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

BUILDING TECHNOLOGIES PROGRAM

Building America's Deep Energy Retrofit Research Project

Case Study: 1915 Home

Dayton, WA

A deep energy retrofit of this 1915 home in Dayton, Washington, could save the homeowners 73% on their energy bills, according to an assessment conducted by Building America.

Deep Energy Retrofit Offers 73% Savings for Century-old Home

The homeowners' complaint is a big one. The diesel-burning furnace in their 1915 home rings up energy bills that can top $700 in a single month. However, good news comes from the Building America researchers who performed an energy assessment for the home in Dayton, Washington. Using assessment data and computer modeling, they project a 73% reduction in heating costs by installing an innovative heating system and adding air-sealing and insulation. The estimated cost looks steep—$16,492. But, with a projected annual savings of $2,500, it will take only 6 years for the homeowners to fully recoup the investment. After that, the $2,500 will simply be money in their pocket.

The assessment is part of Building America's Deep Energy Retrofit Research Project (see sidebar on page 3). It was conducted by the Pacific Northwest National Laboratory (PNNL) for the U.S. Department of Energy. PNNL and other researchers are identifying cost-effective technologies and strategies for reducing energy use in existing homes by more than 30%. When the upgrades are complete, the researchers will measure and analyze the results to develop best practices for deep energy retrofits in various climates.

The Dayton home is in eastern Washington state, a dry area with cold winters and hot summers. Although the wood-framed house is nearly 100 years old, "its bones are good," said the owners. The 3-bedroom home has 2,600 ft^2 of living space on two floors, not counting the unfinished basement.

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(Top) The hundred-year-old diesel boiler can cost $700 a month to fuel. Installing a new boiler means removing the old one and disturbing the asbestos on its top and sides, creating a health hazard. Instead, the Building America researchers recommend installing an innovative alternative, a ductless mini-split heat pump.

(Bottom) The upstairs rooms are often uncomfortable. The insulation for the sloped ceilings has slipped off and fallen into the wall cavities.

The Building America researchers conducted a blower door test to measure whole-house air leakage and used thermal imaging to identify key leaks. They evaluated insulation levels and checked all appliances. Using assessment data and computer modeling, the researchers provided the homeowners with a list of upgrade options, giving the estimated cost and projected savings for each. The researchers met with the homeowners to identify the best options for their needs and budget.

Problems, Options and Recommendations

The heating system. The Building America researchers identified two alternatives for heating the home: an efficient electric boiler and a ductless mini-split heat pump.

A new boiler would continue to supply hot water to the home's radiators, a heat source the homeowners have enjoyed. However, removing the diesel boiler could create a health hazard. Asbestos covers the boiler's top and sides. When asbestos is disturbed, microscopic fibers can become airborne and may be inhaled. Safe removal is difficult and expensive. The team included this expense when calculating the cost of a replacement boiler.

The Building America researchers recommend the second option, a ductless mini-split heat pump. This energy-efficient system includes an outdoor unit like any heat pump. Instead of connecting to indoor ducts, however, it sends compressed gas through small-diameter insulated refrigerant lines to one or more indoor units. Mounted on a wall or ceiling, each unit heats or cools an area of the house. The Building America researchers calculate that four indoor units will effectively heat the Dayton home. If the homeowners choose a ductless heat pump, the old diesel boiler—and the asbestos—can remain undisturbed.

The heat pump costs much more up front than the electric boiler. However, according to computer models, it offers a whopping 68% reduction in the homeowners' energy bills and a short payback period – just 4 years. The big savings will continue for years to come.

Measure	Estimated Reduction in Energy Bills	Estimated Cost	Estimated Savings	Payback Period
High Efficiency Electric Boiler	39%	$3,675	$1,386/year	3 years
Ductless Heat Pump *Recommended*	68%	$9,300	$2,393/year	4 years

Attic Insulation. Parts of the home are poorly insulated. The upstairs has sloped ceilings where the attic insulation has fallen into the wall cavities. This leaves the rooms uninsulated at the slope. The Building America researchers recommend filling the cavities of the sloped ceiling with blown fiberglass. Although savings from the project will be small—an estimated $40 a year—the bedrooms will be warmer in winter and cooler in summer.

The rest of the attic floor has R-15 loose-fill cellulose; R-49 is recommended. Ordinarily, insulating an attic floor is one of the least expensive energy upgrades. However, the Dayton home has active knob-and-tube wiring on the attic floor. Covering this old wiring with insulation could overheat it, creating a fire hazard. Rewiring and adding insulation would be expensive. With an estimated $100 reduction in annual energy bills, it would take 30 years to recoup the cost. The homeowner might consider replacing the old wiring for general safety, but the Building America researchers are not recommending it for energy savings.

Wall insulation. The exterior kitchen wall is uninsulated. Upstairs, the master bedroom has no insulation in the wall facing the street, and the room extends over an open porch, with no insulation in the cantilevered floor. To insulate the walls, the Building America researchers recommend the "drill and fill" method. Workers will remove a piece of siding on each wall and drill holes to blow in insulation. Fiberglass batts are recommended for insulating the cantilevered floor in the master bedroom. (Because the home is in a dry climate, it is acceptable to use fiber insulation in the floor.) With federal tax credits and local incentives, the cost of this project will be recouped in 8 years.

Basement. The Dayton home has a full, unfinished basement. It has no insulation, and active knob-and-tube wiring hangs from the ceiling. Air leaks abound. Daylight comes through cracks in the rim joist. The dining room above the basement is cantilevered over open space, and the cavity around its floor joists is uninsulated and open to the basement.

The drafty basement compromises the comfort, air quality, and energy efficiency of the entire house. In any house that is not airtight, warm air rises and escapes through air leaks in the attic. This "stack effect" creates negative air pressure in the lower part of the house, so replacement air gets pulled from outside, into the basement, and up into the home.

The Building America researchers recommend sealing the rim joist cavities with oriented strand board (OSB) or rigid foam, air-sealed around the edges, and then filling the cavities with R-19 fiberglass batts. The cavity formed by the dining room cantilever should be insulated, blocked off, and air-sealed. Rigid foam insulation should be installed against the basement walls, with the edges of the foam panels air-sealed. Estimates show a minor 2% reduction in energy use. However, these measures are inexpensive and cost-effective, paying for themselves in just 6 years.

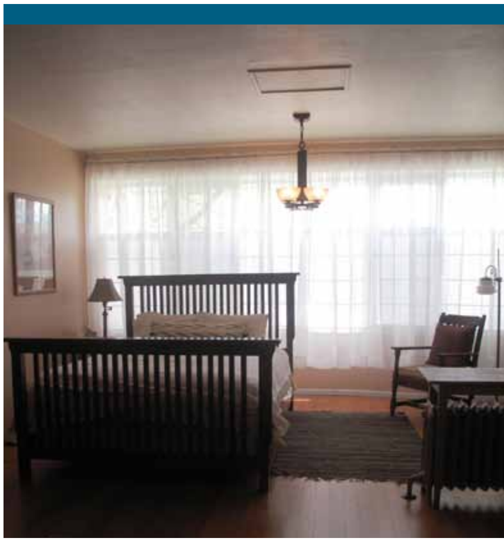
Building America's Deep Energy Retrofit Research Project

This assessment is part of Building America's Deep Energy Retrofit Research Project, conducted by the U.S. Department of Energy's Pacific Northwest National Laboratory (PNNL), Oak Ridge National Laboratory, and other research partners. The researchers are coordinating deep energy retrofits for at least 50 residences throughout the United States.

Deep energy retrofits use comprehensive, whole-house strategies to reach the highest cost-effective level of energy efficiency. For each home, the Building America researchers identify a package of cost-effective technologies and strategies to reduce energy use by more than 30%.

A deep energy retrofit usually requires an investment of $7,000 to $20,000. Rebates, tax credits and low-interest loans are often available.

Once upgrades are complete, the researchers measure energy savings and improvements in comfort, health, and safety. Analysts will use the data to evaluate the benefits and cost-effectiveness of deep energy retrofits. These analyses will inform the U.S. Department of Energy's best practices for retrofitting homes in climate zones across the country.



In the master bedroom, breezes stir the curtains even when the leaky casement windows are closed. The uninsulated floor is also chilly; it extends over the open front porch.

The basement work altogether will reduce energy bills by an estimated 11%, according to computer modeling. While the full project is expensive, it's important. Besides offering significant energy savings, it will reduce the stack effect, which can make the whole house colder.

Windows and other air leaks. The home's single-paned windows fit loosely. With these and other gaps and cracks in the old walls, the house has air leaks equivalent to a 10-inch by 20-inch window open year-round. Cost-effective air sealing can be performed as part of insulation projects in the sloped ceilings, walls, floors, and basement. However, replacing the windows is not cost-effective as an energy-saving measure. It would take 40 years, according to the researchers' calculations, to recoup the cost of new windows. Interior storm windows would help to block the drafts, but they also would have a long payback period—31 years. The Building America researchers are not including window replacement in their energy efficiency recommendations, although the homeowners may wish to replace some of them for comfort.

The Bottom Line

The Dayton homeowners currently pay $3,536 a year for energy. If they choose to implement all the recommendations of the Building America researchers, their annual energy bill will be reduced to an estimated $970.

Measure	Estimated Reduction in Energy Bills	Estimated Cost	Estimated Savings	Payback Period	Payback Period (after incentives)
Ductless Heat Pump	68%	$9,300	$2,393/year	4 years	4 years
Insulate sloped ceilings and air-seal attic	1%	$1,161	$40/year	29 years	17 years
Insulate walls and cantilevered floor	2%	$924	$70/year	13 years	8 years
Air seal and insulate basement walls	11%	$5,107	$511/year	13 years	12 years
TOTAL SAVINGS*	73%	$16,492	$2,566	6 years	6 years

* Total savings is not simply the sum of savings from each measure because the changes are interactive. Actual savings will depend on which measures are implemented, as well as any changes in usage patterns. Costs are calculated with data from the National Residential Efficiency Measures Database, assembled by the U.S. Department of Energy's National Renewable Energy Laboratory. These values are compared to local prices and quotes. Savings are modeled with Energy Gauge software, based on the local electric rate of $0.068/kWh. A simple payback period is used, without adjustments for interest, inflation, or depreciation.

For More Information

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