A photograph of a two-story house under renovation. The roof is covered with a row of solar panels. The exterior walls are covered in yellow sheetrock. There are several windows and a central door. A brick chimney is visible on the right side. The house is surrounded by trees and a lawn. The sky is clear and blue.

# ***Going Positive: Net Positive Energy Renovation in Gloucester, MA***

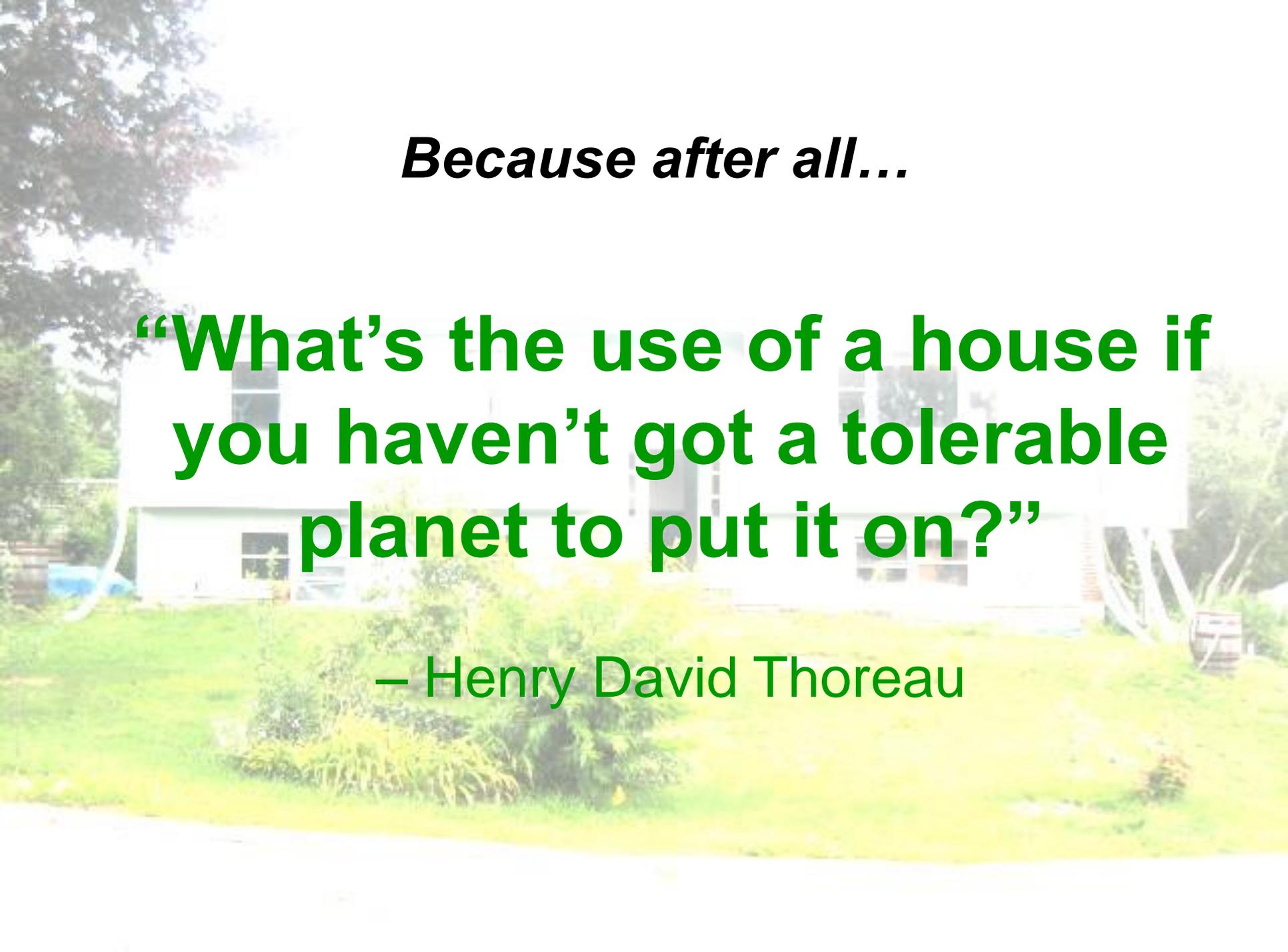
**Deep Energy Retrofit Workshop**

**Merrimack College**

**May 21, 2014**

**John Livermore, Livermore Energy Associates**

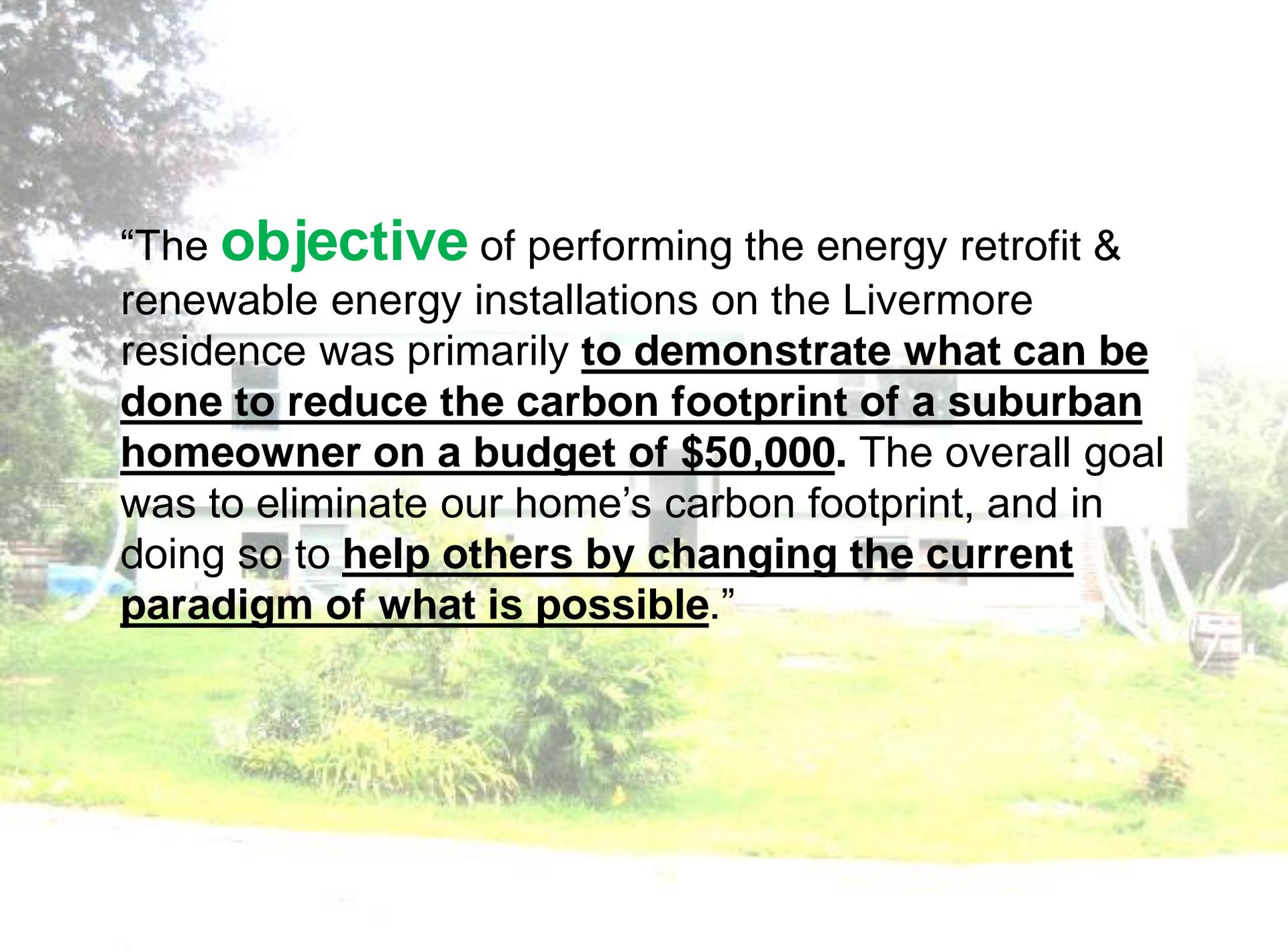
“The **motivation** for taking action to reduce our family’s carbon footprint was the understanding that **carbon emissions need to be reduced by about 90% worldwide by 2030 in order to stabilize the earth’s climate** (at 350 ppm), and the realization that I needed to take personal responsibility for reducing our emissions. Also, I’d been in the energy efficiency business for over 20 years & I felt it was time to put my money where my mouth was, **to walk the talk**, taking everything I’d learned about building science & had dreamed about doing over the years, & applying it toward retrofitting my own house.”



***Because after all...***

**“What’s the use of a house if  
you haven’t got a tolerable  
planet to put it on?”**

**– Henry David Thoreau**

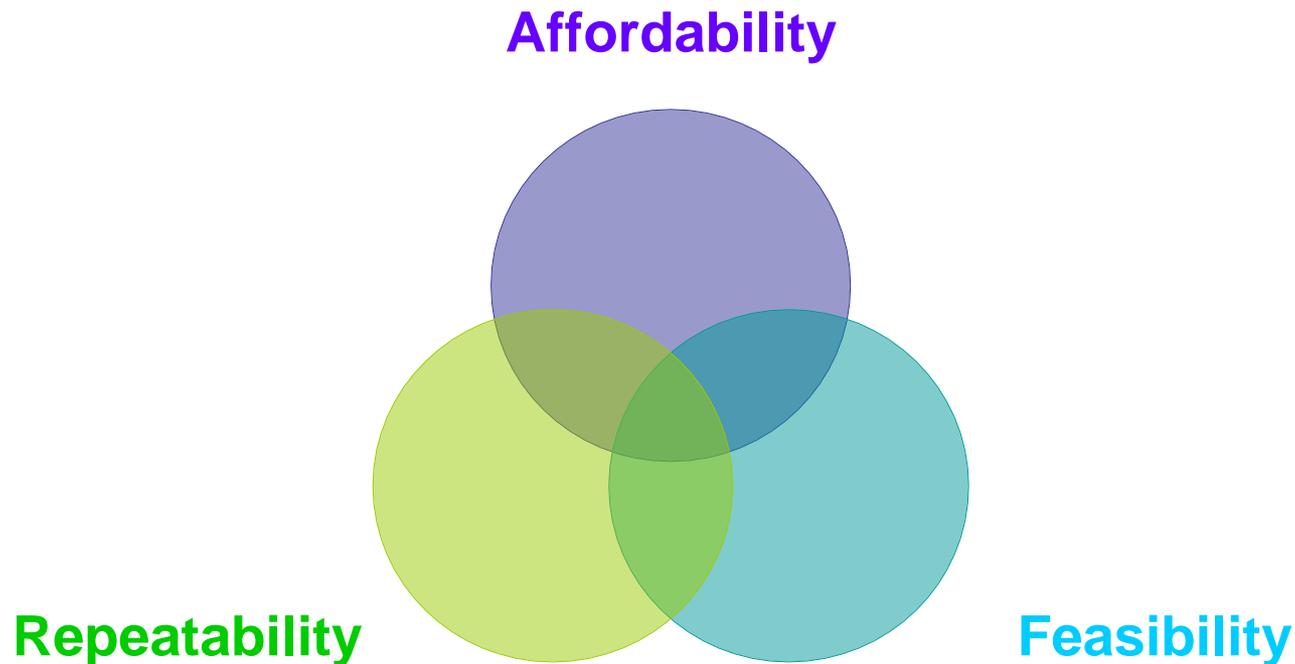


“The **objective** of performing the energy retrofit & renewable energy installations on the Livermore residence was primarily to demonstrate what can be done to reduce the carbon footprint of a suburban homeowner on a budget of \$50,000. The overall goal was to eliminate our home’s carbon footprint, and in doing so to help others by changing the current paradigm of what is possible.”

# The retrofit strategy struck a balance between three objectives:

1. Make it **affordable**
2. Make it **feasible** (use off-the-shelf technologies)
3. Make it **repeatable**

The sweet spot in the middle, where the three circles overlap, is where we focused our strategy.



# Project Cost Breakout

(approximate)

Lumber & materials: \$9,000

Closed-cell foam insulation: \$7,000

High perf. windows/doors: \$19,000

Solar hot water system: \$11,500

Solar PV system: \$9,000

Attic insulation: \$1,000

Other labor: \$4,000

**Total: \$60,500**

Note: Costs do not include my time, but do factor in all rebates & tax credits.

# Our Challenge: Turn this 'Energy Hog' into an 'Energy Producer'!



Note: Home has 2,432 square feet of finished area.

# Project Highlights

- **Walls: R-43** - 5" of closed-cell spray foam (R-30) added to exterior of existing R-13 fiberglass batt-insulated walls.
- **Attic: R-76** blown cellulose w/radiant barrier in rafters (foil-faced bubble wrap).
- **Windows: R-5** Thermotech™, fiberglass, triple-pane, low-E, argon (mostly casements).
- **Doors: R-5** Thermotech™ fiberglass.
- **Basement Walls: R-22** (4½" EPS foam board).
- **Basement Floor: R-7.5** (1½" EPS foam board).

# Project Highlights (continued)

- **Air Sealing:** Reduce from 1,200 to **500 cfm50 (1.0 cfm50/sq.ft. 6-sided shell area); 1.6 ACH/50.**
- **Ventilation:** 50 cfm Panasonic™ fan on 24-hour schedule controlled by digital timer.
- **Heating:** Weil-McLain™ 87.5 AFUE boiler w/hydro air; Scan woodstove.
- **DHW:** SuperStor™ indirect fired tank w/solar.
- **Lighting:** All LED
- **Appliances:** All ENERGY STAR®
- **Renewables:** **4.3 kW** solar electric system & Schuco™ 3-panel solar hot water system.



# Project Team



**John Livermore**

Project Designer &  
Owner

**Caleb Ewing**  
Lead Carpenter



**Marc  
Rosenbaum, P.E.**  
Project Engineer



**Bill Hallaren**  
Project Assistant

# Other Team Members



**My daughters,  
Alix & Samantha**

**My 93-year-old father**



**Jasmine,  
“the supervisor”**



# *Carbon Footprint Reduction Laboratory*

Poster created by Samantha Livermore



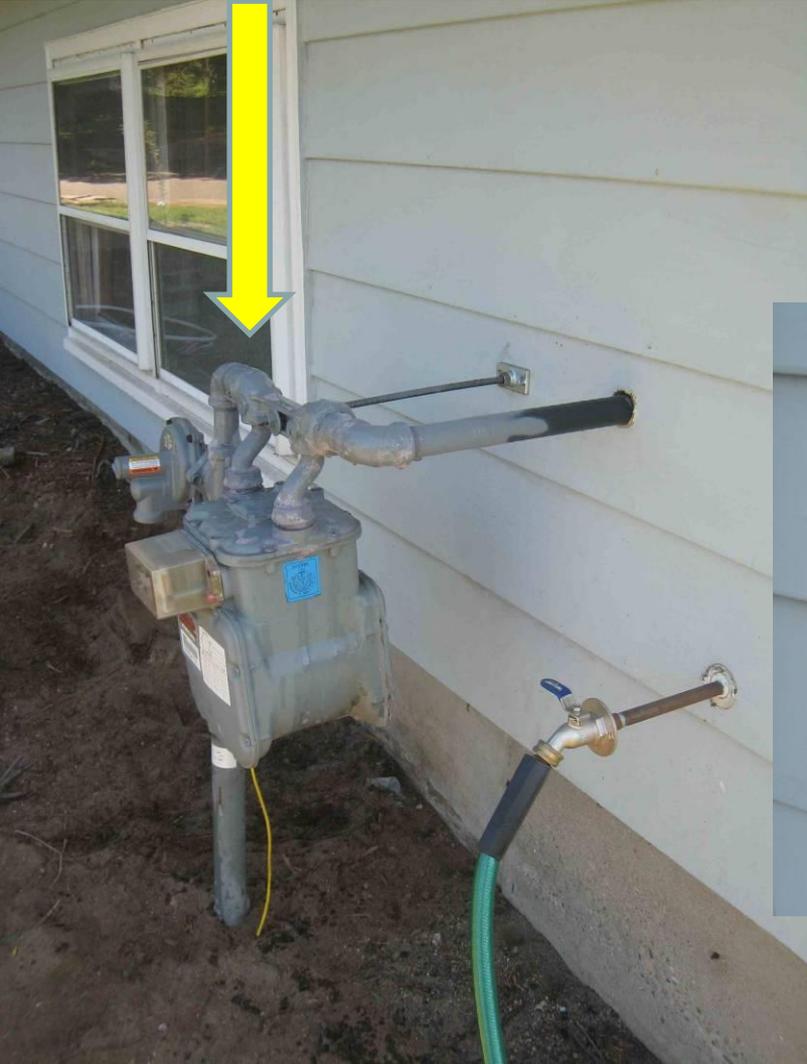
The image shows the interior of an attic. Several wooden rafters are visible, running diagonally across the frame. A dark, foil-faced material, identified as a radiant barrier, is installed over the rafters. Below the radiant barrier, there is a layer of insulation, identified as R-76 blown-in cellulose. The insulation appears as a thick, fibrous material filling the spaces between the rafters. The overall scene is dimly lit, with some light reflecting off the foil surface.

**Radiant Barrier:**  
Foil-faced bubble  
wrap (Reflectix™)

**Attic Insulation:**  
R-76 blown-in cellulose (approx. 22")

# Extending out the Utilities

## Gas Meter & Water Spigots



**Boiler Intake & Exhaust**



# **Gable Roof Extensions**

**August 2008**



# Wall Truss System



Ripped 2x4s down the middle & nailed together with plywood pieces the thickness of the desired wall cavity.



# Window Frame Extensions



**Attached frames with  
9" screws**

# Spraying Foam



# Windows

Thermotech™, triple-pane, Low-E, argon-filled, foam-filled fiberglass frame, R-5





**'The Yellow Cake'**



**January 1, 2009**

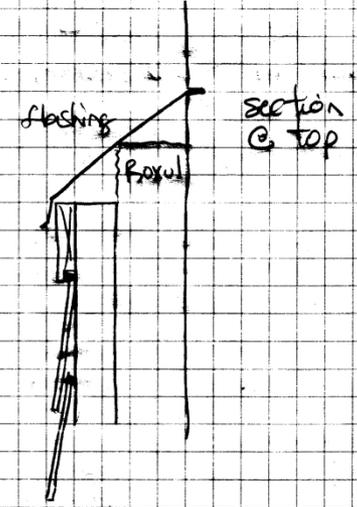
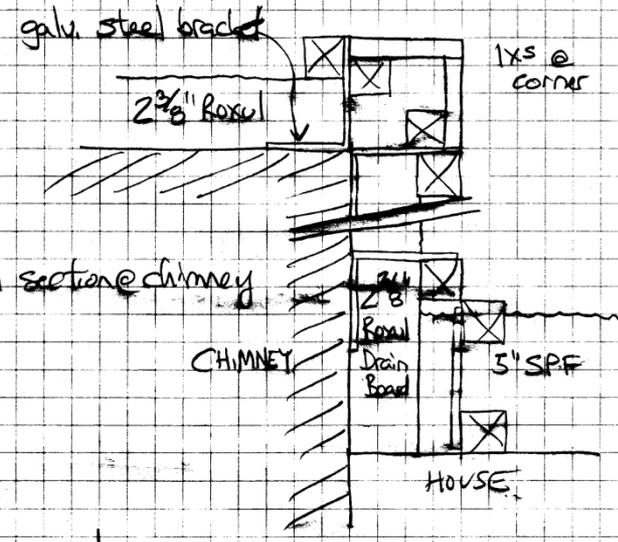


# June 2009



LIVERMORE CHIMNEY

9/8/08  
①



# Chimney Insulation System

**Roxul™ mineral  
wool (2 3/8", R-10)**



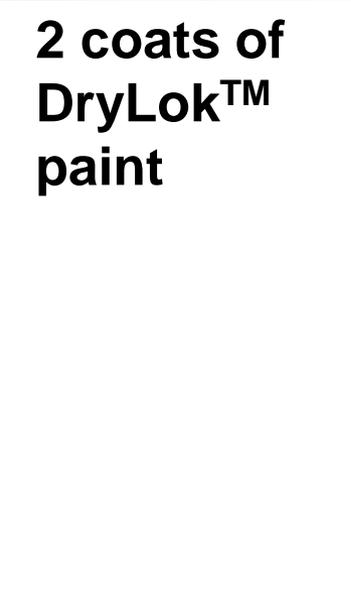
# Basement Floor Insulation System



Install  
2"x3" grid



Install  $\frac{3}{4}$ "  
T&G  
plywood



2 coats of  
DryLok™  
paint



Cut & fit  
1½" EPS  
foam board



# Foundation Wall Insulation System





All LEDs

Lighting





Photo by Dave Legg

# Appliances

*Gave away dryer* →

**Other appliances are  
ENERGY STAR-rated**



# Ventilation



17-watt Panasonic™ fan (50 cfm) on ventilation schedule controlled by digital timer



Enough  
solar energy  
falls on the earth  
**every hour** to  
satisfy the world's  
energy needs for  
**an entire year!**

# Solar Hot Water System

**Free hot water**  
**(April-October)**



**3-panel Schuco™  
system with...  
110 gallon stainless  
steel storage tank**





# Solar Hot Water Production-Usage

## Jan 2009 - Nov 2009

	Approx.	
Solar DHW HP cumul. (hrs)	pump usage cumul. (kWh)	Solar DHW Cumul. (kWh)
134	9	270
245	17	686
355	25	1135
468	33	1648
567	40	2096
685	48	2962
845	59	4358
966	68	5258
1067	75	5749
1186	83	6235
1277	89	6560

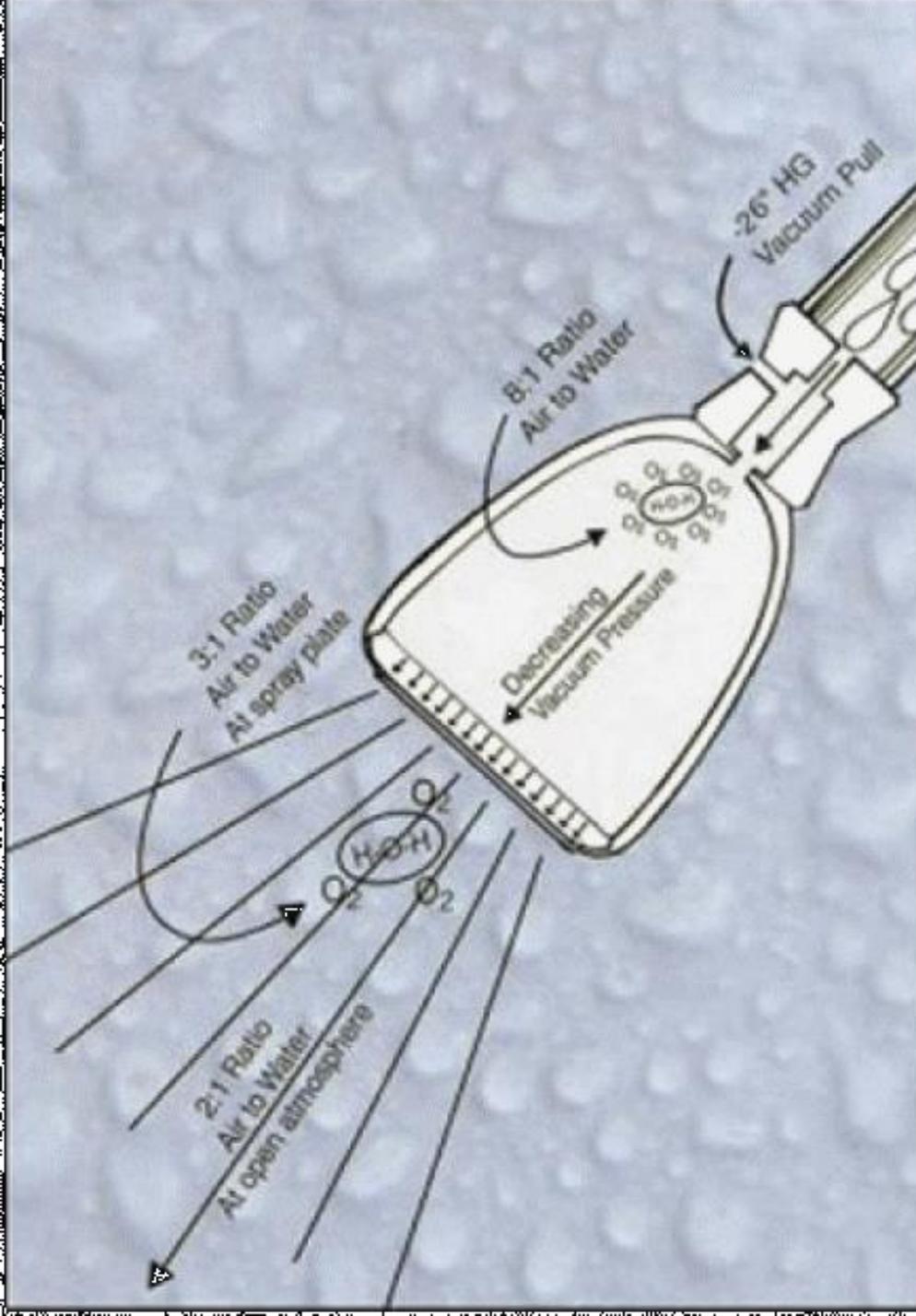
- 110 gallon solar tank heats up to **145° F**
- Annual gas usage: 51 therms (previous baseline about 180 therms)
- Offset approximately 130 therms of gas annually
- **4 therms** of gas usage over 7-month period (Apr-Oct)

HP is hours the 70 watt pump operated

Solar DHW Cumul (KWH) is electricity offset assuming DHW was electric resistance.

# Hot Water Usage

- Bricor™ 1.125 GPM showerhead
- Could take a **2-hour** shower on 1 full tank of **solar** hot water



# Solar PV System

4,300 Watt system  
(14) 310-watt Schott™ panels



# Solar Electricity Production-Usage

Oct 2008 - Sept 2009 (1<sup>st</sup> year)

		Exterior	Total
PV	PV	Meter	calculat.
Prod.	Cumul.	Reading	Electric
(kWh)	(kWh)	(kWh)	Usage
			(kWh)
342	342		
234	576		
151	727	210	
166	893	375	331
329	1222	303	257
434	1656	69	200
548	2204	-290	189
570	2774	-673	187
476	3250	-968	181
586	3836	-1333	221
559	4395	-1712	180
494	<b>4889</b>	<b>-1986</b>	220

- Ann. Prod: **4,889** kWh
- Ann. Use: **2,903** kWh  
(previous baseline: 6,000 kWh)
- Produced **146%** of electricity needs!

# Scan™ Woodstove w/Biobrick™

Sole heat source  
for the house!



Photo by Dave Legg

# Energy & Carbon Reductions: Nov 2009 – Oct 2010

<u>Pre-Retrofit</u>	<u>Usage</u>		<u>Carbon</u>	
Electricity	6,000	kWh	4.1	tons
Hot Water	180	therms	1.1	tons
Heating	700	therms	<u>4.1</u>	tons
<b>Total</b>			<b>9.2</b>	<b>tons</b>
<u>Post-Retrofit</u>				
Electricity	-2,345	kWh	-1.6	tons
Hot Water	49	therms	0.3	tons
Heating-Wood	2,506	lbs	<u>0.3</u>	tons
<b>Total</b>			<b>-1.0</b>	<b>tons</b>



HERE WITH YOU. HERE FOR YOU.

National Grid MA Home Energy Reports  
40 Washington St. Suite 2000  
Westborough, MA 01581-1088

0065706 3193-C01-I -P65771-730880



JOHN LIVERMORE  
13 HIGH POPPLES RD  
GLOUCESTER MA 01930-4266



\*\*\*\*\*AUTO\*\*5-DIGIT 01930

### Home energy report

Account number: 4223620450  
Report period: 09/06/13-11/02/13

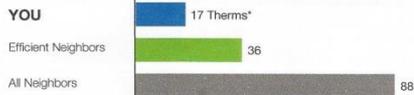
We are pleased to provide you periodic, personalized Home Energy Reports to help you make smart energy saving decisions.

For a full list of energy saving products and services for purchase, including rebates from National Grid, visit: [Ngrid.com/rebatesMA](http://Ngrid.com/rebatesMA)

If you have any questions about these reports or would like to no longer receive them, you can contact us at (877) 313-8803.

### Last 2 Months Neighbor Comparison

You used **53% less** natural gas than your efficient neighbors.



How you're doing:

**GREAT** 😊😊

Good 😊

More than average

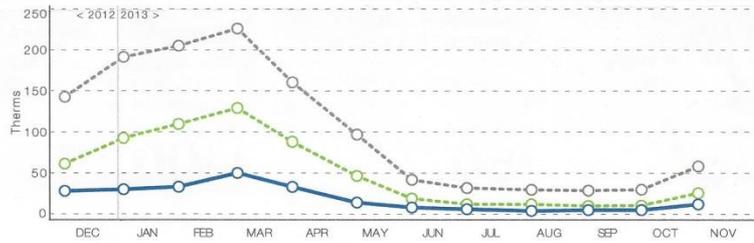
\* Therms: Standard unit of measuring heat energy

### Who are your Neighbors?

- All Neighbors:** Approximately 100 occupied nearby homes that are similar in size to yours (avg 2,395 sq ft) and have gas heat
- Efficient Neighbors:** The most efficient 20 percent from the "All Neighbors" group

### Last 12 Months Neighbor Comparison

You used **82% less** natural gas than your neighbors.  
This saves you about **\$1,682** per year.



Key: You All Neighbors Efficient Neighbors

Turn over for savings →



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National Grid MA Home Energy Reports  
40 Washington St. Suite 2000  
Westborough, MA 01581-1088

0037123 3116-C27-I -P37100-730880



JOHN G LIVERMORE  
13 HIGH POPPLES RD  
GLOUCESTER MA 01930-4266



\*\*\*\*\*AUTO\*\*5-DIGIT 01930

### Home energy report

Account number: 6334701018  
Report period: 01/05/14-03/05/14

We are pleased to provide you periodic, personalized Home Energy Reports to help you make smart energy saving decisions.

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If you have any questions about these reports or would like to no longer receive them, you can contact us at (877) 313-8803.

### Last 2 Months Neighbor Comparison

You used **63% less** electricity than your efficient neighbors.



How you're doing:

**GREAT** 😊😊

Good 😊

More than average

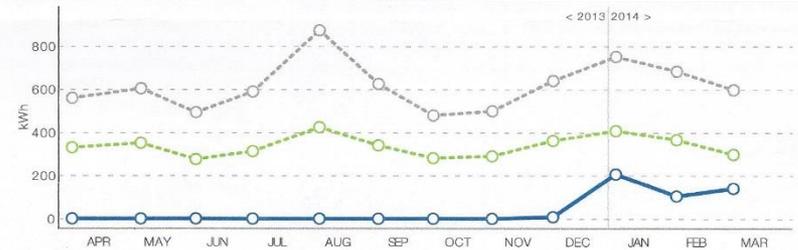
\* kWh: A 100-Watt bulb burning for 10 hours uses 1 kilowatt-hour.

### Who are your Neighbors?

- All Neighbors:** Approximately 100 occupied, nearby homes
- Efficient Neighbors:** The most efficient 20 percent from the "All Neighbors" group

### Last 12 Months Neighbor Comparison

You used **94% less** electricity than your neighbors.  
This saves you about **\$349** per year.



Key: You All Neighbors Efficient Neighbors

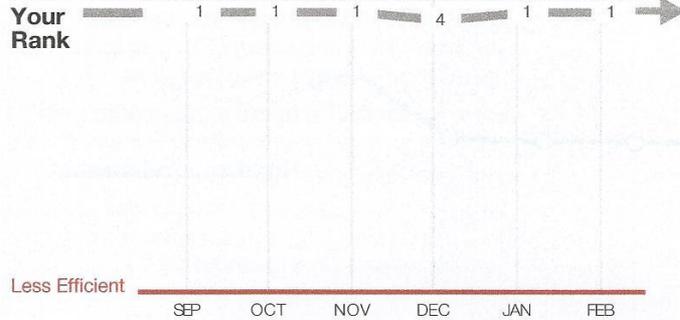
Turn over for savings →

# 1<sup>st</sup> Residential Net Positive Energy Renovation in Massachusetts

## Neighbor Efficiency Rank

More Efficient

Your Rank



★ You are number one! Great job!

Your rank

# 1

Out of 100 neighbors  
#1 is the most efficient

Less Efficient

Your rank is calculated each bill period.

See the Neighbor Comparison section for details about your neighbors.

Looking for ways to stay at the top?

[Ngrid.com/rebatesMA](http://Ngrid.com/rebatesMA)

# A Boatload of Other Benefits

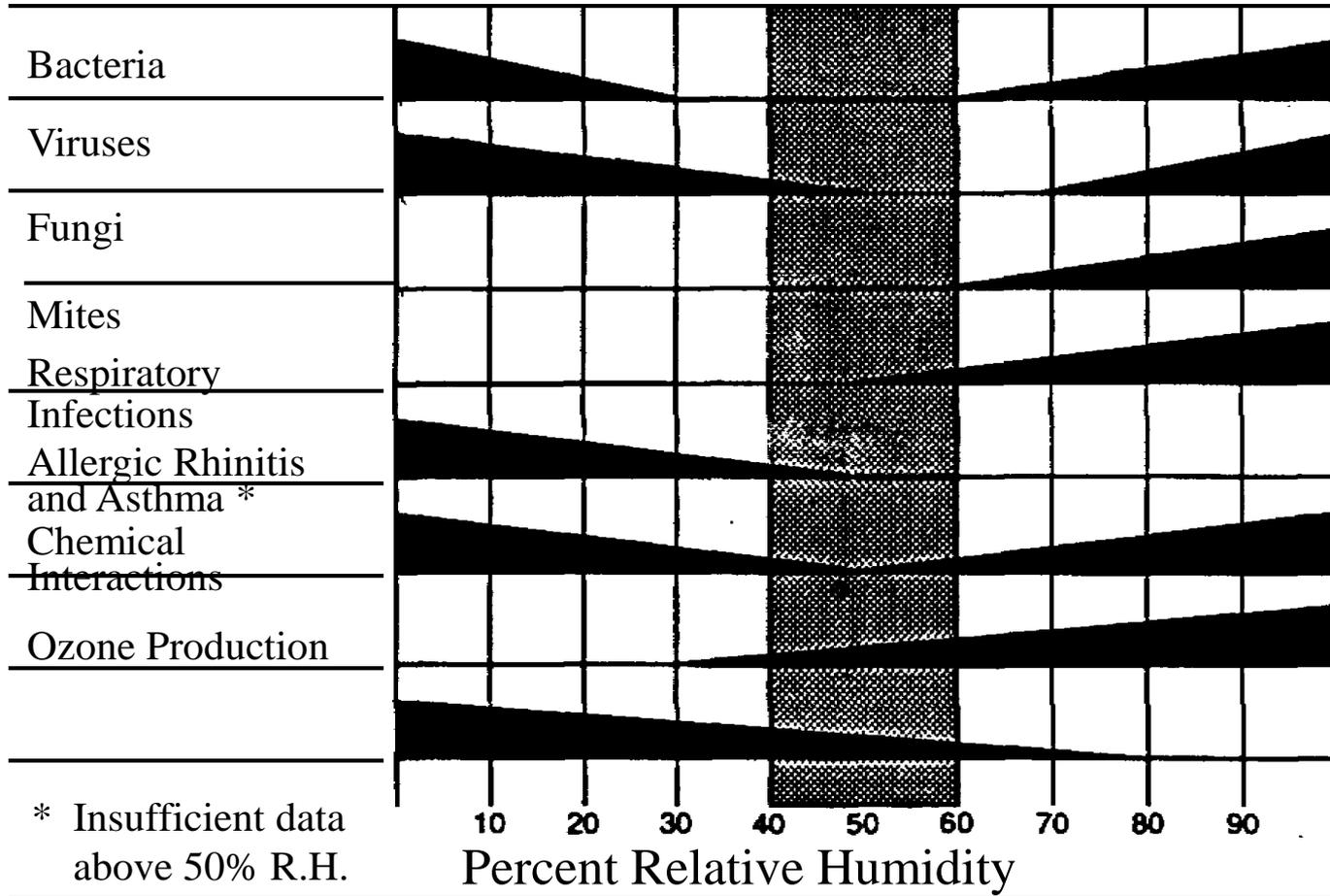
Comfort, *Health*, Durability, *Affordability*, Sustainability, *Economy*, National Security

- **Higher comfort** at lower air temps (heating season)
- **Quiet** interior
- Easy to maintain **good Relative Humidity**
- Significantly **fewer colds & viruses** than previous winters
- **More durable** home: No ice dams & less maintenance (with new building exterior)
- **Provides buffer** against energy price increases
- **Reduced use** of natural resources
- Keeps **money** in the local economy (green jobs)
- **Reduces U.S. dependence** on foreign energy supplies, **strengthening national energy security**

# Health Effects of Humidity

Bar Width Indicates  
Magnitude of Effect

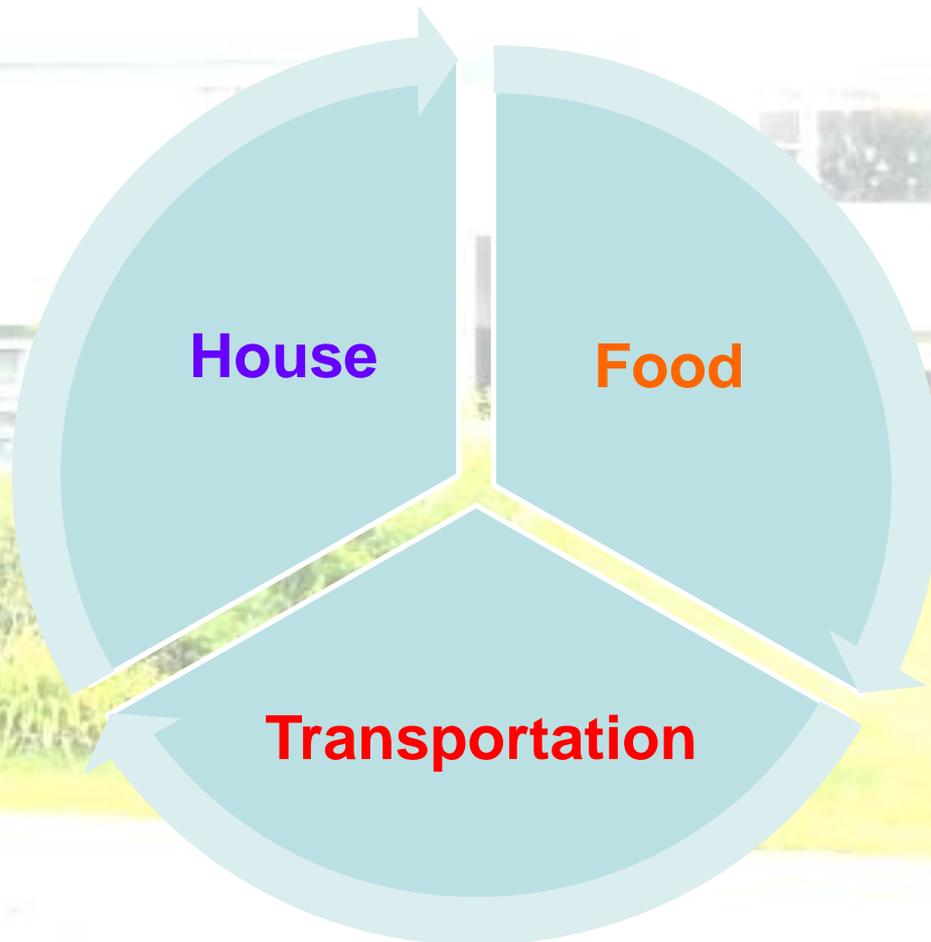
Optimum  
Zone



\* Insufficient data  
above 50% R.H.

Source: Sterling, Arundel, Sterling  
Ch-85-13 No. 1 ASHRAE

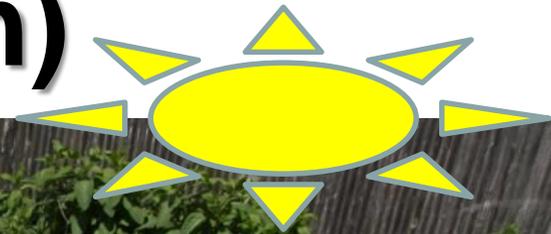
# Living On the Path to Sustainability: Further reducing our **Carbon Footprint**



# Transportation (car/bike)



# Food (the garden)

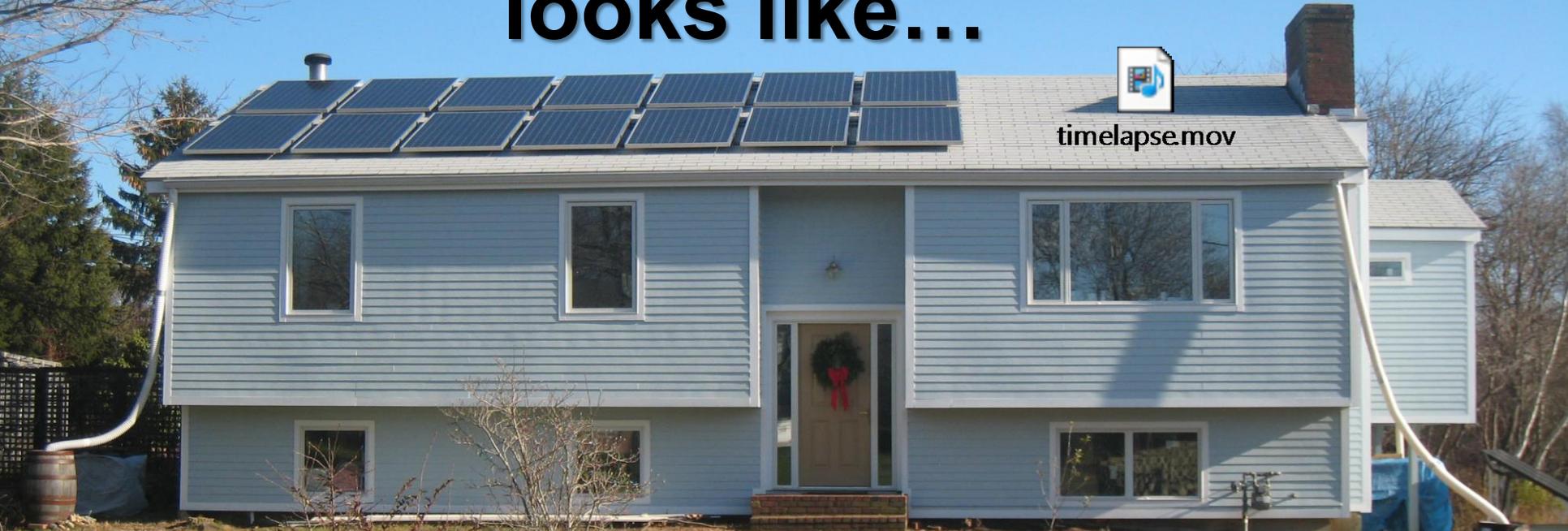


**For More Information**

**[www.onthepathtosustainability.com](http://www.onthepathtosustainability.com)**



**This is what a suburban  
renewable power plant  
looks like...**



**Thank You!**

**[jglivermore@yahoo.com](mailto:jglivermore@yahoo.com)**