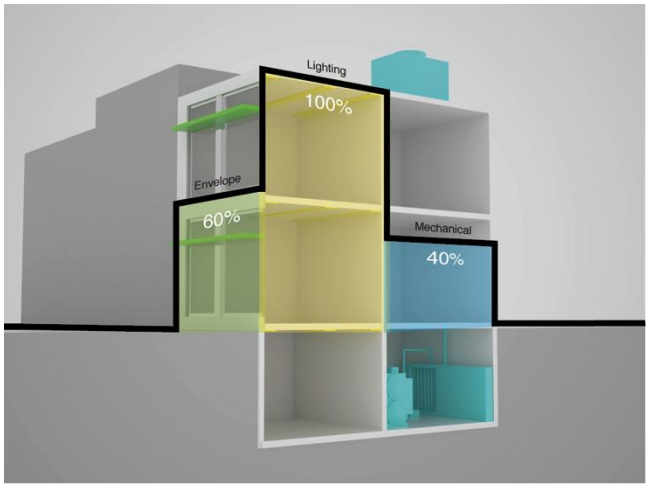
Energy Auditing Tool



Task 2.2
Energy Efficient Buildings Hub

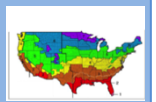
Dr. Russell D. Taylor, UTRC
Dr. Robert M. Leicht, PSU
Dr. Stella M. Oggianu, UTRC

Monday, 9 September 2013

Annex 61 Experts Meeting

Energy Audit and Retrofit Analysis at the EEB Hub

Inputs



Usage	Public assembly
Climate	Cold/Humid
Square Footage	69788
#Floors	1
Peak Occupancy	550
Schedule	80hrs, Open only WD
Glass	13.4%, Single layer glass, Not tinted, Not Reflective
Wall	Concrete Block
Roof	Metal Deck
HVAC Type	•VAV Multizone •Electric Chillers •District Steam

Buildings
HVAC
Weather
Energy bills

Facility Lifecycle

Construct → Operate → Audit → Plan → Design

Analysis

1. Baseline

Baseline simulation ⇄ Parameter calibration

2. Individual ECMs

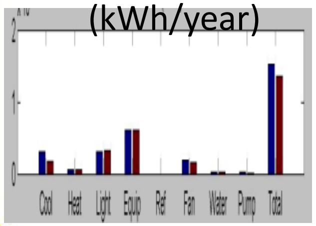
Energy Conservation Measure Assessment (singular)

3. Package Solution

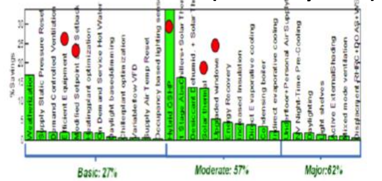
Assessment (multiple ECMs) ⇄ **ECM's vs WBS**

4. Feasibility

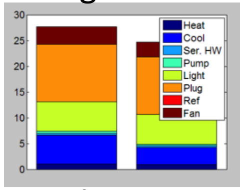
Baseline Energy (kWh/year)



ECMs retrofit: (kWh/year)



Package Retrofit



Baseline Retrofit

- Identify Energy Need / Problem
- Perform Walk-through Assessment
- Baseline Energy Analysis
- Energy Conservation Measure Evaluation
- Feasibility Analysis of ECM's

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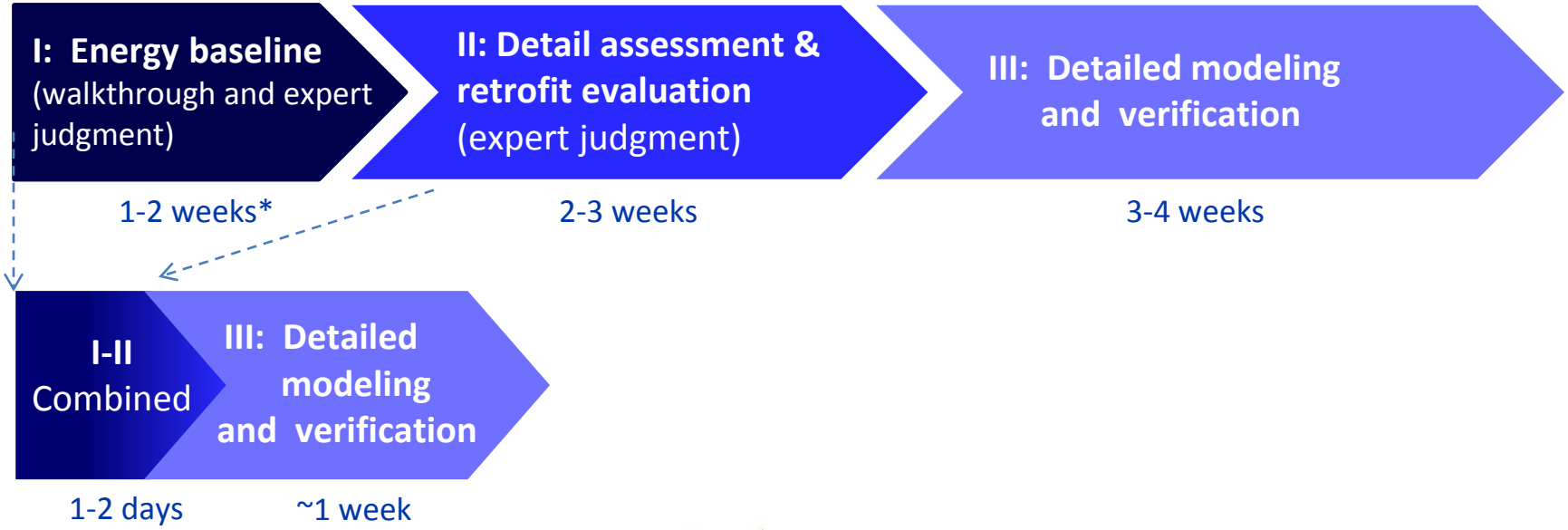
Energy Audit and Retrofit Analysis at the EEB Hub

Objective :

To develop and demonstrate a standard methodology enabling 1) a 10x reduction in the time and labor to perform level I and II audits and retrofit analysis; b) consistent and reproducible outputs

Motivation (1/2):

Current State: 3 levels of audits, defined by ASHRAE



Motivation (2/2): *A systematic methodology and supporting tools needed*

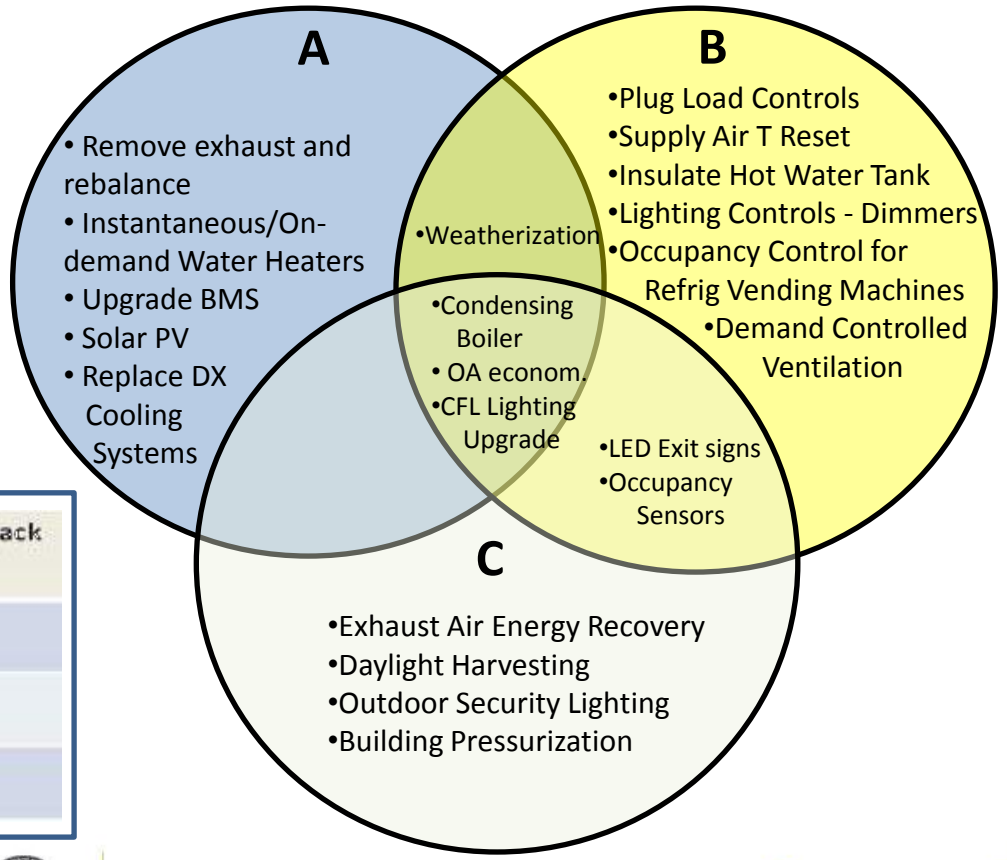
Comparison between 3rd party Audits - Philadelphia Navy Yard Building 101

3 different companies

3 different results

Company	Annual Savings	Installed Costs	Simple Payback (yrs)
A	$52,000	$312,000	6.0
B	$19,000	$79,000	4.2
C	$34,000	$104,000	3.1

Retrofit Recommendations



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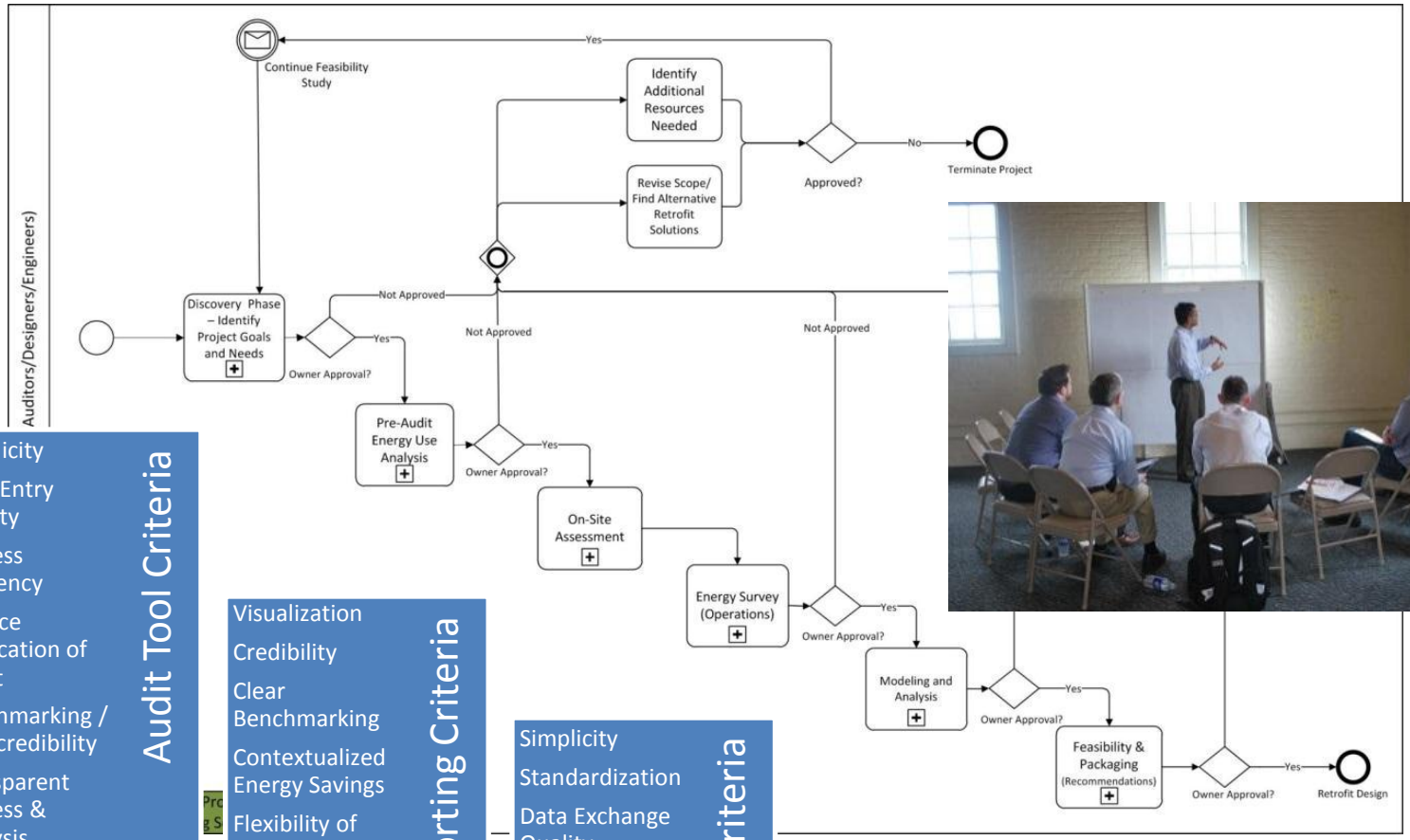
Energy Audit and Retrofit Analysis at the EEB Hub



Audit Tool Criteria

- Simplicity
- Data Entry Quality
- Process Efficiency
- Reduce duplication of Effort
- Benchmarking / Tool credibility
- Transparent Process & Analysis

Reporting Criteria

- Visualization
- Credibility
- Clear Benchmarking
- Contextualized Energy Savings
- Flexibility of comparison between options
- Usability for Decision Making

Exchange Criteria

- Simplicity
- Standardization
- Data Exchange Quality
- Rich Data Collected
- Accessibility to Source Data

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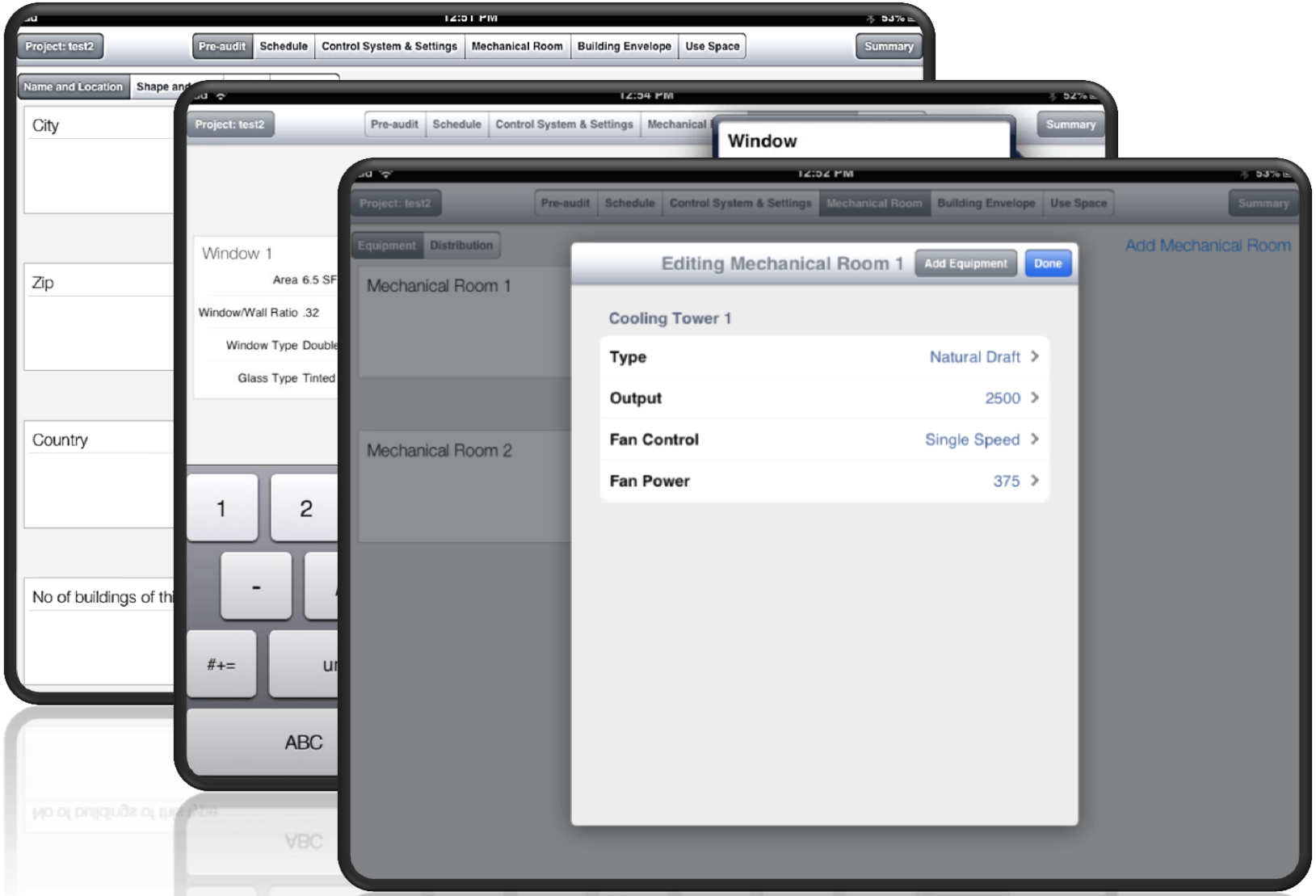
Energy Audit and Retrofit Analysis at the EEB Hub



eeBHUB Energy Efficient Buildings Hub

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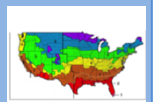
Energy Audit and Retrofit Analysis at the EEB Hub

Facility Lifecycle

Design → Construct → Operate → Audit → Plan

Inputs



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HVAC
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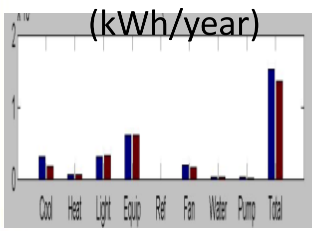
Assessment (multiple ECMs)

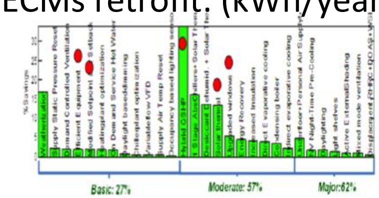
4. Feasibility

ECM's vs WBS

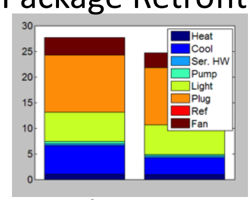
Baseline Energy (kWh/year)



ECMs retrofit: (kWh/year)



Package Retrofit

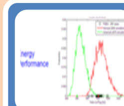


Baseline Retrofit

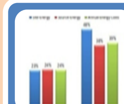
Audit

Identify Energy Need / Problem

Perform Walk-through Assessment



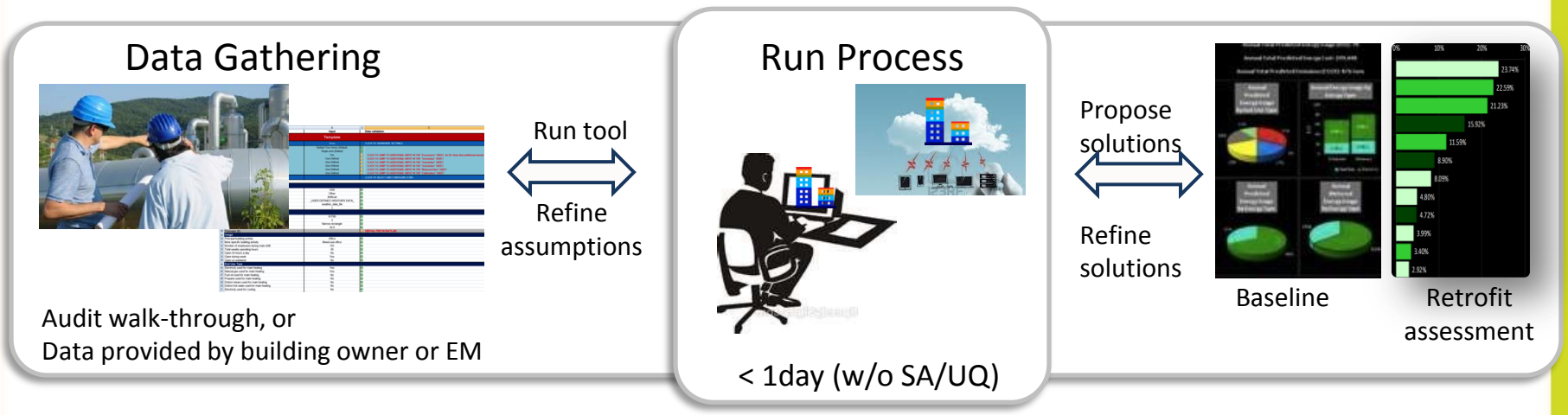
Baseline Energy Analysis



Energy Conservation Measure Evaluation

Feasibility Analysis of ECM's

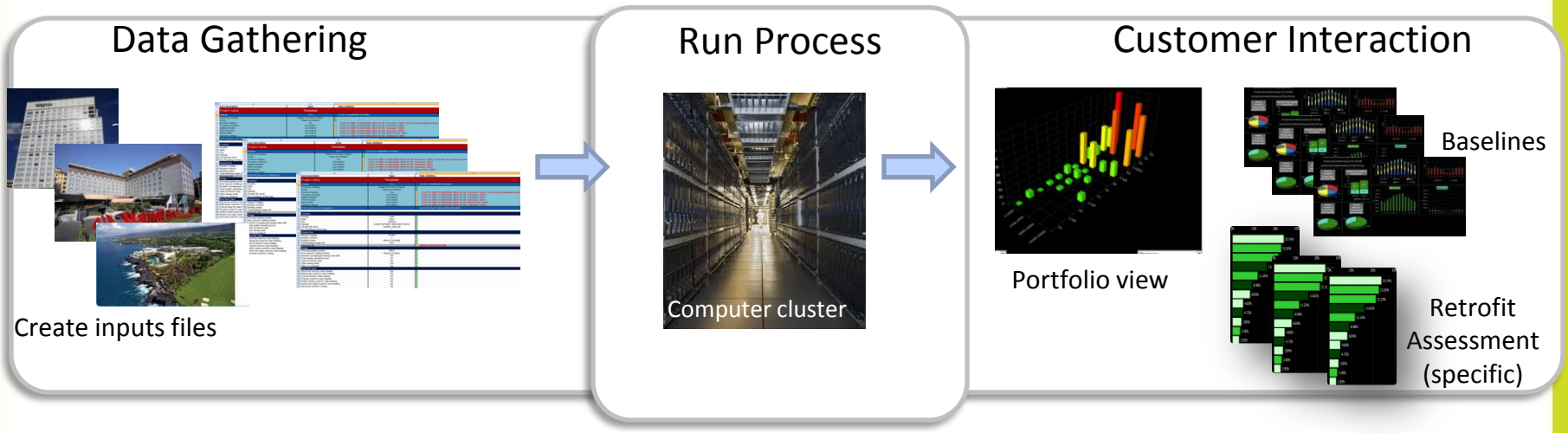
User-case 1: Individual Building



Input data and output results are specific for each building
Unknown inputs can still be defaulted

User-case 2: Detailed Portfolio of Buildings

Buildings of the same type in different geographic zones (e.g. hotel or retail chains)
Buildings of different types in the same geographic area (e.g. campus, base)



Input data and output results are specific for each building
Unknown inputs can still be defaulted

Process Overview

Inputs → **Baseline Evaluation Automatic Calibration** → **ECM Evaluation** → **Sensitivity analysis & uncertainty quantification**

~ 1 hour*

~1-2 min. (w/o calibration)
~4 hrs (automatic calibration)

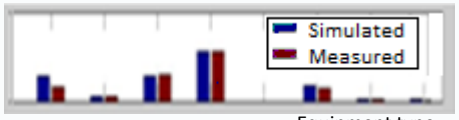
< 2 hrs all ECM
1 min per package

hours

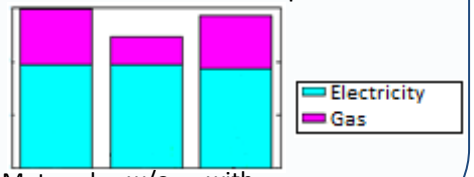
Simplified inputs


- Building attributes
- HVAC type
- Schedules
- Energy bills
- Location

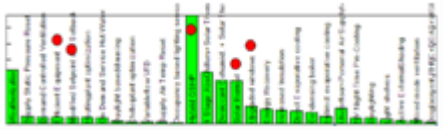

Baseline energy
by energy source and equipment type (kWh/year)



Total energy with and without calibrated inputs

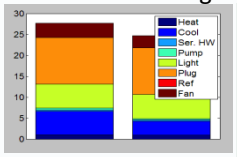


ECMs options
Energy usage (kWh/year); payback by applying individual ECMs

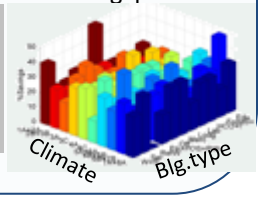


Savings and payback from package ECMs

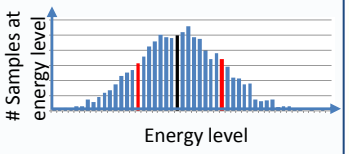
Individual building



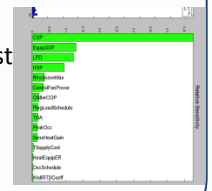
Building portfolio



UQ/SA
Results distribution based on input uncertainty



Rank of most influential parameters



* 'man-working hour'

Differentiators

- Simple inputs, can be defaulted if unknown
  - Incorporates automatic calibration capability
- Considers the physics of each building and its environment, provides results that are specific to each building
- Combines energy audit and retrofit assessment
- Economics and environmental analysis integrated
- Building portfolio tracking and comparison is enabled
- Uncertainty is quantified
- ECM dependencies are considered

1 Sample Test Case - Overview

Building Characteristics

- Office building , built : 1990
- 32,000 ft2 of conditioned space, 1 floor
- Current occupancy: 128 employees plus 10 visitors on average
- Construction type: brick façade with strip windows
- Current EUI ~83.7 kBtuft2-yr

HVAC System

- 22 RTU electric heat pumps ranging from 5-10 tons
- All units run on individual thermostats
- No EMS system
- There are 3 server rooms with split system air conditioners for cooling

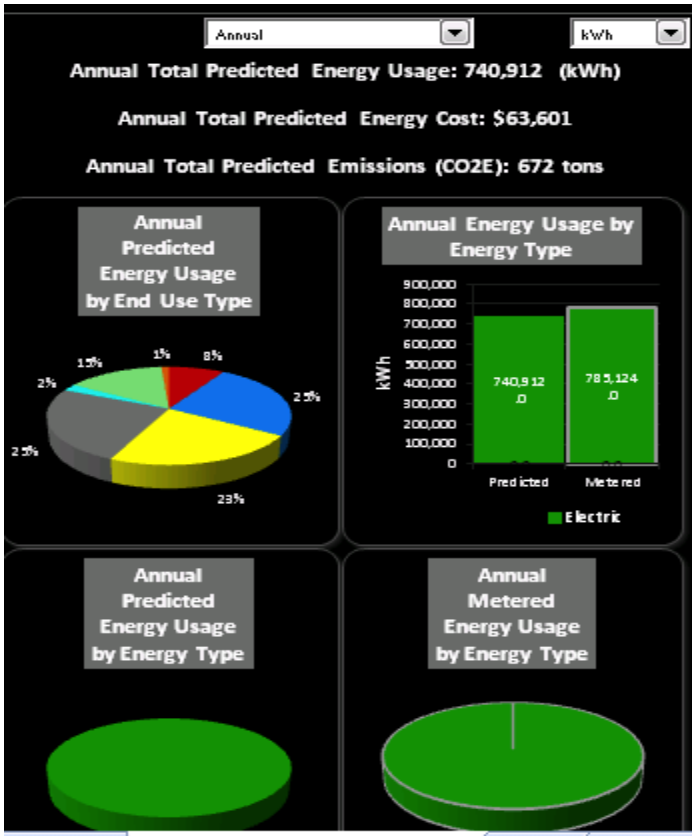
Lighting

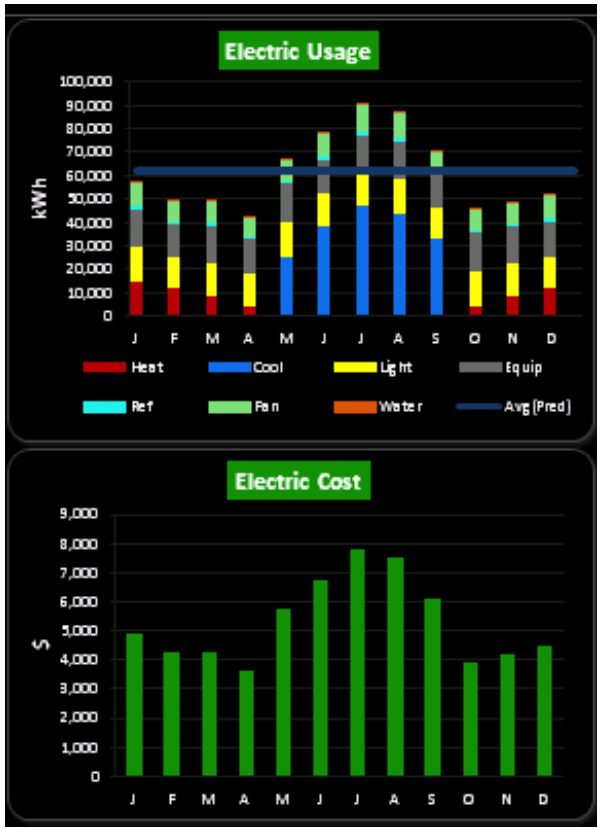
- The interior lighting is mostly T-12 recessed ceiling fixtures with manual controls
- Assumed light power density: 1.5 W/ft2

Plug-in equipment

- There is assumed to be 1 computer and monitor per employee
- There is assumed to be 2 printers and 1 each photocopier, refrigerator and vending machine for the 8 office units
- Each office unit has a kitchenette which is supplied with hot water for the sink by a small electric tank heater that mimics a hot water on demand system

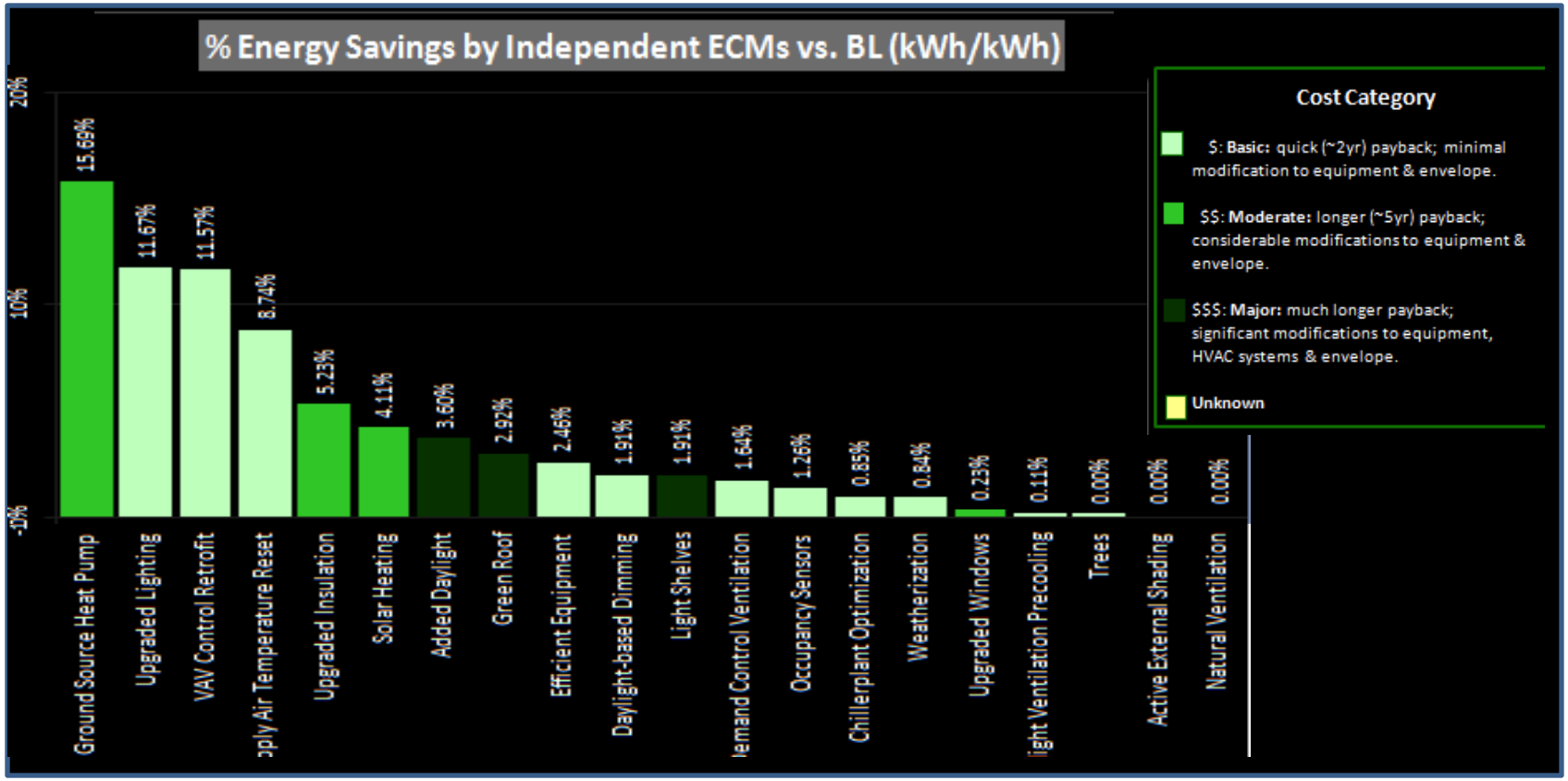
1 Sample Test Case – Baseline Building



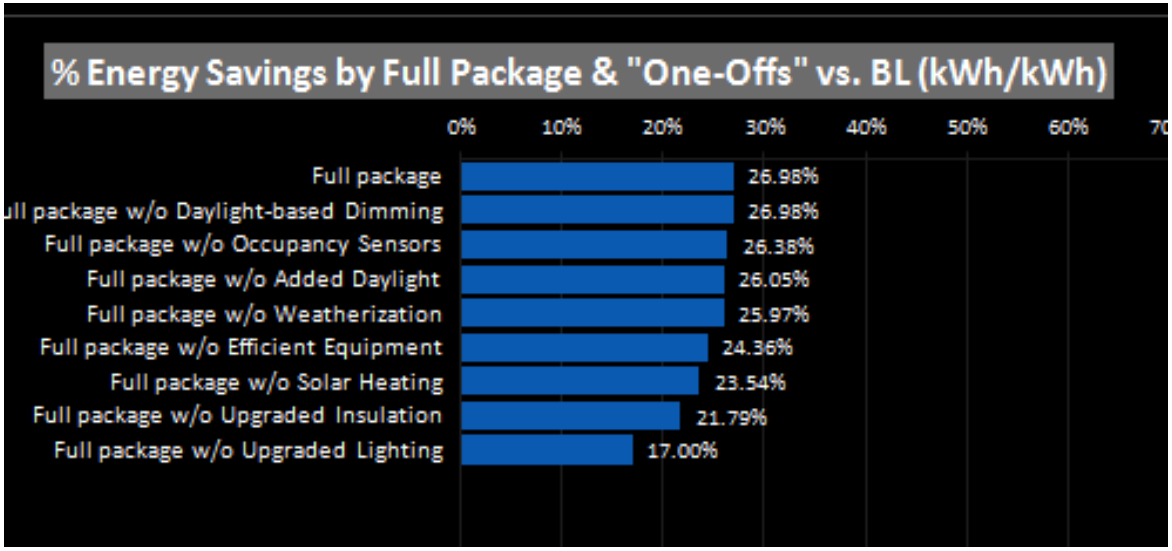


1 Sample Test Case – Calibrated Results

1 Sample Test Case – Energy Conservation Measures



1 Sample Test Case – ECM Packages



Package
Upgraded Lighting
Upgraded Insulation
Solar Heating
Added daylight
Efficient Equipment
Daylight basedimming
Occupancy Sensors
Weatherization

Annex 61 Experts Meeting

Energy Audit and Retrofit Analysis at the EEB Hub

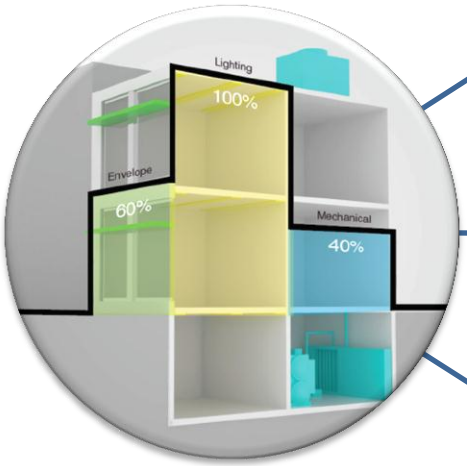
Advanced Energy Retrofits (AER)

Dissemination \ Impact => potential for 20% energy savings identified in at least 10 buildings during BP3 (in addition to the Philadelphia Navy Yard 9 buildings in BP2)

GSA engagement : Energy and retrofit assessment for Philadelphia Customs House performed leading to a potential analysis of GSA portfolio

Building Name	Year Built and Renovation History	Building Type	Number of Floors	Building Area (GSF)
James Weldon Johnson Homes	1939-1940	Multi- and Single-Family Residential Buildings	2 and 3 stories	n/a
West Catholic High School	1926	School	3 stories with full-size basement and a partial sub-basement	135,000
760 Constitution Drive	1994	Office	2.5	36,685
415 Eagleview Blvd	1990	Office	1	32,000
SEPTA- 69th Street Terminal Building	1907; last major overhaul of the building was completed in 1986	Mixed use of office, retails, storages and terminals	2 stories with basement	50,000
Edgmont Township municipality building	n/a	office and storage	2 stories	10,000
Malvern Borough Administration Building	1889; 4000 ft2 addition in 2003	office and library	3 stories including a ground floor; attic for mech.	18,000
Allens Lane Apartment	1962	Multi-family Residential Building	3	45,000
Arts Condominium	originally built in early 1920s as a Hotel; converted to apts in 1950s;	Multi-family residential building	16	232,000
Monsignor Bonner & Archbishop Prendergast Catholic High School	n/a	High School	3-5 from the air photo	n/a

Focus Group participants liked:



Credibility
- Predicted vs. Actual
- Calibration
- Weather Data

Reduced Cost
- Faster Data collection
- Automated analysis

Customizable
- Readily Accessible
- Meet specific needs

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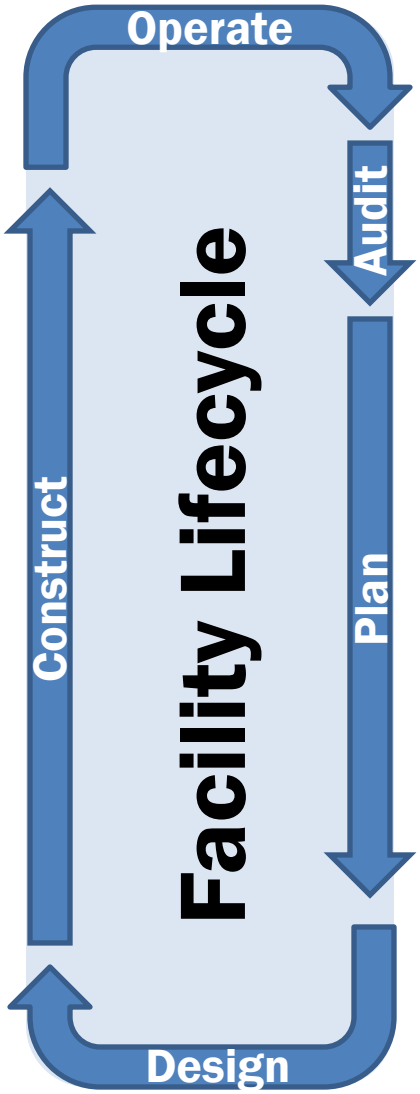
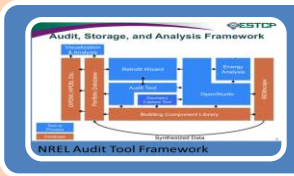
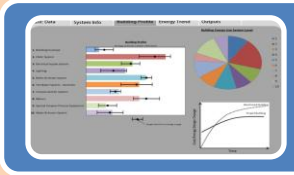
Energy Audit and Retrofit Analysis at the EEB Hub

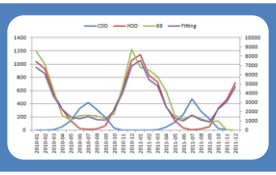




Build in flexible data access mechanism



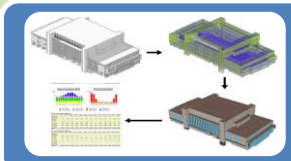
Present Economic Information clearly & compellingly



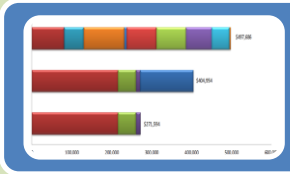
Include error bars to show level of confidence in results

Refine / Improve

Align inputs with Portfolio Manager & outputs with EnergyStar Rating



Modify user interface – enable different roles to have appropriate access to building data



Develop a timeline feature to modify the baseline and predictions as measures are implemented

Extend / Expand