Field Tests of Cool Walls in Cooling and Mixed Climates

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Progress Report on
Joint Research Project

Textured Coatings of America
and the
Oak Ridge National Laboratory

28 October 2005

Quiz

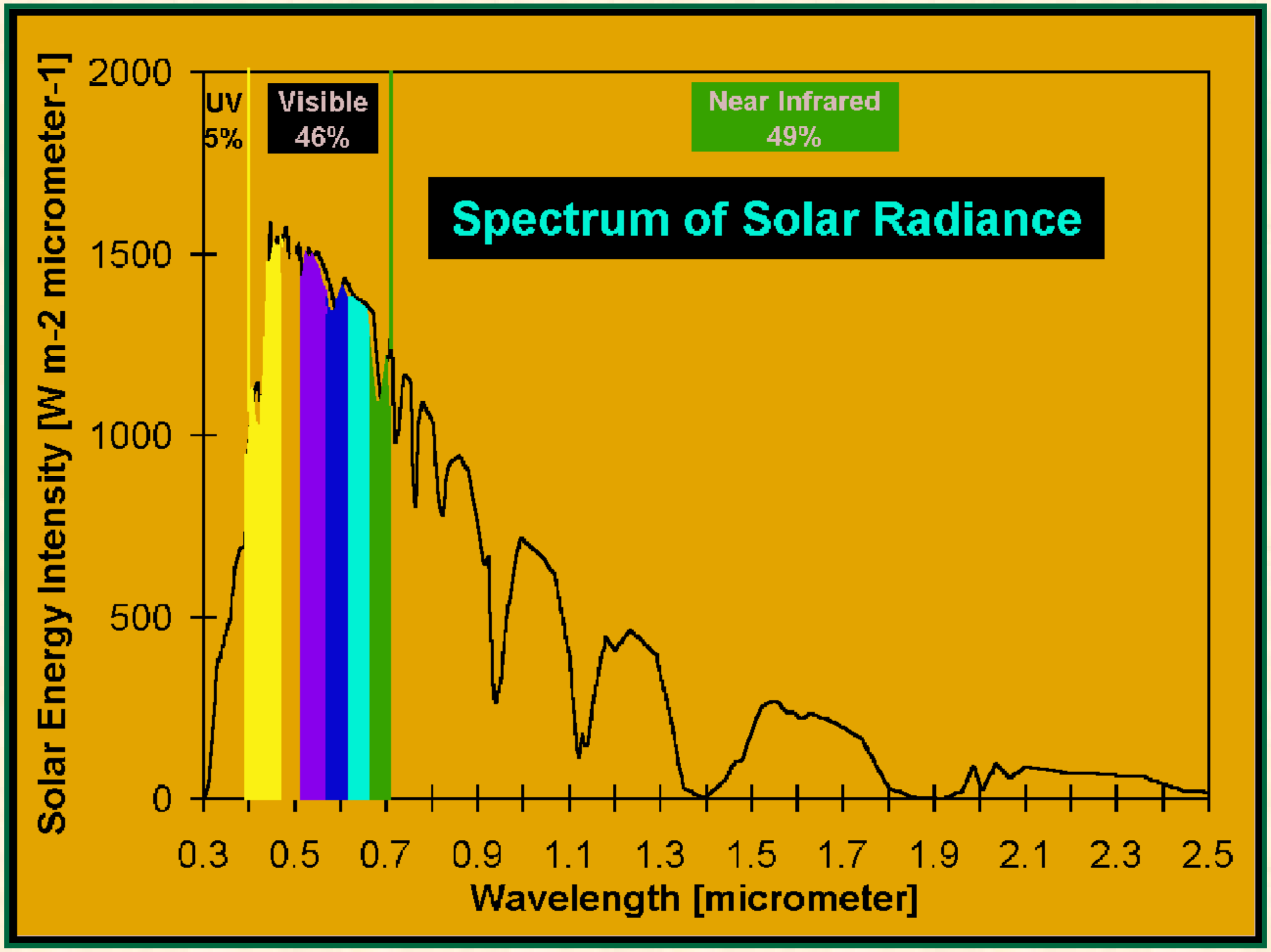
With <u>Comfort and Energy Efficiency</u> in mind, which car do you select to drive in the Panama City during the summer?

Potential Answers

- **The black car (!)**
- **The white car**
- **Pick the black car and move to Denmark**
- **Who cares about energy efficiency or comfort?**

Proof of Concept

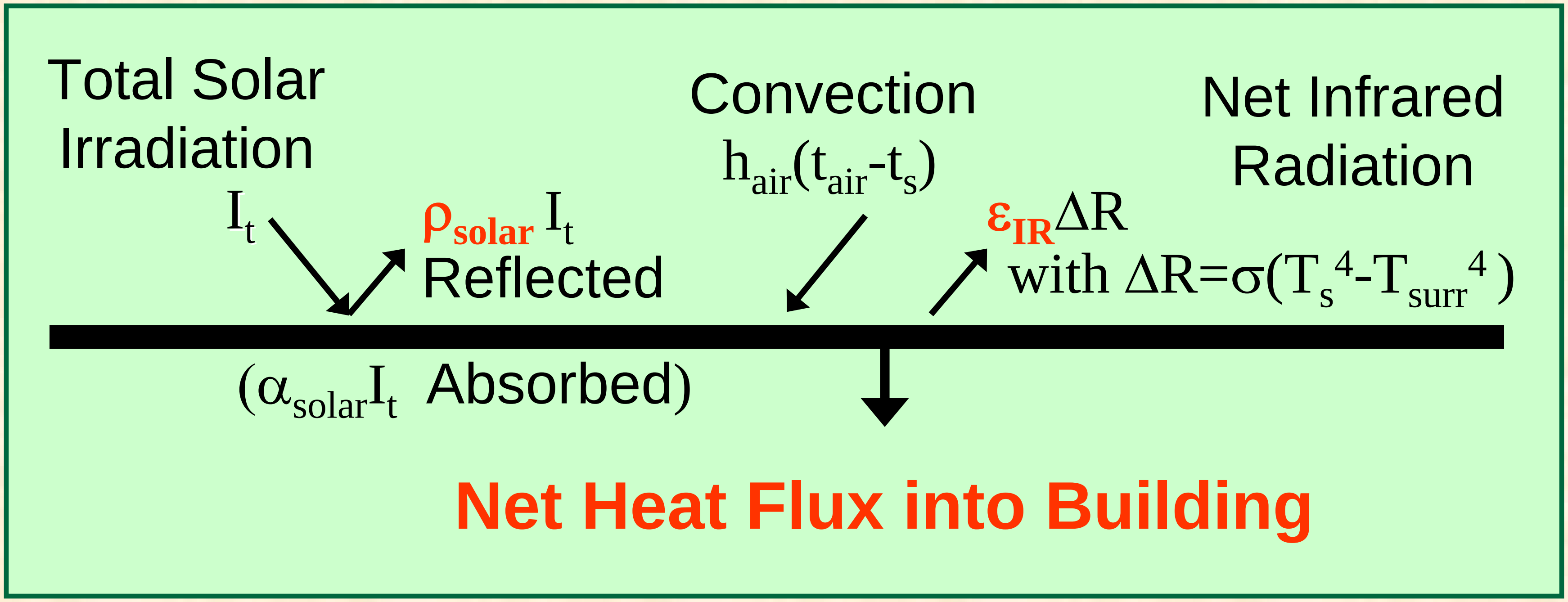
Solar Energy Spectrum



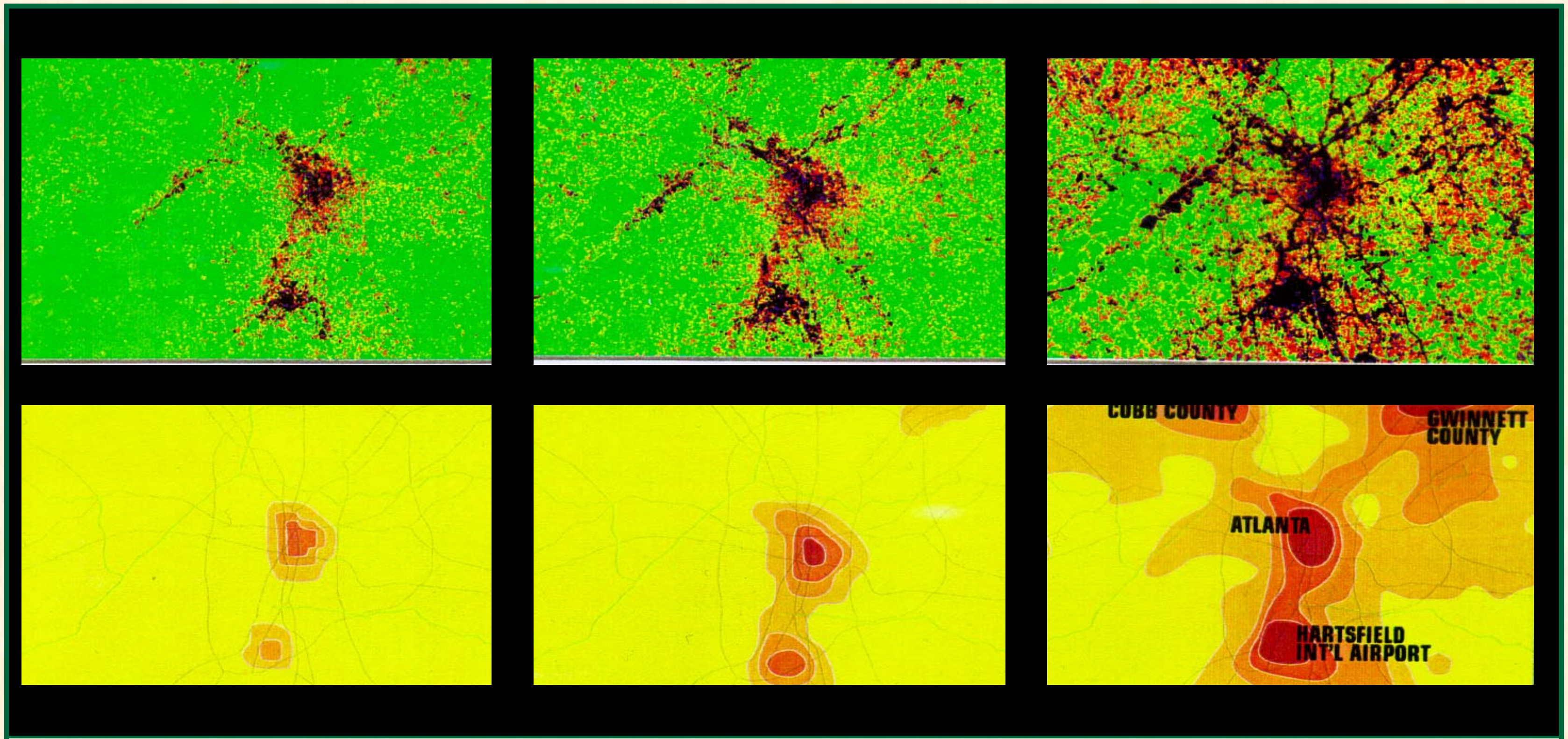
Critical Properties

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

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



Atlanta's Changing Environment



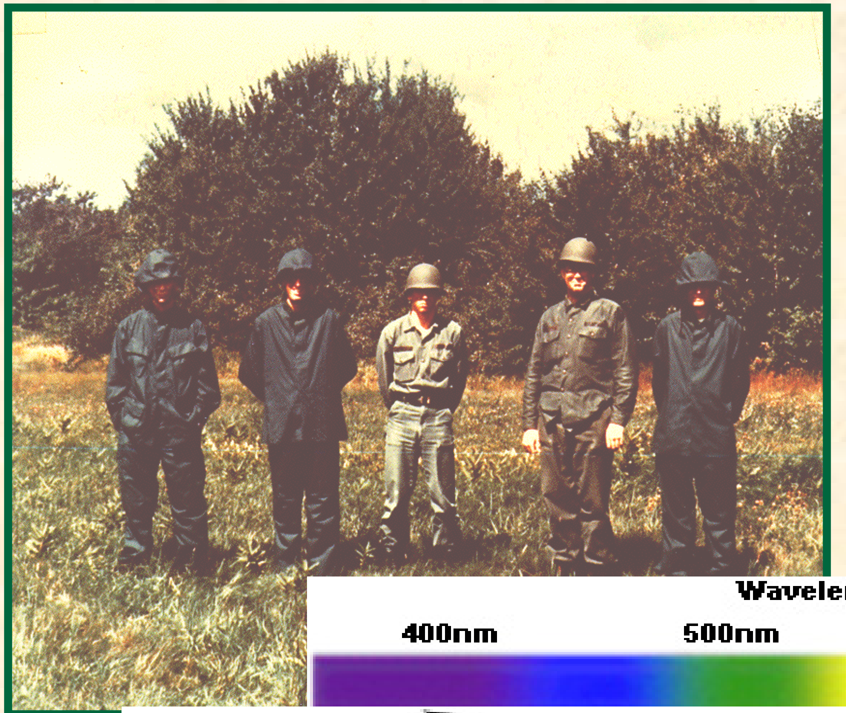
1972 1978 1993

Working with Industry Partners

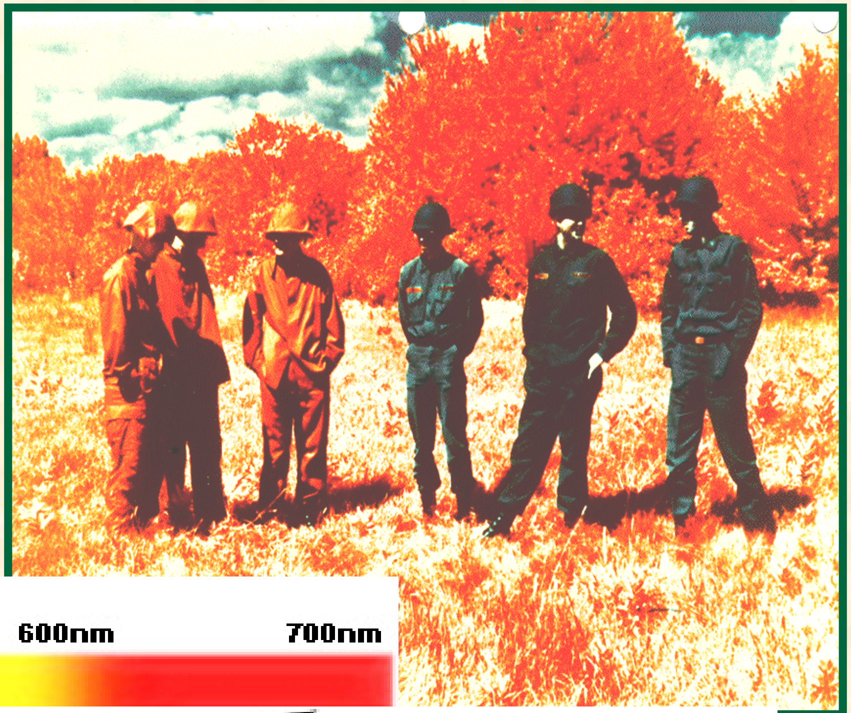
- **Team with metal roof, single ply membrane, and roof coating associations and their members and Textured Coatings**
- **Federally co-funded**

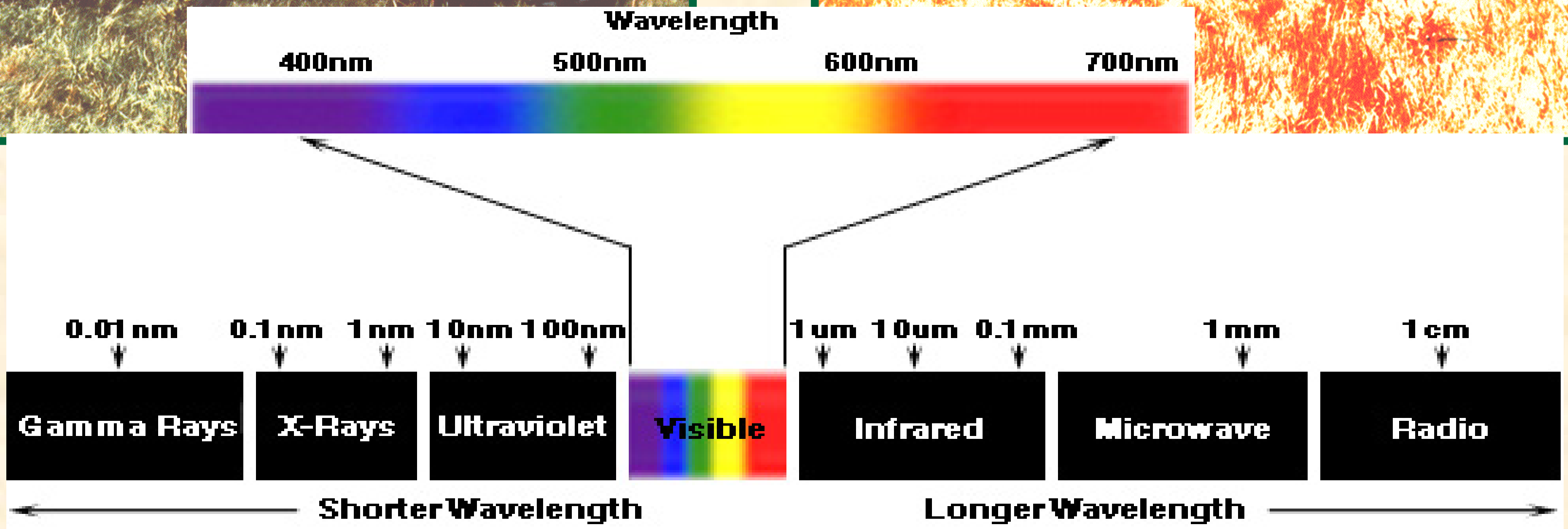
Camouflage Invisible to Night Vision

Conventional Film

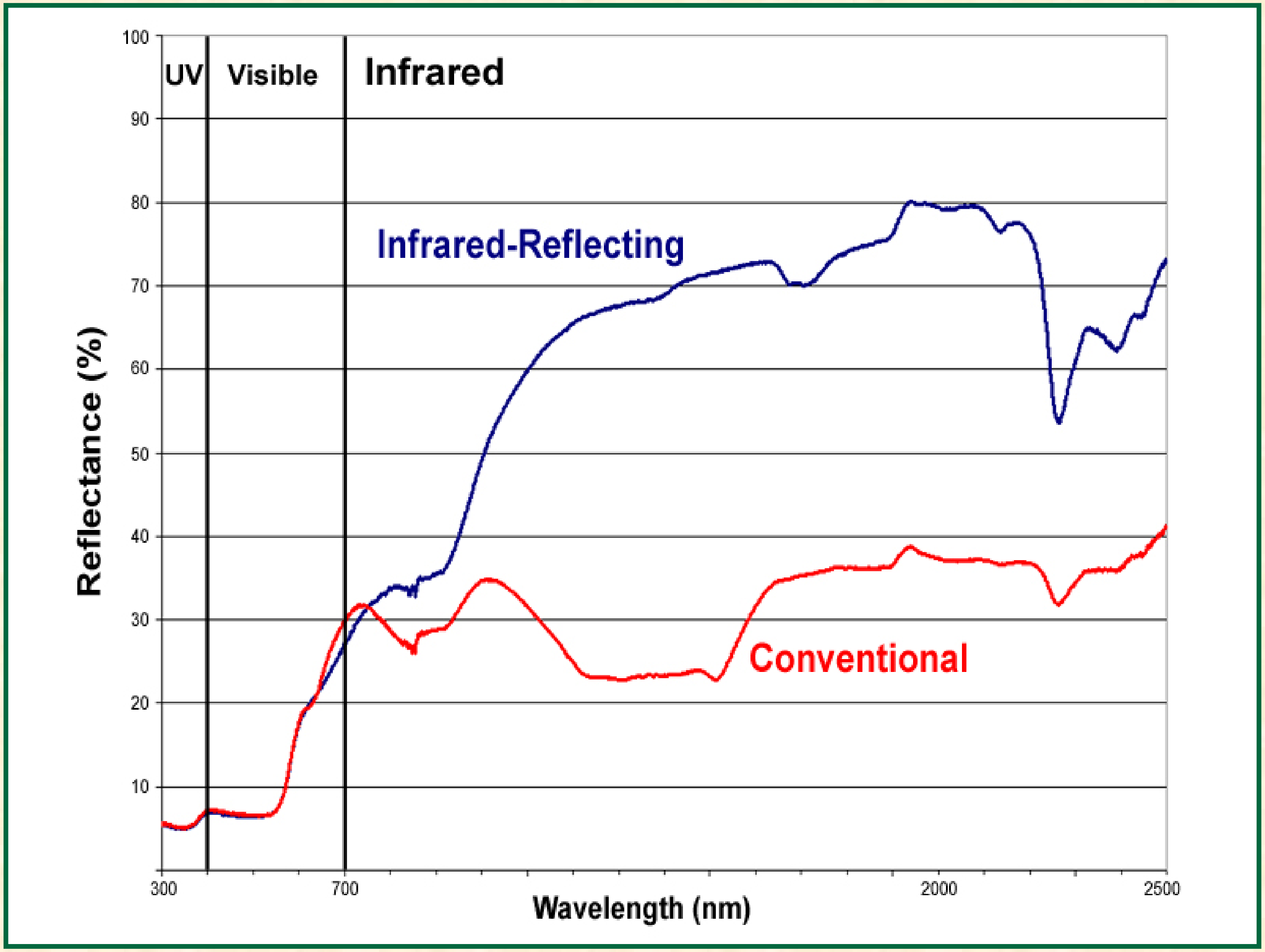


Near Infrared Film

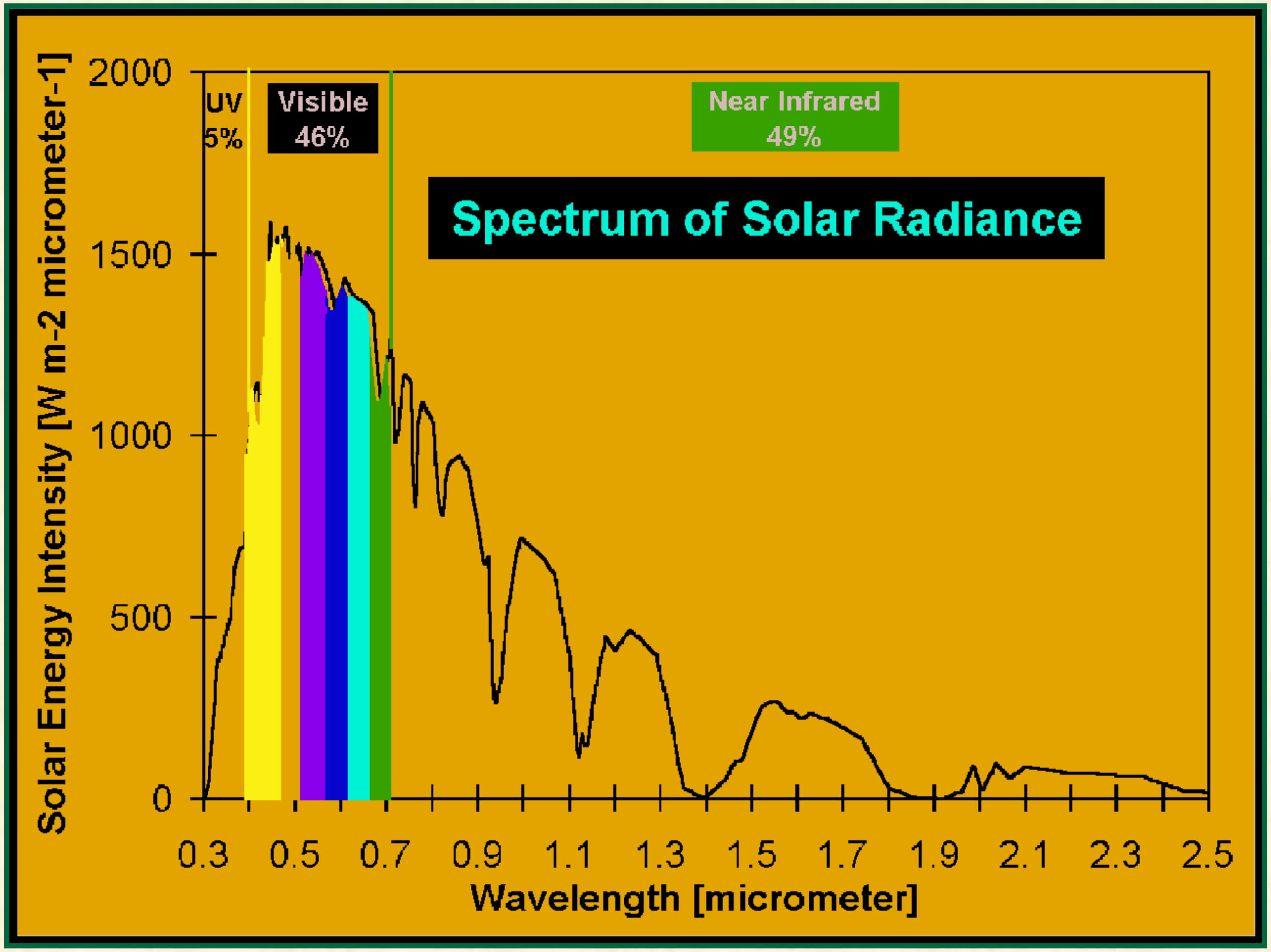




Conventional vs. Infrared Pigments



Solar Energy Spectrum



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

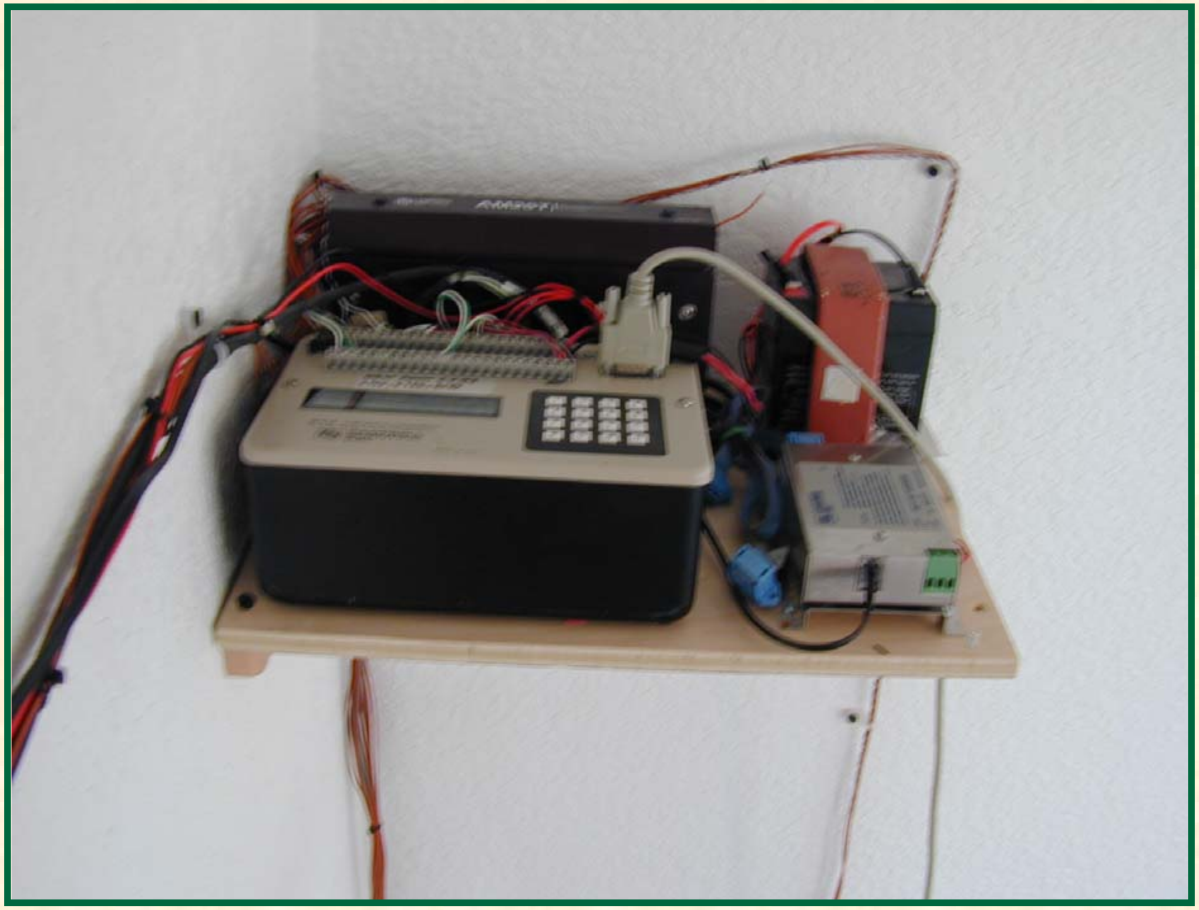
- **South and east exposures on walls of exercise room. South 15 in. thick; east 6¼ in. thick**

Phoenix Site

- **Data logger and modem in exercise room. Wires from west wing in shallow trench through yard**

Phoenix Site

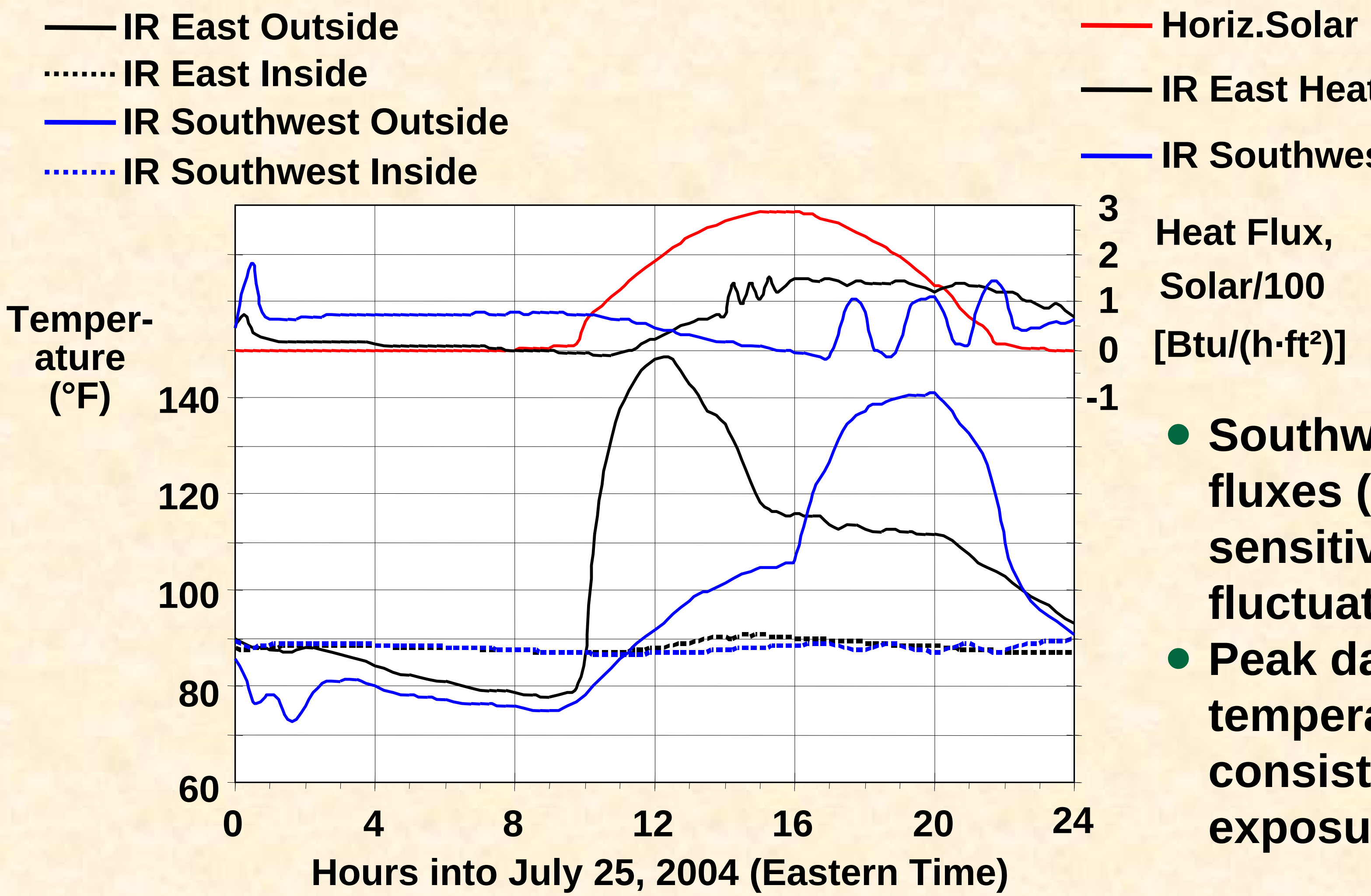
- **Data logger transmits data through modem to computer at Oak Ridge over dedicated line**



Phoenix Site

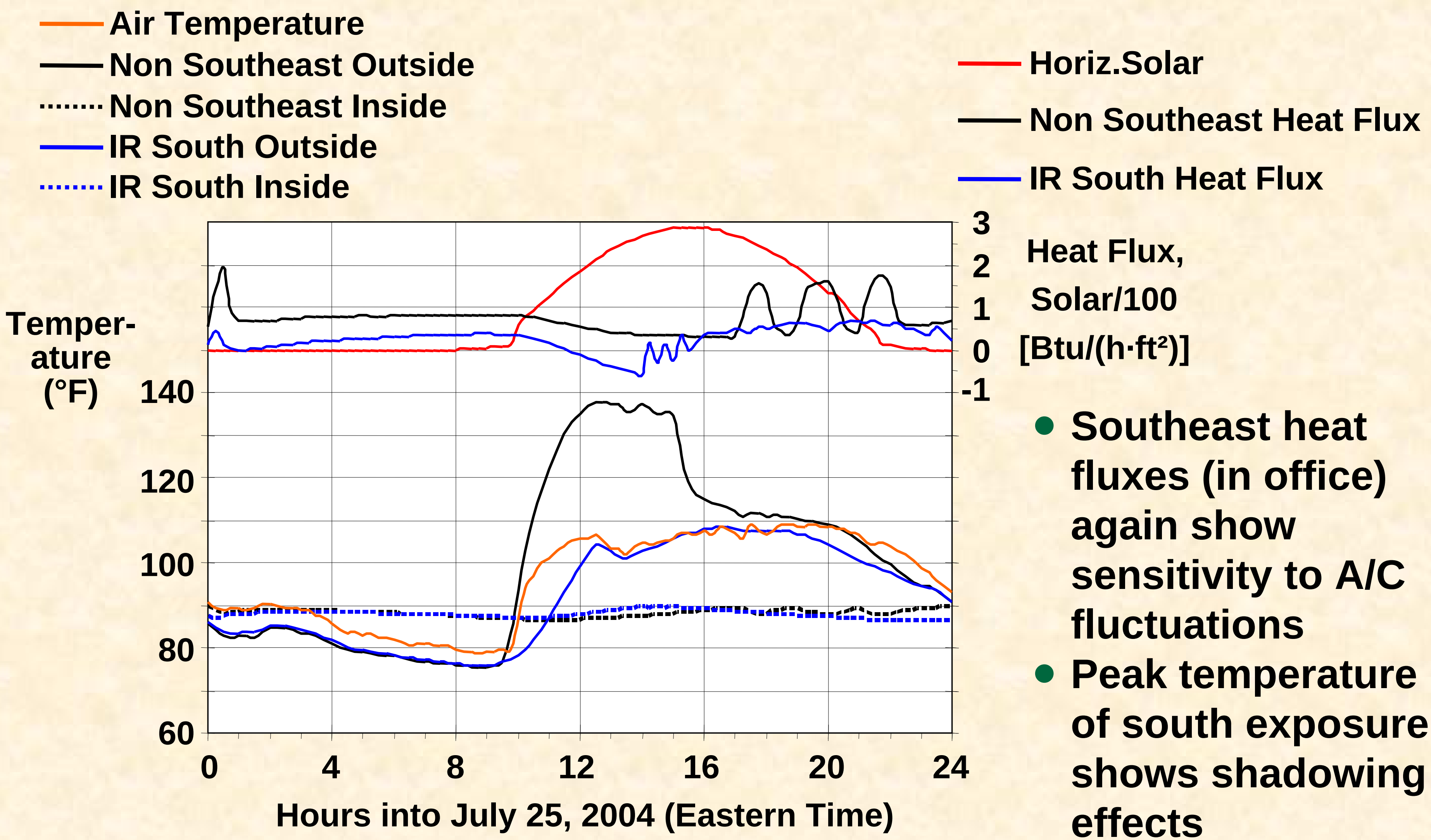
- **Data obtained 5/2/04 through 11/30/04. Remove instrumentation on 12/2/04.**
- **Check consistency of data with program that estimates wall properties from measured temperatures and heat fluxes. R-values vary as expected.**
- **Different directions of exposure and varying thickness make it tough to interpret data.**
- **Limited height of walls and decorative overhang cause shadowing problems.**

Phoenix Site: IR East vs IR Southwest



- Southwest heat fluxes (in office) sensitive to A/C fluctuations
- Peak daytime temperatures are consistent with exposure

Phoenix Site: Non Southeast vs IR South



- Southeast heat fluxes (in office) again show sensitivity to A/C fluctuations
- Peak temperature of south exposure shows shadowing effects

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**

Meter for wall solar between test areas

Jacksonville Site

- **Gypsum panels on inside walls painted to match existing decor**

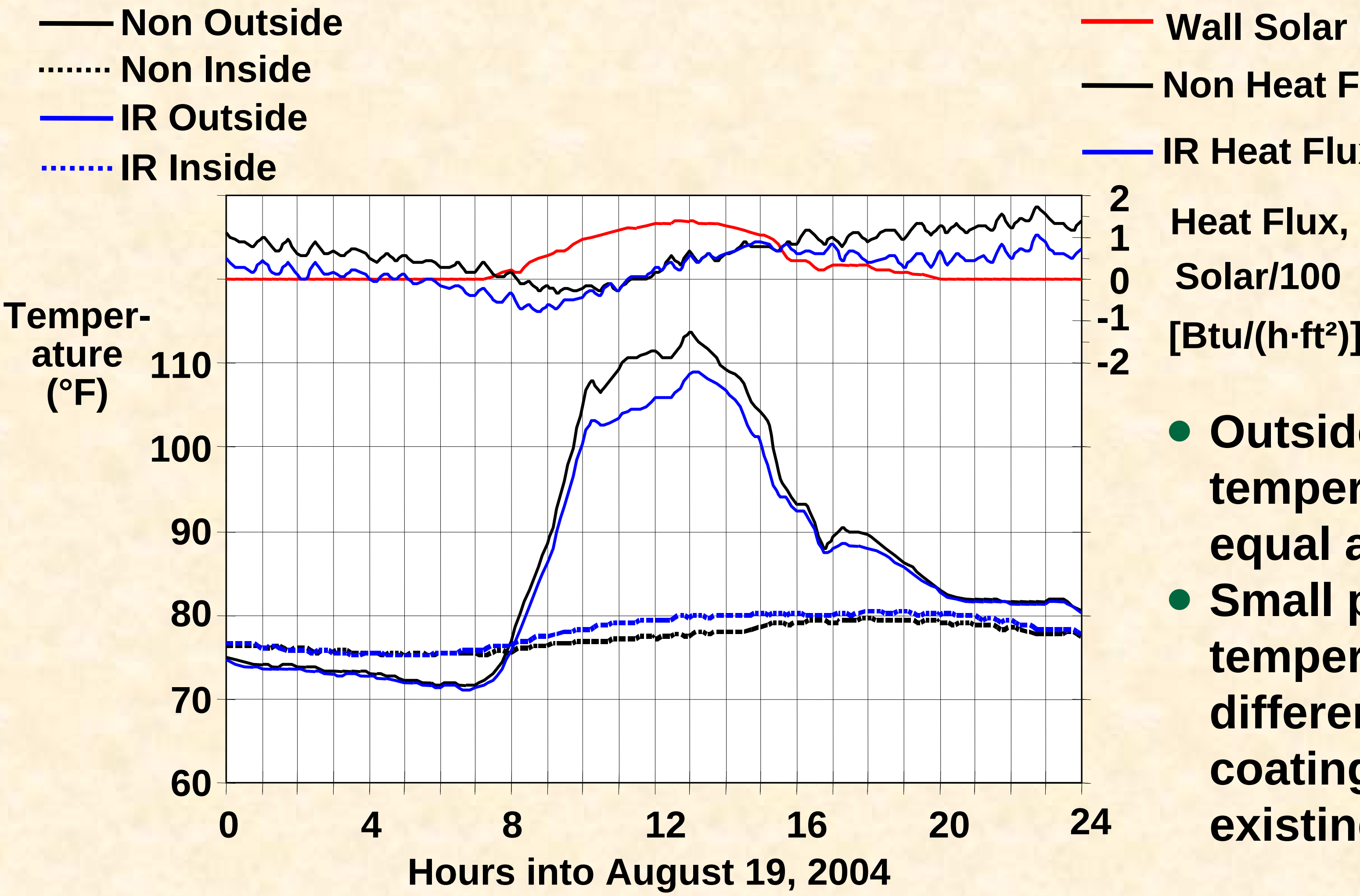
Jacksonville Site

- **Data logger and modem tucked into corner behind TV. Used house phone line for monthly download. Owner plugged in phone line for call**

Jacksonville Site

- **Data obtained 5/5/04 through 12/3/04 with recoating on 7/9/04. Remove instrumentation on 12/8/04**
- **Behaviors of solar flux incident on wall and outside surface temperatures show more cloudiness and rain than in Phoenix. Saw effects of Hurricanes Frances and Jeanne**
- **Exposures not at same level (followed slope of steps) so some height effects both outside and inside**
- **Railing for steps and enclosure for fireplace flue cause shadowing.**

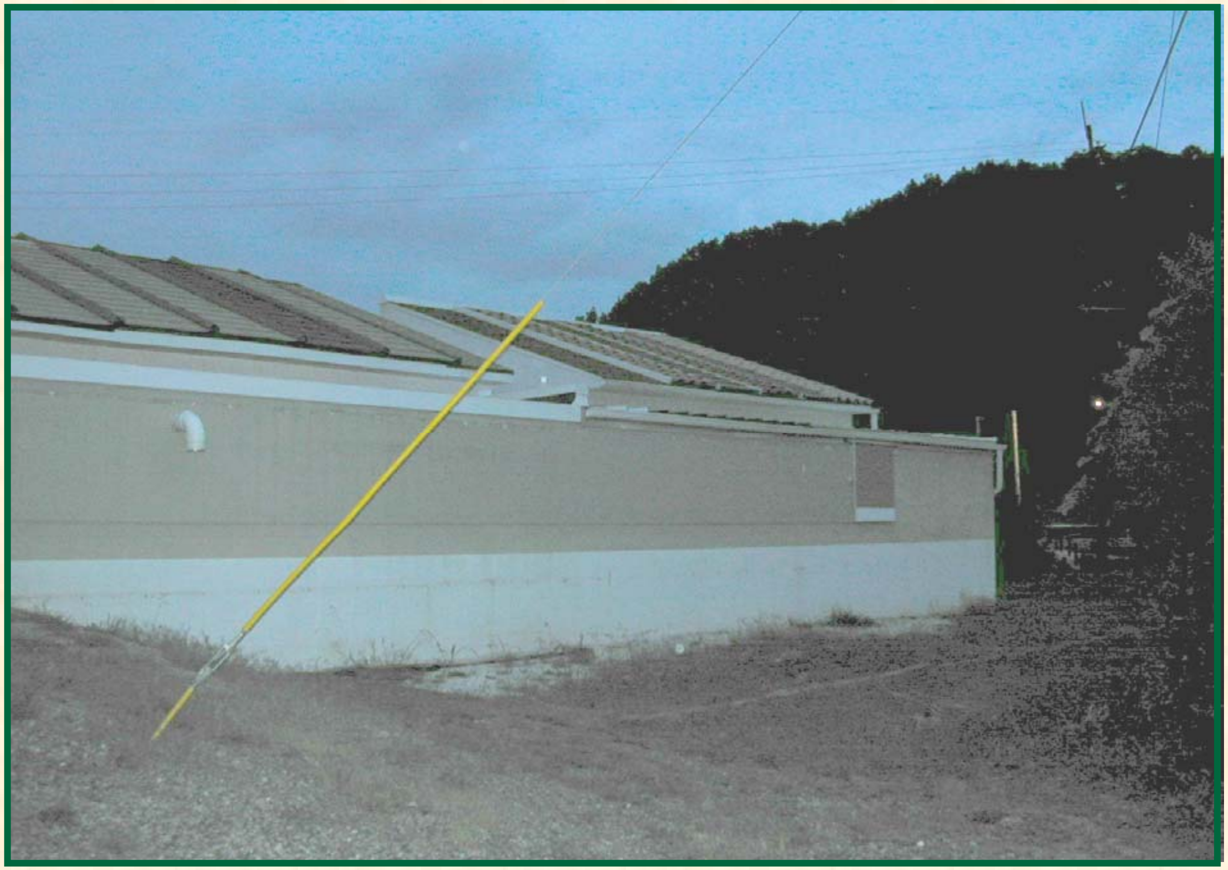
Jacksonville Site: Non Lower vs IR Upper



- Outside wall temperatures equal at night
- Small peak temperature differences: coatings over existing coating

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

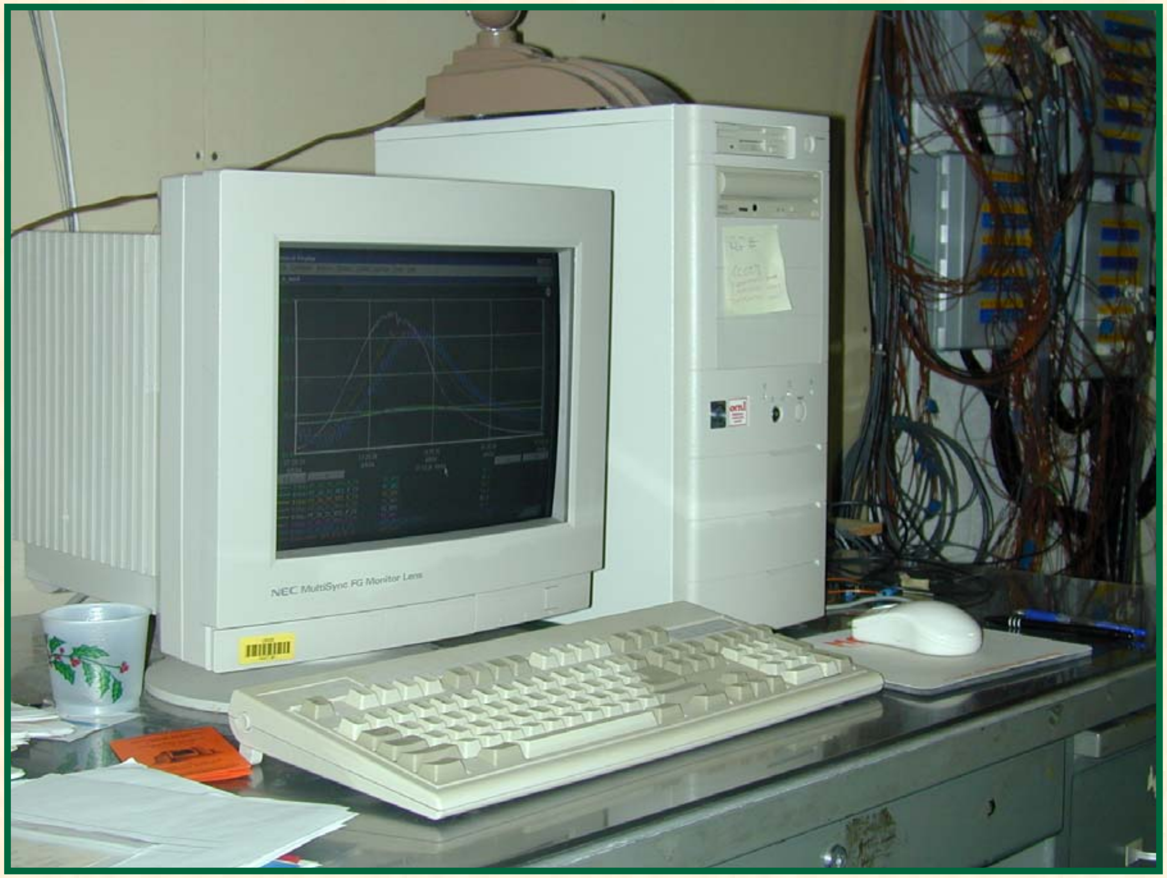
- **Add gypsum panels on inside like at Phoenix and Jacksonville sites**

ORNL Site

- **Have ESRA data acquisition system in place and complete weather station next door**

ORNL Site

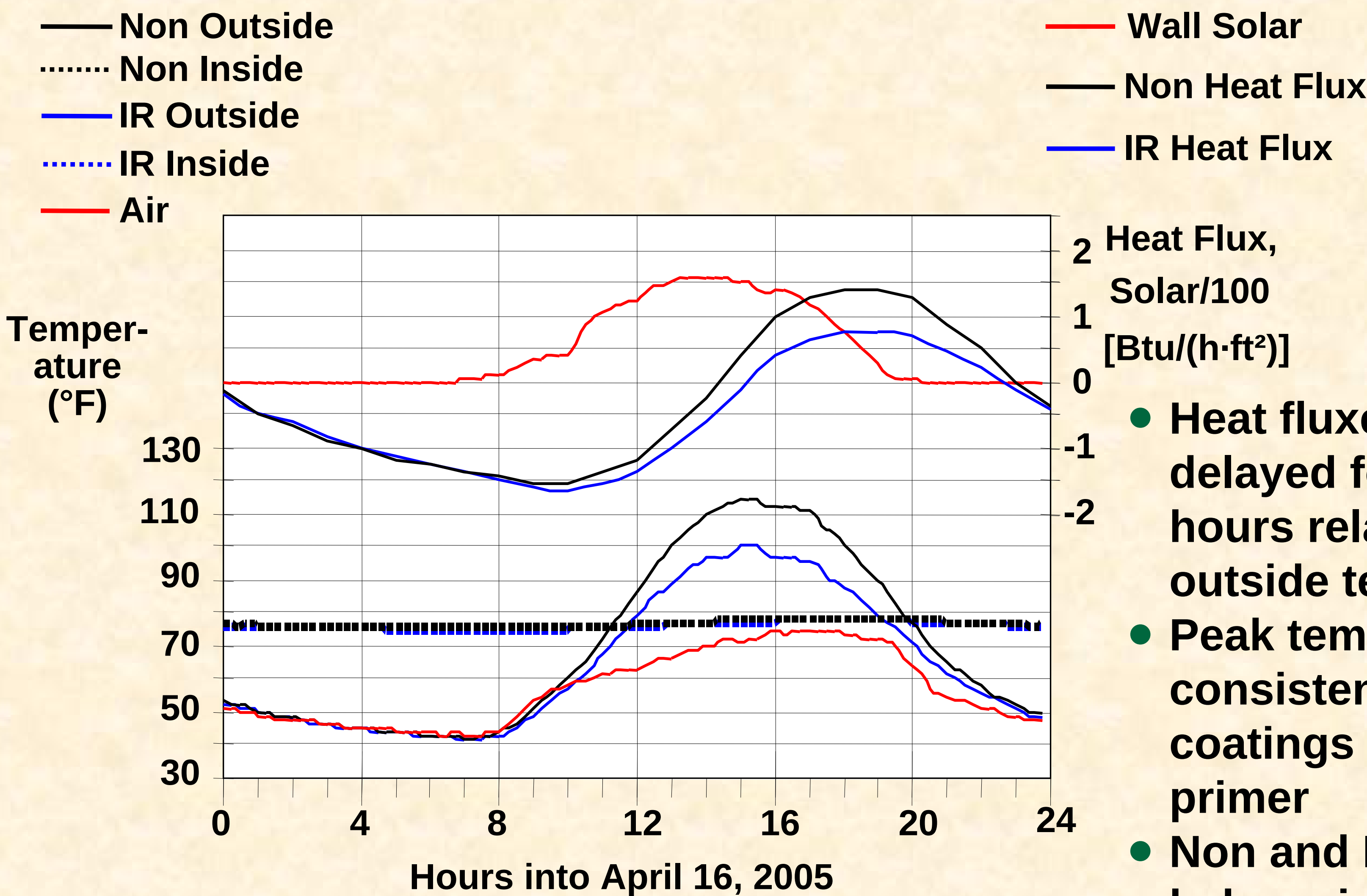
- **Computer dedicated to ESRA data acquisition records detailed thermal performance**



ORNL Site

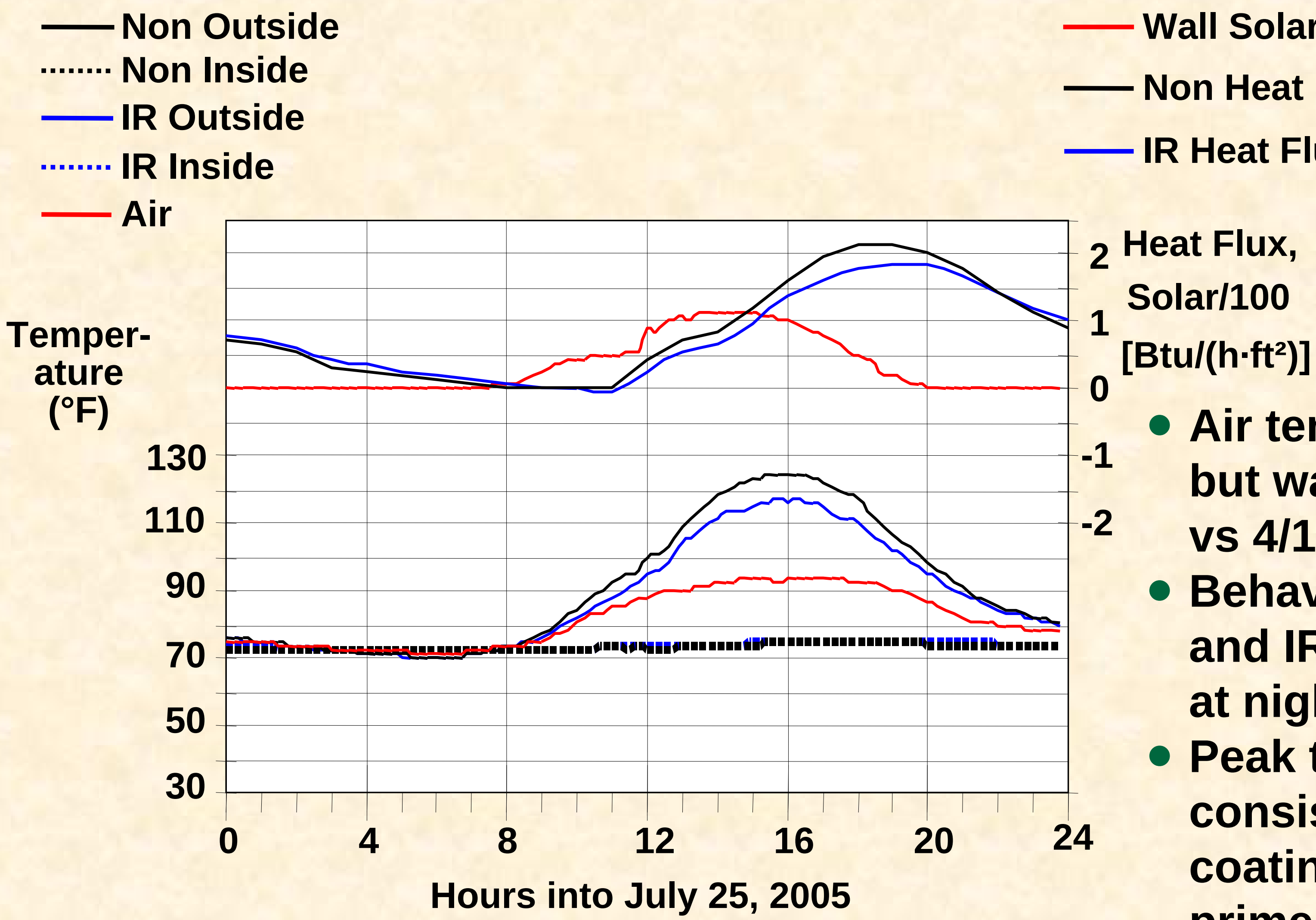
- **Data starting 7/30/04 with coating on 8/3/04. Data acquisition through August 2005**
- **Check consistency of data with program to estimate wall properties from temperature and heat flux measurements. Data very consistent from month to month**
- **Behavior of solar radiation control on vertical walls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

ORNL Site: Non vs IR -- Spring Day



- Heat fluxes delayed four hours relative to outside temp
- Peak temps consistent with coatings over primer
- Non and IR behave identically at night

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

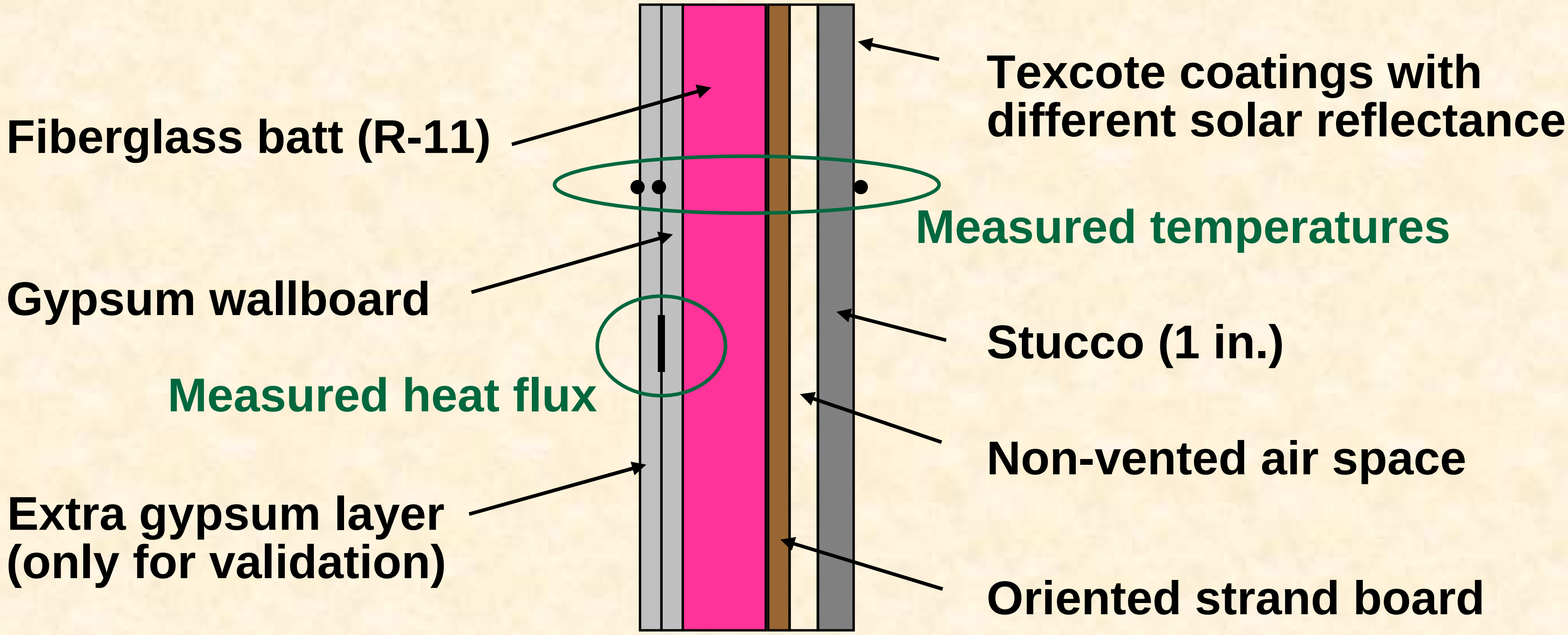
Model for Wall Behavior

- **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**

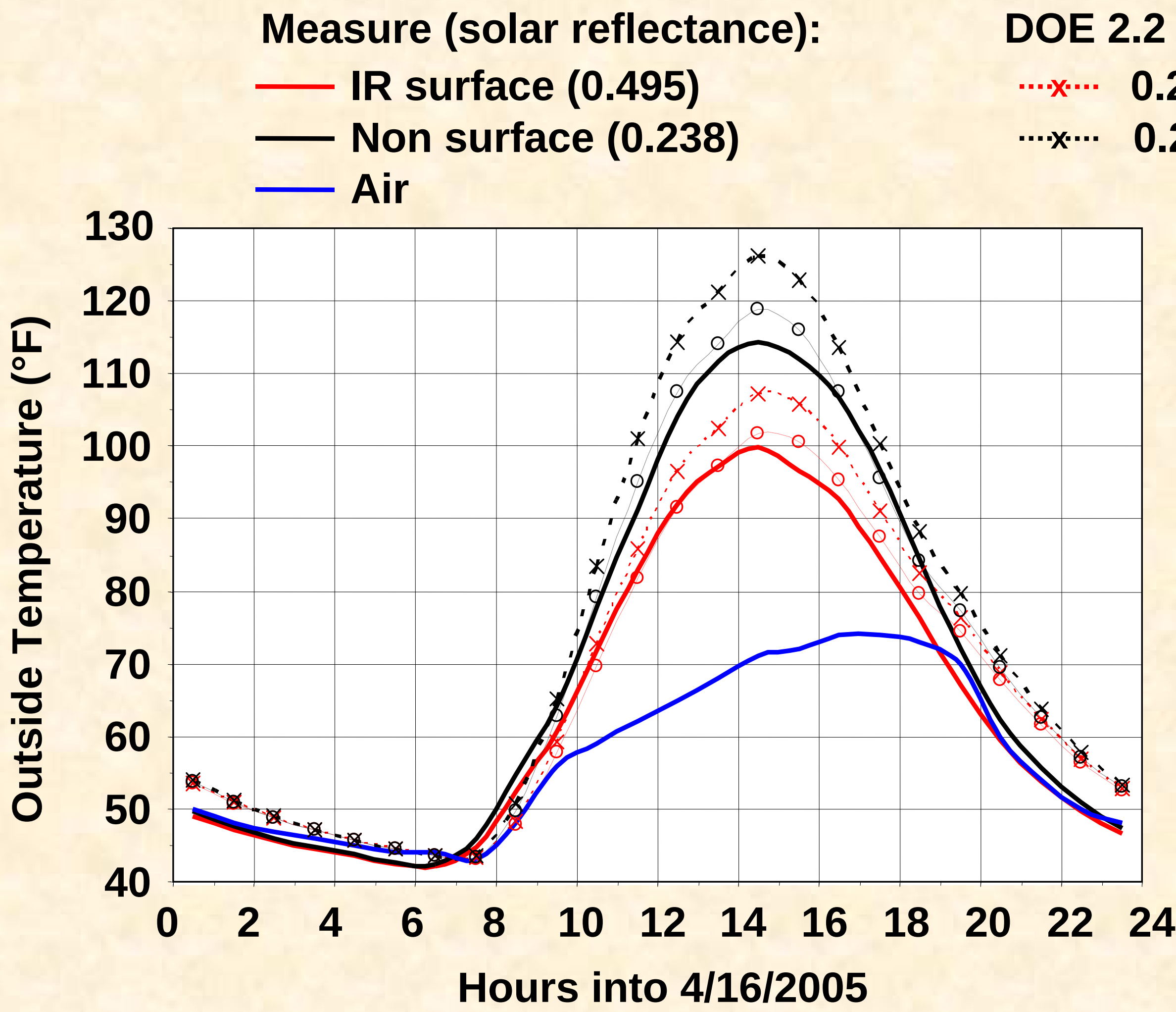
	8/4/04	9/27/04	5/18/05	8/3/05	
Texcote Primer	**0.71**	**0.67**	**0.72**	**0.66**	
Underseas Supercote Pt	**0.49**	**0.50**	**0.49**	**0.49**	**0.50**
Underseas Supercote	**0.24**	**0.24**	**0.24**	**0.24**	**0.24**

Use averages

Features of DOE 2.2 of interest

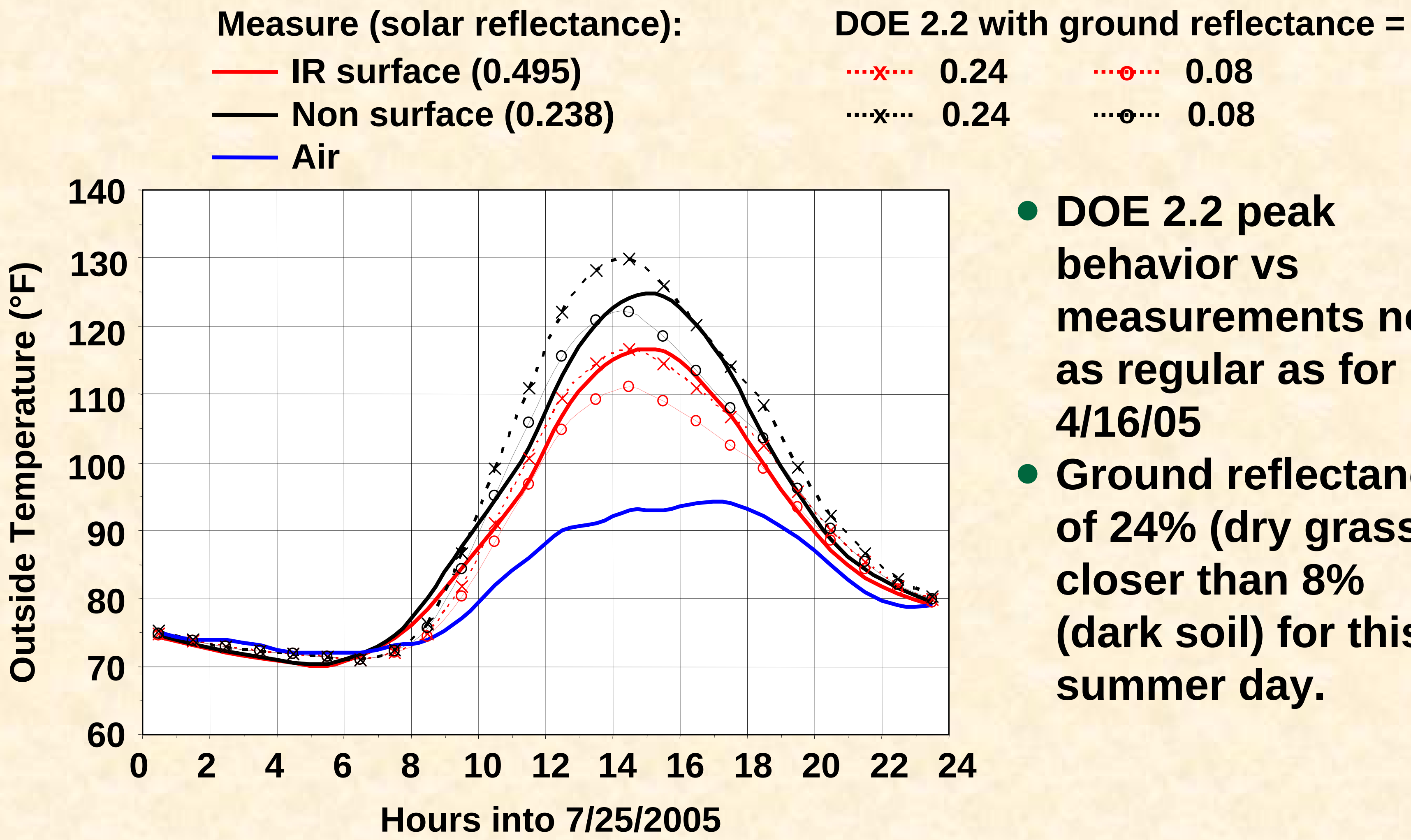
- **Can specify wall and solar reflectance of exterior surface and nearby ground**
- **Sun tracked hour by hour and can shade exterior surfaces by building and landscape**
- **Simulation of annual energy use by heating and cooling system includes response to thermostat schedules and to thermal mass in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

Model of South Wall vs Measurement:
Temperatures at Outside – Spring Day



- Surface measurements and DOE 2.2 predictions equal air temperature at night
- DOE 2.2 peak predictions above peak measurements
- Ground reflectance of 8% (dark soil, asphalt) better than 24% (dry grass) for spring day

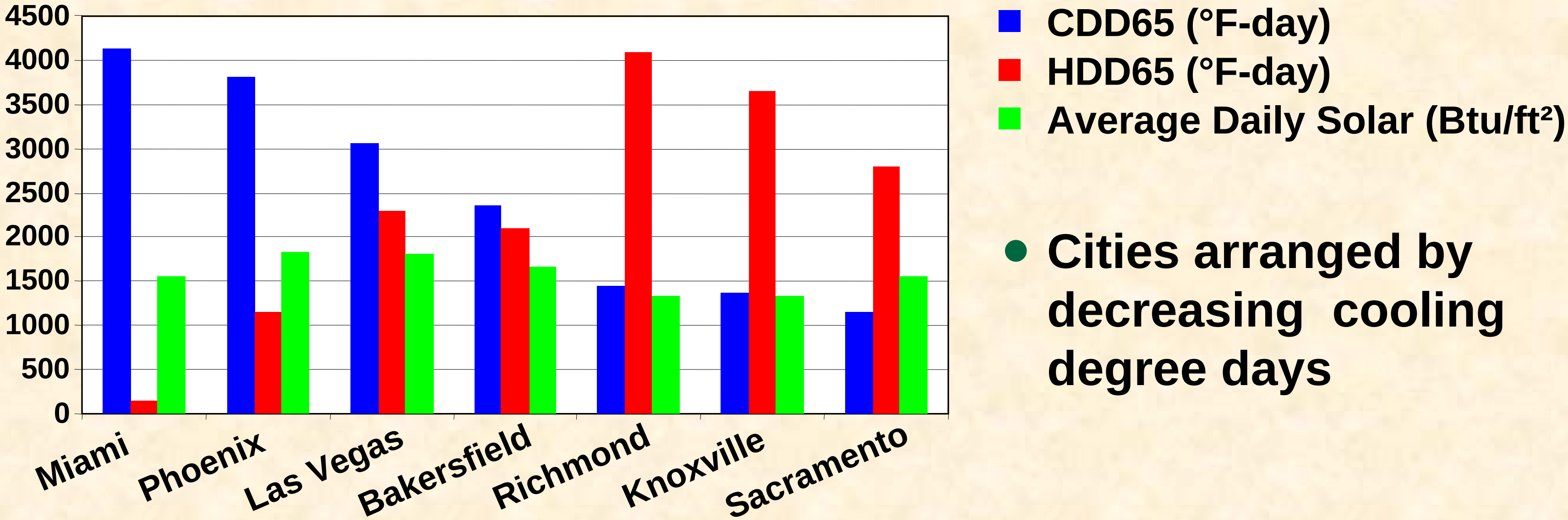
Model of South Wall vs Measurement:
Temperatures at Outside – Summer Day



- DOE 2.2 peak behavior vs measurements not as regular as for 4/16/05
- Ground reflectance of 24% (dry grass) closer than 8% (dark soil) for this summer day.

Model Generalizations

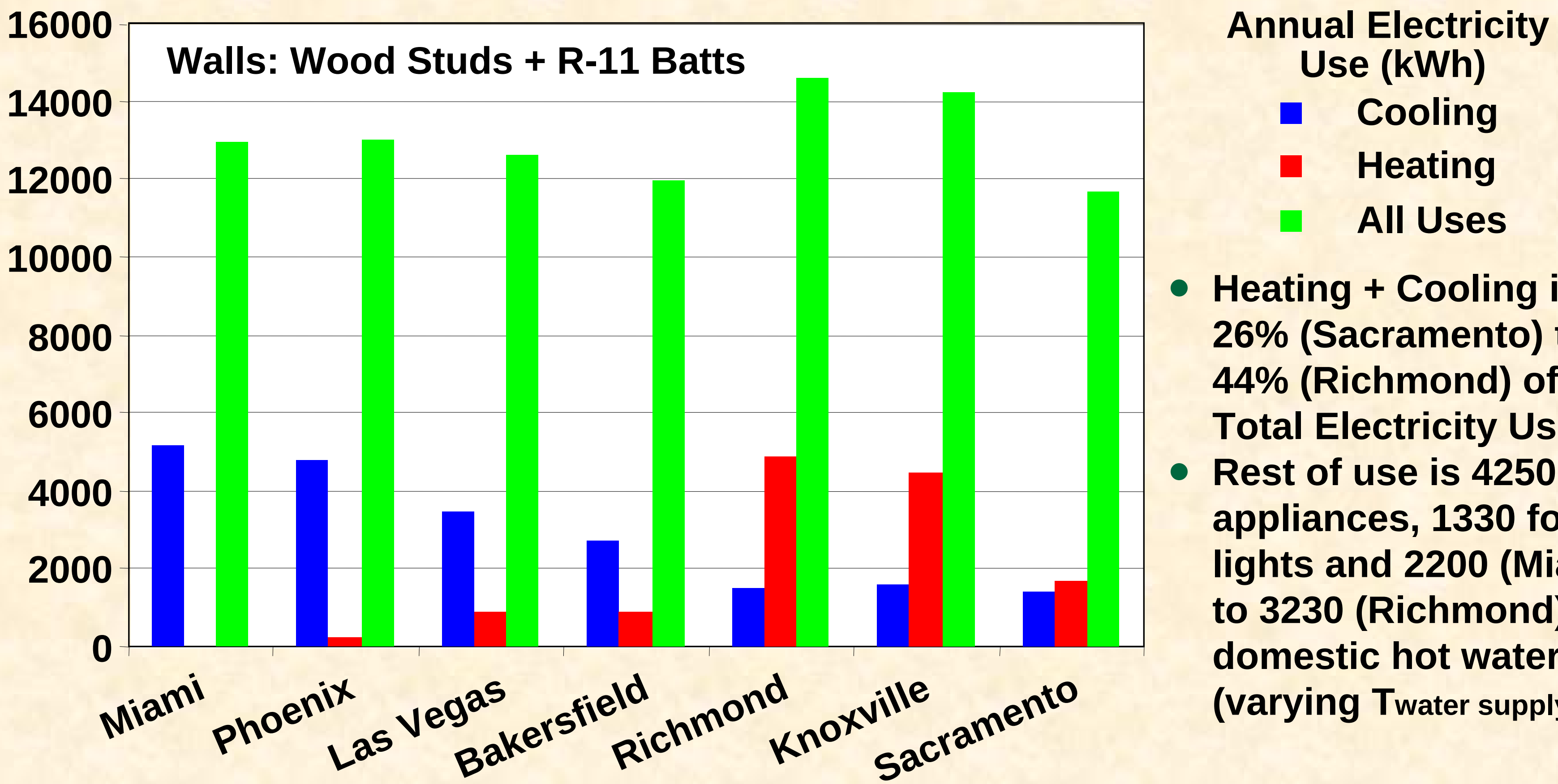
- **Building America Performance Analysis Resources at http://www.eere.energy.gov/buildings/building_america/pa_resources.html gives energy use profiles for three occupants (3 BR home). Choose to heat and cool with air-to-air heat pump (76°F cooling; 68°F heating; no setup or setback)**
- **Choose seven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



- **Cities arranged by decreasing cooling degree days**

Model Generalizations

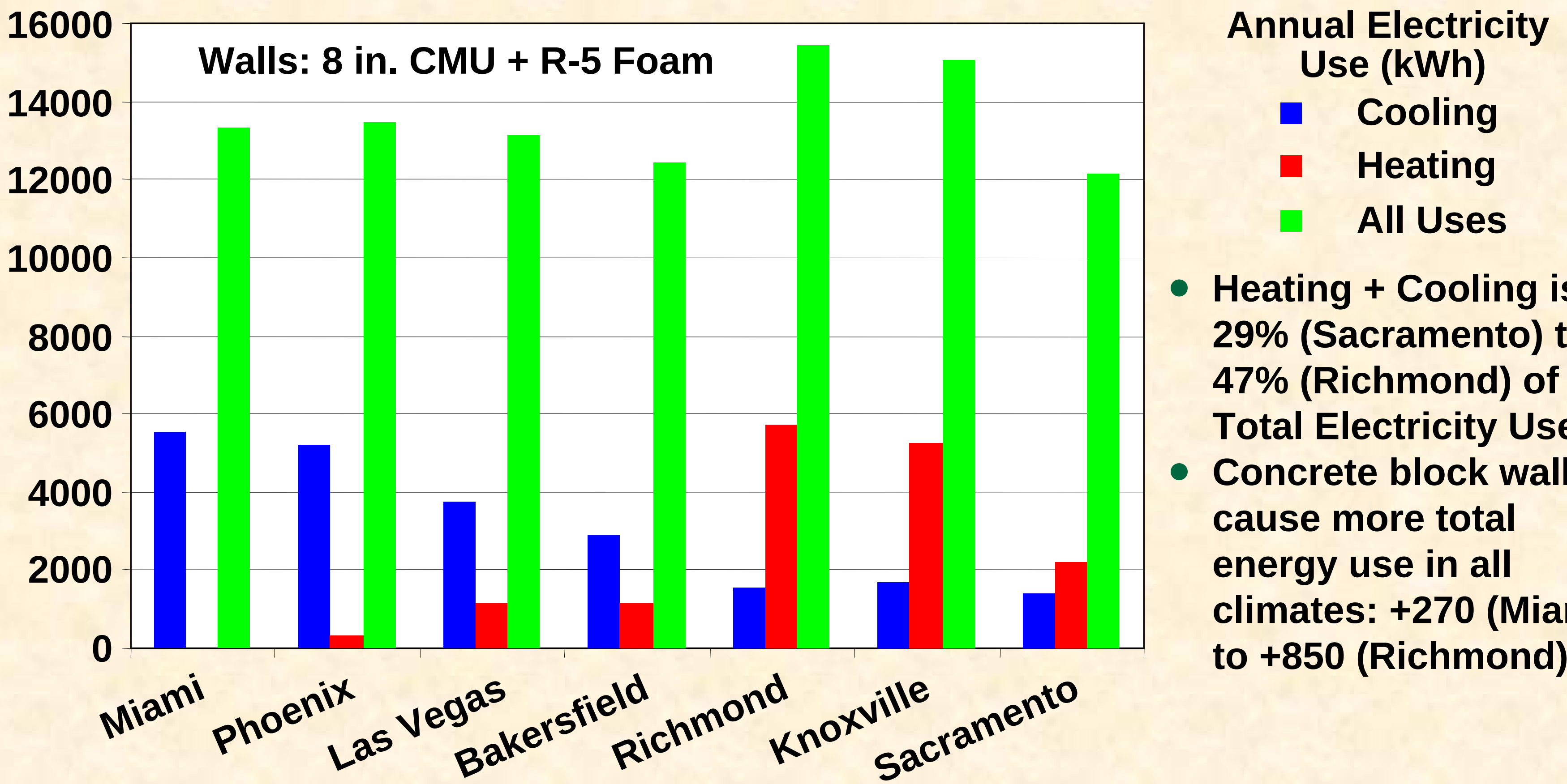
- **Ranch house with non-IR reflecting coating on walls shows variation in heating and cooling energy use that is consistent with climate variation**



- **Heating + Cooling is 26% (Sacramento) to 44% (Richmond) of Total Electricity Use**
- **Rest of use is 4250 for appliances, 1330 for lights and 2200 (Miami) to 3230 (Richmond) for domestic hot water (varying $T_{water\ supply}$)**

Model Generalizations

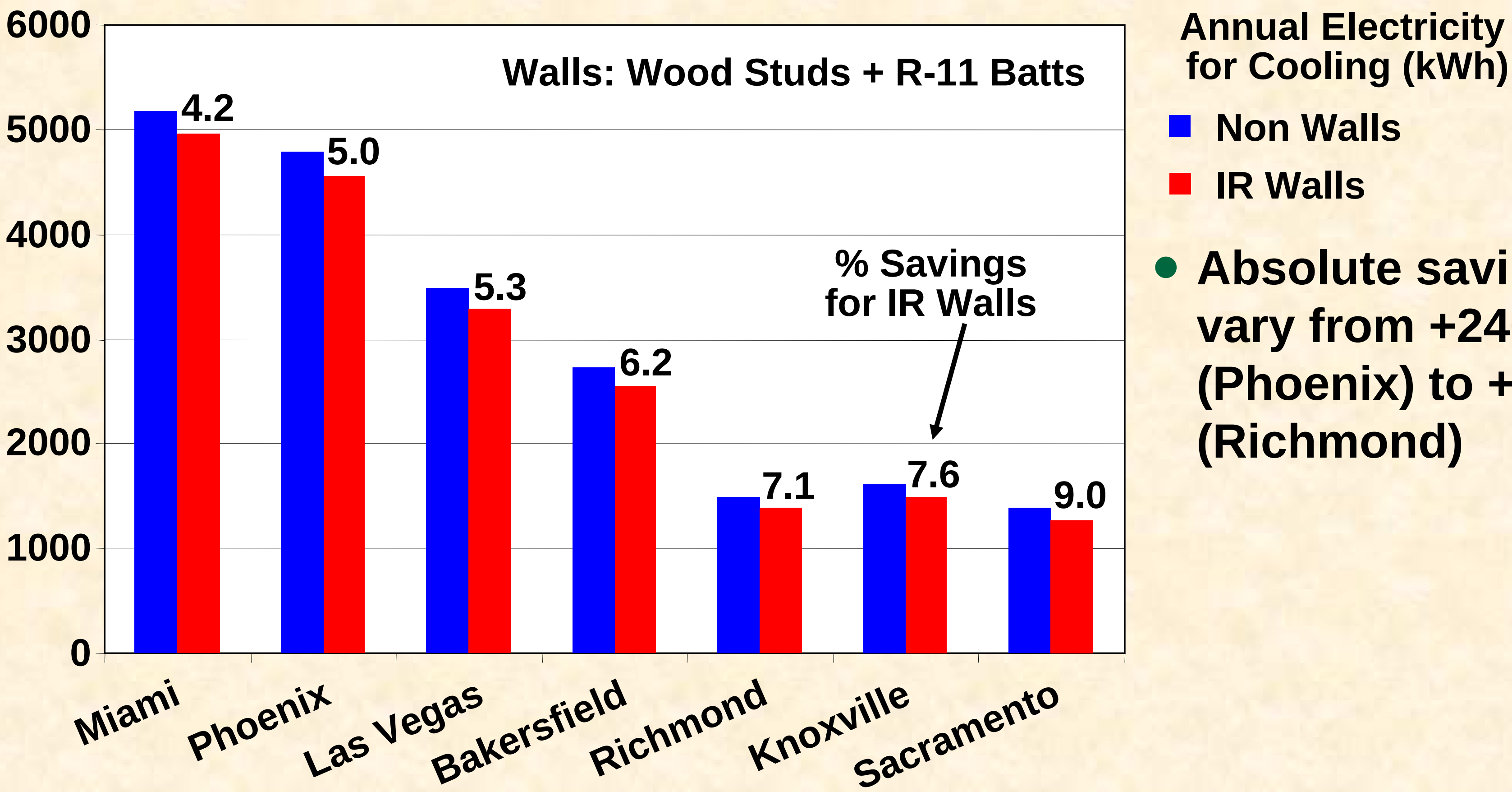
- **Alternate wall configuration of interest for cooling climates. Keep attic and floor insulation levels for consistency**



- **Heating + Cooling is 29% (Sacramento) to 47% (Richmond) of Total Electricity Use**
- **Concrete block walls cause more total energy use in all climates: +270 (Miami) to +850 (Richmond)**

Model Generalizations

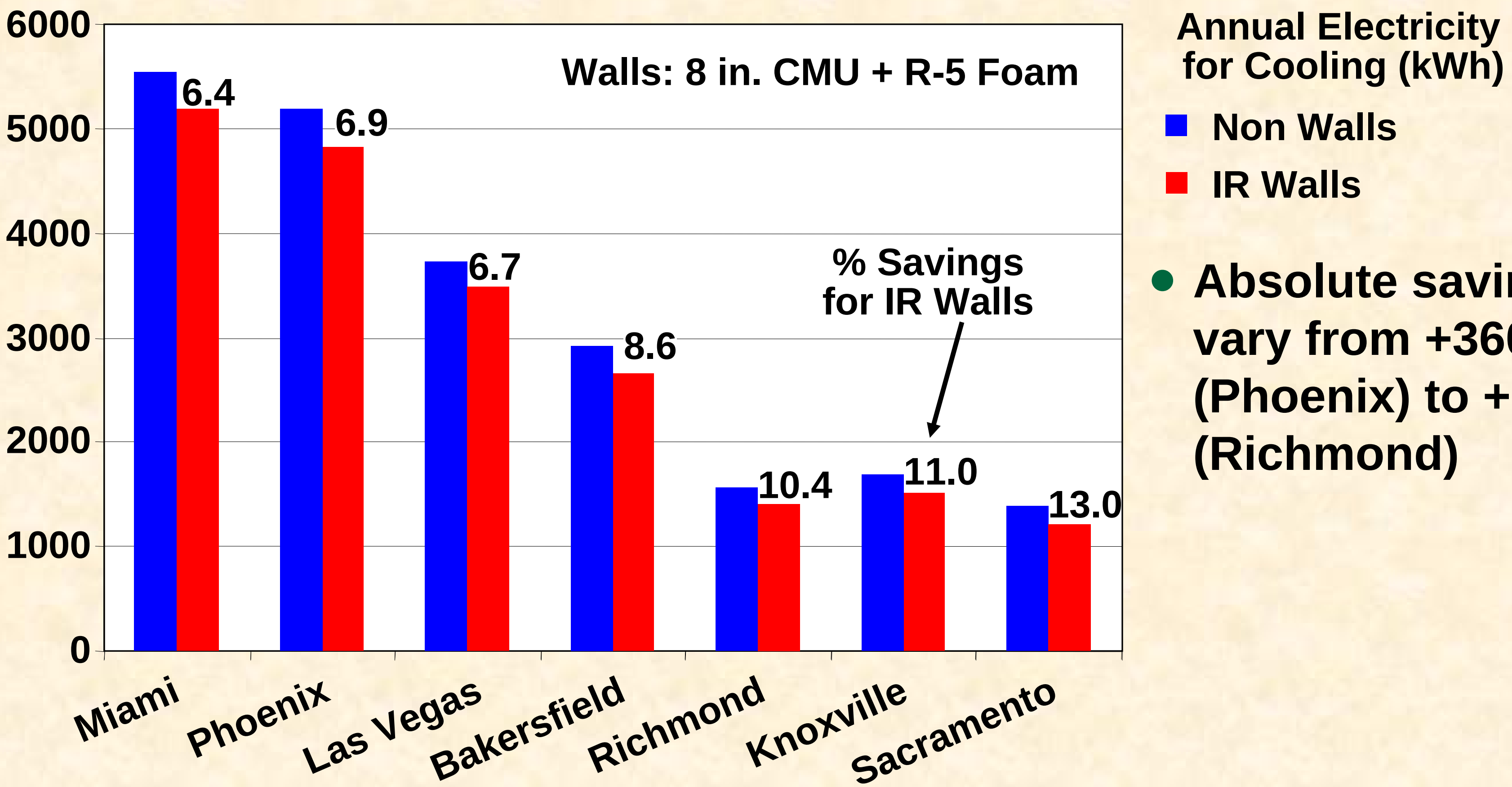
- **IR reflective coating on conventional walls saves cooling energy. Savings are 4% to 9% compared to non-IR reflecting walls**



- **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**



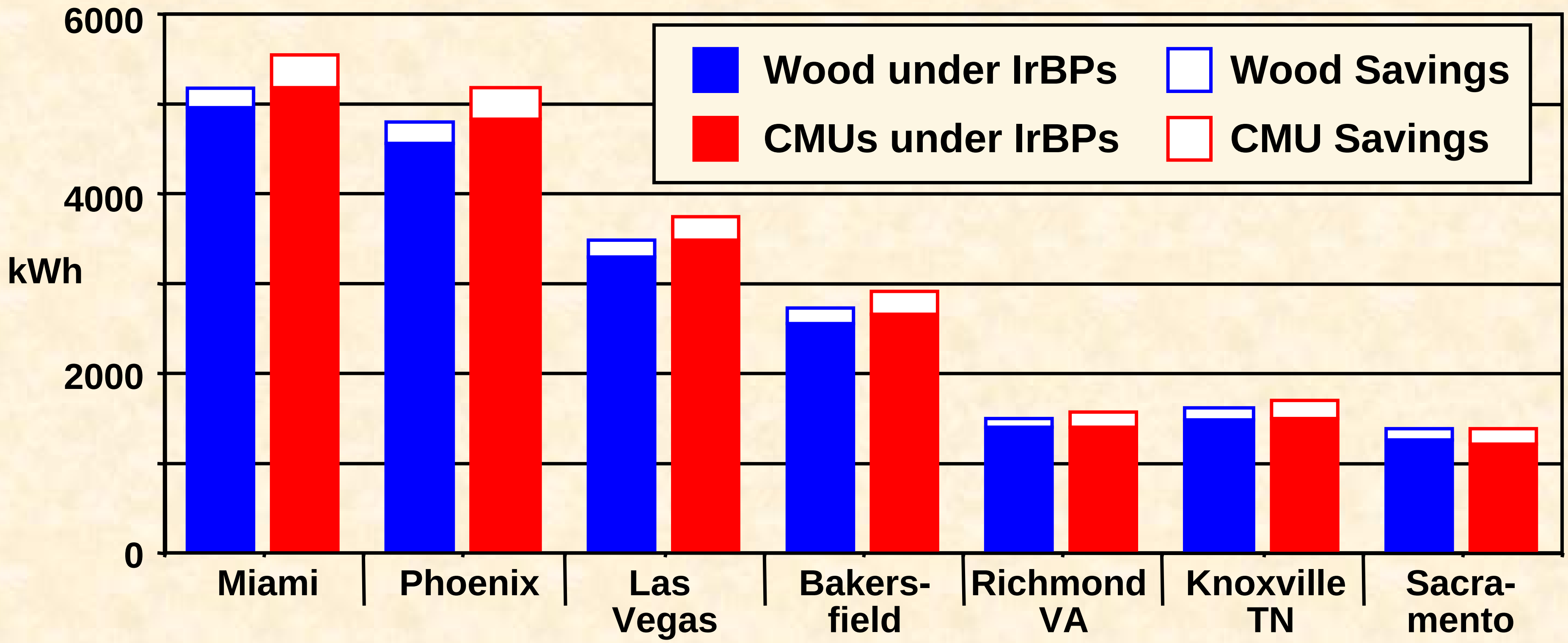
- **Absolute savings vary from +360 (Phoenix) to +160 (Richmond)**

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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Questions or comments?