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A Holistic Approach to Energy Remodeling

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1




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The Holistic Building

- Buildings are compilations of many different systems all designed to work as a single unit.
- Individual Systems anomalies often have an affect on multiple systems operation.
- All Buildings should:
 1. Provide a Comfortable and Healthy Environment
 2. Be Durable, Safe and Secure; and
 3. Be Energy Efficient

2



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Building Science


The study of the interaction between:

- The design, materials, products and systems used in construction;
- the building occupants, and;
- the environment or zone in which they are located.

- Physics is nature's laws and rules that govern energy
- Entropy = Balance
- Energy moves by Conduction, Convection and Radiation
- Temperature is a measure of molecular vibration.
- Heat is the addition or subtraction of energy that changes the motion of molecules

3

Heat




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- **Specific heat** – The number of BTU’s of heat that one pound of a material holds for each degree of temperature increase.
- **Sensible heat** is the relationship between a material’s temperature and the amount of heat it contains.
- **Latent heat** is the unexpectedly large amount of heat absorbed or released when a material changes phase from a liquid to a gas or from a solid to a liquid and back again.
- **Heat flow** – Temperature Difference or Delta T.

4

Sample Energy Math




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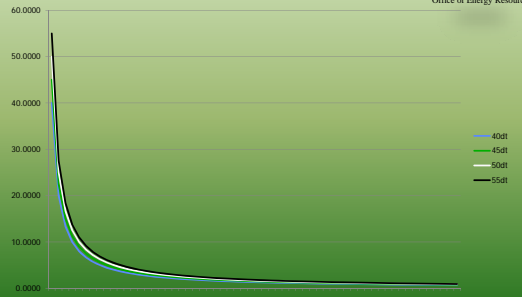
- Basic Plane Geometry
- R-Value = 1/U-Factor & U-Factor = 1/R-Value
- Assembly Heat Loss
 $Q = U \times A \times \Delta T$
- Air leakage Heat Loss
Sensible Heat loss $q = (1.08 \times ACH_n \times V \times \Delta T) / 60$
Latent Heat Loss $q = (0.68 \times ACH_n \times V \times \Delta T) / 60$

5

Heat Loss Compared to R-Value




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6

The Hierarchy of Efficiency



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- Testing and Inspection
- Quality Assurance
- Insulation
- Ductwork
- Building Envelope
- Lighting
- High Efficiency Equipment
- Windows

7

Home Auditing



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- A Key to the success of any program
- Targeted Auditing
- The Comprehensive Home Assessment
- Pre and Post Testing and Inspections
- Energy Modeling
- Project Management
- The Devil in the Details

8

The Code Built Building



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- Building a Community
- Minimum Standard allowable by law
- 10 years behind the science
- Idaho's Construction Culture
- Modeling Energy Efficiency
- HERS Ratings
- Commercial Energy Star
- Scoring an above code building
- The value of Certification

9


Setting Retrofit Project Goals



- Targeted performance improvements
- Must be Creative, Dynamic and Flexible
- Holistic Additions
- Efficient Components
- The importance of Lighting Efficiency
- Qualified Retrofit Contractors
- The need for Quality Assurance

10


Progressive Retrofit Recommendations
Do these First!



- Insulation
 - Ceilings – R-38 vaulted areas & R-49 Flat
 - Walls – blown in to the extent possible
 - Floors – R-30 where possible
 - Foundation Walls and Perimeter Insulated Crawl Spaces
- Duct Sealing – 50% reduction or .10 x home SF
- Air Sealing – Target 3.5 - 7 Air Changes per Hour when tested at 50 Pascals (3.5 - 7 ACH₅₀)
- Lighting – Assess Lighting and change where effective

11

Progressive Retrofit Recommendations
Do these things next!



- Furnaces – 90+ AFUE Gas
- Air Conditioners – 13 SEER
- Heat Pumps – 8.5 HSPF/13 SEER
- Water Heaters - .93 EF
- Windows - .35 U-Factor
- Other – As determined

12

Putting it All Together



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- Carbon Reduction
- Reduced Utility Expenses
- Reduced Stress on Existing Infrastructure
- Benefits of Energy Efficiency
- Comfort, Health, Safety, and Durability

13

Typical Certificate



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Idaho Home Performance with Energy Star® Renovated Home

This certifies the home located at
Address


Was renovated under the Home Performance with Energy Star Standards as adopted by the State of Idaho under authority of the U.S. Environmental Protection Agency. The following improvements were made to the home:

1. **Insulation Improvements** - Insulation Improvement from R-CT to Total R-C7
2. **Duct Sealing Improvements** - Tested Duct Leakage improved from (7) CFM₅₀ to (7) CFM₅₀
3. **Air Sealing Improvements** - Tested Envelope improved from (7) ACH₅₀ to (7) ACH₅₀
4. **HVAC Equipment Improvements** - A new (7) HSPF Heat Pump and a new (7) AFUE Furnace and a new (7) SEER Air Conditioner was (were) installed
5. **Water Heating Improvements** - A new (7) EF water heater was installed
6. **Window Improvements** - New Windows with a (7) U-value were installed

The Energy Analysis of the improved home has resulted in it receiving a Home Energy Rating Score of (****)
 equaling a $\frac{100}{100} + \frac{100}{100} + \frac{100}{100} + \frac{100}{100}$ Home Energy Rating.

Timothy J. O'Leary	Date	(HPS Name)	Date
Program Manager		(HPS Company)	
Idaho Home Performance with Energy Star		Home Performance Specialist	

14



Certified Residential Air Duct System

Testing Company Information

Company Name: _____
 Technician: _____ Date: _____

Duct System Information

Home Conditioned Floor Area (CFA) (ft²): _____
 yes no Air Handler in conditioned space?
 yes no Air Ducts in conditioned space?

Circle Test Method: Leakage to Outside or Total Leakage

Fan Settings:
 Restriction Ring: Open 1 2 3
 Duct Blaster Location: _____
 Pressure Tap Location: _____

Duct Test Date: _____
 Pre-Test Duct Leakage: _____ CFM₅₀
 Target Leakage @ 50% Reduction = _____ CFM₅₀
 Target Leakage @ CFA x 0.10 = _____ CFM₅₀
 Post Test Duct Leakage: _____ CFM₅₀

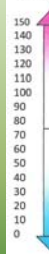
Building Envelope Information

Pre-Test Envelope Air Leakage: _____ CFM₅₀
 Post-Test Envelope Air Leakage: _____ CFM₅₀

Combustion Appliance Zone Test

Baseline CAZ House Pressure WRT Outside: _____ pa
 Tested CAZ with Furnace Fan Running: _____ pa
 NET CAZ (Subtract Baseline from Tested): _____ pa

HERS® Index



New Home
HERS 100

Home Address: _____

Rating Date: _____



Rated By: _____

Annual Estimates*:

Electricity (kWh): _____
 Natural Gas (Therms): _____
 CO2 Emissions (Tons): _____

*Based on standard home operation

Office of Energy Resources
 322 E. Front St., Suite 560
 P.O. Box 83720
 Boise, ID 83720-0399

This home has been inspected and performance tested in accordance with Chapter 3 of the RESNET Standards

15




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Replacement of a typical 6'0" Window

- Existing, Aluminum Frame w/ 1/2" Air Space
- New, Vinyl Frame, Low-e w/ 1/2" Air Space
 - Purchase Price \$250.00
 - Demolition 1 hr @ \$45.00/hr
 - Installation 1 hr @ \$45.00/hr
 - Repairs to building after replacement \$250.00
 - Total Estimated Cost = \$595.00

16



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Cost to Benefit Analysis

$Q \text{ btu/yr} = U\text{-Factor} \times \text{Area} \times \text{HDD} \times 24 \text{ hours}$

Old Window	New Window
$Q = .70 \times 24 \text{ sf} \times 9866 \text{ HDD} \times 24 \text{ hrs}$	$Q = .35 \times 24 \text{ sf} \times 9866 \text{ HDD} \times 24 \text{ hrs}$
$Q = 3,977,971 \text{ btu/yr}$	$Q = 1,988,985 \text{ btu/yr}$

Total Savings = 1,988,985 btu/yr
 kWh = 3413 btu/kwh = 583 kWh/year
 Therms = 100,000 btu/Therm = 19.9 Therms/Yr

Electric Heat	Gas Heat
$583 \text{ kWh} \times \$0.086 = \$50.14/\text{Yr}$	$19.9 \text{ Therms} \times \$9.428 = \$18.76/\text{yr}$
$\$595.00 / \$50.14 = 11.9 \text{ yrs}$	$\$595.00 / \$18.76 = 31.7 \text{ yrs}$

17




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Insulation Upgrade

- 1,700 SF Home
- Existing Flat Ceiling Insulation R-19 Batts
- Proposed Add R-30 Blow-in Fiberglass
 - Installed Purchase Price = \$1,500

18



Cost to Benefit Analysis

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$Q \text{ btu/yr} = U\text{-Factor} \times \text{Area} \times \text{HDD} \times 24 \text{ hrs}$

Existing Ceiling	New Ceiling
$Q = .053 \times 1,700 \text{ sf} \times 9866 \text{ HDD} \times 24 \text{ hrs}$	$Q = .021 \times 1,700 \text{ sf} \times 9866 \text{ HDD} \times 24 \text{ hrs}$
$Q = 21,334,238 \text{ btu/yr}$	$Q = 8,453,189 \text{ btu/yr}$

Total Savings = 12,881,049 btu/yr
 kWh = 3,413btu/kwh = 3,774 kWh/yr
 Therms = 100,000 btu/Therm = 129 Therms/yr

Electric Heat	Gas Heat
$3,774 \text{ kWh/yr} \times \$0.086 = \$324.56/\text{yr}$	$129 \text{ Therms} \times \$0.9428 = \$121.62/\text{yr}$
$\$1,500 / 324.56 = 4.6 \text{ yrs}$	$\$1,500 / 121.62 = 12.3 \text{ yrs}$

19



Cost to Benefit for Both Improvements


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Blend the costs and Recalculate the Payback

Retrofit Cost	Btu/yr
Window = \$595	Window = 1,988,985 btu/yr
Insulation = \$1,500	Insulation = 12,881,049 btu/yr
Combined = \$2,095	Combined = 14,873,034 btu/yr

Total Savings = 14,873,034 btu/yr
 kWh = 3413btu/kWh = 4,358 kWh/yr
 Therms = 100,000 btu/Therm = 149 Therms

Electric Heat	Gas Heat
$4,358 \text{ kWh/yr} \times \$0.086 = \$374.79/\text{yr}$	$149 \text{ Therms} \times \$0.9428 = \$140.48/\text{yr}$
$\$2,095 / \$374.79 = 5.6 \text{ yrs}$	$\$2,095 / 140.48 = 14.9 \text{ yrs}$ ²⁰




Summary

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- **Window Only**
 - Electric Heat \$50.14/Yr savings 11.9 yrs Payback
 - Gas Heat \$18.76/yr savings 31.7 yrs Payback
- **Insulation Only**
 - Electric Heat \$324.56/yr savings 4.6 yrs Payback
 - Gas Heat \$121.62/yr savings 12.3 yrs Payback
- **Combined**
 - Electric Heat \$374.79/yr savings 5.6 yrs Payback
 - Gas Heat \$140.48/yr savings 14.9 yrs Payback

21



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Monthly Benefit

- Electrically Heated Home
 - \$374.79/year / 12 months = \$31.23 / month
- Gas Heated Home
 - \$140.48/year / 12 months = \$11.71 / month

22



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Air Sealing

23



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If light shines through, air gets past.



Foam is cheap but Energy is expensive.

24





