

Chill Chemistry:
How Air Conditioning has Changed our Lives, Culture, and Society

Kathryn Sciamanna

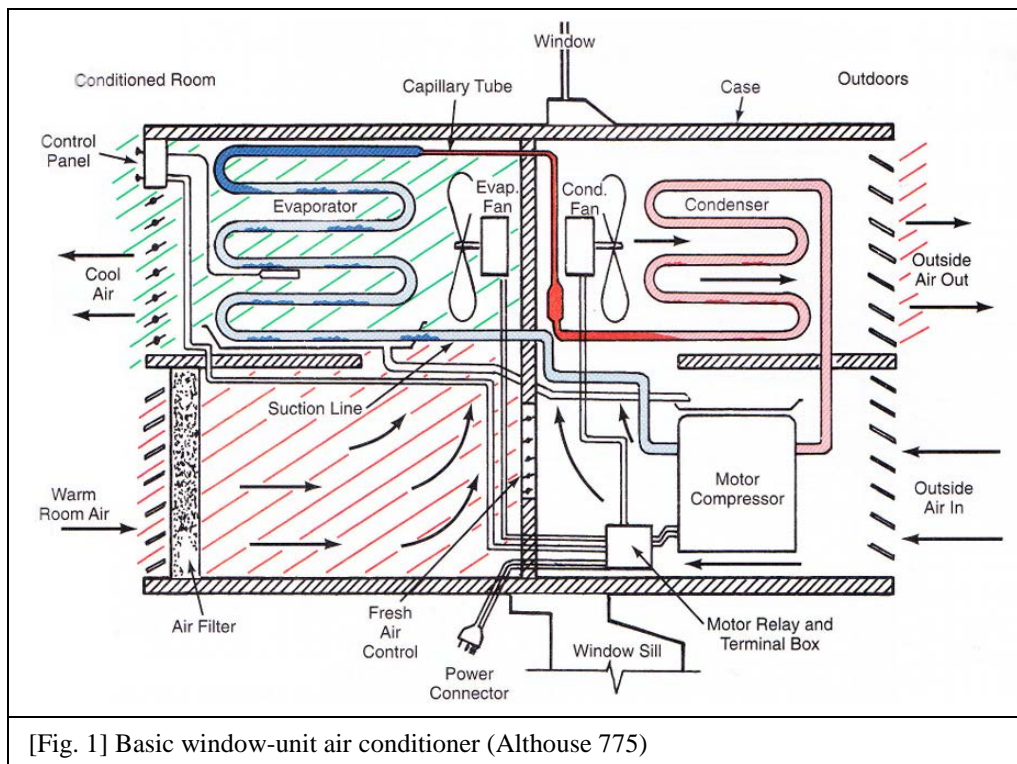
In Dubai, a Middle Eastern city with an average temperature around 80°F, there is an indoor ski resort. It boasts a ski slope about 25 stories tall and it is covered with snow all year round. A massive cooling system keeps the resort at a comfortable 30.2°F throughout the year (skidubai). Ski-Dubai is just one example of the ways in which air conditioning has allowed us to control the temperature of any indoor space, no matter how large, to our liking. However, air conditioning has done more than enable the outlandish excesses of an oil-rich nation. Since its invention in the early 20th century, air conditioning has had a profound impact on every corner of society; it has changed industries, shifted demographics, altered the environment, reshaped cultural norms, and changed basic ways in which we live.

People have been trying to cool air for thousands of years, but it was only in the 1800s that engineers developed the precursors of the air-conditioning technology we use today. Before, ice provided the only method for cooling. It could be harvested in blocks during the winter and stored in an insulated environment until needed. With the rise of industrialization, ice-cutting became a commercial business, and major cities were using thousands of tons of ice per year (Ierly 169). Yet transporting all this ice was inefficient and costly. People began to tinker with mechanical methods of cooling; in 1851 John Gorrie patented the first refrigeration machine (Ierly 171). Gorrie's machine was improved, and by 1900 mechanical refrigeration was readily available (Cooper 9). Air conditioning, however, took a bit longer to arrive.

Refrigeration and air conditioning are not the same; although based on the same technology they differ in purpose. Refrigeration is simply a method of making an environment cold, such as for preserving food in our kitchen refrigerators. Air conditioning cools the air, but also incorporates methods for controlling the air's humidity, cleanliness, and distribution (Cooper 23).

Air conditioning owes its beginning to three different engineers who developed cooling machines around 1900, but only one of them, Willis Carrier, turned his invention into a business (27). His machine provided a series of steps that could control both the temperature and humidity of air. First, a fan sucked air into a chamber filled with spray nozzles that saturated the air with cold water, creating cold air that was fully saturated with water. Next, it mixed the cold moist air with warm dry air, producing cool air with low humidity (25). Carrier started an air-conditioning company in 1907, and a new industry was born (25). Over the next decades air conditioning (A/C) technology improved, especially as new firms entered the market and as air conditioning became more affordable to the average consumer.

Modern air conditioners can differ depending on the specific needs of the consumer, but they all rely on the same basic thermodynamic system, as shown in Figure 1.



On the left side, a fan sucks warm air from the room into a chamber with an evaporator coil that contains cold liquid refrigerant. The warm air loses its heat to the cold coils, heating and

evaporating the refrigerant inside. As the air cools, it loses its capacity to hold moisture, causing water to condense on the sides of the coils and drip into a drain pan. The air is now cold and is blown back into the room by a fan. The refrigerant is then pumped through the coils and into the compressor in the right chamber, which compresses the refrigerant into a hot, high-pressure gas. This gas travels upwards through more coils, and in the process it gradually loses its heat to the outdoor air that is circulated by an outside fan. Eventually the refrigerant cools to become high-pressure liquid. Next, it travels through an expansion valve that turns it into a cold low-pressure liquid. This cold liquid refrigerant then travels back into the left side chamber, repeating the process all over again (Althouse 775).

Although not as sophisticated as the modern ones we used today, early air conditioners had a huge impact on many areas of society, including industry. In the beginning A/C was unaffordable to most consumers, but it became highly valued by factories whose products depended upon a controlled environment. Food factories were especially weather-conscious, but many other types of products were also negatively affected by heat and humidity (Cooper 31). Willis Carrier's first customer was a lithography company that specialized in color printing, a process that required exact alignment of the printing paper through successive impressions of different color inks. Excessive humidity would cause the paper to swell in size, ruining the print job (Ierly 211). A/C not only allowed factories to create optimal weather conditions for their production processes, it also freed their workers from the intense heat generated by factory machinery (Cooper 111). A/C became a way to reconcile the needs of production with the well-being of the workers, and improved worker comfort could increase output as well (53, 56). Thus, air conditioning played a key role in the growth of industrial America in the early part of the 20th century.

Throughout the first half of the century, air conditioning became increasingly common in public places like cinemas, department stores, and schools, but it wasn't until 1950 that A/C became affordable to the average consumer (Cooper 80, 82, Ackerman 52). Companies eager to tap in to the residential air conditioning market had worked hard to scale down existing A/C technology, from large bulky systems to small units (Cooper 112). The first portable air conditioner was introduced by Frigidaire in 1929, and by the 1950s the price of a window-unit air conditioner had dropped to about \$200 (123, 143). This low price, combined with post-war economic growth, caused demand to skyrocket, and by the 1960s, 12% of U.S. homes had at least one air conditioner (147, Cox 36). By 1980, that number was 55%, and today it is about 87% (36, census.gov).

Increased access to air conditioning played a role in the population shift to the 'Sunbelt' states – from South Carolina to Southern California – that began in the 1960s. During the first half of the 20th century, there was a major demographic shift out of this economically-depressed region, and by 1950, the Sunbelt population was less than 33 million (Cox 71). This trend reversed in the 1960s, and by 2002 the Sunbelt population had swelled to 88 million, an increase that also accompanied economic growth and prosperity (71). Air conditioning played a key role in this migration for two reasons. First, air conditioning was crucial to the growth of the region's major industries – cotton, tobacco, paper, and baking; processing these products depended on controlled levels of humidity and temperature (89). Second, air conditioning helped create a more attractive climate for employers who already had an incentive to move to these hot and humid yet business-friendly states (91, Ackerman 162). Cities like Houston, Miami, and Phoenix boomed, and remain some of our nation's most populous cities today.

The rise in air conditioning has also affected our use of electricity. Today, energy consumption by residential and commercial air conditioning is about 435 billion kW/year and growing (Cox 37). In addition, peak energy demand in the summer has outpaced that in the winter for over five decades (37). This puts a strain on utility companies because not only must they supply more electricity, but they must find new sources of energy to satisfy ‘peak power demand,’ the maximum rate for supplying electricity (37). Coal-fired power plants can supply a consistent base load of power, but they can’t be ‘turned up’ or ‘turned down’ hour by hour to meet sharp spikes in demand that often occur as a result of everyone turning on their air conditioning at once during a sudden heat wave (38). To boost their peak electricity capacity, utility companies are increasingly relying on natural gas-fired plants that are more able to provide a sudden power boost.

Our love of air conditioning is also negatively affecting the environment, due to both electricity demand and the chemical effluents of A/C technology. First, the enormous electricity demand for air conditioning is a major contributor to our carbon footprint (37). Energy companies are increasingly turning to natural gas to boost the capacity of our electric grid; natural gas does not provide ‘clean’ energy, despite what some politicians say (39). Methods of extracting natural gas, like fracking, can be harmful to the environment as well (40). Second, air conditioners, especially those from vehicles, can leak refrigerant whenever they are transported, repaired, or discarded (47). Prior to the 1990s, chlorofluorocarbons (CFCs) were used as refrigerants, but they were outlawed after it was discovered that CFCs were destroying the ozone layer (48). Unfortunately, many developing countries such as China and India still use them (48). Most refrigerants today are made of hydrofluorocarbons that, although they do not destroy ozone, are still destructive greenhouse gasses (48).

Air conditioning has also altered cultural norms and the ways in which we live. It changed our basic concept of what it means to be comfortable; as air conditioning has become a standard component of new homes and office buildings, people now see A/C as a necessity rather than a luxury (Ackerman 167, Cooper 164). The presence of air conditioning has affected building design and construction, as people no longer have to rely on natural methods of ventilation like high ceilings and operable windows (Cox 191). Lastly, many people argue that air conditioning has made us more anti-social. Before, people spent unbearably hot summer evenings in outdoor public places, but now we simply recede into the air-conditioned isolation of our own homes (55).

From its invention in the early 20th century, air conditioning has made many beneficial changes to modern society, but it also presents challenges that remain to be solved. Air conditioning spurred the growth of industries that were once impeded by the whims of heat and humidity, and enabled people to move to areas of the country that were once unattractive due to hot climate. Unfortunately, air conditioning also poses environmental problems, from its electricity draw to its use of damaging refrigerants. A major challenge for the future will be to find less costly ways to keep cool, whether it be by designing more energy-efficient air conditioners or simply by turning them off and learning to endure and perhaps even enjoy the heat.

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