CASE 2. USING PAYBACK TO ORDER PROJECTS Updated Feb. 2011

The first act we undertook on purchasing our house in 1989 was to turn down the thermostat by twelve degrees to 62 degrees. We saved 200 gallons of fuel/year on that act alone. None of our subsequent actions save installing a geothermal heat pump in the fall of 2009 has done as much to reduce our use of fuel oil.

In 1999 we began a serious program of retrofits including improving insulation, increasing solar insolation, installing a geothermal heat pump, and then replacing 13 of our worst windows. An overview of the actions, with costs, savings, and paybacks, is shown in the Retrofits Table below.

The payback period represents the time, usually measured in years, required to pay for an energy improvement out of the expected savings from the improvement. The payback period is calculated by knowing: (a) $ cost of retrofit and (b) projected or measured savings of energy (fuel oil in our case) per year as a result of doing that retrofit. Consider the example of foam board shutters placed on 17 windows on the north & west sides of the house. At the time, fuel oil to heat the house was $1.39/gallon, so if we saved 25 gal/year (our estimate at the time). Total projected saving was $1.39/gal x 25 gal/yr = $34.75 per year. Divide the cost of making the shutters of $100 by the $34.75 = a payback interval of 2.9 years.

Later we found that total measured fuel oil savings of all improvements was only half of what we originally estimated, 100 gallons rather than 200 gallons a year, and it is this lower figure that we allocated among the projects in the table below. Even this 100 gallons is suspect, as the average number of degree days has declined by 5% from the before retrofits to after retrofits period. Therefore, we reduced all the projected savings by half, leading to an increase of the payback period for shutters to 7.2 years. It is these revised paybacks that we show.

Paybacks are sensitive to dollar savings in energy costs. We stuck with the fuel oil costs at the time of the project's completion. A more sophisticated calculation would account for yearly changes in fuel oil costs, and the present value of future savings. We kept it simple. Fuel oil costs have not consistently gone up, but peaked, then declined, and are now on the way up again. It is also important to include maintenance and repair costs. These have proven minimal for most of our improvements, other than for the solar hot water system, which already has a long payback period.

While we tracked heating degree days and compared these to fuel oil costs, we concluded that this would not add much resolution to our calculations.

Neo-Terra House Retrofits

Strategy House Retrofits	$/gal	$ Cost	Saving gal/yr	Year done	Pay-back yrs
Reduce use:					
Lower thermostat, wear warmer clothes indoors		0	200	89	**0**
Prevent Heat Loss:					
make foam board shutters ………………….…..	1.39	100	10	00	**7.2**
improve insulation in 2 attic areas (glass wool) ..	1.39	400	15	00	**19**
improve insulation in 3rd attic (polyicynene) …..	1.39	1,600	15	01	**77**
replace old insulation in 3 living room walls with polyicynene foam ……………….……..	1.39	7,600	20	01	**273**
improve insulation in east & south walls ……….	2.90	5,780	20	08	**100**
replace 13 old windows with high R triple-pane windows (includes $1,500 Fed tax credit) ….	2.90	21,388	?	10	**?**
Increase Solar Insolation: (see Note 1)					
Duggin hot air collector ('03), never undertaken ..	1.50	2,000-2,700	(50-100)	No	**18-27**
Install salvaged hot water collectors for domestic heat (winter) and summer hot water …………	2.10	2,854	10+$60 elec	05	**35**
Kreamer hot air collectors (Note 2) …………….	2.90	738	10	08	**25**
Reduce Use: Second Round – Geothermal					
Install geothermal heating (fuel oil cost Sept 09) Total cost includes 30% Federal tax credit	2.35	18,000	450 – elect↑ $208	09	**21**

Note 1. For paybacks greater than the 10 years we assumed the rate of return on investment to be negative, that is, you cannot get your money back in savings sufficiently high to pay for the collector (and therefore its replacement) within the life of the collector (projected at 10 years). Rule of thumb is that each sq.ft. of collector area displaces 1 gal fuel oil/heating season in the northeast.

Note 2. Fuel oil on 11-10-08 was $2.90/gal, down from $3.58 in March 22 of that year. The 10 gallon saving is an estimate based on calculations of incident solar radiation falling on a vertical surface, reduced by the known efficiency of the device, the reflection coefficient of the glazing, and reduced further by the estimated shade factor from tall deciduous trees on the south border.

Through our efforts we have come to appreciate the difficulty in making older homes more energy efficient. In particular, we appreciate that a program of gradual improvement cannot yield dramatic results as long as major heat leaks remain. What good is improving the overall house envelope insulation if the windows leak? Effectively, you have R=30 walls with a large R=2 area for the windows. Still, many of us cannot afford to do all the improvements at once, so payback helps us to select what to do first.

The table above reflects a three-pronged strategy: first reduce use, next prevent heat loss, and then increase solar insolation. It makes little sense to add solar collectors to heat your house if you have not improved the insulation. The solar heat just goes right out again. Of course, there are projects in which you can accomplish both heat loss prevention and improving solar insolation. Adding an attached solar greenhouse comes to mind. This requires careful analysis and design to ensure that the savings actually materialize. Given the expense of this undertaking, it may still have to take a back seat to less expensive alternatives that have longer paybacks.

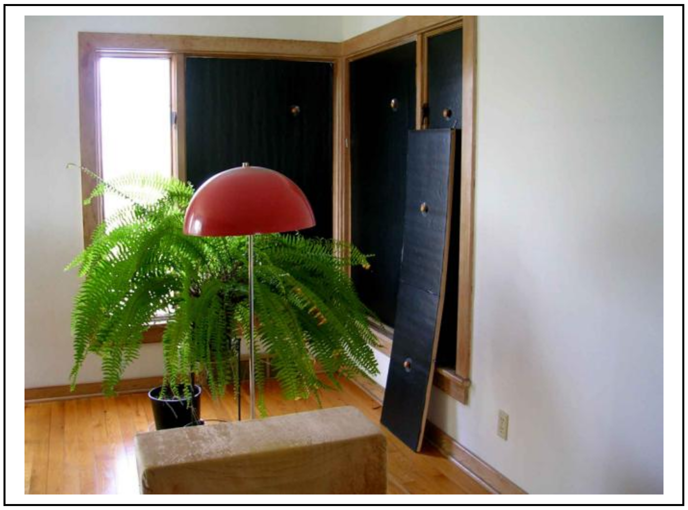
We applied the three-pronged strategy in the following way. First, we reduced use by turning down the thermostat and wearing warmer clothes. Savings: 200 gallons. Next, we undertook the first four "prevent heat loss" retrofits. Totaling $9,700, we realized less than half of the fuel oil savings as we did with the initial step of turning down the thermostat. As the payback period increased (to 273 years with the living room retrofit), we began to explore active solar and installed a four-panel system under $3,000 with a payback of 35 years. In the fall of 2008 we improved two more walls whose savings we estimate at 20 gallons. As part of the south wall retrofit we built two hot air collectors; energy savings for which were modest at best, but the payback is favorable.

In the fall of 2009 we then installed a geothermal heating system using two drilled wells. During the planning stage the contractor urged us to tighten up the house, as this would reduce the size of the heat pump and depth of the wells, and therefore overall project expense. This served as the impetus for improving the south and east walls and adding the hot air collectors the previous year. By the fall of 2010 we had on year's of heating data from the new geothermal heat pump, yielding a favorable payback of 21 years.

In the summer of 2010 we turned our attention to the worst windows in the house. Our house has 24 windows, original to the 1937 house or its addition in 1957. Many are old fashioned double hungs with aluminum storms; others old Anderson double-paned casements or picture windows. All leaked air and moisture. All suffered condensation on the inside storms or panes, even freezing of condensate on cold winter nights. The glass area of all our windows is equivalent to the entire east wall of our house below the attic. Imagine, then, one whole wall of your house having an R value of 2 (and leaky at that).

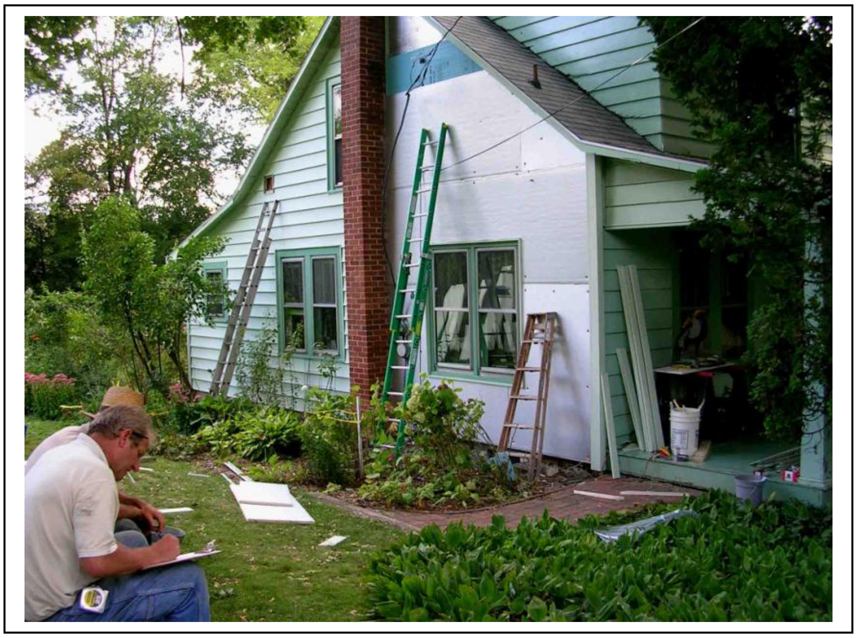
We had first considered replacing the windows 10 years ago, but the prohibitive cost of high quality windows deterred us. We did not want to use vinyl, made with PVC, which is toxic in production and disposal. At that time we decided to start with the lower cost measures indicated in our Retrofits Table. Having exhausted all the easier and less expensive improvements, we replaced the worst windows on the weather walls – windows on the north and west sides of the house – in mid-December 2010. After considerable investigation, we settled on Serious Windows, one of the few American producers of high performance windows.

Following are some images of some of our retrofit projects. For more detail on our retrofits effort, see our file "From Farmhouse to Eco-house," a workshop we gave in February of 2010 at the Pennsylvania Association for Sustainable Agriculture.

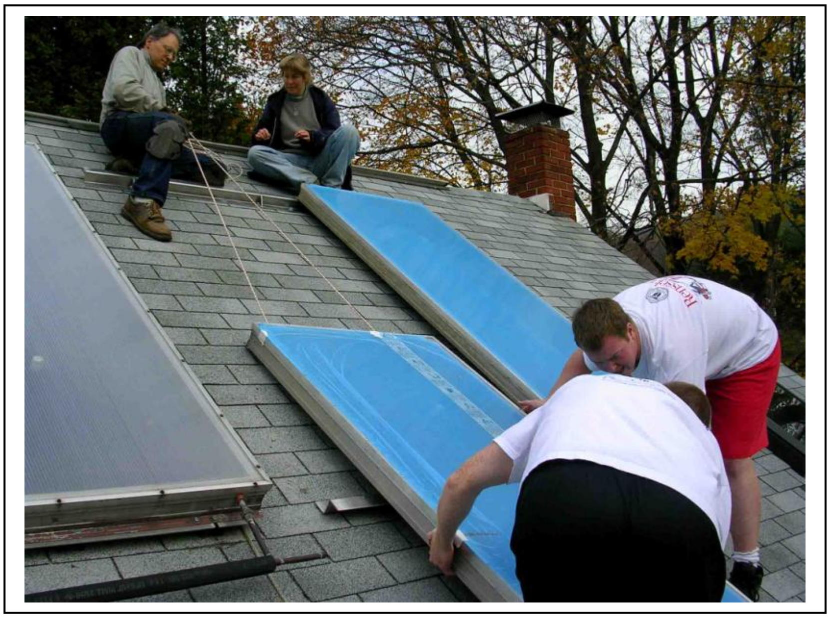


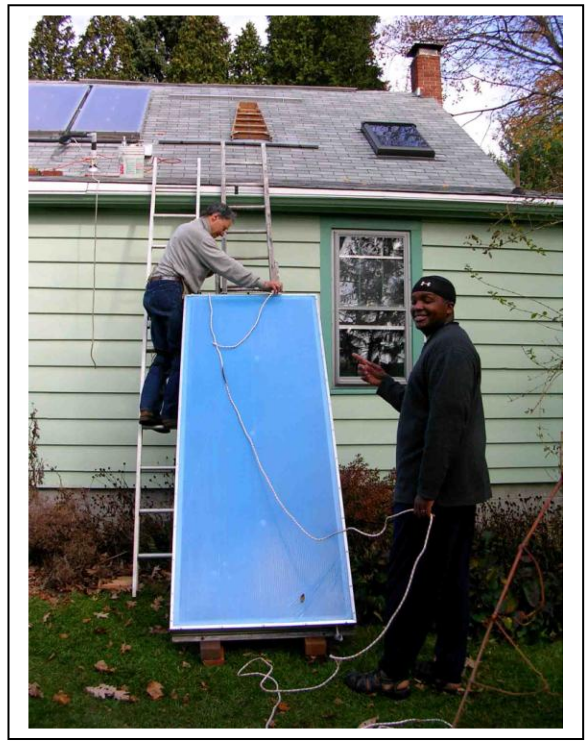
<u>Above: Picture 1</u>. Foamboard shutters in livingroom, 2000

<u>Right: Picture 2.</u> Living room retrofit 2001, polyicynene foam followed by sheathing and 1" foamboard



<u>Right: Picture 3.</u> East wall retrofit 2008, 2" foamboard over existing rock wool





Above: Picture 4. Adding two more hot water panels in 2005

Right: Picture 5. Using ladders to slide collectors to roof

Above: Picture 6. Completed plumbing for our two tank pressurized glycol system

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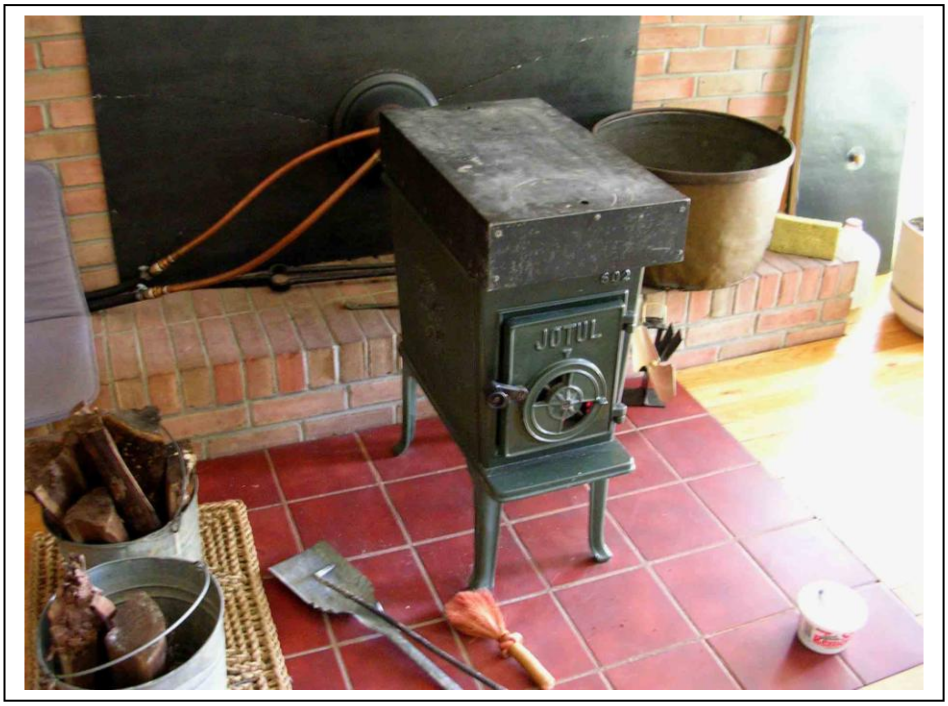

Above: Picture 7. Heat transfer box to move heat from stove to basement apartment via plumbing in Picture 6

Above: Picture 8. Completed Kreamer hot air colletors, fall 2008

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