Emerging Technologies: HVAC, WH and Appliance
BTO Peer Review 2017

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

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HVAC, Water Heating and Appliance R&D

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.

Intro…

The Sub-Program works with national laboratories, academia, small businesses, manufacturers, and other industry stakeholders to advance technology R&D and commercialization toward maintaining the competitiveness of American industry.

Activities done at the national laboratories

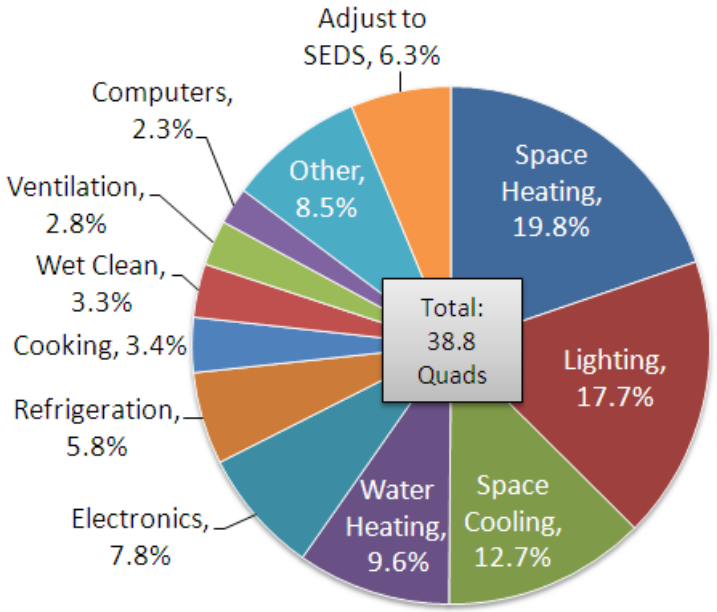
The national laboratories play an important role in meeting our overarching goal for the HVAC/Water Heating/Appliances Sub-Program due to BTO's past investment, technical capacities and talent. Historically, the national labs' strengths for this Sub-Program had been in longer term efforts in which technologies at low technology readiness level (TRL) of 4 or 5 and are fully developed with industry partners to a TRL of 9. These successful projects were only realized with strong industry participation and long term support from BTO.

….*This is more than just a laundry list of discrete one-off projects in the Sub-program research portfolio but developing a continuum or track from a low TRL engineering effort into a "market-ready" product, requiring some shepherding by BTO and leveraging our past investments…*

The challenge…

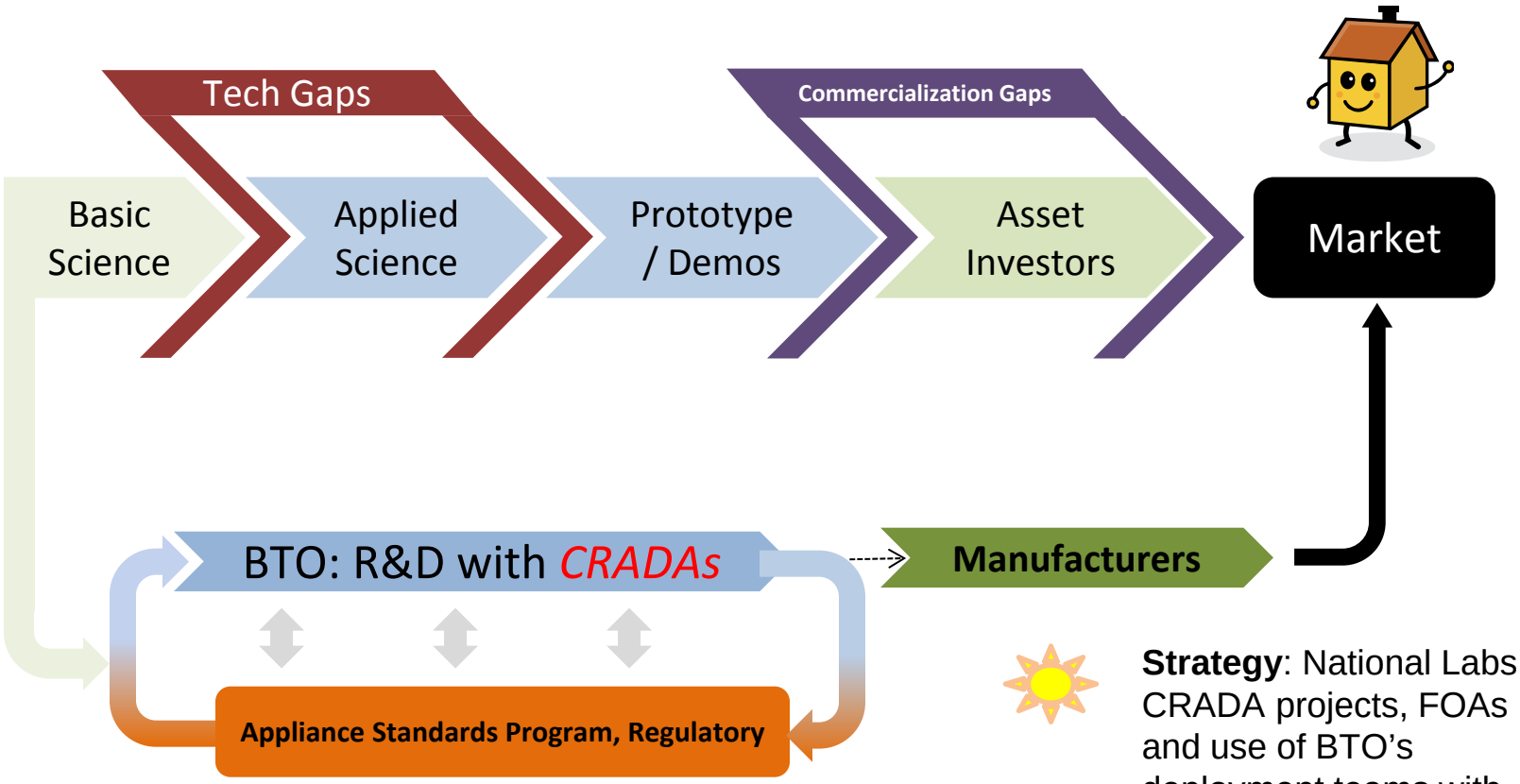
- In addition to individual end-use solutions, integrated solutions are also pursued
- Energy cascading (using the waste heat from one process as the source of energy for another) is utilized
- Optimizing energy use in a building, an optimum point instead of just a local minimum (single end-use)
- Broad 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, Water Heating and Appliance R&D



CRADA : Collaborative Research and Development Agreement

Strategy: National Labs CRADA projects, FOAs and use of BTO's deployment teams with research homes

More than just discrete one-off projects but a continuum from low TRL engineering efforts into a "market-ready" product

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

Program: Core + FOAs + SBIR

CORE

AOP: Critical to the program

2008-Present

FOA

2009

Advanced Energy Efficient Building Technologies, DE-FOA-0000115 (June 29, 2009)

- Research Focus: HVAC, Water Heating and Appliances: Cold Climate, Low-GWP, Refrigerant, Non-vapor compression, and Clothes Dryers

FOA

2012

Energy Savings through Improved Mechanical Systems and Building Envelope Technologies, DE-FOA-0000621 (March 7, 2012)

- High performance air source cold climate heat pumps
- Alternative space-heating systems
- Next generation heat exchangers for electric vapor-compression heat pumps and air conditioners

Program: Core + FOAs

FOA

2013

Building Technologies Innovations Program, DE-FOA-0000823 (March 5, 2013)

- Open Topic: Natural refrigerant air-sourced heat pump, cold-climate applications, heat exchangers and natural gas heat pump and heat engine.

FOA

2014

Building Energy Efficiency Frontiers & Incubators Technologies (BENEFIT) – 2014, DE-FOA-0001027 (Feb 4, 2014)

- Open Topic: Membrane-based absorption to cool and dehumidify (WH, IHP and non-vapor compression), heat exchanger research, and motors
- Frontier Topic: Advanced energy efficient clothes dryers (electric and gas): innovative electrostatic precipitator, thermoelectric heat pumping and ultrasonic technology

Program: Core + FOAs

FOA

2014

Building Energy Efficiency Frontiers and Innovation Technologies (BENEFIT)-2015, DE-FOA-0001166 (Oct 9, 2014)

- Innovation: Non-vapor compression HVAC technologies
- Frontiers: Advanced vapor compression HVAC technologies

FOA

2015

Building Energy Efficiency Frontiers and Innovation Technologies (BENEFIT)-2016, DE-FOA-0001383 (Dec 15, 2015)

- Innovation: HVAC&R Materials Joining Technologies

FOA

2016

Buildings Energy Efficiency Frontiers & Innovation Technologies (BENEFIT) – 2017, DE-FOA-0001632 (Nov 30, 2016)

- Topic 1: Open Topic for Energy Efficiency Solutions for Residential and Commercial Buildings – Early-stage (starting TRL 2-3)
- Topic 2: Advanced HVAC&R Research and Development, FRONTIERS section (starting TRL 4-5)
- Topic 4: Open Topic for Energy Efficiency Solutions for Residential and Commercial Buildings – Pre-Commercial Stage, SCALE-UP section (starting TRL 6-7)

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Monday, March 13th 2017

- 2:00-2:30 ORNL - *Magnetocaloric Refrigerator*
- 2:30-3:00 ORNL - *Flammability Risk Assessment of Alternative Flammable Refrigerants*
- 3:00-3:30 NIST - *Modeling Tools for Flammability Ranking of Low-GWP Refrigerant Blends*
- 4:00-4:30 ORNL - *Residential Gas-fired Cost-effective Triple-state Sorption Heat Pump*
- 4:30-5:00 ORNL - *Heat Pump Dryer*

Tuesday, March 14th 2017

- 9:00-9:30 ORNL - *High Performance Cold-Climate Multi-Stage Heat Pump*
- 9:30-10:00 ORNL - *AS-IHP System Development*
- 10:00-10:30 ORNL - *Commercial Gas Absorption HPWH*
- 11:00-11:30 ORNL - *Novel Ground-Level Integrated Diverse Energy Storage (GLIDES) Coupled with Building Air Conditioning*
- 11:30-12:00 SNL - *RVCC Technology: A Pathway to Ultra-Efficient Air Conditioning, Heating, and Refrigeration*
- 12:00-12:30 Trane - *Improved Braze Joint Quality Through use of Enhanced Surface Technologies*
- 1:30-2:00 GE Global Research - *Energy-Efficient Clothes Dryer with IR Heating and Electrostatic Precipitator*
- 2:00-2:30 Mechanical Solutions - *Development of an Innovative, High-efficiency Radon Fan (SBIR)*
- 2:30-3:00 ORNL - *Next Generation Rooftop Unit*
- 3:00-3:30 ORNL - *Performance Evaluation of Packaged Rooftop Unit at High Ambient Temperature Environments*
- 4:00-4:30 ORNL - *Adhesive Bonding of Aluminum and Copper in HVAC&R Applications*
- 4:30-5:00 Maryland Energy and Sensor Technologies - *Non-Vapor Compression*

Wednesday, March 15th 2017

- 10:00-10:30 OTS - *Advanced Serpentine Heat Exchangers to Minimize the Number of Joints and Leakage in HVAC&R Systems*
- 11:00-11:30 Mechanical Solutions - *Advanced Vapor Compression*
- 11:30-12:00 UTRC - *Advanced Vapor Compression*
- 12:00-12:30 Dais Analytic - *Non-Vapor Compression*
- 1:30-2:00 QM Power - *Higher Efficiency HVAC Motors*
- 2:00-2:30 ORNL - *Non-Vapor Compression*
- 2:30-3:00 UTRC - *Non-Vapor Compression*
- 3:00-3:30 Xergy - *Non-Vapor Compression*
- 4:00-4:30 USF - *University of Florida A Combined Water Heater, Dehumidifier, and Cooler*
- 4:30-5:00 Xergy - *Advanced Hybrid Water-Heater Using Electrochemical Compression (ECC) (SBIR)*

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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