Skyscrapers and District Heating, an inter-related History 1876-1933.

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Introduction

The aim of this article is to examine the relationship between a new urban and architectural form, the skyscraper, and an equally new urban infrastructure, district heating, both of which were born in the north-east United States during the late nineteenth century and then developed in tandem through the 1920s and 1930s. These developments will then be compared with those in Europe, where the context was comparatively conservative as regards such innovations, which virtually never occurred together there. It will be argued that the finest example in Europe of skyscrapers and district heating planned together, at Villeurbanne near Lyons, can be shown to be the direct consequence of American influence.

Whilst central heating had appeared in the United Kingdom in the late eighteenth and early nineteenth centuries, district heating, which developed the same concept at an urban scale, was realised in Lockport, on the Erie Canal, in New York State in the 1880s. In Massachussets were born the two important scientists in the fields of heating and energy, Benjamin Franklin (1706-1790) and Benjamin Thompson Rumford (1753-1814). Standard radiators and boilers, that is, heating surfaces which could be connected to central or district heating, were also first patented in the United States in the late 1850s.[1] A district heating system produces energy in boiler plant, in the forms of steam or high-pressure hot water, with pumps delivering the heating medium to distant buildings, sometimes a few kilometres away. Heat is therefore used just as in other urban networks, such as those for gas and electricity. This system needs a heavy infrastructure, with boiler plant, pumps, and mains laid out beneath the streets, but renders superfluous a large amount of equipment inside the buildings connected to it.

District heating had several practical advantages, as will be indicated below, and also influenced architecture in formal and aesthetic terms. It allowed architects to get rid of chimney stacks and chimney pots on the roof, thus enabling the creation of new building forms. Thus district heating had an impact on the superstructure of skyscrapers, as a newspaper advertisement for the New York Steam Corporation in the early 1930s, entitled "Serving a City of Towers" illustrates perfectly (see Fig.1).[2] One should note that both inventions had an experimental phase and then a growth period before being seriously slowed down by the economic crisis in 1929 (the last skyscrapers of this period were finished in 1933). The history of skyscrapers is well known;[3] but the history of district heating systems is less so. This article will focus on the latter.

The Invention of District Heating

The inventor of district heating was Birdsill Holly (1820-94), an American engineer and self made man. He was involved in a variety of different fields: water supply for fire protection, district steam heating, and projects for a steel framed skyscraper, first on Goat Island (Niagara Falls), then Long Island.[4] His first patent, in 1849, was for a pump, as were most of his patents during the next fifteen years.[5] He also worked on a steam powered fire engine, which could produce a steady stream of water for fire fighting.[6] After a major fire at Lockport in 1854, Birdsill Holly set out the

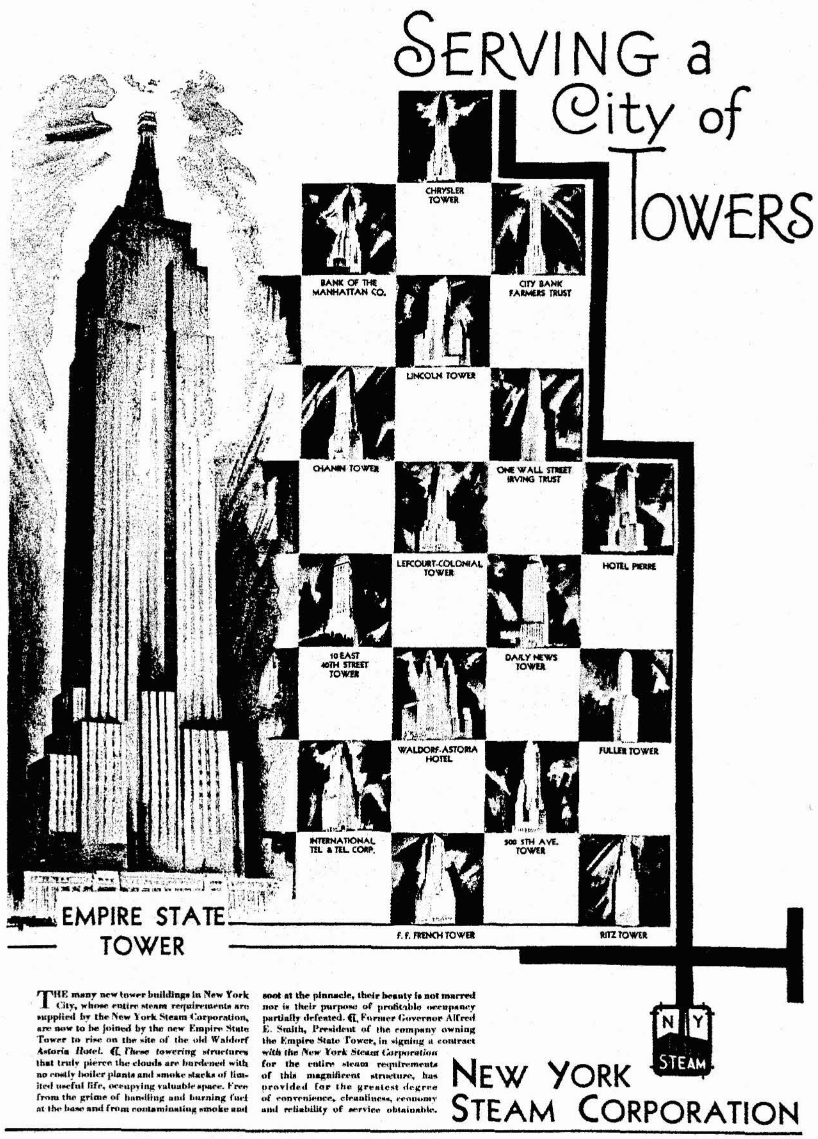

Figure 1. Advertisement by the New York Steam Corporation, early 1930's (By Courtesy of the Avery Library, Columbia University)

Holly System of direct and permanent pressure water supply, more efficient than the reservoirs it replaced. Two years before the Chicago fire of 1871, this city's department of public works had recommended the adoption of the Holly System, but the initiative was not pursued.[7] At the end of the 1870s, Holly undertook a completely new project, a nineteen-story skyscraper on Goat Island. He wrote:

> "The original blueprints revealed a building base of 140 feet square. Elevators, located within artistic columns on each side of the skyscraper, would soar 700 feet above the ground. Winding staircases, parallel to the elevator shafts, would contain 1200 steps to the top. The plans called for 368 rooms to be located on fifth and sixth floors...at the top of the skyscraper there would be a promenade, an observatory, and a little train drawn by a locomotive."[8]

However, the owners of Goat Island, wanting to preserve the island, prevented the execution of the scheme. Holly took his blueprints to New York, where he tried to carry out his project on Long Island, but without success, being considered a lunatic "farmer from the West."

After this fruitless experience Holly returned to plumbing. In 1876 he tried out his idea of distance heating by steam in his own garden in Lockport.[9] He was able to solve problems such as expansion joints, regulatory systems, steam meters, pressure, protection against condensation, and insulation. The year after, incorporated as the Holly Steam Combination Company, he laid out pipes connected to a boiler and a pump throughout the Lockport town centre. As reported a few years later, this network reached 65 houses with 3 miles of pipes.[10] In 1881, several towns, notably New York City, tried out this new way of heating buildings within a given area. The same year, Holly deposited several patents which described the respective features of the system: mains pipes, meters and steam-pressure regulator.[11] His interest in steam networks was a logical progression from working on pipes, pumps, and fire fighting systems, but his project for the tower on Goat Island is more surprising and reveals the open-minded character of the inventor.[12]

New York City and Chicago

Wallace C. Andrews[13] and Charles Edward Emery[14], both from New York, travelled to Lockport to investigate Holly's new system, and decided to introduce it into Manhattan. They formed the New York Steam Company and obtained a franchise from the board of Aldermen in December 1880:

> "The right to lay mains and pipes in any and all the streets, avenues, lanes, alleys, squares, highways and public places in the city of New York, with the necessary and proper laterals and service pipes thereto, for the purpose of supplying to the city and its inhabitants, for motive power, heating, cooking or other useful applications, steam, water, air and other fluids, at both high and low pressure, with necessary return pipes, and all necessary excavations in the said streets, avenues and other places aforesaid, for the purpose of laying such mains and pipes, and of making all necessary additions, repairs and alterations thereto, and of putting in place any manholes and vaults necessary to secure convenient access to parts requiring adjustment."[15]

The first plant was located on Cortland Street, with two chimneys about 68 metres high; they were the tallest structures in lower Manhattan at that time.[16] In 1881, New York, and especially lower Manhattan, was mostly composed of low, flat-roofed houses, but in the 1870s the first office building equipped with elevators had appeared. The first customers of the New York Steam Company, mostly office buildings such as the First National Bank at the north corner of Broadway and Wall Street, were supplied with steam in March 1882. On a later list of customers, the presence

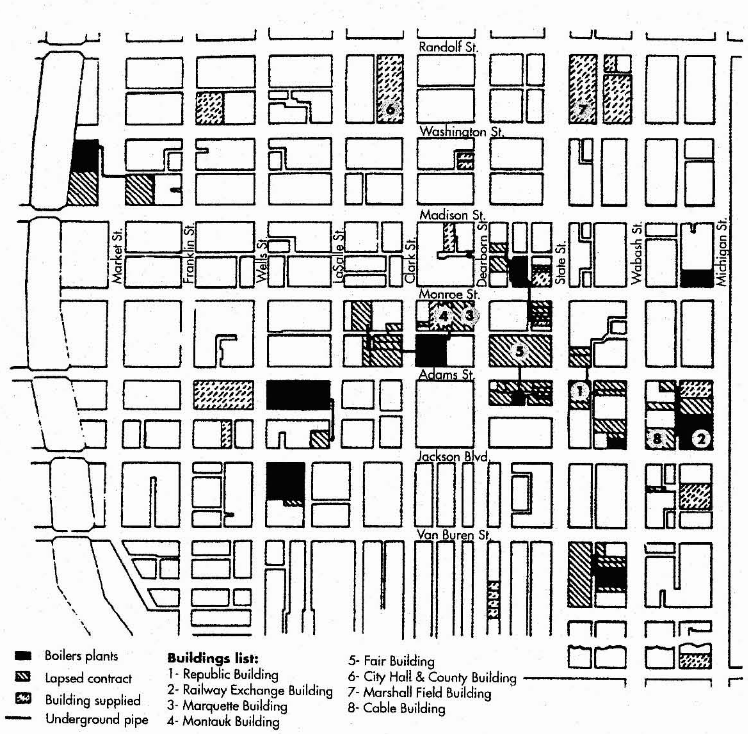

Figure 2. Buildings in Chicago served by the Illinois Maintenance Company, 1914.

of elevators was mentioned after the name of the building: "United Bank Building (2 elevators), American Express Company (1 elevator), Bank of New York (1 elevator)."[17] The Mutual Union, the Telegraph Building and the United States Post Office Building were also among the Company's early customers. In 1886, the New York Steam Company erected another plant located uptown, at that time a wealthy residential area with residents such as John D. Rockefeller. It was he who supplied a testimonial: "I have my house heated for several seasons by steam supplied by your Company and am satisfied with the service given."[18] The aim was to prove that district heating could be convenient for luxurious homes as well as offices. The steam conveyed through pipes to buildings had to be controlled at the point of entry; pressure was reduced by a regulator-reducing valve.[19] The low pressure steam was conveyed around the building through supply pipes to radiators, and a meter measured the amount of steam used in the building.[20]

During the 1880s, after the first "elevator" buildings in New York, skyscrapers were developed in Chicago. The Home Insurance Company Building erected to the designs of Le Baron Jenney in 1884-5 is reckoned to be the first example, using a metal skeleton and elevators. There was, however, no district heating system in this city during the last decades of the nineteenth century. Moreover, in 1910, the Illinois Maintenance Company introduced a different type of heating network. The idea here was to connect existing plants in order to close down the smaller and less efficient one (see Fig.2):[21]

> "Steam was generated by six boiler plants, four of which were linked together into one system... In the system comprising the four plants, one is operated 24 hours per day for base load and the others as needed to pick up peak loads resulting from weather changes... Steam is generated and distributed at pressures of 115 to 136 psi."

The company served important buildings in the Loop, including offices, theatres, department stores, restaurants and shops, but did not supply industrial premises.[22] Boilers were located mostly in basements of the generating building, as in any conventional central heating system. For buildings connected to the system it was just like having heat delivered by a central powerhouse, with all the advantages that this method offered. With this network, however, mains were shorter and thus less expensive to lay out. The buildings which were part of this system included the famous Marquette Building, the Montauk Building, the Manhattan Building, the Republic Building, the Fair Building, the Railway Exchange Building, City Hall and County Buildings, the Marshall Field Building, and the Cable Building.[23] Among them, the Republic Building and Railway Exchange Building produced and supplied steam to other buildings, the last also providing energy to the Cable Building in the Western part of the same block.

Growth

Even if Chicago played an important role in the history of skyscrapers, New York regained its leadership after 1900. Many skyscrapers erected in Manhattan between 1881 and 1909 were connected to the steam distribution system: for instance the New York Produce Exchange, the Tower Building, the St. Paul Building, the Park Row Building, the Times Building, the 90 West Street Building, the Singer Building, the Thames Twins (the Trinity and US Realty Buildings) and the Metropolitan Life Insurance Building (see table). However other famous buildings, like the Flatiron and the New York World Buildings, were not customers of the New York Steam Company. One of the reasons for this was that the heating system had not been extended throughout the city; the pipes ran westwards and southwards from the heating plant at the 60th Street whilst those from the Cortland (downtown) station also ran northwards. The few buildings connected to the system were, however, significant ones. For instance, the St. Paul Building was, at this time, the highest in the city, at over 100 metres high. The Tower Building was the first all-metal frame building in New York. It did not have any other means of heating, thus demonstrating great confidence in the new system. Of course, the heating company had many other customers, most of whom owned more traditional buildings.

Buildings erected between 1909 and 1915 and connected to the steam system then included the Woolworth Building, the Municipal Building, the Adams Building and the Equitable Building (see table).

During the following years the network grew, with further new plants (six in 1932 alone). The most important expansion, however, began after 1921, with an important increase in capital and a new name, the New York Steam Corporation.[24] The 1920s and 1930s constitute a period of real growth for both the district heating network and the erection of skyscrapers. Most of the well known skyscrapers were supplied by the New York Steam Corporation. In the 1920s these included the Crown Building, the Standard Oil Building, the Ritz Tower Building, the Barclay-Vesey Building, the Paramount Building, the Fred F. French Building, the New York Life Insurance Company, the Chanin Building, the Beekman Building, the Hotel Pierre, the 10 East 40th Street Building, the Fuller Building, and the Bank of New York & Trust Co.[25]

The 1930s witnessed an even greater expansion, with amongst others the Helmsley Building, the Lincoln Building, the Chrysler Building, the Western Union Building, the Bank of Manhattan, the

Table: Buildings supplied by the New York Steam Corporation 1881-1931

Name of Building	Years	Address, Architect	Stories	Height
New York Produce Exchange	1881-4	2 Broadway (downtown) George B. Post	11	68.5 m
Tower Building	1888	50 Broadway (dt) Bradford Lee Gilbert	11	48 m
St. Paul Building	1899	St. Anne Street (dt) George B. Post		100 m
Park Row Building	1899	15 Park Row (dt) R. H. Robertson	32	117 m
Times Building	1903-5	1 Times Square C. W. Eidlitz and McKensie	25	110.5 m
90 West Street Building	1905-7	90 West Street (dt) Cass Gilbert	24	99 m
Singer Building	1906-8	149 Broadway (dt) Ernest Flagg	47	204 m
Thames Twins, Trinity and US Realty Buildings	1905-7	111-115 Broaday (dt) Francis H. Kimball	21	90 m
Metropolitan Life Insurance Building (1 Madison Avenue)	1907-9	1 Madison Avenue Napoleon Le Brun & Sons	45	213 m
Woolworth Building	1913	133 Broadway (dt) Cass Gilbert	60	241.5 m
Municipal Building	1909-14	Centre, Reade & Duane Streets William M. Kendall, McKim, Mead & White	39	170.5 m
Adams Building	1914	65 Broadway (dt)	33	136.5 m
Equitable Building	1912-5	120 Broadway (dt) Ernest Graham, Anderson, Probst & White	41	157 m
Crown Building or Heckscher Building	1921	728-34 Fifth Avenue Waren & Wetmore	25	104 m
Standard Oil Building	1922	26 Broadway (dt) Carrere & Hastings and Shreve, Lamb & Blake	30	154 m
Ritz Tower Building	1925	370 Madison Avenue Emery Roth and Carrere & Hastings	41	
Barclay-Vesey Building	1923-7	140 West Street Ralph Walker, McKensie, Voorhees & Gmelin	32	152 m
Paramount Building	1926-7	1501 Broadway C.W. and George L. Rapp	32	139 m
Fred F. French Building	1927	551 Fifth Avenue	36	135 m
New York Life Insurance Co. Building	1927-8	246 Broadway/51 Madison Avenue (dt) Cass Gilbert	40	187.5 m
Chanin Building	1927-9	122 East 42nd Street Sloane & Robertson	56	207.5 m
Beekman Building	1928	3 Mitchell Place John Mead Howells	28	
Hotel Pierre	1928	795 Fifth Avenue	44	160 m
10 East 40th Street Building	1928	10 East 40th Street	48	189 m
Fuller Building	1928-9	41 East 57th Street Walker & Gillette	40	
Bank of New York & Trust Co.	1927-9	48 Wall Street (dt) Benjamin Wistar Morris III	32	156.5 m
Helmsley Building or New York Central Railroad Co.	1929	230 Park Avenue Warren & Wetmore	35	172.5 m
Lincoln Building	1930	60 East 42nd Street J. E. R. Carpenter	53	205.5 m
Chrysler Building	1928-30	395 Lexington Avenue William Van Alen	71	319 m
Western Union Building	1928-30	60 Hudson Street (dt) Voorhees, Gmelin & Walker	24	113 m
Bank of Manhattan-40 Wall Street	1928-30	40 Wall Street (dt) H. Craig Severance and Yasuo Matsui	71	282.5 m
Daily News Building	1929-30	220 East 42nd Street Raymond Hood, André Fouilhoux and John Mead Howells	37	155.5 m
500 Fifth Avenue Building	1930	500 Fifth Avenue Shreve, Lamb & Harmon	60	207 m
Empire State Building	1930-31	350 Fifth Avenue William F. Lambas, Shreve, Lamb & Harmon	102	381 m
Waldorf-Astoria	1929-31	309 Park Avenue Schutze & Weaver	47	190.5 m
Irving Trust Co. Building-Bank of New York	1929-32	1 Wall Street (dt) Ralph Walker, Perry Coke and Voorhees, Gmelin & Walker	50	195 m
120 Wall Street Building	1930	120 Wall Street (dt) Buchman & Kahn		131.5 m
New Yorker Hotel	1930	481-97 Eighth Avenue Sugarman & Berger	43	134.5 m
Essex House (Hotel)	1930	160 Central Park South Frank Grad	43	140.5 m
City Bank Farmers Trust Co. Buiding	1930-1	22 William Street (dt) Cross & Cross	57	229 m
General Electric Tower or RCA Victor Radio Co. Building	1929-31	570 Lexington Avenue Cross & Cross	50	195 m

Nelson Tower	1931	450 Seventh Avenue H. Craig Severance	46	160 m
30 Broad Street Building-Continental Bank	1932	30-34 Broad Street	48	171 m
Rockefeller Centre	1932	Fifth-Sixth Avenue from 48th-50th Streets Reinhardt, Hoffmeister, R. Hood & Fouilhoux, H. W. Corbett, Harrison & Mac Murray	70	259 m max
US Courthouse	1933	40 Centre Street Cass Gilbert & Cass Gilbert Jr.		
Beresford Apartments	1929	211-219 Central Park West Emery Roth	20	85 m
Eldorado Apartments	1929-31	300 Central Park West Margon & Holder and Emery Roth	29	105.5 m
San Remo Apartments	1930	145 Central Park West Emery Roth	28	112 m
Century Apartments	1931	25 Central Park West Irwin Chanin	30	103.5 m
Majestic Apartments	1931	115 Central Park West Jacques Delamarre	30	103.5 m

This list has been compiled from several sources: information about skyscrapers on website greatgridlock.net, and other lists of buildings connected to the New York Steam Corporation, available in New York Steam Corporation, *Fifty years of New York steam service, the story of the founding and development of a public utility* (New York, 1932).

Daily News Building, the 500 Fifth Avenue Building, the Waldorf-Astoria, the Empire State Building, the Irving Trust Co. Building, the 120 Wall Street Building, the New Yorker Hotel, Essex House, the City Bank Farmers Trust Co. Building, the General Electric Tower, the Nelson Tower, the 30 Broad Street Building and the Rockefeller Center (with several buildings). There were also 20 to 30 storey towers of apartments supplied with steam heating, including the Central Park West Apartment Buildings, the Beresford Apartments, the Eldorado Apartments, the San Remo Apartments, the Century Apartments and the Majestic Apartments (see Table). This group demonstrates that the skyscraper building type could be extended to the residential sector. Unfortunately, the great depression of 1929 slowed down the construction of private buildings, and the last towers were finished in 1933 (see Fig.3). Of course these skyscrapers formed just some of the New York Steam Corporation's customers, the other building types supplied being railway stations, theatres, a museum, department stores, medical centres, schools, and a church. In 1931, an agreement was reached with the United States Treasury Department for the supply of steam to all federal buildings within reach of the network. The National City Bank and the City Bank Farmers Trust were also linked with the New York Steam Corporation through having directors in common.[26]

Most customers now gave up their other, independent heating plants, in contrast to the situation during the previous century. The efficiency of a centralised steam supply for heating skyscrapers was

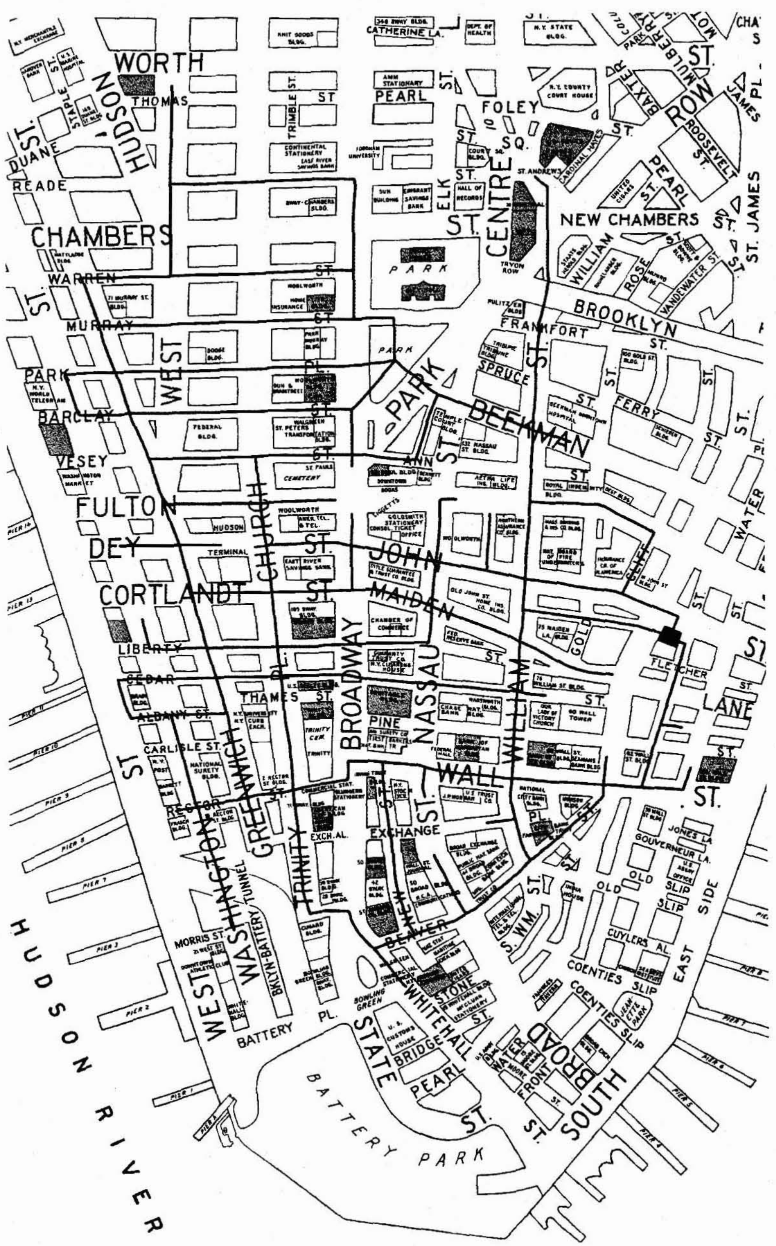

Figure 3. Buildings in Lower Manhattan served by district heating, early 1930's.

proven by the Empire State Building (1930-1), with its 102 stories and a large volume.[27] It contained 7,000 radiators (21,089 square meters of heating surface), and for this especially high and large tower the heating system was divided into four separate zones, each heated from different mains:

"The first five floors were supplied from mains in the sub-basement; the second zone, floors 6-29, was supplied downward from a set of mains in the twenty-ninth floor ceiling; the third zone, floors 30-54, was supplied from mains in the ceiling of the twenty-ninth floor; and the rest of the building, including the tower, was supplied from a set of mains in the ceiling of the fifty-fourth floor."[28]

The chief mechanical engineer of the New Yorker Hotel, W.E. Cameron, replaced the projected pulverised fuel boiler, by a connection to the mains of the New York Steam Corporation. As the building was also rather high, the main distribution, by means of 51cm pipes, went up to the 24th story, and thereafter ran up and down with 20cm pipes.[29]

In the 1930s, the various heating stations were located along the East River waterfront, so that coal could be easily delivered by boat. The lower Manhattan area (district B) was no longer supplied by the old Cortland Street plant but by a power plant (A), built in1917, on Water Street and Burling Slip. The other district (J), with three plants, covered uptown and midtown from 27th to 81st Streets (on the Eastside). The Kip's Bay Station, erected in 1926, was located between 35th and 36th Streets. Station J, located between 59th and 60th Streets, was erected in 1897, but new boilers were installed in 1921-2. Another station JX, close to the J Station, was built in 1908, with several boilers being renovated in 1926. A contract with the New York Edison Corporation, producing electricity, enabled the transit of steam from the Edison Company's Waterside Station, located between 38th and 40th Streets and the Edison Company's East River Station, located at 14th Street.[30]

From 1921, the centralised steam heating service in New York City was growing more rapidly than any other form of public service, the corporation claiming that "the expansion during the past five years alone was exceeding the entire growth during the first forty-five years of its history."[31] Between 1921 and 1932, the annual revenue of the New York Steam Corporation rose from $3m. to almost $10m. From 1927 and 1929, the total amount of steam supplied by all the district heating networks grew by 19 per cent per year, even more than the growth of the electricity network during the same period.[32] In the J district, covering uptown and midtown, the length of steam pipes increased 2.6 times between 1925 and 1932. In 1932, the New York Steam Corporation was the largest district steam distribution network in the world, with 104,600 km. of pipes buried beneath the streets of New York. Seventy five per cent of the buildings of the heart of the city, that is around the 42nd Street, were supplied by the Corporation.[33] In other words, the golden age of Art Deco skyscrapers in Manhattan was also a remarkable growth period for district heating in New York City. The demand generated by all these giant buildings relying on steam obviously strengthened the growth of the New York Steam Corporation.

Urban and architectural benefits

Harvey Wiley Corbett, one of the architects of the Rockefeller Center, wrote: "The individual heating plant is as archaic in a sense as the old-fashioned grate. Today we are concentrating our new fireplaces at a few centrally situated points in the city where steam is made very much as electricity is made, and then through a highly efficient system of pipes and underground conduits, this steam is distributed where needed to any type of building from the simple residence to the great skyscrapers."[34] This clearly demonstrates that, in the 1930s, American architects were as convinced of the use of steam distribution as of other common mains like electricity.

District heating systems have several advantages, some at the level of town planning, others at the level of buildings, or at that of general public health. The first is the decrease in fire hazard, by reducing the number of fires lit inside buildings. One must remember that when the first steam network was laid out in New York, electric light was just being introduced, also to avoid fires arising from gas or oil lighting. Electric lighting was a characteristic of office blocks with elevators (hydraulic and later electric). The use of fewer fires because of district heating had further positive consequences in terms of savings on insurance premiums. A district heating system also avoided the risk of burst boilers inside buildings, something that could happen with central heating. The fight against fire was a real priority in north American towns, and especially in New York. The French writer Paul Morand, in his book about this city, remarked how impressed he was by the efficiency of New York firemen and their fire hydrants.[35]

Another advantage was the reduction of smoke nuisance. In Manhattan the New York Steam Corporation eliminated both the burning of 1.2m. tons of coal, and the smoke and gas from more than 2,500 chimneys. Not only did this smoke reduction benefit public health, it also prevented damage to the external surfaces of buildings. At the end of the nineteenth century and in the first part of the twentieth century, serious air pollution was caused primarily by coal burning, for individual and collective heating, and for energy production. Unchecked individual stoves produced more air pollution than a power plant equipped with smoke-consuming filters.

Other positive aspects of district heating included the maintenance of uniform, controlled temperatures indoors, an absence of dust caused by coal and ash handling, and decreased traffic of fuel in the public domain. All these were factors, which directly benefited public health and, therefore, promoted efficiency. Contemporary "Analytical Reports" noted that: "As an illustration of the saving in coal and ash handling, the New York Steam Company has estimated that the buildings in its uptown district, if individually heated, would require 333 five-ton truck loads per day for 300 days a year to handle coal, ash and refuse."[36]

In a place like Manhattan Island, where everything has to be brought in over bridges or through tunnels, the idea of delivering coal by boat and then heat by steam underground, is especially convenient, as it avoids traffic.

Using district steam network, the probability of failure or breakage of mechanical equipment through interruption of supply was considerably reduced. As the power plants were interconnected and each disposed of several boilers there was no chance of complete system failure. The network could not shut down. Inside the buildings served, workers were no longer required to operate boilers, thus reducing running costs. In the power plants qualified workers were able to manage production efficiently.

Furthermore, service spaces within individual buildings could be reduced: no more boiler rooms, and no more spaces for coal and ash storage. The absence of smokestacks meant an increase in rental value, significant in Manhattan. Space formerly devoted to heating machinery, boiler rooms and coal bunkers could now be used for offices, bank vaults, restaurants and stores. "Profit was central for skyscrapers" as Carol Willis pointed out in *Form follows finance, skyscrapers and skylines in New Yoke and Chicago* and the way of increasing the floor space was going in the best directions. In the late 1920's, Morand expressed his surprise when he encountered luxurious basements in the form of restaurants, hairdressing salons or stores.[37] To gain an idea of amount of space saved by the use of a district heating system, it should be noted that when the Paris town hall was connected to the district heating network in 1934, the heating capacity increased threefold whilst the corresponding service area was reduced thirty-fold.[38] Yet even if it is undeniable that space and income were both increased by adoption of district heating, the idea that skyscrapers were more a matter of symbolism than of financial rationality.[39] There was a certain attraction, for companies and people alike, to be, or to work, in these remarkable buildings. It remains true, however, that the larger useful spaces make possible by connection to the steam district heating system, were beneficial. As Morand wrote, "the soul of these buildings is success; they were tabernacle of success, financial success."[40]

Nevertheless, dependence on the network had several drawbacks. One was an interruption in steam distribution, another the imposition of a price increase, a third was that mains or pipes could be damaged and burst beneath the street. The first, a break in service, never happened, even during severe storms such as that of 1888. The disposal of several stations and several boilers inside each station, and the connection to steam electrical production reduced this possibility to zero. The company maintained large coal reserves in its storage yard, located across the East River in Newton Creek, between Queens and Brooklyn. As for increased rates, whenever the market coal price rose quickly, as it did in 1917, the company then had to follow.[41] Yet the cost still remained cheaper than individual heating, because the company negotiated favourable prices from the seller, on account of the scale of its coal orders. The last problem could be avoided with good maintenance. The New York Steam Corporation took considerable financial risks, investing in several plants, laying our mains under streets, and stockpiling coal, some years before getting any return on its investment.[42]

The architectural impact is certainly the most interesting advantage of connecting skyscrapers to district heating. First, the architect could avoid the issue of dealing with power plant engineering, as no boilers, lonely small-scale equipment, was necessary. As a contemporary report noted: "The recent writings of prominent architects and builders show a decidedly favourable attitude toward central steam heating, which is fast becoming almost an economic necessity in congested areas of New York."[43]

Spaces previously dedicated to power plants and to coal storage could now be used for other purposes. Besides considerations of economy and space, the elimination of the chimney opened up new aesthetic possibilities for the architect. The corporation boasted lyrically, "[i]magine columns of smoke rising where now glitter the graceful pinnacles of many of our skyscrapers of today."[44] For the first time, architects were able to use their imagination freely, especially in the aesthetic treatment of the tops of buildings, where they were released from technical restraints. The result was strikingly apparent in skyscrapers, with the ornamental tops of the most beautiful buildings, such as the Chrysler, the Empire State or the Waldorf-Astroia, having been the impossible without a central steam service.

The construction of a skyline was important from 1897 onwards, especially for a town, which could be viewed from a distance by boat or other shores. The highly spectacular 1930s skyline was likewise an aesthetic consequence of the advantages of district heating. Paul Morand for one was evidently impressed by this skyline: "The Standard Oil Building looks down from its conical campanile with four obelisks on all these square towers. I had a brilliant and uplifting memory of the stepped pyramid of the Banker's Trust, of the Singer Tower, of the square phallus of the Equitable Building, of the American Telegraph and Telephone, of the Woolworth Building. I find in them a beauty which is not lonely decorative: they give me a deep satisfaction."[45]

District heating in Europe

In Europe, skyscrapers and district heating both took time to appear, even though the professional press referred to American experiences of both. Contrary to the American situation, district heating and skyscrapers appeared at different times and in places, except for a unique case in France, to be described below.

Unlike America, Europe had no district heating during the nineteenth century. Chapters in books and papers on the topic bear witness to an interest in heating networks, but considerable financial investment needed to create the entire system often curtailed concrete realisation, due to the lesser availability of capital in the old world. There were no negative preconceptions about this kind of urban network. Europe further contrasted with America, however, in that the mains had to be inserted into established, and even historic town centres, like those of Dresden or Paris.

Countries suffering long periods of cold weather were, of course, the most interested in this

American novelty. Consequently the first European towns with district heating systems were Dresden (1900), Frederiksberg (1903), Manchester (1911) and Bergen (1918).[46] Often power plants already existed, some of them producing electricity as well. Mostly, the pipes did not contain steam but high-pressure hot water, as was usual in central heating systems in Europe from 1900 onwards. Between 1920 and 1935, several towns were equipped with such heat supplies, in France, Belgium, the Netherlands, the United Kingdom, Switzerland, Czechoslovakia, Germany, Norway, the USSR, and Iceland. The United Kingdom, Belgium, and Switzerland had fewer networks during the 1930s. Germany and Denmark, the first countries concerned, were also those where the most extensive networks were developed, with 20 and nine networks respectively. In the USSR, the networks appeared in the 1930s, combining steam-electric plants, and their number increased rapidly. In Germany, most of the systems were installed by Rud. Otto Meyer of Hamburg. The plants burned low quality coal and, as the network never reached industrial customers, production occurred only during the cold season. In Paris, a network created by private funds, started with an electrical plant previously assigned to the subway in the neighbourhood of the Gare de Lyon, laying the pipes westward to the town centre. The town, giving the concession to the *Compagnie Parisienne de Chauffage Urbain* charged with connecting public buildings as a priority. The network of the French capital was created simultaneously with that in Villeurbanne, but was of greater extent.

Skyscrapers in Europe

In Europe the reception of skyscrapers differed from that of district heating and was more negative. The interest in this new form was evident, with a fascination in their novelty and the dramatic skyline they produced. Exotic in nature, this innovation was perceived as foreign; as one French construction journal exclaimed, "for the entire world American skyscrapers are the highest realisation of modern architecture."[47] European society was rather conservative and most people, including architects, considered the idea of erecting tall buildings in Europe as inappropriate or even shocking. There was some reservation about inserting a tall building into any of Europe's historic town centres. The first step towards the introduction of this new building type came into utopian plans and competitions: the designs for two glass skyscrapers by Mies van der Rohe in 1919 and 1920, Le Corbusier's plan for a contemporary town of 1922 and his "*Plan Voisin*" of 1925, and the Berlin competition for the "*Bahnhof Friedrichstrasse*" skyscrapers (1921-2) with entries from the most famous German architects.[48] In France, skyscrapers were also designed for the competition at the "*Porte Maillot*", on the western edge of Paris, in 1931. Erecting skyscrapers eventually became more of a reality on the old continent, but still with relatively few examples. The first appeared in Stockholm in 1922: the "*Kungshornet*" (by Sven Wallander) with 18 stories sited on the Kungsgalan, and a second skyscraper was erected on the other side of the street in 1926 (by the architect Callmandre).[49] In Germany, there were also a few tower buildings: the "*Hochhaus*" in Cologne (1924-5), the "*Neue Tagblatt*" in Stuttgart (1927-8) and the "Hochhass der Zeiss AG" in Jena (1936).[50] In Madrid, the archtitect Don Ignacio Cardena erected a 15 story skyscraper for the Telephone Compant in 1928. In Antwerp, Horncker, Smolderen and Van Averbeke designed a skyscraper in 1933 named "*Torengebow*" for the "*Algemeene Bankvereening*."[51]

A unique case

In Europe, the development of district heating was not linked with that of skyscrapers (at least not until after the Second World War), apart from an interesting French example, that of Villeurbanne, situated on the eastern edge of Lyons.[52] This town, along with Paris, established one of the first district heating networks in France. At almost the same time it saw the creation of high-

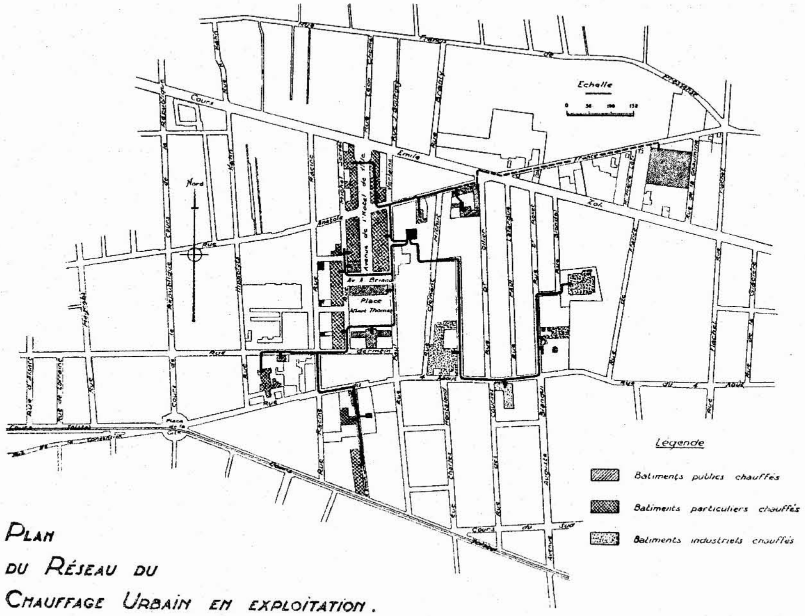

Figure 4. District heating system in Villeurbanne, mid 1930's

rise residential buildings in the American modern style, with art deco, rather than in Modern Movement detailing. Moreover, its two towers repeated later were tellingly called "*gratte-ciel*", a literal translation of the American term skyscraper."[53] The skyscrapers and the district heating system here were both planned by the same designers, and at the same time. Significantly, both were directly influenced by American experience. French architects and town planners knew about skyscrapers and district heating systems through papers written by engineers who recounted their professional visits to the United States. One of them, J.F. Audouin, in his "*Les grands immeubles américains commerciaux d'habitation, leurs installations mécaniques et aménagements*" treated both subjects, skyscrapers and the New York district heating system, together.[54]

From 1924, a socialist deputy and major, Lazare Goujon, who was a doctor and vice-president of a parliamentary commission on hygiene, governed the working class industrial town of Villeurbanne. He proposed a general development plan with social and sanitary aims: promotion of sport, medicine, hygiene, water supply, a sewer infrastructure, water for fire fighting, rubbish collection and incineration, good quality air and comfortable dwellings. Goujon also wanted to build a new town centre, with a theatre, swimming pool, social and health centre grouped in a "*Palais du Travail*" (literally a "Palace of Labour"), and a town hall. All were to be erected on ex-industrial properties, like "new territories" within the city. To achieve his goals the mayor created the "*Société Villeurbannaise d'Urbanisme*", one of the first "*société d'économie mixte*" in France, which brought together private and public funds in the public interest. Lazare Goujon also asked the engineer Jean Fleury, until then working in Rheims, to head the city planning office.[55]

As the old rubbish incineration plant had fallen out of use, due to its age and limited capacity, the planning office proposed its renovation, combining its incinerator with a steam boiler which could provide

Figure 5. Flats at Villeurbanne designed by Morice Leroux

energy for district heating. Two furnaces, were set up which dried and burned the rubbish, which was carried to them automatically. The boiler produced 3 tons of steam at 12 kg. pressure and at 200°C (392°F), before being distributed throughout the district heating mains. At that experimental stage, the mains reached dwellings and factories through a 400 meters long "one-way" pipe.

From 1930, as further sites around the town centre became vacant, high-density dwellings were designed by the young architect Morice Leroux, the winner of the competition for the "*Palais du travail*".[56] It was the ideal opportunity for realising an impressive social housing development (comprising 1,487 flats), culminating in the new skyscrapers which lent visual emphasis to the complex Along both sides of an avenue leading to the town hall were eleven-story blocks stepped back from the street. Both the towers marking the far end of the avenue from the town hall were 18 stories high (59.25 m) (Fig. 5). Throughout, the base consisted of one or two floors occupied by shops, which adhered to the street line. Above, dwellings rose around open courts partly on the street line and partly stepped back (from 7.8m to 17.4m).[57] The tops and upper levels of the two skyscrapers terminating the vista were treated with ziggurat-style step-backs, like American towers of the same period. In respecting the street line the bases of the building followed the street, as they did in American cities, unlike the urban prescriptions of Le Corbusier and other CIAM architects.

The Villeurbanne buildings were made of steel joists clad in masonry, a system which was not as common in France as in the United States. In consequence buildings could be constructed more quickly than was usual in France.[58] The dwellings consisted of flats ranging from two to seven rooms in size, but the majority had three rooms. The level of domestic comfort was very high for the period and for such a clientele. It included waste disposal chutes, passenger lifts and separate goods lifts, central drainage, hot and cold water, bathrooms and toilets, electric ranges and, of course, central heating connected to a district heating system. The indoor temperature was expected to be 18°C in the living room and 15°C in the bedrooms.

After 1933 the district heating system fuelled by rubbish incineration became inadequate for all the new dwellings and nearby factories which could be connected to it. The major's office therefore added new coal-burning elements: two boilers of 20 millions cal./h. capacity and pumps of 250 t./h. At the same time the heating medium was changed from steam to high-pressure hot water (180°C at 15 kg.). A two-ways pipe circulation system was laid out, with one set of pipes taking hot water to the buildings to be heated, and the other set bringing it back. The network operated in three directions, with an overall length of 2.2 km., using steel welded pipes 0.18 meters in diameter (see

Fg..4. Mains were laid in a concrete duct beneath the roadway. Thermal expansion of pipes was allowed by incorporating elbows and other such devices. At the end of the 1930s, Villeurbanne's district heating network was 4.8 km. long, second in France only to that of Paris (13 km.).[59] The cost of all these projects, however, was too heavy for this small town, particularly during that period of economic crisis. Despite the militant and pedagogical approach of the mayor and his team, with evening lectures about town planning and the publication of a book on all these achievements, Goujon's team lost the next election.

The American influence on Villeurbanne's city centre, on its superstructure and infrastructure alike, is obvious. Called "*les gratte-ciel*", the skyscrapers were as much symbols of modernity and progress as was its district heating system and the high level of home comfort it generated. One might suspect the influence of Henri Sauvage's stepped-back buildings. Yet, unlike that avant-garde architect, Morice Leroux lacked any personal commitment to high-rise building. From the beginning of the century onwards, the French professional press had shown great interest in both the seemingly exotic technical experiments and the efficient pragmatism of Americans, particularly their skyscrapers, their elevators, and their heating systems.[60] Throughout the 1920s and 1930s, interest in these expressions of American modernity and in the ability to create new urban forms increased considerably and sketches of both district heating systems and skyscrapers appeared in French architectural journals.

There is also another social dwelling complex with five towers blocks 15 stories high: *la "Cité de la Muette"* in Drancy, a northern suburb of Paris, built by architects Eugène Beaudouin and Marcel Lods during the exact same periode.[61] Even if this complex was not much published unlike the open-air school in Surenes by the same architects, it is still considered by most historians of modern architecture as a decisive icon of modern architecture and town planning as well as an early beginning of building prefabrication.[62] Lods himself wrote in 1976 that his five buildings were the "first towers in Europe."[63] This shows his ignorance of architectural and town planning experiments realized outside Paris by an almost unknown architect, despite numerous publications.[64]

New York through Rheims

There was a clear connection between Villeurbanne and New York, through the town of Rheims, where the engineer Jean Fleury had worked, from 1921 to 1927, prior to coming to Villeurbanne. Rheims had been rebuilt, following its destruction in the First World War, according to plans by George B. Ford, the author of the New York building ordinance of 1916, which dealt with issues of skyscrapers and other tall buildings in this town centre. Although Ford had left Rheims when Jean Fleury was working there, his influence was sill very alive. Moreover, American finance underwrote the city's Carnegie Library, which was rising at that moment, and an American architect, Charles Butler, was building the American Memorial Hospital.[65] Furthermore, in 1920 George B. Ford, with his diploma from the "E*cole des Beaux-Arts*", had published a book on town planning in French, *L'urbanisme en pratique; précis d'urbanisme dans toute son extension pratique comparée en Amérique et en Europe (Town planning in practice; a resume of planning in all its practical applications comparing America and Europe).*[66] In one of his publications, Jean Fleury clearly identified the origin of his influences: Americans have shown themselves to be the practical folk that they are said to be. They have thought that since heating a flat was cheaper overall than heating a room, and heating a high building cheaper than heating a flat, it as logic that the heating of an entire town would be even more economical. They have thought thus, and put their ideas into practice, to the great satisfaction of all, and so that hundreds of towns are provided for in this way."[67]

Nevertheless this was not the only influence on Jean Fleury. He had taken the opportunity to visit German examples of district heating, at Ludwigshafen and Barmen.[68] In fact, his use of high-pressure hot water is closer to the German examples than the American ones.

The Villeurbanne scheme was also innovative in several other respects. One of these was the use of a rubbish incineration system to generate heat. Another original aspect was the absence of co-generation (producing electricity and steam at the same time), due to the low cost of electricity in the region, in turn a result of the hydroelectric production around Lyons. The fact that both the two tower buildings were residential was also original, since although there were some examples of high apartment blocks in New York, most towers there were used for offices.

Conclusion

All this town planning activity was possible because of the presence of an unusually progressive municipal team, mayor, engineer and architect, in favourable political and cultural circumstances. The idea of producing a significant urban and architectural complex with a striking skyline, in order to create a strong image for the town, was as important as the functional purpose of these buildings. Today the "*gratte-ciel*" does not merely evoke American cities, notably New York, it is also a strong symbol for Villeurbanne's town centre within the Lyons agglomeration. It seems paradoxical that it was a socialist, working class town that exploited American pragmatism and the urban form symbolic of capitalism. Yet on both sides of the Atlantic, and of this political divide, the concerns of mayors, of private firms (like the New York Steam Corporation), of city planners and of architects, were the same: the fight against fires, smoke avoidance, promotion of higher levels of comfort, and building as quickly an rationally as possible.

After the Second World War the number of district heating systems increased and the networks grew. It is surprising to note that these networks were developed in "socialist" countries as well as in "capitalist" ones. In eastern Europe, an impressive number of systems were installed. Sometimes the insulated pipes were disposed above ground as in eastern Germany, where it made the networks obvious to visitors.[69] Socialist planning economy meant captive customers for network services, which in turn permitted the security of large-scale investments. At the end of the twentieth century, cooling networks are also widely developed in tandem with heating systems or independently.

The development of skyscrapers and the growth of district heating took several decades in north America and one could interpret the case of Villeurbanne as an American transplant on European soil, prefiguring more recent developments such as "*La Défense*" in the west of Paris, where district heating and skyscrapers have been realised as an integrated development.

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1. Cecil D. Elliot, *Technics and Architecture: the Development of Materials and Systems for Buildings* (Cambridge, 1992), p.282.
2. New York Steam Corporation, *Fifty years of New York steam service: the Story of the Founding and Development of a Public Utility* (New York, 1932), p.132.
3. Carl W. Condit, *Rise of the Skyscraper* (Chicago, 1952); Shara Bradford-Landau & Carl W. Condit, *Rise of the New-York Skyscraper, 1865-1913* (New Haven & London, 1966); George H. Douglas, *Skyscrapers: a social History of the Very Tall Building in America* (Jefferson, 1996).
4. Apprenticed in a machine shop when ten years old, he rose to the status of foreman, engineer, superintendent and then entrepreneur. See Madelynn P. Frederickson, 'The Life and Times of Birdsill Holly' (MA thesis, State University College Buffalo, 1996), p.11.
5. Louis C. Hunter, *Steam Power: a History of Industrial Power in the United States 1780-1930* (Charlotte, 1985), p.560, quoting Appleton's *Cyclopaedia of Applied Mechanics*, vol. 2 (New York, 1880).

6. Frederickson, *Birdsill Holly*, p.89.
7. Ibid. p.106. We know that the destruction of the Loop in Chicago was a reason for the rise of a new building type, the skyscraper.
8. Ibid. p.114.
9. Morris Pierce, 'The Introduction of Direct Pressure Water Supply, Cogeneration, and District Heating in Urban and Institutional Communities, 1863-1882' (PhD thesis, University of Rochester, 1993).
10. James Herbert Bartlett, *District Steam Supply: Heating Buildings by Steam from a Central Source* (Montreal, 1884), p.12.
11. Birdsill Holly, of Lockport, New York, United States Patent Office: Apparatus for Supplying Districts in Cities and Towns with Heat and Power, no.9,821, July 26 1881; Street-Main, no.9,730, May 31 1881; Meter, no.241,217, May 10 1881; Steam-Pressure Regulator, no.246,952, Sept. 13 1881.
12. After focusing on district heating Holly moved his interest to the industrial production of aluminium, at its early beginning.
13. He was a former associate in Cleveland of John D. Rockefeller in the development of oil industry, and member of the first Board of Directors of the Standard Oil Company. See NYSC, Fifty years, p.10.
14. A marine engineer, he was involved in steam distribution and use from 1869. See NYSC, *Fifty years*, p.12.
15. Ibid. p.20.
16. This west part of Cortland St. was located at the north of the south tower of the World Trade Center.
17. NYSC, *Fifty years*, pp.31-4.
18. Ibid. p.43.
19. Bartlett, *District Steam Supply*, p.8.
20. Radiator patents appeared in the late 1850s; commercial building used radiators in the 1880s, even if large-scale commercial manufacture only really began in the 1890s, with series of standard cast-iron units. See Douglas, *Skyscrapers*, p.68.
21. Elliot, *Technics and Architecture*, pp.284-5.
22. There is no by-product generation of electricity. See National District Heating Association, *District Heating Handbook* (Pittsburgh, 1948), p.13.
23. Carl W. Condit, *The Chicago School of Architecture* (Chicago, 1964), p.238.
24. The number of shares of stock increased from 20,000 to 80,000. See *Blakemore Analytical Reports, New York Steam Corporation* (New York, 1928), p.35.
25. NYSC, *Fifty years*, p.79.
26. Ibid. p.68.
27. Ibid. p.77.
28. Douglas, *Skyscrapers*, p.69.
29. Anon., 'New York's largest Hotel to Generate Power and Burn Pulverised Fuel', *Power*, vol. 67, no.25 (19 June 1928), p.1122.
30. Daily peaks in energy demand differed according to power type: for electricity the peak was in the evening, for district heating the morning; so it is useful to share energy (monthly peaks also differed: Dec. for electricity and Jan. for district heating).
31. NYSC, *Fifty years*, p.68.
32. The growth also concerned other networks and the number of networks in the U.S.A. See National District Heating Association, District Heating Handbook (Pittsburgh, 1948).
33. Between 1880 and 1930 commercial activities and newspaper offices moved north in Manhattan and at the same time the steam mains grew in the area between the two stations located at 59th and 60th streets and 35th and 36th streets.

34. NYSC, *Fifty years*, p.116.
35. Paul Morand, *New York* (Paris, 1930), pp.214-5.
36. *Blakemore*, NYSC, p.2.
37. Carol Willis, *Form follows function, skyscrapers and skylines in New York and Chicago* (N.Y, 1995), p.218; *Morand, New York*, p.151.
38. *Les installations de la compagnie parisienne de chauffage urbain* (Paris, 1935), p.15.
39. Thomas A.P. Van Leeuwen, 'Le gratte-ciel ou le mythe de la croissance naturelle', *Américanisme et modernité: l'idéal américain dans 'architecture*, ed. J.-L. Cohen et H. Damisch (Paris, 1993), pp.75-120.
40. Morand, *New York*, p.40.
41. Although the company, endeavouring to meet the problem of rapidly increasing costs of labour and material by corresponding increases in charges for steam, had secured permission from the Public Service Commision to moderately increase its rates and had inaugurated a coal surcharge, unfortunately an adequate return on the investment was delayed. See NYSC, *Fifty years*, pp.64-5.
42. *Blakemore, NYSC*, p.76.
43. *Blakemore, NYSC*, p.34.
44. NYSC, *Fifty years*, pp.112-3.
45. Morand, *New York*, p.27.
46. Sven Werner, *Fjärrvärmens utveckling och utbredning*, 'District heating development and spread' (Stockholm, 1989), p.79. The same author also refers to small-scale experiments in Stockholm (1878), Charlottenbourg (1884) and Hamburg (1893).
47. John Taylor Boyd, 'La construction des gratte-ciel', *La Construction Moderne*, vol. 38, no. 29 (22 April 1923), p.353.
48. Karl-Heinz Hüter, *Architektur in Berlin 1900-1933* (Dresden, 1987), pp.298-302.
49. Two skyscrapers on opposite sides of the street were also found in Villeurbanne, *20th-Century Architecture Sweden* (Munchen, 1998), p.270.
50. Rainer Stommer, *Hochhaus – Der Beginn in Deutschland* (Marburg, 1990).
51. Henri Descamps, 'Gratte-ciel "Torengebow" à Anvers', *La Construction Moderne*, vol. 48, no. 48 (17 Sept. 1933), pp.714-20.
52. For more detail see Emmanuelle Gallo, 'La réception et le quartier des Gratte-ciel, centre de Villeurbanne, ou porquoi des Gratte-ciel à Villeurbanne en 1932', at the VIIth International Docomomo Conference, '*Image, use, heritage: the reception of the architecture of the Modern Movement*', Unesco, Paris, 16-19 Sept. 2002, (in press).
53. CNRS, *Trésor de la langue française 19e – 20e siècles* (Paris, 1981), p.444.
54. J.-F. Audouin, 'Les grands immeubles américains commerciaux et d'habitation, leurs installations mécaniques et aménagements', *Mémoires et compte-rendus de la Société des Ingénieurs Civils de France*, no.1 (March 1922), pp.9-52.
55. Graduating from the Ecole Speciale des Travaux Publics in 1921, he specialised in civil engineering work, and was a member of the association générale des hygiénistes & techniciens municipaux. See *Annuaire de la Société des ingénieurs diplomés des Ecoles de Travaux Publics* (Paris, 1947).
56. Môrice Leroux, a self-taught architect, trained during the First World War on reconstruction building sites, he also worked for a good Parisian architect Paul Lebret, schoolfriend of Tony Garnier, who was president of the jury for the Palais du Travail competition.
57. Charles Dephante & Joëlle Bourgin, *Une histoire de gratte-ciel – Villeurbanne* (Lyons, 1993), p.71.

58. During 1930, G.J. Pistor, treasurer of the American Institute of Steel Construction, New York, gave a lecture in Lyons, entitled '*L'art et l'économie dans le gratte-ciel américain*'.
59. *Compagnie Parisienne de Chauffage Urbain*, (Paris, 1937).
60. Jaques Hermant, *Exposition internationale de Chicago en 1893*, vol. 11-Comité 36, (Paris, 1893), p.18.
61. This complex assembled long and low housing blocks with towers in a geometrical order following the ideas of modern architecture, prefiguring post-war rational town planning.
62. Pierre Bordier, 'La cité de la Muette à Drancy', *Art et Décoration*, vol. 65, no.1 (Janvier 1936), pp3-10. On the open-air school, *Architecture d'Aujourdhui* (1935) and Alfred Roth, *La nouvelle architecture* (Zürich, 1975).
63. Marcel Lods, *Le métier d'architecte* (Paris, 1976), p.78.
64. 'Un bel effort d'urbanisme', *L'Illustration*, no.652 (Avril 1932), pp.532-3. R. Chenevier, 'Villeurbanne, modèle d'urbanisme', *La science et la vie*, no.181 (Juillet 1932), pp.44-45; R. Chenevier, 'L'urbanisme moderne dans la cité moderne', *Science et Monde*, (Mai 1932), pp.300-3; J.-L. Margerand, 'Le nouveau centre de Villeurbanne', *La Construction Moderne*, (Juillet 1934), pp.714-48.
65. Marc Bedarida, 'La reconstruction de Reims (1918-1928), compassions et aides Américaines', *Américanisme et modernité*, ed. J.-L. Cohen et H. Damisch (Paris, 1993), pp.249-66.
66. George Burdett Ford, *L'urbanisme en pratique; précis d'urbanisme dans toute son extension pratique comparée en Amérique et en Europe* (Paris, 1920).
67. Jean Fleury, 'Le chauffage à la portée de tous', *Bulletin municipal Officiel de la Ville de Villeurbanne* (Nov.-Dec. 1927), p.361.
68. Jean Fleury, 'Le chauffage urbain', Bulletin municipal Officiel de la Ville de Villeurbanne (March 1928), pp.473-4.
69. It seems likely that in Moscow skyscrapers coexisted with district heating but this point has not been pursued here.