U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

Siding & Window Retrofit Case Study

Phoenix, AZ: **Insulating Concrete Block Walls**

Rigid foam exterior insulation and solar screens were among the energy-saving retrofits to this 1950s concrete block home in Phoenix.

Builder Profile

AZ Energy Efficient Home
Phoenix, AZ
Jonathan Waterworth
Jonathan@AZEnergyEfficientHome.com

Project Home

- Name: Slump Block Home
- Location: Phoenix, Arizona
- Layout: 3-bdrm, 1 bath, 1 fl, 1,980 ft²
- Climate: IECC 2B, hot-dry
- Year Built: 1949
- Retrofit Completed: July 2021

Performance Data

- Home Energy Score:
  pre-retrofit: 1
  post-retrofit: 5
- Estimated Annual Energy Costs
  $1,925
- Estimated Annual Energy Cost Savings $486
- Blower Door:
  pre-retrofit: 10.1 ACH 50 estimated
  post-retrofit: 5.9 ACH 50
- Decibel Reading:
  pre-retrofit: not available
  post-retrofit: not available

Concrete block homes were built across the southwest and in Florida, especially from the 1940s through the 1980s. In Phoenix, Arizona, about 30% to 40% of existing homes are concrete block homes, known locally as "slump block" homes. Some home owners have upgraded their homes by adding framing plus drywall inside and siding, usually stucco, on the outside. However, many homeowners, because of cost or aesthetics, have chosen to keep them the way they were originally made, just concrete block walls with nothing more than paint on the interior and exterior surfaces. The hollow cells in the blocks were filled with vermiculite insulation or left empty. The home featured in this case study project supported by the U.S. Department of Energy is one such home. The 1,980 ft², 3-bedroom, 1-bath, single-story home was built in downtown Phoenix in 1949 with walls consisting of just concrete block and paint.

Uncomfortably hot rooms and widely varying indoor temperatures prompted the owners to reach out to Jonathan Waterworth, an experienced home performance contractor and owner of AZ Energy Efficient Home in Phoenix. The homeowners had recently purchased the home after renting it for several years and they were ready to make some improvements, especially to tackle the issue of rooms on the east side of the house that stayed hot no matter how long the air conditioning ran.

Waterworth's company often does air sealing, duct sealing, insulation, and HVAC and he recommended these retrofits to the homeowner. However, Waterworth had also been eager to try adding exterior insulation to a slump block home. When researchers from DOE's Pacific Northwest National Laboratory approached him looking for a re-siding project that could involve adding exterior insulation and window upgrades, Waterworth leapt at the opportunity. The homeowner was agreeable to the idea so Waterworth began formulating a retrofit plan, with members of the PNNL team, which included researchers from Earth Advantage, an energy efficiency consulting firm from Portland, Oregon, and Building Science Corporation.

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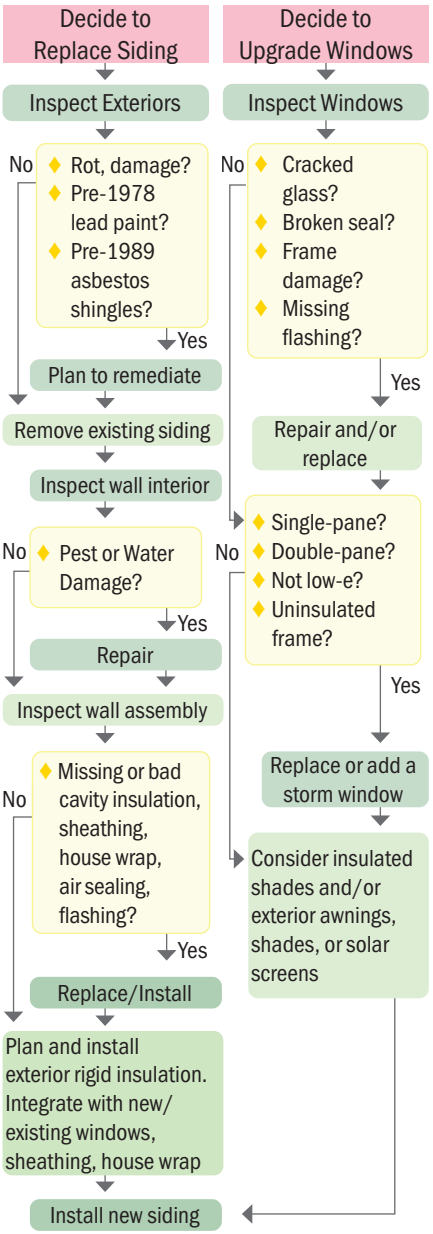
The U.S. Department of Energy's Building Technologies Office is working in partnership with national laboratories, the building industry, and other stakeholders to develop cost-effective energy-saving technologies and strategies to reduce building energy consumption. In support of this effort, Pacific Northwest National Laboratory, in partnership with Building Science Corporation and Earth Advantage, conducted a series of techno-economic studies to evaluate the home performance contractor business case for including window and wall insulation upgrades as part of conventional home siding replacement projects. Five existing homes were selected for study that were already scheduled for siding replacement. These homes represented a variety of U.S. climate zones and existing wall assemblies. DOE management oversight was provided by Marc LaFrance, Manager for DOE's Residential Buildings Integration Market Transformation Program.

The original home had no insulation, no exterior siding, no interior framed wall, and no drywall. The entire wall assembly consisted of uninsulated concrete block that was painted on the interior and exterior. In this retrofit, 2 inches of foil-faced polyisocyanurate rigid foam was added to the exterior of the home then covered with metal lath and two-part stucco. The added insulation greatly improved the comfort of the home, especially on the east side of the home where a driveway reflected heat into the home.

Wall-Window Retrofit Decision Tree



A primary concern of the homeowner was the east-facing side of the house, where rooms were often 10 to 15 degrees hotter than the rest of the home. A 12-ft-wide concrete driveway ran along that unshaded side of the house absorbing morning sun and radiating it into the wall. Waterworth was certain that installing 2 inches of foil-faced foam over the exterior surface would help to alleviate this.

The primary project objective was to wrap the concrete block in continuous rigid foam to bring the thermal mass within the home's thermal boundary. Other upgrade tasks included upgrading the windows and making attic insulation and air sealing improvements. Waterworth's crew removed the existing 4 inches of mineral wool from the low-sloped attic, air sealed all reachable penetrations through the attic floor, air sealed and insulated the ducts where necessary, replaced the furnace and AC with a split-system heat pump, insulated hot water lines, and blew in R-44 of fiberglass attic insulation.

Pre- and Post-Retrofit Conditions

Phoenix	Pre-Retrofit	Post-Retrofit
Vintage	1949	2022
Wall Assembly	Concrete block (i.e., concrete masonry unit, aka “slump block”). Paint. No wall insulation.	Concrete block, 2 inches polyisocyanurate, metal lath, stucco.
Windows	All double pane except one single-pane steel window.	Replaced single-pane window. Added solar screens to all windows.
Other Retrofits	Attic – 4 inches of mineral wool. HVAC – Few supply registers, lacking proper airflow on one side of house. Furnace is a split system in hall closet.	Removed old attic mineral wool, air sealed attic penetrations, installed new R-44 attic insulation. Replaced some ducting in attic. Added supply registers. Sealed all ducts with tape and mastic, insulated all ducts. Replaced furnace and AC with 19 SEER heat pump in closet.

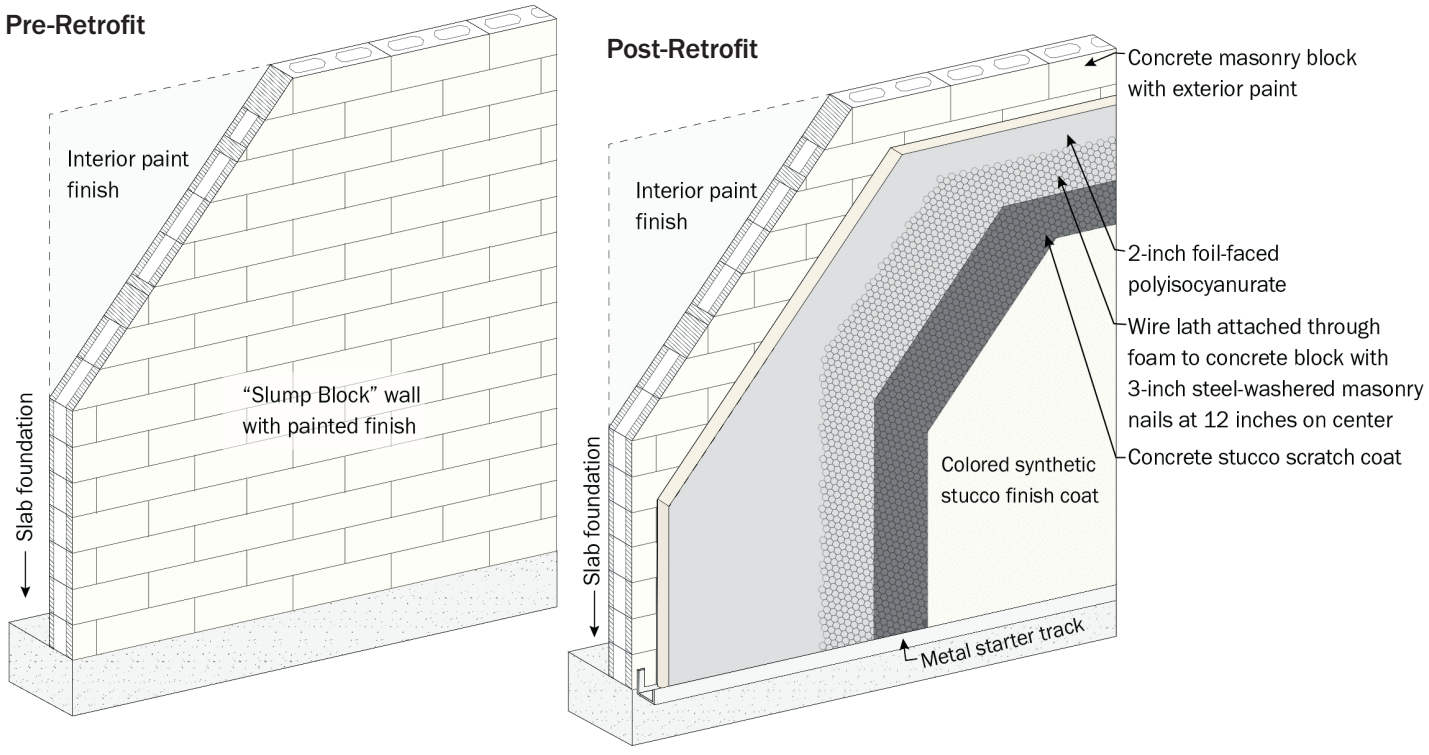
The original single-pane windows were replaced with double-pane low-e windows about 10 years ago. These double-pane windows remained but were upgraded with solar screens to reduce solar heat gain from the intense Arizona sun. Solar screens also provide privacy, limiting visibility into the home but providing visibility for those looking out. A unique hook and loop closure system keeps the screen in place without magnets or brackets.

Waterworth chose traditional two-part stucco, a siding material popular in Phoenix, to cover the rigid foam. Waterworth was originally concerned that the brown (or scratch) coat and colored synthetic finish coat would not stick well to the foil-faced foam so he tried scoring a 1-inch diamond pattern on the foil facing. He also initially considered gluing the foam to the slump block with a foam adhesive product. He tested both steps and realized they were unnecessary. Once the wire lath was attached through the foam to the concrete block with 3-inch steel-washered masonry nails fastened at 12 inches on center, the foam was adequately attached to the concrete walls and the stucco coats had no problem adhering to the lath. Avoiding those two steps saved more than $1,000 in labor and materials costs. Waterworth noted that the 2 inches of polyiso likely only added about 20% to the overall installation time because stucco installers already typically add one inch of EPS under stucco. There were some additional materials costs

"We love how comfortable the home is now. The temperatures inside are more consistent. The air conditioner is able to keep up with the heat."

--Homeowners

Phoenix Pre- and Post-Retrofit Wall Assembly Details



for using polyiso instead of EPS and for the 3-inch fasteners, steel washers, and the J weep flashing, which had to be custom made.

Kohta Ueno of Building Science Corporation noted that while this traditional non-drained stucco system with a non-permeable (foil-faced) insulation will work in a hot-dry climate like Phoenix, especially in this home where the exterior walls are protected from rain by deep overhangs, in damper climates builders may want to consider using a drained foam-stucco External Insulation and Finishing System (EIFS) instead.

One aspect that was important to the overall success of the job was pre-installation visits to the site. In addition to the initial visit to estimate the job, Waterworth visited the home again before foam install and walked around the perimeter noting all penetrations through the exterior walls, such as water and electric lines, security equipment, irrigation and hose bibs, gas piping, etc. Because he was moving the exterior of the house out 2-3/8^{ths} inch, electric boxes and hose bibs had to be extended so they wouldn't be buried in the exterior insulation. At the windows, Waterworth chose to turn into the 3-inch recessed window opening and used a synthetic stucco coating to cover the sill. The foam was run up to the eave and the top edge was covered with synthetic stucco. "We didn't want to leave any exposed foam at the top of the wall; woodpeckers like to peck the foam to clean their beaks," said Waterworth. The stucco subcontractor installed the rigid foam. Waterworth was onsite to supervise but felt that in the future his crew foreman could readily supervise similar jobs, with as few as four visits to the site by Waterworth.

Windows were also a part of the retrofit. All but one of the windows in the home had been upgraded to double-pane in a past retrofit, so the one remaining single-pane window was replaced with a double-pane window for this retrofit. Sun-filtering solar screens were recommended for all of the windows. The Velcro-attached solar screens replace insect screens and allow visibility out but block heat and views coming into the home.

In addition to the siding and window screen upgrades supported by DOE, Waterworth did the attic air sealing, insulation, and duct sealing improvements mentioned above, added more ducts to the overly hot side of the house, and replaced the old furnace and air conditioner with a new 19-SEER inverter-driven central heat pump. The home likely performed better than the Home Energy Score of 5, as HES often underscores homes in the hot-dry climate said Waterworth. "The homeowners are extremely happy with the results. We cut their utilities by 65% and they are much more comfortable in the house," said Waterworth.

Contractor Expectations and Reactions

What worked well? Everything worked well. It went as planned.

How much time did it add to a typical residing job? How many crew? 3 days for install, half day for pre-inspection

How much did it cost? See table.

What were the most challenging aspects of the job? Finishing details around the window. We turned into the window opening and used a synthetic stucco coating for the 3 inches of recessed sill.

Can you sell this to homeowners? If not, why not? Yes, specifically for slump block homes where the homeowners are making upgrades to make this their forever home.

Could you make a profit at this? Yes

What would you do differently next time? There is not much we would change.

What would make it easier next time? It was really pretty easy. The crew that did the stucco also did the rigid foam.

Phoenix Project	Siding[1]	Windows[2]
Planned Material Cost	$5,338	$655
Planned Labor Cost	$12,445	$275
Total Planned Cost	$17,783	$930
Added Upgrade Material Cost	$1,857	$2,606
Added Upgrade Labor Cost	$625	$400
Upgrade Incremental Cost	$2,482	$3,006
Total Project Cost with Upgrades	$20,265	$3,936

[1] Add stucco over 2 inches polyiso insulation.
[2] Add solar screens to all windows, and replace one single-pane window.

Key Take-Aways

- Walk the site several days before the crews show up to identify and prepare for potential problems.
- Putting the insulation exterior of the concrete takes advantage of the thermal mass of the concrete walls. While using a nondrained stucco system with a nonpermeable (foil-faced) insulation will work in a hot-dry climate like Phoenix. In other climates, consider a drained foam-stucco system like EIFS instead.
- Using a whole-house approach yields many benefits for the homeowners including comfort, health, air quality, and cost savings.

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For more information, visit:
Building America Solution Center
basc.pnnl.gov.

PNNL-SA-173602 · December 2022

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Window Retrofit: Phoenix, AZ

Builder Profile

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Project Home

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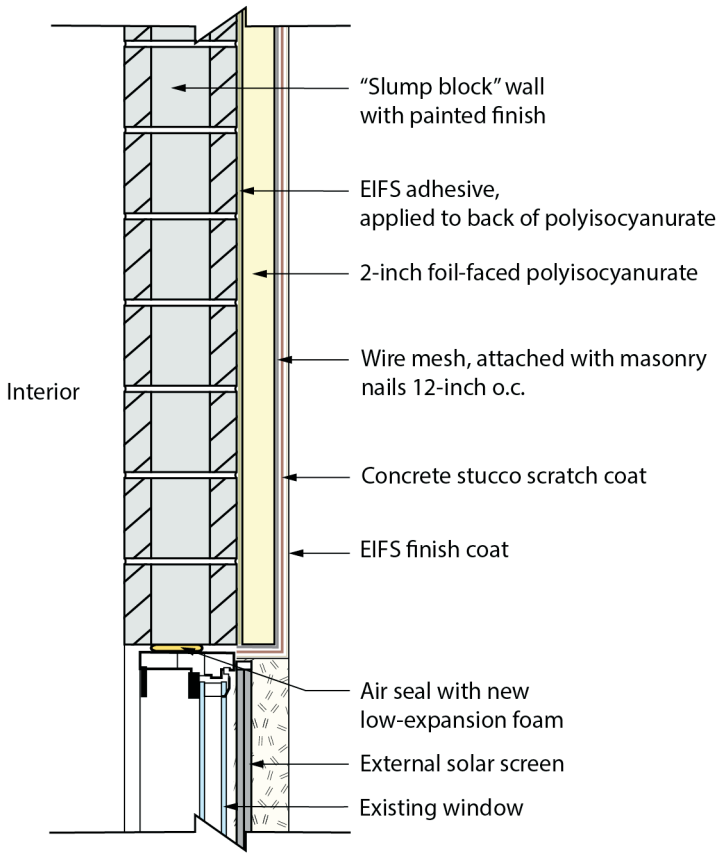
Phoenix – Windows

Pre-Retrofit (1949)	Post-Retrofit (2022)
All double pane	Replaced one single-pane window. Added solar screens to all windows.

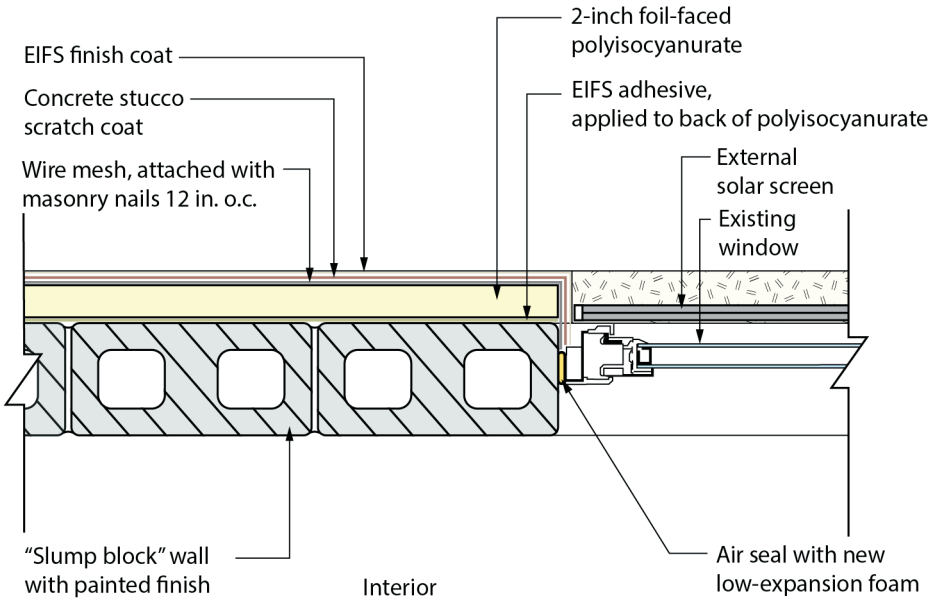
Phoenix Project	Windows
Upgrade	Add solar screens to all windows and replace one single-pane window
Number of Windows Replaced	13
Planned Material Cost	$655
Planned Labor Cost	$275
Total Planned Cost	$930
Added Upgrade Material Cost	$2,606
Added Upgrade Labor Cost	$400
Upgrade Incremental Cost	$3,006
Total Project Cost with Upgrades	$3,936

The comprehensive upgrade of this 1940's concrete block home in Phoenix, Arizona, included adding siding and upgrading windows. Rigid foam and stucco were installed over the concrete block walls. All but one of the home's 13 windows had been replaced with double-pane low-e windows. For this U.S. Department of Energy-sponsored retrofit, the one single-pane window was replaced with a double-pane low-e window. To improve the performance of the remaining 12 windows, sun-filtering solar screens were installed. The screens replace insect screens and are mounted to the existing window's framing with hook-and-loop closure tabs that keep the screens in place without magnets or brackets. The screens allow visibility out but block heat and views coming into the home.

Head Detail

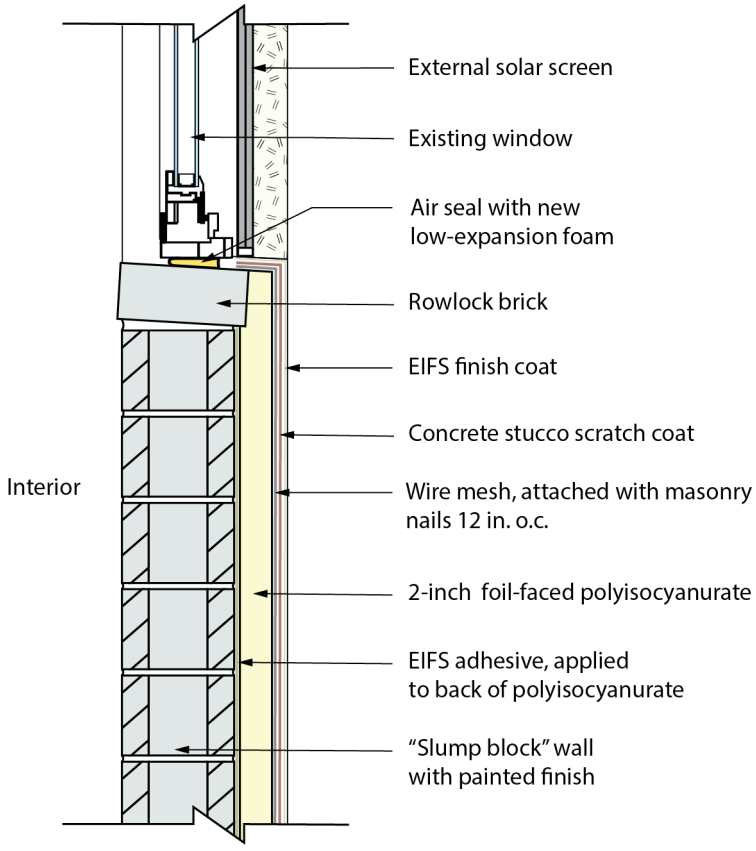


Jamb Detail



Stucco lath wraps around the windows and covers the 2 inches of foil-faced polyisocyanurate rigid foam that was installed over the original concrete block walls.

Sill Detail



Solar screens were attached to the exterior of the window frames with Velcro-like attachments to reduce solar heat gain and views into the home while allowing views out.

For the head and sill details, the view is from the side and the interior of the home is to the left of the wall. For the jamb detail, the view is from the top and the interior of the home is below the wall.

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PNNL-SA-173314 • December 2022