Residential Energy and Water Use Reduction Concepts and Ideas

Presented by:

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Residential Energy Fundamentals

- How is electricity billed for a typical residence?
- For most Maryland utilities you pay for Energy in

  KW-h = Kilowatt-Hours, where:

$$1\,\text{Watt} = \frac{1\,\text{Joule}}{\text{sec}}\,(\text{Power})$$

$$1\,\text{Kilowatt} = 1{,}000\,\text{Watts}\,(\text{Power})$$

$$1\,\text{Kilowatt-hour} = 1{,}000\,\text{Watts-hour}\,(\text{Energy})$$

Residential Energy Fundamentals

- In a Home you are charged for Energy (Watts x Time), not Power (Watts)
- Therefore, a 100 watt light bulb operating for 10 hours would equal:

$$\frac{100\,\text{Watts} \times 10\,\text{hours}}{1{,}000\,\text{watts}/\text{KW}} = 1\,\text{KW-h}$$

- Typical Residential Rate is about 12 Cents/KW-h
- So, the cost = 1 KW-h x (12 Cents/KW-h) = 12 Cents

Residential Energy Fundamentals

What is Efficiency?

$$\eta = \text{Efficiency} = \frac{\text{What you get}}{\text{What is cost you}}$$

Typical Efficiency for Various Fuels

Fuel	Efficiency
No. 2 Fuel Oil	.80
Natural Gas	.85
Propane Gas	.85
Electric	1.0
Air Side Heat Pump	2.25
Water Cooled Heat Pump	5.00

Residential Energy Fundamentals

Typical Fuel Heat Content

Fuel	Heat Content
No. 2 Fuel Oil	140,000 BTU/Gallon
Natural Gas	100,000 BTU/Therm
Propane Gas	92,000 BTU/Gallon
Electric	3,413 BTU/KW
Air Side Heat Pump	3,413 BTU/KW
Water Cooled Heat Pump	3,413 BTU/KW

Residential Energy Fundamentals

Typical Cost Per Unit

Fuel	Cost
No. 2 Fuel Oil	$2.25/Gallon
Natural Gas	$1.60/Therm
Propane Gas	$2.25/Gallon
Electric	$0.12/KW-h
Air Side Heat Pump	$0.12/KW-h
Water Cooled Heat Pump	$0.12/KW-h

Residential Energy Fundamentals

- To make an "Apples-to-Apples" comparison we must take the ***cost per unit*** of the fuel (\$/Gallon) and divide by the ***heat content*** (BTU/Gallon), then multiply by 100,000.
- For Example, for No. 2 Fuel oil:

$$\frac{\text{Cost}/\text{Unit}}{\text{Heat Content}} = \frac{\$2.25/\text{Gallon}}{140{,}000\,\text{BTU}/\text{Gallon}} \times 100{,}000 = \$1.607/100{,}000\,\text{BTU}$$

Residential Energy Fundamentals

- We then divide by efficiency to obtain the true \$/100,000 BTU.
- For Example: For No. 2 Fuel Oil:

$$\frac{\$1.60 / 100{,}000\,\text{BTU}}{.80\,(\text{Efficiency})} = \$2.00 / 100{,}000\,\text{BTU}$$

Residential Energy Fundamentals

- The following Table summarizes the results for all fuel types:

Fuel	True Cost in $ per 100,000 BTU (corrected for efficiency)
No. 2 Fuel Oil	$2.00
Natural Gas	$1.88
Propane Gas	$3.22
Electric	$3.52
Air Side Heat Pump	$1.56
Water Cooled Heat Pump	$0.70

Residential Energy Fundamentals

Monitoring

“*Be thou diligent to know the state of thy flocks, and look well to thy herds*.” – Proverbs 27:23

- Learn how to read your Main Meter and Trend for a couple of months.

Residential Energy Fundamentals

- Purchase a Kill-a-Watt meter (From Amazon.com) for about $23.00.
- Will allow you to monitor actual energy use in KW-h over a period of time so you can determine where the KW-h's are going.

- Also allows you to compare power use of products in a store and will read:
  - ✓ Voltage (Volts)
  - ✓ Current (Amps)
  - ✓ Watts (Power)
  - ✓ Frequency (Hertz)
  - ✓ Power Factor
  - ✓ Elapsed Time

Residential Energy Fundamentals

- Now we know how to calculate and compare Fuels, Read our Meter, and Monitor Appliances.

- We can now review some Energy and Water Use Reduction products.

Simple Payback / Return on Investment (ROI)

$$\text{Simple Payback} = \frac{\text{Cost of Improvement}}{\text{Savings}/\text{Year}}\ (\text{years})$$

$$\text{Return on Investment} = \frac{\text{Annual Cost Savings}}{\text{Installed Cost of the Appliance}} \times 100\ (\%)$$

Lighting

Painted Trim & Reflector White (original was black)

- Compact Fluorescent
- Dimmable Compact Fluorescent
- LED (for night lights)
- LED (mixed with standard CFL's)

Where to purchase:

- Any Hardware store or lighting supply house.

Simple Payback: $1.14 years

Return on Investment: 87.5% (Tax Free)

Additional Thoughts: Minimize the use of recessed lighting where the same is utilized in attic ceilings or use I.C. rated fixtures to reduce heat loss/gain.

Water Heating

- First Step is to Reduce Load
- Try Low Flow Shower Heads and Low Flow Aerators.

1.0 GPM at
30 psig pressure

.375 GPM at
30 psig pressure

Water Heating

- Next, Insulate all pipes…

- Finally, wrap your water heater with a Radiant Barrier product such as Prodex…

Water Heating – Shower Heads

Where to Purchase

- Shower Heads: www.bricor.com

Simple Payback: 2.6 months

ROI: 453% !! (Tax Free)

Additional Thoughts

Low Flow Shower Heads also save on Sewer Cost, domestic water costs, well pump costs (Rural areas) and Septic Tank Pump Costs (Rural areas)

Water Heating – Heater Wrap

Where to Purchase

- Radiant Barrier Wrap: www.insulation4less.com

Simple Payback: 6 months

ROI: 189% !! (Tax Free)

Domestic Re-Circulation

- One of the largest Energy and Water Losses in a home is when homeowners turn on the water waiting for hot water.

OR…

- If the Homeowner has a continuous Domestic Re-circulation loop which results in increasing costs of heating the water all the time.

Domestic Re-Circulation

- The Solution
- To Install an “On-Demand” domestic re-circulation pump kit under the most used vanity.

Domestic Re-Circulation

Where to Purchase

- N.H. Yates & Company – www.nhyates.com

Simple Payback: 3.24 years

ROI: 30.8% (Tax Free)

Additional Thoughts

- Runs only when activated
- Saves energy in heating hot water and saves water and sewer costs (not included in the savings calcs)
- Can be coupled with an infrared remote for activating from more than one location.

Plug Loads

- All of us pay for electricity and heat in our homes on many items that do not even provide us with a benefit.
- Many of these items use electricity all of the time thru wasteful Transformers.

- The solution is to use Smart Strips.

Plug Loads

Where to Purchase

- Amazon – www.amazon.com

Cost: $20.00

Simple Payback: 1.26 years

ROI: 78.8% (Tax Free)

Additional Thoughts

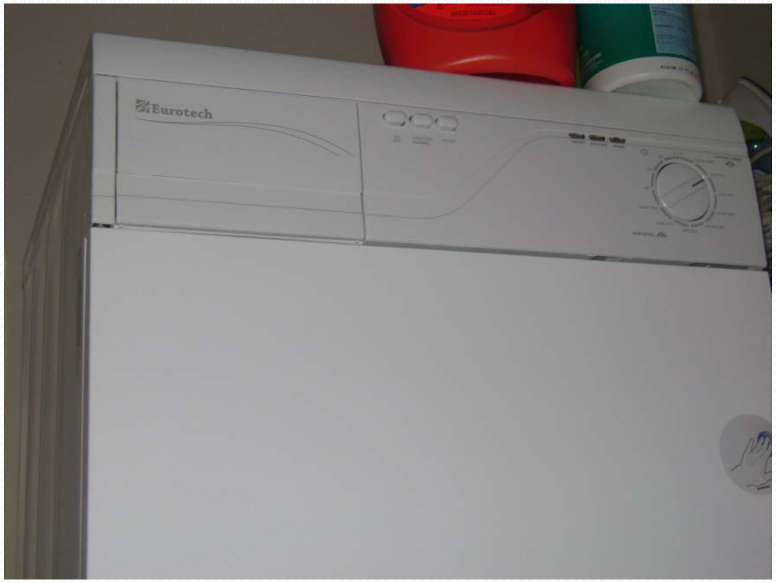
- Reduces Cooling load in summer.
- Also provides surge protection.
- Allows chosen outlets to remain “hot” or energized all the time.

Clothes Drying

- For our House our Utility Bills are so low that Typical Conventional Clothes Drying is a very large percentage of our Energy Use.
- First Recommendation: Use a Clothes Line or Hanger

Clothes Drying

- Second Recommendation: A Vent-less Condensing Dryer



Clothes Drying

Where to Purchase

- Clothes Line or Hanger – Hardware Store

Cost: $53.00

Simple Payback: .90 years

First year ROI: 110% (Tax Free)

Where to Purchase

- Clothes Dryer – Shore Appliance Connection, Salisbury, MD

Cost: $500.00

Simple Payback: 4.3 years

First year ROI: 23.2% (Tax Free)

Additional Thoughts

- Investigate Dryer racks for winter drying
- We use garage in winter to dry clothes.

Energy Star Appliances

<u>Visit the Energy Star Website</u>

- Refrigerators:
  - Keep coils cleaned
  - Purchase with Freezer on Bottom
  - Use Energy Save Feature

<u>Where to Purchase</u>

Any Appliance Store

Cost: $800.00

Simple Payback: 4.76 years

ROI: 21%

Bottom Freezer Position

Energy Star Appliances

Clothes Washers

- Uses Less Water
- Uses Less Hot Water
- Uses Less Detergent
- Due to high spin speeds, drying times are reduced

Dishwashers

- Better insulation – reduces heat gain to kitchen
- Uses Less Hot Water
- Uses Less detergent

In General:

When appliances fail, consider Energy Star and utilize calculation methods given to determine when you should replace an appliance.

Insulating a Garage Door

- If you have an attached garage, it makes sense to insulate your garage door.
- However, you cannot use a product that is too heavy.

Solution:

  - A great solution is Foil Fiberglass Vinyl
  - This has a Fiberglass core, with an aluminum radiant barrier on the outside and a white, scrim-reinforced facing material on the inside.

Insulating a Garage Door

Where to Purchase

- www.insulation4less.com

Cost: $36.00/sq.ft. ($179.95/500sq.ft.)

Simple Payback: .903 years

ROI: 110% (Tax Free)

Additional Thoughts

- Great for insulating the backside of doors that separate conditioned from unconditioned spaces.
- Provide an air space between radiant barrier side and exterior surface to get maximum results.

Solar Photovoltaic System

24 – 180 watt panels

DC to AC Inverter

- The remaining items are not “low hanging fruit”, but should be at least investigated.
- Our Solar Photovoltaic system has so far been a wonderful experience.

Solar Photovoltaic System

- At my house, my electrical bills for April, May, June and July were $4.50…
- AND THAT IS WITH A POOL!!!!

<u>Where to Purchase</u>:

Chesapeake Solar, Green Energy Design

First Cost: $30,000

Simple Payback: 5.72 years

ROI: 17.45% (Tax Free)

Solar Photovoltaic System

Additional Thoughts

- Check Maryland Energy Administration Website and DSIRE website (www.disreusa.org) for Federal and State Incentives.
- Maryland State Incentive has decreased from $10,000 for a 4 KW Solar System to $4,000 due to demand.
- Solar Water Heating may NOT be a good investment. However, this should be calculated similar to other technologies in addition to reducing load.

Solar Hot Water Heating System

Notice all pipes/panels are sloped ¼ inch per foot

Solar Thermal Drain Back

Tank & Piping

Solar Thermal Flat Plate Collectors

- Completely amazed at Performance
- First Cost including estimate for Labor = $6,250
- Simple Payback = 5 years
- Return on Investment = 20% Tax Free
- Where to Purchase: Solar Heat Exchange Manuf.

Solar Hot Water Heating System

- Monitoring is very valuable
- Hoffman House Actual Consumption:
  - From 3/9/10 to 3/16/10 Total gallons = 145
  - Hot Water Use per person per day = 5.17 gallons/person/day
  - Compare with National Average which = 20 gallons/person/day

Spray Foam Insulation

- I converted my attic and crawl space into conditioned areas…

Spray Foam Insulation

- It's difficult to calculate simple payback/return on investment without Energy Modeling.
- Currently, the Second floor unit run time has been reduced by 75%.
- Major advantages:
  - ✓ Retains R-Value over time
  - ✓ Soy Based/ Open-cell
  - ✓ Stops Infiltration
  - ✓ Allows ducts to be located within the envelope
  - ✓ Reduce Noise Transmission
  - ✓ Is a vapor retarder, but NOT a vapor barrier (i.e. allows moisture movement)

Spray Foam Insulation

Where to Purchase

- www.foamworkslic.com

First Cost: $7,000

Simple Payback: 13.6years

ROI: 7.3% (Tax Free)

Additional Thoughts

- Review Codes on conditioned and unconditioned attics & crawl spaces.
- Actual installed R-value of Fiberglass R-19 insulation has been tested to be R-13.7, a 28% reduction from the labeled R-Value.

Variable Speed Pumping

- Due to Pump Affinity Laws, pump energy savings can be dramatic.

$$BHP_2 = BHP_1 \times \left(\frac{\text{Flow Rate}_2}{\text{Flow Rate}_1} \right)^3$$

- Since this is a cubed function, the following will result:
  - 10% Reduction in Flow = 27% Reduction in Power
  - 50% Reduction in Flow = 87% Reduction in Power

Variable Speed Pumping

- If you don't have a flow meter, install one to determine your base line flow rate.

- A variable speed pump can then be dialed into any flow desired using the flow meter and control panel.

Variable Speed Pumping

<u>Where to Purchase</u>

- American best Pool Supply

First Cost: $800.00

Simple Payback (Max): 5.5years

Simple Payback (Min): 4.7years

ROI (Max): 21% (Tax Free)

ROI (Min): 18% (Tax Free)

Summary (In descending order from Best Return to Lowest Return on Investment)

System	First Cost	Simple Payback	Return on Investment
Water Heating – Shower	$118.00	2.6 months	453%
Water Heating – Wrap	$19.98	6 months	189%
Clothes Drying – Hanger	$53.00	0.9 years	110%
Insulate Garage Door	$36.00/sq.ft. (128 sq.ft.)	0.9 years	110%
Lighting	$16.00	1.14 years	87.5%
Plug Loads	$20.00	1.26 years	78.8%
Dom. Re-circulation	$167.00	3.24 years	30.8%
Clothes Drying – Dryer	$500.00	4.3 years	23.2%
Var. Speed Pump – Pool	$800.00	4.7 years (Min.)	21% (Max)
Energy Star – Refrigerator	$800.00	4.76 years	21%
Solar Water Heating	$6,250	5.0 years	20%
Solar Photovoltaic System	$30,000	5.72 years	17.45%
Spray Foam Insulation	$7,000	13.6 years	7.3%

Finally…

<u>A Few Lessons Learned:</u>

"In Design, there are two resources available:

The Laws of Physics and the Products of the Market.

The Designer of Excellence works with the former and the Designer of Mediocrity works with the latter."

The End…

Questions/Answers

RESIDENTIAL ENERGY AND WATER USE REDUCTION CALCULATIONS

Lighting

Quantity	Location	Original Watts	CFL Watts	Watts saved	Hours/day	KW-h Savings/year
7	Kitchen	100	20	560	4	817

Assuming 12 Cents/KW-h = $98/year

$$Simple\ Payback: \frac{Cost\ of\ Fixtures}{\frac{Savings}{year}} = \frac{7 \times \$16.00}{\frac{\$98}{year}} = 1.14\ years$$

$$Return\ on\ Investment: \frac{Annual\ Cost\ Savings}{Installed\ Cost\ of\ the\ Appliance} = \frac{\$98}{\$112} \times 100 = 87.5\%\ (Tax\ Free)$$

Water Heating

Showers:

Quantity of Shower per Day	Number of Heads	Old Flow Rate (GPM)	New Flow Rate (GPM)	Hot Water Saved (GPM)	Duration (Minutes)	Gallons saved per day	Gallons saved per year
2	2	2.5	1.2	1.3	15	78	28,470

To Heat 28,470 Gallons of water from 50°F to 120°F requires…

$$Gallons \times {}^{8.34\ lbs}/_{gallon} \times specific\ heat\ of\ water \times Change\ in\ Temperature$$

$$28{,}470\ Gallons \times \frac{8.34\ lbs}{Gallon} \times 1.0\ \frac{BTU}{F - lbm} \times (120^0F - 50^0F) = 16{,}620{,}786\ BTU$$

Dollars Saved:

For Propane:

$$\frac{\$3.22}{100{,}000\ BTU} \times 16{,}620{,}786\ BTU = \frac{\$535.00}{year}$$

$$Simple\ Payback: \frac{Cost\ of\ Shower\ Heads}{\frac{Savings}{Year}} = \frac{2 \times \$59.00}{\$535.00} = .22 years\ or\ 2.6\ months$$

$$Return\ on\ Investment: \frac{Annual\ Cost\ Savings}{Installation\ Cost\ of\ Shower\ Heads} \times 100 = \frac{\$535.00}{\$118.00} \times 100 = 453\%$$

Water Heating

Water Heater Wrap (Radiant Barrier):

- Reduces heat transfer by about 40%
- Saves about 9% on your water heating bill
- Since water heating represents about 21% of a typical home utility bill and the typical homes utility bills are about $2,000/year:

$$\frac{\$2{,}000}{year} \times 21\% = \frac{\$420}{year} \times 9\%\ savings = \frac{\$37.80}{savings/year}$$

$$Simple\ Payback: \frac{Cost\ of\ Wrap}{\frac{Savings}{Year}} = \frac{\$19.98}{\$37.80} = .52 years\ or\ 6\ months$$

$$Return\ on\ Investment: \frac{Annual\ Cost\ Savings}{Installation\ Cost\ of\ Wrap} \times 100 = \frac{\$37.80}{\$19.98} \times 100 = 189\%$$

Domestic Re-Circ

# of cold starts per day	Flow Rate of Cold start (GPM)	Duration (minutes)	Gallons saved Per day	Gallons saved Per year
2	2.5	3	15	5,475

In this case, the calculations need to reflect the difference between heating water from 40°F - 120°F and 75°F - 120°F. This is due to the fact that the water is at room temperature with the ON DEMAND.

$$Gallons \times {}^{8.34\ lbs}/_{gallon} \times specific\ heat\ of\ water \times Change\ in\ Temperature$$

$$5{,}475\ Gallons \times \frac{8.34\ lbs}{Gallon} \times 1.0\ \frac{BTU}{F - lbm} \times (75^0F - 40^0F) = 1{,}598{,}152\ BTU$$

For Propane:

$$\frac{\$3.22}{100{,}000\ BTU} \times 1{,}598{,}152\ BTU = \frac{\$51.46}{year}$$

$$Simple\ Payback: \frac{Cost\ of\ ON\ DEMAND}{\frac{Savings}{Year}} = \frac{\$167}{\$51.46} = 3.24\ years$$

$$Return\ on\ Investment: \frac{Annual\ Cost\ Savings}{Installation\ Cost\ of\ ON\ DEMAND} \times 100 = \frac{\$51.46}{\$167} \times 100 = 30.8\%$$

Plug Loads

- Typical entertainment station with DVD, T.V. satellite, gaming console, etc…
- Measured actual use with everything "turned off" but still connected to house power.
- This was measured with a "Kill-a-Watt" meter to be 15 watts.

Energy Saved:

$$15\ Watts \times \frac{8{,}760\ hours}{year} \times \frac{1\ KW}{1{,}000\ watts} = 131.4\ KWh$$

Dollars Saved:

$$131.4\ KWh\ \times \frac{12\ cents}{KWh} = \$15.76/_{year}$$

$$Simple\ Payback\colon\ \frac{Cost\ of\ Smart\ Strip}{\frac{Savings}{Year}} = \frac{\$20}{\$15.76} = 1.26\ years$$

$$Return\ on\ Investment\colon\ \frac{Annual\ Cost\ Savings}{Installation\ Cost\ of\ Smart\ Strip} \times 100 = \frac{\$15.76}{\$20} \times 100 = 78.8\%$$

Clothes Drying

Clothes Hanger:

- Typically would do 5 loads of laundry per week

$$\frac{5\ loads}{week} \times \frac{52\ weeks}{year} = \frac{260\ loads}{year}$$

- With clothes hanger we would be able to reduce this amount by approximately 75% by air drying in the summer, spring and fall.

$$\frac{Loads\ saved}{year} = 75\% \times \frac{260\ loads}{year} = \frac{195\ loads}{year}$$

$$\frac{Average\ energy\ used}{load} = \frac{2.5\ KWh}{load}$$

$$Energy\ Saved\ = \frac{2.5\ KWh}{load} \times \frac{195\ loads}{year} = \frac{487.5\ KWh}{year}$$

Dollars saved:

$$\frac{487.5\ KWh}{year} \times \frac{12\ cents}{KWh} = \frac{\$58.5}{year}$$

$$Simple\ Payback:\ \frac{Cost\ of\ Clothes\ hanger}{\frac{Savings}{Year}} = \frac{\$53}{\$58.5} = .9\ years = 10.87\ months$$

$$Return\ on\ Investment:\ \frac{Annual\ Cost\ Savings}{First\ Cost\ of\ Clothes\ Hanger} \times 100 = \frac{\$58.5}{\$53} \times 100 = 110.3\%$$

Ventless/Condensing Dryer:

Total Loads per year = 260

Conventional Dryer Energy use = 2.5KWh per load

Condensing Ventless dryer energy use = 1.0 KWh per load

$$\frac{Energy\ Savings}{Load} = \frac{2.5\ KWh}{load} - \frac{1.0\ KWh}{load} = \frac{1.5\ KWh}{load}$$

$$Energy\ Saved = \frac{260\ loads}{year} \times \frac{1.5\ KWh}{load} = \frac{390\ KWh}{year}$$

$$Electric\ Energy\ Saved = \frac{390\ KWh}{year} \times \frac{12\ cents}{KWh} = \frac{\$46.8}{year}$$

Avoidance of make-up air due to being ventless:

$$\frac{BTU}{Hr} = Dryer\ CFM \times 1.08 \times Change\ in\ Air\ Temperature$$

$$\frac{BTU}{Hr} = 190\ CFM \times 1.08 \times (75°F - 40°F)$$

$$\frac{BTU}{Hr} = 7{,}182\frac{BTU}{Hr} \times \frac{70\ minutes}{load} \times \frac{1\ hour}{60\ minutes} = 8{,}379\frac{BTU}{Load}$$

Assuming total loads/year is 260 loads:

$$8{,}379\frac{BTU}{load} \times \frac{260\ loads}{year} = 2{,}178{,}540\frac{BTU}{year}$$

For Propane:

$$\frac{\$3.22}{100{,}000\ BTU} \times 2{,}178{,}540\ BTU = \frac{\$70.00}{year}$$

Total Dollars Saved:

$$\$46.8\ (Condensing\ Dryer) + \$70.00\ (Avoidance\ of\ Makeup\ air) = \frac{\$116.00}{year}$$

$$Simple\ Payback:\ \frac{Cost\ of\ Dryer}{\frac{Savings}{Year}} = \frac{\$500}{\$116} = 4.3\ years$$

$$Return\ on\ Investment:\ \frac{Annual\ Cost\ Savings}{First\ Cost\ of\ Dryer} \times 100 = \frac{\$116}{\$500} \times 100 = 23.2\%$$

Energy Star Appliances

Energy Calculation to know when to replace an appliance with an Energy Star Appliance

Refrigerator Example:

- Old existing refrigerator used approximately 1,800 KWh/year
- A new Energy Star replacement refrigerator would only use 400 KWh/year
- The net energy savings per year would be 1,400 KWh/year.

Dollars Saved:

$$\frac{1{,}400\ KWh}{year} \times \frac{12\ cents}{KWh} = \frac{\$168}{year}$$

$$Simple\ Payback:\ \frac{Cost\ of\ Refrigerator}{\frac{Savings}{Year}} = \frac{\$800}{\$168} = 4.76\ years$$

$$Return\ on\ Investment:\ \frac{Annual\ Cost\ Savings}{First\ Cost\ of\ Refrigerator} \times 100 = \frac{\$168}{\$800} \times 100 = 21\%$$

Insulating a Garage Door

- From testing in the winter months the garage temperature was maintained 10°F higher previous years without the insulation.
- (Please remember that the garage is a well insulated, sealed, but not heated space)
- Energy savings will only apply in winter since we keep the garage door open in the summer.

Heat Transfer:

$$Q = U \times A \times \Delta T$$

$$where: U = Overall\ heat\ transfer\ coefficient\ \left(\frac{BTU}{Hr \cdot Ft^2 \cdot {}^\circ F}\right)$$

$$A = Area\ of\ Conditioned\ wall\ between\ house\ and\ garage$$

$$\Delta T = Average\ Temperature\ difference\ between\ conditioned\ house\ and\ garage$$

$$Q = \frac{BTU}{Hr} \textit{ saved due to } 10°\text{F} \textit{ increase in average temperature of garage}$$

For our house:

$$Q = \frac{.09\ BTU}{Hr \cdot Ft^2 \cdot °\text{F}} \times (20Ft \times 12Ft) \times 10°\text{F} = 216\frac{BTU}{Hr}$$

*Note: 20 ft x 12 ft is the area of the wall separating conditioned house from garage, not the area of the garage door.

Fuel Required:

$$F = \frac{24 \cdot DD \cdot Q}{\eta(T_i - T_o)H} \times C_d$$

$$where\text{: } F = The\ quantity\ of\ Fuel\ saved, the\ units\ depend\ on\ H$$

$$DD = the\ degree\ days\ for\ period$$

$$Q = the\ calculated\ heat\ loss\ reduction\ in\frac{BTU}{Hr}$$

$$\eta = efficiency\ of\ fuel\ source\ equipment$$

$$H = Heating\ Value\ of\ Fuel\ in\ BTU\ per\ units$$

$$C_d = Correction\ Factor\ for\ degree\ days = .65\ for\ Maryland$$

$$F = \frac{24 \times 4500 \times 216\ BTU/Hr}{.80(10°\text{F}) \times 92{,}000\ BTU/Gallon} \times .65 = 20.6\ Gallons\ of\ Propane$$

Cost of Propane per Gallon = $2.52 per Gallon

Dollars Saved:

$$20.6\ Gallons \times \frac{\$2.52}{Gallon} = \frac{\$51}{Year}$$

First cost of material = $.36/sq.ft.

Assume Garage Door = 128 sq.ft.

$$\frac{Cost}{Area} \times Area = \frac{\$.36}{Ft^2} \times 128Ft^2 = \$46.08$$

$$Simple\ Payback\text{: } \frac{Cost\ of\ Material}{\frac{Savings}{Year}} = \frac{\$46.08}{\$51} = .903\ years = 10.8\ months$$

$$\textit{Return on Investment}: \frac{\textit{Annual Cost Savings}}{\textit{Cost of Product}} \times 100 = \frac{\$51}{\$46.08} \times 100 = 110\%$$

Solar Photovoltaic System

First cost for a 4 KW system = approximately $30,000

Federal Tax Credit = 30% X 30,000 = $9,000

Maryland State Tax Credit = $10,000 (at time of my installation) (current MD Tax Credit is now $4,000)

Net First Cost = $11,000 ($30,000 - $9,000 - $10,000)

Based on current monitoring:

$$\frac{6{,}000\ KWh}{year} \times \frac{12\ cents}{KWh} = \$720$$

$$\frac{\textit{Renewable energy credits}}{year} = \frac{\textit{Average}}{year} = \$1{,}200$$

Dollars Saved:

$$\$1{,}200 + \$700 = \$1{,}920/year$$

$$\textit{Simple Payback}: \frac{\textit{Net First Cost}}{\frac{\textit{Energy Savings} + \textit{Renewable Energy Credits}}{Year}} = \frac{\$11{,}000}{\$1{,}920} = 5.72\ years$$

$$\textit{Return on Investment}: \frac{\textit{Annual Cost Savings}}{\textit{Net First year Cost}} \times 100 = \frac{\$1{,}920}{\$11{,}000} \times 100 = 17.45\%$$

Spray Foam Insulation

*Until further experience this winter, I will estimate energy savings based on expected percentage reduction.

Typical household total energy use = $2,000

Assume total heating/cooling cost = 53% per U.S. Department of Energy consumption estimates.

Actual Heating/Cooling Costs = $2,000 X 53% = $1,060

Actual spray foam insulation savings per manufacturer’s monitoring/testing of homes = 38%

Net Energy Savings = 38% X $1,060 = $402/year

<u>First Cost</u>

Approximately $7,000 for a very large attic with 12/12 pitch

Federal Tax Credit = 30% X $7,000 = $2,100

Reduced to $1,500, Maximum Net Federal Tax Credit = $1,500

Net First Cost = $7,000 - $1,500 = $5,500

$$Simple\ Payback\text{:}\ \frac{Net\ First\ Cost}{\frac{Savings}{Year}} = \frac{\$5{,}500}{\$402} = 13.6\ years$$

$$Return\ on\ Investment\text{:}\ \frac{Annual\ Cost\ Savings}{Net\ First\ year\ Cost} \times 100 = \frac{\$402}{\$5{,}500} \times 100 = 7.3\%$$

Please note that if ductwork is located in Attic and existing insulation is in poor condition the payback will be much quicker. Also, note that the simple payback will be much lower if actual utility costs are higher.

Variable Speed Pumping

Original Pool Pump Power = 1.5 Horsepower

$$Power\ in\ KW = 1.5HP \times \frac{745\ Watts}{HP} = 1117.5\ Watts = 1.1175\ KWatts$$

Hours of Operation per year:

$$6\ months \times \frac{30\ days}{month} \times \frac{8\ hours}{day} = 1{,}440\frac{hours}{year}$$

$$\frac{Total\ Original\ Energy}{year} = 1.1175KW \times \frac{1{,}440\ Hours}{year} = \frac{1{,}609\ KWh}{year}$$

With Variable speed pump we can reduce flow in half

Therefore the new power per the pump affinity laws would be:

$$KW_2 = KW_1 \times (.5)^3 = 1.1175 \times .125 = .1396\ KW$$

Total revised energy per year will be calculated first by doubling the hours of operation.

Total Variable Speed (Double Operating Time):

$$\frac{Energy}{year}(Double\ operating\ time) = .1396\ KW \times \frac{1{,}440\ hours}{year} \times 2 = 402\frac{KWh}{year}$$

$$Minimum\ Energy\ Savings\ per\ year = 1609\ KWh - 402\ KWh = 1{,}207\ KWh$$

$$Minimum\ Dollars\ saved\ per\ year = 1207\ KWh \times \frac{12\ cents}{KWh} = \frac{\$144}{year}$$

$$Simple\ Payback\ (Max):\ \frac{Net\ First\ Cost}{\frac{Savings}{Year}} = \frac{\$800}{\$144} = 5.5\ years$$

$$Return\ on\ Investment\ (Min):\ \frac{Annual\ Cost\ Savings}{Net\ First\ year\ Cost} \times 100 = \frac{\$144}{\$800} \times 100 = 18\%$$

Total Variable Speed (Same Hours of Operation):

$$\frac{Energy}{year}(same\ hours\ of\ operation) = .1396\ KW \times \frac{1{,}440\ hours}{year} = 201\frac{KWh}{year}$$

$$Maximum\ Energy\ Savings\ per\ year = 1609\ KWh - 201\ KWh = 1{,}408\ KWh$$

$$Maximum\ Dollars\ saved\ per\ year = 1408\ KWh \times \frac{12\ cents}{KWh} = \frac{\$168}{year}$$

$$Simple\ Payback\ (Min):\ \frac{Net\ First\ Cost}{\frac{Savings}{Year}} = \frac{\$800}{\$168} = 4.76\ years$$

$$Return\ on\ Investment\ (Max):\ \frac{Annual\ Cost\ Savings}{Net\ First\ year\ Cost} \times 100 = \frac{\$168}{\$800} \times 100 = 21\%$$

Therefore, Savings increase with hours of operation and energy use of original pump.

Domestic Hot Water Use – Hoffman House

I. Original Hot Water Load:

A. Dad Shower = 2.5gpm x 5 minutes = 12.5 gallons/day x 7 days/week x 52 weeks/year = 4,550 gallons

Mom Shower = 2.5gpm x 5 minutes = 12.5 gallons/day x 7 days/week x 52 weeks/year = 4,550 gallons

Jessie Shower = 2.5gpm x 15 minutes = 37.5 gallons/day x 7 days/week x 52 weeks/year = 9,750 gallons

Abby Shower = 2.5gpm x 15 minutes = 37.5 gallons/day x 7 days/week x 52 weeks/year = 9,750 gallons

Dishwasher = 6.8 gallons per load x 4 loads/week x 52 weeks/year = 1,414 gallons

Clotheswasher = 18.4 gallons per load x 5 loads/week x 52 weeks/year = 4,784 gallons

Lav-Washing = 2.0 gpm x 1minute/day = 2gallons per day x 5days per week x 52weeks per year = 520 gallons

Miscellaneous Hot Water Use = 10 gallons per week x 52 weeks per year = 520 gallons

Total Hot Water Use = 35,838 gallons per year

$$Average\ per\ Person\ Per\ Day\ =\ 35{,}838\ gallons\ per\ year\ x\frac{1}{365\ days}\ x\ \frac{1}{4\ people}$$
$$= 24.5\ gallons\ per\ person\ per\ day$$

B. Energy Use Originally = Energy to Heat Hot Water, Energy Loss of Water Heater Jacket, Flue Losses, and Pipe Losses:

1. $Tank\ Losses\ = 100\ watts\ x\ \frac{3.413BTU}{watt} = 341.3BTUs$

$$Per\ Year = 341.3\ BTU\ x\ \frac{24\ hours}{day} x \frac{20\ days}{month}\ x \frac{12 months}{year} = 2{,}948{,}832\ BTUs\ per\ year$$

2. Energy to Heat Water

Gallons x specific Heat x 8.34 lbs per gallons x ΔT.

$$= 35{,}838\ gallons\ per\ year\ x \frac{1.0BTU}{lbs\ x\ °\mathrm{F}}\ x\ 8.34\ lbs\ per\ gallons\ x\ (120°\mathrm{F} - 55°\mathrm{F})$$
$$= 19427779.8BTUs\ per\ year$$

Total Energy Use =
$\frac{Energy\ to\ Heat\ Water + Energy\ Losses\ at\ tank\ and\ piping}{Heat\ Content\ of\ Fuel\ x\ Average\ Efficiency\ of\ Equipment} = \frac{19{,}427{,}779.8BTUs\ +2{,}948{,}832\ BTUs\ per\ year}{92{,}000BTU\ per\ gallon\ x\ .75} =$
$324\ gallons\ per\ year$

3. $Cost = Fuel\ Use\ x\ Cost\ per\ unit = 324\ gallons\ per\ year\ x\ \$2.75\ gallons\ = \$891.00\ per\ year$

II. Current hot water use after installing low flow shower heads, low flow aerator, and radiant barrier at water heater.

C. Dad Shower = 1.3gpm x 5 minutes = 6.5 gallons/day x 7 days/week x 52 weeks/year = 2,366 gallons

Mom Shower = 1.3gpm x 5 minutes = 6.5 gallons/day x 7 days/week x 52 weeks/year = 2,366 gallons

Jessie Shower = 1.3gpm x 15 minutes = 19.5 gallons/day x 7 days/week x 52 weeks/year = 5,050 gallons

Abby Shower = 1.3gpm x 15 minutes = 19.5 gallons/day x 7 days/week x 52 weeks/year = 5,050 gallons

Dishwasher = 6.8 gallons per load x 4 loads/week x 52 weeks/year = 1,414 gallons

Clotheswasher = 18.4 gallons per load x 5 loads/week x 52 weeks/year = 4,784 gallons

Lav-Washing = .75gpm x 1minute/day = .75gallons per day x 5days per week x 52weeks per year = 195 gallons

Miscellaneous Hot Water Use = 10 gallons per week x 52 weeks per year = 520 gallons

Total Hot Water Use = 21,785 gallons per year

$$Average\ per\ Person\ Per\ Day\ =\ 21{,}785\ gallons\ per\ year\ x\frac{1}{365\ days}\ x\ \frac{1}{4\ people}$$
$$=14.92\ gallons\ per\ person\ per\ day$$

B. Energy Use (After upgrade of showers, aerators, etc…)

= Energy to heat hot water + energy loss of water heater jacket + flue losses + pipe losses

1. Tank losses = 75% x 100 watts (25% reduction due to addition of radiant barrier)

$$=\ 75\ watts\ \mathrm{x}\frac{3.413\mathrm{BTU}}{\mathrm{watt}}\ =\ \ 255\mathrm{BTU}$$

$$Per\ Year = 255\ BTU\ x\frac{24hours}{day}x\ \frac{30\ days}{month}\ x\frac{12\ months}{year} = 2{,}211{,}624\ BTUs\ per\ year$$

2. <u>Energy to Heat Hot Water</u>

$$Energy = Gallons\ x\ specific\ heat\ x\ 8.34lbs\ per\ gallon\ x\ \Delta T$$

$$= 21{,}785\ gallons\ x\frac{1.0BTU}{16°\mathrm{F}}\ x\ 8.34lbs\ per\ gallon\ x\ (120°\mathrm{F} - 55°\mathrm{F}) = 11{,}809{,}648BTU's\ per\ year$$

$$Total\ Energy\ Use\ = \frac{Energy\ to\ Heat\ Water + Energy\ Losses\ at\ tank\ and\ piping}{Heating\ Content\ of\ Fuel\ x\ Average\ Efficiency\ of\ Equipment}$$

$$= \frac{11{,}809{,}648 + 2{,}211{,}624\ BTUs\ per\ year}{92{,}000\ BTU's\ per\ Gallon\ x\ .75} = 203\ Gallons\ Per\ Year$$

3. $Cost = Fuel\ Use\ x\ cost\ per\ unit = 203\ gallons\ per\ year\ x\ \$2.75\ per\ gallon = \$558.00\ per\ year$

The simple pay back for the aerators, low flow heads and radiant barrier is, as follows:

$$Simple\ Payback = \frac{Shower\ Heads\ (2\ x\ \$59.00)\ +\ Aerators\ (3\ x\ \$49.00)\ +\ radiant\ barrier\ (\$50.00)}{Savings\ per\ year = \$891.00 - \$558.00}$$

$$Simple\ Payback\ = \frac{\$225.00}{\$333.00\ per\ year} =\ .67\ years = 8\ months$$

If you include well pump energy and lift pump savings then payback period will really be much less.

Also, this analysis does not include energy savings due to less water heater blower fan operation.

Solar Domestic Hot Water

From previous analysis including current hot water use, tank losses etc… the estimated yearly cost for domestic hot water is approximately = 203 gallons of propane at $2.75 per gallon

= $558.00 per year

Assume we can save 85% per year = $474.00 per year

Assume the first cost = $3,750.00 material

<u>$2,500.00 labor</u>

$6,250.00 total

Net cost after federal tax = $6,250.00 – (.30 x 6,250.00) = $4,375.00 (Federal Tax Credit is 30% of Total Cost)

Net cost after state grant = $4,375.00 – 2,000.00 = $2,375.00 (State Incentive is $2,000)

$$Simple\ Pay\ Back\ = \frac{\$2{,}375.00}{\$474.00\ per\ year} = 5\ years$$

This is not a bad payback and it does not include cost to operate solar pump nor does it escalate energy costs. This is a decent return on investment.

Return on Investment = $\frac{Annual\ Cost\ Savings}{Installation\ Cost\ After\ Rebates}\, x\ 100 = \frac{\$474.00}{\$2{,}375.00}\, x\ 100 = 20\%$