Public Tools to Improve Building Energy Efficiency

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### Summary

Small Business Voucher (SBV) paired National Laboratories with small companies

<table>
<thead>
<tr>
<th>Team</th>
<th>Lawrence Berkeley National Laboratory (LBNL)</th>
<th>Lucid, makers of BuildingOS.com</th>
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<tbody>
<tr>
<td></td>
<td>focused on engines</td>
<td>focused on user interface</td>
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<tr>
<th>Software Tools</th>
<th>City Building Energy Saver (CityBES)</th>
<th>BenchmarkMyBuilding.com</th>
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<th>Tools</th>
<th>Retrofit Analysis Software</th>
<th>Energy Conservation Measure (ECM) Database</th>
<th>buildingOS</th>
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<td></td>
<td>OpenStudio</td>
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<td><strong>10,000+ buildings, 1B+ ft²</strong></td>
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<td>across universities, corporations, real estate, government, cities, states</td>
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<td><strong>150+ integrations</strong></td>
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<td>with building hardware &amp; software systems</td>
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<td><strong>700+ customers</strong></td>
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<td>primarily building owners &amp; operators</td>
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City Building Energy Saver
(CityBES) by Lawrence Berkeley National Lab
How can the national labs help cities?

- Data management
- Prioritization
- Policy evaluation
- District-scale technical assistance
- Estimating NEBs
**Seattle:** Modeling effect of a gas-to-electricity mandate without building fuel data

**Boston:** Hired MIT Lincoln Labs to run DER-CAM to find promising micro-grid locations

**San Francisco, CA:** Made tool for citizens to spec home solar installations, don’t know who uses.

**NYC:** Made their own high rise typologies, modeled in eQuest.

**Washington DC:** Prioritizing district energy systems locations to reduce 100 peak hour use.
WHY CITIES?

- Cities drive our economy and dominate energy and environmental challenges.
- Not new end-uses or sectors, but new partnership opportunities with local governments.
IMAGINE A CITY…

…that consumes 50% less total energy per person while improving economic vitality and quality of life and increasing resilience and sustainability
WHAT ARE WE LEARNING?
WHY NOW?

- $40T in new urban infrastructure over the next 2 decades
- Aggressive energy targets
- Economic revitalization
HOW?

- Develop science-based, validated tools
  - Integrated measurement, data and analysis for city-scale, multi-sector models of energy, climate, land use

- Develop, evaluate and demonstrate new technology

- Establish partnerships
  - City and community leaders
  - Industry & NGOs
  - DOE resources and capabilities
WHAT?

- Cities as integrated, dynamic systems vs. places
- Resources and tools for energy planning and analysis — from buildings to transportation to grid
SUCCESS

- Develop, deploy, and validate new integrated technologies at scale, predict impacts on efficiency and sustainability, facilitate evaluation

- Optimize investments based on data-driven cost/benefit analysis across sectors
SUCCESS (CONT.)
WHY CITY BUILDINGS

• 30-70% city total primary energy
• Need deep retrofit and scale up
• Opportunity for integration

City Energy Profiles

GOAL: 50% primary energy reduction in city building stock by 2030
• Supports city/utility scale EE
• Open access web app
• Built upon CityGML

• Cloud computing architecture
• Large scale on-demand simulation
• Modeling, simulation, visualization
Visualizing the San Francisco energy ordinance dataset with 1,573 buildings: (1) filtering buildings by type, size, vintage, and (2) color-coding by EUI, CO₂ emission, ENERGY STAR score, compliance status.
CityBES – Building Retrofit Analysis

540 small/medium commercial buildings in San Francisco, 5 common ECMs Together save 22-48% of site energy per building LED upgrades, air economizer additions most cost effective Long payback for HVAC upgrade in mild climate
CBES (CBES.lbl.gov) is an energy retrofit analysis toolkit for small- and medium-size commercial buildings.
CityGML

International OGC standard for representation and exchange of 3D city models

Started 2002, v.2.0 in 2012

Multi-resolution model

Customization and extensibility
• Translate diverse city data sets into inter-operable, standardized format
• Collaborate with City of San Francisco
Acknowledgements

• Berkeley Lab’s Laboratory Directed Research and Development (LDRD) Program
• Department of Energy: Building Technologies Office, Office of Science
• City of San Francisco
• LBNL team: Mary Ann Piette, Yixing Chen, Xuan Luo
• DOE Labs: ANL, ORNL, NREL, PNNL
Why Was Free Benchmarking Tool Developed?

Our Goals

Leverage Existing Data:
- Energy Star Portfolio Manager
- Building Performance Database

Expansion of CBES:
- Provide national scope and infrastructure to integrate model-based retrofit and ECM engine into BuildingOS.com

Make Benchmarking More Accessible:
- Easy entry point to benchmarking portfolio
- Provide valuable information with basic input data
- Demonstrate dollar savings that are available by improving efficiency
Collaborative Approach
LBNL provided Lucid detailed understanding of DOE tool architecture, APIs, ECMs, facility types, characteristics, underlying analysis in CBES, PM, and BPD
LBNL provided Lucid design guidance and technical assistance to integrate desired benchmarking and ECM analysis capabilities into BuildingOS.com (coding examples, testing and verification process, user presentation).
Lucid leveraged Energy Star Target Finder & DOE BPD to create a public benchmarking web tool
LBNL expanded CBES functionality for applicability beyond CA climates and measures.

Key Issues
Architecture: Ensuring compatibility with cloud-based SaaS infrastructure
User Experience: Ability for users to understand the information and transform the information into actions
Unique Industry Benchmarking Tool

Leverage the most powerful building performance databases to find out where your building ranks.

- Three inputs for a basic benchmark report
- Add consumption and spend data for advanced comparisons
- Engaging and easy to understand outputs
- Access most complete building performance databases created in partnership with Lawrence Berkeley National Labs:
  - Energy Star Buildings Database
  - DOE Building Performance Database
Intuitive benchmark reports to show where you stand

See how you compare in relative and absolute terms to similar buildings across the country.

- Compare against the median and top-percentile (Energy Star):
  - Building energy costs, total and per square foot
  - Annual energy consumption
  - Site Energy Use Intensity (EUI)
  - Median building profile
- Position against the absolute scores of similar buildings (DOE):
  - Site Energy Use Intensity
10,000+ buildings across nation & world track their data with BuildingOS.com
Demos

CityBES.lbl.gov

BenchmarkMyBuilding.com
Questions?
Public Tools to Improve Building Energy Efficiency

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Appendix Slides
BenchmarkMyBuilding.com inputs

Free easy-to-use public benchmarking web tool to motivate the ‘why’ to act

Benchmark My Building web form:

1. Enter your building’s details
   - Building address: 304 12th Street, Oakland, CA 94607
   - Building type: Office
   - Building size: 35,000 square feet

2. Personalize your report (optional)
   - Include all energy sources for your building, such as electricity, natural gas, fuel oil, steam, chilled water, etc.
   - Annual building energy cost: $78,650 USD
   - Annual building energy consumption: 1,599,000 kBTU

3 INPUTS 1) Type, 2) Size, 3) Location

2 ENGINES

Benchmarking API

Energy Star Target Finder

DOE Building Performance Database

15+ OUTPUTS in REST JSON

Future Potential: Asset Score, BOMA
BenchmarkMyBuilding.com outputs

**Median Benchmarks**
from 3 inputs, type, size, location

- Median annual energy cost is $53,830
  for similar office buildings of 30,000 ft² in Oakland, CA

**Personalized Benchmarks**
from all 5 inputs, annual cost & consumption

- Similar buildings spend $60,798 - $93,500 less on energy annually compared to your building

**OUTPUTS**

- **data-driven**
  7k buildings from CBECS representative of 57M
  230k+ commercial buildings of metered & utility data

**Annual energy costs**
for a 35,000 ft² office building in Oakland, CA

- **Median**: $53,830
- **75th percentile**: $37,720
- **90th percentile**: $32,180

1. Bridges gap between finance & engineering
2. Transfers Data: Owner > City > DOE > BenchmarkMyBuilding Tool

Peer group data for 10,000-150,000 ft² office buildings with Warm/Marine climate conditions provided by U.S. Department of Energy Building Performance Database, compiled by Lawrence Berkeley National Laboratory.

We've found 2,345 buildings in your peer group.
Here's how they rank in the U.S. Department of Energy's database.

↑ 13% higher

Energy cost benchmarks for 35,000 ft² office building in Oakland, CA 94607 provided by the U.S. Environmental Protection Agency’s ENERGY STAR® Target Finder, a statistical model based on the Commercial Buildings Energy Consumption Survey (CBECS).

Benchmarks for a 35,000 ft² office building in Oakland, CA 94607 provided by the U.S. Environmental Protection Agency’s ENERGY STAR® Target Finder, a statistical model based on the Commercial Buildings Energy Consumption Survey (CBECS).
Multiscale Coupled Urban Systems – An Exascale Computing Project

- **Application Area**: Coupled computational models integrating urban systems such as atmosphere, buildings, transportation, and social/economics.

- **Challenge Problem**: Support urban design and operations, at multiple scales (district, building, vehicles) through coupled models capturing interdependencies between urban systems and activities.

- **USDOE Office of Science**

- **Five national labs**: ANL, LBNL, ORNL, NREL, PNNL

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This work will provide insights to:
- Impacts of greenhouse gases (GHG) on local climate
- Resulting impacts on city function
- Incorporation of renewables into city energy portfolio
- Resilience of physical infrastructure
- Economic protection, resilience, and enhancement
Challenges

1. **Data**
   A big data problem integrating diverse sources with different temporal and spatial resolutions, quality, and structure/format.

2. **Modeling**
   Integration of multiple domain models with different scales and resolutions.

3. **Simulation**
   An exascale computing problem.