Upgrading: Cost Comparisons of Three 1993 Appliances to 2012 Energy Star Models and Whether Switching is Economically Feasible
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Introduction

The residential sector of the United States uses the most electricity of the four (commercial, transportation, and industrial being the other three). More energy efficient appliances are put on the market every year, however, not enough households take the opportunity to reduce carbon dioxide emissions by replacing their old appliances. In addition, customers can save a significant amount of money by doing so. This paper compares the electricity usage and the upfront and electricity costs of a 1993 fridge/freezer, washing machine, and dishwasher to similar 2012 Energy Star rated models, while calculating the reductions in carbon dioxide emissions due to these purchases. All calculations use estimations and rounded numbers.

I. General Background Information on U.S. Energy and Electricity

In 2010, the United States used 98 quadrillion (98,000 trillion) British Thermal Units (BTU) of energy. This has increased by nearly 100 times since 1950, as the U.S. used only about 34.6 quadrillion BTU.

Of this energy, 3.9 trillion kilowatt-hours (kWh) of electricity were generated for use. Both the energy and electricity come from a variety of sources (see Figure 1). This energy and electricity use caused the U.S. to emit more than 5.6 billion metric tons of carbon dioxide (CO$_2$), a harmful greenhouse gas, into the atmosphere in 2010. In 1990, this value was much less.

a. Coal

Coal is one of the three fuels that are considered fossil fuels. Overall, coal accounts for 21% of the United States’ energy consumption. About

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1 “Electricity in the United States.”
2 “What are the major sources and users of energy in the United States?.”
3 “Annual Energy Review.”
4 “EIA reports a 3.9-percent increase in U.S. energy-related carbon dioxide emissions in 2010.”
6 “What is the role of coal in the United States?.”
45% of the electricity produced in the United States is generated by coal, and coal accounted for 37% of the U.S. carbon dioxide emissions in 2010.

b. Natural Gas

Some forms of natural gas are also fossil fuels. Natural gas makes up 25% of U.S. energy consumption and about 23% of the U.S. carbon dioxide emissions. 24% of the electricity produced in the United States came from natural gas in 2010 (see Figure 1).

c. Nuclear Power

Nuclear accounts for 8% of the United States’ energy consumption and made up 20% of the electricity generation in 2010. Nuclear power does not have comparable emissions of carbon dioxide while the plant is operating, however, it does present the problem of finding safe places to store hazardous radioactive waste.

d. Petroleum

Petroleum is the third fossil fuel. Petroleum makes up 37% of the U.S. energy production, most of which is consumed by the transportation sector. Only 1% of the United States’ electricity comes from petroleum (see Figure 1). Despite this small percentage of electricity generation, petroleum has the largest percentage of carbon dioxide emissions, at 42%.

e. Renewable Sources

Only 8% of U.S. energy is generated by renewable sources (hydropower, geothermal, solar/PV, biomass, wood, wind and biofuels such as ethanol). Of this 8%, in 2010, solar made up 1% of the total U.S. energy consumption, geothermal 3%, biomass waste 6%, wind 11%, biofuels 23%, wood 25%, and hydropower 31%. This overall percentage is increased to 10% when looking at electricity generation from renewable sources. In 2010, hydroelectric made up 60% of the renewable electricity generation, wind 22%, biomass wood 9%, biomass waste 4%, geothermal 4%, and solar less than 1% (see Figure 1). The two main reasons renewable energy is not more widely used are that the plants have larger start up costs and operation costs than coal and natural gas plants. In addition, the resources are not often in the large metropolitan areas that need the most energy, and putting up power lines increases the cost.

II. Additional Information on Electricity

Electricity generated goes to four main sectors; residential, commercial, industrial, and transportation. The residential sector uses the most electricity, and in 2011, it used 38% of what is generated, the commercial sector used 35%, the industrial sector used 26%, and transportation...
used 0.2%. These percentages correspond to 1,424 billion kilowatt hours used in the residential sector, 1,320 billion kilowatt hours used in commercial, 971 billion kilowatt hours used in industrial, and 8 billion kilowatt hours used in transportation.\textsuperscript{12} This total usage was more than 13 times greater than the electricity use in 1950.\textsuperscript{13} The average price of electricity in the United States in 2010 was $0.0988 per kilowatt hour, however, each sector has separate prices. The average price of electricity for the residential sector in 2010 was $0.116/kWh, $0.103/kWh for the commercial sector, and $0.068/kWh for the industrial sector.\textsuperscript{14}

Electricity in the home goes to various appliances and gadgets (see Figures 2 and 3). An average household in 2010 used 11,496 kWh per year, or 958 kWh per month.\textsuperscript{15} According to Calculation 1, with an average price of $0.116/kWh, this usage costs about $1,334 per year.

\textit{Calculation 1:} Cost of Electricity per Year, per Household

\[
\frac{11,496 \text{ kWh}}{\text{yr}} \times \frac{0.116}{\text{kWh}} = \frac{1,334}{\text{yr}}
\]

Figure 3 illustrates some of the gadgets used in the home, and their respective electricity use.

\textit{Figure 3: Gadget Use in the Home}\textsuperscript{16}

<table>
<thead>
<tr>
<th>Gadget</th>
<th>Power Consumption (kW)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>on and active</td>
</tr>
<tr>
<td>computer and peripherals:</td>
<td></td>
</tr>
<tr>
<td>computer box</td>
<td>0.08</td>
</tr>
<tr>
<td>cathode-ray display</td>
<td>0.11</td>
</tr>
<tr>
<td>LCD display</td>
<td>0.034</td>
</tr>
<tr>
<td>projector</td>
<td>0.15</td>
</tr>
<tr>
<td>laser printer</td>
<td>0.5</td>
</tr>
<tr>
<td>wireless &amp; cable modem</td>
<td>0.009</td>
</tr>
<tr>
<td>laptop computer</td>
<td>0.016</td>
</tr>
<tr>
<td>portable CD player</td>
<td>0.002</td>
</tr>
</tbody>
</table>

\textsuperscript{12} “Electricity in the United States.”
\textsuperscript{13} “Use of Electricity.”
\textsuperscript{14} “Factors Affecting Electricity Prices.”
\textsuperscript{15} “How much electricity does an American home use?.”
Figure 4 displays larger appliance use in the home, with different metrics.

<table>
<thead>
<tr>
<th>Appliance/metric</th>
<th>Consumption (kWh)</th>
</tr>
</thead>
<tbody>
<tr>
<td>bedside clock-radio</td>
<td>0.0011 0.001</td>
</tr>
<tr>
<td>digital radio</td>
<td>0.0091 0.003</td>
</tr>
<tr>
<td>radio cassette-player</td>
<td>0.003 0.0012 0.0012</td>
</tr>
<tr>
<td>stereo amplifier</td>
<td>0.006 0.006</td>
</tr>
<tr>
<td>stereo amplifier II</td>
<td>0.013</td>
</tr>
<tr>
<td>home cinema sound</td>
<td>0.007 0.007 0.004</td>
</tr>
<tr>
<td>DVD player II</td>
<td>0.012 0.01 0.005</td>
</tr>
<tr>
<td>TV</td>
<td>0.1</td>
</tr>
<tr>
<td>video recorder</td>
<td>0.013 0.001</td>
</tr>
<tr>
<td>digital TV set up box</td>
<td>0.006 0.005</td>
</tr>
<tr>
<td>clock on microwave</td>
<td>0.002</td>
</tr>
<tr>
<td>Xbox</td>
<td>0.16 0.0024</td>
</tr>
<tr>
<td>Sony Playstation 3</td>
<td>0.19 0.002</td>
</tr>
<tr>
<td>Nintendo Wii</td>
<td>0.018 0.002</td>
</tr>
<tr>
<td>Answering machine</td>
<td>0.002</td>
</tr>
<tr>
<td>cordless phone</td>
<td>0.0017</td>
</tr>
<tr>
<td>cell phone charger</td>
<td>0.005 0.0005</td>
</tr>
</tbody>
</table>

This gives a general idea of the usage of larger appliances, however, within each category, every design uses a different amount of electricity.

III. Research on Electricity and Economic Savings of Appliances

Many people have used Kill-A-Watt meters to measure how much electricity their appliances are using, and some have even gone far enough to record and compare the usage of an old appliance and a newer, more energy efficient appliance. One family estimated that they would save $90 per year by replacing their old refrigerator with a more energy efficient one, while another found that their new 2010 Energy Star refrigerator used about 84% fewer kilowatt hours per year than their 1990 model. Several websites, including www.energystar.gov provide energy calculators for customers to see how much they could save by purchasing a new model.

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17 kWh Usage.
18 The Geoexchange.
19 Fowler, Tim J.
IV. Electricity and Cost Comparisons of Refrigerator/Freezers

This year, about 99.5% of U.S. households have refrigerators\(^{20}\) (most including attached freezers), and 26% have two or more.\(^{21}\) In 1993, these numbers were similar, with about 99.9% of households having a fridge/freezer, and about 15% having two or more.\(^{22}\) This section uses the costs of a 1993 Kenmore 20 cubic foot refrigerator and a 2012 Energy Star qualified Frigidaire 20.6 cubic foot refrigerator, both from Sears, with a freezer on top and an installed icemaker.

a. Upfront Cost

A common cost of a refrigerator of this type in 1993 was about $700.\(^{23}\) To adjust for inflation, the nominal price of $700 needs to be divided by the annual deflator and then multiplied by 100. Calculation 2 shows that adjusted for inflation with a 2010 base (deflator of 117.3),\(^{24}\) this amounts to about $600.

\[
\text{Calculation 2: Price Deflation of 1993 Refrigerator/Freezer (method used for all price deflations)}
\]
\[
\frac{700}{117.3} \times 100 \approx 600
\]

A common cost of the 2012 refrigerator with the specific characteristics detailed above is $1,130,\(^{25}\) and adjusted for inflation with a 2010 base, amounts to about $960. Utility companies may give customers a rebate if they purchase Energy Star appliances and an additional rebate if they recycle their old appliance. These rebates vary widely, from $220 in Miami, Florida to $50 in Reno, Nevada.\(^{26}\) Using Southern California Edison’s rates, the rebates can amount to $85.\(^{27}\) Converting this value to a base 2010 value, it becomes about $80. Subtracting this from the upfront cost of the 2012 fridge/freezer, it becomes $880.

Both the 1993 and 2012 real (inflation-adjusted) costs need to be amortized over their lifetimes. Since the average lifetime of a refrigerator/freezer, both from around 1993 and 2012, is 14-17 years,\(^{28}\) Calculations 3 and 4 use lifetimes of 15.5 years. Formula 1 describes the variable annual cost to amortize the appliances, where VAC is the variable annual cost, FC is the cost being amortized, \(r\) is the discount rate, and \(n\) is the number of years over which the product is being amortized.

\[
\text{Formula 1: Variable Annual Cost}
\]

\(^{20}\) wiseGEEK.
\(^{21}\) Koch, Wendy.
\(^{22}\) “Table 3.16a. Appliances by Census Region and Climate Zone, Million U.S. Households, 1993.”
\(^{23}\) Sears, Roebuck & Co..
\(^{24}\) “Producer Price Indexes.”
\(^{25}\) Sears. (Refrigerators)
\(^{26}\) Sears. (Frigidaire)
\(^{27}\) ibid
\(^{28}\) RepairClinic.
Calculations 3 and 4 use discount rates of 8%, and show that the amortized upfront cost of the 1993 fridge/freezer is about $70 per year, and $100 per year for the 2012 fridge/freezer.

Calculation 3: Amortized Cost of 1993 Fridge/Freezer

\[
\frac{600 (1 + 0.08)^{15.5} (0.08)}{(1 + 0.08)^{15.5} - 1} \approx \frac{70}{yr}
\]

Calculation 4: Amortized Cost of 2012 Fridge/Freezer

\[
\frac{880 (1 + 0.08)^{15.5} (0.08)}{(1 + 0.08)^{15.5} - 1} \approx \frac{100}{yr}
\]

From these calculations, the 2012 fridge/freezer has a $30 larger upfront cost.

b. Cost of Electricity

The estimated annual energy cost of a refrigerator in 1993 was $57, using an average of $0.0825/kWh. Going backwards to find the annual kilowatt hour usage, Calculation 5 shows that the 1993 fridge/freezer used about 690 kWh per year.

Calculation 5: Annual Kilowatt Hour Usage of 1993 Fridge/Freezer

\[
\frac{57}{yr} \div \frac{0.0825}{kWh} \approx \frac{690}{kWh} \approx \frac{690}{yr}
\]

Assuming the customer is currently using the 1993 fridge/freezer, the annual cost needs to be recalculated using the current average cost of electricity. Calculation 6 illustrates that the 1993 fridge/freezer will cost about $80 per year to operate.

Calculation 6: Recalculated Annual Price of Electricity of 1993 Fridge/Freezer

\[
\frac{690}{kWh} \times \frac{0.116}{kWh} \approx \frac{80}{yr}
\]

The average usage of the 2012 fridge/freezer is about 360 kWh per year, which is about 50% of what the 1993 model uses, or 334 kWh fewer. Calculation 7 shows that with an average residential electricity price of $0.116/kWh, the cost of electricity will be about $40 per year for the 2012 model.

Calculation 7: Annual Price of Electricity of 2012 Fridge/Freezer

\[
\frac{360}{kWh} \times \frac{0.116}{kWh} \approx \frac{40}{yr}
\]

---

29 Sears, Roebuck & Co.
30 “SCE Energy Star Qualified Refrigerators - Product list.”
These two annual electricity costs need to be inflation-adjusted as well, so using the same method as before, this time with a deflation value of 154.7, the $80 per year for the 1993 model becomes about $50 per year, and the $40 per year becomes $25 per year for electricity for the 2012 model. With these calculations, annual electricity for the 2012 fridge/freezer costs about $25 less than the 1993 model.

c. Carbon Dioxide Emissions

In southern California, with the utility Southern California Edison, about 680 pounds of carbon dioxide are emitted for every megawatt hour (MWh) of electricity used or about 0.68 pounds are produced per kilowatt hour. Because buying the 2012 Energy Star refrigerator uses about 330 fewer kilowatt hours per year, Calculation 8 shows that this translates to a reduction in carbon dioxide emissions of about 230 pounds per year.

\[
\text{Calculation 8: Carbon Dioxide Emission Reduction} \\
\frac{0.68\text{lbs}}{\text{kWh}} \times \frac{330\text{kWh}}{\text{yr}} \approx \frac{230\text{lbs}}{\text{yr}}
\]

d. Total Costs of Fridge/Freezers

Calculation 9 shows that the 1993 fridge/freezer total costs (upfront and annual electricity costs) amounts to about $110 per year. Calculation 10 shows that the 2012 fridge/freezer total costs amount to about $125 per year.

\[
\text{Calculation 9: Total Annual Cost of 1993 Fridge/Freezer} \\
\frac{\$70}{\text{yr}} + \frac{\$50}{\text{yr}} = \frac{\$120}{\text{yr}}
\]

\[
\text{Calculation 10: Total Annual Cost of 2012 Fridge/Freezer} \\
\frac{\$100}{\text{yr}} + \frac{\$25}{\text{yr}} = \frac{\$125}{\text{yr}}
\]

With these comparisons, the 2012 Energy Star refrigerator/freezer only costs $5 more per year than the 1993 model.

V. Electricity and Cost Comparisons of Washing Machines

In 1993, about 77% of households had a washing machine, and in 2009, about 82% of households had a washing machine. This section compares a 1993 Whirlpool top-loading, 3 cubic foot capacity washing machine to a 2012, Energy Star qualified, Frigidaire Affinity 3.3 cubic foot capacity front-load washer, both from Sears.

\[31\text{“Producer Price Indexes.”}\]
\[32\text{“How Does the Electricity I Use Compare to the National Average?”}\]
\[33\text{“Table 3.16a. Appliances by Census Region and Climate Zone, Million U.S. Households, 1993.”}\]
\[34\text{“Super Efficient Home Appliances Initiative.”}\]
a. Upfront Cost

A common price for a 1993 washing machine with these characteristics was $460,\(^{35}\) and adjusted for inflation to a 2010 base, amounts to about $390. An average price of a 2012 washing machine with these specifications is $790,\(^{36}\) and adjusted for inflation becomes about $670. Many utility companies offer rebates for customers who buy Energy Star qualified washing machines, and using Southern California Edison’s rebate, customers can save $85.\(^{37}\) Adjusting this for inflation with a 2010 base amounts to about $80, so the cost of a 2012 washer is reduced to about $590. Both of these upfront costs need to be amortized over the washing machines’ lifetime. An average lifetime of a washing machine is 10 years.\(^{38}\) Calculations 11 and 12 use Formula 1 and a discount rate of 8% to illustrate that the 1993 washing machine will cost about $60 per year and the 2012 washing machine will cost about $90 per year.

**Calculation 11:** Amortized Cost of 1993 Washing Machine

\[
\frac{390 (1 + 0.08)^{10} (0.08)}{(1 + 0.08)^{10} - 1} \approx \frac{60}{yr}
\]

**Calculation 12:** Amortized Cost of 2012 Washing Machine

\[
\frac{590 (1 + 0.08)^{10} (0.08)}{(1 + 0.08)^{10} - 1} \approx \frac{90}{yr}
\]

According to these calculations, a 2012 Energy Star washing machine will cost about $30 more per year in upfront costs than a 1993 washing machine.

b. Cost of Electricity

A 1993 washing machine uses about 2.6 kWh per load,\(^{39}\) and a 2012 washing machine uses about 130 kWh per year.\(^{40}\) An average American household does about 400 loads of laundry every year,\(^{41}\) so as Calculation 13 shows, a 1993 washing machine will use about 1040 kWh per year, or 910 kWh per year more than the 2012 model.

**Calculation 13:** Electricity Usage of a 1993 Washing Machine

\[
\frac{2.6kWh}{load} \times \frac{400loads}{yr} \approx \frac{1040kWh}{yr}
\]

With an average electricity cost of $0.116/kWh, Calculations 14 and 15 show that running a 1993 washing machine will cost $120 per year and only $15 per year for a 2012 model, in 2012 dollars.

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\(^{35}\) Sears, Roebuck & Co..

\(^{36}\) Sears. (Washers)

\(^{37}\) Sears. (Frigidaire Washer)

\(^{38}\) National Association of Home Builders.

\(^{39}\) “COST ESTIMATES FOR USING ELECTRIC AND GAS APPLIANCES.”

\(^{40}\) Sears. (Kenmore Washer)

\(^{41}\) California Energy Commission.
Calculation 14: Annual Cost of Electricity of a 1993 Washing Machine

\[
\frac{1040 \text{kWh}}{\text{yr}} \times \frac{0.116 \text{ $/kWh}}{} \approx \frac{120 \text{ $/yr}}{}
\]

Calculation 15: Annual Cost of Electricity of a 2012 Washing Machine

\[
\frac{130 \text{kWh}}{\text{yr}} \times \frac{0.116 \text{ $/kWh}}{} \approx \frac{15 \text{ $/yr}}{}
\]

These costs need to be adjusted for inflation to be consistent with the other calculations. With a 2010 base, the $120 per year for the 1993 washing machine becomes about $80 per year and the $15 per year for the 2012 model becomes about $10 per year. By purchasing a 2012 Energy Star qualified washing machine with the specified characteristics, customers can save about $70 per year.

c. Carbon Dioxide Emissions

Using the fact that about 0.68 pounds of carbon dioxide are emitted for every kilowatt hour of electricity used, Calculation 16 illustrates that since a 2012 washing machine uses about 910 kilowatt hours fewer than a 1993 model, carbon dioxide emissions are reduced by about 620 pounds per year.

Calculation 16: Carbon Dioxide Emission Reductions from Washing Machines

\[
\frac{0.68 \text{lbs}}{\text{kWh}} \times \frac{910 \text{kWh}}{\text{yr}} \approx \frac{620 \text{lbs}}{\text{yr}}
\]

d. Total Cost

According to Calculations 17 and 18, a washing machine from 1993 will cost about $180 per year to operate, and a washing machine from 2012 will cost about $105 per year to operate.

Calculation 17: Total Cost of 1993 Washing Machine

\[
\frac{60 \text{ $/yr}}{} + \frac{120 \text{ $/yr}}{} = \frac{180 \text{ $/yr}}{}
\]

Calculation 18: Total Cost of 2012 Washing Machine

\[
\frac{90 \text{ $/yr}}{} + \frac{15 \text{ $/yr}}{} = \frac{105 \text{ $/yr}}{}
\]

According to these calculations, buying a 2012 Energy Star washing machine to replace a 1993 model can save customers about $75 per year.

\[42\] “How Does the Electricity I Use Compare to the National Average?.”
VI. Electricity and Cost Comparisons of Dishwashers

In 1993, about 45% of United States households had a dishwasher,\textsuperscript{43} and by 2009, this grew to about 63%.\textsuperscript{44} This section compares a 1993 Kenmore dishwasher to a 2012 Energy Star qualified Bosch model, both built-in, 24 inch installation width from Sears.

a. Upfront Cost

A common upfront cost of a 1993 dishwasher with these characteristics is about $490,\textsuperscript{45} and adjusted for inflation to a 2010 base amounts to about $420. A 2012 Energy Star dishwasher has an average cost of about $550, and adjusted to 2010 dollars becomes about $470. Calculations 19 and 20 amortize these costs with an 8% discount rate over 10.5 years, as the average lifetime of a dishwasher is 9-12 years.\textsuperscript{46}

\textit{Calculation 19: Amortized Cost of 1993 Dishwasher}

\[
\frac{420 (1 + 0.08)^{10.5} (0.08)}{(1 + 0.08)^{10.5} - 1} \approx \frac{60}{yr}
\]

\textit{Calculation 20: Amortized Cost of 2012 Dishwasher}

\[
\frac{470 (1 + 0.08)^{10.5} (0.08)}{(1 + 0.08)^{10.5} - 1} \approx \frac{70}{yr}
\]

From these calculations, a 1993 dishwasher will cost about $60 per year over its lifetime, and the 2012 dishwasher will cost about $70 per year over its lifetime; a 2012 Energy Star dishwasher is only $10 more per year in the upfront cost.

b. Cost of Electricity

The estimated annual cost of running a 1993 dishwasher is $75 with an electricity cost of $0.0825 per kilowatt hour, in 1993 dollars.\textsuperscript{47} Calculation 21 demonstrates that these costs account for the 1993 dishwasher using about 910 kWh per year.

\textit{Calculation 21: Annual Kilowatt Hour Usage of 1993 Dishwasher}

\[
\frac{75}{yr} \div \frac{0.0825}{kWh} \approx \frac{910}{kWh yr}
\]

\textsuperscript{43}“Table 3.16a. Appliances by Census Region and Climate Zone, Million U.S. Households, 1993.”
\textsuperscript{45}Sears, Roebuck & Co..
\textsuperscript{46}“Dishwashers.”
\textsuperscript{47}Sears, Roebuck & Co.
The annual cost can now be recalculated using the 2010 average electricity price, assuming that the dishwasher is currently being used. Calculation 22 shows that this annual cost amounts to about $105.

Calculation 22: Recalculated Annual Electricity Cost of 1993 Dishwasher

\[
\frac{910 \text{ kWh}}{\text{yr}} \times \frac{0.116 \text{ $/kWh}}{} \approx \frac{105 \text{ $/yr}}{} 
\]

A 2012 Energy Star dishwasher uses about 280 kWh per year.\(^{48}\) Calculation 23 illustrates that with an average cost of $0.116 per kilowatt hour, running a 2012 dishwasher will cost about $30 per year.

Calculation 23: Annual Cost of Electricity for 2012 Dishwasher

\[
\frac{280 \text{ kWh}}{\text{yr}} \times \frac{0.116 \text{ $/kWh}}{} \approx \frac{30 \text{ $/yr}}{} 
\]

Both of these annual electricity costs need to be adjusted for inflation to a 2010 base. Using the method used in the electricity inflation-adjusting calculations, the $105 per year for the 1993 dishwasher becomes about $70 and the $30 per year becomes about $20 per year for the 2012 dishwasher. With this, purchasing electricity for the 2012 model instead of the 1993 dishwasher will save the customer about $50 per year.

c. Carbon Dioxide Emissions

Section b. indirectly provides the fact that the 2012 dishwasher will use 630 fewer kilowatt hours than the 1993 model. Assuming that 0.68 pounds of carbon dioxide are emitted for every kilowatt hour of electricity used, Calculation 24 illustrates that about 430 fewer pounds of carbon dioxide will enter the atmosphere if a 2012 dishwasher is in use instead of a 1993 model.

Calculation 24: Carbon Dioxide Emission Reduction

\[
\frac{0.68 \text{ lb}}{\text{kWh}} \times \frac{630 \text{kWh}}{\text{yr}} \approx \frac{430 \text{ lbs}}{\text{yr}} 
\]

d. Total Costs

Calculations 25 and 26 show that operating a 2012 Energy Star dishwasher will cost about $90 per year, and running a 1993 dishwasher will cost about $130 per year.

Calculation 25: Total Cost of 2012 Dishwasher

\[
\frac{70 \text{ $/yr}}{} + \frac{20 \text{ $/yr}}{} = \frac{90 \text{ $/yr}}{} 
\]

Calculation 26: Total Cost of 1993 Dishwasher

\[
\frac{60 \text{ $/yr}}{} + \frac{70 \text{ $/yr}}{} = \frac{130 \text{ $/yr}}{} 
\]

\(^{48}\) Sears. (Bosch Dishwasher)
According to these calculations, customers will save about $40 per year by using a 2012 Energy Star dishwasher with the specified characteristics instead of a 1993 model.

VII. Cost of Purchasing All Three Appliances

By replacing their 1993 fridge/freezer, washing machine, and dishwasher with 2012 Energy Star rated models of similar characteristics, customers can save about $110 per year, as illustrated in Calculation 29. Calculations 28 and 29 show the total costs of the 1993 models and the 2012 models, respectively.

Calculation 27: Sum of the Total Costs of All Three 1993 Appliances
\[
\frac{120}{\text{yr}} + \frac{180}{\text{yr}} + \frac{130}{\text{yr}} = \frac{430}{\text{yr}}
\]

Calculation 28: Sum of the Total Costs of All Three 2012 Appliances
\[
\frac{125}{\text{yr}} + \frac{105}{\text{yr}} + \frac{90}{\text{yr}} = \frac{320}{\text{yr}}
\]

Calculation 29: Savings From All Three Appliances
\[
\frac{430}{\text{yr}} - \frac{320}{\text{yr}} = \frac{110}{\text{yr}}
\]

In addition, by purchasing all three appliances, customers can reduce carbon dioxide emissions by about 1,280 pounds per year, as illustrated by Calculation 30.

Calculation 30: Carbon Dioxide Emissions Reduction
\[
\frac{230\text{lbs}}{\text{yr}} + \frac{620\text{lbs}}{\text{yr}} + \frac{430\text{lbs}}{\text{yr}} = \frac{1,280\text{lbs}}{\text{yr}}
\]

VIII. Future Work to Be Done

In the future, this paper could be altered to include a cost of carbon emissions for each appliance. This may be possible if the government or utilities begin to charge more for electricity use if the appliances use over a certain amount. Utilities including Southern California Edison currently have a tiered system; as the electricity usage increases, so does the price. This brings up another potential improvement to the paper; customers could tailor it to meet their specific needs. They can directly compare their current appliance to the model that is more energy efficient and use their local electricity rate, and tiered rate if applicable, to compare the costs of each. Because every calculation is a rough estimate, including tax, shipping costs and local rebates would alter the overall costs, and change the outcome of each section. This paper could also include more appliances, lights, or gadgets in the home.
Bibliography


http://www.consumerenergycenter.org/home/appliances/washers.html


<http://www.eia.gov/energyexplained/index.cfm?page=electricity_in_the_united_states#tab2>.


http://www.epa.gov/cleanenergy/energy-and-you/how-clean.html


