Small and Medium Building Efficiency Toolkit and Community Demonstration Program

Commercial Building Energy Saver Pro (CBESPro)

Mary Ann Piette, Tianzhen Hong, Kaiyu Sun

Building Technology and Urban Systems Division

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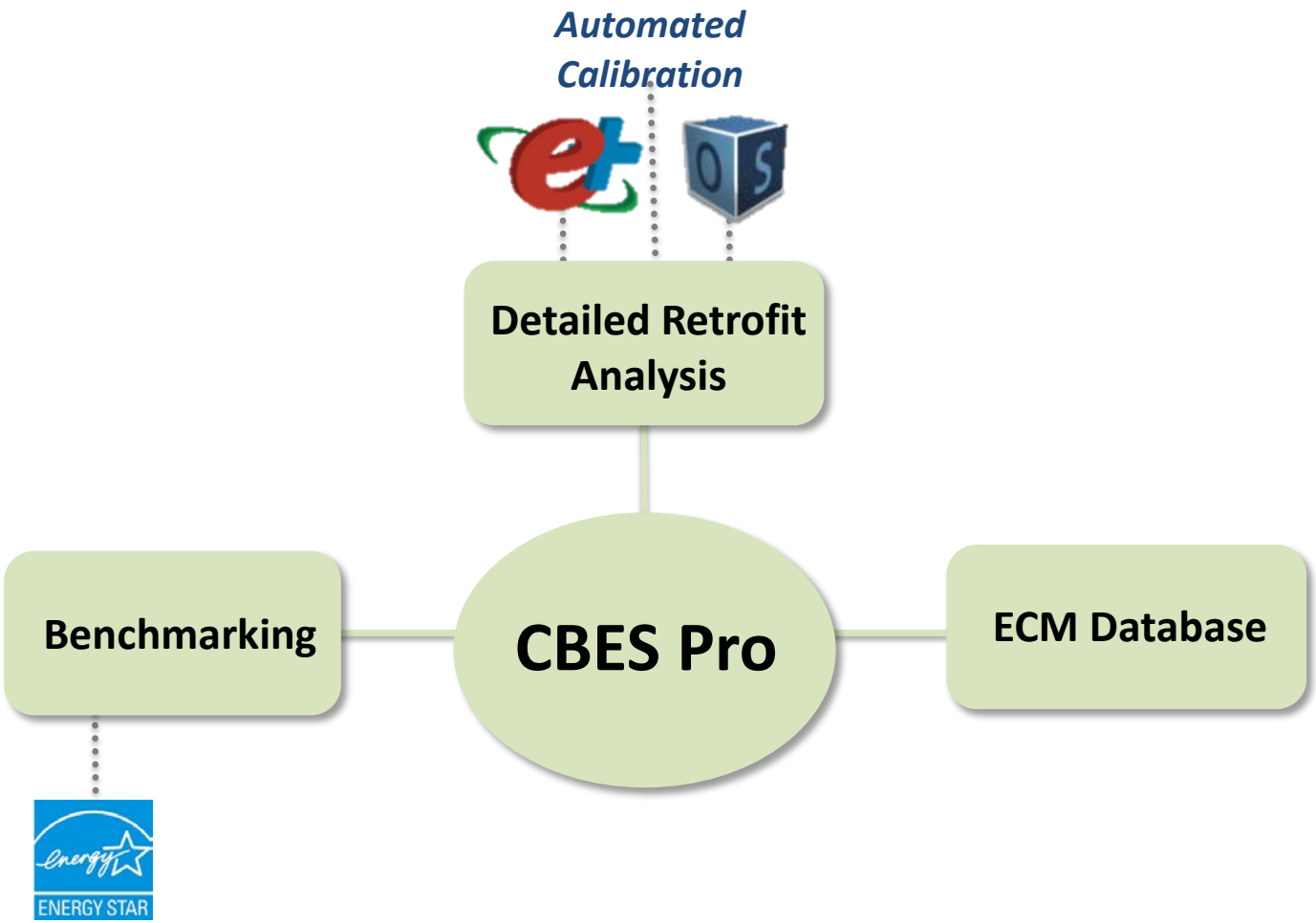
BEST Workshop

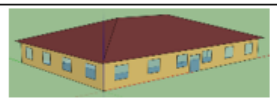
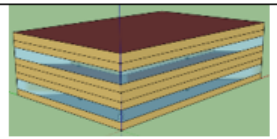
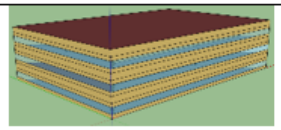
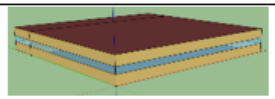
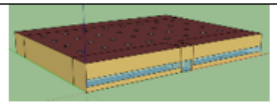
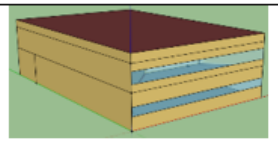
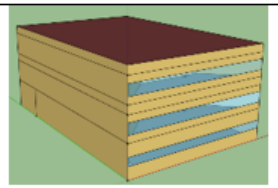
Project Objectives

1. Develop web-based software toolkit for use by small businesses and by owners and operators.
2. Identify retrofit measures and related incentives to improve efficiency and save energy and cost.
3. Deploy and demonstrate CBES Toolkit in partnership with cities and energy service providers.

CBESPro Key Components

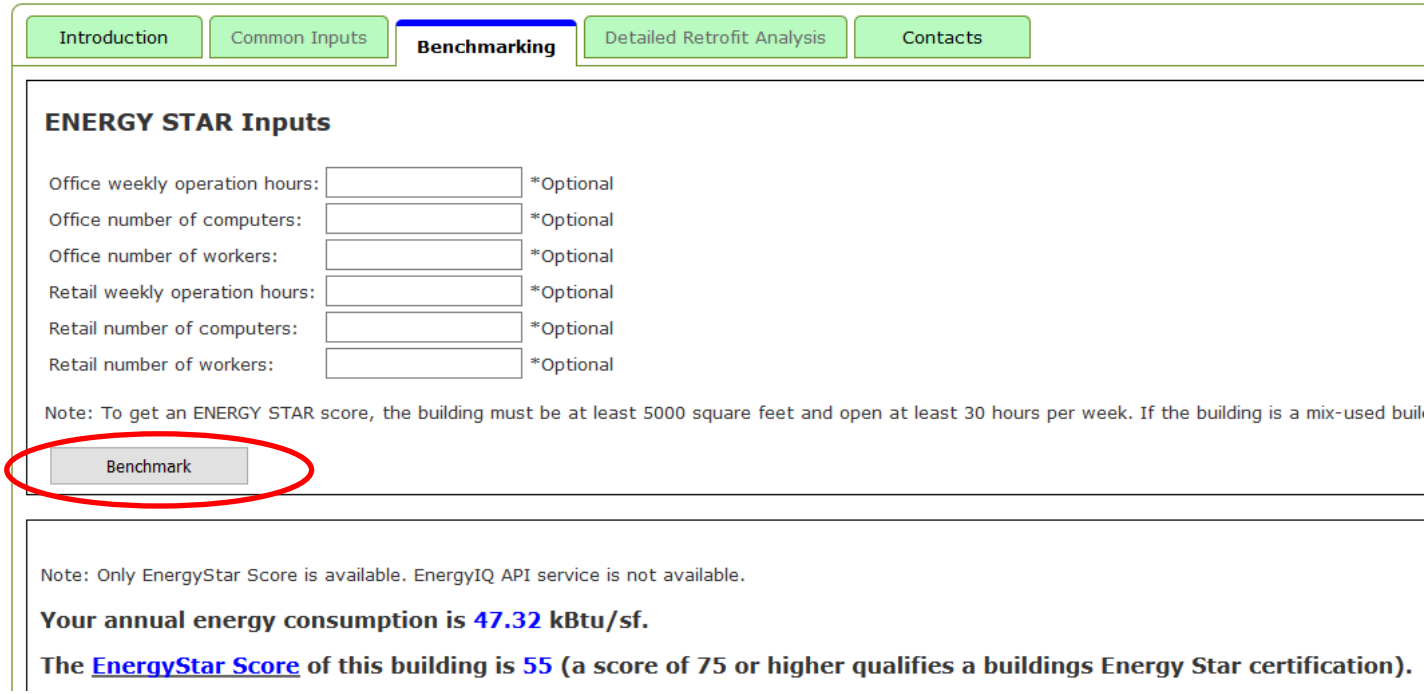


7 Basic Prototype Buildings

Prototype Buildings					
Building types		Gross floor area (m^2 / ft^2)	Forms	Climate zones	Vintages
Office	Small 1-story	511 / 5,500		Los Angeles, CA San Francisco, CA San Jose, CA Denver, CO Stamford, CT Ann Arbor, MI Detroit, MI Albuquerque, NM Cleveland, OH Pittsburgh, PA San Antonio, TX Dallas, TX Seattle, WA Burlington, VT	Before 1978 1978-1992 1993-2001 2002-2005 2006-2008 2009-2013
	Medium 2-stories	929 / 10,000			
	Medium 3-stories	4,982 / 53,628			
Retail	Small	743 / 8,000			
	Medium	2,294 / 24,962			
Mixed-use	Retail at the 1st floor, office at the 2nd Floor (929 / 9,996)				
	Retail at the 1st floor, office at the 2nd and 3rd Floors (1,394 / 14,494)				

Energy Benchmarking

Get ENERGY STAR Score



Detailed Retrofit Analysis

Building design and operation input

Model Calibration

Incentives/ Rebates

User Configurable Single Measures

User Defined Packages of Measures

Detailed Retrofit Analysis Results

75 Energy Conservation Measures

Category	Component	Name	Description
Lighting	Interior Lighting Equipment Retrofit	Replace existing lighting with LED upgrade (0.6W/sf)	Replace existing lighting to LEDs with 6.5 W/m2 [2.38 Btu/h/ft2]. LEDs consume less power and last longer than fluorescent lamps. A retrofit kit is recommended for converting ballasts. Replacement may improve lighting quality.
Plug Loads	Equipment Control	Use Plug Load Controller (30% efficient from Baseline)	Connect plug loads to a smart plug strip with some or all of the following functions: Occupancy sensing, load sensing, timers, remote control.
Envelope - Exterior Wall	Exterior Wall	Apply Wall Insulation (R21)	Apply blown-fiberglass insulation (R21) to wall cavity will help maintain the thermal comfort. Insulation provides resistance to heat flow, taking less energy to heat/cool the space.
Envelope - Roof	Roof	Reroof and Roof with Insulation	Demolish existing roof, install insulation (R24.83) and reroof to reduced unwanted heat gain/loss. This measure is most applicable to older roofs.
Envelope - Window	Window	Replace fixed-window to U-factor (0.25) and SHGC (0.18)	Replace existing window glass and frame with high performance windows by changing the U-factor and SHGC of the window material. The U-factor is a measure of thermal transmittance and SHGC stands for Solar Heat Gain Coefficient, values taken as 0.25 Btu/(h·ft2·°F), SHGC: 0.18. The SHGC and U-factor are 30% below Title 24 values.
Service Hot Water	Storage Tank	Efficiency Upgrade of the Gas Storage Water Heater	Replace the existing service hot water heater with more efficient gas storage unit, with better insulation, heat traps and more efficient burners to increase overall efficiency of (0.93).
HVAC - Cooling	Cooling System	Packaged Rooftop VAV Unit Efficiency Upgrade (SEER 14)	Replace RTU with higher-efficiency unit with reheat, SEER 14. Cooling only; indude standard controls, curb, and economizer.
HVAC - Economizer	Ventilation	Add Economizer	Install economizer for existing HVAC system (indudes temperature sensors, damper motors, motor controls, and dampers). Typically an economizer is a heat exchanger used for preheating.
Envelope - Infiltration	Infiltration	Add Air Sealing to Seal Leaks	Air sealing can reduce cold drafts and help improve thermal comfort in buildings. Air sealing is a weatherization strategy which will change the air exchange rate and IAQ.

4 Types of Incentives

Rebates based on:

- Savings ($/kWh, $/Therm, $/kW)
- Application ($/unit)
- Program Participation ($ each time)
- Interest Savings or Tax Exemption

Retrofit Analysis Results: An Example

	Measure ID(s)	Energy Cost Savings ($)	Energy Savings (kWh)	Electricity Cost Savings ($)	Electricity Savings (kWh)	Natural Gas Cost Savings ($)	Natural Gas Savings (therm)	Investment Cost ($)	Payback (Year)
1	ECM 12;1	13,662	88,901	13,192	95,248	-214	-217	8,564	0.6
2	ECM 1;15	13,472	87,430	12,899	93,132	-193	-195	14,320	1.1
3	ECM 1	11,443	74,429	10,959	79,128	-159	-160	6,320	0.6
4	ECM 12;15	5,788	39,852	5,642	40,736	-30	-30	10,783	1.9
5	ECM 36	4,833	36,818	4,432	32,002	163	164	1,994	0.4
6	ECM 12	4,062	28,519	4,023	29,048	-18	-18	2,896	0.7
7	ECM 31	3,719	22,797	3,618	26,126	-112	-114	654	0.2
8	ECM 33	2,195	11,990	2,189	15,804	-129	-130	0	NA
9	ECM 14	1,847	10,052	1,851	13,367	-112	-113	5,000	2.7

Measure ID	Category	Name	Cost Unit	Total cost per Unit
ECM 1	Lighting	Replace existing lighting with T8 upgrade	$/sf	0.63
ECM 12	HVAC - Economizer	Add Economizer	$/ton	387
ECM 14	Plug Loads	Plug Load Efficiency Upgrade (25% efficient from Baseline)	$/sf	0.5
ECM 15	Plug Loads	Use Plug Load Controller (30% efficient from Baseline)	$/sf	0.8
ECM 30	HVAC - Operation & Maintenance	Add Programmable Thermostat	$/zone	1220
ECM 31	Lighting - Controls	Install daylighting sensors for interior lighting control	$/sf_daylighting	0.81
ECM 33	HVAC - Ventilation	Replace Air Filter	$/cfm	0.07
ECM 36	HVAC - Ventilation	Add Ceiling Fan	$/sf	0.2

CBES Pro Availability

1 The project focus is development of CBESPro API that can be integrated into third-party tools/platforms

2 The prototype CBESPro web app is freely available

3 Software disclosures filed at LBNL

4 Software licensing

- No-fee for CEC, DOE and non-profit use
- A one-time fee for commercial adoption

5. Web site: cbespro.lbl.gov

Acknowledgments

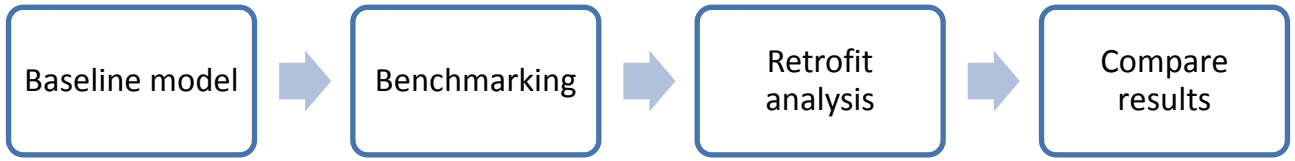
1. **CBES was sponsored by California PIER Program,** PIR-12-031

3. **Extension (CBESPro) to national cities/climates was sponsored by USDOE**

Hands-on Exercise

Overview

- Goal:
  - Learn to use CBES Pro to perform benchmarking and retrofit analysis
  - Understand how the energy savings vary with climates and vintages
- Tasks for each team:
  - Create a baseline model with different inputs due to different climates and vintages
  - Get the EnergyStar score for the baseline model
  - Perform retrofit analysis on 5 retrofit measures
  - Compare results between teams



Major Steps

1. Start CBES Pro at CBESPro.lbl.gov
2. Define baseline buildings
3. Enter monthly utility bills
4. Get EnergyStar Score
5. Select five retrofit measures
6. Calculate energy savings
7. Report out

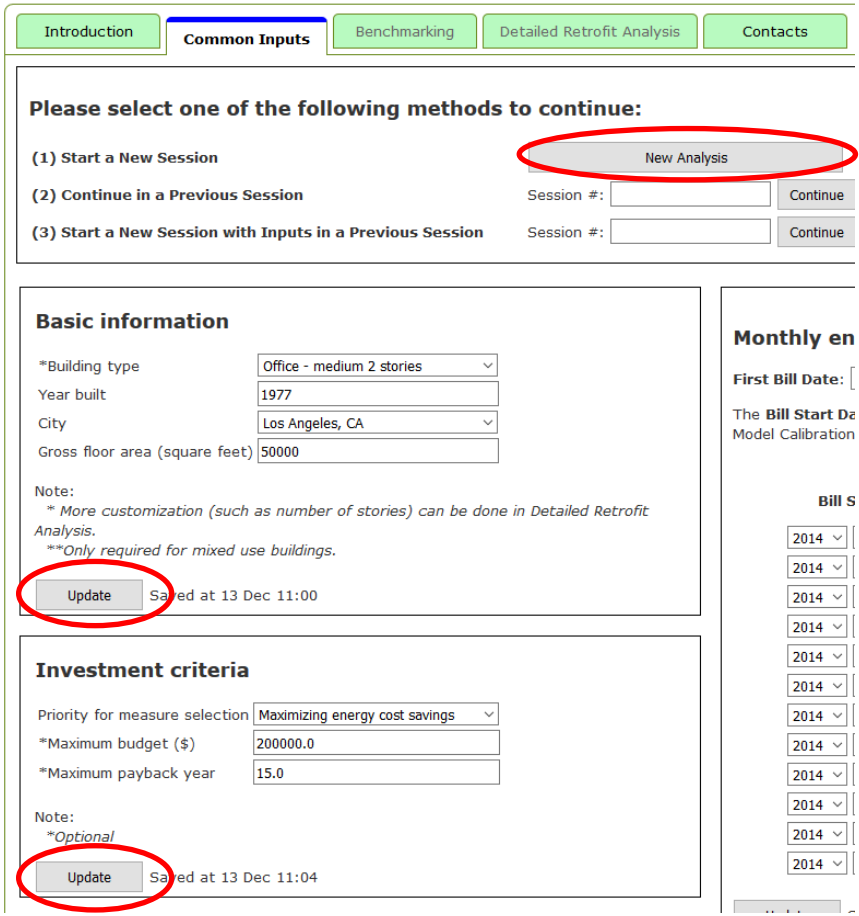
Building overview

- 2-story office building, 50,000 ft^2
- 4 cities/climate zones
  - San Antonio (2A)
  - Los Angeles (3B)
  - Seattle (4C)
  - Burlington/VT (6A)
- 2 vintages: 1977 & 2001

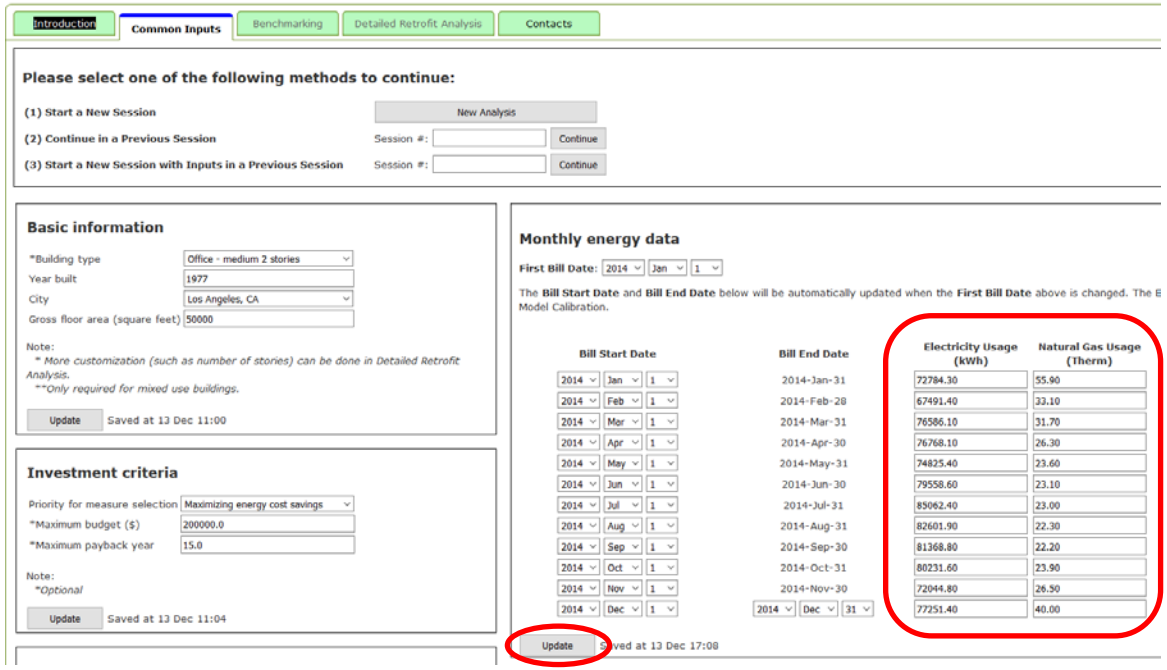
Team	City	Vintage
A1	San Antonio	1977
A2	San Antonio	2001
B1	Los Angeles	1977
B2	Los Angeles	2001
C1	Seattle	1977
C2	Seattle	2001
D1	Burlington	1977
D2	Burlington	2001

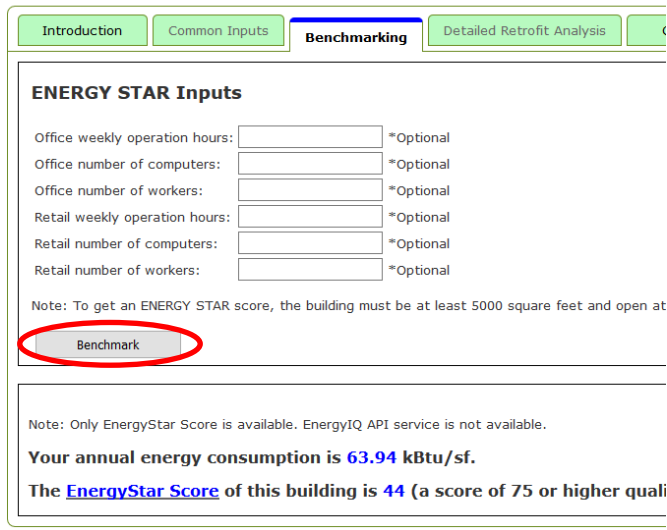
Common inputs

- Click “New Analysis” to start
- Basic information
  - Building type: Office – medium 2 stories
  - Year built: 1977 or 2001
  - City: San Antonio, Los Angeles, Seattle or Burlington
  - Gross floor area (ft^2): 50000
  - Click “update” (“Energy price” and “CO_2 emission factors” generated automatically)
- Investment criteria
  - Priority: Maximizing energy cost savings
  - Maximum budget ($): 200000
  - Maximum payback year: 15
  - Click “update”



Get EnergyStar Score





Enter monthly energy data

*Monthly energy data on the next slide

Monthly Energy Data

	San Antonio, 1977		San Antonio, 2001		Los Angeles, 1977		Los Angeles, 2001	
	KWh	Therm	KWh	Therm	KWh	Therm	KWh	Therm
January	88778	137.3	62247	76.8	87883	39.6	63322	27.0
February	82848	93.2	56420	43.2	81645	28.2	55839	23.5
March	99145	57.0	63414	37.0	92732	28.3	62977	26.3
April	103339	22.0	66566	22.0	92870	25.4	60981	24.8
May	107388	19.0	71057	19.0	90168	23.5	58641	23.4
June	124603	16.9	83811	16.8	95809	23.0	63111	23.0
July	127308	16.4	86085	16.4	101885	23.0	68592	23.0
August	125203	16.0	84352	16.0	98586	22.3	66355	22.3
September	114247	17.4	76086	17.3	97133	22.2	66031	22.2
October	107395	20.5	70061	20.4	96196	23.8	64048	23.6
November	91020	30.5	59241	21.9	86544	24.6	58321	23.0
December	94651	123.0	65650	59.3	93349	31.9	65541	26.0

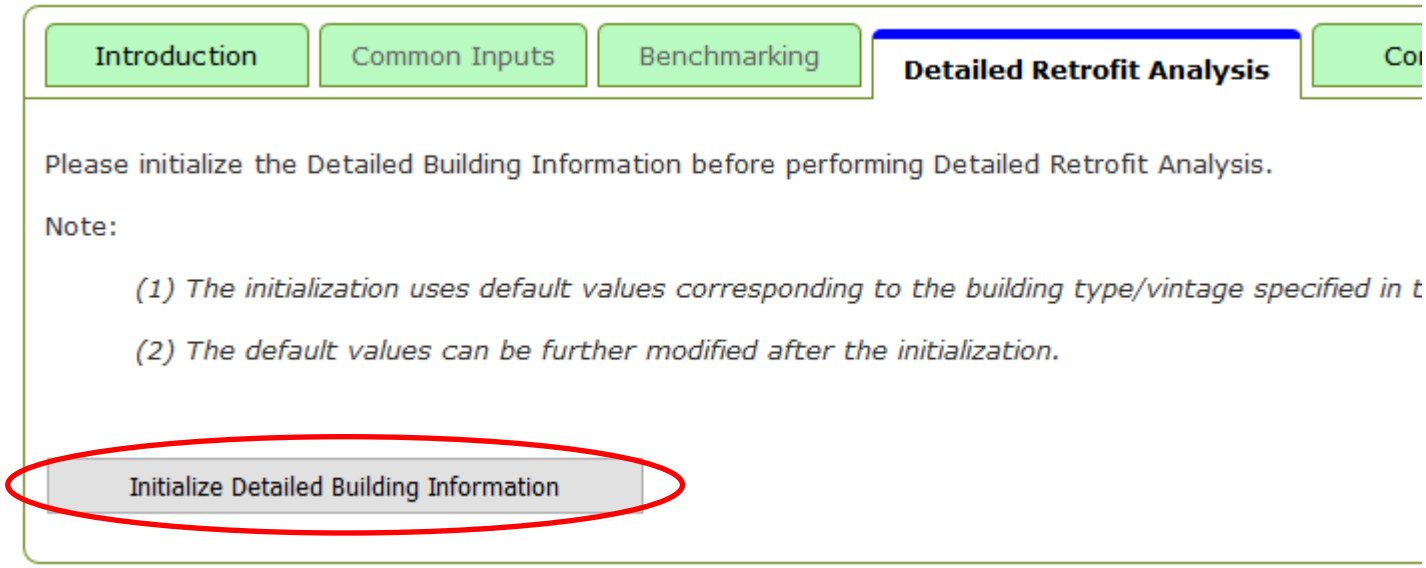
Monthly Energy Data

	Seattle, 1977		Seattle, 2001		Burlington, 1977		Burlington, 2001	
	KWh	Therm	KWh	Therm	KWh	Therm	KWh	Therm
January	81087	463.8	61677	153.3	77848	1933.2	62886	706.1
February	75902	295.5	56164	128.1	71601	1399.1	57433	519.9
March	86751	117.8	62730	60.9	81816	868.0	62934	364.3
April	87603	56.9	58827	38.9	84077	198.8	59072	95.7
May	85568	34.6	55932	28.4	83883	40.7	56196	31.7
June	90853	28.0	57946	27.3	94864	28.5	62791	28.3
July	97734	27.1	62406	26.9	101305	26.9	68286	26.8
August	95231	25.8	61530	25.7	95774	25.7	64407	25.8
September	89801	27.1	58104	26.2	87676	30.2	58709	26.4
October	87390	45.6	63131	29.3	84703	103.0	62127	69.4
November	79330	167.3	59119	85.6	76064	474.7	57337	252.5
December	86204	353.5	65426	137.8	82602	1095.8	65413	425.5

Detailed Building Information

Detailed retrofit analysis

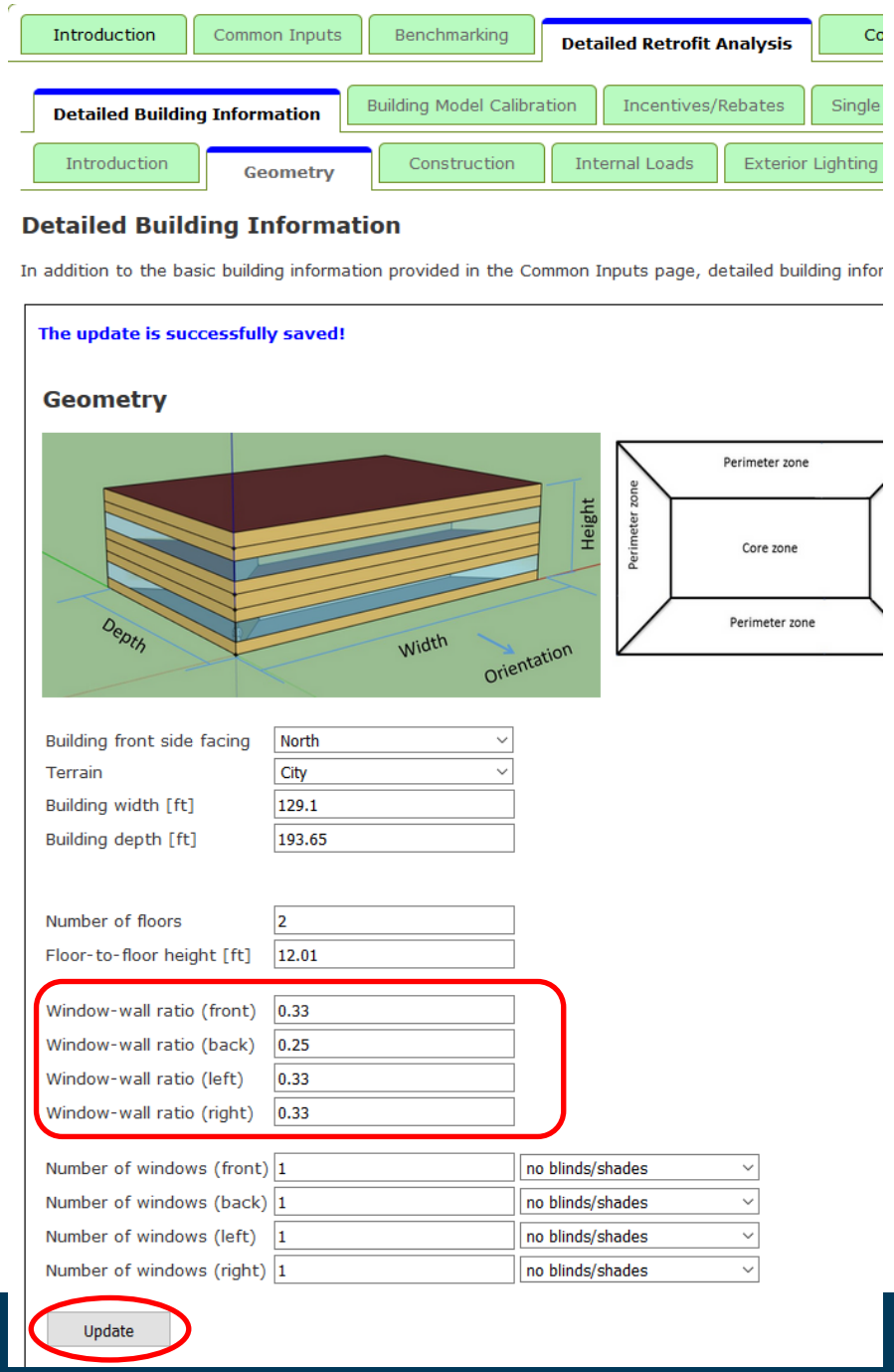
- Initialize Detailed Building Information with default values



• Building orientation

◆ Window-wall ratio

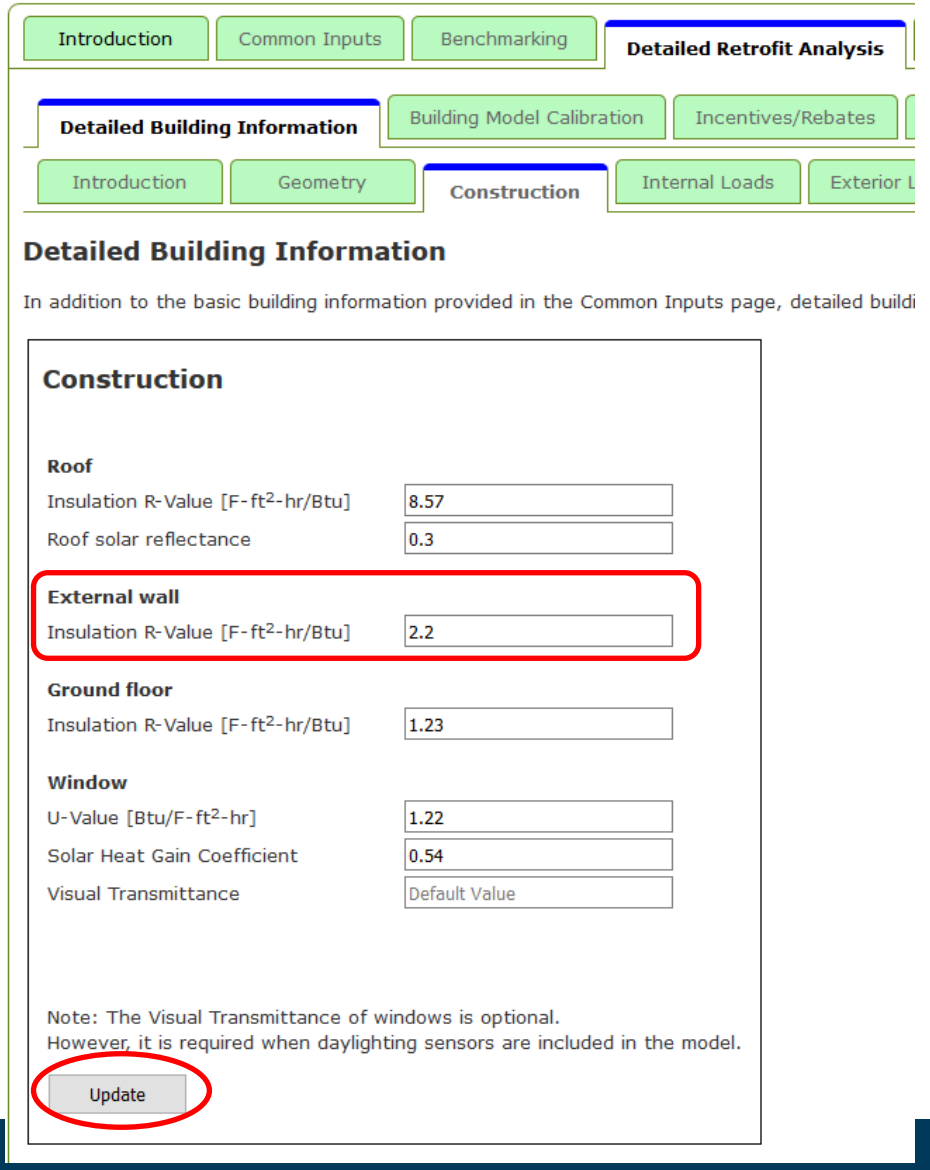
	San Antonio	Los Angeles	Seattle	Burlington
North (front)	0.33	0.33	0.33	0.3
South (back)	0.25	0.25	0.33	0.3
Left (West)	0.33	0.33	0.33	0.3
Right (East)	0.33	0.33	0.33	0.3



Exterior wall insulation

- Insulation R-value ($F.ft^2.hr/Btu$)

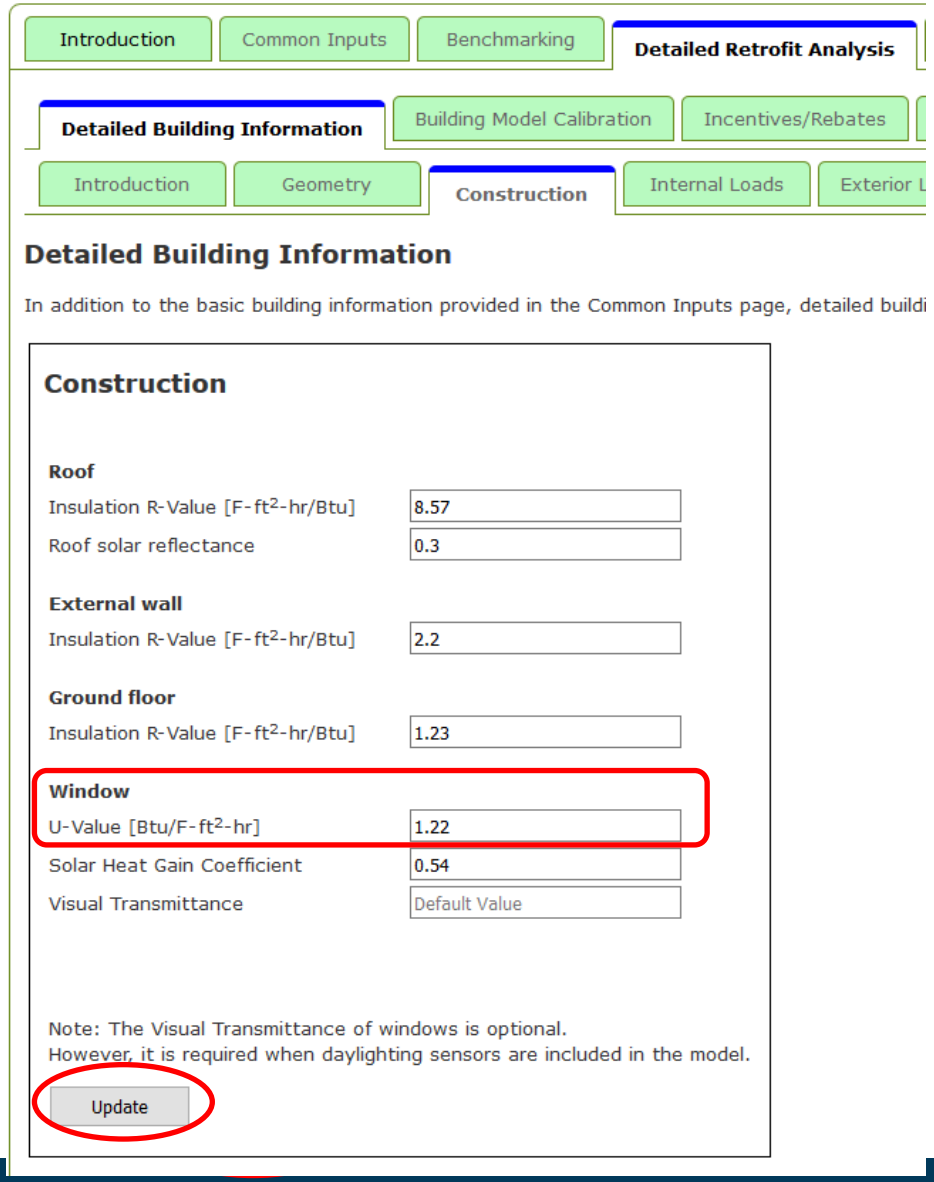
	1977	2001
San Antonio	2.2	3.0
Los Angeles	3.0	4.1
Seattle	4.3	6.2
Burlington	5.1	7.0



Window properties

- Adjust U-value (Btu/F.ft^2.hr)
- No change to Solar Heat Gain Coefficient (SHGC)

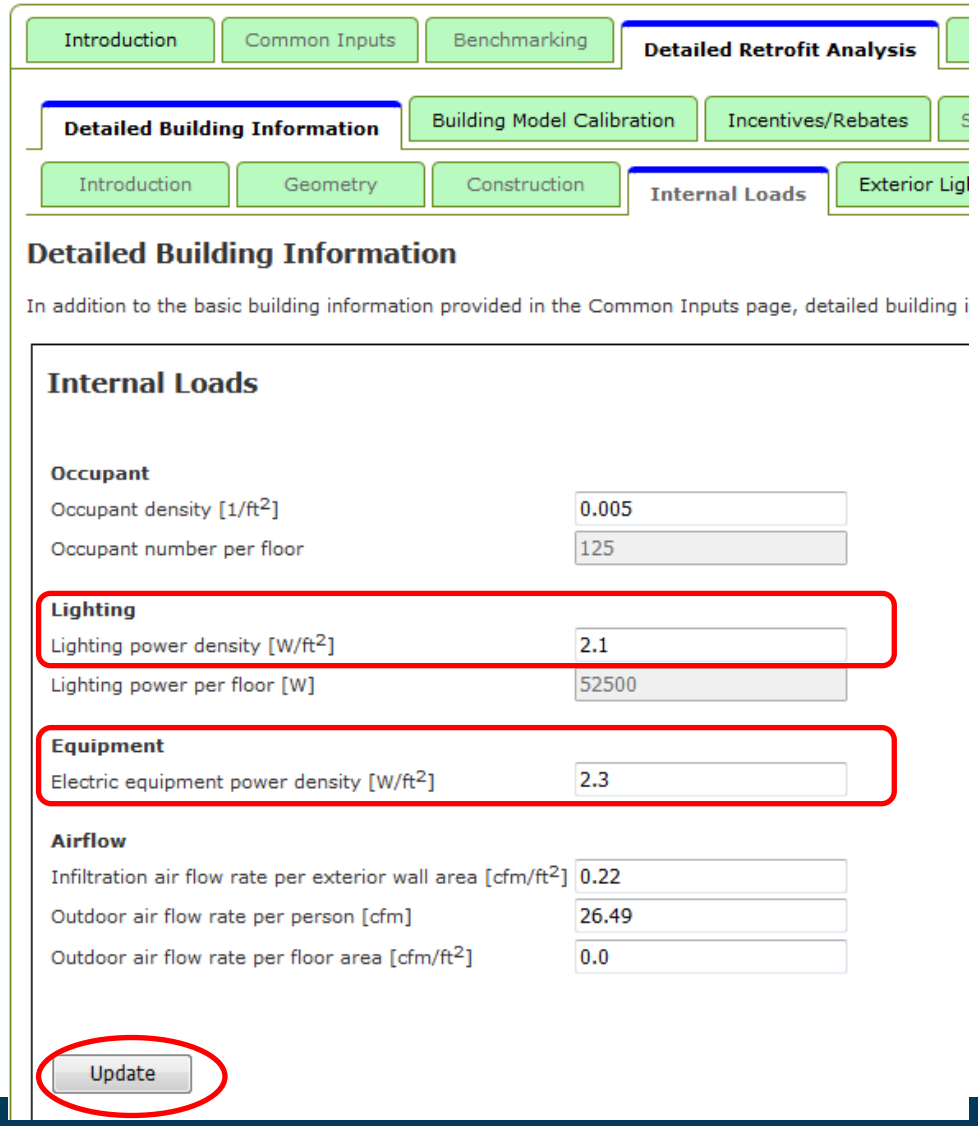
	Window U-value		SHGC	
	1977	2001	1977	2001
San Antonio	1.22	1.15	0.54	0.25
Los Angeles	1.1	1.0	0.54	0.44
Seattle	0.9	0.82	0.54	0.39
Burlington	0.85	0.72	0.41	0.39



Lighting and plug-load power density

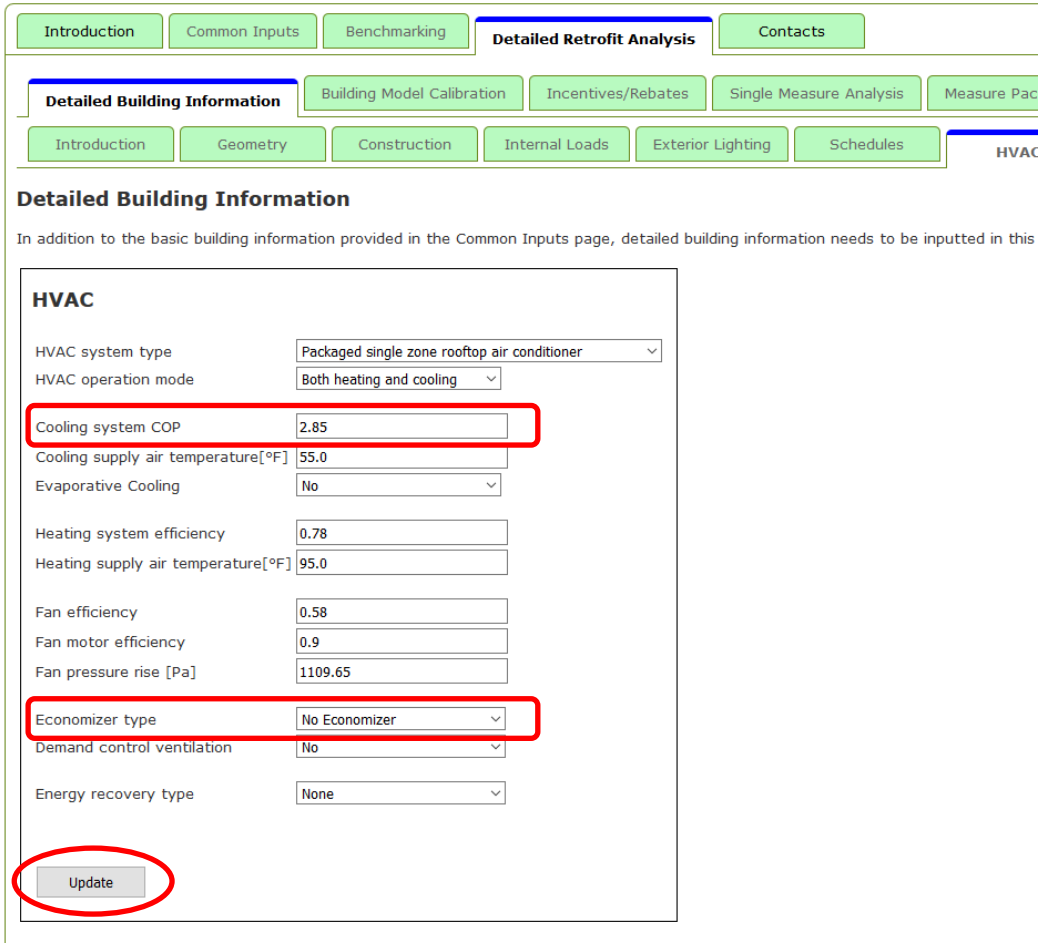
- Unit: W/ft^2

	1977	2001
Lighting power density	2.1	1.8
Plug-load power density	2.3	1.9



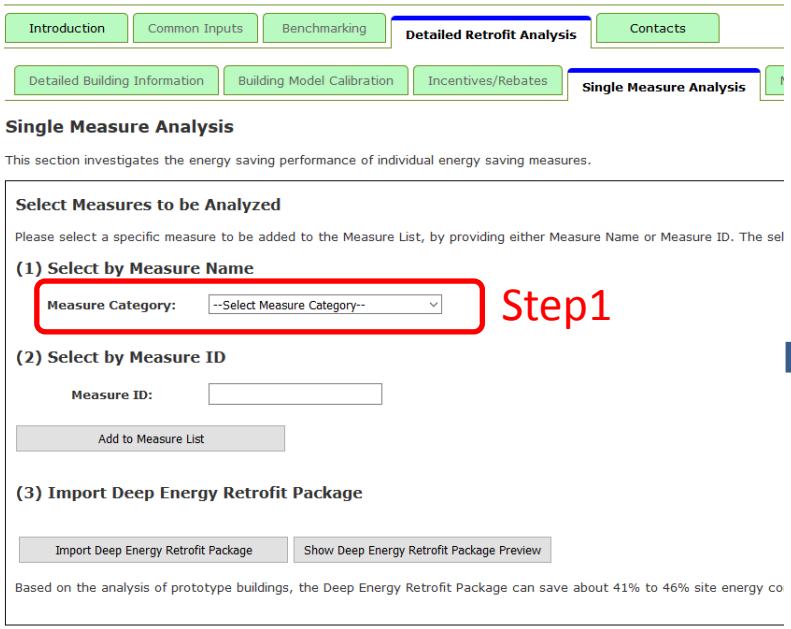
HVAC system

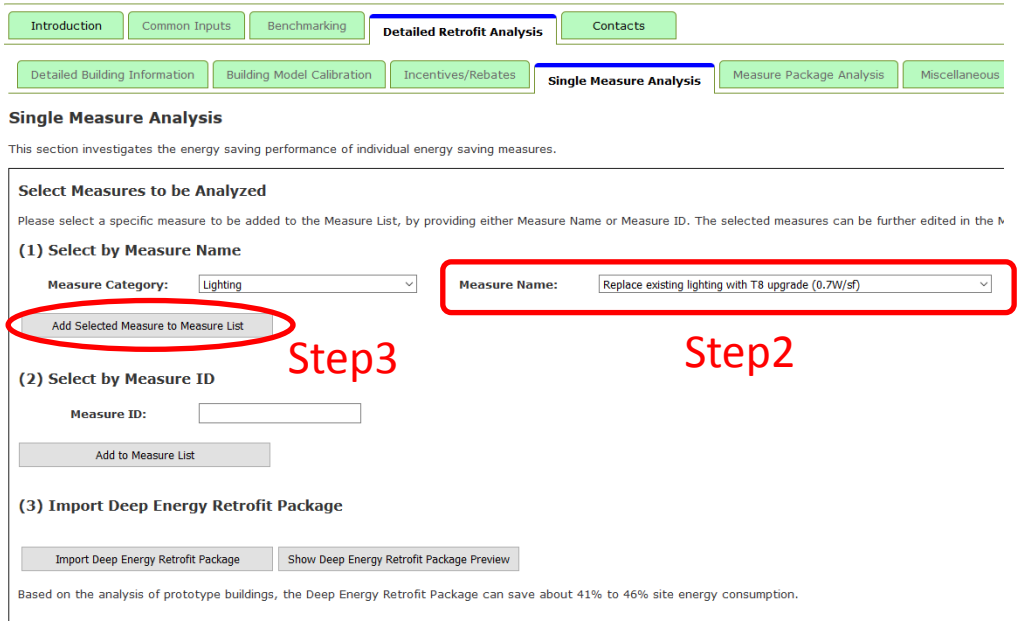
	1977	2001
HVAC system type	Packaged single zone rooftop air conditioner	Packaged rooftop VAV with gas furnace for each story
Cooling system COP	2.85	3.1
Heating system efficiency	0.78	0.8
Economizer	No economizer	No economizer



Detailed Retrofit Analysis

Add a single retrofit measure



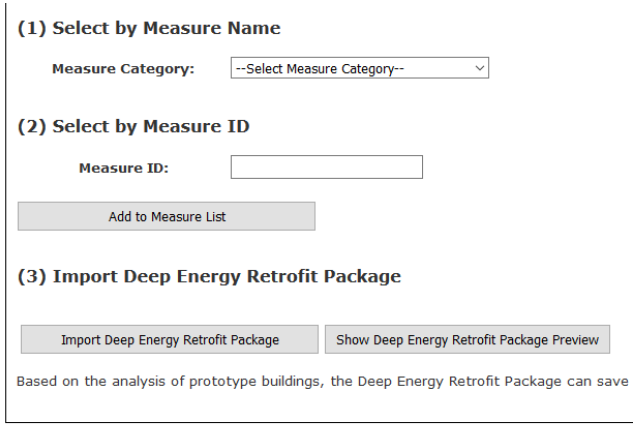


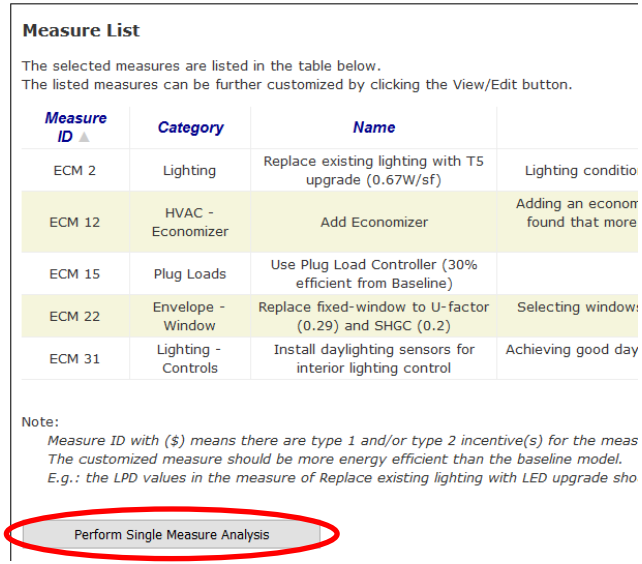
- Step1: Select a measure category
- Step2: Select a measure
- Step3: Add selected measure to the measure list

Retrofit measures – single

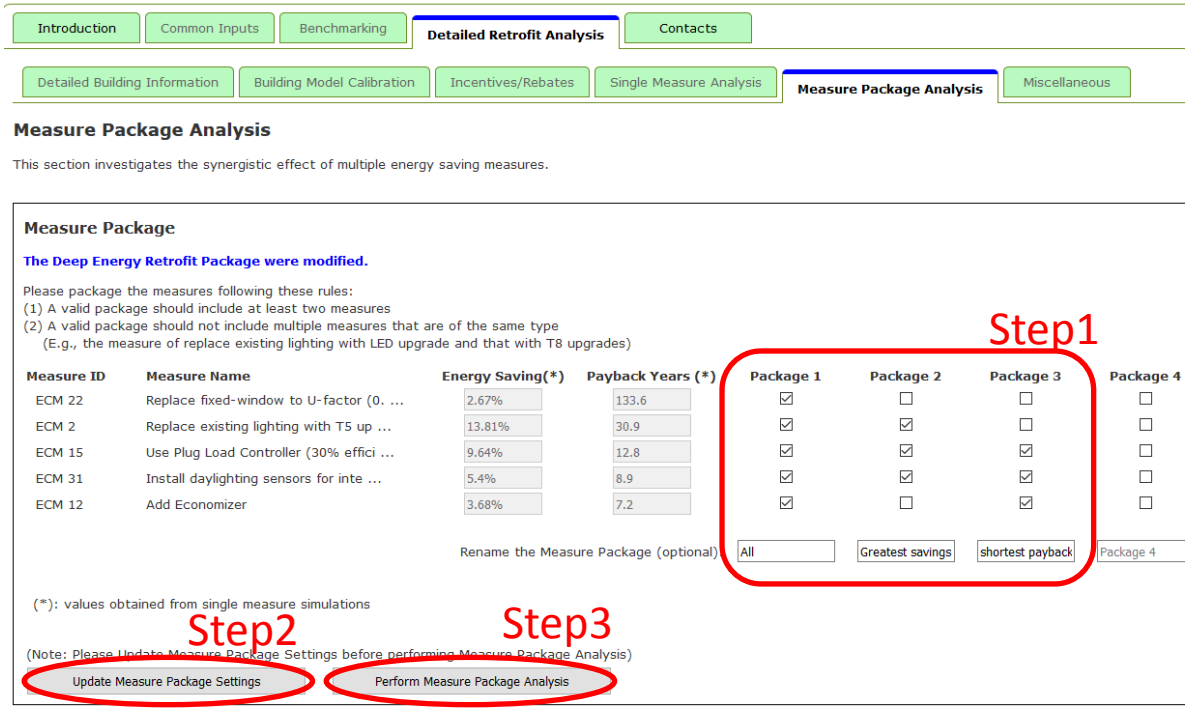
1. Envelope - Window
   - Replace fixed-window with U-factor (0.29) and SHGC (0.2)
2. Lighting
   - Replace existing lighting with T5 upgrade (0.67 W/ft2)
3. Lighting control
   - Install daylighting sensors for interior lighting control
4. Plug load
   - Use plug-load controller (30% more efficient than Baseline)
5. HVAC – Economizer
   - Add Economizer

After adding all the retrofit measures, click "Perform Single Measure Analysis"





Define and run retrofit measure packages



Investigate three packages:

1. All single measures
2. Three measures with the greatest energy savings
3. Three measures with shortest payback years

*if 2 and 3 are the same, keep one

- Step1: Create packages by selecting single measures
- Step2: Click “Update Measure Package Settings”
- Step3: Click “Perform Measure Package Analysis”

Team reports

- Compare across different vintages and climates:
  - Energy use
  - Energy savings
  - Energy cost savings
  - Payback years
- All EnergyPlus IDF files, result html files and weather epw files are downloadable for further study