Better Buildings®
U.S. DEPARTMENT OF ENERGY

Emerging Technologies: The 2016 Watch List

Tuesday, May 10, 2016

2:00-3:15 PM

U.S. DEPARTMENT OF ENERGY

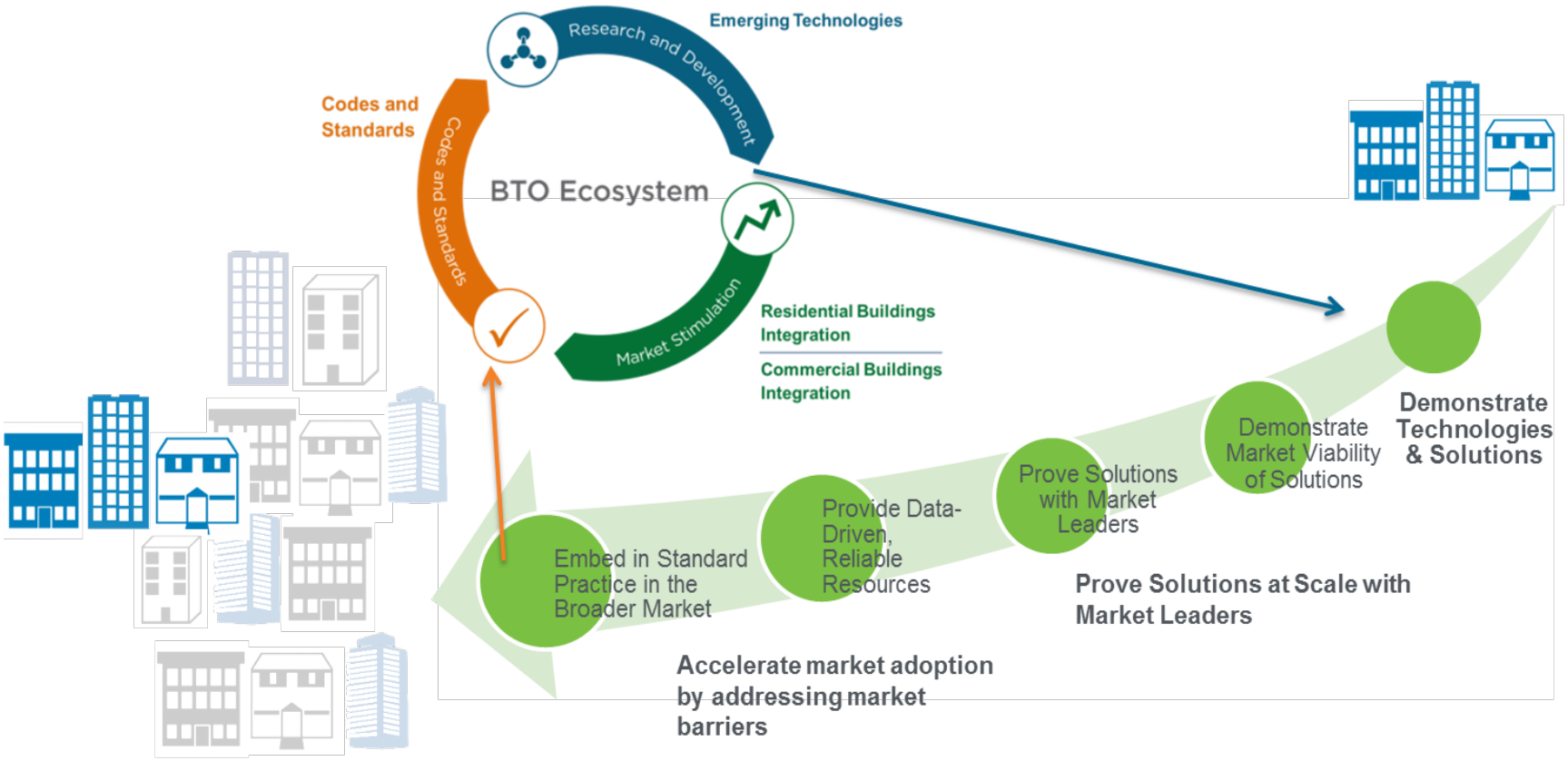
Building Energy

- $410 billion/year
- 75% of the nation's electricity
- Contributes 40% of greenhouse gas emissions

Building efficiency products represent $60 billion in U.S. revenue; up 43% over the last 4 years.

Efficiency through High Impact Technology

Goal: The commercial building technology deployment framework is designed to help identify and prioritize cost-effective, underutilized, energy-efficient technologies so that DOE can focus resource development and deployment activities.



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Agenda

1. Introduction to the Building Technologies Office Emerging Technologies Program
2. New Air Barrier and Air Sealing Products
3. Cold Climate Heat Pumps and Alternative Refrigerants
4. Questions and Discussion

Today's Presenters

- Pat Phelan, Program Manager for Emerging Technologies
- Karma Sawyer, Technology Manager for Windows and Envelope, Technology Analysis and Commercialization Manager
- Tony Bouza, Technology Manager for HVAC, Water Heaters and Appliances

Overview of the Emerging Technologies Program

Pat Phelan
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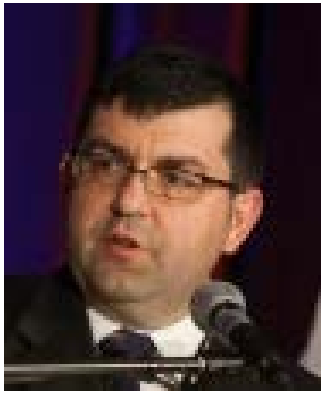
ET Staff: Technology Managers

Jim Brodrick
(Solid-State Lighting)



Tony Bouza
(HVAC/WH/Appliances)

Karma Sawyer & Marc LaFrance
(Windows/Envelope)

Marina Sofos
(Sensors/Controls)

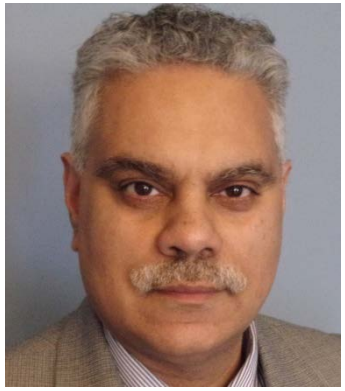
Amir Roth
(Building Energy Modeling)

Karma Sawyer
(Technology Analysis & Commercialization)

Sven Mumme
(Technology Commercialization)

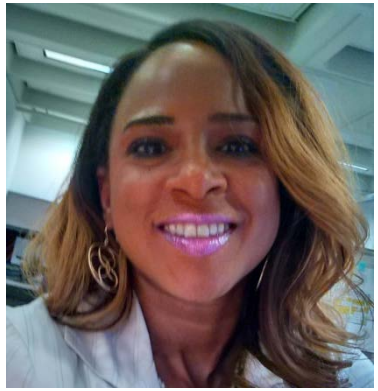
ET Staff: Technical Project Officers, Fellows, & Admin

Jim Payne
(Technical Project Officer)



Mohammed Khan
(Technical Project Officer & SBIR Manager)

Mike Atsbaha
(Senior Management Analyst)



Carla Dunlap
(Program Support Specialist)

Jared Langevin
(BTO Post-Doctoral Fellow)

Stephanie Johnson
(BTO Post-Doctoral Fellow)

Chioke Harris
(AAAS Fellow)

Brent Nelson
(AAAS Fellow)

Who Supports Energy Efficiency R&D (Federal)?

Fundamental Research → **First Commercialization** → **Market Penetration**

Building Technologies Office

Emerging Technologies

- Commercial Buildings Integration
- Residential Buildings Integration

Codes & Standards

- ARPA-E
- NSF
- DOE Office of Science
- ONR
- FEMP
- ESTCP
- GSA Green Proving Grounds

BTO's Emerging Technologies (ET) Program

HVAC, Water Heating, & Appliances

Windows & Building Envelope

Lighting

Building Energy Modeling

Sensors & Controls

Buildings to Grid

http://energy.gov/eere/buildings/emerging-technologies

BTO Emerging Technologies R&D Goal

*As a result of ET-sponsored research, cost-effective technologies will be introduced into the marketplace by 2020 that will be capable of reducing a building's energy use by **30%** relative to 2010 cost effective technologies, and 45% by 2030.*

2020 energy savings by end use, relative to 2010 stock and Energy Star efficiency levels:

End Use	2010 Buildings Sector Energy Use (Quads)	Energy Use if 2010 Cost- Effective Technologies All Adopted (Quads)*	Energy Use if 2020 ET R&D Targets Achieved and Technologies All Adopted (Quads)*	% of End-Use Energy Savings
Lighting	4.8	3.5	0.7	80%
HVAC: Envelope	7.7	4.2	1.7	59%
HVAC: Equipment	5.6	3.1	1.3	59%
Water Heating	2.7	2.0	1.5	27%
Appliances	3.8	2.8	2.3	18%
Other (MELs, multi-family, mobile houses, etc.)	13.0	13.0	13.0	0%
Totals	**37.5**	**28.6**	**20.2**	**29%**

*2010 Cost Effective Technologies and 2020 ET R&D Target Energy Consumption numbers show the technical potential of these technologies under a shared set of assumptions.

Emerging Technologies Program supports R&D of technologies and systems that are capable of substantially reducing building primary energy use, and accelerates their introduction into the marketplace.

Dec. 2015

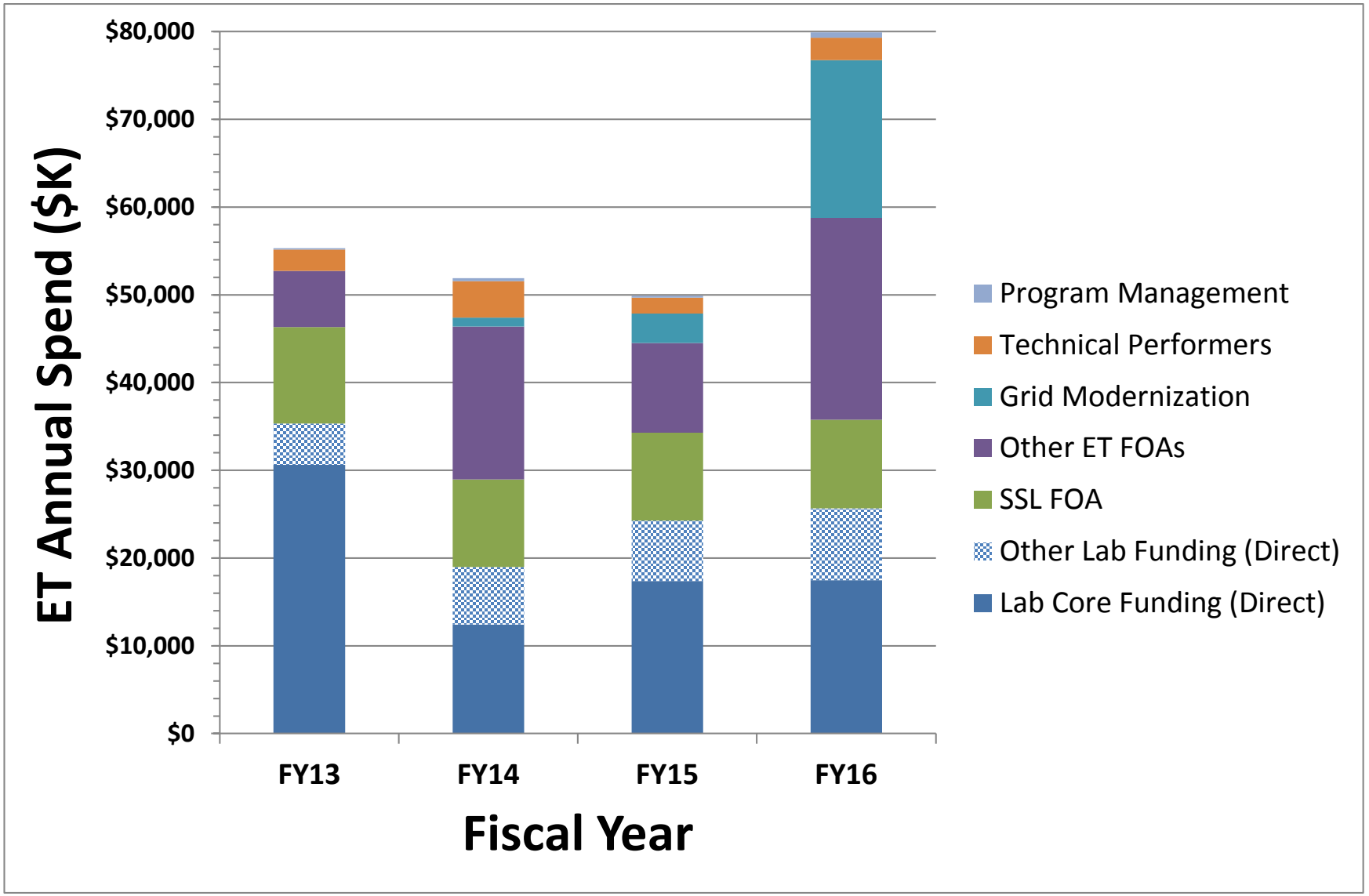
External Influences: DOE budget, Spin-off products, Legislation, Market incentives, Private sector R&D, Energy prices, Legislation / Regulation

Sub-Programs	Objectives	Activities / Partners	Key Outputs	Short Term Outcome	Mid-Term Outcome	Long Term Outcome
Solid State Lighting	Support R&D of high efficiency next-generation technologies & components	Competitive & shared R&D funding focused on energy efficiency performance by researchers in lab & test facilities	Technical pathway & research reports	Private sector has access to validated solutions to develop or improve technologies & reduce cost	Private sector engages in targeted R&D & develops advanced, more cost-effective tech.	*Advanced energy efficient technologies* are regularly innovated, widely available in the market, & have similar or better life-cycle costs relative to conventional technologies. *Energy Efficient Buildings* are designed or upgraded with communicative, energy efficient technologies & controlled to optimize system operations & grid integration, while minimizing energy use & costs.
			Prototypes that fill technical gaps			
HVAC, Water Heating & Appliances	Improve performance & cost of near term technologies & reduce manufacturing costs	Competitive & shared funding of field testing, modeling & validation	Prototypes or packaged solutions that reduce cost	Manufacturers aware of advanced tech. & available reduced cost production solutions	Manufacturers produce highly energy efficient equipment & push in the market	
		Manufacturing R&D with emphasis on cost reduction with industry	Open-source sensor & control platforms & standardized communication protocols	Manufacturers & retailers understand product benefits	Retailers / building industry stock & install more energy efficient products	
Windows & Building Envelope	Accelerate market entry & availability of technologies & processes	Pre-commercial technology demos with industry	Manufacturing advanced, reduced cost solutions	Building industry have solutions to install & integrate products in buildings	Building industry regularly use energy modeling tools to design or retrofit energy efficient buildings	
		Development of installation & verification techniques with industry	Tech. cost & performance data & demo reports			
Sensors & Controls		Outreach to stakeholders with cost & performance data analysis	Installation & verification techniques	Building industry or engine developers have energy modeling tools to improve building or systems design	Government, standards & industry orgs. & EE programs use modeling as basis for market incentives, standards & energy codes	
			Industry competitions, workshops & recognition			
Building Energy Modeling (BEM)	Improve energy modeling tools & capabilities & testing techniques	Competitive & shared funding to develop, improve & test modeling tools	Tech. & market assessments	Governments, standards & industry orgs.& EE programs have approaches & test protocols to differentiate product performance		
		Development of test & simulation protocols by researchers to support industry standards	Comprehensive, accurate, easy to use modeling tools & approaches			
			Standardized simulation & test protocols			

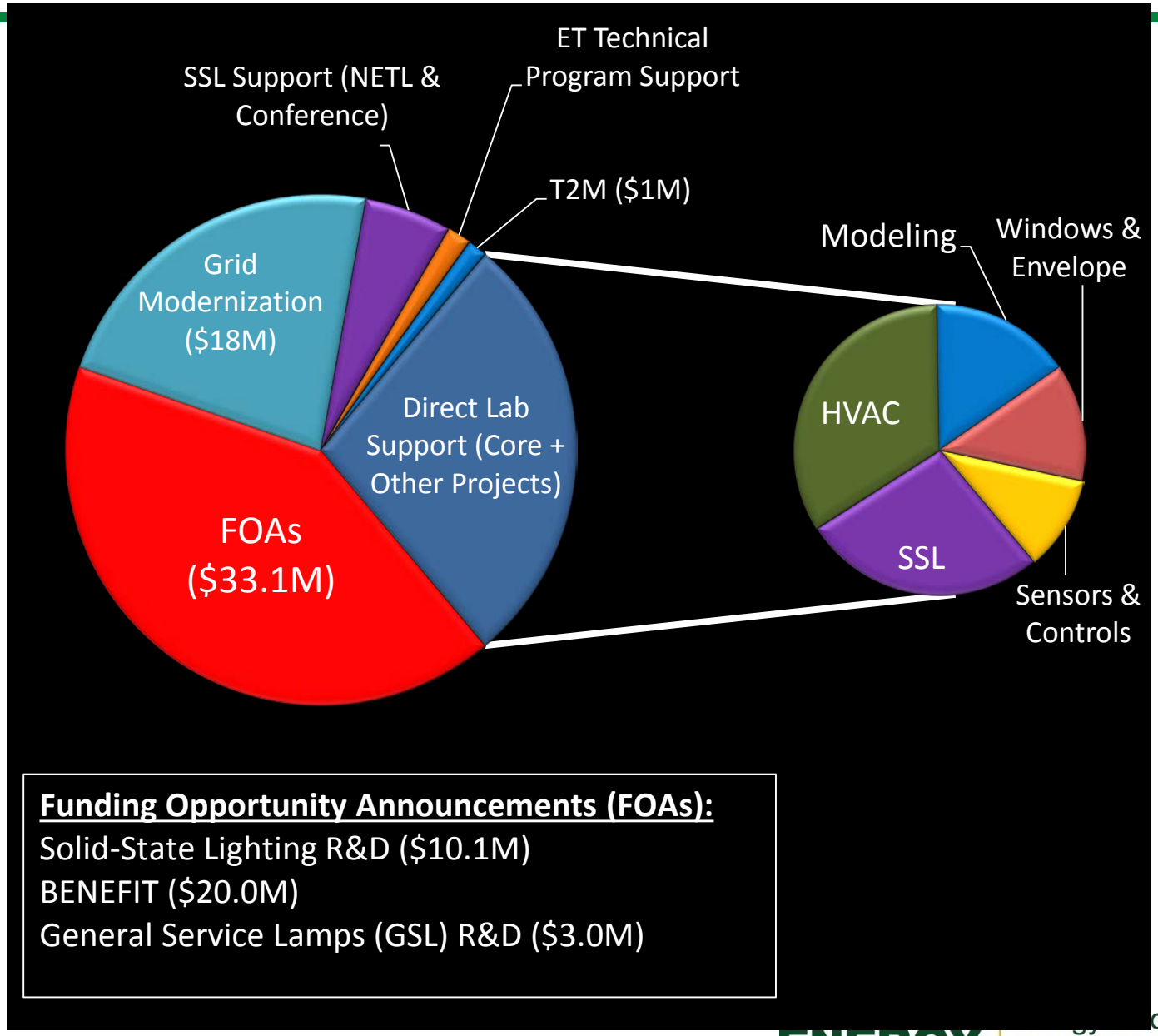
**Researchers are national labs, universities & research institutions*

Impact			
	Meet cost and performance R&D targets for SSL, HVAC, water heating, appliances, windows, building envelope, sensors & controls and BEM	Enable the development of cost-effective technologies that will be capable of reducing bldg. EUI 30% by 2020	Reduce EUI in all bldgs. 30% by 2030

BTO Emerging Technologies Annual Spend FY13 – FY16



ET Fiscal Year 2016 Budget ($79.912M)



Funding Opportunity Announcements (FOAs):
Solid-State Lighting R&D ($10.1M)
BENEFIT ($20.0M)
General Service Lamps (GSL) R&D ($3.0M)

ET Funding Opportunities in FY16

- **BENEFIT (Building Energy Frontiers and Innovation Technologies)**
  - **Rotates among non-SSL topics**
  - **Early stage and later stage R&D; often includes "open" topic**
- **Solid State Lighting (SSL) Advanced Technology R&D**
- **General Service Lamps (GSL) R&D**
- **Catalyst (software solutions; joint with SunShot)**
- **ORNL JUMP (hardware)**
- **Small Business Vouchers (SBV)**

Small Business Innovative Research:

- **2 – 3 topics offered each year**

2016 BENEFIT & SBIR FOA Topics

2016 BENEFIT

Topic 1 Open Topic for Energy Efficiency Solutions for Residential and Commercial Buildings

Topic 2 Human-in-the-Loop Sensor & Control Systems

Topic 3 Infiltration Diagnostic Technologies

Topic 4 Plug-and-Play Sensor Systems

Topic 5 Advanced Air-Sealing Technologies for Existing Buildings

BUILD (Buildings University Innovators and Leaders Development) Supplements

2016 BTO SBIR

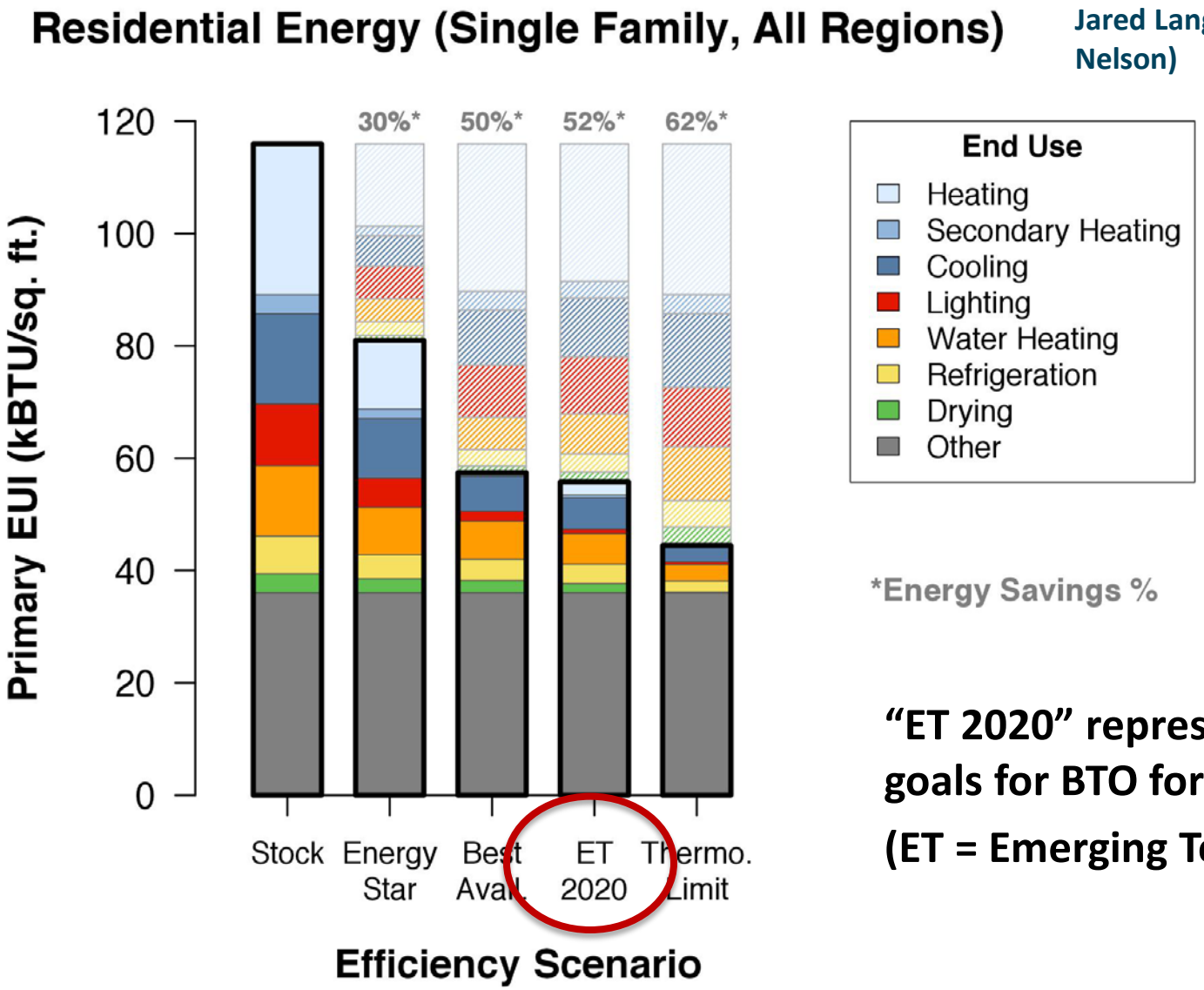
High-Efficiency Materials for Solid-State Lighting

Energy-Efficiency Solid-State Luminaires, Products, and Systems

Technologies for Sensing and Managing Indoor Air Quality in Buildings

Impact of Achieving ET 2020 R&D Goals

Source: *2015 DOE Quadrennial Technology Review* (Chioke Harris, Jared Langevin, Jack Mayernik, & Brent Nelson)



"ET 2020" represents the R&D goals for BTO for the year 2020

(ET = Emerging Technologies)

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Representative ET 2020 R&D Goals

	Current	2020 goal
Insulation	R-6/in and $1.1/ft^2	R-8/in and $0.35/ft^2
Windows (residential)	R-5.9/in and $63/ft^2	R-10/in and $10/ft^2
Vapor-compression heating, ventilation, and air conditioning (HVAC)	1.84 COP and 68.5 $/ kBtu/hr cost premium	2.0 Primary COP and $23/kBtu/hr cost premium
Non-vapor compression HVAC	Not on market	2.3 Primary COP and $20/kBtu/hr cost premium
LEDs (cool white)	166 lm/W and $4/klm	231 lm/W and $0.7/klm
Daylighting and controls	16% reduction in lighting for $4/ft^2	35% reduction in lighting for $13/ft^2
Heat pump clothes dryers	Not on market	50% savings and $570 cost premium

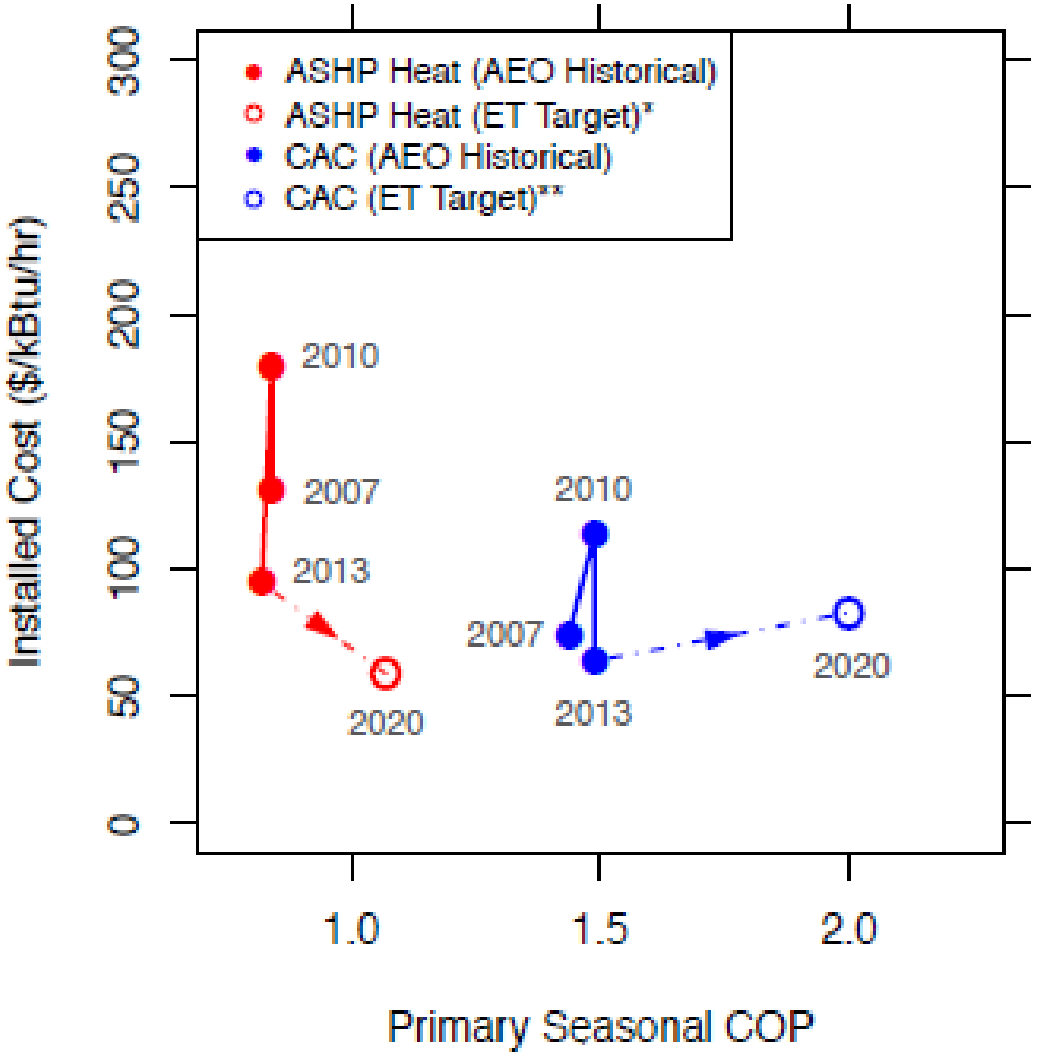
COP = Coefficient of Performance

COP is based on primary energy input.

All goals include performance AND cost.

Source: *2015 DOE Quadrennial Technology Review*

Setting Efficiency & Cost Targets: HVAC (example)



*Corresponds to Cold Climate Heat Pump target in ET MYPP

**Corresponds to Advanced Vapor Compression target in ET MYPP

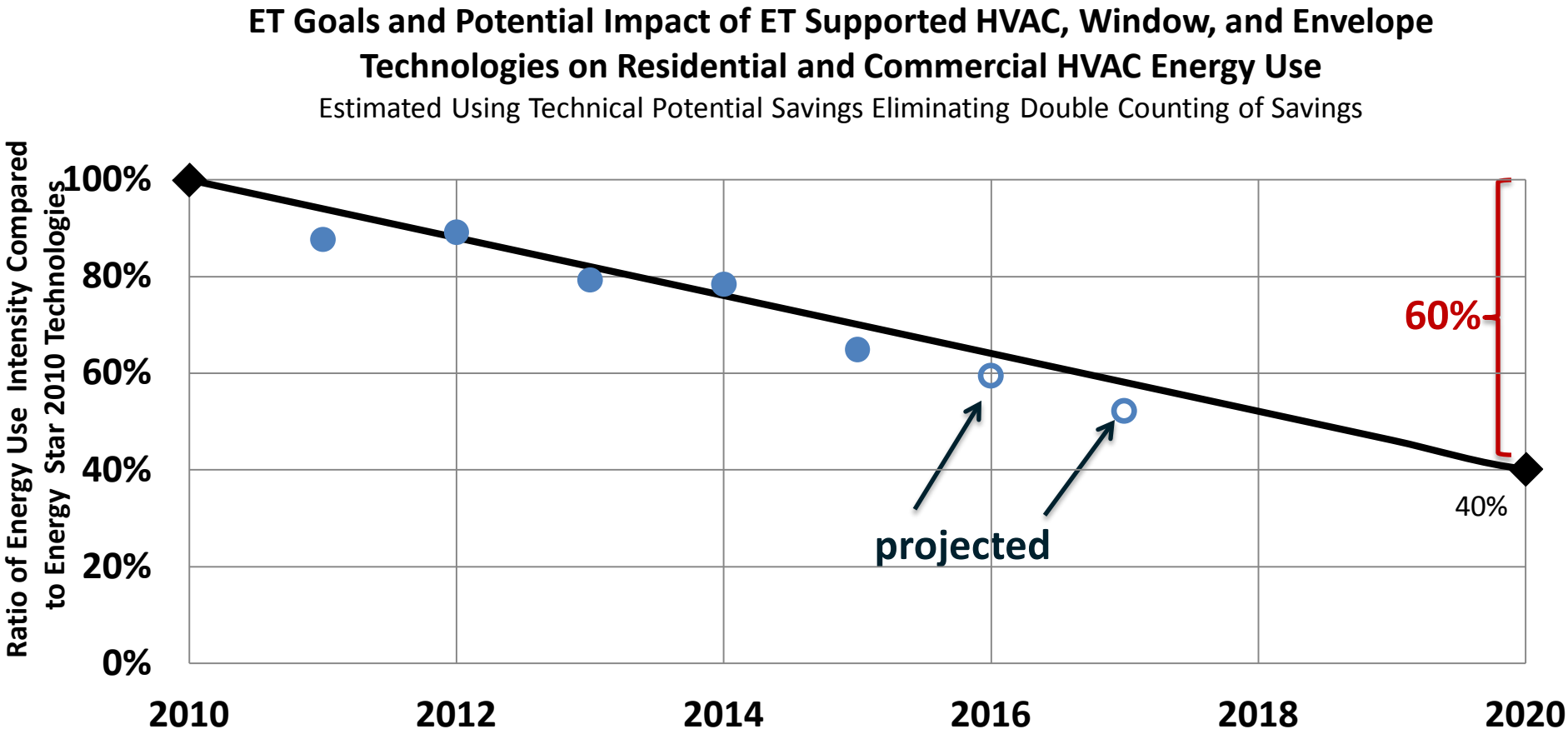
Compares 2020 R&D targets for **cold-climate heat pumps** and **advanced vapor compression air conditioners** to Energy Star units

Analysis is conducted with the P Tool (soon Scout) to set cost and performance targets, vetted with stakeholders, to achieve desired energy savings.

<u>Sources for Energy Star data:</u>

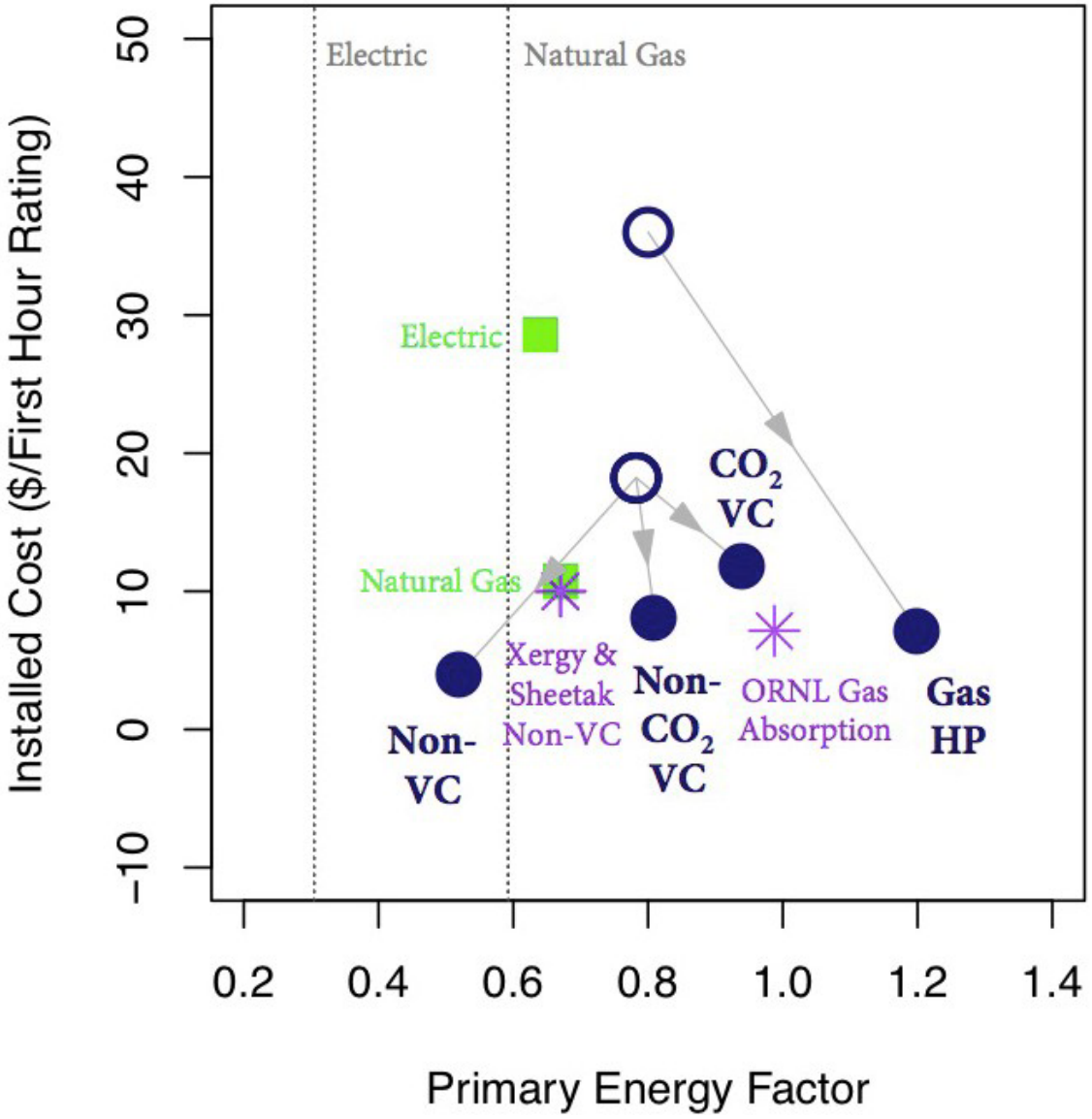
EIA – Technology Forecast Updates – Residential and Commercial Building Technologies – Reference Case (2007, 2010, 2015)

Progress Towards HVAC & Windows/Envelope Energy Savings Goals



Analysis indicates ET 2020 R&D targets for HVAC and windows & envelope lead to 60% space heating & cooling energy savings in 2020. The ET program is on track to meet this goal.

Tracking Progress on Efficiency & Cost: Water Heaters



Fed. Min.
EnergyStar
ET R&D
Current Best
ET 2020 Targets

Electric

- Non-CO_2 vapor compression
- CO_2 vapor compression
- Non vapor compression

Gas-Fired

- Absorption/Adsorption

Moral: Both performance AND cost matter!

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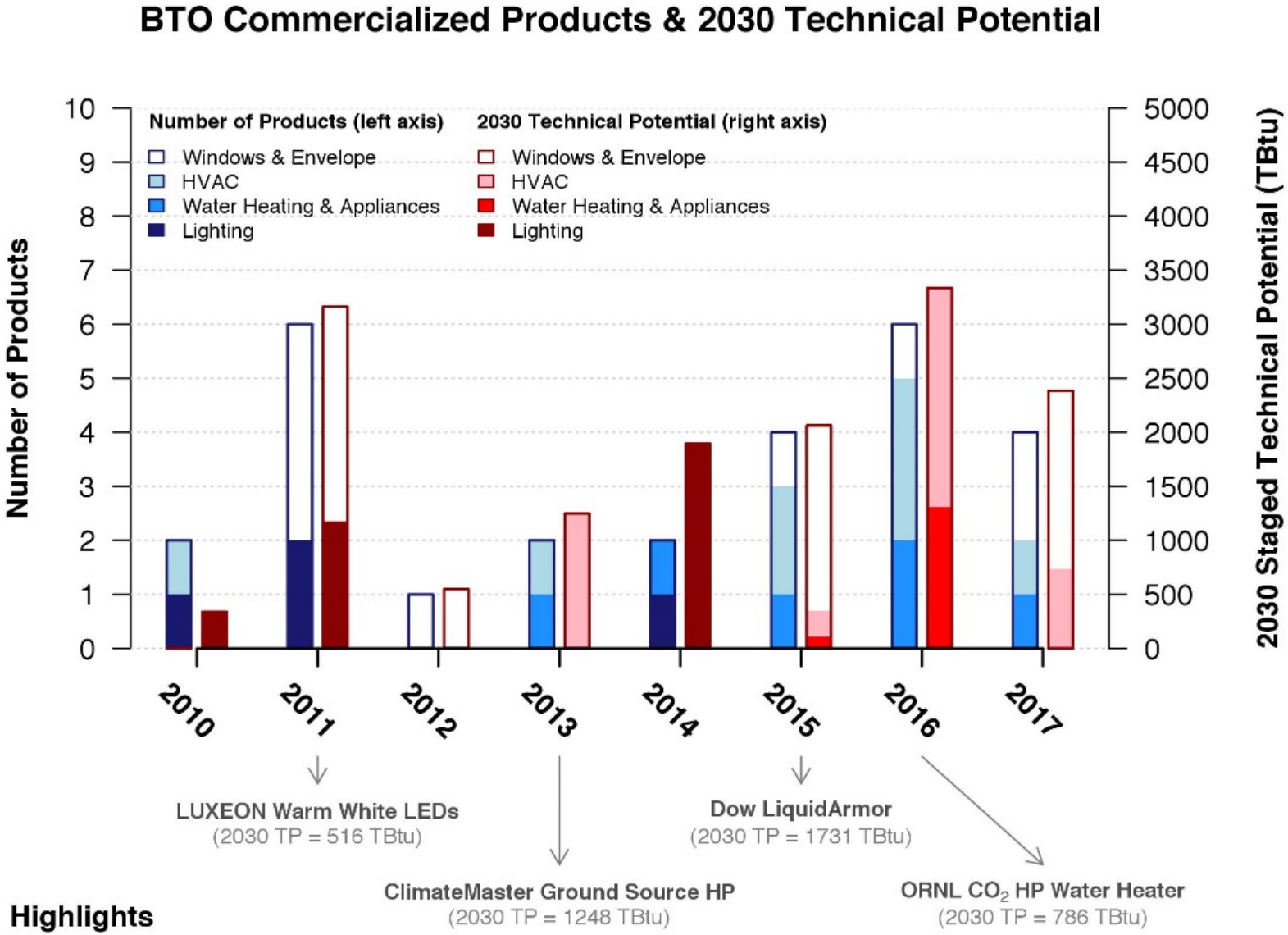
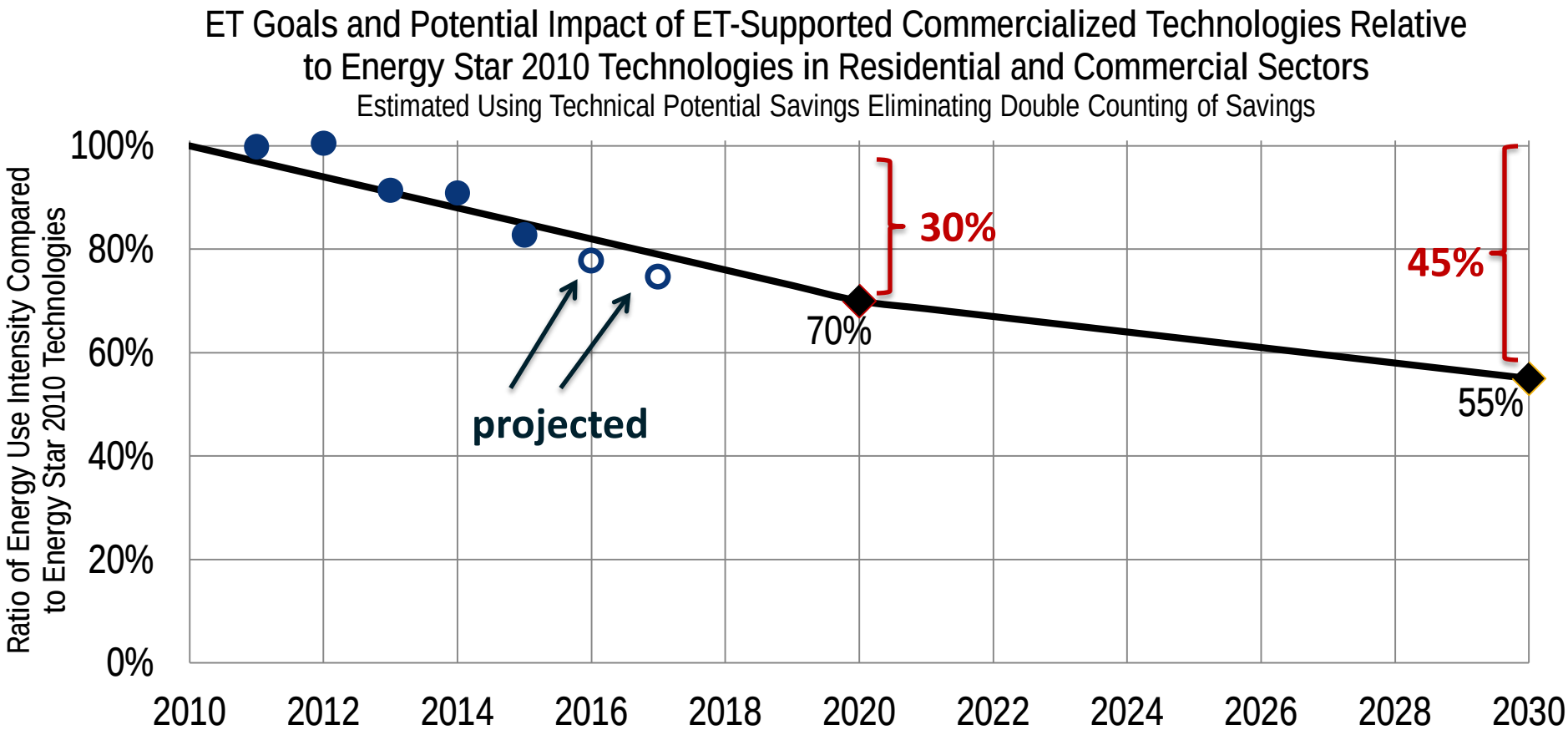
ET-Supported Commercialized Technologies



Highlights

Progress Towards Aggregate Energy Savings Goals



As a result of ET-sponsored research, cost-effective technologies will be introduced into the marketplace by 2020 that will be capable of reducing a building's energy use by 30% relative to 2010 cost effective technologies, and 45% by 2030.
[BTO Multi Year Program Plan]

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FY17 ET Priorities

Proposed FOAs or FOA Topics

- Solid-State Lighting R&D
- BENEFIT FOA
  - Envelope & windows } **Look for an upcoming workshop (June?)**
  - Sensors & controls } **Look for an upcoming roadmap**
  - Open topic
  - BUILD supplements
- Low-Global-Warming-Potential (Low-GWP) HVAC&R
  - **Two previous workshops, upcoming RFI**
- Miscellaneous Electric Loads (MELs) R&D
  - **Panel discussion at this Peer Review (Wednesday afternoon)**
- Decision Science R&D for Buildings
  - **Side meeting at this Peer Review (Thursday afternoon)**
  - **Workshop in San Francisco (early May)**

How To Get Involved with BTO/ET

- Get on our email list (http://www1.eere.energy.gov/buildings/newsletter.html, and click on "Sign up to receive news and events from BTO")
- Attend the annual BTO Peer Review
- Provide feedback on draft roadmaps; currently one available on Building Energy Modeling, and soon one on Sensors & Controls
- Volunteer to be a reviewer (send CV to BTOreviewer@ee.doe.gov)
- Apply to a FOA, postdoc, or other funding opportunity! (https://eere-exchange.energy.gov/)

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New Air Barrier and Air Sealing Technologies

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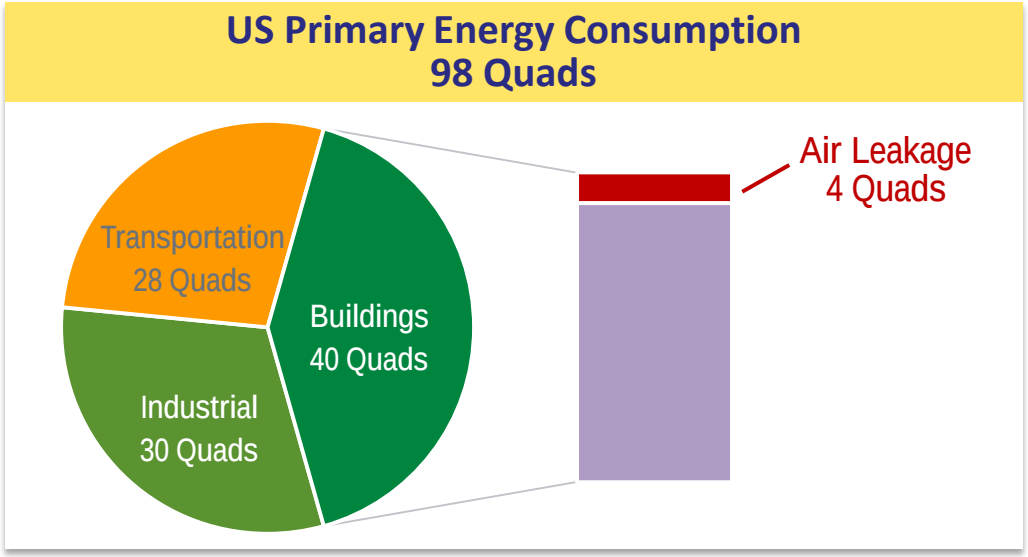
Without the envelope, there is no building

Problem and Impact

- Air leakage
  - Accounts for 10% of US building energy consumption
  - Affects energy use and indoor air quality in China



Office of Energy Efficiency and Renewable Energy, Building Energy Data Book

- New air barriers can potentially reduce infiltration-related energy losses by over 50%
  - Novel materials
  - Superior air sealing
  - Excellent long-term performance
  - Foolproof installation
  - Lower installed cost
  - Less time to install

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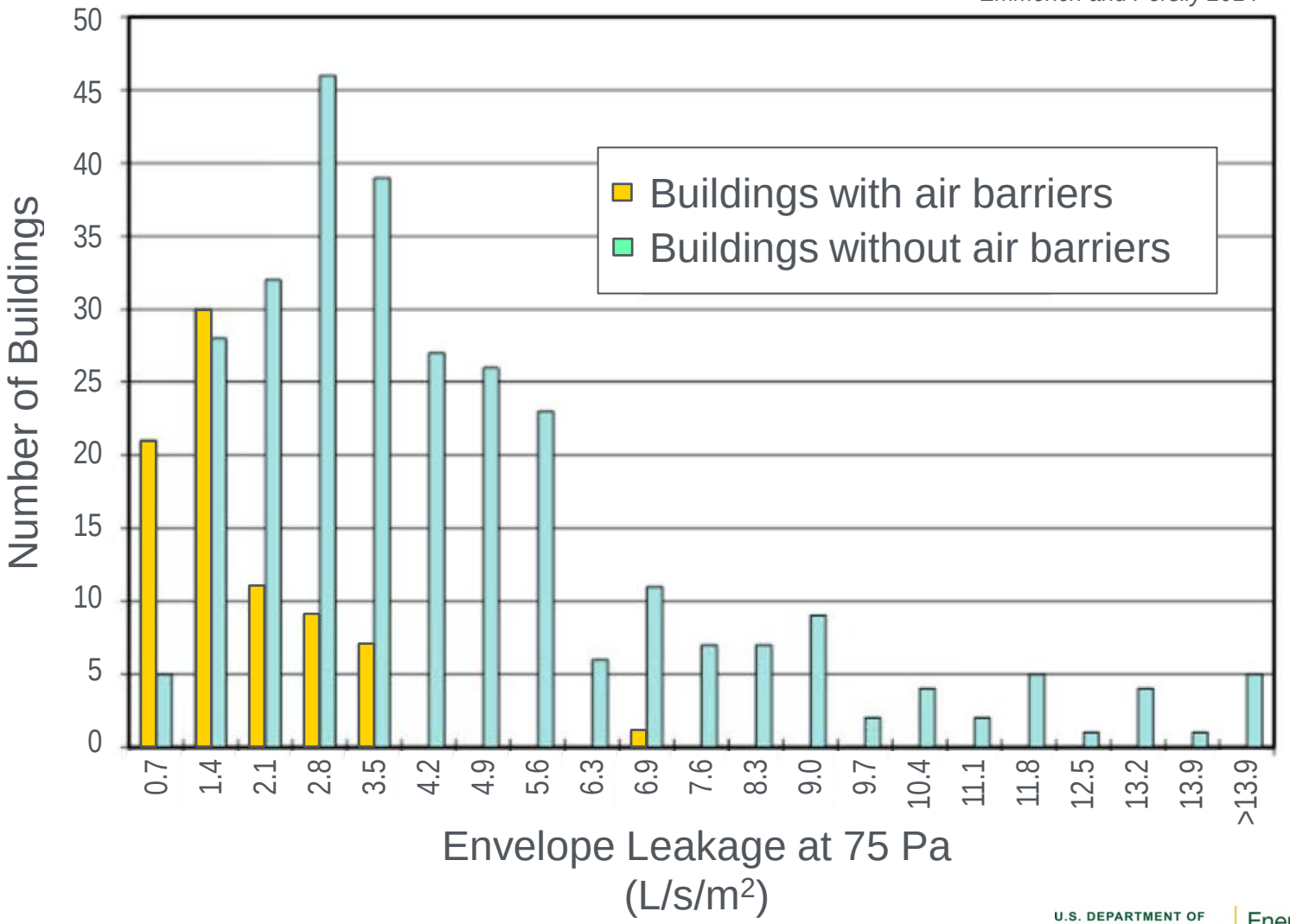
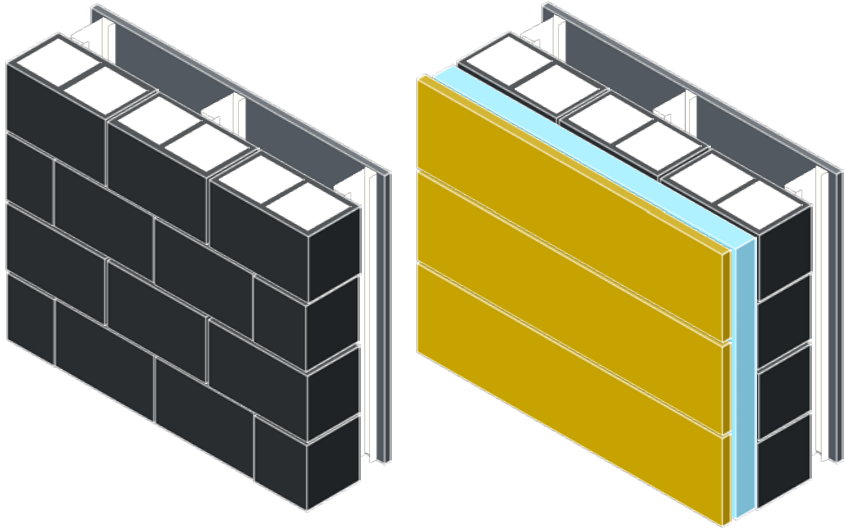
Air Barrier Effects

Emmerich and Persily 2014



Commercial building envelope retrofits are at a very early stage

- Critical market needs
  - Case studies
    - Energy savings
    - Return on investment
    - Available technologies
    - Lessons learned
  - User-friendly tool from third-party
  - Financial incentives
  - R&D to achieve payback < 15 years



Before Retrofit

Retrofit Measures
- Increased insulation
- Improved airtightness
- New cladding

Tool Estimates
- Energy savings
- Increase in real estate value
- Payback time

Air Barrier System Requirements

- Low air permeance
  - Varies with building code/standard
- Continuous over the entire building envelope
  - Seal gaps around penetrations (install before cladding)
  - Seal wall-to-roof joint
  - Seal wall-to-foundation joint
- Withstands forces during and after construction
- Durable over expected lifetime of building

Overall Comparison

- Similarities
  - Can serve as air and water barrier, and drainage plane
  - Many manufacturers require installation training

- Differences
  - Material cost
  - Installation
    - Procedure, training, workmanship skills, time, cost
    - Temperature
    - Location: interior or exterior side of wall cavity
  - Vapor permeance
  - Thermal resistance

Latest Technologies Reduce Labor and Installation Time (and $$)

Primer-Less Self-Adhered Membranes

Liquid Flashings

Installed with gun and putty knife or spreader

Spray applied

One-Step Sprayable Liquid Flashing

LIQUIDARMOR™

Video courtesy of Dow Chemical

Current Technologies

Liquid flashing
Needs bridging materials

Peel & stick
Time consuming
and prone to error

- Seamless air and water sealant
- One-step, sprayable, water-based, liquid flashing
  - Bridges gaps up to ¼" (6 mm) wide without supporting materials
  - 3-4 times faster installation than flashing tape
  - Easily conforms to any shape
- Excellent adherence to common building materials
  - Residential and commercial construction
  - New and existing buildings
- Patent US 8,641,846 B2
- Introduced to US market as LIQUIDARMOR™

DOW
OAK RIDGE National Laboratory
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LIQUIDARMOR™ Market Deployment

CABR's tests indicate that LIQUIDARMOR™ improved airtightness around windows

CABR – Beijing

Illinois

North Carolina

Texas

Photos courtesy of Dow Chemical and CABR

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Primer-Less Self-Adhered Membrane

3M 3015

Video courtesy of 3M

Current Technologies

Typical asphalt-based self-adhered membrane requires priming of substrate. Failure can occur if primer is not adequately dried.

- Air, water, and vapor barrier
- Excellent adherence to common building materials without priming
  - Up to 2 times faster installation than membranes that require priming
  - Residential and commercial construction
  - New and existing construction
- Low temperature application ~ 0°F
- Introduced to US market as 3M 3015
- ORNL/3M were awarded $1.1M to continue research on improvements in airtightness

3M | OAK RIDGE National Laboratory

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3M 3015 Market Deployment

CABR – Beijing

CABR will issue the first national guidelines that recommend air barriers in low energy buildings

Minnesota

Massachusetts

Minnesota

Photos courtesy of 3M

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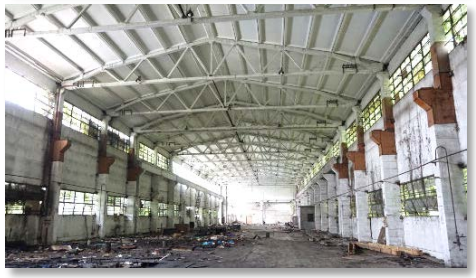
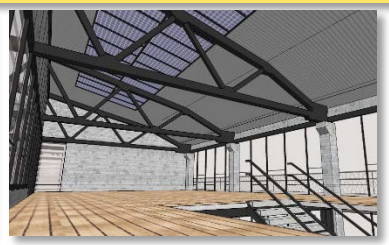
Future RD&D Directions for Air Barriers

- Pilot project in Shanghai
  - Maximize preservation of existing structure
  - Develop models for low-cost green retrofits
  - Demonstrate innovative technologies
- 9 sites to be redeveloped from 2015 to 2019
  - Potential future projects for the Dow and 3M technologies

Existing Building



Redevelopment Design



OAK RIDGE National Laboratory DOW 3M SHANGHAI University of Colorado Boulder

Future RD&D Directions for Air Barriers

Oak Ridge National Laboratory Customer Discovery

- Case studies on building envelope retrofit methods
  - Interior retrofit Re-cladding Over-cladding
  - Evaluation of improvements in airtightness and insulation
    - Dow and 3M technologies already accepted by the construction industry
    - Determine what is achievable with what is available and what is needed
  - Two case studies per year

3M 8067 flashing tape

- Methodology
  - Conduct hygrothermal analysis of proposed retrofit
  - Perform blower door test before and after retrofit
  - Generate Energy+ model
  - Estimate energy savings

Dow FROTH-PAK ULTRA

- Leads: ORNL, Dow, 3M

3M 3015 & 3015VP primer-less self-adhered membranes

Dow LIQUIDARMOR sprayable liquid flashing

Acknowledgements

Diana Hun, PI

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http://energy.gov/eere/buildings/windows-and-building-envelope
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Department of Energy
karma.sawyer@ee.doe.gov

I like to push the envelope…both opaque & fenestration

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New HVAC, Water Heaters and Appliances

Antonio M Bouza
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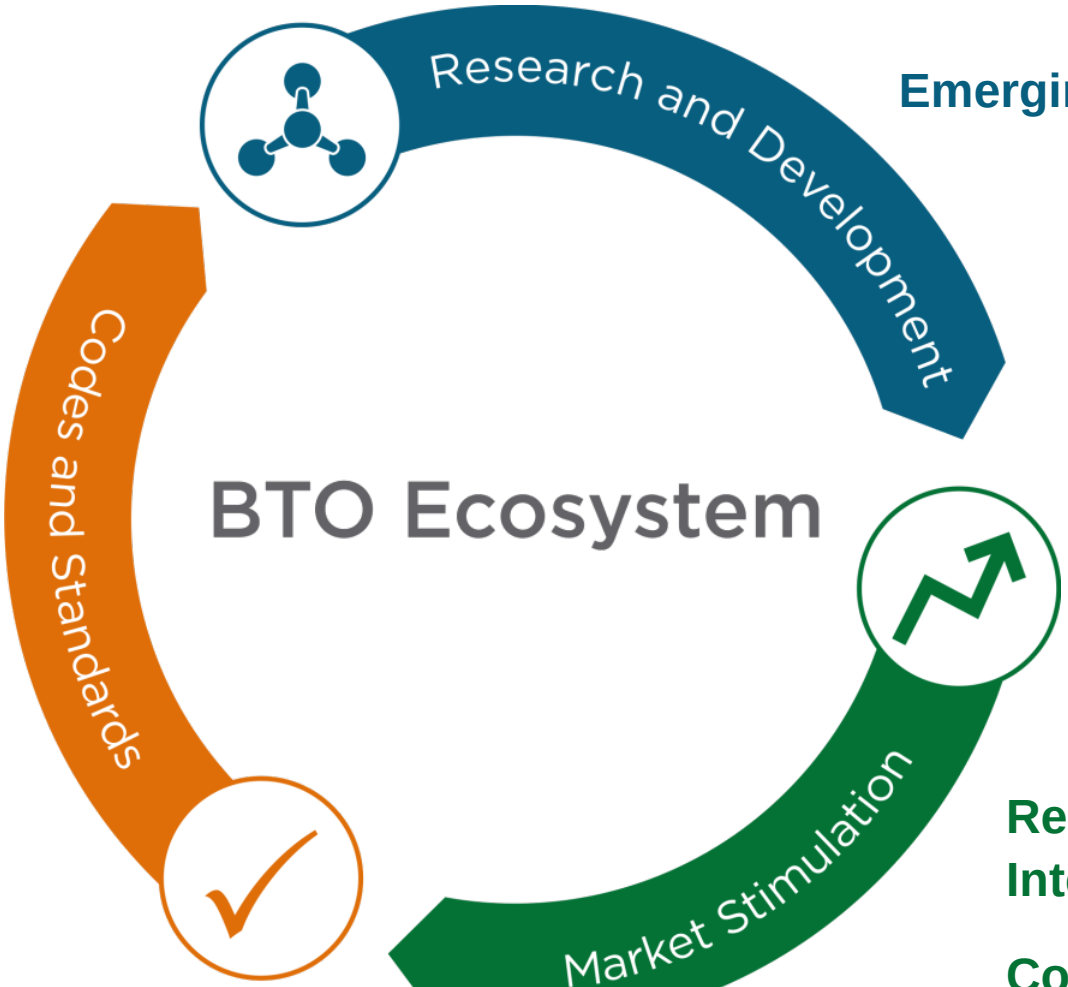
Building Technologies Office (BTO) Ecosystem



Emerging Technologies

Codes and Standards

Residential Buildings Integration

Commercial Buildings Integration

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Introduction

Program Goals:

BTO's ultimate goal is to reduce the average energy use per square foot of all U.S. buildings by 50% from 2010 levels. Emerging Technologies Program's goal is to enable the development of cost-effective technologies capable of reducing a building's energy use per square foot by 30% by 2020 and cutting a building's use by 45% by 2030, relative to 2010 high-efficiency technologies.

HVAC/WH/Appliances goals require by 2020 that the potential energy use intensity (EUI) for:

- HVAC would be 60% lower
- WH would be 25% lower
- Appliances would be 15% lower
- All relative to 2010 energy-efficient baseline

Two-pronged approach to accelerate the development of new technologies:

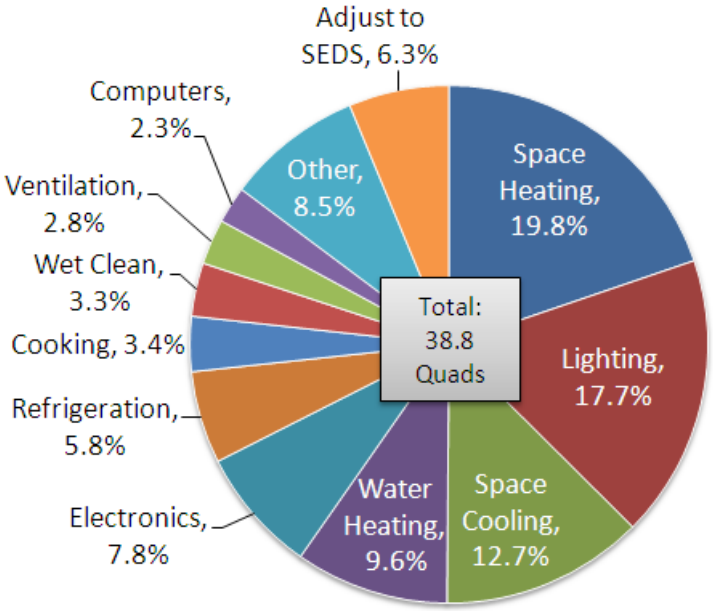
1) Accelerate the development of **near term** technologies that have the potential to save significant amount of energy (including cost reduction activities, bending the cost curve)
2) Accelerate the development of the **next generation** of technologies that have the potential of "leapfrogging" existing technologies by pursuing entirely new approaches (including crosscutting efforts)

The goal is to develop technologies that save energy and reduce our environment burden while introducing them in the simplest application first, highest probability of success.

The challenge…

- In addition to individual end-use solutions, integrated solutions are also pursued
- Energy cascading (using the waste heat from one process as the source of energy for another) is utilized
- Optimizing energy use in a building, an optimum point instead of just a local minimum (single end-use)
- Broad approach includes pursuing crosscutting technologies that enable better HVAC, water heating and appliances
- A **fast way to develop new technologies** and get them into the market is through CRADAs and FOAs (with manufactures as primes or as team members)
- Program seeks to build upon its past results and speed market availability and acceptance of economically viable new technologies
- *Not working in a vacuum*, most equipment is covered by appliance standards
- Engage manufacturers and BTO deployment teams
- ***Efficiency first***

Buildings Primary Energy Consumption



CRADAs: *Collaborative Research and Development Agreements*

HVAC: Innovative and Economically Viable Solutions, *Efficiency first*

Regional Solutions

- *Low Ambient Heat Pump Research*
  - Where natural gas is unavailable or want to displace oil heat
  - Unlike standard heat pumps, can maintain capacity and efficiency (COP) at low ambient temperatures
- *Regional Solutions (Hot, Humid and Mixed)*
  - Air conditioning (AC) is more than just cooling air
  - Significant savings, on the order of 50-90%, are possible for technologies optimized for specific climates and applications
  - Large portion of the current building stock is located in hot and humid environments, which have the potential to create large latent (humidity) loads within buildings

Integrated Heat Pump (IHP) research, energy saving potentials approaching 50% when HVAC and water heating is coupled

Non-vapor compression research, no refrigerants (saving energy while reducing environment burdens)

- Potential of "leapfrogging" existing HVAC technologies by pursuing entirely new approaches
- Examples: Ab/Ad-sorption Heat Pumps, Electrocaloric, Electro Chemical Compression (ECC) technology, Magnetocaloric, Membranes, Thermoelastic, Thermoelectric, etc

Crosscutting technologies

- Heat exchanger research
- Compressor research
- Refrigerant research (Low-GWP solutions)
- Motors
- Materials Joining Technologies

Heat Pump Technologies: Regional Solutions (Cold Climates)

Cold Climate Heat Pump Technology

- Where natural gas is unavailable or want to displace oil heat
- Improving the performance of natural gas systems
- Unlike standard heat pumps, can maintain capacity and efficiency (COP) at low ambient temperatures
- Setting the standard for cold climate performance
- Targets for both electrical and natural gas systems

Current and Past BTO Activities

- IEA Annex 41, Cold Climate Heat Pumps
- Development of a High Performance Cold Climate Heat Pump (Purdue University)
- Supercharger for Heat Pumps in Cold Climates (Mechanical Solutions, Inc.)
- Cold Climate Heat Pump (CRADA Project at ORNL)
- High Performance Commercial Cold Climate Heat Pump (CCCHP) , (United Technologies Research Center)
- Residential Cold Climate Heat Pump (Unico)
- Natural Refrigerant High Performance Heat Pump for Commercial Applications, (S-RAM Dynamics)
- Natural Gas Air Conditioner and Heat Pump, (ThermoLift, Inc., Vuilleumier cycle)
- Low-Cost Gas Heat Pump For Building Space Heating, (Stone Mountain Technologies, Inc.)

DOE Cold Climate Heat Pump R&D Performance Targets (Electricity, Residential)

Ambient Temperature (°F)	COP	Maximum Capacity Decrease from Nominal (%)
47	4	0
17	3.5	10
-13	3	25

DOE Cold Climate Heat Pump R&D Performance Targets (Natural Gas, Residential)*

Ambient Temperature (°F)	COP	Maximum Capacity Decrease from Nominal (%)
47	1.3	0
17	1.15	20
-13	1.0	50

DOE Cold Climate Heat Pump R&D Performance Targets (Electricity, Commercial)

Ambient Temperature (°F)	COP	Maximum Capacity Decrease from Nominal (%)
47	4	0
17	3	10
-13	2.5	25

**COP based on higher heating value of natural gas*

High-Efficiency Commercial Cold Climate Heat Pump (UTRC)

Problem Statement:

- State-of-the-art industry standard heat pumps that can degrade by up to 60% in capacity and 50% in system Coefficient of Performance (COP) at the DOE targeted -13F ambient condition
- Cold blow effect further cements that heat pumps are not a viable technology for space heating even in Climate Zone 3A (Memphis TN)
- Scalable and cost-effective compression technologies as well as system optimization/integration are necessary to deploy cold climate heat pumps

Project Goals:

- Design and develop a prototype 10 TR high performance cold climate commercial heat pump system
- Execute a Technology Readiness Level (TRL) 5 prototype demonstration
- Conduct psychrometric testing of prototype CCCHP system to demonstrate targeted COP=2.5 at -13F design point with <15% capacity degradation
- Meet COP and Capacity targets at 47F and 17F ambient conditions
- <3 year customer payback on price premium

Target Market and Audience: *Commercial building owners with a need for a superior heating and cooling solution air-source HP that operates over extreme heating and cooling seasons. Commercial buildings in cold climates represent 45% of the national building stock. 32% use electricity as the primary source of space heating representing 149 billion kWh and $9.2 billion.*

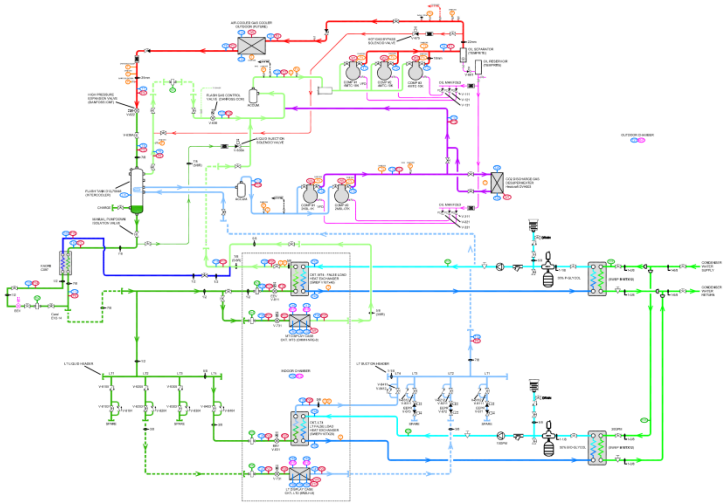
DOE Cold Climate Heat Pump R&D Performance Targets (Electricity, Commercial)		
Ambient Temperature (°F)	COP	Maximum Capacity Decrease from Nominal (%)
47	4	0
17	3	10
-13	2.5	25

Carrier Corporation is the commercialization path…

HillPhoenix: Transcritical CO2 Supermarket Refrigeration System (Advansor System)

Research supported by BTO, Oak Ridge National Laboratory's (ORNL's) cooperative research and development agreement (CRADA) with **HillPhoenix**

- Low GWP refrigerant (CO2), with 25 percent lower energy consumption than existing systems, and 78% lower GHG emissions
- Traditional supermarket refrigeration systems found in most grocery stores across the country are vulnerable to issues which can cause significant refrigerant leakage, emitting environmentally harmful greenhouse gases at an average rate of about 25% of their total normal operating charge per year (EPA, 2012).
- ORNL (CRADA with Hillphoenix
- Low-emission, high-efficiency commercial refrigeration system suitable for use in current U.S. supermarkets
- Hillphoenix's Second Nature® "Advansor System" is the first to be UL listed in North America and already has 12 applications in the U.S.



Hillphoenix
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OAK RIDGE National Laboratory

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

Honeywell (R-448A): New Refrigerant Boosts Energy Efficiency of Supermarket Display Cases

Research supported by BTO, Oak Ridge National Laboratory's (ORNL's) cooperative research and development agreement (CRADA) with **Honeywell**

- Alternative refrigerant that minimizes the environmental footprint of supermarket refrigeration systems
- Can retaining their existing hardware and simply replace their current refrigerant with this option, greatly reducing the threat of environmentally harmful greenhouse gas emissions at a modest cost.
- Supported White House initiative to phase down hydrofluorocarbons (HFCs), powerful greenhouse gases that contribute to climate change
- Honeywell and ORNL have developed Solstice N40, a non-toxic hydrofluoroolefin (HFO) -based refrigerant alternative for R-404A, most common refrigerant used
- Offers a lower-global-warming potential and energy-saving replacement for R-404A
    - GWP potential of 1,300, making it 67 percent less potent than R-404A
    - Creates energy savings of 10 percent compared to R-404A

Honeywell

OAK RIDGE National Laboratory

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

Thank You and Contact Info…

The HVAC/Water Heating/Appliance subprogram develops cost effective, energy efficient technologies with national labs and industry partners. Technical analysis has shown that heat pumps have the technical potential to save up to 50% of the energy used by conventional HVAC technologies in residential buildings. Our focus is on the introduction of new heat pumping technologies, heat exchanger technologies, and advanced appliances, e.g., refrigerator and clothes dryers. Heat exchangers are used not only in air conditioning, heating, water heating and refrigeration but also in nearly every application that generates waste heat, a major crosscutting research opportunity. We are also pursuing non-vapor compression technologies, which have the potential to replace or be integrated with conventional vapor compression technologies, can provide 50% reductions in energy consumption, and have extremely low-global warming potential.

http://energy.gov/eere/buildings/hvac-water-heating-and-appliances

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Questions?

U.S. DEPARTMENT OF ENERGY

Thank you!

For more information on Emerging Technologies for buildings visit:

http://energy.gov/eere/buildings/emerging-technologies