UT-BATTELLE

Energy Efficiency Benefits of "Cool" Walls

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OAK RIDGE NATIONAL LABORATORY
U. S. DEPARTMENT OF ENERGY

Presentation Summary

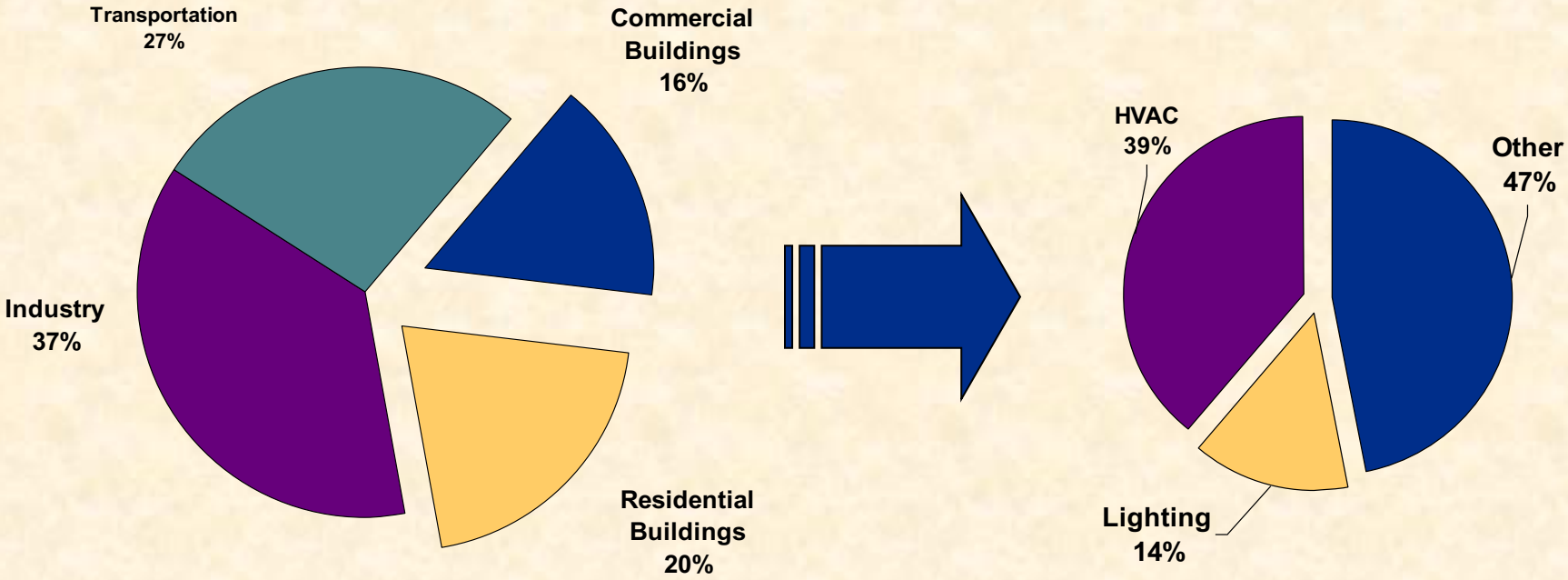
- Is energy efficiency in buildings and walls important? Some statistics……
- What is ORNL?
- What research is going on to measure energy benefits of “Cool” Walls?
- What are the energy savings of this technology?

Buildings Use a Lot of Energy

1/3 of all energy and 2/3 of all electricity used in the US
$220 billion in annual energy costs

Source: US Department of Energy, Gensler Associates

Energy Consumption in Buildings



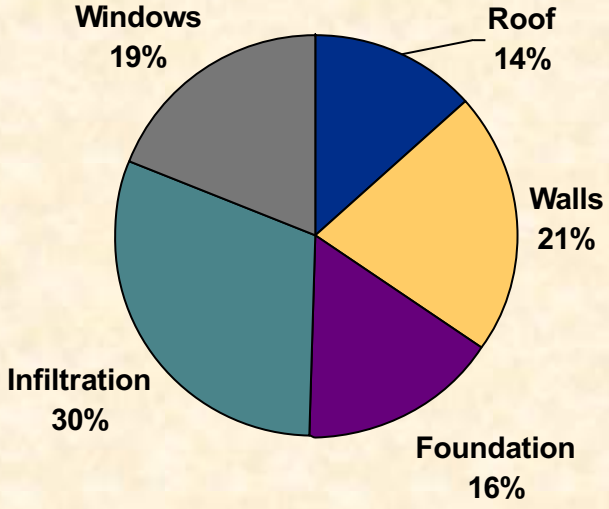
Total Building Envelope Energy Loss:

13.4 quads

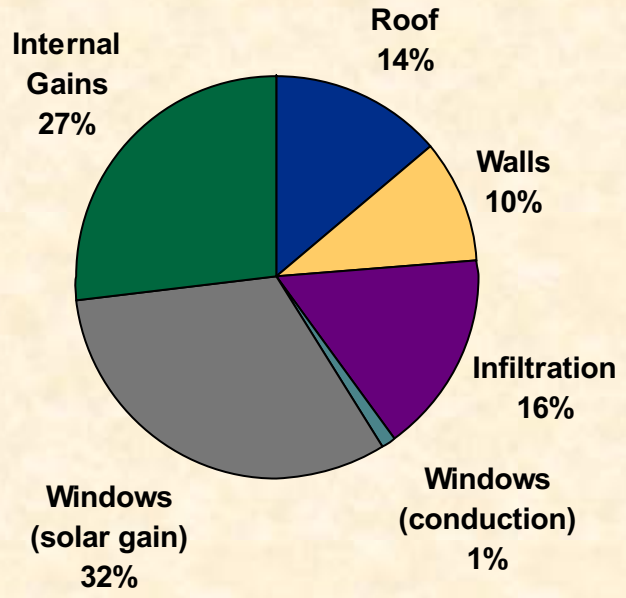
14% of energy in US economy and about 3.5% of the world

Energy Consumption in Buildings

Heating Load

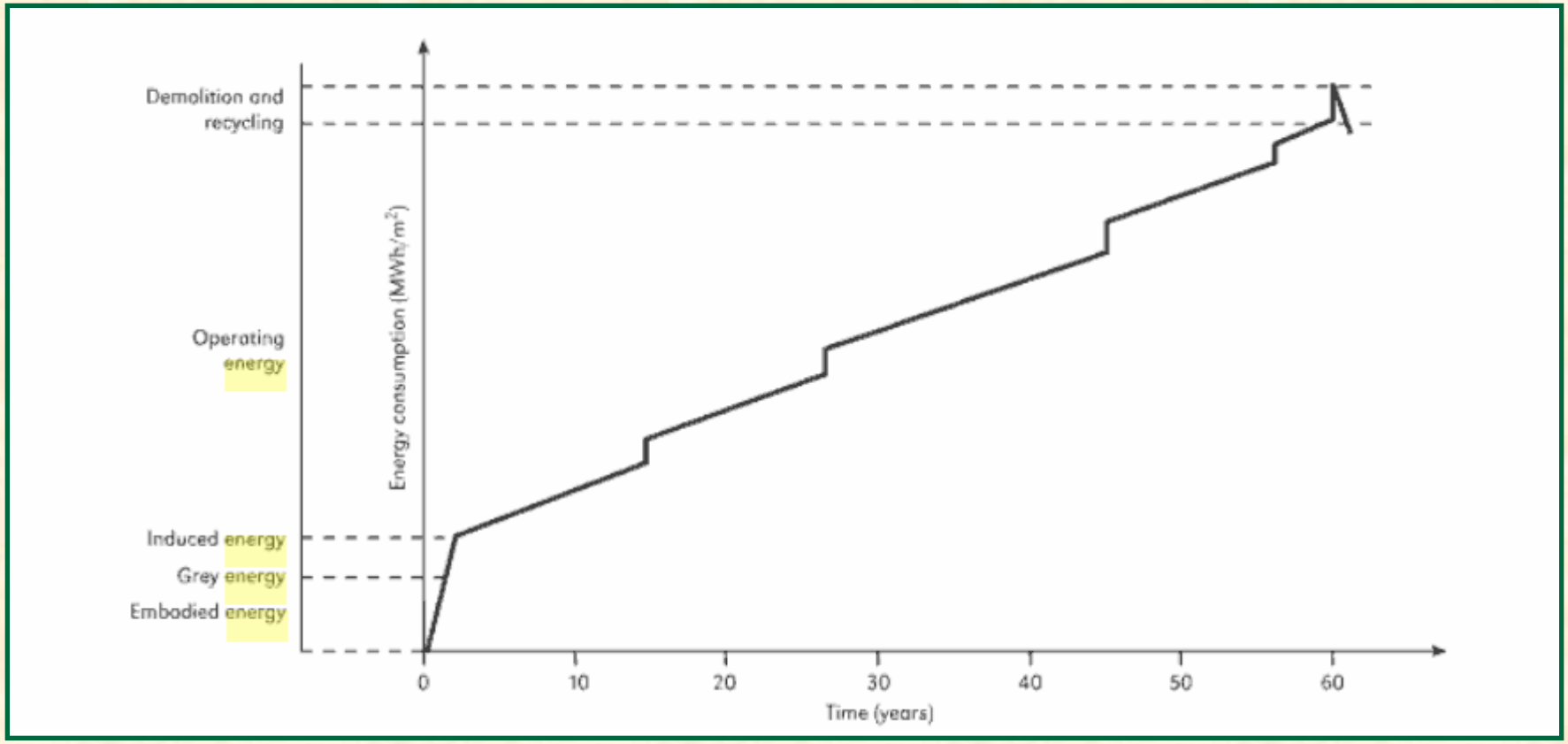


Cooling Load



Sources: DOE BTS Core Databook 2006

Energy Consumed in the Life of a Building

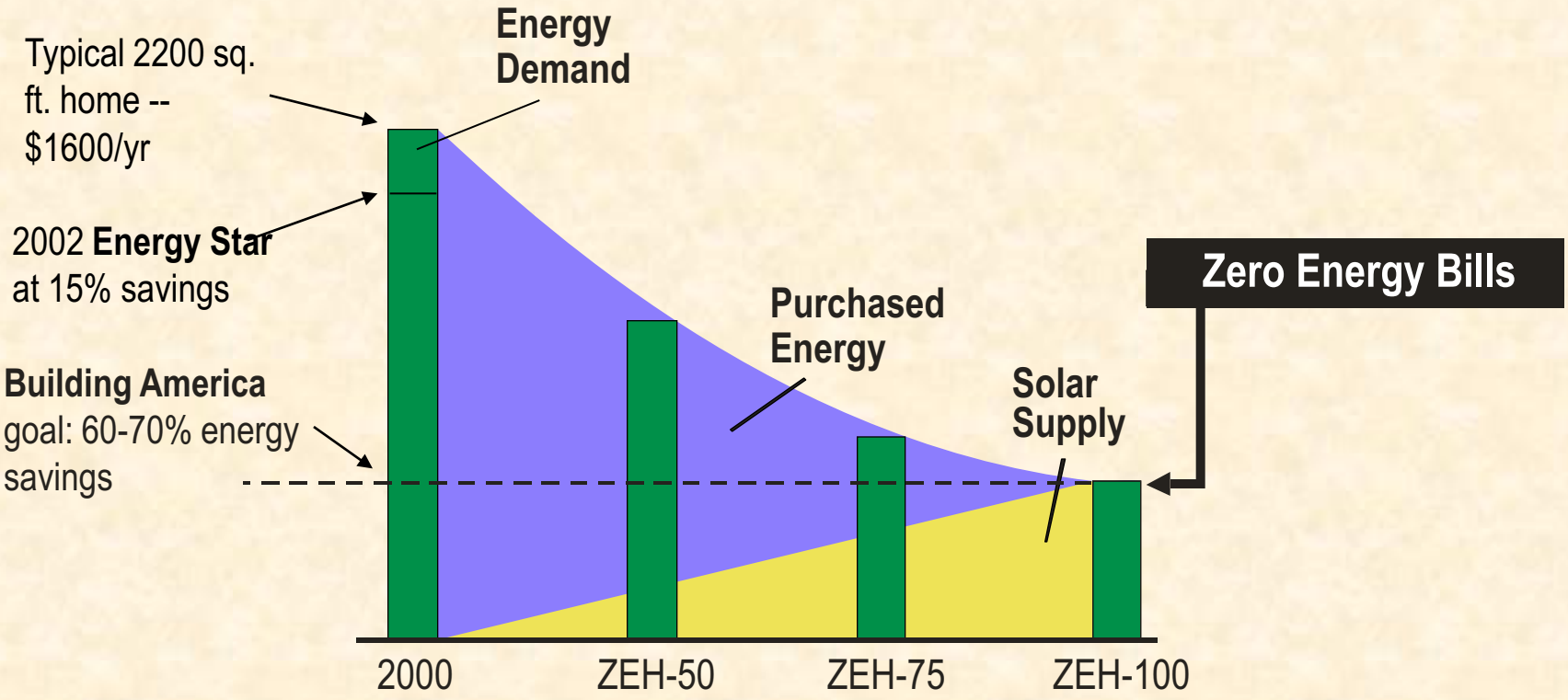


Source: Lloyd Jones, 1998

DOE Building Technologies Goal

By 2025, the Program will create technologies and design approaches that enable the construction of net-zero energy buildings at low incremental cost.

The Zero Energy Building

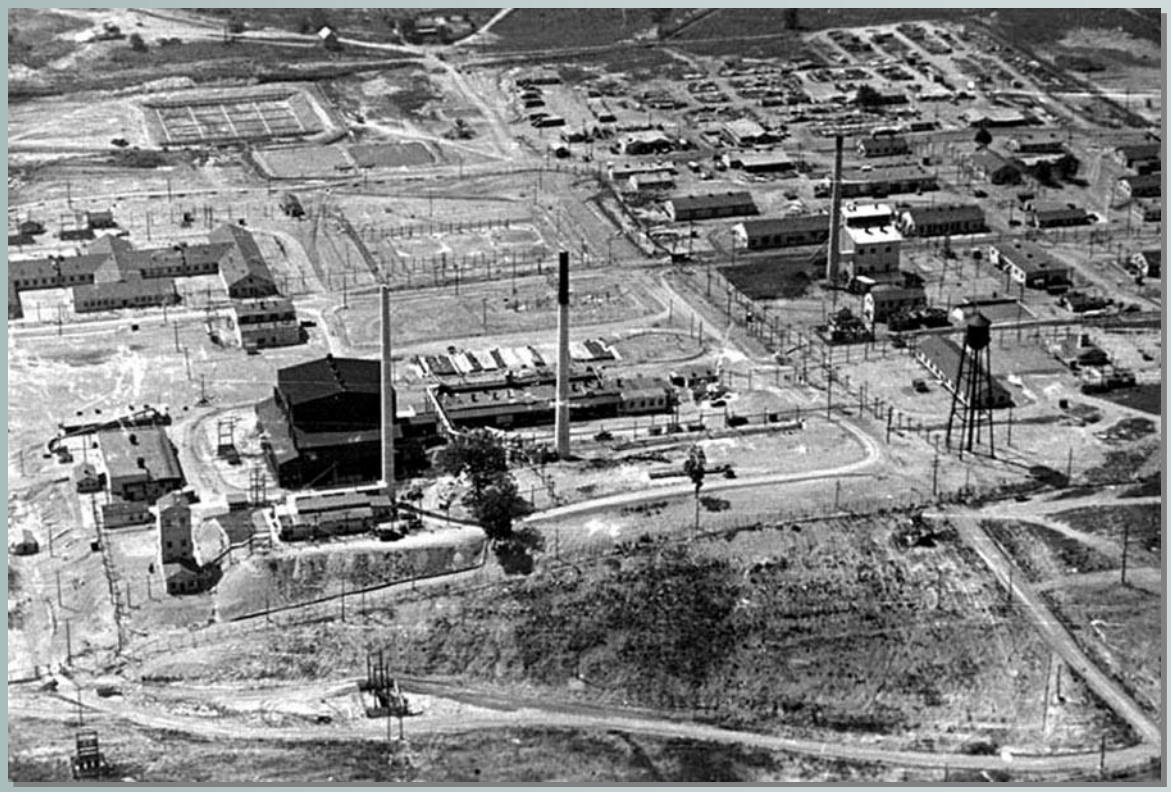


ZEH-100 Saves 100% of Traditional Household Energy Use

Can ZEB be Reached?
Aug Total Energy Bill $14.52

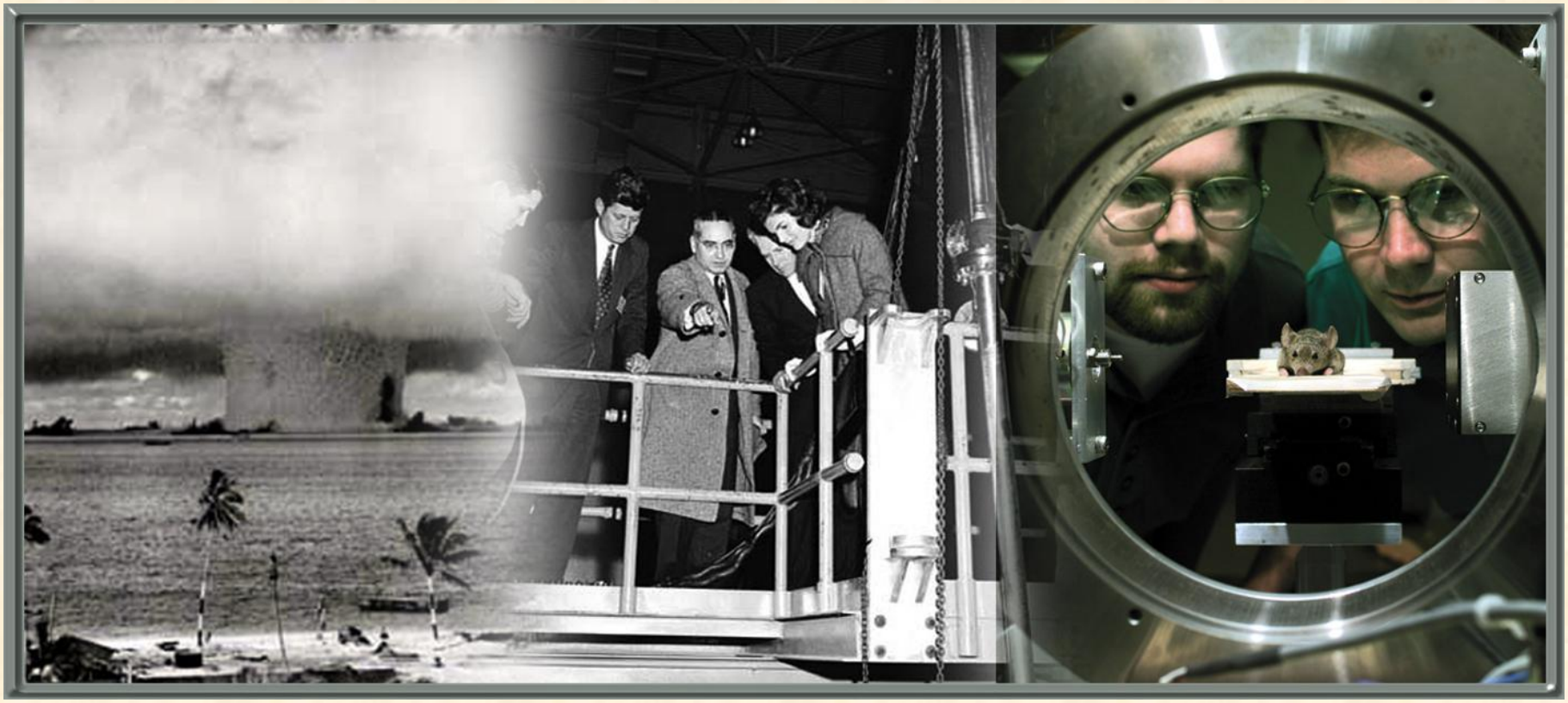
Oak Ridge National Laboratory was Established during World War II

Senator
Kenneth D. McKellar



The Graphite Reactor was the world's first continuously operated nuclear reactor

ORNL's Mission has Continuously Evolved Since 1943



Manhattan Project **Cold War** **Multi-purpose Science**

Today, ORNL is DOE's largest multipurpose science laboratory

- $1.04 billion budget
- 3,900 employees
- 3,000 research guests annually
- Nation's largest unclassified scientific computing facility

- Nation's largest science facility: the $1.4 billion Spallation Neutron Source
- Nation's largest concentration of open source materials research
- Nation's largest energy laboratory
- $300 million modernization in progress

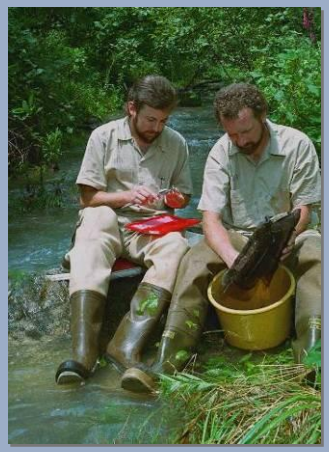
We Operate User Facilities that Serve the Research Community

Buildings Technology Center

High Flux Isotope Reactor

High Temperature Materials Laboratory

Metals Processing Laboratory User Center



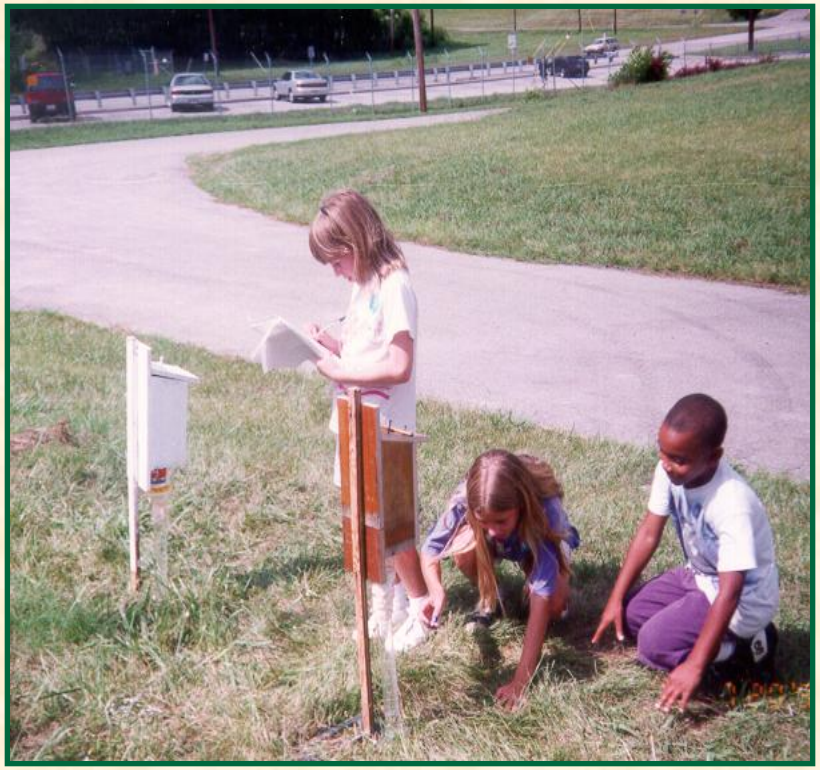
National Environmental Research Park

Providing access to unique and expensive tools and facilities for cutting-edge research

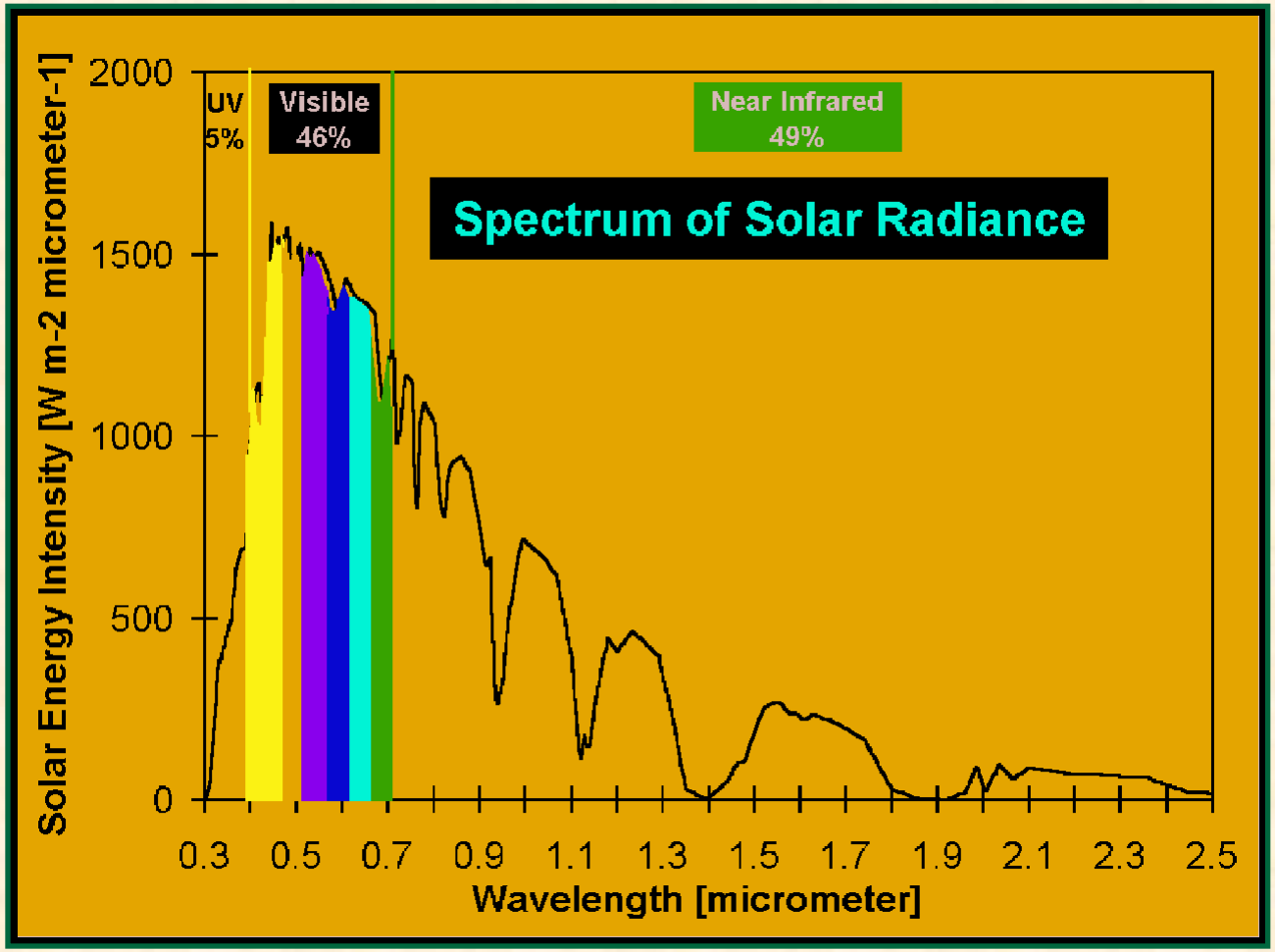
Quiz

With Comfort and Energy Efficiency in mind, which car do you select to drive in the Las Vegas during the summer?

Proof of Concept



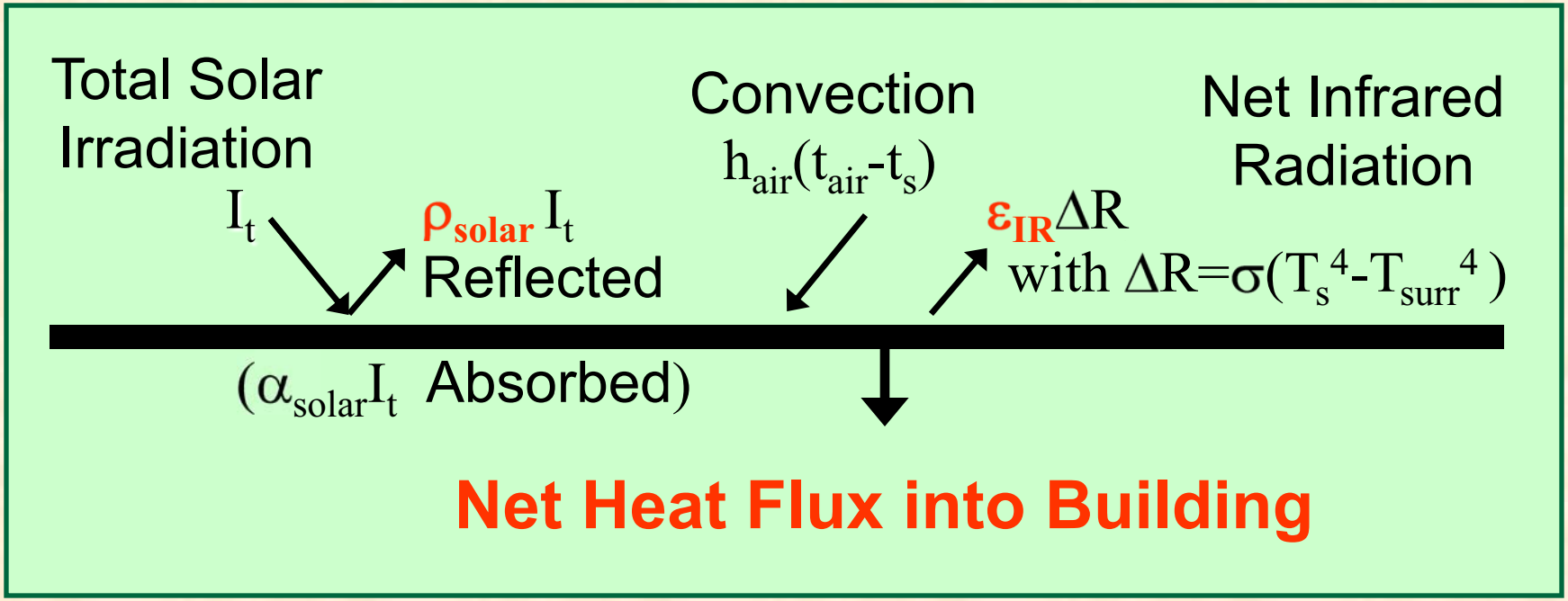
Solar Energy Spectrum



Critical Properties

Reflectance (ρ_{solar}) **Emittance (ε_{IR})**

ρ_{solar} and ε_{IR} are Both Very Important

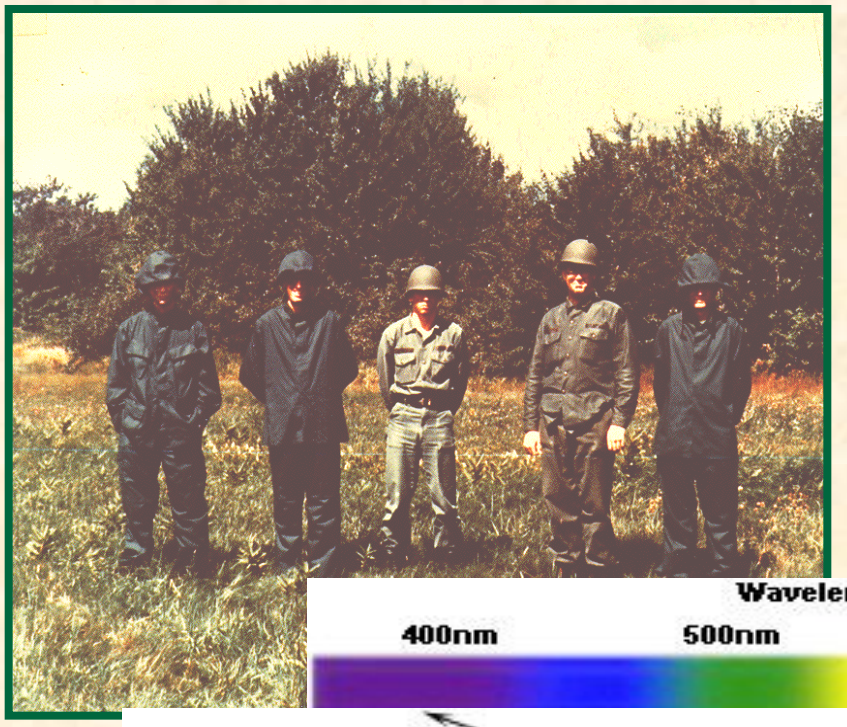


Working with Industry Partners

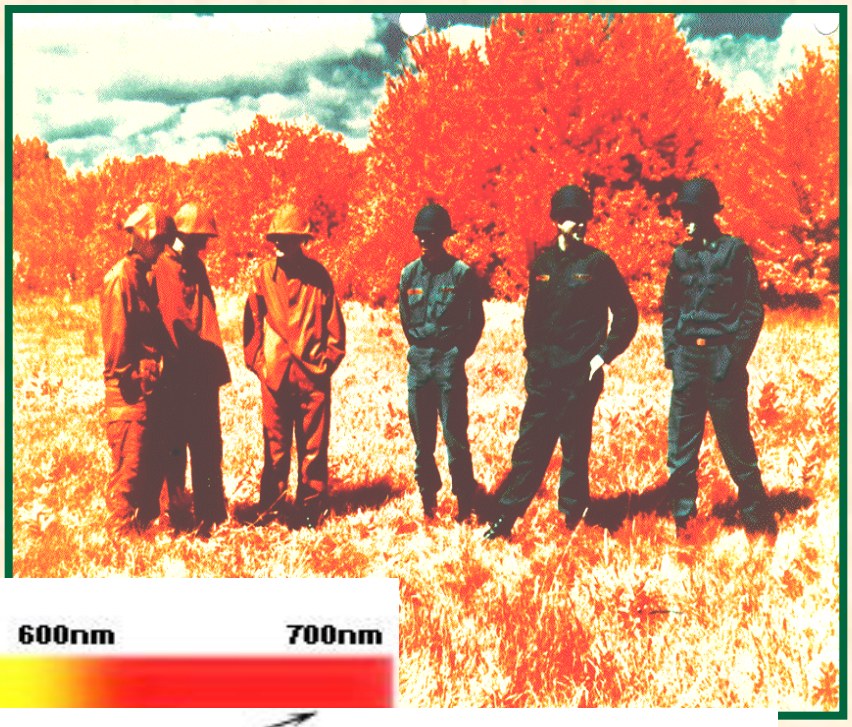
- Team with metal roof, single ply membrane, and roof coating associations and their members and Textured Coatings
- Federally co-funded

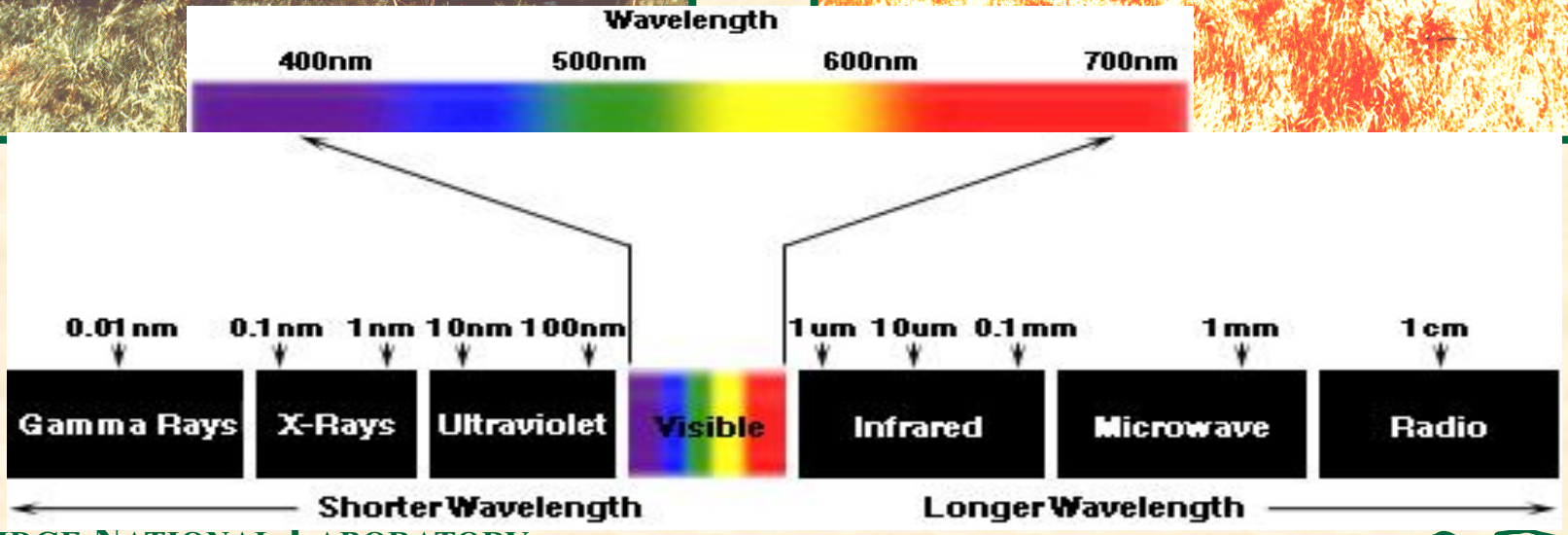
Camouflage Invisible to Night Vision

Conventional Film

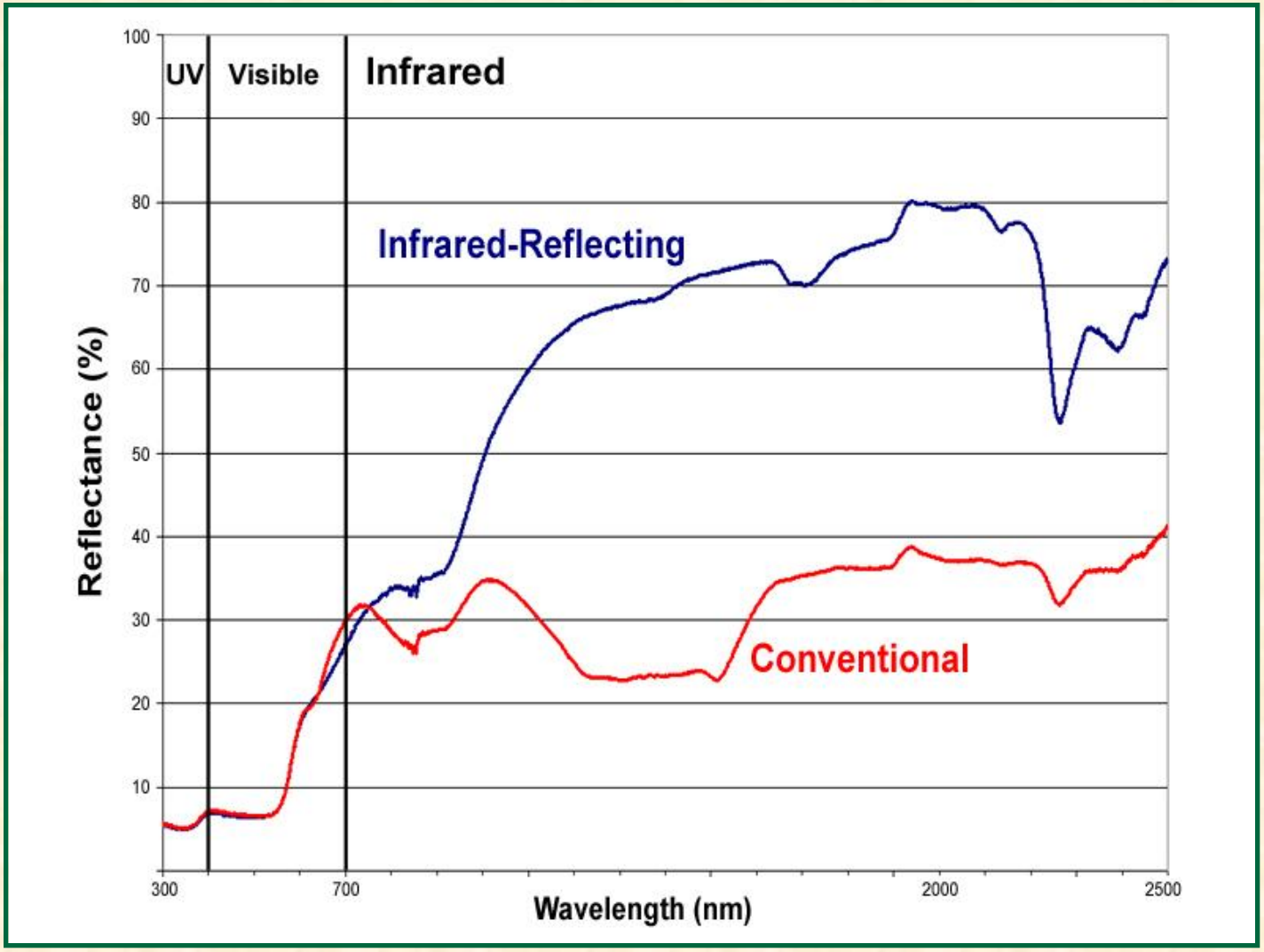


Near Infrared Film





Conventional vs. Infrared Pigments



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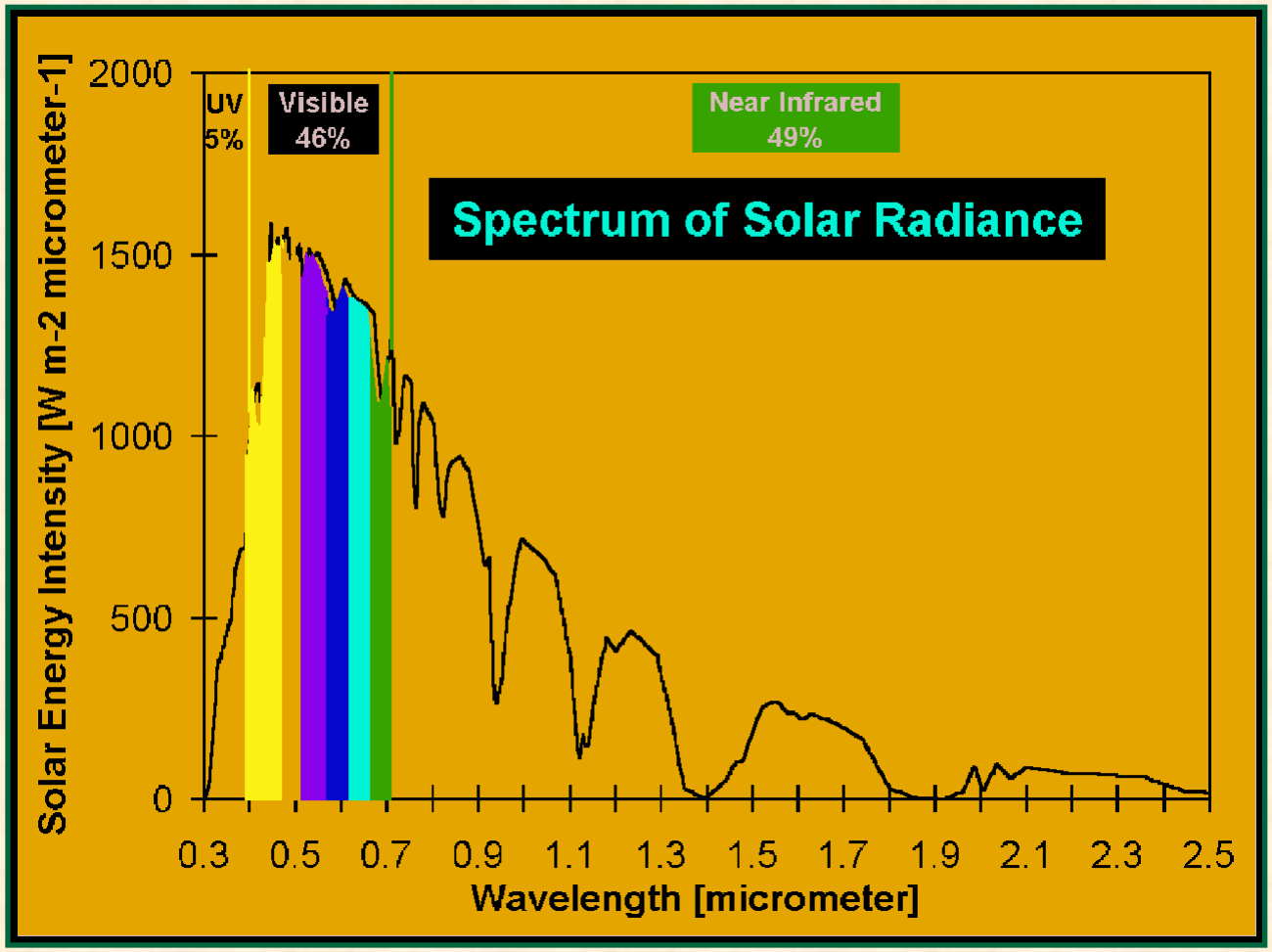


What About Nanoinsulation and Ceramic Bead Additivies to Coatings?

- Coatings do not have R-value; gain energy savings from reflecting solar radiation
- Numerous unsubstantiated claims in the marketplace
- In 2001 ORNL demonstrated coating with "ceramic beads" equal to a unfilled paint in terms of energy savings
- In 2004, FTC fines Kryton Coatings for their "Liquid Siding" Product

Overview: Scope of Work

- Compare thermal performance of walls with cool (high infrared reflectance) and standard colors
- Use Textured Coatings of America's SuperCote Platinum and SuperCote products

Overview: Scope of Work

- Phoenix site: Stucco-coated with various constructions facing east, south, southeast and southwest already covered with Mountain Gray color. Install instrumentation and recoat test areas.
- Jacksonville site: Wood siding facing south already covered with Underseas color. Install instrumentation and recoat test areas.
- Oak Ridge campus site: Bare stucco-coated test area facing south. Add instrumentation; prime and coat test areas.

Phoenix Site

- Single-story wings with central vaulted ceiling area for family room + dining room/kitchen

Phoenix Site

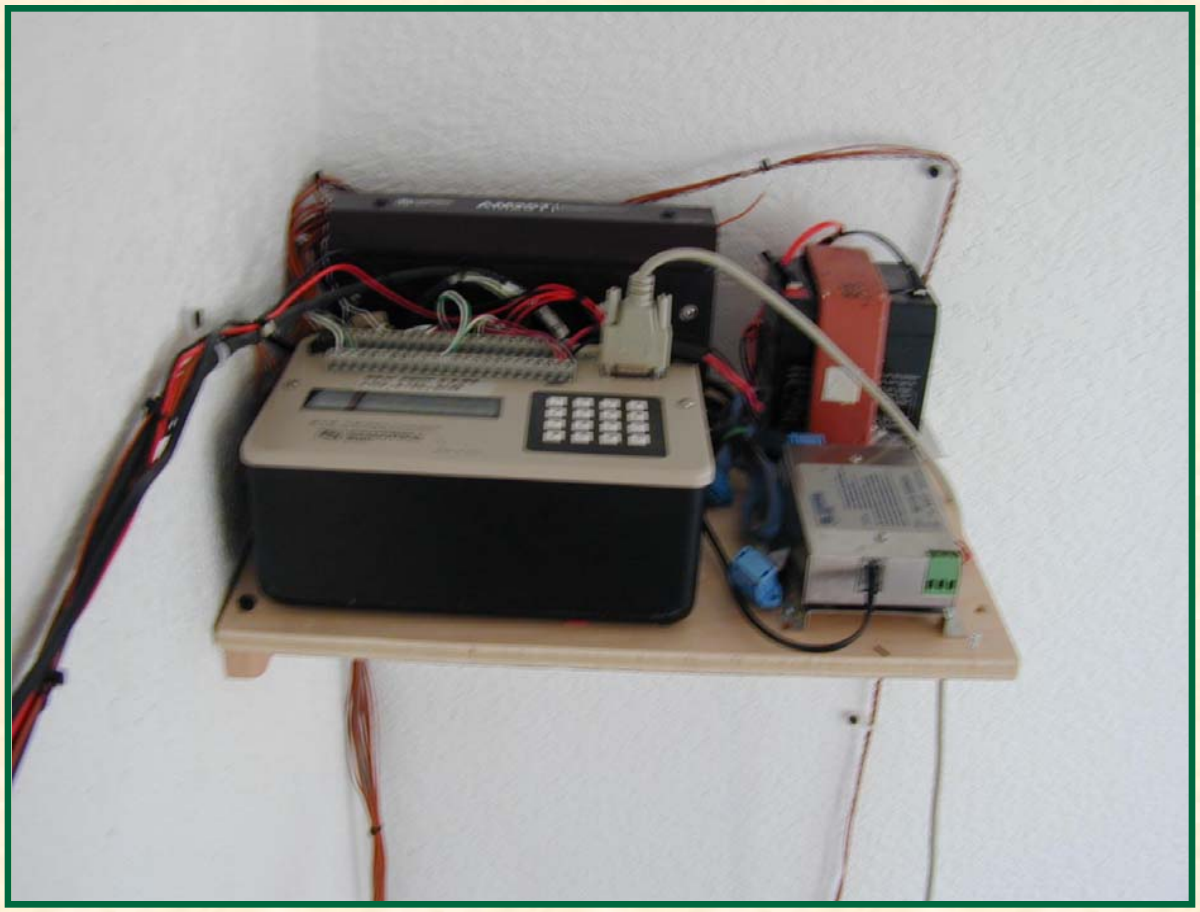
- Southeast and southwest exposures on walls of office in west wing. Outside temperature sensors attached to 10¾ in. thick walls

Phoenix Site

- Add gypsum panels for instruments to sense inside temperatures and heat flow through walls

Phoenix Site

- Data logger transmits data through modem to computer at Oak Ridge over dedicated line



Jacksonville Site

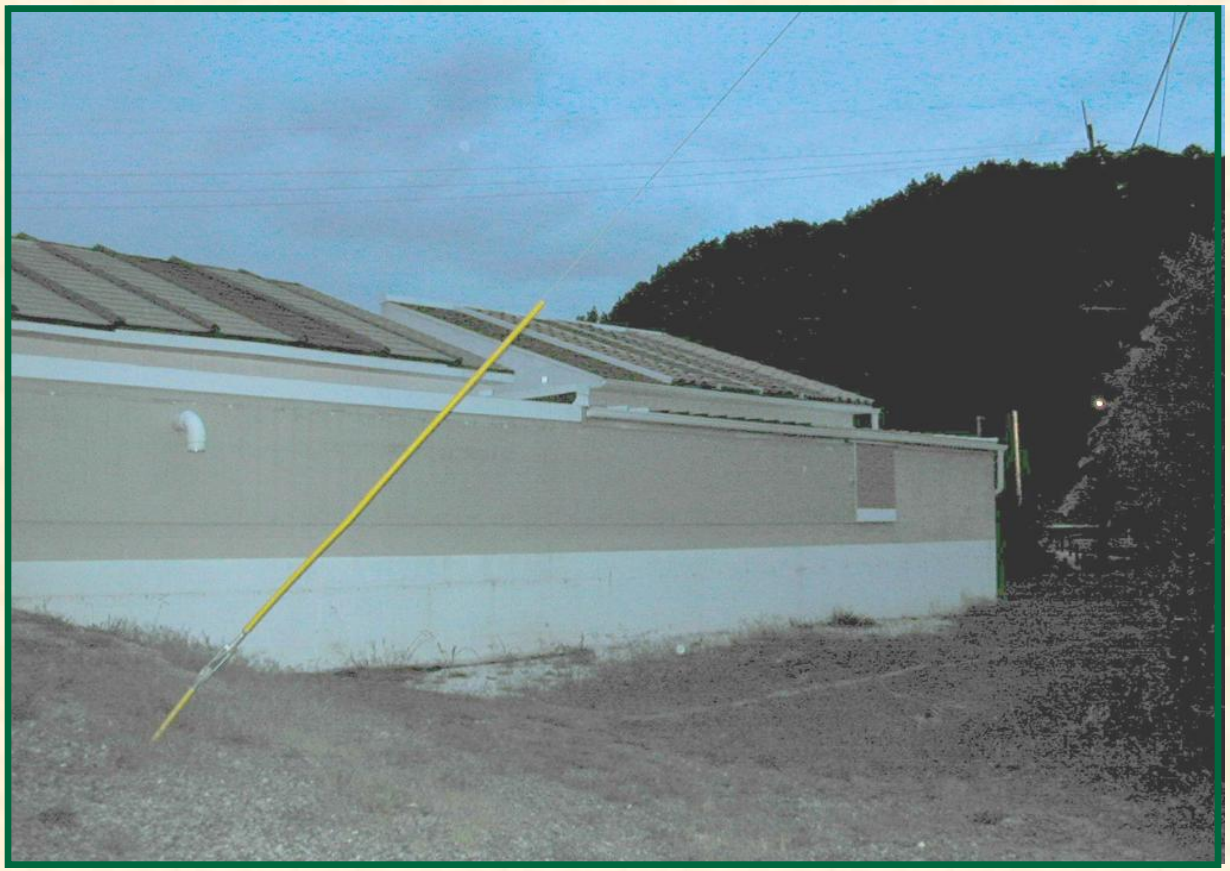
- Two-story house on Ponte Vedra beach

Jacksonville Site

- South-facing test exposures outside family room above steps from deck that faces ocean

ORNL Site

- Stucco test section on south wall of Envelope Systems Research Apparatus (ESRA)



ORNL Site

- Underseas Supercote Platinum (IR) on right stud space and upper half of middle; Supercote (Non) on rest except for strip of uncoated primer at bottom

ORNL Site

- Add gypsum panels on inside like at Phoenix and Jacksonville sites

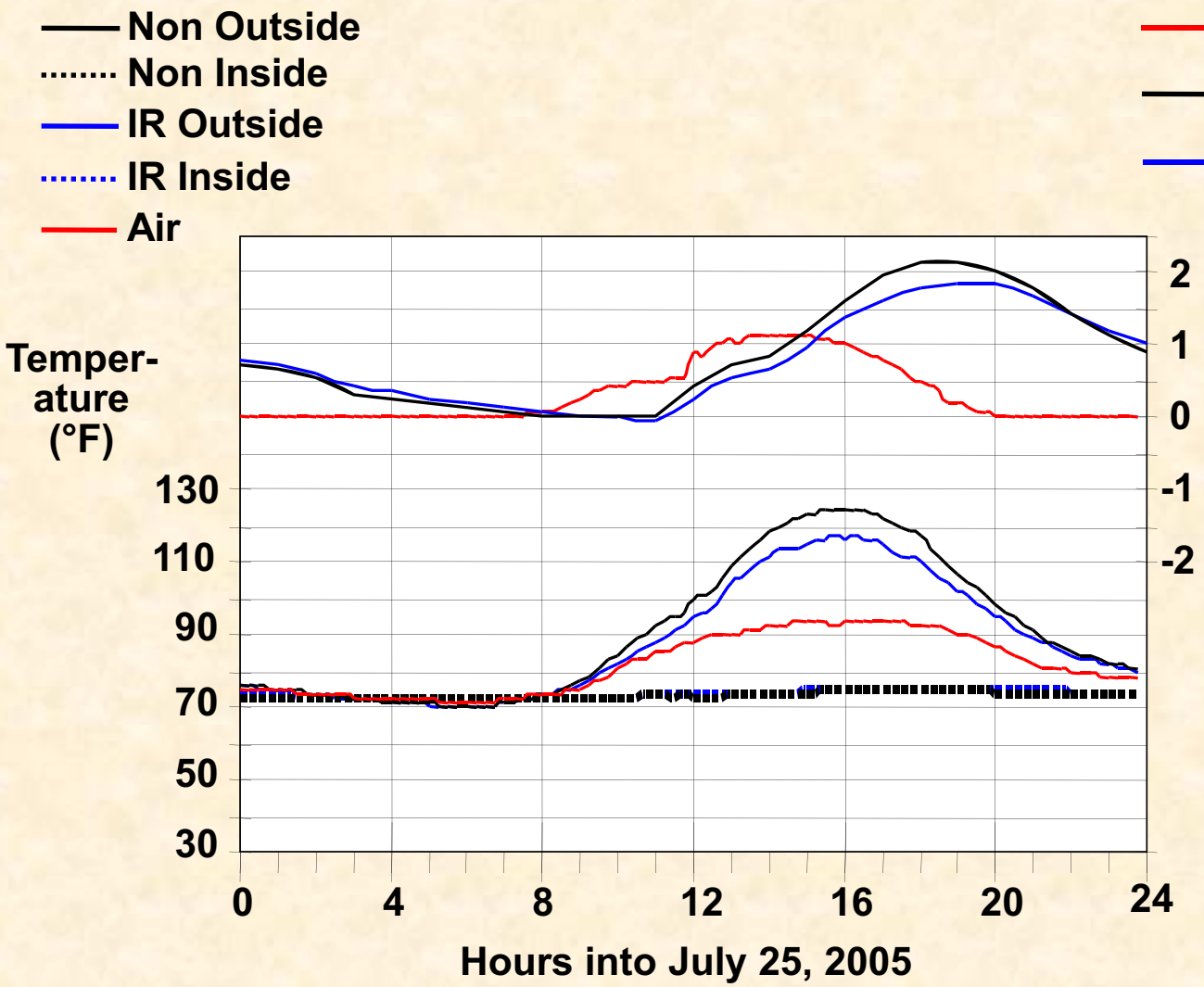
ORNL Site

- Computer dedicated to ESRA data acquisition records detailed thermal performance

ORNL Site

- Data starting 7/30/04 with coating on 8/3/04. Data acquisition through August 2005
- Check consistency of data with program to estimate wall properties from temperature and heat flux measurements. Data very consistent from month to month
- Behavior of solar radiation control on vertical walls more complicated than low-slope roofs. Difficult to generalize simply

ORNL Site: Non vs IR -- Summer Day



- Air temp warmer but wall solar lower vs 4/16/05
- Behavior of Non and IR again same at night
- Peak temps again consistent with coatings over primer

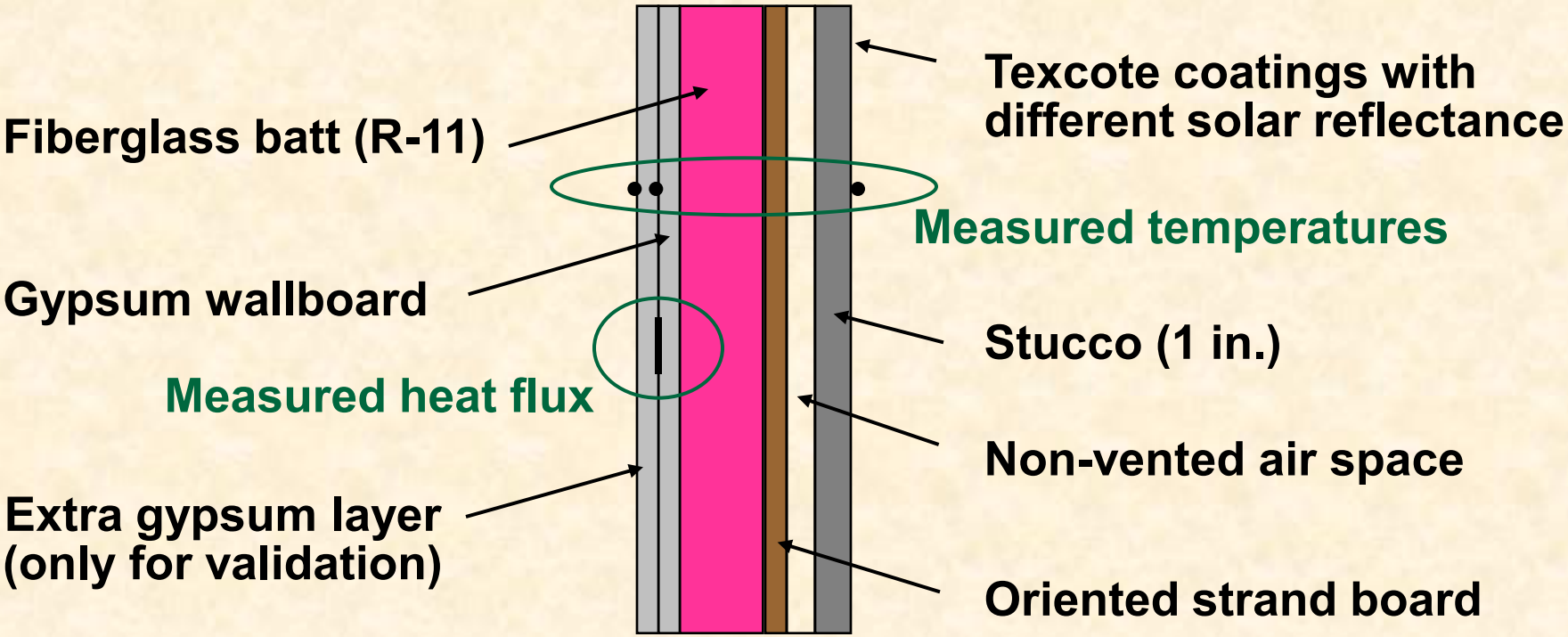
Model for Wall Behavior

- Seek a model that can be generalized to give results for whole buildings
- Have done extensive validation of a model in DOE 2.2 for a 1100 ft² ranch house

- Heat/cool with heat pump: 68°F winter; 76°F summer; size heat pump for climate
- Occupy with 3 people + Building America energy use profiles

Model for Wall Behavior

- To validate model, generate climatic data from ORNL weather station records for year of test
- Use properties of wall materials along with construction details for test section



Solar Reflectance of Coatings

- **Samples over primer: Mountain Gray (Phoenix) and Underseas (Jacksonville and ORNL) 7/2/04**

Mountain Gray Supercote Platinum	0.44
Mountain Gray Supercote	0.30
Underseas Supercote Platinum	0.51
Underseas Supercote	0.25

- **Jacksonville on wood siding and existing coating 12/8/04**

Underseas Supercote Platinum	0.40
Underseas Supercote	0.24

- **ORNL on Stucco**

		8/4/04	9/27/04	5/18/05	8/3/05	
Texcote Primer	0.71	0.67	0.72	0.66		
Underseas Supercote Pt		0.49	0.50	0.49	0.49	0.50
Underseas Supercote		0.24	0.24	0.24	0.24	0.24

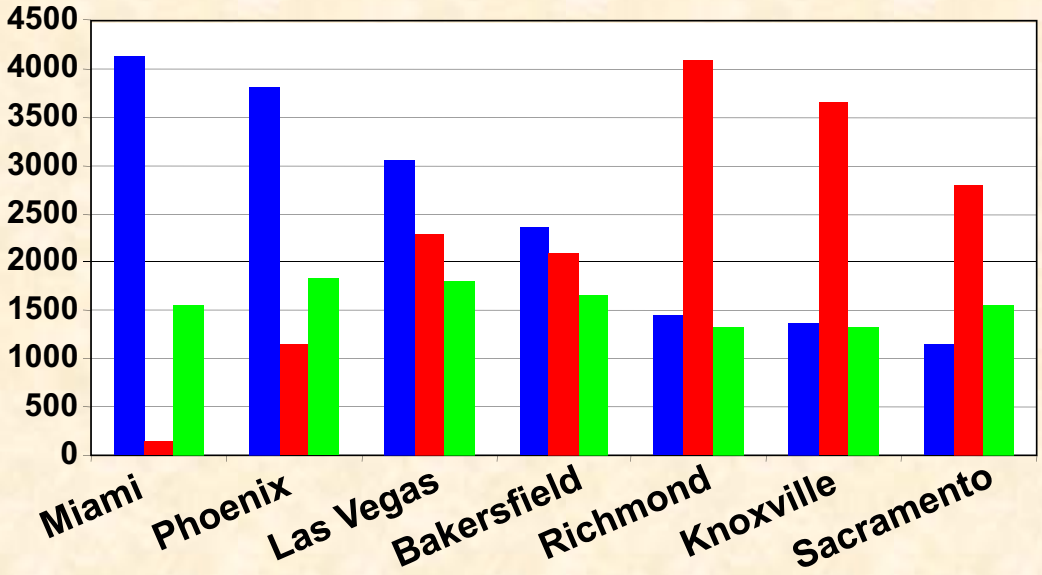
Use averages

Features of DOE 2.2 of interest

- Can specify wall and solar reflectance of exterior surface and nearby ground
- Sun tracked hour by hour and can shade exterior surfaces by building and landscape
- Simulation of annual energy use by heating and cooling system includes response to thermostat schedules and to thermal mass in envelope

Model Generalizations

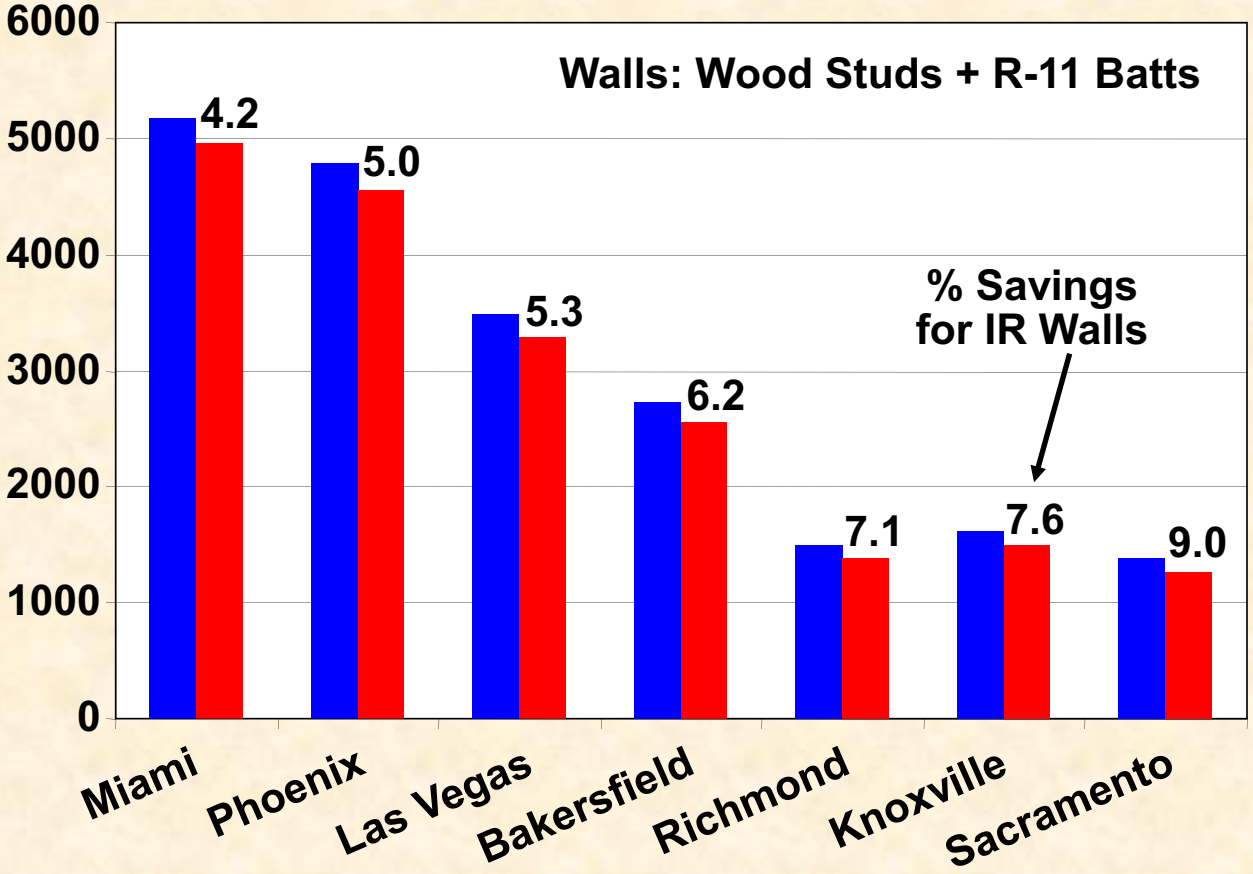
- Building America Performance Analysis Resources at http://www.eere.energy.gov/buildings/building_america/pa_resources.html gives energy use profiles for three occupants (3 BR home). Choose to heat and cool with air-to-air heat pump (76°F cooling; 68°F heating; no setup or setback)
- Choose seven different climates to show response of typical house to cooling and mixed climates of interest



- Cities arranged by decreasing cooling degree days

Model Generalizations

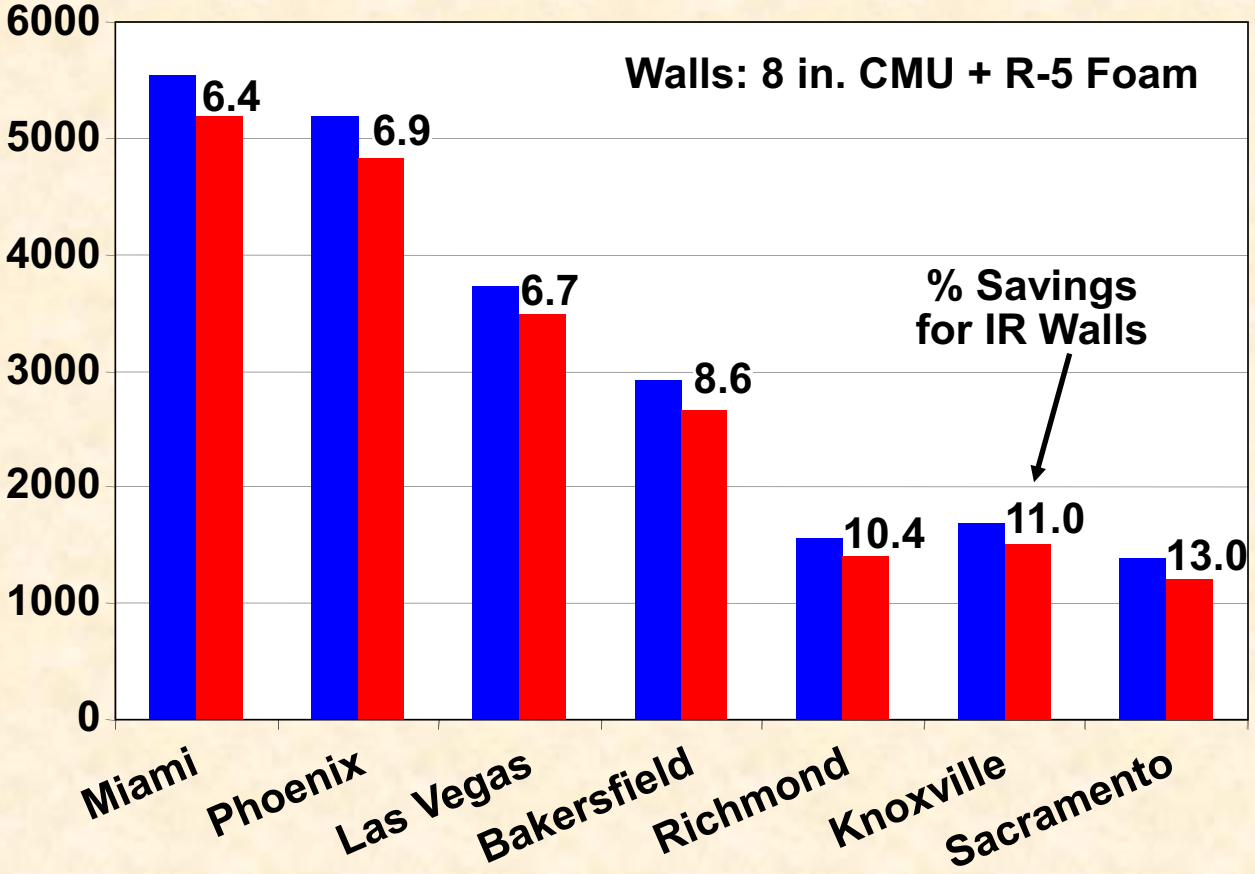
- IR reflective coating on conventional walls saves cooling energy. Savings are 4% to 9% compared to non-IR reflecting walls



- Absolute savings vary from +240 (Phoenix) to +110 (Richmond)

Model Generalizations

- IR reflective coating on CMU walls shows larger savings of cooling energy. Savings are 6% to 13% compared to cooling energy with non-IR reflecting walls



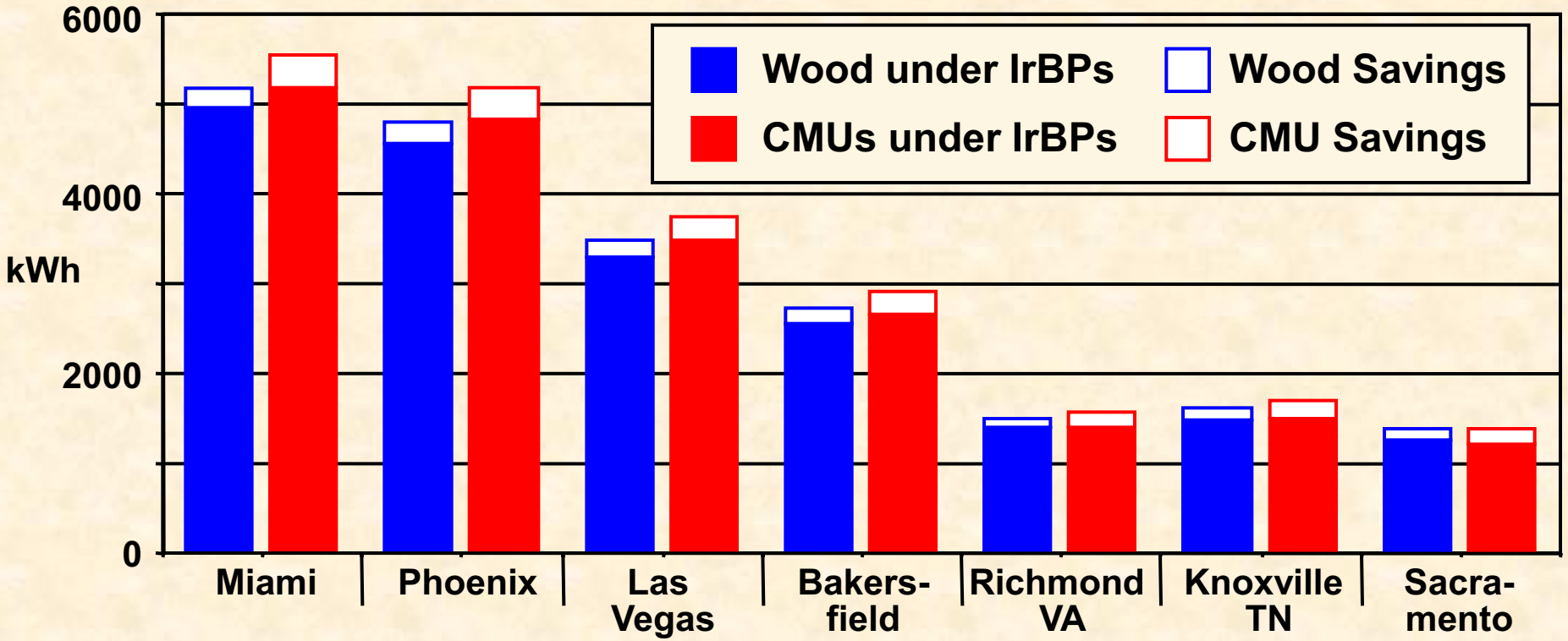
- Absolute savings vary from +360 (Phoenix) to +160 (Richmond)

Project Summary

- Demo sites in Phoenix and Jacksonville depict energy savings
- Full year of ORNL data validated DOE 2.2 model
- Complexity of real wall applications (different orientations, shading and construction) makes generalization very difficult
- DOE 2.2 whole building annual energy estimates for ranch house show that IR reflecting pigments save 4% to 13% of cooling energy

Project Summary

- Cooling a 1100 ft² ranch house in various climates



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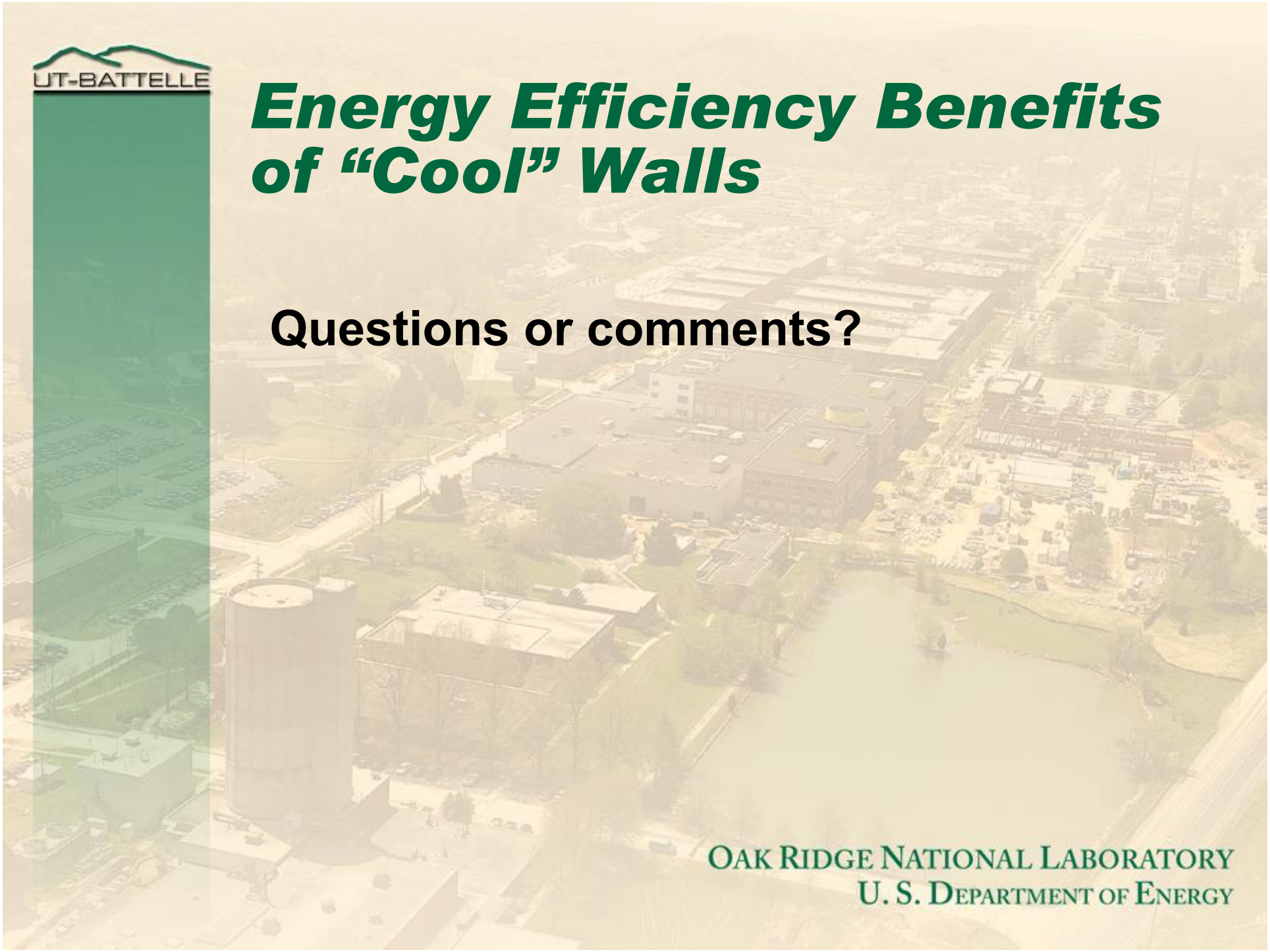
Energy Efficiency Benefits of "Cool" Walls

Questions or comments?



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