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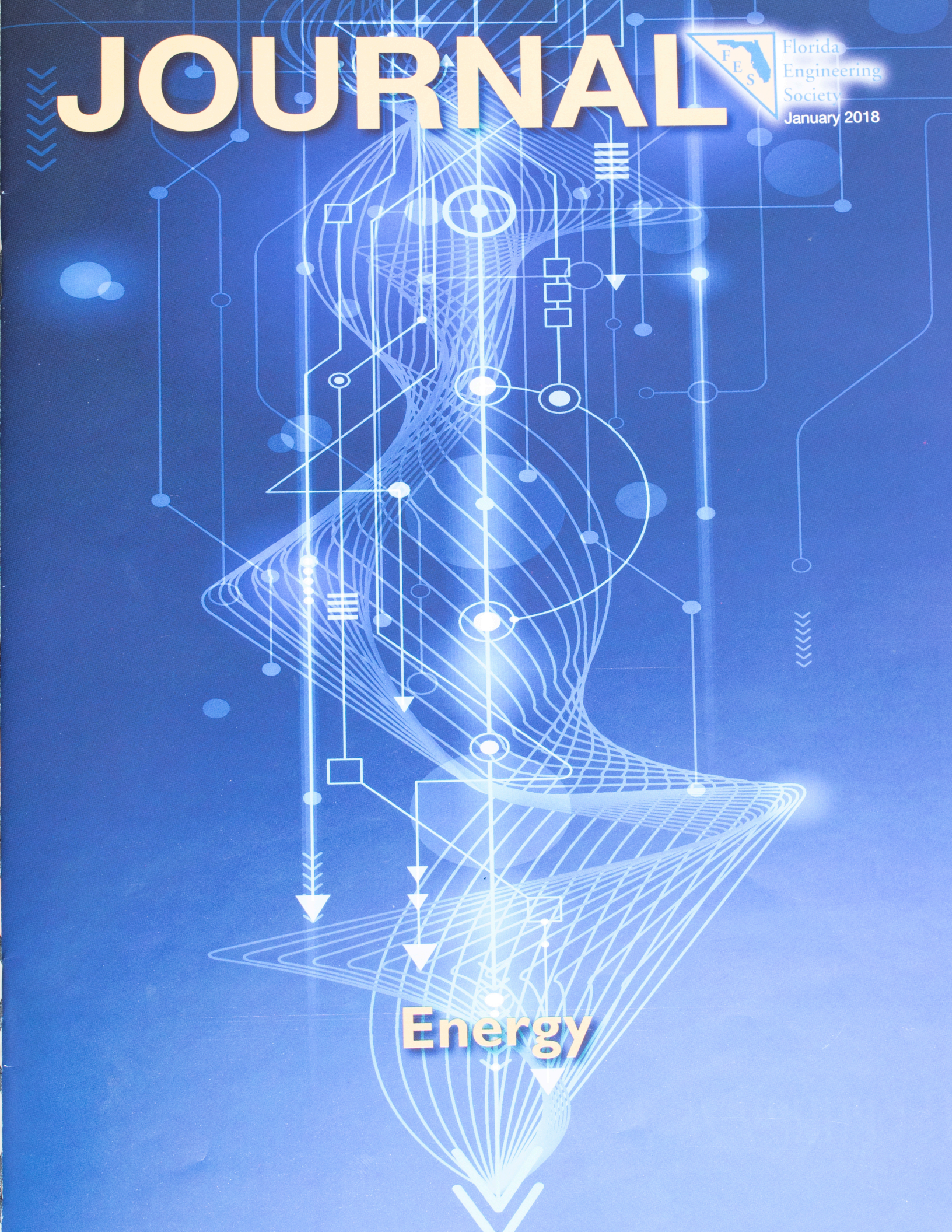
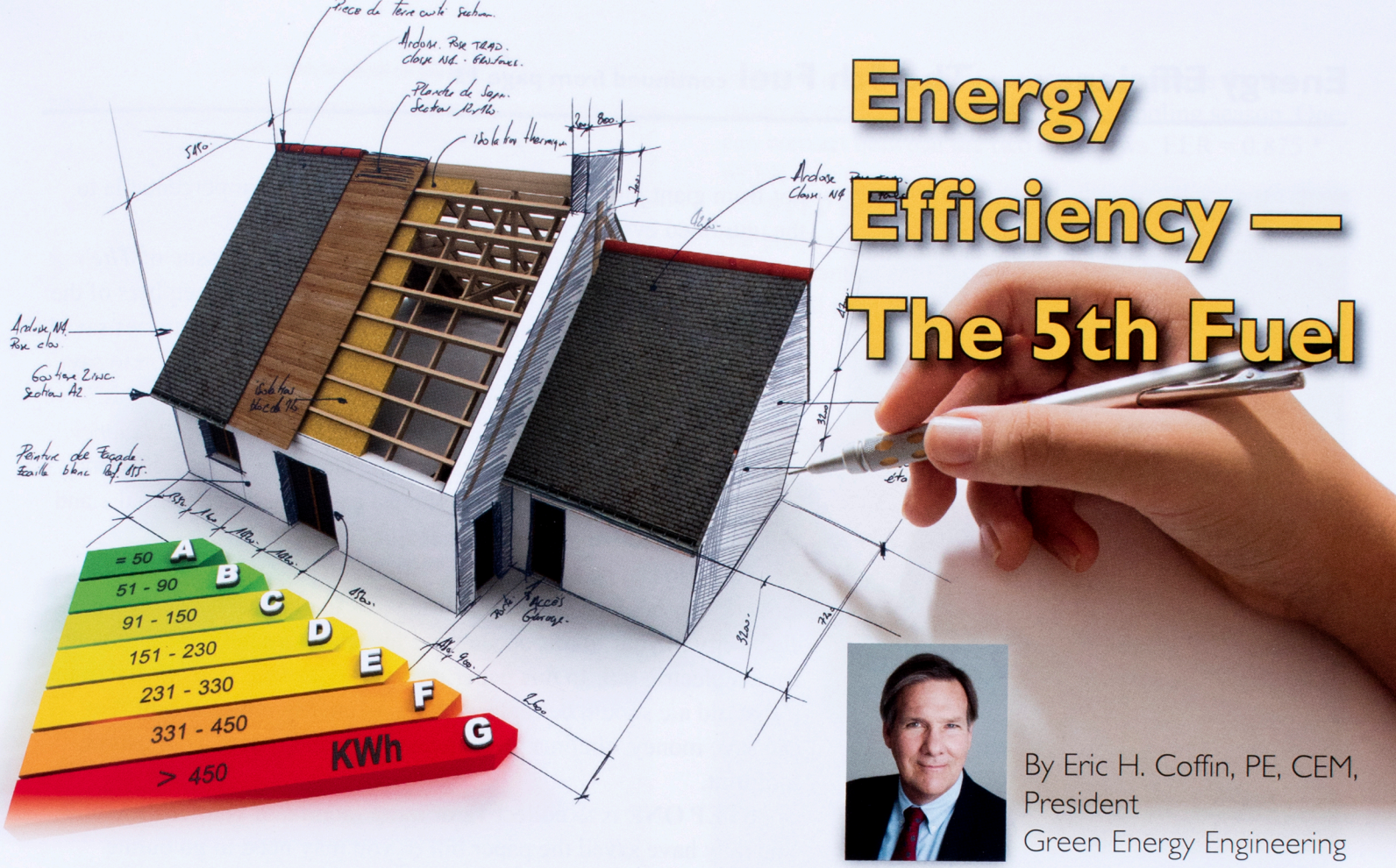


Energy

Energy Efficiency — The 5th Fuel



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President
Green Energy Engineering

First came coal, then petroleum, then nuclear, and then alternative energy. The new kid on the block (5th fuel[1]) is downstream of the electric utility and is called energy efficiency[2]. This is a large and mostly untapped method of reducing greenhouse gases, by considering the life cycle cost of energy consuming equipment and applying existing energy efficient technologies. While the initial capital cost of more efficient equipment may be higher, this is more than made up in reduced recurring fuel cost.

Consider the traveling salesperson who puts 300 hundred miles on their car each week and is buying $4 per gallon gasoline. By trading in that 13 mpg for a new 35 mpg they could save over $3,000 per year. Air conditioners also have a "mpg" and it is called Energy Efficiency Ratio (EER). It is defined as BTU per hour of enjoyed cooling divided by watts of electricity painfully purchased at an outside temperature of 95°F. This article will show how you, the payer of electric bills, can make an informed a/c purchasing decision that will yield a better rate of return than enjoyed by the famous investor Warren Buffett.

According to the article in the July 7, 2008 issue of *Forbes Magazine*, "The Case for Efficiency," there was a 46% drop in U.S. energy intensity between 1975-2005. But because these savings came

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[1]The 5th Fuel term was first coined by American physicist Amory Lovins in the mid 1980s . Dr. Lovins is co-founder, chairman, and chief scientist of the Rocky Mountain Institute, an independent, entrepreneurial, nonprofit think-and-do tank that implements transformational energy and resource efficiency, chiefly in the private sector.

[2]The term "Energy Efficiency Gap" was first coined by Eric Hirst and Marilny Brown in their 1990 paper *Closing the efficiency gap: barriers to the efficient use of energy*. Dr. Brown is a professor in the School of Public Policy at Georgia Tech and her research papers can be found https://spp.gatech.edu/people/person/91044ab3-9e96-5940-80a3-46f80924f3d1.

not from giant plants, but in zillions of tiny pieces impercentable to the untrained eye, energy efficiency gets little respect.

A similar story comes from the January 17, 2015 issue of ***The Economist*** magazine entitled "Invisible fuel." Eleven members of the International Energy Agency—the U.S. and European countries saved 1.4 billion tons of oil in 2011, worth $753 billion. They go on to say "The cheapest and cleanest energy choice of all is not to waste it."

A 2010 McKinsey & Company report entitled *Energy efficiency: A compelling global resource* states that "Globally, energy efficiency represents about 40% of the greenhouse gas reduction potential…and extremely attractive upfront investment…"

You also can be one of those "zillions of tiny pieces" by looking around your home. Your air conditioner is the largest consumer of electricity in your home, accounting for approximately[3] 65% of your annual electric bill. In this paper we will lay out the steps to determine if that old a/c should be replaced with an energy-efficient unit. You can save money, obtain a great investment, and reduce your carbon footprint.

STEP ONE is to collect 12 or more months of your electric bills. You may have saved the paper bill or you may need to go online to your local utility and retrieve them. Take note of the total kWh consumption and enter the values into a spreadsheet. Ensure that you are looking at the total kWh and not just the first step of what may be a tiered bill. Also enter the total monies paid and you will notice that there are a host of charges including customer charge, demand, energy, conservation cost recover, taxes, fees, etc. Table 1 to the left is an example for my kWh and dollars; yours should look the same. You can also divide the monthly money by the kWh to obtain the overall $/kWh which will be higher than the listed electric tariff due to all the add-on taxes.

Month	kWh	$
Jan	2,319	$373.72
Feb	1,757	$278.96
Mar	1,552	$244.40
Apr	2,529	$366.31
May	3,312	$485.07
Jun	4,353	$642.97
Jul	4,830	$715.32
Aug	5,264	$781.15
Sep	5,586	$829.99
Oct	4,741	$701.82
Nov	1,981	$283.19
Dec	2,201	$316.56
TOTALS	40,425	$6,019.46

Tabulate your annual electric bills

Table 1

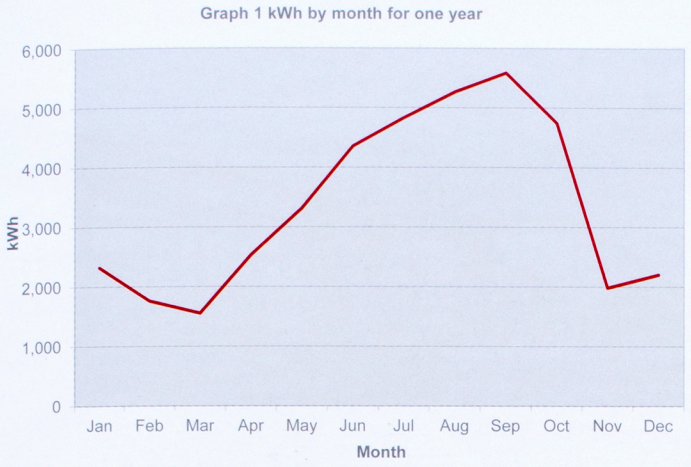
STEP TWO is to plot the data. Plot both the kWh by month and you should have a kWh curve that looks like graph 1.

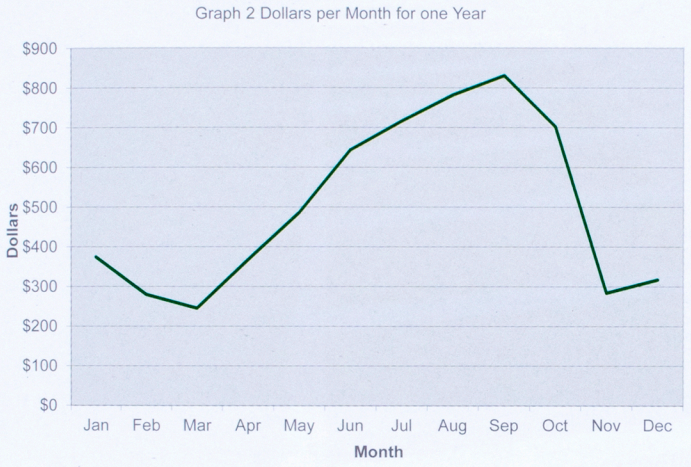
Also plot the dollar curve as shown in graph 2. We all know that the summer bill is quite large and this graphically shows the summer peak.

If you now chose the minimum value and draw a straight line across the bottom you should have a graph that looks similar to chart 3. The assumption here is that March is a mild month with no heating or air conditioning. This base load is comprised of water heater, dishwasher, refrigerator, lights, washer and dryer, etc. Note the green shaded area that represents a/c which is required for 4,000 to 6,000 hours (8,760 hours per year) per year here in Florida. Also notice the low values for Jan., Feb., and Dec. which show just how mild our winters are.

STEP THREE is to read your air conditioner name plate (see

[3]See http://michaelbluejay.com/electricity/howmuch.html for a breakdown of appliance usage.





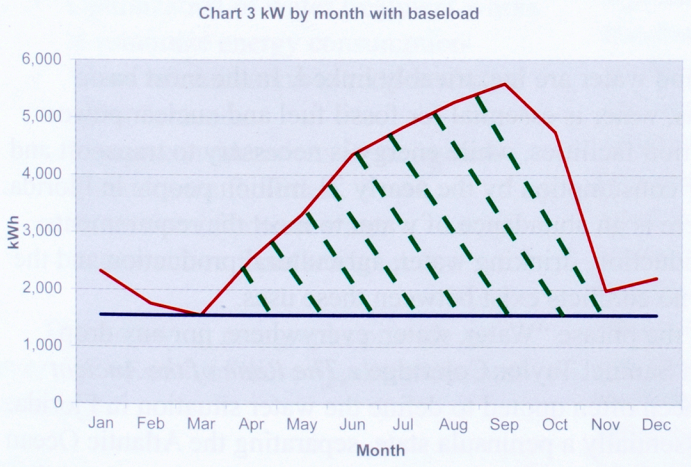


photo top right) and find the tonnage of the unit such as 3 tons or 36,000 BTU per hour. Also find the mpg or in this case the EER or SEER rating. EER is known as the energy efficiency rating and has been around for many years.

$$EER = \frac{BTU\_per\_Hour\_of\_cooling}{Watts\_of\_Electric\_Purchased}$$

At a constant outdoor condenser temperature of 95°F SEER or seasonal energy efficiency rating is similar except it uses a range of various temperatures for the outdoor condenser that makeup up a cooling season. One can convert between the two as follows. EER = 0.875 * SEER

STEP FOUR is to add together the kWh identified by the green hash marks under the kWh curve by subtracting the constant base load represented by the blue line from the actual peak load represented by the red line. Only add

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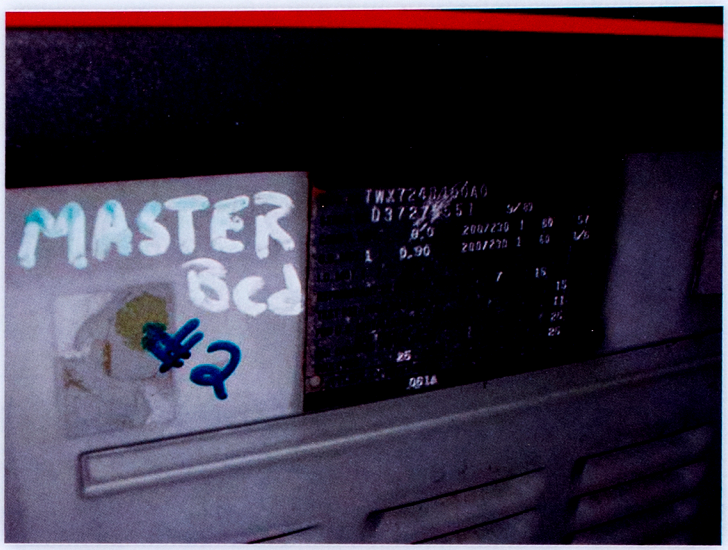
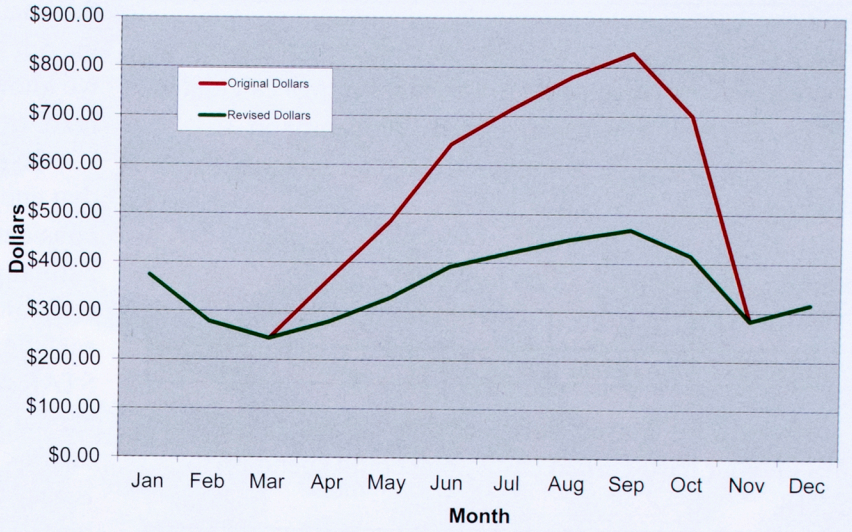


The area between the red and green curve represents the dollars saved by installing a more efficient a/c unit. These savings are the 5th fuel, aka energy efficiency that I introduced in the beginning. The homeowner enjoys the dollar savings and the electric utility burns less fuel.

Chart 4 Dollars Saved by Month = area between red & green curves



together the cooling season. This will yield the kWh consumed in the a/c season which in this case is 19,751 kWh or 19,751,000 watt hours. Some calculations are required to uncover some important information.

The wattage draw of this 3 ton example a/c unit is (12,000 BTU/ton * 3 tons) / (8 BTU/hour / watt) = 4,500 watts.

The actual hours of a/c use = 19,751,000 watt hours / 4,500 watts = 4,389 hours.

The cost for operating this example a/c unit is 19,751 kWh * $0.1612 $/kWh = $3,183.

The carbon footprint is 40,425 kWh * 1.35 #/year of CO^2/kWh = 54,574 pounds of CO^2 annually

STEP FIVE is to obtain bids and EER ratings on new units and calculate your new operating cost. This example is for a 3 ton unit with an EER of 14.

The new wattage draw is (12,000 BTU/ton * 3 tons) / (14 BTU/hour/watt) = 2,571 watts.

The new a/c consumption is 2,571 watts/1,000 watts / kW * 4,389 hours = 11,284 kWh.

The new operating cost is 2,571 watts/1000 watts/ kW) * 4,389 hours * $0.1612/kWh = $1,819.

The savings are $3,183 - $1,819 = $1,364 per year.

The original annual kWh consumption was 40,425.

The new consumption is 40,425 total – 19,751 old a/c + 11,284 new a/c = 31,958 kWh.

The new carbon footprint is 31,958 kWh * 1.35 #/ year of CO^2/kWh = 43,143 pounds of CO^2/y.

This yields a savings of 54,574 – 43,143 = 11,431 pounds of CO^2 annually.

You should construct a table as follows with the bid price and the new calculated cost and annual savings. Note that the EER of 14 has an annual savings of $1,364 (this will be used below).

New Installed Cost	$0	$2,000	$2,200	$2,400	$2,600	$2,800	$3,000
EER	8	9	10	11	12	13	14
Watts	4,500	4,000	3,600	3,273	3,000	2,769	2,571
a/c Operational Cost	$3,183	$2,829	$2,546	$2,315	$2,122	$1,959	$1,819
Savings from Existing	$0	$354	$637	$868	$1,061	$1,224	$1,364

The above calculations can be input to a spread sheet and before and after dollar curves can be created for the year, such as shown in Chart 4. The area between the red and green curve represents the dollars saved by installing a more efficient a/c unit. These savings are the 5th fuel, aka energy efficiency that I introduced in the beginning. The homeowner enjoys the dollar savings and the electric utility burns less fuel.

STEP SIX is to determine the rate of return on this investment. This can be done by using the uniform series present worth equation shown here.

$$P = A\left[\frac{(1+i)^n - 1}{i(1+i)^n}\right]$$

Where A = annual savings

P = the total installed cost (note this is the unknown we are seeking)

N = the number of years

i is the interest rate

If you program this uniform series present worth equation into your spreadsheet you can work backwards

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P	A	*i*	n	Factor
$8,381.19	$1,364.00	10.00000%	10	6.1445671

towards your allowed total installed cost or P in the above equation. For instance using the annual savings calculated above, a ten year life, and a desired 10% return on investment...one could spend up to $8,381 on a new EER 14 a/c unit.

If, however, you wanted a 15% return on your money…one could spend up to $6,845.

P	A	*i*	n	Factor
$6,845.60	$1,364.00	15.00000%	10	5.0187686

If you were Warren Buffett and would only except 20% on your hard-earned cash…one could spend up to $5,718.

P	A	*i*	n	Factor
$5,718.53	$1,364.00	20.00000%	10	4.1924721

By calculating different EER values you can create different annual savings and arrive at different total installed costs. Use this family of savings data to select the best bid and I would suggest at least three bids, (and more is better). The bids should include items such as: equipment, installation, permits, removal and proper disposal of old unit, Freon, and start-up. If required, a new air handler, duct work upgrades, thermostat, electrical wiring, circuit breaker, etc. Compare the details of the bids to ensure that you are comparing apples to apples. Some contractors will only quote equipment and a/c installation and ignore any electrical wire cost so as to avoid a high bid, and also to avoid running new wires through walls and attic.

This table below is a summary of the before and after results of upgrading to a more energy-efficient EER14 air conditioner using our typical 3 ton unit. As you can see from this summary there are impressive savings across the board and the percent savings indicate the power of the 5th fuel. For those of us in the power plant business we know that increasing boiler/steam turbine efficiency is hard, expensive and yields results of less than 1%.

To recap from the introduction we have seen that energy efficiency is the 5th fuel, as it allows for considerable reduction in the burning of oil, coal, natural gas, etc. Air conditioning is a very well-known technology and efficiency improvements are introduced each year as the government requires ever better energy STAR ratings. We have shown that the higher initial capital cost pays a better return then your bank without the risk of a stock market fall, and this short paper is easy to read compared to the hundreds of annual reports that Warren Buffett reads looking for value. This air conditioner evaluation process has allowed you, the homeowner, some insight into just what a great investment you have outside your home in those bushes.

About the Author:

Eric Coffin, PE graduated from the University of South Florida in 1978 with a BS 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 the founder and president of Green Energy Engineering in St. Petersburg, Florida where he specializes in energy and financial studies for large energy consuming plants around the world. He can be reached at EricCoffinEngineer@Gmail.com

Variable under consideration	Existing Condition	New a/c Installed	Total Savings	Percent Savings
Total annual kWh used	40,425	31,958	8,467	21%
Annual $ dollars	$6,019	$4,428	1,591	26%
EER	8	14		
Watts used in a/c	4,500	2,571	1,929	43%
kWh used in a/c	19,751	11,284	8,467	43%
Annual $ of a/c	$3,183	$1,819	1,364	43%
A/C as percentage of bill	53%	41%	12%	22%
# CO2/Yr	54,574	43,143	11,431	21%