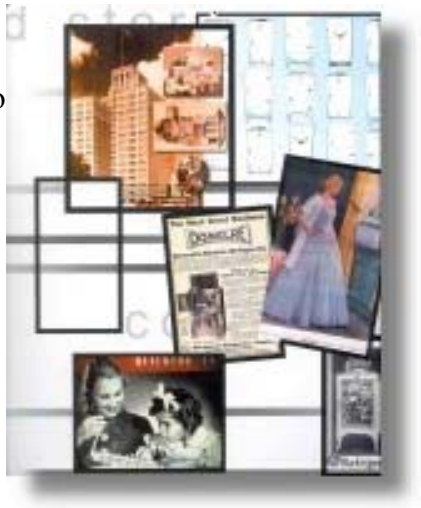
ACHIEVEMENT #7:

Air Conditioning and Refrigeration

Teacher's Guide

Introduction



For the first half of the century the average family had to buy food on a daily basis. Many foods spoiled quickly and were available only at certain times during the year. Wealthy people could rent food lockers to store frozen fish and meat, and some could even afford commercial systems in their mansions.

While engineers were working out the problems of making smaller refrigerators that everyone could afford, Fred McKinley Jones was working on a way to refrigerate trucks so that foods that spoiled easily could be shipped safely. In 1939 he solved the problem. ThermoKing revolutionized the transportation of food, and other delicate cargo like flowers, film and pharmaceuticals. It helped the frozen food industry grow and led to the supermarket.

Mr. Jones modified his original design for trains, boats and ships. During WWII he made a portable version so that food and blood could be parachuted behind enemy lines. Thanks to Mr. Jones and other mechanical engineers, we can enjoy many foods year-round, and we can store them right in our own homes. More importantly, we can eat "COOL" foods- especially ice cream.

Another problem early in the century was cooling and drying the air. Much of the South was unlivable, because of heat and humidity. Many people sweltered in the hot summers, and many died of heat exhaustion. Engineers like Willis Haviland Carrier changed all that. After many experiments, Mr. Carrier figured out that chilling air with water to condense it could also dry it. His first air conditioner had the cooling power of 108,000 pounds of ice. That's a lot of ice – think how many soft drinks that would chill. The first machines were used to condition air in factories – to improve the quality of products that didn't do well in heat and humidity. – Soon department stores and movie theaters lured customers in by advertising their air conditioning.

Today, we can live, work and play in any climate. We even build indoor ice skating rinks. It is hard to imagine life without cool, comfortable air. All because inquisitive engineers believed that we could live comfortably even in the hottest climates.

Lesson Focus: Energy Efficiency

Lesson Synopsis: Students attempt to delay the melting of an ice cube by insulating it, consider the importance of purchasing energy efficient products, and design a subdivision where home cooling costs are reduced.

Related Benchmarks from Benchmarks for Science Literacy:

Section 3C (Issues in Technology):

By the end of 5th grade, students should know that:

- Scientific laws, engineering principles, properties of materials, and construction techniques must be taken into account in designing engineering solutions to problems.

By the end of 8th grade, students should know that:

- Technology … is largely responsible for the great revolutions in agriculture, manufacturing, sanitation and medicine, warfare, transportation, information processing, and communications that have radically changed how people live.

Section 4E (Energy Transformations):

By the end of the 5th grade, students should know that:

- Some materials conduct heat much better than others. Poor conductors can reduce heat (transfer) …

Related Standards for Technological Literacy:

Standard 4 (Cultural, Social, Economic and Political Effects of Technology):

In order to recognize the changes in society caused by the use of technology, students in grades 6-8 should learn that:

- Technology, by itself, is neither good nor bad, but decisions about the use of products and systems can result in desirable or undesirable consequences.

Standard 16 (Energy and Power Technologies):

In order to select, use, and understand energy and power technologies, students in grades 6-8 should learn that:

- Much of the energy used in our environment is not used efficiently.

Standard 20 (Construction Technologies):

In order to select, use, and understand construction technologies, students in grades 6-8 should learn that:

- The selection of designs for structures is based on factors such as building laws and codes, style, convenience, cost, climate, and function.

Glossary:

EnergyGuide labels Yellow labels required by law on certain products to provide consumers with information to allow selection of energy efficient products.

sun controls Features which reduce the amount of sunlight entering south-facing windows in the summer.

freon Chlorine-containing gas used as a refrigerant. When released into the stratosphere, the chlorine destroys ozone.

stratospheric ozone A layer of ozone high in the atmosphere that reduces the amount of UV radiation reaching the Earth's surface. Its depletion over the South Pole creates the Ozone Hole.

Important Concepts:

- Refrigeration and air conditioning account for a major fraction of all home energy costs.
- Home energy costs can be reduced by purchasing energy efficient air conditioners and refrigerators, and by reducing the impact of summer heat on indoor temperatures.
- Choices made in the construction and landscaping of new homes can reduce energy costs.

Materials for Ice Cube Challenge:

Materials for Each Inquiry Team:

- 1 ice cube
- Small disposable cup
- Assigned insulation material

Materials for Entire Class:

- 1 ice cube
- Small disposable cup (for setting up a "control")
- Various insulation materials (newspapers, foam chips, corrugated cardboard, fleece fabric, etc.)

Materials for Subdivision Design:

Materials for Each Team of Consultants:

- Posterboard or sheet of newsprint
- Markers and pens
- Graph Paper
- Ruler

Safety Precautions:

No special precautions needed.

Procedure:

Engagement: Have students work in teams on the Ice Cube Challenge. Assign a type of insulating material to each group, with at least 2 groups having the same type.

Exploration, Explanation: Have students read the handout and examine the Timeline.

Extension: Have students do the subdivision-design activity Planning to Reduce Home Cooling Costs.

Evaluation: Student posters and presentations may be evaluated for evidence of comprehension of concepts.

Ideas for Further Exploration:

Have students research R factors and their significance.

Have students research landscaping for energy efficiency and improve their subdivision design based on what they learn.

Have students research the causes and potential consequences of ozone depletion.

References:

The Energy Sourcebook (High School Unit), published in 1990 by TVA (out of print). (The activity **Planning to Reduce Home Cooling Costs** is taken from the activity Energy Efficient Structures.)

Energy Saving Landscaping Ideas for the Department of Energy, online at: http://www.eren.doe.gov/consumerinfo/energy_savers/landscaping.html

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Student Handout

The Ice Cube Challenge

Before the invention of the electric refrigerator, people had "ice boxes" to refrigerate food and large chunks of ice were regularly delivered to homes to replace the ice as it melted.

Materials for Each Inquiry Team:

- 1 ice cube
- Small disposable cup
- Assigned insulation material

Your challenge is to use the material assigned to you to create a package that will insulate your ice cube so that it melts more slowly than those of the other inquiry teams. After all teams have planned their design, get an ice cube from the teacher. After the ice cube that is placed in an empty cup is totally melted, all teams should unwrap their cubes and compare them.

By comparing the results for teams using your same assigned material and for teams using a different material, what can you conclude about how the type of material and the amount of material affect its insulation capacity?

The Development of Air Conditioning and Refrigeration

Engineers propose solutions relating to human problems, needs, and aspirations. Carl von Linde, a locomotive engineer, invented a machine to compress ammonia in order to cool beer vats in Germany, allowing lager beer to be brewed even in the summer. John Gorrie, a medical doctor, invented a machine to make ice because he wanted to be able to cool the wards in a hospital in Florida. Willis Haviland Carrier invented the first air conditioning system because a printer needed a way to control humidity to keep the paper from changing size as he printed one color on top of another.

As you use the Timelines to trace later events, you will see how quickly both air conditioning and refrigeration have become commonplace in the US.

Unanticipated Environmental Effects

The early developers of air conditioning and refrigeration technologies could not have foreseen two significant problems resulting from the technologies – the amount of energy they consume and the effects of the refrigerant freon on the Stratospheric Ozone layer. Recent innovations have focused on use of alternative refrigerants and on improving energy efficiency.

Why Buy An Energy Efficient Refrigerator?

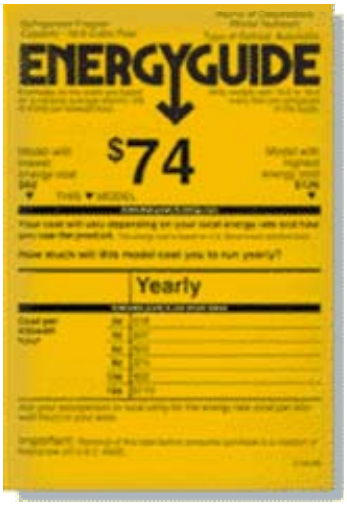
According to the Department of Energy, your refrigerator uses the most electricity of all your kitchen appliances. It can account for as much as 15 percent of a home's total energy usage. (Most of the energy used by a refrigerator is used to pump heat out of the cabinet. A small amount is used to keep the cabinet from sweating, to defrost the refrigerator, and to illuminate the interior.)

The energy bill for a typical new refrigerator, with automatic defrost and top-mounted freezer, will be about $55/year, whereas a typical model sold in 1973 will cost nearly $160/year. If your present refrigerator is more than 15 years old, you'll save money on your electric bills if you replace it with a new, more efficient unit. Although many energy-efficient products may be more expensive to purchase, they will cost less to operate over the lifetime of the appliance. For example, a more expensive model could pay for itself in a little over three years. Over the 15-year lifetime, the more expensive refrigerator might save $750!

Refrigerators made to meet the latest 2001 DOE standards will cut consumers' energy costs by 30 percent compared to the previous (1993) standards, and a family replacing a 1972-vintage model with a product that meets the new standard will see their utility bills drop by over $120 a year. There are super-efficient refrigerators currently on the market that save even more. If every household in the United States had the most efficient refrigerators available, the electricity savings would eliminate the need for more than 20 large power plants.

Using EnergyGuide Labels

Energy Cost Labels are used on refrigerators, refrigerator-freezers, freezers, and other appliances. The large number in the center of the label is the estimated annual cost of the energy needed to use the appliance. This cost is based on a national average electricity rate, which is listed on the upper left under the EnergyGuide headline.



The bar beneath the estimated cost shows the range of operating costs of competing brands and models of similar size and features. The chart at the bottom of the label lets you estimate more closely what your cost to operate the appliance will be based on the price you pay for your energy.

Planning to Reduce Home Cooling Costs

If you are planning to build a new home, there are many ways to cut home cooling costs, including increasing the home's insulation. One important decision is deciding how to orient the house. By having south-facing windows, the sun can help heat the home in winter, but, if we use air-conditioning in summer, the sun can increase energy use and bills unless we provide "sun controls" in the summer. "Sun controls" that might be used include deciduous shade trees, roof overhangs, window blinds and drapes, and thermal insulated windows.

Materials for Each Team of Consultants:

- Posterboard or sheet of newsprint
- Markers and pens
- Graph Paper
- Ruler

Procedure:

1. Imagine that you are consultants for a real estate developer who wishes to develop a subdivision in which the homes are designed to maximize energy conservation.

2. Draw a simple aerial map showing the compass directions and the meadows and hills where you will construct the "Sunny Acres" Subdivision. Draw in the nearest road that leads into town.

3. Now, plan the access streets that will lead to the main road and mark out the lots on which the contractor will build new homes.

4. Being mindful of the contractor's intention to use heat from the sun to help heat the home in the winter, draw in the placement of the new homes on the map, showing placement of shade trees.

5. Being mindful of the contractor's intention to use heat from the sun to help heat the home in the winter, use graph paper to sketch a simple floor plan showing the walls, doors, and windows of one of the new homes.

6. Indicate special features you would include to prevent unwanted summer sun from entering the windows and to prevent heat loss through the windows during winter.

7. Be prepared to share your team's plan with the rest of the class and to explain why you believe that your plan will allow the contractor to meet his goal.

Timeline of Events Related to Development of Refrigeration:

1873 Locomotive engineer Carl Von Linde invents a machine to compress ammonia.

1876 An ammonia refrigerator is invented by Linde

1913 First electric refrigerator manufactured.

1914 Clarence Birdseye observes how fish that he catches while ice fishing freeze quickly in the cold air and pioneers the quick freezing of fish.

1925 Clarence Birdseye and Charles Seabrook develop a deep-freezing process for cooked foods that Birdseye patents in 1926.

1929 U.S. electric refrigerator sales top 800,000, and the average price of a refrigerator falls to $292.

1931 GM's Frigidaire division adopts Freon-12 refrigerant gas.

1931 Birds Eye Frosted Foods go on sale across the U.S.

1972 ORNL researchers begin a program of energy research, which later results in more-energy-efficient designs for refrigerators.

1988 Ozone Trends Panel concludes that Antarctic Ozone Hole is caused by Freon.

1996 Carrier produces first air conditioners using a Freon-free refrigerant.

2001 New refrigerator standards go into effect that will increase their required energy efficiency by 30 percent as compared to the 1993 standard.

Timeline of Events Related to Development of Air Conditioning:

1830s	Dr. John Gorrie experiments with air conditioning at the U.S. Marine Hospital in Apalachicola, Fla., by blowing air over buckets of ice suspended from the ceiling.
1851	Gorrie receives the first patent for an ice-making machine.
1902	Willis Haviland Carrier pioneers modern air conditioning.
1906	Stuart Cramer coins the term "air conditioning."
1920s	Carrier introduces small air-conditioning units for residences.
1924	Hudson Department Store air conditions its “bargain basement”.
1930s	Air conditioners are placed in railroad cars transporting food.
1936	United Airlines begins air-conditioning its planes.
1939	First air-conditioned automobile, engineered by Packard.
1960	According to the U.S. Census, 12.4 percent of all U.S. households, and 18.3 percent of Florida households, have some kind of air conditioning.
1965	The Astrodome, the world's first air-conditioned indoor stadium, opens in Houston.
1973	80 percent of cars in the South are equipped with air conditioning.
1980	The census reports a majority of American homes, and 84 percent of Florida homes, have air conditioning.
2006	New standards for efficiency of central air conditioners in new homes go into effect that will increase their required efficiency by 30% as compared to the 1987 standard.