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Competition and Cooperation: The Growth of District Heating and Cooling, 1882-1917

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ABSTRACT

This is a continuation of the author's work on the history of district heating and cooling. Between 1882 and 1917 the industry grew from a handful of commercial systems to over 400. The marketplace demanded heating systems that reduced the environmental impacts of smoke and fuel delivery, a reduction of costs, and reliable service. By 1917 most district heating systems were operated in conjunction with electric power plants, using exhaust steam to warm districts with hot water or low pressure steam. This era also saw the introduction of high and low temperature hot water and district cooling, along with the use of absorption chillers.

Several associations served district heating during these years. The Holly District Steam Engineers, Superintendents, and Managers Association was formed in 1886 and held annual meetings for the next four years. The National Electric Light Association, formed in 1885, established a district heating committee in the mid-1890s to serve the many electric companies that also provided district heating. In 1909, the National District Heating Association was formed to more directly serve the needs of the many commercial district heating companies.

The period from 1882 to 1917 was very important in proving the viability and value of district heating and cooling. The heating marketplace in the 1990s is not unlike that found at the turn of the century, when environmental concerns and fuel prices made district heating very attractive.

Key words: history, district heating, district cooling, cogeneration, ammonia

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INTRODUCTION

At last year's IDHCA convention in Harrisburg, I spoke on the introduction of district heating in urban and institutional communities up to 1882. As promised, the tale will now be moved forward to 1917, but first a few additions to the findings in my earlier work.

As if to further prove that the ancients have stolen our best ideas, shortly after the first London waterworks was completed in 1613, the Dutchman Cornelius Drebbel proposed that a similar system be adopted for the supply of heat. Drebbel wanted twenty thousand pounds sterling to execute the scheme and it was never acted upon. District heating nevertheless did evolve slowly from early developments in steam and hot water heating, both of which were apparently used as early as 1777 in the Soho Manufactory of Boulton and Watt. Several district heating schemes were proposed in England starting in the late 1820s to heat areas around public squares, worker housing projects, and buildings near factories with surplus exhaust steam. Some of these may actually have been built and I hope to get to England this summer to research this more thoroughly. In Russia, Immanuel Nobel, father of Swedish dynamite inventor Alfred Nobel, installed several small hot water district heating systems in St. Petersburg in the 1840s. London's Crystal Palace exposition of 1850 had a separate boiler plant located 150 feet away from the main building. In 1853, the United States Naval Academy at Annapolis installed what is probably the earliest district system in this country to heat several new buildings constructed that year. I have found very little information about this early system, with different accounts mentioning steam and hot water as a thermal distribution media. Although greatly expanded and modified over the years, the Naval Academy system remains in operation today. Intriguingly , Alfred Nobel visited the United States in 1850 to study under American naval engineers, leading to the possibility that he in turn introduced the technology used at the Naval Academy. A Russian connection can also be found in the low temperature district hot water system at the Banstead Downs Asylum in England in 1876, as the engineer would built that system had visited St. Petersburg the year before.

My dissertation recorded the historical background to Birdsill Holly's introduction of commercial steam heating in Lockport, New York in 1877 and its subsequent expansion to several American cities over the next four years. Although I despaired of ever finding the original records of the Holly Steam Combination Company, some of these were recently donated to the Niagara County Historical Society in Lockport by an individual who had obtained them many years ago from a former officer of the American District Steam Company. These records, which I have just started reviewing, greatly illuminate the finances of these early systems. I have also found the engineering journal written by Holly's son Edgar, who installed many of these early district heating systems. Several of Holly's great-grandchildren have been located, including a prominent Cleveland scientist who was named after him.

I have also been researching the history of the three Holly steam companies that have been operating since the 1880s: Denver (November 1880), New York (March 1882), and Harrisburg (March 1887). In each case a large quantity of early material has been located and is now being pieced together. A history of the Denver system is scheduled for presentation to the ASHRAE centennial meeting next January and will be printed in their *Transactions*. The Harrisburg history will be presented to the Pennsylvania Historical Association next October and will also be published. The history of district heating in New York, partially presented in the 1932 *Fifty Years of New York Steam Service*, is also in preparation and will prove of enormous interest. Unlike most early steam enterprises, the New York Steam Company had enough capital to implement some exciting ideas. For instance, they sold steam to power several electric light company plants, and even got into the electric lighting business themselves for a time. In 1885, the company actively pursued the use of absorption chillers for air conditioning, largely as a means to increase their summer load.

DISTRICT HEATING AND COGENERATION

The world of district heating changed very rapidly in its first decade of service. One of these changes was the adoption of cogeneration. Exhaust steam had been used for heating as early as 1805 and was widely used to heat buildings and factories that had steam engines. Many early Holly systems supplied steam to engines that powered elevators, pumps, and other machinery, with the exhaust steam warming the same building. Holly recognized the commercial potential of this exhaust steam and in 1880 designed and installed a dual pressure system for the Citizens Steam Company of Lynn, Massachusetts. The boiler plant, as before, sent out steam at about eighty psig to power engines, but here the exhaust was captured and distributed through a second set of low pressure street mains to heat other buildings. The Lynn company was not successfully managed, but another dual pressure system was installed in New Haven, Connecticut the following year and operated successfully. Another variant can be found in the San Francisco Steam Company, which was incorporated in 1886 with the idea of purchasing the exhaust steam from the many isolated plants in that city and reselling it to other customers through a system of street mains. It appears that this company operated for several years and may be the predecessor the present San Francisco system, but the destruction of most city records in the 1906 earthquake and fire makes extensive research difficult. These difficulties are compounded by the lack of property records for their steam plant, since they never had one.

Cogeneration became more widespread as the new electric light came into use. Except for those lucky folks near a waterfall or dam, a steam engine was essential for generating electricity and many early isolated plants in factories, hospitals, and colleges simply powered the engine-generator with existing boilers and used the exhaust steam for warming, resulting in a very low fuel cost lighting. Others concluded that they were actually getting very low cost heat. The combination, in any event, was certainly less expensive than two separate processes.

HOLLY DISTRICT STEAM ASSOCIATION

More than fifty steam companies operated during the 1880s, and it was perhaps inevitable that these companies should seek a forum to meet and exchange ideas. In June 1886, the Holly District Steam Engineers, Managers, and Superintendents Association met in Lockport, for the "mutual benefits of all parties interested in the several places where the Holly system has been, or is going to be introduced." The second annual convention was held the following June in Williamsport, Pennsylvania, where the following papers were presented:

"High and low pressure, which is the most economical in heating a building from a central station?" by R. H. Gallagher of Williamsport

"The best and most economical way of generating steam, the size and kind of boilers, etc." William Ridley of Denver

"Street mains, and the relieving the same of the condensation" E. P. Holly of Springfield, Massachusetts

"Piping buildings, which is the best system, one or two pipes?" George S. Chase of New York

"Which is the more practical way to sell steam, by meter or contract?" Charles E. Emery of New York

The third annual meeting was hosted by the Springfield [Mass.] Gas Light Company in June 1888. The papers presented were:

"High and Low Pressure for Heating Buildings from a Central Station," by R. H. Gallagher, Harrisburg

"Crude Oil and Coal Compared as Fuels," by E. P. Holly

"Can Cooking be done economically by Steam?" by Charles S. Chase, New York

"General Management of the Holly Steam Plants," by A. Z. Schook, Bloomsburg

"Incrustation in Boilers," by William Ridley, Denver, Col.

"Is it Advisable to Heat Feed Water by Direct Steam" by B. C. Smith, Auburn, N.Y.

"Cost of Maintaining Steam Meters," by John Walsh, Lockport, N.Y.

"Saving Fuel by the Automatic Regulation of the Damper," by N.C. Locke, Salem, Mass.

"Combustion of Fuel and Boiler Furnaces," by Thomas Murphy, Detroit, Mich.

"Rocking Grate Bars," by C. B. Holly, Phillipsburg, Pa.

The fourth convention was hosted by the Wilkes-Barré Heat, Light, and Motor Company in June 1889, with the following presentations:

"Which is the best system of piping houses in connection with the street system?" by John Walsh, Lockport

"Cost per annum of maintaining steam meters" by R. Gallagher, Harrisburg

The fifth convention was scheduled for Syracuse, New York in June 1890, but this has not yet been confirmed.

I have already mentioned that the New York Steam Company provided steam to numerous electric light companies. Several other steam companies did likewise, and, perhaps inevitably, the two interests started to coincide. In Hartford, Connecticut, the electric light company leased space for its generators in the Hartford Steam Company's plant, a practice followed shortly thereafter in Auburn, New York, Burlington, Iowa, and Lock Haven, Pennsylvania. In Harrisburg, the steam company purchased exhaust steam from the nearby electric light plant to heat its feedwater.

It was not long before the profit potentials of exhaust steam came to the attention of electric central station owners, and the stage was set for a fundamental transition to take place. The 1886 charter of the Albany Edison Illuminating Company includes supplying steam as well as electricity to the city of Albany and is the first electric company found that got into the district heating business on its own. Boston Edison followed in their footsteps a year later, starting a district heating system that still operates. The process was accelerated by the great blizzard of March 1888 that paralyzed the Northeast, greatly restricting fuel deliveries for several days, by which time the only warm buildings in Manhattan were the customers of the New York Steam Company. By the following year Edison companies in Philadelphia, Kansas City, Rochester, and Indianapolis were selling exhaust steam to nearby buildings. The electric light companies, which previously had said unkind words about steam companies and the effect of steam pipes on electric insulation, started talking about district heating in their meetings, and during the 1890s many electric companies added district heating to boost their otherwise slim revenues.

So far we have been talking about steam, both "live," or high pressure supplied directly from a boiler, and low pressure (generally under five psig) engine exhaust. Steam was not the only way to distribute heat and competing media also made an appearance in the 1880s and 1890s. Several intrepid souls proposed hot air district heating systems, primarily to provide fresh air in cities that were already filled with smoke. William Bliss of Springfield, Massachusetts, patented such a system in 1876 and received a franchise in Cincinnati in 1880. In 1889 Theodore R. Timby (more famous as the inventor of the rotating turret found on tanks and warships) started a company to distribute fresh air through an underground conduit that would be heated by a steam or hot water pipe in the same conduit. No hot air systems are known to have actually operated, although a company in Paris did provide compressed air for power for many decades and a company in Norwich, Connecticut operated a compressed air cooling system for some time.

HIGH TEMPERATURE HOT WATER

Another means to distribute heat was high temperature hot water, which could supply both heat and power. William E. Prall, a Washington, D. C. inventor, had patented such a system in 1879 and installed a small system in uptown Manhattan, which was demonstrated to the American Society of Civil Engineers in November 1880. Another was installed in Washington and several more were proposed, but not much happened until Prall received the financial backing of Theodore N. Vail, who had made a fortune in the young telephone business. Vail, who was twice president of AT&T, invested over half a million dollars of his own money in the Boston Heating Company, which supplied 400°F hot water to a large section of the downtown area. The system had no pumps, relying on the boiler pressure to force heated water through the supply mains. In each building it was flashed into steam for power and heating purposes, and afterwards returned through an open condensate return system. The system began supplying heat in early 1887 and worked quite well until November 1889, when it was discovered that the return pipes had corroded beyond repair. The system had to be abandoned, Vail lost his fortune, and high temperature hot water disappeared from America for half a century, while some of the Boston pipes ended up as telephone conduits. European engineers, who were more familiar with the older high pressure Perkins heating system, took an interest in the use of high temperature hot water. They soon solved the corrosion problem and made extensive use of this medium in the early twentieth century before it was reintroduced into the United States just prior to the second world war.

LOW TEMPERATURE HOT WATER

Yet another distribution medium was low temperature hot water. Although low pressure steam provided good profits for electric lighting companies, this potential was limited by the inherent limitations in distributing it. One solution was to use vacuum heating systems, such as that invented by Warren Webster, which enabled the use of very low distribution pressures. These became quite common and the University of Rochester is probably not along in operating a rather large vacuum condensate system. An alternative was to use low temperature water, which could be heated by the low pressure steam and distributed to a larger area. A company in Boise, Idaho began to distribute low temperature hot water from a geothermal well in 1890. This was a "once-through" system and the water was not returned to the station. Two competing hot water distribution systems appeared in the 1890s. The first was developed by Homer T. Yaryan of Toledo, a successful naval stores merchant and inventor who had been fired as an Internal Revenue agent by President U.S. Grant for failing to comply with Grant's wishes to "cook the books." Yaryan's system utilized two pipes for supply and return, and he also incorporated a thermal storage tank to make better use of the exhaust heat from an electric plant. Yaryan installed about thirty commercial plants in the midwest, including several in Ohio and around Chicago.

A second system was marketed by Quimby N. Evans and Juan Almirall. Evans & Almirall's system utilized a single continuous pipe with shunt connections into each building. Use of a single pipe greatly reduced the cost of installation. At least two dozen of these systems were operated by electric light plants, and many more were installed in institutions and factories.

More than two hundred companies used low pressure steam and hot water, with the majority of installations occurring in the Midwest between 1898 and 1902. The reasons for this were mysterious until I discovered that many, if not most, communities in this region were utilizing natural gas from fields discovered in the 1880s and 1890s. Natural gas was supplied at very low cost and could supply light, heat and power to both commercial and residential customers, allowing them to abandon coal and oil in their houses and businesses. Unfortunately for everyone concerned (except the district heating industry), much of the gas was wasted and the gas fields were not managed very well, causing many of the fields to become exhausted. Rather than return to their hated coal furnaces, entrepreneurs such as William Schott of Chicago and Robert Eldrige of Indianapolis installed dozens of combination heat and power plants in affected communities, sometimes completing them within a matter of weeks. Many of these systems operated quite successfully into the 1960s and 70s, with a handful going into the early 1980s. Two hot water systems were installed in Indianapolis and later incorporated into the Indianapolis Power and Light Company district heating system. A history of district heating in Indianapolis will be included in the ASHRAE centennial celebration.

RELATIONSHIP WITH ELECTRIC COMPANIES

Most of these systems had been designed around the exhaust steam capacity of the lighting plant engines and some became victims of their own success. It was common for plant managers to charge the entire fuel cost of the plant to the heating ledger, allowing electricity to be both cheap and profitable. Prior to the first world war, electrical networks were rather small and connected together several nearby towns. Improvements in electrical transmission, hydro-generator and steam turbine-generator technology made it possible for a single large plant to replace several small plants, and thus made consolidation practical and profitable. After a company had bought up several local companies, it would often decide to construct a single larger plant to serve its customers. Where local conditions were favorable to hydroelectric power, district heating was often, but not always, abandoned. Companies that chose steam power seem to have fallen into one of two group. One group, supported by many early conservationists, was convinced that plants should be located away from cities to reduce air pollution. Plants built by these parties were either located either near large bodies of water (for access to condensing water and coal deliveries) or at coal mine, to reduce transportation costs. The other group recognized the value of cogenerated heat and made equally conscious choices to build plants that could supply district heating.

Available technology seems to have had little effect on these choices, since steam turbines could be, and were, made to perform any combination of condensing, extraction, and backpressure exhausting. The consolidated electric companies often controlled plants in widely separated territories which were not interconnected, but these plants all tended to follow the policies of the parent corporation. If the parent was pro-district heating, the plants were built near cities. If they were not, the potential thermal output of the plants was ignored. The arrival of state public service commissions starting in 1912 further complicated the issue, because they liked simplicity and uniformity to make their job easier. Allocating heat and power costs in a cogeneration plant was (and still is) a difficult and messy exercise for most utility regulators, especially when other companies they regulated just supplied electricity.

The numerous regional and national electric lighting associations argued the merits of district heating and many formed committees interested in the subject. The National Electric Light Association was the largest group and wielded great influence. Examples of their involvement in district heating can be seen from the following papers read at their meetings:

1891 - F. A. Prentiss, General Manager of the New York Steam Company, "Distribution of Steam from Central Stations."

1900 - Harry J. Firth, Watseka, Illinois, "Utilization of Exhaust Steam for Heating." Promoted the use of hot water.

1901 - Charles R. Maunsell, Superintendent of the Edison Electric Illuminating Company, Topeka, Kansas, "Steam Heating from Central Stations." Promoted the use of low pressure (2-5 psig) steam.

1902 - Panel discussion of "Hot Water vs. Steam Heating" with J. F. Porter (hot water); P. H. Korst, Janesville, Wisconsin (hot water); Charles R. Maunsell, Topeka (low pressure steam); D. F. McGee, Red Oak, Iowa (hot water)

1903 - John W. Glidden, DeKalb, Illinois, "Report of Committee on District Heating,"

1905 - William H. Blood, Jr., Seattle, "Report of the Committee on District Heating."

THE FOUNDING OF THE NATIONAL DISTRICT HEATING ASSOCIATION

Although these committees offered some venue for district heating activity, they were clearly subordinated to the interests of the electric production and sales. In 1907 William Jennings of the Harrisburg Steam Heating Company sent out letters to over 160 heating companies asking about interest in form a district heating association. Some thought that such a group would be allied with, and perhaps auxiliary to, the electric associations. On July 15, 1909, at the Toledo convention of the Ohio Electric Light Association, a group interested in district heating gathered after the day's sessions and formed the National District Heating Association. There were at that time nearly sixty district heating companies in Ohio, most connected with electric companies. (Ohio was not unique in this, Iowa and Pennsylvania each had more than fifty and Illinois had more than thirty.). The first convention was scheduled for the Southern Hotel in Columbus, Ohio on November 10 & 11, 1909. Forty-one men attended this first convention, representing the following companies as charter members of NDHA:

DISTRICT HEATING COMPANIES
Springfield Light, Heat & Power Co., Springfield, Illinois
Quincy Gas, Electric & Heat Co., Quincy, Illinois
Penn Yan Steam Heating Co., Penn Yan, New York
Topeka-Edison, Topeka, Kansas
Springfield, Light, Heat & Power Co., Springfield, Ohio
Delaware Light, Heat, and Power Co., Delaware, Ohio
Cleveland Light & Power Co., Cleveland, Ohio
Grand Rapids-Muskegon Power Co., Grand Rapids, Michigan
Phoenix Electric Co., Butte, Montana
Fremont Yaryan Co., Fremont, Ohio

Oskaloosa Traction & Light Co., Oskaloosa, Iowa
Toledo Railways & Light Co., Toledo, Ohio
Central Heating Co., Toledo, Ohio
Valentine Heating Co., Toledo, Ohio
Economy Steam Heating & Electric Co., Sedalia, Missouri
Columbus Railway & Light Co., Columbus, Ohio
Paducah Light & Power Co., Paducah, Kentucky
Coshocton Light & Power Co., Coshocton, Ohio
Central Heating Co., Detroit, Michigan
Murphy Heating Co., Detroit, Michigan
Washington Heat & Electric Co., Washington Court House, Ohio
LaPorte Electric Co., LaPorte, Indiana
Youngstown Heating Co., Youngstown, Ohio
Pottsville Steam Heat & Power Co., Pottsville, Pennsylvania

MANUFACTURERS, ENGINEERS, ETC.
The Schott Engineering Co., Chicago, Illinois
American Radiator Co., New York, New York
American District Steam Co., Lockport, New York
Central Station Steam Co., Detroit, Michigan
The Strong, Carlisle & Hammond Co., Cleveland, Ohio
American Foundry & Construction Co., Pittsburgh, Pennsylvania
Best Manufacturing Co., Pittsburgh, Pennsylvania
Holland Radiator Co., Chicago, Illinois
Engineering Review, New York, New York
The Central Station Engineering Co., Chicago, Illinois

The convention adopted a constitution stating that the object of the association shall be to foster and promote the common interest of its members and to advance scientific and practical knowledge in all matters relating to Hot Water and Steam Heating, especially district or Central Station Heating; also to establish cordial and beneficial relations with kindred associations and between manufacturers of Heating equipment and appliances and installers of same and the members of this Association.

Dues for district heating companies were set at $5.00 annually, while vendors paid $10. The new association published its *Proceedings* in 1909, as it has every year since with the single exception of 1918. The annual *Proceedings* was joined by the quarterly *Bulletin* in October 1915, which has since evolved into the current *District Heating and Cooling*.

It is of interest to note that of the twenty-four district heating companies who were charter members, several are still operating. The Central and Murphy Heating Companies in Detroit became part of Detroit Edison's system, the Youngstown Heating Company became part of Ohio Edison and is now Youngstown Thermal, L.P., and the Cleveland Light and Power Company, which heated a ten-square block area of downtown Cleveland was incorporated into the Cleveland Electric Illuminating Company system, now Cleveland Energy Resources. I also believe that Kent County now operates some of the old Grand Rapids system, although I have not confirmed this. In Topeka and Columbus, the state capitols are heated by systems that appear to be remnants of the old systems, although I recently read that the Columbus system is being replaced with heat pumps.

WAR AND REGULATION

Regulation also made district heating difficult in many other ways. As mentioned above, many small systems had been built to take maximum advantage of the characteristics of a particular engine-generator set. As a practical matter, this put very real limits on how many customers could be connected to a distribution system. Utility commissioners, however, enforced the idea of universal service, and often ruled that heating companies had to take any and all customers who applied for service. Fighting such rulings was expensive and not always successful.

The final blow for many companies came from the extraordinary events surrounding the first world war. Those who remember the generally disastrous results of government intervention in the energy marketplace during the 1970s are often shocked to find these were minor compared to government antics during the first world war. Many still remember the second world war, when gasoline was rationed to save scarce tires, but it is remarkable to note that there was no rationing or shortages of electricity and coal during this conflict, despite the enormous growth in war industries. Such was not the case in 1917 and 1918, when the United States experienced its worst energy crisis.

The war in Europe had been raging for nearly three years before the United States entered the conflict in April, 1917. Although many American industries had expanded to meet the needs of the Allied forces, in general America was unprepared for the job it had to do. The principal weapon of this war was coal, which powered both industry and sea-going ships. Petroleum, which was to play such an enormous role in the next war, played a minor role in this war to end all wars. The best French coal fields had been captured by the German army early in the war and the enormous reserves of America had been called upon to fill the gap and in addition to fuel its own wartime expansion.

Unlike steel, petroleum, anthracite, and, to a lesser extent, railroads, the American bituminous coal industry had never undergone the mergers and rationalization that made industry more efficient, if also monopolistic. Several attempts were made to form bituminous trade associations in an attempt to control intense price competition, waste, and inefficient mining, but without success. Despite these problems, the European war had created strong demand. Coal production increased by one-third by 1917 and average prices doubled to roughly $2.00 per ton. The United States entry into the war only added to the demand for coal. By summer, panic buying drove the spot market for coal to $6 per ton and often higher, which along with some rail car shortages created something resembling hysteria. Although less than twenty-percent of coal was purchased on the spot market, the progressive administration of Woodrow Wilson had cut its teeth on anti-trust issues and was in the process of prosecuting West Virginia operators who were selling "smokeless" coal for $3 per ton. Unfortunately, this happened to be the price that the Committee on Coal Production selected in late June as a tentative maximum price. Although the fifteen-member Committee for Coal Production had been formed by the government in May to promote business-government cooperation and included the Secretary of the Interior as well as representatives of business, labor, and consumers, it was attacked by Secretary of War Newton D. Baker, who called it "exorbitant, unjust, and oppressive."

The effect of Baker's announcement was a postponement of coal orders, as industry anticipated that the government would soon mandate a lower price. Instead of normal stockpiling of coal for the winter, production dropped drastically in August. Congress passed the Lever Act on the tenth of that month, giving Wilson power to fix coal prices. Eleven days later, Wilson set the benchmark price at $2 per ton and the coal industry protested that the set price was below their war-inflated production costs. Many marginal mines were simply closed and September production dropped 2.2 million tons below the already low output of August.

To head the new United States Fuel Administration, Wilson appointed his old friend Harry A. Garfield, President of Williams College, whose only energy experience had been as a short stint as lawyer for a Cleveland coal syndicate. Unlike Herbert Hoover's Food Administration, which set minimum prices for meat and grain to stimulate production, Garfield set maximum fuel prices and tried desperately to allocate distribution, which was greatly hampered by the unwieldy railroad network. In Ohio, citizens without coal tore up railroad tracks to prevent shipments out of state. Despite such actions, Garfield was making some progress in getting coal mined and delivered. But for two factors, he might have been successful.

The first was a shortage of coal cars caused by shipments of war material and congestion in major railroad yards on the east coast, where many coal cars would sit for weeks before being unloaded. Despite this, coal was not placed in a high priority for shipment, placing behind food and weapons bound for Europe. To alleviate the shortages, Garfield requested that interior temperatures be lowered five degrees and that outdoor lights only be used on Saturday night. The second factor was the weather. The winter of 1917-18 was one of the worst to hit the northeast United States. Temperatures dropped to 20 below zero in Boston. It was possible to walk five miles across frozen Raritan Bay, between Staten Island and Sandy Hook, New Jersey. Many coal barges were frozen in place. In late December, Wilson nationalized the railroads, but most of the nation's major industrial regions were without fuel.

Two major blizzards hit in January, bringing all train traffic to a halt in the midwest. A battleship broke three-foot thick ice in Baltimore harbor. Garfield concluded that shutting down all manufacturing for five days would permit the railroad yards to be cleared and implemented that order on 17 January 1918. After the initial five days, most factories and institutions were also to be denied fuel for the next several Mondays. This order required many district heating and electric companies to shut down and the heatless Mondays lasted until the second week of February. The coal crisis continued for nearly two years after the end of the war, as inflation and strikes ravaged the energy economy.

In addition to these measures, the Fuel Administration employed a corps of engineers to inspect the 250,000 steam power plants in the country, suggest improvements, and in some cases to recommend consolidation with more efficient plants. Many small isolated and central stations were shut down to save coal and it is doubtful that many ever restarted. A tremendous amount of effort was put into energy conservation, resulting in many improvements in meters, controls, insulation, and operating procedures.

The new regulatory commissions in many states took a very serious view of their responsibility to approve rates, and the extraordinary wartime inflation required virtually all district heating company to apply for substantial rate increases. In some states, such as Indiana, the commission acted quickly, while others were very slow to respond. More than a few companies went bankrupt, including the New York Steam Company, and often the bankruptcy court granted rate increases that kept steam in the pipes.

DISTRICT COOLING

Despite the fact that the National District Heating Association was solely concerned with heating when it was founded, district cooling has a history in this period as well. More than twenty attempts were made in the 1880s to distribute cold salt water solutions serve the meat-packing and brewing industries in such cities as Paris, London, New York, Boston, Louisville, and Nashville. These met with failure from many technical problems, but by the end of that decade two different methods were ready for commercial operation, not including the compressed air system in Norwalk, Connecticut mentioned above. One of these was similar to older proposals and distributed brine through a system of underground mains, similar to that of a low temperature hot water system. It is likely that much technology was shared between the hot water and bring systems, as inventors such as Yaryan developed devices used in both. The Manhattan Refrigerating Company currently operates a brine system that dates to 1890.

The other method of district refrigeration was to distribute ammonia at up to 150 psig. This would be expanded on a customer's premises and returned through a vapor line, with a third line providing a vacuum. This was the more widely used system, and one of the original refrigeration companies provided ammonia service in St. Louis until the 1960s, when it was unable to afford the cost of moving lines to avoid a new highway.

Although primarily concerned with cold-storage applications, many of these systems provided space cooling and humidification control in hospitals, restaurants, and office buildings. As mentioned above, the New York Steam Company in 1885 promoted the use of steam-powered absorption chillers for air conditioning, but it was not until the early 1930s that commercial air conditioning came to the attention of the district heating industry. Predecessors of at least two existing district heating companies, in Seattle and Baltimore, appear to have provided district cooling before entering the heating business. In addition, many companies made and sold artificial ice with steam absorbers before mechanical refrigerators became popular in the 1930s.

CONCLUSION

The years between 1882 and World War I were of great importance to district heating and cooling. Great strides were made in technology and business methods, while companies learned how to deal with new government agencies and regulations. By learning how this industry reacted during times of enormous change can be helpful in dealing with new changes. It is also helpful to remember that however bad things might appear, they have been worse. Above all else, district heating and cooling is an industry marked by an ability to adapt to new and changed market forces.