

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

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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

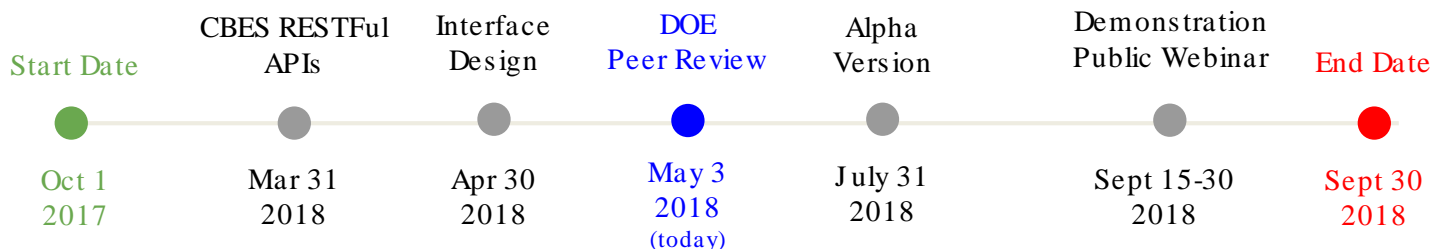
Total Project Funding:

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)
Building Technologies & Urban Systems Division
Founded 1931



Lucid, an Acuity Brands company
45+ Lucid employees, 12K+ Acuity employees
Founded 2004, Funded 2014, Acquired 2018

Software Tools

Commercial Building Energy Saver (CBES)

Focused on “engines”
Retrofit Analysis Software
Energy Conservation Measure (ECM) Database
Builds upon:



OpenStudio



EnergyPlus

BenchmarkMyBuilding (free) buildingOS_ (paid)

Focused on “user interfaces”
700+ customers
primarily building owners & operators
15,000+ buildings, 1B+ ft²
across universities, corporations, real estate,
government, cities, states
150+ integrations
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.

BARRIERS

WHY

WHAT

WHERE

HOW

Why do I care?

What can I do?

Where should I
focus?

How can I do it?

ANSWERS

MONEY

Save money,
lots of money.

TRACK

your
data.

COMPARE

across your portfolio.
Submeter each
building.

IMPLEMENT

ECMs that work for
your building profile.

DOE SBV

"Small Business
Voucher"

2016 - 2017

BenchmarkMyBuilding.com

TRACK

your
data.

BuildingOS.com

COMPARE

across your portfolio.
Submeter each
building.

BuildingOS.com

DOE TCF
"Technology
Commercialization
Fund"

2017 - 2018

CBES + BuildingOS.com

BenchmarkMyBuilding.com (DOE SBV outcome)

WHY

Median Benchmarks

Median annual energy cost is

\$53,830

for similar office buildings of 30,000 ft² in Oakland, CA

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).

Personalized Benchmarks

Similar buildings spend

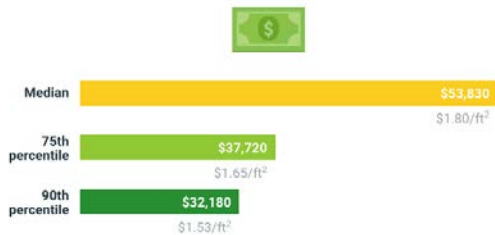
\$60,798 - \$93,500 less

on energy annually compared to your building

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).

Annual energy costs

for a 35,000 ft² office building in Oakland, CA



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).

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 (optional)

\$ 78,650

USD

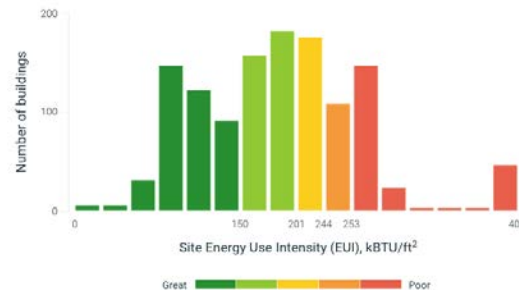
Annual building energy consumption (optional)

1,599,000

kBTU

We've found 2,345 buildings in your peer group

Here's how they rank in the U.S. Department of Energy's database



Peer group data for 50,000 100,000 ft² office buildings with Warm/Moderate climate conditions provided by U.S. Department of Energy Building Performance Database, compiled by Lawrence Berkeley National Laboratory.

Your building's annual energy costs

compared to similar buildings in the 75th percentile



Energy cost benchmarks for 35,000 ft² office buildings in Oakland, CA 94607 provided by U.S. Environmental Protection Agency Energy Star Target Finder®.

WHAT

buildingOS

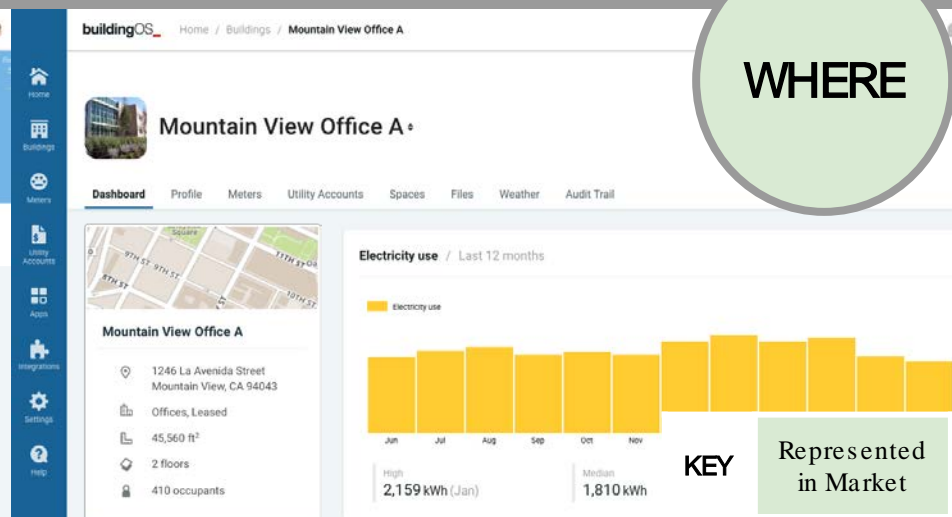
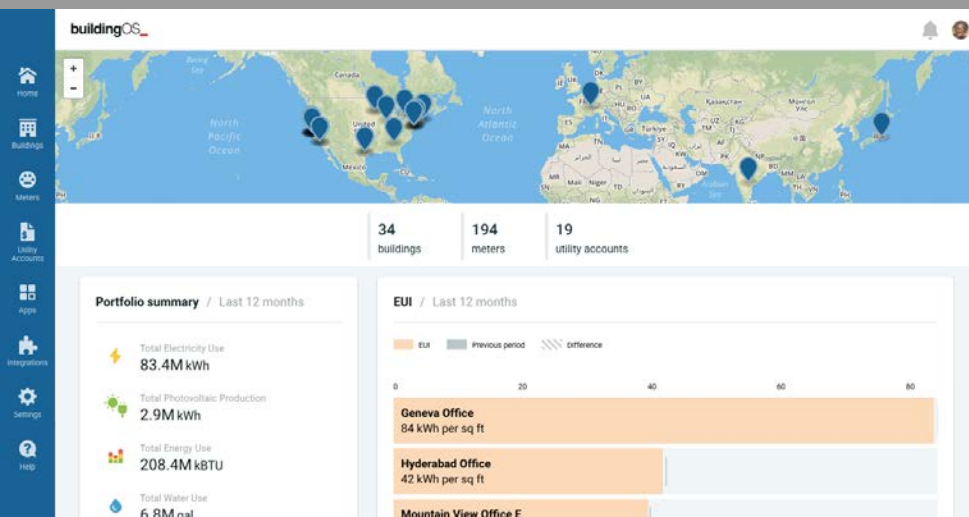
Utility
Bills

Weather
Data

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.

Commercial Building Energy Saver Pro Welcome! Your session number is 4432780.

Introduction Common Inputs Benchmarking **Detailed Retrofit Analysis** Contacts

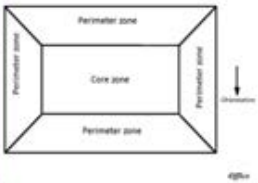
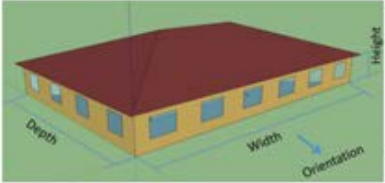
Detailed Building Information Building Model Calibration Incentives/Rebates Single Measure Analysis Measure Package Analysis Miscellaneous

Introduction **Geometry** Construction Internal Loads Exterior Lighting Schedules HVAC Water Heater

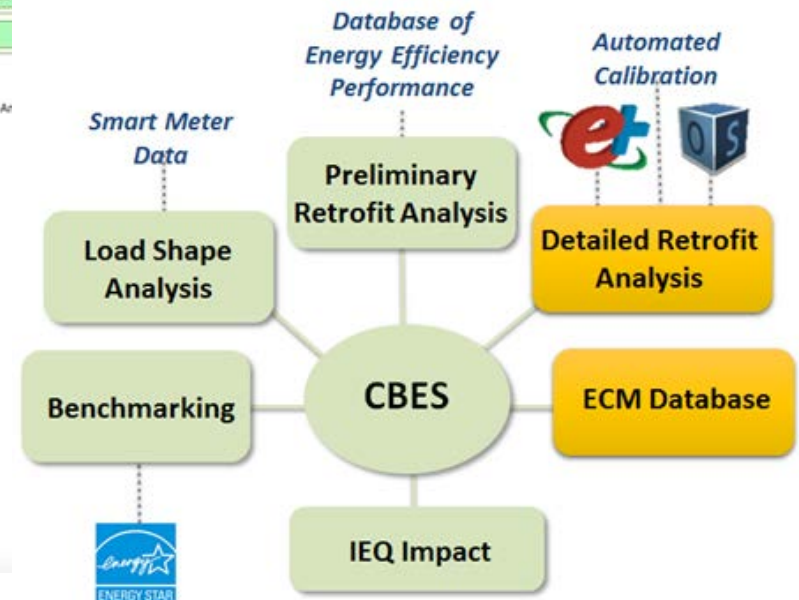
Detailed Building Information

In addition to the basic building information provided in the Common Inputs page, detailed building information needs to be inputted in this page for the Detailed Retrofit Analysis.

Geometry



Building front side facing: North
Terrain: City
Building width [ft]: 81.65
Building depth [ft]: 122.47
Number of floors: 1
Floor-to-floor height [ft]: 10.01
Window-wall ratio (front): 0.24



WHY

WHAT

WHERE

EASY
HOW





...

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	<div>Cost Savings Outputs</div> <div>  "Top 5 ECMs" by building type, size, location </div>	<div>Advanced Inputs & Output Tables</div>	<div>Dashboards</div> <div>Advanced Inputs & ECM Outputs Cards</div>
Engines	<div>  Energy Star Target Finder DOE Building Performance Database </div> <div>CBES Integration (ECM Database only)</div>	<div>CBES Engine</div> <div>  CBES Engine Enhancements (on top of OpenStudio + EnergyPlus) </div>	<div>CBES Integration (full)</div>
Servers	<div>Lucid</div> <div>  *CBES production server deployment </div>	<div>LBNL</div>	<div>Lucid</div> <div>*CBES production server deployment</div>
Answers	the "Why"	the "How"	the "What", "Where", "How"



Engine

CBES Enhancements



CBES RESTFul
APIs



CBES

Model-based retrofit analysis



User Interface

Production-Grade
Integration



Building Profile
Inputs / ECM
Outputs Design



Servers

Cloud infrastructure deployment



DOE TCF
Start Date

Oct 1
2017

CBES RESTFul
APIs



Mar 31
2018

Interface
Design



Apr 30
2018

DOE
Peer Review



May 3
2018
(today)

Alpha
Version



July 31
2018

Demonstration
Public Webinar



Sept 15-30
2018

DOE TCF
End Date

Sept 30
2018

Progress / User Interface Design



BuildingOS
Inputs

Design Charette / Design Thinking



BuildingOS (&
BenchmarkMyBuilding
Outputs

buildingOS_ Home / Buildings / Atlanta Headquarters

Atlanta Headquarters

Dashboards Profile Metrics Utility Accounts Spaces Assets Work Orders Files Weather Audit Trail

Profile Completeness

Building Details

Area & Occupancy

Architecture & Construction

Operating Hours

Lighting

HVAC

Building Groups

Profile Completeness

Upload a photo to easily identify this building across BuildingOS.

70% complete

Complete this building's profile to unlock valuable insights, comparisons, and normalization features.

Photo

Area

Occupancy

Types

HVAC

Lighting

Building Groups

Details

Building name: Atlanta Headquarters

Address: 480 Peachtree Avenue

Building photo: Upload a photo

Postal code: 30253

Map

Default dashboard: Atlanta HQ Summary

Status: Enabled

Year built: 1990

Year of last major renovation: 2013

Certification: LEED Gold

Vendor Building ID: at-0021

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

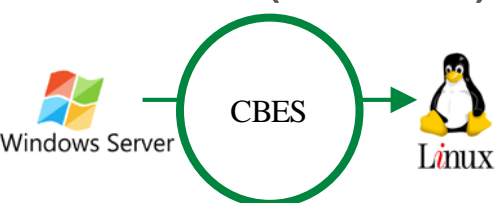


i See defaulted inputs & assumptions.

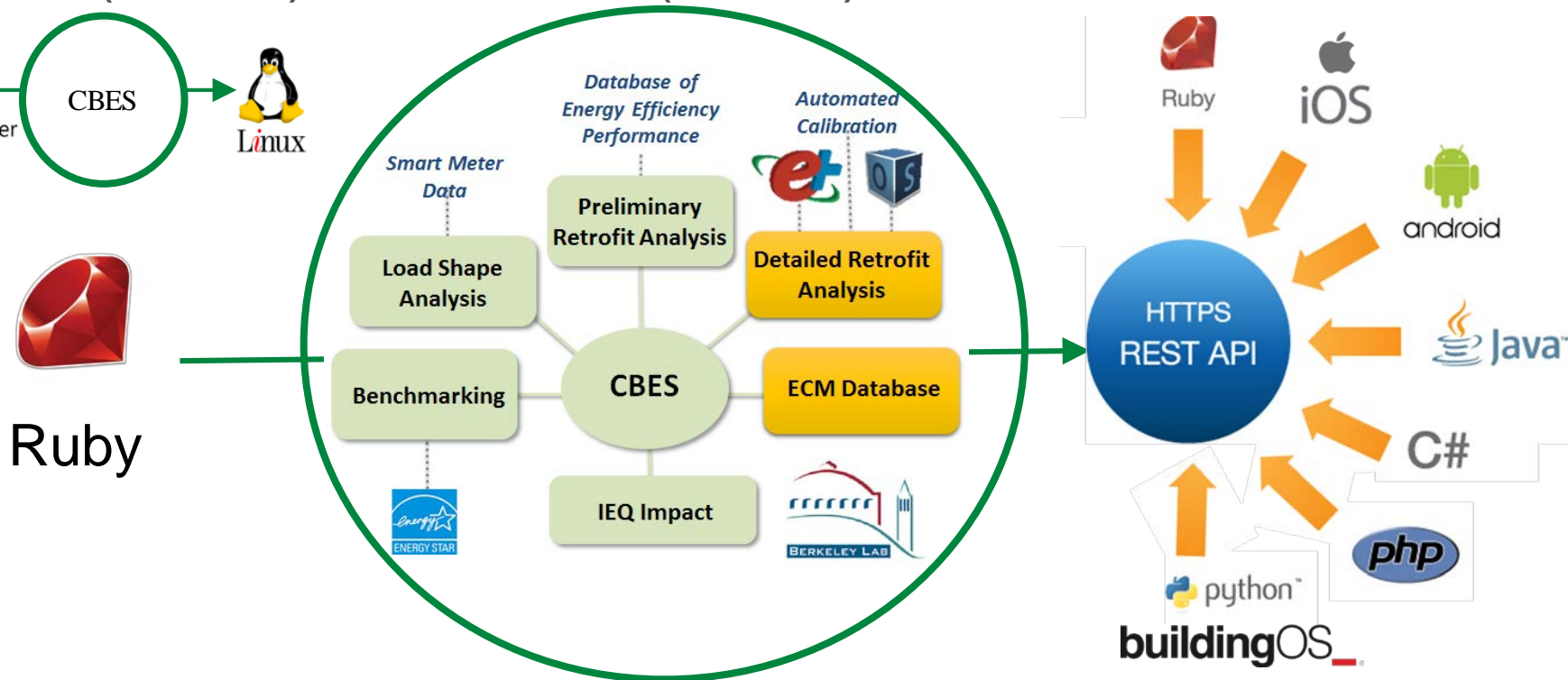
Progress / CBES Engine REST API

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.

2016-17 (DOE SBV)



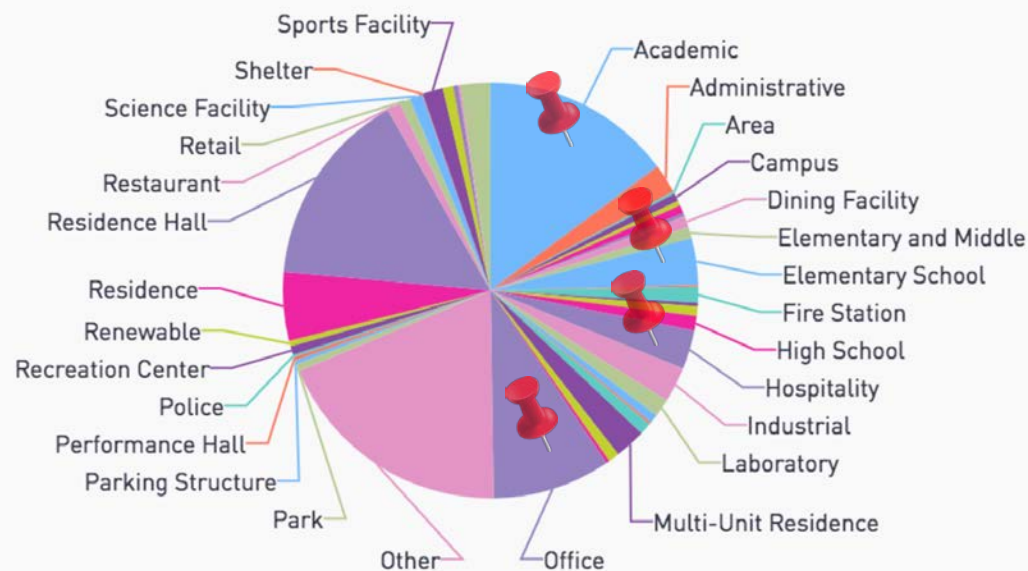
2017-18 (DOE TCF)



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

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 Medium Office Large Office Small Retail Medium Retail Mixed-use (office and retail)	Small Office Medium Office Large Office Small Retail Medium Retail Mixed-use (office and retail) Large Hotel (done) Primary School (in progress)
82 ECMs	85+ ECMs 3+ new ECMs for Primary School (in progress)



Buildings by Building Type in **buildingOS**.



CBES provides model-driven outputs via OpenStudio and EnergyPlus.



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 ft², 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



lucid™

Engine

CBES Enhancements



CBES RESTful
APIs



CBES

Model-based retrofit analysis



User Interface

Production-Grade
Integration



Building Profile
Inputs / ECM
Outputs Design



Servers

cloud infrastructure deployment



DOE TCF
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Public Webinar



Sept 15-30
2018

DOE TCF
End Date



Sept 30
2018

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

