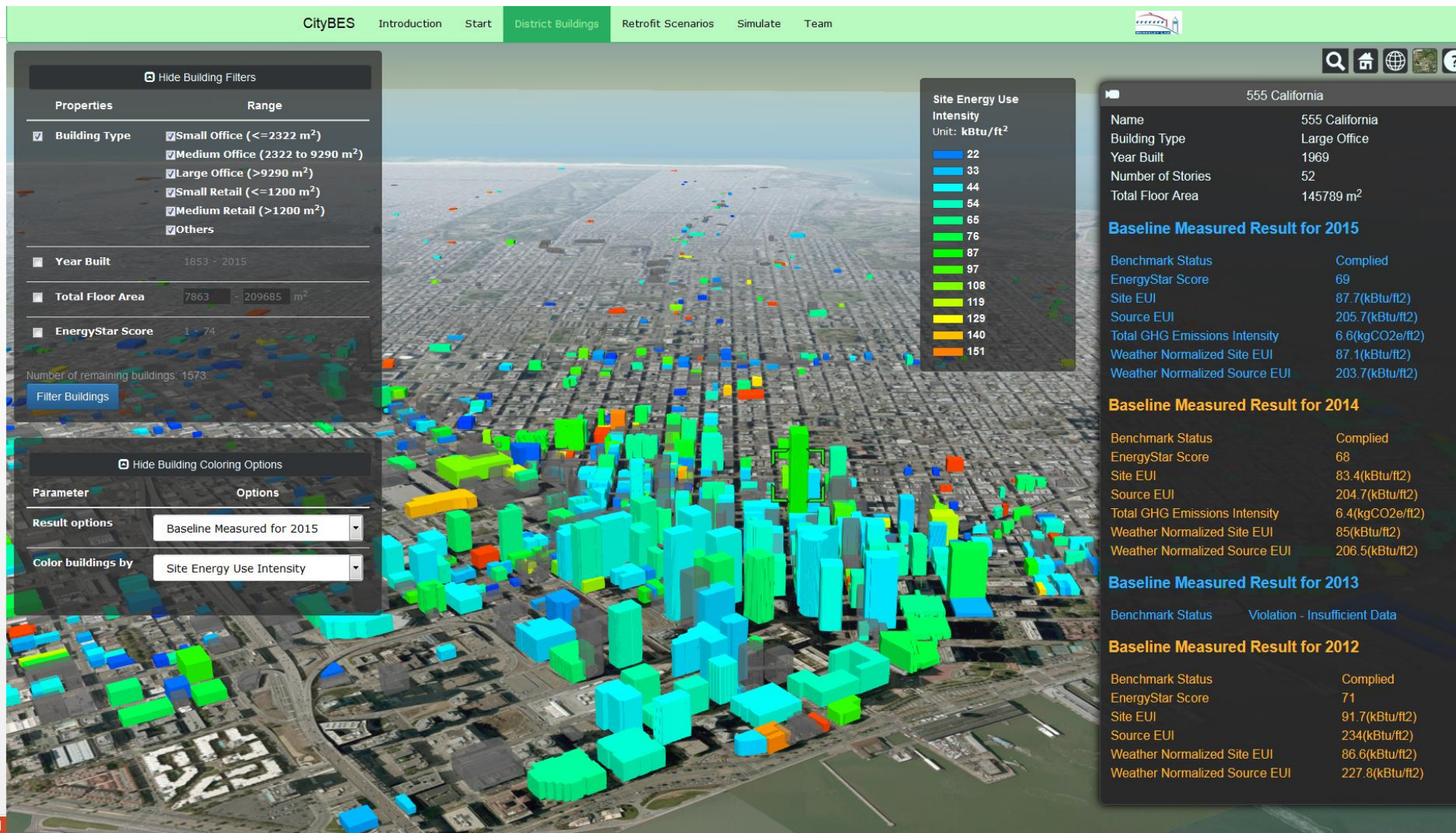
Our Partners / Collaborators

- ❑ **Cities:** San Francisco, Oakland, San Jose, Los Angeles
- ❑ **Developers:** FivePoint
- ❑ **DOE labs:** ANL, NREL, ORNL, PNNL
- ❑ **NIST** Global City Teams Challenge
- ❑ **Organizations:** NYSERDA, RTA, C40, USDN, Smart Cities Council, IEA EBC
- ❑ **Universities:** UCB, EPFL, Darmstadt, Tsinghua,
- ❑ **Companies:** SideWalk Labs, Autodesk, MEP Associates, Integral Group

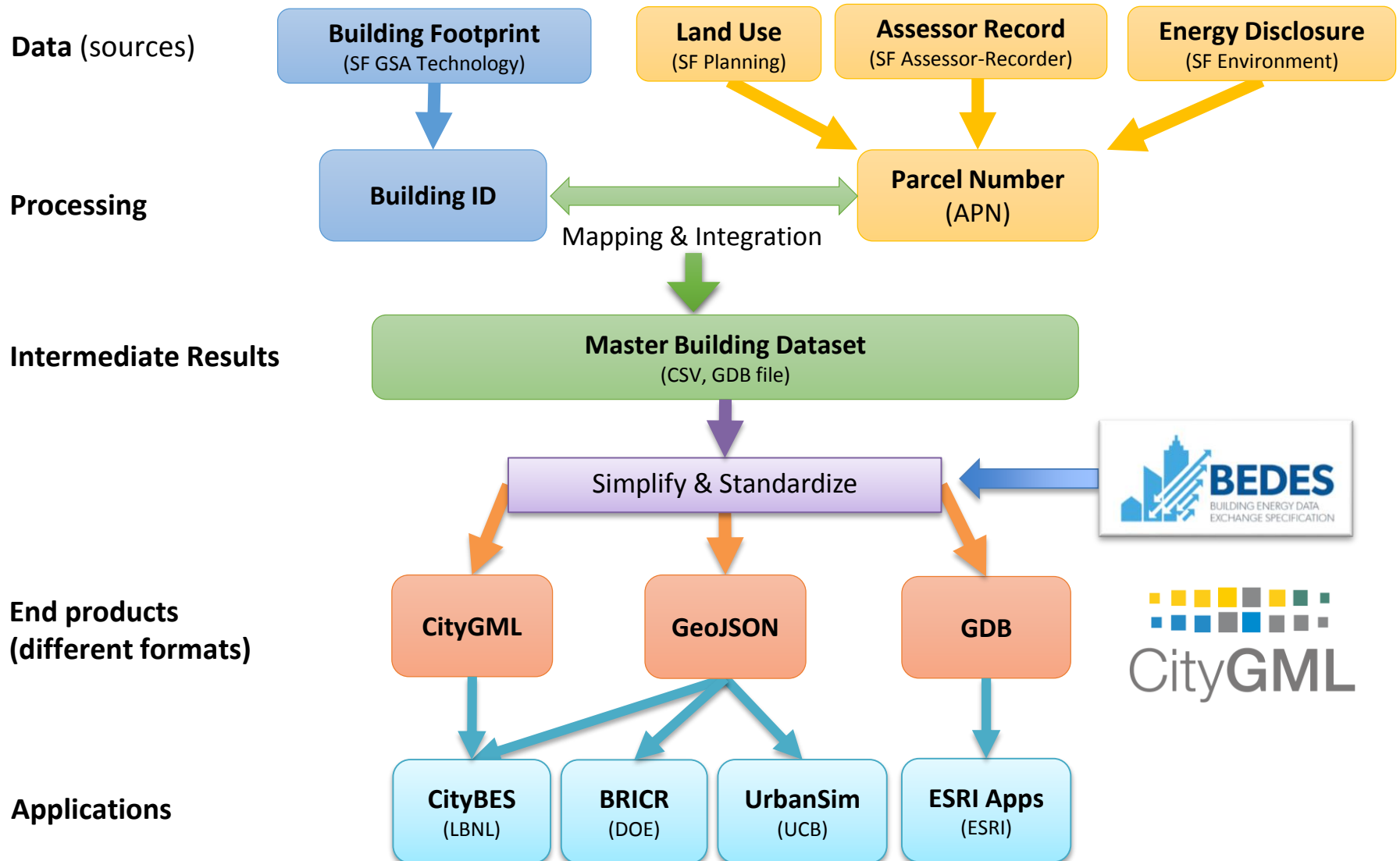


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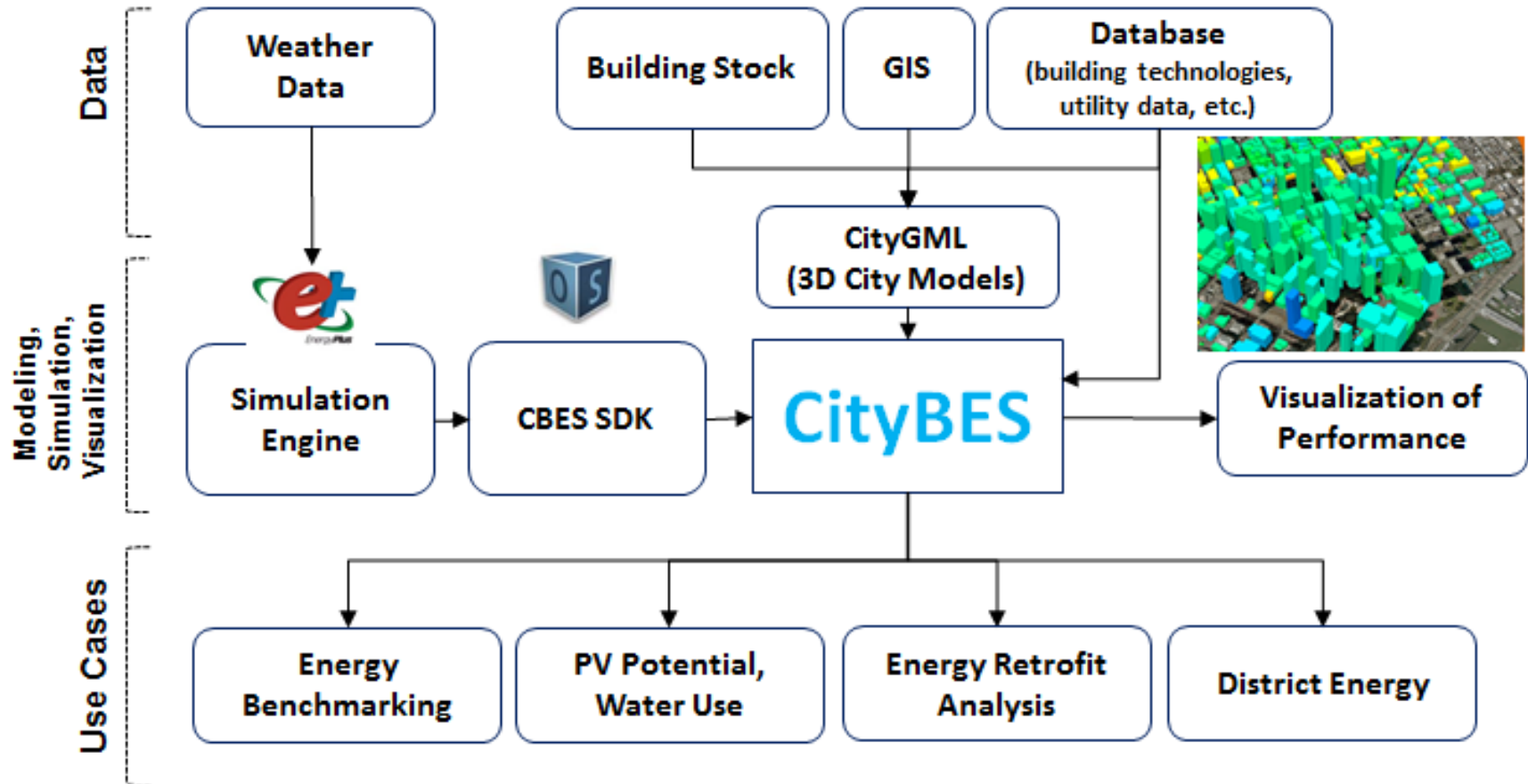
(A Platform for City Buildings)



Integrating City Data in Open Standards

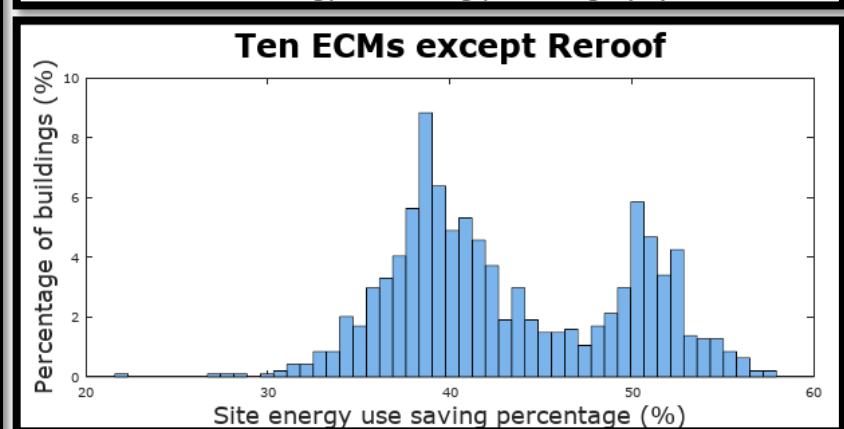
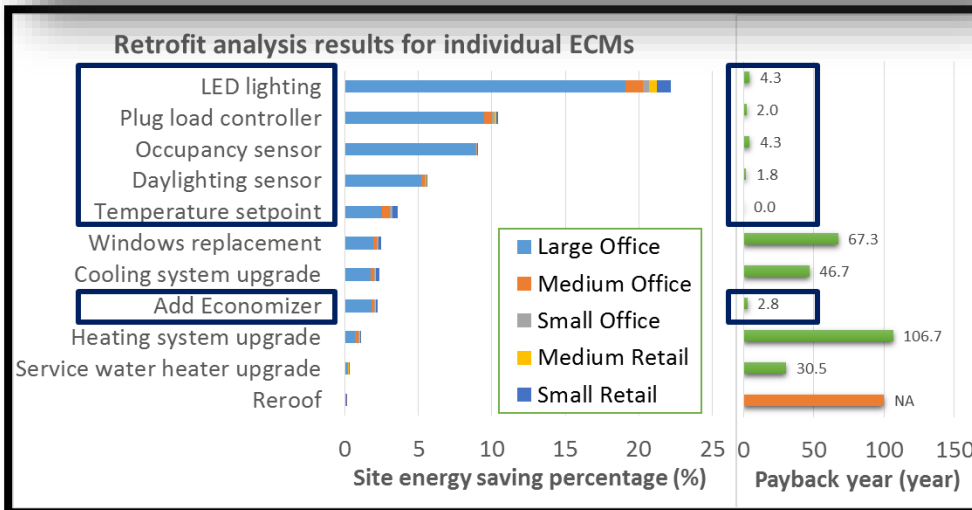
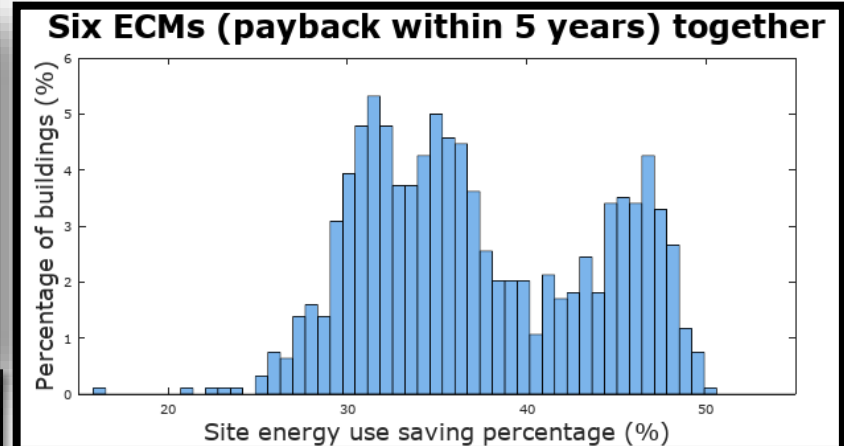
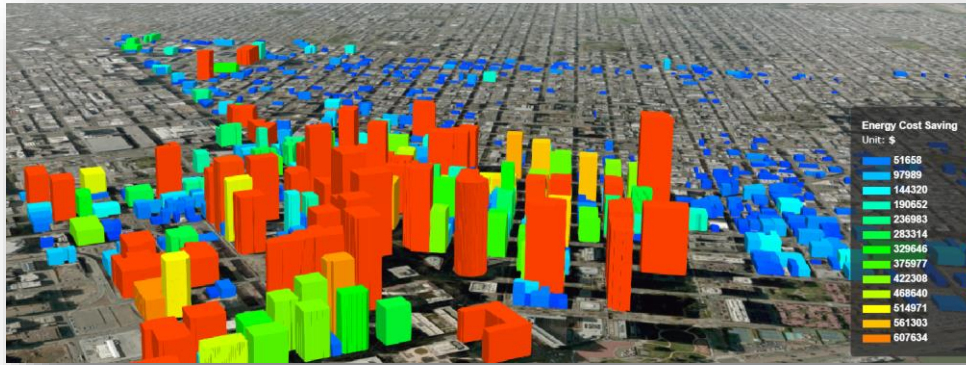


CityBES Workflow and Use Cases

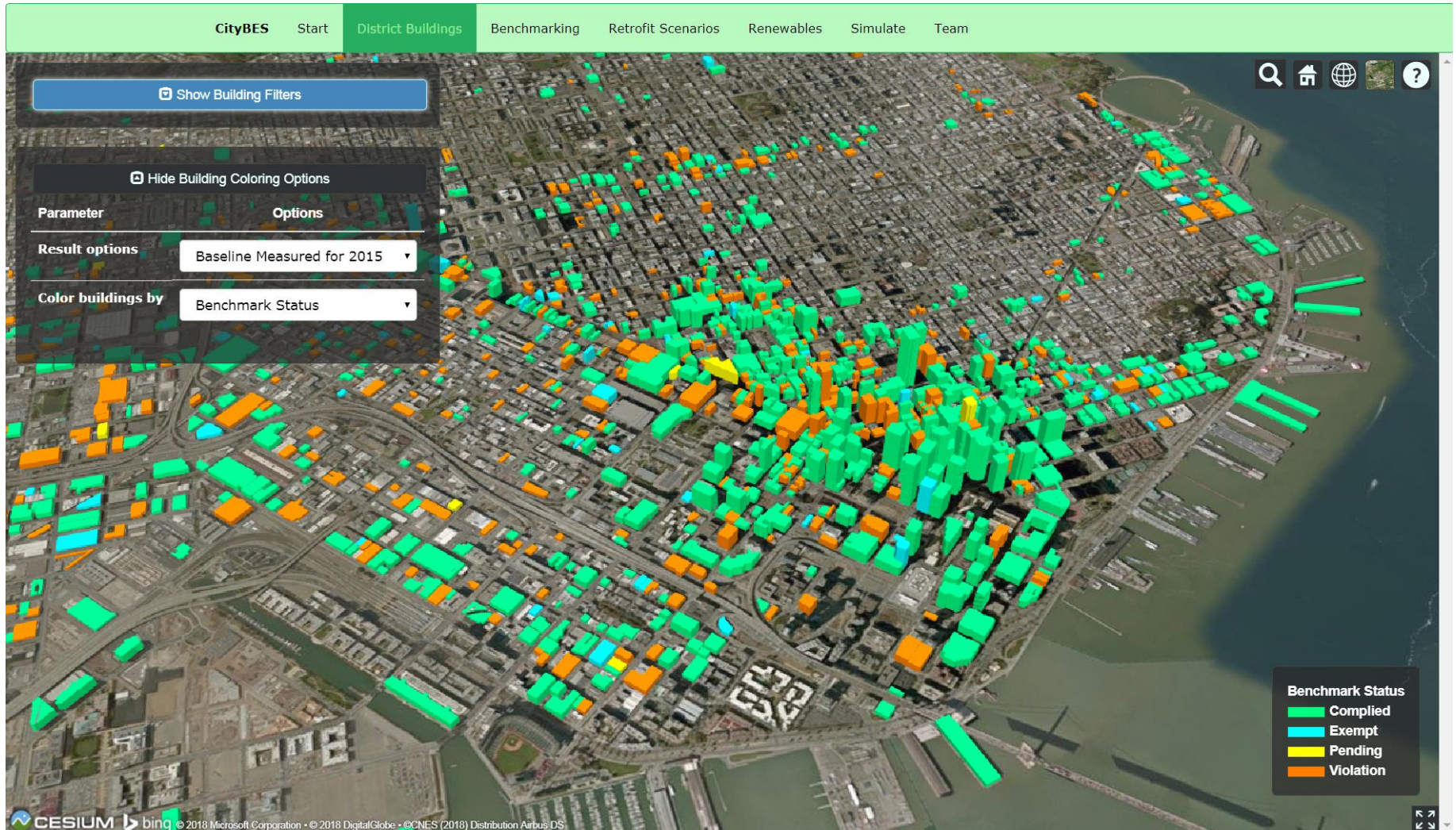


Evaluate building retrofits at large scale:

940 office and retail buildings in Northeast San Francisco

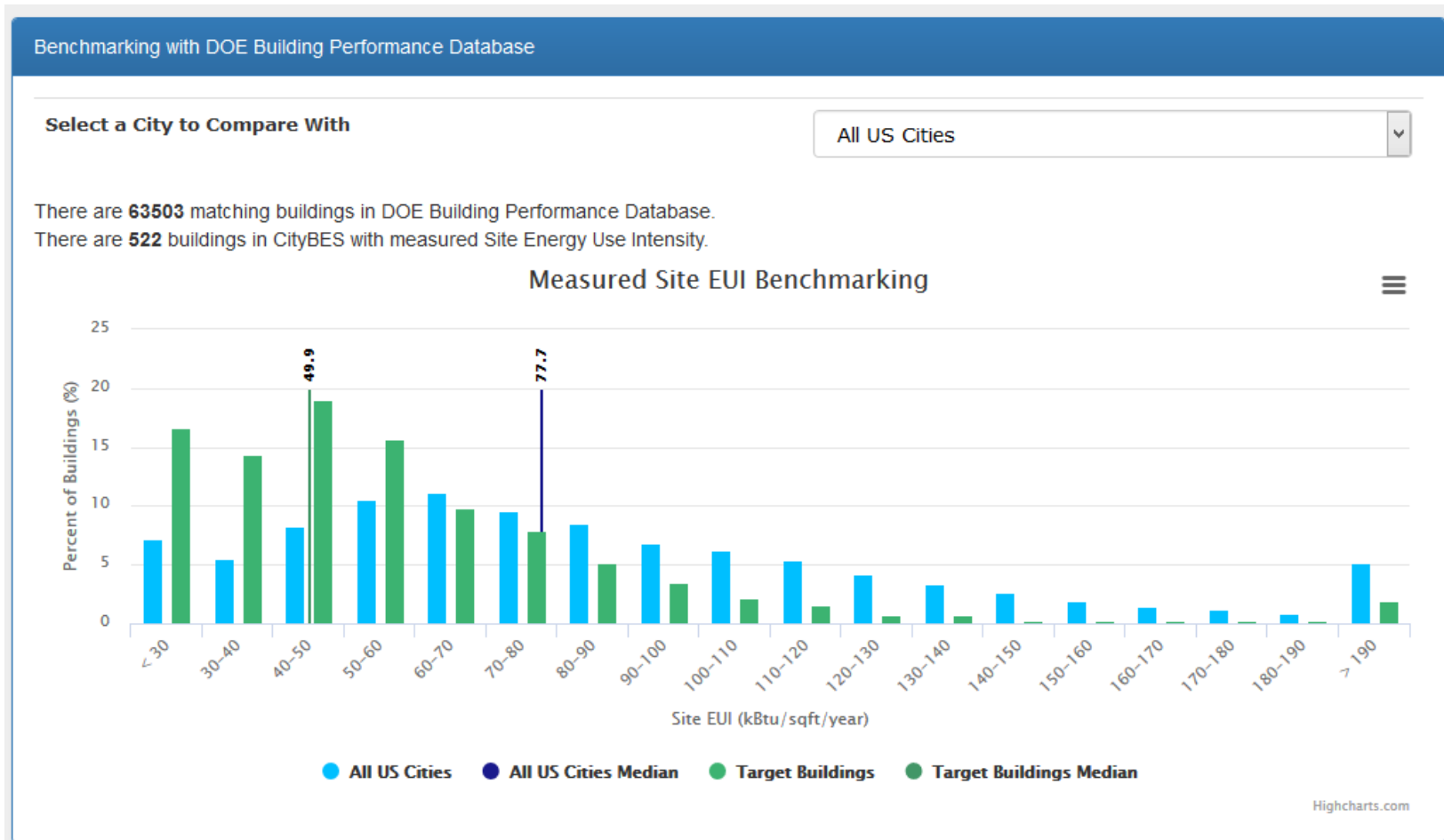


SF building energy ordinance



https://citybes.lbl.gov/?sf_ecbo=1

Benchmarking Performance of City Buildings



Comparing site EUI of 522 office buildings in San Francisco with 63503 office buildings in the BPD.

Evaluate Rooftop PV Potential

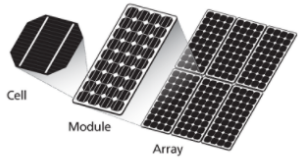
CityBES Start District Buildings Benchmarking Retrofit Scenarios **Renewables** District Energy Simulate Team

Renewables: Photovoltaic (PV)

This feature estimate the energy generation of the photovoltaic (PV) energy systems. Please specify the area for PV and modify the parameters of a PV module in the following panels.

Parameters of a PV module (Available from manufacturer's specifications)

| | |
|---|--------------------|
| Cell Type | CrystallineSilicon |
| Number of cells in a module | 60 |
| Current at maximum power (A) | 7.5 |
| Voltage at maximum power (V) | 30 |
| Short circuit current (A) | 8.3 |
| Open circuit voltage (V) | 36.4 |
| Area of the PV module (m ²) | 1.65 |



Cell Module Array

Fig. Illustration of a PV system: Cell=>Module=>Array

Area for PV

| | |
|-------------------------------------|-------|
| Percentage of roof area for PV (%) | 60 |
| Tilt angle from horizontal (degree) | 31.8 |
| Orientation | South |

Click the Calculate Photovoltaic Potential button below to start the simulation.

Calculate Photovoltaic Potential


CityBES Start District Buildings Benchmarking Retrofit Scenarios Renewables District Energy Simulate Team

Show Building Filters

Hide Building Coloring Options

| | |
|--------------------|-------------------------------|
| Parameter | Options |
| Result options | Photovoltaics Potential |
| Color buildings by | PV Generated Energy Intensity |
| Show summary by | Current result option |

Show Debug Options



Roof Area (m²)

- Small Office: 12.0%
- Medium Office: 2.6%
- Large Office: 7.7%
- Small Retail: 5.6%
- Medium Retail: 9.9%
- Full Service Restaurant: 14.7%
- Large Hotel: 47.5%

Total: 814,762 m²

PV Generated Energy (GWh)

- Small Office: 2.2%
- Medium Office: 13.9%
- Large Office: 7.0%
- Small Retail: 5.7%
- Medium Retail: 8.3%
- Full Service Restaurant: 13.6%
- Large Hotel: 49.2%

Total: 137.3 GWh

PV Generated Energy Intensity Unit: kWh/m²/roof area

- 79
- 88
- 97
- 107
- 116
- 126
- 135
- 144
- 154
- 163
- 173
- 182
- 191

Evaluate the photovoltaic potential of 8,665 buildings in Northeast San Francisco

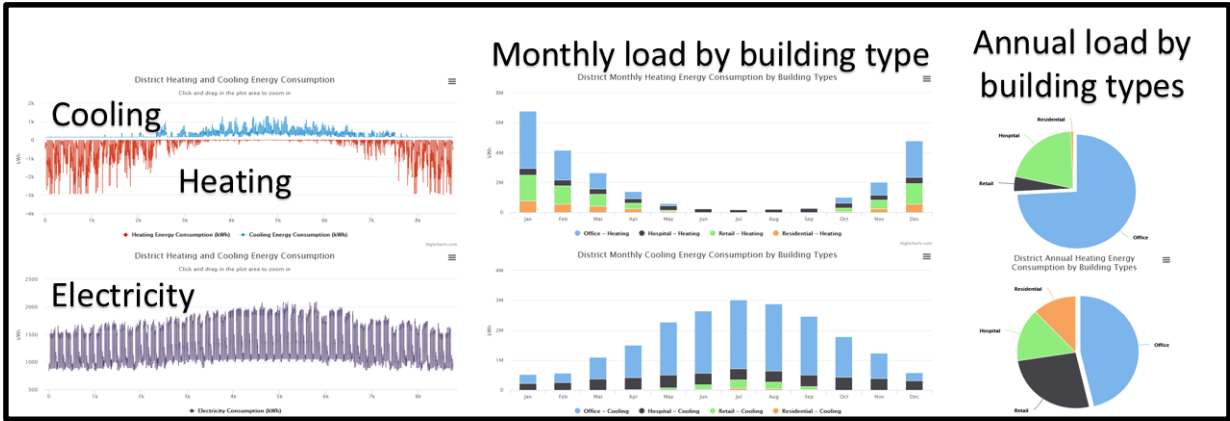
District Energy

(A feature in development)

Load profile inputs

Load profiles (simulation or user upload)

Load profile & heat recovery potential visualization



District systems assumptions

District System Simulation and Comparison

Please specify the systems you want to compare

Boiler and Chiller
 Inputs for Traditional Boiler and Chiller

Fuel Type: Natural Gas (dropdown) | Chiller Type: (dropdown)

Condensing Type: Condensing (dropdown) | Chiller IPLV: (input)

Boiler Efficiency (%): (input)

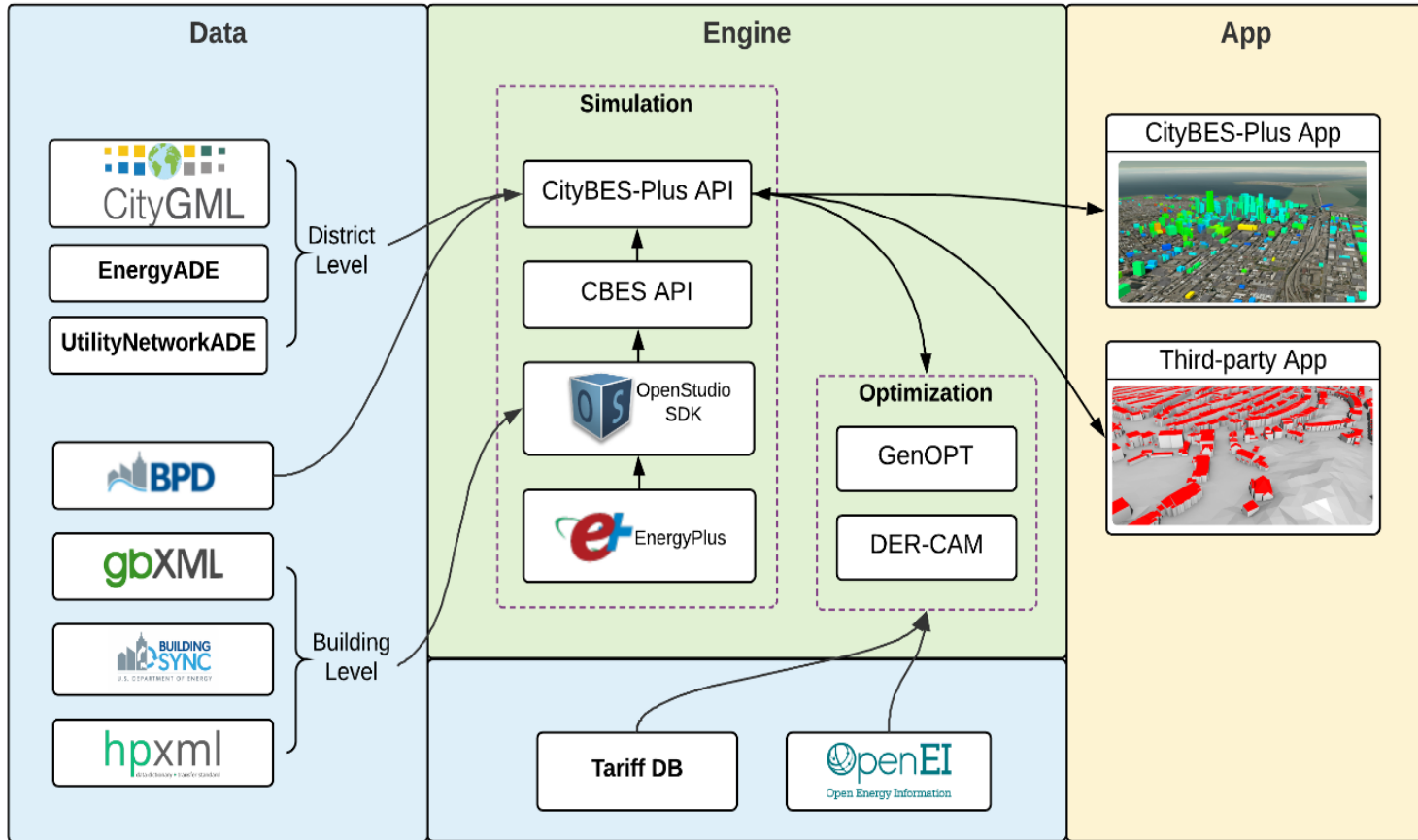
Combined Heat and Power
 Ground Source Heat Pump
 Other System

District system performance comparison

| | Boiler + Chiller | CHP | GSHP | ... |
|--------------------|------------------|-----|------|-----|
| Capital Cost | ... | ... | ... | ... |
| Operation Cost | ... | ... | ... | ... |
| NPV | ... | ... | ... | ... |
| Energy Consumption | ... | ... | ... | ... |
| GHG Emission | ... | ... | ... | ... |
| ... | ... | ... | ... | ... |

Future of CityBES

(A submitted DOE proposal)



Publications

1. Y. Chen, T. Hong, M.A. Piette. Automatic Generation and Simulation of Urban Building Energy Models Based on City Datasets for City-Scale Building Retrofit Analysis. **Applied Energy**, 2017.
2. R.Z. Pass, M. Wetter, M.A. Piette. A thermodynamic analysis of a novel bidirectional district heating and cooling network, **Energy**, 2017.
3. C. Weissmann, T. Hong, C.A. Graubner. Analysis of heating load diversity in German residential districts and implications for the applications in district heating systems. **Energy and Buildings**, 2017.
4. J. An, D. Yan, T. Hong, K. Sun. A novel stochastic modeling method to simulate cooling loads in residential districts. **Applied Energy**, 2017.
5. B. van der Heijde, M. Fuchs, C.R. Tugores, G. Schweiger, K. Sartor, D. Basciotti, D. Müller, C. Nytsch-Geusen, M. Wetter and L. Helsen. Dynamic equation-based thermo-hydraulic pipe model for district heating and cooling systems. **Energy Conversion and Management**, 151:158-169, 2017.
6. F. Buenning, M. Wetter, M. Fuchs, D. Mueller. Bidirectional low temperature district energy systems with agent-based control: Performance comparison and operation optimization. **Applied Energy**. 2017.
7. Y. Chen, T. Hong. Impacts of Building Geometry Modeling Methods on the Simulation Results of Urban Building Energy Models. **Applied Energy**, 2018.
8. Y. Chen, T. Hong, M.A. Piette. City-Scale Building Retrofit Analysis: A Case Study using CityBES. IBPSA Building Simulation Conference, San Francisco, August 2017.
9. T. Hong, Y. Chen, S.H. Lee, M.A. Piette. CityBES: A Web-based platform to support city-scale building energy efficiency. Urban Computing, August 2016, San Francisco.
10. R.Z. Pass, M. Wetter, M.A. Piette. A Tale of Three District Energy Systems: Metrics and Future Opportunities, ACEEE Summer Study Conference, 2016.

Acknowledgments

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- ◆ Research team: Mary Ann Piette, Xuan Luo, Han Li

Thank You

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