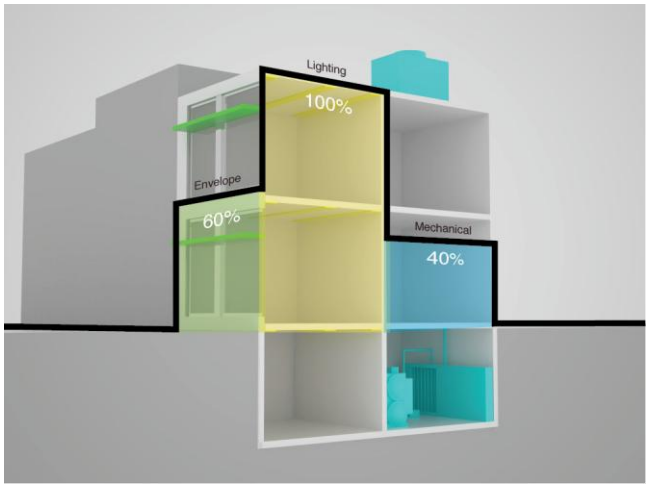
Energy Auditing Tool



Task 2.2
Energy Efficient Buildings Hub

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

Benchmarking Education Session

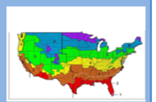
Wednesday, 14 August 2013

eeBHUB Energy Efficient Buildings Hub

Stakeholder Workshop

Subtask 2.2 – *Energy Audit and Retrofit Analysis*

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)

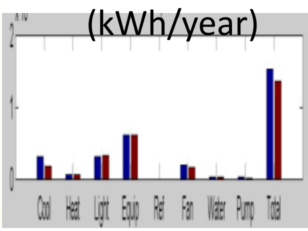
3. Package Solution

Assessment (multiple ECMs)

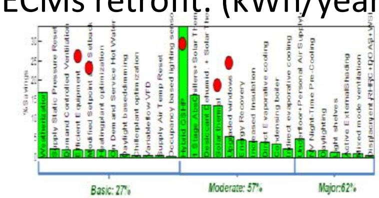
4. Feasibility

ECM's vs WBS

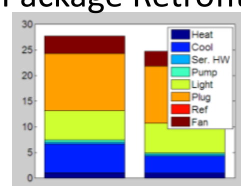
Baseline Energy (kWh/year)



ECMs retrofit: (kWh/year)



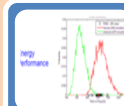
Package Retrofit

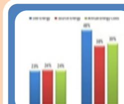


Baseline Retrofit


Identify Energy Need / Problem


Perform Walk-through Assessment


Baseline Energy Analysis


Energy Conservation Measure Evaluation


Feasibility Analysis of ECM's

Stakeholder Workshop

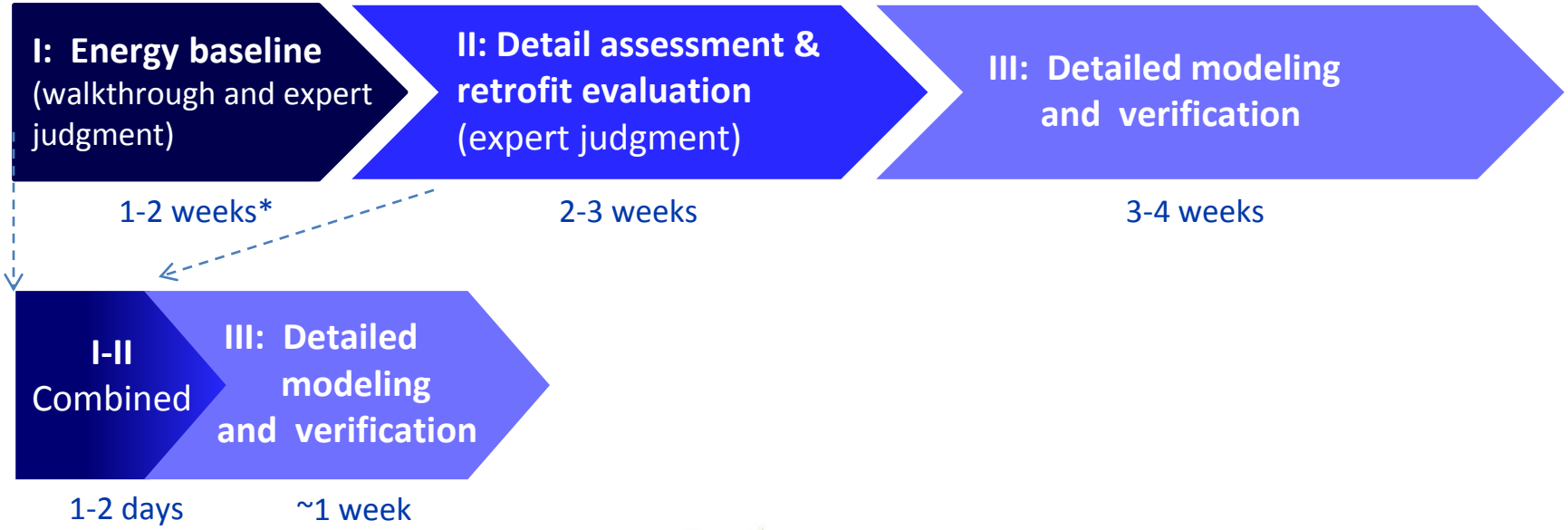
Subtask 2.2 – *Energy Audit and Retrofit Analysis*

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



Stakeholder Workshop

Subtask 2.2 – *Energy Audit and Retrofit Analysis*

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

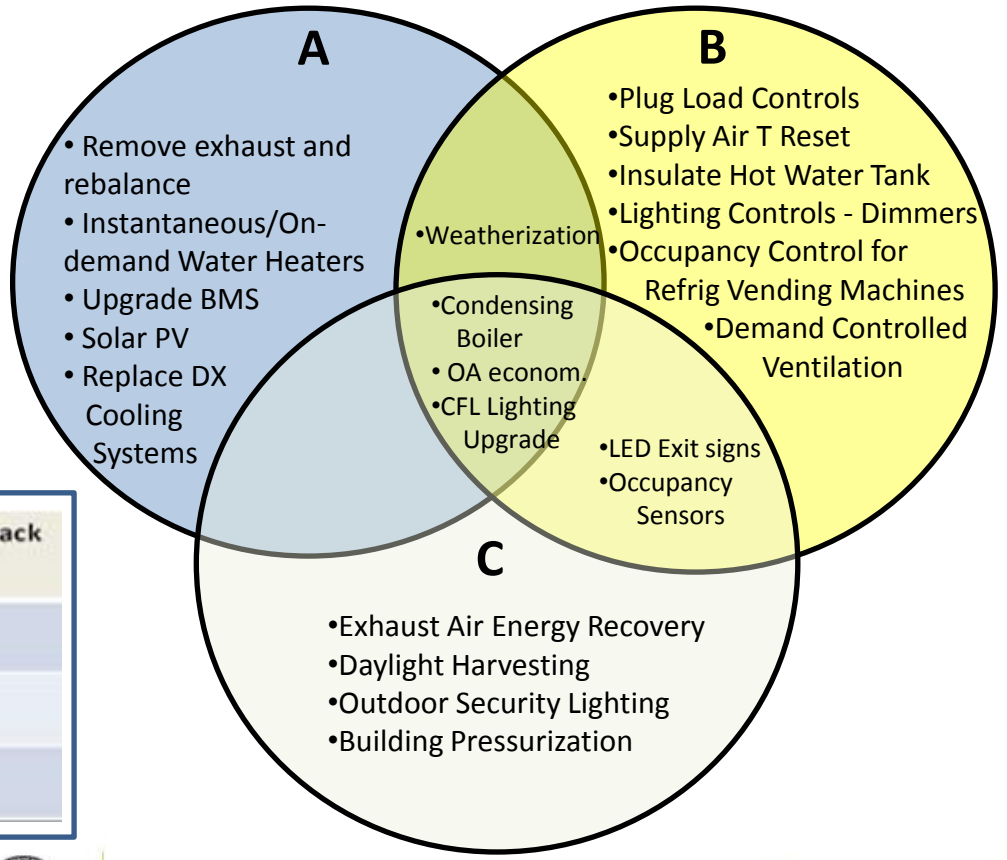
Comparison between 3rd party Audits - Philadelphia Navy Yard Building 101

3 different companies

3 different results

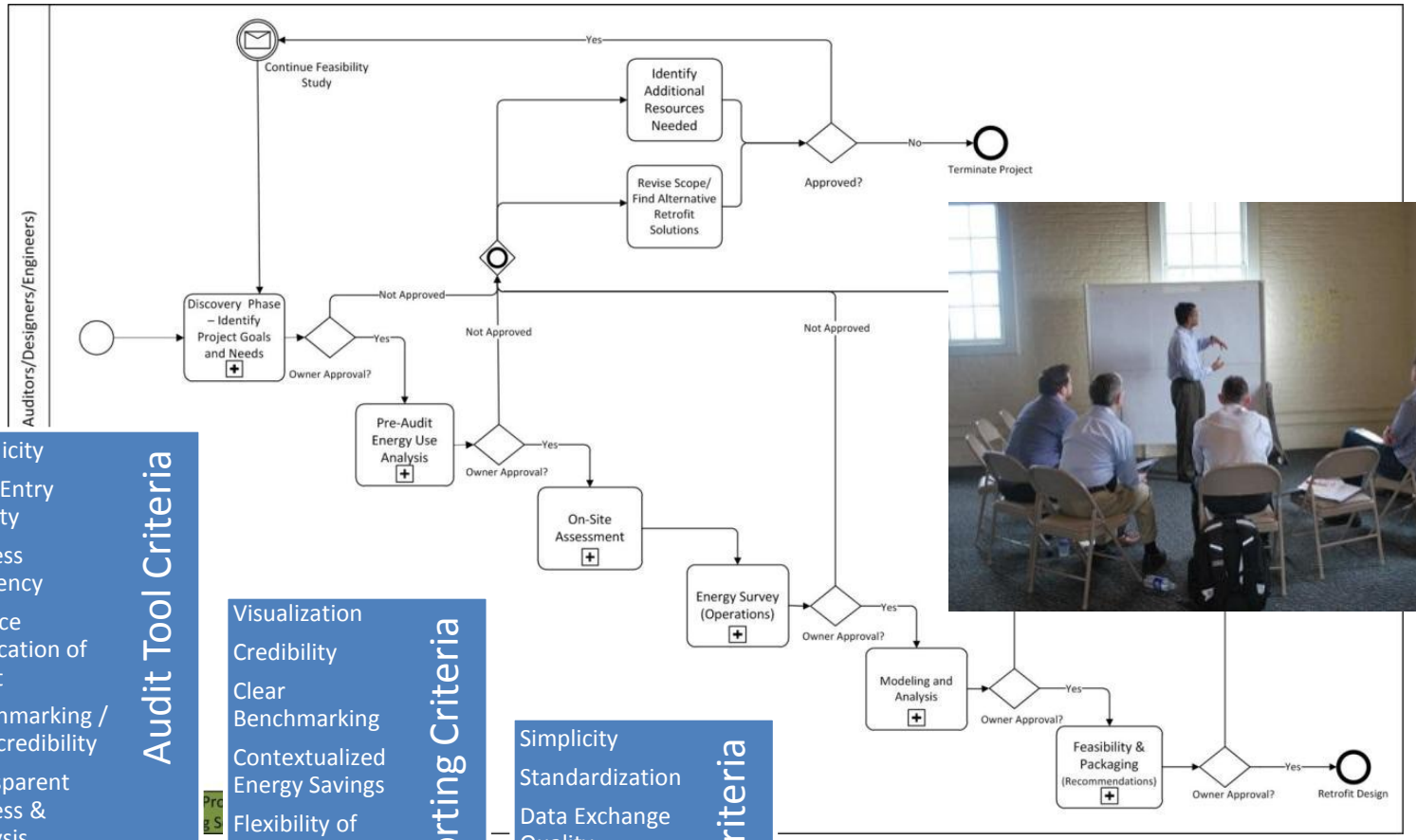
Company	Annual Savings	Installed Costs	Simple Payback (yrs)
A	$52,000	$312,000	6.0
B	$19,000	$79,000	4.2
C	$34,000	$104,000	3.1

Retrofit Recommendations



Stakeholder Workshop

Subtask 2.2 – *Energy Audit and Retrofit Analysis*



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

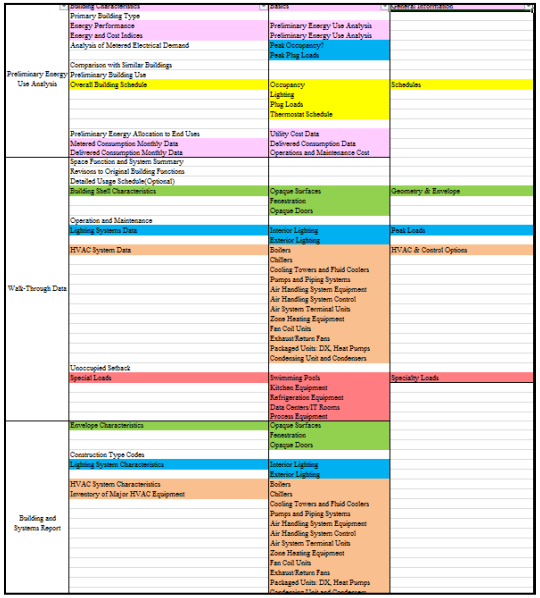
- Simplicity
- Standardization
- Data Exchange Quality
- Rich Data Collected
- Accessibility to Source Data

Stakeholder Workshop

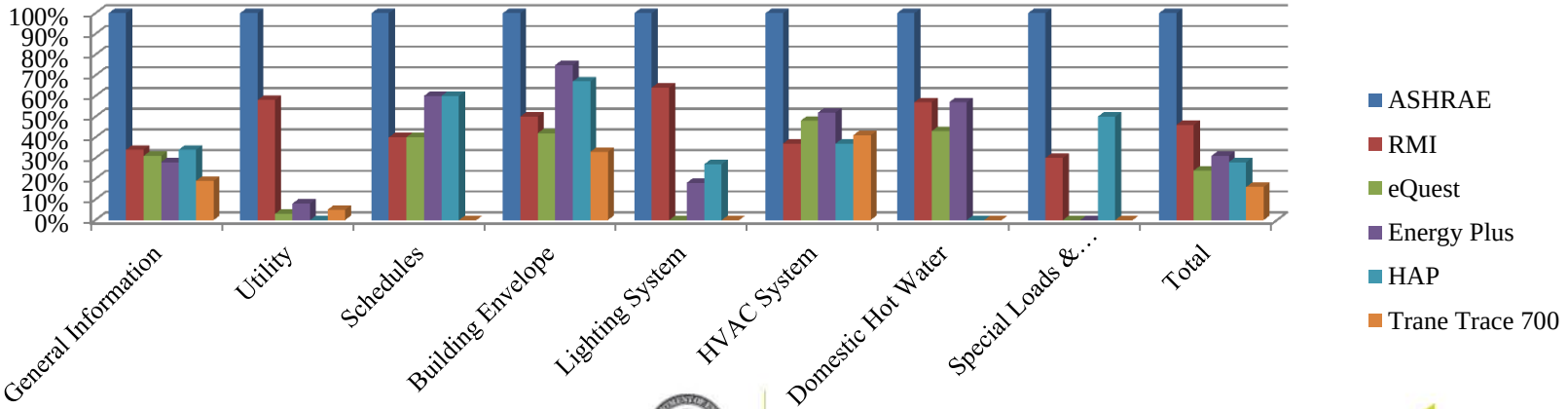
Subtask 2.2 – *Energy Audit and Retrofit Analysis*

- General Information
- Schedules
- Building Envelope Data
- Lighting System Data
- HVAC System Data
- Domestic Hot Water
- Special Loads

ASHRAE RMI

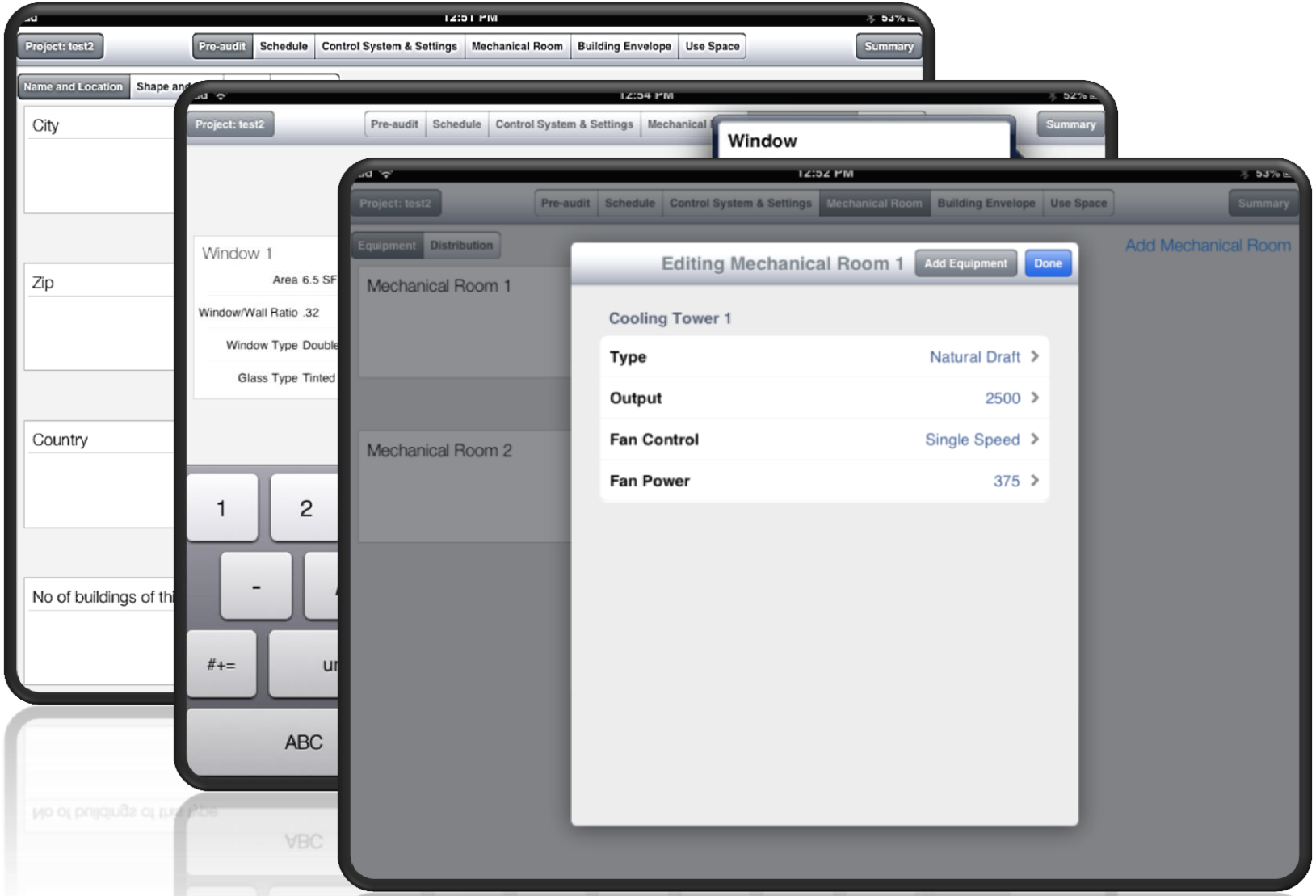


15-30% of ASHRAE defined data can be transfer to energy modeling tools !



Stakeholder Workshop

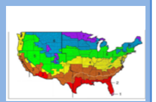
Subtask 2.2 – *Energy Audit and Retrofit Analysis*



Stakeholder Workshop

Subtask 2.2 – *Energy Audit and Retrofit Analysis*

Inputs

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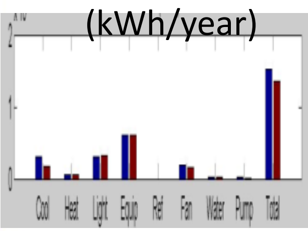
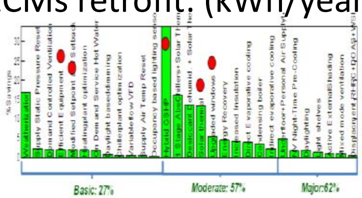
ECM's vs WBS

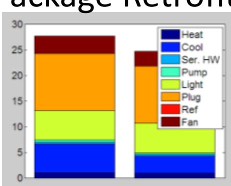
Baseline Energy (kWh/year)



ECMs retrofit: (kWh/year)

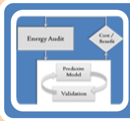


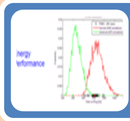
Package Retrofit

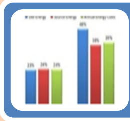


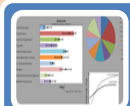
Baseline Retrofit


Identify Energy Need / Problem

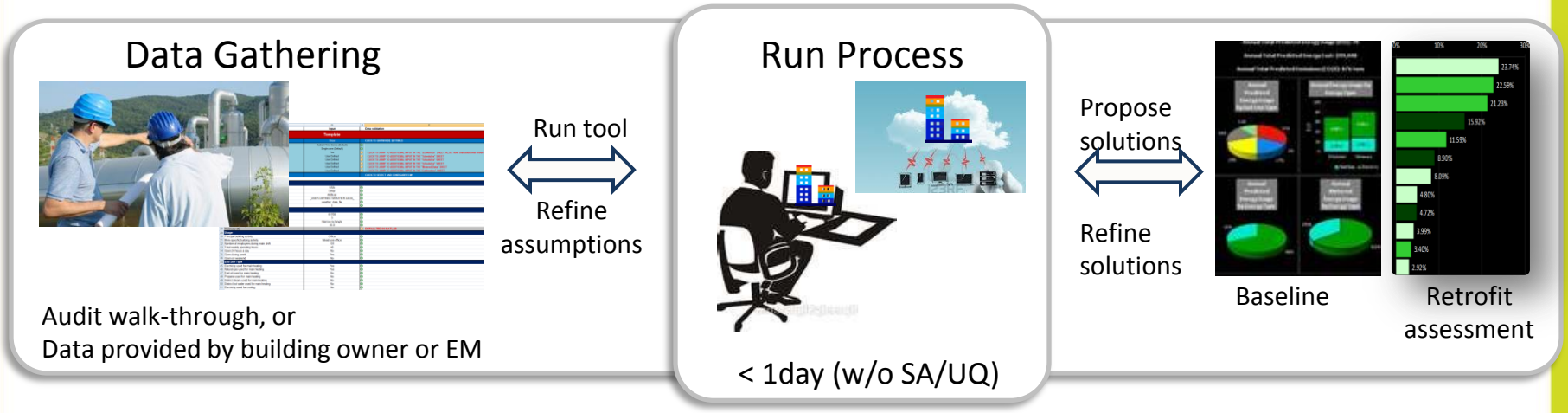

Perform Walk-through Assessment


Baseline Energy Analysis


Energy Conservation Measure Evaluation


Feasibility Analysis of ECM's

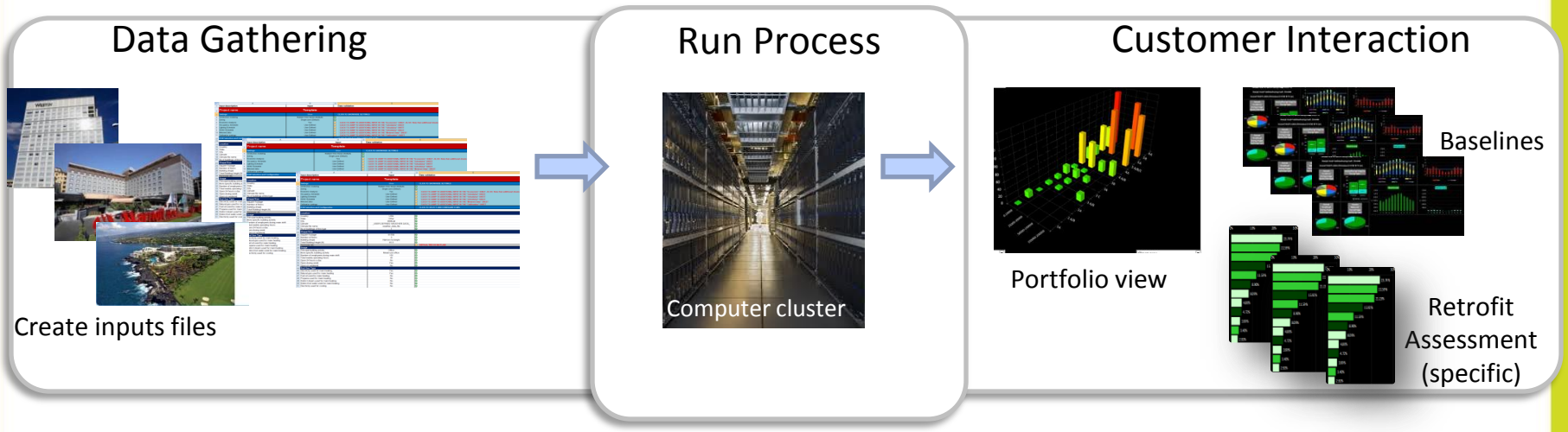
User-case 1: Individual Building



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

Stakeholder Workshop

Subtask 2.2 – *Energy Audit and Retrofit Analysis*

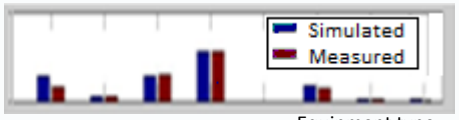
Process Overview

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

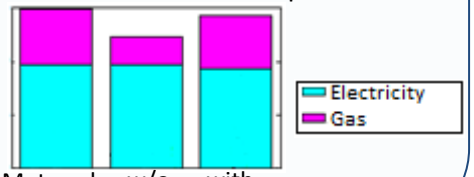
Simplified inputs


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

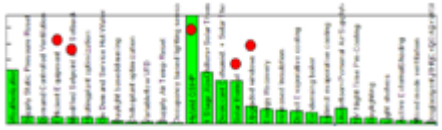

Baseline energy
by energy source and equipment type (kWh/year)



Total energy with and without calibrated inputs

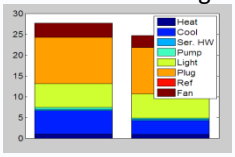


ECMs options
Energy usage (kWh/year); payback by applying individual ECMs

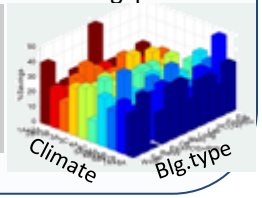


Savings and payback from package ECMs

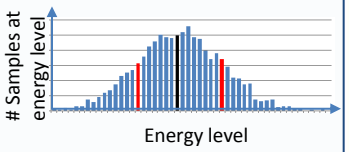
Individual building



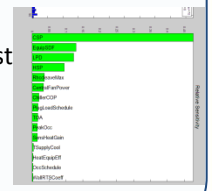
Building portfolio



UQ/SA
Results distribution based on input uncertainty



Rank of most influential parameters



* 'man-working hour'

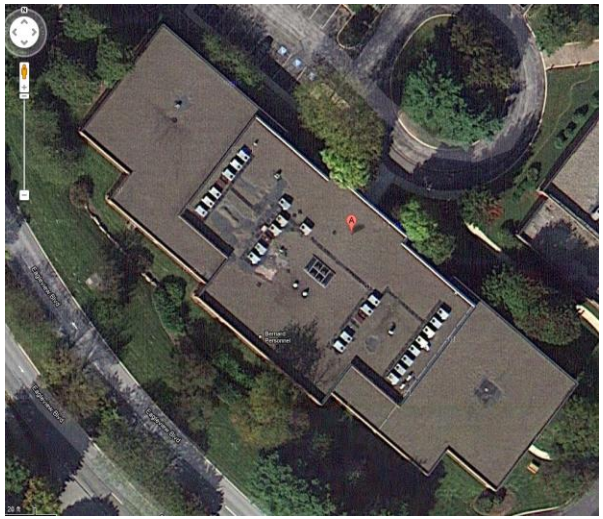
Differentiators

- 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

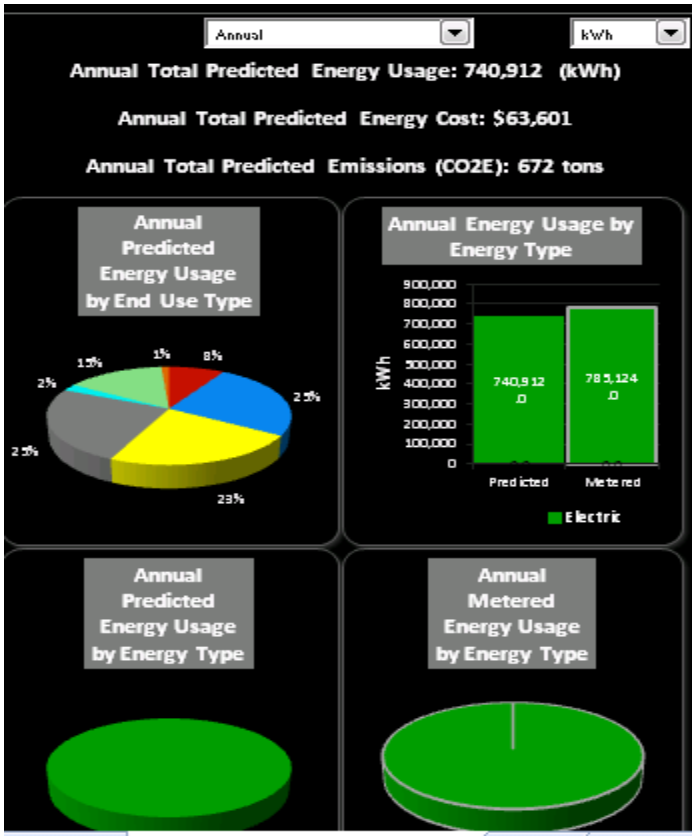
Lighting

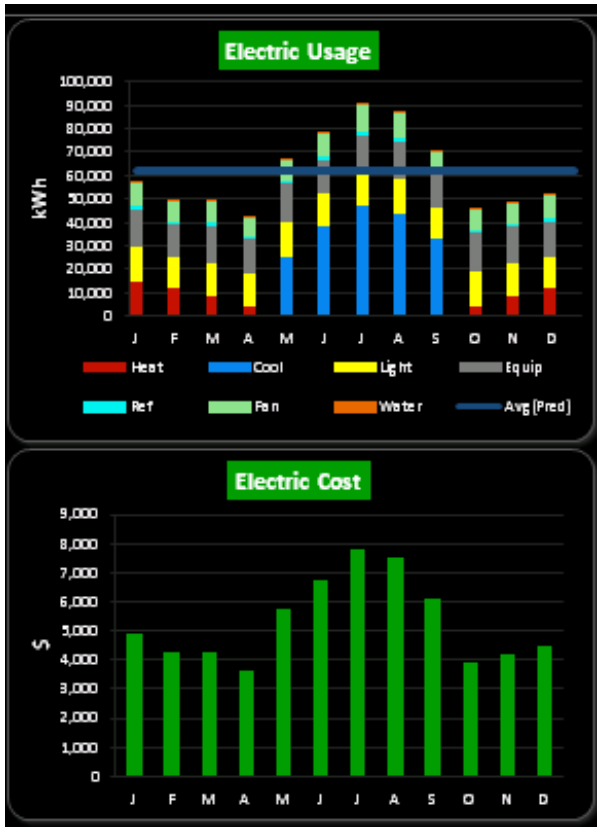
- The interior lighting is mostly T-12 recessed ceiling fixtures with manual controls
- Assumed light power density: 1.5 W/ft2

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

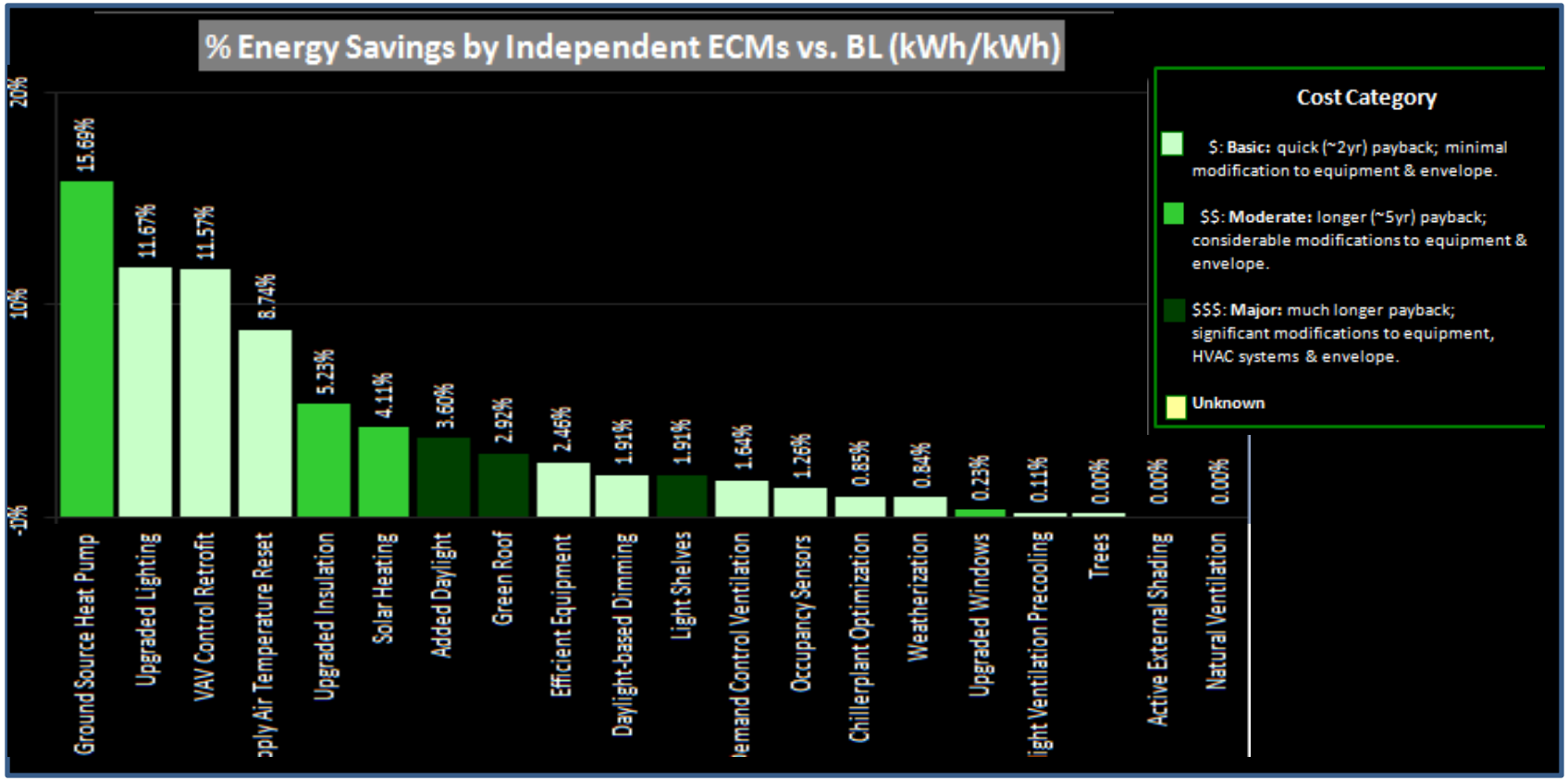
1 Sample Test Case – Baseline Building



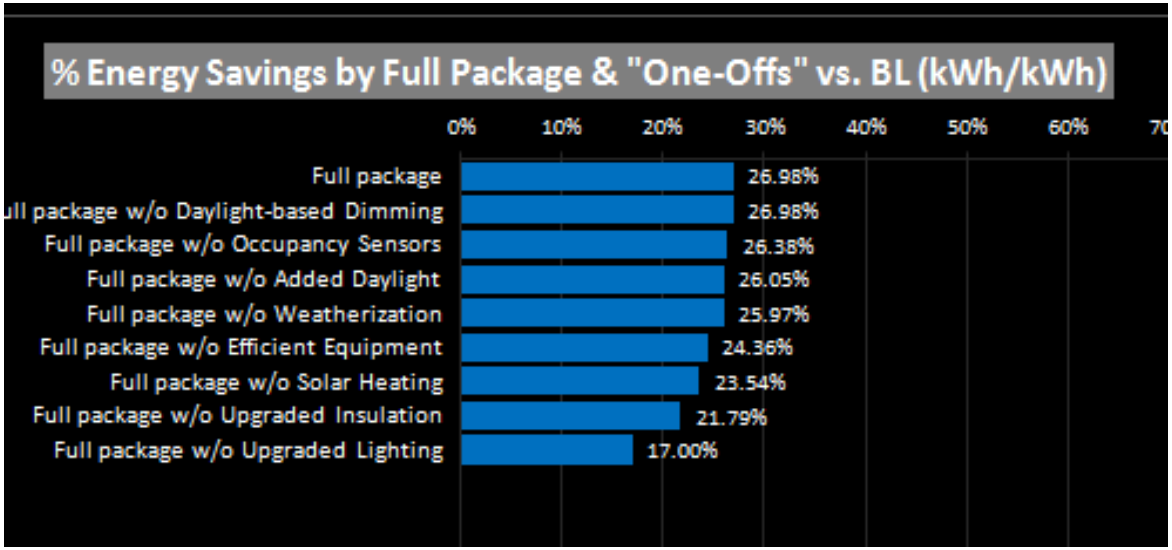


1 Sample Test Case – Calibrated Results

1 Sample Test Case – Energy Conservation Measures



1 Sample Test Case – ECM Packages

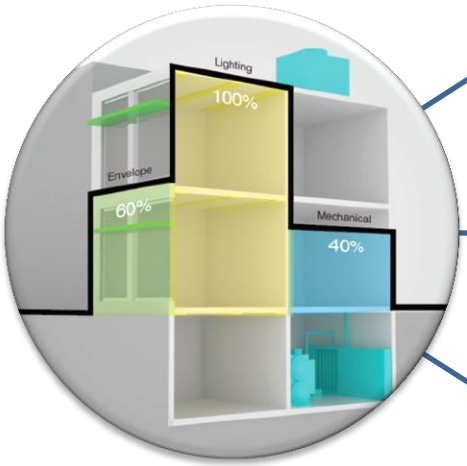


Package
Upgraded Lighting
Upgraded Insulation
Solar Heating
Added daylight
Efficient Equipment
Daylight basedimming
Occupancy Sensors
Weatherization

Stakeholder Workshop

Subtask 2.2 – *Energy Audit and Retrofit Analysis*

Focus Group participants liked:



Credibility

- Predicted vs. Actual
- Calibration
- Weather Data

Reduced Cost

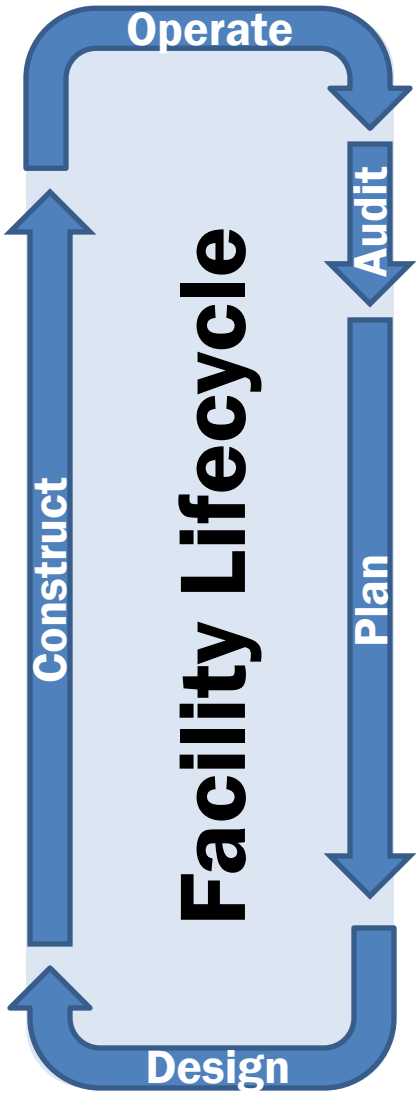
- Faster Data collection
- Automated analysis

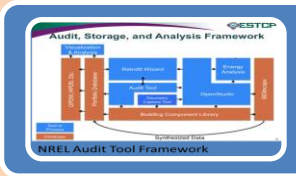
Customizable

- Readily Accessible
- Meet specific needs

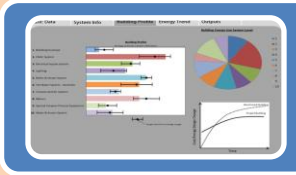
Stakeholder Workshop

Subtask 2.2 – *Energy Audit and Retrofit Analysis*

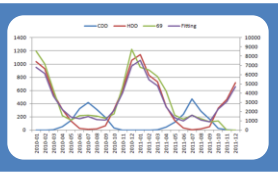




Build in flexible data access mechanism



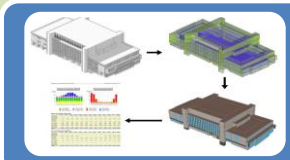
Present Economic Information clearly & compellingly



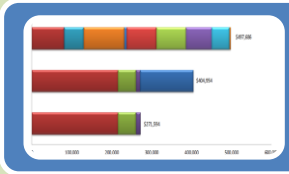
Include error bars to show level of confidence in results

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