Back to the Technology Future II (Decades That Is)!

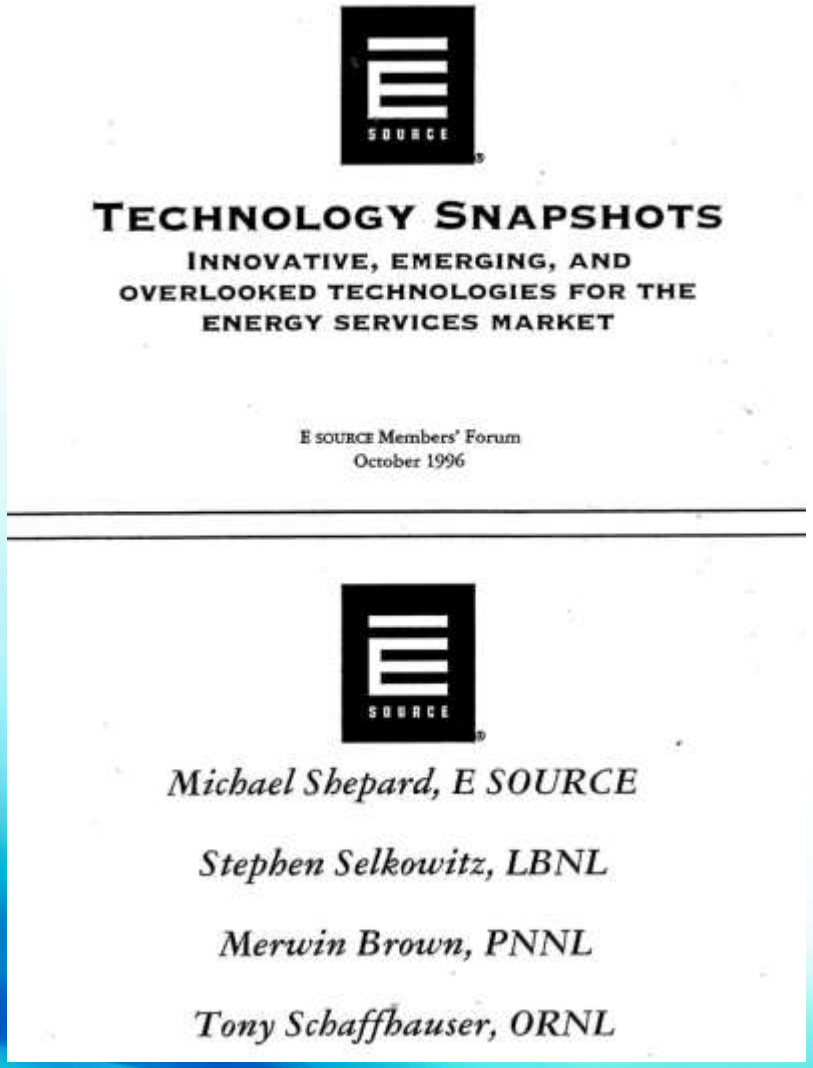
Graham Parker, Graham Parker & Associates LLC

Utility Energy Forum

May 4, 2017

Utility Energy Forum

1996 E-Source Technology Presentation



TECHNOLOGY SNAPSHOTS

INNOVATIVE, EMERGING, AND OVERLOOKED TECHNOLOGIES FOR THE ENERGY SERVICES MARKET

E SOURCE Members' Forum
October 1996

Michael Shepard, E SOURCE

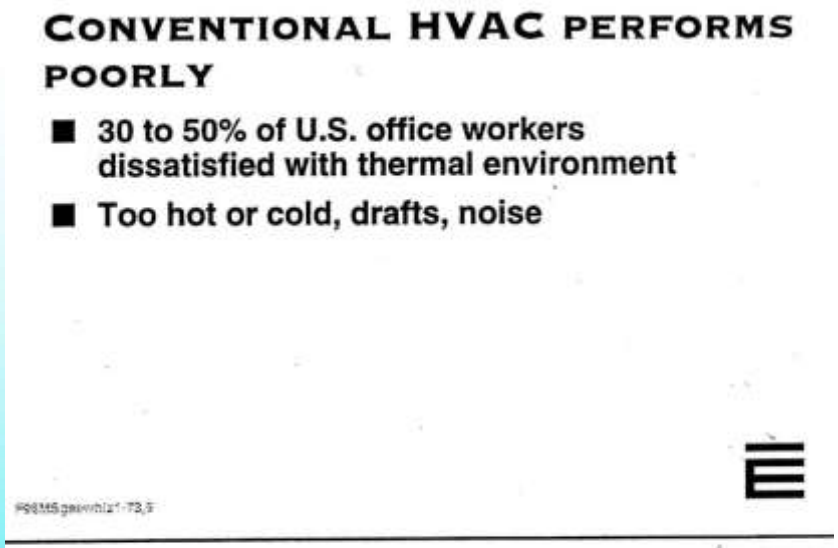
Stephen Selkowitz, LBNL

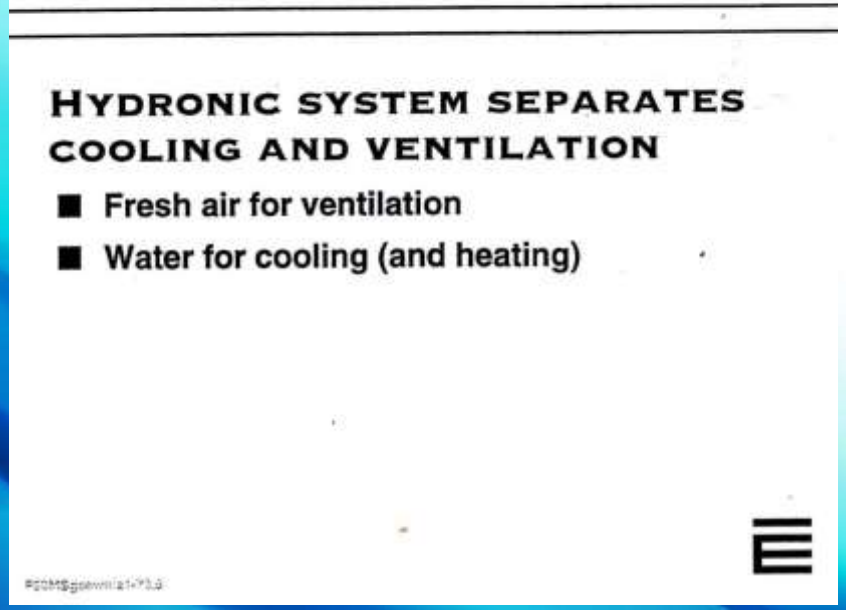
Merwin Brown, PNNL

Tony Schaffhauser, ORNL

HVAC Technologies: Then

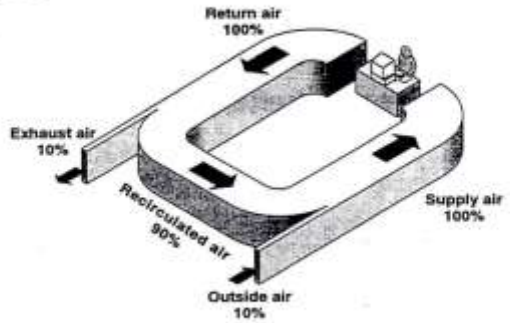
HVAC Technologies: Then



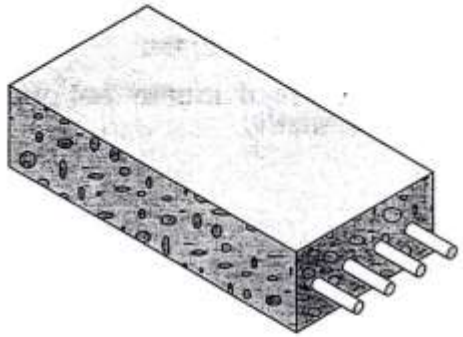


HVAC Technologies: Then

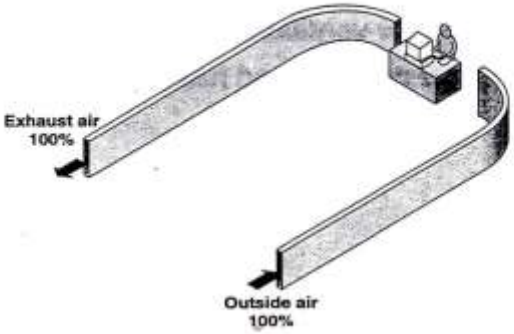
Air Flow with Conventional HVAC



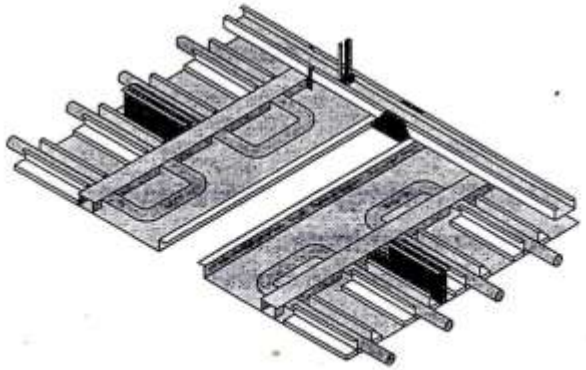
Core-cooled ceiling



Air Flow with Hydronic HVAC



Panel systems

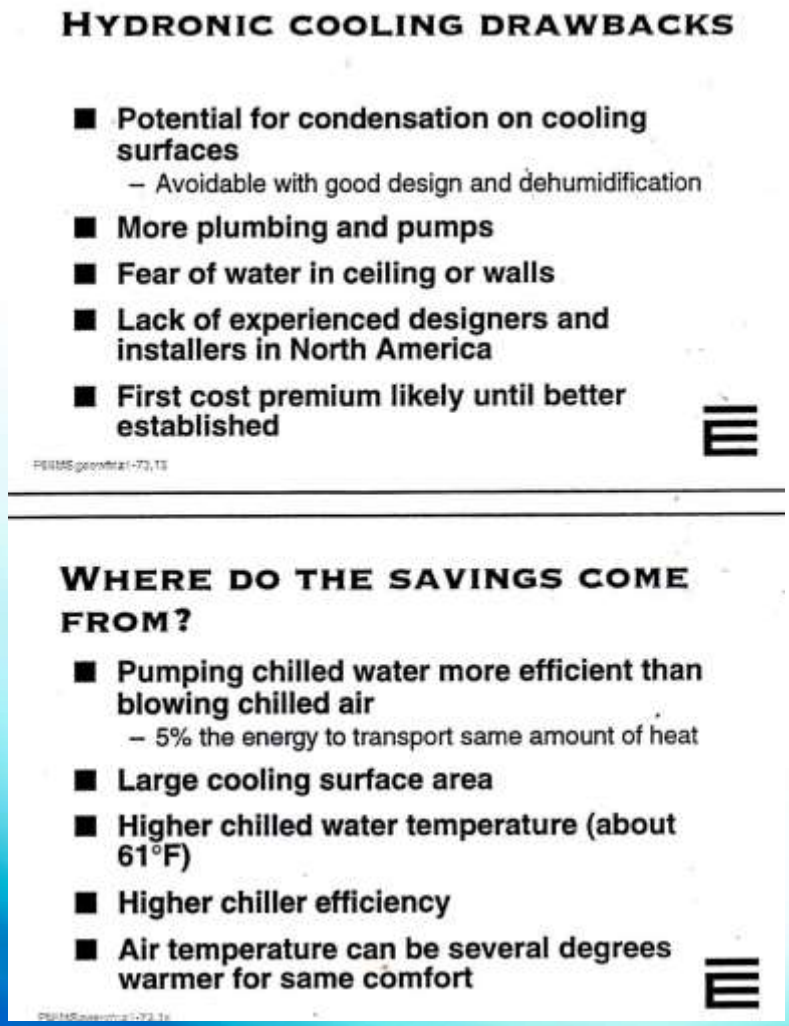


HVAC Technologies: Then

HYDRONIC COOLING BENEFITS

- Improved comfort and air quality
- Quiet
- Draft free
- 20 to 40% energy and peak savings
- Reduce or eliminate ducts
  - less height per floor, capital savings, less leakage
- Potential productivity gains

HVAC Technologies: Then



HVAC Technologies: Today

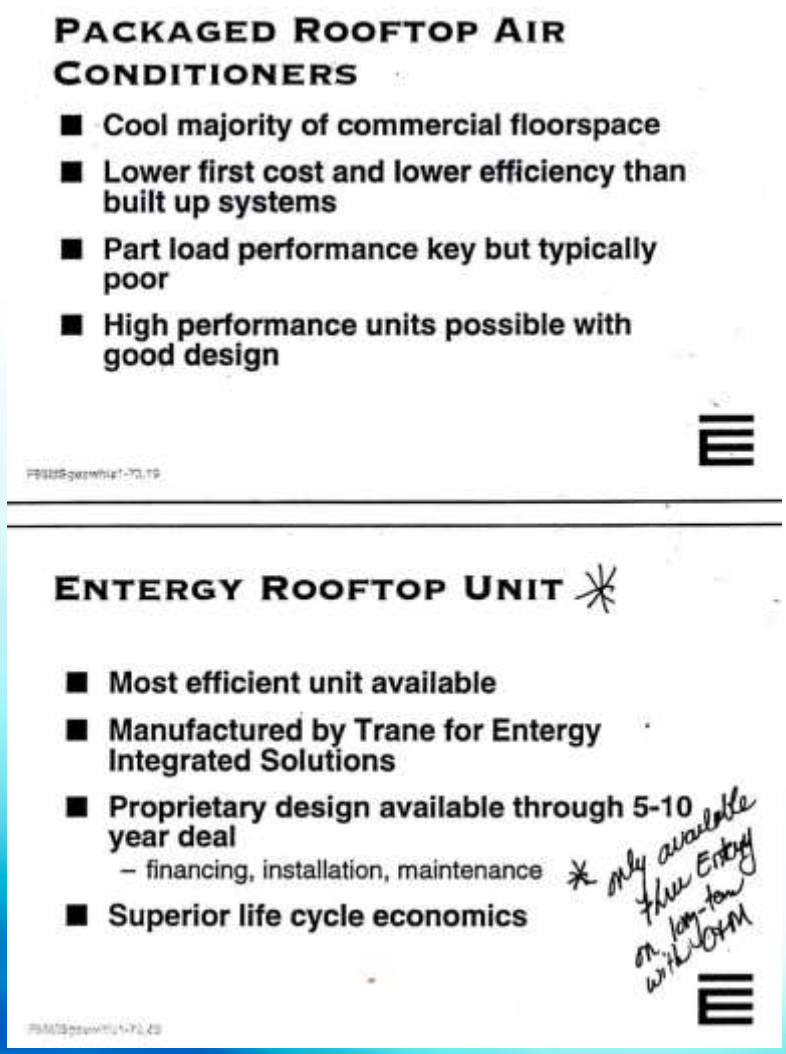
- Hydronic (radiant) heating/cooling more common…but not the 1st choice for new construction
  - Costs have yet to be substantially reduced.
- Recognized by professionals as the more efficient & "green" HVAC system for buildings (including residential)
  - Ideal for geothermal systems
  - Easily meet ASHRAE IAQ/ventilation requirements & can include exhaust air heat recovery
- Remaining lack of widespread experience & reluctance to recommend by A&E industry

HVAC Technologies: Today

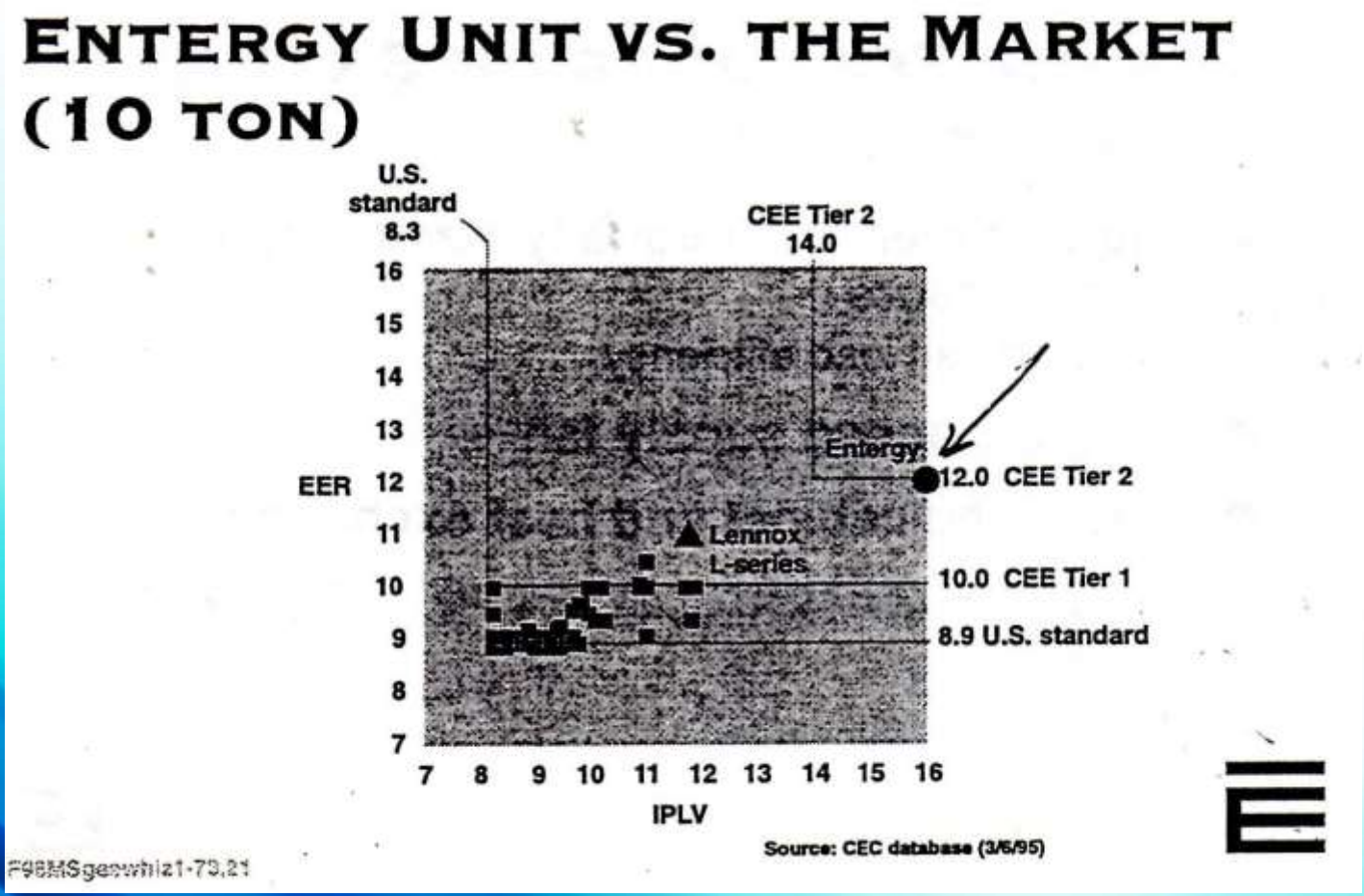
- Example of building with hydronic system
  - Lane Community College (Eugene) Northwest Water and Energy Education Institute – Downtown Campus

Photo by SRG Partnership and Christian Columbres

HVAC Technologies: Then



HVAC Technologies: Then



HVAC Technologies: Today

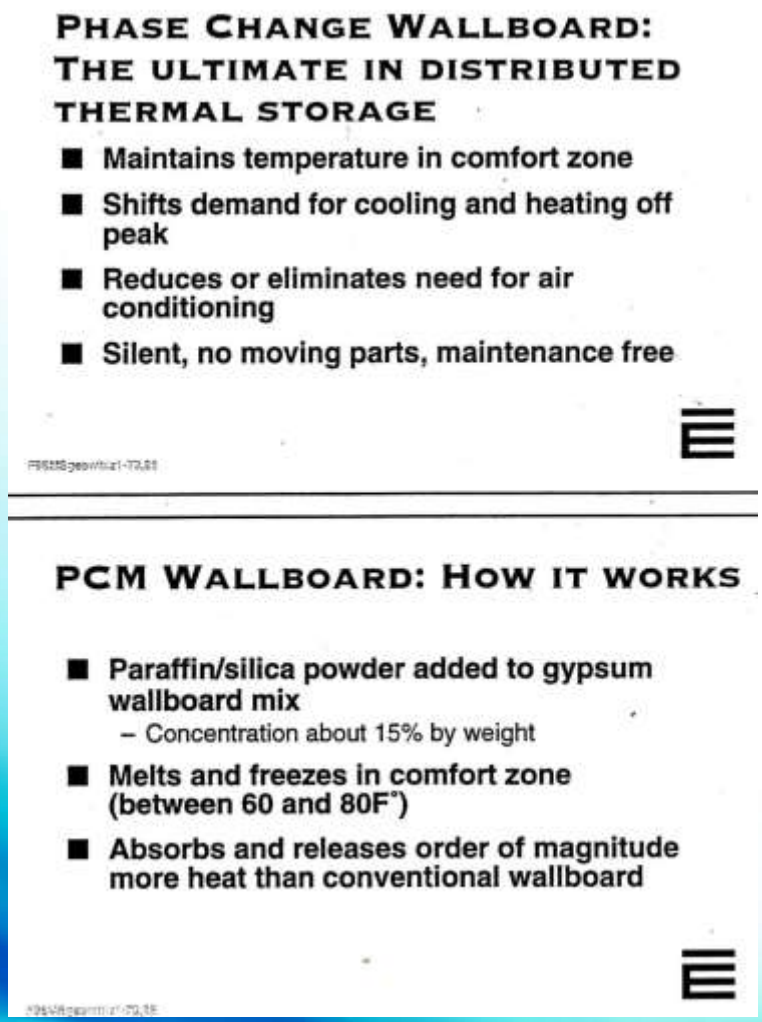
- DOE initiated the 'Rooftop Unit Challenge' in 2011:
  - 10-ton
  - IEER 18
  - AFUE 80
- In 2012, *Daiken McQuay* was first to meet the challenge; others followed: Carrier, Trane, Lennox, York, and AAON
- Thousands of units installed in all climate zones.
  - Up to 21 IEER
  - ~$1,000/ton installed

HVAC Technologies: Today

"Standards" for 10 ton RTUs have changed:

	Federal (2018 effective date)	**CEE Tier 1**	**CEE Tier 2**	**CEE Advanced Tier**
Electric heat	12.9 IEER	11.7 EER 12.9 IEER	12.2 EER 14 IEER	12.6 EER 18 IEER
Other heat	12.7 IEER	11.5 EER 12.7 IEER	12 EER 13.8 IEER	12.4 EER 17.8 IEER

Phase Change Materials: Then



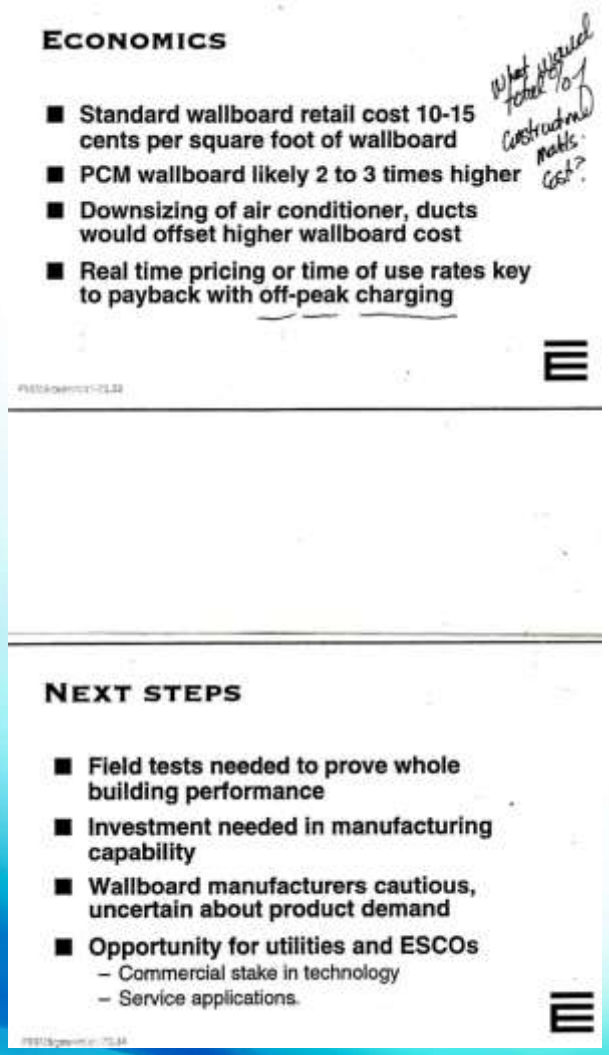
PHASE CHANGE WALLBOARD: THE ULTIMATE IN DISTRIBUTED THERMAL STORAGE

- Maintains temperature in comfort zone
- Shifts demand for cooling and heating off peak
- Reduces or eliminates need for air conditioning
- Silent, no moving parts, maintenance free

PCM WALLBOARD: HOW IT WORKS

- Paraffin/silica powder added to gypsum wallboard mix
  - Concentration about 15% by weight
- Melts and freezes in comfort zone (between 60 and 80F°)
- Absorbs and releases order of magnitude more heat than conventional wallboard

Phase Change Materials: Then



ECONOMICS

- Standard wallboard retail cost 10-15 cents per square foot of wallboard
- PCM wallboard likely 2 to 3 times higher
- Downsizing of air conditioner, ducts would offset higher wallboard cost
- Real time pricing or time of use rates key to payback with off-peak charging

NEXT STEPS

- Field tests needed to prove whole building performance
- Investment needed in manufacturing capability
- Wallboard manufacturers cautious, uncertain about product demand
- Opportunity for utilities and ESCOs
  - Commercial stake in technology
  - Service applications

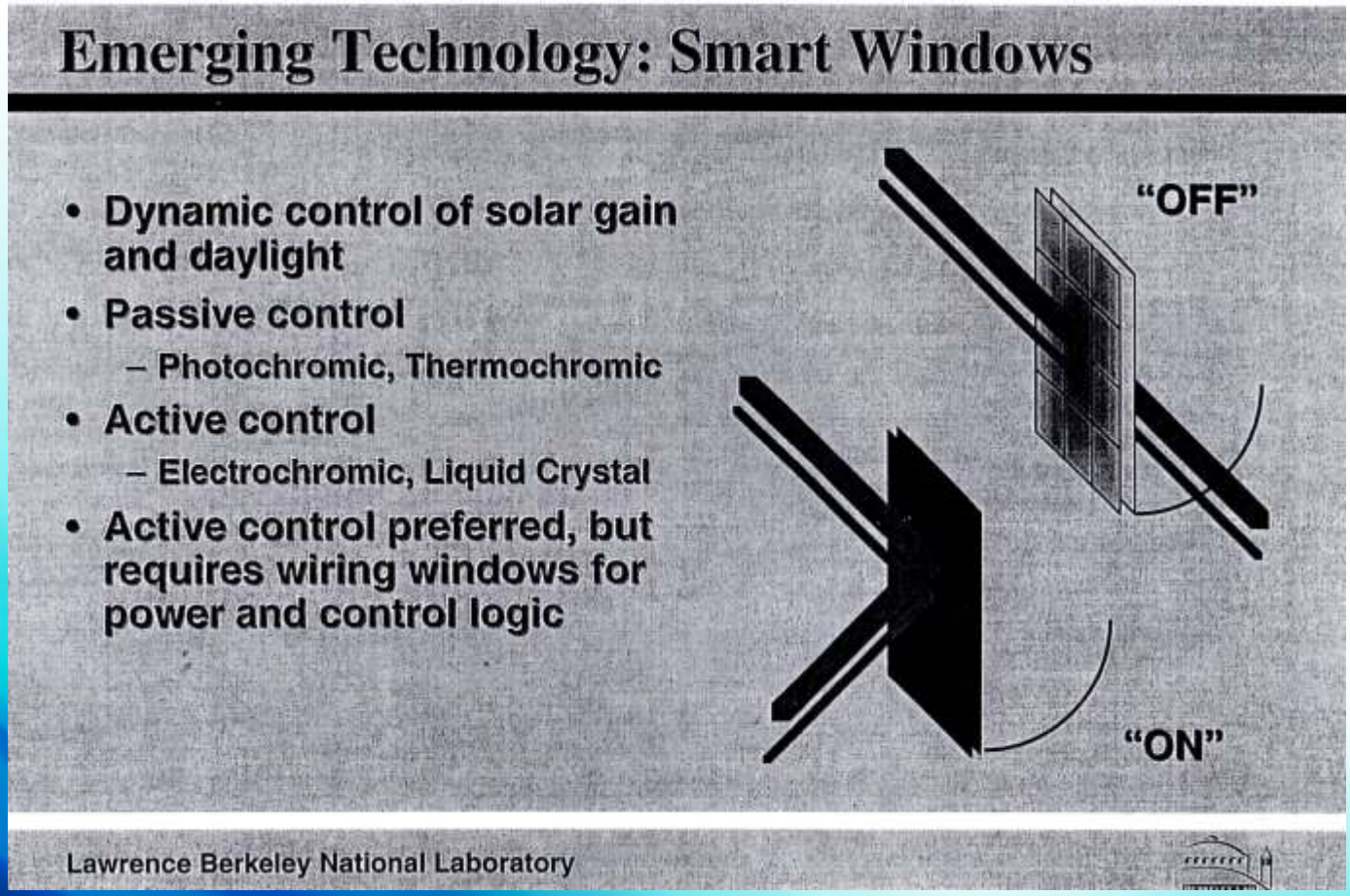
Phase Change Materials: Today

- PCM is available in various products, including roll-out mats for suspended ceilings/attic floors, batts for application between roof rafters, mixed material with blow-in cellulose insulation, and PCM-impregnated gypsum board
- Although PCM is a commercially available product, it remains an emerging technology in the commercial sector due to a lack of familiarity, performance uncertainty, and limited distribution.
- 3 known manufacturers: PureTemp, Infinite RT, and Phase Change Energy Solutions. ***No cost information available***.
- 11 case study briefs summarizing projects in commercial buildings. These briefs include examples of applying PCM as an insulator in offices, hotels, dormitories, and schools.
- A more systematic evaluation of the various PCM integrated in the building structure is needed, in particular in real use condition. Few unbiased studies with detailed quantitative results/costs demonstrating energy or demand savings in commercial buildings.

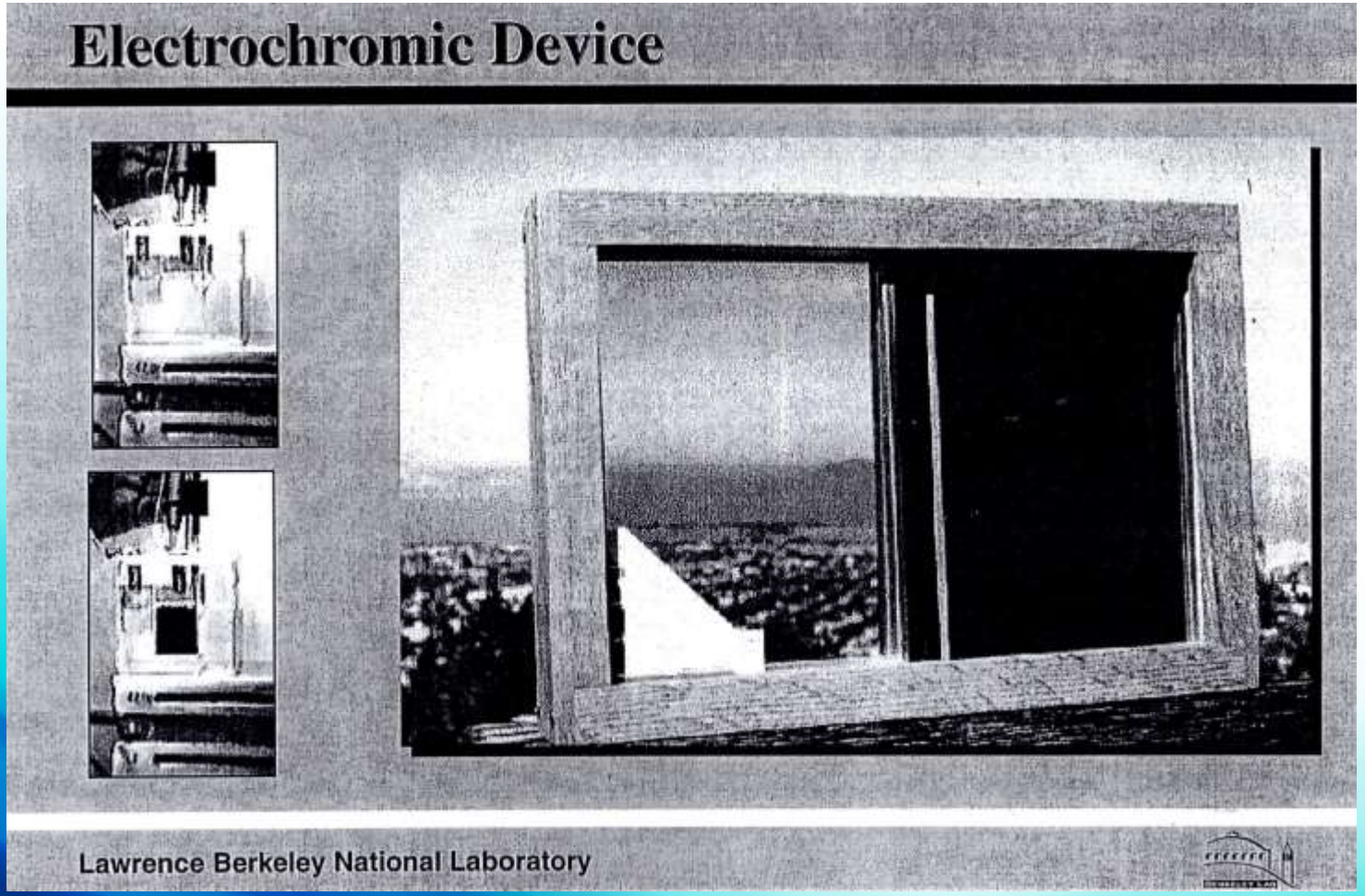
Phase Change Materials: Today

- In 2008, Oak Ridge National Laboratory performed testing of PCM enhanced cellulose wall insulation at their laboratory and at small test facilities in Charleston, South Carolina, and Oak Ridge, Tennessee.
- In 2010, the University of Arizona published the results of a study that applied PCM mats in an insulated shed and compared it to an identical shed with window-mounted heat pumps. This setup showed maximum energy savings of about 30%, a maximum peak load shift of ~ 60 min, and maximum cost savings of about 30%.
- In 2015, the Army Materiel Command (AMC) installed PCM mats along with R19 batt insulation in a warehouse at the Sierra Army Depot and compared the heating energy to an identical warehouse at the same location.
- Currently, the U.S. Army Corps of Engineers, Engineer Research and Development Center, Construction Engineering Research Laboratory is demonstrating PCM-enhanced blow-in insulation at a small classroom building at Fort Bragg, North Carolina, as part of the Environmental Security Technology Certification Program.

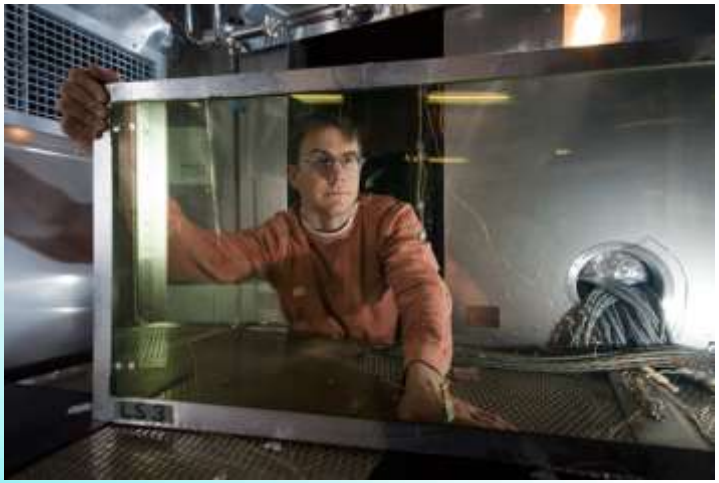
Smart Window Technology: Then



Smart Window Technology: Then



Dynamic "Smart" Windows (2010)



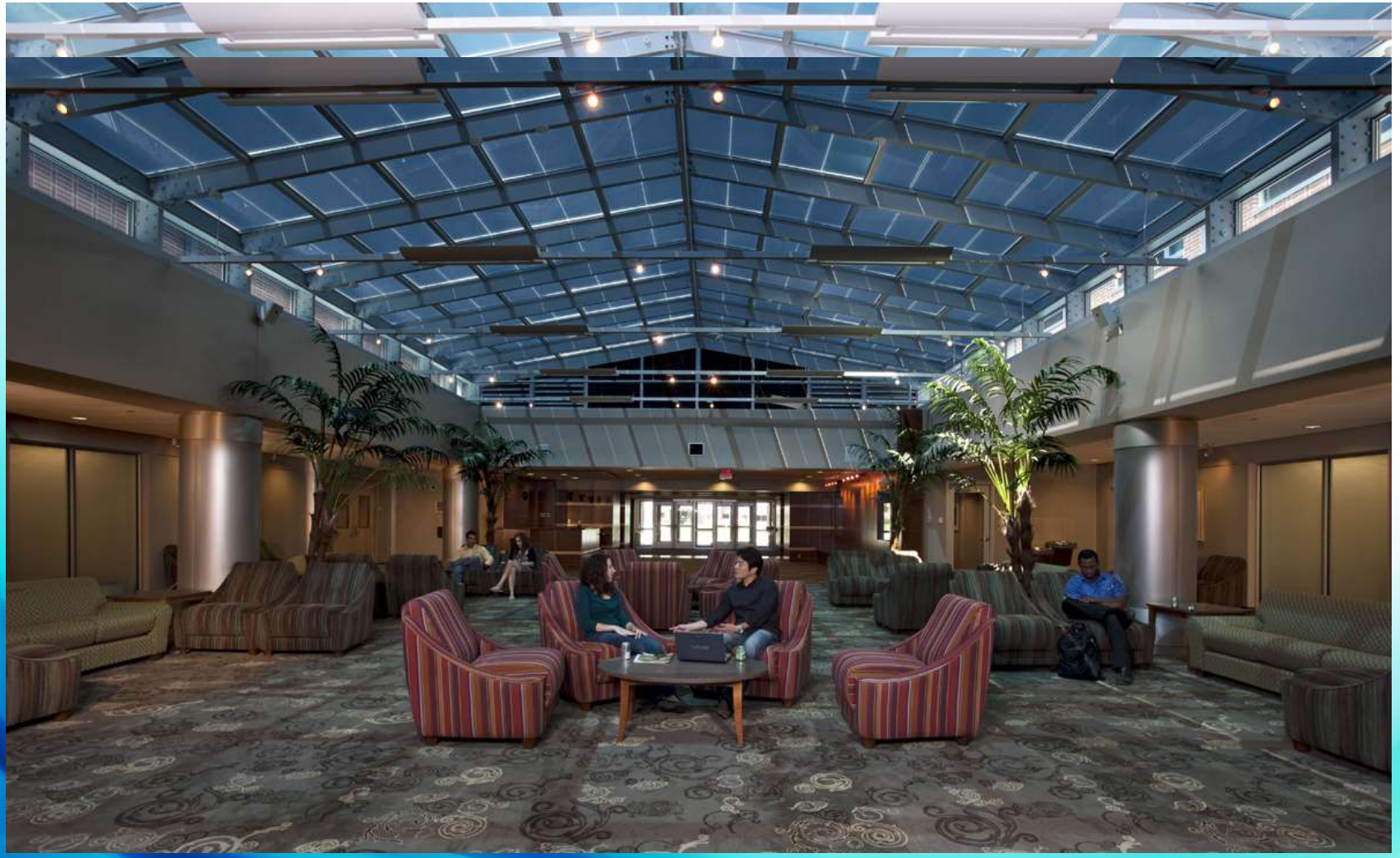
Source: Pat Corkery, NREL

An entire house equipped with electrochromic windows can be operated using the equivalent of a 75-watt light bulb.
[Sage Electrochromics, Inc.]

- A new generation of 'dynamic' windows is being developed after ~20 years of R&D.
  - Dynamic windows react to sunlight to electronically 'dim' or tint to reduce interior solar heating or – more importantly – interior heat from escaping.
  - Triple-pane glazing + electronic tinting using new nanotechnology thin film on outside pane can produce a window with an R-value of ~8.
  - Durability and cost (~$1,000/ft^2) remain as barriers to overcome.
- DOE recently awarded Sage Electrochromics over $100 million in tax credits to mass produce dynamic window glass.
  - Sage is working under an agreement with NREL to lab test dynamic windows.

Advanced (Smart) Windows are Here! (2011)
Dynamic Windows – Cost Neutral within 5 Years

DeHority Hall, Ball State University, Muncie, IN



Sage Glass Saint-Gobain

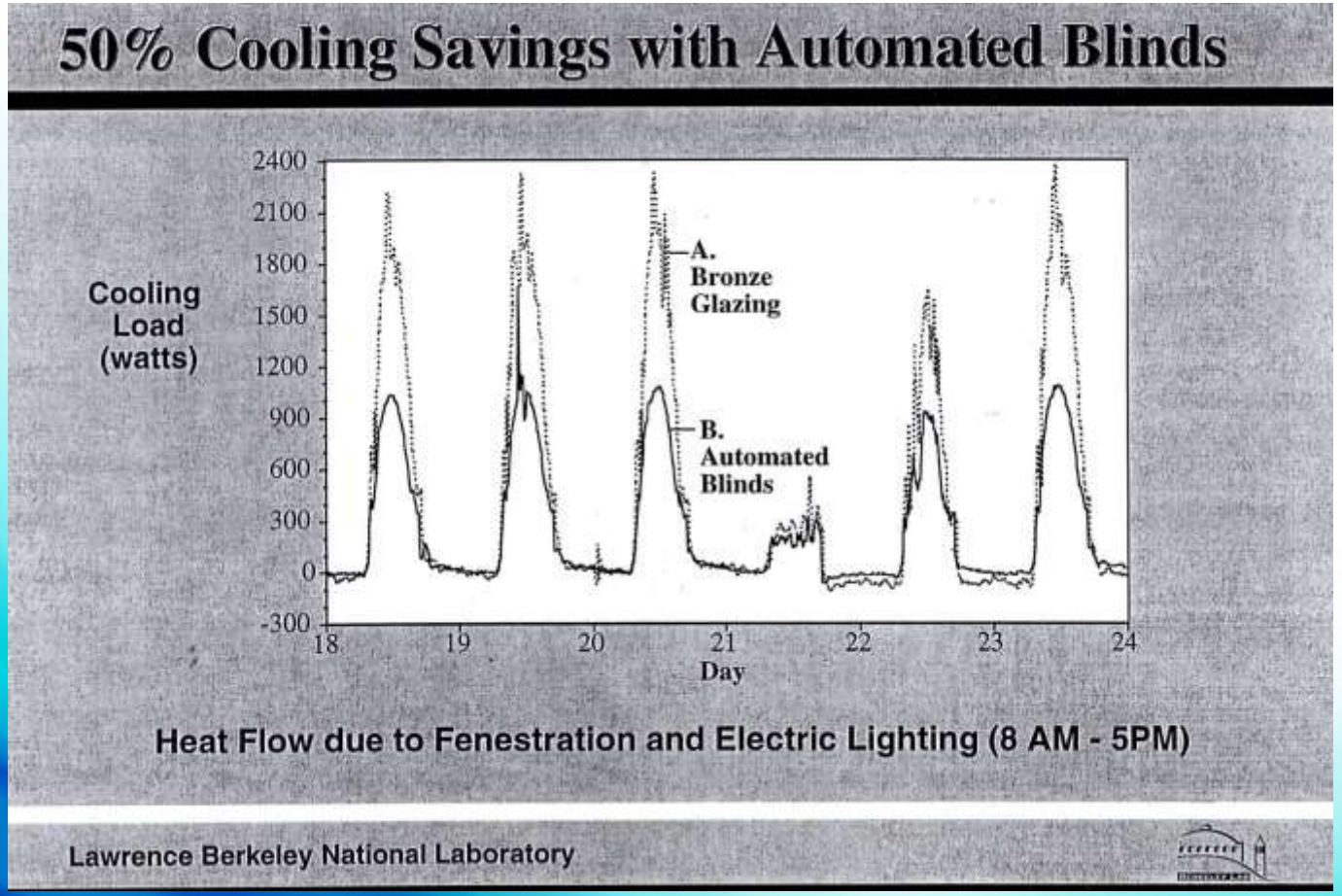
Dynamic (Smart) Windows: Today

Can be customized to give different layers of tint across surface

Can use dynamic controls to track the sun as it moves across the sky, so that occupants can always strike the ideal balance between comfort and daylighting.

Highly insulating and dynamic with SHGC 0.04 – 0.34

Smart Window Shade Technology: Then



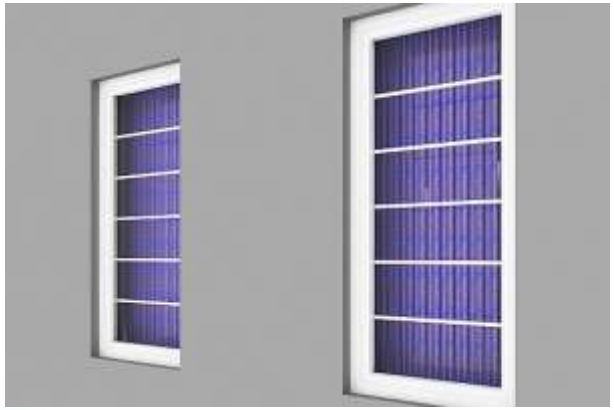
Smart Window Shade Technology: Today

- Multiple efficient ‘window coverings’, some of which are automated. See https://www.efficientwindowcoverings.org/
- Automated (open and close) shades still expensive and emerging. Including but not limited to:
  - Hunter Douglas PowerView®
  - Somfy Systems
  - Lutron Senera™ shades
  - Bali Blinds
  - Graber® Virtual Cord™
- ***Independent*** field studies are few.

Tomorrow: Energy-*Generating* Window Shades

Energy Generating Window Shades

Light-in-the-Dark



SunIT

Energy Curtain

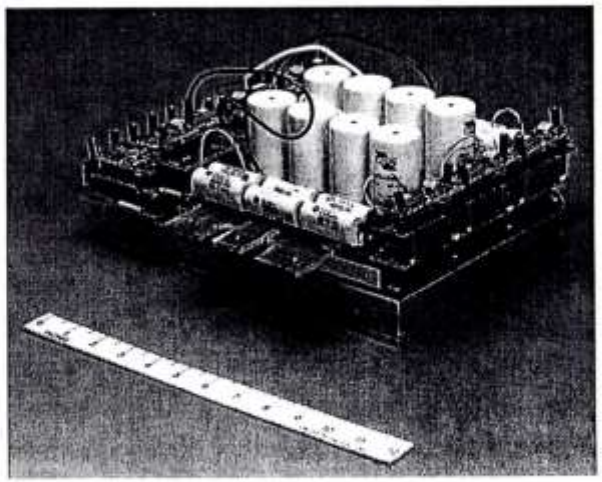
Solar Modules

Source: www.ecofriend.org

High Efficiency Power Inverter: Then

High-Efficiency Electric Power Inverter

- Converts dc to ac
- Light weight, high reliability
- High efficiency over wide operating range
- Very low electromagnetic interference
- Potential application in any device that uses electricity to power pumps, fans, compressors, motors, etc.; estimated annual savings of $160 million in electric power applications alone



Sponsor:
ORNL Laboratory-Directed R&D Fund
Office of Transportation Technologies

High Efficiency Power Inverter: Today

Most efficient solar power inverter

- Google undertook a challenge in 2014 to give away $1 million to the company that can pack the most power density per square inch into a solar inverter.
  - Note that solar DC to AC was not a big market in 1996!

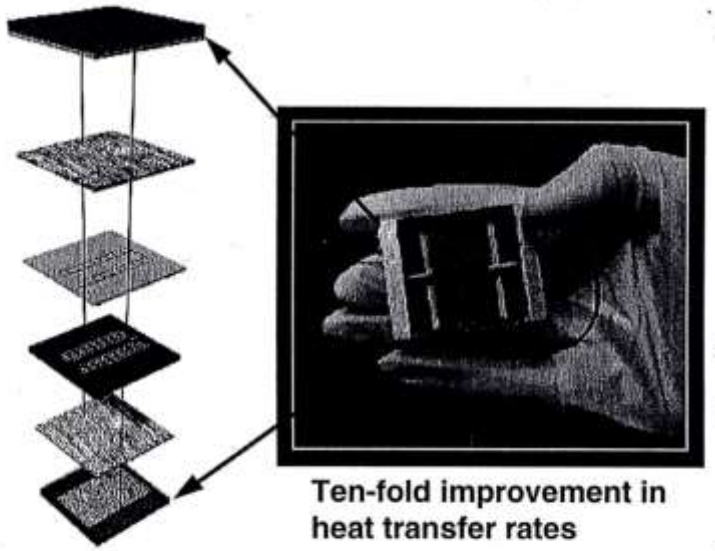
	CE+T Power's Red Electric Devils	Schneider Electric	Virginia Tech's Future Energy Electronics Center	Little Box Challenge requirements
Power Density (W/in^3)	142.9	96.2	68.7	>50
Volume (in^3)	14.0	20.8	29.1	<40

- Most of today's inverters are already highly efficient and meet the 1996 goals, losing only a few percentage points of power in DC-to-AC conversion, but the challenge was designed to make the inverter smaller and even more efficient.
- Some of today's solar inverters are also 'smart' that includes digital architecture, bidirectional communications capability and robust software infrastructure with the ability to provide grid support services as well as software updates that can be done without any hardware replacement.

Microtechnologies: Then

ENERGY
Commercial Market Sector

Engineered Microstructure Heat Exchangers



Ten-fold improvement in heat transfer rates

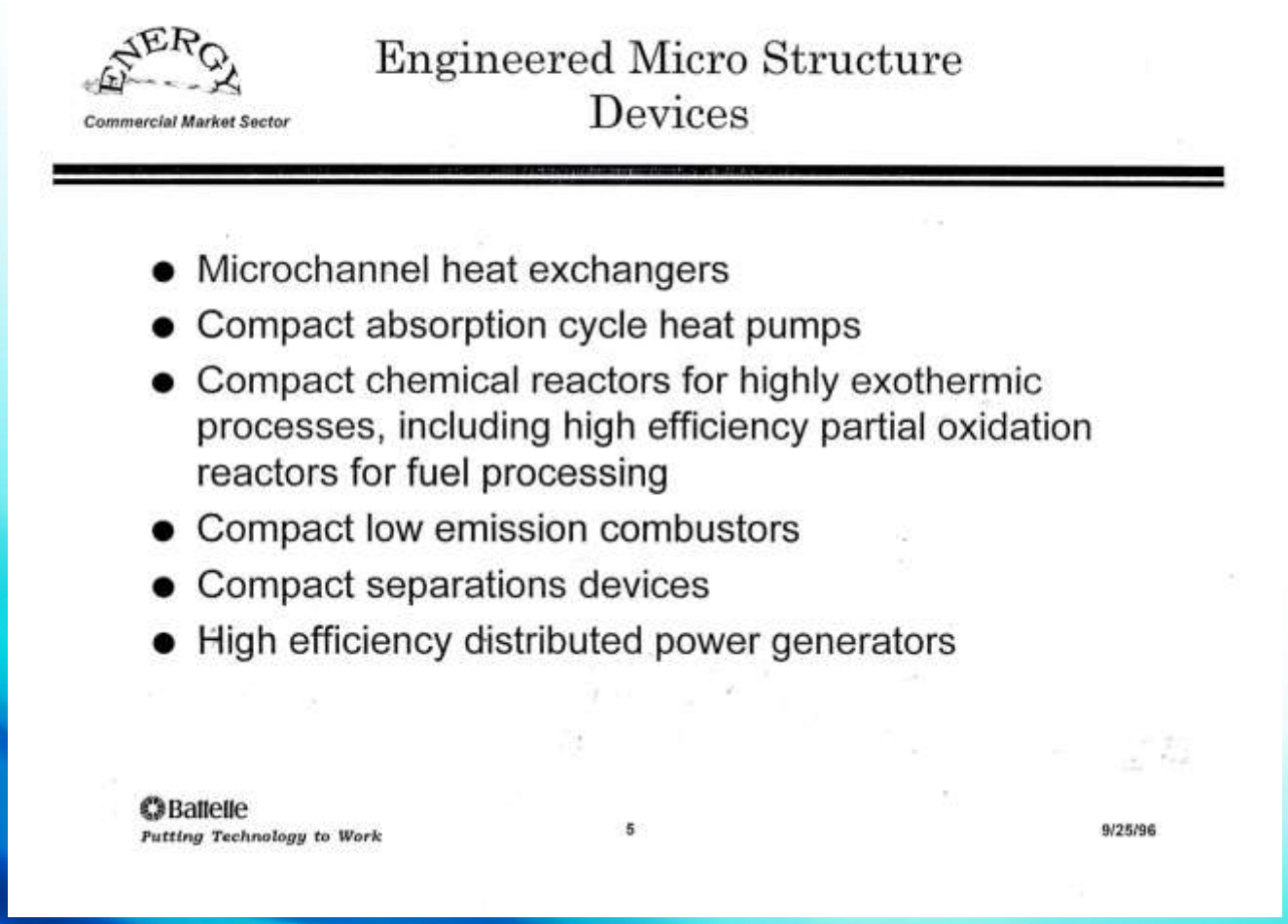
- Critical Component to many systems applications:
  - Heat pumps
  - Chemical processing
  - Combustion
  - Micro-processors
- Heat Fluxes: 100 W/cm^2
- Convective Heat Transfer Coefficients: 10,000 - 35,000 W/m^2-^{o}C
- Pressure Drops: 1-2 psi

Battelle
Putting Technology to Work

6

9/25/96

Microtechnologies: Then



Microtechnologies: Today

May be some limited or classified application in DoD, primarily soldier/field equipment