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

Siding & Window Retrofit Case Study

Kalamazoo, MI: **Kit Home Retrofit**

This 1946 kit home in Kalamazoo got new exterior foil-faced polyisocyanurate insulation and interior storm windows as part of a re-siding retrofit. The new insulation covers the walls but not the gable ends of the vented attic.

Builder Profile

Tom Tishler
Portage, MI
tishlertom@gmail.com

Project Home

- Name: Kalamazoo Kit Home Re-Siding
- Location: Portage, Michigan
- Layout: 2 bdrm, 1 bath, 1 fl + basement, 1,500 ft^2
- Climate: IECC 5B, cold
- Year Built: 1946
- Retrofit Completed: Jan. 2022

Performance Data:

- Home Energy Score:
  pre-retrofit: 7
  post-retrofit: 10
- Est. Annual Energy Costs: $1,140
- Est. Annual Energy Savings: $277
- Blower Door:
  pre-retrofit: Unknown
  post-retrofit: 3.2 ACH 50
- Decibel Reading:
  pre-retrofit: 56.1
  post-retrofit: 47.7

Tom Tishler has been helping families improve their housing situations for years, as construction manager of Kalamazoo Valley Habitat for Humanity and recently as a construction manager for Community Homeworks, a nonprofit in Kalamazoo that provides urgent home repairs for families in need. But his own home, built in 1946, was in need of some TLC. Tom purchased the 750-ft^2 home with an unfinished basement in 2002 and has gradually made improvements to it over the years, including adding new vinyl siding, windows, and interior window trim in the early 2000s, but a furnace failure in 2020 prompted him to get serious about insulation upgrades to the home. Wanting to downsize from the old 60,000-BTU furnace, Tishler decided to add mineral wool batts to the stud bay cavities and continuous rigid insulation over the studs along with new siding. He was starting on the insulation when he heard about the re-siding and window retrofit case studies project being conducted by the U.S. Department of Energy's Building Technologies Office. Tishler volunteered his home as a case study project and began meeting with project staff from Pacific Northwest National Laboratory, Earth Advantage, and Building Science Corporation to discuss upgrade options.

Tishler's house has an interesting history. It is one of thousands of homes built in the United States in the early to mid 20th century from kits - supplies and plans were sold by various companies including hardware stores, mail order catalogs, and in Tishler's case a local ship builder turned home builder. Tishler's home was constructed of 2x4 framing set on a cinderblock foundation. Metal straps were used for cross-bracing. The sheathing was two ½-inch sheets of original pressed board also known as fiberboard. Waxed paper served as house wrap. There was no wall insulation. The original 1x6 wood siding was replaced with aluminum siding in the 1960s. Tishler replaced that with new vinyl siding in 2005. He also added house wrap and replaced the original single-pane clear-glass windows with double-pane windows. In the current retrofit, Tishler removed the vinyl siding and the old fiberboard sheathing then air sealed extensively, from the open exterior side of the stud bays. "I used at least 100 tubes of caulk," said Tishler. Tishler estimated his pre-retrofit air leakage was about 1,500 cfm and a post-retrofit blower door test showed whole-house air leakage of 600 cfm, for a reduction of 60%.

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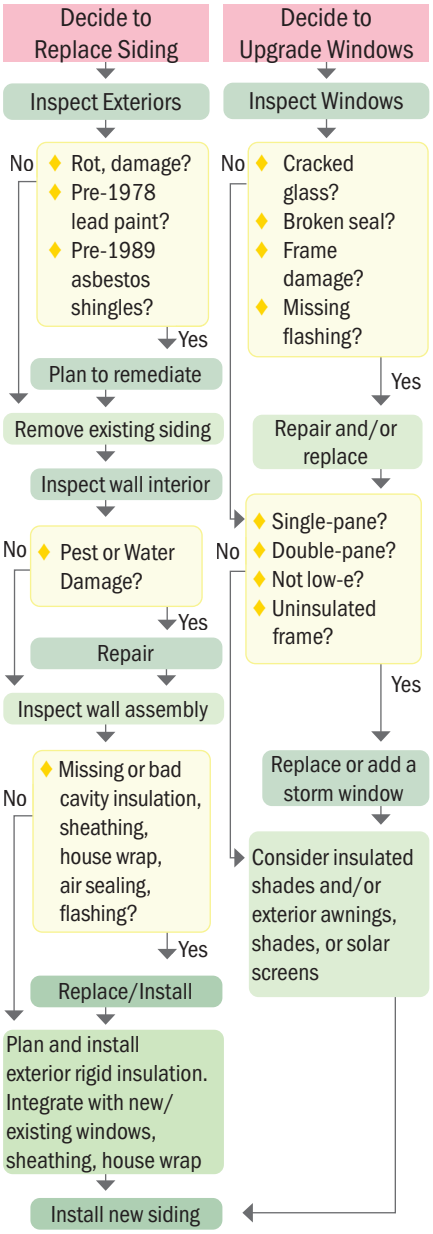
The U.S. Department of Energy's Building Technologies Office is working in partnership with national laboratories, the building industry, and other stakeholders to develop cost-effective energy-saving technologies and strategies to reduce building energy consumption. In support of this effort, Pacific 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.

Once the old siding was pulled off, the homeowner/contractor removed the old fiberboard sheathing, then caulked every wood-to-wood and wood-to-plaster joint before filling the empty wall cavities with mineral wool batts and sheathing the walls with one inch of foil-faced polyisocyanurate rigid foam. He also air sealed the rim joists, behind the tub, and all holes in the attic, and flashed dryer vents, hose bibs, etc., through the exterior wall.

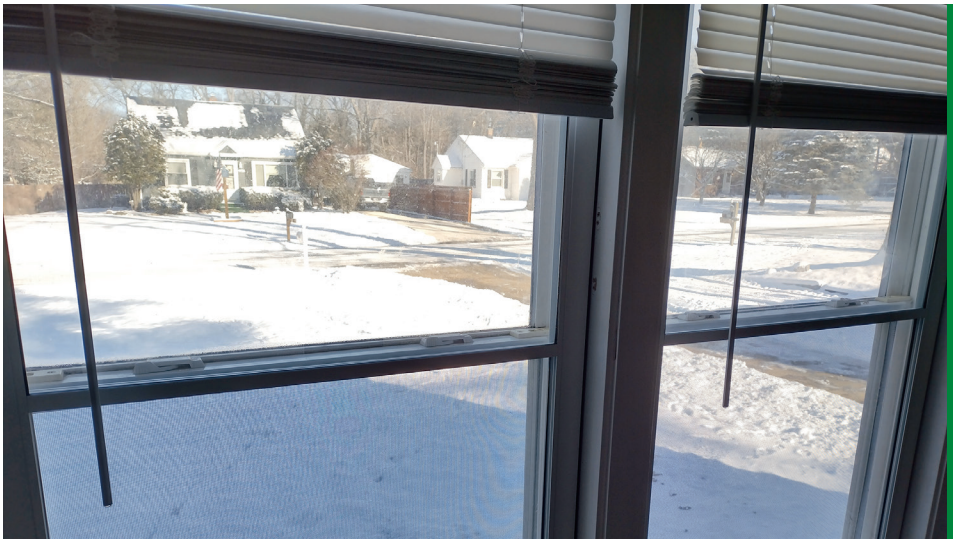
Wall-Window Retrofit Decision Tree



Using the 1-inch space left around the window flanges where the old fiberboard was removed, Tishler carefully installed 1 inch of foil-faced polyisocyanurate. This was the most challenging part of the project said Tishler as it was very time consuming to pull out the old fiberboard and install the new rigid foam without breaking the flanges off the window frames. Tishler seriously considered pulling and replacing the windows with triple-pane windows, which would have made the rigid foam install much easier, allowed for better flashing under the windows, and possibly offered the opportunity to increase the insulation thickness to two inches. However, Tishler had redone all the interior wood window trim after installing the double-pane windows 15 years earlier and didn't want to replace the trim again. As part of the new remodel, he also installed exhaust fans in the bathroom and kitchen to reduce indoor humidity. Tom chose not to replace the 1-inch fiberboard with the 1 inch of rigid foam at the gable ends because the attic was vented and unconditioned.

Pre- and Post-Retrofit Conditions

Phoenix	Pre-Retrofit	Post-Retrofit
Vintage	1946	2022
Wall Assembly	1940s kit house, previously remodeled, 2x4, 16-inch on center stud framing. House wrap was a waxed paper. Sheathing was two layers of ½-inch fiber board. Metal cross bracing. Added 8 inches of cellulose blown insulation to attic 15 years ago. Tom replaced old aluminum siding with vinyl in 2005.	Original 2x4 framing. Removed old sheathing. Picture frame caulked drywall to framing in every wall cavity. Added mineral wool batt cavity insulation. Installed 1 inch foil-faced polyisocyanurate with seams taped, then house wrap, then new vinyl siding.
Windows	2005 double-pane vinyl-frame windows.	Added interior low-e storm windows.
Other Retrofits	Uninsulated basement, air leaks at top of foundation wall. 96% AFUE two-stage furnace added in 2020.	Did extensive air sealing of rim joists, around tub, and in the attic. Insulated rim joist from inside with rigid foam. Added exhaust fans to kitchen and bath that vent outside.



The interior storm windows have white frames that match the trim and are hardly visible once installed but have a very noticeable impact on comfort, making the windows feel warmer and less drafty, Temperature readings showed the interior surface of the glass was 30% warmer, increasing from 40°F to 60°F on a 20-degree winter day when the storm windows were in place. A sound test showed that the storm windows cut exterior noise by 8 decibels, from 56 decibels to 48 decibels, making for much quieter interiors.

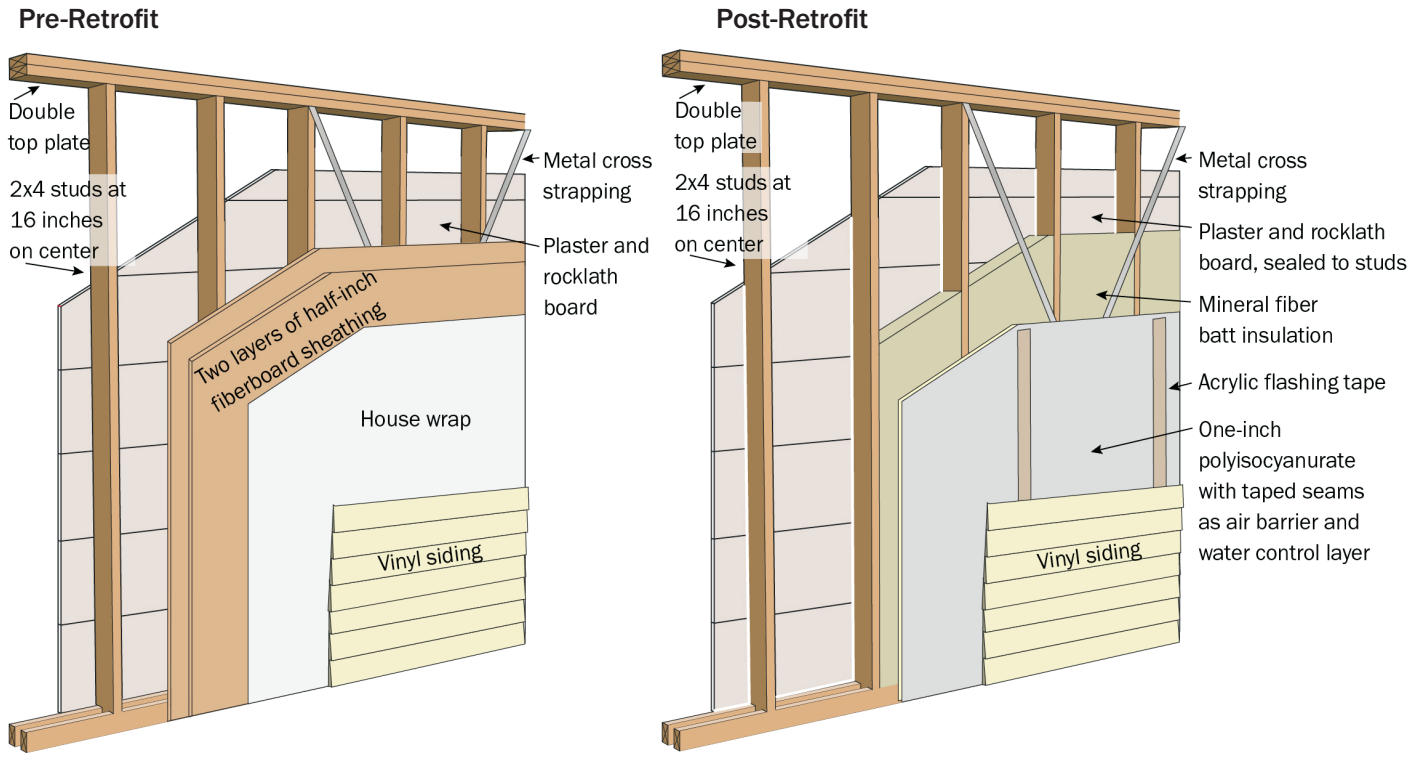
Tishler was used to humidity issues in the small home. So much condensation formed on the cold window surfaces during the winter that he had to wipe down the windows with a towel every morning to reduce mold growth. In very cold weather, the condensation would often turn to ice on the inside surface of the windows.

Understanding Tishler's reluctance to replace the double-pane windows because of the interior wood trim, the PNNL project team offered another solution – adding low-emissivity (low-E) high-performance interior storm windows. Tishler was not familiar with modern storm windows, but was willing to try them. "I grew up with the old galvanized aluminum storm windows. They didn't stop much air. These are much higher quality. They open and close really well; they seal really nicely. They are barely noticeable. My wife almost couldn't tell which windows I'd installed them on," said

"The storm windows have been working great! The comfort difference is very noticeable. All the drafts are eliminated. We don't feel cold coming off windows. And there's no condensation!"

–Tom Tishler, home owner and remodeler

Kalamazoo Pre- and Post-Retrofit Wall Assembly Details



Tishler. Tishler installed the 12 storm windows himself. “They were easy to install, 45 minutes each at first, then 20 minutes per window for the last few.” said Tishler.

Tishler chose interior storm windows because his windows have a very narrow exterior trim. “The only trick with the interior installation is you do have to allow an inch of space between the storm window and the existing window to be able to lock and unlock the original window.” One risk with interior storm windows is that with an imperfect seal, air can leak from the interior to the gap between windows, and condense in cold weather. However, Tom has not experienced any of these problems in his house.

The storm windows have been in place since January 2022 and Tishler and his family are extremely pleased with the results. “They have been working great,” said Tishler. Tishler noted that thermal imaging showed a substantial difference in temperature on the inside surface of the windows and the storm windows have made a big difference in noise levels. "We are 2.5 blocks from I-94. I can hear traffic through the front door but not through the windows.” Tishler’s utility bills two years ago for gas and electric were $200 to $250/month; this winter they were $130 to $140/month, a savings of 30% to 40%.

However, for Tishler, the biggest benefit may be the condensation control they provide in Michigan's cold humid climate. At Habitat for Humanity Tishler was a big advocate of triple-pane windows, for energy efficiency but more so for condensation control. “Condensation in old houses can be terrible. It can destroy wood sashes and cause lead paint to peel. With vinyl windows, the condensation doesn’t rot the frame but it can allow mold and ice to form on the windows and it can rot the interior sill. Triple-panes make condensation a non issue but they are not affordable for many folks. It’s great to see there is another option,” said Tishler.

Tom now works at Community Homeworks, a small nonprofit in Kalamazoo that does critical home repairs and weatherization for families, some of whom are at 50% of the poverty level paying $500 to $800 per month on utilities. “Mostly with weatherization you are doing air sealing, insulation, then HVAC and water heating. It costs $12,000 to $15,000 to do all that. Windows are almost never in the budget. They add $10,000 to the costs. These storm windows would be a really good option for our clients," said Tishler.

Contractor Expectations and Reactions

What worked well? Insulating the above-grade walls and air sealing really improved the home’s efficiency. Storm windows greatly increased the comfort and nearly eliminated condensation.

How much time did it add to a typical residing job? How many crew? Tishler did the work himself on weekends and evenings. Installing rigid foam added about 100 hours to the total re-siding install. He estimates the storm window install took 20 to 45 minutes per window.

How much did it cost? The storm windows cost less than $150 each. Rigid foam and tape added $2,600 to the full cost of the re-siding.

What were the most challenging aspects of the job? Trying to install rigid foam under existing window flanges without removing the existing windows.

Can you sell this to homeowners? If not, why not? A contractor could sell exterior insulation with re-siding and new windows to higher income folks who could afford it. Storm windows would be especially beneficial for homeowners in historic districts and those with limited budgets.

Could you make a profit at this? You could very likely make a profit selling and installing storm windows. If I were a for-profit contractor, I’d probably charge an hour per window to install.

What would you do differently next time? Take out the old windows and put in new triple-pane windows. It was very labor intensive to try to pull out the old sheathing and nails and install the new foam without breaking the flanges off the vinyl windows.

Kalamazoo Project	Siding[1]	Windows[2]
Planned Material Cost	$2,000	$0
Planned Labor Cost[3]	$5,000	$0
Total Planned Cost	$7,000	$0
Added Upgrade Material Cost	$2,600	$1,594
Added Upgrade Labor Cost[3]	$3,500	$250
Upgrade Incremental Cost	$6,100	$1,844
Total Project Cost with Upgrades	$13,100	$1,844

[1] Add 1 inch of foil-faced polyiso continuous exterior foam insulation.
[2] Install interior low-e storm windows.
[3] Estimated labor.

Key Take-Aways

- Be intentional about measuring air leakage, decibels, and other metrics before and after to verify results.
- It’s easier to properly integrate the windows and foam if you remove and reinstall or replace the windows.
- Don’t skimp on air sealing while doing other upgrades; caulk, foam, and better fitting windows can have a huge impact on comfort and performance.
- When tightening up a house, make sure

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Window Retrofit: Kalamazoo, MI

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Kalamazoo – Windows

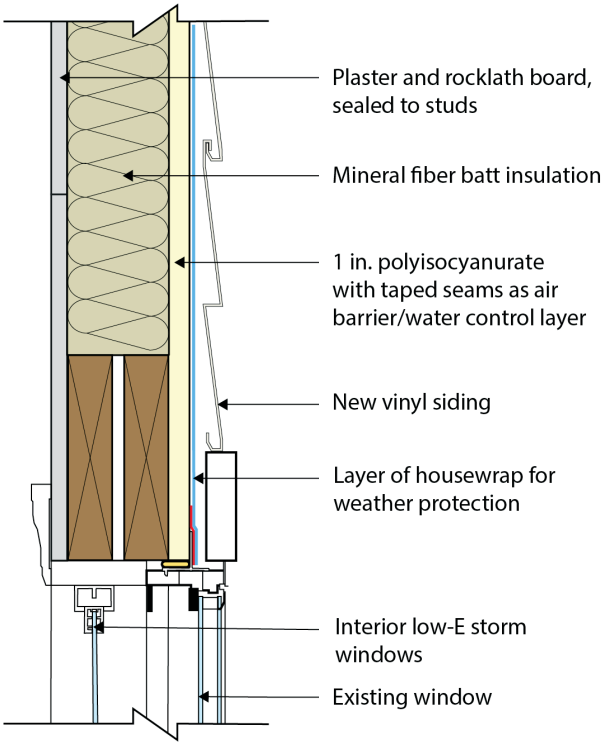
Pre-Retrofit (1946)	Post-Retrofit (2022)
2005 double-pane vinyl-frame windows	Added interior low-e storm windows

Kalamazoo Project	Windows
Upgrade	Install interior low-e storm windows
Number of Windows Upgraded	12
Planned Material Cost	$0
Planned Labor Cost	$0
Total Planned Cost	$0
Added Upgrade Material Cost	$1,594
Added Upgrade Labor Cost	$250[1]
Upgrade Incremental Cost	$1,844
Total Project Cost with Upgrades	$1,844

[1] Estimated labor.

The homeowner/contractor on this home had already begun a retrofit of this 1946 kit home to remove vinyl siding installed in 2005 so he could air seal the walls and install new cavity insulation plus 1 inch of rigid foam topped by new vinyl siding, when he was approached with the possibility of upgrading the windows as well as part of a U.S. Department of Energy wall and window residing retrofit case study. He had already decided against replacing the windows because he had replaced the original single-pane clear-glass windows with double-pane vinyl-framed windows 15 years prior and had then painstakingly installed new interior wood trim around all of the windows. The homeowner realized, however, that after increasing the wall insulation so much, the lower grade windows would feel even more cold and drafty. Wiping down the windows had been a daily chore to reduce ice formation inside the home in winter and water accumulation and mold around the windows the rest of the year. Low-emissivity storm windows were recommended as a retrofit. Powder-coated aluminum storm windows were selected that attached to the interior of the window frames and had openable glass panels.

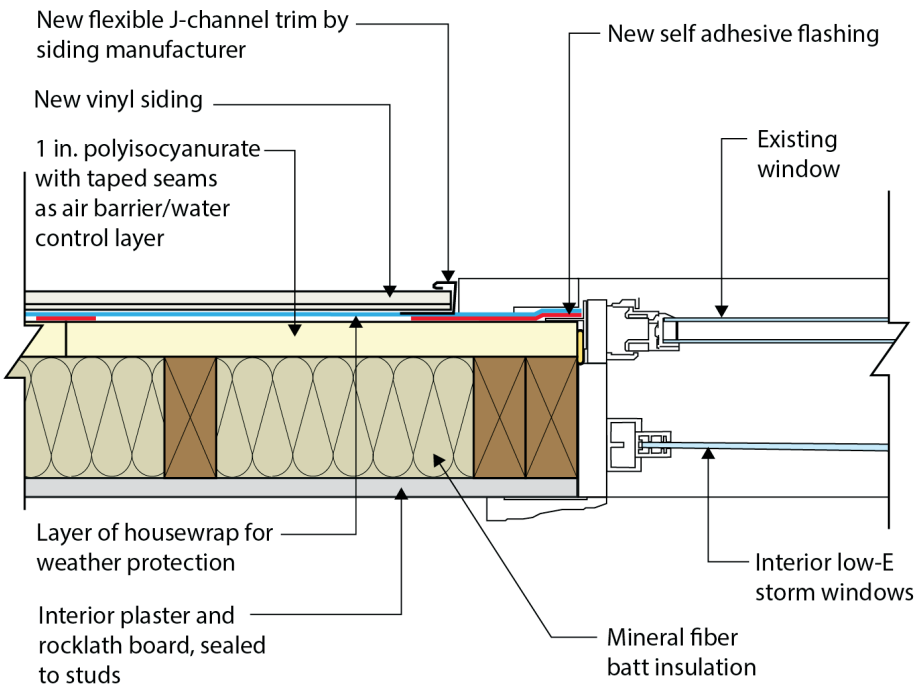
Head Detail



The homeowners love the new storm windows; they have nearly eliminated condensation and have greatly reduced sound transmission. Temperature readings showed the interior surface of the glass was 30% warmer, increasing from 40°F to 60°F on a 20-degree winter day when the storm windows were in place. A sound test showed that the storm windows cut exterior noise by 8 decibels, from 56 decibels to 48 decibels.

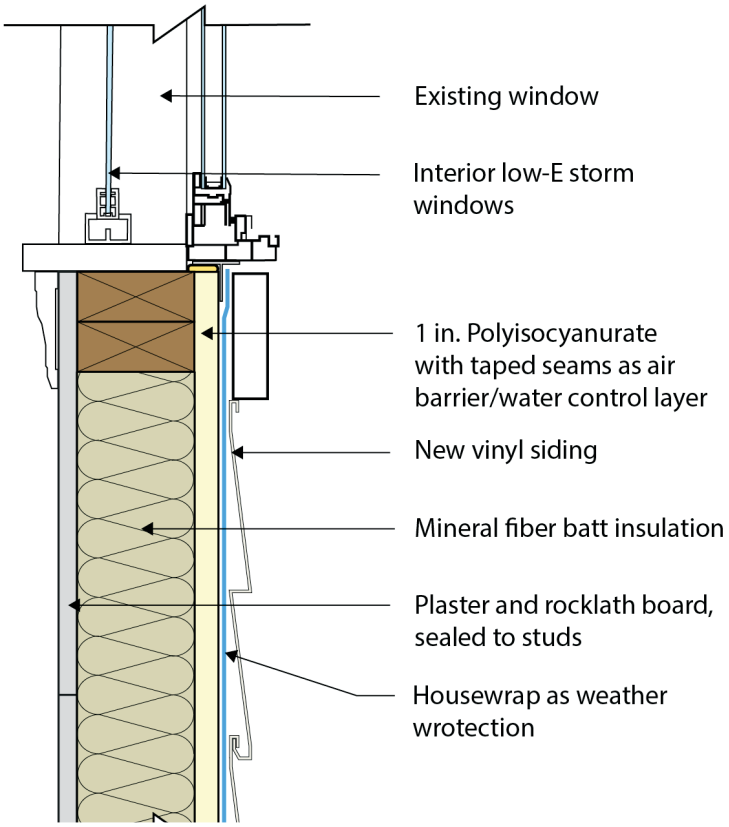
The homeowner/contractor did the installation and commented that they were very easy to install, taking about 20 minutes per storm window once he got through the learning curve.

Jamb Detail



The new storm windows have powder-coated aluminum frames that provide a tight seal to the existing window frame. They also have low-emissivity coatings to reduce heat transfer and operable openings that match the single-hung original windows.

Sill Detail



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.

Each storm window took less than 20 minutes to install and they are nearly invisible once installed. The increase in comfort and decrease in condensation and noise were immediately noticeable.

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