# APPROACHING NET-ZERO ENERGY IN AN 1834 FARM HOUSE THROUGH INTEGRATING MULTIPLE ENERGY STRATEGIES

Energy consumed < Energy produced

# Energy consumed < Energy produced

Reduce consumption … Increase production

# Energy consumed < Energy produced

## Reduce consumption … Increase production

## Net zero – vs – Preservation

# Preservation Options/Strategies

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1. Build a more efficient building.

*It's not as picturesque as the old building but it's saving a fortune in energy bills.*

# Preservation Options/Strategies

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2. Live with the current situation

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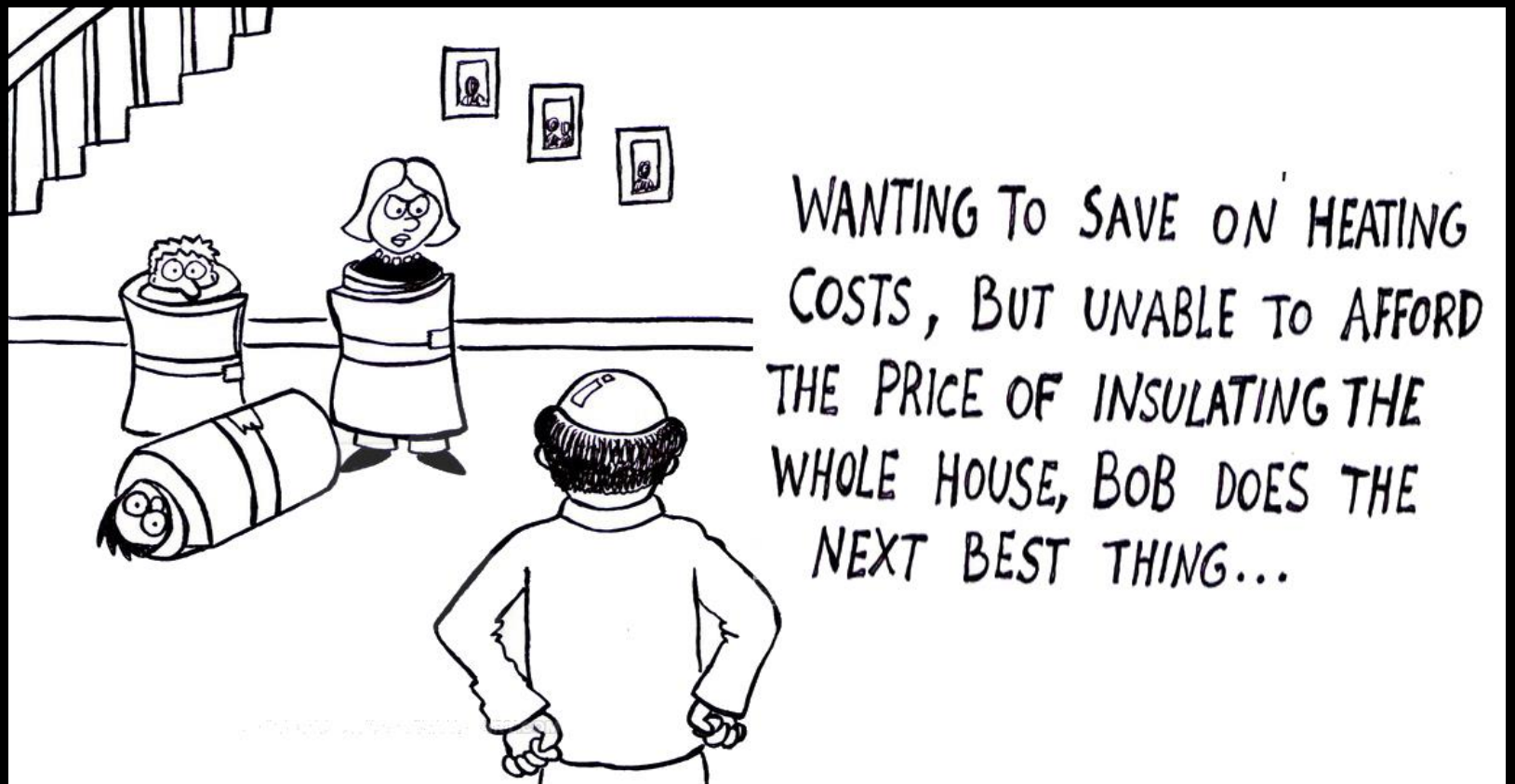
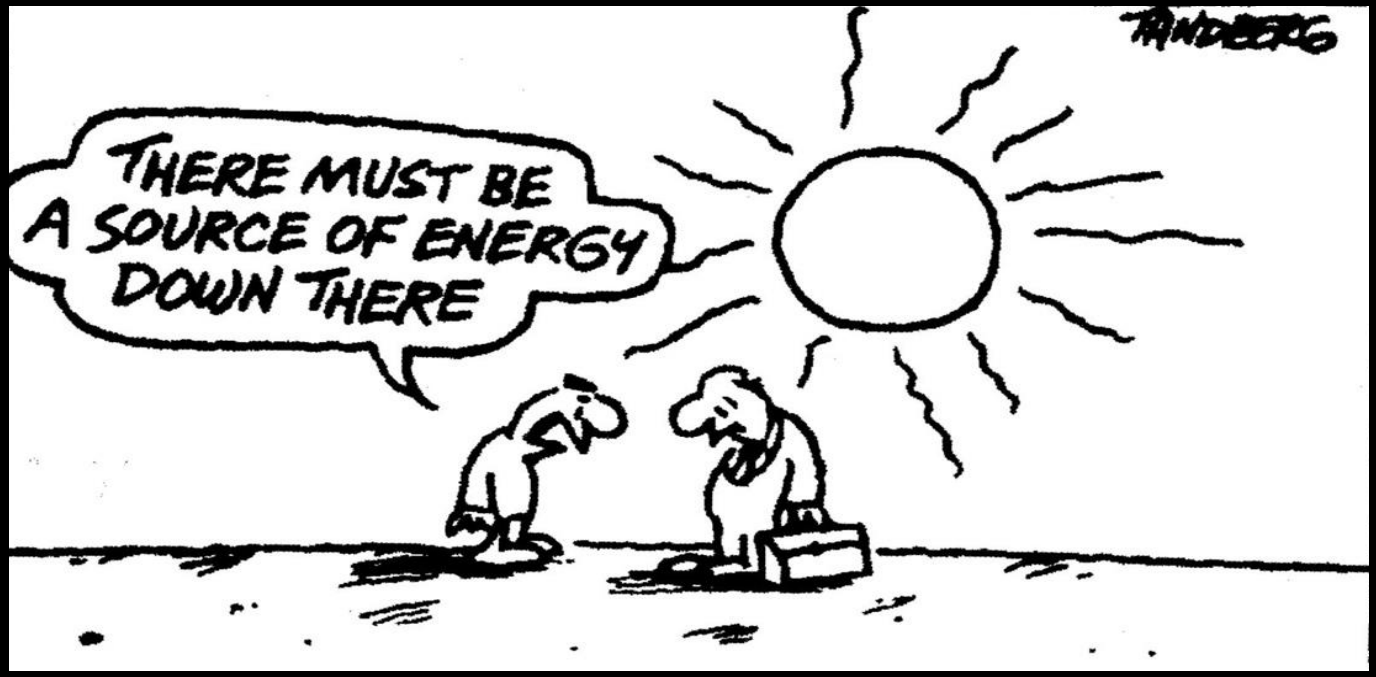
2. Live with the current situation
3. Improve energy conservation/efficiency



# Preservation Options/Strategies

1. Build a more efficient building
2. Live with the current situation
3. Improve energy conservation/efficiency
4. Increase energy production



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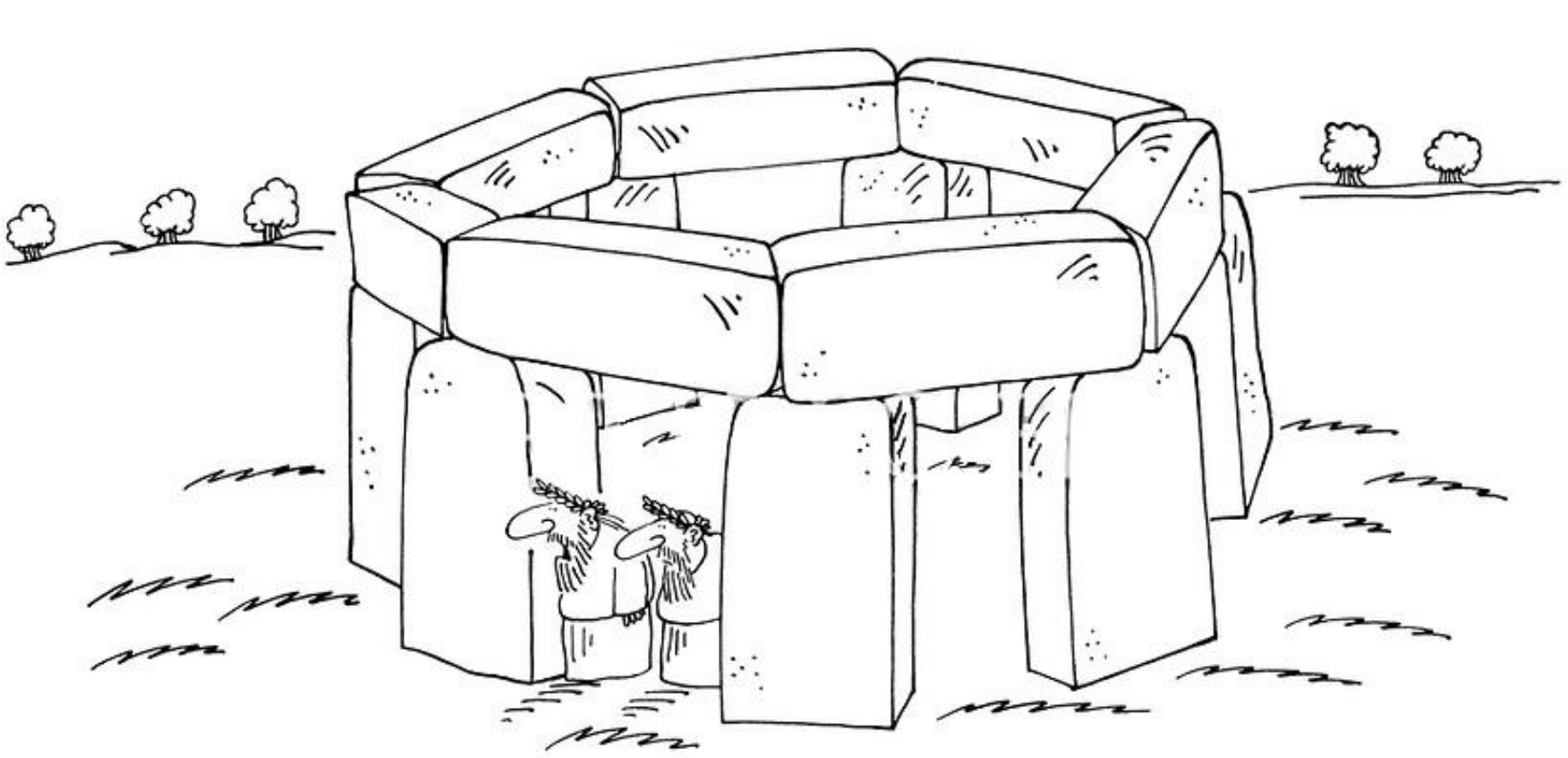
# Preservation Options/Strategies

1. Build a more efficient building
2. Live with the current situation
3. **Improve energy conservation/efficiency**
4. **Increase energy production**

# Improve energy conservation/efficiency



"I wish someone would invent cavity wall insulation"

# Improve energy conservation/efficiency

- Insulate Attic
- Alter thermostat - 62$^{o}$ F Winter,  76$^{o}$ F Summer
- New high efficiency furnace
- New storm windows
- Repair envelope breaches

# Base Energy Consumption Analysis

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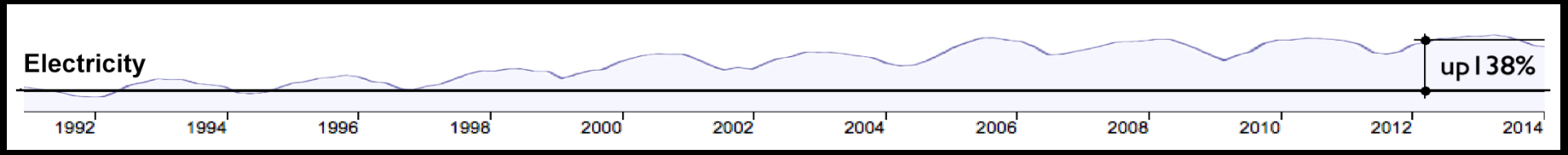
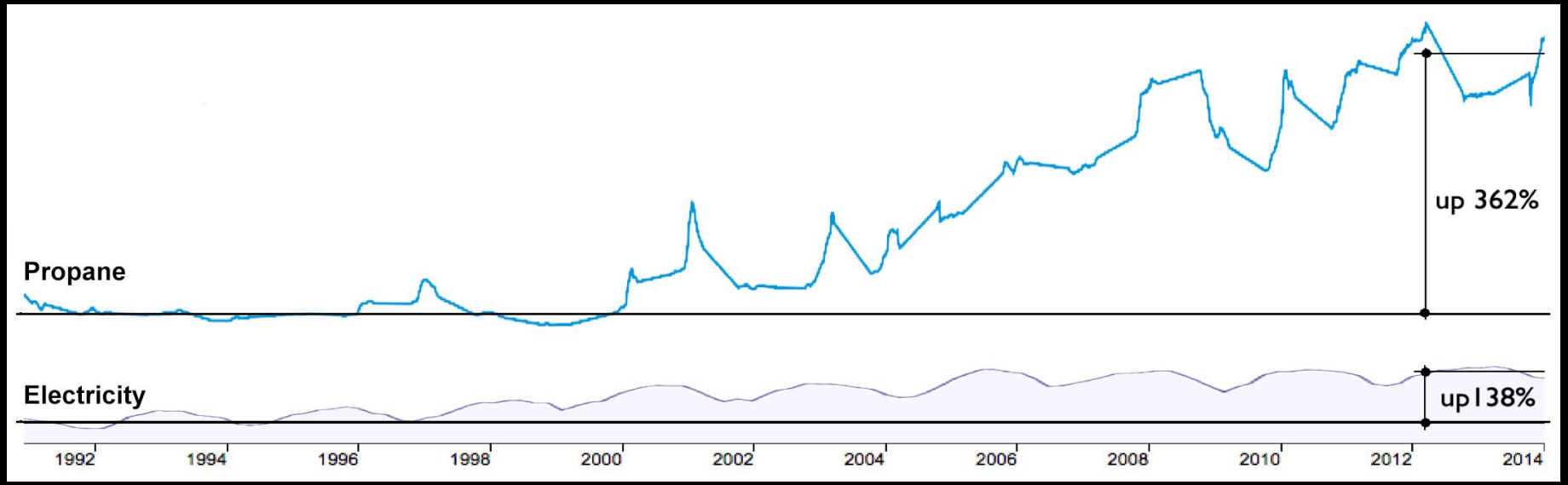
Electricity $0.08 to 0.11/kWh up 1.38 x



# Base Energy Consumption Analysis

| | | |
|---|---|---|
| Electricity | $0.08 to 0.11/kWh | up 1.38 x |
| Propane | $0.99 to 3.69/gal | up 3.62 x |



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| | | |
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| Electricity | $0.08 to 0.11/kWh | up 1.38 x |
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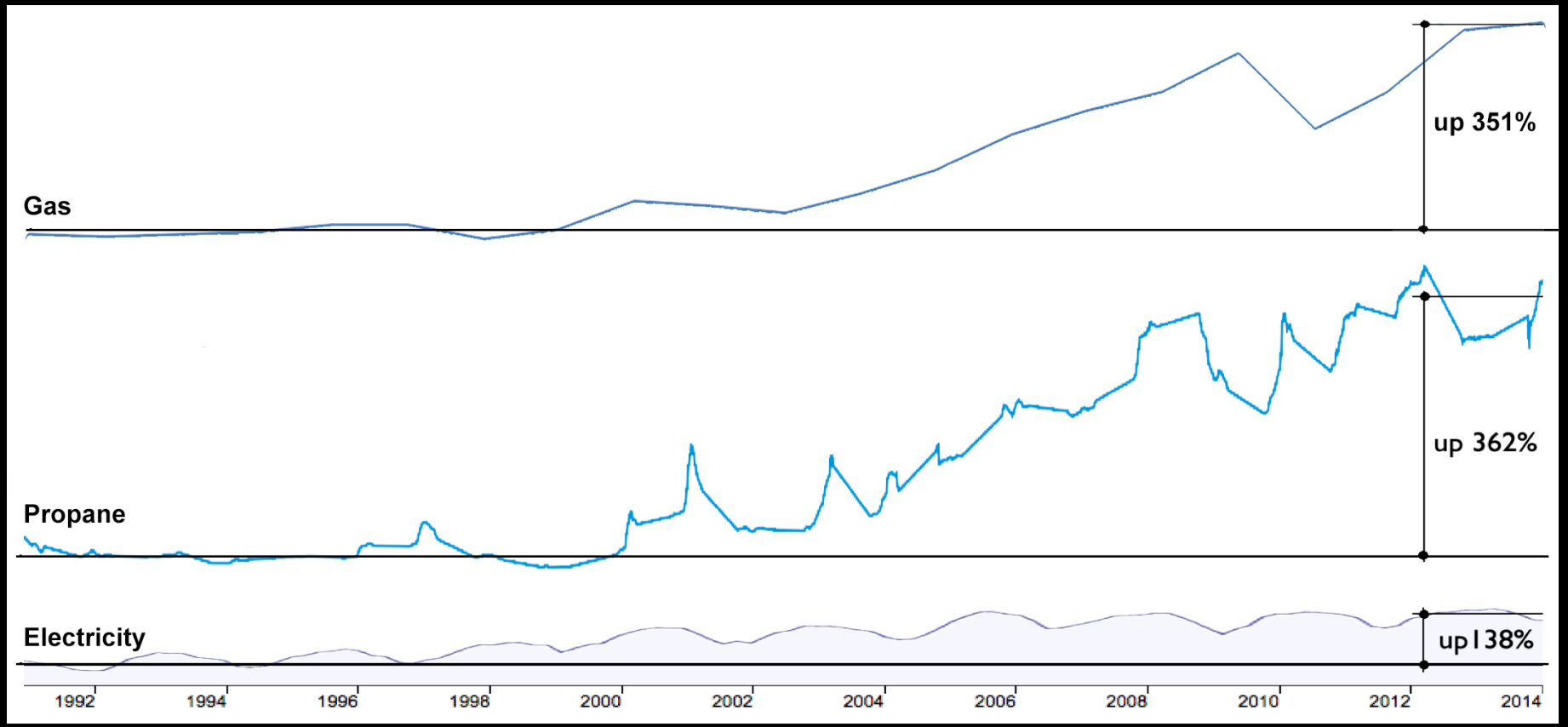
| Gasoline | $0.96 to 3.36/gal | up 3.51 x |



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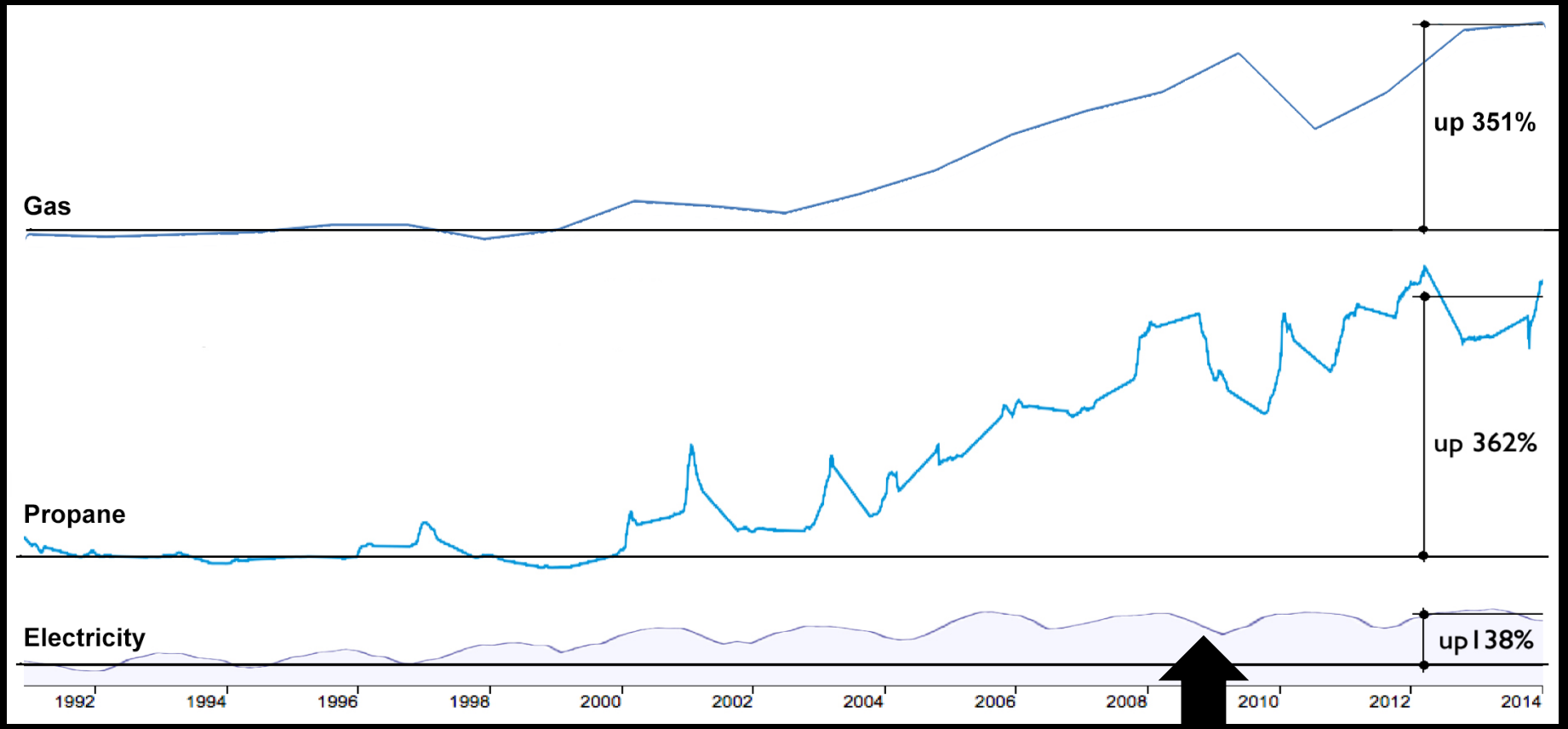
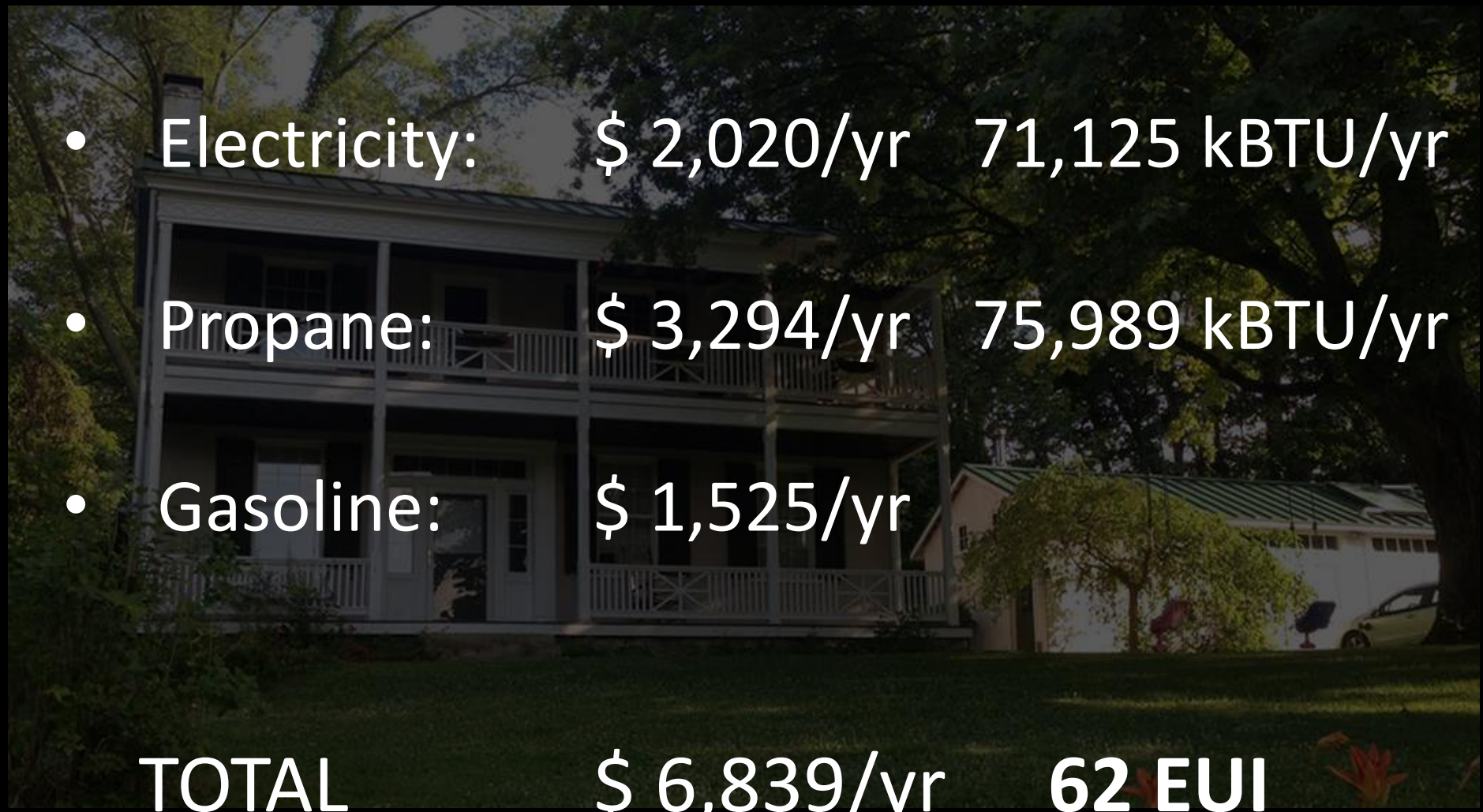



Begin detailed tracking of energy use

# Summary Energy Consumption Profile

2010 – 2011 snapshot 2375 sf house



- Electricity: $ 2,020/yr 71,125 kBTU/yr
- Propane: $ 3,294/yr 75,989 kBTU/yr
- Gasoline: $ 1,525/yr

TOTAL $ 6,839/yr **62 EUI**

# Approaching Net Zero

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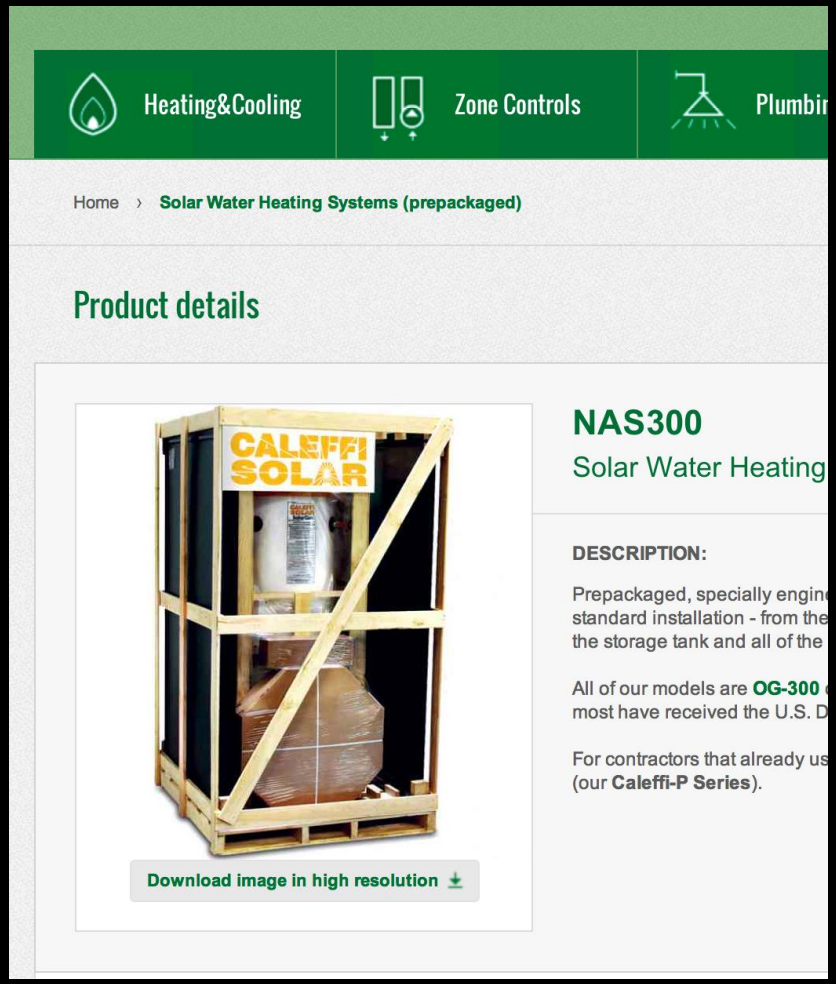
## Four Phases

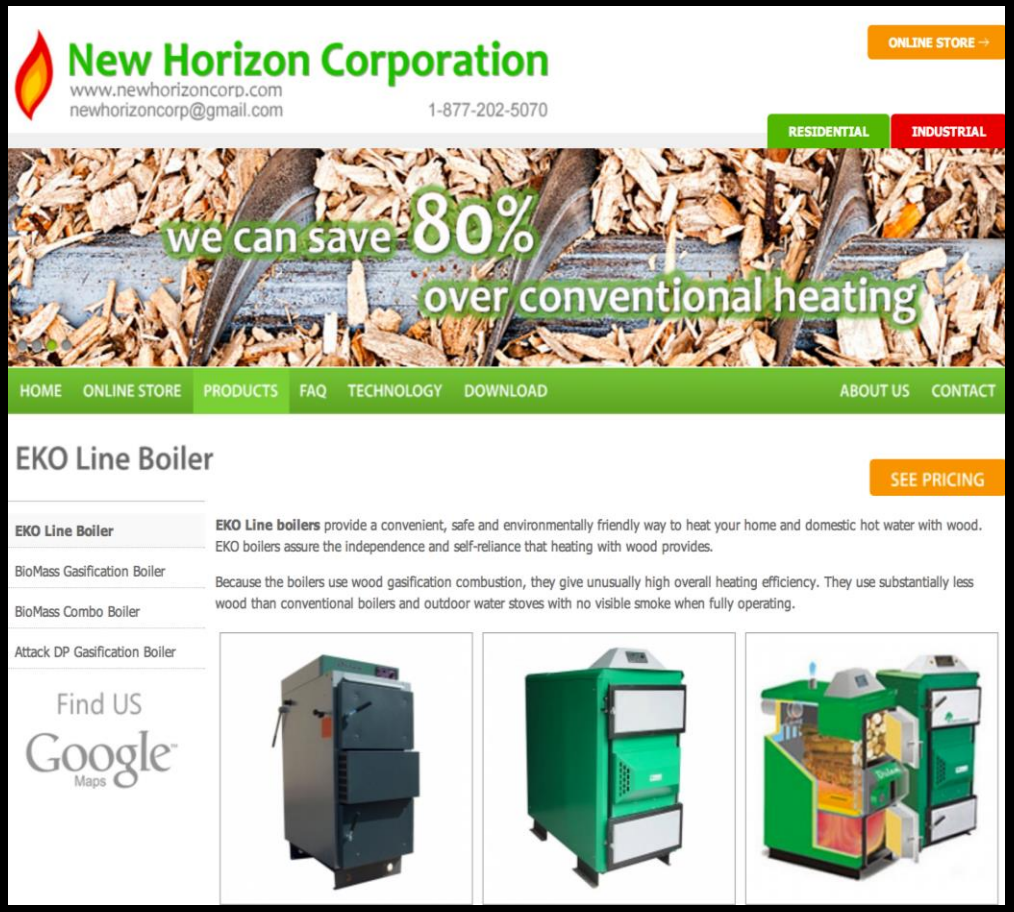
1. Solar Thermal – Domestic Hot Water
2. Wood Gasification – Hydronic Heating
3. Electric Car
4. Photo Voltaic Installation

# Phase One
# Solar Thermal - Domestic Hot Water




# Phase One
# Solar Thermal - Domestic Hot Water

# Phase Two
# Wood gasification – Hydronic heating




https://www.youtube.com/watch?v=Linp0XI_gWg

# Phase Two
# Wood gasification – Hydronic heating
## *Sizing the boiler*

Estimating heat loss from historical use of gallons of propane required per heating degree day.

| | | |
|---|---|---|
| 2009 – 2010 HDD | = | 9559 |
| 2009 – 2010 propane gallons used | = | 1352.61 |
| Gallons of propane per HDD | = | 0.1415 |

# Phase Two
# Wood gasification – Hydronic heating
## *Sizing the boiler*

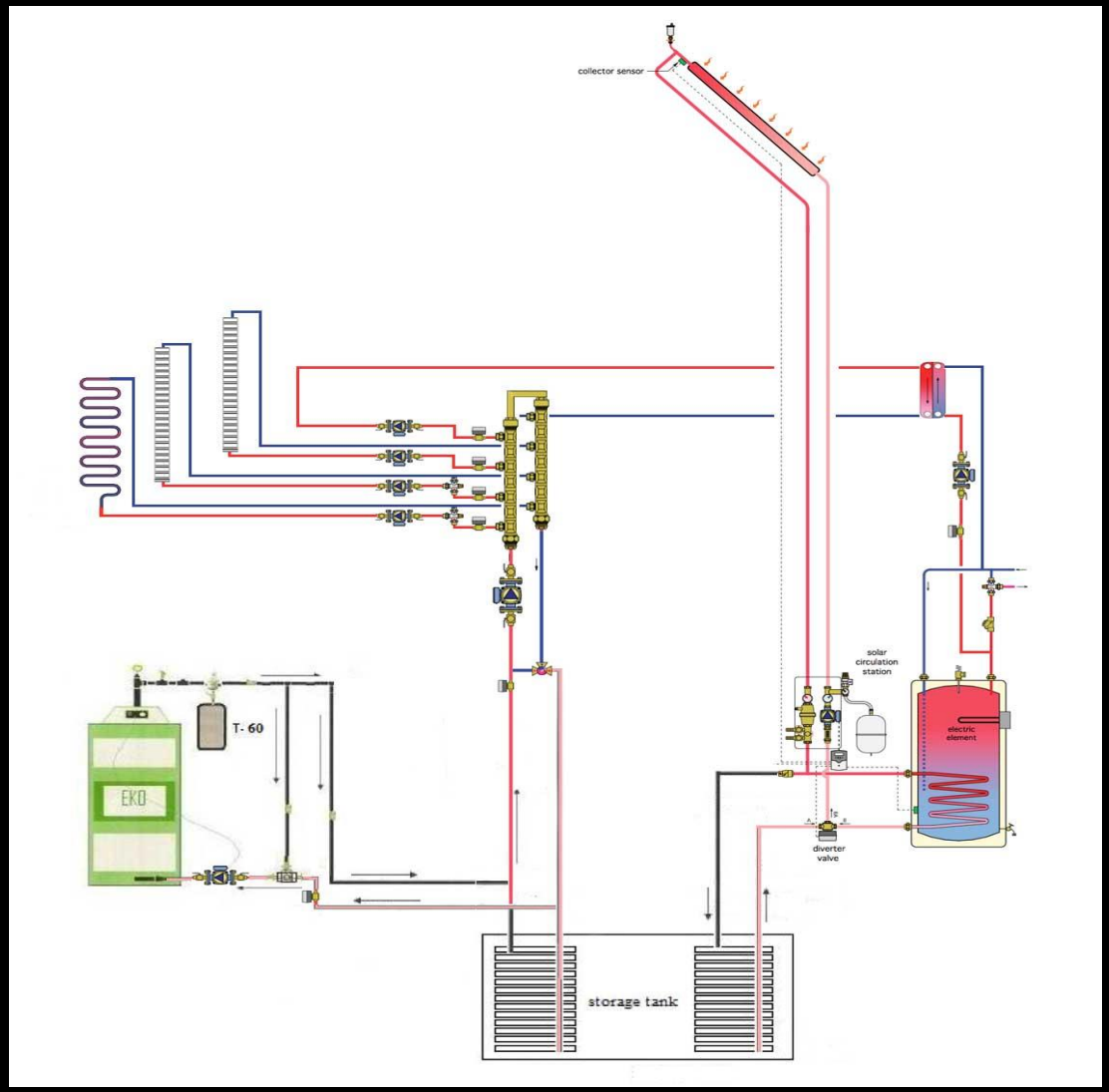
| | | |
|---|---|---|
| Gallons of propane per HDD | | = 0.1415 |
| Assuming a cold day; | 62F – 10F | = 52 HDD |
| 8.18 gallons req'd x 91,333BTU/gal | | = 746,704 BTU |
| 764,704/24 hours | | = 31,113 BTUh |
| Boiler Output (25kW/hr) @85% eff. | | = 72,569 BTUh |

# Phase Two
# Wood gasification – Hydronic heating
## *Sizing the boiler (peak heating)*

| | | |
|---|---|---|
| Gallons of propane per HDD | | = 0.1415 |
| Assuming a cold day; | 62F – 10F | = 52 HDD |
| 8.18 gallons req'd x 91,333BTU/gal | | = 746,704 BTU |
| 764,704/24 hours | | = 31,113 BTUh |
| Boiler Output (25kW/hr) @85% eff. | | = 72,569 BTUh |
| **Surplus energy** | | **35,000** BTUh |

# Phase Two (what to do with 35,000 extra BTUs/hr)
# Thermal storage - 957 gallon storage

# Phase One + Phase Two
# Joining systems



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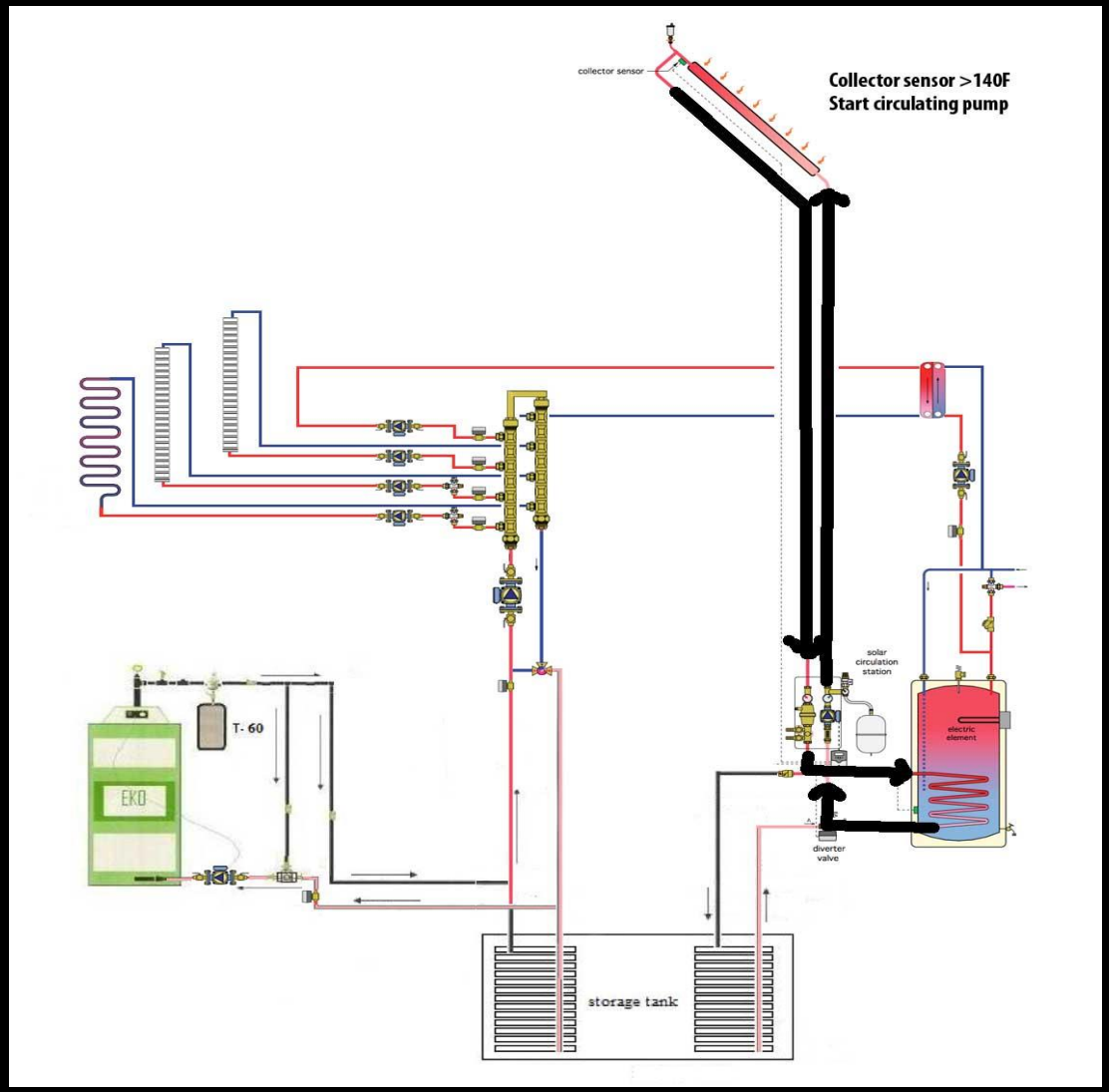

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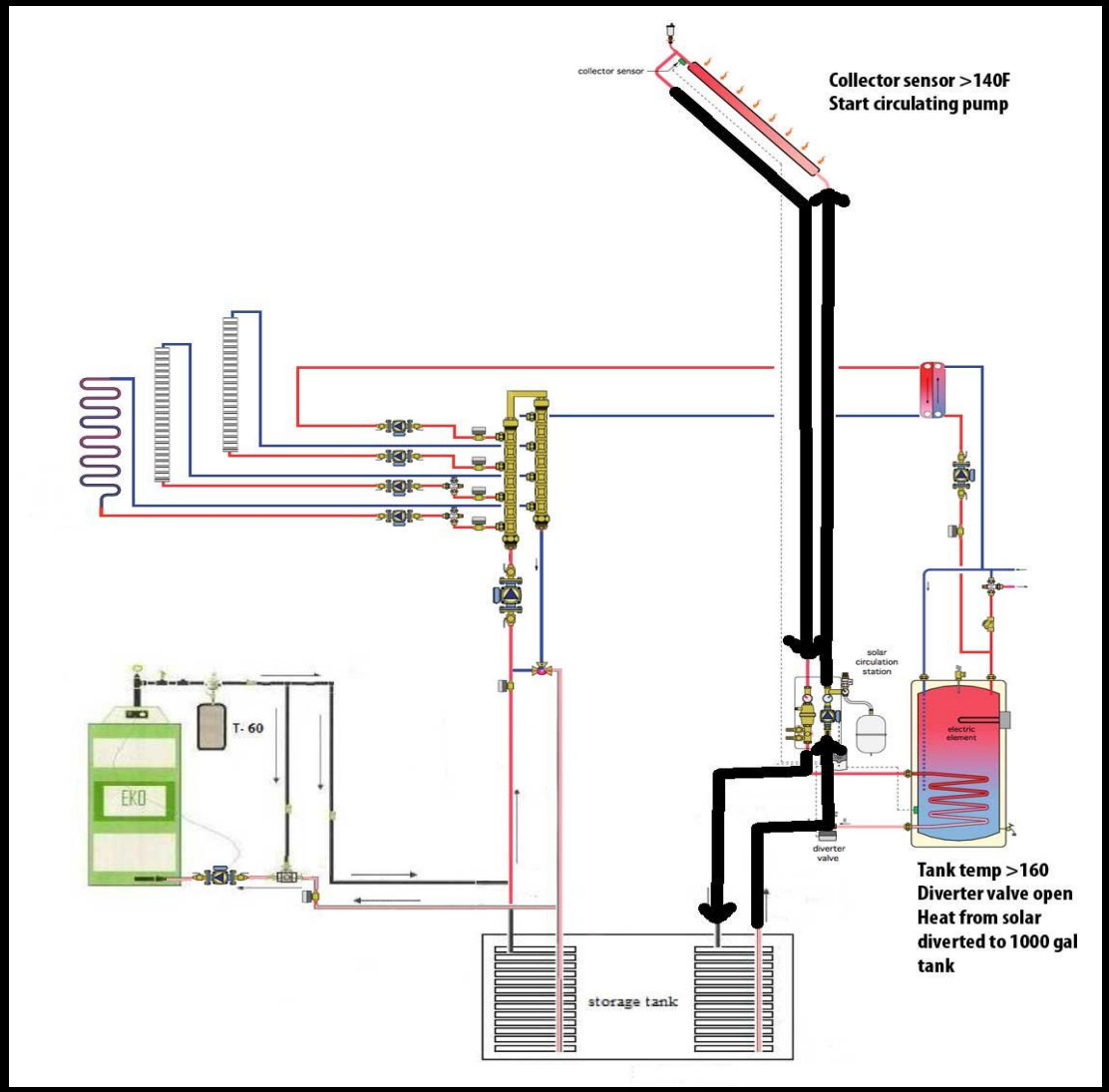

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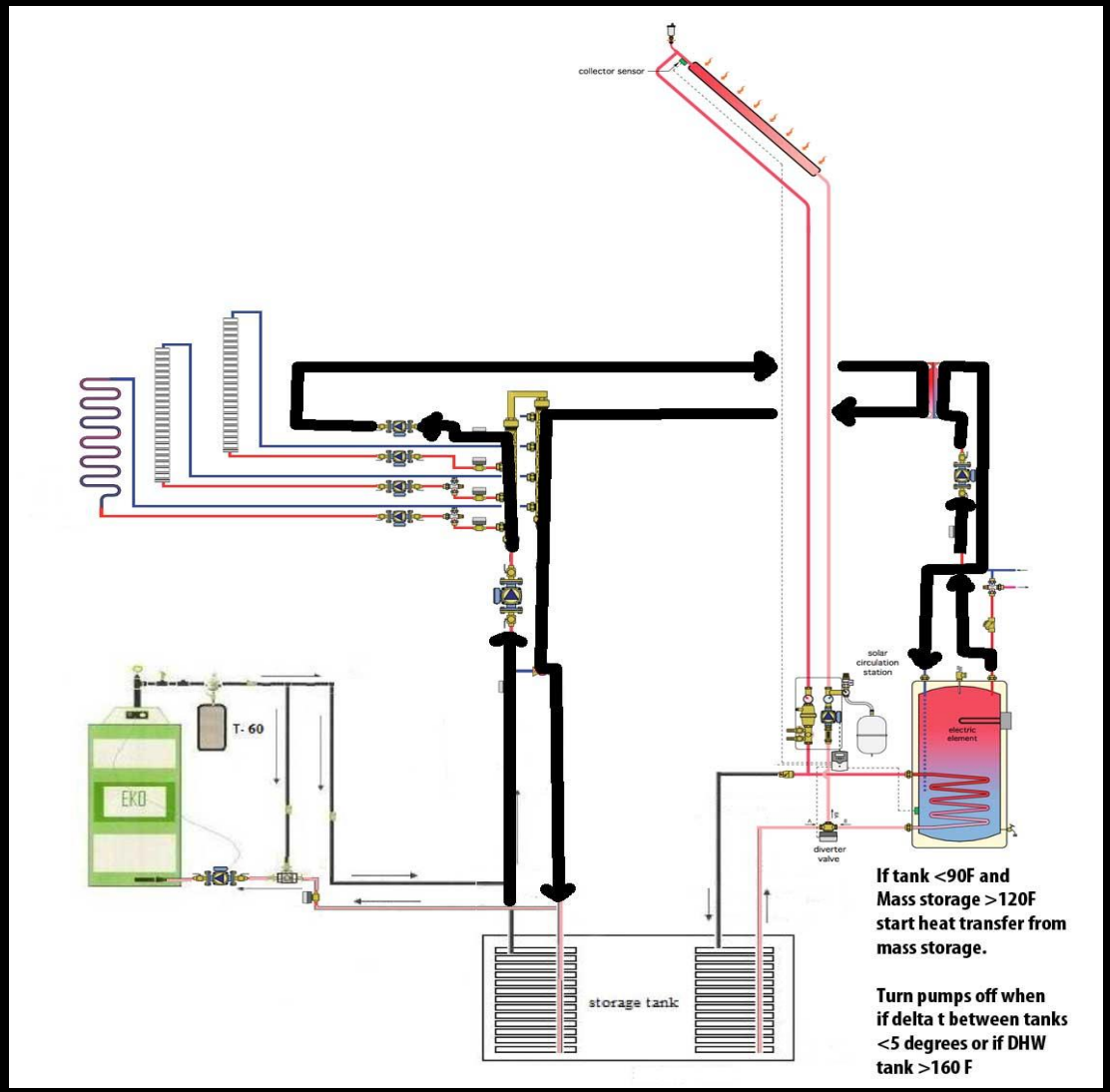


# Boiler + Thermal Storage Performance

## Boiler and thermal storage installation

| | | | | |
|---|---|---|---|---|
| **TTL HDD W11/12** | **3783.1** | | 595 | $2,200.14 Expected cost to heat propane only |
| Nov 25 2011 | $191.68 | $3.699 | 45.8 | |
| wood purchase | $140.00 | | | **$1,868.46** savings in heating for season |
| **TTL HDD W12/13** | **4656.8** | | 732 | $2,671.65 Expected cost to heat propane only |
| Feb 3 2013 | $472.19 | $3.649 | 118.5 | |
| wood purchase | $175.00 | | | **$2,024.46** savings in heating for season |
| **TTL HDD W13/14** | **5246.6** | | 825 | $3,092.51 Expected cost to heat propane only |
| Nov 23 2013 | $395.53 | $3.749 | 95.8 | |
| wood purchase | $82.00 | | | **$2,614.98** savings in heating for season |
| **TTL HDD W14/15** | **5463.5** | | 859 | $3,134.46 Expected cost to heat propane only |
| Sep 5 2014 | $606.68 | $3.649 | 150 | |
| | | | | **$2,527.78** savings in heating for season |
| **TTL HDD W 15/16** | **3827** | | 602 | $1,318.91 Expected cost to heat propane only |
| | | $2.192 | 150 | |
| | | | | **$1,318.91** savings in heating for season |

Total savings $ 10,354.59

# Phase Three
# Electric car - Chevy Volt

# Volt performance – three-year summary

(while living in country)



94,000 driven

62,000 miles electric

About 65% electric

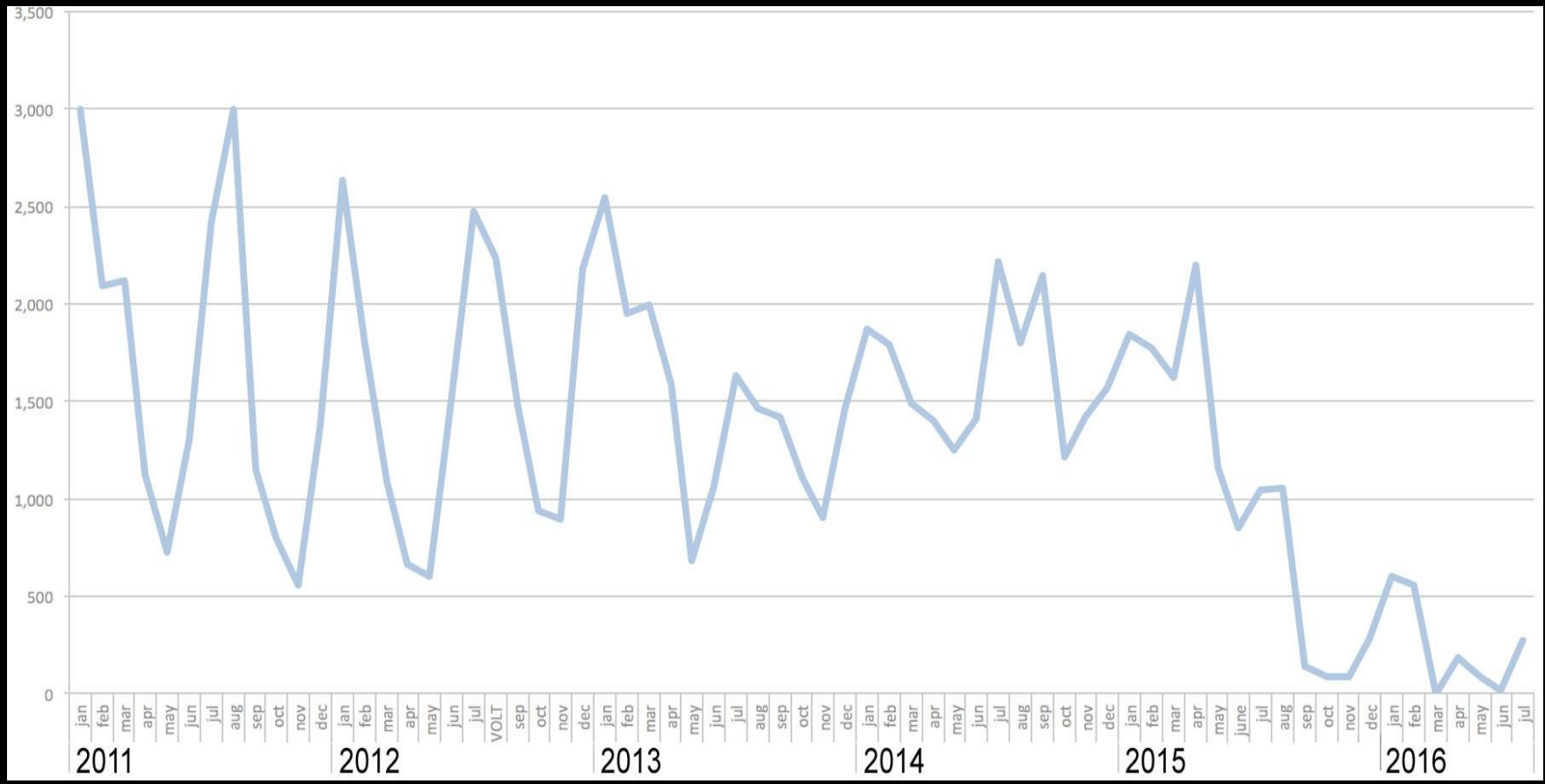
28,000 lbs of $CO_2$ avoided

1500 gallons of gas saved

Gamification incentive

# Phase Four
# Photo Voltaic Installation

# Photo Voltaic Installation
# Electric energy monitoring



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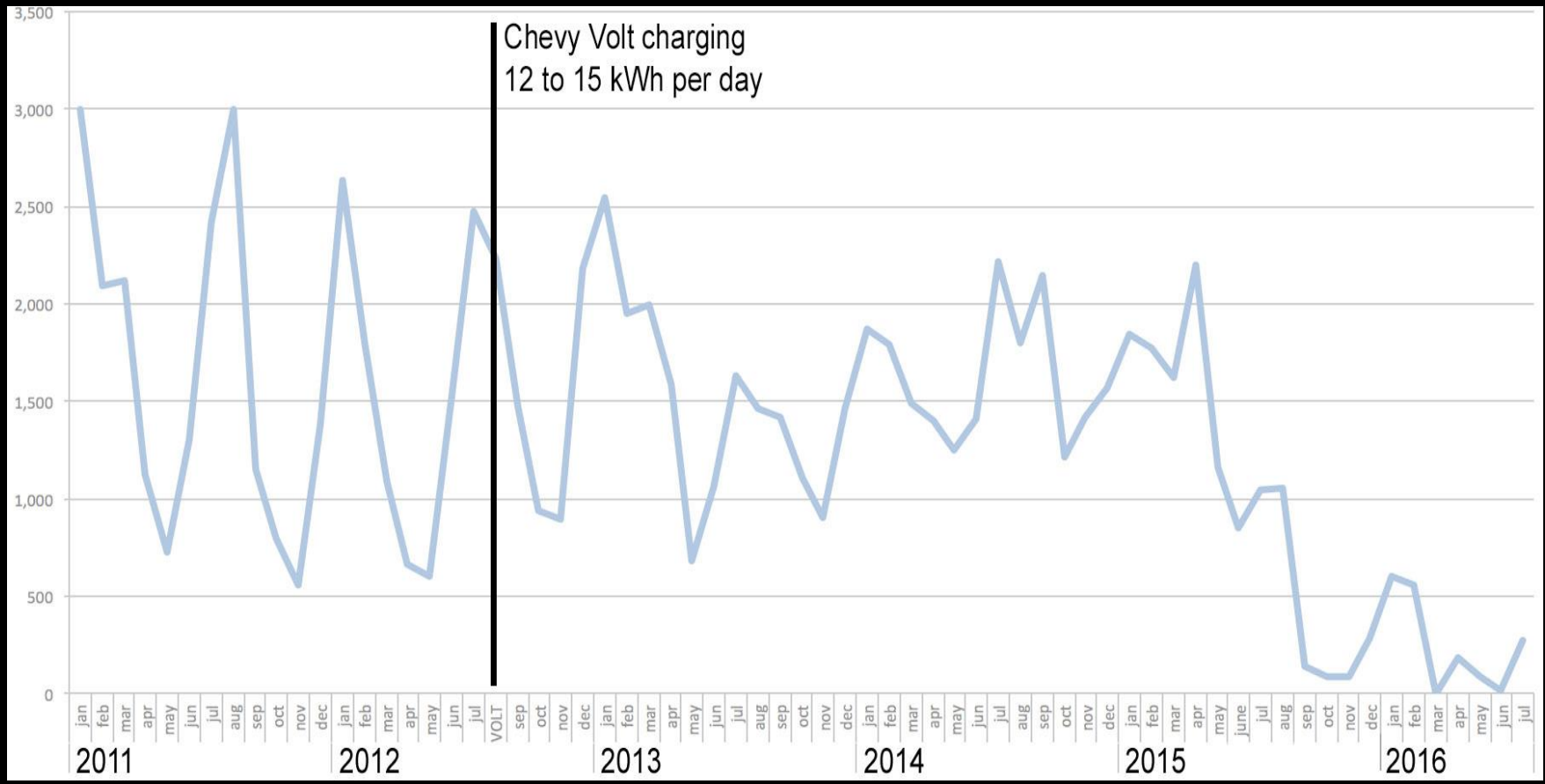

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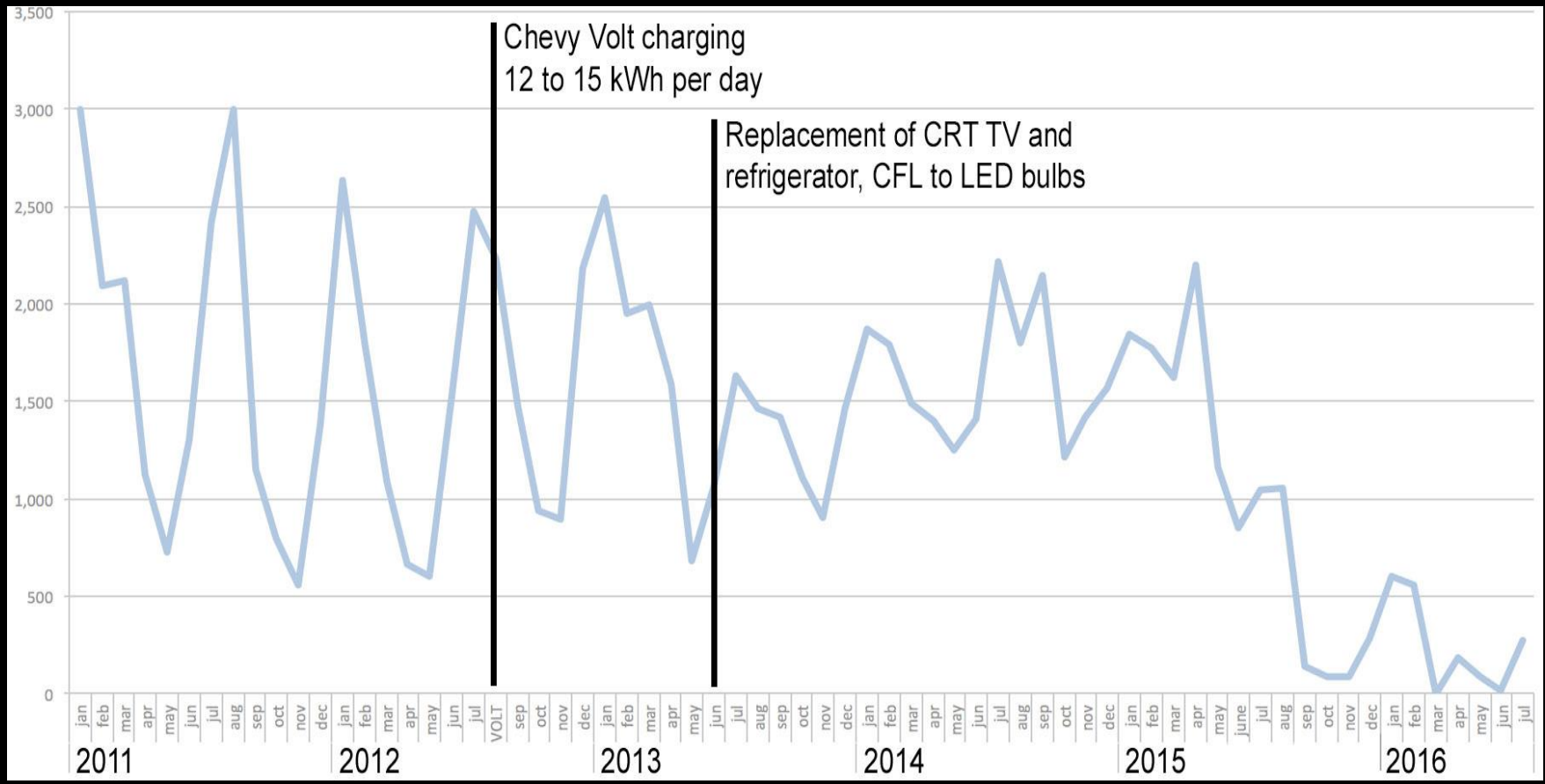

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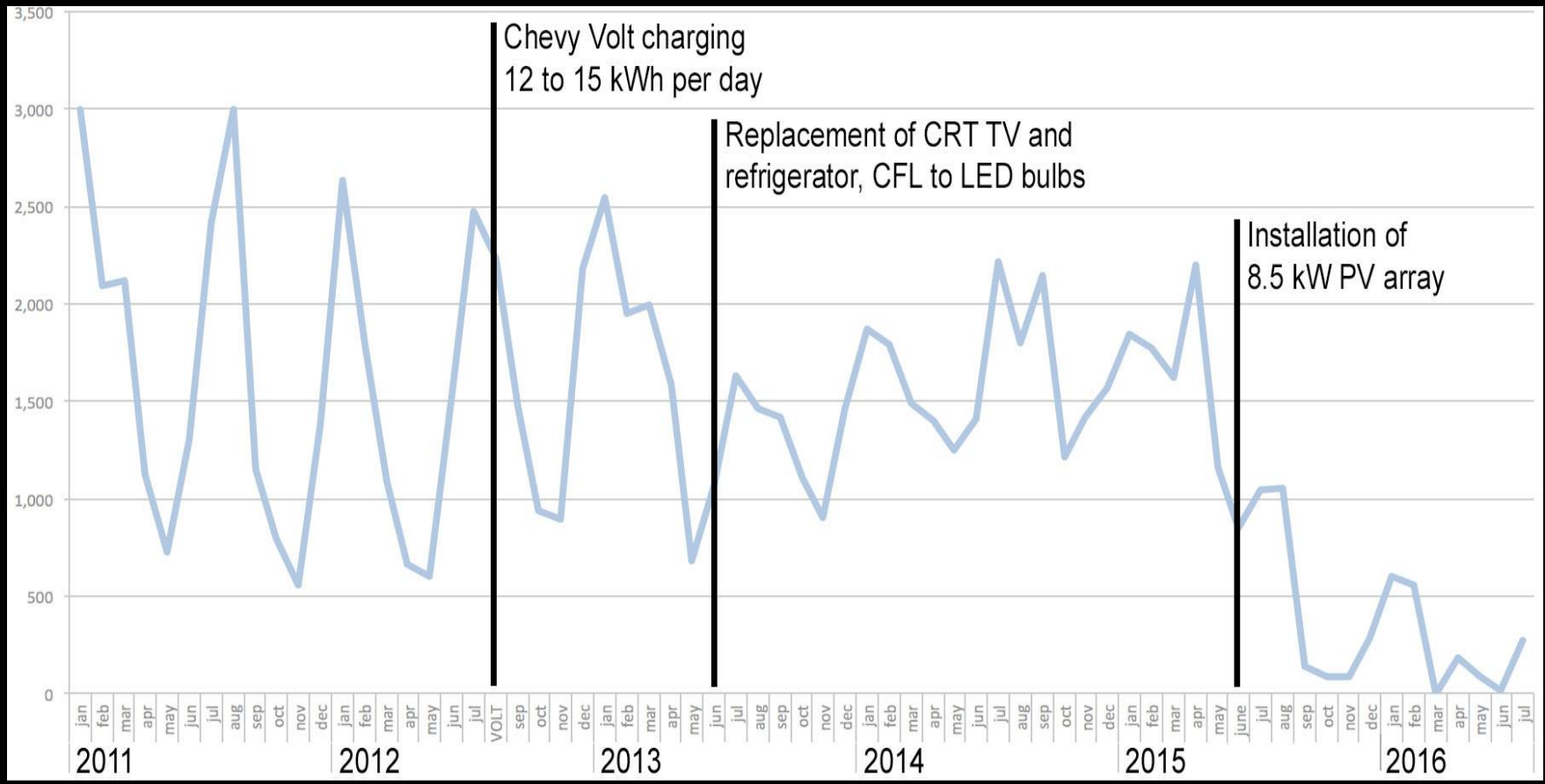

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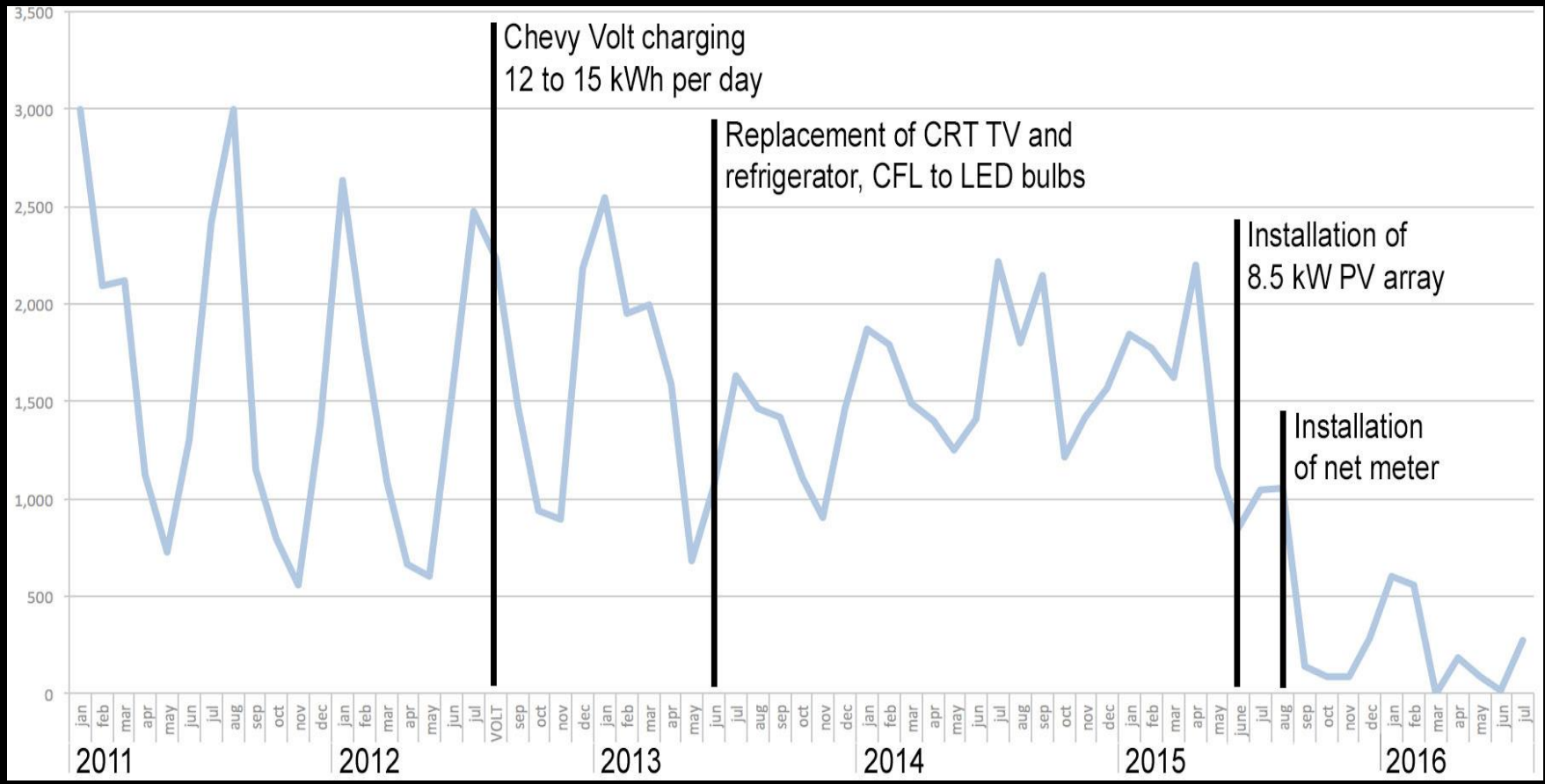

# Summary - approaching carbon neutrality

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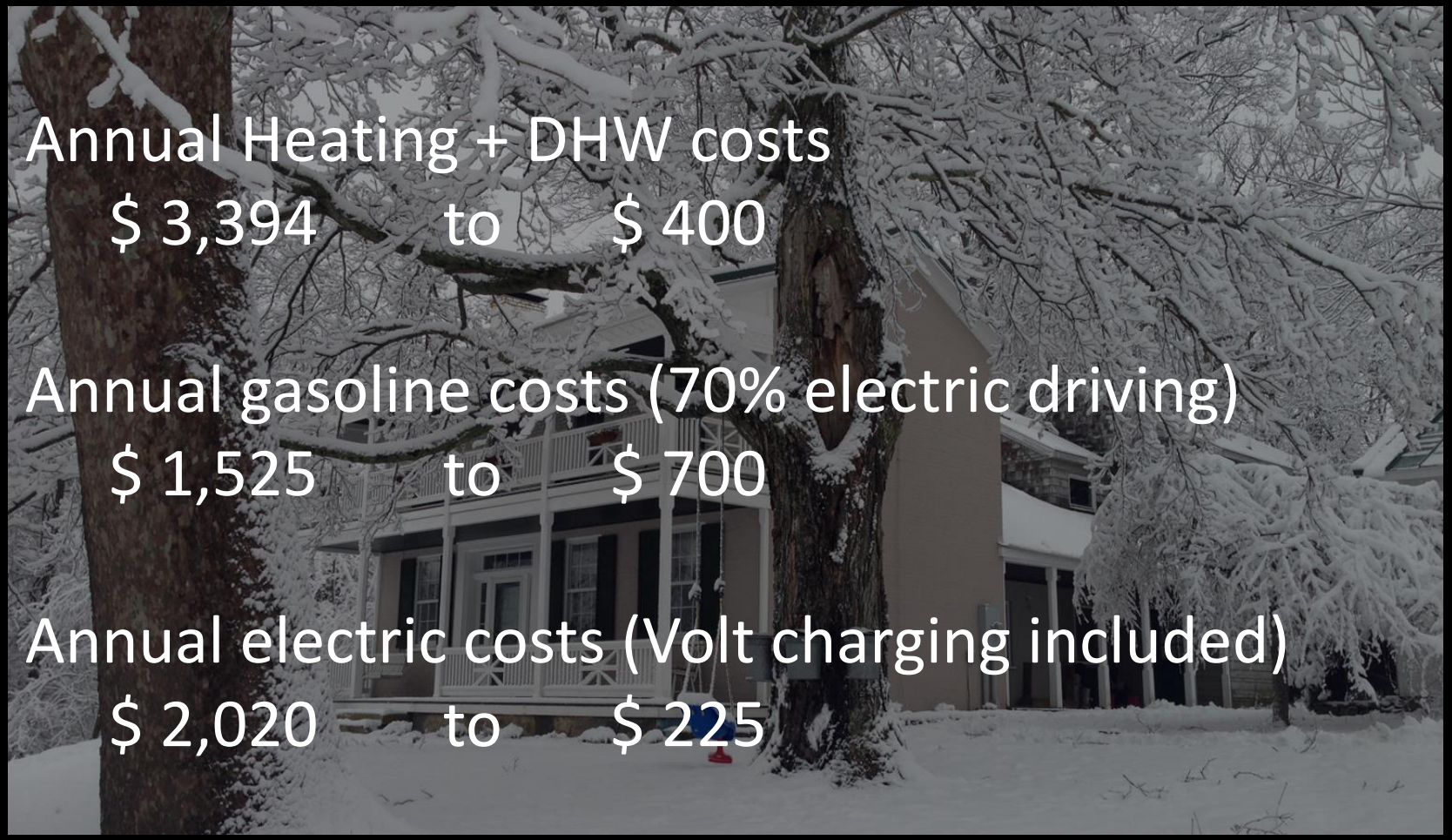
"Doing something because it's right, not because it's useful or convenient."

Paraphrasing Immanuel Kant

# Summary - approaching carbon neutrality



Annual Heating + DHW costs

$ 3,394 to $ 400

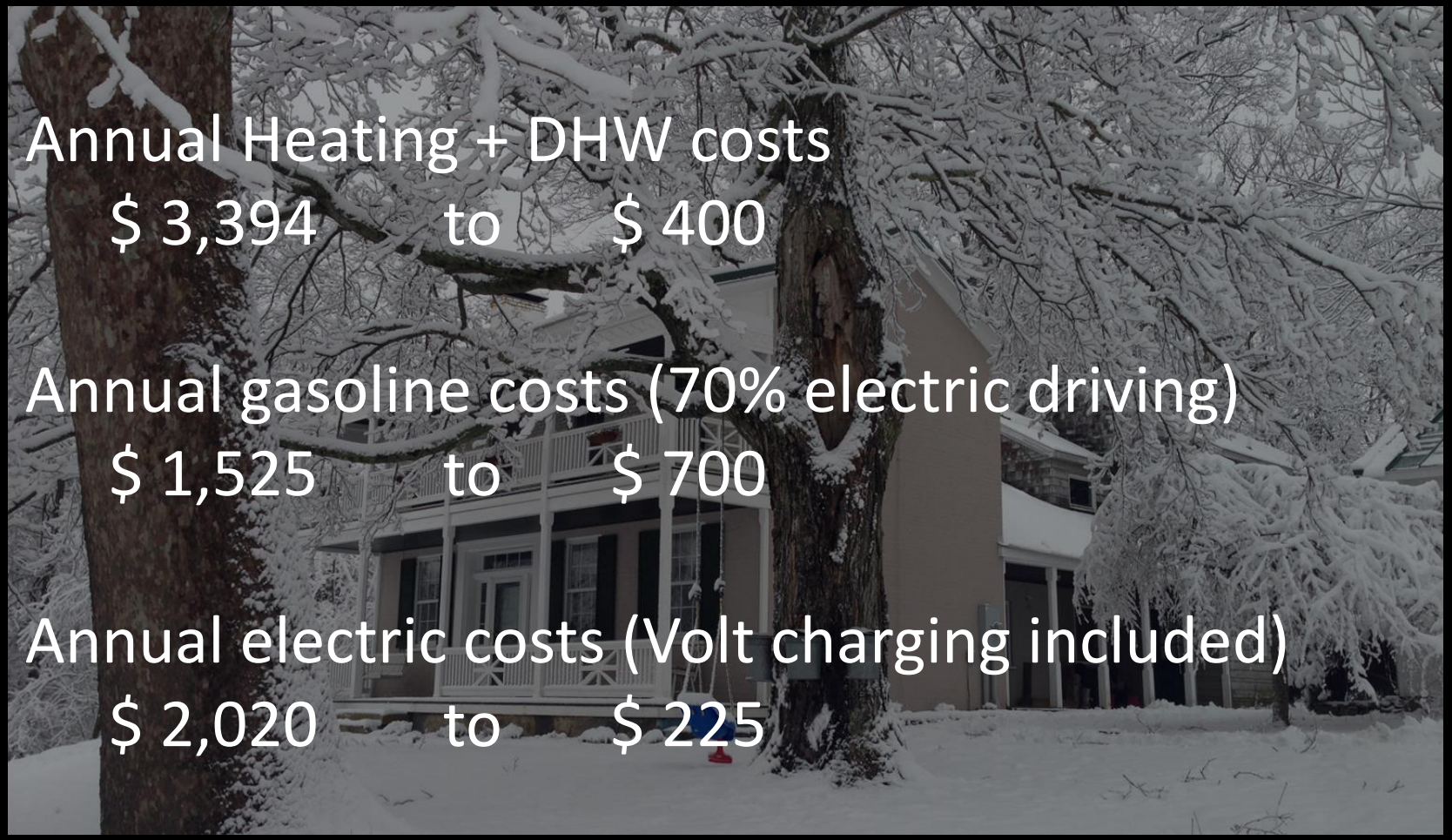
Annual gasoline costs (70% electric driving)

$ 1,525 to $ 700

Annual electric costs (Volt charging included)

$ 2,020 to $ 225

# Summary - approaching carbon neutrality



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$ 3,394 to $ 400

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Annual electric costs (Volt charging included)

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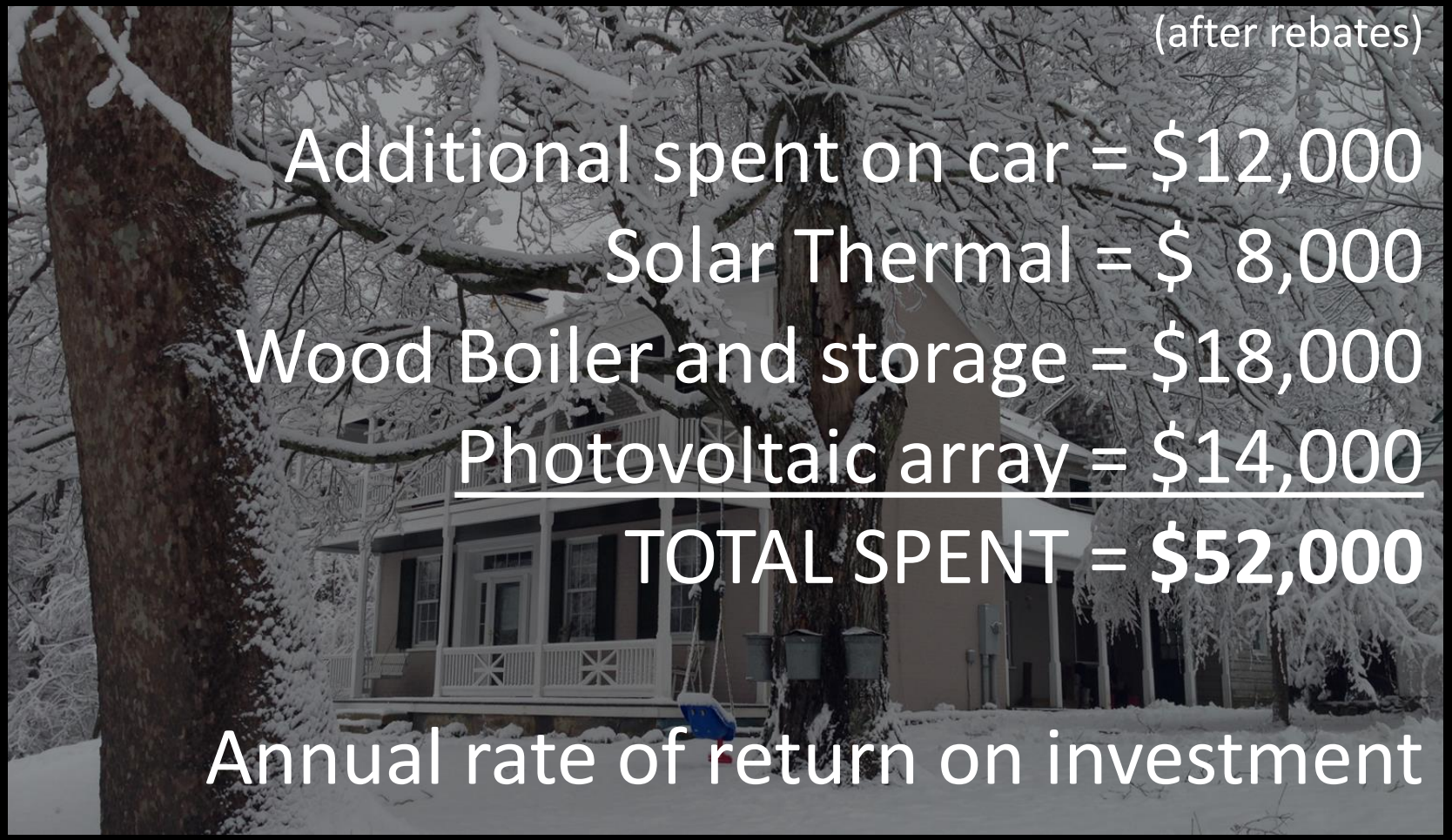
**$ 6,939 to $ 1,325 $ 5,614 savings/yr**

# Total investment in alternative energy



(after rebates)

Additional spent on car = $12,000

Solar Thermal = $ 8,000

Wood Boiler and storage = $18,000

Photovoltaic array = $14,000

TOTAL SPENT = **$52,000**

Annual rate of return on investment

$5,614/$52,000 = **10.79%**