Quadrennial Technology Review-2015

Chapter 7: Increasing Efficiency of Building Systems and Technologies

Public Webinar

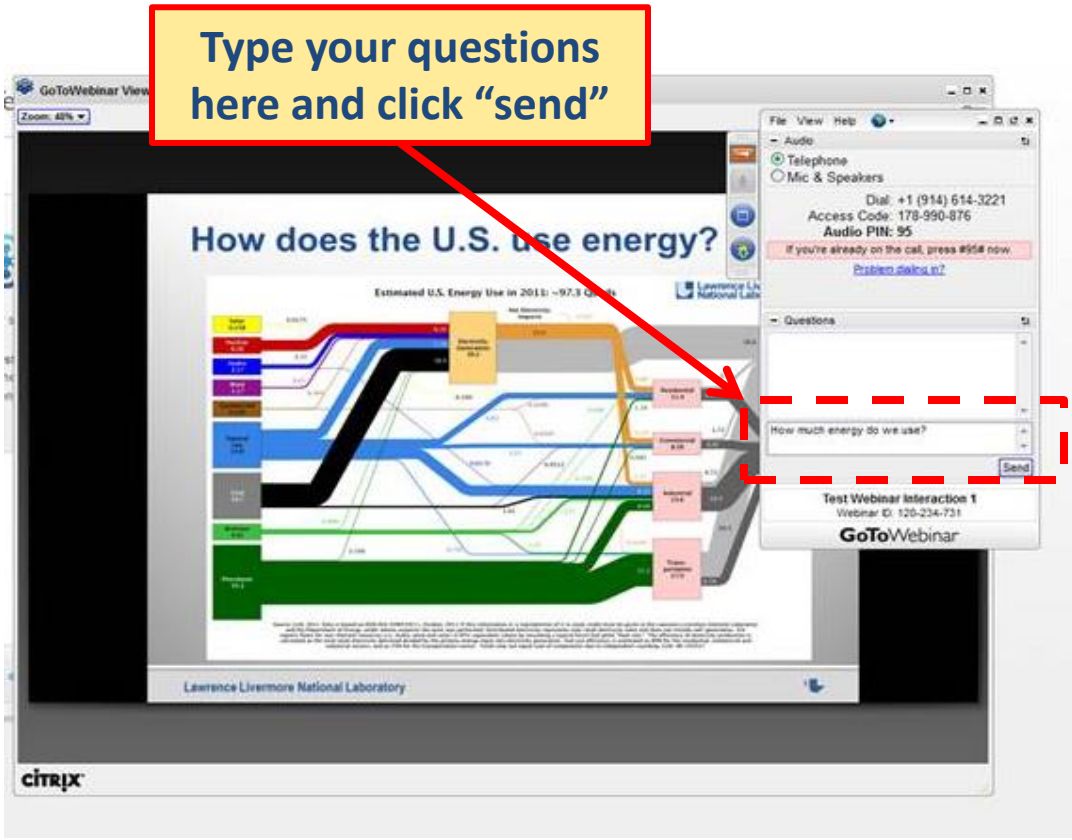
Chapter Leads:
Henry Kelly
Pat Phelan

2015-02-18

Webinar Logistics

- Due to the large number of expected participants, the audio and video portions of this webinar will be a “one way” broadcast. Only the organizers and QTR authors will be allowed to speak.

- You are encouraged to submit questions using GoToWebinar’s “Questions” functionality. The moderators will respond, via audio broadcast, to as many appropriate questions as time allows.



QTR 2015 Chapter Outline

Introduction

1. Energy Challenges
2. What has changed since QTR 2011
3. Energy Systems and Strategies

Assessments

4. Advancing Systems and Technologies to Produce Cleaner Fuels
5. Enabling Modernization of Electric Power Systems
6. Advancing Clean Electric Power Technologies
7. **Increasing Efficiency of Buildings Systems and Technologies**
8. Increasing Efficiency and Effectiveness of Industry and Manufacturing
9. Advancing Clean Transportation and Vehicle Systems and Technologies
10. Enabling Capabilities for Science and Energy

Integrated Analysis

11. U.S. Competitiveness
12. Integrated Analysis
13. Accelerating Science and Energy RDD&D
14. Action Agenda and Conclusions; Web-Appendices

Web Appendices

Quadrennial Technology Review: Buildings

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

Pat Phelan, Emerging Technologies
Building Technologies Office
Feb 18, 2015

Chapter Overview

- Covers opportunities for increasing the efficiency of energy use in residential and commercial buildings
- Includes technologies impacting thermal comfort and air quality, lighting, major energy-using appliances, electronics and miscellaneous building energy loads
- Also includes discussion of system-level energy-savings opportunities
- Production, transmission, and distribution of energy, as well as electric vehicle loads, are handled in other chapters

Systems Approach

- Energy use in buildings depends on a skillful combination of good architecture and good energy systems design, and on effective operations and maintenance once building is occupied.
- The value of any component technology depends on the system in which it is embedded and how the system is operated.
- Buildings can also impact utility operations, by shifting their own demand away from peak demand periods. Coordinating building energy systems, on-site generation and storage systems, and with the utility and with other buildings can lower overall system costs and increase system-wide reliability.
- Chapter includes a discussion of system-wide strategies for reducing building energy use through improved sensors and controls, behavioral research, and other methods.

Chapter Outline

(Each section ends with a section on Research Priorities)

1. Introduction
2. Thermal Comfort and Air Quality
    1. Building Envelope
    2. Ventilation and Air Quality
    3. Space Conditioning Equipment
    4. Moisture Removal
    5. Heat Exchangers
    6. Thermal Storage
    7. Integrated System Analysis
3. Lighting
    1. Windows, Daylighting and Lighting Controls
    2. Lighting Devices

Chapter Outline (continued)

3. Integrated System Analysis

4. Major Energy Consuming Appliances: Hot Water, Clothes Dryers, Refrigerators

5. Electronics and Miscellaneous Building Energy Loads
   1. Information Processing
   2. Displays and Other Miscellaneous Uses

6. System-Level Opportunities
   1. Sensors, Controls, and Networks
   2. Building Design and Operations
   3. Social and Behavioral Research
   4. Embodied Energy
   5. DC Systems

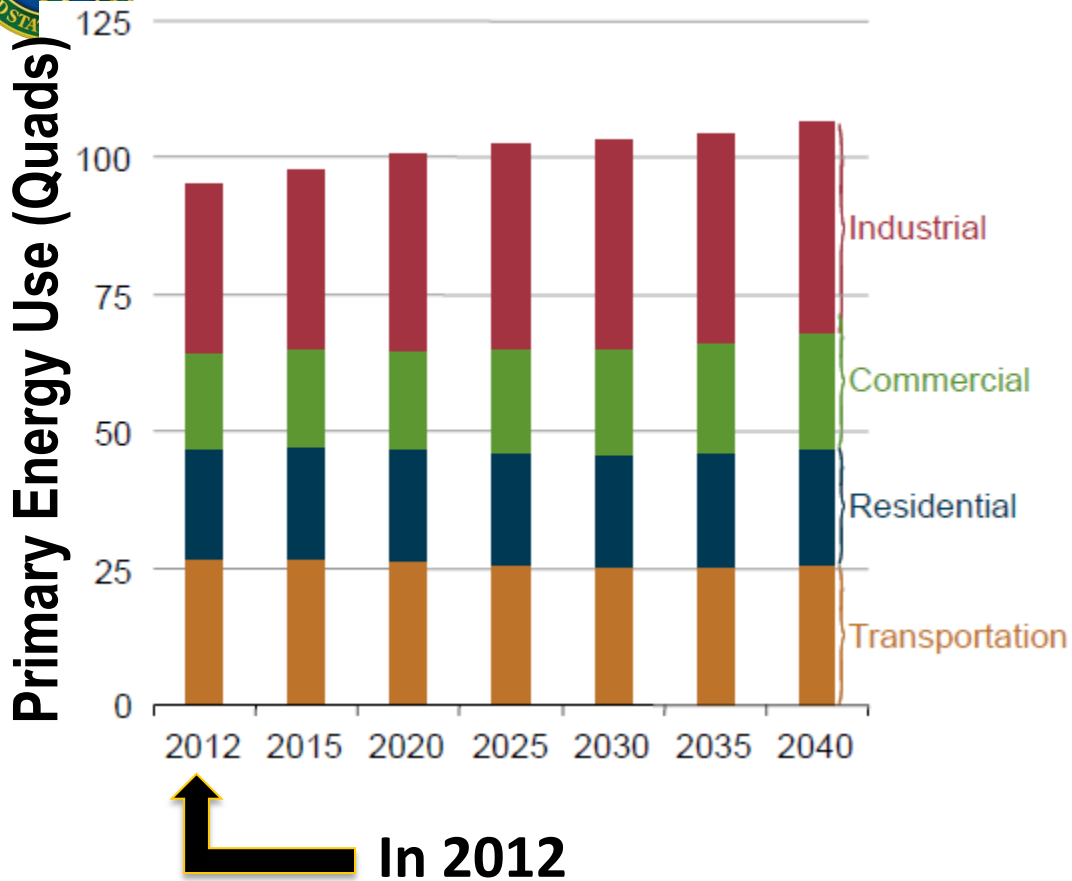
7. The Potential for Building Efficiency

Technology Assessments

- Updated Analysis of Building Energy Efficiency Potential
- Building Envelope Technologies
- Building Integrated Solar
- Heating, Ventilation and Air Conditioning (HVAC): Non-Vapor Compression Technologies
- Heating, Ventilation and Air Conditioning (HVAC): Cross-Cutting Electric Motors
- Lighting
- Data Centers

These assessments, separate from the main report, will contain the data and analysis that supports the technology discussion in the chapter. They will be available on the web.

ildings Are a Significant Consumer of Energy



In 2012

Buildings were responsible for 71% of the electricity, and 53% of the natural gas, consumed in the USA.

In 2012

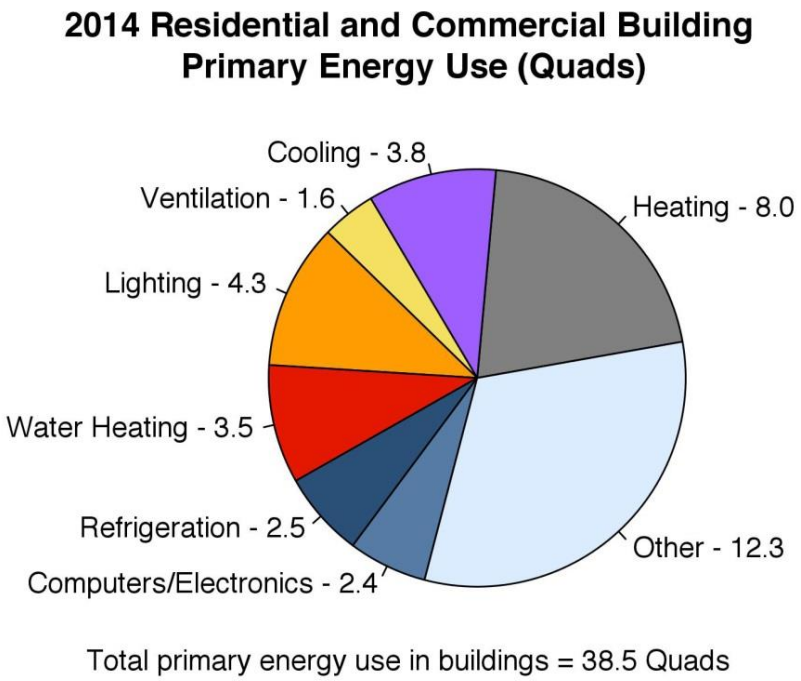
40% Buildings

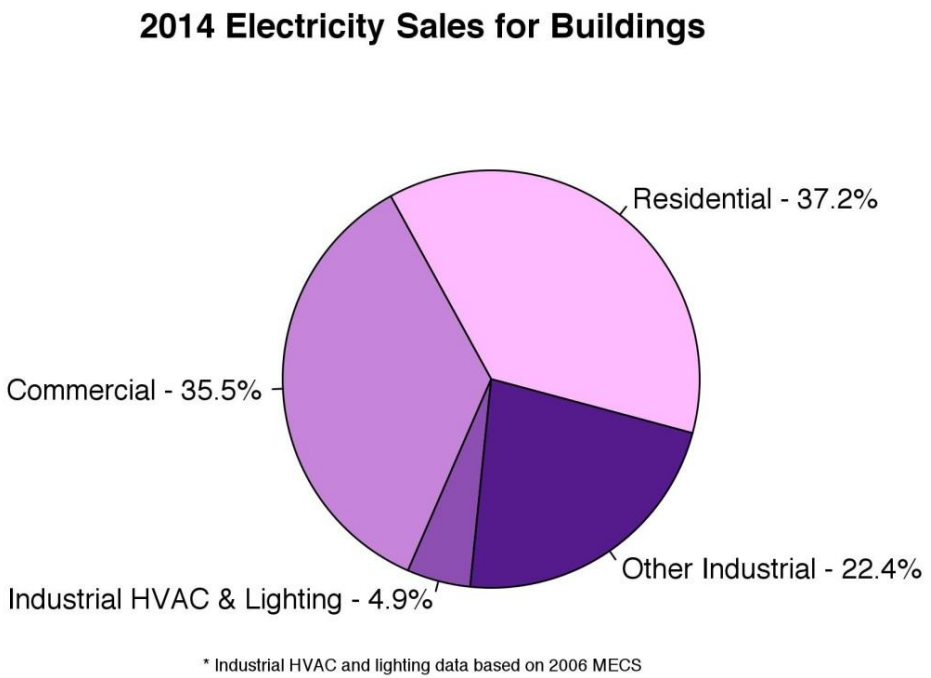
32% Industry

28% Transportation

2014 Annual Energy Outlook (AEO)

Energy & Electricity Consumption in Buildings





Major energy consumers in buildings:

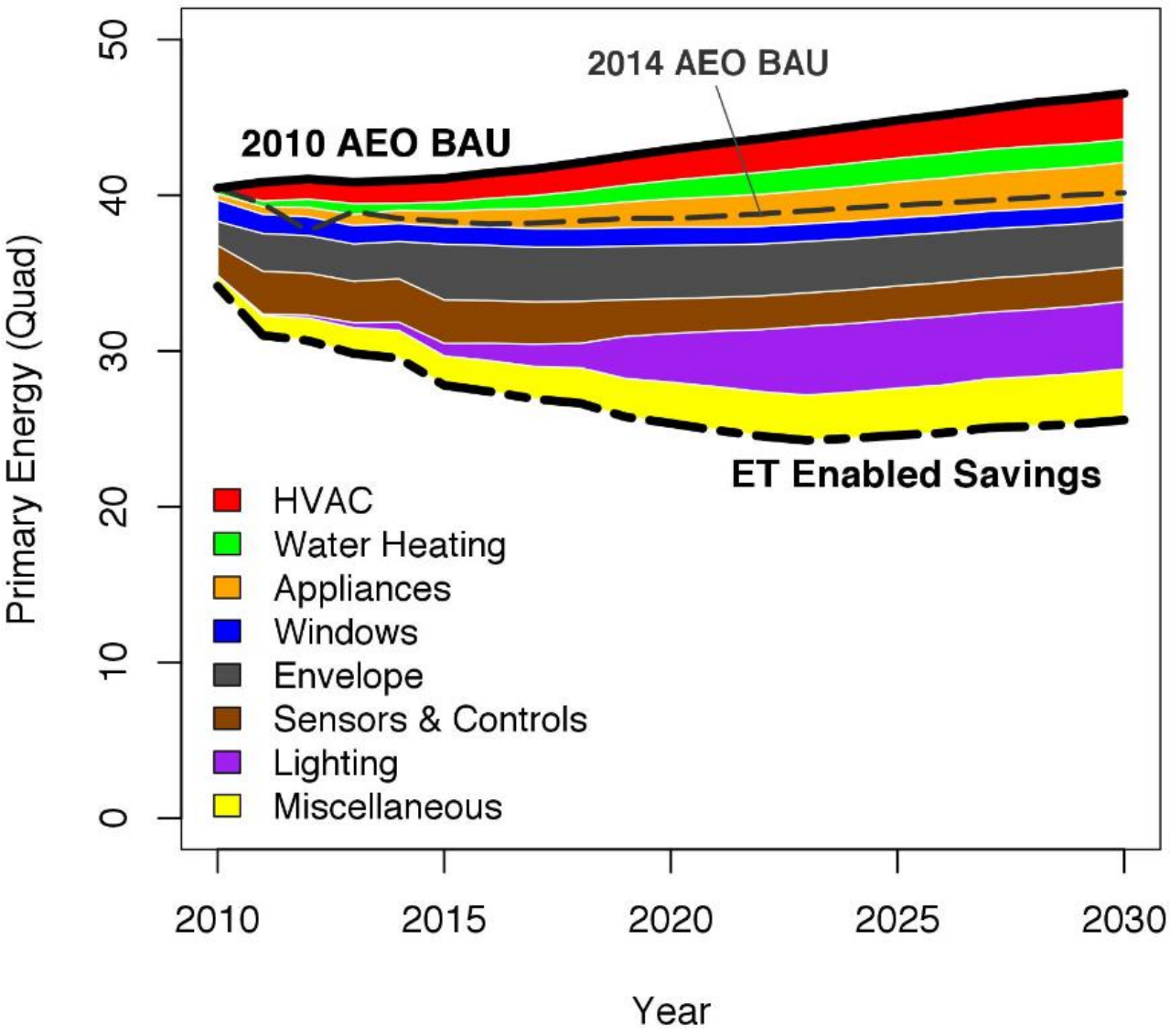
Cooling/Heating/Ventilation: 35%

Lighting: 11%

Water Heating: 9%

Other (miscellaneous electric loads, other appliances, furnace fans, transformers, elevators, etc.): 32%

Projected Cost-Effective Energy Savings by End Use



AEO: Annual Energy Outlook

ET: Emerging Technologies

BAU: Business As Usual

Note: These projections are based on BTO's Prioritization Tool (http://energy.gov/eere/buildings/prioritization-tool)

Buildings: Topics Covered (Slide 1 of 2)

Thermal Comfort and Air Quality

- The Building Envelope
  - Walls, Roofs and Foundations
  - Windows and Skylights
- Ventilation and Air Quality
- Space Conditioning Equipment
- Moisture Removal
- Heat Exchangers

Lighting

- Windows, Daylighting, and Lighting Controls
- Lighting Devices

Buildings: Topics Covered (Slide 2 of 2)

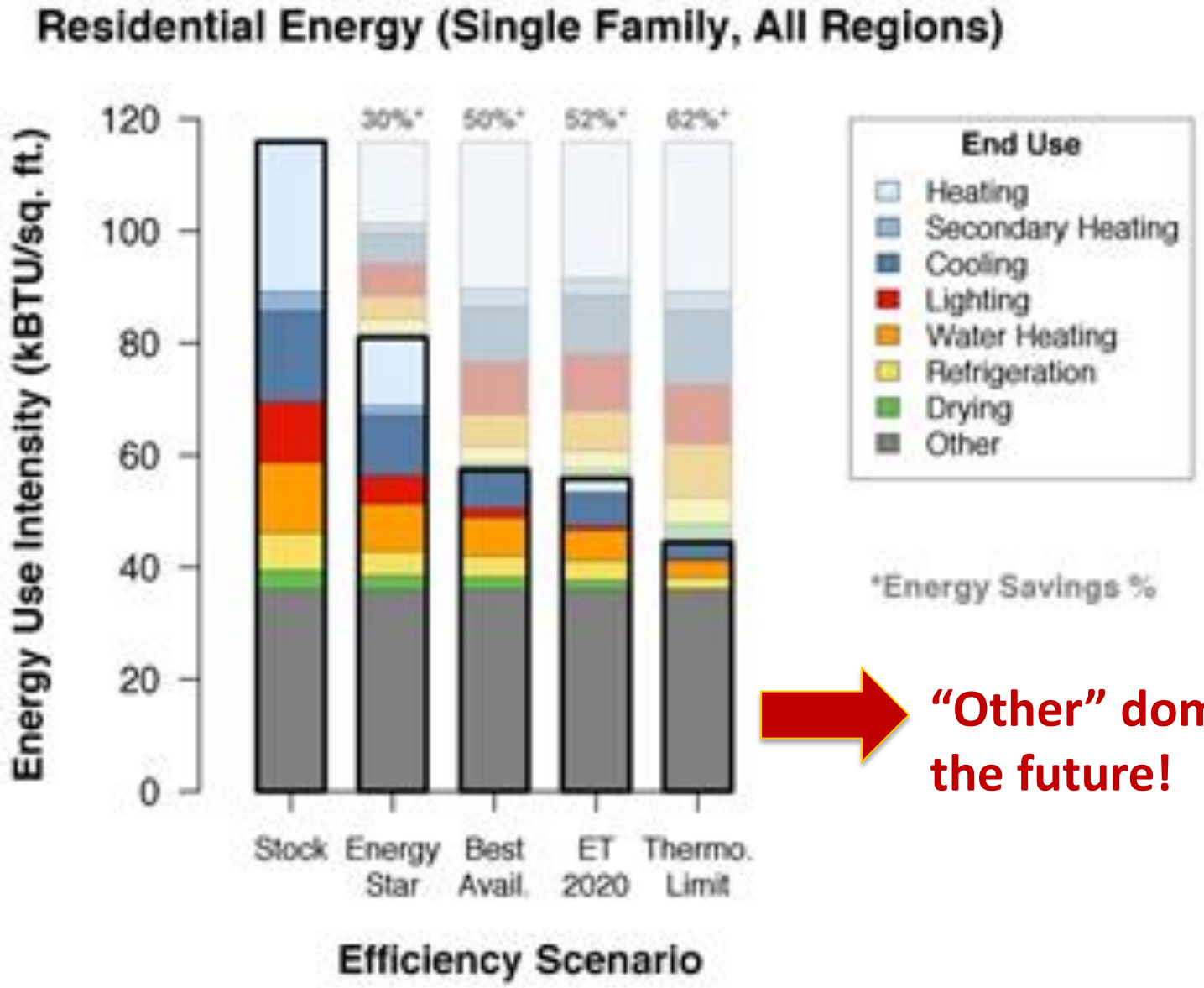
Major Energy Consuming Appliances: Hot Water, Clothes Dryers, Refrigerators

Electronics and Miscellaneous Building Energy Loads

Systems Level Opportunities

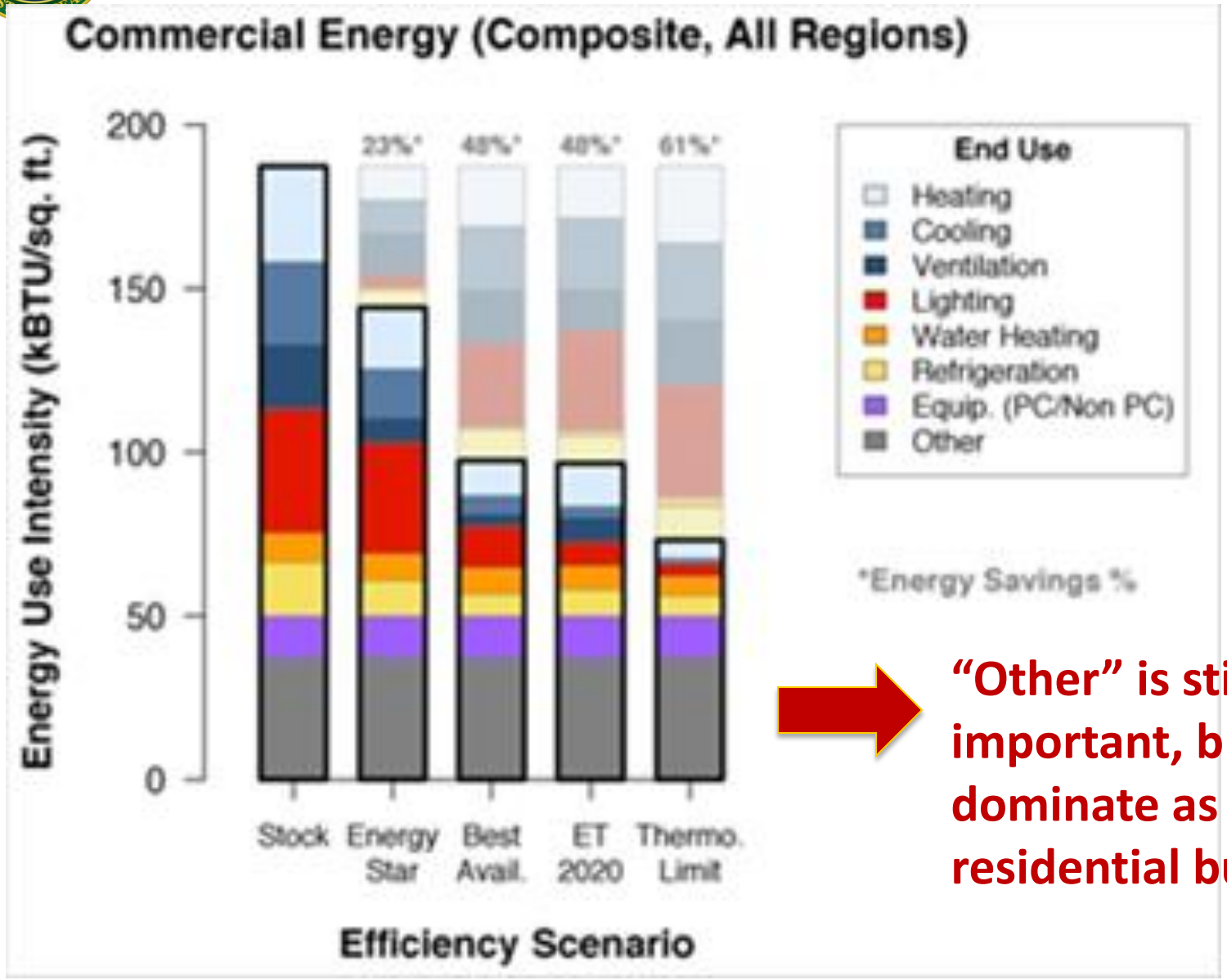
- **Sensors, Controls and Networks**
- **Building Design and Operation**
- **Social and Behavioral Research**
- **Embodied Energy**
- **DC systems**

otential Limits of Building Energy Efficiency (Res.)



"Other" dominates in the future!

Potential Limits of Building Energy Efficiency (Com.)



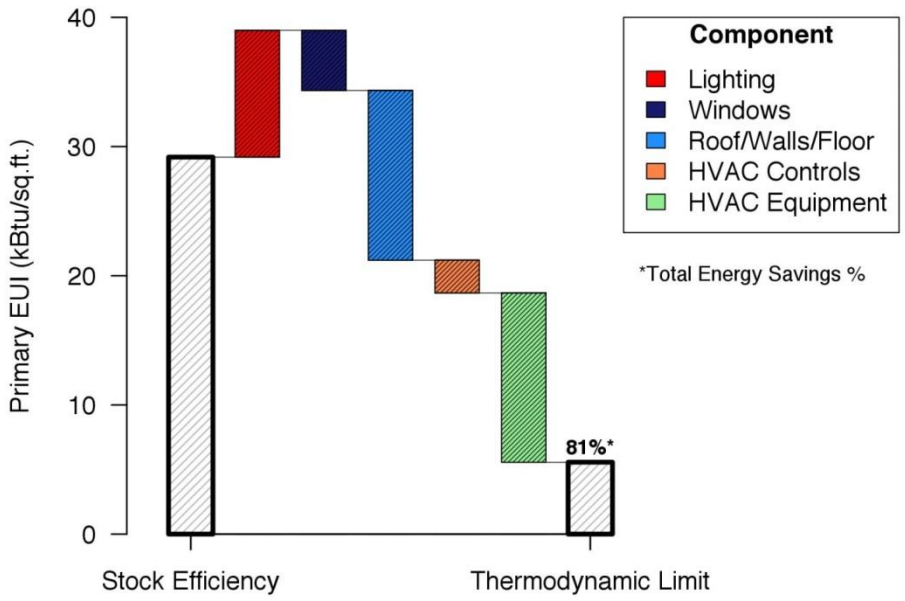
"Other" is still important, but doesn't dominate as in residential buildings

Potential Research Priorities: Thermal Comfort & Air Quality

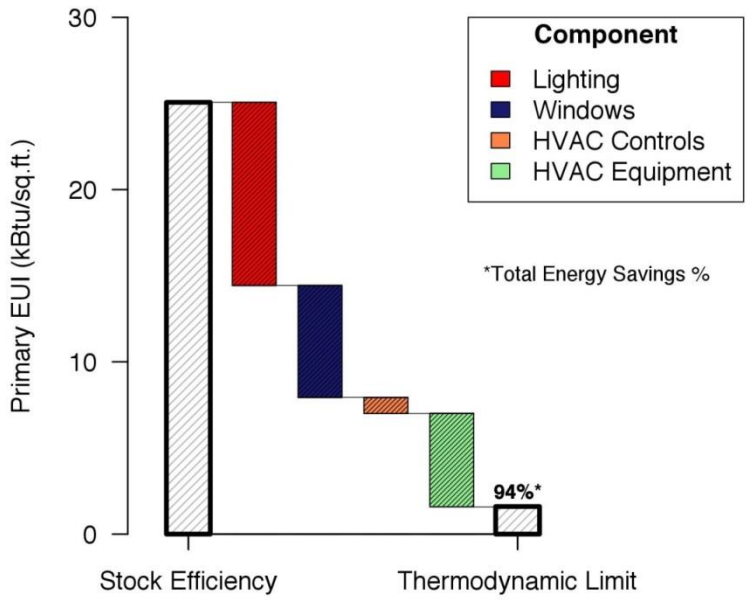
- **Glazing materials with tunable optical properties (transmissivity and emissivity adjustable by wavelength)**
- **Materials that are thin and provide tunable insulating and vapor permeability and materials that could be used in next-generation enthalpy exchange devices**
- **Technologies that could lower the cost of producing noble gases and identifying transparent, low-conductivity gases that could substitute for noble gases**
- **Strategies for using vacuum as a window insulation**
- **Innovative heat exchanger designs for heat pumps and other uses (variety of scales); reducing volume and weight of heat exchangers.**
- **Components for non-GHG (greenhouse gas) heat pumps**
- **Sensors and controls**

Commercial Buildings: Pathways for HVAC Efficiency

Heating

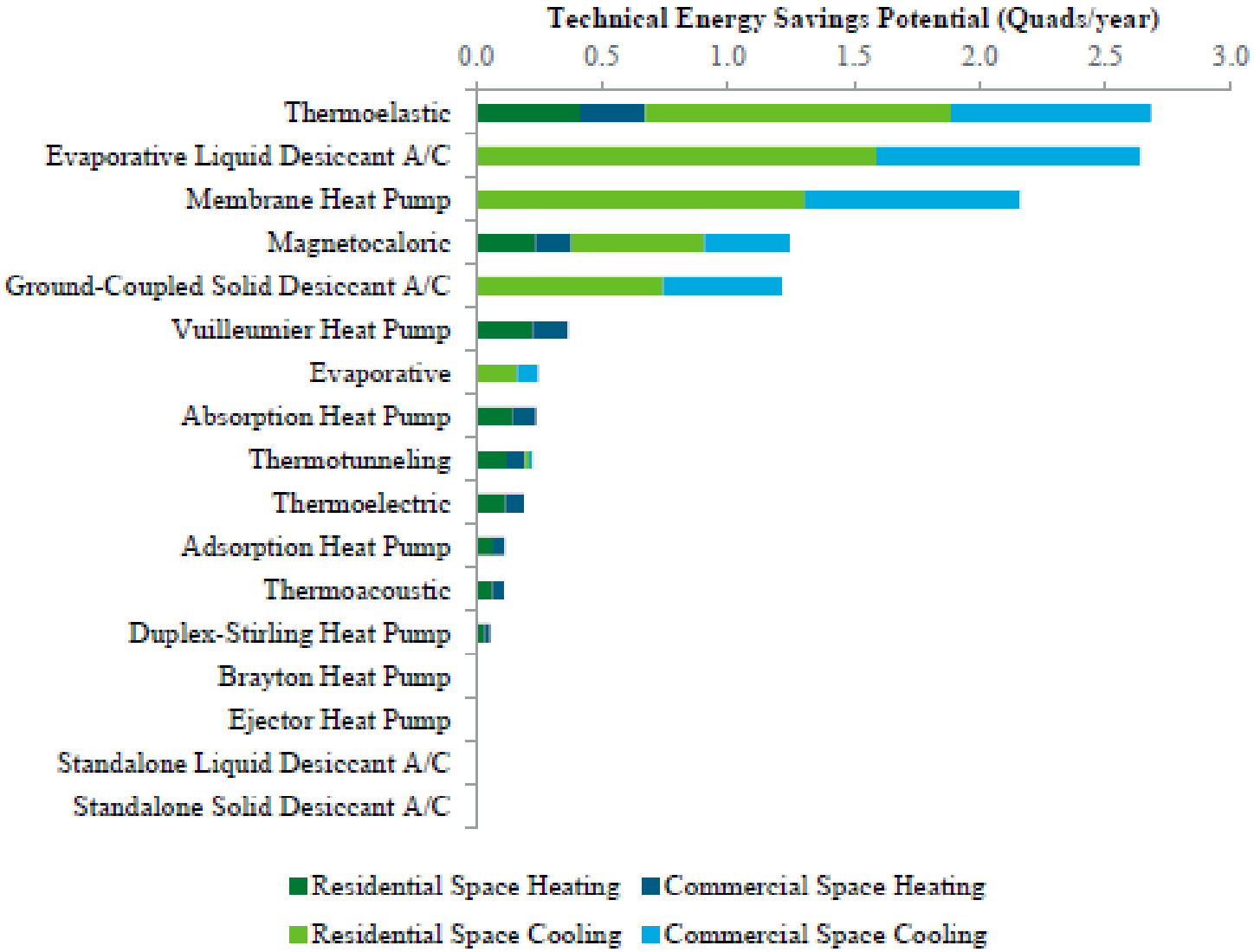


Cooling



Improvements in lighting efficiency increase heating energy consumption!

Non-Vapor-Compression HVAC Systems



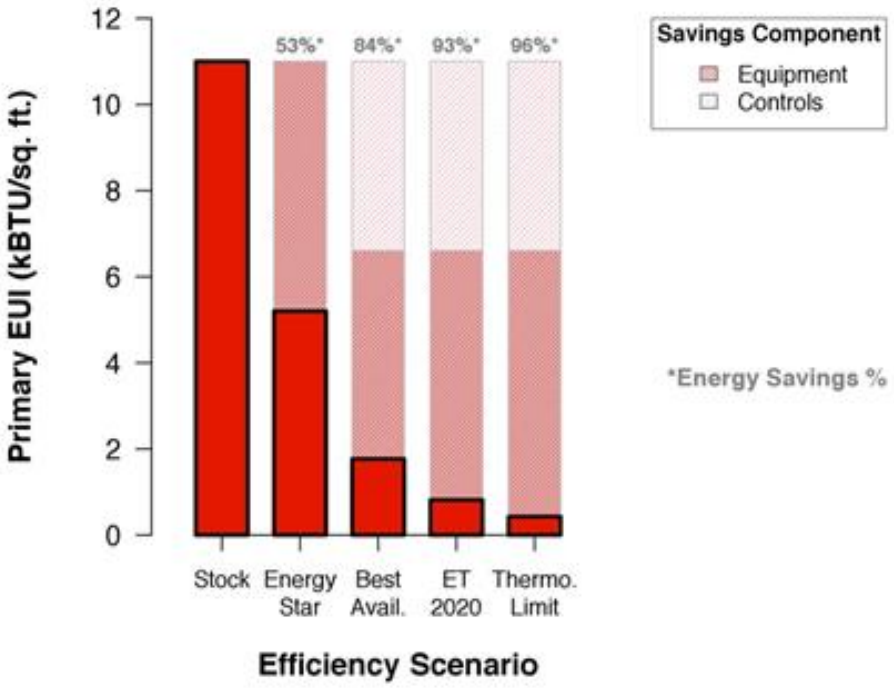
Source: Energy Savings Potential and RD&D Opportunities for Non-Vapor-Compression HVAC Technologies, 2014, http://energy.gov/eere/buildings/downloads/non-vapor-compression-hvac-technologies-report

Potential Research Priorities: Lighting

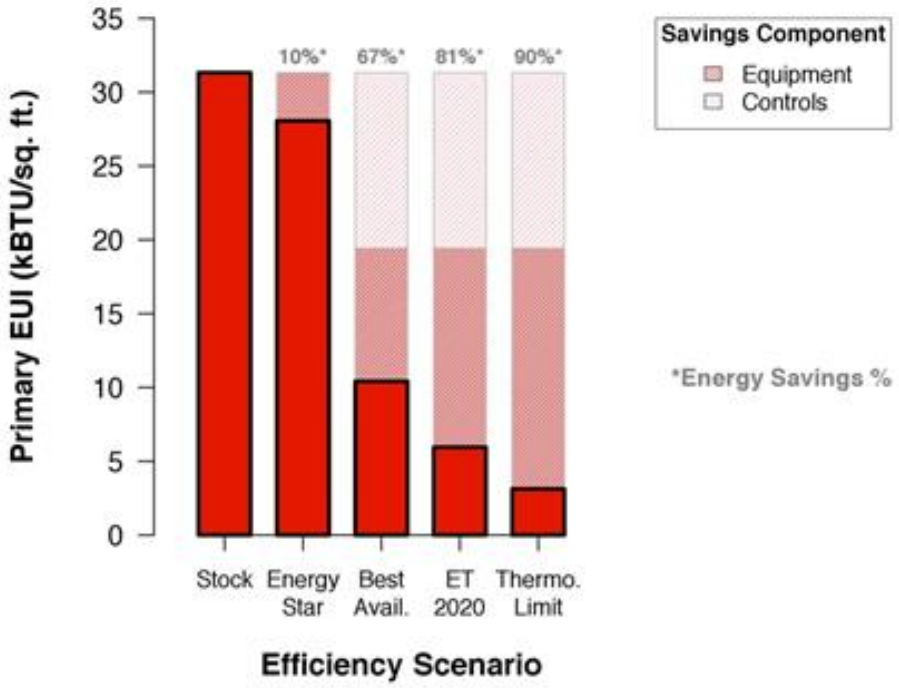
- **LED components including understanding why efficiency declines at high power densities, organic LED components, high efficiency green LEDs**
- **High efficiency green LEDs**
- **Glazing with tunable optical properties (also needed for thermal load management)**
- **Efficient, durable, low cost organic LEDs**
- **Sensors and controls**
- **Lowering retrofit costs of new light fixtures**

Improving Lighting Energy Efficiency

Residential

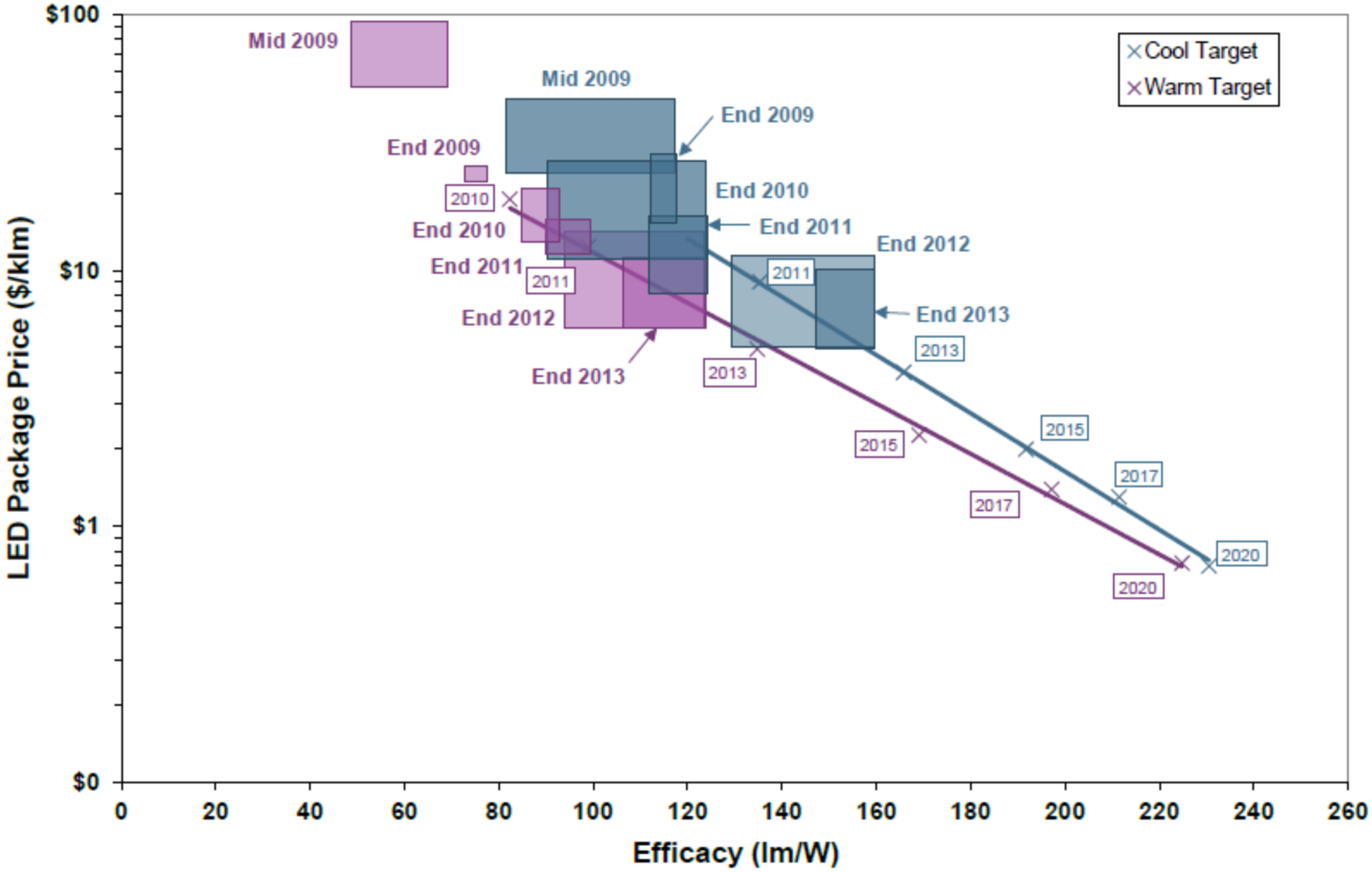


Commercial



Improving lighting efficiency is a combination of improving the efficiency of lighting devices, and of improved controls

Price vs. Efficacy for LEDs (Light-Emitting Diodes)

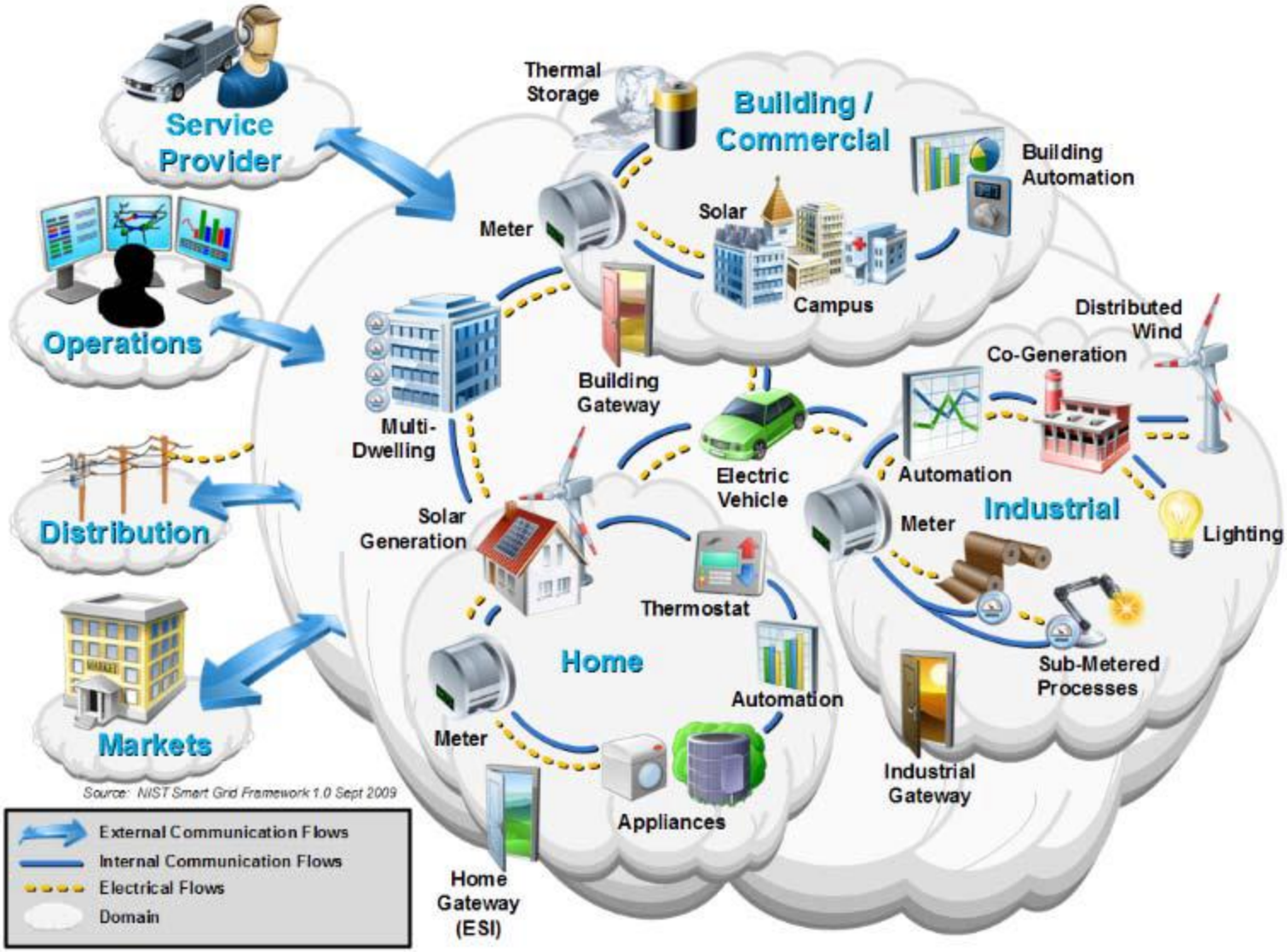


Source: Solid-State Lighting Research and Development, Multi-Year Program Plan, 2014, http://apps1.eere.energy.gov/buildings/publications/pdfs/ssl/ssl_mypp2014_web.pdf

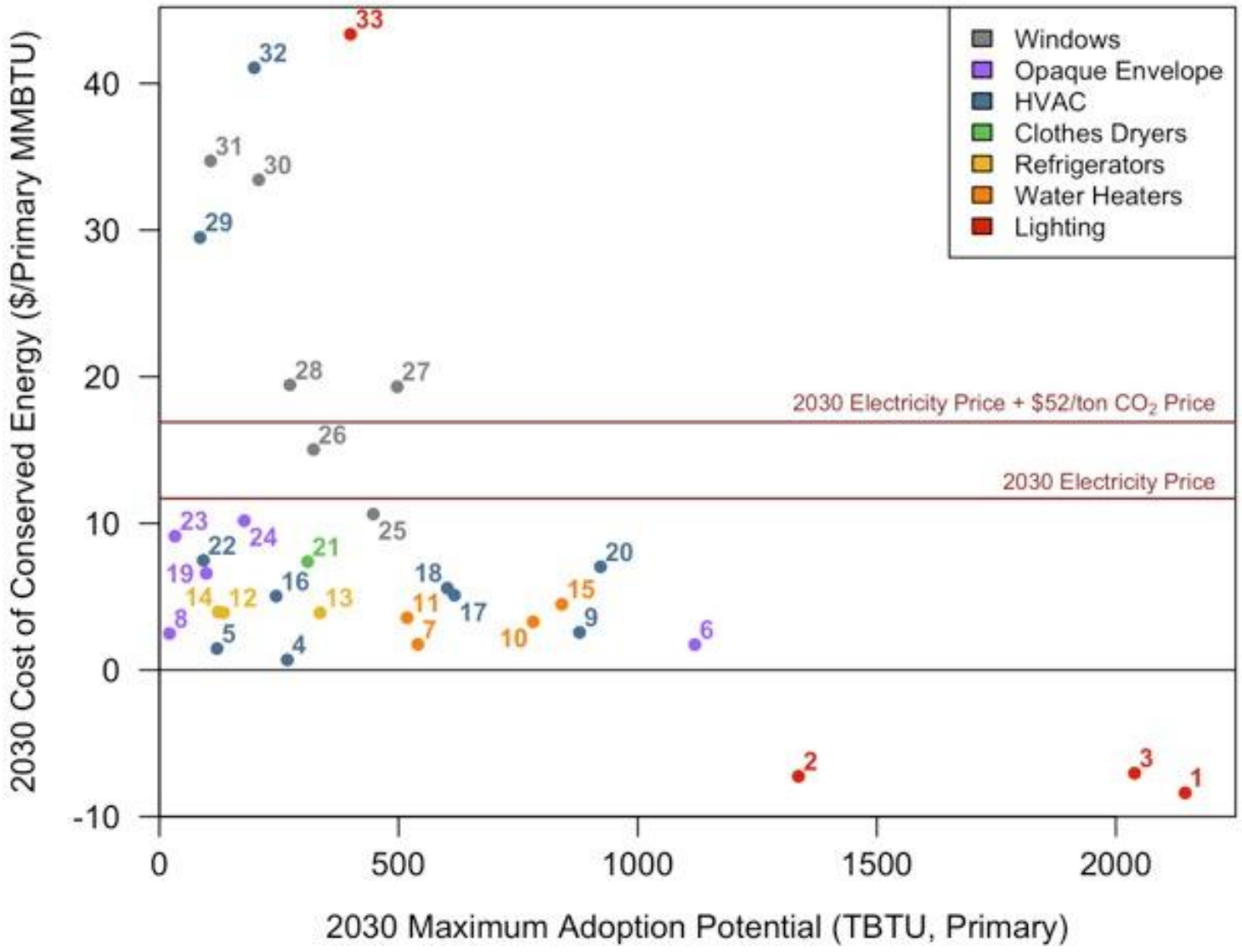
Potential Research Priorities: Building Systems

- **Develop easy-to-use, fast, accurate software tools to design highly efficient buildings and to assist operations.**
- **Development of algorithms that can allow building sensor and control systems to automatically optimize system performance without large inputs from skilled designers.**
- **Develop open source software modules that can be combined to form sophisticated commercial control systems to enable flexible and dynamic buildings that provide value on both sides of the utility meter.**
- **Develop accurate, reliable sensors with low installed costs.**
- **Develop energy reporting technology so that energy-using devices can report their energy use, status, and associated information, such as to the local network.**
- **Develop energy harvesting systems that allow sensors and controls of all kinds to operate without battery replacement or hard wiring**

Buildings and Grid Integration



Buildings Energy Efficiency R&D Opportunities



1. LED Lighting (Commercial/Industrial)
2. LED Lighting (Residential)
3. OLED Lighting (Commercial)
4. Advanced Vapor Compression (Commercial)
5. Non-Vapor Compression HVAC (Commercial)
6. Air Sealing (Residential)
7. Non-Vapor Compression HPWH (Residential)
8. Envelope Insulation (Commercial)
9. Natural Gas HP (Residential)
10. HPWH (Residential)
11. Sorption-based HPWH (Residential)
12. Compressor Refrigerators (Residential)
13. Advanced Refrigerators (Residential)
14. Non-Vapor Compression Refrigerators (Residential)
15. CO2 HPWH (Residential)
16. Non-Vapor Compression HVAC (Residential)
17. Advanced Vapor Compression (Residential)
18. Natural Gas ICE HP (Commercial)
19. Air Sealing (Commercial)
20. Natural Gas ICE HP (Residential)
21. HP Clothes Dryer (Residential)
22. Integrated ASHP (Commercial)
23. Highly Insulating Roofs (New, Commercial)
24. Envelope Insulation (Residential)
25. Dynamic Window Films (Residential)
26. Dynamic Windows (Res)
27. R-10 Windows (Res, $10/SF)
28. Dynamic Window Films (Com)
29. Cold Climate ASHP (Com)
30. R-7 Windows (Com, $8/SF)
31. Dynamic Windows (Commercial)
32. Integrated ASHP (Residential)
33. Perimeter Zone Daylighting

Public Input

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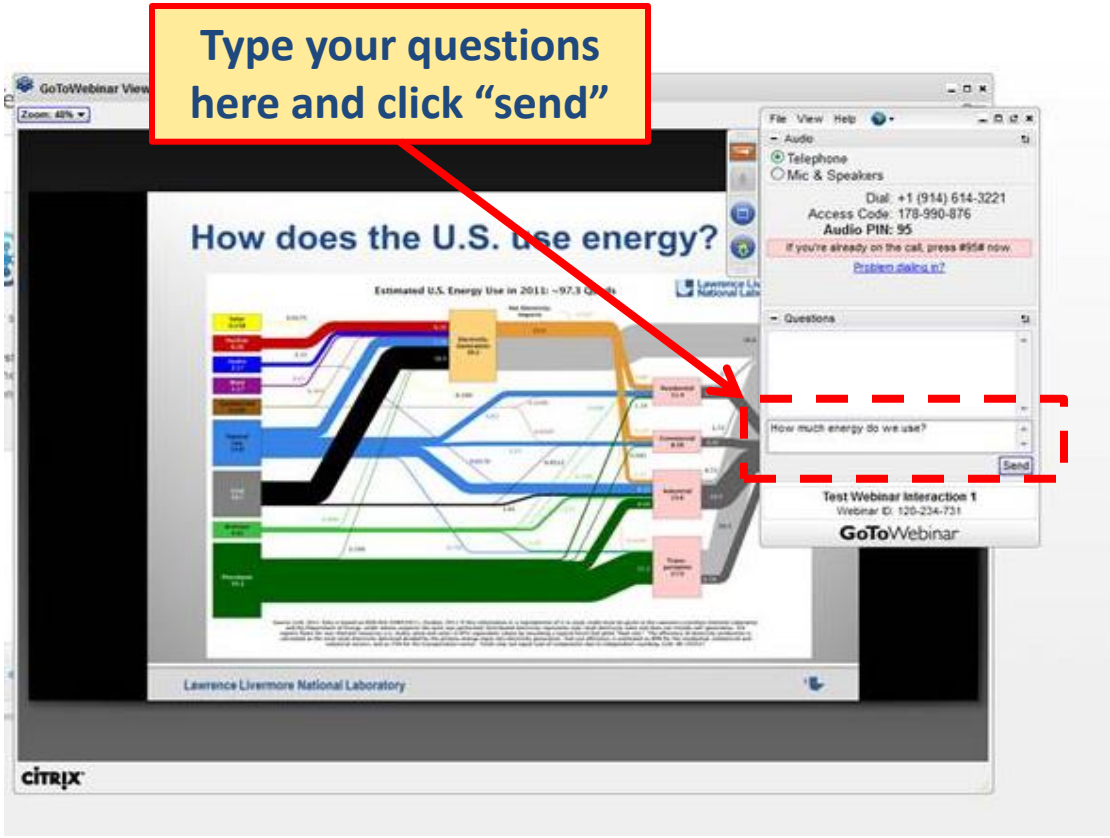

- If you have questions or comments that cannot be addressed during the webinar, email them to DOE-QTR2015@hq.doe.gov

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