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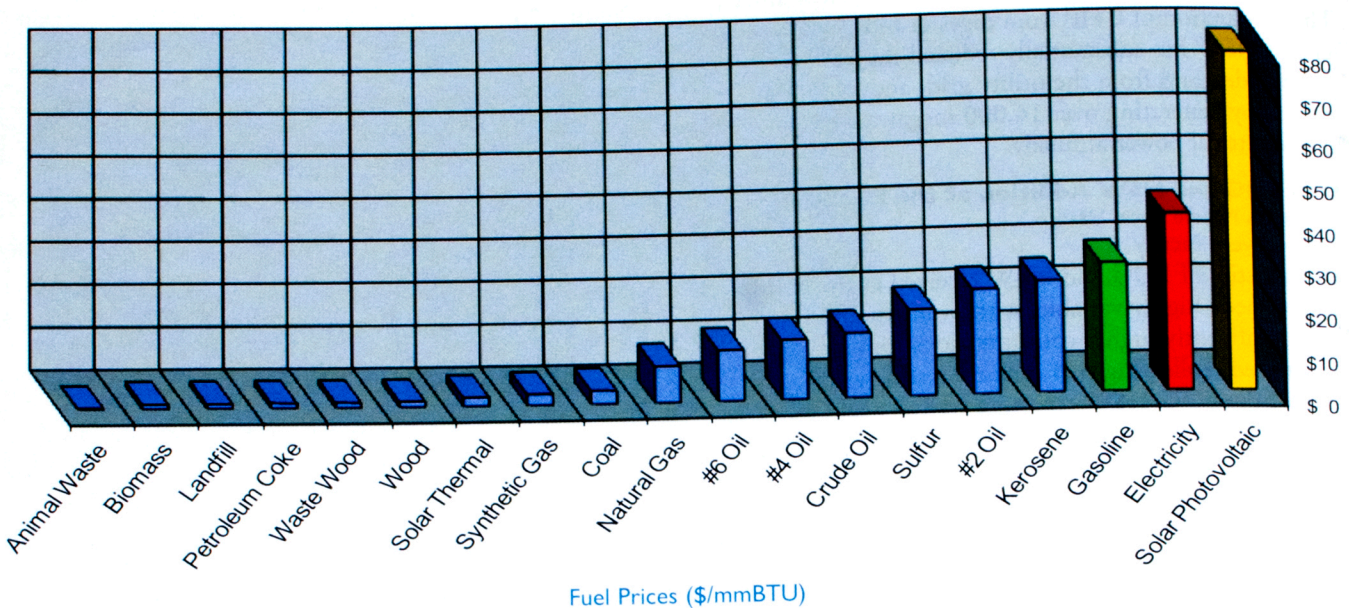
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Energy Cost Comparison of Alternative Fuels

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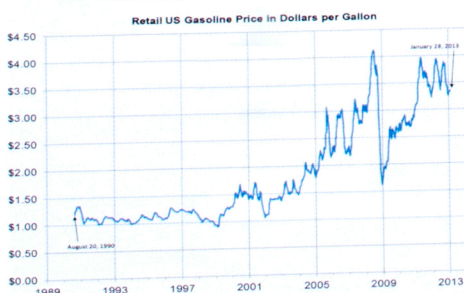
Alternative energy and alternative fuels have received considerable attention the past few years as traditional fuels have risen in cost. What are alternative fuels? This article introduces some of them. What are the relative costs between traditional fuels and alternative fuels? Fuels are priced as \$/gallon, \$/Ton, and \$/mmBTU, and by using a common comparative cost of “dollars per million BTUs” (\$/mmBTU) traditional, alternative, solid and liquid fuels can be compared. What impact would a cheaper fuel have on operating costs? A steam boiler example, included in this article, shows the savings associated with changing to an alternative fuel.

The fuel prices used in this article are for general reference and comparison for both the traditional fuels and alternative fuels. The reader is encouraged to see the relative differences between fuels and the procedure to compare them and not focus on the specific value given the wide swings in today’s fuel prices.

Traditional Fuels Gasoline

Energy prices have risen dramatically over the past 30 years. Gone are the days when gasoline was 23¢ per gallon and the gas tank was filled for \$4.00. Graph 1 is plotted using data from the United States Energy Information Administration website and clearly

Graph 1: Weekly U.S. Regular All Formulations Retail Gasoline Prices



Source: http://www.eia.gov/dnav/pet/hist/LeafHandler.ashx?n=PET&s=EMM_EPMR_PTE_NUS_DPG&f=W

shows the wide price swings of gasoline.

Compared to gasoline prices worldwide, gasoline prices in the U.S. are relatively low, as shown in Table 1.

Because gasoline prices have risen, people have taken action in several ways:

- They drive less
- Car pools have formed
- Consumers are buying higher-mileage cars
- Consumers are selling big SUV and Hummers
- People are buying diesel-fueled cars (more fuel-efficient versus gasoline)
- People are looking at alternative fuels such as wood

A great historical story and some very old (and new state-of-the-art) pictures of wood-burning cars and trucks can be found at *Low-Tech* magazine at the following link: [http://www.](http://www.lowtechmagazine.com/2010/01/wood-gas-cars.html)

[lowtechmagazine.com/2010/01/wood-gas-cars.html](http://www.lowtechmagazine.com/2010/01/wood-gas-cars.html). There are hundreds of vehicles spanning over 50 years, which makes for great reading and viewing. YouTube also has a large collection of mini movies of these vehicles being started and operated.

Consider for a moment why these individuals would invest their precious time and limited money in designing and constructing these unique wood-

Table 1: Gasoline Price by Country

Country	Price in U.S. \$/Gal
Norway	9.25
Liverpool, United Kingdom	8.42
Israel	8.00
Nairobi, Kenya	6.16
Canada	5.25
Colombia	4.21
United States	4.00
Nigeria	1.85
Iran	0.33
Venezuela	0.12

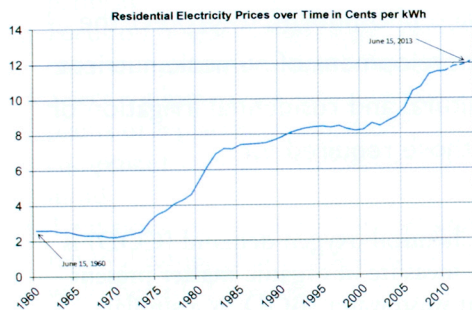
burning vehicles. They were first motivated by the high cost of gasoline, and they obviously have a passion for their craft. They are pursuing an alternative energy source for their vehicles where no commercial option exists. Furthermore, they consider the ongoing cost and price increase of gasoline to be worth the capital investment.

The average American drives 12,000 miles per year and assuming the typical automobile gets 25 miles per gallon, the annual budget for gasoline has increased from seven percent to 28 percent of ownership cost. This calculation assumes a \$20,000 automobile kept for five years with zero salvage value, maintenance at \$800 per year and insurance at \$1,500 per year.

Electricity

In the 1960s, electricity was 2¢ per kilowatt hour (kWh) and today the cost is over 12¢ for that same power. Graph 2 is plotted using data from the United States Energy Information Administration website showing the upward trend of electricity prices.

Graph 2. Residential Electricity Prices



Source: Table 8.10 Average Retail Prices of Electricity, <http://www.eia.gov/totalenergy/data/annual/txt/ptb0810.html>

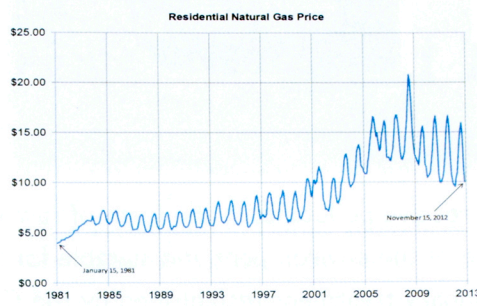
The all-electric home has now given way to other fuels. Some homes are heated with natural gas, oil or wood. Water heating can be accomplished with natural gas, heat recovery from the air conditioner or solar hot water panels. Solar hot water panels can be cost-effective not only for domestic water heating but also swimming pool heating. Installation cost can vary widely and this, along with electric cost and family size, can affect the payback.

Natural Gas

As stated, some homes are heated with natural gas and this fuel has undergone many changes. At one time Congress passed laws to limit natural gas use to residential use only because it was

believed the resource was depleting. Electric utilities had to switch to other fuels because natural gas prices continued to rise. With new technology called hydraulic fracturing, natural gas prices have fallen. Vast reserves of gas are now economically available to the point that the U.S. is seeking to export natural gas. Graph 3 is plotted using data from the United States Energy Information Administration website. The up-and-down cycle shown on the graph represents the winter heating demand and the moderate summer residential use. Winter pricing is typically higher than summer rates.

Graph 3. Residential Natural Gas Prices



Source: U.S. Price of Natural Gas Delivered to Residential Consumers <http://www.eia.gov/dnav/ng/hist/n3010us3m.htm>

Alternative Fuels

Energy and fuels are, as economists say, an elastic market. In an elastic market, if coffee prices rise people switch to tea. If sugar prices rise, consumers use honey and artificial sweeteners. In the case of gasoline, oil, natural gas and electricity some people and/or companies are able to purchase and use alternative fuels. Most of these fuels are used for heating; steam is used for process needs or high pressure steam to drive steam turbine generators.

As Georgia Tech energy professor Sam Shelton states, "There is no single silver bullet for our energy situation; however, there are 100 brass bullets and we just need to find the right match." With this in mind, the three major fuel sources of electricity, natural gas and gasoline are overlooked for some of those "100 brass bullets." Table 2 includes a short list of some of the alternative energy/fuel sources within easy reach that have a proven history of application.

Recall that fuels are sold at different prices and different measures are used such as gallon, pound, therm, ton,

Table 2. Alternative Fuel Prices

Fuel	Commonly Quoted Price	Commonly Used Units of Sale	\$/mmBTU
Animal waste	\$1.00	\$/ton	\$0.11
Biomass	\$8.00	\$/ton	\$1.00
Landfill methane gas	\$0.10	\$/therm	\$1.00
Petroleum coke	\$1.10	\$/mmBTU	\$1.10
Waste wood	\$10.00	\$/ton	\$1.11
Wood	\$12.50	\$/ton	\$1.25
Solar thermal	\$2.00	\$/mmBTU	\$2.00
Synthetic gas	\$0.25	\$/therm	\$2.50
Coal	\$80.00	\$/ton	\$3.08
Natural gas	\$0.85	\$/therm	\$8.50
#6 oil	\$1.75	\$/gallon	\$11.88
#4 oil	\$2.00	\$/gallon	\$13.84
Crude oil	\$100.00	\$/barrel	\$15.03
Sulfur	\$160.00	\$/ton	\$20.10
#2 oil	\$3.20	\$/gallon	\$24.31
Kerosene	\$3.50	\$/gallon	\$25.93
Gasoline	\$4.00	\$/gallon	\$29.79
Electricity	\$0.14	\$/kWh	\$41.02
Solar photovoltaic	\$0.27	\$/kWh	\$79.11

The calculation for \$/mmBTU is included at the end of this article.

as shown in the columns in Table 2 titled "Commonly Quoted Price" and "Commonly Used Units of Sale." The "\$/mmBTU" column provides a common basis to compare the cost of these various energy types.

The graph shown at the beginning of this article presents the data from Table 2 in a graph format, and clearly shows why alternative energy and fuel sources are gaining in popularity over traditional sources. Providing alternative fuel choices could eventually wean the U.S. from using more expensive fuels. As shown on the graph, gasoline (green bar), electricity (red bar) and solar photovoltaic electricity (orange bar) are the most expensive alternatives, but there are 16 other "brass bullets" available at a lower cost.

Steam Boiler Operating Cost

Boiler steam production and/or electrical generation is much more fuel-intensive than the automobile example given

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About the Author:



Eric Coffin, PE, graduated from the University of South Florida in 1978 with a bachelor's in mechanical engineering. He specialized in thermodynamics, fluids and process control.

He has experience in electric utility, large industrial and heavy commercial markets. Eric is employed as a senior process engineer for Jacobs Engineering in Lakeland, Florida, where he specializes in energy and financial studies for large fertilizer plants around the world. He can be reached at Eric.Coffin@Jacobs.com.