U.S. DEPARTMENT OF ENERGY

Office of ENERGY EFFICIENCY & RENEWABLE ENERGY

# Accelerating Energy Savings in Commercial Buildings with CBES & Lucid

2018 Building Technologies Office Peer Review / Project TCF-17-13293


**Team** / Lawrence Berkeley National Laboratory (LBNL) and Lucid

**Tianzhen Hong** / Staff Scientist, LBNL / thong@lbl.gov

**Josh Wentz** / Director of Product & Engineering, Lucid / josh@luciddg.com

# Project Summary

## TEAM

Lawrence Berkeley National Laboratory (LBNL)
**Tianzhen Hong**, *Lead Scientist*
**Yixing Chen**, *Lead Programmer*

Lucid, makers of BuildingOS.com
**Josh Wentz**, *Director of Product & Engineering*
**Gavin Platt**, *Product Designer*
**Nathan Gould**, *Data Scientist & Engineer*
**Susie McMullen, Will Finnie**, *Product Managers*

## BUDGET

**"Technology Commercialization Fund" (TCF):** $300K
**Total Project Funding:** DOE: $150k Cost Share: $150k
**Total Project Funding (to date):** DOE: $75k Cost Share: $90k

## TIMELINE


## OUTCOME

The project succeeds in commercializing key Department of Energy software packages.

1. **Expansion of CBES Pro to provide RESTFul APIs:** expand the CBES Pro to provide web-based RESTFul APIs to facilitate the integration with BuildingOS.com.
2. **Integration of CBES Pro with BuildingOS platform:** integrate CBES Pro with BuildingOS.com to enable automatic physics-based modeling and evaluation of retrofit measures for portfolios of buildings to achieve large scale and deep energy savings.
3. **Enhancement of CBES Pro based on market needs:** expand CBES Pro to include more building types, including large hotels and primary schools.

# Team

| | | |
|---|---|---|
| **TEAM** | **Lawrence Berkeley National Laboratory** (LBNL)<br>Building Technologies & Urban Systems Division<br>Founded **1931** | **Lucid**, an Acuity Brands company<br>**45**+ Lucid employees, **12K**+ Acuity employees<br>Founded **2004**, Funded **2014**, Acquired **2018** |
| **Software Tools** | **Commercial Building Energy Saver** (CBES) | **BenchmarkMyBuilding** (free)<br>**buildingOS** (paid) |
| | Focused on "engines"<br>Retrofit Analysis Software<br>Energy Conservation Measure (ECM) Database<br>Builds upon:<br>OpenStudio<br>EnergyPlus | Focused on "user interfaces"<br>**700**+ customers<br>primarily building owners & operators<br>**15,000**+ buildings, **1B**+ ft$^2$<br>across universities, corporations, real estate, government, cities, states<br>**150**+ integrations<br>with building hardware & software systems |

# Challenges

**TARGET MARKET**

**5.7M** commercial buildings comprising **87B** sq.ft. in the U.S.

*Accounting for 4.5 trillion BTU per year, 40% of all U.S. emissions of greenhouse gases.*
*According to Energy Star, commercial buildings waste 30% of that energy.*
*Audience: Building owners & operators.*

## PROBLEM DEFINITION

1. Commercial Analytics Doesn't Address Retrofit Needs. Ongoing analytics tools enable operational savings of 10%+, yet do not rigorously address retrofit measures.

1. Lack of Commercialization. Building software companies have yet to commercialize benchmarking and retrofit analytics on a broad scale.

1. Current tools are siloed and hard to use, requiring expertise and significant effort.

## PROGRAM GOALS

1. Deep energy savings of existing buildings through retrofits at large scale.

2. Commercialize technology broadly across the market

## SOLUTIONS

1. Enable CBES to provide RESTFUL APIs to integrate model-based retrofit and ECM engine into BuildingOS.com

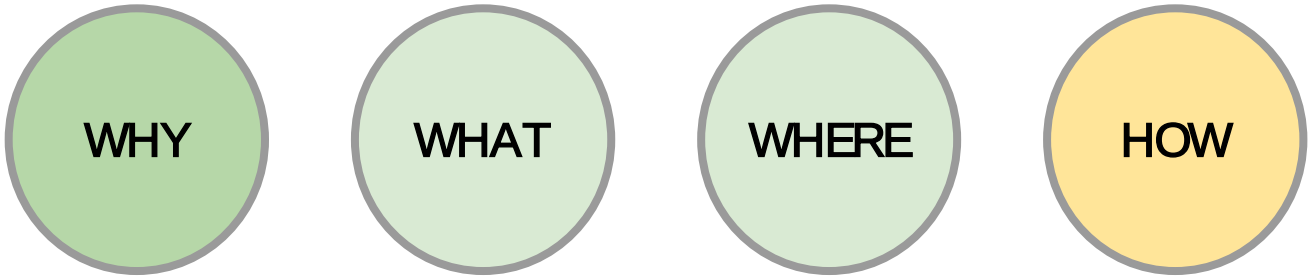
2. Integrate CBES Pro API with BuildingOS platform

3. Expand CBES to cover more building types

# Approach

KEY | Represented in Market | Gap in Market

**MUTUAL MISSION** — Reduce the energy use of buildings on a broad scale.




**ANSWERS**

| MONEY | TRACK | COMPARE | IMPLEMENT |
|---|---|---|---|
| Save money, lots of money. | your data. | across your portfolio. Submeter each building. | ECMs that work for your building profile. |

**DOE SBV** — "Small Business Voucher" → **DOE TCF** — "Technology Commercialization Fund"

2016 - 2017 → 2017 - 2018

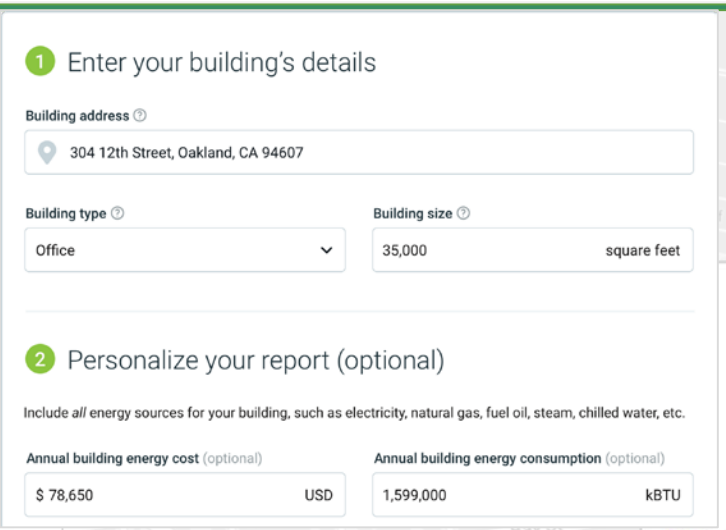
BenchmarkMyBuilding.com | BuildingOS.com | BuildingOS.com | CBES + BuildingOS.com

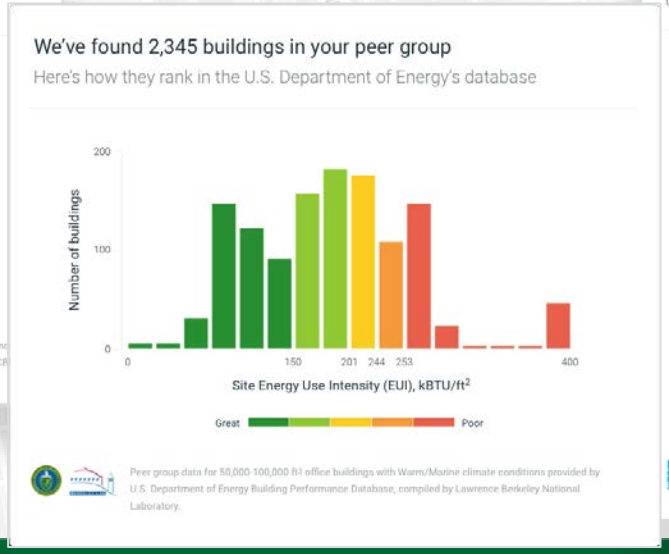
# BenchmarkMyBuilding.com (DOE SBV outcome)

WHY

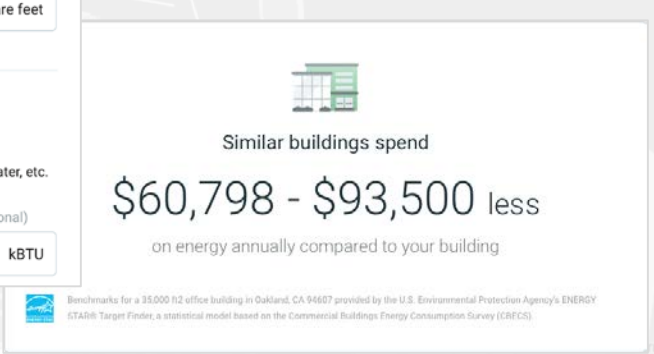
## Median Benchmarks






## Personalized Benchmarks





KEY

Represented in Market

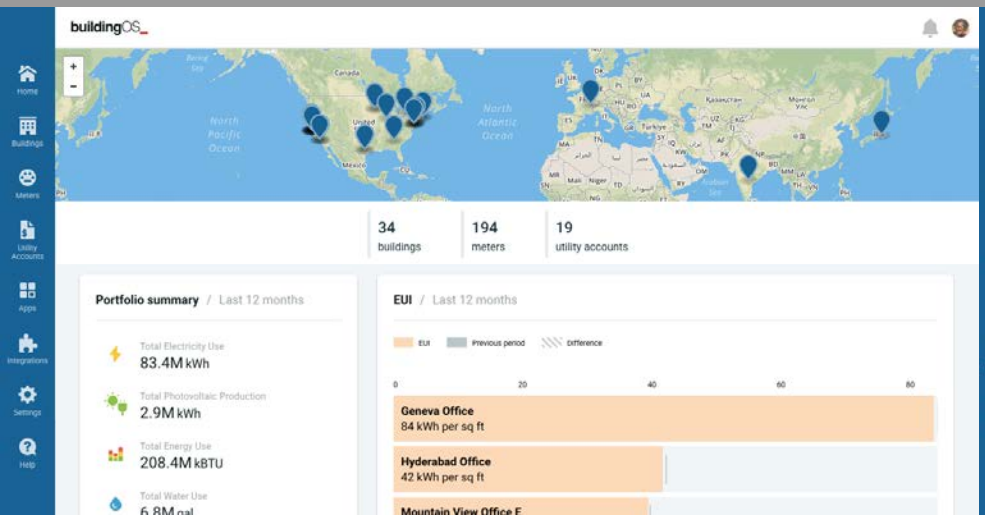
MACH ENERGY · WAYPOINT · EnergyCAP · eSightenergy · SWITCH AUTOMATION

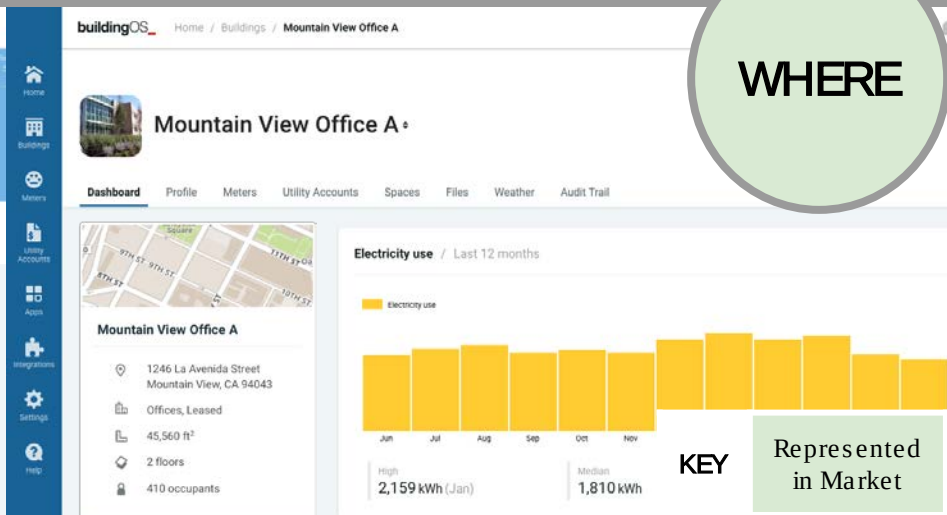
# WHAT


**150+** building hardware & software integrations

**15,000+** buildings across the nation & world track data with BuildingOS.com

# WHERE

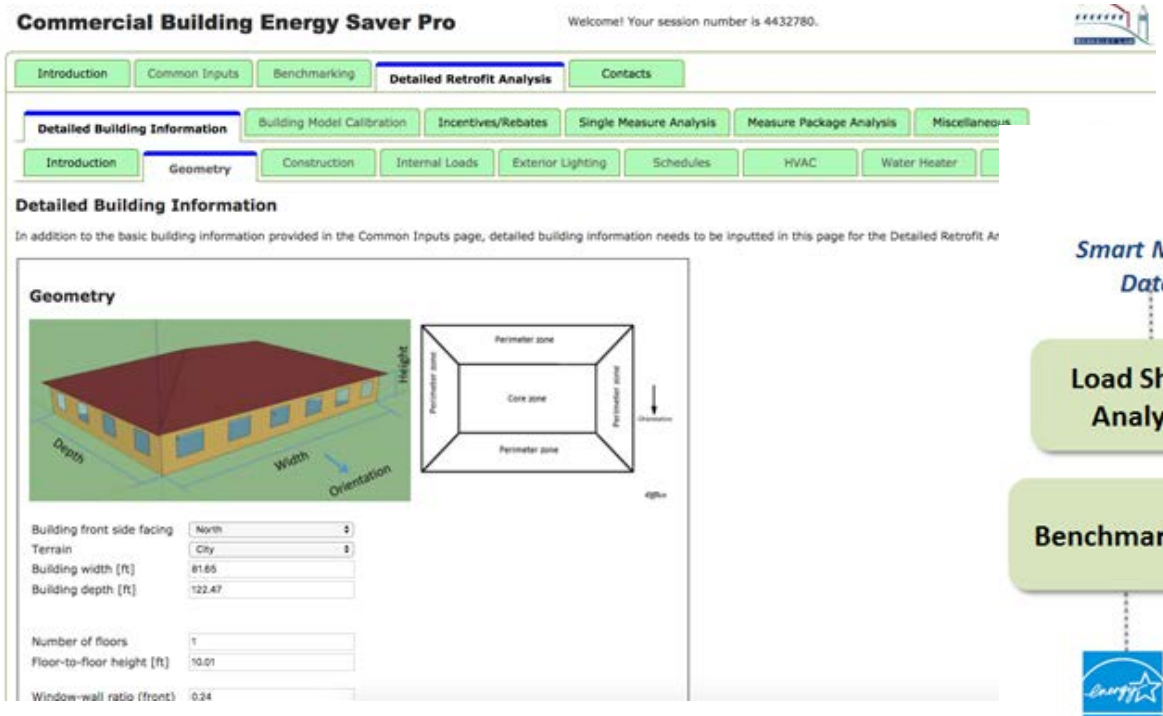


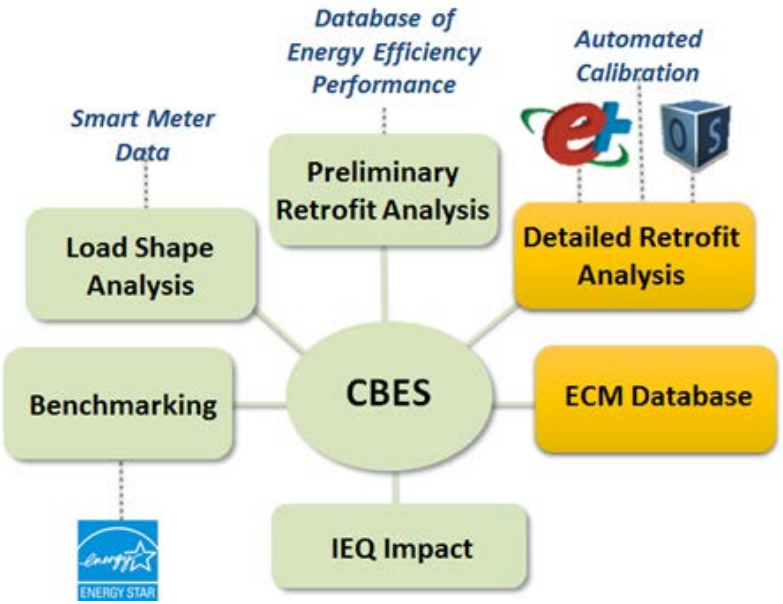



# Commercial Building Energy Saver (CBES)

HOW

CBES is a web-based software toolkit for model-based building energy retrofit analysis. It currently covers small-medium sized commercial buildings and uses a database of 82 energy conservation measures.




WHY

WHAT

WHERE

EASY HOW

KEY

Gap in Market

# Progress / Before & After Overview

KEY: Existing Features | To Do via DOE TCF

| Web App | BenchmarkMyBuilding.com | CBESPro.lbl.gov | buildingOS_.com |
|---|---|---|---|
| Audience | Simple | Technical | Simple + Technical |
| Availability | Free + Public | Free + Licensed | Paid Subscription |
| User Interface | Cost Savings Outputs | Advanced Inputs & Output Tables | Dashboards |
| lucid | "Top 5 ECMs" by building type, size, location | | Advanced Inputs & ECM Outputs Cards |
| Engines | Energy Star Target Finder | CBES Engine | CBES Integration (full) |
| | DOE Building Performance Database | | |
| | CBES Integration (ECM Database only) | CBES Engine Enhancements (on top of OpenStudio + EnergyPlus) | |
| Servers | Lucid | LBNL | Lucid |
| lucid | *CBES production server deployment | | *CBES production server deployment |
| Answers | the "Why" | the "How" | the "What", "Where", "How" |

# Progress / DOE TCF Tasks

KEY | Done | To Do via DOE TCF

**Engine**
- CBES Enhancements
- CBES RESTFul APIs

**User Interface**
- Production-Grade Integration
- Building Profile Inputs / ECM Outputs Design

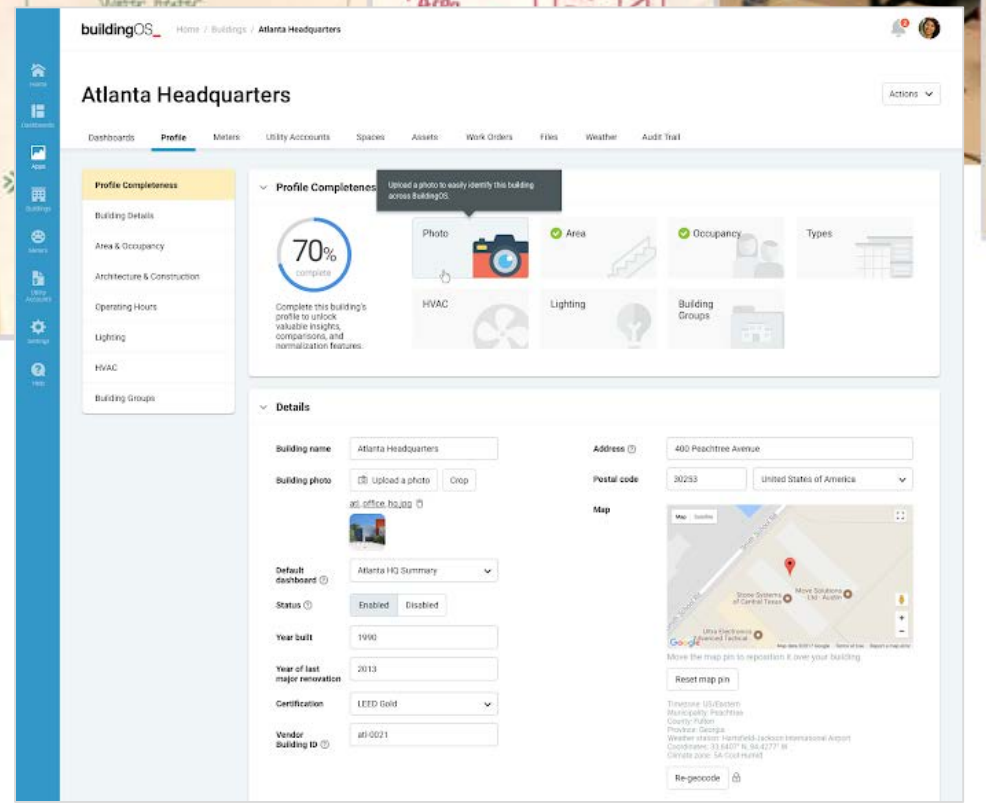
**CBES**
Model-based retrofit analysis

**Servers**
Cloud infrastructure deployment

# Progress / User Interface Design


BuildingOS Inputs


BuildingOS (&) BenchmarkMyBuilding Outputs



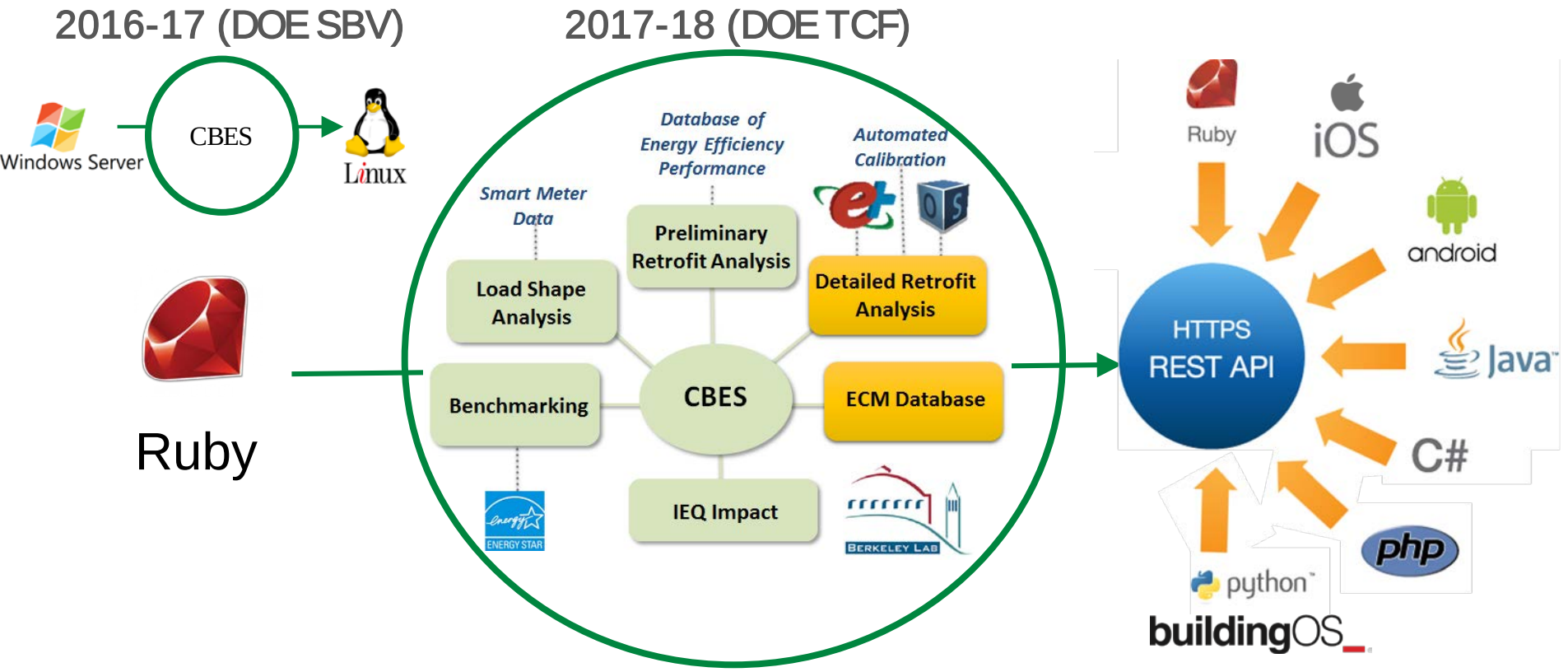

**Top Recommended ECMs for Brick, Inc.**

| Project | Estimated savings |
|---|---|
| Replace existing lighting with T8 upgrade (0.7 W/sf) | $800,000 one-time |
| Single zone rooftop unit efficiency upgrade (SEER 14) | $340,000/year |
| Widen zone temperature deadband (cooling: +2F; heating: -2F) | $290,000/year |
| Plug load efficiency upgrade (25% efficient from Baseline) | $220,000/year |
| Apply cool roof coating with reflectivity (0.4) | $150,000/year |
| Efficiency upgrade of the gas storage water heater (0.93) | $130,000/year |
| Improve water tank insulation | $80,000/year |
| Packaged unit VAV unit efficiency upgrade (SEER 12.5) | $60,000/year |
| Lower VAV box minimum flow setpoints (25%) | $50,000/year |

See defaulted inputs &assumptions.

# Progress / CBES Engine REST API

Commercial Building Energy Saver (CBES) Pro ported from Ruby-based Software Development Kit (SDK) to Web-based REST (Representational State Transfer) APIs, enabling the integration using any major languages.



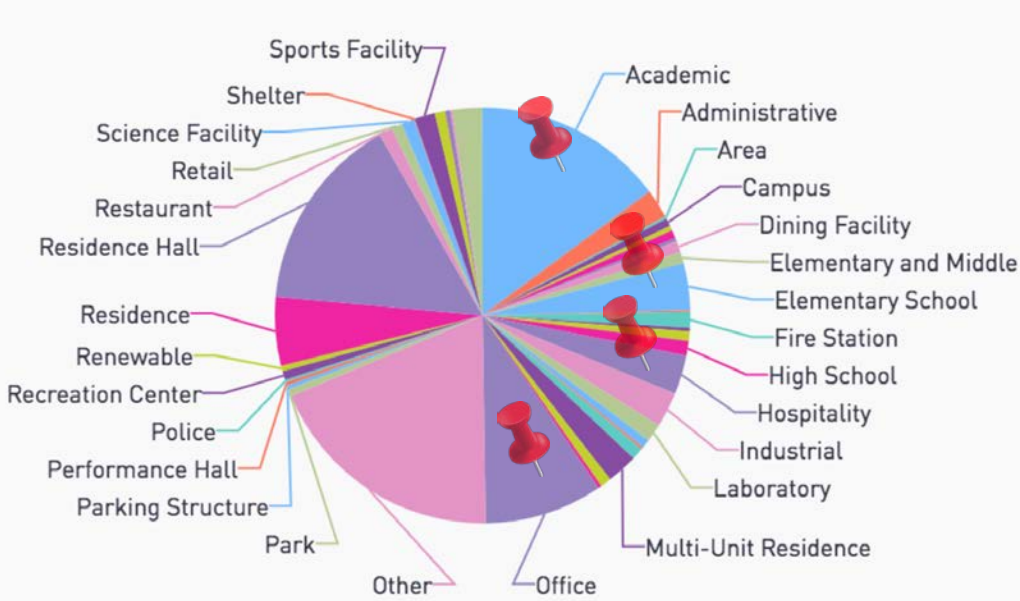

HOW can I save energy? Implement Energy Conservation Measures tailored to your building profile via CBES/OpenStudio/EnergyPlus. Accomplishment: Expanded coverage + scaled codebase.

# Progress / CBES Engine Enhancements

KEY: Done | To Do via DOE TCF

Commercial Building Energy Saver (CBES) Pro expanded coverage for new building types and energy conservation measures (ECMs).

| BUILDING TYPES & ECMs | |
|---|---|
| *BEFORE TCF* | *AFTER TCF* |
| Small Office<br>Medium Office<br>Large Office<br>Small Retail<br>Medium Retail<br>Mixed-use (office and retail) | Small Office<br>Medium Office<br>Large Office<br>Small Retail<br>Medium Retail<br>Mixed-use (office and retail)<br><br>Large Hotel (done)<br>Primary School (in progress) |
| 82 ECMs | 85+ ECMs<br>3+ new ECMs for Primary School (in progress) |




# Buildings by Building Type in buildingOS

CBES provides model-driven outputs via OpenStudio and EnergyPlus.

# Impact



MARKET

**5.7M** commercial buildings comprising **87B** sq.ft. in the U.S.

*Audience: Building owners & operators.*

IMPACT

1. Save time: building managers or operators currently have to spend significant amount of time and resources to analyze potential ECMs for retrofit

1. Accelerate retrofit projects: leverage energy modeling to provide building operators with an incentive and business case to drive new projects

1. Direct technology transfer for use in **1 Billion** sq.ft. of commercial building space through Lucid's current customer base

1. Operational analytics paired with retrofit assessment accessible to building owners to enable comprehensive capital efficiency improvements on the order of 15-50%

# Stakeholder Engagement

## PROJECT CONTENTS WILL BE RELEASED TO THE:

- Public: anyone can use the public BenchmarkMyBuilding.com tool
- 15,000+ buildings, 1B ft$^2$, 700+ building owners/operator customers: for all of Lucid's current and prospective customers via BuildingOS.com


## ENGAGEMENT

- FEB 2018: User interface design session with 10+ stakeholders
- APR 24-26, 2018: CxEnergy conference speaker
- MAY 7-9, 2018: Smart Cities Week, Silicon Valley, conference speaker
- AUG 2018: Anonymous user test conducted with building operators
- SEP 18-19, 2018: Connected Buildings Summit, SF
- SEP 30, 2018: Launch webinar for the public
- FUTURE: Conferences of ACEEE, ASHRAE, etc

# Remaining Work & Future Plans

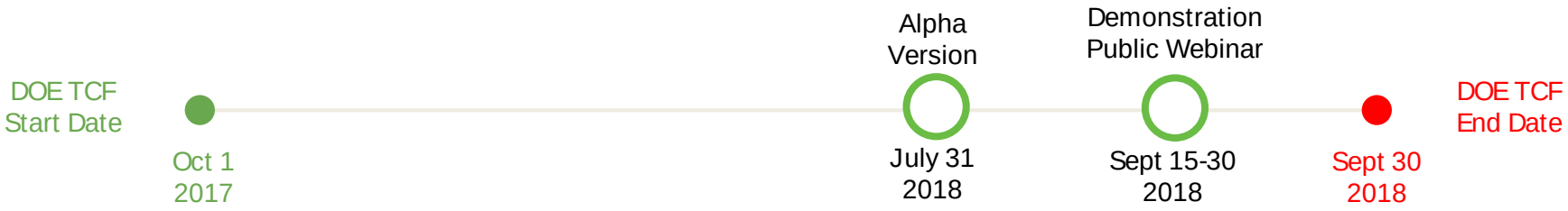
HOW

**Engine**
- CBES Enhancements
- CBES RESTFul APIs

**User Interface**
- Production-Grade Integration
- Building Profile Inputs / ECM Outputs Design

**CBES**
Model-based retrofit analysis

**Servers**
cloud infrastructure deployment




**Future Plans (beyond DOE TCF):** A proposal has been submitted to CEC EPIC GFO-17-308: Bringing Rapid Innovation Development to Green Energy (BRIDGE) to continue LBNL & Lucid collaborations and expand CBES APIs for portfolio level building retrofit analysis.

# Thank You

**Tianzhen Hong** / Staff Scientist, LBNL / thong@lbl.gov
**Josh Wentz** / Director of Product & Engineering, Lucid / josh@luciddg.com

# Reference Slides

# Project Budget

**Project Budget**: $150k LBNL (DOE) + $150k Lucid (In-Kind)
**Variances**: None
**Cost to Date**: $75k LBNL + $90k Lucid
**Additional Funding**: NA

| Budget History | | | | | |
|---|---|---|---|---|---|
| FY2017 (past) | | FY2018 (current) | | FY2019 (planned) | |
| DOE | Cost-share | DOE | Cost-share | DOE | Cost-share |
| NA | NA | $150k | $150k | NA | NA |

# Project Plan and Schedule

- Initiation date: October 1, 2017
- Completion date: September 30, 2018