



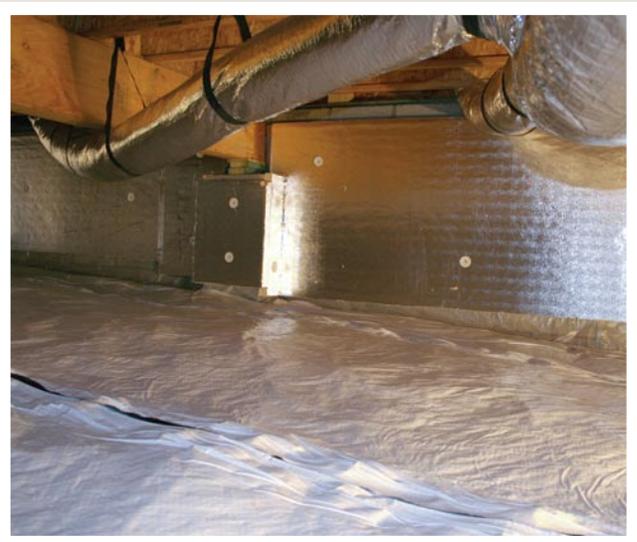
## CLOSED CRAWL SPACES: TOP PERFORMERS NATIONWIDE

### ***New research shows that properly closed crawl spaces earn their keep***

FROM ADVANCED ENERGY'S APPLIED BUILDING SCIENCE TEAM  
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Research results indicate that closed crawl spaces are a great moisture control strategy and also save energy if the installer follows climate-appropriate insulation strategies, as reported by Advanced Energy, a Raleigh, N.C.-based nonprofit.

It's no secret that wall-vented crawl spaces can breed mold and moisture — leading to rot, structural failure and unhealthy indoor air. In 2005, Advanced Energy showed that properly closed crawl spaces in central





North Carolina minimize these problems and provide energy savings, but it was questioned whether they would perform equally well in other climate zones.

Advanced Energy recently completed similar studies in two new locations, the results of which show that closed crawl spaces deliver performance improvements in varying climates.



## The Homes

Researchers monitored two sets of new homes in different climates: a 15-home modular housing development in hot, humid Baton Rouge, La.; and 12 stick-framed homes in cold, dry Flagstaff, Ariz.

To keep moisture out of the crawl space, installers sealed gaps and penetrations in the crawl space walls, then covered the walls with a 6 mil reinforced clear polyethylene vapor retarder. An 8 mil white version was applied over the earth floor and sealed to the wall liner.

BATON ROUGE HOME, TOP.  
FLAGSTAFF BELOW.

In Baton Rouge, researchers tested three closed crawl space designs with two heating, ventilation and air conditioning (HVAC) ductwork configurations:

- Three homes with R-8 Thermax foam board on the foundation walls, and ductwork in the crawl space (**CCS-W-C**).
- Four homes with R-8 Thermax foam board on the foundation walls and ductwork in the attic (**CCS-W-A**).
- Four homes with R-19 fiberglass batts between the floor joists and ductwork in the attic (**CCS-F-A**).

Every Baton Rouge home with a closed crawl space had a small supply duct that delivered conditioned air to the crawl space whenever the HVAC system was running.

In Flagstaff, researchers tested two closed crawl space designs, both with ductwork in the crawl space.

- Four homes with R-30 fiberglass batts between the floor joists (**CCS-F-C**).
- Four homes with R-13 Thermax foam board on the foundation walls (**CCS-W-C**).



SUPPLY AIR DUCT IN A CRAWL SPACE

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Each site included four control homes (**CTL**) built with locally code-compliant vented crawls. The ductwork in Baton Rouge control homes was in the attic, and the ductwork in Flagstaff control homes was in the crawl space.

## The Results

Researchers measured crawl space humidity and home energy use for more than a year in Baton Rouge and for five months in Flagstaff. While the closed crawl spaces stayed considerably drier than the controls, energy use was more varied and included some surprises.

### MOISTURE CONTROL

The primary reason for closing a crawl space is to keep it dry. As intended, humidity stayed low in all the closed crawl spaces regardless of climate, insulation or duct placement.

In Baton Rouge, average daily relative humidity (RH) in closed crawls barely exceeded 60 percent, even in summer, while the vented control crawl spaces often exceeded 80 percent. In Flagstaff, crawl spaces in the control homes remained less than 70 percent RH, but the crawls with the sealed liner system performed even better, never exceeding 50 percent RH.

The research clearly indicates that properly closed crawl spaces are a robust tool for humidity control.

### ENERGY SAVINGS

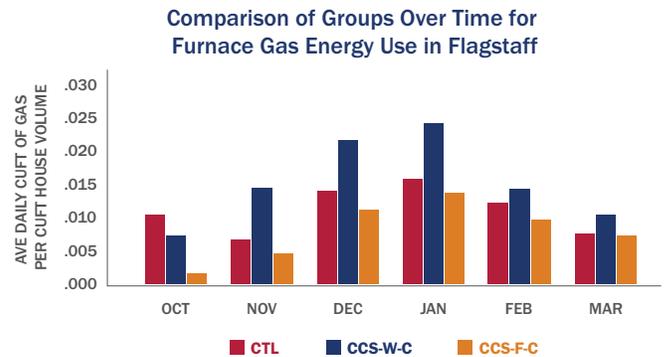
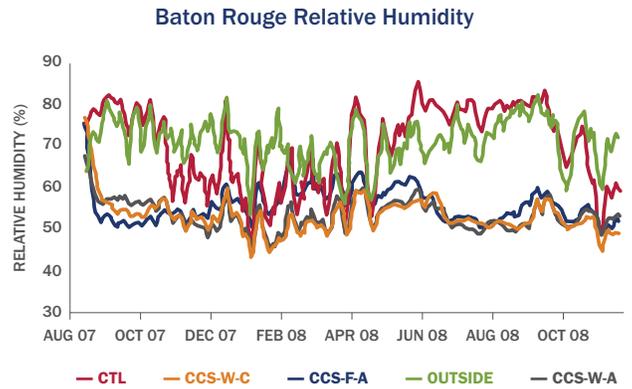
While moisture reduction was consistent, energy savings varied with climate, insulation and duct placement.

In Flagstaff, researchers monitored energy use throughout a single heating season. While the homes with insulated floors used 20 percent less natural gas than the controls, those with insulated foundation walls used 53 percent more.

This seemed counterintuitive; ducts are a notorious source of heat loss. With all the Flagstaff homes' ductwork in the crawl space, one would expect better performance from the warmer, wall-insulated crawl spaces. But according to Cyrus Dastur, the Advanced Energy building scientist who directed the research, those homes' lack of floor insulation let heat radiate from the first floor to the crawl space, robbing more heat from the house than was saved by keeping the ductwork warm.

The research makes it evident that in cold climates, it's better to insulate the floor above the closed crawl space than to insulate the foundation walls.

Baton Rouge results also varied, ranging from a 6 percent savings to a 29 percent penalty. Here, homeowner behavior and the location of insulation and ductwork appears to have caused significant variation. While Advanced Energy plans more monitoring to quantify the impact of occupants in the home, duct placement had an unmistakable effect. Among homes with attic ducts, those with wall-insulated



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crawl spaces performed better in some months while those with floor-insulated crawls did better in other months. But homes with ducts in wall-insulated closed crawls used less energy all year.

***The research indicates that in a hot climate, energy performance is optimized by locating HVAC ductwork in a wall-insulated closed crawl space.***

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### **RADON WORRIES**

Radon can be a concern with closed crawl spaces (in this regard, a closed crawl space is like a short basement), and indeed the Flagstaff closed crawl spaces were re-vented after the discovery of elevated radon levels. Dastur echoes the recommendation of the Environmental Protection Agency (EPA) to test for radon in all homes. Where there is a known radon risk, builders should follow EPA's radon-ready guidelines. If testing indicates elevated radon after the crawl space is complete, the mitigation system can be activated with the addition of an appropriate exhaust fan.

### **Ensuring Performance**

Performance of the closed crawl space over time was also in question. For instance, could a plumbing leak puddle on the floor and raise humidity? Dastur says that while several homes had such leaks, RH did not noticeably increase.



***The biggest challenge to getting a properly closed crawl space is finding a qualified installer.***

Maintenance of the air seal is a bigger concern. A Baton Rouge homeowner installed a satellite dish after moving in. Despite a large sign inside the crawl space indicating that it must remain sealed, the satellite dish installer left a large hole in the wall liner. A wireless remote humidity sensor indicated the problem and repairs were made before any damage occurred. Advanced Energy recommends the installation of wireless humidity sensors in closed crawl spaces, paired with an alarm inside the home, to catch such problems.

The biggest challenge to getting a properly closed crawl space is finding a qualified installer. Crawl spaces in this study were installed to Advanced Energy's guidelines by professionals from E3 Energy and CrawlSpace Care Technologies (CSCT). Advanced Energy is developing a training curriculum that it plans to offer through electric utilities and builder groups, and CSCT provides both training and materials distribution.

Dastur reports that the cost for a closed crawl space in a new N.C. home is typically less than \$2 per square foot. While the air quality and durability benefits alone can make this a worthwhile investment, an added benefit is that the energy savings may pay for the system well before the owners pay off the mortgage.



For more information about closed crawl spaces, visit [www.crawlspaces.org](http://www.crawlspaces.org) or call (919) 857-9000.