GREEN IMPROVEMENTS: A CONSUMER'S GUIDE TO ENVIRONMENTALLY AND ECONOMICALLY RESPONSIBLE HOME REPAIRS AND IMPROVEMENTS FOR THE NORTH CENTRAL TEXAS REGION

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The *Consumer's Guide* is designed to help consumers by providing guidelines for the purchase of specific energy-efficient household appliances- water heaters, air conditioning and heating systems, windows, dishwashers, refrigerators, clothes washers, and dryers. This serves two major purposes: to decrease the environmental impact of those products and to save consumers money over the lifetime of the products.

The seven major appliances covered in this work are things that consumers tend to purchase quickly when their older models wear out and with little research into their energy and/or water efficiency. The guide begins with a general introduction and an explanation of the need for energy conservation. Explanations of how they work, purchasing tips, installation tips, maintenance tips, tips for additional energy efficiency, and case studies are given for each appliance. Printable pamphlets are included at the end.

TABLE OF CONTENTS

PART I

Purpose

Purchasing replacement appliances, such as hot water heaters or air conditioners, for the home can be somewhat overwhelming, especially for the first time consumer. There are a lot of choices from which to pick and making such important decisions can be a daunting task. New models with more options turn up regularly, and sometimes there are options other than the obvious ones.

Furthermore, many major household items are purchased quickly and with very little research. This situation occurs, perhaps, when a home's air conditioner goes out in the middle of a hot Texas July and replacing the air conditioner as quickly and cheaply as possible becomes the main priority. At times like this, energy and environmental considerations are not generally the priorities.

The intent of my research and subsequent thesis was to do that research before it is needed rather than waiting until a point where there is no time for in-depth investigation. The final objective of my research was to produce a guide for average consumers like myself that will aid us in making quick decisions on major purchases that are economical as well as energy and water efficient, and as a result, less environmentally costly. I gathered the research and then compiled the information in a consumer-friendly format which is *Green Improvements: A Consumer's Guide to Environmentally & Economically Responsible Home Repairs and Improvements for the North Central Texas Region.* The *Guide* is designed to help homeowners make quick, yet effective, purchases of certain major household appliances. It gives them easy ways to compare costs versus energy and/or water efficiency for various products.

Beyond providing information for purchasing new appliances, the *Guide* attempts to educate consumers. It includes basic overviews on how different products work so that homeowners gain some basic background knowledge that may aid them in asking educated questions and making educated decisions. Additionally, since home energy efficiency does not end simply with the purchase of a new appliance, the *Guide* also provides tips on installation and maintenance of those appliances as well as tips for other things that can be done around a home to supplement the use of a high-efficiency product.

Moreover, the information given is, in a sense, generic in that it does not limit itself to details that would not allow for personal preferences. Rather, the suggestions given in the *Guide* are broader in scope. For example, it contains advice on purchasing new windows, but does not limit the consumer to specific brands, models, styles, colors, size, or the like.

Finally, the Guide is geared specifically towards homeowners in the North Central Texas area. This is because conditions are different in different geographic regions and therefore homes in various locations may have different requirements. What is most efficient in other parts of the country is not necessarily what is most efficient in this part, and vice versa.

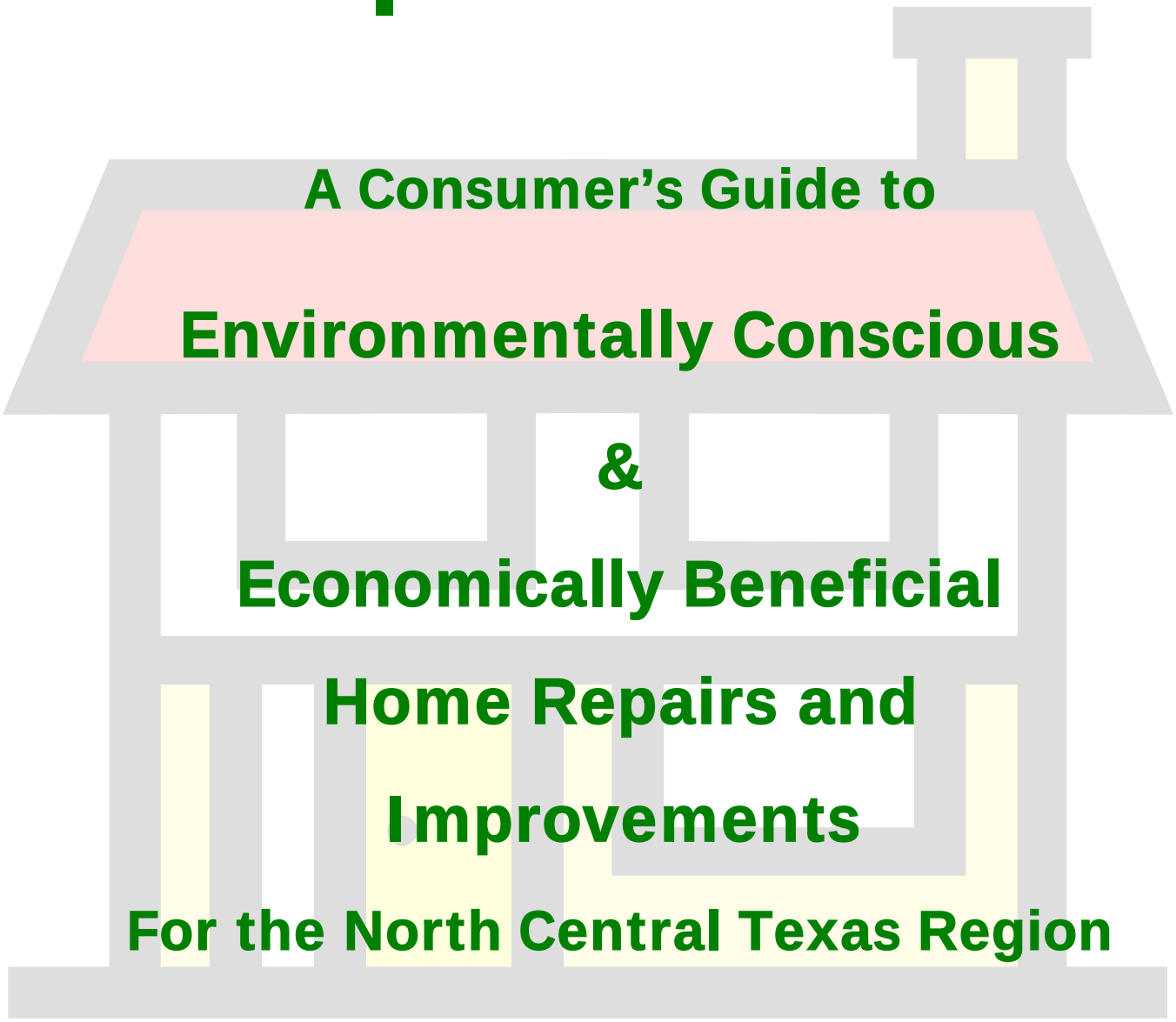
Preface

In 1999, I bought my first home. The house was built in the 1960s, and true to the nature of older homes, requires frequent repairs and upgrades. A year after I moved in, for example, my central air conditioning unit went out. As a conservationist, I wanted to choose a new air conditioner model that had the least environmental impact. As a single homeowner on a teacher's salary, however, I wanted the cheapest model. A year later, I was faced with another difficult decision when my hot water heater flooded my garage. I wanted my new heater to be energy efficient and cheap at the same time. In both cases, I had to make major purchasing decisions in a relatively short amount of time.

Through my research, I found that, in most cases, energy and/or water efficient products cost more initially, but pay for themselves in energy savings over time. The *Guide* should give homeowners the knowledge they need to choose those more efficient products.

It is my hope, that this *Guide* will help other homeowners avoid making rash decisions that could potentially cost them more money and hassle in the long run. Also, it is my hope that, as a result of homeowners purchasing energy efficient products through wise and informed decisions, the environment as a whole will ultimately benefit. Energy efficiency causes fewer natural resources to be consumed and fewer pollutants to enter the environment.

Green Improvements



A Consumer's Guide to

Environmentally Conscious

&

Economically Beneficial

Home Repairs and

Improvements

For the North Central Texas Region

By Deborah Dickason

Table of Contents

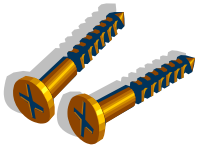
List of Illustrations

List of Tables

Introduction

Purpose

A quick trip to the average American shopping center reveals just how many choices the typical consumer faces. For example, in one Dallas area home improvement center alone, there are over 275 different types and sizes of screws to choose from alone. Choosing just one out of



so many choices can be overwhelming. It can be even more so for a consumer who has never had to buy such devices before. In addition, new types of screws- such as more specialized ones or ones made from stronger materials- occasionally enter the market. And then, sometimes, there are even options other than what is right there on the shelf.

Purchasing replacement appliances can be somewhat like choosing those screws, especially for the first time buyer. There are a lot of choices out there. New models with more options turn up regularly. And, then, sometimes there are options other than the obvious ones. With a little education, however, even the novice buyer can make wise decisions that best suit their individual home's needs.

Many major household items are purchased quickly and with very little research. This situation occurs, perhaps, when a home's air conditioner goes out in the middle of a hot Texas July, for instance, and replacing the air conditioner as quickly and cheaply as possible becomes

the main priority. At times like this, energy and environmental considerations are not generally the priorities.

It is my intent to do that research now before it is needed rather than waiting until a point where there is no time for in-depth investigation. The objective of this research is to produce a guide for average consumer's that will aid them in making quick decisions on major purchases that are economical as well as energy and water efficient, and as a result, less environmentally costly.

"**Energy efficiency** is the percentage of total energy input that does useful work (is not converted to low-quality, essentially useless heat) in an energy conversion system. Improving energy efficiency means getting the same work out of a device with a lower energy input." (Living in the Environment, page 334)

While there are many aspects of a home that may need repairing or replacing over the years, it is the intention of this research to focus primarily on those things that generally need replacing quickly, or in an "emergency", and specifically, those things that consume large amounts of energy.

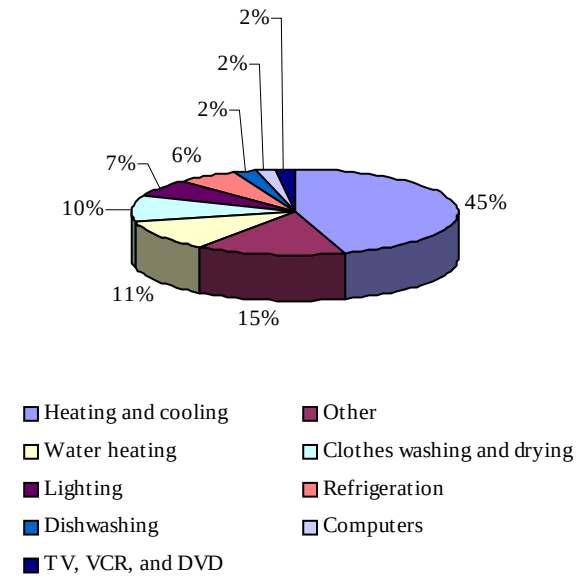
Replacing a small household appliance such as a broken blender does not generally constitute an "emergency". And while blenders do consume energy, it is a negligible amount when compared to the energy consumption of, for example, a dishwasher. Therefore small appliances will not be covered in this paper.

By the same token, re-painting walls, re-carpeting floors, or replacing fencing and siding are activities that generally allow time for individual research into the chemistry or technology used in the manufacturing of such products and their impact on the environment. This paper will

focus on things that homeowners usually want replaced within a few days such as broken windows, hot water heaters, air conditioners, and other inoperative major household appliances.

Beyond providing tips for purchasing new appliances, this research seeks to educate consumers. It will include basic reviews on how different products work in order to give homeowners some basic background knowledge that aids them in asking educated questions and making educated decisions. Additionally, home energy efficiency does not end with the purchase of a new appliance. Rather, it is a combination of many factors that work together with energy efficient appliances. For that reason, this guide will also provide tips on installation and maintenance of appliances as well as tips for other things that can be done around a home to supplement the use of a high-efficiency product.

Home Energy Use



(Source: www.energystar.gov)

Finally, the information to be given is, in a sense, generic in that it will not limit itself to details that would not allow for personal preferences. Rather, the suggestions given in this text will be broader in scope. For example, it will contain advice on purchasing new windows. It will not, however, limit the consumer to specific brands, models, styles, colors, size, or the like.

Geographic Region

This research is not the first of its kind. However, unlike other similar studies, this one is specific to the North Central Texas region. The climate in this region is different from other Texas regions and from other parts of the United States. Therefore, what is most efficient in other parts of the country is not necessarily what is most efficient in this part, and vice versa.

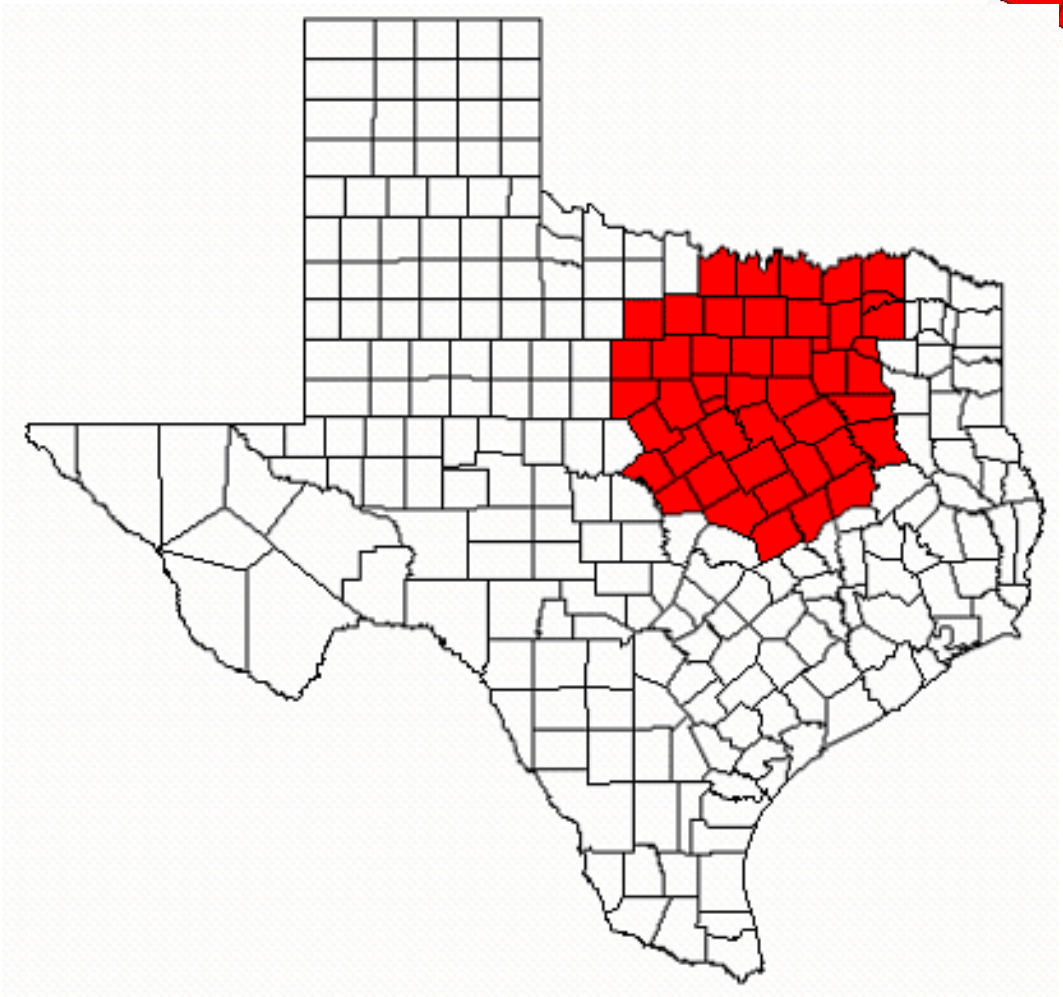
The research contained within this paper applies mainly to homes that are permanent structures. It does not apply to mobile homes, travel trailers (campers), or recreational vehicles. Some of the tips will apply to the non-permanent homes, especially the more energy efficient newer ones, but because they fall into a different category of structures, information given here should be researched further.

For the purpose of this study, the National Weather Service defines the North Central Texas area. It includes 46 counties, as well as the Dallas-Fort Worth Metroplex, Denton, Paris, and Waco.[1]

[1] National Weather Service Forecast Office- www.srh.noaa.gov

Right: Labeled counties of North Central Texas

Below: Texas State map highlighting the counties considered to be part of North Central Texas



Brief Overview of Major Organizations

The purpose of this study is not to "re-invent the wheel" by conducting research on specific products. Rather, the purpose is to take the results and information gleaned from the works of numerous other respectable organizations and put it into a consumer-friendly, region-specific format. It is intended to serve as an educational tool. While the information gathered comes from many sources, there are a few specific sources that are exceptionally valuable to researchers and consumers alike.

U.S. Department of Energy

The United States Department of Energy was activated on October 1, 1977 under The Department of Energy Organization Act. Over the years, the Department's goals have changed as the country's needs have changed. Now, it "contributes to the future of the nation by ensuring our energy security, maintaining the safety and reliability of our nuclear stockpile, cleaning up the environment from the legacy of the Cold War, and developing innovations in science and technology."[2]

One of the department's primary missions is to reduce America's dependence on foreign oil and to "develop energy efficient technologies for buildings, homes, transportation, power systems and industry."[3]

[2] Department of Energy History: An Overview- www.doe.gov
[3] U.S. Department of Energy- www.doe.gov

Office of Energy Efficiency and Renewable Energy

The Office of Energy Efficiency and Renewable Energy (EERE) is an organization within the Department of Energy. Its mission is "to strengthen America's energy security, environmental quality, and economic vitality in public-private partnerships that: enhance energy efficiency and productivity; bring clean, reliable and affordable energy technologies to the marketplace; and make a difference in the everyday lives of Americans by enhancing their energy choices and their quality of life."[4]

In addition, the EERE provides education and valuable information to consumers through their website. The site provides information on sources of energy as well as tips for conserving that energy.

U. S. Environmental Protection Agency

The U.S. Environmental Protection Agency (EPA) was established in July, 1970. Its job was to begin repairing damages to the natural environment as well as to establish criteria which would lead to a cleaner environment. "EPA's mission is to protect human health and to safeguard the natural environment — air, water, and land — upon which life depends."[5]

The EPA develops and enforces regulations that apply environmental laws set up by congress. It also performs environmental research, sponsors voluntary partnerships and programs, and furthers environmental education.

[4] U.S. Department of Energy: www.doe.gov
[5] Environmental Protection Agency: www.epa.gov

Energy Policy Act (EPAct)

In 1975, the Energy Policy and Conservation Act was enacted. It established an energy conservation program for major home appliances. That act was amended in 1987, and became known as the National Appliance Energy Conservation Act (NAECA). It was further amended in 1992, when it became known as the Energy Policy Act (EPAct).

The EPAct requires the U.S. Department of Energy to set minimum energy consumption or maximum energy efficiency standards for certain consumer products. These minimum energy standards may change and become stricter as technology advances and meeting those standards becomes economically justified for manufacturers. The Department of Energy is also charged with developing testing procedures by which the standards are measured. It is then the job of the Federal Trade Commission to set labeling requirements for those residential appliances.

At several points in this paper, the term "Federal standard" will be used. These standards are the ones established by the U.S. Department of Energy under the EPAct of 1992.

Energy Star

Energy Star is a voluntary labeling program supported by the United States Environmental Protection Agency and the U.S. Department of Energy. It is comprised of government and industry partnerships. Its goal is to protect the environment by promoting energy efficient products and by educating consumers.

Energy Star was introduced in 1992 in an effort to help cut down on America's greenhouse emissions. Currently, it has partnerships with over 7,000 private and public sector organizations. It is estimated to save businesses, organizations, and consumers over $7 billion a

year through technical information and education.[6] Energy Star has been a big supporter of many major technological innovations as well as energy management strategies.

Products bearing the Energy Star label meet "strict energy efficiency guidelines set by the U.S. Environmental Protection Agency (EPA) and the Department of Energy (DOE)."[7]

Clarifications

The term "environmentally responsible" as used in this paper does not necessarily imply that the product, advice, or technology is beneficial to the environment, nor does it mean that the product, advice, or technology is completely without impact to the environment.

Anytime electricity, water, or any other resources are used, there are environmental impacts, even if they are negligible. A home, no matter how energy efficient, water conservative or well designed, has an environmental cost. Every time an appliance is plugged in, every time a door is opened, every time a water faucet is turned on, there is a cost to the environment. "Environmentally responsible", as it is used here, simply means that the product, advice, or technology will have less impact on the environment than comparable equipment and practices, or even older, less efficient products or technologies.

The intent is to find those products and technologies that will have the minimum negative environmental impact and to offer advice and tips, which should give homeowners ways to conserve water, electricity and other resources that would not otherwise have been conserved.

[6] Energy Star Program: www.energystar.gov

[7] Guide to Energy Efficient Cooling and Heating, page 3

The phrase “reduce, reuse, recycle” has become fairly common in our society. The first one, “reduce”, is the most important of the three. Using renewable energy sources, such as solar power and wind power, is a positive move. But, what is more important than that is reducing energy usage in the first place. Even renewable energy has an environmental cost. Solar energy, for instance, involves the use of solar panels that consume natural resources in their construction. This paper contains many tips on reducing power usage in the home for, in part, this very reason. The added benefit is that, in this case, what is good for the environment, in most cases, also happens to be what is good for the wallet.

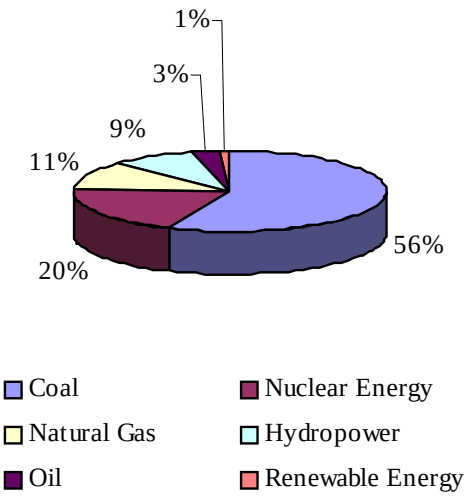
Benefits of Energy Efficiency

- Makes nonrenewable resources last longer
- Allows more time to phase in renewable energy
- Decreases dependence on foreign oil
- Reduces local and global environmental damage
- Keeps greenhouse gases out of the air and slows global warming
- Saves money and promotes economic growth
- Improves American manufacturers’ competitiveness in the international marketplace

(Source: *Living in the Environment*, page 335)

Sources of Electrical Energy

Sources of Energy in the United States



(Source: *Introduction to Environmental Geology*)

To expand on the idea that energy production is not without an environmental cost, this section will present a brief overview of the common types of electrical energy production in use today, and their impacts on the environment.

There are two kinds of energy- renewable energy and non-renewable energy. Renewable energy, such as water, wind, and sunlight, can be replaced quickly by nature. Non-renewable energy, such as the fossil fuels coal, oil, and natural gas, are finite in supply. Nature can replace non-renewable sources, but not in any amount of time that would be considered reasonable by human standards. Non-renewable energies are the most prevalent energies currently used in the United States.

All forms of energy, whether renewable or non-renewable have both advantages and disadvantages. These pros and cons extend to both economics and to environmental health or degradation.

Coal

Coal is the primary source of electrical power in the Untied States. Coal is a fossil fuel, meaning that it is formed, over several million years, by the decomposition of plants and animals under the influence of pressure and heat. It is a non-renewable resource.

Coal is considered a very 'dirty' form of power. Its pollution potential to air, land, and water, is very high.

First, coal must be mined and coal mining can be dangerous to human health as well as detrimental to the local landscape. In humid areas, there is great potential for water contamination by acid wastes, if the mine is not carefully managed. Mining can lead to soil erosion, and mineshaft collapses may cause the surrounding land to sink.

Additionally, the burning of coal can produce a great deal of air pollution, especially carbon dioxide, which may be released into the atmosphere. Carbon dioxide is considered a 'greenhouse gas' which has been linked to the phenomenon called 'global warming'. Ash is left behind when coal is burned. The ash must be collected and disposed of- usually in landfills.

Finally, coal mines, power plants, and other facilities connected with the coal industry may be considered aesthetically unappealing.

On the flip side, coal is relatively cheap and fairly abundant. Because of this, American consumers "benefit from some of the lowest electricity rates of any free-market economy."[8] Coal is an efficient source of energy in terms of net energy yield (energy provided by the resource minus the energy used to mine it, process it, transport it, etc.).

Furthermore, strategies to reduce environmental damage have been put into practice. Acid drainage is curtailed by properly implemented water diversion practices. Federal

[8] U.S. Department of Energy: www.doe.gov

guidelines also require that mined land be restored when mining activities are completed. The use of scrubbers and filters on power plants, the use of lower-polluting types of coal, and the development of new technologies to make coal burning cleaner and more efficient are other attempts to minimize air pollution.[9,10]

Nuclear power

Nuclear power is the source of great controversy. Its prospective benefits are often overshadowed by its potential danger and long-term environmental hazard. There are 103 nuclear power plants in the United States that supply 20% of the nation's electricity. It also is considered a non-renewable resource.

Power is acquired from the fission (splitting) of atoms, such as uranium-235 or plutonium-239, by neutron bombardment. In uranium fission for example, uranium pellets are arranged in rods and then bundled. The bundles are generally submerged in a coolant such as water. When the fission reaction occurs, large amounts of heat are released. The water becomes very hot and is converted into steam. The steam then drives a turbine, which spins a generator so that electrical power is generated. However, "various amounts of radiation are released into the environment, at every step of the nuclear cycle: mining and processing of uranium, controlled fission in reactors, reprocessing of spent nuclear fuel, and final disposal of the radioactive wastes."[11]

Radioactive waste disposal poses a fundamental problem for nuclear power production. The radioactive materials produced in the nuclear power process generally need at least ten half-

[9] Living in the Environment, pages 381-383
[10] Introduction to Environmental Geology, pages 233-235
[11] Introduction to Environmental Geology, pages 244--245

lives to break down into their non-hazardous components. In the case of plutonium, this may take 250,000 years or more. During that time, the materials must be isolated from the biological environment. Isolating materials for such long periods of time is a phenomenal task and there are no guarantees about future geologic, climatic, or social situations.

Another, very serious threat is the risk of terrorist activity. Nuclear power plants may become targets of attacks. In addition, the plutonium produced by nuclear reactors can be used to make nuclear weapons. There is some danger that the plutonium could fall into terrorist hands.

There are inherent dangers in any type of energy retrieval system. Freak accidents can occur in even the safest facilities. The difference with nuclear power plants is the danger of long-term damage. While nuclear explosions cannot occur in nuclear reactors (the concentration of fissionable matter is not sufficient), smaller explosions can occur and radioactive material could be released.

Still, there are many, many safeguards in place that aid in the prevention of major disasters such as a meltdown or terrorist attack. Also, it is a source of power that does not contribute to greenhouse gases, so research continues to look for ways to make nuclear energy safer and more cost-efficient. Finally, it is still a hope that nuclear power will reduce America's dependence on foreign oil and other non-renewable resources.[12, 13]

Natural gas

Natural gas is considered a fossil fuel and is non-renewable. It comprised mainly of methane with smaller amounts of other hydrocarbons such as ethane, butane

[12] Introduction to Environmental Geology, pages 243-249
[13] Living in the Environment, pages 243-249

and propane in addition to some impurities. The U. S. Department of Energy states, "natural gas is the fastest growing fuel. More than 90 percent of the power plants to be built in the next 20 years will likely be fueled by natural gas."[14]

Despite its growing demand, natural gas has some downfalls. For one, it must be converted into a liquid before it can be shipped via tanker. Conversion itself is costly, potentially dangerous, and cuts down on the net useful energy yield. Moreover, there is the potential for explosions near loading and unloading facilities. There is also the possibility of gas leaks from pipelines, storage tanks, and other facilities. Finally, the methane that comprises natural gas is a greenhouse gas.

But, natural gas has several advantages over coal, oil or nuclear power. It produces less air pollution than other fossil fuels. It is cheaper, cleaner, and more efficient than coal, oil, or nuclear power. It is also relatively easy to process. And, improved construction and maintenance of pipelines and other facilities can reduce risks of leaks or explosions.

Hydro power

Hydropower, or hydroelectric power, is the fourth largest source of electricity in the United States and is a renewable resource. Rivers may be dammed in order to control the flow of water. With large-scale projects, big reservoirs are formed behind the dam. Water then flows through pipes in the dam, spinning turbines connected to generators which create electricity.

Electricity may also be produced from falling water, tidal power, and wave power. However, the technology is not yet available to make these a viable source of power.

[14] U.S. Department of Energy: www.doe.gov

Hydropower is not without environmental and economic drawbacks. First, there are very few sites left available for large dams and reservoirs. Construction of such is very costly both in terms of money and land area. When reservoirs are created, vast areas are flooded causing such problems as destroying wildlife habitat, uprooting people from their homes, flooding agricultural land, ruining archaeological sites, disrupting fishing downstream of the dam, disturbing the natural flow of rivers, causing fish kills, devastating wetlands, trapping sediment that would otherwise flow to the ocean to replace beach sand, and so on.

Conversely, hydropower is clean and efficient. It does not cause air pollution or emit radioactive wastes. Dams have longer life spans than coal and nuclear plants and can be used to help control flooding. The creation of reservoirs can add recreational and aesthetic value to an area as well as adding a greater freshwater supply. Researchers are working to minimize the negative effects on the environment.[15, 16, 17]

Oil

Only around 3% of the electricity produced in the United States comes from the burning of oil. Crude oil, a non-renewable resource also known as petroleum, is a thick, viscous liquid that must be pumped from the ground. "Most crude oil travels by pipeline to a refinery, where it is heated and distilled to separate it into gasoline, heating oil, diesel oil, asphalt, residual oil, and other components."[18]

Exploration to locate oil reserves as well as mining involves road building, drilling, and building pipelines and other structures. There are also the additional problems of disposing of

[15] Living in the Environment, pages 354 and glossary
[16] Introduction to Environmental Geology, page 256
[17] U.S. Department of Energy: www.doe.gov
[18] Living in the Environment, page 373

the wastewater associated with oil wells, shipping the oil by way of tankers, converting crude oil into useable commodities, oil leaks or spills, and the fact that many of the world's oil reserves are located in politically unstable parts of the world. Finally, burning oil releases carbon dioxide along with other air pollutants that may be harmful to humans and wildlife.

Still, oil is rather inexpensive. It is transported fairly easily, and it has a high net energy yield.[19, 20]

Solar power

Solar power is an underutilized renewable resource. "The total amount of solar energy that reaches Earth's surface is tremendous. On a global scale, two weeks' worth of solar energy is roughly equivalent to the energy stored in all known reserves of coal, oil, and natural gas on Earth."[21] Solar energy, in the form of sunlight, can be collected by photovoltaic cells and directly converted into electricity.

There are some disadvantages to solar power, but they are few when compared to the burning of fossil fuels or the use of nuclear energy. There is some disturbance to the land, for instance, when large solar farms are built. Also, solar power plants are not as cheap to build as other types of power facilities. The manufacture of solar cells can result in low to moderate levels of water pollution.

North Central Texas gets, on average, four to six kilowatt hours of solar radiation per square meter per day.
(Source: National Renewable Energy Laboratory)

But, sunlight is free. There are no exploration costs to locate new reserves of it, there is no need for pumps or wells, there are no transportation costs to move it from one location to

[19] Living in the Environment, pages 373 and 377
[20] Introduction to Environmental Geology, pages 238-239
[21] Introduction to Environmental Geology, page 254

another, and there is no need for refining processes. Solar power does not contribute to global warming by producing carbon dioxide. Solar cells are mostly made from silicon, which is an exceptionally plentiful resource. Solar farms can be placed in a variety of areas including deserts, along roads and highways, in yards, and on the roofs or sides of buildings. Lastly, advances in technology are improving net energy yield values, which are already fairly high.[22, 23]

Wind power

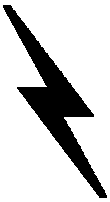
Wind power is a renewable energy resource, so there is virtually no chance of running out of it. The only major problem from the supply and demand side is that wind is decidedly variable in time, location, and intensity. There are places on the planet where conditions are more stable, however, and the global potential for wind-generated power is very high.

Wind energy is not without environmental problems, though. First of all, construction of windmills does consume natural resources. The placement of windmills poses another series of problems. When placed in scenic locations, windmills may disrupt the view or cause the scenery to be altered. Also, they can potentially cause interference with radio and television broadcasts. Disruptions in bird migratory patterns and bird kills are other concerns. Some raptors, for example, prefer to hunt in the type of terrain that is ideally suited for windmills.

On the other hand, energy from the wind is clean. Wind power plants do not contribute to the pollution of air, land, or water (other than, possibly, noise pollution or ground vibrations). It is a cheap form of energy that may someday become the cheapest form of energy. Land under windmills may be used for grazing animals or other productive purposes. Some research

[22] Living in the Environment, pages 351-353
[23] Introduction to Environmental Geology, page 254

suggests that the number of birds killed, while unfortunate, may be small in comparison to the number that could be killed by pollution from other types of power plants, global warming, and so on. Finally, wind power has the potential of reducing America's dependence on foreign energy sources.[24, 25]



As stated above, there is always an environmental cost to living in a home. That does not have to be a negative thing. Humans need shelter and the environment can sustainably provide for them. The idea is that homes can be run more efficiently without people having to give up the comforts and luxuries that they currently enjoy.

[24] Introduction to Environmental Geology, pages 256-257
[25] Living in the Environment, page 357

Bibliography

***Note:** Where websites are used as sources, the citation gives the name of the organization, the website address for the organization's home page, and the links followed to the pages where specific information may be found. For example, Energy Star Program- www.energystar.gov: Home> Products> Appliances> Dishwashers, means that the information can be found by going to the Energy Star website at www.energystar.gov, clicking on "Products", then on "Appliances", and finally on "Dishwashers".

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2. *Department of Energy History: An Overview*; Executive Secretariat, History Division, Department of Energy- www.doe.gov: Home> About DOE > History> Origins and Evolution of the Department of Energy> Histories, Timelines, Photographs > Department of Energy History: An Overview

3. Energy Star Program- www.energystar.gov: Home > Products > What does my energy bill pay for?

4. Energy Star Program- www.energystar.gov: Home > What is Energy Star?

5. Energy Star Program- www.energystar.gov: Home > What is Energy Star? > History

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Water Heaters

Introduction

Providing hot water for things such as washing dirty dishes and for taking steaming hot showers is the esteemed job of the hot water heater. Thanks to this convenient appliance, gone are the days of boiling kettles of water over a fire just to provide warm bath water. The country has become a much more sanitary (and slightly better-smelling) place to live because of the water heater.

Waking up to a nice hot shower in the morning is something many homeowners take for granted. That is, until they wake up one morning to a not-so-nice icy cold shower. Water heaters do occasionally need maintenance and even replacement. Since most homeowners do not relish the idea of cold showers, they want malfunctioning water heaters repaired or replaced as quickly as possible.

What one should consider first is the idea that heating water accounts for about 14% of the home's utility bill. It can be one of the largest energy expenses in the home.[26] Even when facing another chilly cascade in the bathtub, choosing a new hot water heater should be done with care. There are more options out there than what there may seem upon one trip to the appliance store.

[26] Water Heating: www.eere.energy.gov/consumerinfo/energy_savers

Ideally, a hot water heater should last from about ten to fifteen years.[27] Ideally, a homeowner would begin researching new hot water heaters before the old one fails so that they would be able to pick the best possible new one quickly. Ideally, it would be a simple matter to choose a new water heater because they would all be top-of-the line energy-efficient models at low prices. Ideally, every new water heater would be installed perfectly to maximize their energy efficiency.

Unfortunately, this is not an ideal world. However, a little background knowledge can go a long way towards those ideals.

Types of Water Heaters

There are three basic types of water heaters available in the North Central Texas region: storage water heaters, tankless water heaters, and solar water heaters.

Storage water heaters are the most common type used in the United States and the ones with which most homeowners are familiar. Tankless, or Demand, water heaters are an efficient alternative to the traditional Storage Water heaters.

The third type, the solar water heater (not to be confused with solar power), is another alternative to storage water heaters, although they can be used in conjunction with the traditional models in order to reduce

[27] Water Heating Tips: www.eere.energy.gov/consumerinfo/energy_savers

energy bills. They are more environmentally friendly since solar power does not contribute to air pollution in the form of greenhouse gases, as do some other types of power production. In fact, it is estimated that a solar water heater in one home, can save 50 tons of carbon dioxide emissions over 20 years since a well-designed and installed system can meet most of a home's demand for hot water.[28]

How They Work

Storage Water Heaters

A storage water heater in a typical home is powered by either electricity or natural gas. (They can also be powered by oil or propane.) Additionally, they may hold from 20 to 80 gallons (75.7 to 302.8 liters) of water and can handle the 50-100 psi (pounds per square inch) of pressure forced on it by a residential water system.[29, 30]

Storage water heaters function on the basic principle that warmer liquid rises to the top, while cooler liquid settles at the bottom. This is because cool water is heavier than warm water. Cool water is added to the bottom of the tank through a pipe, called a dip tube, and warm water is released through another pipe at the top of the tank.

When a water faucet is turned on or hot water tap is opened, hot water is released through the pipe at the top of the heater. Cold water replaces the lost hot water in the insulated tank

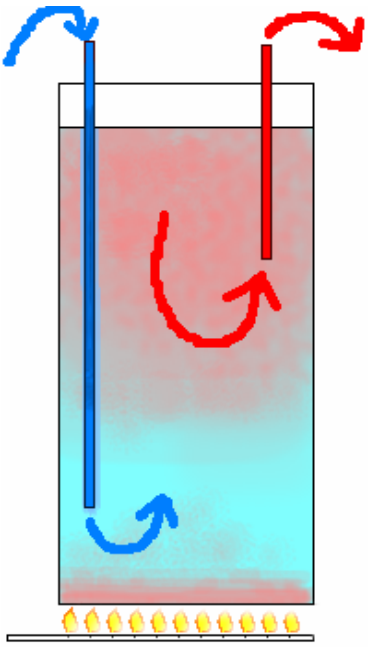
[28] *Selecting a New Water Heater*

[29] Brain, Marshall. *How Water Heaters Work*

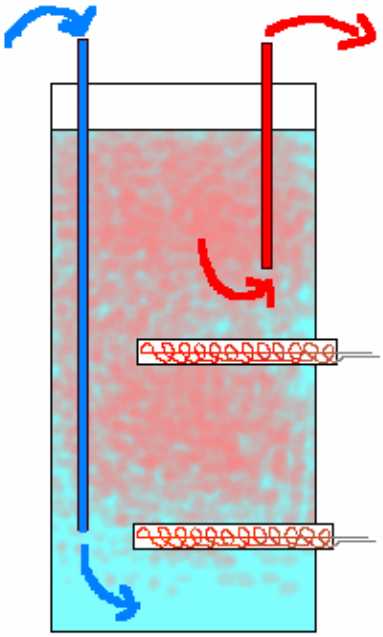
[30] *Selecting a New Water Heater*

through the dip tube, so that it always stays full. This causes a drop in the temperature of the water in the tank, which causes a thermostat to activate a heat source.

In an electric heater, the heat source is a pair of electrically powered heating elements. In a gas heater, it is a burner. To release potentially dangerous gases, gas heaters also have a type of chimney, which runs from the burner and up through the tank. The source of heat is the main difference between gas and electric water heaters. The thermostat can be adjusted to keep the water inside the tank hotter or cooler



Gas Storage Water Heater



Electric Storage Water Heater

Other major parts in a hot water heater include the drain valve, the pressure relief valve, and the sacrificial anode rod. The drain valve permits the water to be drained from the tank in order to repair or move the unit. The pressure relief valve prevents pressure build-up, which could lead to an explosion. Finally, the sacrificial anode rod helps prevent corrosion on the tank's walls.

Even though the tank stays full of water, it is possible to use hot water faster than the tank can heat the replacement water entering it. This can be a problem especially if the tank is too small for the home and its uses.

The major obstacle to storage water heater efficiency is the standby heat loss. Storage water heaters constantly keep water at a given temperature even when no water is being used. Though the tank is insulated, some heat does escape from its walls bringing about the need for reheating the water. Energy is consumed in the process of reheating. The standby heat loss is essentially wasted energy.

Tankless Water Heaters

Tankless water heaters (also known as demand, point of use, or instantaneous water heaters) are an alternative to the conventional storage water heaters. They have been available in the United States for about the last twenty-five years and available for about seventy-five years elsewhere in the world. Unlike the traditional systems, tankless heaters do not store water and so, do not need to keep it at a constant high temperature. Rather, these water heaters heat water only as it is used.

Tankless systems come in many different sizes and for different applications. Point of use systems, for example, may be used to heat water in a remote bathroom or laundry room. However, for the purpose of this study, only those used for whole-house water heating will be discussed.

Like the traditional storage tanks, the tankless systems can be powered by either electricity or gas. While the gas-fired units “tend to have higher flow rates than electric ones,

they can waste energy even when no water is being heated if their pilot lights stay on. However, the amount of energy consumed by a pilot light is quite small."[31]

Tankless water heaters work only when they are needed. When a faucet or tap is on, cold water enters the unit through a pipe. The system senses the need for hot water and quickly begins heating the water with a powerful heating element in the case of electric systems, or with a powerful burner in the case of gas systems. The water is then sent out to where it is needed. Some models are thermostatically controlled. This means that as water flow changes (i.e. the person using the water adjusts the temperature at the faucet for hotter or cooler water), a thermostat changes the amount of heat released by the heating unit to control the water's temperature. "The amount of energy used is always proportional to the volume of hot water being used. When the hot water tap is turned off, the system shuts down."[32]

These systems have several advantages over the storage heaters. First of all, there is no standby heat loss since there is no storage tank from which heat may be lost. Additionally, "most homes use hot water for a cumulative total of about one hour per day, yet they typically keep 40 or 50 gallons (oftentimes more) of water hot 24 hours a day."[33] Energy consumption may be reduced by an estimated 20% to 30% or more simply by eliminating the process of heating water that is not being used. As an added bonus, with a tankless system, there is no chance of running out of hot water in the middle of a shower. Plus, they are smaller than storage water heaters, have longer life spans, maintain their high efficiency levels better, and since they can be mounted on a wall, save floor space.[34]

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[31] Selecting a New Water Heater
[32] Tanklesswater: www.tanklesswater.com
[33] Tanklesswater: www.tanklesswater.com
[34] *Selecting a New Water Heater*

There are two small disadvantages of tankless systems compared to storage water heaters- limited flow rate and higher initial cost. Tankless heaters generally provide only 2 to 4 gallons (7.6 to 15.2 liters) of hot water per minute. This may not be so much of a problem when using the hot water tempered with cold water directly from the residential supply system or when considering that showerheads manufactured after 1992 are designed to deliver only up to 2.5 gallons of water per minute anyway. And then, tankless systems are more expensive and the payback times are longer than for conventional storage systems. It essentially boils down to individual homeowners weighing the advantages against the disadvantages of tankless water heaters. [35,36]

Solar Water Heaters

Solar water heaters work well in warm and sunny climates such as North Central Texas. In order to take advantage of a solar water heating system, there must be an un-shaded south-facing location on the property, such as on a roof, where the system can be placed.

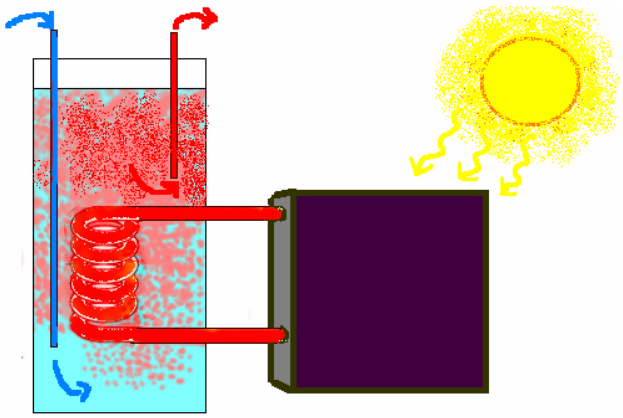
Unfortunately, there is still little demand for solar water heaters and so they may not be available in all areas. It is important to investigate local retailers thoroughly to make sure that someone will be around in the future if a system needs servicing or if parts need replacement.

There are two types of solar water heaters: the simple passive type and the more complex active type.

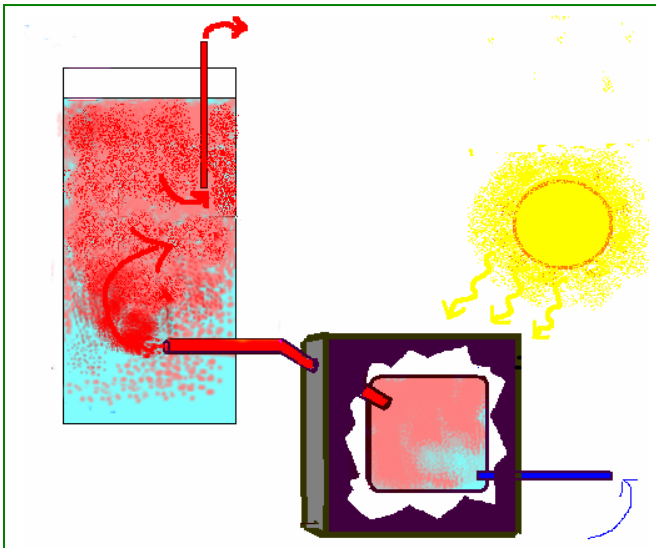
[35] Karney, P.E., Richard H.
[36] *Selecting a New Water Heater*

The simplest passive system is basically a small water tank placed inside a black box that has glass or plastic on one side and is positioned so that the sun's rays hit the black box and are absorbed. The idea is to preheat the water before it is sent to the storage water heater tank. Since the water entering the storage tank is already at least partially heated, the storage water heater does not have to use as much energy heating water. The storage heater essentially acts as a back-up system.

The other advantage is the lack of maintenance required of passive systems. There are no pumps or controls to deal with since they use the pressure present when the water arrives from the residential system. They are also durable and have very low operating costs.



Passive Solar Water Heater



Active Solar Water Heater

Unlike passive systems, active systems do use pumps and controls and require equipment such as solar collectors, and sensors. But, active systems are more efficient than passive systems.

Active Systems can be further broken down into two categories: direct, or open loop, systems and indirect, or closed loop, systems. The more efficient direct systems heat the home's water directly in the solar collectors. Indirect systems, on the other hand, heat another liquid medium such as freon at the collector site. The liquid goes through a heat exchanger and the heat is transferred to the water there. Pumps are used with both systems to move the fluids. The water is eventually transferred to a storage tank. Pumps can either be powered by electricity or by solar energy from small photovoltaic panels.

The word "photovoltaic", or PV, comes from the two root words *photo*, meaning light, and *voltaic*, which refers to producing electricity. The photovoltaic process is "producing electricity directly from sunlight."
(Source: *Introduction to Photovoltaic Systems*. SECO Fact Sheet No.11)

A disadvantage of the direct system compared to the indirect system is that it requires more maintenance and cleaning. Scale buildup and corrosions can put the direct system out of action, especially if the local water is hard or acidic. Also, they cannot be allowed to either freeze or overheat. Freezing is not a concern for indirect systems because the liquid medium is generally an anti-freezing agent.

The basic design of an active solar heater includes a collector, storage tank (in addition to the storage water heater tank), and in some systems a pump. However, the overall design of solar heaters does vary considerably. A positive trait of solar units is that they can be designed and installed to blend well with a home's style.

Standards, ratings and Certifications

There are a few notable organizations that set standards for the different types of water heaters. The United States Government, for instance, sets certain standards, which must be met.

Energy Star

Unfortunately, Energy Star, the U.S. Department of Energy's high efficiency rating program does not currently grant Energy Star labels for water heaters. In a recent letter from Richard H. Karney, P.E., the manager of the Energy Star Program, he stated that, "After analyzing the market, the potential energy savings and economics of the various technologies, and considering feedback from stakeholders, the Department of Energy has decided not to establish ENERGY STAR criteria for domestic water heaters at this time." He contends that the difference between the federal standards and the most efficient models currently on the market are not significant enough to make the Energy Star label "meaningful".[37]

In general, Energy Star labels are given to those products that have a wide range of efficiency levels. Storage water heaters do not currently have that wide of a range. Furthermore, "Conventional gas and electric storage water heaters are approaching the physical limits of energy performance." The manager went on to say that, "In order to achieve significant energy efficiency gains, manufacturers will have to pursue condensing or tankless technologies."[38]

However, tankless and solar water heaters are not considered either since they are not yet available in every market. They are still considered new technologies that have not had time to prove themselves in Energy Star's judgment. It is hoped that solar and tankless (among other

[37] Karney, P.E., Richard H.
[38] Karney, P.E., Richard H.

alternative technologies) will find inclusion in the Energy Star program some time in the future. Their potential energy savings is promising although there are some challenges to be faced along the way.

Solar Rating and Certification Corporation and Florida Solar Energy Center

Two of the organizations recognized by the U.S. Department of Energy produce ratings for solar water heating systems. The first is the Solar Rating and Certification Corporation (SRCC) and the second is the Florida Solar Energy Center (FSEC).

The SRCC, a non-profit organization, sets benchmarks for comparing solar water heating system performances. Products are tested by independent third-party laboratories and then are certified by the SRCC. The products bearing the SRCC label, however, are not guaranteed to have superior performances. It is important to compare and contrast the SRCC labels on different products. The SRCC also publishes those performance ratings.

"A national standard (OG-300) addresses a variety of concerns, including safety and health, durability and reliability, installation, performance, and operation and maintenance. To meet this standard, a system is rigorously tested. A certified solar water heater carries the SRCC OG-300 label, and the system performance is listed in a published directory."[39] Both the SRCC and the FSEC provide solar collector testing and rating programs.

The Florida Solar Energy Center "maintains solar equipment testing facilities and publishes performance ratings for solar water heating systems."[40] This is also a resource for finding information on manufacturers and contractors of solar products.

[39] *Solar Water Heating*
[40] *Selecting a New Water Heater*

Purchasing Tips

Purchasing a new water heater, no matter which type, is an important issue and should not be taken lightly. It is essential for the consumer to appreciate the fact that the total cost of a water heater is not just the initial purchase price. It is the cost of installation, the future maintenance costs, and the cost of the energy used over the life span of the water heater on top of the initial purchase price. Very often, the cheaper initial cost lures the consumer into believing that they are getting the better deal. However, the purchase of an inefficient model can end up costing a good deal more in the long run.

Storage Water Heaters

Gas or Electric?

First of all, if a home's water heater does need replacing, the consumer must determine whether the current unit is electric or gas. If it is not evident, a contractor will be able to determine the power source.

Demand

"Although some consumers base their purchases on the size of the storage tank, the peak hour demand capacity, referred to as the first-hour rating (FHR) on the Energy Guide label, is actually the more important figure. The FHR is a measure of how much hot water the heater will deliver during a busy hour, and it is required by law to appear on the unit's Energy Guide

label."[41] The tank's FHR is dependent on several factors such as tank capacity, heat source, and burner or element size. Before shopping the homeowner should estimate the household's peak hour demand and then seek a heater with an FHR within that range. A table for calculating a home's daily peak one-hour hot water demand is located below.

First Hour Rating/ Peak Hour Demands

Hot Water Use	Avg. gal. hot water per usage		Times used in hour		Gal. used in hour
showering	15	X		=	
bathing	20	X		=	
shaving	2	X		=	
washing hands and face	2	X		=	
shampooing hair	4	X		=	
hand dishwashing	2	X		=	
automatic dishwashing	14	X		=	
preparing food	5	X		=	
clothes washing	32	X		=	
PEAK HOUR DEMAND (total gallons used in an hour)				=	

Left: The chart provides a worksheet for calculating First Hour Rating. (Source: Water Heating Fact Sheet, Office of Energy Efficiency and Renewable Energy)

[41] *Selecting a New Water Hater*

Energy Guide Label

When comparing different models, the main thing for a consumer to do is to study the bright yellow Energy Guide label conspicuously located on the tank. The labels show either the energy efficiency ratings or the estimated annual cost of operating the system.

"The best indicator of a heater's efficiency is its Energy Factor (EF), which is based on recovery efficiency (i.e., how efficiently the heat from the energy source is transferred to the water), standby losses (i.e., the percentage of heat lost per hour from the stored water compared to the heat content of the water), and cycling losses."[42]

The closer to 1 the EF is, the more efficient it is. Some alternative water heaters can reach energy factors above 1, but storage water heaters have not reached that level of efficiency yet. Energy Factors can usually be found in the product literature for the water heater.

Insulation

A tank should have at least 1.5 inches (3.8 centimeters) of foam insulation. Insulation helps keep heat inside the tank, thereby lessening the need for water reheating. Adequate insulation translates to better energy efficiency.

[42] *Selecting a New Water Heater*

Tankless Water Heaters

Gas or Electric?

When replacing an existing water heater with a tankless one, the consumer must first determine whether to purchase an electric or gas unit. If it is not evident, a contractor should be able to determine the power source. Gas models may have either vertical venting (exhaust vent running through the roof) or horizontal venting (exhaust vent running through the wall). Consumers should pay close attention to this since some homes may not be set up for one or the other type.

Fixture	Minimum Flow (gallons per minute)	Maximum flow (gallons per minute)
Bath tub faucet	2	3.5
Low-flow shower head	1.2	2.5
Older shower head	2.5	3.5
Washing machine	1	3
Dishwasher	1	2
Bathroom sink	0.8	2
Kitchen sink	1	2

Left: The chart shows average water flow rate for various household fixtures. (Source: TanklessWater.com and *Demand (Tankless or Instantaneous) Water Heaters*)

Demand

Tankless water heaters should be selected based on the maximum amount of hot water needed to meet the home's peak demand. This can be done by first estimating the maximum water flow required by different appliances, and then adding the few that would be running simultaneously. (For example, a tankless water heater may need to be able to provide enough hot water for a low-flow shower running at once. Based on the chart below, the maximum flow

for a low-flow shower head is 2.5 gallons per minute. Since 2.5 + 2.5 = 5, the homeowner in this example should purchase a unit capable of delivering up to 5 gallons per minute.)

Energy Guide Label

When comparing different models, the main thing for a consumer to do is to study the bright yellow Energy Guide label conspicuously located on the product or its packaging. The labels show either the energy efficiency ratings or the estimated annual cost of operating the system.

Solar Water Heaters

SRCC Certification

The solar water heater customer would be wise to find products certified by the Solar Rating and Certification Corporation and compare them.

Size

Solar equipment dealers should be able to use worksheets or computer programs that help homeowners choose the best system for an individual home. The size of the system depends on the number of inhabitants and their needs. Essentially, a solar water heater should be able to meet 100% of a household's hot water needs during the summer. The National Renewable Energy Laboratory suggests a 'rule of thumb' sizing method for solar collectors. They suggest allowing 20 square feet (2 square meters) of collector are for each of the first two family members and 8 square feet (0.7 square meter) for each additional family member.[43]

[43] *Solar Water Heating*

Storage tanks range from about 50 gallons to 120 gallons depending on the number of people living in a home. It is also suggested that there be at least 2 gallons (7.6 liters) of water storage capacity to each square foot (0.1 square meter) of solar collector area.[44]

Life Cycle Cost

The entire life cycle cost, not just the initial purchase and installation expenses, should be analyzed carefully. Cheaper systems do not mean cheaper operating costs. Additionally, the fuel for solar water heaters (sunshine) is free whereas there are fees for each kilowatt-hour of electricity and gas used. The money saved in decreased energy costs over the lifetime of the system could easily offset its higher installation costs.

Shop Around

Solar heating systems do not necessarily have to be added or replaced immediately since they are generally used in association with storage water heaters. Therefore, it is wise for consumers to "shop around" to find the most reliable distributors and installers.

Warranties

Homeowners are advised to learn about manufacturer warranties. They should be aware of what, exactly, the warranty covers and for how long. They should also find out if the system would still be covered, should the dealer go out of business.

[44] *Solar Water Heating*

Installation Tips

Storage Water Heaters

Since water heaters can produce both heat and humidity, it is suggested that they be placed in a location that is sealed off from the rest of the house. It is essential for the installer to check with the local city codes, zoning laws or covenants, and ordinances before putting in a storage water heater. Also, for safety reasons, storing things in gas water heater closets is discouraged.

Tankless Water Heaters

Tankless water heaters can be installed by plumbers willing to do so and more than one tankless water heater can be installed in sequence, if necessary, to meet a higher hot water demand for a home.

Because they must heat water quickly, tankless water heaters are very powerful and require a lot of energy while they are running. Some gas models may require expansion of vent pipes and some electric models may require upgraded electrical service in the home.

Solar Water Heaters

Suitable design and sizing as well as careful installation is an important key to an efficient solar heating system. A homeowner can successfully install solar water heating systems, but professional installation may produce better results. It is essential for the installer to check with the local city codes, zoning laws or covenants, and ordinances before putting in a system. Homeowners associations should also be contacted and permits may be required.

Maintenance and Cleaning

The homeowner should check the manufacturer's product literature for maintenance suggestions on the home's specific water heating system.

It is further advised that water be drained from storage tanks approximately every three to six months. (This is not necessary with self-cleaning water heaters) This can be accomplished by opening the drain valve located at the bottom of the tank. The water should run into a bucket until it looks clear. The objective is to prevent buildup of sediments.

Tips for Additional Energy Efficiency

Even with an energy efficient water heater, there are other ways to reduce energy, and even water consumption in the home.

Lower water temperatures

The thermostat on a water heater should be kept between 120 and 140 degrees for maximum comfort, safety and energy-efficiency. It should be kept at 120 degrees in homes with either no dishwasher or with a dishwasher that has a heating booster. It homes that have dishwashers without heating boosters, the thermostat should be kept at 140 degrees. (There is more information about dishwasher heating boosters in the "Appliances" section under "Dishwashers.")

Lower demand for hot water

One estimate suggests that a five-minute shower each day by a family of four consumes 700 gallons of water per week.[45] Less energy is needed to heat water if less hot water is used at the outset. There are ways to conserve water other than taking 2-minute showers every-other day or letting the dog wash the dishes.

Using low-flow showerheads, low-flow toilets, and aerating faucets, for instance, are three ways of cutting down water use. Leaky faucets waste significant amounts of water and should be repaired without delay. In addition, showers generally take less water than baths. An average bath takes 15-25 gallons of hot water while an average 5-minute shower uses only 10 gallons.

Water heater insulation

It is advisable to insulate the tank of a storage water heater. This serves to further reduce the standby heat loss. This can be done by a homeowner or by a professional.

New water heater

It is possible that an older water heater can be repaired rather than replaced. Still, purchasing a new water heater rather than repairing an old one may be more economical in the long run. Newer models tend to be more efficient and energy conservative than older ones. This is an option that should be carefully considered.

[45] Water Heating: www.eere.energy.gov/consumerinfo/energy_savers

Case Study

In 2002, the homeowner on Cherry Street in Duncanville, Texas found it necessary to replace the home's hot water heater. The old one had corroded and would no longer hold water. The homeowner knew nothing about how to choose the most energy-efficient model or about the alternatives to the traditional storage hot water system. It was a case where the unit needed to be replaced as quickly as possible, which she did with a quickly-selected mid-range natural gas powered storage type water heater.

At the time, she did not know of the potential advantages of a tankless water heater. Tankless systems seemed out of the question at the time because of their higher purchase price. What that homeowner did not know, is that the extra expense would have easily been paid back over time. In addition, research shows that tankless water heaters use less energy, which results in less air pollution. This would have in itself been a selling point for this particular homeowner.

The homeowner originally chose a 40-gallon storage tank. The home has only one resident, but she felt that a larger tank was necessary to maintain the home's resale value. As a result, much energy is wasted heating a storage tank meant for a family of three or four. A tankless system heats only water that is needed as it is needed. For a lone resident living in a large house, this would have been a more efficient choice.

Product Comparison Chart for Storage and Tankless Water Heaters

Product Description	Price	Installation Cost	EF (Energy Factor)	Therms per year	Operating Cost	First Hour Rating (storage only)	Number of Applications (tankless only)	Efficiency	Ignition type	Self Cleaning (storage)	
Bosch Aquastar 125B	$497		0.68	218	$132	NA	1 major	82%	pilot light	NA	
Bosch Aquastar 125 HX	$599		0.78	193	$117	NA	1 major	82%	hydro-ignition	NA	
Aquastar 240 FX	$929		0.81	183	$111	NA	2 major	83%	electric	NA	
Hot Point Energy Miser tank	$215		0.59	252	$152	67	NA				
GE Smartwater "Good" tank	$249		0.59	252	$152	67	NA			no	
GE Smartwater "Better" tank	$299		0.59	252	$152	68	NA			no	
GE Smartwater "Best" tank	$349		0.62	242	$146	68	NA			yes	

There were seven models available from which to chose- four gas-powered storage tanks and three gas-powered tankless units. They ranged in price from $215 to $929.* Initially, the tankless systems appeared significantly more expensive than the storage tanks. The most expensive storage tank was $148 cheaper than the cheapest tankless unit. However, the operating and life-cycle costs told a different story.

The operating costs for tankless systems were not readily available at the store or on The Home Depot's web pages. That information was obtained by going directly to the website for the manufacturer of the tankless water heaters, Controlled Energy Corporation. Their figures were obtained using a higher price per therm cost for gas than the one used on Energy Guide labels, and so had to be re-adjusted to match.

Four products were compared- the original "Better" storage tank, the more efficient "Best" storage tank, and two Bosch Aquastar 125-series tankless models. The Bosch 125B has a standing pilot light whereas the Bosch Aquastar 125HX has a hydro-ignition meaning that the flow of water triggers the unit to ignite. The third tankless model, the Aquastar 240FX was not seriously considered because it was bigger than the homeowner needed. The other two storage tanks were not seriously considered because their efficiency ratings equaled the "Better" model.

As the life-cycle comparison chart shows, over a ten-year period, any of the three alternatives would have resulted in monetary savings for the homeowner. The hydro-ignited

* Note: The models and prices reflected in this comparison were obtained from only one store, The Home Depot. The purpose here is not to find the store with the cheapest prices; rather it is to simply go through the process of choosing a new appliance. The Home Depot has a selection of both types of water heaters as well as easily accessible information. By using only one store, price comparisons may be made with greater relevance.

Example:

Life-cycle Cost Comparison Chart

		Purchase Price	Yearly Operating Cost	Operating cost over 10 years	Life-cycle cost	Cost difference
	Product Description	Price	Operating cost	Operating cost x 10	Price + 10-year operating cost	Total cost difference between models
Model **most likely** purchased	GE Smartwater "Better" tank	$299	$152.00	$1,520.00	$1,819.00	$0
Comparable model #1	Bosch Aquastar 125B tankless	$497	$132.00	$1,320.00	$1,817.00	$2.00
Comparable model #2	Bosch Aquastar 125HX tankless	$599	$117.00	$1,170.00	$1,769.00	$50.00
Comparable model #3	Aquastar 240 FX tankless	$929	$111.00	$1,110.00	$2,039.00	-$220.00

*In this example of hot water heater comparisons, the GE Smartwater "Better" storage tank model was the one that the homeowner chose without considering tankless models. However, the chart shows a clear economic advantage of the second and especially third models- the Bosch Aquastar 125 tankless series'- over the storage heater.

Bosch Aquastar 125HX, the one she would choose given the opportunity again, would have saved her an estimated $50. However, this figure does not account for the loss in efficiency of the storage tanks over time versus the tankless unit's ability to maintain its efficiency over time. Nor does the figure take into account that the unit would only be used to heat water for one person as opposed to heating water for three or four. In actuality, the savings would most likely be greater than what was estimated.

While $50 is not a great deal of money, given the opportunity, the homeowner would choose the tankless model over the storage tank. She would consider the higher purchase price a worthwhile trade-off for the long-term environmental benefits.

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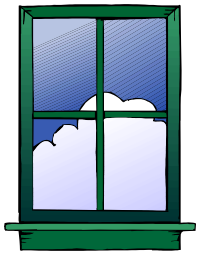
Windows

Introduction



Windows are vital components of any building. They let in light and fresh air. They provide views to the outside world. They let in heat during winter. For many, they also add to a home's décor. But, windows do, on occasion, get broken.

Broken windows do not always constitute an emergency purchase as described in the introduction to this text. However, stray softballs or errant hailstones can do serious damage to existing windows at rather inconvenient times. Windows can be patched quickly, which can, at least, delay the need to purchase new ones. But, windows play a very important role in the 0heating and cooling of a home. They should be repaired or replaced in a timely manner in order to minimize the effects on the cost of temperature control.

Because windows have a large influence on the amount of air conditioning or heating a home needs, new ones should be chosen with great care. There are many choices on the market and it can be overwhelming to know which ones are the best. Energy efficiency should be a top priority. Fortunately, this does not necessarily require a compromise on aesthetics.

How they work

Several different performance ratings are given to windows. These ratings are useful when comparing different window options. It may be helpful for the purchaser to be familiar with what these ratings mean.

U-factor and R-factor

When rating a window's heat loss or heat gain, the terms *U-Factor* and *R-Factor* (also known as U-value and R-value) are used. The U-Factor reveals the rate at which heat is permitted to flow through the window either from the outside to the inside in warm weather, or from the inside to the outside in cool. It is also the value typically listed on product labels. U-factors generally range between 0.20 and 1.20. "It is expressed in units of Btu/hr-sq ft-°F."[1] Lower U-values indicate a better insulating value and a greater resistance to heat flow. The R-factor represents a window's insulating value, or how well it resists heat flow. High R-values indicate better insulating properties of the glazing, and hence better resistance to heat. It "is expressed in units of hr-sq ft-°F/Btu".[2]

The two values are the reciprocals of each other (U = 1/R or R = 1/U). A window with a low U-Factor has a high R-factor, and it is energy efficient. Conversely, a window with a high U-Factor has a low R-factor is energy wasteful.

In the past, a window's R-value was based on the value obtained from the center of the glass. Now, it has been found to be more accurate to get the value based on the entire unit. It is

[1] Efficient Windows Collaborative, glossary, "U-factor"
[2] Efficient Windows Collaborative, glossary, "R-factor"

not just the glass that determines how a window resists or conducts heat. The frame around the window and the types of materials that are used to produce the window, also combine to determine that value. It is necessary for models to be rated in the same way so that comparisons between them are accurate. A window with an R-value obtained from the center of the glass, may actually be lower than the same window with the value obtained by testing the entire window unit.

SHGC

Along with light, windows let in heat from the sun. Heat may be directly transmitted through a window to the interior or it may be absorbed by the window and released later to the cooler interior. The *solar heat gain coefficient* (SHGC) determines how well the window blocks that heat. The SHGC falls between 0 and 1. It is the fraction, or percentage, of incident solar radiation that is allowed through. For instance, a window with a solar heat gain coefficient of 0.33 lets only 33% of the potential heat get through. The lower the SHGC, the lower the amount of heat that gets through.

VT

Visible transmittance (VT) is a percentage of light that is transmitted through a window. The number, which ranges from 0 to 1, is a fraction of what is called the visible spectrum (the range of light that can be seen by humans). Higher VT values signify that more light is permitted into the home.

Air Leakage

Some of the heat either allowed into the home or escaping from it, does so in the form of *air leakage*. Air leakage can occur through cracks in walls, around windows, doors, and skylights, and so on. It happens when there is a pressure difference between two areas. The air leakage rating found on window product labels, is a measure of the rate at which air enters or escapes through such gaps. It is written in terms of cubic feet of air per minute per square foot of frame area (cfm/sq ft). The more air tight a window's frame is, the less air will get through, and the lower its air-leakage rating will be. An air leakage rating may not be listed on labels by all manufacturers.

Condensation resistance

Some window products allow condensation to form on their interior surfaces. This may happen, for instance, when humid indoor air meets a cold window. The measure of a product's ability to resist the creation of condensation is rated as *condensation resistance* (CR). The CR is shown as a number between 0 and 100. Higher numbers are preferable as they indicate that the product is better at resisting condensation formation. Not all manufacturers choose to include a condensation resistance rating on their product's label.

Windows can be described by three major components: style, glazing type and frame type. Each of these components work together to determine a window's energy efficiency and performance.

Style

Window styles by and large fall into one of two groups: operable or fixed. Operable windows can be opened to let air in or out. Fixed windows cannot be opened at all.

Both types of windows come in many different shapes and styles. Different windows are made from different materials or different combinations of materials. And, they each have varying degrees of energy efficiency depending on a number of factors.

Fixed windows are non-moving units permanently set within a frame. Fixed windows can let in light and heat, but not air. They come in many sizes as wells as in many shapes such as circles, half circles, octagons, and triangles.

Operable windows come in several forms and are identified based on the way the sash opens. (The Sash is "the portion of a window that includes the glass and the framing sections directly attached to the glass."[3]) Horizontal sliders and single-hung or double-hung windows are common in most homes. Sliders have one or both sections that slide horizontally on a track (single-sliding vs. double-sliding) and allow up to half of the total window area to be opened to the outside. Single and double hung windows have one or two sections that slide up and down vertically on a track. Like the sliders, the hung windows traditionally allow only one-half of the total window space to be opened at a time. Screens can be placed on either the interior or exterior of the building with these types of windows.

There are also awnings, hoppers and casements, which open more fully and can allow for better ventilation than sliders or hung windows. Awning windows are suspended from the top and swing out diagonally from the bottom. Hopper windows are hung at the bottom and open inwardly at the top. Casement windows, can open from one side inward or outward, and are hinged from the opposite side. These three types tend to be more energy efficient than sliders

[3] Efficient Windows Collaborative, glossary, "Sash"

and hung windows due to the idea that the sash closes flush with the frame. This results in less air leakage. Screens must be placed on the interior of the house for casement and awning-type windows. They need to be placed on the exterior for hoppers. Casements have an advantage of being able to be angled in such a way as to catch passing breezes.

Finally, there are Bay and Bow windows, which project outward from the home's wall. They generally have several sections, which may be operable, fixed or a combination of both. The operable sections are usually casements, double hung or single-hung windows.

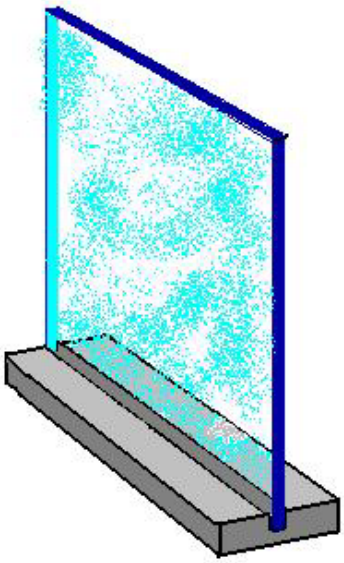
Glazing Type

Glazing is another word for the glass pane in windows, doors and skylights. (It can also be made out of plastic or a film material.) It is the glass part of the sash. Glazing type is quite possibly the biggest determinant of a window's efficiency.

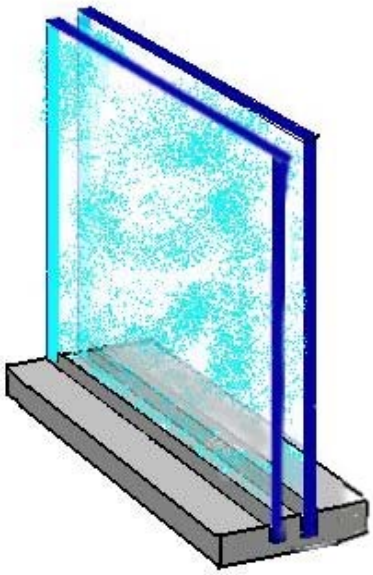
Windows can be single-glazed, double-glazed, or triple-glazed. Single-glazed windows have a single layer of glass. They offer very little insulation from heat loss or gain, and have low R-values.

Adding an additional layer of glass or two can significantly increase a window's ability to resist heat flow. Double-glazed windows normally contain two layers of glass that are separated by a sealed and air tight space. Triple-glazed windows have three panes of glass with two air spaces between them. The space between the panes may contain air or a special insulating gas. The layers of glass and air spaces help the window better resist heat flow. Multi-pane windows, especially triple-framed ones, may have more limited framing options due to their increased weight. Also, they can be more expensive than single pane windows initially, but the price difference may be made up in terms of energy savings.

As a rule of thumb, single glazing is the least energy efficient, triple glazing is the most efficient, and double glazing falls in the middle. This is because single glazing allows the highest heat gain in warm weather and the highest heat loss in cold weather. (It also allows the most light in.) Triple glazing has very low heat loss and heat gain rates.



Single-glazed window



Double-glazed window

Beyond varying amounts of glazing, there are additional treatments that some manufacturers can add to windows to make them more energy efficient. Tints, low-e coatings, gas fills, and low conductance spacers are some of the available technologies.

Tints

Glass can be manufactured with a bronze, gray, or even black tint. (Black-tinted glass is not recommended for warm climates.) Tinting does help reduce the solar heat gain (light and

heat from the sun) through windows. The potential downside of tinting is the reduced visibility from the inside. Also, some of the heat may be absorbed only to be released inside later on.

Low-e coatings

"The principal mechanism of heat transfer in multiplayer glazing is thermal radiation from a warm pane of glass to a cooler pane. Coating a glass surface with a low-emittance material and facing that coating in the gap between the glass layers blocks a significant amount of this radiant heat transfer, thus lowering the total heat flow through the window."[4] Low-e (Low-emittance) coatings are designed to reduce heat transfer and, subsequently, the U-factor. They are microscopically thin, transparent and reflective layers made of metal, metallic oxides, or a semiconductor film, which are added to one or more of a window's surfaces. They are either placed between panes on a plastic film or are added directly to the glazing, typically on the side facing the air spaces between panes.

The common type of coating is transparent to short-wave infrared radiation (visible light) but reflects long-wave infrared radiation (heat). In other words, the windows let in as much light as possible from the sun, but not as much heat. Heat also has a more difficult time escaping during the cold season. The combined factors may reduce energy loss by as much as 30% to 50%, which could offset their higher price tag.

"Different types of Low-E coatings have been designed to allow for high solar gain, moderate solar gain, or low solar gain."[5] Low solar gain Low-E glass, or spectrally selective low-e coatings, are considered the 'next generation' of low-e coatings. They can reflect 40% to 70% of incoming heat, while allowing nearly the same amount of light to enter as through clear

[4] Efficient Windows Collaborative: www.efficientwindows.org

[5] Efficient Windows Collaborative: www.efficientwindows.org

glass. They are well suited for warm climates, such as North Central Texas, where air-conditioning is needed more than heating.

An additional benefit of low-e coatings is that much of the ultraviolet rays from the sun are filtered out. This helps to prevent furniture, carpets, window treatments, and other fabrics from fading.

Gas-fills

Many manufacturers are now using a special gas to fill the air spaces found between the panes in double- or triple-glazed windows. This gas, krypton, argon or a combination of the two, has low-conductivity, which means that it acts as further insulation. In general, the movement of heat between the exterior and the interior is cut more than by filling the air spaces with just plain air. Krypton is slightly better than argon, but it is also more expensive to produce. It allows the air spaces to be thinner and it has a better thermal performance. Argon, is less expensive, but needs slightly wider air spaces. Some manufacturers combine the two gases as a compromise between cost and performance. Both gases are inert, nontoxic, clear, odorless, and occur naturally in the atmosphere. There is no known risk if one of these windows should break and permit the gas to escape.

Gas-filled windows have some advantages over air-filled windows. First, since the gases are less conductive of heat, they are better insulated, and thus have higher R-values and lower U-values. Second, the addition of gas makes it possible for the window unit itself to be thinner, especially when using krypton.

Low conductance spacers

Two or more panes of glass are separated at specific distances by spacers. Spacers are traditionally made of a metal such as aluminum, which is a ready conductor of heat. Use of aluminum spacers can reduce the benefits of better glazings.

"One approach to reducing heat loss has been to replace the aluminum spacer with a metal that is less conductive, e.g. stainless steel, and change the cross-sectional shape of the spacer. These designs are widely used in windows today."[6]

Other approaches include replacing metal spacers with materials that are better insulating.

Frame Type

The frame is the fixed part of a window that holds the sash, glazing, and hardware. The third major component of a window's design is the frame type. The type of framing material used (wood, aluminum, etc.) and how it is constructed, determines a window's frame type. It affects the U-factor and R-factor as well.

Since so many improvements have been made in the energy efficiency of glazing types, more attention has been given to frame type. Certain materials conduct heat more readily than others. Other materials are better at hindering heat flow.

Aluminum frames

Aluminum is lightweight, strong, durable, and easy to work with in terms of frame manufacture. Factory-baked enamel finishes can be added to frames for easy maintenance and to protect them from corrosion.

[6] Efficient Windows Collaborative: www.efficientwindows.org

On the downside, aluminum is a good conductor of heat. Aluminum frames readily allow heat to flow through them. To solve this problem, thermal breaks may be included in a window's design. A low-conducting material separates interior and exterior aluminum components. This technology has significantly reduced the U-values of aluminum frames, although not generally to the levels of other frame types.

Wood frames

Wood is a conventional framing material. It is often preferred because of its traditional appearance. Wood has a relatively low conductance of heat and wooden frames have average U-values. In some cases, the frame may be finished or painted to match an individual home's style. Wood is readily available and easy to work with from a manufacturing point of view.

Wood frames have a downside as well. Wood can shrink and swell which may cause warping, rotting, and sticking over time. Wood framed windows require maintenance, such as painting and staining, to prevent rotting and warping.

Wood clad frames, also known as vinyl-clad frames, offer a solution to that problem. They are wood frame windows that have the exterior side covered with a tough material such as aluminum or vinyl. The cladding protects the wood from the environment outside while maintaining the traditional appearance inside. It reduces maintenance considerably and will not rust or rot. Cladding does not appreciably affect the U-factor.

Vinyl frames

Window frames may also be made from a rigid vinyl. In terms of heat loss and gain, vinyl frames are comparable to wood and wood clad frames. Unlike wood frames, they do not

require painting and are basically maintenance free. Because of vinyl's versatile nature, frames are available in a wide range of colors, styles and shapes, and are easily customized. They are also competitively priced.

Some of the inherent problems with vinyl frames, such as fading colors and weakness, have been improved upon through recent advances. They can be built with improved stability and more durable coatings.

Insulated vinyl frames are essentially the same as standard vinyl frames except that the frame's hollow cavities are filled with insulation. They have improved thermal performance over standard vinyl frame, but the trade-off may be a higher solar heat gain coefficient.

Fiberglass frames

Using fiberglass as framing material is a relatively new, and promising, technology. It may not be, in fact, available in all areas. Fiberglass frames can reach very low U-values and solar heat gain coefficients, especially when used with a high-performance glazing. They will not shrink, swell, warp, rot, or corrode like wood or aluminum frames. Fiberglass frames may contain either hollow cavities or be filled with additional insulation.

Hybrids and Composites

Designs that use two or more of the available framing materials are called hybrids. Materials that are made by combining different materials are called composites. More hybrids and composite based materials are likely to enter the market as manufacturers continue to search for better-performing and cost-competitive designs.

Standards, ratings, and Certifications

National Fenestration Rating Council (NFRC)

The National Fenestration Rating Council is a non-profit organization formed by the window, door and skylight industry. They offer a standardized rating system on fenestration products. The NFRC strives to "provide accurate information to measure and compare the energy performance of window, door, or skylight products."[7] A voluntary national energy performance rating and labeling system has been established that endeavors to consistently rate U-factor, solar heat gain, visible light transmittance, and air leakage. The labels help consumers reliably compare one product to another in order to make the most informed decision possible about a purchase.

> "Fenestration: Any opening in a building's envelope including windows, doors and skylights."
> (Source: National Fenestration Rating Council: www.nfrc.org)

Energy Star

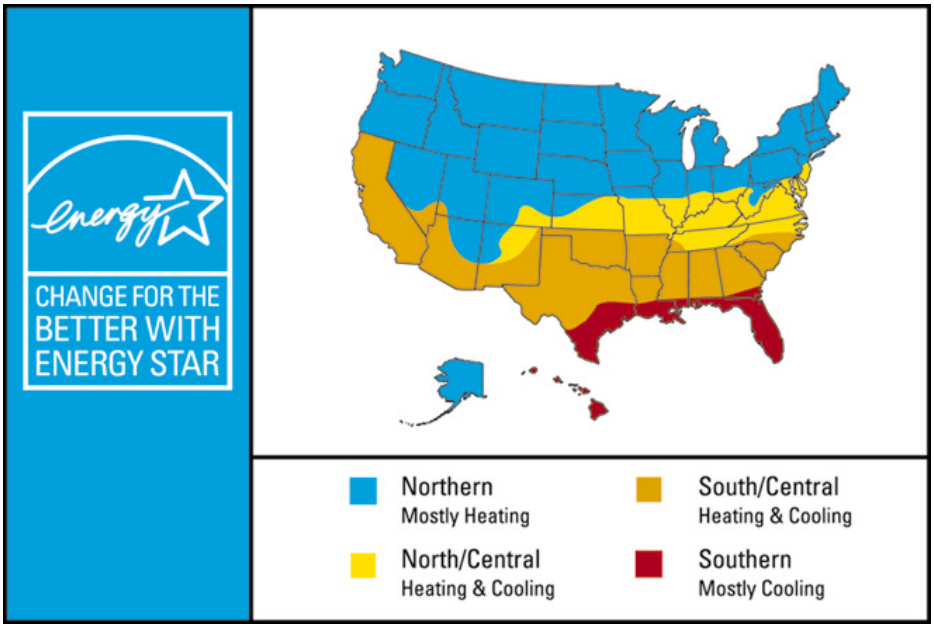
Energy Star, the U.S. Department of Energy's high efficiency rating program, provides the Energy Star label to certain window, door and skylight products. Products earning the Energy Star label are estimated to save up to 15% on energy

[7] National Fenestration Rating Council: www.nfrc.org

bills, which can be a "substantial" return on the initial investment. "ENERGY STAR qualified windows, doors and skylights also provide a host of benefits, including: increased comfort, noise reduction, and protection against sun damage to carpet, wood floors, furniture, fabrics and artwork in the home."[8]

Energy Star qualified fenestration products will also include a label from NFRC.

Because different parts of the country have different climates, Energy Star rates products for different areas.



North Central Texas falls in to the South/Central heating and cooling region. Qualifying products rated for this area must have both a U-factor and a solar heat gain coefficient (SHGC) rating equal to or below 0.40. Along with the Energy Star label, maps can be found on qualifying products indicating the regions(s) in which they qualify.[9]

[8] Energy Star Program: www.energystar.gov
[9] Climate Map, Energy Star Program: www.energystar.gov

Purchasing Tips

Windows are a long-term investment. They have a considerable impact on a home's energy usage, especially in terms of heating and cooling. Therefore, the purchase of a new window unit or the replacement of broken panes should be given careful thought. Many factors should be taken into consideration by homeowners in order to get the most out their money.

Labels

Two labels can provide valuable information to the consumer- the Energy Star label and the NFRC label. Looking for the presence of an Energy Star label is the fastest, easiest way to ensure an energy efficient purchase. For North Central Texas consumers, the Energy Star label should be found in conjunction with a map indicating the Southern/Central climate zone. Northern, Northern/Central, or Southern climate zone rated products are not necessarily the most efficient for this area of the country. Energy Star rated products for most of Texas will have a U-factor and an SHGC less than or equal to 0.40. A window with those values or lower can be considered high-performance windows.

Examining the NFRC label takes it a step further. The NFRC label allows the consumer to easily compare the energy performance levels of different windows. It gives the U-factor, solar heat gain coefficient (SHGC), visible transmittance (VT) and air leakage (AL) values estimated for each window. The Efficient Windows Collaborative recommends that homeowners in North Central Texas[10]:

- Select windows with a U-factor lower than 0.75 and preferably lower than 0.60.
- Select windows with a SHGC (solar heat gain coefficient) less than 0.40.

[10] Efficient Windows Collaborative: www.efficientwindows.org

- Select windows with a higher VT (visible transmittance) to maximize daylight and view.
- Select windows with an AL (air leakage) of 0.30 or less.

Features

Because there is such a wide array of window styles, colors, and features, it may be advisable for the homeowner to prioritize those features that are most important to them.

- Style- casement, sliding, fixed, etc.
- Glazing type- single-glazed, double-glazed, low-e coating, etc.
- Frame type- wood, vinyl, etc.
- Maintenance factors- how easy the window is to clean, etc.
- Daylighting- clear, tinted, etc.
- Aesthetic value
- Cost
- Security
- Comfort- noise and privacy considerations, etc.
- Energy Efficiency

Installation

There are many reputable companies that offer window installation services. The main thing for the homeowner to keep in mind is to ask questions. An educated consumer should be fully aware of a window's qualities before installation begins.

After a window is installed, the area around the frame should be airtight. This can be achieved by caulking and weather-stripping. Caulk is a compound used for filling in cracks and

holes that would otherwise allow air to move in or out of a dwelling. Weather-stripping is a thin strip of metal, vinyl, rubber, felt, or foam used for sealing the area between a window's sash and frame to prevent air and water leaks. This is a very cost-effective method to help increase a window's energy efficiency.

Window units can be custom fit for specific windows or various pre-determined sizes can be purchased.

Tips for Energy Efficiency

Aside from the purchase and installation of high-performance windows, there are other options for reducing heat gain in the home. Natural shading is one such option. Planting trees, especially by east and west-facing windows can help to reduce indoor temperatures. One estimate suggests that the inside temperature can be reduced by up to 20° F (11° C) just from shading. Mature trees may shade the roof as well. (See Appendix A for more tips on landscaping.)

Shutters and awnings can also be added around exterior windows, especially on south and west facing windows, to provide shading.

Applying sun-control, other reflective films, or solar screens to windows may reduce solar gain. Sun-control films, which may reflect up to 80% of the incoming sunlight, may be added to windows as well. They cut down on the amount of heat let in and are suitable for warm climates such as North Central Texas. The potential disadvantage to reflective films is that some

of them are tinted and may not let as much light in as a homeowner may wish. Solar screens can vary in price range. They can also be made by manufacturers or by the homeowners.

Storm windows may be added to either the inside or outside of windows to provide further insulation to single-glazed windows. They are an economical way of increasing the efficiency of older, low-performing windows. Storm windows may a film that can be easily installed and removed, or they can be more like a second set of windows.

There are things that can be done inside the home as well to cut down on the amount of heat entering windows, especially on south and west facing windows. White window shades, drapes, and blinds help reflect heat away from the house. Thermal draperies are specially made to block the sun's rays. Also, some blinds can be coated with reflective finishes that are more effective at reflecting heat. Shades and drapes should be closed during the day in order to keep heat out.

Case Study

The house on Cherry Street in Duncanville, Texas is an older home. Many parts of the house are in need of repair or replacement. The windows are one such example. Most of the windows are either horizontal or vertical sliders that have two separate pieces of glass with a

screen in the middle on the opening side and two fixed pieces of glass on the stationary side. The frame is aluminum. Most of the windows are sticky and are either difficult to open and close or will not open or close at all. As a result, several of the windows have one of the glass panes open all the time. In addition, the border around the windows (caulking and weather-stripping) is in very poor shape. Although the homeowner has not had an energy audit of the home, she can assume, with some degree of certainty, that the home is loosing a lot of energy through its windows, especially in the summer.

The homeowner is hoping to replace some or all of the windows at some point in the future even if none of them require emergency replacement. When the opportunity arrives for full window replacement, the homeowner wants high-quality, energy-efficient windows that do not cost a fortune.

For the sake of example, the replacement of one particular window will be demonstrated. The window, a bedroom window, is a horizontal slider and is 48” long and 34” high. It is a south-facing window that is partially shaded by a large tree at the far side of the yard from the tree. (A deciduous, native pecan tree has been planted in front of that window to shade it in the future). She wants the entire window unit replaced, not just the glazing. As a framing material, vinyl would be her first choice and aluminum her second. She does not want wood. She also wants one with a U-factor of at most 0.75, and preferably lower than 0.60. She wants the Solar Heat Gain Coefficient (SHGC) to be less than 0.4. Finally, she would prefer that the Visible Transmittance (VT) be as high as possible since she likes to use natural lighting during the day as opposed to light bulbs. This homeowner is extremely energy-conscious and would willingly pay a little bit extra for energy-efficient windows.

The homeowner is somewhat limited in her choices because of the size of the window and because it is a horizontal slider, which is not a common configuration. It will be necessary to have it custom-ordered.

For comparison, six different window models are used. Three of them are aluminum frames and three are vinyl. Three glazing and fill-types are used for each of the framing materials- standard insulated air-filled glass, low-E air-filled glass, and low-E argon-filled glass. They range in price from $116 to $181.*

* Note: The models and prices reflected in this comparison were obtained from only one company, M I Home Products via Lowe's. The purpose here is not to find the store and company with the cheapest prices; rather it is to simply go through the process of choosing window products. M I Home Products has both aluminum and vinyl framed windows. By using only one store, price comparisons may be made with greater relevance.

Product Comparison Chart for Windows

Product Description	Price	Dimensions	U-Factor	SHCG	VT	Air Leakage	Glazing type	Frame type	NFRC labeled	Color
B.B. Aluminum- standard w/air	116	48″ x 34″	0.72	0.56	0.55		double	aluminum	yes	white
B.B. Alum. Low-E w/air	131	48″ x 34″	0.41	0.32	0.55		double	aluminum	yes	white
B.B. Alum. Low-E w/ Argon	142	48″ x 34″	0.37	0.32	0.55		double	aluminum	yes	white
B.B. Vinyl- standard w/air	155	48″ x 34″	0.49	0.51	0.52		double	vinyl	yes	white
B.B Vinyl- Low-E w/air	170	48″ x 34″	0.35	0.29	0.48		double	vinyl	yes	white
B.B. vinyl- Low-E w/ Argon	181	48″ x 34″	0.31	0.28	0.46		double	vinyl	yes	white

Five of the windows have U-factors of less than 0.6. Four of them have Solar Heat Gain Coefficients of less than 0.4. The aluminum windows have the better Visible Transmittance, but this is probably because of the individual model, and not because of the aluminum frame. The aluminum windows are also about $40 cheaper than their vinyl counterparts. $40 is not unreasonable when considering only one window, but it would add up to quite a bit considering that the house has 6 slider windows and two large bow windows.

Any of the four low-E glazed windows would be acceptable window replacements. Since the home already has a highly efficient central air conditioner, high-efficiency windows would most likely make a significant impact on the home's cooling bills. Although, exact savings cannot be readily calculated or estimated, it is very likely that the addition of highly-efficient windows (in addition to the high efficiency central air conditioner already in place) would make a significant impact on the home's cooling bills.

Although argon-filled windows are the most efficient, the homeowner would most likely choose the vinyl low-e air-filled model. They are only approximately $30 more expensive than the aluminum argon-filled units and have better U-factor and SHGC ratings.

In either case, the homeowner would also include solar-screens (at a cost of approximately $17 each) on the two un-shaded windows in the home. The two rooms containing those windows tend to get very warm in the summer and she believes that cooling the rooms down can be accomplished by adding energy-efficient windows with heat-blocking screens.

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***Note:** Where websites are used as sources, the citation gives the name of the organization, the website address for the organization's home page, and the links followed to the pages where specific information may be found. For example, Energy Star Program- www.energystar.gov: Home> Products> Appliances> Dishwashers, means that the information can be found by going to the Energy Star website at www.energystar.gov, clicking on "Products", then on "Appliances", and finally on "Dishwashers".

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Air Conditioning and Heating

Introduction

As a nation, Americans have become very dependent on their air conditioning and heating appliances. According to the Office of Energy Efficiency and Renewable Energy, heating and cooling account for about 45% of a home's energy use.

Texans in North Central Texas are, in general, especially dependant on air conditioning. Given the choice, few would choose to be inside a building without air conditioning during a hot Texas summer. When a home air conditioning system conks out and the homeowner is facing another ninety-degree summer day, it can be very tempting to want to replace that system as quickly and cheaply as possible. When trying to choose a new system, homeowners do not always have the luxury of time to do research into its energy efficiency or the long-term costs or pay-offs.

While North Central Texas winters are mild compared to those in the northern states, homeowners still may not want to be without a heater for long periods of time. Like air conditioners, heaters often break down when they are needed the most and there is often little time for comparisons among models.

Air Conditioning and Heating Options

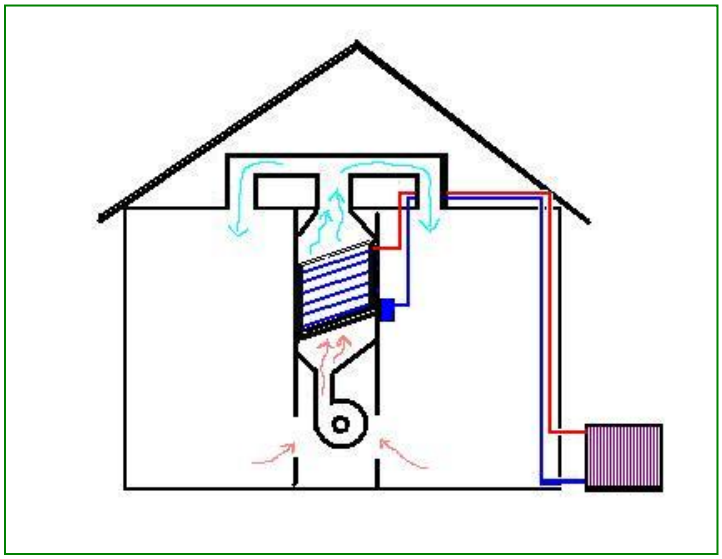
There are a number of different heating and cooling options available to homeowners, although choices may be limited due to the individual home's design. Most modern homes, for instance, have central heat and air while older homes rely more on furnaces for heating and room air conditioning units for cooling. In some cases, central heat and air systems may be added to an older home.

This section focuses on central heat and air systems, heat pumps (an alternative to central systems), furnaces, and room air conditioning units. It also focuses on tips for making a home more energy efficient, which, in turn, makes the heating and cooling systems work more efficiently.

How They Work

Central heating and air conditioning systems

Central heat and air systems are responsible for both the heating and cooling of a home as well as the cleaning and dehumidifying of its air. There are two main types of central systems: split-systems and packaged systems. The main difference between the two is that split-systems have both indoor and outdoor components, while packaged systems have only an outdoor component. Split systems are the common types found in most homes with central heat and air systems and are the ones that will be covered in this section.



Split system air conditioners have two main parts: the condenser (condensing coil and compressor) and the air handler (evaporating coil or evaporator coil). The condenser is located outside and contained within a metal cabinet. The air handler is located inside the home either in an attic or in a mechanical closet. The indoor evaporating coil is generally installed within the cabinet or main supply duct of a heating system such as a furnace or heat pump. Pipes that carry some type of refrigerant connect the indoor and outdoor parts.

Air conditioners do not actually the cool air. Rather, heat is absorbed from it. Air moves in a loop within the home. Cool air is released to the living area through supply registers (also called air ducts, supply ducts, or vents). As the air circulates through the home, it becomes

warmer. The warm air returns to the air conditioning system through return ducts located near the mechanical closet. It passes through a filter and into the air handler (a motorized fan, also called a blower) where the heat is absorbed by a refrigerant. It is then released through the ducts as cooled air.

It is the responsibility of a refrigerant (also called coolant), such as Freon or Puron, to absorb heat from indoor air. The refrigerant moves in a loop, as well, from the indoor evaporator to the outdoor condenser. It is forced through the evaporator and condenser coils (winding copper tubes or pipes) by a pump called the compressor, which is located in the outdoor part with the condenser. Inside, the liquid coolant evaporates into a gas. The gas absorbs the heat from indoor air as it passes over the evaporator coils. The heated gas then flows back outside to the condenser coils. Outside air is blown over the condenser coils by a fan. The refrigerant releases its heat to the outside air and then converts back to a liquid, completing the loop.

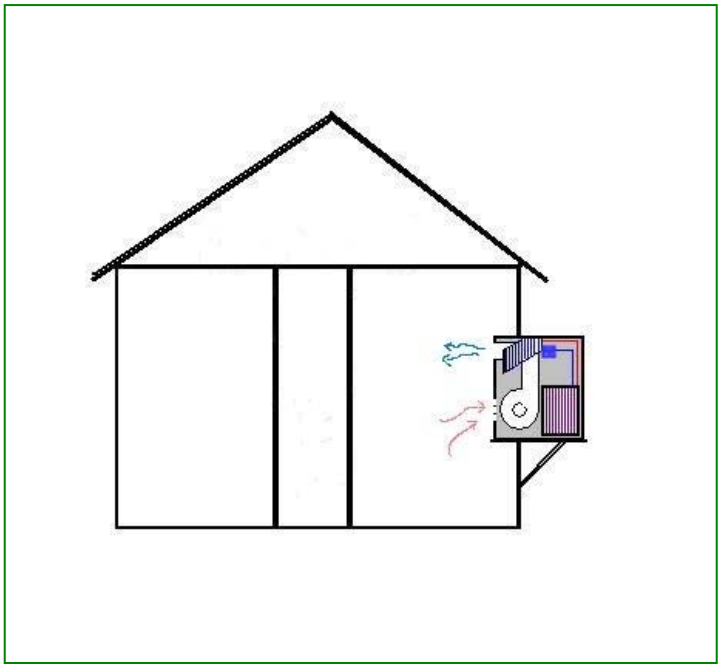
Over the years, air conditioning systems have been designed for greater and greater efficiency. Much progress has been made by manufacturers trying to produce more energy efficient units.

The segments labeled “furnaces” and “heat pumps” later in this section will explain more about the heating side of a central heat and air unit.

Room air conditioners

Room air conditioners, also known as window units or through-the-wall units, are used to cool single rooms rather than the entire house. They are generally not as efficient as central air conditioners but are more easily installed, especially in homes without existing central systems.

Room air conditioners work under the same basic principle as do central air conditioning units except that they do not perform the heating function. The unit is placed in a window or through a wall leaving half of it outside and half of it inside. A coolant is sent through the unit's coils by a compressor. Warm air is taken in and made to pass over the coils. As this happens, heat is absorbed from the air. The coolant carries the heat outside where a fan blows outdoor air over the coils to draw out the heat. Meanwhile, cooled air is released inside.



Furnaces

While winters in North Central Texas do not get and stay extremely cold, heaters remain a somewhat necessary part of homes in the region. And, it does get cold enough for parts of the winter, that when a heater goes out, it would need replacing quickly. Even when making a quick

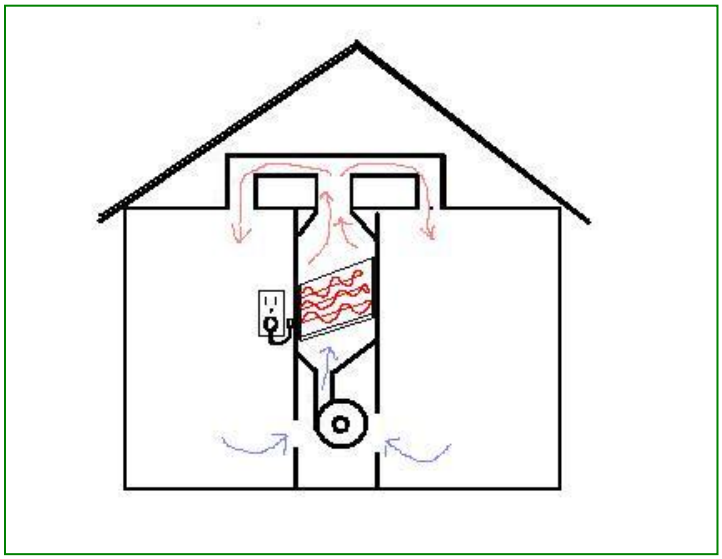
purchase, there are some things a homeowner can look for in order to get the most efficiency for his or her dollar.

Some furnaces are better at conserving energy than others. Higher efficiency furnaces do often come with a higher price tag, but they are generally cheaper to run and can save money in the long run.

Central air conditioning systems generally work in conjunction with a furnace. The two entities share an air-circulating fan and the ductwork through which air moves. Homes without central heat and air may have just a furnace.

Gas Furnaces

Gas furnaces operate by pulling cooled air in from the living area through return ducts, heating it, and returning warmed air through supply ducts. To create heat, fuel (generally gas or propane) is burned, which creates hot gasses. The gasses move into metal tubing called the heat exchanger and heat it up. The gases are then released outside through a vent pipe.



Cool air enters the supply ducts and passes over the hot heat exchanger. It then absorbs heat from the metal. The heated air continues through the ducts and back into the living area.

Electric Furnaces

Electric furnaces operate similarly to gas furnaces by pulling cooled air in from the living area through return ducts, heating it, and returning warmed air through supply ducts. However, instead of burning gas, electric furnaces use electricity. Electricity is run through a high resistance coil which produces heat and warms up a heat exchanger (also called a resistor). Air is forced across the heat exchanger by a fan, called the air handler. The warmed air then returns through a duct to the living area.

Electric furnaces do not generate carbon monoxide like gas furnaces. Therefore, they are considered somewhat safer. On the other hand, gas furnaces are normally cheaper to run than electric furnaces. The specific amount of savings depends upon the local prices for natural gas.

Heat pumps

Heat pumps, specifically air source heat pumps, are alternatives to traditional central heat and air systems and/or furnaces. Heat pumps tend to be less energy consuming than traditional systems, a fact that is creating more interest in them.

As with almost any major appliance, better heat pump efficiency may come with a higher price tag. However, the difference in cost can conceivably be more than recovered through savings in energy.

Heat pumps can work with a conventional central heat and air system by replacing the furnace. Or, another type can function as both air conditioner and heater. They may also perform the functions of dehumidifying and cleaning indoor air.

Heat pumps for cooling

The cooling function of a heat pump is not unlike a traditional air conditioner. During warm weather, heat is absorbed from indoor air by a refrigerant and released outside. Also like most residential systems, most heat pump systems are split meaning that they have both outdoor and indoor coils with a coolant flowing between them. Indoor air is moved through supply and return ducts by an air handler (also called a fan or a blower).

Heat pumps for heating

Heat pumps distinguish themselves by their heating function. Rather than converting heat from a fuel, as does a furnace, heat pumps move heat. Essentially, a heat pump works the same as an air conditioner, only in reverse. Through this process, a heat pump can produce one-and-a-half to three times more energy (in the form of heat) than it consumes. Homeowners can potentially realize a significant savings on energy bills by installing a heat pump.

Even very cold outdoor air, down to around 40°F, has some heat. Heat pumps remove some of that heat from cold outside air during cold weather and transfers it to the inside air. When outdoor air temperatures fall below 40°F, back-up gas systems or electric resistance coils kick in to provide indoor heat.

Heat is absorbed from cool outdoor air by a refrigerant, which "moves it inside as it evaporates into a gas. The indoor coils transfer heat from the refrigerant as it condenses back into a liquid. A reversing valve, near the compressor, can change the direction of the refrigerant flow for cooling as well as for defrosting the outdoor coils in winter."[11]

[11] Air-Source Heat Pumps, Office of Energy Efficiency and Renewable Energy: www.eere.enegy.gov

Heat pumps may be more sensitive to the problems related to substandard installation, inadequate maintenance and duct losses than traditional furnaces. These are, however, problems that can be easily remedied.

Cooling capacity

Cooling capacity is the ability of an air conditioner or heat pump to remove heat from air inside the home. The capacity is measured in terms of either how many Btu's or how many tons an air conditioning unit can remove in one hour. Window units start at a capacity of around 4,000 Btu's. Central air conditioners start at around 1.5 tons and can reach up to about 5 tons. Heat pump cooling capacity is measured in tons as well.

One Btu, or British thermal unit, is equal to 1,055 joules. (More specifically, "a Btu is the amount of cooling capacity that will lower the temperature of a pound of water by one degree Fahrenheit.") 12,000 Btu's equals 1 ton (derived from the notion that it takes 12,000 btu's to melt on ton of ice). (Sources: *Air Conditioning*- www.ci.austin.tx.us/greenbuilder and *Air Conditioning The Cool and E-Z Way*, page 84)

Seasonal Energy Efficiency Ratio (SEER)

Each air conditioner or heat pump has what is called a SEER, or Seasonal Energy Efficiency Rating, that measures its cooling capacity. Mathematically, it is the dividend of Btu's (cooling output) divided by watts (energy input). Fundamentally, it is the measure of how much a unit cools compared to how much energy it consumes. The SEER is shown on the Energy

Guide label placed on air conditioning units. The more efficient the air conditioner, the higher the SEER it will have.

As of 1992, both split-system central air conditioners and air-cooling heat pumps are required, by federal standards, to have a SEER of at least 10. The U.S. Department of Energy has established the testing procedures which determine a system's SEER. Those procedures are listed in Title 10 of the Code of Federal Regulations.

Energy Efficiency Ratio (EER)

Room air conditioners are required to meet minimum Federal standards of energy efficiency in terms of their energy efficiency ratio (EER). "The EER is the cooling capacity in BTUs divided by the watts."[12]

Heating capacity

Heating capacity is the ability of a furnace or heat pump to provide heat.

AFUE

The overall performance of a gas furnace is determined by its Annual Fuel Utilization Efficiency (AFUE) ratings. It is an indication of the efficiency with which a furnace converts fuel to heat. Higher AFUE ratings indicate higher efficiency while lower ratings indicate lower efficiency.

[12] Energy Star Program: www.energystar.gov

The minimum AFUE rating, set by the government in 1992, is 78%. Mid-efficiency furnaces range between 78%-80% and high-efficiency furnaces range between 80%-96%.

Heating Seasonal Performance Factor (HSPF)

The Heating Seasonal Performance Factor (HSPF) is a measure of a heat pump's heating capabilities. Mathematically, it is the dividend of Btu's (heating output) divided by watts (energy input) in terms of Btu's harvested per watt-hour used. Fundamentally, it is the ratio of how much heat a unit puts out compared to how much power it consumes. The higher the HSPF, the more energy efficient a unit is. The efficiency of a heat pump will be higher in a mild climate such as North Central Texas, than in a cold climate.

As of 1992, split-system heat pumps are required, by federal standards, to have a HSPF of at least 6.8. The U.S. Department of Energy has established the testing procedures which determine a system's SEER. Those procedures are listed in Title 10 of the Code of Federal Regulations.

Note

From this point on, the term "air conditioner" or "air conditioning system" will refer to the entire split-system cooling and heating system including the furnace. Also, the term "heat pump" or "air source heat pump" will refer to a split-system heat pump that has both heating and cooling capabilities.

Standards, Ratings, and Certifications

Energy Star

Energy Star, the U.S. Environmental Protection Agency's high efficiency labeling program, sets high standards for air conditioning and heating products. The primary goal of Energy Star is to reduce pollution by reducing home power consumption through the use energy efficient products. Energy Star estimates that "if one household in ten bought cooling and heating products that have earned The Energy Star, the change would keep 17 billion pounds of pollution out of our air."[13] The second goal of its labeling program is to help consumers save money by purchasing energy efficient products. "Though these products can be more expensive to purchase up front, the cost difference will be paid back over time through lower energy bills."[14]

Energy Star readily provides lists of companies that make products earning the Energy Star label as well as lists of products themselves. It is also a source of practical information for consumers.

[13] *Guide to Energy Efficient Cooling and Heating*, page 2
[14] Energy Star Program: www.energystar.gov

Equipment	Federal Standard	Energy Star Standard
Split-system Central Air Conditioner	SEER of at least 10	SEER of at least 13
Split-system Air Source Heat Pump	SEER of at least 10	SEER of at least 13
	HSPF of at least 6.8	HSPF of at least 8.0
Furnace	AFUE of at least 78%	AFUE of at least 90%

These tables compare the Energy Star minimum standards to the Federal minimum standards of certain air conditioning and heating products. (Source: Energy Star Program: www.energystar.gov)

Room Air Conditioner				
Capacity (Btu/Hr)	**Federal Standard, with louvered sides**	**Energy Star Standard, with louvered sides**	**Federal Standard, without louvered sides**	**Energy Star Standard, without louvered sides**
< 6,000	EER of at least 9.7	EER of at least 10.7	EER of at least 9.0	EER of at least 9.9
6,000 to 7,999				
8,000 to 13,999	EER of at least 9.8	EER of at least 10.8	EER of at least 8.5	EER of at least 9.4
14,000 to 19,999	EER of at least 9.7			
≥ 20,000	EER of at least 8.5	EER of at least 9.4		
	Federal Standard EER		**ENERGY STAR EER**	
Casement-only	EER of at least 8.7		EER of at least 9.6	
Casement-slider	EER of at least 9.5		EER of at least 10.5	

The Air-Conditioning and Refrigeration Institute (ARI)

The Air-Conditioning and Refrigeration Institute (ARI) is a nonprofit national trade association representing manufacturers of central air conditioning and commercial refrigeration equipment. ARI develops and publishes technical standards that establish rating criteria and procedures for air conditioning and refrigeration products to measure and certify their performance. Voluntary ARI certification programs "protect the consumer and assure fair and honest competition by subjecting products to testing by independent laboratories to verify accuracy of performance ratings by manufacturers."[15] Many ARI standards are accepted and used as American National Standards.

Purchasing Tips

Central heating and air conditioning systems

"Air conditioners come in various sizes, cooling capacities and prices."[16] Choosing among the alternatives can seem either overwhelming or unnecessary. After all, contractors and technicians are supposed to know what they are doing and should be able to guide the homeowner in making the best choice. However, turning all the decisions over to a contractor or technician is not always the best thing to do. An energy-wise consumer is an educated consumer- one who knows which questions to ask and which answers to expect.

[15] *Some Matches Don't Make Sense*
[16] Brain, Marshall. *How Air Conditioners Work*

Determining the Need for a new system

Often, an existing air conditioning system that is acting up can be repaired and will continue to function usefully for a given time. However, two other scenarios may come into play. One is that the unit cannot be repaired or that the cost of a new system will not significantly outweigh the cost of the repair and subsequent repairs. The other is that the unit is an older unit which can be repaired, but replacing the system with a more efficient new system would result in enough energy savings to offset the cost of replacing vs. repairing. An air conditioning system may need replacing if it meets certain criteria:

- If a system is more than ten years old, it may not be as efficient as newer models. Replacing the unit before it completely wears out may be more cost effective through decreased energy bills.
- If an air conditioner needs frequent repairs and the home's energy bills have increased, the system may have become less efficient. Replacement may be a viable option. Extra money spent on replacing rather than repairing could be returned in the form of lower maintenance and servicing costs as well as decreased energy bills.
- If some of the rooms in a home are too hot or too cold despite thermostat controls, ineffective equipment operation, problems with the ductwork, or poor insulation could be to blame. This does not necessarily mean a new system is required, but it does indicate problems which need addressing.
- If a home has problems with excess humidity, several factors may be at the root of the problem. The system may not be functioning properly, for instance, and may require a service call. Or, the system may be too big or too small. Leaky ductwork may also be a culprit in humidity problems.
- A system that is noisier than it should be may indicate a problem with the indoor evaporator coil. Or, an undersized duct system may also cause noisy conditions and should be inspected.

Getting the right size

For highest possible energy efficiency, it is essential that an air conditioning system be the correct size for the home where it is being installed. Oversized or undersized units cannot function as efficiently as correctly sized ones.

Undersized units are forced to work too hard and may wear out sooner than they should. In addition, they may not be able to meet a home's heating or cooling demands.

Oversized units cost more and use more electricity than necessary. They may cycle on an off more frequently than a smaller unit would. This may cause uneven cooling within a home. Shorter cycles may also inhibit the dehumidifying function of a unit since systems generally do not begin removing moisture from the air for about ten minutes. Also, the frequent cycling puts more wear and tear on the compressor and electrical parts.

The size of an older system should not be used to determine the size of a new one. The original system, for instance, may have been incorrectly sized. Or, changes in the home such as room additions or improvements in insulation may have affected the size requirements.

Contractors should use a calculating tool called "Manual J" or something like it to determine the best size of air conditioning equipment. The Air Conditioning Contractors of America (ACCA) and the American Society of Heating and Refrigerating (ASHRAE) are two groups that set procedures for sizing calculations. Sizing requirements may depend on factors such as which direction widows face and how many there are, how well the home is insulated, how big the home is, how well the walls, windows and roof are shaded, and how well sealed the house is.

Homeowners may request a copy of the design load calculations used to determine the size of their unit. Contractors who base the size of a system solely on a home's square footage should not be hired.

Matching the units

There are situations where only one component of a split system may need replacing. For instance, the compressor may go out, but the evaporator might still work. It would be tempting in that situation to replace only the outdoor part. But, matching indoor parts to the outdoor parts is the only reliable way to know an air conditioning system is reaching its fullest energy efficiency. The two parts are specially designed to work together as a coordinated set.

Checking efficiency ratings

Systems with higher efficiencies do tend to cost more than ones with lower efficiencies. However, they are generally worth the extra cost since that money will probably be repaid several times over the lifespan of the system in lower operating costs. Systems with SEER's of at least 12 or 13 are recommended for this climate.

Most utility companies offer rebates on ARI-certified combinations of coils and condensing units. It may well be worth a homeowner's time to call their local utility company to inquire about such rebates. The utility companies benefit because efficient systems reduce their need to build more power plants.

Web Sites of Major Retail Electric Providers in North Central Texas

First Choice Power
www.firstchoicepower.com

TXU Energy, Inc.
www.txu.com

WTU Retail Energy
www.wturetailenergy.com

Room air conditioners

Determining the need for a new system

Often, an existing air conditioning unit that is acting up can be repaired and will continue to function usefully for a given time. However, two other scenarios may come into play. One is that the unit cannot be repaired or that the cost of a new system will not significantly outweigh the cost of the repair and subsequent repairs. The second is that the unit is an older unit which can be repaired, but replacing the system with a more efficient new system would result in enough energy savings to offset the cost of replacing vs. repairing.

Getting the right size

The first step that a homeowner should take when replacing a room air conditioner is to measure the square footage of the room in which it will be placed. Energy Star suggests the following formulas for measuring a room:

- Square and rectangular rooms- the length of the room should be multiplied by the width (area = length x width)
- Triangular rooms- the length of the room should be multiplied by the width and the product divided by 2. (area = (length x width) / 2)
- "Most rooms can be further divided into these basic shapes to determine the square footage."[17] (ES: I.A.4.h)

[17] Energy Star Program: www.energystar.gov

- A sales associate should be able to help determine the square footage of a room shape other than those listed above.

The second step is to determine the best size of unit for the room. It is especially important to remember that a unit that is either too big or too small will not cool as effectively as it should. A unit that is too big, for example, may cool a room quickly, but will probably cost more than and not remove the suitable amount of humidity from the air as would a smaller appropriately-sized unit. The unit with the correct capacity will get the best results.

Energy Star offers the chart[18] on the right for choosing the best size (capacity measured in Btu's per hour) of room air conditioner:

Area To Be Cooled (square feet)	Capacity Needed (BTUs per hour)
100 to 150	5,000
150 to 250	6,000
250 to 300	7,000
300 to 350	8,000
350 to 400	9,000
400 to 450	10,000
450 to 550	12,000
550 to 700	14,000
700 to 1,000	18,000
1,000 to 1,200	21,000
1,200 to 1,400	23,000
1,400 to 1,500	24,000
1,500 to 2,000	30,000
2,000 to 2,500	34,000

Because rooms are different, windows face different directions with differences and shading, and because rooms are used for different functions, Energy Star[19] also offers the following adjustments to the chart:

- If the room is heavily shaded, capacity should be reduced by 10 percent.
- If the room is very sunny, capacity should be increased by 10 percent.
- If more than two people regularly occupy the room, 600 Btu's should be added for each additional person.

[18] Energy Star Program: www.energystar.gov
[19] Energy Star Program: www.energystar.gov

- If the unit is used in a kitchen, capacity should be increased by 4,000 BTUs.

In addition to knowing the size of the room, it is vital to know the dimensions and location of the window in which the unit will be placed. Also, the homeowner should be aware of the voltage requirements of the unit. Most units are powered by a standard 115-volt outlet, but some window units may be rated for 230-volts and may call for a special circuit.

Checking efficiency ratings

The bright yellow Energy Guide labels are a valuable source of information for the prospective buyer. The label lets the buyer know upfront how much energy the unit will consume and gives an estimated annual operating cost. Also, a consumer should keep in mind that higher EER ratings will result in greater savings. For North Central Texas, EERs over 10 are recommended.

Other

Clean filters are essential for high efficiency performance. Therefore, an air conditioning unit whose filter slides out easily is desirable.

Moreover, it is advisable for the consumer to inspect what controls are available. Thermostats that may be set with digital readouts and built-in timers, for instance, make the unit more adjustable which can result in lower energy use.

Furnaces

Before purchasing an entirely new furnace, the homeowner should carefully consider the option of retrofitting the existing unit. "Retrofits to existing gas heating systems usually include new controls, pumps, or distribution systems. These upgrades improve the safety and efficiency of otherwise sound, older systems."[1] However, when a furnace does need replacing, there are some guidelines that can be followed.

Getting the right size

When purchasing any new major appliance, the consumer must be sure to get the right size for their specific needs. In the case of a new furnace, the heating capacity should be appropriate for the specific home. Furnaces that are too large do not operate at peak efficiency because they cycle on and off more often than necessary. Plus, larger systems boost up the purchase price. A contractor should perform a heat loss analysis of the particular home in order to size the new furnace appropriately.

If energy-efficient improvements, such as better insulation or upgraded windows, were made to the home after the older furnace system was installed, a new furnace may not need to be as big or powerful as the old one.

Heat pumps

Once the need for a new system has been established, homeowners should consider replacing the home's air conditioning system with an air source heat pump. They are more expensive to install, but significant savings can be realized on monthly heating costs.

[1] *Energy-Efficient Gas Heating for the Home: www.eere.energy.gov*

Getting the right size

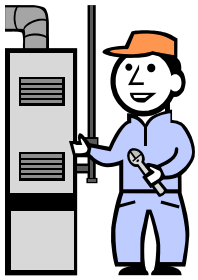
Getting the right size of heat pump is just as important, if not more so, as getting the right size of central air conditioning system. Contractors should use sizing methods accepted by the heat pump industry as opposed to using 'rule-of-thumb' sizing techniques.

Checking efficiency ratings

A heat pump's SEER rating is located on the Energy Guide label just as with a central unit.

Installation Tips

Hiring and working with a contractor



A contractor is person or company with whom a homeowner does business. The person performing the work in the home is not necessarily a contractor. Rather, technicians are hired by contractors to perform services in the field. Technicians are not required to have any special certifications or training. That is not to say that most technicians do not have training, it is only saying that they are not required to have any special skills.

An air conditioning and heating service contractor, on the other hand, must be certified by the Texas Department of Licenses and Regulations before they or their representatives can accept payment for services. Homeowners may verify certification by contacting the Texas Department of Licensing and Regulations in Austin, Texas. From this point on, the term "contractor" will refer to a licensed contractor, a dealer, or the technician representing them.

The term "general contractor" does not imply certification. People with the title of general contractor are not required to be certified, although they cannot take money for air conditioning and heating services unless they are licensed.

Hiring a new contractor can be a little overwhelming. In any given town, there may be 50 or 60 different contractors from which to choose. There are a few simple steps that can help narrow down the choices. First of all, consumers can take advantage of the Texas Department of Licensing and Regulations or the Better Business Bureau. Word of mouth is also a good source of information- friends and trusted neighbors may be able to provide either recommendations or warnings.

Service calls by a technician can go a bit smoother if some preparation is taken. First of all, it is a good idea for the customer to know the locations of outdoor condensers, mechanical closets, attic units, ducts, and fuse boxes. It also helps if the technician has unrestricted access (nothing in the way) to attics, mechanical closets, outdoor units, and breakers.

There are a few things that a homeowner should expect from the contractor during the early stages of air conditioner, furnace, or heat pump replacement. The contractor should use a computer program or written calculation to size the systems and the homeowner should receive a copy of the calculations. In addition, a written contract that lists the major points of the installation and a written warranty on equipment and workmanship should be provided. Finally, the homeowner should be allowed to hold the final payment until the work is completed satisfactorily.

Central heating and air conditioning systems

Upon completion of air conditioner installation, the technician should perform several tasks. They should, among other things, check the amount of coolant, test for coolant leaks, check for seal and duct leakage, measure the air flow through the evaporator coil, clean and tighten electrical connections, lubricate moving parts, and check the thermostat for accuracy.

Room air conditioners

There are a few things that a property owner should keep in mind when installing a new window air conditioning unit. First of all, if possible, the unit should be located on the shadiest side of the house. Also, if possible, it should be located near the center of the room. Furthermore, after being placed in the window or wall, gaps around the unit should be sealed with a foam weather-stripping material to minimize air leakage.

Heat pumps

Proper installation of heat pumps can avoid most common comfort and performance problems. Air circulation may be improved by providing unobstructed pathways back to return registers. This can be accomplished by installing grills or ducts between rooms and adding return ducts to rooms that have supply registers, but no return ones.

It is imperative that heat pumps contain the correct amount of refrigerant. The technician should verify that the heat pump is within a few ounces of the charge specified by the manufacturers. Performance and efficiency are reduced when there is either too much or too little refrigerant. In addition, the system should be checked for leaks.

Maintenance and Cleaning

Central air conditioning systems and heat pumps

Clean air conditioning and heating systems mean better efficiency and less wasted energy. Well maintained systems mean better efficiency plus less wasted money on repair bills. "Preventive maintenance is the least expensive kind."[2] Many contractors offer service contracts for performing routine maintenance. The Air-Conditioning and Refrigeration Institute generally considers the cost of service contracts to be good investments. The maintenance checks include such tasks as cleaning compressor coils, checking for refrigerant leaks, lubricating moving parts, and so on. These should preferably be done twice a year- once before the heating season, and

[2] *Consumer Guide to Efficient Central Climate Control Systems*: www.ari.org:

once before the cooling season. This may help prevent major break-downs during the coldest or hottest parts of the year.

Cleaning or changing filters is one of the most important maintenance tasks that can be done, and it can be completed by the home's proprietor. If filters get dirty and clogged, air cannot flow smoothly into the air handler. This causes inefficient operation by the system. Plus, air carrying dirt can bypass the filter causing the evaporator coils to get dirty, which reduces their heat-absorbing capacity. Filters may need cleaning or replacing more often than what is recommended by the manufacturer, especially during the cooling season, in dusty areas or in homes with fur-bearing pets.

Outdoor condenser coils can get very dirty. When this happens, air flow is restricted. With the power off, the condenser can be washed with a water hose. Additionally, homeowners are discouraged from planting tall foliage within 2 feet (0.6 meters) of the outdoor cabinet.

Window units

Keeping a room air conditioner in good working condition is a key to keeping efficiency up. The owner's manual for individual units is a good source of information on maintaining that unit. Sears, for instance, recommends that the unit be serviced every year by a service technician before it is turned on.

Keeping the filter clean is an elemental step in keeping the unit in good working condition. Build up of dust, pollen, and other particles can cause the unit to work harder or even cause frost

on the cooling coils. It should be checked at least once a month and cleaned, if necessary, especially in dusty areas or during a heavy pollen season. The owner's manual should give advice on the best way to clean the filter.

It is possible to store the window unit during winter. In this case, it should be covered or returned to the original box and stored in an upright position and in a dry place.

Furnaces

Routine maintenance, cleaning, and servicing will help keep furnaces in top working order, at top efficiency, and in safer condition. Keeping up the routine maintenance can be cheaper than not keeping it up and having to replace the system sooner.

Energy Star recommends that the furnace system be checked by a contractor twice a year during the spring and the fall. The following is a partial maintenance checklist:

- The thermostat should be checked to make sure that the air conditioner and heater cuts on and off at the correct temperatures.
- Faulty electrical connections can cause unsafe conditions and shorten the lives of major components. Therefore, those connections should be checked and tightened and the voltage and current on the motor should be measured.
- To reduce friction on motors and thereby reduce the amount of electricity consumed, all moving parts should be lubricated.
- The system's controls should also be checked to assure safe and proper operation.
- Gas, or oil, connections, gas pressure, burner combustion, and the heat exchanger should be checked as defective connections can be a fire hazard and even cause heath problems. "A dirty burner cracked heat

exchanger causes improper burner operation. Either can cause the equipment to operate less safely and efficiently."[3]

- A cracked furnace can cause carbon monoxide leaks. This can lead to carbon monoxide poisoning for a home's inhabitants. Routine maintenance checks should detect such leaks.

Additionally, the homeowner should check the air filters once a month and clean or replace air filters as needed. Dirty filters can cause the system to work harder than it should need to. They can cause damage which may eventually lead to a breakdown of the appliance. Furthermore, it is inadvisable for the home's residents to store anything near gas furnaces or in gas furnace closets.

Tips for Energy Efficiency

Buying an energy-efficient heating and/or cooling system for the home is only one part of increasing a home's energy efficiency. There are many, many more things a homeowner can do to save energy in the home.

There are three major benefits from increasing a home's energy efficiency. The first, most obvious, benefit is saving money. Increased efficiency means less energy consumption, which translates into increased monetary savings.

The second benefit is the reduction of wear and tear on the heating and cooling systems. In summer, for example, a well-sealed home lets in less warm air. This means that the air

[3] *Guide to Energy Efficient Cooling and Heating, page 6*

conditioner has less work to do to cool the air. That means that it may require less maintenance and could possibly last longer.

The third benefit is to the environment. When a home is more energy efficient, smaller quantities of pollutants are sent into the air from power production facilities. Also, fewer natural resources (fossil fuels, coal, etc.) are consumed in the creation of that power. To take it a step further, one could say that when the environment benefits, humans and human health benefits.

There are a number of factors which influence the amount of energy consumed by a home. The number of people inhabiting the home and their living habits, the thermal integrity of the house's structure, and the relative efficiency of the heating and cooling system are some major ones.

Heat buildup is another major factor. Heat entering the house through the walls, roof, and windows in the form of sunlight is a principal source of heat buildup. Taking measures to reduce the amount of heat allowed to be absorbed can help reduce the amount of air conditioning a home needs as well as serve to lower air conditioning bills. Listed below are some such measures. They do not all have to be completed in order to improve efficiency and some are not feasible with all homes. However, any one of these tips will go a short way towards energy conservation:

- Exterior walls should be painted a light color since dull and dark colored walls can absorb up to 90% of the sun's radiant energy and then transfer that heat into the home.
- When replacing a roof, light colored materials ought to be used. Ideally, a roof would consist of bright white or shiny materials, although this is out of the question on most homes.

- Radiant barriers can be installed in the attic to reflect a large portion of the incoming heat from the sun.
- Reflective coatings may be added to windows or windows may be replaced with higher efficiency ones.
- Attics and walls should be insulated.
- Areas around windows, doors, and other gaps, cracks and holes should be caulked and weather-stripped to keep out cool drafts in cold weather and keep in cool air during warm weather.
- Landscaping with shade trees, bushes, or vines can significantly cut down on the amount of light and heat although that shading should allow for unrestricted air circulation (See Appendix A for more tips on landscaping.)
- Adding awnings and shades around windows provides extra protection from heat and light.
- Inside the home, drapes, thermal drapes, and shades can help keep heat out, especially if they are closed during parts of the day when the sun directly hits them.
- Attic ventilation removes built-up heat from the attic .
- Heat generating appliances such as washers, driers, water heaters, refrigerators, dishwashers and ovens can be isolated and/or used during cooler parts of the day.
- Exhaust fans near ovens and ranges help to remove the extra heat and humidity that are the byproducts of cooking.
- When the air conditioner is on, attic and window fans should not be run.
- Excess heat and moisture from clothes dryers can be removed from the home by providing a vent to the outside, or they can be avoided altogether by line drying outside.

- Turning lights off when they are not in use and replacing standard light bulbs with energy-efficient fluorescents would cut down on both electricity use and on indoor heat generation.

Light Source	Wattages	Avg. Rated Life (Hrs.)	Advantages	Disadvantages
Flourescent	4-215	7,500 - 24,000	do not produce much heat, long lasting very efficient	high purchase price, limited bulb choices
Tungsten Halogen	10-1,500	2,000 - 4,000	low purchase price, large variety	produce a lot of heat, fire hazard, limited choices
Standard Incandescent	3-1,500	750 - 2,000	low purchase price, large variety	produce a lot of heat, high operational cost, short life

(Source: *Lighting:* www.ci.austin.tx.us/greenbuilder)

- The level of outdoor humidity should be considered before doors and windows are opened as air conditioners must work to remove excess humidity from the air.
- Thermostats should be set at a comfortable temperature and left alone since continuous re-setting ends up wasting energy.
- Unused rooms should not have blocked or closed air supply registers in a central air conditioned house. Air should be able to move freely throughout a house in order to function at peak efficiency.

More information is readily available on any one of the previous tips. The United States Department of Energy and its related programs as well as many other dependable sources eagerly provide reliable information to consumers.

In addition, some utility companies offer energy audits of homes. A fee may be charged for the service, but it could be worth it to homeowners since the audits reveal ways to improve a

specific home's energy efficiency. The auditors may be able to give estimates on how much energy improvements would cost as well as how much energy can be saved by making said improvements.

Finally, it is important to note that "an enormous waste of energy occurs when cooled air escapes from supply ducts or when hot attic air leaks into return ducts. Recent studies indicate that 10% to 30% of the conditioned air in an average central air conditioning system escapes from the ducts."[4]

Ducts must be as airtight as possible for cooling equipment to be at is highest performance level. Although they are difficult to find, qualified professional contractors have the experience and equipment to detect and seal leaky ducts. They look for appropriate insulation in addition to tight seams and joints. Ducts should be checked periodically to ensure an effective system. It is estimated that wasted air before testing and repair is 25%. The goal is to get leakage to below 10%.

Programmable Thermostats

Programmable thermostats are found in more and more homes. They help increase a home's energy efficiency because they can be programmed to keep the temperature at different levels during different parts of the day. In addition, they can be manually changed at any time to suit the existing situation without changing the overall programming.

[4] *Energy-Efficient Air Conditioning:* www.eere.energy.gov:

For example, a home's occupants may find 74 degrees to be a comfortable temperature level. During the summer, the air conditioner has to work hard to retain that cool of a temperature. During the winter, the furnace must work to keep up that level of warmth. They both consume energy in the process. When the occupants are gone to school or work for extended periods during the week, the home does not need to remain at 74 degrees. Doing so, results in a large waste of energy. The home can reasonably get several degrees above that temperature during the summer or below it during winter. A programmable thermostat allows the inhabitants to set higher or lower temperatures for times when they are away from home. This way, they do not forget to set it before they leave or have to reset it again when they return- the thermostat adjusts the temperature automatically. The key advantage of a programmable thermostat is that it can be facilitate energy conservation, and consequently, money. (Energy Star I.B.6)

One estimate claims that if the heat is lowered by just one degree for eight-hours a day, there will be a 1% drop in the home's heating energy costs. Alternately, if the air conditioning is raised by one degree for eight-hours a day, there will be a 1% drop in the energy bill. The number of degrees raised or dropped is proportional to the percent-savings on the energy bill (10 degrees up or down depending on the season equals a 10% savings, etc.) One further estimate says that a dwelling can save around $100 per year by aptly using a programmable Thermostat.

Programmable thermostats should be set lower or than comfortable in winter and higher than normally comfortable in summer while occupants are away from the home for more than four hours at a time. 82 degrees is the recommended maximum temperature during warm periods. It is also a good idea to set them higher on summer nights or lower on winter nights while residents are asleep.

While the inhabitants are home and active, the thermostat should be set at a comfortable level and left there. It should not be frequently re-adjusted. The recommended efficient level for warm-weather daily use is between 78 and 80 degrees. However, during times of high humidity, the air conditioner will require a lower temperature setting in order to remove the extra moisture from the air.

Ceiling fans and other small electric fans can be used to circulate air in inhabited rooms. The moving air has the effect of making a room seem cooler which allows the thermostat to be set higher while maintaining a good comfort level. Fans should be turned off when the room is not in use to avoid electricity waste.

Although there are recommended temperature settings for a home, different people in different locations will have different comfort levels. The residents of a home should experiment with different thermostat settings to find what works best for that individual household.

It can be tempting on a particularly hot day to turn the thermostat down to well below what would be considered comfortable in an effort to cool a place quickly. This is ill-advised as it will not make the area cool any faster. In addition, it can end up wasting energy by reaching a temperature that is lower than what was intended. Plus, a forgotten thermostat may keep that colder temperature longer making the air conditioning work harder. The opposite notion applies to heaters.

Like most household appliances, thermostats must meet certain standards. And similarly, there are some models that are, for one reason or another, more efficient than others. Energy Star, the U.S. Department of Energy's high efficiency rating program, grants Energy Star labels

to individual models that exceed those standards. Programmable thermostats that have earned the Energy Star label are, for instance, more accommodating than standard models.

Equipment	Specification
Programmable Thermostats	Shipped with a default energy saving program that is capable of maintaining two separate programs (to address the different comfort needs of weekdays and weekends) and four temperature settings or more for each day.

(Source: Energy Star Program: www.energystar.gov)

Thermostats should be placed away from naturally cool or warm spots such as in the kitchen. They should not be placed in locations where they will be in direct sunlight either. Excess heat can bring about an inaccurate temperature reading and force the air conditioner to turn on when it is not actually needed.

Case Study

A homeowner on Kiest Road in Dallas, Texas, must replace a defunct room air conditioning unit in her living room window. She is always on the look out for a good deal and leans towards those appliances that cost the least. She does like the idea of having a remote controlled system and would like one that has an easily accessible filter for easy cleaning.

In order to choose a new window unit, she should first determine what capacity is required. To do this, she must find the area (squared) of her living room. The room is rectangular in shape, 15 feet long and 13 feet wide. To obtain the area, the length of the room is

multiplied by its width. The room is 195 feet squared. According to the previously shown Energy Star chart, this means that her new air conditioner should have a capacity of about 6,000 BTU. No adjustments need to be made to this figure since the room is neither heavily shaded nor very sunny. Also, most of the time, there are no more than two people occupying the room at once.

Five window units were found to fit her needs. The models range in capacity from 5,600 BTU to 7,000 BTU. They range in price from $150 to $450.[*] If her unit is too small, it will not cool the room efficiently and the unit may not last as long as she would like. If her unit is too big, it will cost her more to run. However, while the 7,000 BTU unit is bigger than the room actually needs, it is not an out of the question purchase as her living room is centrally located within the house and the cool air would circulate into the kitchen and bedrooms.

Of the five units, two of them are not Energy Star rated. This does not necessarily mean that they should not be considered. Even without the certification, they could still be the more energy-efficient choices. The 5,600 BTU, 5,700 BTU, and the 6,000 BTU low-profile units are Energy Star rated and are the three cheapest models.

At the outset, the 6,000 BTU low-profile unit seems to be the most logical choice and is the one that the homeowner could be expected to purchase. It is the correct size and is reasonably priced. However, it uses almost twice the amount of electricity (750 kWh) as the smaller two. It also costs twice as much to run ($62 per year).

[*] Note: The models and prices reflected in this comparison are obtained from only one store, Sears. The purpose here is not to find the store with the cheapest prices. Rather, it is simply to go through the process of choosing a new room air conditioner. Sears has a limited selection, but easily accessible information. Despite the more limited selection, by using only one store, comparisons may be made with greater relativity.

Product Comparison Chart for Window Air Conditioning Units

Product Description	Price	Capacity (BTU)	Dimensions (D x H x W)	EER	Operating Cost	Energy Star Compliant?	Remote Control?	Easy Access Filter?	Control Type?	kWh per year?
Kenmore 5600 BTU	$150.00	5600	15 x 12 x 19	11	$31.00	yes	yes	yes	electronic	382.5
Kenmore 5700 BTU	$180.00	5700	15 x 13 x 19	11	$31.00	yes	yes	yes	electronic	382.5
Kenmore 6000 BTU, Low Profile	$219.00	6000	18 x 12 x 21	10.7	$62.00	yes	yes	yes	electronic	750
Kenmore 6000 BTU	$450.00	6000	23 x 20 x 15	9.5	$39.00	no	yes	yes	mechanical	472.5
Kenmore 7000	$420.00	7000	21 x 14 x 19	9.7	$59.00	no	no	yes	mechanical	720

The homeowner could still choose the 5,600 BTU low-profile. However, if she were to go with the slightly smaller 5,700 BTU unit, she could save an estimated $350 over the next ten years. The unit is not so small that it would not provide adequate cooling. If used in conjunction with fans, it could reasonably be expected to provide enough cooling for the living room as well as some air in the other rooms. It has all the features she would like and will easily fit into her window.

In addition, she would be saving over 365 kWh worth of electricity per year. This means that she would be keeping that much more pollution out of the air and, as a result, doing her part in reducing the severity of ozone alert days which are common in Dallas during the summer. This is important to her as she has a son with asthma and those with asthma are often negatively affected by high-ozone level days.

Example:

Life-cycle Cost Comparison Chart

		Purchase Price	Yearly Operating Cost	Operating cost over 10 years	Life-cycle cost	Cost difference
	Product Description	Price	Operating cost	Operating cost x 10	Price + 10-year operating cost	Total cost difference between models
Model **most likely** purchased	6,000 BTU Low-profile	$219	$62.00	$620.00	$839.00	$0
Comparable model #1	5,700 BTU	$180	$31.00	$310.00	$490.00	-$349
Comparable model #2	6,000 BTU	$450	$39.00	$390.00	$840.00	$1
Comparable model #3	7,000 BTU	$420	$59.00	$590.00	$1,010.00	$171

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Appliances

Introduction

Major household appliances, such as refrigerators, dishwashers, washing machines, and clothes dryers are some of the largest energy and water consumers in most homes. For one, they consume water and energy in their day-to-day operations. For another, they are a source of interior heat gain, which affects the house's air conditioning system and forces it to work harder causing further energy consumption. For these very reasons, it is crucial that homeowners take energy efficiency into consideration anytime they purchase a new major appliance for their home.

$$\frac{\text{Wattage} \times \text{Hours Used Per Day}}{1000} = \text{Daily Kilowatt-hour (kWh) consumption*}$$

(1 kilowatt = 1,000 Watts)

*Daily kWh should be multiplied by the total number of days the appliance is used during the year for annual consumption. Annual consumption can further be multiplied by the local utility rate per kWh consumed to determine the annual cost of running an appliance.

(Source: *Air Conditioning The Cool and E-Z Way)*

The formula on the left is a formula for the estimation of appliance energy consumption

Dishwashers

Introduction

Dishwashers are different from most other appliances mentioned in this paper in that there is an alternative within the home. Dishes can be washed by hand in the sink, so replacing one does not necessarily constitute an "emergency". However, many families do rely heavily on their dishwashers, especially when it comes to saving time, and would want to replace a malfunctioning one as quickly as possible.

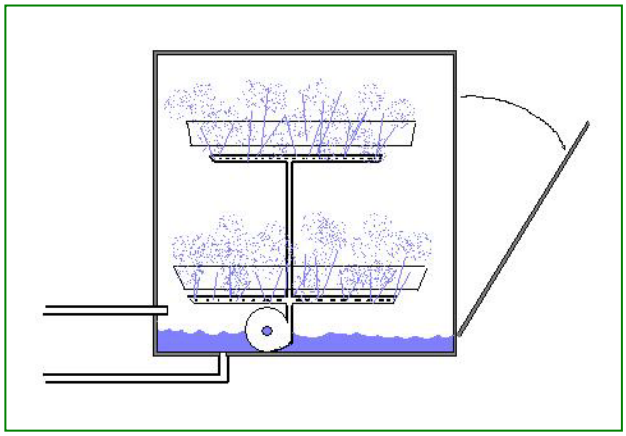
Dishwashers are similar to other appliances mentioned in that they have the potential to play a major role in energy con7sumption as well as energy savings around the home. They require energy to heat water for dishes, to wash the dishes, and to dry dishes. Like other major appliances, dishwashers also can vary in their levels of energy efficiency.

Water conservation is an area where dishwashers can have an additional impact. There are some dishwashers that are more water efficient than others. Water efficiency, like energy efficiency, should be taken into consideration by homeowners when purchasing a new dishwasher. Not only is water conservation alone financially beneficial, but the less water a dishwasher uses, the less energy will be consumed to heat that water and thus, less money will be spent on electricity.

How They Work

There are three main types of dishwashers that can be found in a home: built-in dishwashers, portable dishwashers, and compact dishwashers. Built-in dishwashers are the ones to be covered here.

A dishwasher is, in essence, a watertight box used for washing dishes. Water enters the unit through a water inlet valve from a pipe attached to the hot water supply line. Some dishwashers have booster heaters that increase water temperature for optimum cleaning. If the unit has a booster, the water is heated before moving on. From there, a pump forces the water up into one or more sprayer arms. The sprayer arms turn and spray water out. The water picks up dishwasher soap and showers the dirty dishes.



Some newer models of dishwashers have soil sensors. The sensors monitor water during the washing process. They help select the correct washing time depending on how dirty the dishes are. When the water appears clear enough, the soil sensor allows the dishwasher to move on to the next cycle. This is opposed to a standard timer, which cleans for a pre-set period.

Finally, the dirty water is pumped out of the unit through a drain hose. Many dishwashers dry the dishes by blowing air over the dishes with a fan. The air may be heated if the unit has a heating element or a booster heater.

Standards, Ratings and Certifications

The Energy Guide label found on new dishwashers rates the unit in terms of kWh/year. That figure is derived from the dishwasher's Energy Factor (EF). Basically, EF= 1/ M + W, where M is the amount of energy used to run the motors, and W is the energy used to heat the water.

The higher the energy factor, the more efficient the dishwasher is. However, the terms "Energy Factor" of "EF" are not generally found on the Energy Guide Label. Rather, the label lists the estimated yearly energy consumption of the model in kWh/year. The lower that latter rating, the more efficient the unit is, as it shows a lower amount of energy needed to run the machine. Energy Factor is the rating used by Federal Standards and by Energy Star.

Energy Star

Energy Star, the U.S. Environmental Protection Agency's voluntary high efficiency labeling program, sets high standards for dishwashers. Energy Star labeled dishwashers must be "at least 25% more energy efficient than minimum federal government standards."[5] The table below compares the Energy Star minimum standard to the Federal minimum standard of dishwashers:

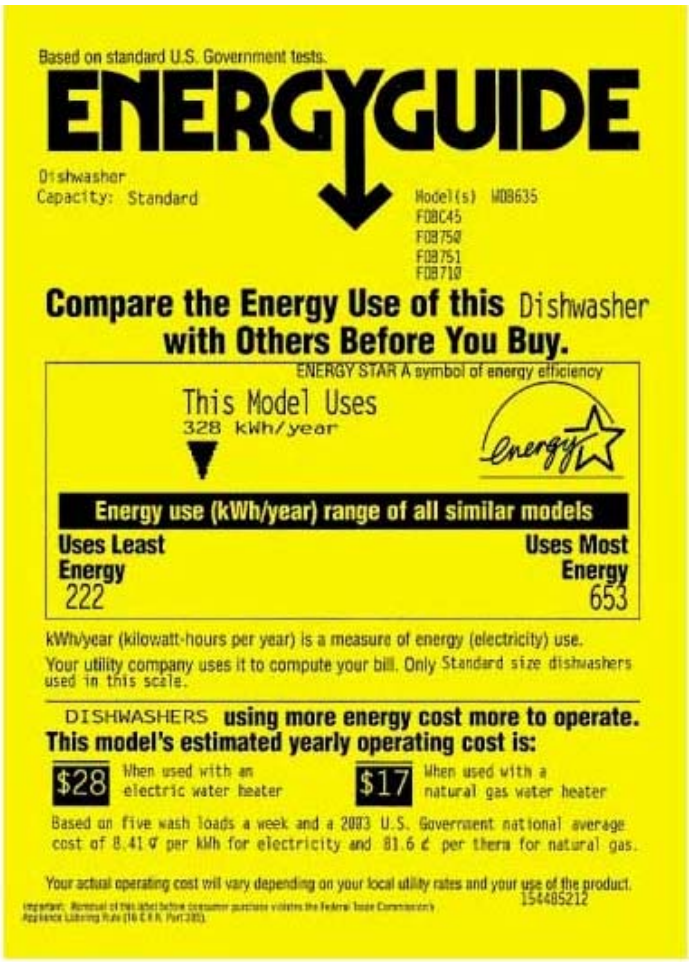
Equipment	Federal Standard	Energy Star Standard
Standard Dishwasher	ER of at least 0.46	ER of at least 0.58

[5] Energy Star Program: www.energystar.gov

Purchasing Tips

Checking efficiency ratings

The Energy Guide label is an excellent source of information on a unit's energy use. It is bright yellow and conspicuously located somewhere on the product itself or on its packaging. The label can be used to compare different models of dishwashers.


Based on standard U.S. Government tests.

ENERGYGUIDE

Dishwasher
Capacity: Standard

Model(s) WDB635
FDBC45
FDB750
FDB751
FDB710

Compare the Energy Use of this Dishwasher **with Others Before You Buy.**

ENERGY STAR A symbol of energy efficiency

This Model Uses
328 kWh/year

Energy use (kWh/year) range of all similar models

Uses Least Energy	Uses Most Energy
222	653

kWh/year (kilowatt-hours per year) is a measure of energy (electricity) use.
Your utility company uses it to compute your bill. Only Standard size dishwashers used in this scale.

DISHWASHERS **using more energy cost more to operate.**
This model's estimated yearly operating cost is:

$28 When used with an electric water heater

$17 When used with a natural gas water heater

Based on five wash loads a week and a 2003 U.S. Government national average cost of 8.41¢ per kWh for electricity and 81.6¢ per therm for natural gas.

Your actual operating cost will vary depending on your local utility rates and your use of the product.

154485212

Important: Removal of this label before consumer purchase violates the Federal Trade Commission's Appliance Labeling Rule (16 C.F.R. Part 305).

This Energy Guide label on the left is for a dishwasher. Under the ENERGYGUIDE logo, the label describes the model of the dishwasher as well as its capacity. It shows that this model is Energy Star compliant. It also gives a range of energy use of similar models (between 222 kWh and 653 kWh) and compares its use (328 kWh based on 5 loads per week) to that. Finally, it gives an estimated annual operating cost for the unit.

(Source: Frigidaire: www.frigidaire.com)

Choosing features

Different dishwashers come with many different options, or features:

- Some models include a food disposal that grinds foods into smaller particles that may be safely washed down the drain.
- The interior of the dishwasher, or tub, may be made of plastic or stainless steel.
- Dishwashers may have different dish drying options. They may dry with heated air or with a low- or no-heat air drying fan.
- Some models have racks and tines that are adjustable for easier loading.
- There are basically two types of controls: digital control keys or mechanical buttons and dials.
- Some manufacturers offer quieter models than others.
- Some models have more interior space than other dishwashers.
- Various dishwashers have different numbers of spraying levels for multi-directional soaking of dishes.

Different models of dishwasher have different cycle options. Cycles may include a normal wash cycle, a pots and pans cycle, a delicate cycle for washing fragile dishes, a pre-washing cycle, or a sanitizing rinse cycle that rinses dishes in very hot water. Energy Star recommends choosing a dishwasher with several wash cycles. For example, light or energy-saving cycles can be used for dishes that are only slightly soiled. This saves both energy and water since the dishwasher runs for a shorter period than it would otherwise.

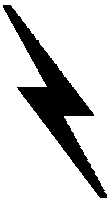
Not all dishwashers come with the entire list of features. When selecting a new dishwasher, homeowners should prioritize. There is a dishwasher comparison chart at the end of this dishwasher section.

Maintenance and Cleaning

Like all major household appliances, a well-maintained dishwasher can work more efficiently and last longer:

- Chipped plastic coating on racks can lead to rusting and should be repaired promptly.
- Sears recommends that the strainer and the spray arms be removed and cleaned twice a year.

Tips for Energy and Water Savings



Dishwashers consume energy in three phases: heating the water, running the dishwasher itself, and heat-drying the dishes. A set amount of both energy and water is consumed whether there is one glass being washed or a full load. There is no way to adjust a dishwasher for smaller loads. Therefore, the main way to save energy and water is for the home's residents to run only full dishwasher loads. This reduces the total number of times that the dishwasher must be run.

If possible, the homeowner should avoid pre-rinsing dishes either in the sink or with a pre-rinsing dishwasher cycle. Quality dishwashers should be able to clean off most food residue during the regular washing cycle. In addition, the shortest cycle needed to clean the dishes effectively should be used. The shorter the cycle, the less energy is consumed.

The no-heat drying option should be used at the end of the washing cycle. Heat-drying consumes costly energy doing a job that can easily be done by air, which is free. If a dishwasher

does not have the non-heat or air-dry option, the door can be opened before the beginning of the drying cycle, allowing dishes to air dry.

If the home's dishwasher has a booster heater, a lower temperature (120^{o}F) can be maintained in the home's hot water heater. If it does not, the water heaters should be kept at a recommended 140^{o}F.

Case Study

A family on Center Street in Duncanville, Texas is in need of a new dishwasher. They plan on living in their home for only two more years, and are therefore not interested in a long-term investment. Their sole priority is finding the cheapest model possible. Energy and water efficiency is not even in consideration at this point. The family's plan is to basically walk into the store, pick out the cheapest model available, and buy it. They are not looking for any specific features or qualifications.

The search for a new dishwasher will begin by selecting those models that have purchase prices of $300 or less. There are eleven models that range from $230 to $300.*

While the consumers in question do not have any preferences, several additional features have been listed for the sake of comparison. All eleven models are roughly comparable, but some have certain convenience features that the others do not.

* Note: The models and prices reflected in this comparison are obtained from only one store, Sears. The purpose here is simply to go through the process of choosing a new dishwasher. Sears has a wide selection and easily accessible information. By using only one store, comparisons may be made with greater relativity.

Product Comparison Chart for Dishwashers

Product Description	Price	kWh/year	Operating Cost	food disposal	Energy Star Compliant?	# of cycles	Low/no heat dry	rinse aid dispenser	pots & pans cycle	delay start	
Kenmore #15121	230	699	19	yes	no	11	no	no	yes	no	
Kenmore #16121	230	699	19	yes	no	11	no	yes	yes	no	
Frigidaire #FDB75ORCW	250	403	11	yes	yes	5	yes	yes	yes	yes	
Whirlpool #DU8505WLQ	250	455	13	no	yes	4	yes	yes	yes	yes	
Fridgidaire #FDB641RAS	250	498	14	yes	yes	5	yes	yes	yes	yes	
Kenmore #15322	260	450	13	yes	yes	4	yes	yes	yes	yes	
GE #GSD26006	270	549	15	yes	yes	5	yes	yes	yes	yes	
Kenmore #15222	280	450	13	yes	yes	4	yes	yes	yes	yes	
Kenmore #16222	280	450	13	yes	yes	3	yes	yes	yes	yes	
GE #GSO4000JWW	300	361	10	yes	yes	6	yes	yes	yes	yes	
Maytag #MDB3700AWE	300	465	13	yes	no	4	yes	yes	no	yes	

The family would most likely choose one of the two $230 Kenmore models. Of the eleven models, the two Kenmore models use the most energy and cost the most to operate per year. By looking only at a 2-year payback period (life-cycle cost), the $230 Kenmore models do seem like the "best buy".

Life-cycle Cost Comparison Chart

		Purchase Price	Yearly Operating Cost	Operating cost over 2 years	Life-cycle cost	Cost difference
	Product Description	Price	Operating cost	Operating cost x 2	Price + 2-year operating cost	Total cost difference between models
Model **most likely** purchased	Kenmore #15121	$230	$19.00	$38.00	$268.00	$0
Comparable model #1	Frigidaire #FDB750RCW	$250	$11.00	$22.00	$272.00	$4
Comparable model #2	Whirlpool #DU8505WLQ	$250	$13.00	$26.00	$276.00	$8
Comparable model #3	GE #GSO4000JWW	$300	$10.00	$20.00	$320.00	$52

*In this example (above) of dishwasher comparisons, the $230 Kenmore is the model that the homeowner will most likely choose without consideration of energy efficiency. This chart is based on a 2-year life cycle, and so does not show any real savings. However, as the chart below shows, after 3 years, the $250 Frigidaire is actually cheaper (in the long-term) than the Kenmore. After 4 years, it becomes clear that the $350 Whirlpool is cheaper than the Kenmore. After 8 years, even the $300 GE model is the more economical model.

A third model, the $250 Frigidaire has very low energy usage and a very low yearly operating cost. It costs $30 more initially than the aforementioned Kenmores. However, over the two years, it will only cost an extra $4 when considering the energy savings on its operating cost. The Frigidaire also has a booster heater, which could save money on water heating costs if the water heater (gas in this case) is kept at the lower 120oF temperature. In addition, the

Frigidaire has some additional features that the Kenmores do not. It has a low/no heat drying option, a delayed start option, and the rinse aid dispenser has an indicator light. The model is Energy Star compliant as well.

Even though, they are not looking for a long-term investment, the consumers in this example would be wise to consider an alternative to the cheapest models. The slightly more expensive models are more energy-efficient and more water-efficient as well. As a bonus, they may include features that may make using them over the next two years more convenient.

Refrigerators

Introduction

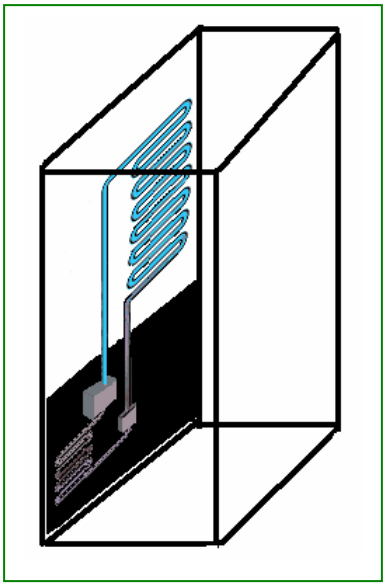
Refrigerators are familiar sites in most homes. Refrigeration reduces the waste of foods due to spoilage, and they keep food fresh, cold, and well-preserved.

On occasion, it becomes necessary for an older refrigerator to be replaced. There are, naturally, logical reasons why homeowners would want it replaced without delay. Because refrigerators are one of the biggest energy consumers in the home, quick decisions can lead to non-energy efficient, and costly, purchases.

Note

This section will focus only on refrigeration units that are full-sized and contain both a refrigeration (fresh food) compartment and a freezer compartment. The term "refrigerator" will apply to this type. The section will not cover storage freezers or compact refrigerators.

How they Work



Interestingly, refrigerators do not actually cool the air inside them. Rather, heat is absorbed and removed from the air by a low-pressure, gaseous refrigerant, or coolant, flowing through a set of pipes called the evaporator. (A coolant is a liquid that evaporates into a gas at very low temperatures.) The heated coolant flows through tubes to a compressor outside of the refrigerator. Through the compression procedure, the coolant's pressure is increased turning it into a high-pressure gas. From the compressor, the coolant flows into a condenser, where it becomes a liquid. The process of changing from high-pressure gas to liquid causes the coolant to give off the heat it collected from inside the appliance. The cooled liquid refrigerant then moves into an expansion valve, or capillary tube, where it is exposed to another change in pressure. The pressure change causes the liquid to expand back into a low-pressure gas. That evaporation process causes the gaseous coolant to absorb heat from inside the refrigerator and the cycle begins anew.

The refrigerant does not go through this cycle continuously. The process begins only when the refrigerator's interior temperature needs decreasing. The frequency of this process depends on such factors as refrigerator insulation, room temperature, refrigerator and freezer thermostat temperature setting, how often the door is opened, how clean the coils are, and how well the doors are sealed.

Standards, Ratings and Certifications

Technically, refrigerators and freezers are rated according to their Adjusted Volume (AV). Adjusted Volume is the rating used by Federal Standards and by Energy Star. AV= Fresh Volume + (1.63 * Freezer Volume), where Fresh volume is the total volume of the fresh food compartment and Freezer Volume is the total volume of the freezer compartment. The lower the adjusted volume, the more efficient the refrigerator is.

However, the term "Adjusted Volume" is not generally placed on the Energy Guide labels found on new refrigerators. Rather, the label lists the estimated yearly energy consumption of the model in terms of kWh/year. The lower that rating, the more efficient the unit is, as it shows a lower amount of energy needed to run the refrigerator.

Energy Star

Energy Star, the U.S. Environmental Protection Agency's voluntary high efficiency labeling program, sets high standards for refrigerators. **"**Energy Star qualified refrigerators require about half as much energy as models manufactured before 1993. Energy Star qualified refrigerators provide energy savings without sacrificing the features [desired by homeowners]."[6]

[6] Energy Star Program: www.energystar.gov)

Equipment	Federal Standard	Energy Star Standard
Refrigerators with manual defrost	8.82*AV+248.4	7.497*AV+211.14
Refrigerator with partial automatic defrost	8.82*AV+248.4	7.497*AV+211.14
Refrigerators with automatic defrost and top-mounted freezer without through-the-door ice service	9.80*AV+276	8.33*AV+234.6
Refrigerators with automatic defrost	9.80*AV+276	8.33*AV+234.6
Refrigerators with automatic defrost and side-mounted freezer without through-the-door ice service	4.91*AV+507.5	4.1735*AV+431.375
Refrigerators with automatic defrost and bottom-mounted freezer without through-the-door ice service	4.60*AV+459	3.91*AV+390.15
Refrigerators with automatic defrost and top-mounted freezer with through-the-door ice service	10.20*AV+356	8.67*AV+302.6
Refrigerator-Freezers--automatic defrost with side-mounted freezer with through-the-door ice service	10.10*AV+406	8.585*AV+345.1

Left: The table compares the Energy Star minimum standard to the Federal minimum standard of various configurations of refrigerators. (Source: Energy Star Program: www.energystar.gov)

Purchasing Tips

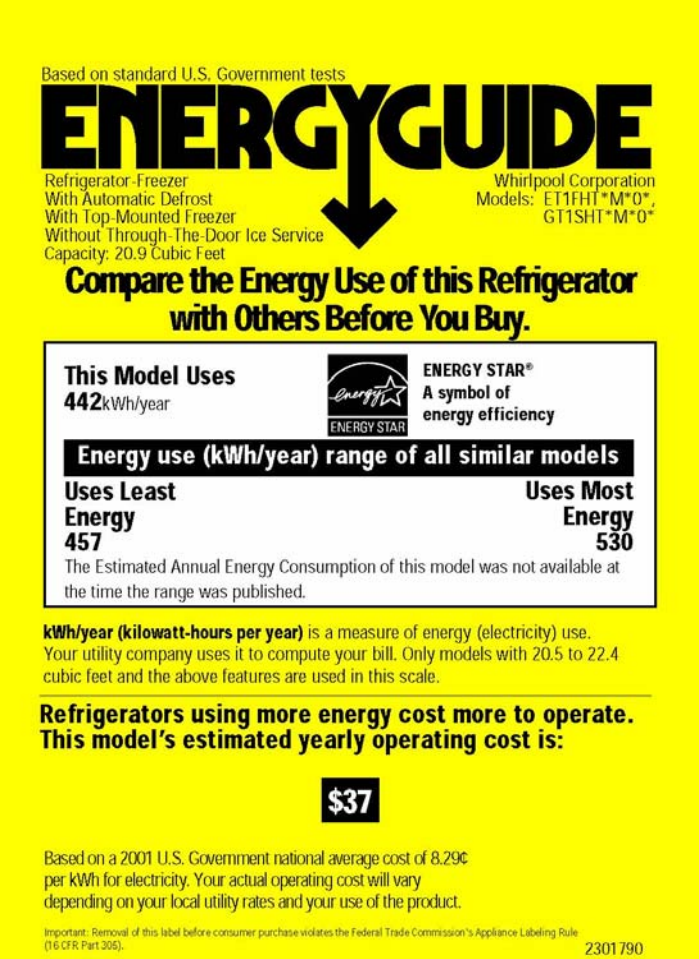
Choosing the right size

Different models come in different sizes. The depth, width, and height of the area available for refrigerator placement should be measured carefully before purchasing a new one. Not all refrigerators may fit in available spaces.

Additionally, a large space does not necessarily mean that the largest unit available should be purchased. Models which are too large for a family may result in wasted space and energy. On the other hand, models which are too small may require extra trips to the grocery store. Energy Star suggests that models with capacities between 16 and 20 cubic feet are the most energy-efficient. Total capacity, given in product descriptions, is the combination of fresh food volume and freezer volume.

Checking efficiency ratings

The Energy Guide label is an excellent source of information on a unit's energy use. It is bright yellow and conspicuously located somewhere on the product itself or on its packaging. The label can be used to compare different models of refrigerators.



This Energy Guide label on the left is for a refrigerator. Under the ENERGYGUIDE logo, the label describes the model of the refrigerator as well as its features. It shows that the refrigerator is Energy Star compliant. It also gives a range of energy use of similar models (between 457 kWh and 530 kWh) and compares its use (442 kWh) to that. Finally, it gives an estimated annual operating cost for the unit. (Source: Whirlpool: www.whirlpool.com)

It may be worth the homeowner's time to place a call to their local electric company. Many companies offer incentives or rebates to customers who purchase new, energy-efficient refrigerators. As an added bonus, energy-efficient models often cost less than their less-efficient counterparts. This is due to the fact that they may not have some of the more expensive and energy consuming features such as through-the-door ice and water dispensers or anti-sweat heaters.

Choosing the best configuration

Refrigerators come in three basic configurations. There are top freezer models which have the freezer compartment on top and the refrigeration compartment on bottom. Bottom freezer models have the freezer compartment on bottom and the refrigeration section on top. Finally, side-by-side models have two vertical sections with the freezer on one side, and the refrigeration section on the other. Top freezer models tend to be somewhat more energy efficient than bottom freezer models and significantly more energy-efficient than side-by-side models. Top freezer models should be considered when comparing new refrigerators.

Choosing Features

Refrigerators come with many different options, or features:

- Many or most new refrigerators come with automatic defrost. Automatic defrosters can add to the energy consumption rate of refrigerators. Manual defrosting can help the homeowner realize more energy savings, but freezers must be defrosted periodically to do so. Some newer refrigerator models, on the other hand, have more efficient defrosting capabilities and may be almost as efficient as manual defrost models.
- Automatic moisture control is a feature designed to prevent moisture from accumulating on the model's exterior. This feature should be chosen over a model with an anti-sweat heater. Models with anti-sweat heaters consume more energy than those with automatic moisture controls.
- Some refrigerator models include ice makers while others include through-the-door ice and water dispensers in addition to the ice maker. Consumers should carefully weigh the option of purchasing a refrigerator with these options. Such refrigerators can have a higher purchase price and may consume greater amounts of energy than those appliances without those features. Homeowners should thoroughly consider whether the convenience is worth the extra costs.

- Different models come with different numbers and sizes of shelves, bins, and baskets.
- Spill-proof glass shelves have an advantage over wire shelves in that spills are more easily contained.
- Special drawers, such as meat or crisper drawers, may have their own temperature or humidity controls, separate from the rest of the refrigerator, for the purpose of keeping foods such as meats, fruits, and vegetables fresher longer.
- Adjustable shelves and bins give homeowners the flexibility to fit their needs.
- Some models offer better insulation from noise or more advanced noise reduction systems.

Not all refrigerators come with every possible feature. When selecting a new unit, homeowners should prioritize which ones are most important to them and compare models with those attributes. There is a refrigerator comparison chart at the end of this refrigerator section.

Installation

When possible, refrigerators should be located in areas protected from direct sunlight. Also, if possible, they should not be located next to an oven or dishwasher.

They should be placed so that there is plenty of room for air to circulate freely around condenser coils. Finally, they should be positioned in such a way that they may be moved out easily for cleaning the coils.

Care should be taken in the disposal of old refrigerators. Refrigerants contain harmful chemicals that should be disposed of in an environmentally responsible manner. Also, in order

to conserve natural resources, parts of the old refrigerator can be recycled. Local utility companies may be contacted for information on proper refrigerator disposal.

Maintenance and Cleaning

Like all major household appliances, a well-maintained refrigerator can work more efficiently and last longer with proper cleaning and maintenance.

Condenser coils

The condenser coils are generally located on the back of the refrigerator or behind the front grill. The coils are responsible for removing heat from the unit. Clean condenser coils work more efficiently. At least once a year, dust and dirt accumulation should be cleaned from the condenser coils. It may be done more often if the dust and dirt builds up faster. The manufacturer's guide for the specific model should include instructions on the best procedure for this.

Door seals

The door should be checked periodically to make sure the seal is strong. If there is any detectable leakage or if the seal is weak, it may need replacement. Furthermore, the seals should be kept clean to ensure a tighter fit.

Defrosting

If the freezer does not have an automatic defroster, it should be manually defrosted regularly. Ice accumulation causes the refrigerator's compressor to work harder and longer than necessary, which is a waste of energy. Defrosting should be done every three months or when the build-up of ice exceeds one-quarter of an inch. The manufacturer's guide for the specific model should include instructions on the best procedure for defrosting a freezer.

Tips for Energy Efficiency

One important and easy way to increase a refrigerator's energy efficiency is to keep its door closed. When the door is open warm air enters the unit and the cooling cycle must work to compensate. The air-cooling process consumes energy. There are a few ways to reduce the amount of time in which the door is open. First, when it is necessary for the door to be opened, it should be closed again as quickly as possible. Packages and containers should be clearly identifiable so that they may be located and removed swiftly. Finally, if the refrigeration and freezer compartments are kept well-stocked, less cold air escapes when the door is opened.

It is recommended that the temperature for the fresh food section be kept between 36°F and 40°F and that the freezer section be kept 0°F and 5°F. Since some refrigerator and freezer thermostats do not show a numerical temperature, a thermometer may be used to check the actual temperature and the thermostat can be adjusted accordingly.

It is further recommended that clutter and decorative objects not be placed on top of the refrigerator. This can block air circulation necessary for efficient compressor functioning.

In addition, food and liquids should be kept covered, hot foods should never be placed in the refrigerator, and the condensation, or “sweat,” should be wiped off of containers before they are placed in the refrigerator.

Case Study

The home on Cherry Street in Duncanville, Texas has a very old side-by-side refrigerator. At any time, it could go into "retirement" without warning. The homeowner is extremely energy conscious, but also financially limited. Like most people, she wants the most out of her money. She is willing to spend more money initially, however, if it means getting a better deal in the long-run. Since time will be limited when the occasion for replacement arrives, she wants to be armed with the tools she needs to make an educated and energy-wise decision quickly.

The homeowner, first of all, measured the limited space available for a new refrigerator. The new unit could have a depth anywhere between 27-inches and 34-inches, but the height must be less than 66.5-inches and the width must be less than 32-inches. That narrowed down the choices considerably.

She then considered which features were most important to her and which ones she would look for and use for comparison. She wanted shelves that were adjustable and constructed of glass as opposed to wire. She also, for the sake of convenience, wanted an automatic ice

maker. Finally, because she knows that she would not get around to manually defrosting a freezer as often as is necessary for optimum efficiency, she wanted a model with automatic defrost.

The next step involved looking at several different models of refrigerators. She also took all three configurations into consideration. There were, at that stage, 10 models to choose from ranging in price from $579.00 to $1,049.99.*

Without any consideration of energy efficiency, she would otherwise have leaned towards a side-by-side model. She would have gone with a well known brand that has a reputation for being reliable. Of the two side-by-side choices, she would most likely have gone with the Maytag 21.6 cu.ft. for $950.

However, with a new understanding of how big a role can refrigerators play in home energy savings, she now leans towards a top-freezer model. There are two that are comparable to the Maytag side-by-side- a Whirlpool 20.9 cu.ft. and a Kitchen Aid 21.5 cu.ft. The Whirlpool is the cheaper of the two and is a brand name with which she is most familiar. It is also the lower of the two in energy efficiency and yearly operating cost. It is Energy Star compliant and has all of the features she wants.

* Note: The models and prices reflected in this comparison are obtained from only one store, Sears. The purpose here is not to find the store with the cheapest prices; rather it is to simply go through the process of choosing a new appliance. Sears has a wide selection and easily accessible information. By using only one store, better price comparisons may be made.

Product Comparison Chart for Refrigerators

Product Description	Configuration	Dimensions (D x H x W)	Price	kWh/year	Operating Cost	Freezer Capacity (cubic feet)	Fresh Food Capacity (cubic feet)	Energy Star Compliant	Adjustable & Spillproof shelves	Icemaker	Auto Defrost
GE 17.9 cu.ft.	top freezer	32 x 66 x 30	$580	411	$34	5.03	12.9	yes	yes	no	?
Whirlpool 20.9 cu.ft.	top freezer	32 x 66 x 32.5	$829	442	$36	6.5	14.5	yes	yes	yes	?
Kenmore 19.0 cu.ft.	top freezer	33 x 66 x 30	$869	443	$36	5.31	13.7	no	yes	yes	yes
Kitchen Aid 21.5 cu.ft.	top freezer	32 x 66 x 32.5	$1,000	448	$37	6.4	15.1	yes	yes	yes	?
GE, 3 sh., 2 bin, 1 bskt	bottom freezer	31 x 66 x 31	$700	499	$41	4.64	13.4	yes	yes	no	?
GE, 4 sh., 4 bin, 1 bskt	bottom freezer	31 x 66 x 31	$850	499	$41	4.64	13.4	yes	yes	no	?
GE, 4 sh., 3 bin, 3 bskt	bottom freezer	31 x 66 x 31	$1,000	499	$41	4.64	13.4	yes	yes	no	?
GE, 4 sh., 3 bin, 3 bskt	bottom freezer	31 x 66 x 31	$1,050	499	$41	4.64	13.4	yes	yes	yes	?
Maytag 21.6 cu.ft.	side-by-side	34 x 66.5 x 32	$950	625	$51	7.19	14.4	no	yes	no	?
GE, 19.8 cu.ft.	side-by-side	34 x 66.5 cx 31	$855	625	$51	7	12.9	no	adjus, wire	no	?

Life-cycle Cost Comparison Chart

	Product Description	Purchase Price: Price	Yearly Operating Cost: Operating cost	Operating cost over 10 years: Operating cost x 10	Life-cycle cost: Price + 10-year operating cost	Cost difference: Total cost difference between models
Model **most likely** purchased	Maytag side-by-side refrigerator	$950	$51.00	$510.00	$1,460.00	$0
Comparable model #1	Whirlpool 20.9 cu.ft. top-freezer	$829	$36.00	$360.00	$1,189.00	$271.00
Comparable model #2	Kitchen Aid 21.5 cu.ft. top-freezer	$1,000	$37.00	$370.00	$1,370.00	$90.00
Comparable model #3	GE bottom freezer	$850	$41.00	$410.00	$1,260.00	$200.00

*In this example of refrigerator comparisons, the Maytag side-by-side was the model that the homeowner would most likely have chosen without consideration of energy efficiency. However, the chart shows a clear advantage of the second model- the Whirlpool 20.9 cu.ft. top-freezer model- over the Maytag.

Compared to the side-by-side Maytag, the Whirlpool top-freezer costs $121 less on the purchase price. Plus, it uses an average of 183 fewer kilowatt hours per year and costs approximately $15 less per year to run. Based on these figures alone, the Whirlpool will save her roughly $271 over a ten-year life-cycle. (That figure does not account for any increases or decreases in energy costs over the next ten years.) In addition, the Whirlpool has an icemaker included whereas she would have to pay extra to install one in the Maytag.

As an energy-conscious, environmentally responsible consumer, the homeowner in this scenario would choose the more efficient Whirlpool. Even though, in all honesty, she would prefer the side-by-side, she feels that the advantages of a top-freezer model outweigh the convenience of the side-by-side.

Clothes Washers

Introduction

Few people today would choose to go back to the days of washing clothes on a washboard. Most Americans are inclined to want their clothes and linens clean and would rather not have to put much effort into the task. Washing machines usually perform that job quite effectively. But, sometimes they don't. Sometimes washers break down, and sometimes they need replacing.

How They Work

After clothes are placed in a washer and the cycle choices have been made, the washer tub is filled with water that enters from the home's water lines. The clothes are agitated, or stirred, around for a given amount of time getting cleaned in the process. After that, the dirty water drains out through holes in the tub and the clothes are spun to remove excess water. The tub fills again with clean water and the clothes are again agitated to rinse the soap out of them. The water drains a second time, and the clothes are spun once more.

There are actually two tubs in a washing machine. The inner tub, the one with the holes, holds the laundry, while the outer tub confines the water. The inner tub moves, but the outer tub remains stationary. An agitator is located in the center of the inner tub.

Washers contain a single pump that has two jobs. One, it circulates water within the tub by taking water from the bottom of the tub and forcing it out at the top of the tub during the agitation phase. Its second job is to remove water from the tub and force it down a drain hose during the draining phase.

There is also a gearbox that has two jobs. It is located beneath and connected to the agitator. During the washing cycle, the gearbox causes the agitator to churn the clothes. During the spin cycle, the gearbox spins the inner tub to launch the water out.

Front loading washers are slightly different from the traditional top-loading models. Rather than turning clothes around a vertical agitator and churning the water around them, front-loading models spin clothes around a horizontal axis. Clothes are tumbled through the water at the bottom of the drum. This allows for a much lower fill level, which means less water is used.

Standards, ratings, and Certifications

Modified Energy Factor (MEF)

Federal standards rate washers by their Modified Energy Factor (MEF). MEF = C / M + E + D, where C is the washer's capacity, M is the amount of energy used by the washer itself, E is the amount of energy used by the hot water heater to heat the water, and D is the amount of

energy used by the dryer to remove the remaining moisture from the laundry. The higher the MEF is, the more efficient the washer is.

Energy Star

Energy Star, the U.S. Environmental Protection Agency's voluntary high efficiency labeling program, sets high standards for washing machines. "Through superior design and system features, Energy Star qualified clothes washers clean clothes using 50% less energy than standard washers."[7] In addition, "Energy Star qualified washers use 18-25 gallons of water per load, compared to the 40 gallons used by a standard machine."[8] They also take more water out of laundry during the spin cycle, which lessens drying time and therefore saves energy.

Equipment	Federal Standard	Energy Star Standard
Top Loading Washers	MEF of at least 1.04	MEF of at least 1.42
Front Loading Washers	MEF of at least 1.04	MEF of at least 1.42

(Source: Energy Star Program: www.energystar.gov)

Water Factor (WF)

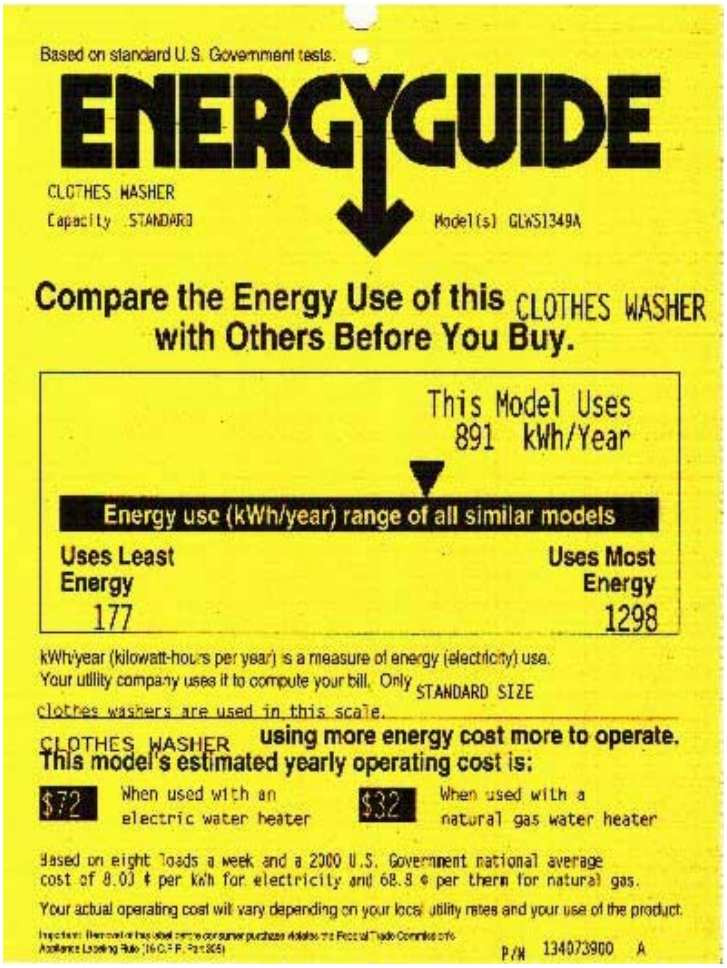
1. Their Water Factor (WF) rates the water consumption of washing machines**.** WF = Q / C, where Q is the amount of water consumed and C is the capacity of the washer. The lower the

[7] Energy Star Program: www.energystar.gov
[8] Energy Star Program: www.energystar.gov

WF is, the more water efficient the washing machine is. A submission of the WF is required for Energy Star qualified products. However, there is no set maximum WF level.

Note

The terms "MEF" and "WF" do not generally appear on Energy Guide Labels found on new washing machines. Rather, the label lists the estimated yearly energy consumption of the model in terms of kWh/year. The lower that rating, the more efficient the unit is, as it shows a lower amount of energy needed to run the washer.


Based on standard U.S. Government tests.

ENERGYGUIDE

CLOTHES WASHER
Capacity STANDARD
Model(s) GLWS1349A

Compare the Energy Use of this CLOTHES WASHER with Others Before You Buy.

This Model Uses 891 kWh/Year

Energy use (kWh/year) range of all similar models

Uses Least Energy 177

Uses Most Energy 1298

kWh/year (kilowatt-hours per year) is a measure of energy (electricity) use. Your utility company uses it to compute your bill. Only STANDARD SIZE clothes washers are used in this scale.

CLOTHES WASHER using more energy cost more to operate.

This model's estimated yearly operating cost is:

$72 When used with an electric water heater

$32 When used with a natural gas water heater

Based on eight loads a week and a 2000 U.S. Government national average cost of 8.03 ¢ per kWh for electricity and 68.9 ¢ per therm for natural gas.

Your actual operating cost will vary depending on your local utility rates and your use of the product.

Appliance Labeling Rule (16 C.F.R. Part 305)

P/N 134073900 A

This Energy Guide label on the left is for a clothes washer. (www.frigidaire.com) Under the ENERGYGUIDE logo, the label describes the model of the clothes washer as well as its capacity. It also gives a range of energy use of similar models (between 177 kWh and 1298 kWh) and compares its use (891 kWh based on 8 loads per week) to that. Finally, it gives estimated annual operating costs for the unit depending on whether an electric or gas water heater is used.

Purchasing Tips

Checking efficiency ratings

The Energy Guide label is an excellent source of information on a unit's energy use. It is bright yellow and conspicuously located somewhere on the product itself or on its packaging. The label can be used to compare different models of clothes washers.

Choosing a size

The capacity of a washing machine is expressed in cubic feet. They vary in volume from about 2.5 to 3.5 cubic feet. There are some smaller, compact washers but they will not be covered here. A washer's capacity is a matter of choice for the homeowner. It should be determined by the number of people in the home and how many loads are washed per week.

Top loading or front loading?

Most washing machines sold in the United States are top-loading models. However, front-loading models are more prevalent in the market now than they were just a few years ago. They are gaining ground because they are capable of using less water and less energy than top-loaders. They have fast spin cycles, which cuts down on drying time. They may have larger capacities and may be more conveniently placed under a counter, or such. In addition, they may have increased performance levels over top-loading models. Front-loaders do tend to cost a bit more than top-loaders, but the price difference may be made up in lower energy and water costs.

Choosing features

Different washers come with different options and features. In general, the more features a washing machine has, the more expensive it will be. When selecting a new clothes washer, homeowners should prioritize the ones that are most important to them and compare models with those attributes. They should also evaluate which of those features will actually be regularly used, and are not just initially appealing. There is a dishwasher comparison chart at the end of this dishwasher section. There is a clothes washer comparison chart at the end of this clothes washer section.

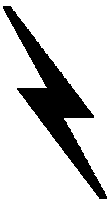
- Water temperature- more water temperature settings allow the homeowner more flexibility in cleaning laundry with varying levels of dirtiness.
- Load size- a washer with several water level options allows homeowners to wash smaller loads without wasting water.
- Cycles- more cycles and washing options allow the consumer more flexibility in cleaning individual types of laundry. A pre-soaking option helps to conserve energy. A “suds saver” option saves energy by saving soapy water from one cycle to the next. Higher spinning speeds reduce energy by reducing drying time.
- Ease of use- washers with large lids may make loading and unloading clothes more convenient
- Sensors- some more sophisticated machines have sensors that automatically sense load size, water dirtiness, and fabric type. The sensors allow the machine to adjust water levels and wash cycles to best meet the needs of the individual load. This could take some of the guesswork out of the washing process for users.

Installation

If possible, it is a good idea to locate the washing machine near the home's hot water heater. This helps to reduce heat loss from water as it travels from the tank to the washer.

When possible, washers and dryers should be located in a laundry room that is sealed off from the rest of the house. This prevents the air conditioning system from having to remove extra heat and humidity from the air. In addition, the noise from the appliances will be less noticeable. When placing them in non-sealed off locations, homeowners may want to consider purchasing models that offer better sound insulation.

Tips for Energy and Water Savings



Most of the energy used by washing machines is from water heating. One way to for homeowners to conserve energy is to wash clothes in cold or warm water only. A warm pre-soak can be used for extra dirty laundry, but for most loads, cold or low-temperature water is sufficient. Cold water is all that should ever be used for rinsing clothes.

To save both water and energy, washers should be filled to their intended capacity. If a load is too small, the washer does not operate as efficiently as it should, even with a small load setting. However, the small load setting should definitely be used when a small load is necessary. On the other hand, if the washer is overfilled, the motor can become strained. The tub should be filled, at most, to a level just below the top of the agitator. In addition, clothes

should be washed correctly the first time (stains pre-treated, adequate detergent used, water and temperature levels correctly set, etc.) so that re-washing does not become necessary.

Case Study

A family in Dallas consists of four adults and a child. In any given week, they go through quite a bit of laundry. Frequent trips to the laundry mat are difficult errands due to the schedules and health limitations of the family members. Their current washing machine is 15-years old and the time is approaching when they will need a new one. As with most families, funds are limited, but they are willing to spend more initially if it means getting a better quality product or saving money in the long-run.

The homeowner prefers Kenmore brand appliances, as she has dealt with them before and finds them to be very reliable. Size of the machine is not an issue, but she would prefer a top-loading white one. Due to the size of the family, a large-capacity washer is preferable as well, although water level options are important since she often does small loads of certain fabric types. She only finds three cycle options necessary- delicate, permanent press, and regular. She always rinses clothes in cold water, so cold-water rinse options are required of a new machine. Finally, if given a choice, she would prefer that the unit has a bleach dispenser.

Product Comparison Chart for Clothes Washers

Product Description	Configuration	Price	kWh/year	Operating Cost	Capacity (cu.ft)	Delicate/perm press/ regular cycle?	# of wash/rinse cycles	Agitator type	# of water levels	Bleach dispenser?	
24642	top	350	597	14	3.2	yes	3	dual-action	5	yes	
24732	top	400	596	14	3.2	yes	3	triple-action	variable	yes	
24872	top	460	612	14	3.2	yes	4	triple-action	variable	yes	
24902	top	520	529	12	3	yes	ATC-7	triple-action	4	yes	
24962	top	580	552	13	3.2	yes	ATC-7	total care	variable	yes, timed	
249852	top	700	510	12	3	yes	ATC-7	total care	5	triple dispenser	
24052	top	750	508	12	3	yes	ATC-7	total care	variable	triple dispenser	
22062	top	800	309	7	3.5	yes	ATC-5	wash plate	auto-adjusted	detergent only	
42822	front	1100	268	6	3.7	yes	4	tumble	auto level	triple dispenser	
44832	front	1100	286	7	3.7	yes	4	tumble	auto level	triple dispenser	
44921	front	1300	278	7	3.7	yes	ATC-6	tumble	auto level	triple dispenser	

There are about twenty-one models fitting the homeowner's specifications, ranging in price from $258 to $900. There are also six front loading models that she could choose from ranging from $800 to $1430.* Models of clothes washers vary by only minor differences. They generally vary only by capacity, the number of cycles, the number of wash/rinse temperatures, and the number of water levels.

In trying to compare different models of clothes washers, certain limitations appear. For one, energy usage among models does not generally vary by much. All of the models used in this comparison (with the exception of the front-loaders) have operating costs of either $12, $13, or $14 per year. Even over a ten-year life-cycle, higher-priced machines do not pay for themselves in energy efficiency alone.

The second limitation is that water efficiency cannot be easily compared. Energy Star takes water conservation into consideration, but none of the top-loading models compared are Energy Star compliant.

Finally, while the front-loading models used in this comparison use significantly less energy, and run on as little as half of the operating cost, the energy savings cannot make up for the considerably higher price tag. Even the most energy-conscious, environmentally responsible consumer would have a difficult time justifying spending $400 or $500 extra on an energy-efficient machine.

The consumer from the example, while willing to spend some extra money simply cannot afford a high-efficiency machine. If she had to purchase a new washer now, she would most

*Note: The models and prices reflected in this comparison are obtained from only one store, Sears. The purpose here is not to find the store with the cheapest prices; rather it is to simply go through the process of choosing a new clothes washer. Sears has a wide selection and easily accessible information. By using only one store, better and more relative price comparisons may be made. In addition, Sears carries the brand preferred by this particular consumer.

likely choose Kenmore Model #24642, which costs $350. Models with even slightly better energy efficiencies start at around $520. The chosen model has the lowest energy usage (592 kWh/year) of any others in the same price range, and it has all the features she desires.

As history has shown, most appliances on the market continue to improve in quality, performance, and efficiency while decreasing in price. It is the hope, then, that this will apply to washing machines as well. Perhaps, in the near future, machines that are highly efficient in terms of energy and water conservation will be more economically-friendly to the average consumer.

Clothes Dryers

Introduction

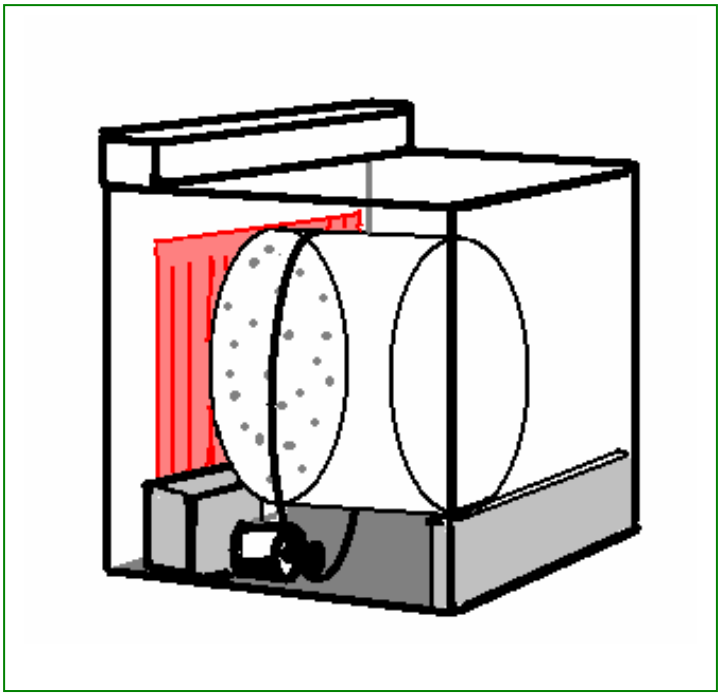
With the exception of dishwashers, clothes dryers are different from other appliances mentioned in this paper in that there is an alternative within the home. Clothes can be hung up to dry, so replacing one does not have to constitute an "emergency". However, many families do rely heavily on their clothes dryers, especially when it comes to saving time, and would want to replace a non-working one fairly quickly.

Drying clothes in a dryer consumes energy, so the purchase of a new one should be done with careful consideration of energy efficiency.

How They Work

After clothes are placed in the dryer and the machine is turned on, the motor starts up. The motor runs a fan that draws air in. The air flows through a heating element (which may be either an electrical element or a gas-burner) located at the back of the dryer where it is warmed up. The warm air then flows into the drum (the circular tub where the clothes are tumbled). The air passes through and warms the wet clothes causing the water to evaporate. It is then forced

through the holes located in the back of the dryer door. From there, the air passes through the lint screen and through a fan that forces it outside through an exhaust vent.



Meanwhile, the motor also turns a small pulley, which, in turn, causes the drum to spin. The spinning drum then tumbles the clothes inside it. A timer located on the control panel, which is set by the person running the dryer, determines the duration of the drying cycle.

Different models of dryers differ only slightly in terms of technology. Mostly, they vary by their available controls. On one end, there are dryers that have only timers to dictate when the drying cycle ends. Timer-controlled machines dry for pre-set amounts of time regardless of whether the clothes dry before the cycle ends or not. More advanced dryers have temperature sensors which cause the dryer to stop running when the temperature reaches a point where the clothes should be dry. Highly advanced dryers have moisture sensors that sense moisture levels and shut the dryer off when the clothes are finished drying.

Standards, Ratings, and Certifications

Energy Star, the U.S. Environmental Protection Agency's voluntary high efficiency labeling program, does not offer certifications to clothes dryers. Nor, are clothes dryers required to display an Energy Guide Label. This does make it more complicated for consumers to compare levels of energy efficiency among different models.

Purchasing Tips

Checking efficiency ratings

Since dryers are not required to display Energy Guide labels, comparing efficiency ratings directly is not always possible. Instead, consumers can look at some of the available features that can influence energy efficiency.

Another factor effecting efficiency is the energy source. Electric dryers tend to be more efficient than gas ones, but gas dryers are generally cheaper to run. This is based on the notion that gas is generally cheaper to purchase than electricity.

Choosing the capacity

Dryer capacity runs from about 5.7 cubic feet to 7.5 cubic feet. There are some smaller, compact dryers but they will not be covered here. A dryer's capacity is a matter of choice for the homeowner. It should be determined by the number of people in the home and how many loads are washed and dried per week.

Gas or electric?

Gas dryers tend to cost more initially than electric dryers, but the cost difference may be made up since running costs are often lower depending on local rates for natural gas.

Choosing features

Different dryers come with different available features. In general, the more features a dryer has, the more expensive it will be. When selecting a new clothes dryer, homeowners should prioritize the ones that are most important to them and compare models with those attributes. They should also evaluate which of those features will actually be regularly used, and are not just initially appealing.

- Moisture sensors can reduce energy use by about 15%. In addition, they can protect clothing by not over-drying them. Temperature sensors are not as efficient as moisture sensors, but they can also average a 10% energy reduction.
- Number of cycles- more cycles can give the homeowner more choices on drying options. Examples of cycle choices are heavy duty, permanent press, delicate, etc.
- Wrinkle guard- once the drying cycle ends, wrinkle guard periodically fluffs clothes before they are removed from the dryer in order to prevent wrinkles.
- Ease of use- dryers with large doors that open downward may make loading and unloading clothes easier. In addition, the lint screen should be located in a convenient place where they are easy to remove and clean.
- Control panel- the control panel may be mechanical with buttons and knobs, or electronic with digital controls.

Installation

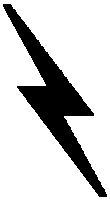
When possible, dryers should be located in a laundry room that is sealed off from the rest of the house. This prevents the air conditioning system from having to remove extra heat and humidity from the air. In addition, the noise from the dryer will be less noticeable.

If it is feasible, the dryer should not be located in a cold, damp location. It will take the clothes longer to dry and make the dryer work harder in the process.

Maintenance and Cleaning

The lint filter should be cleaned after each load. At least twice a year, the screen should be cleaned with soapy water to remove the accumulation of soap and fabric softener. Clean lint filters allow clothes to dry faster.

Tips for Energy Savings



Most of the energy consumed by dryers goes toward heating the air. One way to make dryers run more efficiently is to dry several loads consecutively. Energy is saved in this way because the heating element does not have time to cool down between loads, so there is no energy wasted in heating it up to the correct temperature.

Running the dryer longer than necessary is a way to waste energy and wear out fabric faster. Dryers should only be run long enough to dry the clothes and not over-dry them. If the machine has a moisture or temperature sensor, it should be used. If it has a timer, the homeowner should determine the shortest drying time necessary to dry clothes. Heavy fabrics should be dried separately from light fabrics because they take longer to dry. Wet clothes should not be added to loads that are nearly dry. Finally, if the dryer has a cool-down cycle, it should be used so that clothes finish drying with the residual heat.

In addition, the dryer should be filled to its intended capacity. Dryers use the same amount of energy whether they are drying one sock or a whole load of towels. If a load is too small, energy is wasted. If a load is too big, air cannot circulate freely around the clothes, as it needs to do.

Case Study

A family in Dallas consists of four adults and a child. In any given week, they go through quite a bit of laundry. Frequent trips to the laundry mat are difficult errands due to the schedules and health limitations of the family members. Their current dryer is 25-years old and the time is fast approaching when they will need a new one. As with most families, funds are limited, but they are willing to spend more initially if it means getting a better quality product or saving money in the long-run.

Because there are no standard ways to compare dryers, the consumer must look instead for energy saving features. The homeowner prefers Kenmore brand appliances, as she has dealt with them before and finds them to be very reliable. The machine must run on gas. Due to the size of the family, a large-capacity dryer is preferable as well. She needs at least a delicate, a permanent press, a regular, and cotton drying cycle as well as a cool-down cycle (energy-saving feature). She prefers a door that opens to the side (as opposed to a drop-down door), a dryer with the wrinkle guard feature, and a dryer that has signals when the drying cycle is finished, but these are not major necessities. Finally, she wants a dryer with an automatic moisture sensor (major energy-saving feature).

There are sixteen dryers from which she may choose.[*] Eleven of the dryers fall below the homeowners $700 price limit. None of the dryers has every one of the features she is looking for, but most of them would appeal to her. Five of the models have both a cool-down cycle and automatic moisture sensing, which are the two big energy-saving features for which she should look. Two of the remaining five have 7.0 cubic foot capacities, whereas the other three have 7.5 cubic foot capacities. Since dryers expend the same amount of energy no matter how full the load, and since the family occasionally dries smaller loads, they should not purchase the biggest models available. Therefore, the homeowner in this scenario, would be wisest to purchase either the Kenmore Model #72822 or the Kenmore Model #72862- both are $750.

[*] [*]Note: The models and prices reflected in this comparison are obtained from only one store, Sears. The purpose here is not to find the store with the cheapest prices; rather it is to simply go through the process of choosing a new clothes dryer. Sears has a wide selection and easily accessible information. By using only one store, better and more relative price comparisons may be made. In addition, Sears carries the brand preferred by this particular consumer.

Product Comparison Chart for Clothes Dryers

Product Description	Price	Capacity	Dimensions (D x W x H)	delicate, regular, cotton & perm. Press cycle	cool-down cycle	warning signal	side-opening door	automatic moisture control	wrinkle guard			
#72702	430	7		yes	yes	yes	no	no	yes			
#74712	430	7		yes	yes	yes	no	no	yes			
#72822	450	7		yes	yes	yes	no	yes	yes			
#72862	450	7		yes	yes	yes	no	yes	yes			
#74902	500	7		yes	no	yes	yes	yes	yes			
#74932	500	7		yes	no	yes	yes	yes	yes			
#74942	510	7.5		yes	no	yes	no	yes	yes			
#74962	510	7.5		yes	no	yes	no	yes	no			
#74982	630	7.5		yes	yes	yes	no	yes	yes			
#74992	630	7.5		yes	yes	yes	no	yes	yes			
#74972	630	7.5		yes	yes	yes	no	yes	yes			

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Appendix A

Landscaping

Landscaping is another area where good planning by homeowners can lead to considerable energy savings. According to the Office of Energy Efficiency and Renewable Energy, U.S. Department of Energy, a well-designed landscape will dramatically cut summer and winter energy costs, protect homes from winter wind and summer sun, and help to control microclimate temperature as well as air pollution.

The climate immediately surrounding a residential dwelling can be considered the home's microclimate. The weather conditions in the microclimate can be different from the ambient weather conditions. For example, it may be sunnier or shadier, windier or calmer, drier or more humid, or hotter or cooler within the microclimate than in the area surrounding it.

In the summer, cooler conditions in the microclimate around the home can lead to cooler, more energy efficient conditions inside the home. Landscaping can play a big part in improving those conditions.

For one, pavement such as patios, driveways and sidewalks can reflect heat rather than absorb it. Shading these areas with vegetation such as trees, hedges, shrubs, vine-covered trellises, and grass or other groundcover reduces heat radiation and serves to cool the air before it reaches a house's walls or windows.

Trees and other vegetation can also make the interior of a home cooler by providing shade directly to the house itself. By limiting the amount of heat that enters through windows, roofs, and walls, heat build-up inside the home is reduced. This has the added benefit of cutting the need for air-conditioning, which can in turn reduce the amount of the utility bill.

Based on computer models, the U.S. Department of energy estimates that careful positioning of trees alone, may save the average homeowner between $100 and $250, or up to 25%, per year in energy costs. By adding shade trees and other vegetation, previously un-shaded homes may cut summer air-conditioning costs by up to 50%. In fact, it is conceivable for the homeowner to recover his or her initial investment on a well-designed landscape in less than eight years because of the annual savings on energy.

Designing an effective landscape does require some background knowledge on the part of the homeowner. One should have awareness of what direction each side of the house faces and where the majority of sunlight comes from during different parts of the day and of the year. With that information, one can determine where best to locate plant life so that shadows will be cast in desired locations at desired times. Professional landscapers and qualified nursery specialists should be able to assist with the designing process.

When deciding what to plant, the property owner should give due consideration to native planting. Trees, shrubs, grass, vines, flowering plants, etc. that grow naturally in the area without human assistance, (in the form of irrigation, fertilizing, pest control, etc.) will most likely be the hardiest, easiest to care for plants. Native plants generally require less care than do introduced or exotic species. In addition, they can be more cost effective since they tend to

consume less water and rarely need added chemicals. Homeowners are advised to visit local nurseries or talk to local landscapers specifically about plants that are native to their specific area. There is a plethora of information available on the benefits of native landscaping as well as on topics such as organic gardening.

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Appendix B

Appliance Comparison Charts

Product Comparison Chart for Storage and Tankless Water Heaters

											Product Description
											Price
											Installation Cost
											EF (Energy Factor)
											Therms per year
											Operating Cost
											First Hour Rating (storage only)
											Number of Applications (tankless only)

Product Comparison Chart for Windows

											Product Description
											Price
											Dimensions
											U-Factor
											SHCG
											VT
											Air Leakage
											Glazing type
											Frame type

Product Comparison Chart for Dishwashers

											Product Description
											Price
											kWh/year
											Operating Cost

Product Comparison Chart for Refrigerators

											Product Description
											Configuration
											Dimensions (D x H x W)
											Price
											kWh/year
											Operating Cost
											Freezer Capacity (cubic feet)
											Fresh Food Capacity (cubic feet)

Product Comparison Chart for Clothes Washers

											Product Description
											Configuration
											Price
											kWh/year
											Operating Cost
											Capacity (cubic feet)
											Dimensions (D x W x H)

Product Comparison Chart for Clothes Dryers

												Product Description
												Price
												Capacity
												Dimensions (D x W x H)

Life-cycle Cost Comparison Chart

	Product Description	Purchase Price Price	Yearly Operating Cost Operating cost	Operating cost over 10 years Operating cost x 10	Life-cycle cost Price + 10-year operating cost	Cost difference Total cost difference between models
Model **most likely** purchased						$0
Comparable model #1						
Comparable model #2						
Comparable model #3						

Step 1) The model or product that would have most likely been purchased without regards to efficiency should be listed first including product description, purchase price and operating cost.

Step 2) Two or three models comparable to the one most likely chosen should be listed next.

Step 3) The operating costs over ten years (the estimated life cycle of appliances) can be obtained by multiplying the yearly operating cost by 10.

Step 4) The total estimated lie cycle cost can be roughly estimated by adding the purchase price to the ten-year operating costs.

Step 5) To compare the costs of different appliances over their entire estimated lifetime, the individual life cycle costs of comparable models should be subtracted from the life-cycle cost of the model most likely purchased. Negative numbers indicate money saved while positive numbers indicate some extra expense.

Appendix C

Complete Bibliography

***Note:** Where websites are used as sources, the citation gives the name of the organization, the website address for the organization's home page, and the links followed to the pages where specific information may be found. For example, Energy Star Program- www.energystar.gov: Home> Products> Appliances> Dishwashers, means that the information can be found by going to the Energy Star website at www.energystar.gov, clicking on "Products", then on "Appliances", and finally on "Dishwashers".

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