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State and Local Heat Supply Planning: Insurance for a Warm Future

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ABSTRACT

Communities large and small plan extensively for future transportation and water, sewer, and other urban needs but rarely for heat supply. Although extensive planning is done for future power needs, heat supply planning has been left to individual building owners, developers, and design professionals. In Europe, community and regional heat supply planning has been common since the 1970s.

Local communities need to establish a community heating plan, ideally with the input and cooperation of state and federal agencies and public utilities. Such a plan would address not only heating fuels and environmental impacts but would explore ways to provide low-cost universal service, improve safety, and expand use of existing heat sources.

Energy systems in the United States are undergoing great transformation, and this is an ideal time for communities to plan their own heat supply future.

BACKGROUND: THE RESIDENTIAL AND COMMERCIAL HEATING MARKET IN AMERICA

Americans in 1994 used 85.3 quadrillion Btu (90.0 EJ) of energy for all purposes, a record amount. The residential and commercial sectors consumed 30.7 quads (32.4 EJ), also a new record. In these sectors, 10.4 quads (11.0 EJ) of coal, natural gas, and petroleum were used for primary consumption, while 6.6 quads (7.0 EJ) of electricity brought total net consumption to 17.0 quads (17.9 EJ). In the residential sector, 54% of net energy was used for space heating, 18% for water heating, 5% for air conditioning, and the remaining 23% for lighting and appliances. Similar data for commercial buildings are not available, but by one estimate 41.5% of commercial building net energy was used for space and water heating, 24% for lighting, 11.5% each for ventilating and air conditioning, and 35.5% for lighting and appliances. Taken in aggregate, approximately 10.0 quads (10.5 EJ) of energy were used for water and space heating in American commercial and residential buildings in 1994, while another 1.3 quads (1.4 EJ) were used for space cooling in this sector, which includes 94 million residential housing units and 4.5 million commercial buildings.

Energy use intensity, of course, varies considerably according to climatic zone, activity, and individual building characteristics, but few areas of the United States do not require artificial warming during some portion of the year. When heating is necessary but unavailable due to fuel supply interruptions or apparatus malfunctions, economic activity grinds to a halt, and if warmth is not restored quickly, it can place the young and old at great risk. Despite the critical importance of artificial heating, few individuals, institutions, or communities have given much thought to their future heat supply. While enormous resources are directed at power supply planning, both to ensure future availability and to avoid interruptions in critical functions such as health care and air traffic control, heat supply planning has been largely ignored. Even when short-term energy supplies appear plentiful, heat supply planning could identify near- and long-term supplies of current fuels and explore a range of alternative fuel and heat sources. As a minimum, a heat supply plan will identify the true energy and environmental impacts of existing heating infrastructures.

The lack of heat supply planning in the United States has resulted in the construction of inefficient, irrational, and, to some extent, unsafe energy networks, causing enormous energy waste and environmental damage. Because these networks work reasonably well (most of the time) and in many parts of the country offer consumers relatively low rates, there has been little demand to question their underlying technological structure. An entire industry has been built to prepare power supply plans, resulting in huge resource allocation to electric energy conservation and repowering existing condensing power plants, occasionally to the point of economic absurdity. In New York State, for instance, a surplus of nonutility power has driven down the marginal cost of utility electricity, while these utilities are simultaneously mandated to raise rates to pay for demand-side management programs. One looks in vain to discover the public

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policy benefits of these costly programs. With natural gas and electric markets in the midst of great upheaval and deregulation, it may be timely for local, state, and federal officials to consider the fundamental question of how heat should be supplied in the future. Without such plans, change will only come with crisis.

ENERGY IN AMERICA: A HISTORY OF CRISIS

America suffered its first energy crisis not in 1973, or even 1917, but in 1638, when residents of the new city of Boston, having consumed all local fuel supplies, were forced to gather wood from outlying areas at great cost (Winthrop 1908). Benjamin Franklin invented his Pennsylvania fireplace in 1744 primarily to reduce wasteful fuel wood use by English colonists, who used nearly six times as much wood as German immigrants.

Despite great improvements in heat, light, and power systems, the overwhelming majority of residential and commercial buildings in 1920 were heated by coal or wood burned in individual boilers and furnaces. As late as 1935, wood provided 20% of the energy used in these sectors and even held 15% of the residential market in 1950. Even the small inroads made by cogenerating and district heating systems declined after the 1907 collapse of the municipal bond market, effectively halting the widespread growth of municipal utilities. Magnates such as Samuel Insull of Chicago's Commonwealth Edison envisioned an interconnected electric system powered by large condensing stations and had little tolerance for other points of view. He successfully installed ever-larger steam turbines in his electric empire and abandoned smaller stations, however efficient they might be. He also considered local utility regulation to be especially burdensome to his grandiose scheme and lobbied successfully for state regulation, which was widely adopted between 1907 and 1915. Insull's scheme got its greatest boost from the greatest energy crisis in American history, which struck during the terrible war winter of 1917-18. Insull had made adequate arrangements for coal to fuel his stations, which not only delivered power reliably during the crisis but were the only public utility stations in the United States that did not seek a rate increase during the inflationary war years. Chicago also had the good fortune of being largely unaffected by the rail chaos that paralyzed the eastern states. This energy crisis had enormous effects on American energy planning, some of which are still felt today.

The 1918 crisis arose from a number of factors. Railroads had greatly reduced purchases of rolling stock, including coal cars, after regulators restricted return on investments. The large coal industry itself was fragmented and remained chaotic despite numerous attempts to regulate it during the late nineteenth and early twentieth centuries. Demand for coal increased to feed war manufacturing and, after America joined the conflict in April 1917, President Woodrow Wilson asked for and received broad authority to fix coal prices. He did not exercise this authority immediately, which had the twin effects of encouraging coal mines to raise prices while discouraging purchases by consumers in hopes that prices would be lowered in the near future. During the summer of 1917, meanwhile, Washington bureaucrats squabbled over allocating priorities for the limited number of rail cars. Normal summer stockpiling did not occur, and by October serious shortages had developed. Government orders to move coal were stymied as tracks were torn up to prevent shipments from coal-short locales, and at least one mayor hijacked a coal train and arrested its crew. In December a massive cold wave blanketed the nation, increasing the demand for fuel while coal trains sat on sidings, unable to get to unloading points. Wilson nationalized the railroads to break the logjam, but to little avail. Thousands died, including babies frozen to death in their cribs while their families desperately looked for scraps of wood. Coal wagon drivers were assaulted and loads destined for hospitals were stolen by freezing citizens. Rationing was instituted in certain areas and outdoor lighting was generally forbidden in New York State. Ships laden with war materiel could not sail for the front. Electric power was turned off in Jersey City and most factories in Cleveland shut down to save fuel for streetcars and homes (Johnson 1917).

The government's fuel administrator reacted in mid-January by shutting down all manufacturing plants east of the Mississippi River for five days to stop the flow of manufactured goods, theoretically freeing the railroads to move coal. Furthermore, all wholesale and retail establishments were to stay closed for the next nine Mondays to save fuel. Taverns were allowed to open on Mondays but could not use heat or light. Nevertheless most were crowded. New York's Mayor John F. Hylan found that he could not confiscate coal and ordered his police to go door-to-door begging for coal for the poor. The crisis passed as warm weather returned, and although this episode is now long forgotten, it loomed large in the subsequent debate over American utility policy. The crisis was viewed as one of fuel transport, and the solution offered by both government and utilities was to build large power plants and move the energy over electric transmission lines. Debate on the issue was sometimes vociferous but was concentrated on the issue of government (giant power) vs. private (superpower) ownership of the plants and networks. The matter was never clearly resolved, and both forms of ownership came into widespread use. The trend of utility consolidation continued, and many of the remaining small utilities, both municipal and private, became consumers themselves as they abandoned their own generation plants.

Ignored by government planners at all levels, the heating marketplace entered the 1920s resembling nothing so much as a vacuum, into which the oil industry was first to rush. Use of oil as a fuel received its first impetus from the discovery of the Lima oil field in Ohio and Indiana in the mid-1880s. Unlike Pennsylvania crude, Lima oil was not suitable for illumination use, and other markets were sought. Russian oil burners were imported and successfully used in steam boilers, but eventual success in refining the Lima crude into kerosene curtailed much of the experimentation, although a large market in residual fuel oil did develop. The first widespread use of petroleum for heating came in 1890s California, which relied on coal imported from Australia, England, Japan, and other distant sources. In 1895 one correspondent wrote that in Los Angeles, "fuel is so scarce and high here that it is the practice of local manufacturers to utilize for their furnaces the dried manure of the streets, and even office sweepings, carted for the purpose to their doors" (Williamson and Daum 1953). Discovery of oil in that state was quickly followed by its use for heat and power purposes, and by 1904 California was the largest petroleum-producing state.

The oil-heating market did not develop quickly, primarily because oil-heating apparatus was costly, unreliable, and would only burn more expensive distillates such as kerosene. Vigorous development by apparatus manufacturers resulted in a variety of efficient furnaces and boilers for residential and commercial users. Large oil discoveries in the 1920s resulted in price reductions and the added marketing strength of oil firms, some of which developed extensive sales and support organizations for home heating. Between the end of the World War II and the mid-1950s, fuel oil was the dominant heating fuel for residential and commercial buildings, after which it was overtaken by natural gas. Fuel oil in 1990 was used for space heating in 12.2% of households, while only 5.4% used it for water heating.

The earliest use of natural gas in the United States was in Fredonia, New York, in 1821, where residents dug a 27-foot-deep well and piped gas through hollowed-out wood logs to light their houses. A number of other communities also used local natural gas wells for various purposes, including extensive use around Pittsburgh in the 1880s. Natural gas fields in Ohio and Indiana were tapped, and many communities adopted natural gas to get rid of the coal nuisance. Unfortunately, much of this resource was wasted and by the late 1890s many fields had been depleted. Cities such as Indianapolis carefully studied alternatives, and many selected district heating. New gas fields were discovered in Oklahoma, Texas, and California in the early years of the twentieth century, but gas pipeline technology did not permit long distance (more than 300 miles [480 km]) transport until the late 1920s. Gas use slowly and steadily increased as these pipelines were extended into colder climates, until reaching a peak in 1972. Price regulation dampened enthusiasm for drilling new gas wells, and many gas producers simply declined to ship gas in the unprofitable interstate market. The resulting natural gas curtailments caused 8,900 plant shutdowns and the layoffs of 547,000 workers in the East and Midwest in 1977 and caused many state regulatory agencies to impose moratoriums on new gas connections. From a low in 1986, gas consumption has once again been increasing and in 1994 reached 93% of 1972 use.

Another form of gas was manufactured by burning coal or oil in a gas plant and distributing the product through a piping network. This was the original type of gas and was the predominant form of gas until the 1920s. Manufactured gas was primarily used for illumination, and as electric lighting become predominant, the industry sought to increase sales by encouraging sales of gas appliances such as water heaters, stoves, and refrigerators. Some efforts were made to heat houses with manufactured gas, especially targeting wealthier customers, who would find the convenience worth the added cost. In 1940, manufactured gas provided less than 1% of house heating energy. Mixed gas, a combination of natural and manufactured gas, was commonly used as a transition fuel as local gas utilities converted to natural gas, but again it appears to have gained little use for space heating (Hungerford 1928).

Natural gas production also generates liquids, which are sold as heating and cooking fuel and are commonly used in backyard gas barbecue grills. Data on the use of liquefied petroleum gas (LPG) are scarce, but it appears to supply between 3% and 4% of residential and commercial heating. In many areas LPG holds a larger percentage of the heating market than does oil. Slightly less than 5% of households used LPG as a main house-heating fuel in 1990.

Electric heating has been promoted since shortly after Edison's first electric system started operating. Initially used on a small scale in irons, toasters, and other small appliances, electric water heaters appeared on the market in the 1920s and became very popular, especially where electric utilities could shift their energy use to off-peak rate periods with clocks or other controls. By 1990, 37.3% of American households used electric water heating. Electric space heating took longer to gain a significant market share but was greatly aided by preferential rates for "all-electric" buildings, just as gas had used similar rates to encourage fuel use starting in the 1870s. Between 1985 and 1987, 59.2% of new houses had electric heating, but that percentage dropped back to 27.1% between 1988 and 1990. For all households in 1990, 22.9% used electricity for space heating. This dropoff was probably due to rate increases in the late 1980s, coupled with capacity shortages during cold winter weather. In January 1994, for instance, rolling blackouts in Pennsylvania, Maryland, and New Jersey left thousands of residential customers without heat during bitterly cold weather. This affected not only electrically heated buildings, of course, since almost all heating systems require electricity to power control valves and motors.

Despite this long history of crises, often devastating to economic and physical well-being, few communities have become involved in energy planning, although such plans are common (and often mandated) for water, sewers, roads, health care, land use, and public transportation.

WHAT IS TO BE DONE WITH THE HEATING?

Although the American heating marketplace has always been slightly chaotic, until the 1920s most Americans only had two solid fuels to choose from, coal and wood. Twenty percent of occupied households were using other fuels by 1940, half by 1950, and more than 80% by 1960. During these four decades, enormous resources went into developing a national power plan, culminating in the nuclear power movement of the 1950s. Few noticed, or at least questioned, the absence of heat supply planning, although anyone familiar with basic thermodynamics would recognize the close relationship between heat and power. Ira Evans, a Detroit consulting engineer whose father had installed many cogenerating district heating systems at the turn of the century, questioned the building of large condensing stations, asking in 1921, "What is to be done with the heating?" (Evans 1921). Proponents of condensing power promised great

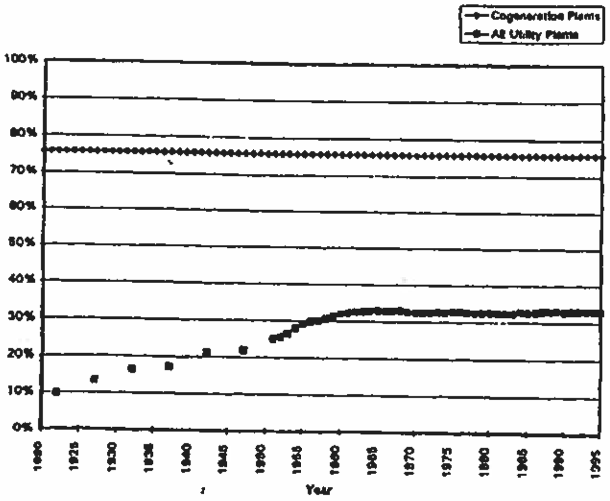

Figure 1 Average thermal efficiency of U.S. cogeneration and utillity power plants, 1900 - 1995.

improvements in generation efficiency, but the editors of *Power* magazine warned in 1926 that under "the most favorable conditions," condensing plants still required "about fourteen thousand heat units" to deliver a kilowatt-hour to the busbar, with the potential of material improvement "not promising in the light of present experience." A better alternative, they pointed out, would be combined heat and power plants that could deliver a kilowatt-hour for "considerably less than five thousand heat units" (*Power* 1926).

Several utilities and many industries took advantage of this thermodynamic fact and used cogeneration plants to supply district heating and industrial needs. Substantial system additions were made in the 1930s to district heating systems in New York, Indianapolis, and Detroit, while Denver started large-scale cogeneration in 1948 to keep customers from building their own cogeneration plants. Other utilities, seeing the rosy promise of cheap and abundant condensing power, abandoned cogeneration in favor of even larger condensing stations, a trend that historian Richard Hirsch attributes in part to the drying up of the utility engineer gene pool after the 1950s.

Condensing power plants did provide efficiency improvements and lower rates in the short term from economies of scale for larger generating units and improvements in thermal efficiency. Residential rates hit their low point in 1969 (2.09¢/kWh), a year after the industry average net heat rate reached 10,371 Btu/kWh (10,951 kJ/kWh), representing a thermal efficiency of 32.9%. In 1973 generator unit size reached a similar plateau at 1,300 MW. Since 1969, average thermal efficiency for the industry has increased by less than 1%, while residential rates in 1994 had increased by 403%, to 8.44¢/kWh, sparking extensive (and expensive) efforts to conserve electricity but with almost no concurrent efforts to increase utility generation efficiency. Condensing power generation had indeed reached a plateau, just as *Power* had predicted in 1926, while cogeneration, still largely ignored by electric utilities, remains more than twice as efficient, as shown in Figure 1.

To review the thermodynamics of cogeneration, consider a sample back-pressure turbine-generator where the power output for each pound of steam is equal to the enthalpy in (h_{in}) minus the enthalpy out (h_{out}) times the generator and turbine mechanical efficiencies. For a turbine inlet of 615 psia (4,250 kPa) and 750°F (399°C) exhausting to a hot water heat exchanger at 12.1 psia (83.3 kPa), each pound (kg) of steam passing through the turbine gives up (1378.9 – 1097.3) or 281.6 Btu [(3212.9 – 2558.1) or 654.8 kJ] chargeable to the turbine. If the turbine is driving a generator that is 96% efficient and the turbine has a mechanical efficiency of 97%, then the output at the generator terminals for each pound of steam flow is

$$281.6 \times 0.96 \times 0.97 = 262.2 \text{ Btu}$$

$$(658.8 \times 0.96 \times 0.97 = 613.5 \text{ kJ}).$$

The energy charged to the turbine should be charged for its share of boiler losses, if applicable. The total fuel charged to the turbine with a boiler efficiency of 85% would be

$$281.6/0.85 = 331.3 \text{ Btu per lb of steam flow}$$

$$(658.8/0.85 = 775.1 \text{ kJ per kg of steam flow}).$$

The thermal efficiency of the electrical generation process would then be

$$e = W/Q_a = 262.2/331.3 = 79.1\%$$

$$(e = W/Q_a = 613.5/775.1 = 79.1\%)$$

and the heat rate is

$$HR = 3413/e = 3413/.791 = 4312 \text{ Btu/kWh}$$

$$(HR = 3600/e = 3600/.791 = 4552.1 \text{ kJ/kWh}).$$

This can be compared with the average heat rate of 10,302 Btu/kWh (10,869 kJ/kWh) for all utility generation in the United States in 1994. Other types of prime movers, such as combustion turbines and reciprocating engines, will generate electricity at similar heat rates, again with the requirement that the exhaust heat is used for useful thermal purposes. Many reports prepared by and about the electric utility industry do not take cogeneration into consideration, which creates the false impression that cogeneration units are actually inefficient, once again showing that evaluating power without simultaneously considering heat can easily produce illogical outcomes.

Before considering the potential impact of wider use of cogeneration on the residential and commercial heating market, it will be helpful to consider its current use in the United States. One of the critical factors in cogeneration plant design in Europe but little used in American practice is the ratio of power to heat for a given plant, referred to variously as the C_m or α factor. For the example of back-pressure steam turbine given above, the power to heat ratio is 262.2/1097.3, or 0.24, meaning that for every unit of heat produced by the turbine, 0.24 units of power are generated. Typical C_m or α values are shown in Table 1.

Among electric utilities, only a handful use a significant amount of cogeneration, primarily to supply large district heating systems such as in New York City, Indianapolis, Milwaukee, and Detroit. A few others supply process steam for industrial customers. In aggregate, total annual output from electric utility cogeneration plants is no more than 10 billion kWh, about 0.3%

of total industry generation. Almost all of this is generated with steam turbines, and an estimate of the annual heat production is given is Table 2. The other source of cogenerated power is nonutility generators, which actually have a longer history than the electric utility industry itself, as many early electric light plants were initially used in industrial and institutional steam plants. Power to heat ratios for typical cogeneration plants in America and Europe are shown in Table 3. At the end of 1992, 40,691 MW of nonutility cogeneration capacity was on line, of which one-fourth was in use prior to the Public Utility Regulatory Policy Act of 1978 mandating of utility purchase from certain nonutility generators. These cogenerators produced 245 billion kWh in 1992, of which about half was used by the host facility and the rest delivered to an electric utility. Of the delivered energy, 63% was sold back to the host facility under a buy all/sell all transaction.

Available data on nonutility generator prime movers do not specifically identify those devoted to cogeneration use, but since cogenerators in 1992 produced 79.2% total nonutility generation, it will be assumed here that this generation was equally divided between steam turbines and combustion turbines, and combustion turbines were again divided roughly into simple-cycle and combined-cycle halves. Table 4 shows estimated heat and power production from these nonutility cogenerators in 1992, plus the amount used in the commercial and residential sectors. The cogeneration industry is changing rapidly, with most new capacity taking the form of large combined-cycle plants with high C_m ratios. In the author's opinion, C_m ratios higher than 2.0 start to stretch the concept of cogeneration beyond thermodynamic legitimacy and have been largely responsible, not only for the epithet "PURPA machine" becoming a term of widespread derision in the electricity utility, but more important, of having tarnished the reputation of cogeneration in the United States. Many such plants, however, can produce dispatchable peaking power, which is certainly an important part of the electric industry but needs to be identified as such in statistical accounting.

WHY HEAT SUPPLY PLANNING?

Residential and commercial heat consumers used approximately 10 quads of energy in 1994 at a cost of between $50 and $100 billion. Availability of heating fuels in the future, and insuring their ability at a reasonable cost, are surely matters of some importance. Likewise, heating has a significant impact on the environment, but specific studies of this area are unknown. Yet power supply planning and environmental studies are quite common, just as they were in the 1920s. Unlike every other area of the economy, heat supply has been virtually ignored except by those who directly profit from it. One exception can be found in codes and regulations governing construction of new buildings, which commonly specify certain maximum energy use requirements. Few of these are known to be rigidly enforced, although in general such requirements have been of value in reducing the amount of energy used in newly constructed buildings. Even efficient new buildings, however, need a reliable heat supply, but most owners, developers, and design professionals are content with connecting to existing public utility energy services. Indeed, few would have any viable options to such connections.

Heat supply planning can be found in most European countries, usually dating back to the 1970s. The 1973 German Energy Program called upon local authorities and energy companies to develop new energy supply concepts that would aid the sensible combination of energy forms. In Denmark, the 1979 Heat Supply Act had the principal objective of selecting the most economic systems for space and water heating. Guidelines were given to local and regional heat planners, and priorities were established for the use of fuels as well as surplus or waste heat. As was the case with other countries, these plans were designed to ensure the following:

- long-term and safe supplies of heat for consumers,
- substitution of imported fuels with indigenous fuels,
- safeguarding the economic viability and low cost of heat supplies,
- use of heat supply technology that causes as little pollution as possible, and
- retention of customer choice in the energy market.

In planning for residential and commercial heat supply, the first consideration is to identify the total size of the heating market and its geographic concentrations. As mentioned above, the total residential and commercial heat supply market in the United States is roughly 10 quads (10.5 EJ). This energy was consumed in 92 million occupied housing units and 4.5 million commercial buildings. Of the households, 74.4 million are located in 23,435 places, which are both incorporated communities and census-designated housing clusters. Commercial buildings are not similarly enumerated, but by their nature at least 95% would be located in or near places, and those located outside would make up a smaller fraction of total square footage and energy use. The heat supply market can then be divided into two parts: one consisting of buildings located within a place and another for buildings located elsewhere, such as rural farms

Heat supply planning for buildings located outside the 23,435 places will involve a different methodology than for those within these places. Many of these consumers already have worked out their own heat supply plan and can choose from a wide variety of alternative heating methods, including solid biomass fuels. The state of Minnesota even publishes a catalog of such apparatus (MDPS 1992). Ground-source heat pumps can also be advantageously utilized in many instances. Federal and state agricultural agencies have already accomplished much in this area, which could in many cases be easily assembled into a comprehensive heat supply plan for such consumers.

Residential and commercial consumers located within a community are faced with a different set of problems. On one hand, a wider, or at least different, set of fuels is available for..

TABLE 1 Typical Power to Heat Ratios for Cogeneration Prime Movers

Prime Mover	C_m or α ratio
Back-pressure steam turbine	0.2 - 0.5
Reciprocating engine	0.8 - 1.0
Simple-cycle combustion turbine	0.5 - 0.6
Combined-cycle combustion turbine	0.8 - 1.2

TABLE 2 Electric Utility Heat Production from Cogeneration

Utility cogeneration	Power generated (1992)	C_m ratio (Estimated average)	Heat generated (1992)	Heat generated (1992)
Steam turbine	10,000,000 MWh	0.35	0.098 quads	103 PJ
Total utility cogeneration	10,000,000 MWh		0.098 quads	103 PJ
Total utility cogeneration (commercial and residential)	5,000,000 MWh		0.049 quads	52 PJ

TABLE 3 Typical Power/Heat Ratios for Selected Cogeneration Plants

Cogeneration Plant	Prime Mover	Power Output	Heat Output	C_m
SUNY Stony Brook	LM 6000 (simple cycle)	40 MW	175 mm Btu/h (51 MW)	.78
JFK Airport	Two LM 6000 (combined cycle with extraction-condensing steam turbine)	100 MW	225 mm Btu/h (65.9 MW)	1.5
Heizkraftwerk Tiefstack, Hamburg	Back-pressure steam turbine	162 MW	976 mm Btu/h (286 MW)	.57
Wellesley College	Reciprocating engines	5.6 MW	20 mm Btu/h (5.8 MW)	.96
Avedøre Power Station, Copenhagen	Extraction-condensing steam turbine	250 MW	1,126 mm Btu/h (330 MW)	.75
University of Northern Colorado	Two LM 5000 (combined cycle with extraction-condensing steam turbine)	67 MW	80 mm Btu/h (23 MW)	2.91
Schuylkill Plant Trigen Philadelphia	Back-pressure steam turbine	55 MW	1,300 mm Btu/h (381 MW)	.15
Waterside Station Consolidated Edison	Back-pressure steam turbine	284 MW	3,000 mm Btu/h (878 MW)	.32

TABLE 4 Estimated Nonutility Cogenerator Heat Production

Nonutility cogenerator prime mover	Power generated (1992)	C_m ratio (estimated average)	Heat generated (1992)	Heat generated (1992)
Steam turbine	125,602,000 MWh	0.35	1.22 quads	1,291 PJ
Simple-cycle combustion turbine	68,217,000 MWh	0.55	0.42 quads	446 PJ
Combined-cycle combustion turbine	51,291,000 MWh	1.2	0.15 quads	154 PJ
Total nonutility cogeneration	245,110,000 MWH		1.79 quads	1,891 PJ
Total nonutility cogeneration (commercial and residential)	83,385,000 MWh		0.48 quads	509 PJ

heating use. A building owner is almost always free to choose from at least two, and perhaps more, of these for water- and space-heating fuels, but often such choices are made on the basis of lowest system installed cost, local custom, or availability of utility and manufacturer rebates. Since emissions from small heating systems are usually unregulated, present and future environmental impacts are usually ignored. This freedom of fuel choice can quickly turn into a liability, because once selected the vast majority of heating apparatus is limited to a single fuel. Larger users, such as colleges, universities, hospitals, and other institutions, generally have more resources to invest in heat planning and often are able to use this advantageously by using less expensive fuels with alternative fuel sources. Similarly, households with sufficient disposable income are usually able to invest in more efficient building envelopes and heating equipment, creating the anomaly of richer households using less energy than poorer ones.

Energy planning must consider available heating technology, fuels, environmental impacts, and economics. Together these can be weighed using the following criteria, commonly used in European heat planning.

Reduced Energy Consumption

Although newer residential and small commercial heating apparatus have high efficiencies, in general such apparatus is fairly inefficient, especially on a seasonal basis. A properly designed heating plant will have a high annual efficiency. Heating systems should also incorporate waste heat from industrial facilities, power plants, and geothermal sites, as well as employ nontraditional fuels, such as municipal waste and biofuels.

Cleaner Environment

Emissions from all heating plants need to be regulated and monitored, just as power plant emissions. This is commonly done for automobile emissions, and similar equipment could potentially be used to measure emissions from smaller heating plants.

Lower Operating Costs

All heating apparatus requires space and maintenance. Even a homeowner has to have a furnace filter changed and a safety inspection, and failure on a cold day will require expensive overtime labor to repair or replace it. Similarly, domestic and commercial hot water heaters have a limited life. Such equipment can often be removed to a central location, which can reduce maintenance costs and lower insurance premiums.

Fuel Flexibility

Heating systems must be designed to incorporate multiple fuels. Nothing is more inevitable than future fuel crises, which can often be alleviated instantly by switching to an alternate fuel source. The well-designed heating system should also have the ability to incorporate on-site fuel storage and more than two fuels.

Increased Safety

Carbon monoxide from gas and oil appliances kills more than 3,800 Americans annually. Many cities, including Chicago, now require carbon monoxide detectors. Delivery and storage of such fuels are also dangerous, and removing flames from occupied structures can greatly improve safety.

Reduced Space Requirements

Where possible, heating apparatus should be located in low-cost space. Often this can be in a separate remote building, which can create more space for use or rental.

Increased Reliability

Few buildings have redundant heating equipment, but heat supply planning must consider the incorporation of backup heating equipment in most occupied buildings. Such systems should also be operable without commercial electric power. Lower-income neighborhoods, in particular, often have a high incidence of inadequate and unreliable heating systems. Society as a whole pays for this poor heating, either directly through low-income heating assistance programs or indirectly by increased health problems by residents of these neighborhoods.

CONCLUSION

Although state and local officials have not taken a large role in energy planning, they are in a unique position to plan future heat supplies for their jurisdictions. Many communities will be able to draw on expertise in this field from local institutions, industrial facilities, and public utilities. By considering the heating needs of an entire community, the heat supply plan can incorporate a much wider range of options than individual consumers. Communities in warmer climates may find existing heating systems to be adequate, while those in colder areas might uncover numerous way to improve heat supply methods.

Heat supply planning can be of great value in better utilizing America's energy resourc-.5es and lessening the environmental impact of heating fuel use. Communities with a well-considered heat supply plan will be able to face the deregulated energy future from a position of strength.

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