

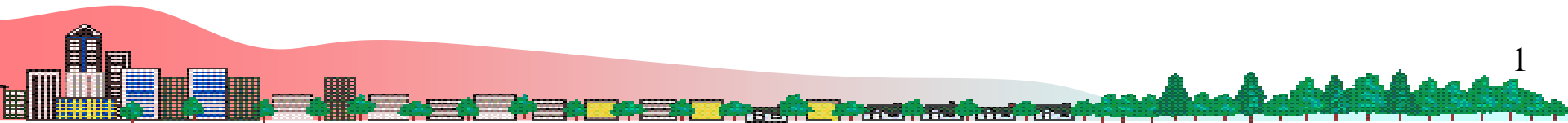
# Comparison of Software Models for Energy Savings from Cool Roofs

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# The Roof Savings Calculator (RSC) is a web-based tool to estimate cool-roof energy savings

## Roof Savings Calculator (RSC)

Beta Release v0.92

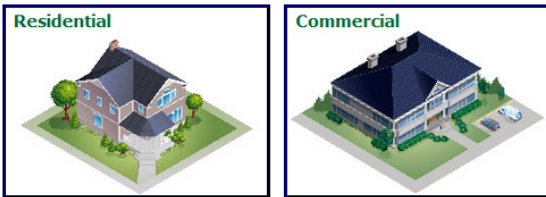
Oak Ridge National Laboratory  
Lawrence Berkeley National Laboratory

### Introduction

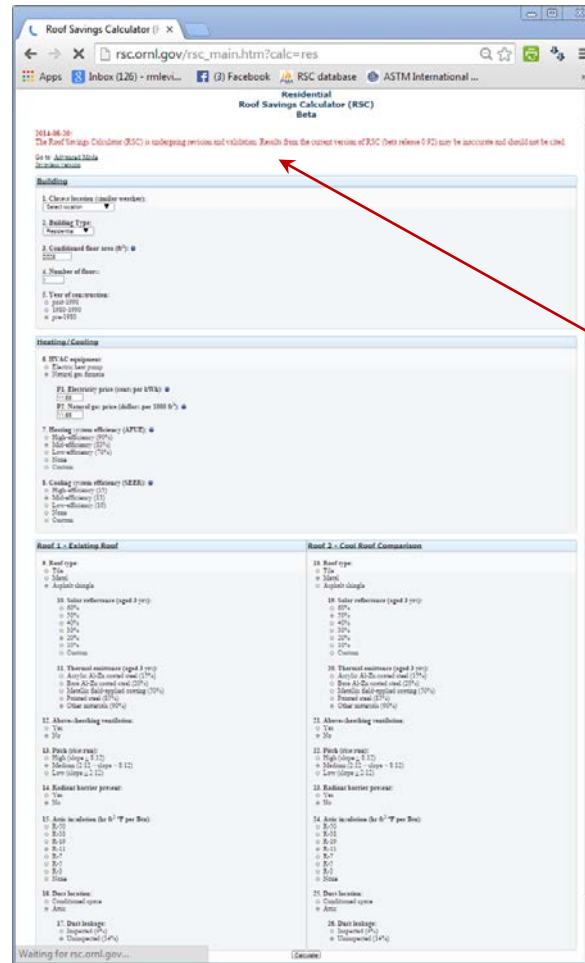
The Roof Savings Calculator was developed as an industry-consensus roof savings calculator for commercial and residential buildings using whole-building energy simulations. It is built upon the DOE-2.1E engine for fast energy simulation and integrates AtticSim for advanced modeling of modern attic and cool roofing technologies. An annual simulation of hour-by-hour performance is calculated for the building properties provided based on weather data for the selected location. Annual energy savings reported are based upon heating and cooling loads and thus this calculator is only relevant to buildings with a heating and/or cooling unit.

### Roof Savings Calculator

To begin, please select from the following options:



RSC = doe2attic + web interface  
doe2attic = DOE2.1E + AtticSim



2014-08-20:  
The Roof Savings Calculator (RSC) is undergoing revision and validation. Results from the current version of RSC (beta release 0.92) may be inaccurate and should not be cited.

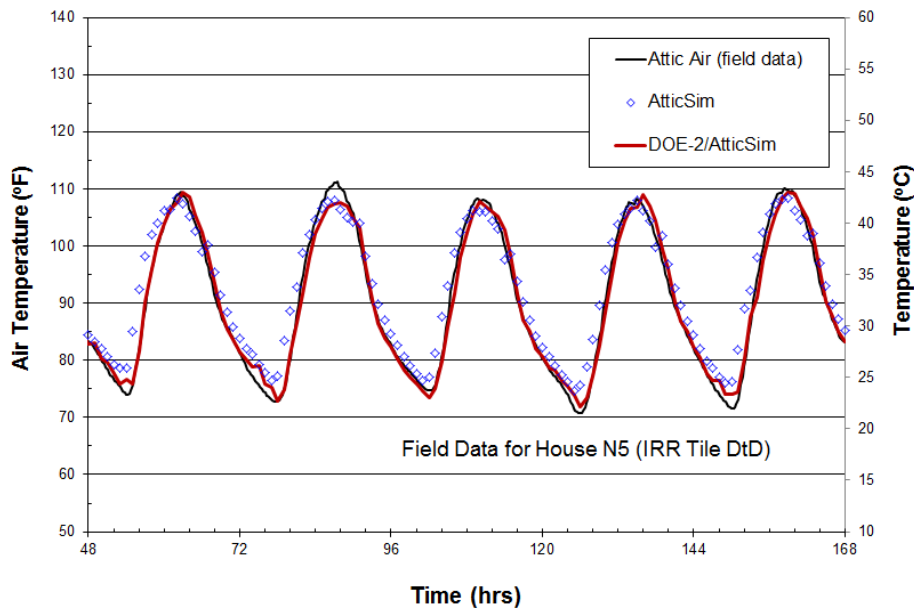
## **RSC uses doe2attic, a modified version of DOE-2.1E coupled with AtticSim**

- DOE-2.1E is used as the whole-building simulation program to take the ceiling heat flows and duct losses calculated by AtticSim and simulate their effects on the building's heating and cooling energy use
- AtticSim is a detailed simulation program to model attic heat transfer, developed by ORNL starting in the 1990s
- AtticSim is an ASTM-certified procedure for estimating heat gain and loss through ceilings under attics (ASTM C1340/C1340M-10)
- AtticSim has been calibrated against measured data
- AtticSim runtime for two simulations of a two-zone home is 58 seconds with ducts in the attic, and 14 seconds without
- DOE-2 requires less than 5 seconds for the two annual building simulations, thus accounting for only 7-25% of total RSC runtime

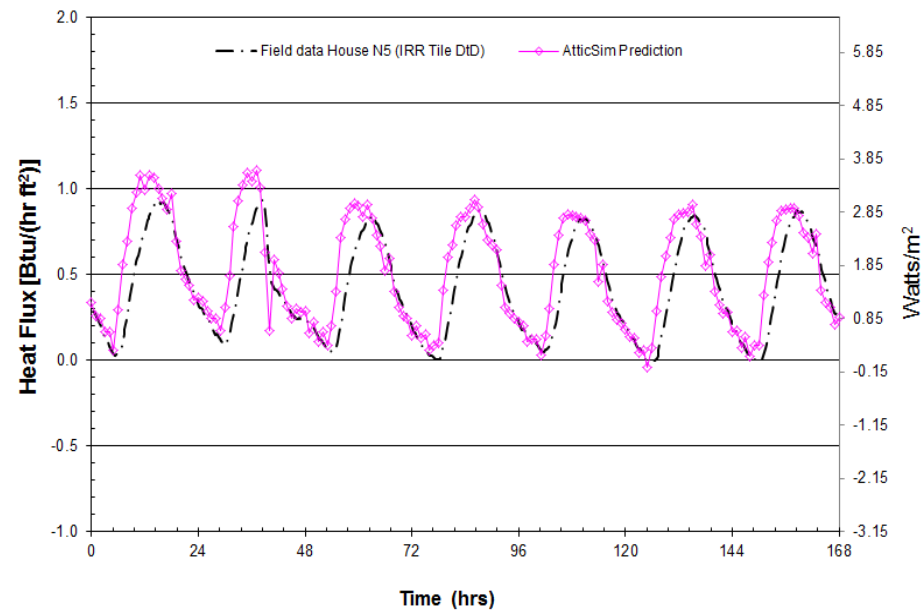


# Early benchmarking efforts validated AtticSim, doe2attic against southern California homes

Attic air temperature



Attic floor heat flux



- single-family home
- direct-to-deck cool tile roof
- RSI-6.7 (R-38) batt insulation on attic floor
- tested August 2008 in Fort Irwin, CA



# RSC results diverged from earlier LBNL studies

## Old office w/built-up-roof

RSC v0.92 (2010)

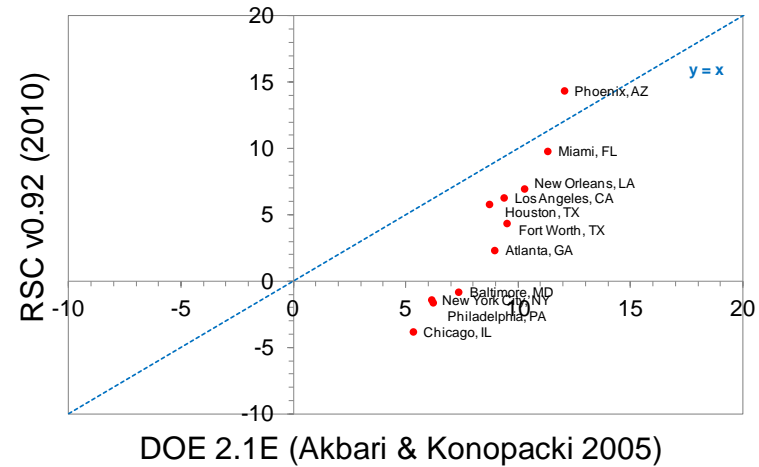
vs.

DOE2.1E (Akbari & Konopacki 2005):

- cooling savings  $\approx 1.2X$
- heating penalty  $\approx 12X$



source energy savings (kBtu/y·ft<sup>2</sup> attic)



## New home w/asphalt shingle roof

RSC v0.92 (2010)

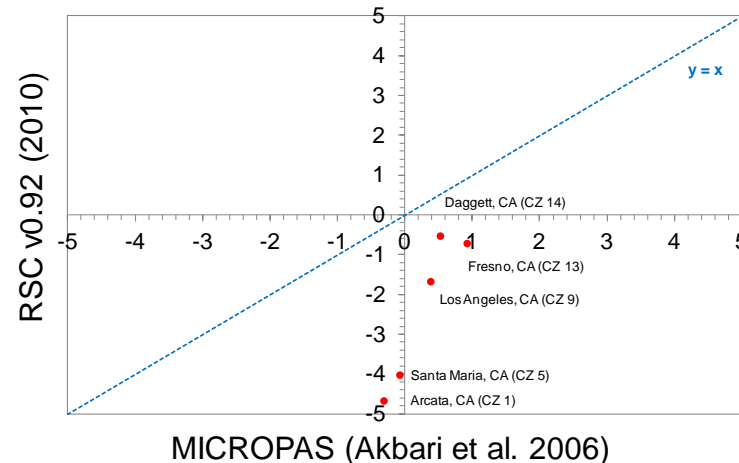
vs.

MICROPAS (Akbari et al. 2006):

- cooling savings  $\approx 1.4X$
- heating penalty  $\approx 11X$



source energy savings (kBtu/y·ft<sup>2</sup> attic)



# Adding radiant heat transfer to attic model should *amplify* annual source energy savings

Old office w/built-up roof, unventilated attic, no ducts in attic

doe2attic (2014-04-28)

vs.

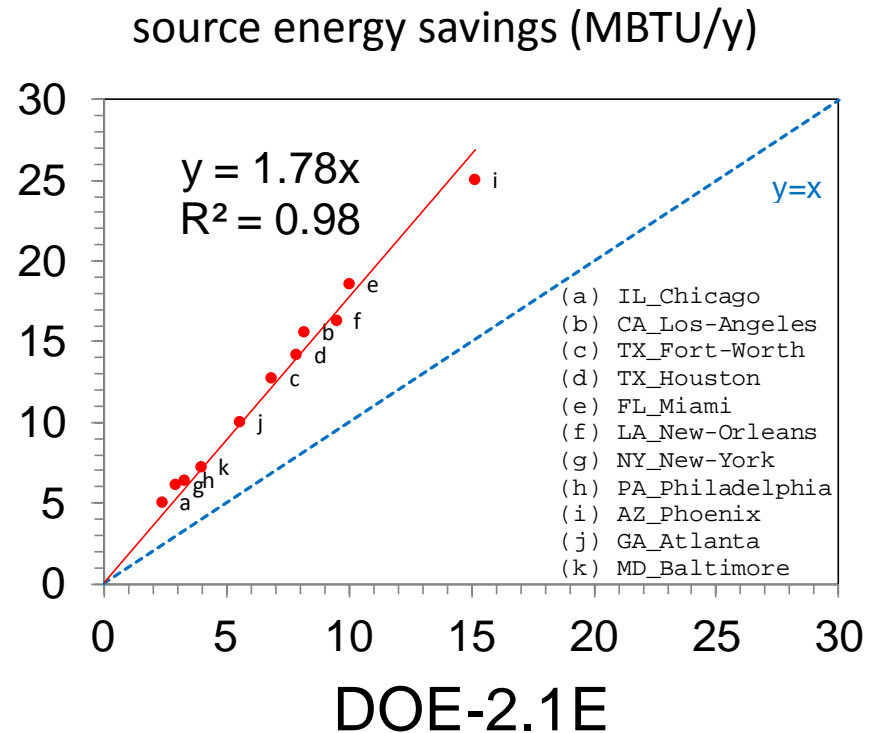
DOE2.1E:

- cooling savings  $\approx 1.73X$
- heating penalty  $\approx 1.59X$

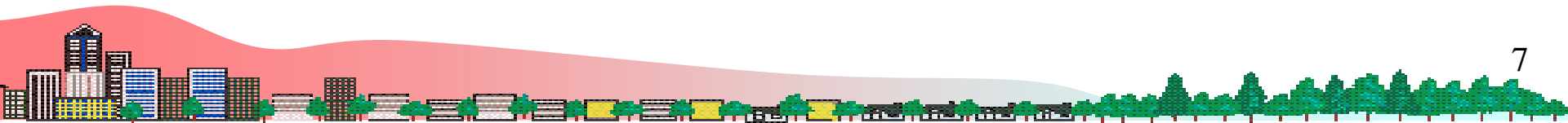
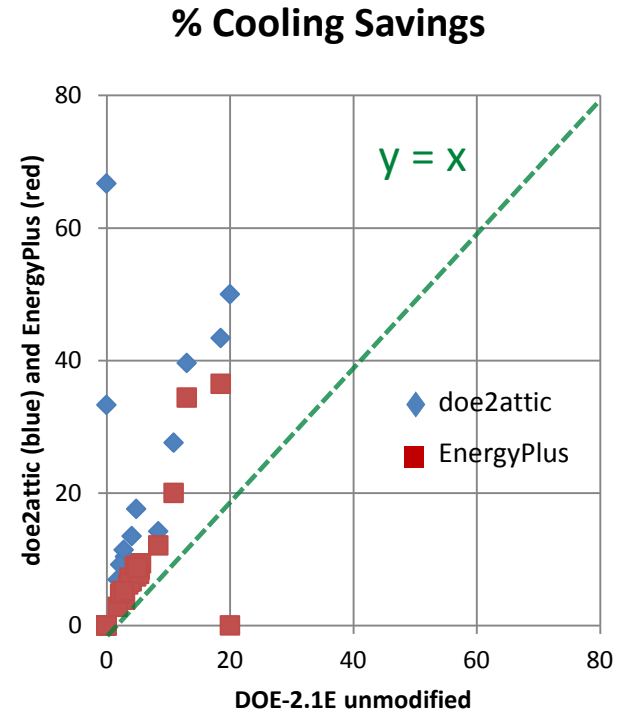
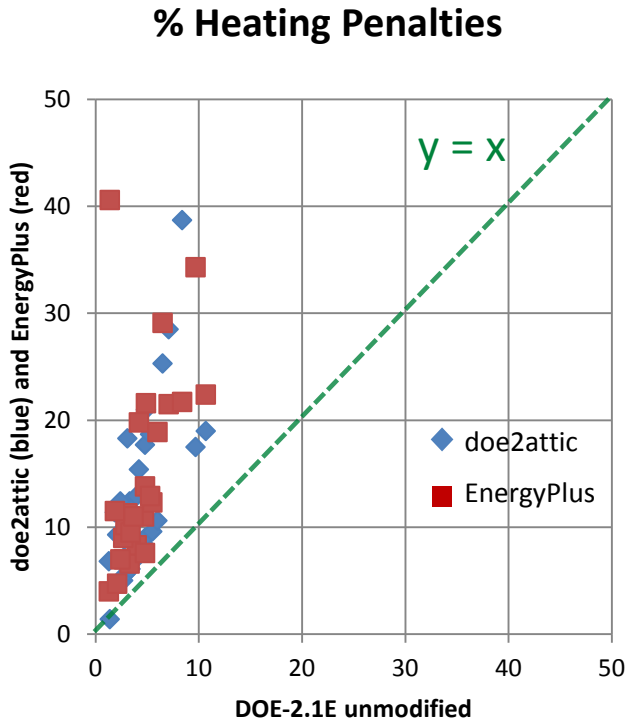


source energy savings  $\approx 1.78X$

doe2attic (2014-04)

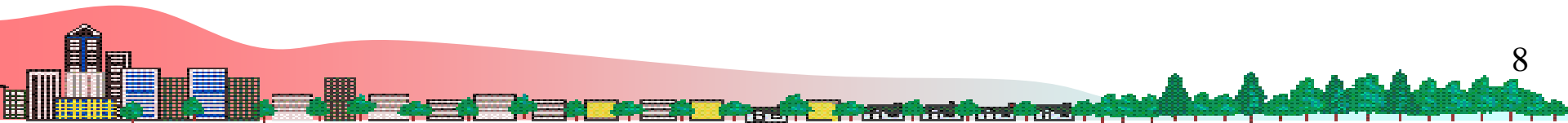


# doe2attic, EnergyPlus each predict % heating penalties, % cooling savings >> DOE-2.1E



## Team has identified several issues (to date) with RSC 0.92

Symptom	Cause	Resolution
Attic temperatures did not vary with amount of ceiling insulation	Mix-up between Conduction Transfer Functions (CTF) in AtticSim and Response Factors (RF) in DOE-2	DOE-2 RFs converted to CTFs when passed to AtticSim
AC undersized in office building	Order of zones in SYSTEM did not match that in LOADS, causing heat flows calculated by AtticSim to be added to the wrong zone	Input file correction
Roof bottom, attic, ceiling temperatures and heat flows incorrect in office		
Unusual heat flow timing in top of attic	Arrays for duct elements in AtticSim too small, causing overwriting of heat flows	Arrays for ducts expanded in AtticSim

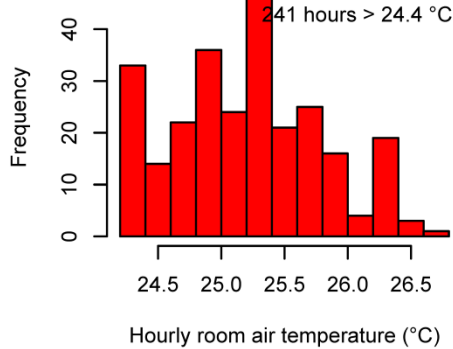




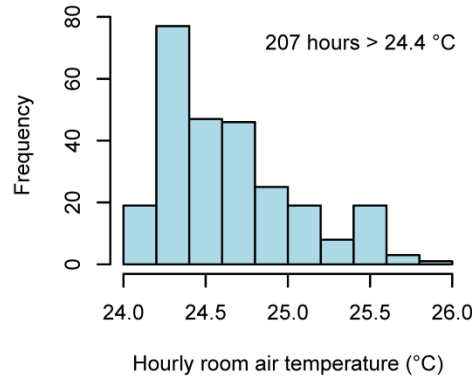
# Undersized AC in office building diminished cooling energy savings in RSC v0.92

## RSC v0.92 (2010), Fresno

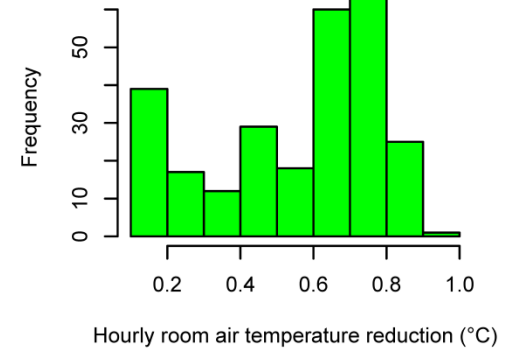
Jul: old\_office\_wdroof, SR=20



Jul: old\_office\_wdroof, SR=60

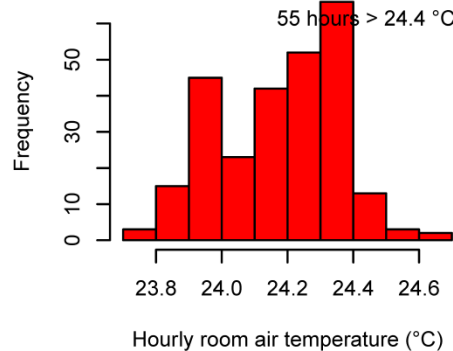


Jul: old\_office\_wdroof (reduction)

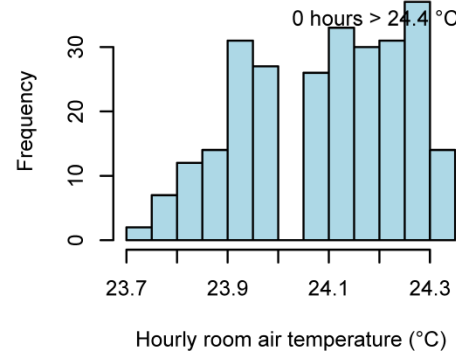


## doe2attic (2014-03-30), Fresno — fixed

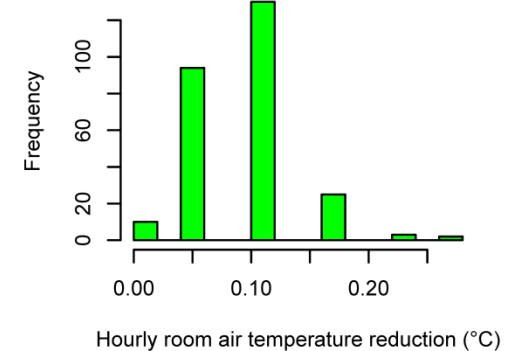
Jul: old\_office\_wdroof, SR=20



Jul: old\_office\_wdroof, SR=60

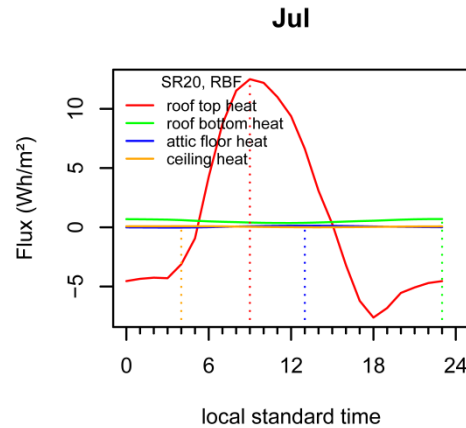
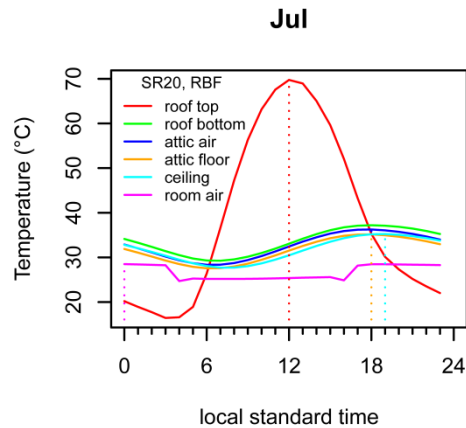


Jul: old\_office\_wdroof (reduction)

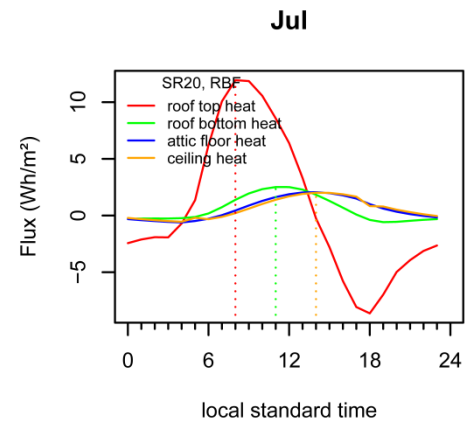
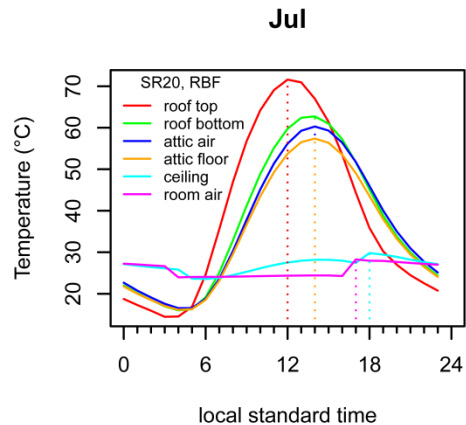


# Office building's roof bottom, attic, ceiling temperatures and heat flows were incorrect

RSC v0.92 (2010), Fresno

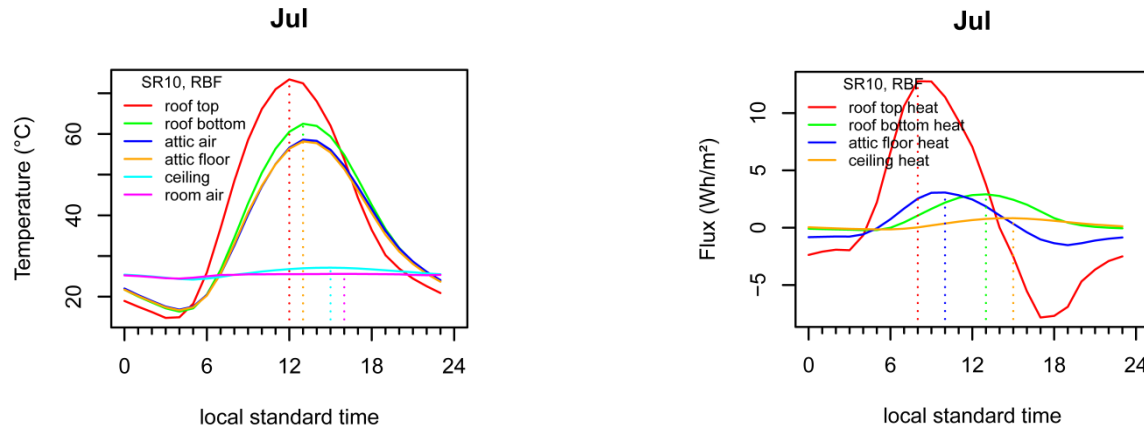


doe2attic (2014-03-30), Fresno — fixed

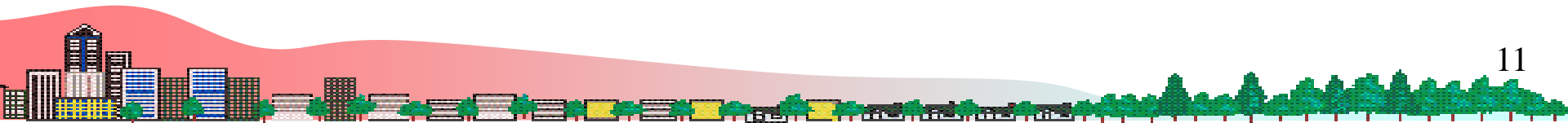


# Home's attic-floor heat flux peaks at 10:00 LST, about 4 to 5 hours earlier than expected

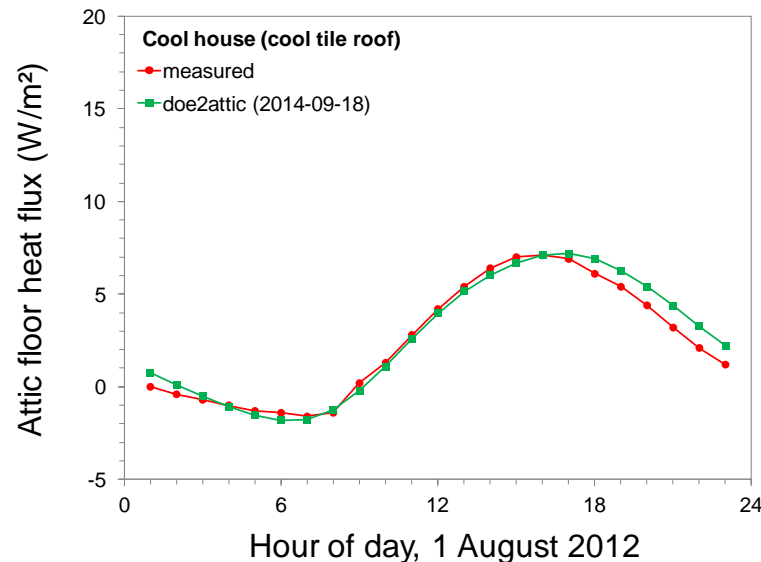
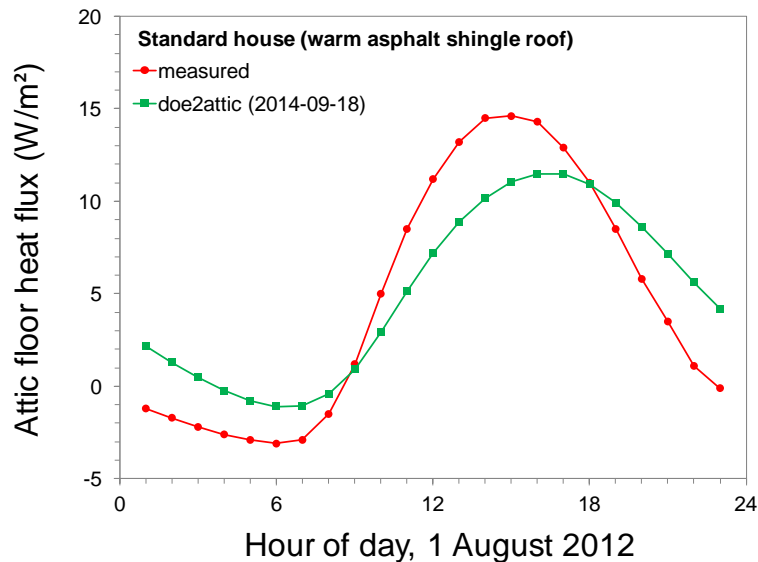
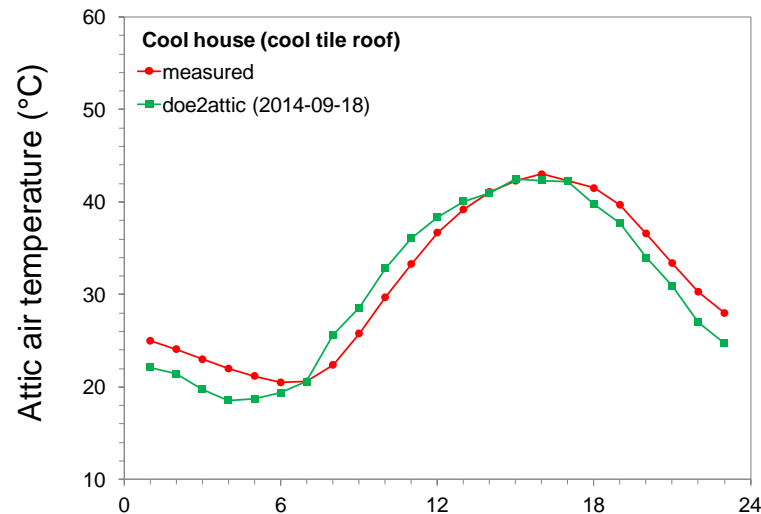
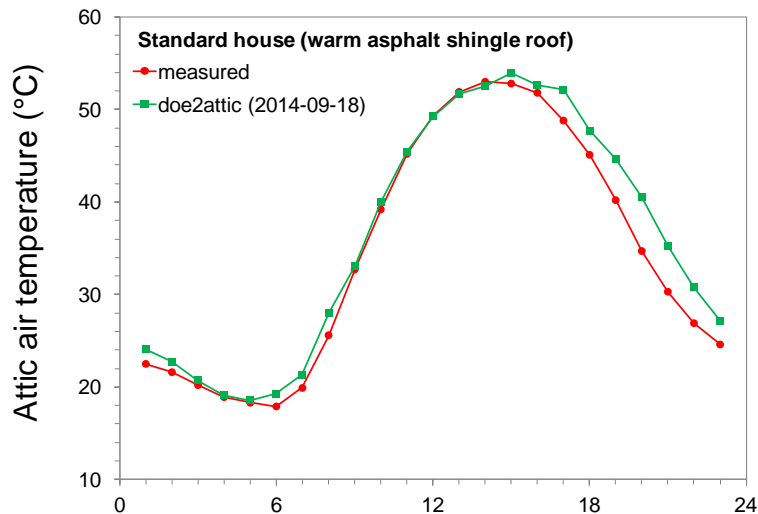
RSC v0.92 (2010), Fresno



Issue appears to be fixed  
in latest runs (September 2014).

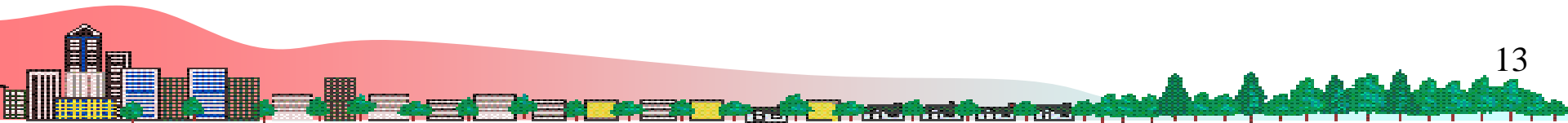


# doe2attic is being validated against measurements from Fresno cool roof study (Rosado et al. 2014)

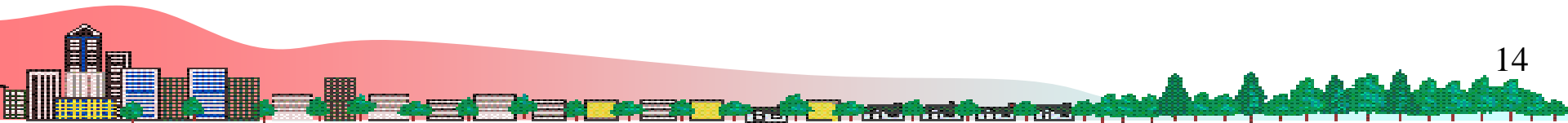


## **We seek to repair and validate RSC this fall, release update in 2015**

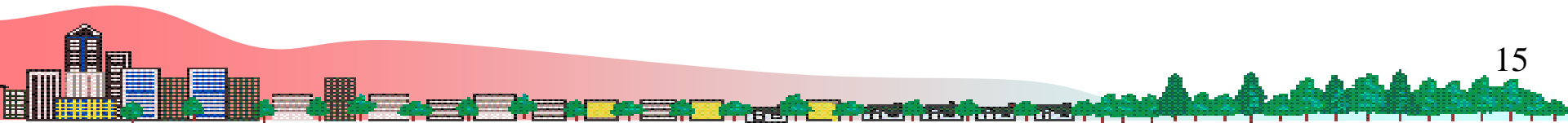
- All identified problems have been resolved
- Continue review of code (e.g., for reasonableness of local heat transfer coefficients)
- Evaluate magnitudes, timing of temperatures, heat fluxes, energy uses, energy savings predicted by doe2attic
- Validate doe2attic against Fresno home measurements
- Release RSC v1.0 in 2015



**Thank you**

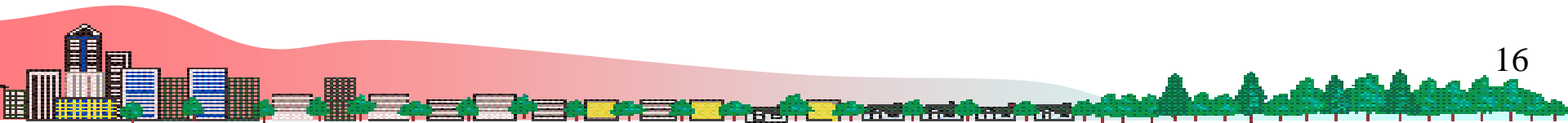


# **SUPPLEMENTAL SLIDES**



## Why doe2attic (DOE-2.1E + AtticSim) instead of EnergyPlus (i/ii)

- AtticSim is an ASTM standard (C1340 / C1340M-10)
- AtticSim has better algorithms for modeling the attic and ducts
- DOE-2 runs up to 80 times faster in calculating the building loads, thus minimizing RSC runtime
- The authors are intimately familiar with AtticSim and DOE-2 and able to modify them as needed





# Why doe2attic (DOE-2.1E + AtticSim) instead of EnergyPlus (ii/ii)

Heat transfer mechanism	AtticSim method of calculation	EnergyPlus method of calculation	Recommended changes to EnergyPlus
<b>Radiation</b>	View factors  Calculated internally based on fixed geometry shape	Approximated method or view factor inputs  The approximated method based on area ratios may be too simple.  Inputs may be used to provide more accurate view factors.	E+ will use Radiance to calculate view factors. This configuration algebra approach requires fixed geometry.  Mean Radiant Temperature may be better than the approximated method as a simplified approach
<b>Ventilation</b>	The ventilation air is a combination of stack and wind.  Heat transfer includes multiple surfaces in contact with ventilation air.	Have multiple ventilation objects to calculate ventilation rate as a function of temperature, wind speed, and stack effect.  No heat transfer along flow pathway between surfaces and ventilation air.	E+ may adopt this approach.  Authors are unsure if EnergyPlus includes heat transfer between ventilated air and surfaces.