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A chronology of building systems technology, 1929 through 1979

Our industry has made dramatic contributions to society; here's a look at what they have been and what they must be in the years ahead.

The early nineteenth century gave birth to an era known to every elementary school student, the industrial revolution. Along with the industrial revolution, the student readily identifies names such as Whitney, Watt, and Fulton. This was an era in which man learned to harness thermal energy and convert it to work, thereby amplifying his potential productivity many orders of magnitude. This vast increase in human productivity converted mankind's lot from a crude, almost primitive existence to the advanced society of comfort, accomplishment, and opportunity we know today. It is the *economic advances* born of the industrial revolution that are most commonly acknowledged.

Other names, not so readily recognized by the young student or the man on the street, are those of such men as Carnot, Rankine, Maxwell, and a host of other thermodynamicists of the nineteenth century. These names are generally recognized only by physical scientists and engineers. It was they who pondered the deep questions of the behavior of materials, fluids, and energy; identified these elements of behavior; and developed the science of thermodynamics. This science, in turn, formed the foundation of the industrial revolution, then went on to carry it into the twentieth century in high gear.

The primary goal of the vast majority of early machines (and consequently the direction of thermodynamic development) was to provide work or so-called shaft energy. This shaft energy was, and is, considered the highest form of energy; that is, the form with the highest "value." The next and related area of attention in thermodynamics was that concerned with machines that cause heat to flow from lower temperature sinks to those at higher temperatures—refrigeration machines. Then, to supplement the use of the thermodynamically produced shaft power, following discoveries by Oersted and Faraday in the early nineteenth century, electric energy was developed to transport the shaft level energy from place to place.

If we pick up the chronology of the development at the beginning of the twentieth century, we find that many exciting events were either occurring or were about to occur in the conversion of heat to work:

- Locomotives drawing long trains of people and cargo were crossing the continents, some containing their own power conversion plants and others utilizing power in the form of electricity.
- The factories of the world were humming with machines making everything from clothes

to wagon wheels to locomotives. Again, some of the factories had engines connected to line shafts while others used electricity provided from a nearby power plant.

- In the cities, there was no longer the need to travel by foot, horseback, or horsedrawn coach. Public transportation was available in the form of streetcars, powered by electricity or cables driven from central power plants.
- In western Europe and the United States, companies were being formed to manufacture machines that were actually intended to replace the horse—automobiles.
- Professor Langley's steam powered "aerodrome" had successfully flown for 1 minute and 49 seconds in 1896, and the race was on to develop a craft that would carry man through the air. (The Wright brothers accomplished the feat at Kitty Hawk, N.C., on December 17, 1903.)
- Candles and oil lanterns were being replaced throughout much of the Western world with gas lamps; electric arc lights were used in some cities to light the streets; and the successful development of the incandescent filament lamp was just around the corner.
- The process of generating steam from fuel, which had been developed for the then-commonly used steam power cycle systems, had been turned to another use, one not generally considered at the time to be a thermodynamic cycle. This use was as a heat transfer fluid, to heat buildings. The multiplicity of fireplaces and chimneys was giving way in many of the larger buildings to so-called central heating systems where the fuel (usually wood or coal) was converted to steam at a central point and the steam piped to the rooms and condensed in cast iron radiators to heat the space.
- Refrigeration plants were constructed in most larger population centers in order to make block ice from river water. The ice thus enabled people to preserve perishable foods—a concept that was about to change the eating habits of the world, significantly improving human diets, health, and quality of life.

From this beginning at the turn of the century, the continued industrial development to 1929 is generally recognized as being in transportation (the automobile and the airplane) as well as in industrial processes, which were turning to mass production. Public attention to the depression, the related economic hardships of the 1930s, the war in the 1940s, and the cold war in the 1950s drew attention from the continued development of the industrial revolution. An aspect of this period that generally comes to mind, however, is the conversion of the industrial war machine of World War II to civilian purposes.

Some of the evident highlights of this conversion took a notable turn from the trend of the prewar era. In rail travel, the 1940s and 1950s saw the steam locomotive replaced by the diesel-electric and also saw the rail passenger business virtually disappear. Very little happened with postwar development of the private automobile, except for slow modernization with increases in size, increases in horsepower, and increases in fuel consumption. (It must be recognized, however, that improved manufacturing processes brought on the era of two-car families.) The most recognized change was perhaps in aircraft development and air travel. The propeller plane was replaced almost totally by jet powered aircraft, until today we have gigantic jumbo jets that hold hundreds of passengers and fly just under Mach I as well as the European Concord that crosses the Atlantic at supersonic speeds.

But behind the romance . . .

These are the "romantic" remembrances of the continued impetus of the nineteenth century industrial revolution in the mid-twentieth century. But there was another branch of this development that had an even greater impact on most of our lives and provided the catalyst for further improvements in productivity and science. (Keep in mind that increases in productivity per capita are the *only* way mankind can improve its lot!) This branch of development was in the *environmental sciences*. This area of technology probably had the least time in development, the least research or development supported by public monies, and yet the greatest impact on our lives and life styles of any branch of science or engineering during the twentieth century.

Central heating systems advanced slowly from the nineteenth century through the World War II era, picking up other central heating concepts along the way such as gravity hot water heating and warm air. In some cases, in large buildings, systems were combined, particularly to address the need for ventilation. But by today's standards, the systems of a mere 35 years ago were primitive to say the least. Around 1911, Willis Haviland Carrier, an engineer whose name and contributions are little known to those outside the industry, initiated the twentieth century advances in the science of conditioning the air (prior work had been documented as early as 1837, but little use for the mathematical relationships was recognized).

Carrier's work grew out of the cotton mills and other limited industrial applications prior to World War I and, supplemented with the thermodynamic refrigeration cycles of the previous century, started creeping into the eyes of the public during the post depression era of mid and late 1930s. In those years, theaters and other places of public assembly such as large hotel ballrooms and meeting rooms were seen to be advertising "20 degrees cooler inside." The prior option was that such spaces simply were not used during hot weather. Parallel activities during the same era found the household ice box being replaced by a refrigeration plant, not on the river but right in the kitchen!, and the centrifugal pump applied to the gravity hot water heating system to make it more forgiving of pipe sizing, balance, and response problems.

These developments ceased during the war years, as did those in most nondefense-oriented fields of endeavor. The post war years saw environmental systems develop like a new industrial revolution, with nearly as significant a social and economic impact as the nineteenth century industrial revolution.

Some engineering and business talents were directly convertible from military to civilian activities and were channeled into such fields as transportation and communications. Others were seeking a new home, and with no involvement or direction from the federal government, United States society found a slot for technologists in the little recognized area of environmental control. Admittedly, in the manufacture of explosives during the war, the recognition of the integration of space cooling and heating had developed. Thus was born the concept of space air conditioning as we know it now.

How we contributed

It is almost awe inspiring to reflect upon the impact the building environmental industry has had on United States economic growth following World War II and on other advances in science and industry. And it is interesting to note that, scientifically, there have been no so-called breakthroughs; the entire process has been one of ingenuity in application engineering and product development.

The United States economy has been basically inflationary since 1946. Energy sources developed to serve the United States defense machine during the war were made available to the civilian market at a very modest price. This availability tended to exert market pressures on those areas of technology that could benefit the economic system and the social welfare while retaining the needed growth in the energy supply industry. The response was that a total change occurred in the methods of constructing indoor space.

The architect was released from the prior comfort-related constraints of mass control, ceiling heights, window designs, and the very shape and siting of the building. He was totally free to shape and arrange the space to suit the functional needs of the occupants. The availability of low-cost energy and the technological advances in the engineering disciplines that comprise the building environmental systems industry combined to provide the necessary environmental control irrespective of the envelope shape or material. Not only did this technology enable the industry to create more comfortable spaces regardless of weather or building location, but the improved space quality was also provided at a lower real cost per usable unit of area.

The effect this had on the economy is analogous to increased productivity: we were getting more for less. Thus, the building industry, conceptually, was a high-productivity industry that contributed to a growing economy rather than to inflation!

The far-reaching effects of the revolution in building designs and technology are difficult to identify and summarize, but the following is an attempt to recognize a few of the more significant contributions:

• On July 20, 1969, the United States Spaceship Apollo 11 landed on the moon, and astronauts Neil Armstrong and Ed Aldrin walked on the moon's surface. All mankind recognizes this as a magnificent accomplishment of the aerospace industry, but a key component of that industry is the building environmental component. Without specific and substantial contributions from the environmental sciences, the feat would not have been accomplished. One such contribution was the extensive research on human comfort and human heat dissipation (much of it sponsored by private industry through ASHRAE). Another was the ability to provide essentially sterile atmospheres with extremely accurate temperature and humidity control, which were necessary for the manufacture of sensitive electronic components and for subsequent assembly of these components.

Health care advanced

• The field of health care has certainly been advanced by developments in heating, ventilating, and air conditioning. Modern surgical suites are dependent on high-efficiency filtration and pressurization techniques that remove airborne dirt and bacteria from entering air and prevent infiltration of contaminated air from adjacent areas. Precise humidity control also provides an effective means of maintaining cleanliness since the growth rate of microorganisms is minimal at approximately 50 percent RH. Also, stable temperatures and humidities are important for patients in burn treatment centers and intensive care units as well as those weakened following surgery or other trauma.

On a less sophisticated level, modern air conditioning systems have provided relief to millions of sufferers of allergies and respiratory problems. And it would be virtually impossible to estimate the number of cases of heat stress and other medical problems that have been prevented by air conditioning and ventilating systems in our homes and workplaces.

Enter computer technology

• Computer technology touches on virtually every phase of our lives. Computers read the prices of the goods at the grocery store and department store; they calculate the monthly bills and invoices for virtually all industries from the family doctor to the credit card agency; they schedule industrial production and control inventory; they calculate our paychecks and bank balances; they categorize real estate listings. In virtually all occupations, we find ourselves interfacing (if not competing) with some form of computer technology.

But to do all this "thinking," the computer appears to be a second law machine (much like man) and must therefore dissipate or reject heat. As such, the computer is quite sensitive to its environmental conditions of temperature and humidity. It could never have been developed in the manner and within the economic structure that it was were we not able to provide the computer with an environment of closely controlled limits of air temperature, humidity, cleanliness, and distribution.

• The economic effect of computer technology and use development, properly applied, was and is to increase the productivity of man. But consider a more direct relationship between environment and man's productivity. After a good night's sleep in the controlled temperature of a modern home, a person is as physically and psychologically fresh at the start of a workday following a 90 F humid night in August as he is following a "perfect" 60 F evening in spring or fall. The office worker can cope with his production requirements equally well year round. *It is not simply a matter of comfort.* Consider the problem of an engineering or architectural office trying to produce tracings for blueprints during warm, humid weather in the years preceding the quality of air conditioning known today. Not only did extreme discomfort tend to reduce productivity, but the mundane challenge of protecting the tracings from perspiration smears consumed as much time as putting the lines on the paper. If a truly scientifically accurate study addressing all of the relevant considerations were undertaken, it would not be surprising to find that summer productivity (in the moderate four-season zones) has increased at least 100 percent as a result of air conditioning technology.

Air conditioning opens sun belt

• In some areas of the United States, the period of thermal discomfort for indoor activity was not a simple seasonal problem but rather a continual condition. These areas included much of the Southeast, South, and Southwest. Because of the indoor discomfort due to high temperatures, these areas were predominantly rural in nature, and the major industries (except for mining and petroleum drilling) were farming and ranching. The first decades of the past 50 years saw an overabundance of farm products, which, even with governmental support, pointed to a certain economic decline of those areas.

Just as the decline was imminent, the new building technology freed the sun belt from decline and opened up a future of dramatic growth. Not only did it provide opportunities to increase productivity significantly through both residential and commercial air conditioning, but it also provided the vehicle for a massive movement of people and industrial activity from the congested areas in more northern sectors of the nation.

Auto cooling aids market

• Air conditioning and refrigeration technology has contributed more to the expansion of the automobile market than any other single contributor. Early efforts, like those in most commercial developments were add-on cooling units, which started to impact the market in the early 1950s. Then the auto manufacturers saw a public demand and began to integrate cooling systems into auto design to provide year-round indoor comfort control in the family car. An initial observation is that this "accessory" simply makes the ride in the car a bit more comfortable during hot weather. The fact is that a few days to several weeks of driving on a family vacation in hot weather without a cooling system was an almost unbearable experience that relatively few people took to. It was the addition of cooling that sent a vast number of American families across the nation's highways during the school vacation months of June, July, and August.

A natural next step in the evolution was the advent of the recreational vehicle, a home wherever one chooses to go. Without current air conditioning technology, the RV as it is known today would never have existed.

Another industry that was virtually built upon the air conditioned car is the modern motel industry. Increased numbers of travelers, needless to say, required places of rest and refreshment, and to provide for this need, a whole new industry of modern motels grew up along the nation's interstate highways, which are themselves at least partially attributable to the air conditioned car.

GNP per capita climbs

• The best measure of standard of living is thought by some to be the adjusted GNP per capita. Another measure of what might be more correctly called quality of living is the percentage of personal income spent on leisure activities. This ratio has continually climbed during these past 50 years with few temporary declines. Consider the impact that advances in HVAC technology have had on leisure activities, starting with bowling. Admittedly, the bowling pinsetting machine was a catalyst for the growth of the industry in the 1950s. But without the year-round revenues from use of the machines during all outdoor temperatures, it is doubtful that the industry could have supported the cost of the pinsetters. In other areas of leisure time activities, one of the major recreation growth industries in the past decade has been the racquet sports of tennis, racquetball, and squash, all played now indoors in controlled environments. Hockey, both professional and amateur, can now be played at any time of the year in Houston, Texas as well as Ottawa, Ontario because of the advanced technologies of refrigeration and air conditioning. Even the massive spectator sports of football, baseball, and soccer are played in indoor "stadiums" in some places where it tends to be too warm for outdoor baseball in summer or too cold for outdoor football in winter.

A plan has even been developed to provide indoor facilities for skiing in areas of the country that do not have the needed mountains and temperatures.

These have been but a few brief examples of the impact that the air conditioning and refrigeration industry has had on society over the past 50 years. A key element in the dissertation has been that the technological growth was a response to needs of the United States socioeconomic system following World War II. As previously stated, the needs were:

1) A job market was required for scientists, engineers, and technologists following the war effort.

2) The energy industry, which had geared up for massive productivity during the war, was pressuring society to create a market for their goods so that their industries could continue on the necessary growth curves.

The next 50 years

As we in the industries of building environment and refrigeration embark on the next 50 years, we might look proudly on our contributions over the past half century, but might then reflect on whether there is to be a change in the previously set course.

It was mentioned that the accomplishments achieved, initiated to satisfy society's needs as stated above, came about through free market pressures. There was no master plan, so to speak, developed by the government or our political leadership. This observation is most significant as we glance forward to the coming half century.

Many of today's practitioners in the industry are those who have had the opportunity to participate in the industry's growth in the past 50 years. It now appears that the ground rules or society's needs have changed and that we will have the opportunity to lead in the solution of a new problem. It is doubtful whether *any* given sector of technology has ever had such an opportunity to assist the socioeconomic system on so significant an undertaking before; *and in this industry, we are about to be given the opportunity for a second time within five decades.*

To address the needs of our emphasis and directed energies for the coming half century, compare them to the above-stated needs of society following World War II. Coincidentally, the first need, that of retraining, has run a complete cycle and exists once again. This time, the federal government, bent on solving all social needs, is attempting (with little fruition) to handle the retraining through government contracts and by directing thousands of former aerospace and AEC scientists and engineers into government sponsored programs concerned with building environments, most of which have had, or show promise to have, little effect on the industry or society. More quietly, there has been a personnel shift of aerospace scientific and engineering talent into the free enterprise market of the environmental and refrigeration industries. This is a time when the industry needs new talent at a greater rate than our educational system can provide, for a reason that may not be immediately evident and that leads to the second need of today.

In the late 1940s, the energy supply and production industry had a need to grow—a need that was real—and the resulting growth catalyzed an unprecedented period of economic growth. This situation has changed markedly.

Growth problems recognized

There were problems with this growth that were fairly well recognized by all knowledgeable practitioners in energy systems. The vast majority of the citizenry and, unfortunately, many of our political leaders, however, were not cognizant of them. A most timely observation came in a paper presented by G. W. Gleeson, dean of engineering at Oregon State

College, at the Semiannual Meeting of ASHVE in July 1951.* His paper, entitled "Energy—Choose It Wisely Today for Safety Tomorrow," presented an in-depth study of the then-current use patterns of energy resources (coal, oil, oil shale, natural gas, nuclear, hydro, vegetation, solar, wind, geothermal, tidal, tropical waters, and heat pump potential) and compared them to the resource availability. The paper illustrated clearly that continued dependence on United States resources in energy (particularly oil) would lead to a short-lived growth economy. A similar message related strictly to petroleum was delivered by Dr. M. King Hubbert in his address to the American Petroleum Institute on March 7, 1956.

The oil industry responded to the situation by seeking other sources and commenced rapid development of oil resources in other parts of the free world, including South America, the Middle East, and other relatively undeveloped areas. Thus, with the full knowledge and blessing of the United States government, we continued our growth economy on borrowed time while becoming the world's largest oil importer, until today we are dependent on foreign petroleum products for the survival of our economy.

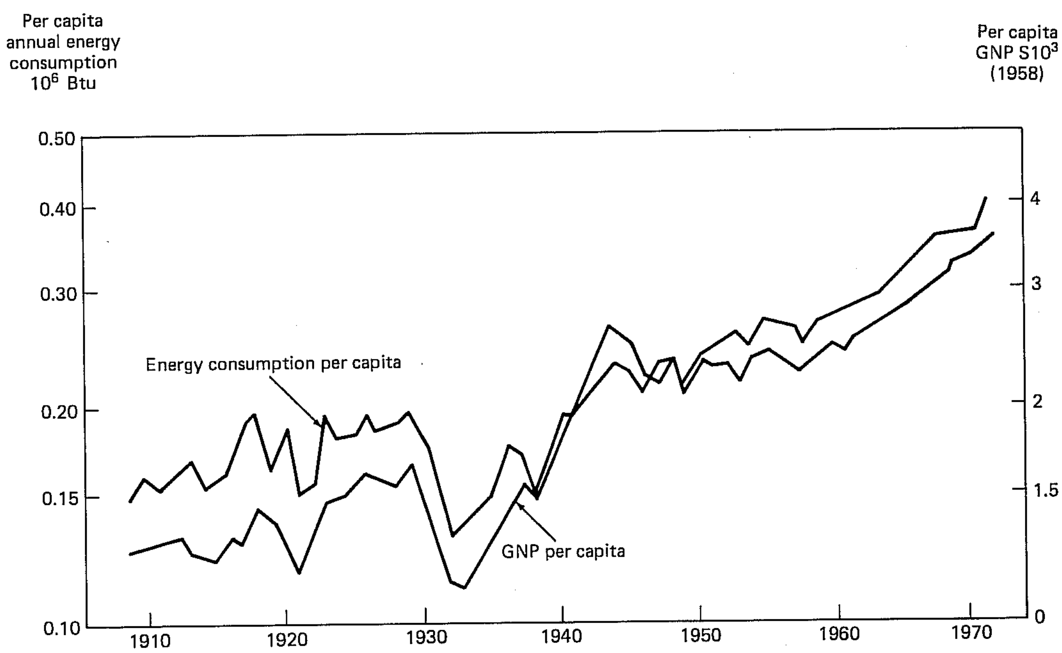
*Gleeson, G. W., "Energy—Choose It Wisely Today for Safety Tomorrow," *Transactions, The American Society of Heating and Ventilating Engineers*, Vol. 57, 1951, pp. 523–540.

Our leadership, instead of recognizing the need for redirecting our efforts in technology, urged us to go on spending with programs such as "atoms for peace," with one of the slogans informing us that with this new energy technology, electricity would be so inexpensive we would not need meters!

Now we must conserve!

We must now as an industry redirect our efforts toward the goal of preserving for our society all of those benefits that we have provided, such as those enumerated above, while reducing the rate of consumption of energy resources. If this can be accomplished, it will be an economic achievement of the first order.

Figure 13-1 is a graph of GNP per capita versus energy consumption per capita for the period of 1909 through 1973. An observation



Source: Institute of Gas Technology

Fig. 13-1 Trends of per capita GNP and annual per capita energy consumption in the U.S. 1909–1973 of the near congruence of the two curves leads to the inevitable conclusion that unless non-depleting sources can be found to replace our present depleting sources, *in equivalent quantities*, we have but one choice in charting our future course of action: that is to solve the problem of direct interdependence between energy consumption and GNP.

This can be done through more judicious use of energy. We can design and build homes and buildings in such a way as to provide high levels of comfort while consuming less energy. We can market frozen and perishable foods effectively while consuming less energy to do so. We can run our gigantic industrial system on a fraction of the resource energy we are consuming.

There will be relocation of people from one industry to another, just as personnel shifted from the railroads to the airlines in the late 1940s and 1950s; the appearance of buildings will change, just as it has over the past 50 years. It will be an exciting time. Our successes are behind us, and the challenge is before us!