CHANGING WHAT'S POSSIBLE

# ARPA-E Workshop Overview:

## Personal Thermal Management Systems to Reduce Building Energy Consumption

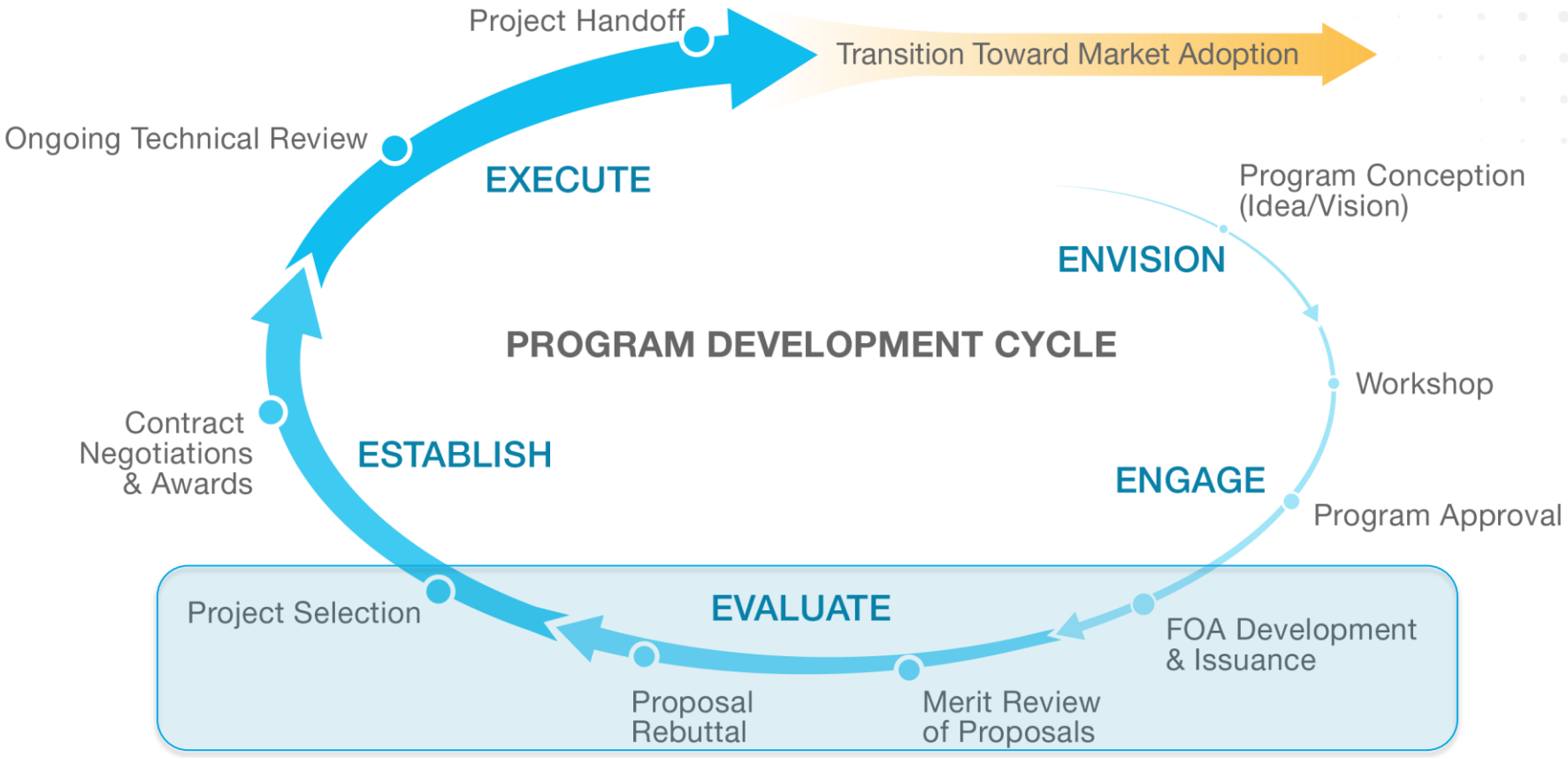
Dr. Ping Liu, ARPA-E Program Director

November 12th & 13th, 2013

# Focal Points

- The Reason for Holding an ARPA-E Workshop
- How Personal Thermal Management fits ARPA-E
- Setting Expectations

# Technology Acceleration Model



# Schedule Overview

## DAY 1: Introductions

| | | |
|---|---|---|
| 11am-1pm | REGISTRATION | Nancy Hicks, BAH |
| 12pm-1pm | **--- Technology Demo Session & Lunch ---** | |
| 1:10 | ARPA-E Introduction | Dr. Eric Rohfling, ARPA-E |
| 1:30 | Overview of Personal Thermal Management | Dr. Ping Liu, ARPA-E |
| **2:00-2:10** | **--- BREAK ---** | |
| 2:10 | Building Energy Consumption & HVAC | Prof. Jim Freihaut, DOE eebHub |
| 2:30 | The Energy Benefits for Going Local | Prof. Ed Arens, Berkeley CBE |
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| 3:20 | Modeling Physiology & Thermal Regulation | Prof. Hui Zhang, Berkeley CBE |
| 3:40 | Technology Adoption | Prof. Karen Leonas, NCSU TATI |
| 4:00 | Tech Adoption Discussion | Dr. Maurice Gunderson, GenTherm |
| **4:30-4:40** | **--- BREAK ---** | |
| 4:40-6:15 | Attendee quad chart presentations (7 min for each technology pitch) | Breakout Groups |

## DAY 2: Discussions

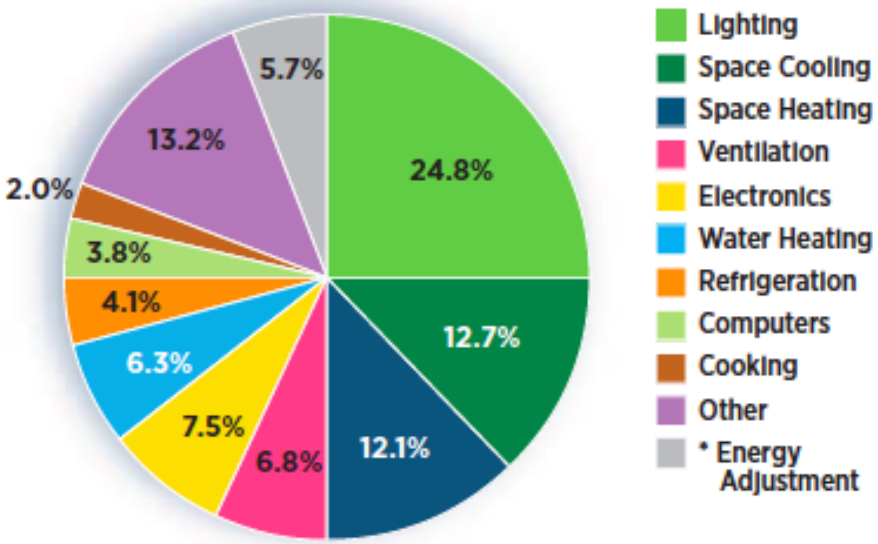
| | | |
|---|---|---|
| **Pre-8am*** | **BREAKFAST ON YOUR OWN*** | |
| 8:00-9:30 | Breakout Cont'd: Building a program pitch. | |
| **9:30-9:45** | **--- BREAK ---** | |
| 9:45-11:10 | Breakout Readout: Present program pitches | ARPA-E Program Directors |
| 11:10-Noon | Closing Discussions: Priority list of technological topics | Dr. Ping Liu, ARPA-E |
| **12:00pm** | **--- LUNCH ---** | |
| 1:00-5:00pm | Tour of the Non-Woven Institute: Includes travel to and from Centennial Campus | |

# Expectations of Attendees

- Understand the PTM approach
- Understand the ARPA-E approach
- Work through group quad charts
- Sit in the seat of
  - An ARPA-E program director
  - An ARPA-E reviewer
  - An ARPA-E proposer
- Detail specific metrics that represent a step change in SOA
- Make connections and constructive comments

# The Big Problem to be Solved:
## Heating and Cooling is 25-40% of Building Energy Use

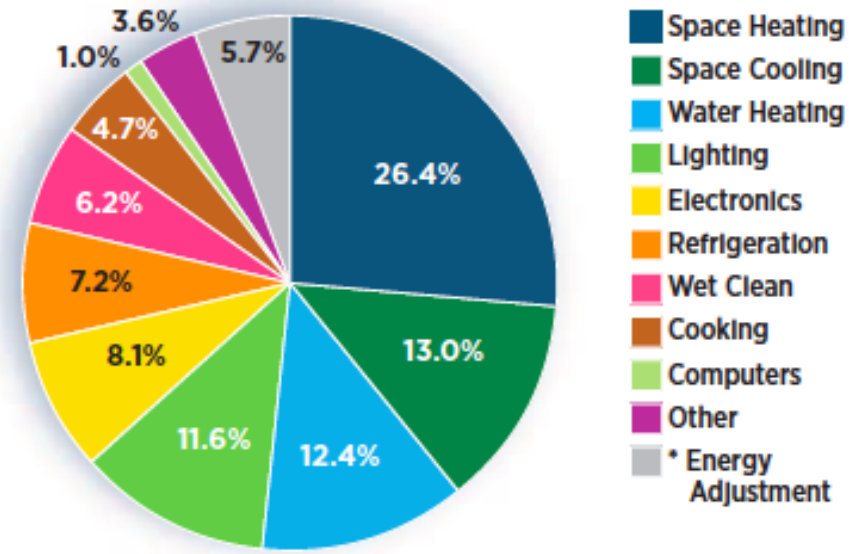
**Figure 17**
**Commercial Primary Energy End-Use Splits, 2006**




**Source:** 2009 Buildings Energy Data Book, U.S. Department of Energy, Table 3.1.4 <http://buildingsdatabook.eere.energy.gov/docs/xls_pdf/3.1.4.pdf>

* Energy adjustment U.S. Department of Energy, Energy Information Administration uses to adjust for discrepencies between data sources. Energy attributed to the commercial buildings sector, but not directly to any specific end-use.

**Figure 18**
**Residential Primary Energy End-Use Splits, 2006**




**Source:** 2009 Buildings Energy Data Book, U.S. Department of Energy, Table 2.1.5 <http://buildingsdatabook.eere.energy.gov/docs/xls_pdf/2.1.5.pdf>

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**Cooling is particularly critical since it uses electricity**

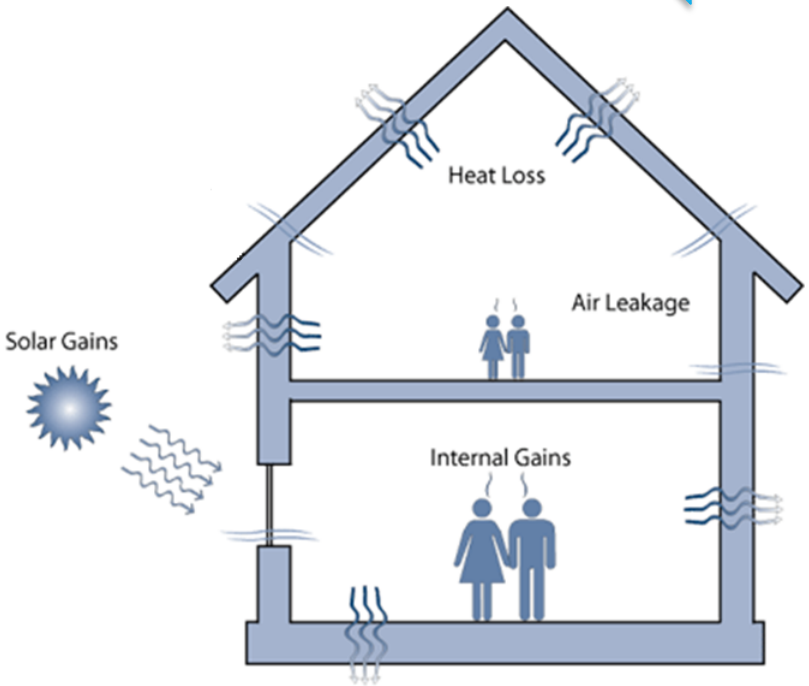
# PTM Rather Than Building

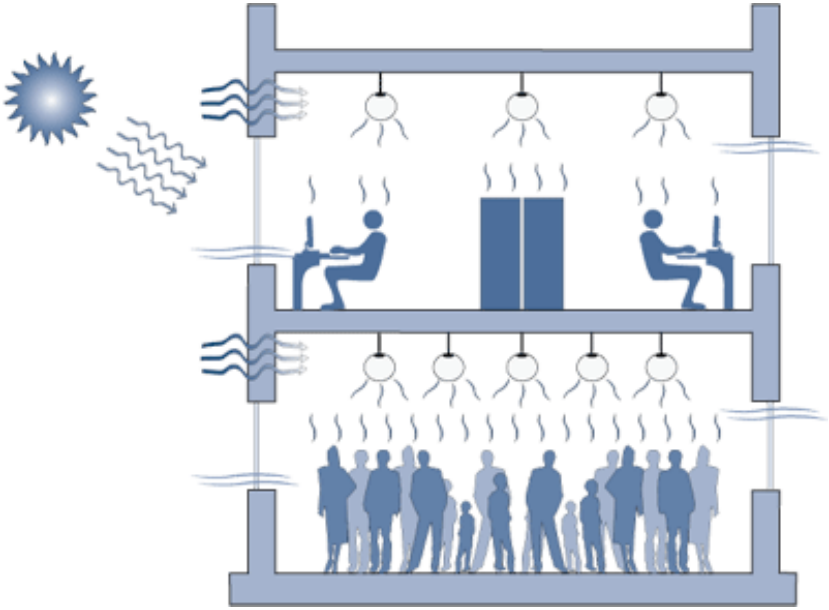
All buildings function between two extremes.

Envelope Driven HVAC

Continuum of Building Thermal Loads

Internal Load Driven HVAC



**In every scenario PTM can make a difference**

# Advantages of PTM

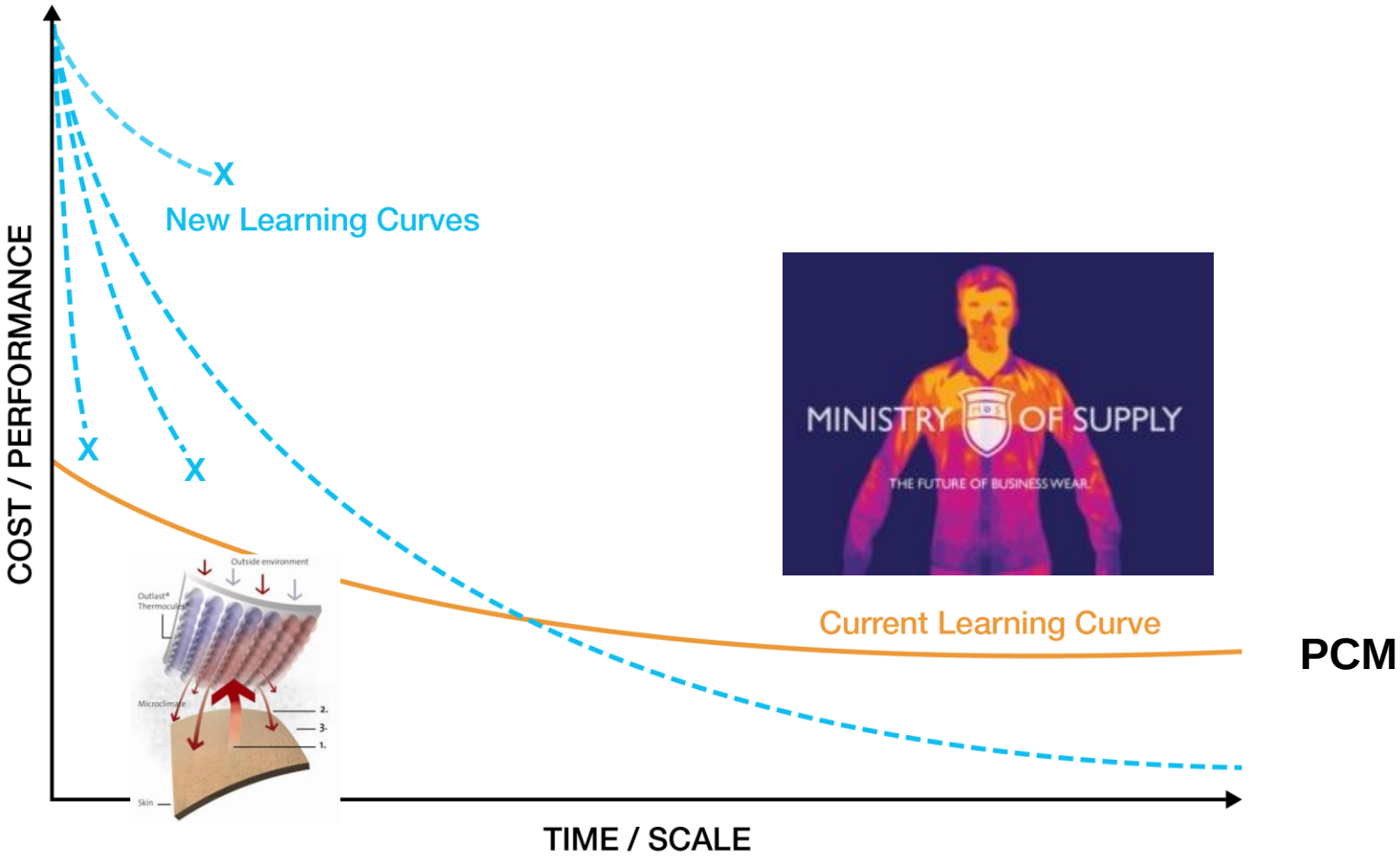
Thermal exchange rate is proportional to surface area and thermal conductivity,

**Q=UA(dT)**

- Surface area of a building vs. a person, **>50X**
- Thermal resistivity of a building vs. clothing, **<10X**

**PTM is inherently more efficient and easier to improve further**

# Creating New Learning Curves



# ARPA-E Utilizes Metrics to Identify Transformational Technologies

- **Metrics are the center piece of any Funding Opportunity Announcement**

PRIMARY TECHNICAL REQUIREMENTS:

| *Requirement ID Number* | *Requirement Category* | *Value (Units)* |
|---|---|---|
| **1.1** | System Capital Cost per Unit of Rated Energy Capacity (for measured capacity at Rated Power) | <$100/kWh |
| **1.2** | Minimum Operating Time at Rated Power (time at Rated Power for charge and discharge) | 60 minutes |
| **1.3** | Maximum Response Time (time for system to go from 0% to 100% of rated power in discharge and in charge mode) | 10 minutes |
| **1.4** | Rated Power Capacity for Charge and Discharge in Advanced System Prototypes | ≥20kW |

ARPA-E GRIDS

**A single cost target effectively eliminates incremental approaches**

# ARPA-E Utilizes Metrics to Identify Transformational Technologies

- **Metrics are the center piece of any Funding Opportunity Announcement**

**ARPA-E AMPED**

Objective 1: Safety
detection certainty, specificity, etc

Objective 2: Performance
> 25% reduction in packaging

Objective 3: Prognostics
< 10% error in life prediction

**Program establishes detailed targets for multiple objectives**

# What Should It Be For PTM?

- A complete PTM that can save > ?% of building energy?
- A complete PTM adaptable to neutral band by 4$^{o}$F?
  - A pair of shoes?
  - A dress shirt?
- A piece of fabric that can vary clo value by ?%?
- A polymer fiber that can change shape by ?
- A wearable device that weighs ? grams and can keep a person comfortable from ?? To ??? $^{o}$F?

**Your group pitch should clearly define the deliverable with its associated metrics**

# Defining Metrics:
## Leave No Stone Unturned

- This is an open forum to voice your opinion.
- ARPA-E staff and contractors will be in each room, please let us know of:
  - Specific groups/people/technologies we should involve or make aware of this program concept,
  - Industry, Research or Economic metrics we need to specifically address,
  - Any potential glaring problems with a particular approach,
  - And anything else you didn't want to voice publicly.
    - Such as: detailed concepts…

# Metrics Define The Areas of Interest

- New polymeric materials
- Emerging thermal electric devices
- Additive manufacturing/wearable technology
- Architectural textile designs
- Bio-compatible, wearable polymer membrane
- Printed electronics
- Wearable sensors
- Energy harvesting, including from the human body
- Wearable heat exchange devices
- Water permeable membrane
- Localized emissivity manipulation
- Electrospinning of nanofiber yarn…

**Help us to define areas of interest**
**that can deliver the energy saving metrics**

# Next up for Day #1

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