Emerging Technologies Program

An Overview of ET

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

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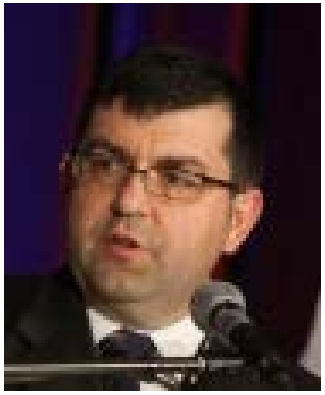
ET Staff: Technology Managers

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
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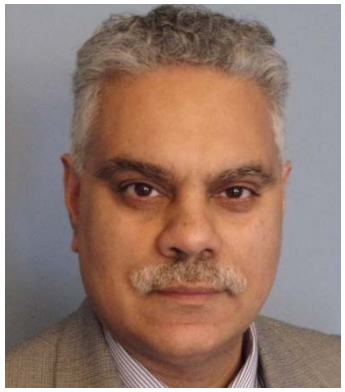
ET Staff: Technical Project Officers, Fellows, & Admin

Jim Payne
(Technical Project Officer)



Mohammed Khan
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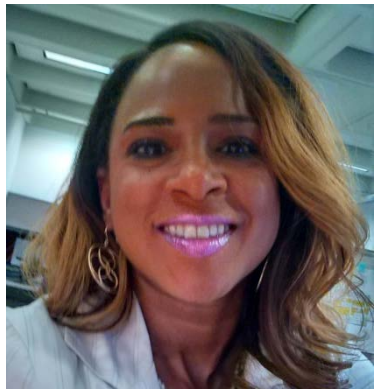
Mike Atsbaha
(Senior Management Analyst)



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)?

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			
Windows & Building Envelope	Accelerate market entry & availability of technologies & processes	Pre-commercial technology demos with industry	Manufacturing advanced, reduced cost solutions	Manufacturers & retailers understand product benefits	Retailers / building industry stock & install more energy efficient products	
		Development of installation & verification techniques with industry	Tech. cost & performance data & demo reports	Building industry have solutions to install & integrate products in buildings		
Sensors & Controls		Outreach to stakeholders with cost & performance data analysis	Installation & verification techniques		Building industry regularly use energy modeling tools to design or retrofit energy efficient buildings	
			Industry competitions, workshops & recognition	Building industry or engine developers have energy modeling tools to improve building or systems design		
Building Energy Modeling (BEM)	Improve energy modeling tools & capabilities & testing techniques	Competitive & shared funding to develop, improve & test modeling tools	Tech. & market assessments		Government, standards & industry orgs. & EE programs use modeling as basis for market incentives, standards & energy codes	
			Comprehensive, accurate, easy to use modeling tools & approaches	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	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

Emerging Technologies Program Logic Model

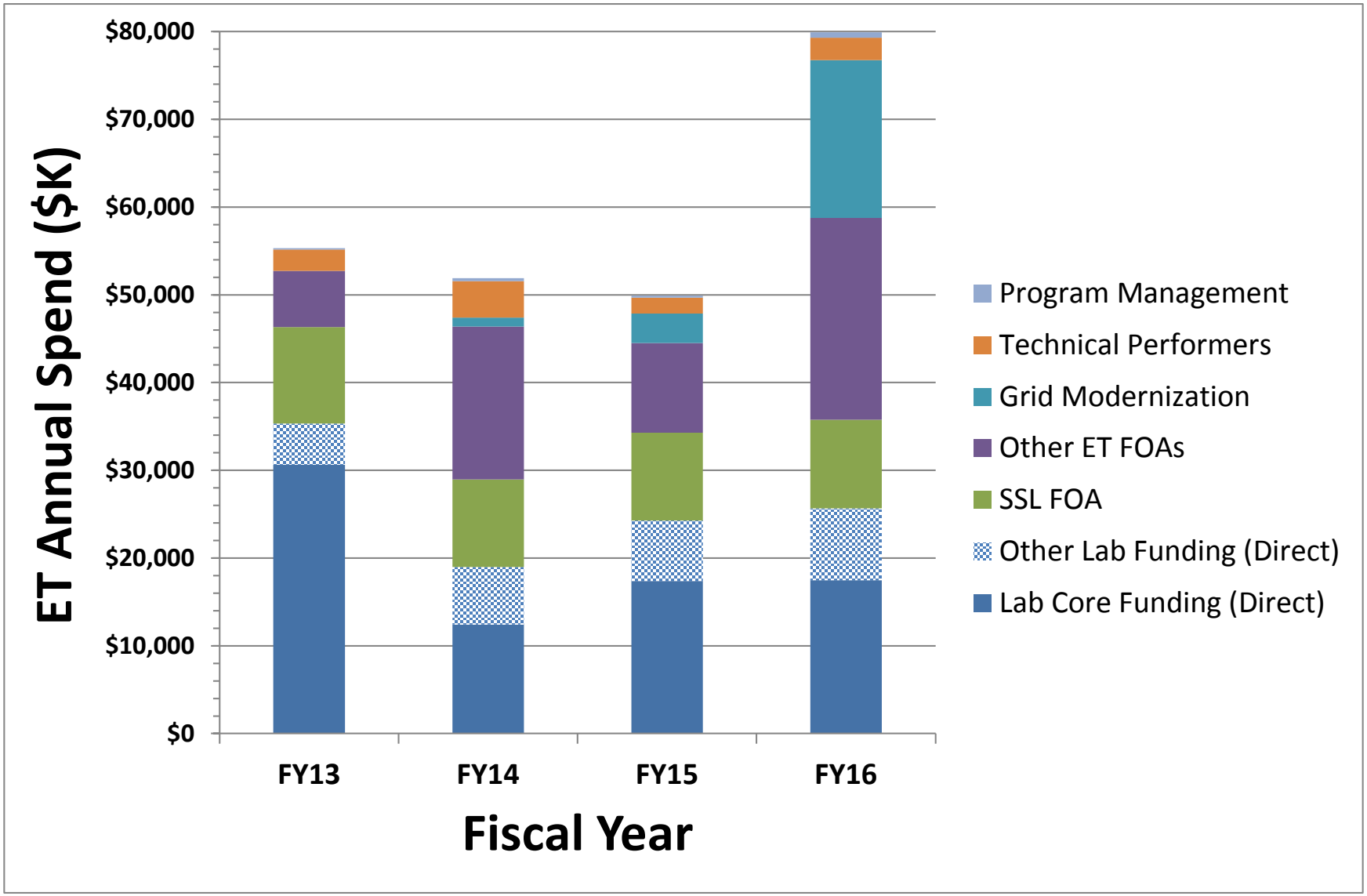
OBJECTIVE	ACTIVITIES	KEY OUTPUT	SHORT-TERM OUTCOME	MID-TERM OUTCOME	LONG-TERM OUTCOME
Develop next-gen tech	Next-gen tech & component R&D	Next-gen prototypes	Performance goals met	Private sector R&D	Advanced tech and tools in market on a national scale
Improve near-term tech	Cost reduction R&D	Reduced cost prototypes	Validated products	Adopted products	
	Demonstrate pre-commercial technologies	Validated demo results			
Provide modeling tools	Update and validate key tools	Widely used modeling tools	Adopted tools	Wide use	

Updated Dec. 2015

EXTERNAL INFLUENCES

- DOE Budget
- Spin-off Products
- Market Incentives
- Legislation / Regulation
- Energy Prices
- Private R&D

BTO Emerging Technologies Annual Spend FY13 – FY16



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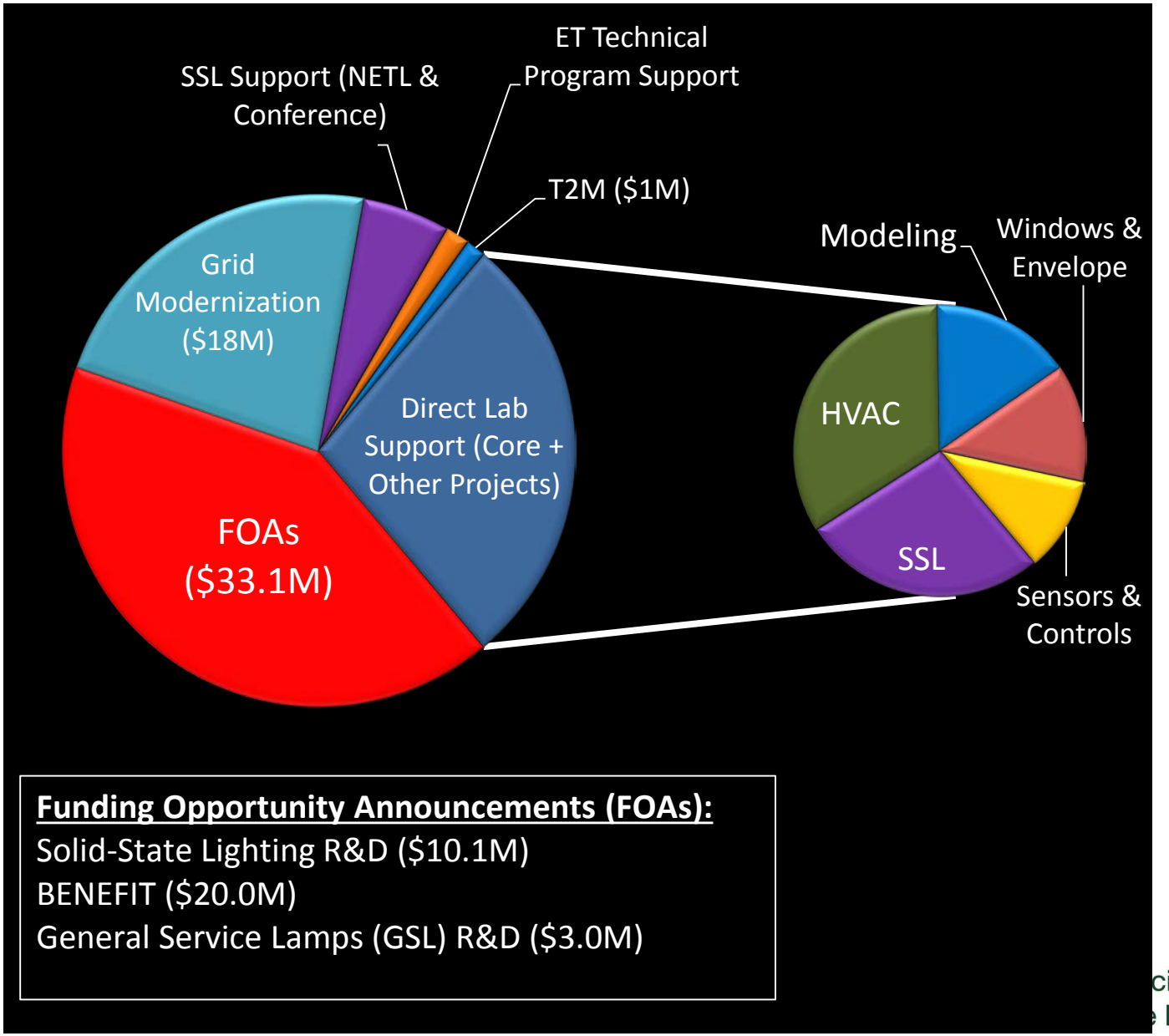
ET Fiscal Year 2016 Budget ($79.912M)



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

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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

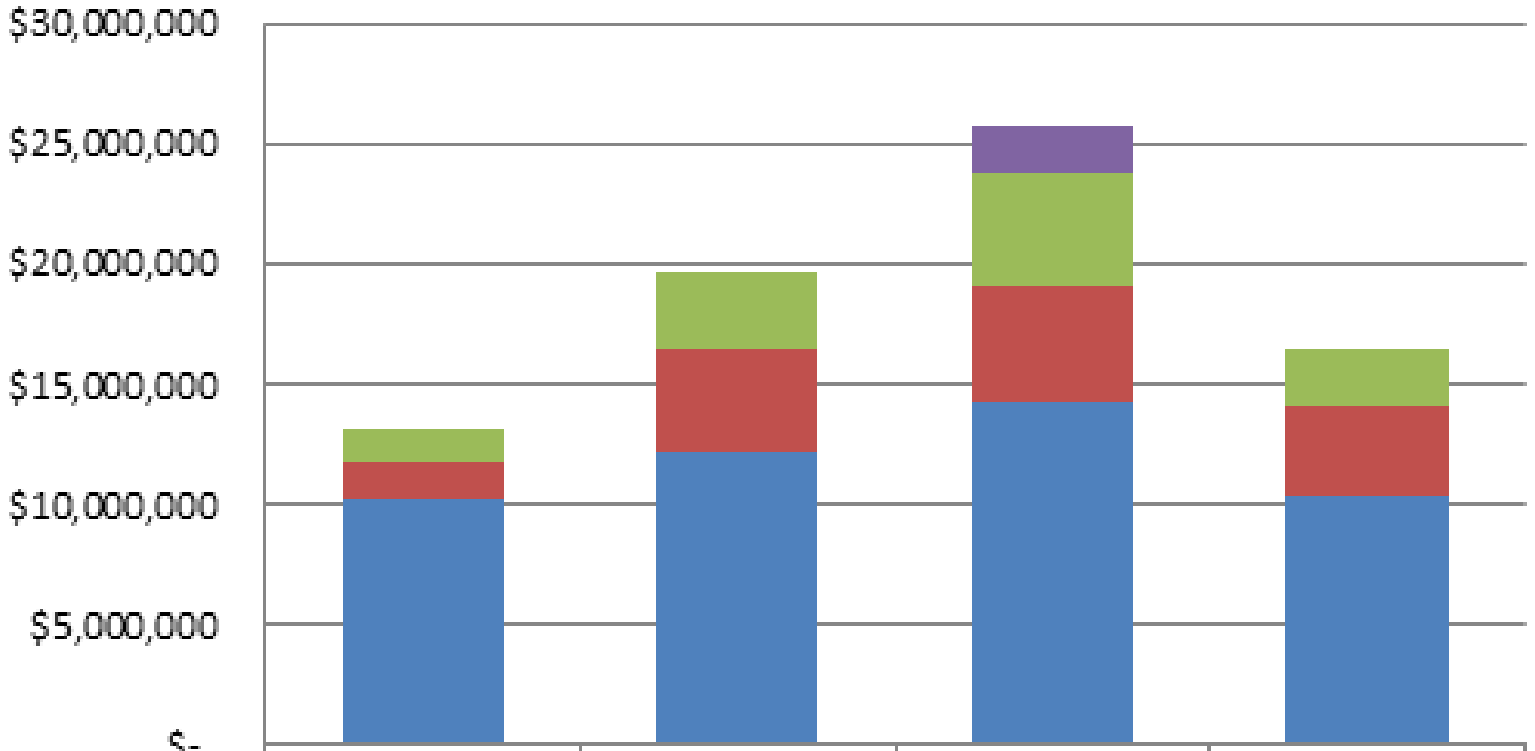
High-Efficiency Materials for Solid-State Lighting

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

Technologies for Sensing and Managing Indoor Air Quality in Buildings

Organizations Supported by ET FOAs

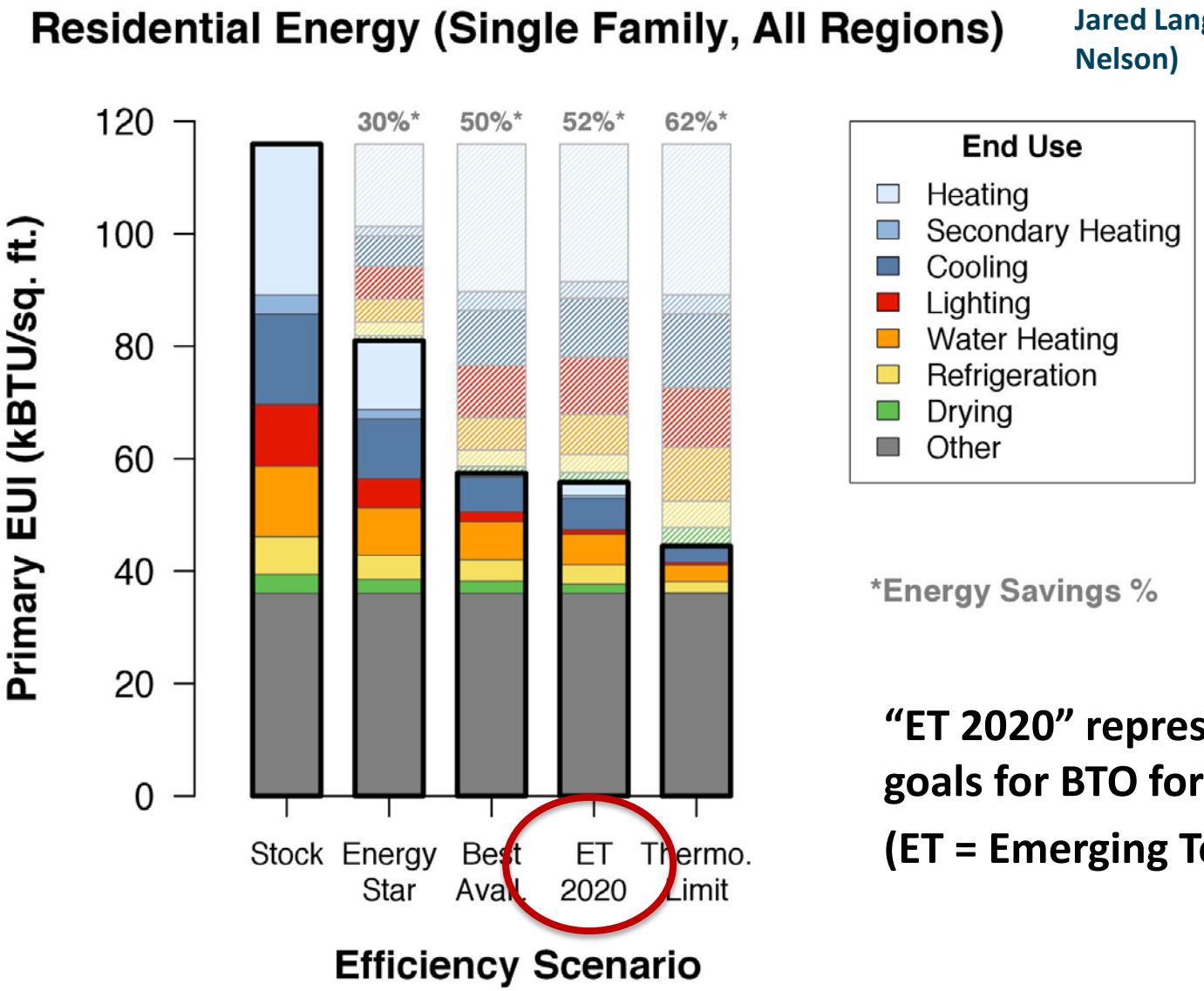
BTO/ET FOA Funding



	FY12	FY13	FY14	FY15
Non-Profit	$-	$-	$1,911,116	$-
Lab	$1,317,976	$3,159,402	$4,629,063	$2,400,000
University	$1,572,000	$4,254,604	$4,899,911	$3,614,240
Company	$10,169,675	$12,175,046	$14,226,504	$10,405,403

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)

Energy Efficiency & Renewable Energy

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

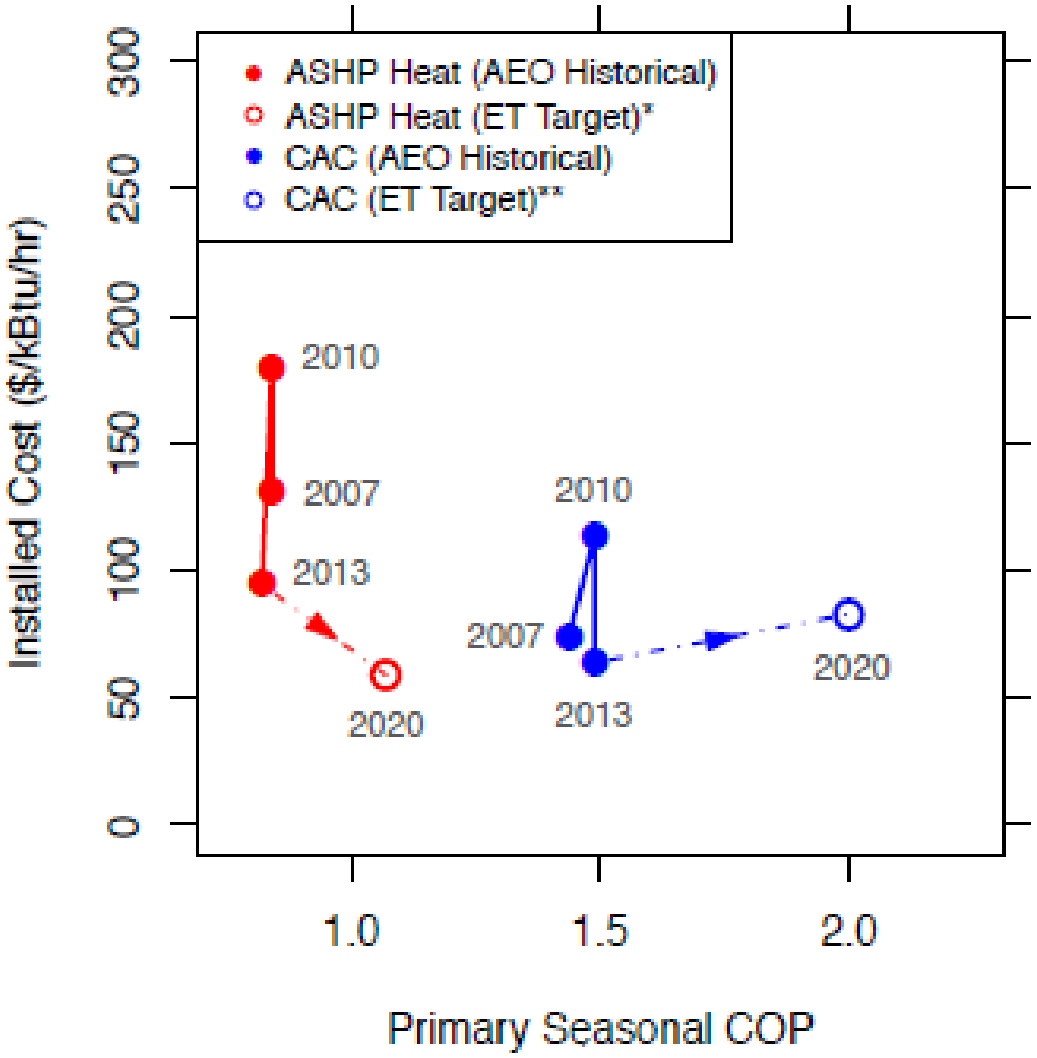
COP = Coefficient of Performance

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)

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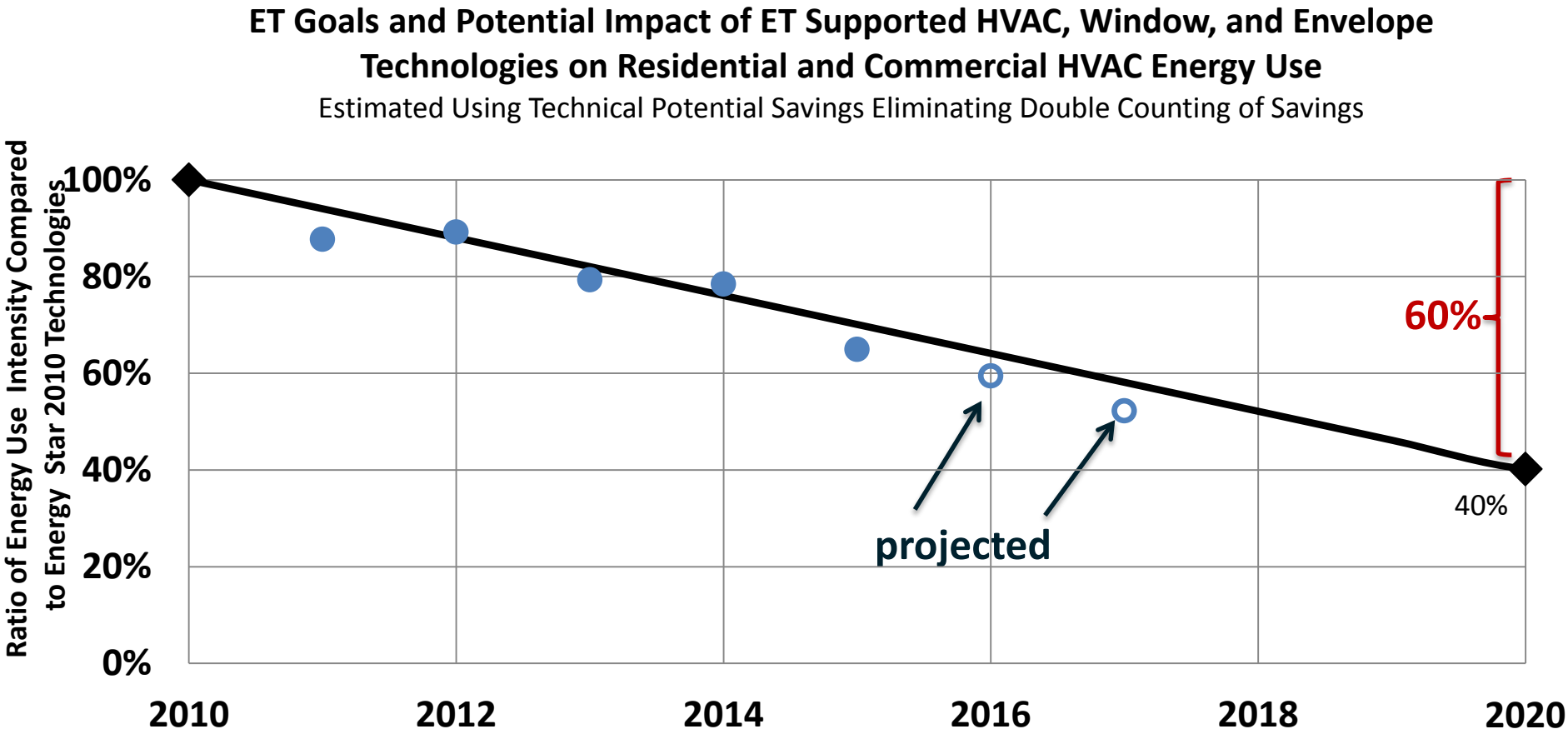
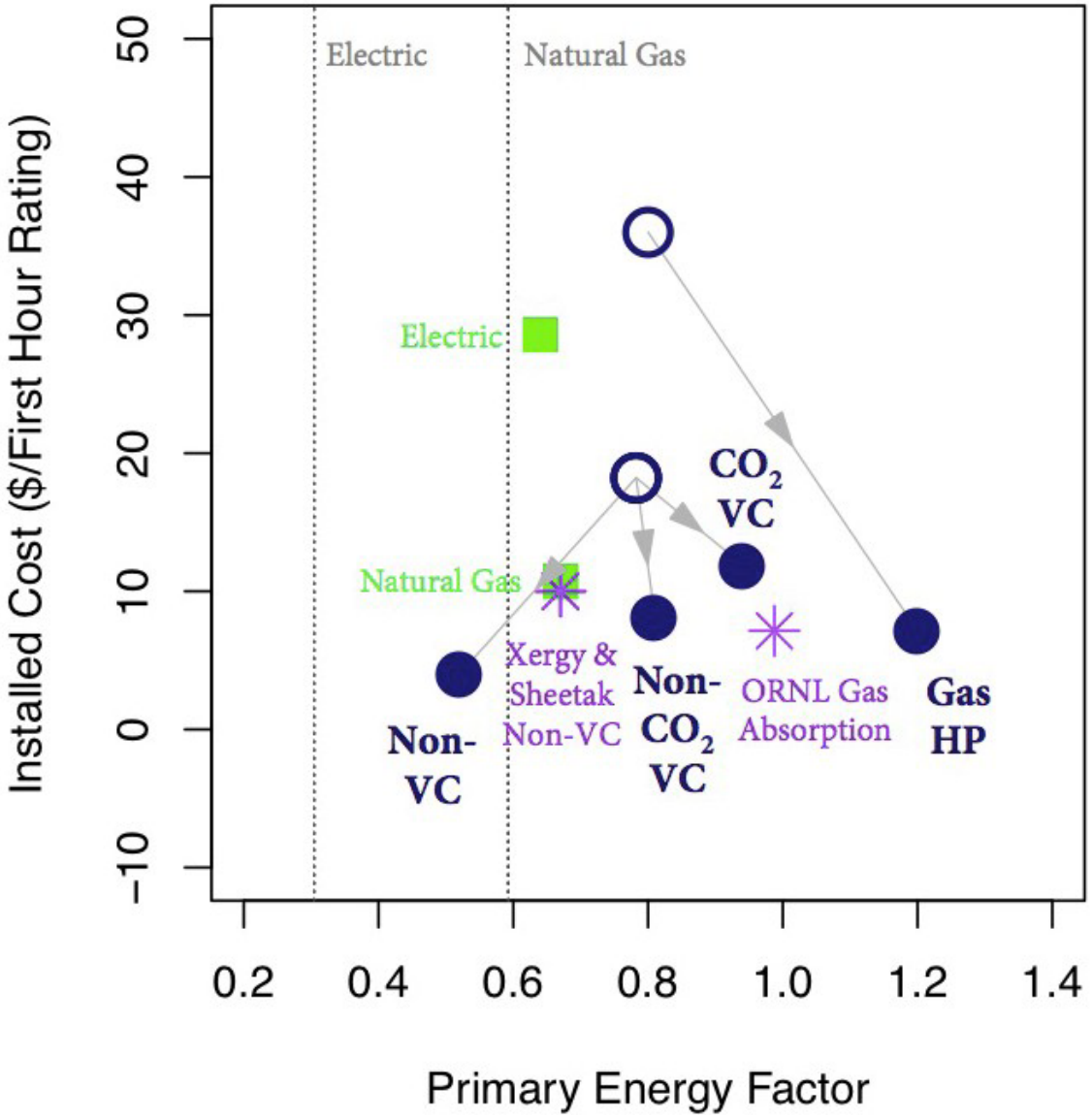
Progress Towards HVAC & Windows/Envelope Energy Savings Goals



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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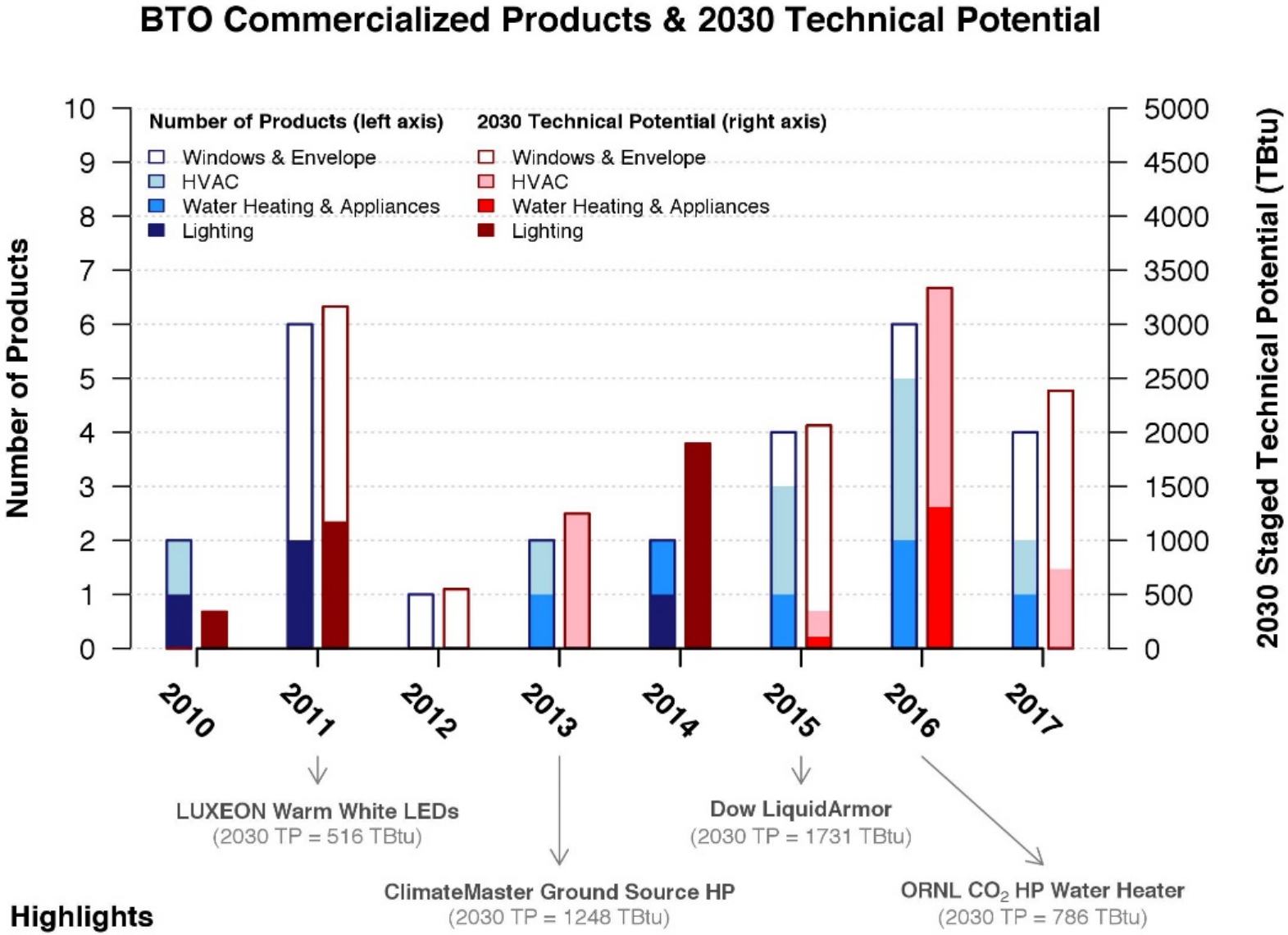
ET-Supported Commercialized Technologies



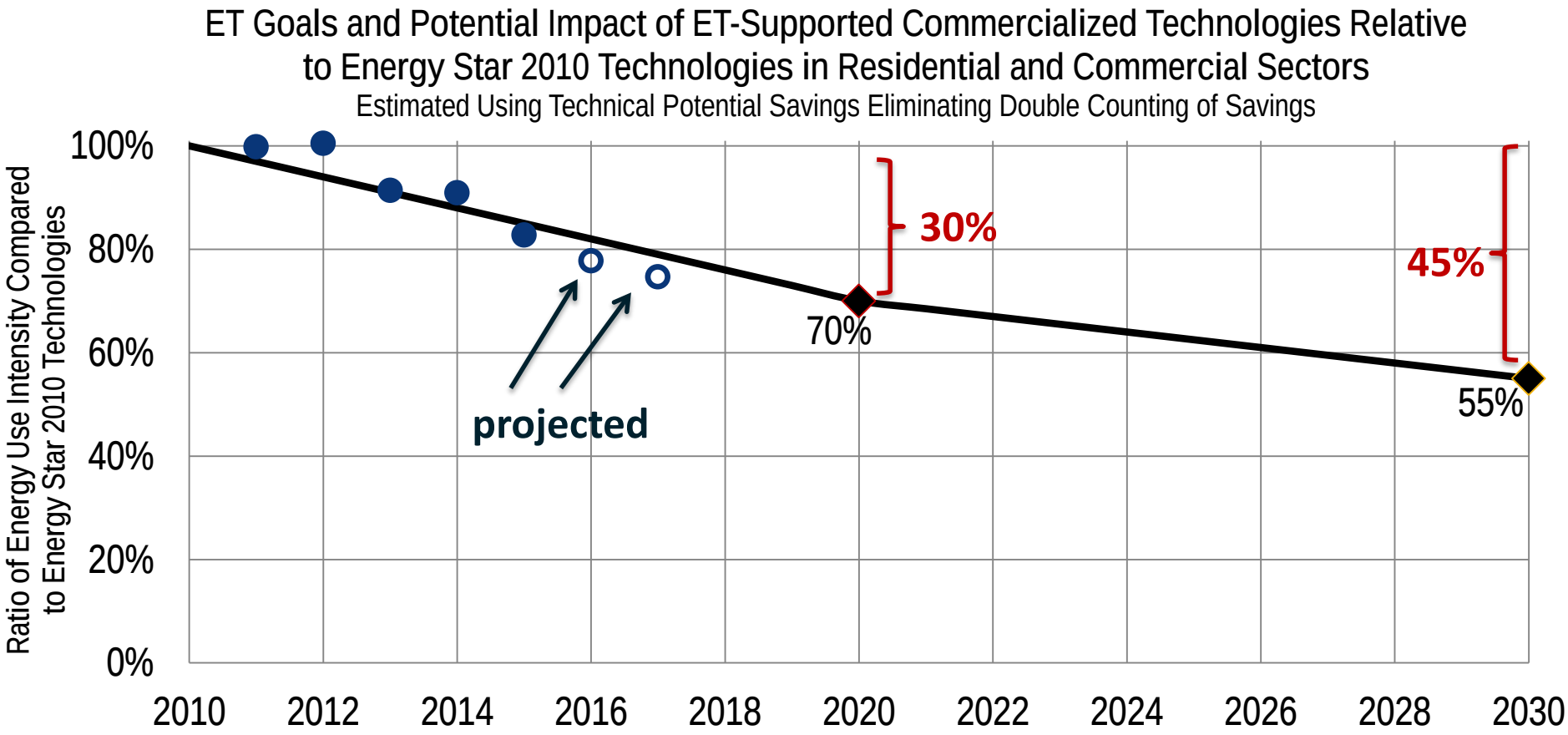
Highlights

Other ET Highlights

Subprogram	Journal Publications		IP		Licenses	
	2014	2015	2014	2015	2014	2015
HVAC	3	12	12	15	0	4
Lighting	1	1	10	1	0	0
Windows/ Envelope	7	7	11	6	4	0
Sensors and Controls	0	8	3	0	0	1
Modeling	13	14	0	0	0	1
Totals:	***24***	***42***	***36***	***22***	***4***	***6***

Read more about ET highlights at
http://energy.gov/eere/buildings/emerging-technologies-program-accomplishments-and-outcomes-2015

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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Buildings RD&D Opportunities in the 2015 QTR

Building thermal comfort and appliances	▪ Materials that facilitate deep retrofits (e.g., thin insulating materials) ▪ Low/no-GWP heat pump systems ▪ Improved tools for diagnosing heat flows over the lifetime of a building ▪ Clear metrics for the performance of building shells for heat and air flows
Lighting	▪ Test procedures for reliably determining the expected lifetime of commercial LED and OLED products ▪ Understanding why LED efficiency decreases at high power densities ▪ High efficiency green LEDs ▪ Efficient quantum dot materials ▪ Advanced sensors and controls for lighting ▪ Glazing with tunable optical properties ▪ Efficient, durable, low-cost OLEDs ▪ Lower cost retrofit solutions for lighting fixtures
Electronics and miscellaneous building energy loads	▪ More efficient circuitry (hardware and software) ▪ More flexible power management (hardware and software) ▪ Standardized communications protocols ▪ Wide-band-gap semiconductors for power supplies
Systems-level opportunities	▪ Accurate, reliable, low installed cost sensors ▪ Energy harvesting to power wireless sensors and controls ▪ Improved control systems (cybersecurity, install/commissioning) ▪ Control algorithms to automatically optimize building system performance ▪ Open-source software modules supporting interoperability ▪ Easy-to-use, fast, accurate software tools to design and operate buildings ▪ Co-simulation modeling with a widely used interface standard ▪ Decision science research incorporating personal information security ▪ Components and systems that allow building devices to share waste heat

Source: ***2015 DOE Quadrennial Technology Review (QTR)***

Fundamental Research Challenges in the 2015 QTR

- **Materials with tunable optical properties (adjust transmissivity and absorptivity by wavelength)**
- **Materials for efficient LEDs**
- **Materials for efficient motors and controls (magnets, wide-band-gap semiconductors)**
- **Enthalpy exchange materials**
- **Materials for low-cost Krypton/Xenon replacement**
- **Materials for non-vapor-compression heat pumps (e.g. thermoelectric, magnetocaloric, electrocaloric)**
- **Big-data management for large networks of building controls and next-generation grid systems**
- **Ultra-efficient computation (neural networks)**
- **Decision science research**

Source: ***2015 DOE Quadrennial Technology Review (QTR)***

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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