

# 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

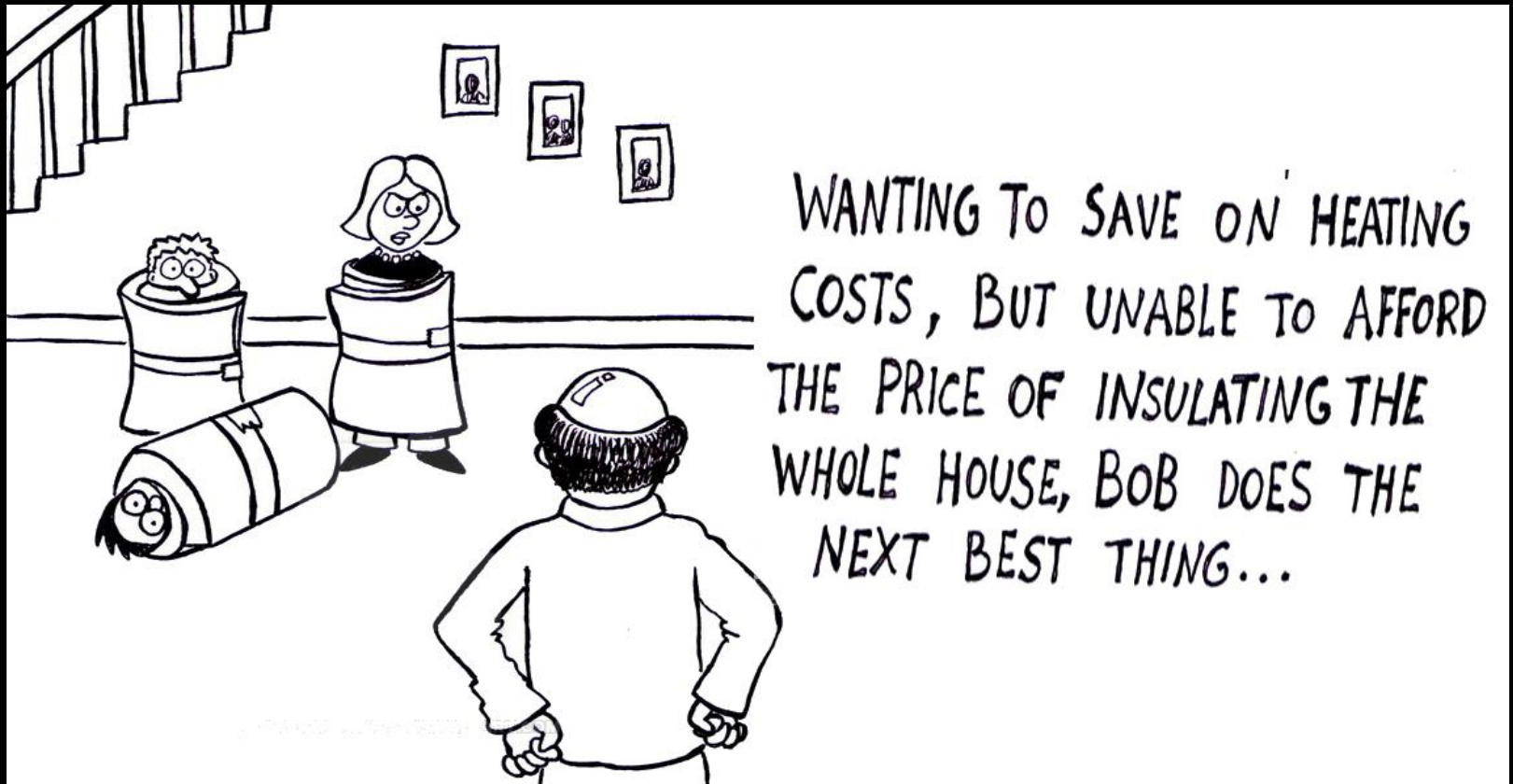
1. Build a more efficient building
2. Live with the current situation





# Preservation Options/Strategies

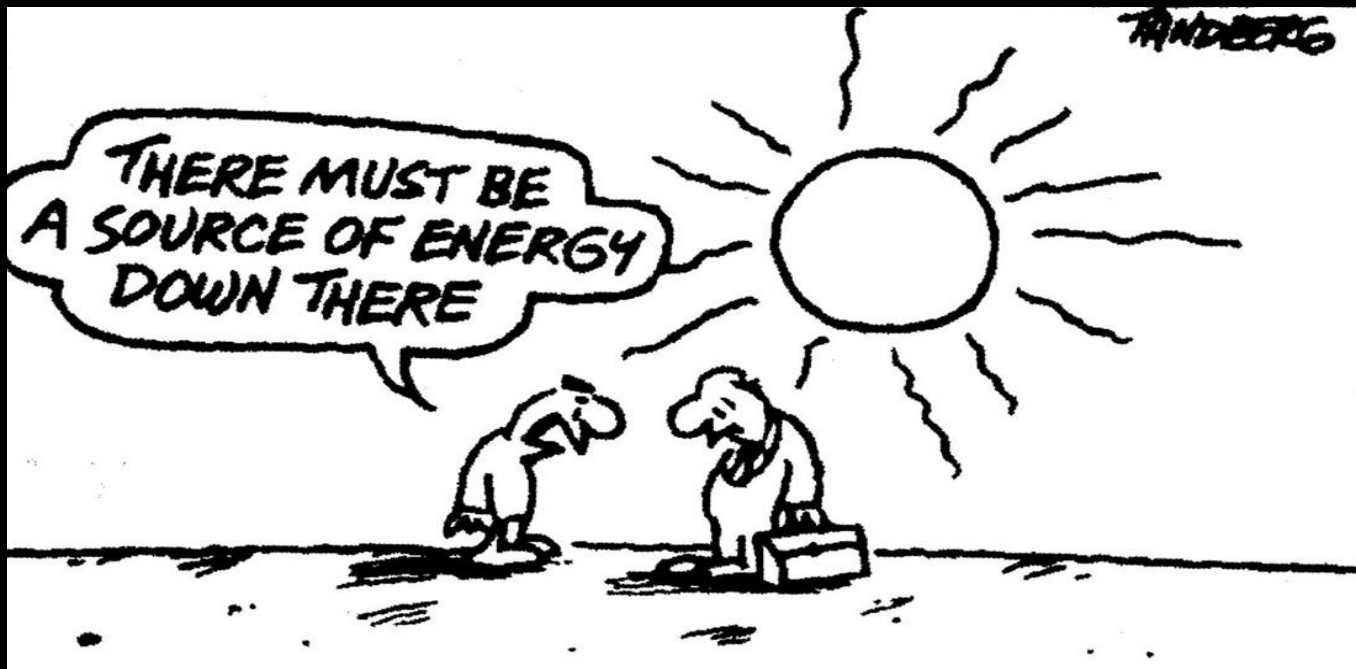
1. Build a more efficient building
2. Live with the current situation
3. Improve energy conservation/efficiency





# Preservation Options/Strategies

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4. Increase energy production



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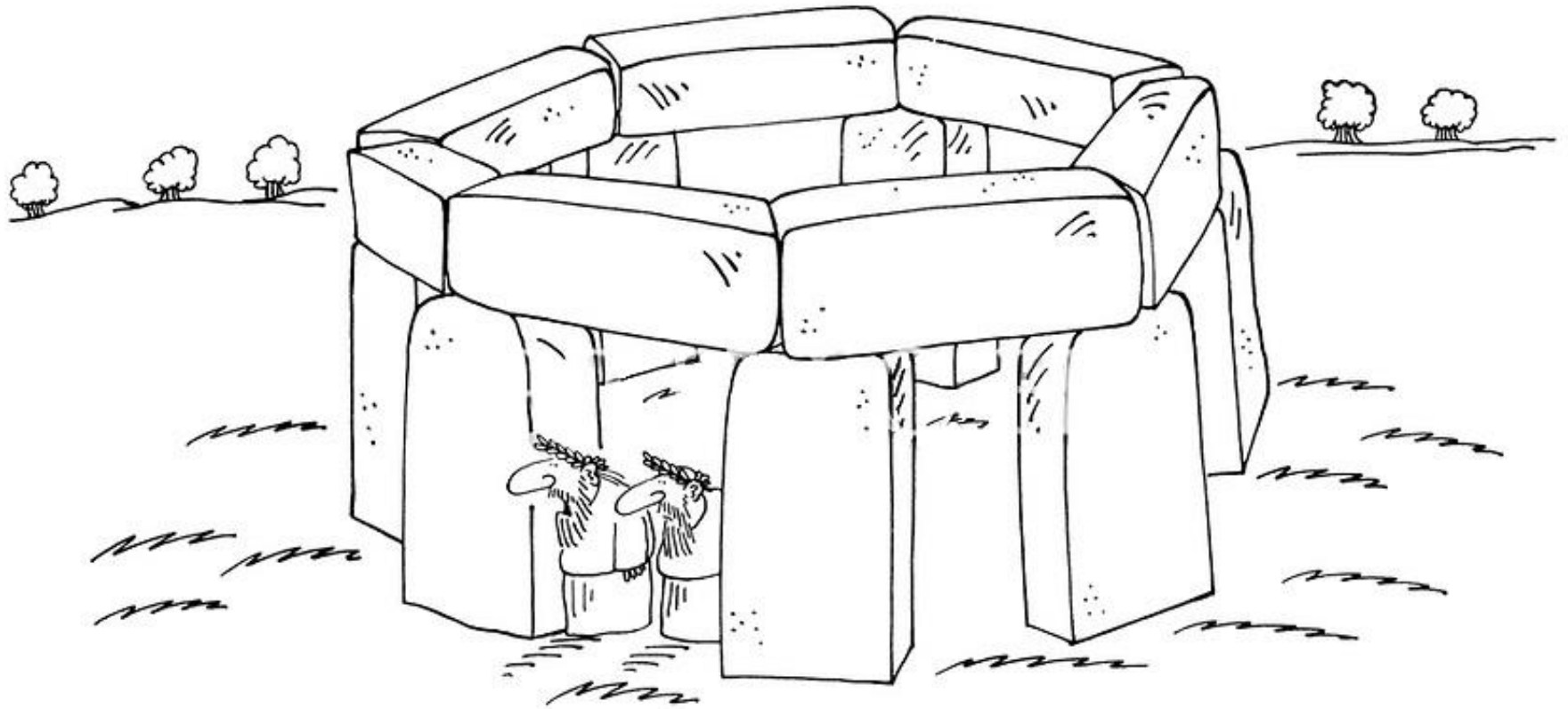
1. Build a more efficient building
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# Preservation Options/Strategies

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° F Winter, 76° F Summer
- New high efficiency furnace
- New storm windows
- Repair envelope breaches

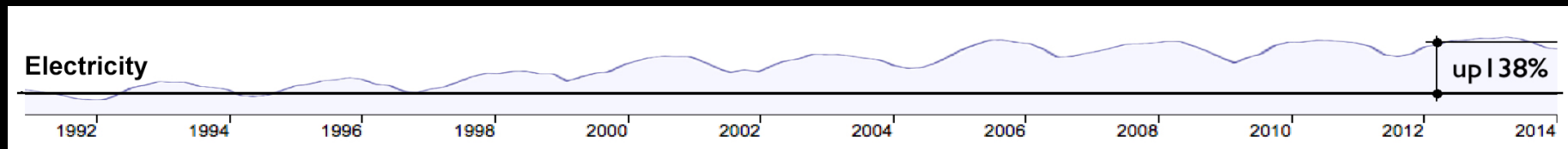


# Base Energy Consumption Analysis

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Electricity \$0.08 to 0.11/kWh

up 1.38 x





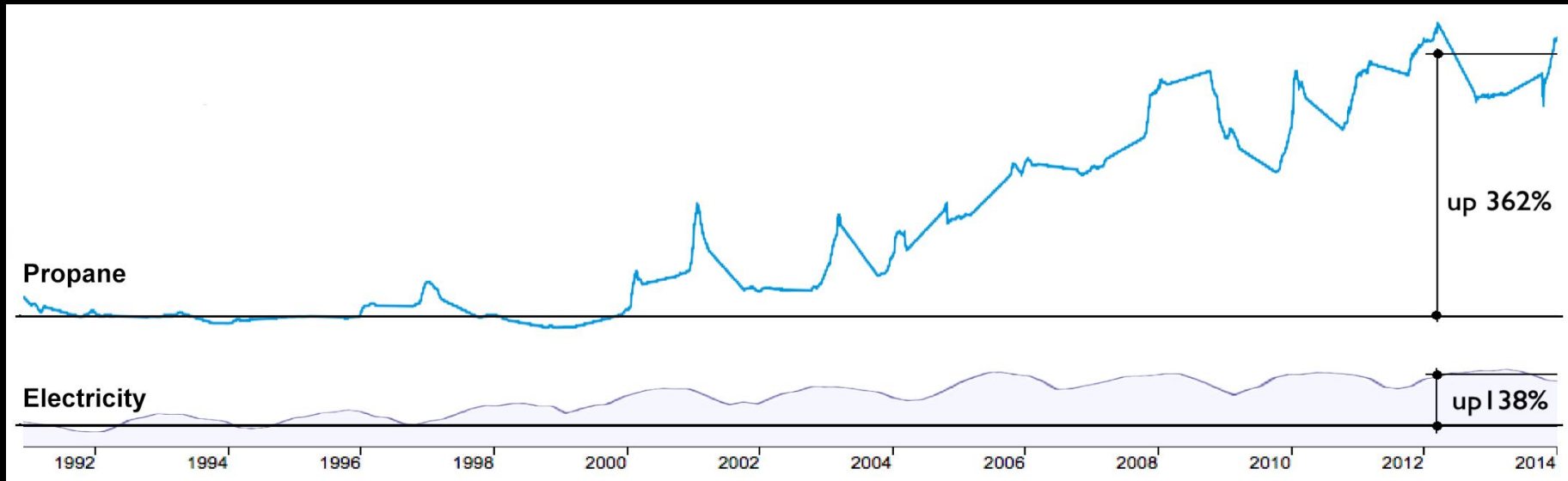
# Base Energy Consumption Analysis

Electricity     \$0.08 to 0.11/kWh

up 1.38 x

Propane        \$0.99 to 3.69/gal

up 3.62 x

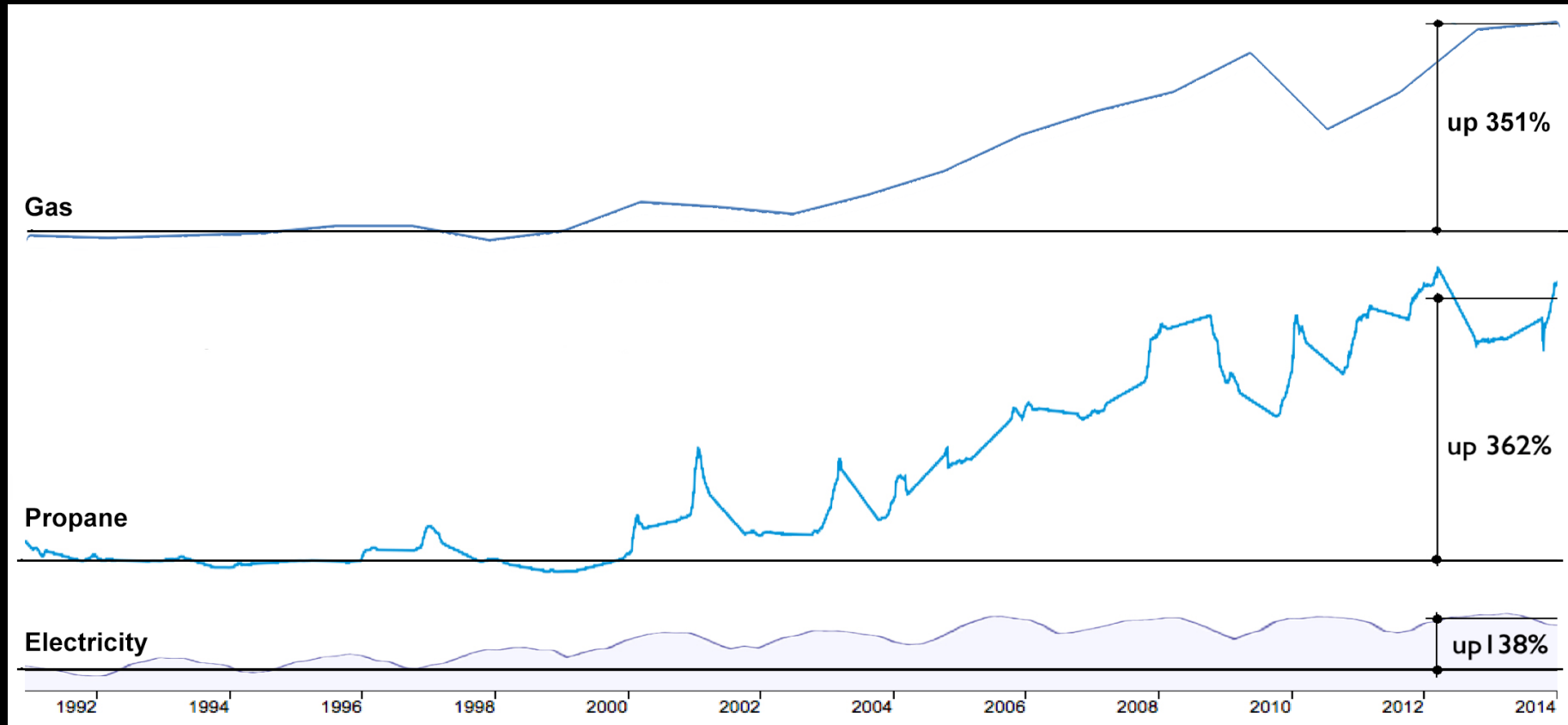


# Base Energy Consumption Analysis

Electricity     \$0.08 to 0.11/kWh     up 1.38 x

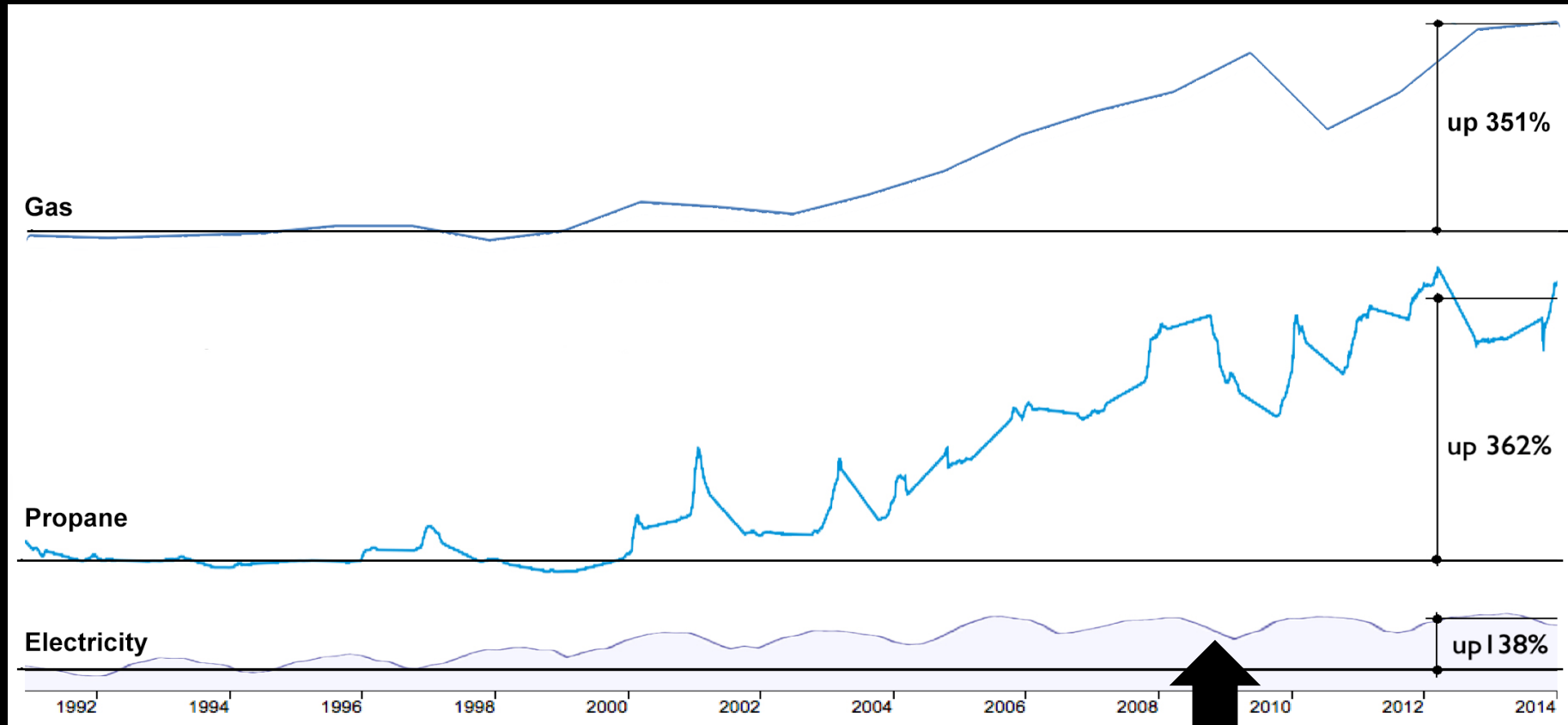
Propane     \$0.99 to 3.69/gal     up 3.62 x

Gasoline     \$0.96 to 3.36/gal     up 3.51 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
Gasoline	\$0.96 to 3.36/gal	up 3.51 x



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

## Four Phases



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## Four Phases

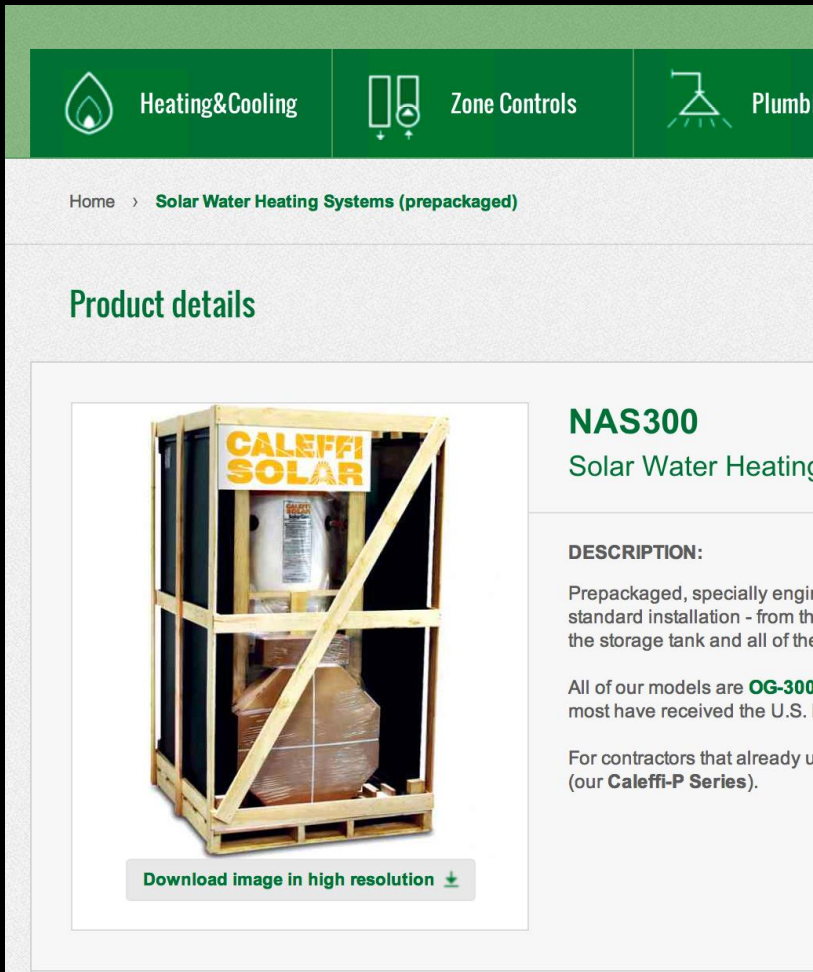
1. Solar Thermal – Domestic Hot Water
2. Wood Gasification – Hydronic Heating
3. Electric Car
4. Photo Voltaic Installation





# Phase One

## Solar Thermal - Domestic Hot Water



The screenshot shows a website interface with a green navigation bar containing icons for 'Heating & Cooling', 'Zone Controls', and 'Plumbing'. Below the navigation bar, the breadcrumb trail reads 'Home > Solar Water Heating Systems (prepackaged)'. The main content area is titled 'Product details' and features a product image of the NAS300 system in a wooden crate. To the right of the image, the product name 'NAS300 Solar Water Heating' is displayed. Below the name, a 'DESCRIPTION:' section contains the following text: 'Prepackaged, specially engineered for standard installation - from the solar collector to the storage tank and all of the components in between.' It also states 'All of our models are **OG-300** class and most have received the U.S. Department of Energy's Energy Star certification.' and 'For contractors that already use our solar water heating systems (our **Caleffi-P Series**).' A button at the bottom of the image area says 'Download image in high resolution' with a download icon.



# Phase One

## Solar Thermal - Domestic Hot Water





# Phase Two

## Wood gasification – Hydronic heating

The screenshot shows the New Horizon Corporation website. At the top left is the company logo, a stylized flame, followed by the name "New Horizon Corporation" in green, the website URL "www.newhorizoncorp.com", the email "newhorizoncorp@gmail.com", and the phone number "1-877-202-5070". To the right is an "ONLINE STORE" button. Below the header is a navigation bar with "RESIDENTIAL" and "INDUSTRIAL" tabs. A large banner image of wood chips contains the text "we can save 80% over conventional heating". Below the banner is a green navigation bar with links: HOME, ONLINE STORE, PRODUCTS, FAQ, TECHNOLOGY, DOWNLOAD, ABOUT US, CONTACT. The main content area is titled "EKO Line Boiler" and includes a "SEE PRICING" button. A list of boiler models is shown: EKO Line Boiler, BioMass Gasification Boiler, BioMass Combo Boiler, and Attack DP Gasification Boiler. A "Find US" section with the Google Maps logo is also present. Three images of the boiler units are displayed at the bottom: a grey unit, a green unit, and a cutaway view of a green unit showing internal components.



[https://www.youtube.com/watch?v=Linp0XI\\_gWg](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 91,333 BTU/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 91,333 BTU/gal = 746,704 BTU

764,704/24 hours = 31,113 BTUh

Boiler Output (25kW/hr) @85% eff. = 72,569 BTUh

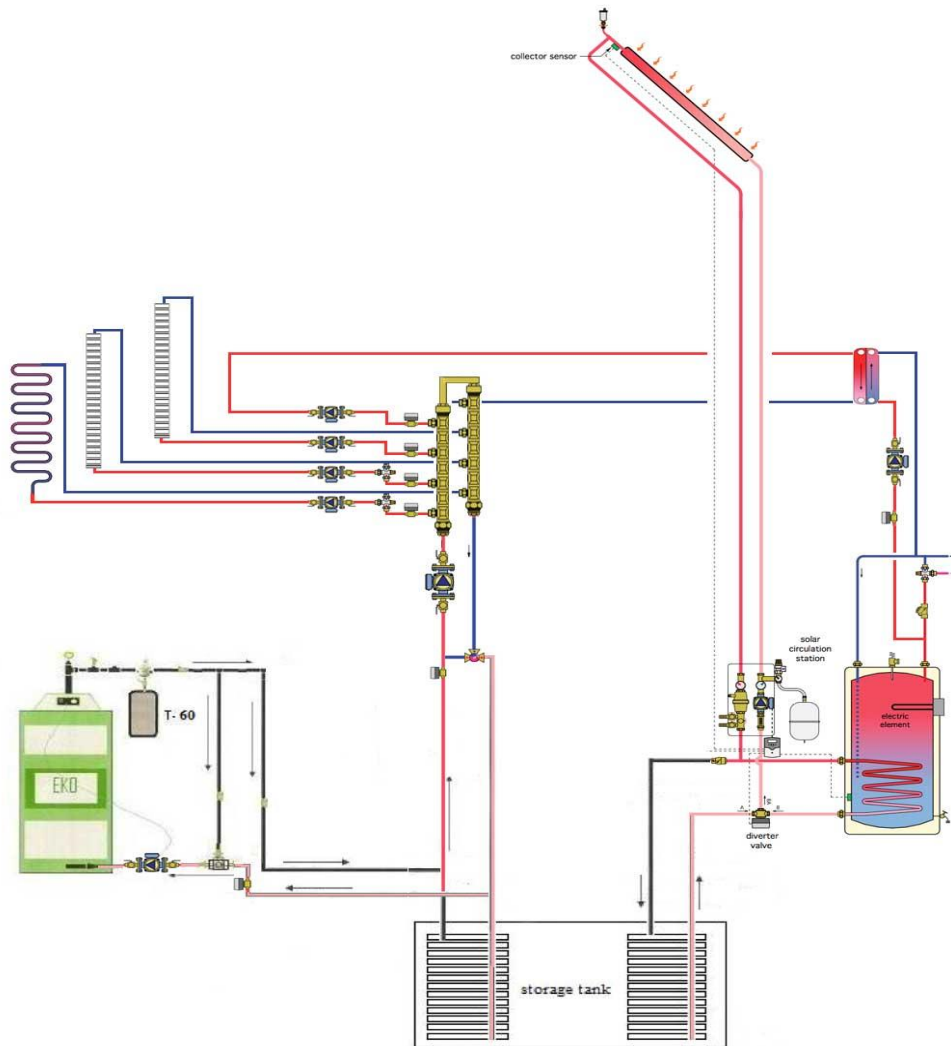
**Surplus energy**      **35,000** BTUh

# Phase Two (what to do with 35,000 extra BTUs/hr)

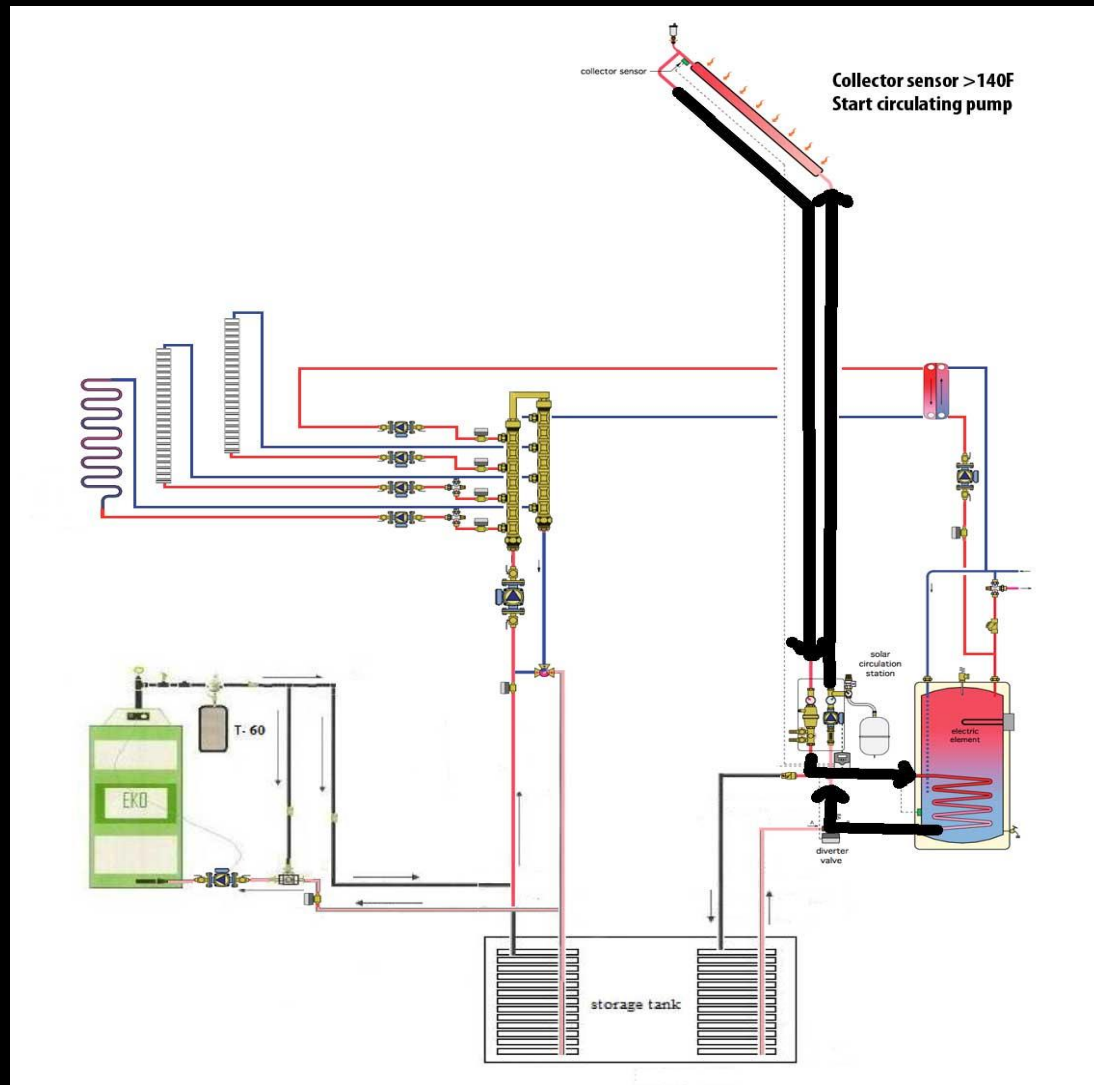
## Thermal storage - 957 gallon storage



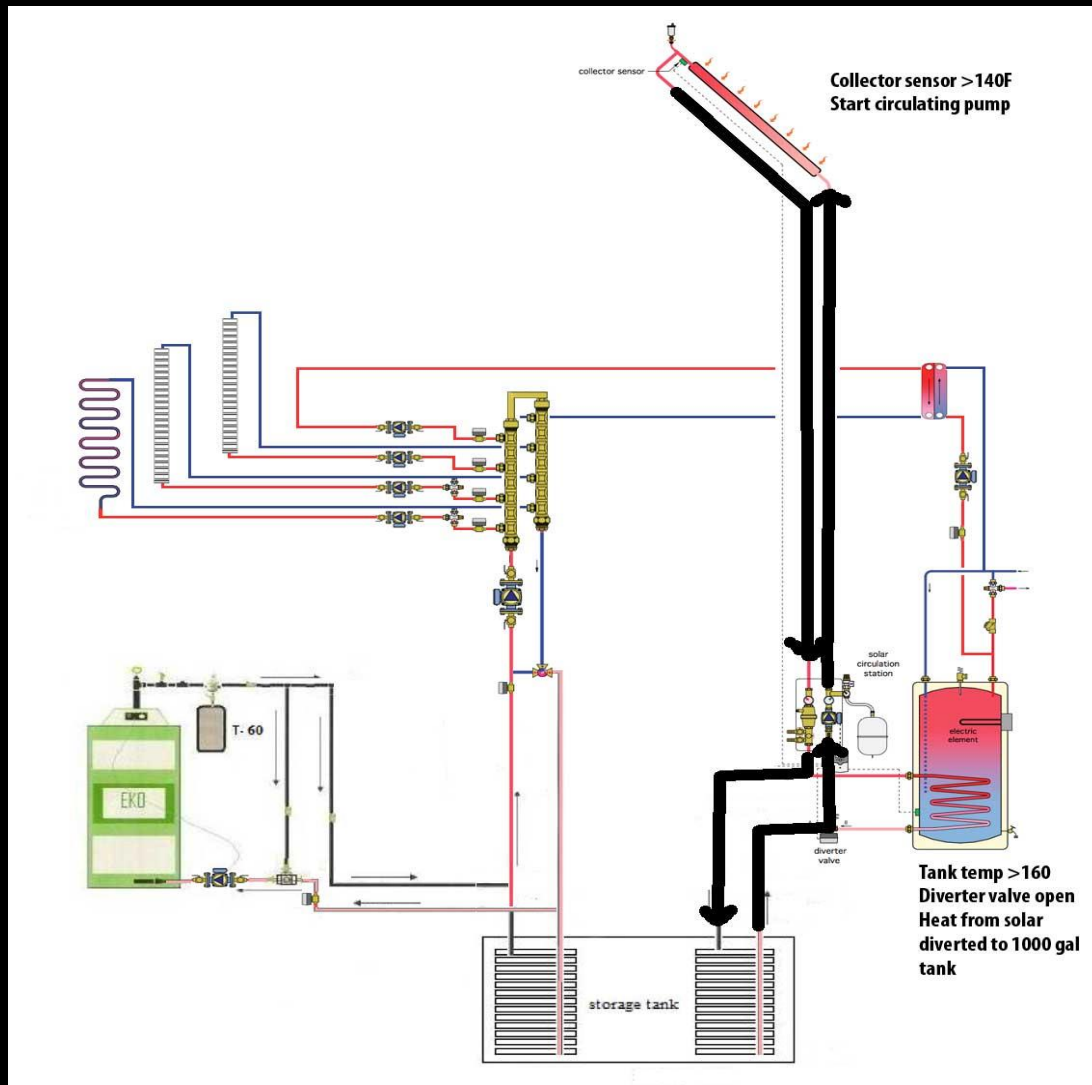
# Phase One + Phase Two Joining systems



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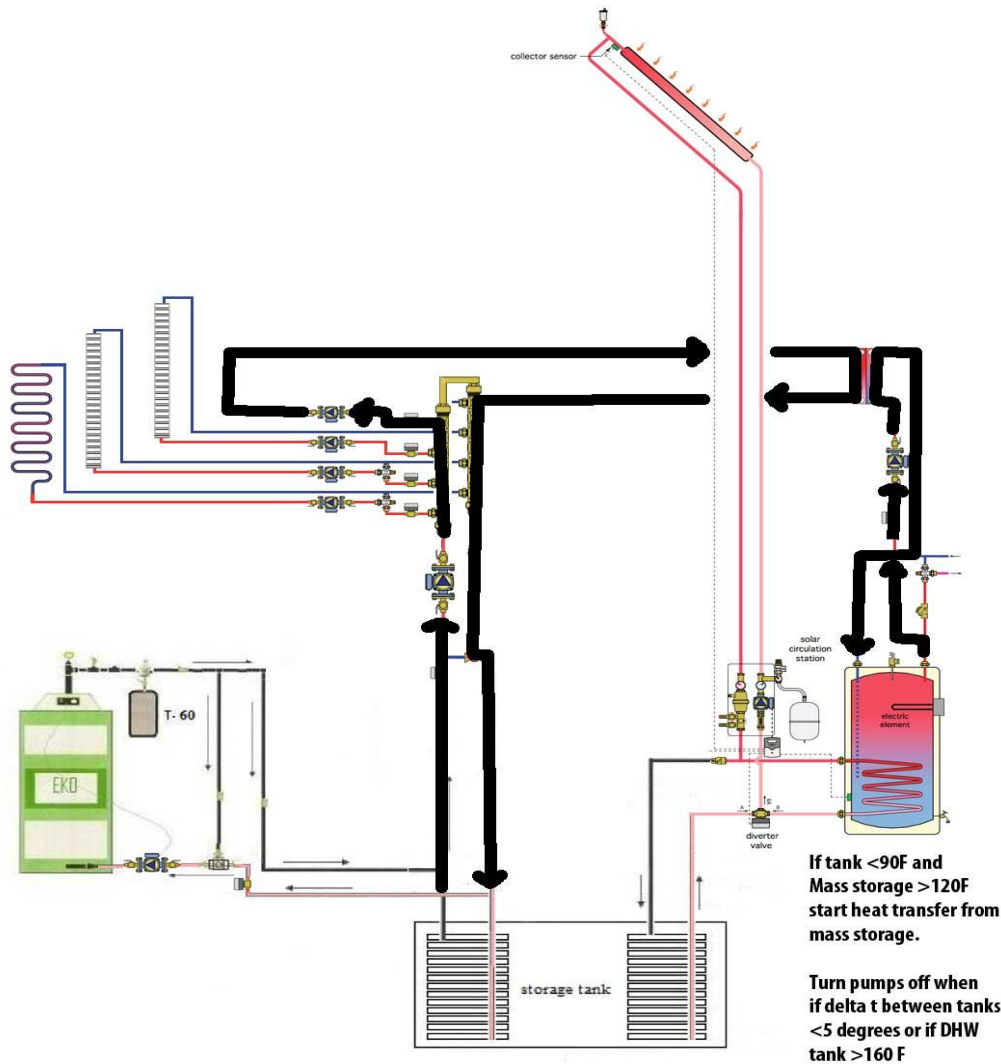


# Phase One + Phase Two Joining systems





# Phase One + Phase Two Joining systems



# Boiler + Thermal Storage Performance

## Boiler and thermal storage installation

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

1500 gallons of gas saved

Gamification incentive





# Phase Four Photo Voltaic Installation

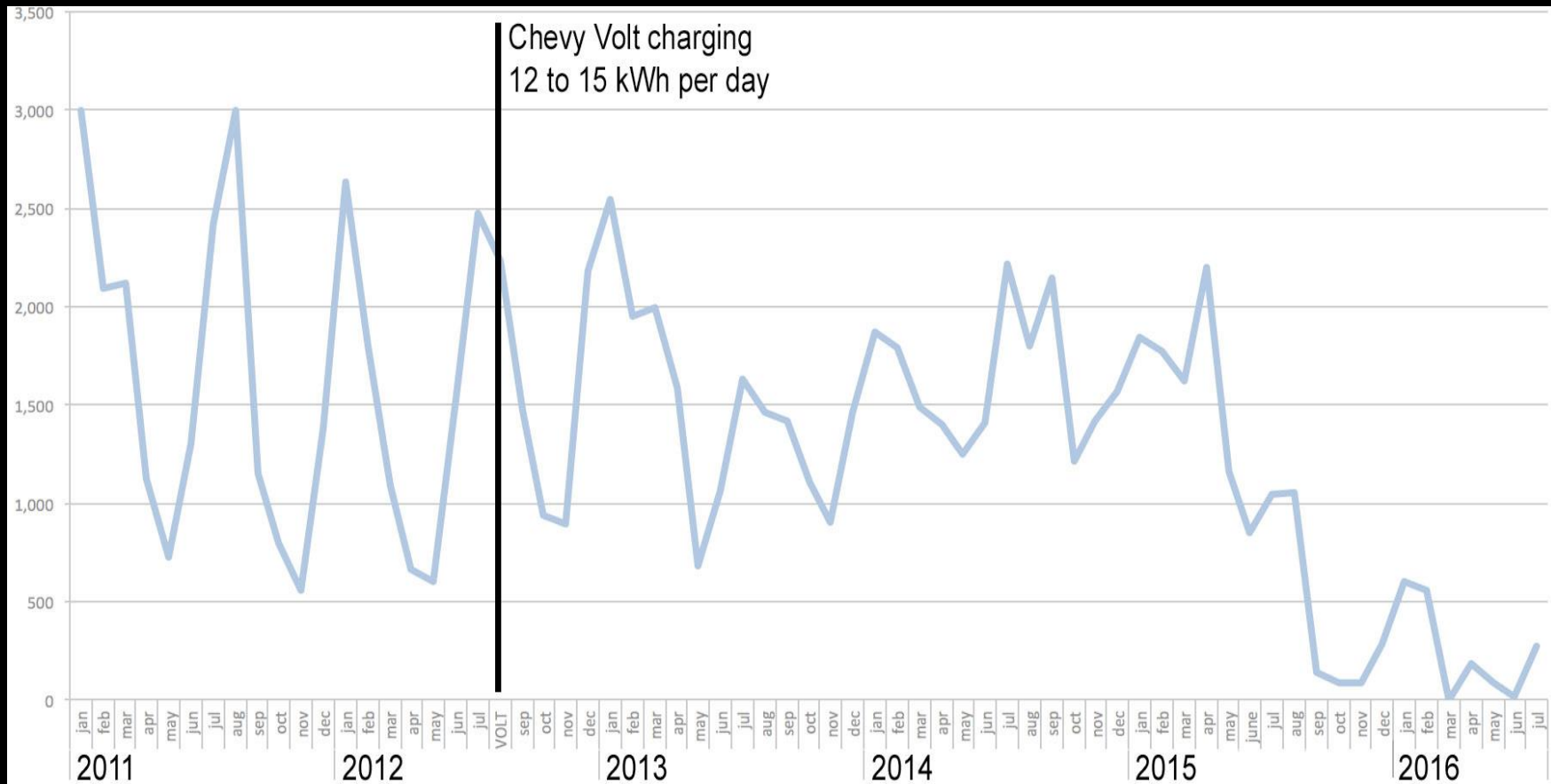






# Photo Voltaic Installation

## Electric energy monitoring











# 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

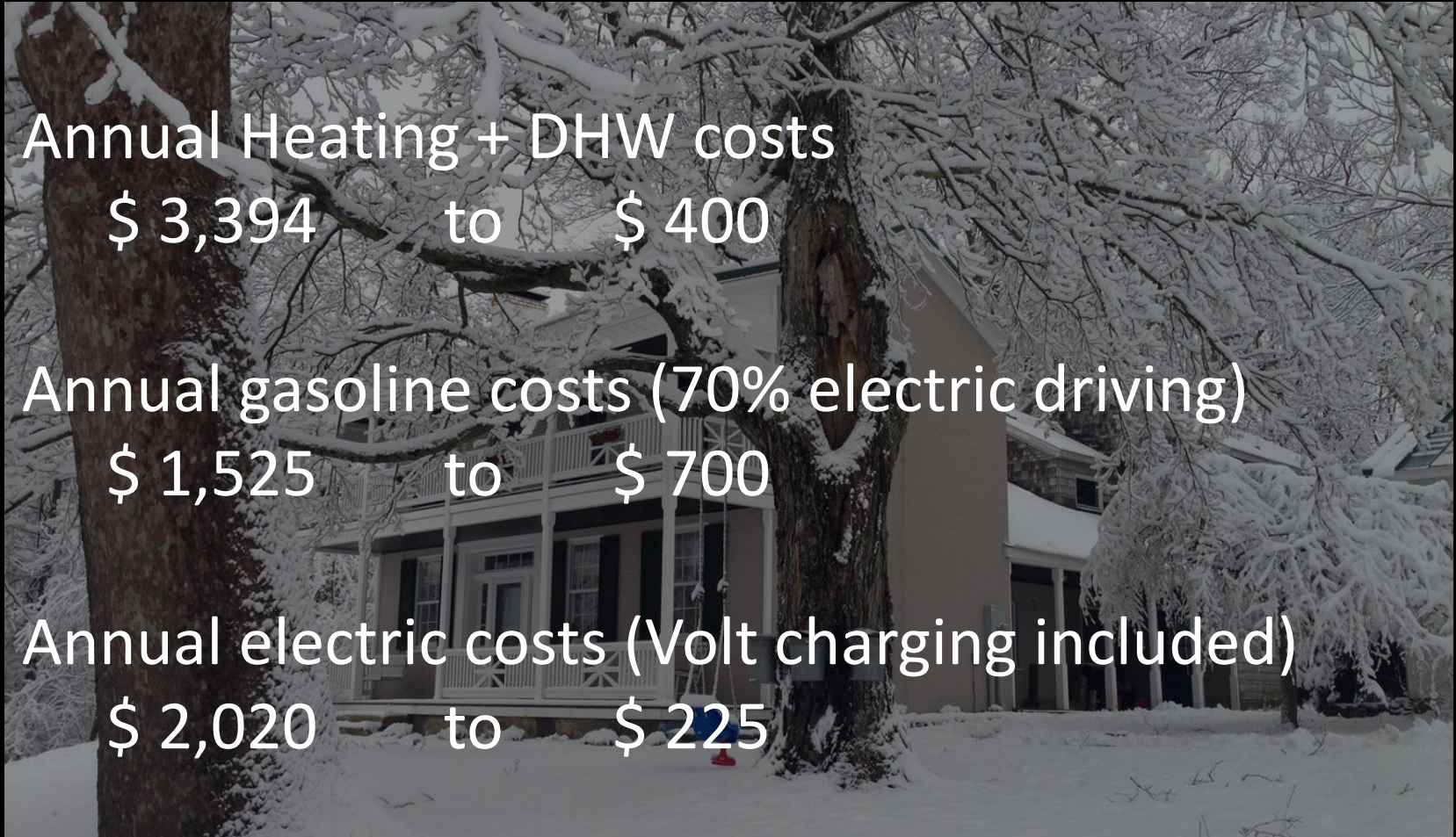
\$ 3,394 to \$ 400

Annual gasoline costs (70% electric driving)

\$ 1,525 to \$ 700

Annual electric costs (Volt charging included)

\$ 2,020 to \$ 225



# Summary - approaching carbon neutrality

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

**\$ 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

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