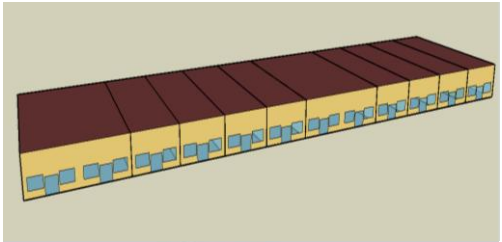
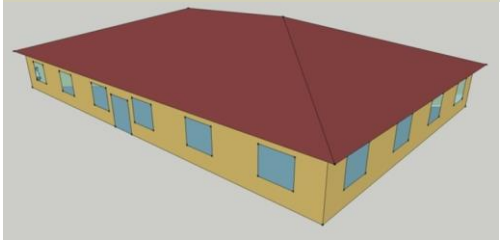
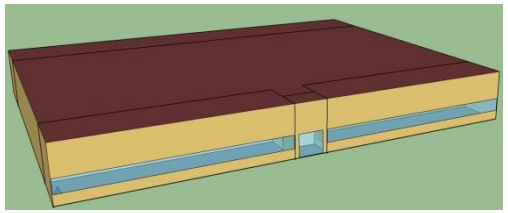
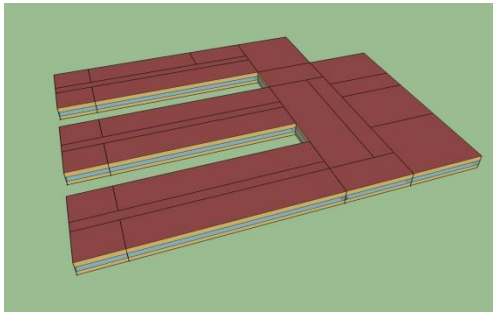
HVAC Packages for SMSCB*

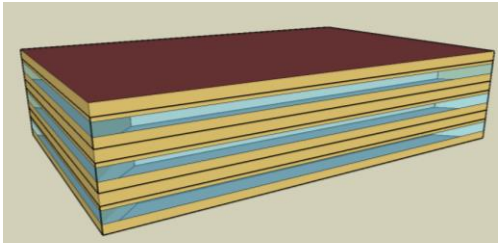
2015 Building Technologies Office Peer Review

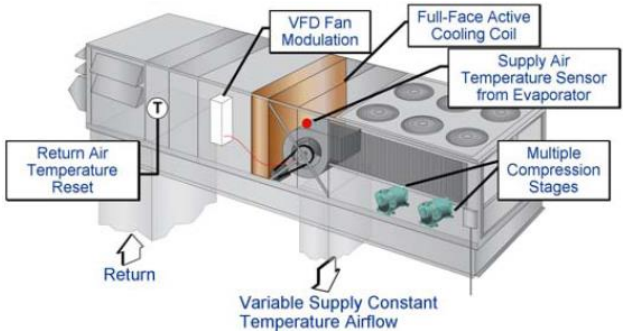


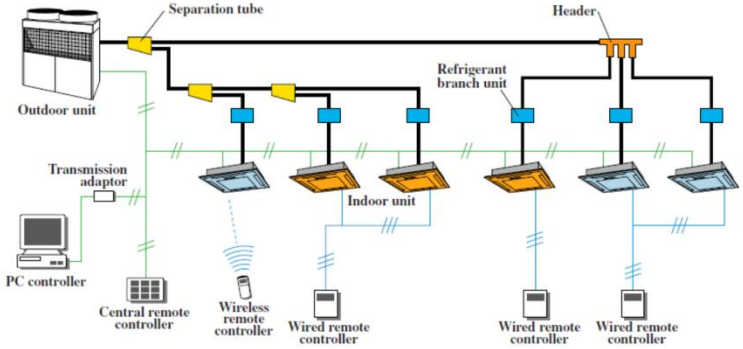












* Small and Medium Sized Commercial Buildings

Russell D. Taylor, TaylorRD@utrc.utc.com

CBEI – United Technologies Research Center

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

Project Summary

Timeline:

Start date: 5/1/2014

Planned end date: 4/30/2016

Key Milestones

1. Identify target SMSCB building types and climate zones; June 2014
2. Define integrated retrofit option; Sep 2014
3. Finish evaluation of retrofit options and identify HVAC retrofit packages; April 2015

Budget:

Total DOE $ to date: $0.47 M

Total future DOE $: $0.32 M

Key Partners:

CBEI-UTRC	
CBEI-Purdue	

Project Goal:

Evaluate and select 4 packaged HVAC retrofit solutions suitable for SMSCB in at least 3 different climate zones and provide 50% HVAC energy savings with a payback of less than 4 years.

Target Market/Audience:

Small to medium sized commercial building owners, HVAC contractors and equipment suppliers

Utility companies

Purpose and Objectives

Problem Statement: For SMSCB, retrofit decisions are typically made without detailed evaluation of the design alternatives. New technologies incorporated in retrofit by SMSCB fail to achieve energy savings targets due to:

- Inadequate knowledge of the energy savings potentials of new technology
- Poor compatibility between retrofit components/measures

Target Market and Audience: Target market: small to medium sized commercial buildings (~1.95 Quads site energy by HVAC system).
Target audience: This project targets small to medium sized building owners, HVAC contractors and equipment suppliers to be aware of the integrated retrofit solutions. Utility companies to target their incentive programs.

Impact of Project: Provide cost effective packaged HVAC retrofit solutions to SMSCB.

a. Near-term: identification of cost effective retrofit solutions
b. Intermediate-term: demonstration of retrofit solutions
c. Long-term: wide-spread market adoption of retrofit solutions

Approach

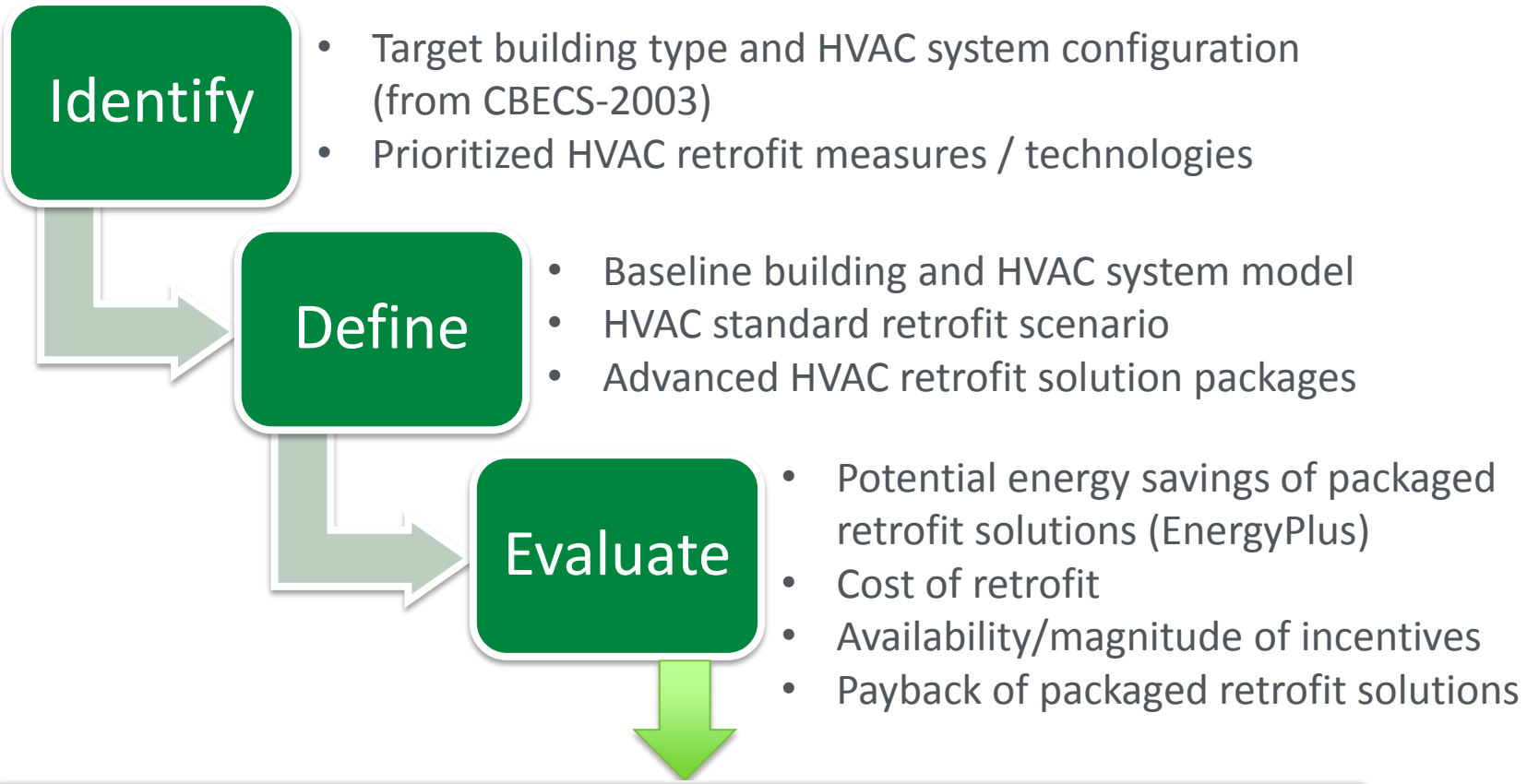
Approach: Identify target building types and climate zones based on CBECS database. Develop integrated retrofit solutions from DOE prioritized list of technologies. Simulation analysis of the retrofit solutions with NREL's post-1980 commercial building reference models .

Key Issues: Cost-effectiveness and robustness of packaged HVAC retrofit solutions.

Distinctive Characteristics:

- Leveraging existing data and DOE resources to characterize SMSCB
- Realistic and regionally specific retrofit cost estimation.
- Retrofit HVAC solutions based on existing technologies and near future technologies from DOE BTO Prioritization Tool database

Approach



Progress and Accomplishments

Lessons Learned:

1. Acceptable retrofit cost needs to be low to achieve the 4-year payback target, typical SMSCB have low HVAC energy cost (<$1.5/ft^2/year).
2. Energy efficiency incentives may be necessary to drive substantial uptake of energy efficient HAVC retrofits
3. Current simulation tools have gaps in simulation of new and near future HVAC technologies

Accomplishments:

Identified 30 packaged HVAC solutions - one package for each building type and selected climate zone

Market Impact:

1. Information dissemination - Webinar for SMSCB HVAC contractors, equipment suppliers, owners and operators (Planned 4/22/15)
2. Develop OpenStudio Measures for identified solutions
3. Identify potential demonstration sites

Awards/Recognition: None

Progress and Accomplishments: Target Buildings

Target building type and characteristics from CBECS-2003 database

Location & Climate
Midwest (Zone 2)
Northeast (Zone 2)
West (Zone 4)
South (Zone 4 & 5)

X

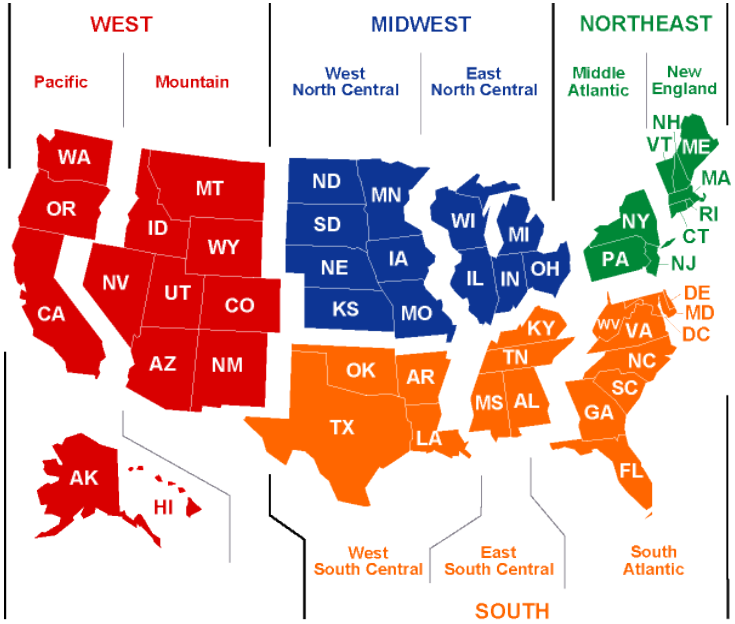
Building Type
Office
Mercantile
Education

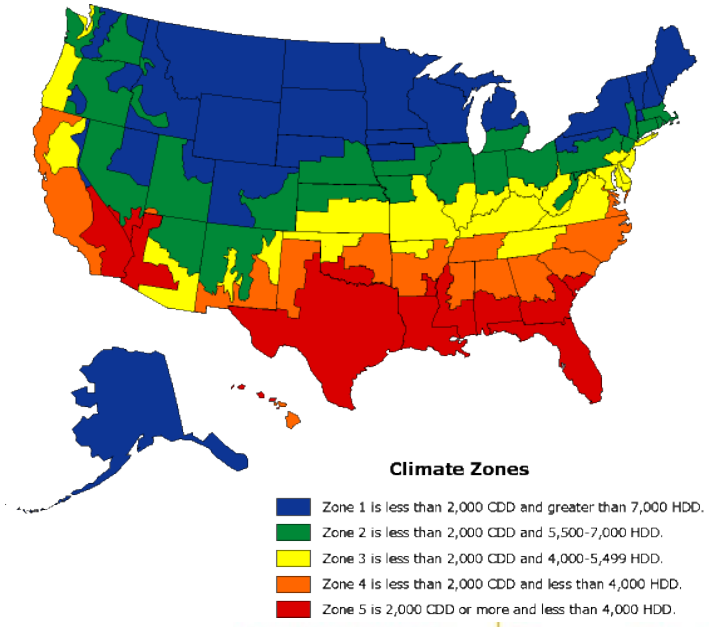
X

Existing HVAC System
Packaged Central - RTU
Split Central - DX AHU
PTAC -Window AC

X

Heating Source
Electric
Gas
Oil
Heat Pump





U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

Progress and Accomplishments: Retrofit Technologies

Sources of Information

ASHRAE AEDG for Small Office (30% Energy Savings)
ASHRAE AEDG for Small to Medium Office (50% Energy Savings)
Advanced Energy Retrofit Guide for Office Buildings by PNNL
DOE P-Tool (List of technologies and metrics: performance, cost, and market prediction)

47 Prioritized HVAC Technologies for SMSCB in the following 7 categories

- Design
- Air distribution
- Cooling
- Heating
- Cooling & Heating
- Outside air and ventilation
- Operation, control & diagnostics

Progress and Accomplishments: Summary

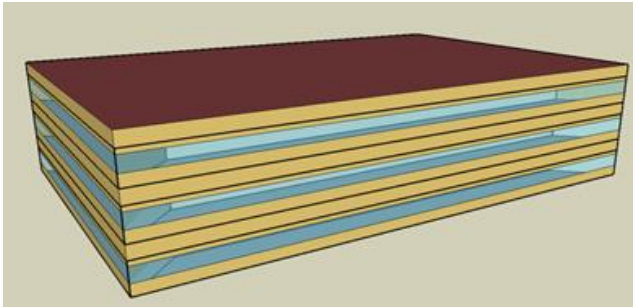
Potential HVAC Energy Savings of Packaged Retrofit Solutions

U. S. Census Regions and Divisions		South	Midwest	South	Northeast	Midwest	West
U. S. Climate Zones for 2003 CBECS		**Zone 4**	**Zone 2**	**Zone 5**	**Zone 2**	**Zone 1**	**Zone 4**
Representative City (ASHRAE Climate Zone)		**Charlotte, NC (3A)**	**Indianapolis, IN (5A)**	**Houston, TX (2A)**	**Boston, MA (5A)**	**Minneapolis, MN (6A)**	**Los Angeles, CA (3B)**
Office	**Small Office**	45%	55%	51%	52%	55%	47%
	Medium Office	40%	58%	58% (54%)	61% (45%)	64%	49%
Mercantile	**Stand-Alone Retail**	48%	51%	50%	53%	48%	50%
	Strip Mall	TBD	TBD	TBD	TBD	TBD	TBD
Education	**Primary School**	TBD	TBD	TBD	TBD	TBD	TBD

Progress and Accomplishments: Retrofit Packages

Packaged Solution for Medium Office in Boston

Reference building model by NREL
Three Floor, 5 Zones Each Floor
Total Floor Area: 53,600 ft^2
Post 1980 construction



Baseline HVAC System: CAV RTU with Gas Heat for each floor, SEER 11

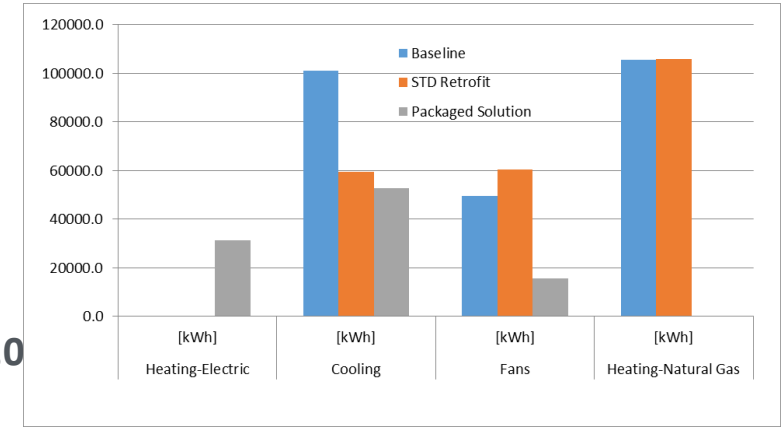
Standard HVAC Retrofit (12% HVAC Energy Savings)

- **CAV RTU with Gas Heat, SEER 14**
- **Retrofit cost $ 13.92/ft^2**
- **Annual HVAC Energy Cost: $0.43/ft^2**

Packaged Retrofit Measures (61% HVAC Energy Savings)

1. **VRF Multi-Split with Cooling COP 3.3, Heating COP 3.0**
2. **Individual zone thermostat control**

- **Retrofit Cost: $25.44/ft^2 ($14.06/ft^2 incentivized)**
- **Annual HVAC Energy Cost: $0.29/ft^2**



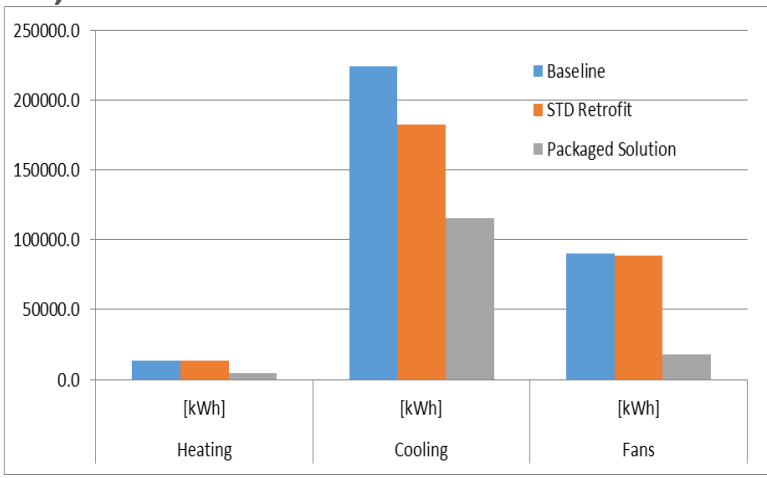
Simple Payback 1 **years with existing incentive**

(Simple Payback without incentives: 83 years)

Progress and Accomplishments: Retrofit Packages

Packaged Solution for Medium Office in Houston

Baseline HVAC System: CAV RTU with Electric Heat for each floor, SEER 11



Standard HVAC Retrofit (12% HVAC Energy Savings)

- **CAV RTU with Electric Heat, SEER 14**
- **Retrofit cost $ 12.79/ft^2**
- **Annual HVAC Energy Cost: $0.72/ft^2**

Packaged Retrofit Measures (58% HVAC Energy Savings)

1. **VRF Multi-Split with Cooling COP 3.3, Heating COP 3.0**
2. **Individual zone thermostat control**

- **Retrofit Cost: $19.42/ft^2 ($19.00/ft^2 incentivized)**
- **Annual HVAC Energy Cost: $0.35/ft^2**

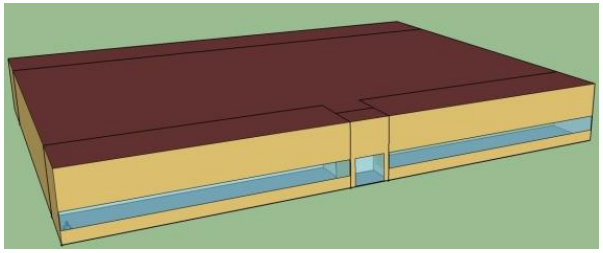
Simple Payback 16.8 **years with existing incentive**

(Simple Payback without incentives: 17.8 years)

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

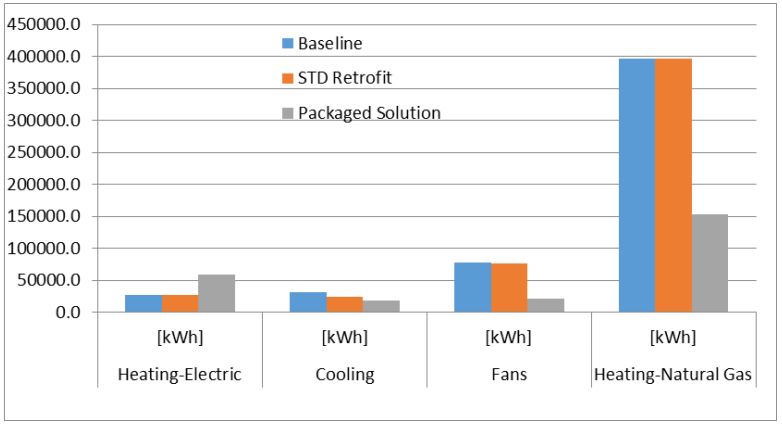
Progress and Accomplishments: Retrofit Packages

Packaged Solution for Standalone Retail in Boston



Reference building model by NREL
One Floor, 5 Zones
Total Floor Area: 24,682 ft^2
Post 1980 construction

Baseline HVAC System: CAV RTU with Gas Heat, SEER 11



Standard HVAC Retrofit (2% HVAC Energy Savings)

- **CAV RTU with Gas Heat, SEER 14**
- **Retrofit cost $ 6.13/ft^2**
- **Annual HVAC Energy Cost: $1.46/ft^2**

Packaged Retrofit Measures (53% HVAC Energy Savings)

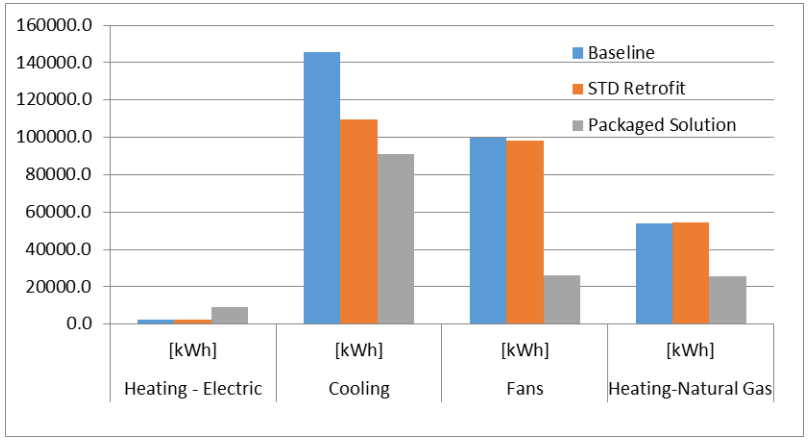
1. **Single-zone VAV unit with gas heat (SEER 14) for Core Retail**
2. **Multi-split heat pump for other zones**

- **Retrofit Cost: $4.48/ft^2**
- **Annual HVAC Energy Cost: $0.87/ft^2**

Packaged solution cheaper than standard retrofit

Progress and Accomplishments: Retrofit Packages

Packaged Solution for Standalone Retail in Houston



Baseline HVAC System: CAV RTU with Gas Heat, SEER 11

Standard HVAC Retrofit (12% HVAC Energy Savings)

- **CAV RTU with Gas Heat, SEER 14**
- **Retrofit cost $ 4.51/ft^2**
- **Annual HVAC Energy Cost: $1.25/ft^2**

Packaged Retrofit Measures (50% HVAC Energy Savings)

1. **Single-zone VAV unit with Gas heat (SEER 14) for Core Retail**
2. **Multi-split heat pump for other zones**

- **Retrofit Cost: $4.97/ft^2 ($4.40/ft^2 incentivized)**
- **Annual HVAC Energy Cost: $0.74/ft^2**

Packaged solution with incentives cheaper than standard retrofit

Project Integration and Collaboration

Project Integration:

- Vidaris, Inc – Provider of energy efficiency and sustainability services for commercial buildings
- US Army Engineer Research and Development Center – Developer of energy efficient retrofit solutions for US Army building stock

Partners, Subcontractors, and Collaborators:

Project team:

- UTRC – Analysis of retrofit packages
- Purdue University – Baseline building and HVAC models
- Booz Allen Hamilton – Regional incentive information

This work is part of the Penn State Consortium for Building Energy Innovation (CBEI)

Communications: CBEI webinar for HVAC contractors and equipment suppliers (4/22/2015).

Next Steps and Future Plans

1. Expand analysis to other major building types
2. Develop OpenStudio Measures for HVAC retrofit packages
3. Identify potential demonstration sites for packaged retrofit solutions

REFERENCE SLIDES

Project Budget

Project Budget: Annually funded as part of CBEI. Total DOE budget $0.79 M.
Variances: No project budget variances to date.
Cost to Date: $0.47M of DOE funds expended to date

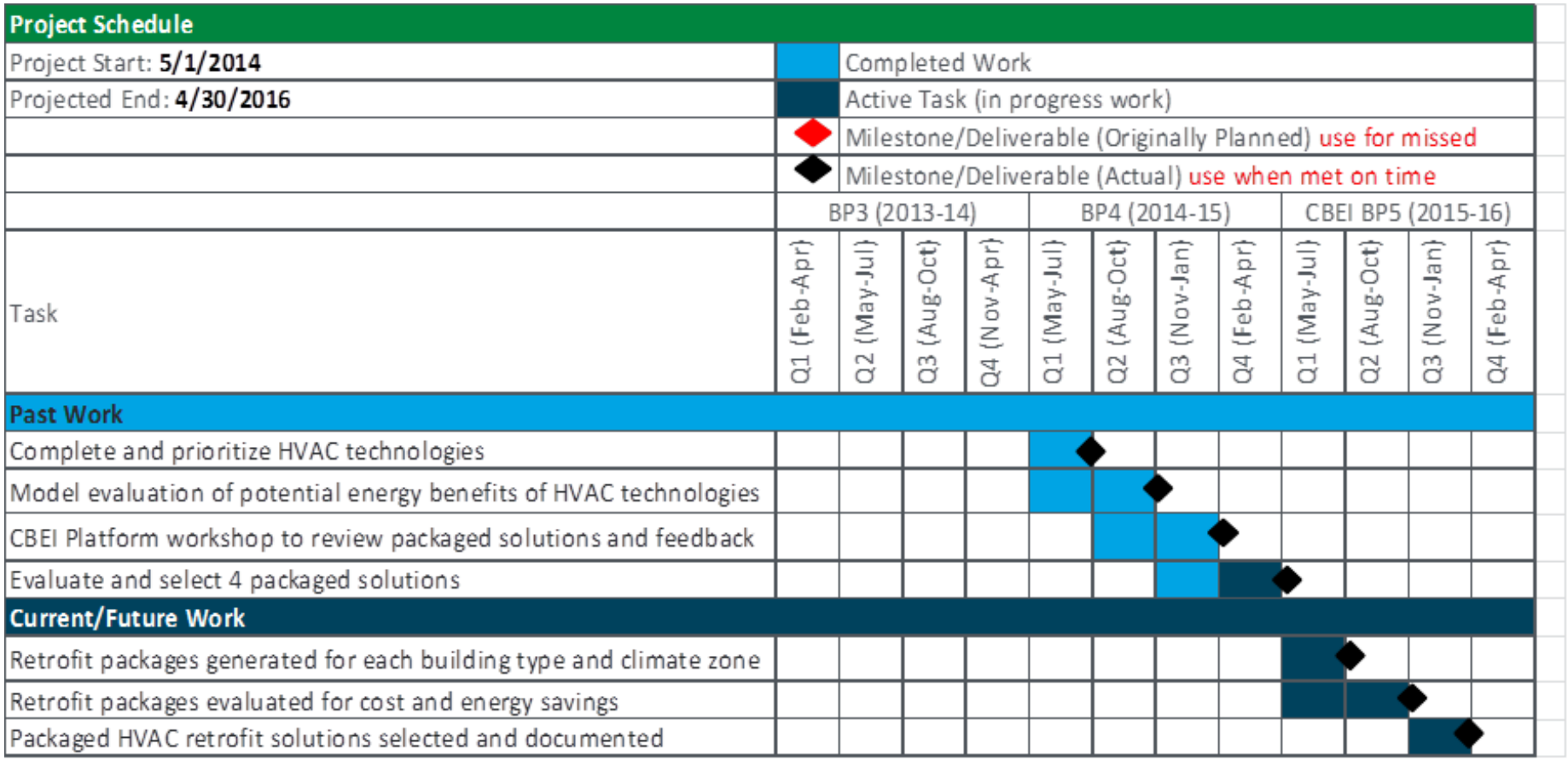
Budget History

CBEI BP3 (past) 2/1/2013 – 4/30/2014		CBEI BP4 (current) 5/1/2014 – 4/30/2015		CBEI BP5 (planned) 5/1/2015 – 4/30/2016	
DOE	Cost-share	DOE	Cost-share	DOE	Cost-share
$0K	$0K	$470K	$98K	$320K	$62K

CBEI – Consortium for Building Energy Innovation (formerly EEB Hub)
BP – Budget Period

Project Plan and Schedule

- Go/No-Go: 1) Develop packaged retrofit solutions (6 months); 2) Evaluate and select 4 packaged retrofit solutions suitable for SMSCB (11 months)



BP – Budget Period for Consortium for Building Energy Innovation (formerly EEB Hub)