CASE STUDY: North Portland Affordable Housing

Outcome: Energy Savings Benefits Outweigh Added Costs

The homes built by Terrafirma in North Portland exceeded program expectations. The efficiency measures required for the 15% home were estimated at half of the cost of the 30% efficiency measures, yet both homes achieved 30% greater efficiency than 2008 Code.

The "15%" home performed at a "30%" level due to the following reasons: First and most importantly, Terrafirma was able to utilize some of the simple techniques required in the 30% home due to economy of scale; i.e. they were already doing it on one project, thus it was simple (and low to no cost) to replicate on the adjacent construction site. Second, the process of ordering materials was simplified by ordering more of the same products rather than specifying different products for each home, as was the case with the windows. Lastly, the HVAC contractor upgraded the 15% homes' specified heat pump with the exact same equipment as the 30% home's. This was a mistake by the contractor provided to the builder at no extra cost. In actuality, there would have been a $1500 premium for this added efficiency. The upgraded heat pump and air handler increased the efficiency of heating and cooling as well as ventilation, thus bumping the "15%" homes up to the "30%" level.

The efficiency of these homes translates to utility bills cut by one third, saving the occupants $12,700 to $13,200 over 30 years (at today's energy prices). For all four homes, more than 88% of the cost savings are associated with the reduction in electricity usage for space and water heating. In fact, over half of the cost savings come from reduced heating needs, while providing the occupant with greater thermal comfort and air conditioning.

In addition to the grant funds noted above, each home in the study (15% and 30% homes) received $1,600 - $1,800 in incentives from Energy Trust, reducing the up-front incremental costs by approximately 17%. This case study illustrates that even in the absence of the PEEHP grant program; advantages of greater comfort to the home occupants, significantly reduced energy bills, and potentially higher asset value build a strong case for investing in high performance homes.

Successes and Challenges: An Interview with the Builder

Did implementing the required efficiency measures make the project more complex than you expected?

Meeting the energy efficiency goals was not particularly challenging, it just required more rigorous management of subcontractors to ensure they followed the criteria.

It was important to select efficiency measures with the future homeowners in mind. We chose not to use ENERGY STAR® rated lighting fixtures that require harder-to-find and more expensive pin-based bulbs. ENERGY STAR's ® Technical Compliance Option was selected to bring the lighting energy needs to just under 0.6 watts/square foot. This allowed us to meet the more rigorous ENERGY STAR® standard for 90% of the sockets while retaining dimmable incandescent bulbs in the dining room chandelier. The non-rated fixtures we used elsewhere in the house accept standard screw-in ENERGY STAR® rated compact fluorescent bulbs.

Were there any unexpected costs?

No. We followed the efficiency path as planned. One of the big "take-aways" is that it is not significantly expensive to increase the efficiency of a home from 2008 Code by 15%, In fact, it is more cost effective to push a home from 15% to 25% greater efficiency than it is to bring a home to a full 30% greater efficiency than 2008 Code.

The biggest difference between the 15% and 30% houses was the insulation method (spray foam and blown fiberglass) and the use of an ERV for ventilation in the 30% home. These were among the highest cost items, yet the 15% home performed beyond our expectations with an air handler set to a timer for ventilation, without the added cost of including the ERV.

In our case, the efficiency measures we used in the 15% units made up just 3% of our construction costs, but still achieved 30% greater efficiency. That was unexpected.

Would you recommend the efficiency measures to other projects?

Yes, we will use these strategies on future projects. Air sealing the building envelope is easy and effective, and better insulation does not cost a great deal more. Advanced framing should save money on lumber, but you must plan for it and engineer it into the design early on. We would also like to use heat pumps again, now that we are familiar with them.

What would you, as the builder, do differently next time?

I would plan for post-occupancy energy performance monitoring. This is the only real way that we, as builders, can verify the efficacy of our efforts.

Have your homes made an impression on the homeowners?

The first home we sold was one of the 30% homes. The new owner specifically chose the home because of its efficiency. The other homes have also been well received by their owners.

While the new owners are generally less interested in the technical details of how we achieved high efficiency, low utility bills were an attractive feature of the homes. The new owners are also impressed with the comfort of the homes during cold weather, provided in large part by the diligent insulation and air sealing.

Program Contacts:

For more information about the PEEHP case studies, visit: www.portlandoregon.gov/bds/PEEHP

Learn how Energy Trust resources and incentives can help you build and sell high efficiency homes, call the Energy Trust's trade ally coordinator at 1.877.283.0698, option 1.

Bureau of Development Services FROM CONCEPT TO CONSTRUCTION

PEEHP
Portland Energy Efficient Home Pilot

CASE STUDY: N. Fessenden St. and N. Exeter Ave.
"Green-plexes" are Models of Energy Efficiency in Affordable Housing

Project at a Glance

Site Location
North Portland
Portsmouth Neighborhood

Utility Partner
PGE

Building Type
Two-Family Row Houses

Number of Bedrooms
3

Unit Square Footage
Approx. 1600 sf per unit, 3200 sf per building

Total Grant Award
$26,280

Certifications
ENERGY STAR®
Earth Advantage®
LEED® Gold®

Project Team & Subs

Contractor
Terrafirma Building Inc.

Structural Engineer
Hayden Engineering

Designer
eMZed Design

Interiors
Kismet Design

LEED Consultant
Earth Advantage Institute

Insulation
JB Insulation

Framing
Perfect Custom Home

Windows & House Wrap
NW Commercial Exteriors

HVAC
Pyramid Heating & Cooling

Vendors/Products

Heat Pump
Carrier

Water Heater
Rheem Marathon

Lumber
Parr Lumber

ERV
American Standard

Trusses
Precision Trusses

Program Overview

The Portland Energy Efficient Home Pilot (PEEHP), a competitive grant program, was developed to encourage the construction of energy efficient homes in the Portland area. Participating builders were required to build a minimum of two new homes to exceed the energy efficiency standards of the 2008 Oregon Residential Energy Code (2008 Code). The PEEHP grant provided funding for builders to implement the energy saving measures necessary to increase the efficiency of their homes by 15% or 30%.

Several diverse development projects received awards. The average award was $4,266 per unit that performs 15% more efficiently than 2008 Code and $10,320 per unit that performs 30% more efficiently than 2008 Code. Grant recipients include Fish Construction NW, Inc., Terrafirma Building, Inc. for Portland Community Reinvestment Initiatives (PCRI), and Habitat for Humanity Portland/Metro East.

Administered by the City of Portland, grant matching funds and technical assistance for the PEEHP were provided by the National Home Builders Association, the Home Builder's Association of Metropolitan Portland, Portland General Electric (PGE), NW Natural Gas, Pacific Power, and Energy Trust of Oregon's New Homes program. This public/private partnership leveraged $113,000 in grant funds, resulting in energy saving measures for 14 homes.

"Meeting the energy efficiency goals was not particularly challenging, it just required more rigorous management."

Builder David Hassin, Terrafirma Building, Inc.

Project Summary

PEEHP awarded Terrafirma Building, Inc (Terrafirma) a grant worth $26,280.00 to construct four row houses in North Portland for Portland Community Reinvestment Initiatives (PCRI), an affordable housing developer. Terrafirma has been renovating, building, and developing residential and commercial properties for more than 30 years. Both Terrafirma and PCRI are committed to building high-performance and sustainably constructed homes.

Terrafirma has built more than two-dozen homes to ENERGY STAR® and Earth Advantage® certification standards. Terrafirma's project features two buildings, each with t wo units of modest size. One building is built to be 15% more efficient than the 2008 Code requirement, and the second building is 30% more efficient than 2008 Code.

This project challenged Terrafirma to achieve high efficiency while maintaining a purchase price and cost of operation that would be affordable for lower income residents. Energy Trust's New Homes program worked with Terrafirma to determine what actions needed to be taken to meet the efficiency goals of the PEEHP. Affordable housing projects such as this one often use a zonal electric heating method. The upfront costs are low; however zonal electric heat is not energy efficient and may result in high heating costs for residents. With this in mind, an electric energy path was used, specifying high efficiency electric heat pumps and water heating for the homes.

The PEEHP program helped the builder to achieve overall efficiency by upgrading the mechanical systems, tightly sealing HVAC heating ducts, and locating both within the conditioned space. The building envelope was tightly sealed and the framing was modified to increase insulation and reduce thermal transfer through the walls. These steps kept the homes affordable and less expensive to operate and maintain for the residents in the future.

Aggregate Cost of Project		
Efficiency above 2008 code	15% Unit	30% Unit
List price per unit	$250,000	$250,000
Actual cost of upgraded efficiency measures per unit	$4,305	$9,485
Grant award per unit	$4,305	$9,485

What does it take to create a highly efficient home?

Terrafirma capitalized on the inherent efficiency of a modest house plan to achieve very high efficiency for their two-story row-houses. The energy and associated utility savings realized in these homes, as compared to a code home, were achieved by using high efficiency heating equipment for space and water, intermediate framing techniques (insulated window & door headers and exterior wall corners to reduce heat loss), greater insulation throughout the house (for example, from R38 to R60 in the attic), more efficient windows (U-0.30 rather than U-0.35), duct placement inside conditioned space, and improved duct and whole house envelope tightness (minimizing heat loss). The homes also feature ENERGY STAR ® appliances and lighting.

Homes with tightly sealed exterior envelopes require mechanical ventilation to maintain indoor air quality. In the 15% more efficient home, fresh air supply was integrated into the duct system and is operated on a timer. An energy recovery ventilation system (ERV) was used for the 30% more efficient home. The ERV uses the heat and energy from the exhaust air to pre-condition fresh air before it is circulated through the home

The builder exceeded the efficiency levels required by the grant for each unit by implementing the construction methods and measures specified above, however other factors also contributed to the exceptional results. First, the houses have a compact, family-size floor plan, which both reduces the amount of building materials needed and also reduces the heating and cooling demand. Second, the homes are row houses, which share an interior wall. The wall decreases exterior exposure to weather, reducing heat loss from the home. Last, the builder installed some of the same measures in both units, including raised heel trusses, higher U-value windows, and placing the ducts inside conditioned space. Duplication of the design and materials simplifies installation, reducing the overall cost of the project while increasing the efficiency of both units.

PEEHP Energy Efficiency Features

15% Unit

- High-efficiency ducted electric heat pump, 8.5 HSPF
- Electric furnace back-up heat, with variable speed motor
- Air cycler, supply-only, whole house ventilation provided by air handler and programmable timer
- Raised heel trusses with R-38 attic insulation
- R-21 wall insulation with 2x6 walls utilizing intermediate framing techniques
- Blown fiberglass insulation
- R-30 under floor joist cavity insulation
- Upgraded building envelope with max 6.5 ACH @ 50 Pa (Air Changes/ Hour)
- 75% of the light fixtures are fitted with ENERGY STAR ® rated compact fluorescent lights (CFL)

30% Unit

- High-efficiency ducted electric heat pump, 9.0 HSPF
- Energy Recovery Ventilator (ERV) system– 70% Sensible Recovery Efficiency
- Raised heel trusses with R-60 attic insulation
- R-26 wall insulation with 2x6 walls utilizing intermediate framing techniques
- Wall Insulation; 1 inch of spray foam and 4.5 inches of blown fiberglass
- R-38 under floor joist cavity insulation
- Upgraded building envelope with max 5 ACH @ 50 Pa (Air Changes/ Hour)
- 90% of the light fixtures are fitted with ENERGY STAR ® rated Compact Fluorescent Lights (CFL)

Both Units

- High-efficiency 50 gallon Marathon water heater – 0.94 EF (efficiency)
- Sealed ductwork with mastic paste, located inside the conditioned envelope of the home
- Duct blast tests administered to ensure tightly sealed ductwork with less than 6% leakage
- U-0.30 U-value windows (technically only needed U-0.35 for the 15% path)
- Air sealed envelope with caulked and sealed framing and sheathing joints
- ENERGY STAR ® rated appliances
- ENERGY STAR ®, Earth Advantage ®, and LEED ® for Homes Gold certifications

"We will surely use these strategies on future projects."

Builder David Hassin , Terrafirma Building, Inc.

EPS
EnergyPerformanceScore
brought to you by Energy Trust of Oregon

Each PEEHP home received an EPS

EPS™ is an energy performance scoring tool brought to you by Energy Trust to help home buyers assess a home's energy consumption, costs, and carbon emissions. It's helping builders frame the value of energy efficiency features they include in their homes.

The Easy Way To Compare Energy Use

Energy efficiency, utility costs and environmental impact are important factors to consider when buying or building a home. They can affect the real and perceived value of a home, but are not always easy to quantify. EPS compares a home's energy consumption, costs and carbon emissions with those of similar sized homes in Oregon.

Measuring Energy Use and Costs

EPS calculation is based on several factors: building size, air leakage and ventilation, insulation, windows, heating and cooling systems, water heating, lighting, major appliances and standard operating conditions. Actual energy use will vary with occupant behavior and weather. Fuel costs are based on retail prices of each gas and/or electric utility at the time the EPS is issued.

Carbon Emissions

A home's energy consumption affects carbon emissions and impacts the environment. EPS estimates these emissions from the electric production and natural gas consumption of the home to create a carbon score. You can change your carbon footprint by purchasing renewable energy options from your utility or other carbon offset programs.

For more information about EPS, contact Energy Trust at 1.877.283.0698 or visit www.energytrust.org/eps.

To view EPS details for the PEEHP case studies, visit the PEEHP web site: www.portlandoregon.gov/bds/peehp.

CASE STUDY: North Portland Affordable Housing

Setting Goals: Determining a 2008 Code Baseline Efficiency Standard

The intent of the PEEHP is to provide costs and feasibility data for constructing single and multiple-family houses to the 2008 Oregon Residential Energy Code (2008 Code) in comparison with constructing homes that perform 15% and 30% more efficiently than the 2008 Code.

To track the relative improvement in efficiency of the homes in this case study, appropriate efficiency measures were determined using the 2008 Oregon Residential Energy Code requirements as a baseline.

The 2008 Code requires that certain prescriptive standards be met, and beyond that, builders are required to choose one of nine additional energy efficiency options. The baseline 2008 Code path for this home was the most commonly selected path in new construction for natural gas homes - *Option 1: installation of high efficiency HVAC equipment.*

Gathering Data: Estimating Costs

The PEEHP grant process funded the incremental cost of energy efficiency measures over what is required by the 2008 Code. To determine the additional construction costs to be covered by the grant, each builder was required to provide cost estimates from three different subcontractors for the work to be performed.

Further, each subcontractor had to provide bids for the costs associated with building the home to 2008 Code, to 15% above 2008 Code, and to 30% above 2008 Code, as appropriate based on the different energy efficient measures selected by the builder.

Based on this information, it was possible to calculate incremental costs. Using the lowest bids, the grant covered the cost difference between the "code home" and the higher efficiency home (see the performance table for exact figures).

Achieving Results: Modeling and Verification

Through Energy Trust's New Homes program, Andrew Shepard, a green building consultant with Earth Advantage Institute, provided ongoing technical assistance to Fish Construction NW by examining building plans and building practices, and identifying opportunities for energy savings. Energy modeling software was used to calculate efficiency goals and the measures necessary to achieve those goals. The consultant estimated the savings from individual efficiency measures to assemble a package of measures to meet the homes energy use reduction targets. To ensure the calculated savings were achieved, third-party modeling and verification services were conducted, including:

- Home energy use modeling using the REM/Rate software tool. REM/Rate is published by Architectural Energy Corporation of Boulder, Colorado, and complies with Residential Energy Services Network (RESNET) protocols for modeling home energy ratings.
- Third-party testing, involving at least two physical inspections, a duct blast, and blower door test verified that systems and materials were correctly installed and working properly. An EPS confirmed the level at which a home is performing.

Home Energy Performance Information

Builder	Terrafirma Building, Inc.						
Home Address	5107 N. Fessenden Ave. & 9517 N. Adriatic St. 2 units 15% more efficient than 2008 Code			9435 N. Exeter St. & 5412 N. Fessenden Ave. 2 units 30% more efficient than 2008 Code			
Home Style	2-Story row house with a shared interior wall						
Square Feet	Approximately 1600 sf per unit						
# of Occupants	4, based on 3 bedrooms per unit						
Heating & Hot Water Source	High Efficiency Electric Heat Pumps and Marathon Hot Water Heaters						
Target Efficiency Increase	Meet Code	15% Grant Requirement	15% Unit 1 Actual ** Construction	15% Unit 2 Actual ** Construction	30% Grant Requirement	30% Unit 1 Actual ** Construction	30% Unit 2 Actual ** Construction
Efficiency Increase**	0	15%	30%	30%	30%	30%	30%
Incremental Cost of All Measures**	0	$4,305	$4,305	$4,305	$9,485	$9,485	$9,485
Est. Annual Energy Cost Savings	$1,537 (Total Cost/Yr.)	N/A	$403	$431	N/A	$415	$415
Annual kWh Savings	0	2,932 kWh	4,261 kWh	4,560 kWh	3,384 kWh	4,390 kWh	4,388 kWh
Annual Carbon Emmissions	7.4-7.7 tons/yr	N/A	6.2 tons/yr	6 tons/yr	N/A	6 tons/yr	6.1 tons/yr
EPS*	55.5	44.7	40.9	39	40.7	39	39

*A lower EPS score reflects less energy use and lower operating costs. Energy Trust is in the process of modifying the formula for calculating EPS scores. Under this new methodology, the EPS scores for gas or electric homes constructed in the same way would be very similar. For more details visit: *www.energytrust.org/library/meetings/other/EPS_HES_Proposal_CAC.pdf*

**Actual construction cost and savings data may differ from that funded by the grant due to a number of factors, including
a) different equipment being installed compared to what was originally planned,
b) use of a different contractor to improve installation or warranty services, and
c) variation in the bidding approach of the contractor.