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*Consultant to Oak Ridge National Laboratory

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FOREWORD

The Department of Energy (DOE) and the Department of Housing and Urban Development (HUD) are jointly initiating a new program to stimulate the development of district heating systems in a number of U.S. cities. The program is intended to promote district heating in combination with cogeneration and use of domestic fuels to conserve energy and save scarce fuels.

A number of cities already have district heating systems, but many of the systems are old and in danger of being abandoned due to high fuel costs and system inefficiencies. The creditability of modern district heating in this country requires that the old systems be upgraded and expanded to demonstrate their utility and economic viability. Prior to initiation of the anticipated new program in 1980, HUD has instructed the Oak Ridge National Laboratory (ORNL) to provide direct assistance for cities and utilities interested in rescuing their old district systems. ORNL has formed a team of staff and distinguished consultants to provide technical and financial advice for at least four cities with distressed systems. Oak Ridge National Laboratory will prepare a written report on each city which may be used in applying for an Urban Development Action Grant from HUD, hiring an engineering firm, or taking other actions necessary to revitalize the district heating system.

ABSTRACT

The district heating system of Rochester, New York was founded in 1889 and prospered for the first seventy years. The steam system grew in conjunction with the electrical service and became accepted as the preferred service for new buildings in downtown Rochester. In 1963, the system was the fourth largest in the U.S. and had a peak hourly sendout of 390 MW(t). The system served 621 customers and was growing steadily. Since 1963 there has been a loss of about 320 customers and the system's peak sendout has been reduced to 275 MW(t) in 1979. The loss of customers appears to be a combined result of a massive urban renewal program and the high price of steam. The urban renewal program removed many of former steam customers which have not been replaced. The increased cost of steam can be attributed to the increased cost of oil, the system's prime fuel. The system was originally designed, constructed, and operated on coal until the early 1970's. With federal legislation on emission and air quality regulations, Rochester Gas and Electric (RG&E) converted the pulverized coal-fired boilers to oil and natural gas. The system is presently earning a very low rate of return and there is the possibility of abandonment of the business.

Three options have been proposed to assist in making the system viable in order to serve the city and also to make it an attractive business venture. Two options represent potential short-term solutions: (1) conversion of a coal-fired unit to cogeneration and (2) building a municipal incinerator operated on refuse derived fuel. Both options would lessen the district heating system's dependence upon oil and scarce fuels. The third option is a long range strategy to develop hot water heat islands adjacent to the downtown system. The successful development of heat islands would represent the first growth nodes for a major new district heating system in Rochester. The Department of Housing and Urban Development Action Grant funds could possibly be used to assist in implementing the three options. All of the options demonstrate potentially significant scarce fuel savings.

1. INTRODUCTION

Our society puts a high priority on the heating of our buildings and homes, and demands that the space heating energy be available. There is also a strong desire to maintain a stable price. Currently, space and water heating combined accounts for about 20% of the total U.S. energy demand. Furthermore, over 90% of these requirements are supplied by oil and natural gas, fuels which are subject to rapid escalation. In addition, our increasing dependence on foreign oil threatens our national security and economic stability and adds significantly to the U.S. international trade deficit. District heating, which can use more plentiful domestic fuels, can result in more stable prices and greater national self-sufficiency.

District heating is a process in which thermal energy from a central source is distributed to commercial, industrial, and residential consumers for space heating and domestic water needs. The heat energy is distributed from a central plant to individual buildings by either steam or hot water pipelines. Buildings connected to the district heating system extract thermal energy from it rather than use fuel directly in boilers located in each building. Plants can be built for a district heating system that can use a variety of available domestic fuels including coal, nuclear energy, and refuse. There is also the possibility of thermal energy being supplied from industrial waste heat, solar energy, and geothermal sources.

The Department of Energy (DOE) and the Department of Housing and Urban Development (HUD) are jointly initiating a new program to stimulate the development of district heating systems in a number of U.S. cities. Both departments recognize that modern forms of district heating can bring about major social, economic, environmental, and energy benefits to many U.S. cities. Analytical investigations indicate that district heating is a viable concept capable of serving the thermal energy needs of a significant portion of the county. From a national energy perspective, district heating appears to be the most practical alternative for converting the existing heating systems of a vast number of urban buildings to more plentiful domestic fuels and renewable energy sources.

Recognizing the need to conserve scarce fuels, reduce the importation of foreign oil, and provide a means for upgrading and assisting in the restoration of existing cities, the Department of Housing and Urban Development has instructed the Oak Ridge National Laboratory to provide direct assistance for cities and utilities interested in rescuing their old district heating systems. The Department of Housing and Urban Development views the restoration of district heating systems as a strategy for revitalizing many distressed urban areas. District heating offers the long range potential for supplying the energy needs of commercial and retail establishments, thus maintaining the value and desirability of existing buildings in metropolitan areas. District heating offers the advantage of providing the urban business community with a competitive edge on space heating utility rates. With the expectation of ever increasing cost and uncertainty of fuel supplies, a viable and economically competitive district heating system could serve to draw commercial businesses back into urban core areas with a minimum of physical disruption and change to the central cities.

1.1 District Heating History and Current Status

District heating is not a new technology. The concept was first used in Lockport, New York over 100 years ago.[1] The first systems were designed around heat-only boilers that supplied steam for space heating. During the early part of the 20th century, the first small cogeneration/ district heating plants came into existence. These systems used the exhaust steam from small dual-purpose power plants to heat buildings in the nearby business districts. As a result, district heating combined with cogeneration was widely accepted. During the late 1940's, the situation changed when the introduction of inexpensive oil and natural gas for space heating reduced the rapid growth of district heating. At about the same time, utilities were introducing large condensing electric power plants remotely located from urban areas. It was not economical to transport steam over such long distances. As the smaller, older cogeneration units were retired, sources for the steam district heating system were eliminated and the costs of supplying steam from boilers escalated; making district heating even less attractive.

Many U.S. steam district heating businesses were not profitable due to inadequate rates or the lack of proper metering devices. For example, as the costs increased during the transition from the use of exhaust steam to prime steam, rates were kept low by regulation. As a result, utilities shut down many small district heating systems because they were not profitable. Current statistics from the International District Heating Association (IDHA) indicate a total utility steam sale of 80 x 10^{12} Btu, in 1979.[2] It is estimated that non-utility district heating systems (government institutions and college campuses) use a total quantity of steam about equal to that of utilities. District heating thus satisfies approximately 1% of the demand for heating in the United States.

One of the remaining successful U.S. steam district heating businesses is in Milwaukee, Wisconsin where Wisconsin Electric owns and operates a steam system that dates back to the turn of the century.[3] The company has continually made investments to maintain and improve the system. The Wisconsin Electric system is profitable and at the same time sells thermal energy 20-25% lower than the most competitive space heating option, natural gas. Steam energy is presently being sold to consumers in the range of $4-5/$10^6$ Btu.

The Milwaukee system serves an area of approximately 2 square miles in the heart of the city. Of three cogeneration units that supply thermal energy to the system, the largest is a coal-fired unit. It was completed in 1968 and has a capacity of 280 MW(e) and 470 MW(t) (1.6 x 10^9 Btu/hour). This fuel flexibility feature is the single most important advantage of the concept of district heating. It allows the opportunity for competitive space heating energy prices. The Milwaukee system is a good example of how the United States can utilize its more plentiful fuel (in this case coal) for space heating.

European district heating history

The history of district heating in Europe is somewhat different from that in the United States. The development of district heating networks in northern and eastern Europe started in the early 1950's.

Hot water, rather than steam, was used as a transport media and for large systems hot water has proven to be more economical. European systems tend to have larger service areas than those in the United States. They serve lower heat load density regions and use remotely located cogeneration power plants. The aggregated annual growth rate of district heating in these countries is about 20%/yr.

The dramatic surge in the use of district heating occurred in the past twenty-five years. Figures 1.1 and 1.2 show this growth from 1960 to 1975. As can be seen, the district heating capacity of Germany has more than quadrupled between 1960 and 1975 from 5000 to over 20,000 MW(t). In Eastern Europe, the Czechoslovokian district heating capacity rose from less than 5000 MW(t) in 1965 to approximately 35,000 MW(t) in 1975.

Sweden, a country with a population of 8.1 million, has been one of the leaders in the development of modern district heating systems.[4] Approximately 3 million Swedes live or work in premises served by district heating. About 40% of the total energy consumed in Sweden is for space heating, and at present more than 25% of the heat demand is supplied by means of district heating. The country has an installed capacity of 12,000 MW(t) and by the year 2000 expects an installed capacity of 30,000 MW(t). A rough estimation of the potential for district heating in the United States can be made by multiplying the Swedish numbers by a factor of 10. This factor is based on segmenting our northern tier areas into 10 population regions roughly the size of Sweden. All of the larger Swedish systems use combined heat/electric power stations which operate at high thermal efficiencies and contribute to the country's fuel conservation effort.

An example of a modern hot water district heating system is the city of Uppsala, with a population of 110,000 people.[5] Uppsala, a university city 40 miles north of Stockholm, started district heating in the beginning of the 1960's. The city dates back to the 12th century and many problems had to be solved to introduce district heating in such an old city. A parliamentary committee of politicians and technicians studied the system feasibility for Uppsala. The study results showed that during the next 10 years Uppsala would have a large heating load

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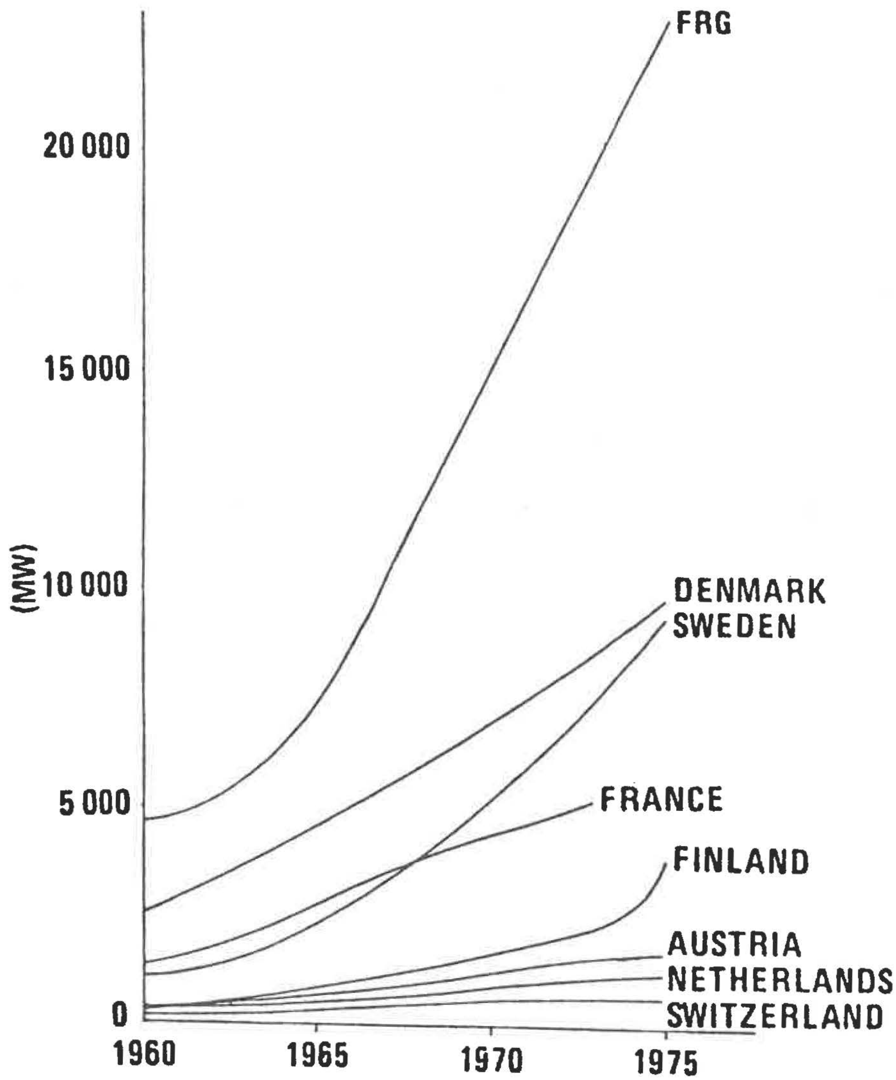

Fig. 1.1. Development of connected thermal capacity (Western Europe).[6]

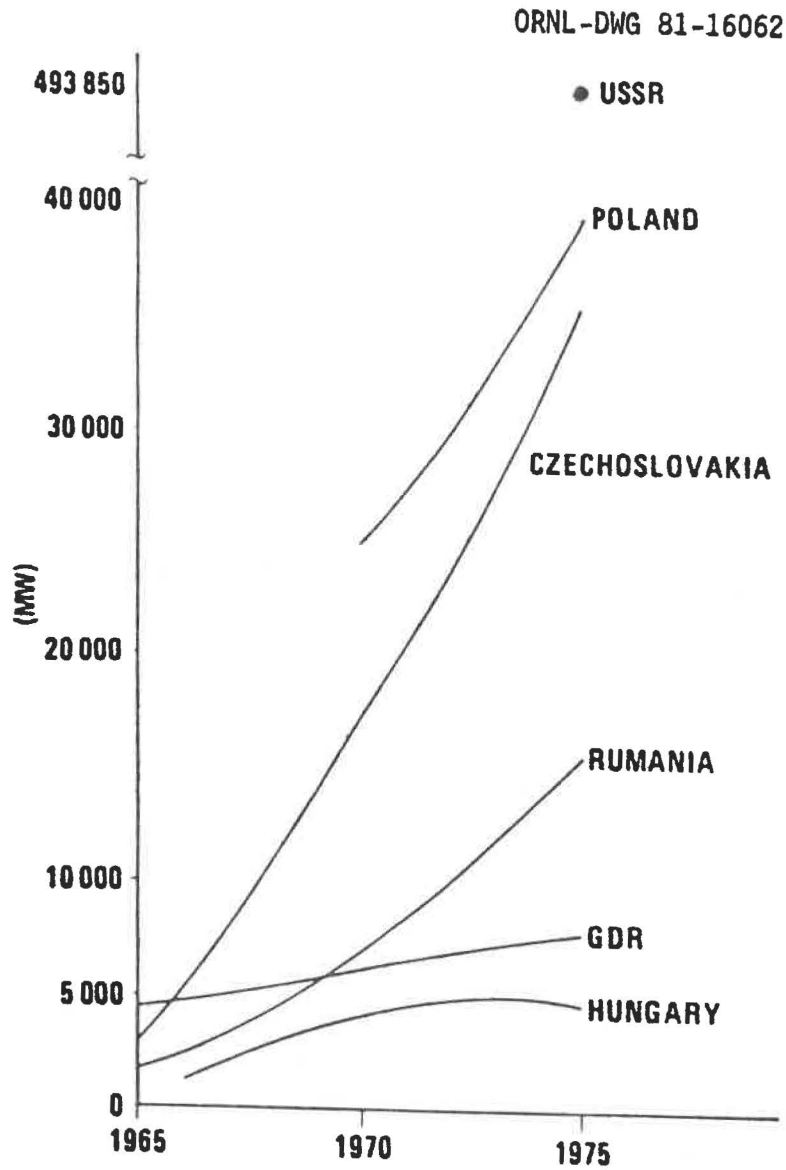

Fig. 1.2. Development of connected thermal capacity (Eastern Europe).[6]

with a heating density even higher than other Swedish towns that had successful district heating systems.

In 1961, the first district heating service (using transportable boilers) was initiated in the middle of Uppsala to a new building. The first permanent hot water boiler plant began operation in the new part of the city of Uppsala in 1962. After two years, there were about 10 customers all satisfied with the heating system. The system had proven reliable, and through satisfied customers and public relations an increasing amount of building owners became interested in district heating.

The standard design for the Uppsala system are as follows: the system pressure is 250 psig, the hot water supply temperature is a minimum of 175°F and maximum 250°F, the return temperature is between 130°F and 170°F. The variation of forward and return water temperature and flow in relationship to outside temperature is given in Fig. 1.3. The Uppsala system grew very rapidly and by 1978 had a connected load of 800 MW(t) (Fig. 1.4). The system presently covers 75% of the total heat demand in the area and the objective is to cover 95% by the middle of the 1980's. The system has approximately 4000 customers with about 140 miles of main transmission line.

In 1974, a cogeneration plant was put into operation. The plant can deliver simultaneously 200 MW of electricity and 340 MW of hot water energy. The Uppsala cogeneration plant uses oil, however, the Uppsala system is a modern efficient distribution system (approximately 90% efficient) and the consumer's main alternative is also imported oil. The cogeneration/conservation effect of the district heating system allows the utility to sell the space heating energy at a much lower price than the consumer could produce the energy through an individual boiler-only plant.

A total of $95 million had been spent on the district heating system by the end of 1978. The main problem is their dependence on oil. To lessen this dependence on oil, they are investigating the feasibility of burning wood in a new hot water boiler, and using reject heat from a nuclear plant 44 miles north of Uppsala. The fuel flexibility advantage of district heating allows these options to the considered.

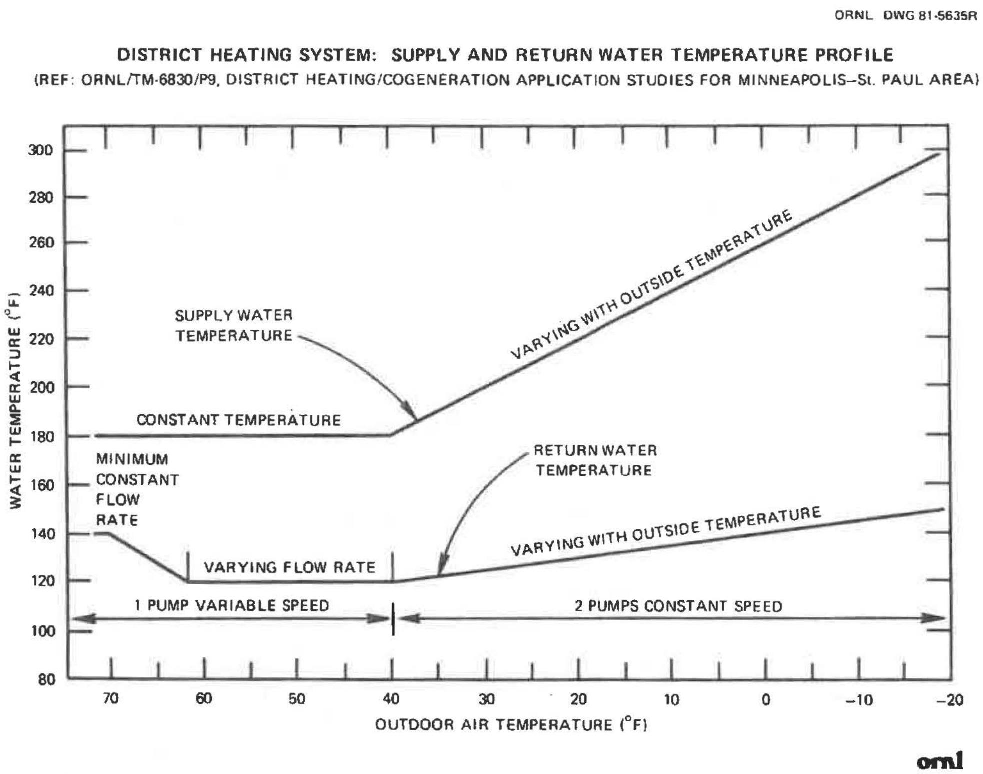

Fig. 1.3. Relation of temperature to flow rate of district heating system.

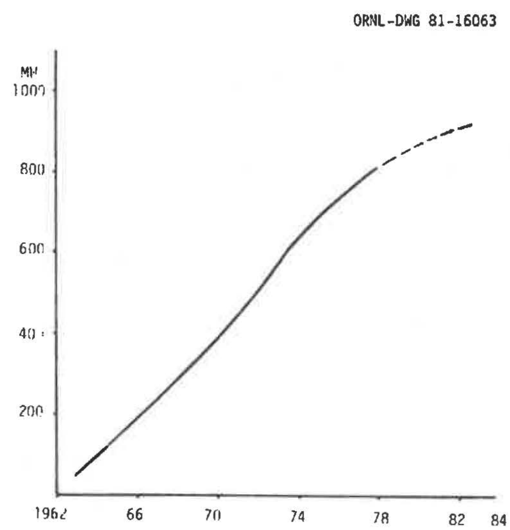

Fig. 1.4. Connected heat load growth for Uppsala.

1.2 District Heating — The Advantages for the Consumers

A district heating system has the potential to offer the consumers four major advantages over operating their own building boiler. They include: (1) competitive space heating energy costs, (2) lower maintenance costs and higher reliability, (3) improved air quality in the community, and (4) lower initial captal costs for new buildings. The most important advantage to the consumer is clearly the economic advantage. This advantage is usually achieved through the fuel flexibility aspect of district heating and the conservation potential of cogeneration. The steam district heating system in Milwaukee successfully competes with the natural gas space heating fuel by using both the fuel flexibility and the cogeneration conservation features. The system in Uppsala, Sweden competes with oil and is successful due only to the cogeneration conservation aspects. By far, the single most important item to the consumer is the cost of the space heating energy. In Rochester, as in numerous other cities in the United States, a building system using natural gas is the alternative to district heating. The only way that a district heating system can compete is through the fuel flexibility feature available to district heating systems which implies the need to use a relatively inexpensive fuel such as coal.

Another consumer advantage is the lower maintenance cost and the high reliability. These advantages are due to the simplicity of the consumers equipment. The main component of this equipment is a series of heat exchangers which are similar to car radiators. The heat exchangers seldom need maintenance and there is no need for a boiler operator.

The district heating system also has the potential for improving air quality in a community. Emissions from one stack at a central power plant replaces emissions from many low-level space heating stacks. More effective controls can be put on the central stack than on the many low level stacks. However, the overall effect of district heating on air quality depends to a large extent on the type of fuels being replaced in the individual units.

The developers of new buildings that connect directly to a district heating system have lower capital costs because the cost of a heat exchanger is much lower than that of a boiler. Also, there is additional floor space because a boiler room is not required. The consumer advantages are summarized in Table 1.1.

Table 1.1. Advantages for consumers that are connected to a district heating system

- Competitive space heating energy costs
  - a. Fuel flexibility
  - b. Cogeneration/conservation
- Lower maintenance costs and higher reliability for consumers
- Improved air quality in the community
- Lower capital costs for new buildings

1.3 Steam Versus Hot Water District Heating

A new hot water district heating system has many advantages over a steam system. A hot water system has lower energy transport costs that result in economical distribution over larger distances than is typical for steam systems. Thermal energy transported by steam is limited to a maximum distance of about 5 miles, whereas a hot water system can transport energy economically and with low energy losses for up to 50 miles.[7] Another significant advantage is that hot water can be produced more cheaply. A modified or new cogeneration plant does not sacrifice as much electricity when producing 250°F hot water as when producing steam (75 to 150 psig) for a district heating system. The lower electricity sacrifice means lower thermal energy costs. Also, a hot water distribution system is more flexible than a steam system. Hot water from various sources can be used and new pumping stations can be added to extend the system. As a result, a hot water system is more adaptable to meeting the changing needs of a community.

A majority of modern buildings are now constructed with internal hot water distribution systems. These systems allow for more effective control of the heating system, and do so with considerably less noise. The modern heating and ventilation systems are compatible with the hot water district heating system. These buildings could be heated with a steam district heating system, but losses are incurred in the use of pressure reducing equipment.

1.4 Urban Development Action Grants

The Urban Development Action Grant program (UDAG) was created by the Housing and Community Development Act of 1977 (P.L.95-128) to provide grants for "severly distressed cities and urban counties to help alleviate physical and economic deterioration." The UDAG program was designed to improve the physical condition of cities by assisting in the redevelopment of underutilized property; by building or rehabilitating housing, factories, offices, and stores; and by building access roads, sewers, and utility facilities.

A significant difference between UDAG and earlier federal urban redevelopment programs is the necessity for firm financial commitments from the private sector. It is not the intent of the program to supplant private capital but rather to make otherwise economically unattractive projects desirable undertakings for private investment. It is an underlying goal of the program to support projects that improve the economic climate to favor further private investment in an area.

Major advantages of the UDAG program are inherent flexibility and an expeditious review process. Funds are awarded to local governments, which can then lend or grant them to private or municipal developers. Flexibility in management of funds is designed to promote stronger working relationships among local government, the commercial and industrial sectors, and the public in overcoming development problems. The assurance of a rapid review process is another positive aspect of the UDAG program. Applicants can reasonably expect a decision on their proposal within two months of its submission. The review process is further enhanced by having four separate dates each year for filing applications. The annual schedule for the application process is presented in Table 1.2 for metropolitan and small cities.

Table 1.2. Calendar of the application process for Urban Development Action Grant programs

	Determination of eligibility (pre-application; SF-424) to be submitted by	Application period	Review period	Decision date
Metro cities	November 30	January 1 — 31	February 1 — March 31	March 31
	February 28	April 1 — 30	May 1 — June 30	June 30
	May 31	July 1 — 31	August 1 — September 30	September 30
	August 31	October 1 — 31	November 1 — December 31	December 31
Small cities	December 31	February 1 — 28	March 1 — April 30	April 30
	March 31	May 1 — 31	June 1 July 31	July 31
	June 30	August 1 — 31	September 1 — October 31	October 31
	September 30	November 1 — 30	December 1 — January 31	January 31

Applicant eligibility requirements

Action Grant projects are selected on the basis of a national competition. The first major eligibility criterium is the necessity to acquire firm financial commitments from the private sector. The program is meant to catalyze increased investment in distressed communities by private sector involvement so that such investments must be firm before a grant can be approved. An appropriate measure of economic viability would be a committment of $2.50 private for each dollar of UDAG funding.

The second major requirement of the applicant is determination of the level of economic and physical distress in the community. HUD periodically publishes minimum standards of distress which metropolitan cities, urban counties, small cities, and unique locations (pockets of poverty) must meet. Factors such as age and condition of housing stock (including residential abandonment), per capita income, population out-migration, unemployment and others are used to indicate distress.

In addition to the appropriate distress factors, applicants are judged based upon sixteen other factors delineated in the regulations. Factors such as impact upon employment in the community, affect on the tax base, likelihood that the proposed project will be completed upon schedule and within budget, applicants housing and development record, relocations needs, and participation by and benefits to various groups within the community. The final criterium is intended to demonstrate the applicants history of providing housing for persons of low and moderate income and in providing equal opportunity for low and moderate income persons and minority groups.

Energy Urban Development Action Grants

The Department of Housing and Development has recently proposed an amendment to the UDAG program which would give more favorable consideration in the selection of applicants for energy conservation and alternative energy supply projects (Appendix A). The purpose of the energy UDAG is to improve the physical and economic viability of urban areas by supporting projects which are designed to conserve scarce fuels and result in direct energy cost savings to the public, municipal governments, private commerce, and industry. HUD recognizes that many proven and valuable energy conservation practices and alternative supply technologies may have difficulty in obtaining 100% private financing. Even projects with the potential for conserving significant amounts of energy or scarce fuels may have difficulty attracting private investment because of an insufficient rate of return. Energy UDAG's are intended to be used to make otherwise infeasible projects desirable undertakings for private developers. It is not, however, the purpose of the Action Grant Program to fund research, development or demonstration projects which lack commercial viability.

The current set of energy conservation and alternative supply technologies that HUD has defined as appropriate for energy UDAG consideration include:

- district heating
- geothermal systems
- small-scale hydroelectric systems
- cogeneration systems (industrial, commercial, municipal)
- modular integrated utility systems (MIUS)
- alcohol fuels production systems
- wind power systems
- energy conversion from wastes
- solar thermal systems
- low and medium Btu gasification facilities
- loan/grant pools for building conservation
- recycling or reclaimation facilities
- photovoltaic manufacturing facilities

The application, processing, and eligibility requirements for participation in an energy UDAG are essentially those necessary to compete for another Action Grant project. Energy projects, however, are favored to the extent that they conserve scarce fuels or increase energy efficiency. In comparisons among energy UDAG applicants, those from communities that have adopted plans or programs to conserve energy or provide alternative sources of supply on a community-wide basis will be favored over communities making no effort in this regard, all other factors being equal.

Energy Action Grant applicants are required to submit some additional information to become eligible for funds. The following information should accompany the energy UDAG application:

- a technical and economic feasibility study;
- evidence that the project does not provide an undue energy subsidy to any customer or class of customers;
- the ratio of scarce fuels saved to the amount of UDAG funds requested; and
- a description of any community-wide energy conservation plan or program undertaken by the applicant, and the relationship, if any, of the project to such plan or program.

The recent origin of the Energy Action Grant program provides little indication of the time that may be required to review each application. The two month rapid review process characteristic of the conventional Action Grant program could be extended to accommodate the additional engineering and economic reviews required for an energy project.

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2. DESCRIPTION OF ROCHESTER, NEW YORK

2.1 History

Rochester is located in the western region of New York state on the southern shore of Lake Ontario. The city developed along the shores of the Genesee River where four consecutive waterfalls provided power for an early local flour-milling industry. The falls formed the focus of the city's early industrial and commercial development by providing hydroelectric power for manufacturing. A variety of different industries rapidly established Rochester as a regional center for both commerce and manufacturing. Establishment of the photographic and optical industries during the early part of the twentieth century continued the tradition of specialized industrial and technological development which characterized early Rochester. The city has continued to enhance its heritage by maintaining many different centers of scientific and industrial research. With such an innovative history, it is difficult to imagine that Rochester is confronting many of the problems which are so typical of the older industrialized cities in the northeast. The poor, the elderly, the poorly educated, and minority groups constitute an increasingly large share of the city's population. Many physical characteristics of the city — the housing stock, commercial and industrial buildings, public utilities, and the transportation network — are either outmoded or inadequate. The result of these many factors is a continually shrinking tax base combined with the prospect of ever increasing costs of municipal services. The city has recognized the need to resolve these problems and has taken action to develop both short and long range economic plans. This chapter will focus upon selective problems of Rochester and attempt to define those factors which may significantly affect the growth and development of the city.

2.2 Population Characteristics

Population

Rochester is the third largest city in New York State with an estimated population of 256,285 in 1977. As indicated in Table 2.1, there

Table 2.1. Population changes in the city of Rochester and Monroe County, New York between 1950 and 1977

	Monroe County	City of Rochester
1950	487,632	332,488
1960	586,387	318,611
1970	711,917	296,233
1975	708,400	267,163
1976	710,500	262,766
1977	706,500	256,285
% of change		
1950-1960	20.25	(4.17)
1960-1970	21.41	(7.02)
1970-1977	(0.76)	(13.49)

has been a population loss of approximately 76,000 since the estimated peak of 330,448 in 1950. Results of the 1980 census will indicate whether or not the population continues to decline. Although the population has fallen sharply since 1960, age composition has not changed significantly (Table 2.2).[1] In the 1970 census, approximately 35% of the city's population was nineteen years of age or younger. Nearly one-half of the population fell between the 20-59 year age bracket and those 60 years or older constituted 18% of the total city population. It should be noted that the proportion of the Rochester population 65 or older (18.3%) remains relatively stable even though these estimates are higher than those for New York State (14.11%) and almost twice as high as their representation in the general U.S. population (10.7%).

Race

Census data indicate that the county's minority population resides predominantly within the city limits of Rochester (Table 2.3). Population estimates prepared in 1970 indicate that white outmigration is continuing from the city and that the total number and percentage of minorities have continued to increase.[1] It is also believed that the 1970 census significantly undercounted the members of the city's Spanish

Table 2.2. Composition of city of Rochester population by age

Age groups	1960	1970	1975	1977
Less than 20	32.3%	34.5%	33.3%	32.9%
20-39	24.7%	27.0%	27.0%	27.0%
40-64	29.4%	25.1%	26.2%	26.5%
65 or older	13.6%	13.4%	13.5%	13.6%
	100.0%	100.0%	100.0%	100.0%

Table 2.3. Racial mix in the city of Rochester and Monroe County, New York

	Black		Spanish speaking		White and other	
	Total	%	Total	%	Total	%
Monroe County	52,218	7.3	10,680	1.5	649,019	91.2
City of Rochester (1970)	49,647	16.8	8,255	2.7	238,331	80.5

speaking population. It is therefore likely that the difference in racial composition between the city and its suburbs is even greater than projected.

Labor and employment

Because of the number and character of the local industries, the Rochester area has a highly technical and diversified work force. As indicated in Table 2.4, professional, technical, managerial, administrative, and craft categories represent 40% of the total labor force. The labor force in the Rochester area was estimated in 1978 at approximately 330,000 of which 42% (140,467) resided within the city. The New York State labor department has estimated that during 1978 unemployment rates in Rochester averaged 7.1% of the civilian labor force. The city anticipates the unemployment rate to be higher than that proposed by the state given the number of layoffs, plant closings, and departure of a significant portion of the middle class from downtown Rochester.

Table 2.4. Occupational employment by major occupations in the Rochester, New York area[1]

Occupation	%	1976	%	1978	Change 1976-1978	
					Net	Percent
Professional, technical, and kindred workers	19.8	77,000	19.8	79,100	+ 2,100	+2.7
Managers and administrators	7.4	28,800	7.4	29,600	+ 800	+2.6
Sales workers	6.9	26,700	6.9	27,600	+ 900	+3.0
Clerical workers	20.1	77,900	20.0	79,900	+ 2,000	+2.6
Craftsmen and kindred workers	12.8	49.700	12.8	51,000	+ 1,300	+2.5
Operatives (except transportation)	14.8	57,500	14.8	58,800	+ 1,300	+2.2
Transportation operatives	2.7	10,400	2.7	10,600	+ 200	+1.7
Laborers	3.2	12,400	3.2	12,700	+ 300	+2.6
Service workers	12.3	47,900	12.4	49,500	+ 1,600	+3.4
Totals	99.7	388,300	100.0	398,800	+10,500	

2.3 Residential Sector

Rochester is a city that was established around the falls of the Genesse River. Subsequently, the neighborhoods and suburbs of Rochester have evolved in response to the industrial development which is spread from the rivers and along the main arteries of transport. Although highly industrialized, the dominant form of housing in Rochester is low to medium density residential housing. Of the estimated 104,866 homes in Rochester, almost 45% are owner operated and 55% are rental units. The most salient characteristic of the housing stock is its age and lack of multi-unit development. More than 79% of the housing stock was built before 1940, with the median age of the housing being approximately 60 years old.

Another aspect of the housing stock is its restricted potential for growth. Very few vacant tracts of land remain within the city to serve as a base for residential construction. Vacant lands that are available for building are also highly desirable for industrial applications. With less than 5% of the land available to support new housing stock, the housing market can expand only at the expense of the existing stock. Demolition or rezoning of housing is not a desirable alternative for the city of Rochester. The city has proposed investing approximately $75 million into neighborhood activities and improvements over the next 3 years. The neighborhood improvement programs would offer a new dimension in the way of home ownership, to the residential programs now being offered, such as the City's Home Improvement Loan Program (HILP), Residential UDAG Program (HIP), and Street Beautification/ Improvement Program. The various community improvement programs to restore the neighborhoods and the condition of undesirable housing to former levels is an important factor in stabilizing the declining housing market. The loss in both single family and residential housing has been dramatic in the last 20 years.[2] Since 1960, the number of single family houses in Rochester has decreased by approximately 14% from a high of 53,251 in 1960 to a current estimated level of 45,948. As the single family housing market has continued to decline, the demand has been met by conversion of houses to rental units and by the construction of rental properties. In 1960, the number of rental units in the city numbered 52,819 and had expanded by 11.5% to an estimated 58,922 units in 1980. The loss in single family dwellings can be attributed to demolition of abandoned or distressed structures and the conversion to different uses within the community. Although the rental units have increased dramatically in the last 20 years, the total housing stock continues to decline. Of the estimated 106,070 housing units available in 1960, only 104,866 are available today.

The most dramatic change in residential housing within the city occurred in the Central Business District. In 1960, over 6255 units were reported. By 1975 that number have decreased to 2820. An active building program and multi-family housing has increased the number of residential units in the central business district by 728, thus bringing the total to 3548 units in the downtown area. Of the total, only 87 units are privately owned. The remainder, 3461, are rental units.

2.4 Commercial Sector

Central Business District (CBD)

The majority of Rochester's commercial activity is focused in the downtown Central Business District (CBD). The Central Business District of Rochester is a major center of activity for business, finance, and government in western New York State. The CBD has, until relatively recently, been an established center for retailing, cultural, convention, and entertainment activity for the region. During the past several decades, downtown Rochester has changed significantly. Financial and administrative institutions have increased in importance while residential, public institutions, and business establishments have declined markedly.

Retail

Downtown Rochester is still the largest shopping area in the region. There are over three million square feet of retail space in use in the downtown area. Retail sales in the Central Business District declined sharply between 1967 and 1972. Although the most current business statistics are not available in the downtown area, data presented in Table 2.5 indicate the general magnitude and brevity of lost sales revenue.

Table 2.5. Central Business District retail sales, 1967-1972[1]

Kind of business	CBD sales (x 1000)		% of all retail sales in CBD		CBD sales as % of city sales	
	1967	1972	1967	1972	1967	1972
Building materials	$ 695	462	0.3	0.2	2.5	2.0
General merchandise	87,197	75,732	40.5	36.4	66.6	56.8
Department store	81,698	70,337	37.9	33.8	70.5	57.9
Food	6,544	6,633	3.0	3.2	4.6	4.8
Automotive and gasoline	42,596	54,446	19.8	26.2	24.0	28.1
Apparel	32,022	26,864	14.9	12.9	67.6	8.3
Furniture	13,049	6,993	6.1	3.4	28.3	16.9
Eating and drinking	12,209	12,471	5.6	6.0	20.6	20.8
Pharmaceuticals	3,099	3,502	1.4	1.6	13.0	12.0
Miscellaneous	18,045	20,929	8.4	10.1	34.8	28.0
	$215,456	$208,038				

Office space

Approximately 7.5 million square feet of office space exists in downtown Rochester. The downtown space represents approximately 70% of the total area in the entire metropolitan statistical area.[3] First class buildings are estimated at 96% occupancy with an overall office space of 88%. The relatively low overall occupancy rate in office space can be attributed to the development of new office space which has not been accompanied by an equal expansion in employment. A recent survey of office vacancy indicates that while the newly constructed office space has finally reached capacity, high vacancy rates still exist in older buildings.

Residential

Urban renewal activities in the late 50's and early 60's effectively removed many older residential buildings from the central city. Replacement of residential building stock has been relatively insignificant until the recent past when over 1000 building units were installed in the Central Business District. A projected demand for up to 1800 units of new or rehabilitated housing has been estimated for the next ten years. The housing will probably be medium density, low- and mid-rise design taking into account the strong local preferences for such housing. Demand for high density, high-rise housing is not anticipated unless it is part of a mixed-use plan of development incorporating a variety of uses including offices, shopping, entertainment, and dining.

Industrial demand

Analysis of industrial space demand in the downtown area indicates that no additional space is either needed or feasible. Relocation of manufacturing and warehousing firms from older loft type buildings located in the Central Business Ditrict to more efficient one-story facilities in the outlying areas is anticipated to continue.

Hotel and convention industry

In recent years, the tourism industry has also played an important role in the area's economy. Rochester currently ranks as the second major convention center in the state of New York. In 1975, an estimated 33,500 delegates stayed in downtown hotels. This represents 68% of the areas total convention business and generated annual revenues of approximately $4.5 million. In recent years, hotels in downtown Rochester have not done well in relation to those in suburban locations. Downtown hotels operate at low occupancy rates despite recent closing of older hotels which have reduced the competition for rooms. The major factor in the reduction of convention business appears to be in the development of convention centers in such closely associated cities as Buffalo, Niagara Falls, and Albany. The competition for regional conventions in these areas is making it increasingly difficult for Rochester to recruit convention business.

2.5 Industrial Sector

Rochester is a highly industrialized community with many manufacturing firms operating within the city. Such Rochester based firms as Eastman Kodak, Sybron, Gannett, and Xerox (currently headquartered in Connecticut) have developed from local manufacturing companies into major national or multi-national corporations. Manufacturing accounts for more than 87,000 jobs, 38.5% of the cities employment, and 60% of such jobs within the metropolitan area (1977 base year).[4]

Between 1970 and 1977, 82 industrial firms have either located or expanded within Rochester. The companies added about 2,700 jobs, absorbed 237 acres of land, and constructed 3.4 million square feet of industrial floor space. The city has encouraged real estate development through local assistance efforts which have resulted in the expansion of R. F. Communications, Ragu Foods, Taylor Instruments, Great Lakes Press, and other industries.

During the same seven year period, however, 71 industrial firms either discontinued operation or relocated from the city with the subsequent loss of approximate 15,000 jobs. The most critical factors in the loss of manufacturing firms were unprofitability (in some cases bankruptcy) attributed to product obsolescence, competition, plant obsolescence, or site problems. The majority (87%) of the job losses were in four industries: food, apparal, machinery, and electrical machinery. Projected manufacturing employment is expected to remain relatively stable at 87,000 jobs through 1980 with modest increases up to 91,000 during 1981 through 1985.

A principal weakness in Rochester's industrial sector is the age and growing obsolescence of the building stock. During the last two decades, the city urban renewal and community development programs have been directed at improving the city's residential neighborhoods and its Central Business District. Until recently, deteriorating industrial properties were removed and the land converted to non-industrial uses with no provision for replacement. At present, there are approximately 45 million square feet of industrial floor space (including administrative office space) in Rochester. By the end of 1985, almost 4.7 million square feet will be either demolished or converted to other uses. Anticipated demand for industrial floor space during the same period is estimated at 8.5 million square feet. As illustrated in Table 2.6, 3.3 million square feet will be required to replace inadequate facilities and 5.5 million square feet will be needed for additional expansion.

Table 2.6. Anticipated demand and availability of industrial floor space in Rochester through 1985[4]

	Floor space (10^6 ft^2)	Acreage required
A. Total potential demand through 1985	8.4	
B. Total building space to accommodate demand through 1985	1.9	
1. Existing vacant space	1.4	
2. Anticipated turnover in space	0.5	
C. Potential demand which cannot be accommodated in existing space	6.5	
1. Anticipated expansion — same or adjacent site	3.25	163
2. Anticipated expansion — new sites	3.25	224
D. Potential new industrial space on land available for industrial development	4.5	260
E. Potential demand which cannot be accommodated either in existing space or in new space on available vacant industrial land	2.0	127

Some of the demand for industrial floor space will be met by existing vacant space and through turnover in the existing building stock. In June of 1978, there existed approximately 2.8 million square feet of vacant industrial floor space in Rochester. Of the available floor space, 850,000 square feet (30%) has a high potential for continued industrial use, 1.1 million square feet (40%) has a moderate potential, and 850,000 square feet (30%) has a low potential. Approximately 1.4 million of the 2.8 million square feet of vacant space is expected to be occupied by the end of 1985. The balance, 1.4 million, will be either converted to other uses or demolished. The amount of industrial space that may become available through turnover has been estimated to be approximately 500,000 square feet. Utilization of vacant space and turnover can be expected to contribute almost 1.9 million square feet to the anticipated demand for industrial floor space.

Additional industrial floor space can be made available in new space constructed on vacant or readily buildable industrial land. At present, Rochester's industrial space is located either in manufacturing nodes or corridors. The industrial nodes are usually independent sites or small complexes located in older residential neighborhoods, adjacent to railroad lines. Most of Rochester's industrial parks and major plant sites are located along five industrial corridors (Fig. 2.1). A majority of the manufacturing is restricted to three major locations. Corridor No. 3 is occupied exclusively by Eastman Kodak. Corridors 1 and 2 have mixed uses; principally machinery, electrical machinery, food and fabricated metal industries. Corridors 4 and 5 are significantly smaller than the three preceeding and are considered minor manufacturing areas.

The entire city of Rochester was surveyed in 1978 to determine the amount of vacant land for industrial development. Analyses of the survey data indicate that of the 852 acres of vacant land, only 17 parcels totaling 181 acres have high potential for industrial development.[1] Most of the major vacant land areas are located on the west side of the city, in or adjacent to, existing industrial corridors. Figure 2.2 illustrates the location and configuration and the three most suitable areas for industrial development: McKee Road (33.6 acres), Ferrano Street-Western Gateway (72.4 acres), and LaGrange Avenue (67.2 acres).

Based upon the projected turnover in existing floor space, the inventory of vacant floor space, and available vacant land, the city can

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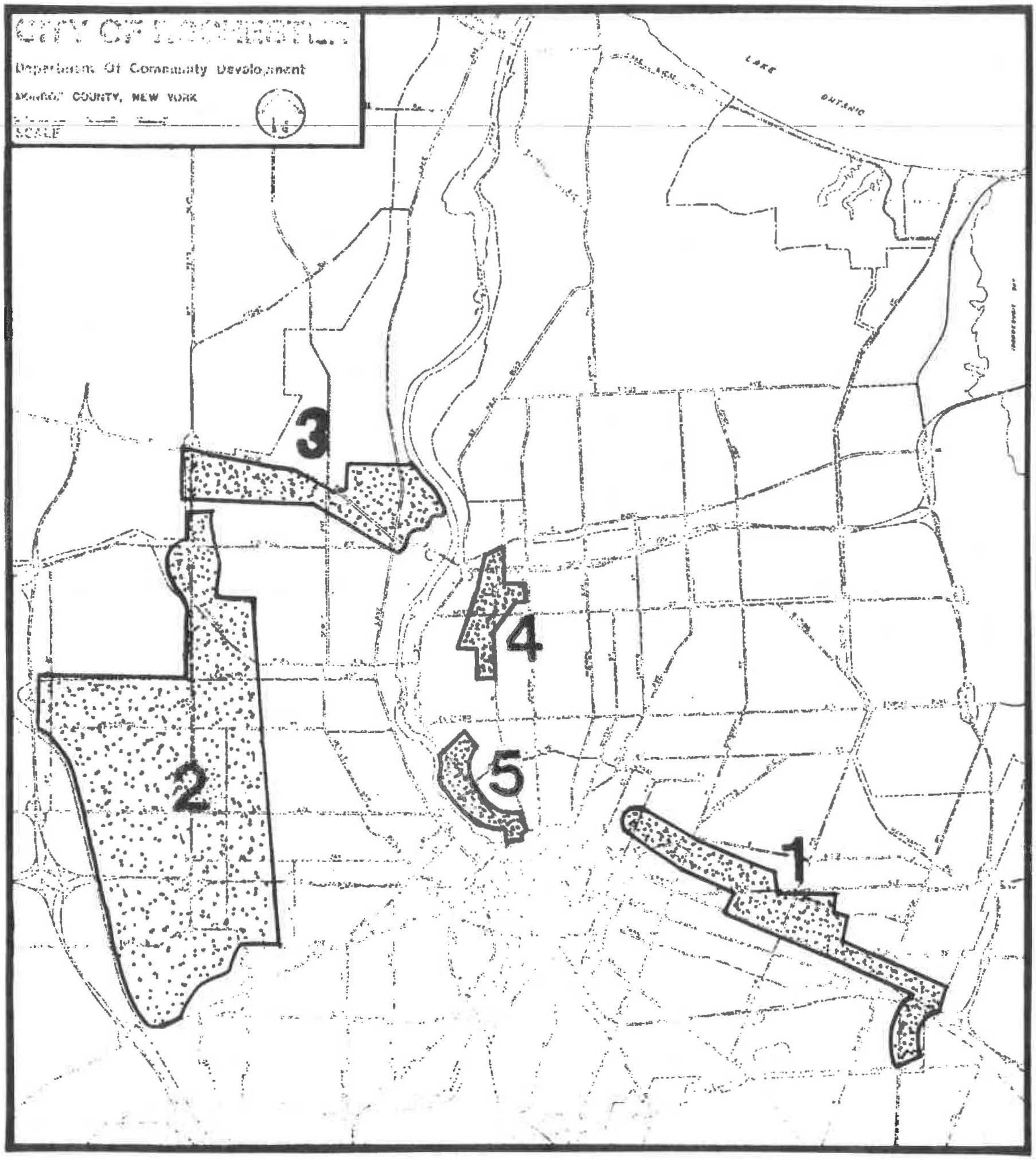

Fig. 2.1. Major industrial corridors in Rochester.

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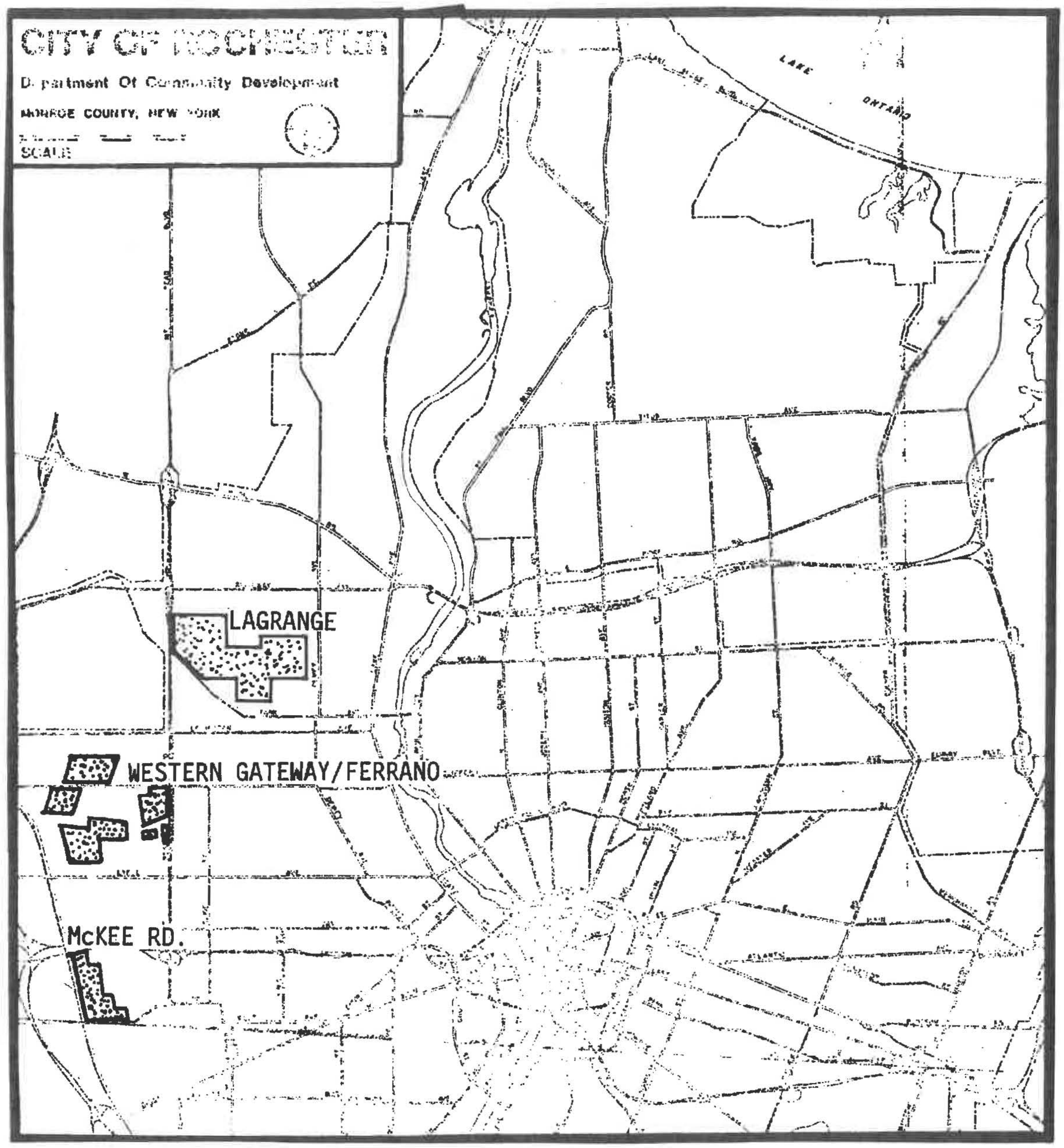

Fig. 2.2. Three major vacant land areas most suitable for industrial development.

accommodate about 6.4 million square feet of industrial floor space requirements through 1985. Rochester will need an additional 2.0 million square feet (approximately 127 acres) of floor space in order to satisfy the anticipated market demand through the same period. To meet the anticipated demand for industrial space, the city has undertaken a three year program, "Rochester Economic Development Program 1980-1983." The program is aimed at improving the marketability of the few remaining tracks of land suitable for industrial development and planning the redevelopment of deteriorating areas within the city for industrial use. The city has targeted the McKee Road, Ferreno Street-Western Gateway, and LaGrange Avenue sites for active redevelopment.

Four areas of mixed land use have been identified, outside of the central business district, as potential sites for gradual redevelopment or conversion to industrial property. The areas are referred to as Dutchtown, Lyell-Broad, East Main-University, and Hudson Avenue districts (Fig. 2.3). The Dutchtown and Lyell-Broad districts are located between the Central Business District and the west side industrial park with these sites encompassing 275 and 300 acres, respectively. The areas contain extensively under-utilized railroad property, vacant residential lots, and obsolete industrial buildings. The East Main-University District contains approximately 275 acres on the east side of the city. The Penn Central Railroad yard represents the core of this district which also contains dilapidated industrial structures, vacant and under-utilized industrial complexes, vacant residential lots, and abandoned housing. The Hudson Avenue district is predominantly a residential area, but one which has the highest housing abandonment rate in the city. Of the approximately 180 acres in the district, about one-third is municipally owned. Successful redevelopment of the four target areas would provide over 800 acres of property for potential industrial development in Rochester.

2.6 Urban Redevelopment Strategies

Two major and interrelated strategies have been proposed to direct the redevelopment activities of Rochester. The first strategy entitled

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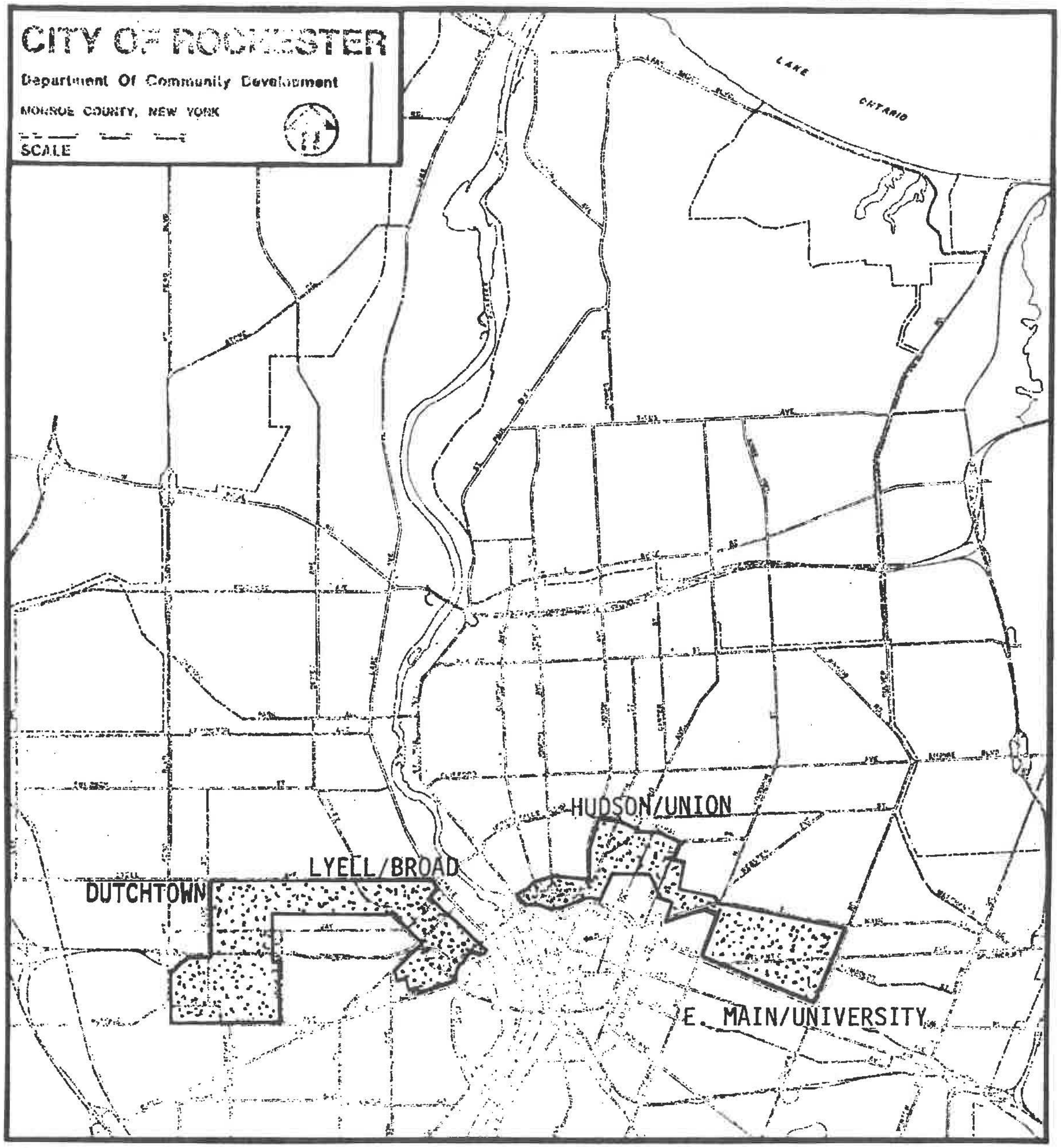

Fig. 2.3. Location of industrial lands targeted for redevelopment.

"Economic Development Program Strategy, 1980-83," represents a comprehensive planning approach to a continued economic revitalization of the city. The second strategy, "Downtown Development Plan 1977-87," was prepared by the city's Department of Community Development and represents a guide for the future growth of Rochester's major commercial district.

Downtown Development Plan 1977-87

As its name implies, Downtown Development Plan is specific to the area known as the Central Business District (CBD). The CBD and most of the downtown area is surrounded by the interloop expressway. As described earlier, the CBD is composed mainly of retail commercial, office, and public buildings. The changes that have occurred in the downtown district in the last twenty years have not been desirable or conducive to the long term economic success of this area. The ten-year development plan was prepared in response to the existing conditions in downtown Rochester and proposes strategies for changing the environment in this area. The plan was developed to give positive guidance and direction to the investments that will be made so as to encourage confidence in the downtown area while at the same time preserving and protecting existing investments. The development proposals concentrate on the public and private construction that will help make the downtown a comfortable, attractive, and efficient place to work, shop, live, and find entertainment.

The Development Plan contains many different objectives which are considered important in the revitalization of this area. The major objectives of the ten-year plan are:

1. Improving the circulation system to upgrade the quality of pedestrain environment and clarify transit and automobile movement.
2. Upgrading the overall physical appearance of downtown to eliminate areas of blight and deterioration which presently impede private investment and reinvestment in downtown.
3. Conserving existing viable activities and encouraging new opportunities for private and office investment downtown.

4. Providing opportunities for in-town housing with related facilities which are competitive in the regional market place.
5. Expanding the cultural and entertainment role of downtown; making it an attractive and exciting place in the evening as well as in the daytime.
6. Exploiting the potential that exists for increased tourist and convention business.
7. Stabilizing the retail core and fostering those adjustments necessary to strengthen the drawing power of downtown as a competitive retail center.
8. Improving and providing additional landscape areas to capitalize on the aesthetic potential of the Genesee River,
9. Stabilize and expand the city's tax base downtown.
10. Providing opportunities for expanded employment recognizing that downtown is an accessable and convenient location for city and many urban residents.

Many of the projects are interrelated and will require the coordinated efforts of both the public and private sector. With a total estimated capital cost of over $61 million for the ten-year period, the projects represent a major commitment to the future of downtown.

Economic Development Program Strategy: 1980-83

The three year economic development program represents a composite of objectives and related long and short term strategies designed to achieve three major economic development goals. The three major goals are:

1. Create job and business opportunities and strengthen the tax base through:
    a. Industrial retention, expansion, and relocation,
    b. Creation of new businesses,
    c. Redevelopment of the Central Business District,
    d. Capitalization of Rochester's role as a convention center, and

e. Development of human potential through job training, vocational education, higher education, etc., to insure that the jobs created address the city's long-term unemployment problem in industry's skilled labor shortages.

2. Revitalize neighborhood commercial areas.
3. Improve the city's long-range economic development planning and implementation capacity.

The first major objective of the three year economic development program is to retain and create industrial jobs to stabilize and strengthen the industrial tax base. The city intends to achieve this objective by (a) improving the marketability of the few remaining tracts of vacant land suitable for industrial development, (b) planning the redevelopment of four deteriorating areas which have potential for industrial development, and (c) exploring the possiblity of creating or using an existing local non-profit or quasi-public corporation to implement the first two recommendations. The city also proposes to provide ongoing technical assistance to both areas targeted for industrial redevelopment and those outside of the target areas. As a support for the target area programs and to enhance ongoing economic development efforts, the following additional programs are in the planning or implementation stages. These programs are:

1. Improved business access to loan funds.
2. Develop non-financial programs to assist small business, especially those operated by minorities or handicapped persons.
3. Promote the city as an industrial center.
4. Continue to assist businesses to determine their security needs to the ongoing Business Security Program.
5. Develop additional means to further encourage the reuse of vacant or under-utilized buildings, especially in the four major proposed redevelopment areas.
6. Continue to advise businesses adversely affected by imports.

The program goal of retaining and creating non-industrial jobs and stabilizing and strengthening the commercial tax base in the central business district can be achieved by;

1. Re-establishment of downtown Rochester as a cultural center,
2. Improving traffic circulation and access to downtown activity centers,
3. Encouraging retention and expansion of existing downtown businesses,
4. Attracting non-industrial businesses into downtown to create jobs,
5. Redeveloping and rehabilitate downtown buildings for new development,
6. Revitalization of deteriorating commercial areas, and
7. Upgrading the physical appearance of downtown and improving the pedestrain environment.

The second strategy for retaining and creating non-industrial jobs is to capitalize on Rochester's role as a convention center. This can be accomplished by the development of a major convention and conference center in conjunction with the American Hotel and the Holiday Inn in downtown Rochester. Secondly, development of an industrial exhibit center and the capitalization on highly successful downtown festivals should increase tourist traffic.

This third goal of the program is improvement of neighborhood business areas. Two major strategies for improving the neighborhood business areas are upgrading the physical appearance of neighborhood centers and encouraging the expansion of businesses for small entrepreneurs.

The objective of developing human potential will require the creation of facilities, mechanisms, and programs to insure the participation of all residents in the community's economic growth. The strategy for developing the human potential relies heavily upon the development and implementation of programs which not only provide technical training and skills to a large number of potential employees, but also encourage the coordination of existing agencies to improve job placement efforts and to determine additional training needs.

The final economic development goal of improving the city's long range planning and implementation capacity relies upon three related strategies. The first is to develop procedures for maintaining records on tax exempt property. The second requires systematization of the available data on local firms and industries for use in connection with technical assistance efforts. Thirdly, develop a mechanism to monitor and update business trends and characteristics of the city.

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2. Center for Governmental Research, Inc., Rochester Community Profile (unpublished), Rochester, New York, March 1978.
3. City of Rochester, New York, "Downtown Development Plan, 1977-78," no publication date.
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3. ROCHESTER DISTRICT HEATING SYSTEM

3.1 History of Rochester Steam District Heating System

The district heating story[1] in Rochester began in the year 1889. At that time, Rochester became the third community in the nation to install a central steam system. The steam system was the outgrowth of Rochester Gas & Electric Corporation's (RG&E) desire to sell electricity in the downtown area. Many of RG&E's prospective electric customers were already producing their own electricity on site with small coal-fired steam turbines. The exhaust steam from the turbines was used to heat buildings and provide process heat. Purchasing electricity from the utility would require building owners to not only abandon their own facilities, but to seek alternative sources of space heating and process steam. To overcome these obstacles to electrical sales, RG&E offered to deliver steam to their initial electric customers. The steam system grew in conjunction with the electrical service and became accepted as the desired service for new buildings in downtown Rochester.

In 1963, the system was the fourth largest in the United States and had a peak hourly send-out of 390 MW(t) (1331 x 10^6 Btu/hr).[1] The system served 621 customers and was growing steadily. Since 1963 there has been a loss of about 320 customers, and the systems peak send-out has been reduced to 275 MW(t) (937 x 10^6 Btu/hr) in 1979. The loss of customers appears to be the combined result of a massive urban renewal program and the high price of steam. The urban renewal program removed many steam-served buildings which have not been replaced. The increased cost of steam can be attributed to the rapid escalation in the price of oil, the system's prime fuel. Even with the loss of one-half of its customers, the RG&E system is still the sixth largest in the United States. The minor reduction in standing of the RG&E system reflects the general condition of steam sales throughout the entire steam district heating industry.

Currently, the RG&E district heating business is made of two separate and distinct systems, the downtown and the industrial district systems (Fig. 3.1). The Downtown system is where the district heating business started and which now serves predominantly commercial space

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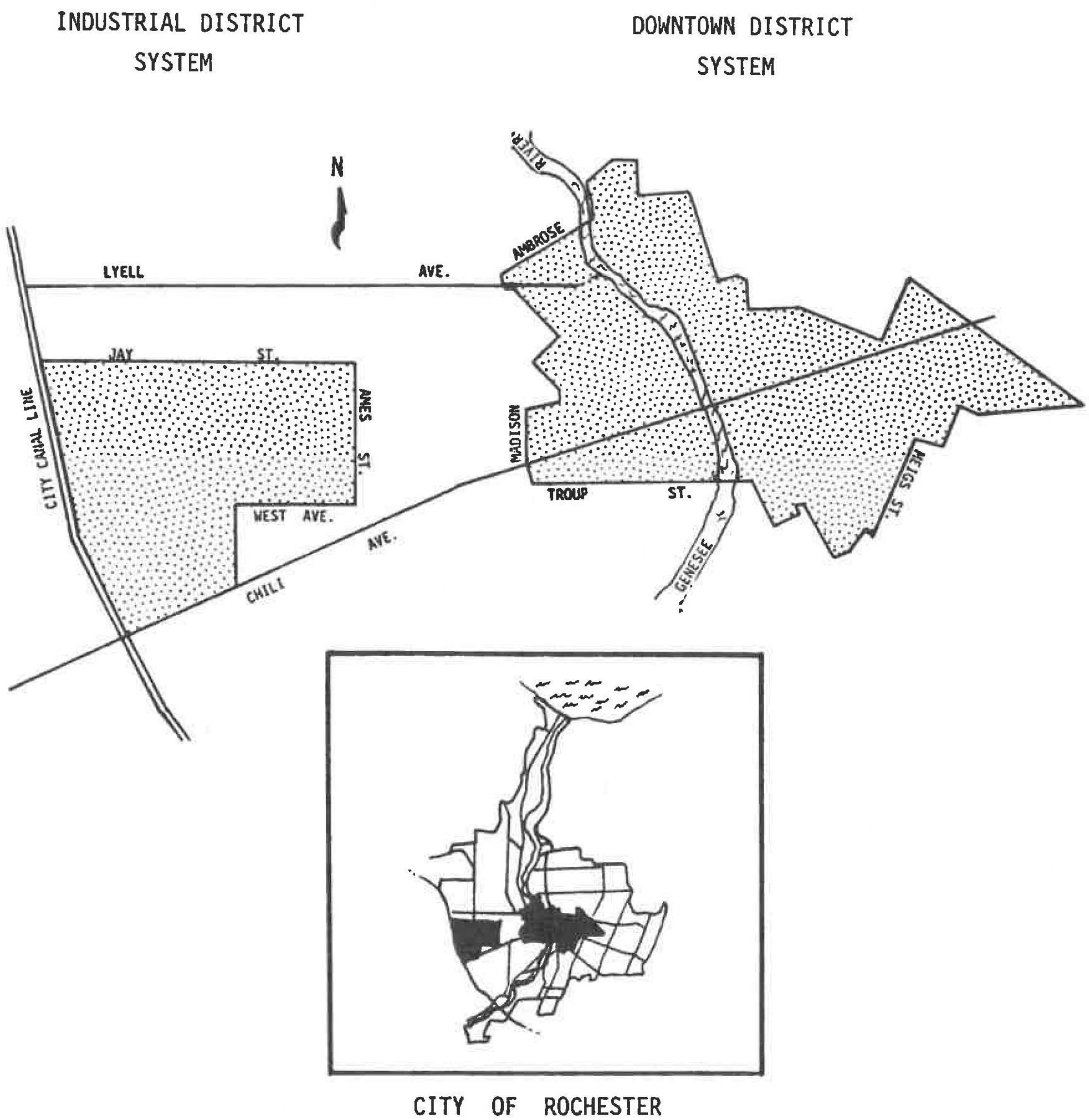

Fig. 3.1. Rochester Gas and Electric Steam franchise areas.

heating and hot water loads (Fig. 3.2). At present, 275 customers are connected to the Downtown system with a total annual sales of 1710 x 10^9 Btu in 1979 (assumes 1000 Btu = 1 lb of steam). Steam is supplied to the downtown area from Station #8 and Station #3. The Rochester District Heating System originated in the area surrounding Station #8, which initially served as a cogeneration facility for 15 psig sendout steam. Station #8 is now primarily used as a heat only station, to supply supplemental steam to Station #3 during winter peaking days. Station #3 (Bee Bee Station) is primarily a cogeneration plant which supplies steam to the district heating system from the exhaust of two topping turbines.

The industrial district system is on the west side of Rochester and is referred to as the Station #9 system (Fig. 3.3). The steam district was formed in the mid-twenties with the construction of Station #9 to supply high pressure steam to the soon-to-be industrialized west side of Rochester. It serves approximately 25 industrial customers with a total annual sales of 1080 x 10^9 Btu in 1979.

3.2 Description of the Cogeneration Facilities and Other District Heating Steam Stations

All three stations and their district heating system were designed and operated on coal. In the early 1970s, with promulgation of federal emission and air quality regulations, RG&E converted the pulverized, coal-fired boilers to oil and natural gas. Station #3 has six operating boilers with a continuous capacity rating of 398 MW(t) (1360 x 10^6 Btu/hr).[2] Most of the boilers (Table 3.1) in Station #3 were built by Combustion Engineering between 1936 and 1947; the turbines were supplied by General Electric. The turbine arrangement and statistics are given in Fig. 3.4 and Table 3.2 for Station #3. Station #3 is a cogeneration plant that has a common high pressure header of 660 psig. There are three main operating modes: (1) 660 psig steam is supplied to the topping turbines 8 and 9 and exhausted at 200 psig which is supplied to the district heating system, (2) during peak days 660 psig prime steam is fed into part of the district heating system, and (3) during peak electrical demand, 660 psig steam is also supplied to condensing turbines 6, 10, and 11. Bottoming turbines 1, 2,

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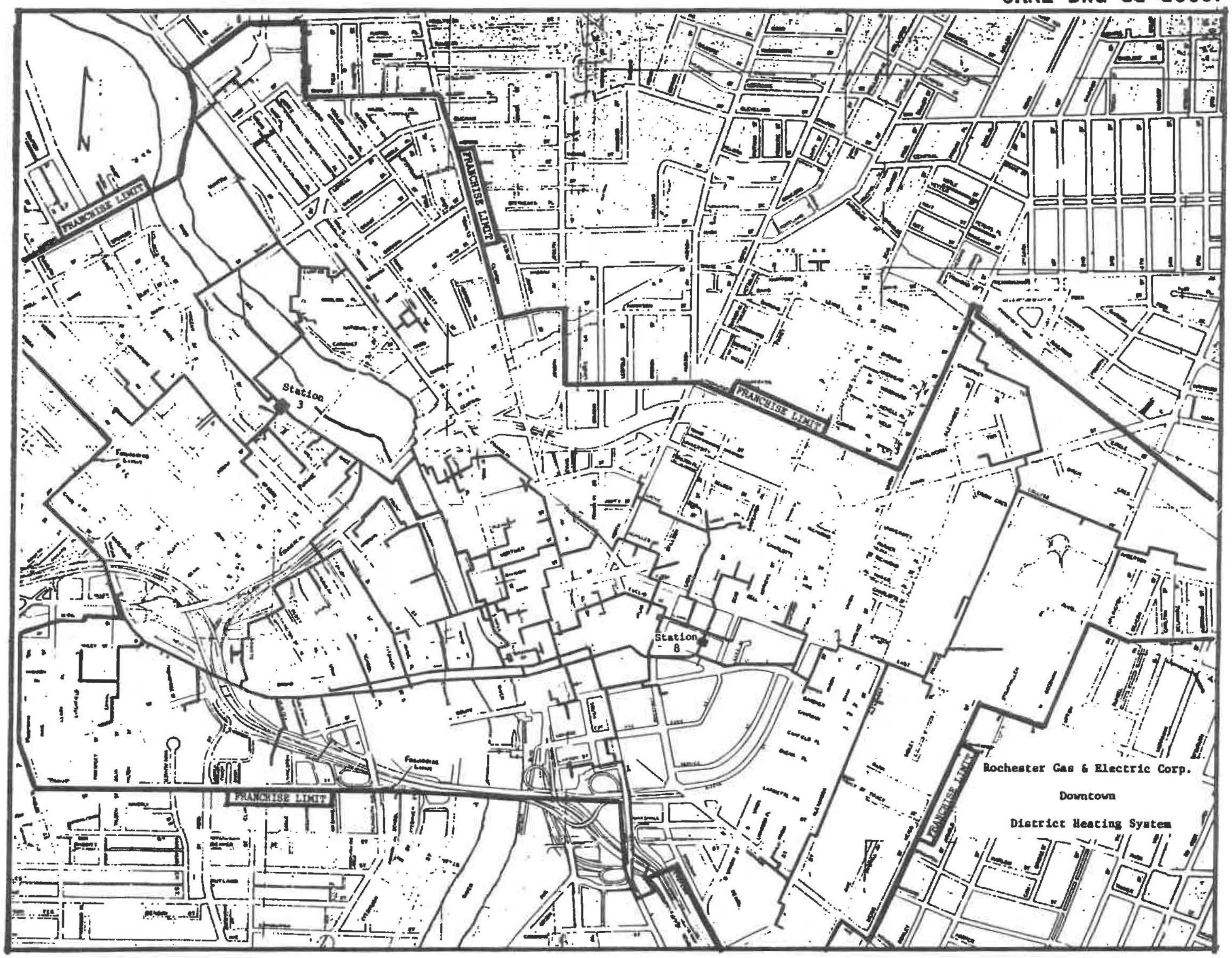

Fig. 3.2. Rochester Gas and Electric Downtown district heating system.

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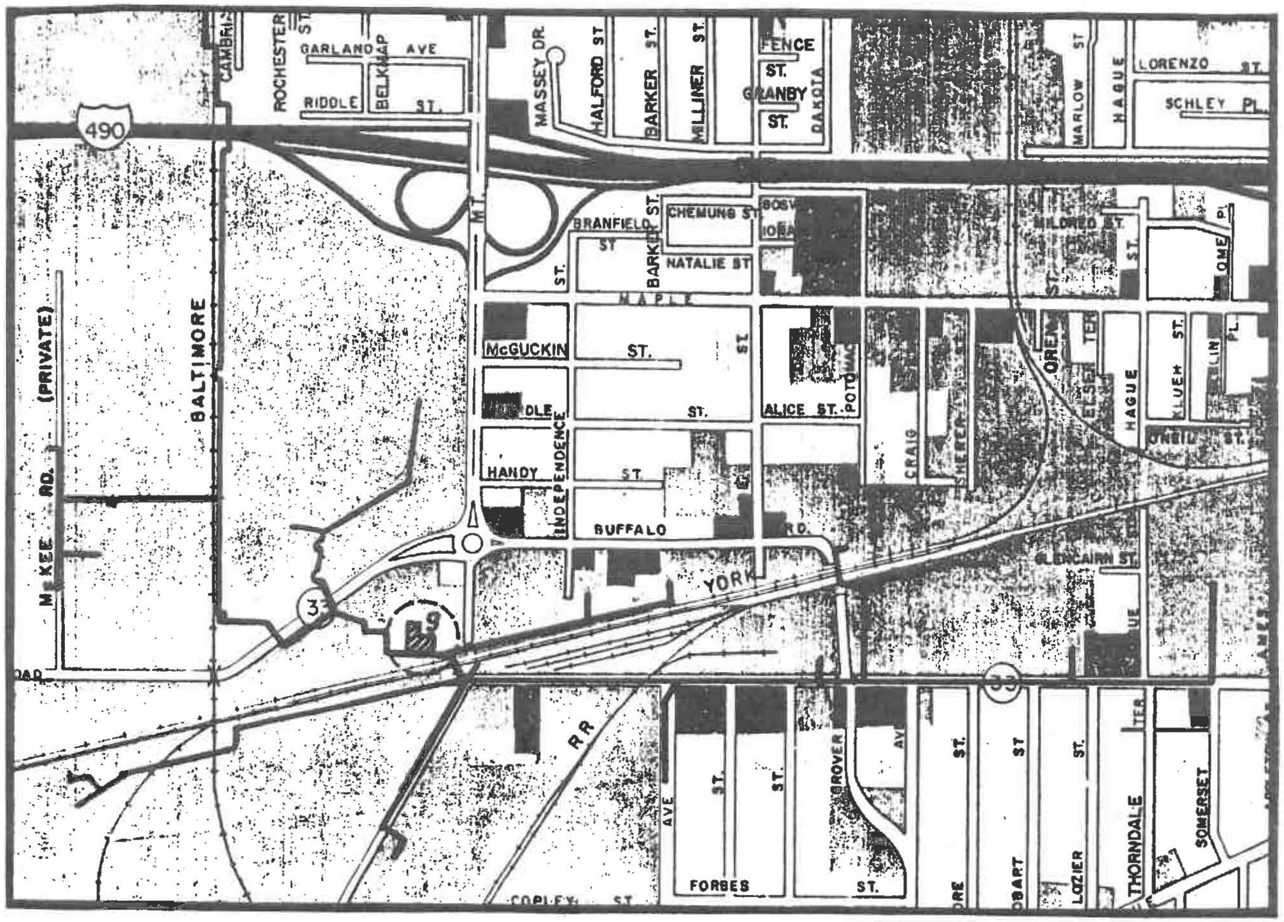

Fig. 3.3. Rochester Gas and Electric Station #9 district heating station (industrial system).

Table 3.1. Rochester Gas and Electric Corporation boiler plant statistics

Steam district	Sta. No.	Boiler No.	Make	Year	Rated pressure PSIG	Operating pressure PSIG	Rated temp. F°	Maximum capacity M-lb./hr.	Continuous capacity M-lb./hr.	Notes
	3									
		1	C.E.	1936	750	660	750	240	190	Converted to oil 6/72
		2	C.E.	1937	750	660	750	240	190	Converted to oil 12/71
Downtown System		3	C.E.	1938	750	660	750	240	190	Converted to oil 3/73
		4	C.E.	1940	750	660	750	240	190	Converted to oil 4/73
		7	C.E.	1947	750	660	825	400	400	Converted to oil 8/73
		8	C.E.	1942	750	660	825	300	250	Converted to oil 9/72 Coincident station capacity 1360 M-lb./hr. net, continuous 1410 M-lb./hr. net-4 hrs.
		12		1959		1800	1080		505	Coal (electric-only unit)
	8									
		1	B.H.	1926	375	350	560	130		
		2	B.H.	1926	375	350	560	130	280	Rebuilt in 1938, converted to gas 9/70
		3	C.E.	1927	375	350	560	130		Coincident station capacity 180 M-lb./hr. net
	9	IA	Riley	12/68	350	350	550	200	175	Gas
		2	B.H.	1927	375	350	500	120	60	Convert to gas 8/72
		3	C.E.	3/48	385	350	560	175	150	Converted to oil 1/73
Station 9 System		4	C.E.	1954	385	350	560	200	175	Converted to oil 6/73
		5	Riley	1/65	350	350	500	100	100	Gas
										Coincident station capacity 500 M-lb./hr. net (degasifier)

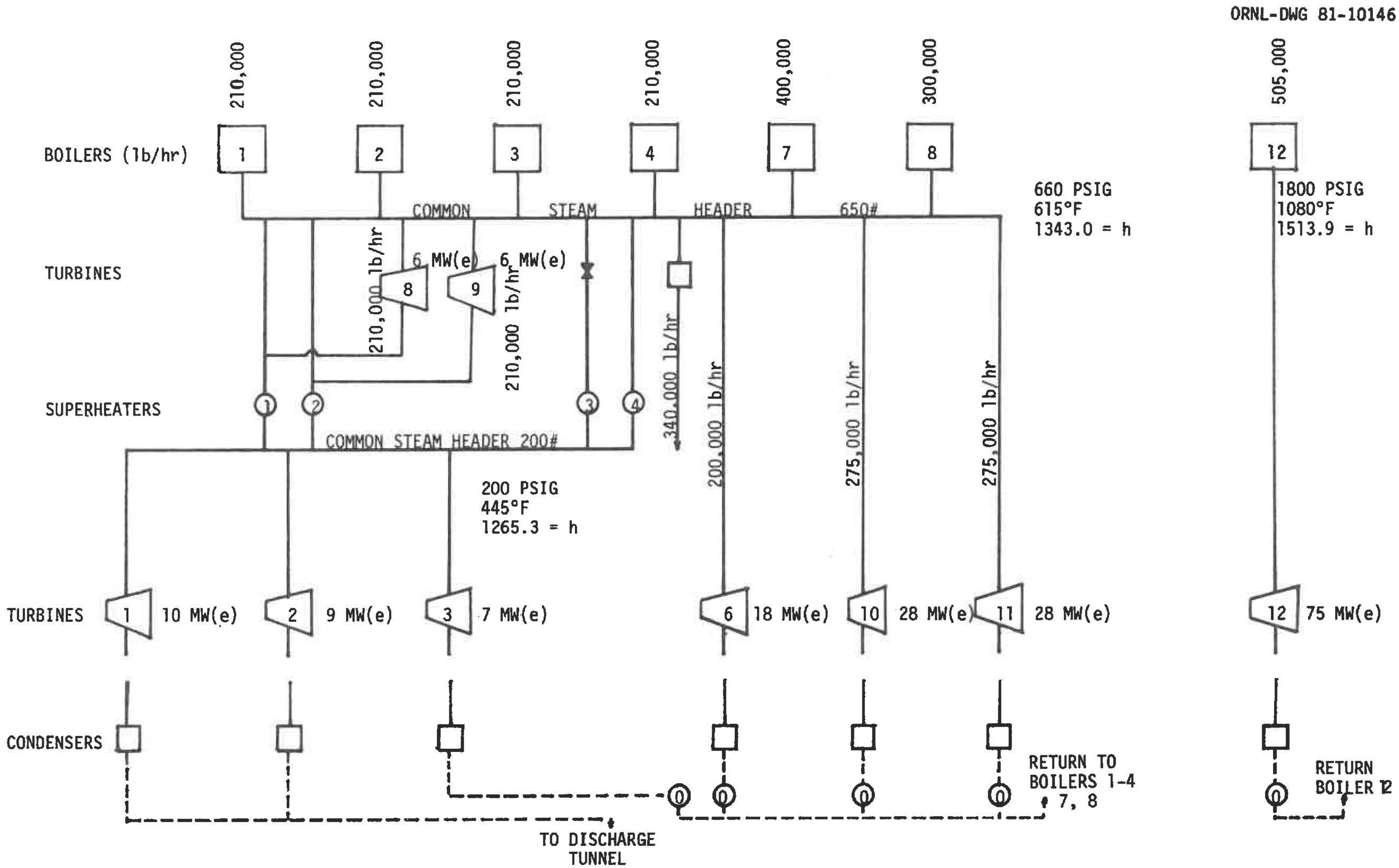

Fig. 3.4. Rochester Gas & Electric Station #3 steam flow diagram.

Table 3.2. Rochester Gas and Electric-boiler and turbine data

Station #3 — Boiler and turbine data

	Year	Operating pressure PSIG	Rated temp. °F	Continuous capacity lbs./hr.	Fuel
Boiler #1	1936	660	750	210,000	Oil
Boiler #2	1937	660	750	210,000	Oil
Boiler #3	1938	660	750	210,000	Oil
Boiler #4	1940	660	750	210,000	Oil
Boiler #7	1947	660	825	400,000	Oil
Boiler #8	1942	660	825	400,000	
		Total continuous capacity		1,640,000	
		Less losses		180,000	
		Net continuous capacity		1,410,000	

	Exhaust capacity lbs./hr.	Exhaust PSIG	Operating PSIG	Operating Temp. °F	Elec. generation
Topping turbine #8	210,000	200	660	750	6 MWH
Topping turbine #9	210,000	200	660	750	6 MWH
Total capacity	420,000				
Less sta. auxiliaries	40,000				
Available to steam system	380,000				

	Full capacity lbs./hr.	Operating PSIG	Operating Temp. °F	Elec. generation
Condensing turbine #6	200,000	660	825	18 MWH
Condensing turbine #10	275,000	660	825	28 MWH
Condensing turbine #11	275,000	660	825	28 MWH
Condensing turbine #1	Retirement considered			
Condensing turbine #2	Retired			
Condensing turbine #3	Retirement considered			

Boiler capacity available to east side tie-line at full turbine capacity at 660 psig, 240,000 pounds per hour.

Table 3.2 (Continued)

Station #8 — Boiler and turbine data

	Year	Operating pressure PSIG	Rated temp. °F	Continuous capacity lbs./hr.	Fuel
Boiler #1	1926	350	560	180	Gas
Boiler #2	1926	350	560		Gas
Boiler #3	1927	350	560		Gas

	Exhaust capacity lbs./hr.	Exhaust PSIG	Operating PSIG	Operating Temp. °F	Elec. generation
Topping turbine	80,000	15	350	560	3 MWH

and 3 are seldom used. In the same facility, but physically detached from the other units, is Boiler #12 and Unit #12. This unit is dedicated to electrical generation and currently cannot provide steam to the district heating system. It is a 75 MW(e) fully condensing unit manufactured by General Electrical that was put into operation in 1959 and is the only unit that is still coal-fired. Unit #12 has an operating pressure of 1800 psig, which necessitates the need for demineralized feed water.

Station #3 is in daily operation and has a total manpower requirement of 150 employees. For a typical mild winter or fall day, the station might have two boilers in operation generating electricity with topping turbines #8 and #9 [6 MW(e) each]. Exhaust steam from the two turbines is supplied to the district heating system at pressures between 195 and 215 psig, depending upon the system load. For cold winter days, when the system load is extremely high, other boilers are put into operation and high pressure steam (660 psig) is put into the east side tie-line (Fig. 3.5). In addition, during the high load days, Station #8 is put into service.

Station #8 has three boilers that were constructed during the mid-1920s. The plant has one 3 MW(e) topping turbine that exhausts steam at 15 psig and is seldom used. For all practical considerations, Station #8 is a boiler-only plant. The boilers were originally designed for coal and were converted to gas in 1970. Conversion of the boilers back to coal is unrealistic, given Station 3's location in downtown Rochester (transportation of coal and current space limitations).

Station #9 (the west side industrial district) is for all practical purposes a boiler-only plant. The station contains only one small topping turbine that exhausts 15 psig, low pressure steam. Steam is distributed from Station #9 at one of three pressures, either 335, 180, or 15 psig. The plant has five boilers, one of which dates back to the original construction in the mid-1920s. The three oldest boilers were converted from coal to gas and oil in the early 1970s. The two newest boilers, installed in the 1960s, were designed to operate on natural gas. Station #9 has a net capacity of 150 MW(t) (500 x 10^6 Btu/hr). The station has a staff of 22 employees.

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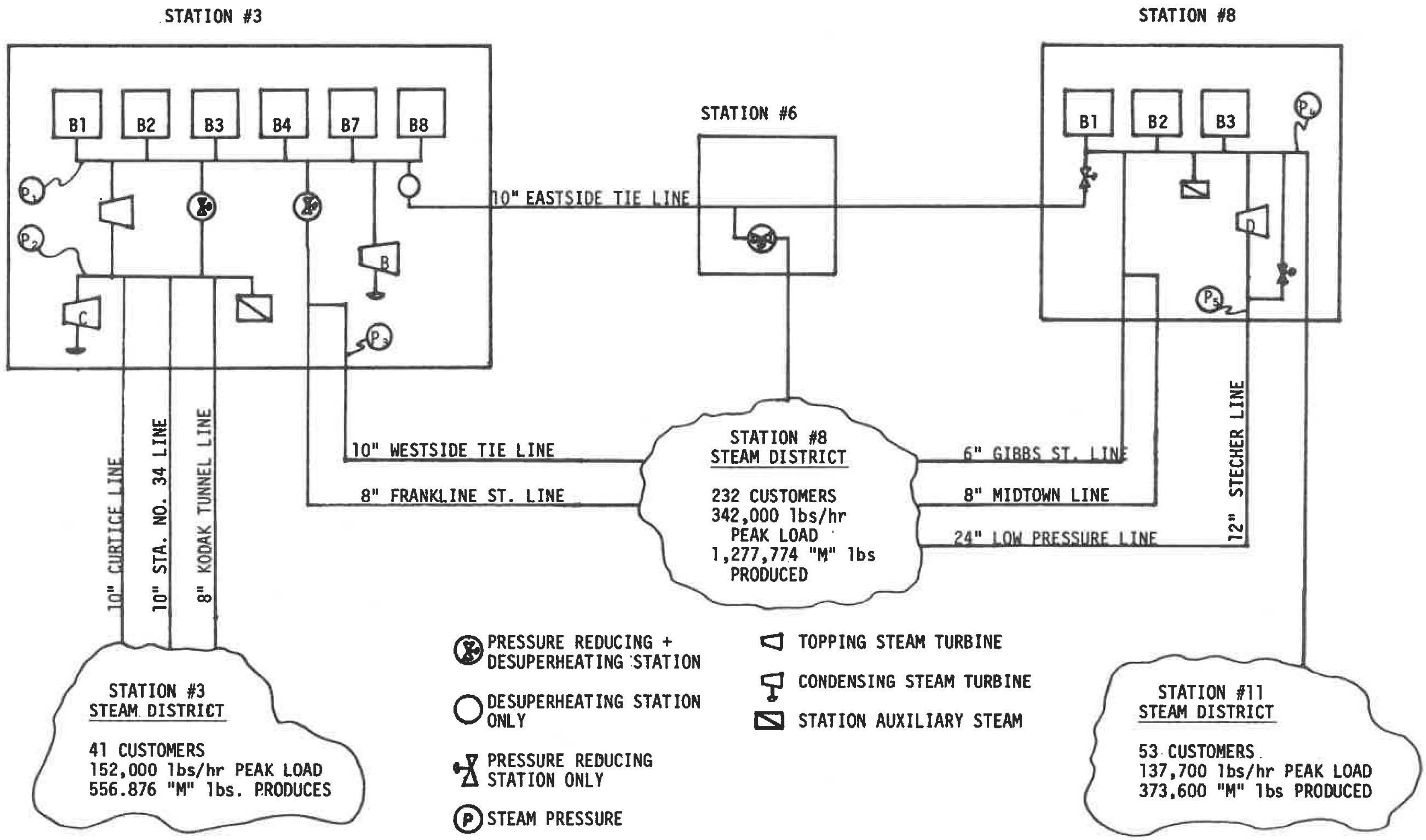

Fig. 3.5. Rochester Gas & Electric simplified district heating system flow diagram.

3.3 Description of the Steam Distribution System

The downtown steam distribution system began as a 15 psig, low pressure system and gradually evolved into the present 200 psig high pressure system. Most of the changes in the pressure rating of the system occurred after World War II. Increasing steam sales placed a strain on Station #8 and a high pressure transmission line from Station #3 to supplement Station #8 was constructed in 1946. An additional line was installed in 1950. Gradually, Station #3 became the main steam generating station of the whole downtown area, and Station #8 became a peaking plant. A simplified schematic, depicting the relationship between the two systems, is presented in Fig. 3.4. The last improvements in the system were made in 1978 to permit additional interconnection of Station #8 and Station #3. The improvement increased the cogeneration output of Station #3 from 20,000 MWh/yr to over 40,000 MWh/yr.

The physical condition of both distribution systems, including piping, steam traps, and valving is reported to be in good operating condition. An indication of the systems overall condition is the unaccounted for steam loss. A recent IDHA report indicated that the Rochester system had an unaccountable steam loss of 8.1%, one of the lowest values of any system without condensate return.[3] Inefficiencies in the distribution system are not the result of operation or maintenance but are due to a design which does not have condensate return. Lack of condensate return is not unique to the Rochester system. Most district heating systems in the United States do not have condensate return. Steam systems equipped with condensate return can obtain distribution efficiencies approaching 90%, while even well-maintained systems without condensate return can only achieve 75% distribution efficiencies.

RG&E has long realized that the consumers in the Downtown system do not need 200 psig steam. Most are space heating customers and only need low pressure steam. High pressures are required, however, to transport the steam over the relatively large distances to the distribution system. To meet steam demands during peaking winter days, portions of the transmission system must also be operated at its maximum (660 psig) pressure, while the distribution system pressure may be as high as 250 psig. For milder days, RG&E has been gradually lowering the pressure, on an experimental basis, down to the range of 150 psig.

REFERENCES FOR SECTION 3

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2. R. Botsford, M. Silvestrone, A. B. Spetz, H. W. Brew, Rochester Gas and Electric material pertaining to steam sales, customers, and system operation, received July 1980.

3. Proceedings of Seventieth Annual Conference, Vol. LXV, of the International District Heating Association, Dirville Notch, New Hampshire, June 1979.

4. STATUS OF RG&E STEAM DISTRICT HEATING BUSINESS

4.1 The Decline of the Steam District Heating Business

The Rochester District Heating System was a dynamic growing system during the 1950's and early 1960's. New lines were constructed from Station #3 which gradually assumed the responsibility of Station #8 and supplied service to most of the downtown area. The number of steam customers grew steadily until a peak was reached of 621 in 1963. The system was earning a respectable rate of return and the outlook for continued growth was extremely positive. In the mid-1960's, the city of Rochester undertook a major urban renewal program. The first major project in the urban renewal program was to clear out a two block area of the city which contained 52 steam customers. As urban renewal progressed, there was continual demolition of buildings and the loss of customers. During that time RG&E was also required to reroute, at its own expense, several steam lines in the urban renewal areas. On the east side of the river, a section of 650 psig transmission lines and a major 8-inch distribution line had to be relocated. Relocation expenses were added into the rate base and increased the price of steam without improving service to the customer.

The urban renewal program was perceived by both the city and the utility company as being mutually beneficial. The intent of urban renewal was to remove slums and other blighted property within the city. The cleared land could then be redeveloped in an organized manner, more consistent with the anticipated future needs of the city. It was the cities goal to replace numerous antiquated, low-level buildings, with fewer more modern multi-story commercial structures. The new buildings would have a higher assessment evaluation, therefore providing a larger tax base for the city.

The RG&E district heating system was also expected to benefit from the urban renewal program. The utility recognized that most of the older, low-level buildings that were currently being supplied with steam would be removed from the system. During the time of renewal, the new heat load would be somewhat spotty but overall steam sales were anticipated to increase with the redevelopment of the downtown area. The building demolition phase of the urban redevelopment program is now over but the city has been only partially successful in developing new multi-story commercial buildings in the downtown area. The lack of anticipated commercial redevelopment has prevented the district heating system from attaining its former level of sales. The district heating system can be anticipated to operate well below its capacity until new customers are added to the system. Without new customers, operation of the system will continue to be marginal and the loss of each additional customer will become more critical to the long term economic viability of the Downtown system.

The second major event that contributed to the decline of the district heating business was the decision, in the early 1970's, to convert the existing coal-fired boilers to operation on either natural gas or oil. The conversion to the cleaner burning oil and natural gas fuels was in direct response to new federal air quality and emission regulations for generating facilities. RG&E concluded that conversion to these cleaner burning fuels was preferable to the installation of stack-gas cleanup equipment. Shortly after the stations were converted from coal to No. 6 oil, the United States was confronted with the 1973 Arab Oil Embargo. The cost of oil escalated dramatically from approximately $\$0.80/10^6$ Btu to a recent high of approximately $\$3.60/10^6$ Btu (Fig. 4.1).[1] The dramatic increase in the price of fuel has resulted in an corresponding increase in the cost of delivered steam. The price of delivered steam is now more expensive than that of natural gas. Faced with the prospect of ever increasing steam costs, many district heating customers have either converted to natural gas directly or purchase steam intermittently. At the most recent steam rate hearing before the New York State Public Service Commission, RG&E was asked to respond to several questions concerning the loss of these steam customers.[2] RG&E responded to these questions of customer loss by providing data presented in Table 4.1 to support their contention that customers were initially lost due to urban renewal and demolition of owner buildings. They further stated that in recent years the losses were attributable to the increasing

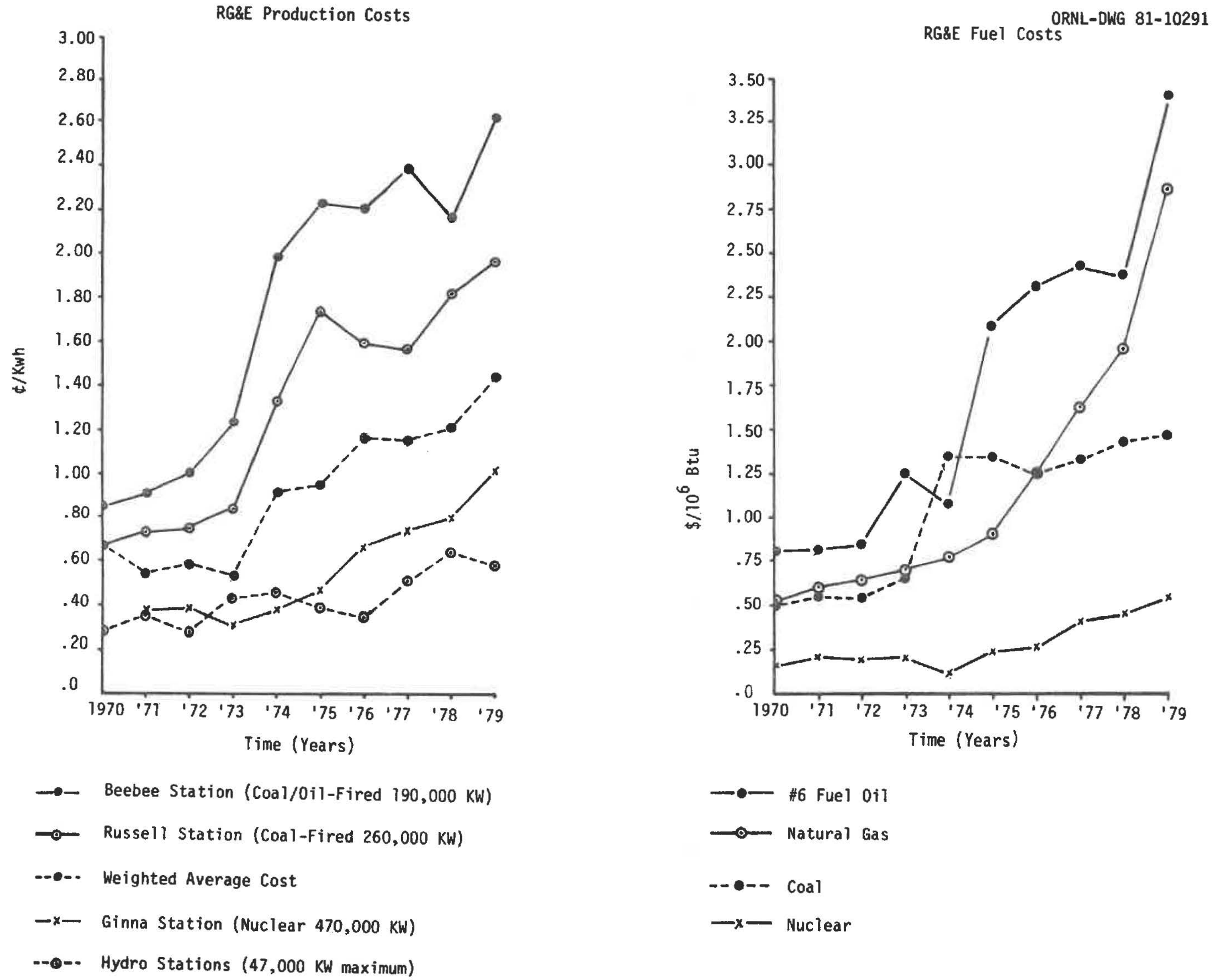

Fig. 4.1. RG&E production and fuel cost.[1]

Table 4.1. Reasons for consumers leaving the Rochester steam district heating system (New York Public Service Commission Rate Case 27566)

	Losses to conversion	Losses due to demolition urban renewal	Losses due to demolition building owners	Other losses	Gains
1970	3	8	2	1	1
1971	2	10	9	0	4
1972	2	9	8	0	5
1973	0	2	10	1	0
1974	2	5	5	1	2
1975	2	8	5	2	6
1976	5	2	5	2	3
1977	10	4	2	5	1
1978	12	1	7	4	1
1979	17	2	1	3	0
1980	6	1	0	1	0
Total	61	52	54	20	23

cost of fuel and subsequently steam. The details of the answer to the question on the loss of customers is presented in Appendix B. The concern that was expressed by the New York State Public Service Commission over the loss of customers does not indicate the magnitude of the problem. The 50% decrease in the number of customers is not as an important factor as the annual steam sales. Steam sales reached a high of 4.0 x 10^{12} Btu/yr in 1972 and subsequently dropped to 2.8 x 10^{12} Btu/yr in 1979, this reduction of approximately 30% of the annual steam sales is significant to the continued viability of the steam system.

In summary, two problems must be addressed at the present time in order to assure the long term stability of the district heating system. The most immediate problem confronting the district heating system is the necessity to convert from oil and natural gas to a less expensive fuel such as coal. If conversion to less expensive fuel is possible, this could reduce or at least stabilize the cost of steam. Once steam prices become competitive with other energy sources, there would be no economic incentive for customers to disconnect from the system. In the current and future environment of unstable fuel costs and availability, the prospect of a competitively priced and reliable energy source should be a positive inducement for both old and new customers to reconnect to the district heating system.

The second major problem that confronts the long term economic viability of the district heating system is a question of heat load density. The initial impact of urban redevelopment in downtown Rochester has had a major adverse effect on the steam system. The impact has not been lethal and the system still remains marginally viable. If the trend in customer losses and declined steam sales cannot be offset by the acquisition of new customers, it is unlikely that the Downtown steam system will remain active.

In addition, during the 80's all utilities will be faced with the impact of energy conservation. This will cause a definite deterioration in heat load density. Electric and gas distribution systems will also be affected in a similar manner. The only way to deal with energy conservation is to improve the efficiency of steam generation and distribution.

4.2 Financial Status

The 1979 Corporate Financial Statement prepared by RG&E reported an operating income of $260,000 from the district heating business on total revenues of approximately $20 million (Table 4.2). The operating income represents a rate of return of only 1.5%. The Rochester district heating system's rate of return is very low in comparison to other utilities which normally expect returns to range between 10% and 14%.

The single largest operating expense for both systems was the cost of fuel. Fuel costs constituted approximately 79% of the total operating expense at the Downtown system and 58% for Station #9. The fuel cost numbers, however, can be somewhat misleading. For the Station #9 system, which is essentially a boiler-only plant, fuel costs relate directly to the price paid for the oil and gas. The O&M expenses include operation

Table 4.2. Rochester Gas & Electric steam department cost of service in 1979

	Station 3 & 8	Station 9	Total
Total revenue	$12,393,604	$7,593,877	$19,987,481
Operating expense			
Fuel	9,824,084	4,229,934	14,054,081
Other O&M	1,180,489	1,513,650	2,694,139
Depreciation	328,403	262,618	591,021
Tax excl. fit.	1,404,755	1,151,572	2,556,327
Fed. inc.	(265,340)	97,505	(167,835)
Total operating expense	$12,472,392	$7,255,279	$19,727,671
Operating income	$ (78,788)	$ 338,598	$ 259,816
Rate base	$10,941,238	$6,260,955	$17,202,193
Rate of return	(0.7%)	5.4%	1.5%
Steam delivered M lbs	2,001,780	1,126,229	3,127,989[a]
Steam sales M lbs	1,710,348	1,081,823	2,792,171
Op. cost / M lb sold	$7.29	$6.71	$7.07
Revenue / M lb sold	7.25	7.02	7.16
Cogeneration M lb sold	1,529,790 (Sta. 3 only)	329,240	1,859,030

[a]59% of total per RG&E.

of the system and the plant. The Downtown system has a more complicated procedure for determining the fuel cost. In the Downtown system, O&M is only for the distribution system and Station #8. Station #3 is in the electric rate base and steam is sold to the district heating system. The Station #3 O&M charges are included in the steam transfer rate, therefore, the fuel cost of $9.5 million listed on Table 4.2 does not relate directly to the cost of oil.

RG&E has a steam transfer rate that allocates the cost of steam delivered to Station #3. First, they determine the price of the high pressure steam (660 psig) including the cost of fuel and other operation and maintenance charges. The low pressure steam for district heating is then charged 90% of the high pressure steam rate. A cost breakdown as of mid-1980 is given in Table 4.3. Station #3's capital charges are all in the electric departments rate base. This transfer rate only includes fuel and other production costs. By mid-1980 the cost of steam to the consumer is about $\$11/10^6$ Btu of which $6.47 was the fee charged to the steam department at the gate of Station #3. The difference between these two numbers includes the capital and operating costs of the distribution system. The most recent cost of #6 oil is $\$3.60/10^6$ Btu compared to an average in 1979 of $\$2.79/10^6$ Btu. The cost of cogeneration electricity from topping turbines 8 and 9, when assuming a heat rate of 4000 Btu/kWh, is estimated to be in the range of 2-3¢/kWh.[3]

Table 4.3. Cost breakdown as of mid-1980 for the Downtown steam system

	$\$/10^3$ lb or $\$/10^6$ Btu
Fuel and O&M for high pressure steam (660 psig)	7.19
Transfer charge for low pressure district heating system (90%)	6.47
Mid-1980 cost of steam to the customer	11.00
Cost of #6 oil	3.50
Cost of electricity produced from station #3's topping units	
$\frac{(\$7.19/10^3\ \text{lb}) \times 10\% \times 4000\ \text{Btu/kWh}}{1375\ \text{Btu/lb} - 1250\ \text{Btu/lb}}$	= $0.023/kWh

The transfer rate on a thermodynamic enthalpy basis is technically justifiable. The RG&E allocation scheme is one of many acknowledged methods for allocating cogeneration cost. In theory and usually practice, cogeneration provides cost benefits for both products. When selling two products from one plant there are an infinite number of cost combinations that can produce the equivalent required revenue. The cogeneration revenue requirement line on Fig. 4.2a shows a benefit can be achieved for both products if the line falls in the range lower than the cost of electricity from a condensing plant and lower than cost of steam from a

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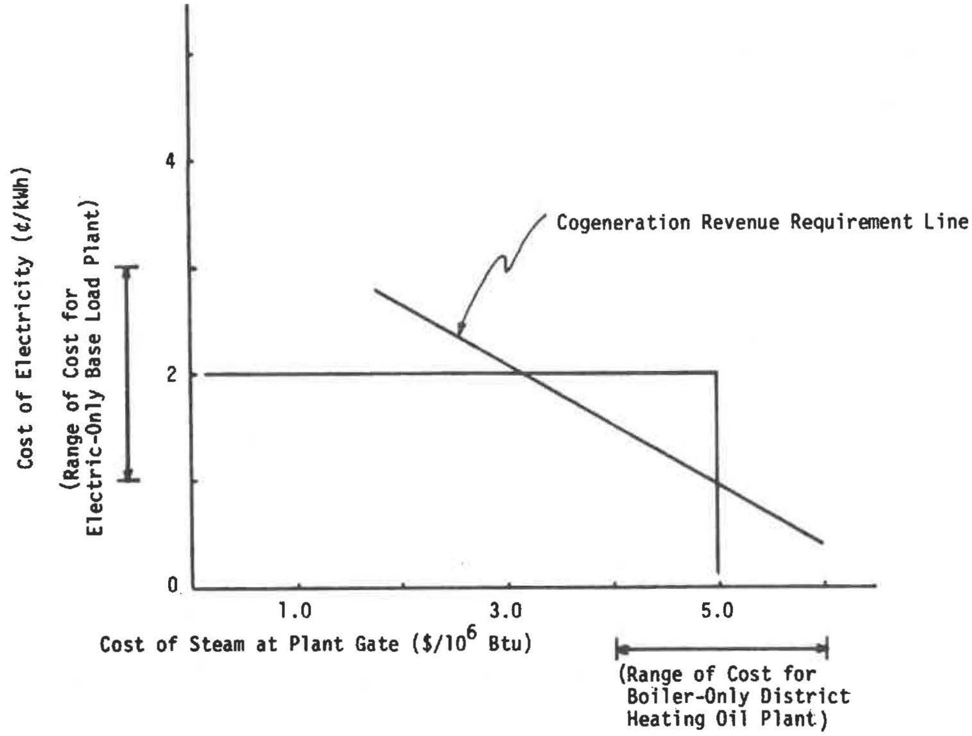

4.2(a). Possible benefits of cogeneration.

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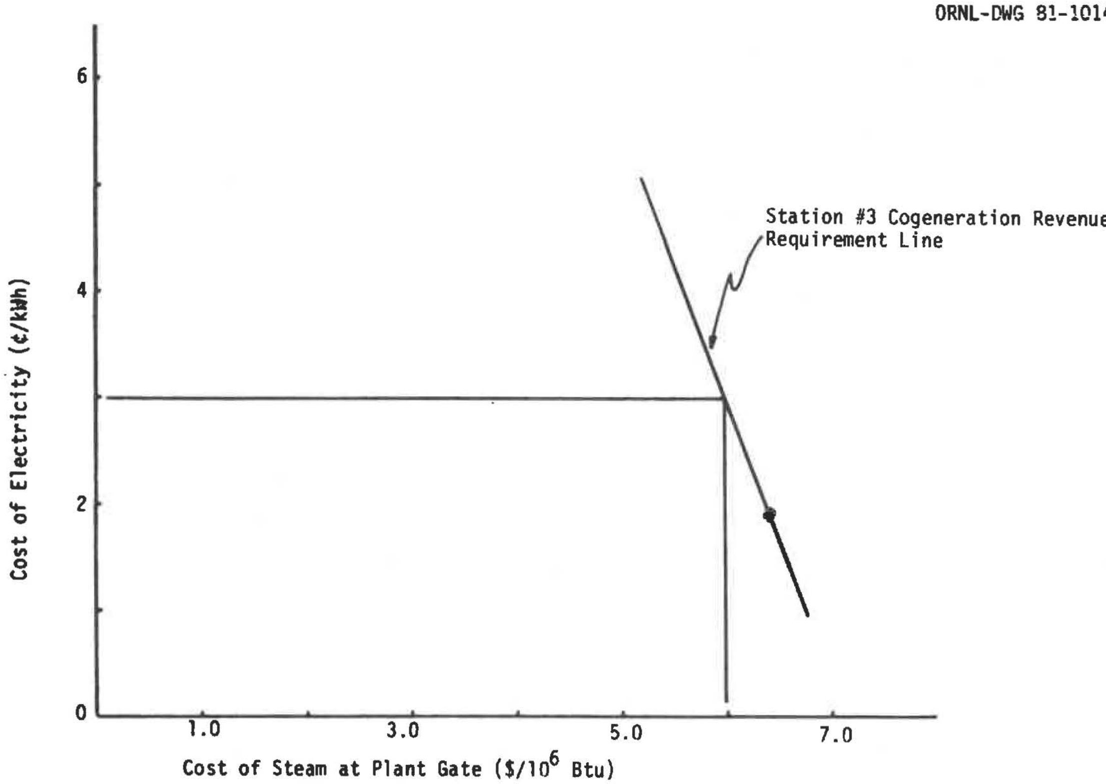

4.2(b). Rochester cogeneration station #3.

Fig. 4.2. Cogeneration cost allocation.
Note: Cost includes only fuel and plant O&M.

boiler-only plant. However, the present situation in Rochester is somewhat unusual. The cogeneration revenue requirement line (Fig. 4.2b) indicates that cogeneration is a borderline situation in comparison to the cost benefits over separately produced products. This results from the high price of oil and inherent characteristics of the Station #3 cogeneration concept. The high oil and operating costs of Station #3 move the revenue requirement line upward and further to the right. The steep slope of the revenue line results from the high extraction pressure (200 psig) which reduces the electrical generating capacity. Therefore, even if the price of electricity is increased drastically (by 2-3¢/kWh), only a slight reduction in the cost of thermal energy would occur.

Station #3, except for Unit 12, is considered to be an electric peaking power plant and is needed to serve the peak load to downtown Rochester through the mid-80's. At that time, planned modification to the electric grid will alleviate the need for peaking power in the downtown area. Station #3 is presently staffed in accordance with requirements for a peaking electric generation station.

The steam produced from Station #3 for district heating is higher than the cost of steam from a boiler-only oil fueled plant (Fig. 4.2b, high range for district heating boiler-only steam). A specific example of this is the cost of boiler-only steam produced at Station #9. The plant uses $3.50/10^6 Btu oil, with a boiler efficiency of 85%, to produce steam for approximately $4/10^6 Btu. Adding on only the plant O&M, depreciation, and taxes would bring the cost up to approximately $6.00/10^6 Btu. The cost of cogenerated steam from Unit 3 is $6.47/10^6 Btu. This analysis is not rigorous in detail, however, it does point to some clues that could help resolve the problem. One questions that has to be asked: Can the Rochester district heating customer afford the luxury of cogeneration from Station #3?

One approach that RG&E might attempt in answering this question is to separate Station #3 into a district heating boiler plant operation and a peaking electric-only plant operation. For example, the plant could be separated so that three of the boilers on the 660 psig common header would be sold to the district heating system and their capital cost put into the district heating rate base. The same number of people could run this new operation that now run the Station #9 operation. This type of operation could lower the price for steam sold to the steam department, because cogenerated steam would have to be sold at an equivalent or lower price. The cost of electrical generation at Station #3 would increase because little electricity is produced by this plant (approximately 40,000 MWh/yr). One solution might be to separate the two businesses rather than cogeneration at Station #3.

If Station #3 were to be split into two businesses it would only have a minor impact on the rate of return of the Downtown system. It could boost the rate of return to the Station #9 system's rate of return, 5.4%. This certainly is not the factor that will allow the system to earn a respectable rate of return of about 12%. The mechanism for doing this, as stated before, is to reduce the dependence on oil.

4.3 Decommissioning the Downtown Steam System

RG&E has verbally indicated that they are not ready to discontinue the district heating business. They are, however, hesitant about making a major investment. If the customer base continued to erode, and this is likely without some major changes, the business could be terminated. The Downtown system probably would be abandoned first. The financial status of the Station #9 is better than the Downtown system and the customers are less likely to abandon steam service. The large industrial customers on the Station #9 system cannot convert to natural gas and are also quite hesitant about making a major initial investment in new coal boiler equipment. For the near future, it is the Downtown system that is in jeopardy of abandonment. This section will attempt to outline but not quantify a few of the possible impacts of the abandonment of the system on the city and on the utility — RG&E.

The city of Rochester has the most to lose if the steam system is abandoned. Loss of taxes generated by the steam system is the most immediate impact. The balance sheets for 1979 show a tax revenue to the city from the Downtown steam system of over a million dollars (Table 4.2). The immediate loss in taxes would cause an extra burden on the city. This would come at the same time that the city would have to raise capital for the conversion to gas of the municipal buildings. The city has many structures in the downtown area and the initial cost of conversion could amount to several million dollars. A secondary impact on the city is loss of businesses located in marginal building structures where the initial cost of conversion to gas is not justifiable. This would be another stimulus in the trend of outmigration from the city to the suburbs.

The abandonment of the Downtown system by RG&E would mean justifying the loss of an $11 million business (the amount in the rate base as indicated on Table 4.2) to the stockholder's. However, the major impact would be on the gas distribution business. The majority of customers on the steam system would connect to the gas system, requiring major investments in the gas distribution system. Another impact would be on the purchase of new gas at marginal cost to supply these new customers. This would be spread across the whole customer base of the RG&E gas distribution system and all gas customers would suffer due to the failure of the steam district heating business. The city would then be totally dependent on natural gas and face increased cost as Federal deregulation becomes fully implemented in 1985. Natural gas costs are expected to undergo the same type of rapid escalation over the next decade as oil did during the later half of the 1970's. There is also no reason to believe that the state regulatory climate will change, therefore there will continue to be a regulatory time lag as scarce fuels prices escalate. The natural gas business might face the same low rates of return that are presently jeopardizing the steam business.

There are only minor differences between the steam business and the natural gas business. Natural gas can serve a lower heat load density, therefore serve a much larger area and is not as susceptible to poor economic conditions in one isolated area of a city. The modern hot water district heating systems in northern Europe enjoy the same flexibility as natural gas systems. The advantage of the district heating business over the natural gas business is the fuel flexibility aspect. The local utility has control over the energy source that produces the steam. The natural gas system is dependent on a pipeline supplier. It does not take a sophisticated analysis to determine that steam produced from a coal cogeneration facility will be less expensive than synthetic high-Btu gas. The main reason is a cogeneration facility can operate at a thermal efficiency between 80-90% as compared to a high-Btu gasification plant efficiency of 60-70%. The northern European hot water cogeneration facilities are experiencing seasonal thermal efficiencies of 80%.

The district heating business and the natural gas distribution business are very similar and both will suffer during periods of rapidly escalating fuel cost. However, RG&E may use the two businesses to balance each other. If the district heating business were viable and had the potential to expand with hot water, it could be used to alleviate the need to purchase marginal gas from the pipeline supplier. By having the two system, the utility would have more control and could better manage the rapid cost escalation of scarce fuels. Therefore, they are more likely to earn a better rate of return.

REFERENCES FOR SECTION 4

1. Rochester Gas and Electric Corporation Annual Report 1979, 89 East Avenue, Rochester, New York.
2. Rochester Gas and Electric Rate Case, Hearing before the New York Public Service Commission Case 27566, Staff's Initial Brief, November 1979, RG&E response to staff questions, May 1980.
3. W. W. Willoughby, Steam Rate: Key to Turbine Selection, Chemical Engineering, September 11, 1978, p. 146.

5. POSSIBLE OPTIONS TO IMPROVE THE EARNINGS POTENTIAL OF THE ROCHESTER DISTRICT HEATING BUSINESS

5.1 Options for Modifying the Status of the Rochester District Heating System

Three options have been proposed to demonstrate the potential alternatives that exist for sustaining and improving the Rochester district heating system. The proposed options represent only a few of the available alternatives that could be applied to revitalize Rochester's district heating system. Many other options could accomplish the same goals, and there are a multitude of variations of these options. Among the options that were proposed, two represent potential short-term solutions and the third, an overall strategy for long-term viability. All three options indicate a potential for large, scarce-fuel savings, one of the requirements for applying for an energy UDAG grant. No attempt has been made to conduct an economic analysis of any of the alternatives. It is acknowledged that before a final evaluation of any option a thorough economic analysis must be conducted.

The two near-term options are attempts to reduce the steam system's dependence on oil. The first option is conversion of the coal-fueled Unit #12 at Station #3 to cogeneration. The steam supplied from Unit #12 cogeneration could reduce oil consumption by at least 10% and possibly by as much as 30%. Because fuel cost is the primary expense to the district heating system, steam produced from low cost coal offers the opportunity to stabilize or even lower the price of steam to the customer. The second option involves generating and marketing steam produced from municipal refuse incineration. Small modular incinerators with heat recovery systems could be installed at both Station #3 and #9. High quality refuse derived fuel (RDF) could be supplied from the Monroe County Resource Recovery Plant. Depending upon the quality and availability of RDF, oil savings from municipal incineration could amount to 20%. Successful implementation of both options could result in up to a 50% reduction in current oil consumption.

The third option is a long-range strategy to develop hot water heat islands adjacent to the Downtown system. A hot water district heating system is analogous to a natural gas distribution system; they can economically serve a lower heat load density over a longer distance than steam. The greater flexibility of hot water enables the district heating system to extend service across the community, increase the number of customers, and change with community redevelopment patterns. Hot water systems can utilize a larger range of energy sources including industrial waste heat, cogeneration from coal (Russell Station), cogeneration from nuclear power (Ginna Station), and the existing steam district heating plants. Development of a successful heat island could represent the first growth node for a major 1200 MW(t) district heating system in Rochester [existing steam system is 275 MW(t)].

The immediate and long-term economic viability of the Rochester district heating system requires aggressive and coordinated interaction between both the city and the utility. Recognizing the differences between the objectives, concerns, and operating practices of the city and the utility represents the first major consideration in the selection and development of options. Of the proposed options, the city appears best suited to take the lead role on refuse incineration, RG&E on the conversion of Unit #12, and a combination of utility and city efforts on hot water heat island development.

The following sections will present more detail on the specific development of each option.

5.2 Conversion of Coal Unit #12 at Station #3 to Cogeneration

Conversion of Unit #12 to cogeneration has already been considered by RG&E but rejected due to the loss of electrical production from Unit #12 and the dramatic increase required in the amount of demineralized water. As a condensing unit, the system operates in a closed loop and only makeup demineralized water is required. Conversion to cogeneration and connection to the district heating system would open the loop, a great deal of condensate would not come back to the unit, and the requirement for additional demineralized water would be greatly increased.

Steam Pressure and Enthalphy

The conversion of Unit #12 would drastically reduce the production of electricity. To minimize electrical production losses, steam district heating supply pressures should be reduced. With lower steam pressures, the thermodynamics of cogeneration become more attractive. Presently, the district heating system is supplied by exhaust steam from topping turbines and steam cost is allocated at a rate of 90% of the cost on high pressure steam. Conversion of Unit #12 should supply steam at a low pressure and enthalpy, to significantly reduce the cost allocation percentage. An extreme example of minimal impact of cogeneration of electrical production is an extraction machine that is used to produce 250°F hot water for a hot water district heating system. The steam would be extracted at 20 psig, and this would give a cost allocation percentage of about 25%. For the Rochester system, the more realistic low pressures are in the range of 100-150 psig.

A system pressure flow study is needed to determine how much the steam supply pressure can be lowered from the existing 170-200 psig range. The study would establish the range of supply pressures required for different heat load conditions. Computer simulation models of the steam system would compliment the investigation by assessing the systems response to further reductions in supply pressure. Highly sophisticated computer programs have been developed to determine balanced, steady state pressure flow relationships for steam networks.[1] An example of a computer analysis of a municipal steam distribution network is given in Appendix C. The example code was originally developed for natural gas distribution systems, but the Baltimore Gas and Electric Company has modified and validated the code for use on their steam system. The computer code is currently being used by many other steam systems in the northeast.

An attempt should be made to determine the requirements of operating the steam system at a supply pressure of 100 psig for a large portion of the year. Total annual operation at 100 psig is impractical due to the need for high pressure steam in the tie-line during periods of peak demand (Fig. 3.4). However, operation of the steam system at this lower pressure for most of the year should result in significant reductions in the amount of fuel oil. Peak system demands can be met as usual by the use of 660 psig headers steam, which is supplied directly from oil-fired boilers. Lowering the pressure in the distribution system should permit a greater utilization of the available steam from converted Unit #12, minimize changes to the distribution system, and reduce the impact on the electrical generating capacity. A system pressure flow study could address many of the distribution system questions.

Turbine

RG&E Unit #12 consists of a General Electric turbine generator and a Combustion Engineering boiler. The turbine generator is a 75,000 KW machine with tandem compound, double-flow reheat turbine, and a hydrogen cooled generator. The Combustion Engineering boiler is a controlled circulation, reheat-type steam generator. The unit is designed for a main steam flow at the superheater outlet of 560,000 lb/hr at 1825 psig and 1055°F, and a reheat steam flow of 441,000 lb/hr with reheat to 1005°F. The turbine consists of high, intermediate, and double-flow low pressure sections. Unit #12 is located in Station #3 but isolated from the other existing units. Currently, Unit #12 is the only coal-fired unit operating in the vicinity of the Downtown district heating system. Conversion of the existing turbine to cogeneration can be extremely complex. If the goal were to extract steam to produce 250°F hot water, the retrofit would be significantly easier. Retrofitting a single case machine to allow steam extraction in the range of 100-150 psig is extremely difficult. A preliminary heat balance and other technical details of conversion are presented in Appendix D.[2] The preliminary heat balance proposed extracting steam at 96 psig from Stage 15 of the intermediate pressure section (Fig. D.1, Appendix D). It is not obvious if a suitable flow rate can be obtained by extracting steam at 96 psig; this is a question that has to be answered by the turbine manufacturer. Adequate flow rate is extremely critical since Unit #12 steam would be used as base load to the Downtown system. If 150,000 lb/hr (150 x 10^6 Btu/hr) could be extracted from converted Unit #12 for district heating, 47%

(900×10^9 Btu/yr or 165,000 bbl of oil equivalent) of the oil used for cogeneration of the Downtown system could be displaced. Translated across the total steam system, conversion could reduce dependence upon scarce fuels by 30%. Due to the turbine design of Unit #12, it might only be feasible to achieve a flow rate of 50,000 lb/hr (50×10^6 Btu/hr) or an annual production of 300×10^9 Btu/year. Even with less steam production, Unit #12 could displace approximately 16% (55,000 bbl of oil equivalent) of the oil used in the Downtown system or a 10% scarce-fuel savings between both systems.

Reheat boiler

The steam extracted from Unit #12 turbine could flow into a reheat boiler (Fig. 5.1). A reheat boiler is essentially a steam-to-steam heat exchanger that interfaces between the exhaust demineralized vapor of the turbine and the lower quality vapor sent out to the district heating system. The steam flowing from the turbine is on the primary side of the heat exchanger and the water that is being converted to steam for the district heating system is on the secondary side. There is a significant pressure drop across the heat exchanger and the steam being sent out to the district heating system is at approximately 80 psig. The reheat boiler has a significant disadvantage of lowering the pressure; however, it relieves the requirement for vastly increased amounts of demineralized water. The lowering of the distribution system supply pressure to 80 psig is probably unrealistic. Therefore, the reheat boiler using this preliminary heat balance is probably not feasible. There are two options: (1) to extract steam at 96 psig at Stage 15 and send it directly to the district heating system or (2) extract steam at the cold reheat, 308 psig, 630°F, and use a reheat boiler. The first option, without the reheat boiler, has the advantage of minimizing the impact on electric production, allowing a lower cost allocation percentage for the district heating system. It has the disadvantage of a more complicated turbine retrofit and the increased requirement for demineralized water. The option of using the cold reheat steam and a reheat boiler means a higher sacrifice in electricity. It is recommended that the economics of both options be investigated.

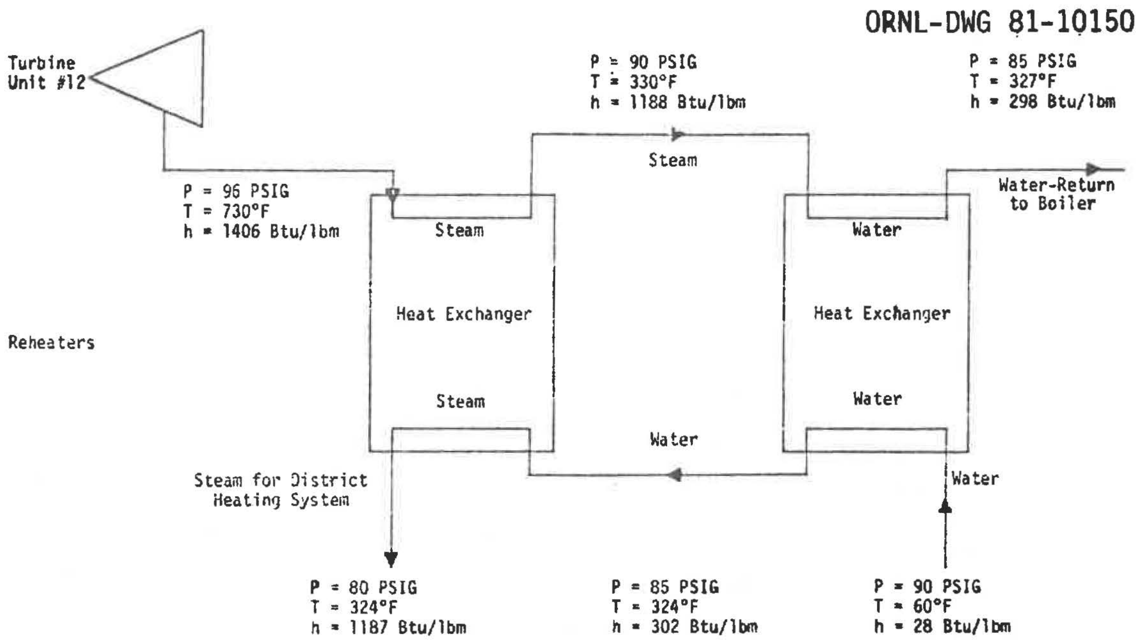

Fig. 5.1. Reheat boiler schematic for Unit #12 conversion to cogeneration.

The thermodynamics of the cost allocation calculation for the option without a reheat boiler (Stage 15 extraction) show an exhaust steam charge of 62% of the high pressure steam charge (Appendix D). RG&E is presently using $1.50/10^6 Btu for coal in Unit #12, and it is estimated that the high pressure steam cost is in the range of $3-4/10^6 Btu. Steam generated from the coal-fired Unit #12 could be sold to the district heating system in the range of $1.90-$2.50/10^6 Btu. A capital charge of at least $2.00/10^6 Btu could be applied for conversion of Unit #12. The capital charge would increase steam cost to approximately $4.50/10^6 Btu, significantly below the $6.50/10^6 Btu currently being charged for exhaust heat from the cogeneration units at Station #3.

There are many variations to the options on the conversion of Unit #12. Before the best variations can be identified, there definitely has to be an interaction between any system pressure flow investigation and the investigation of the turbine manufacturer. Due to all the possible variations, there is a definite need for innovation in determining the most appropriate configuration and operational procedures for utilizing the full potential of Unit #12 cogeneration.

5.3 Refuse Incineration with Heat Recovery

The city of Rochester and the communities of Monroe County have historically depended upon landfilling as the primary means of municipal solid waste disposal. By the late 1960s, most of the available landfill sites had been exhausted and acceptable new locations could not be found to meet the ever increasing supply of municipal solid waste. The lack of acceptable disposal sites was brought into focus in a 1960 engineering study of Monroe County which predicted that the generation of solid waste would approach 2000 tons/day by the end of the decade. The study also indicated that public dissatisfaction with the landfilling concept was growing throughout the areas.

Faced with the prospect of increased solid waste generation and a lack of available landfill sites, Monroe County initiated a long range solid waste management program in the early 1970s. The long range program was designed to fulfill future disposal needs and ultimately to reduce and/or eliminate the county's need for landfill sites. A comprehensive resource recovery plan was determined to be the most appropriate strategy for achieving the long range goals. Hercules, Inc., was commissioned to design a basic resource recovery system and to conduct a detailed market analysis of the system for the county. Results of the study indicate a strong local market potential for the products recovered by the system. Markets were located for ferrous and nonferrous metals, glass, sand, and refuse derived fuel (RDF).

In 1975, the county negotiated a three-phase contract with Raytheon Service Company. The services to be performed under each phase of the contract were: Phase I — design and construction supervision, Phase II — start-up, and Phase III — operations. Actual construction of the Monroe County Resource Recovery Facility (MCRRF) began in the fall of 1976. All of the major construction phases of the operation have been completed and the facility is undergoing startup and shakedown test runs. The facility will become fully operational by the spring of 1981.

RDF Facility

The Monroe County Resource Recovery Facility (MCRRF) is located on approximately 11 acres of land in the southwest corner of Rochester.[3] As indicated in Fig. 5.2, the MCRRF is located approximately 2.5 miles from RG&E's Station #9 and approximately 5 miles from Station #3.

The facility is designed to process municipal, commercial, and light industrial waste at a rate of approximately 140 tons/hr = 1000 tons/day or 520,000 tons/year of solid waste. The facility is expected to operate on a two-shift, 16-hour, 5-day/week basis. Additional solid waste processing capacity can be achieved by the operation of a daily third shift and a Saturday shift.

Monroe County has contracted with Rochester to accept the city's municipal waste. Rochester's residential, commercial, and light industrial solid wastes are collected and transported to municipal transfer stations for storage. The county periodically transfers the Rochester municipal waste to the resource recovery facility. The facility accepts refuse from packer trucks, transfer trailers, or open trucks and trailers.

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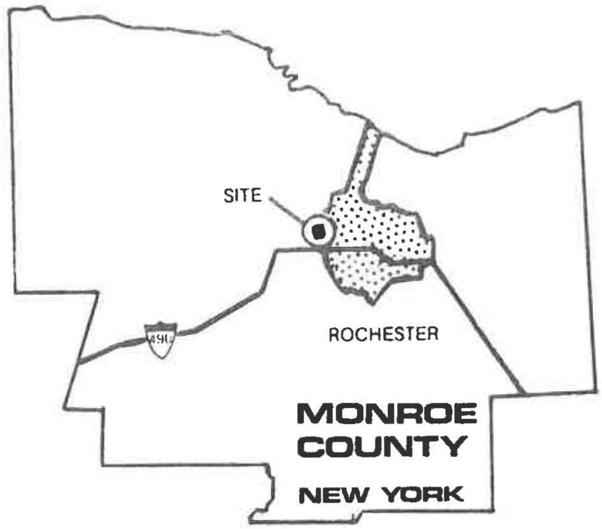
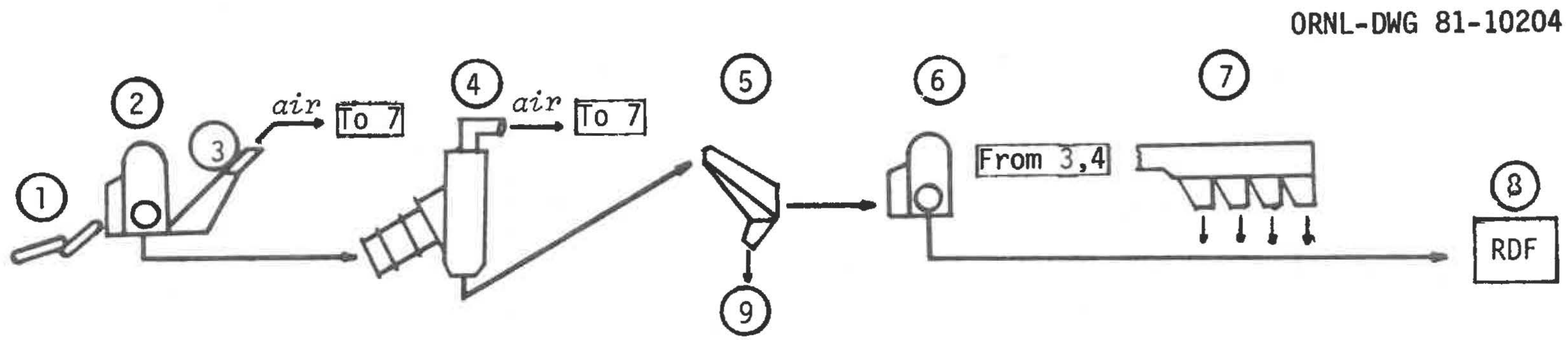


Fig. 5.2. Relative location of the Monroe County Resource Recovery Facility.

All incoming vehicles are automatically weighed before proceeding to the tipping room area and backed into one of ten, 25-ft-wide tipping bays. Solid waste is discharged into a storage area that is 12-ft deep and capable of storing 2000 tons. The solid waste is transferred from the storage bays into the processing plant by front-end loaders.

The Monroe County resource recovery plant consists of four subsystems: baseline process, residue recovery, ferrous refining, and nonferrous refining (Fig. 5.3). The baseline process handles all the incoming waste in two identical and parallel lines. The four major subsystems in the process line are: refuse derived fuel (RDF), ferrous scrap, heavy combustibles, and a residual fraction. The residue recovery system receives the residual fraction and separates it into mixed-colored glass, sand, mixed nonferrous metals, and light waste. The ferrous refining subsystem cleans and densifies the ferrous scrap. The nonferrous subsystem recovers aluminum and nonferrous metals as separate products.



1. SOLID WASTE FEED
2. PRIMARY SHREDDER
3. SKIM CLASSIFIER
4. PRIMARY AIR CLASSIFIER
5. SCREEN
6. COMBUSTIBLE SHREDDER
7. DUST COLLECTOR
8. REFUSE DERIVED FUEL
9. JIG

Fig. 5.3. Process for producing refuse derived fuel from municipal solid waste in the Monroe County, New York Resource Recovery Facility.

The baseline process consists of twelve fundamental steps:

1. Primary shredder — reduces the incoming waste to less than 12 in. in size.
2. Skim classifier — removes the initial small quantity (15%) of light combustible materials (paper, plastic, and dust) from the coarse shredded refuse and controls dust from the primary shredder.
3. Primary air classifier — separates shredded feed material into light and heavy fractions.
4. Magnetic separator — removes ferrous metals from the air classifier heavy fraction.
5. Rotary trommel screen — removes a glass-rich fraction from the non-magnetic discharge of the magnetic separator.
6. Secondary shredder — reduces the rotary screen oversized material to approximately 2-in. particle size.
7. Secondary air classifier — separates the light combustible materials liberated by secondary shredding.
8. Magnetic separator — removes the weakly magnetic materials from the secondary air classifier heavy fraction.
9. Nonferrous metal separator — removes nonferrous metals from the heavy combustible materials.
10. Screen — removes fine glass, grit, and dirt from the light fraction of the air classifiers.
11. Combustible shredder — fine shreds the screen oversize from screen (10) to 90% (<3/4 in.), discharges refuse derived fuel for storage and loading.
12. Dust collector — removes dust from the processed air. Dust is added to light combustibles, becoming part of the RDF fraction.

The principal resources recovered by the facility are, by percentage of weight: RDF (60%), heavy combustibles (5%), ferrous metals (7%), aluminum (0.35%), heavy nonferrous metals (0.05%), mixed-colored glass (9%), sand (3%), and a residual product for disposal (9%). A description and product specification of the refuse derived fuel is presented in Table 5.1 and Table 5.2.

Table 5.1. Composition and characteristics of refuse-derived fuel (RDF) produced by the Monroe County Resource Recovery Facility

Composition:	Paper, plastics, textiles, organics, and other low density materials that have been air classified from coarse shredded municipal waste, screened to remove grit and dirt, and shredded to a fine particle size.	
Characteristics:	Moisture content (as received)	13-25%
	Ash (as recieved)	17% approx.
	Calorific value (as received)	5000-7000 Btu/lb
	Particle size (dry)	90% minus 3/4-in.
	Density (as received)	2-7 lb/ft^3

Table 5.2. Description of the principal materials obtained from 2000 ton/day operation at the Monroe County Resource Recovery Facility

Material	% by weight	Weight (tons/day)
Refuse derived fuel	66.0	1320
Heavy combustibles	5.0	100
Ferrous metals	7.0	140
Aluminum	0.35	7
Heavy nonferrous metals	0.05	1
Mixed color glass	9.0	180
Sand	3.0	60
Residual	9.0	180
Total	99.4%	1988

Modular Incineration

Approximately one-half, 600 tons per day, of the RDF will be sold to RG&E for combination with coal at the Russell Station power plant. The remaining quantity of RDF will be deposited in sanitary landfills until a market can be found. The approximately 600 tons per day of excess RDF represents a potential low cost heat source which is substitutable for scarce fuels in the Rochester district heating system. The municipality should consider studying modular incineration at Station #3 and #9. Preliminary estimates indicate that RDF from the resource recovery facility could supply approximately 50 x 10^6 Btu/hr (50,000 lb/hr) of steam at each site.

Currently, a number of municipalities are investigating the possibility of employing municipal RDF in modular incinerators to supply industrial customers.[4] The siting of a refuse incinerator at Station #9 system or the Downtown system has many advantages over serving a single industrial customer. The Rochester district heating load is very large, predictable, and capable of accepting all the steam produced from the two package incinerators. Supplying a portion of the district system's base load by refuse incineration would make the project more economically attractive since steam sales would constitute a source of revenue. Another major advantage of modular incineration is the possibility of negotiating with RG&E or other companies with boiler handling experience to manage the installations. Additionally, the cost differential between supplying steam to the district heating system from RDF versus that of oil should not be overlooked.

Modular incineration has received increasing attention from municipal governments as a means of acceptably reducing the volume of municipal solid waste while simultaneously producing marketable energy products, steam, or hot water. The modular design allows increased flexibility over conventional municipal incinerators in siting, pollution control, and operation requirements. The capability to expand incineration capacity, by integrating additional modules, permits the system to accommodate future growth in the solid waste supply. Factory fabrication permits cost savings and increases system reliability.

Most modular incinerators used for municipal solid waste employ a multichamber design.[5] Multichamber incinerators consist of a primary burning chamber, a low-velocity settling section, and a reaction chamber (Fig. 5.4). The municipal waste is placed and burned in the primary chamber, frequently with the assistance of an auxiliary burner and with a minimum amount of air. The floor and the primary chamber may be cast iron grates or a refractory hearth. The hearth is claimed to be less susceptible to fouling by noncombustibles. Gases and particulates from the primary combustion chamber pass to a low velocity transmission section where particulates are allowed to settle out by gravity. In the reaction section, the gases are completely oxidized by maintaining the temperature at approximately 1600°F, employing an auxiliary burner, and by the addition of excess air for combustion.

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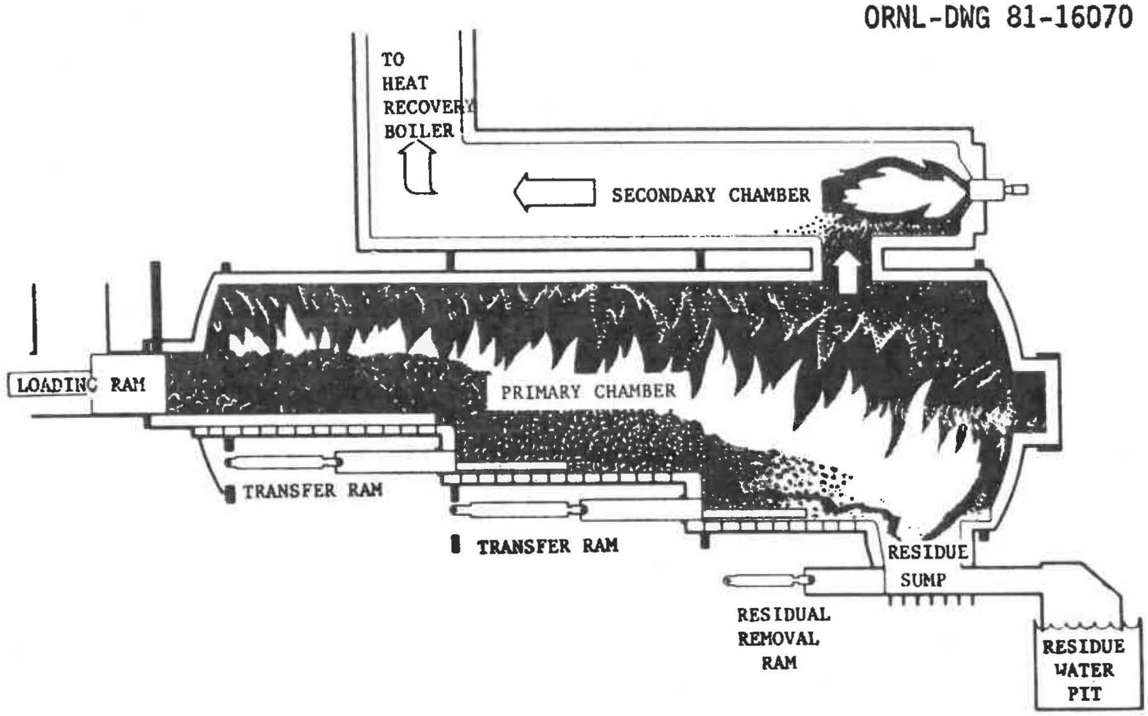

Fig. 5.4. Typical multi-chamber type incinerator.

Marketable steam (or hot water) is produced by heat exchangers located in the secondary combustion chamber (Fig. 5.5). During steam production, feedwater is pumped into the heat exchanger tubes, converted into steam, and passed into the steam separator drum. The steam pressure available for delivery is a function of steam generation rate and the system pressure.

Stations #3 and #9 are logical sites for the installation of modular incinerators. Both sites offer the advantages of available land area, short connection distances, and high quality service roads from the RDF facility. A typical incinerator complex located at Station #3 and at Station #9 may contain three incinerators, each capable of burning 50 tons/day of RDF. Assuming that the municipal RDF has a caloric value of 7000 Btu/lb, each unit within the modular incinerator is capable of producing 16 x 10^6 Btu/hr of steam. The incinerator complex at each station would have the capability of burning 150 tons of RDF per day, supplying approximately 50 x 10^6 Btu/hr (50,000 lb/hr) of steam to the district systems. Assuming a 55% energy burn recovery efficiency and a steam output of 150 psig, each unit could produce approximately 300 x 10^9 Btu/yr of steam. A module at Station #9 would displace approximately 20% of the oil currently being consumed and a module at Station #3 would displace approximately 16% of the oil. RDF has the potential to displace approximately 20% of the oil currently being used throughout the total Rochester district heating system.

Many of the problems which have traditionally plagued municipal incinerators can be accommodated with the new improved technology of modular incinerators and the superior quality of the RDF from the Monroe County Resource Recovery Facility. The modular incinerators have a relatively successful track record for the combustion of municipal solid waste. Numerous modular units have been constructed across the country and have operated successfully over the past three or four years. The major problems with modular incineration are difficulties associated with handling and loading of municipal solid waste, maintenance, and labor costs. The smaller incinerator units are typically batch fed, which leads to high labor cost and uneven burning. The larger units have

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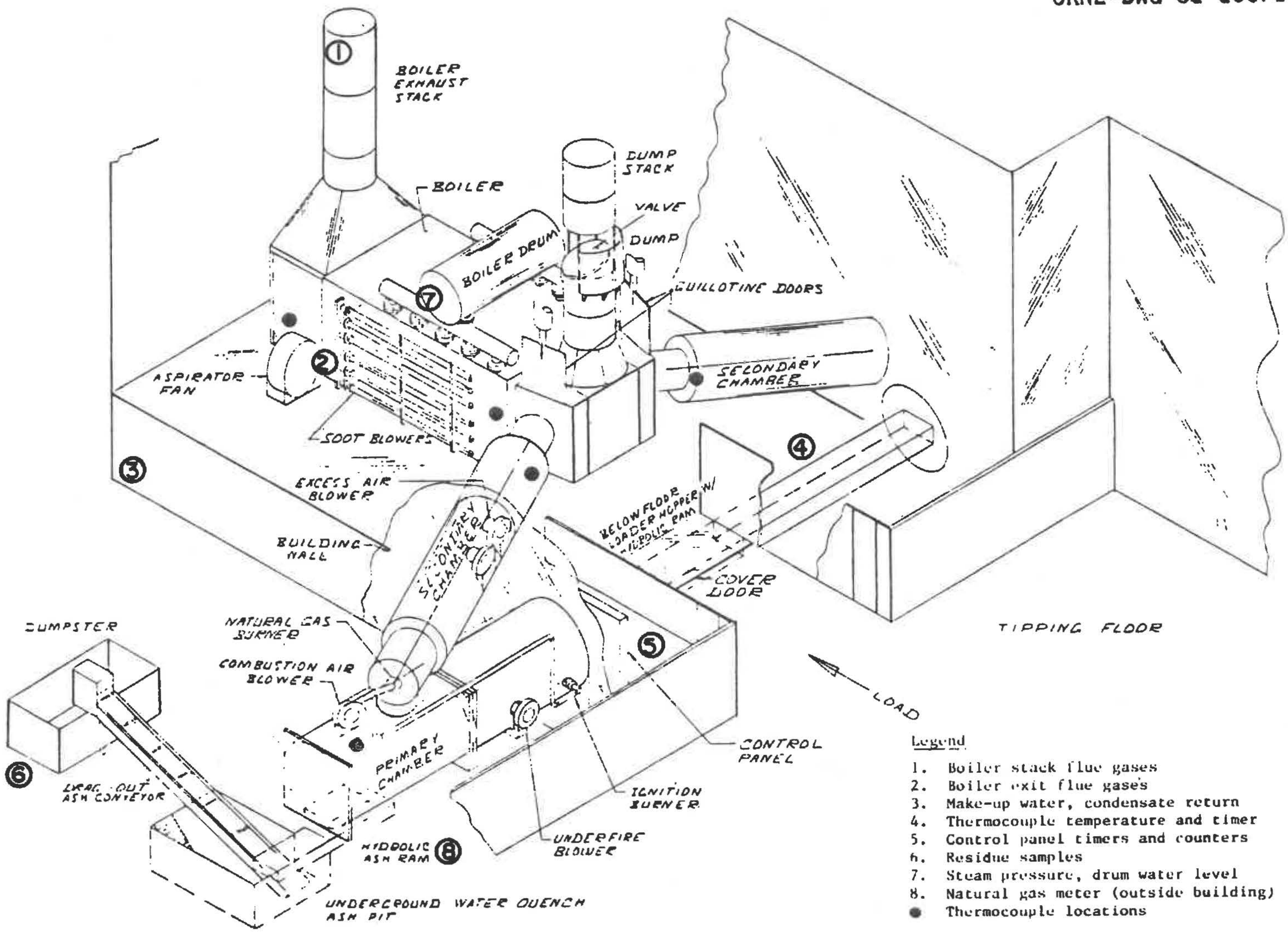

Fig. 5.5. Example of an incinerator-heat recovery module facility.

attempted to overcome these problems by installing automatic feed systems, but, unfortunately, automatic feed systems have encountered their own difficulty in jamming and bridging of municipal solid waste. The major maintenance requirement for modular incinerators is replacement of the refractory hearth lining. Replacement is required from 3-8 years after initial startup, depending on the quantity and composition of municipal solid waste. Many of the problems associated with operating modular incinerators on municipal solid waste might be overcome by the quality of RDF available from the resource recovery center. The high degree of processing that municipal solid waste receives at the recovery center removes many of the hazards associated with handling, combustion, and storage of solid waste. Highly combustible materials, glass and soil fractions, ferrous and nonferrous metals, and large unmanageable objects are removed. The high quality RDF from the Monroe County facility could be transported over short distances from the treatment facility to the incinerators, reducing both on-site storage, odor, and vector control requirements. The uniformity of the RDF also lends itself to handling by automatic equipment, such as automatic feed equipment, so that deliveries could be made directly from the Monroe County facility to an incinerator holding hopper. The cost of labor and the time involved in handling the material can be reduced. The uniformity and relatively low moisture content of the RDF make it a desirable fuel for uniform steam production with a minimum of potential air pollution.

The other significant advantage of employing RDF in combination with modular incineration to supply the Rochester district heating system is RDF's competitive price with oil. The initial cost of steam sold to utilities could be approximately $\$4/10^6$ Btu as compared with the current cost of $\$6.50/10^6$ Btu for producing steam. The cost differential between the two energy sources and the potential savings for the steam customers should be apparent. Although steam derived from RDF is not the same quality as that provided from combustion of residual oil, there are many potential uses for this low pressure steam.

5.4 Development of Hot Water Heat Islands

To justify the investment for conversion to coal and new refuse incinerators, there will be the requirement of additional revenue. Portions of the revenue can be derived from reconnecting old customers and connecting new customers in the present steam district heating service area. There will also be the need to connect new customers that are outside the present service area. The service to these customers should be the starting point of a modern hot water district heating system. The development of several hot water heat islands at the extremes of the present steam system could be the beginning of an efficient new system not restricted to the downtown core area.[6] Modern northern European hot water systems stretch across the community almost to the same degree as our natural gas distribution systems. The new hot water system would have the flexibility to change as the community changes.

If a hot water heat island can be developed near one of the energy sources then the drastic improvement in efficieny can be achieved immediately. A hot water distribution system can achieve annual efficiencies of 90%, and it will be desirable to achieve this as early as possible. If the new heat island is on the tip of the existing steam distribution system, then the heat sources have to have excess capacity to compensate for the losses in a steam system. The hot water heat island would have an efficiency of 90%; however, the steam system that is serving the heat exchanger of the hot water distribution system has an efficiency of only 75%. The benefit of the hot water system would only be achieved when a number of these heat islands are connected directly to the energy source. This could possibly take as long as five years. The major drawback of initiating these heat islands is the cost of heat exchangers and water pumping equipment. The additional cost of this equipment has to be justified on the long-term potential efficiency improvements of the new hot water district heating system. Additional costs might be covered by a UDAG grant because the hot water system can be classified as a long-term infrastructure investment.

The City of Rochester is comparable to Uppsala, Sweden, which presently has an 800 MW(t) hot water district heating system. Uppsala has a population of 140,000 and the district heating system serves 80% of the potential space heating load. The downtown multi-story area of Uppsala has a thermal density between 50-70 MW/km^2, and the remainder of the city core area has a heat load density between 20-50 MW/km^2. The heat load density in Rochester is approximately equivalent to Uppsala's. Extrapolation between the sizes of the two cities indicates that Rochester has the potential for a 1200 MW(t) district heating system. The existing system is 275 MW and the additional growth of 900 MW would cost approximately $250 million (1980 dollars). Development of the hot water system might require 12-20 years for completion. Upon completion, strong consideration should be given to replacing the steam system.

The preeminent energy source for the hot water system will be thermally cogenerated energy from RG&E's Russell Station. The Russell Station units could be retrofitted to provide 400 MW(t) of 250°F hot water [there is about 1.5 x 260 MW(e) = 400 MW(t) of thermal energy potential]. This would be sufficient to serve 45% of the capacity and approximately 80% of the annual energy. The Russell Station is 7 miles from the center of downtown Rochester (Fig. 5.6) and such a long pipeline would not be justifiable until about 500 MW(t) of the load has been developed. Therefore, energy sources that are closer in must be found and used for the development of the new system. The potential sources include: spare capacity at Station #3, reject industrial waste heat, and new permanent coal-fired boilers that cascade energy first to industrial customers and then to the district heating system. The Ginna Nuclear Station is another retrofit candidate to provide cogenerated thermal energy. In Sweden, there is serious considerations for retrofitting the Forsmark Nuclear Plant and transporting the thermal energy 80 miles to the city of Stockholm. The Ginna Station is only 15 miles from downtown Rochester.

The first phase of the new system is the development of hot water heat islands. An initial feasibility study that examines the potential of 5-6 heat islands is recommended. The results of the study should identify the prime target areas and also a strategy for interconnection. Selection of market areas is not an exact science, but the following principles can be used as guidelines in assessing candidate areas:

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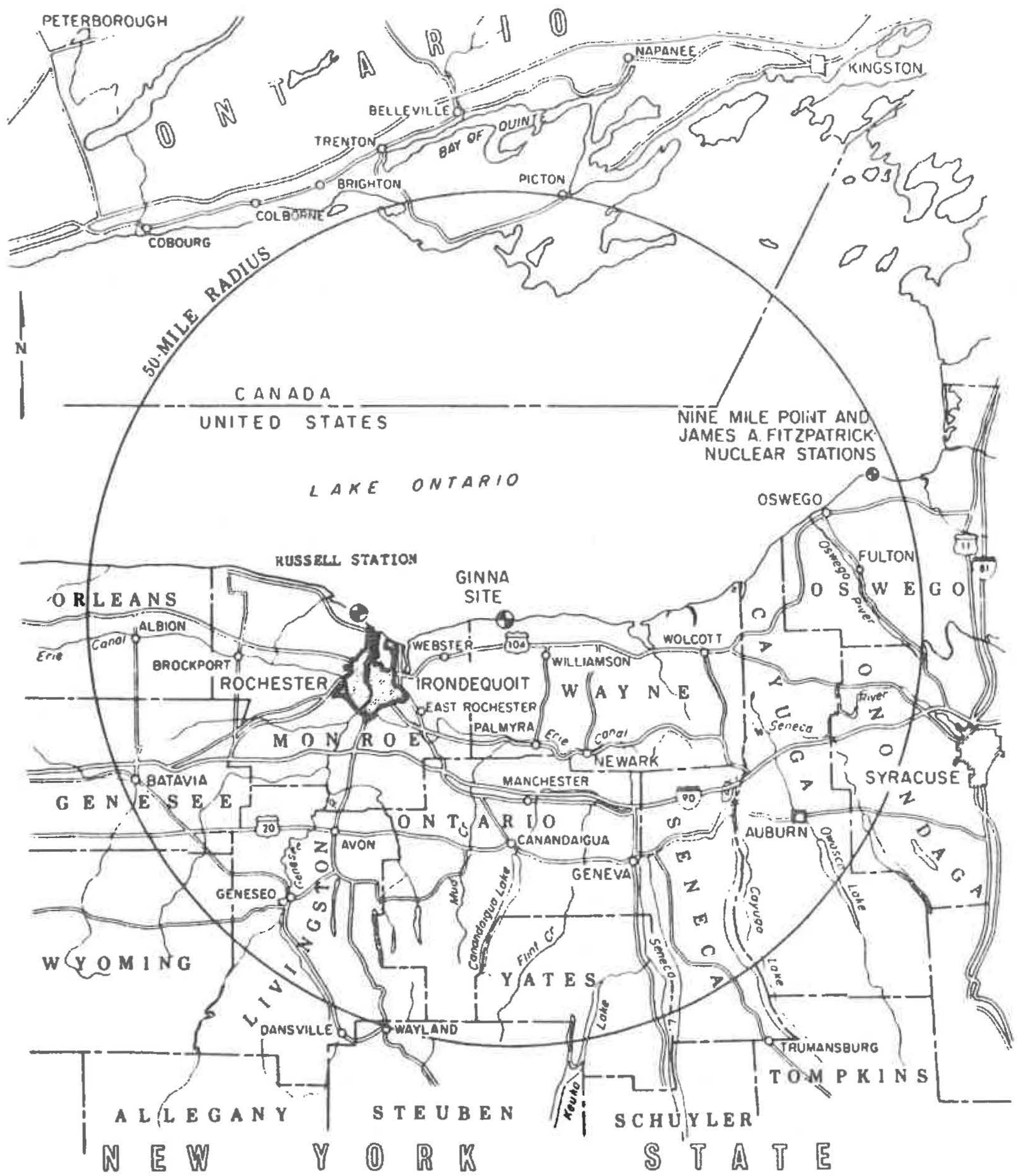

Fig. 5.6. Relative location of RG&E's Ginna Nuclear Station 470 MW(e) and Russel Coal Station 260 MW(e).

- Areas to be served should have a high thermal load density. Each heat island must be segmented and estimates must be made of the thermal heat load density. The thermal load density of an area is determined by the thermal load per unit of building flood space, the number of stories in the building, and a number of buildings within the area.
- The heat islands should be as close as possible to the thermal source. Often the best approach is to begin selecting the most energy intensive area until the available thermal capacity is entirely allocated. Close proximity between the thermal loads and the source reduces capital costs.
- Areas of new development or redevelopment are often excellent targets for initial heat islands. Areas of new construction and redevelopment offer the advantages of reduced cost of piping installation in streets and reduced costs to the building developer due to the elimination of buying boiler equipment.
- Groups of buildings under single ownership should be given special consideration. This includes university campuses, medical complexes, and other high heat load factor complexes. This does not include civic centers and sports arenas, which have highly cyclic load factors.

In many cases, the most attractive service areas for a new heat island will become obvious from the consideration and principles just mentioned. However, for large cities such as Rochester, there might be several other alternatives.

The initial heat island feasibility study should concentrate on the potential market with a secondary emphasis on the distribution system and the energy sources. The results of this study should identify the two or three prime heat island targets for follow-up detailed conceptual design and economic feasibility studies.

The long-term viability of district heating in Rochester is directly linked to the initiation of a new hot water distribution system around the present system. This new distribution medium can serve the customer efficiently throughout a period of enhanced conservation. It can utilize the cogeneration conservation concept to its fullest extreme, which relates to a minimal sacrifice in the production of electricity. The European design, thin pipe wall construction and shallow burial, has reduced the distribution system capital costs to a point where economic feasibility can be achieved. This is not implying that building a hot water system or a hot water heat island can be done in a haphazard manner. However, with careful planning and a great deal of innovation, a hot water system is a real possibility for Rochester.

5.5 Applications for an Energy UDAG for One or More Proposed Options

The purpose of the energy UDAG program is to improve the physical and economic viability of urban areas by supporting projects which are designed to conserve energy and develop alternative energy supplies. The program was designed to permit communities seeking the most equitable use of their existing resources to plan their energy futures. The energy UDAG is intended to facilitate urban redevelopment in a time of uncertain and costly energy supplies. By requiring a minimum of $2.50 of private sector investment to each $1.00 of federal funds, the UDAG program insures community cooperation and interaction in the planning process.

The city of Rochester may seek an energy UDAG grant to revitalize RG&E's district heating system. Development of an economically viable and price-competitive district system would benefit the city directly by lowering the operating (heating and hot water)cost of municipal buildings. Improved steam sales and relocation of business into the downtown area also benefit the city. The potentially positive impacts of retaining the district heating system should motivate the city to apply for an energy UDAG. The energy UDAG program is designed to promote energy conservation and alternative energy supply projects with long-range potential for improving urban viability. Preference is given to applications which can indicate sustained community benefits from energy UDAG projects. The two proposed short-term options, municipal incineration and Unit #12 cogeneration, are intermediate measures designed to reestablish the economic viability of the Rochester district heating system. Both options appear to meet the energy UDAG prerequisites of scarce fuel savings, technical feasibility, and economic feasibility. Neither short-term option can be expected to support a major, sustained revitalization of Rochester.

The third option is a long-range strategy to develop hot water heat islands adjacent to the existing steam district heating system. The increased flexibility of hot water distribution enables the system to expand into the community, increase the number and types of customers, and utilize a greater number of local heat sources. Hot water systems could permit increased scarce fuel savings, increase employment, and provide a reliable energy source at competitive rates. The third option can have a significant and lasting impact upon the growth and revitalization of Rochester.

Before Rochester can submit an application for an energy UDAG, the city and the utility must more thoroughly investigate the technical and economic viability of the proposed options. The combination of feasibility studies and an energy strategy will enable the city to develop a long-range plan (which may incorporate one or more of the proposed options) to apply for an energy UDAG. Because all UDAG's are competitive awards, any application submitted by Rochester that demonstrates a continual and long-range impact would have a higher probability of acceptance. If the longer range considerations are ignored, the possibility of a successful UDAG award could be significantly reduced.

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6. SUMMARY AND CONCLUSIONS

The Rochester district heating system is typical of other U.S. steam district heating systems. Many of the systems are not profitable or earn a relatively low rate of return. The Rochester district heating business is in the latter category but could easily become a business with substantial losses. To avoid this possibility, there is a need to address the immediate problem and to examine the long-term outlook for the business. The two are not independent; a major investment to resolve the short-term problem cannot be made without an estimate of the future potential of the business.

The immediate problem is to reduce the system's dependence on oil; however, the most significant problem is the business's limited service area in the redeveloped inner city of Rochester. The district heating business has deteriorated over the last decade because it could not reach beyond this limited service area. The electric business has also suffered some revenue loss in the central business area; however, it is much more diverse and has had the flexibility to follow the outmigration to the suburbs. The steam technology has constrained the district heating business to this small pocket. Low and medium pressure steam can be transported only a short distance and a system with no condensate return can only serve extremely high heat load densities. Therefore, there is a perceived risk in making an investment in an area with such a limited market.

The district heating business in Rochester is worth saving. It has the potential, using the modern hot water district heating technology, to become a large successful business venture. It could serve the whole city in a manner similar to the natural gas distribution business.

The city of Rochester and not RG&E would be the most severely affected by the loss of steam service to the downtown area. The most immediate impact would be the loss in municipal taxes generated by the steam system. The substantial revenues lost from steam sales and other municipal taxes could force curtailment of municipal services or increase local property taxes. Simultaneously, the city would be faced with the prospect of raising substantial amounts of capital to convert all the downtown municipal buildings to natural gas. The city would then be totally dependent upon natural gas. A secondary effect of abandoning the district heating system is the potential loss of marginal business from the downtown area. Businesses incapable of meeting the initial conversion costs to natural gas may close or relocate. Conversion costs would be another stimulus to accelerate the current trend of retail migration from the city to the suburbs.

For RG&E, abandoning the Downsteam steam business would result in an immediate impact upon the natural gas business. Most of the former steam customers would expect or even demand service from the gas system. The utility would then be faced with the prospect of making an investment in the downtown gas distribution system. Also, to meet the increased demand for natural gas, RG&E would be required to purchase new gas at marginal cost. The increased cost of new gas would be distributed among all of the natural gas customers. Natural gas is being deregulated and will undergo a rapid cost escalation over the next decade, similar to the cost escalation of steam during the latter half of the 1970s. During periods of rapidly escalating fuel costs, both the gas and district heating businesses face the possibility of low rates of return on their investment. Regulators cannot politically pass along rate increases required to cover utility costs. The major advantage of district heating during periods of fuel escalation is the inherent flexibility to switch fuel supplies. RG&E and the community have control over the energy source that produces steam for the district heating system. Coal, refuse derived fuel, or industrial waste heat could be incorporated into the Downtown district heating system, thus maintaining or lowering the cost of delivered steam.

To sustain a viable gas business in the downtown area, RG&E should use the two businesses to balance each other. If the district heating business were revitalized and had the potential to expand to hot water, it could alleviate the need for the purchase of marginal gas from the pipeline supplier. By having the two systems, the utility could have more control and could better manage the rapid cost escalation of scarce fuels. Both businesses could then expect to earn a better rate of return.

Three options have been proposed to demonstrate the potential alternatives that exist for sustaining and improving the Rochester district heating system. The proposed options represent only a few of the available alternatives that could apply to revitalizing the Rochester district heating business. Among the options that were proposed, two represent potential short-term solutions and the third an overall strategy for long-term viability. All three options indicate a potential for large scarce-fuel savings, one of the requirements for applying for an energy UDAG grant.

The two near-term options are attempts to reduce the steam system's dependence on oil. The first option is conversion of the existing coal-fired Unit #12 in downtown Rochester to cogeneration. The steam supplied from Unit #12 cogeneration would reduce oil consumption by at least 10% and possibly by as much as 30%. Because fuel costs are the primary expense of the district heating system, steam produced from low cost coal offers the opportunity to stabilize or even lower the price of steam to the customer. The second option involves generating steam produced from municipal refuse incineration. A small modular incinerator with heat recovery capability could be installed at both Station #3 and Station #9. High quality refuse derived fuel (RDF) would be supplied from the Monroe County Resource Recovery Plant and, depending upon the supply, oil savings from municipal incineration could amount to 20%.

The third option is a long-range strategy to develop hot water heat islands adjacent to the Downtown system. A hot water district heating system has many of the characteristics of a natural gas distribution system. Both systems can economically serve a lower heat load density over a longer distance than steam. The greater flexibility of hot water enables the district heating system to extend service across the community. The development of a successful hot water heat island would represent the first growth node of a major new district heating system in Rochester.

The immediate and long-term economic viability of the Rochester district heating system requires aggressive and coordinated interaction between both the city and the utility. Recognizing the differences between the objectives, concerns, and operating practices of the city and the utility represents the first consideration in the selection and development of options. Of the proposed options, the city appears best suited to take the lead role on the refuse incineration, RG&E on the conversion of Unit #12, and a combination of utility and city effort is needed for hot water heat island development.

The option that looks the most promising is modular incineration using RDF fuel. Incineration is rated above conversion of Unit #12 due to the complex technical issues involved with retrofitting an existing single-case steam turbine. However, both options deserve immediate and thorough investigation. Announcing a commitment to pursue either or both of these options would have a psychological impact on the existing steam consumers. Existing customers would be given the option to defer for a year or two a decision to switch to another fuel. If the customers felt that in the near future the system would again be cost competitive, steam sales would be stabilized and the eroding customer base could be solidified.

Justifying the investment to convert Unit #12 or to purchase modular refuse incinerators will require additional sources of revenue. Portions of the revenue can be derived from reconnecting old customers and connecting new customers in the present steam district heating service area. The need also exists to connect new customers that are outside the present service area. The service to these customers should be the starting point of a modern hot water district heating system. The development of several hot water heat islands at the extremes of the present steam system would be the beginning of an efficient new system that would not be restricted to the downtown core area. The new system would have the flexibility to change as the community changes. The long-term viability of district heating in Rochester is directly linked to the initiation of a new hot water distribution system around the present system. This new distribution media can serve the customer efficiently throughout a period of enhanced conservation. It can utilize the cogeneration conservation concept to its fullest extreme, which relates directly to a minimal sacrifice in the production of electricity. The Rochester district heating system could be made viable with careful planning and a great deal of innovation.

Appendix A

HUD GUIDELINES FOR UDAG APPLICATIONS FOR ENERGY CONSERVATION OR ALTERNATIVE ENERGY SUPPLY PROJECTS

U.S. Department of Housing and Urban Development
COMMUNITY PLANNING AND DEVELOPMENT

Special Attention of:

Regional Administrators
Regional Directors for CPD
Area Managers
CPD Division Directors

Notice CPD 80-21

Issued: September, 1980
Expires: March 31, 1980

Cross References:

Subject: Guidelines for UDAG Applications for Energy Conservation or Alternative Energy Supply Projects

In February, 1980, Notice CPD 80-4 was issued to provide guidance to applicants who wish to use the Urban Development Action Grant (UDAG) program to finance energy conservation or alternative energy supply projects. This Notice is an expansion and clarification of the version issued in February.

On May 12, 1980, at 45 Federal Register 31272, HUD proposed an amendment to 24 CFR Section 570.459 to add energy efficiency or scarce fuel saving as a selection factor for Action Grant awards. The amendment also provides that among energy project applications, those submitted by communities which have started to plan and manage energy on a community-wide basis will be preferred over those from communities which have not begun this process. In anticipation of the amendment's publication as a final rule, this Notice reflects its energy provisions.

The guidelines contained herein indicate (a) the kinds of energy projects for which UDAG funding is suitable and (b) additional information required for a UDAG energy project application.

C : Distribution: W-3-1, R-1, R-2, R-3, R-3-1 (CPD), R-4, R-5, R-5-1, 048

Previous Editions Are Obsolete

HUD 21B(3-80)
GPO 871 902

Guidelines for Soliciting Additional Information for UDAG Applications for Energy Conservation or Alternative Energy Supply Projects

I. INTRODUCTION

Action Grants can be used for energy conservation or alternative energy supply projects which are technically feasible and have sufficient economic viability to attract the private investment required under the UDAG program. The minimum is $2.5 private to $1 Action Grant, but the higher the ratio of private investment to UDAG requested, the more competitive the application will be. As in other Action Grant applications, a government guaranteed loan or a revenue bond (but not a local government general obligation bond) can qualify as private investment.

HUD recognizes that many valuable and proven energy conservation or alternative energy supply technologies, which can help the nation conserve scarce fuel and improve the economic viability of urban areas, may have difficulty in obtaining 100% private financing. For some projects, even though the energy conservation effect is significant, the rates of return may be insufficient to call forth the total amount of private investment required. In others, a lack of operating experience may be the major barrier. In either case, the Action Grant can help qualified energy projects fill the financing gap.

These guidelines address a specific set of energy conservation or supply technologies, namely: district heating, geothermal systems, small scale hydro, co-generation, modular integrated utility systems, alcohol fuel production plants, wind power systems, waste-to-energy projects, recycling or reclamation facilities, solar thermal energy sytems, photovoltaic manufacturing facilities, low and medium BTU gasification facilities, and loan/grant pools to finance building conservation or alternative energy resource measures in buildings. HUD believes that all of these systems are technically feasible. Many communities have already initiated projects in one or more of these areas. This list of project categories, however, in no way precludes a distressed city, county, or pocket of poverty community from applying for any other energy conservation or alternative resource measure which conserves scarce fuels or increases energy efficiency, adapting the guidelines set forth herein to the circumstances. From time to time, the list of project categories will be expanded to reflect new project categories. For assistance in applying these guidelines to technologies not listed in this notice Christine McElligott, Mary Allman, or Mark Williams of the UDAG staff in Washington may be contacted at 202-472-3947.

II. APPLICATION PROCEDURE

An energy UDAG application shall be applied for and processed in the same manner as any other UDAG. It shall be evaluated against all other UDAG applications received for a particular large city or small city round and all normal UDAG selection criteria shall apply. Energy projects, however, are favored to the extent they conserve scarce fuel or increase energy efficiency. The method by which the scarce fuel savings shall be measured is described below. In addition, as between energy UDAG applications in any given round, those from communities which have adopted plans or programs to conserve energy or provide alternative sources of supply on a community-wide basis shall be favored, all other factors being equal, over communities making no effort in this regard.

The following additional data should be submitted with an application for an energy UDAG:

A. A technical and economic feasibility study;

B. Evidence that the project does not provide an undue energy subsidy to any customer or class of customers;

C. The UDAG cost of scarce fuel saved;

D. A description of any community-wide energy conservation plan or program undertaken by the applicant, and the relationship, if any, of the project to such plan or program.

The information requested in B and C can be included as part of the technical and economic feasibility study.

A. The Technical and Economic Feasibility Study

A UDAG application for an energy conservation or alternative energy supply project must be supported by a technical and economic feasibility study prepared by a competent professional. For each project type, HUD will have an expert either at HUD, DOE, or one of the national laboratories review and evaluate the study, and in particular, the cost and market estimates.

Separate appendices are attached indicating factors which the study for each project type should address. The factors listed do not cover all elements that should be contained in a comprehensive feasibility study, but do set forth the factors deemed critical by the HUD and DOE technical advisors. The term "internal rate of return" as used in the appendices means the interest rate at which the present value of the net cash flow for the project is zero. Each appendix contains the

II. APPLICATION PROCEDURE

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A. <u>The Technical and Economic Feasibility Study</u>

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Project Type	Appendix
District heating, either with or without power plan co-generation, except for geothermal systems	A
Geothermal systems	B
Small scale hydro power systems	C
Co-generation systems	D
Modular integrated utility systems (M.I.U.S.)	E
Alcohol fuels production systems	F
Loan/grant pools for building conservation or alternative resource measures	G
Wind power systems	H
Waste-to-energy systems	I
Recycling or reclamation facilities or systems	J
Solar thermal energy systems	K
Photovoltaic manufacturing facilities	L
Low and medium BTU gasification facilities	M

B. Evidence of No Undue Energy Subsidy

The amount of any Action Grant should be no more than the minimum amount required to cause private investment to take place and under any circumstance no more than the amount necessary to achieve the minimum leverage ratio of $2.5 private to $1 UDAG. In the case of energy projects with lower than normal rates of return, the amount of an appropriate Action Grant would be the minimum amount required to bring the estimated rate of return of the project to a level sufficient to induce private investment.

In the case of energy projects which provide heat or electrical services to customers, such as district heating or small scale hydro facilities, the rate of return, and thus the amount of UDAG needed if the rate is unduly low, will depend on the prices charged for energy to customers of the system. This price to customers should not be so low as to constitute in effect an energy subsidy, as described below, because under those circumstances the amount of the UDAG requested will be more than required to cause private investment to occur.

HUD recognizes that the viability of a conservation or alternative energy project may depend upon selling energy at a price below the price of available scarce fuels to induce customers to convert to the new system. This price incentive should be no more than is required to obtain conversions, nor, under any circumstance, unreasonably large.

It is not possible to specify any precise formula or pricing system which will satisfy this requirement but this issue should be addressed in the technical and economic feasibility study.

C. UDAG Cost of Scarce Fuel Saved

Energy conservation or alternative energy supply UDAG applications should indicate how many UDAG dollars will be required to save one barrel of crude oil per year, usually for the first year of project operation. Applicants should calculate this cost in the following manner:

Step 1

A summary analysis should be submitted which demonstrates that the proposed project results in a greater reduction in the consumption of scarce fuel(s) (oil or gas) than alternative methods available for satisfying the same service demand. The overall reduction expected can take place directly on-site if the facility has its own power generating capability, or it may be computed as an indirect reduction in scarce fuel usage in a remote power facility, i.e., displacing oil or gas used to generate electricity by a utility company which services the project. It is expected that an applicant will be able to prepare this required summary analysis from energy data available from the technical and feasibility study to be submitted in conformance with the relevant appendix.

Step 2

The amount of scarce fuel savings calculated in Step 1 should then be translated into barrels of crude oil equivalent saved per year. HUD recognizes that applicants may be working with different fuels and that actual savings in a given project may not be in barrels of crude oil but in another fuel type. For purposes of standardized information which HUD will use in its decision making, the savings should be presented as barrels of crude oil equivalent saved per year. The conversion equivalences in the following Table should be used in preparing this figure:

Energy Equivalences

General

One million = M

British Thermal Unit (BTU) = a unit of heat; the quantity of heat needed to raise the temperature of one pound of water one degree Fahrenheit

Petroleum

1 barrel (bbl) of crude oil = 5.8 M BTU
1 bbl of residual oil = 6.3 M BTU
1 bbl of distillate fuel = 5.8 M BTU
1 bbl of gasoline = 5.3 M BTU

Gas

1 cubic foot (ft^3) of dry natural gas = 1,020 BTU
5,700 ft^3 of dry natural gas = 1 bbl of crude oil

Coal

1 short ton bituminous = 22.4 M BTU
1 short ton anthracite = 23.5 M BTU
.26 short tons bituminous = 1 bbl of crude oil
.25 short tons anthracite = 1 bbl of crude oil

Electricity

1 kwhr solar (1) = 10,400 BTU
1 kwhr fossil = 10,400 BTU
1 kwhr hydropower (2) = 10,400 BTU
1 kwhr geothermal (1) (2) = 10,400 BTU
558 kwhr fossil = 1 bbl of crude oil
558 kwhr hydropower (2) = 1 bbl of crude oil
558 kwhr geothermal (1) (2) = 1 bbl of crude oil

Units of Measure
Weight
1 metric ton contains 1,000 kilograms or 2,204.62 pounds
1 long ton contains 2,240 pounds
1 short ton contains 2000 pounds

Conversion factor for crude oil (average gravity)
1 barrel contains 42 gallons

(1) If solar or geothermal displaces fossil fuel burned onsite in a commercial or residential building, then, assuming the onsite boiler or furnace has a seasonal efficiency of 50%, 1 kwhr solar or geothermal equals 6800 BTU.

(2) There is no generally accepted practice for measuring hydropower and geothermal power to thermal conversion rates. For the displacement of crude oil the conversion factor is assumed equal to the heat rate factor of a fossil fuel steam electric power plant.

Step 3

The amount of barrels of oil equivalent saved per year calculated in Step 2 should then be divided into the amount of UDAG dollars requested to give the UDAG cost per barrel of crude oil saved. This figure will be used as one measure of the project's acceptability and competitiveness. Generally, the fewer UDAG dollars required for each barrel saved, the greater the project's comparative chances for funding.

$$\text{UDAG Cost of Scarce Fuel Saved} = \frac{\text{UDAG dollars requested}}{\text{Barrels of crude oil to be saved per year}}$$

Normally, the UDAG cost of scarce fuel saved will be based on the first year of the proposed project's operation. If the project is expected to result in scarce fuel savings significantly greater in subsequent years than in the first, an average UDAG cost of scarce fuel saved may be calculated and presented by dividing the average amount of barrels of crude oil saved per year into the UDAG dollars requested.

For example, a large district heating system may not meet its full potential for scarce fuel savings until 10 to 15 years into its operating life. The applicant, therefore, could calculate the different scarce fuel savings in barrels of oil equivalent to be accomplished each year for the full life span of the project, say 30 years. The 30-year cumulative savings would be presented as an average scarce fuel savings per year. This would then be divided into the total UDAG dollars being requested for the UDAG cost of scarce fuel saved.

$$\text{Average Scarce Fuel Savings Ratio} = \frac{\text{UDAG dollars requested}}{\dfrac{\text{Cumulative barrels of crude oil to be saved over project's fuel saving life span}}{\text{Number of years in project's fuel saving life span}}}$$

D. Description of Community Energy Conservation Plan or Programs

If an applicant community has undertaken the process of determining where and how energy use can be made more efficient and less wasteful, or has made legal and institutional changes to bring about greater energy efficiency or scarce fuel savings, these actions should be described. The relationship of the project itself, if any, to a local or community-wide energy conservation plan or program should be provided. The development of a community-wide energy conservation plan or program is not a requirement for the submission of an Action Grant application; however, applications for energy UDAGs from communities which have undertaken such efforts will be more favorably regarded over those from communities making no efforts in this respect.

In addition, the economic feasibility and true worth of certain energy conservation projects may require an analysis of the costs and design of the system in relation to other energy conservation measures available to the community. For example, the cost effectiveness of a district heating system may require analysis of the reduction in home and business energy demand and the relative cost thereof, that could be achieved through building conservation measures. It is possible that a district heating system, in the interest of cost and energy efficiency, should be designed to permit the hookup of thermal energy from sources such as industrial co-generation plants or solid waste incinerators. This kind of project specific analysis should be part of the feasibility study.

APPENDIX A

DISTRICT HEATING

1. Project Description

Provide a description of the community in terms of its existing and projected land use mix and zoning. The description should include a space heating market study of the building stock and related heating systems in the proposed service area. There should be maps that show the heat load density and significant detail on potential large customers within the service area. Finally, there should be a discussion of the utility service that exists within the area with specific emphasis on how currently the space heating load is served.

2. Development Plan

Provide a time-phased integrated development plan for all phases of the project with key milestones identified.

(a) Engineering Design

The design should include all aspects of the district heating system, the piping system, the energy source, and conversion of the building heating systems. The expansion potential of the system without Federal financing subsidies and the scarce fuel savings beyond the segment for which funding is sought should be estimated.

(b) Economic Feasibility

Plans for financing the proposed district heating system should be outlined including amounts, sources, and timing. The economic feasibility assessment should include all project costs and estimating assumptions, cash flow, capital amortization, and internal rate of return, both with and without the UDAG requested. The applicant should submit letters of intent from building owners to convert to the system at the energy prices used in the feasibility study as an indication of the project's economic viability. The applicant should also address the long term supply stability of the energy source of the proposed system.

3. Environmental and Legal

The project may be subject to local, county, or state environmental statutes and/or the national environmental protection laws. Provide an assessment of the applicable environmental regulations for the proposed system. Include in the development plan all task and key milestones denoting the successful completion of environmental associated requirements. There should also be evidence that all legal requirements have been met or are scheduled and integrated into the development plan.

4. Technical Consultants

Michael Karnitz
Oak Ridge National Laboratory
P. O. Box X
Oak Ridge, Tennessee 37830
(615) 574-5178
(FTS) 624-5178

James O. Kolb
Oak Ridge National Laboratory
P. O. Box X
Oak Ridge, Tennessee 37830
(615) 574-5179
(FTS) 624-5179

Jerome Rothenberg, Program Manager
Utility and Energy Systems
Department of Housing and Urban Development
Division of Energy, Building and Technology Standards
451 7th Street, N.W., Room 8158
Washington, D.C. 20410
(202) 755-8154

APPENDIX B

GEOTHERMAL SYSTEMS

1. Project Description

Provide a description of the geothermal resource and the proposed utilization project. Describe the existing geothermal resource or evidence of a developable resource and any further planned development of the resource. Describe how the geothermal energy will be used (i.e., generate electricity, provide space heating, etc.) and the magnitude of the project (i.e., total electric power generated; number; type, and size of buildings to be heated). The compatibility of the geothermal resource and the proposed utilization should be discussed. Include temperature and peak power requirements of the application and flow, temperature, and reservoir life estimates for the geothermal resource.

2. Development Plan

Provide a time-phased integrated development plan for all phases of the project with key milestones. The development plan should cover all aspects of the project including investigations and field operations to further explore and define the geothermal resource, drilling, and testing of production and injection wells, construction of all surface plants, equipment procurement, pipelines, and utilization facilities. Tasks and milestones should also be established for completion of associated phases of the project such as completion of an Environmental Impact Statement (if required), resource leasing, water rights, etc. and their integration into the construction schedule. The expansion potential of the system without Federal financial subsidies and the scarce fuel savings, beyond the segment for which UDAG funding is sought should be estimated.

3. Resource Data

Provide data sufficient to describe the geothermal resource and compatibility with the project. If the resource is not in production or wells drilled, provide a development plan. This includes geological, geophysical, and geochemical evaluation of the site as well as the reservoir and well data.

4. Engineering Design

A complete engineering design of the geothermal system including all subsystems for geothermal fluid extraction and reinjection, energy conversion and/or transfer, transport, and application.

5. Environmental Assessment

A project may be subject to local, county, or state environmental statutes and/or the National Environmental Protection laws. Provide an assessment of the applicable environmental regulations for the proposed site and utilization. Include in the development plan all tasks and key milestones denoting the successful completion of environmentally associated requirements.

6. Legal Requirements

Provide substantiation that all legal requirements have been met or are scheduled and integrated into the development plan. These include, but are not limited to, resource rights, water rights, local and state licensing, disposal permits, and other regulatory permits required for the specific project application.

7. Economic Feasibility Assessment

Provide an economic feasibility assessment which includes all project costs and estimating assumptions, cash flow, capital amortization, and internal rate of return, both with and without the UDAG requested. The economic feasibility should include a market study for the end product of the project. The market study should address such items as the product unit cost, price and demand, compared to other energy sources. The information and letters of intent described in Items 1 and 2 of Appendix A should be included.

8. Technical Consultant

Eric Peterson, Program Manager
Department of Energy RA/DGRM
12th and Pennsylvania Avenue, N.W.
Room 7119
Washington, D.C. 20461
(202) 633-8760

APPENDIX C

SMALL SCALE HYDRO

1. Project Description

The project description should include a narrative description of the proposed site, providing the dimension, general configuration, composition, age, and condition of the dams, spillways, penstocks, powerhouse, or other structures; stream characteristics; and capacity potential and average annual energy generation.

2. Development Plan

Provide a time-phased integrated development plan for the project with key milestones.

3. Financial

Provide estimates of the following:

(a) Annual kilowatt hours (Kwh) of electricity produced.

(b) Itemized project costs, including costs resulting from issues described in Part 4 below.

(c) Cost per Kwh of electricity produced.

(d) Revenue from electricity sold based on a market survey, letter of intent, or electricity sales contract. The assumptions concerning projected increase in the value of the output should be explicitly stated.

(e) Projected internal rate of return over a 20-30 year period, both with and without the UDAG assistance requested.

(f) Benefit/cost ratio for the project over a 20-30 year period.

4. Environmental and Legal

Provide an environmental and legal review of the project to identify potential environmental and legal issues such as historic restorations, fish passages, and water rights. Costs associated with resolving these issues should be listed as non-hydro project costs in the above financial calculations.

5. Permit and Licensing

   Provide the status of all Federal, state, and local licensing.

6. Technical Consultants

   Robert Grubenmann
   Small Scale Hydro Office
   Department of Energy
   12th and Pennsylvania Avenue, N.W.
   Room 1433
   Washington, D.C. 20461
   (202) 633-8828

   Charles Gilmore
   Chief, Advanced Technology Branch
   Idaho Operations Office
   Department of Energy
   550 Second Street
   Idaho Falls, Idaho 83401
   (208) 526-1808

APPENDIX D

CO-GENERATION SYSTEMS

1. Introduction

Co-generation is the combined production of electricity or mechanical power and heat energy. Briefly, fuel is burned to produce high temperature steam or liquids which are expanded through a turbine to generate electricity. After passing through the turbine, the reject steam or hot liquid is then used as process heat energy. The total fuel required to produce both power and process heat in one system is less than the total fuel required to produce the same amount of power and heat in separate systems. Co-generation systems include dual purpose power plants, waste heat utilization systems, certain types of district-heating systems, and total energy systems.

2. Project Description

A narrative description of the co-generation project should be submitted. The applicant should fully discuss the proposed method of co-generation and the use to which the energy will be put. The size of the energy project in terms of total heat steam and electricity generated, the size of the buildings or systems to be supplied with the energy product should be covered. If either excess energy is produced or supplementary energy supplies are necessary, the applicant should described how these will be dealt with. In addition, the description should outline why a UDAG is necessary for the co-generation project. Information on alternatives to the project considered by the applicant should be provided.

3. Development Plan

Provide a time-phased integrated development plan for all phases of the project with key milestones identified. The expansion potential of the system should be discussed.

4. Engineering Design

A complete engineering design of the co-generation system should be submitted.

5. Environmental and Legal

A project may be subject to local county or state environmental statutes and/or national environmental protection laws. An assessment of the applicable environmental regulations should be made. Evidence that all legal requirements have been met or are scheduled and integrated into the development plan should be provided. These include but are not limited to local and state licensing, zoning, and other such regulatory permits required for the project's implementation and operation.

6. Economic Feasibility Assessment

Provide an economic feasibility assessment which includes all project costs and estimating assumptions, cash flow, capital amortization, and internal rate of return, both with and without the UDAG requested. If the project is to supply energy to an outside customer, an analysis of the market demand should be presented. The market study should address such items as the product unit cost, price and demand, compared to other energy sources. Evidence of the proposed customer's commitment to receive the energy product should be presented.

7. Technical Consultants

William Mixon
Oak Ridge National Laboratory
P.O. Box X
Oak Ridge, Tennessee 37830
(615)576-7323
(FTS)624-7324

Michael Karnitz
Oak Ridge National Laboratory
P.O. Box X
Oak Ridge, Tennessee 37830
(615)574-5178
(FTS)624-5178

APPENDIX E

MODULAR INTEGRATED UTILITY SYSTEMS

1. Introduction

A Modular Integrated Utility System (MIUS) is a system that provides all of the basic utility services for the needs of a community on-site in an integrated system. A MIUS provides electricity, heating and cooling, as well as liquid waste processing, solid waste processing, and/or potable water supply. The primary fuel source can be fossil (oil, gas, or coal) for diesel engines, boilers, or turbines or renewable sources, such as solar (solar-total energy). A MIUS utilizes rejected heat from the power generation, which can be supplemented by the energy content of the onsite trash, sewage sludge, as well as solar, geothermal, wind, bio-mass, or any other available, renewable source.

2. Project Description

Provide a description of the proposed site in terms of its existing and projected land use mix and zoning. Describe the number of residential dwelling units and the content of commercial/institutional space to be served by the Modular Integrated Utility System (M.I.U.S.) and the approximate size of the facility that is required. Finally, discuss the present availability of conventional utilities to serve this site and describe the benefits of M.I.U.S. as an alternative.

3. Development Plan

Provide a time-phased integrated development plan for all phases of the project with key milestones identified.

(a) Technical

This plan should cover all aspects of the M.I.U.S. application and should include estimates of site utility needs on a typical peak monthly basis. In addition, the plan should include a conceptual design of the M.I.U.S., including a list of major equipment items and their respective sizes, subsystem interfacing, and load/capacity factors for all subsystems. The potential for system expansion to accommodate site growth should be addressed.

(b) Economic

Plans for financing the proposed M.I.U.S. should be outlined including amounts, sources, and timing. An economic feasibility assessment which includes all project costs and estimating assumptions, cash flow, capital amortization, and internal rate of return, both with and without the UDAG funds requested, should be provided. In addition, estimates of the following must be submitted:

(i) itemized project costs, including construction, capital with the resolution of environmental legal issues should be included.

(ii) average cost of utility services including electricity (S/Kwh), wastewater treatment ($/$10^3$ gallons), and solid waste management ($/ton).

(iii) net scarce fuel savings, if the prime mover selected uses oil or gas.

4. Environmental Assessments

A project may be subject to local, county, or state environmental statutes and/or the national environmental protection laws. Provide an assessment of the applicable environmental regulations for the proposed site and utilization. Include in the development plan all tasks and key milestones denoting the successful completion of environmentally associated requirements.

5. Legal Requirements

Provide substantiation that all legal requirements have been met or are scheduled and integrated into the development plan. These include, but are not limited to, resources rights, water rights, local and state licensing, disposal permits, and other regulatory permits required for the specific project application.

6. Technical Consultant

Jerome Rothenberg, Program Manager
Utility and Energy Systems
Department of Housing and Urban Development
Division of Energy, Building and Technology Standards
451 7th Street, S.W., Room 8158
Washington, D.C. 20410
(202)755-8154

APPENDIX F

ALCOHOL FUELS PRODUCTION SYSTEMS

1. Project Description

Provide a narrative description of the proposed project. Provide a description of the site, the production plant, integration with other technologies in terms of process heat use (i.e., co-generation), and other non-conventional fuels, feedstock availability, treatment of stillage and other wastes generated from the alcohol production (i.e., fusel oils, mash, CO_2, etc.) and storage plans.

2. Development Plan

Provide a time-phased integrated development plan for the project with key milestones.

3. Net Energy

Discuss energy (BTUs) used in the alcohol production vs. energy (BTUs) produced (which can include alcohol and by products).

4. Economic Feasibility

Provide an economic feasibility assessment which includes all project costs and estimating assumptions, cash flow, capital amortization, and internal rate of return, both with and without the UDAG requested. The economic feasibility should include a market study for the end products. The market study should address such items as the product unit cost, selling price, and demand compared to other energy sources. The economic feasibility assessment should also include an analysis of the stability of the feedstock supply (grain, potatoes, processing wastes) in terms of the project's continuing operation and payback.

5. Legal and Environmental

(a) Evidence of application for Bureau of Alcohol, Tabacco, and Firearms permit must be enclosed.

(b) Evidence of applications for storage permit from Health Department must be enclosed along with all other state and local permits.

(c) Discuss the environmental consequences and potential issues relative to plant operation and waste disposition.

6. Technical Consultants

Ted Tarr, Acting Director
Financial Incentives Program
Office of Alcohol Fuels
Department of Energy
Forrestal Building
Washington, D.C. 20585
(202) 252-9487

M. David Feld
Farmers Home Administration
Environmental and Technology Staff
U.S. Department of Agriculture
Washington, D.C. 20250
(202) 447-3394

(Below 3 million gallons per year)

Scott Sklar
National Center for Appropriate Technology
815 15th Street, N.W.
Suite 624
Washington, D.C. 20005
(202) 347-20005

DOE toll free alcohol fuels information number: 800-525-5555

APPENDIX G

GRANT/LOAN FUNDS FOR BUILDING ENERGY CONSERVATION OR ALTERNATIVE ENERGY SYSTEMS

I. INTRODUCTION

Action Grants can be used to help establish grant/loan funds to provide lower than market rate loans or grants for building owners or tenants who will invest in energy conservation or alternative resource measures.

Measures for energy conservation can include weatherstripping or caulking, improvements to the building envelope - insulation, storm windows or storm doors - or equipment to increase efficiency, such as clock thermostats, burner controls, heat pumps, or thermal storage units. Measures for alternative energy supply can include solar hot water heaters, wood burning stoves, or heat exchangers to be connected with a district heating facility.

Private lenders must commit to fund a loan/grant pool in an amount which meets the minimum UDAG leverage requirement: $2 1/2 private to $1 Action Grant. A higher leverage ratio will make an application more competitive.

Applications must be accompanied by a feasibility study which provides details of the city program for administering the loan pool. The program may include loan programs for different building types or persons in different income classes: e.g., commercial, industrial, multi-family low-income.

Applicants can also submit a program component which involves energy audits only for a class of buildings. Experience has shown that an audit alone will often induce building owners to make investments in energy conserving measures because the audit reveals that such investments are cost effective. This kind of straight audit program is probably most relevant to commercial, industrial, or multi-family structures. For UDAG purposes, the applicant must produce evidence that users of the audit service will commit to invest a minimum dollar amount in retrofit measures which will produce a satisfactory leverage ratio.

Up to 5% of the UDAG for a loan/pool grant may be used for administrative expenses and up to an additional 5% may be used for education and marketing.

The loan pool program may be directed primarily toward housing rehabilitation; however, rehab loan pools funded with Action Grants must incorporate an energy conservation component as explained below.

In addition to the information on scarce fuel savings, on no undue energy subsidy, and on community energy management efforts required by the guidelines, the following additional information should also be provided:

II. PROJECT DESCRIPTION

The applicant should describe in some detail the nature of the city program, who will administer it, the proposed use of the UDAG, why a grant or subsidy is needed, the timing of the drawdown of UDAG funds in the project, what education and marketing efforts will be undertaken, who will be responsible for performing audits, initial and final inspetions, loan origination and servicing, preparation of work specifications, security required for loans, each separate class of buildings to be targeted, eligibility criteria for borrowers, the time period for project completion, an estimate of the size of individual loans, the typical retrofit measures for particular classes of buildings and borrowers anticipated to be financed, and data concerning the selection, availability, and monitoring of contractors. The applicant must also provide evidence of its capacity to run the program, which may be based on a record of successful administration of a housing rehabilitation program.

III. ARRANGEMENT WITH FINANCIAL INSTITUTIONS OR LENDERS

For each separate lending program, the applicant must specify the private lender or landers involved, the amount and terms of the private lender commitment (rate, terms, security), and the way the Action Grant will be used to reduce the effective interest rate (principal write down, lending institution requires a lump sum draw down of the UDAG, additional banks services to be provided must be shown to justify such a lump sum draw. Letters of intent from each lender must be included.

IV. EVIDENCE OF MARKET DEMAND

Where UDAG funds will be used to write down interest rates for loans for single-family and owner-occupied structures, there must be a demand analysis based on an adequate sample. For investor-owned property, the application must include a commitment letter from each owner under which he commits to borrow the investment the audit shows to be cost effective or an amount negotiated with the city. If he does not invest at least 2 1/2 times the cost of the audit, the investor-owner must also comit to pay for the audit.

V. STAND ALONE AUDIT PROGRAMS

Where UDAG funds are being used for an energy audit program only, each owner of a building targeted for audit must enter into an agreement to invest at least 2 1/2 times the cost of the audit in energy conservation measures or to pay the cost of the audit.

If the amount of energy conservation measures recommended by the audit is less than 2 1/2 times the cost of the audit, and the owner does not invest that amount, the owner will also reimburse the city for so much of the audit cost up to the total cost such that the ratio of the investment committed to the cost of the audit at a minimum will always be 2 1/2 to 1. The city should estimate the amount of the investment which it believes the audit program will produce and must include letters of intent from targeted building owners to participate on the terms described above.

VI. LOAN/GRANT POOL FOR BUILDING REHABILITATION

Any loan/grant pool application designed primarily to provide low-interest rate financing for the rehabilitation of buildings shall include an energy-conservation component, which shall require an energy audit of any structure to be rehabilitated, inclusion of all cost-effective energy conservation measures and adherance to HUD's cost effective energy standards, as part of the rehabilitation loan.

VII. CONSULTANT

Christine McElligott
Department of Housing and Urban Development
451 7th Street, S.W.
Washington, D.C. 20410
(202) 755-0268

APPENDIX H

WIND POWER SYSTEMS

1. Project Description

The project description should include a narrative description of the proposed site, including topography, climate, and physical environment surrounding and immediately adjacent to the proposed installation.

2. Wind Resource

The best available data on the wind resources, including to the extent possible, information on daily, monthly, and annual velocity distribution, as well as data on the characteristics of the collection stations and instrumentation should be submitted.

3. Load Data

Load data for the specific application or the electric power system, to which the machine(s) will be intertied should be provided, including:

- diurnal and seasonal load profiles;
- generation capacity mix by plant size and fuel type; and
- current capacity expansion plans including plant size, type, and capital and fuel cost.

4. Wind Power Equipment

The application should include a discussion of the size and number of wind power systems considered and manufacturers or distributors who will provide the equipment.

5. Development Plan

Provide a time-phased integrated development plan for the project with key milestones.

6. Financial

Provide estimates of the following: project cost; annual and/or monthly energy production; life-cycle cost of energy produced; projected revenues from electricity sold, based on a market survey; letter of intent or sales contract; and internal rate of return over the anticipated life of the equipment, both with and without UDAG assistance.

7. Environmental and Legal

Provide an environmental and legal review of the project to identify potential environmental and legal issues including: zoning, noise, TV interferences, safety, and State Utility Commission regulation.

8. Permit and Licensing

Provide the status of all Federal, state, and local licensing.

9. Technical Consultants

(Systems greater than 100 kw)

Ron Thomas
National Aeronautics and Space Administration
21000 Brookpark Road
Cleveland, Ohio 44135
(216) 433-4000 (Ext. 6134)

Ted Ankrum
Director, Resources Management
Office of Conservation and Solar
Department.of Energy
Washington, D.C. 20585
(202) 252-9258

(Systems less than 100 kw capacity)

Terry Healy
Rockwell International
Rocky Flats Plant
P. O. Box 464
Golden, Colorado 80401
(303) 441-1300

APPENDIX I

ENERGY RECOVERY FROM WASTE

1. Project Description

A narrative description of the nature and type of proposed project, i.e., landfill to methane gas, waste to refuse derived fuels (RDF), or direct energy production from waste should be provided. Describe the method to be used to generate the energy, i.e., bioconversion, combustion, pyrolysis, etc. and how the energy produced will be used. The magnitude of the project in terms of total power generated, number, type, and size of buildings serviced should be described. The compatibility of the waste resources to the proposed conversion and utilization objectives should be addressed. Alternatives to the project, such as recycling centers, source reduction, landfills, or ocean dumping should be discussed.

2. Development Plan

Provide an integrated development plan for all phases of the project, with tasks and key milestones identified. The plan should cover all aspects of the project including all work related to the construction of surface plants, equipment procurement, pipelines, and facilities for the utilization of energy produced. The plan's schedule of tasks and milestones should also include projected completion of all local, state, and Federal environmental requirements and completion of any necessary resource leasing, water rights, and auxiliary landfill arrangements.

The expansion potential of the system without Federal financial subsidies and the scarce fuel savings beyond the segment for which UDAG funding is sought should be estimated. In addition, the development plan should include information on the control of an adequate waste stream supply and on contractual obligations as well as other institutional requirements pertinent to the project's successful implementation.

3. Resource Data

Particular emphasis should be placed on providing information on the nature of the waste stream and the adequacy of supply for successful project operation in the long term.

4. Engineering Design

Complete engineering design and feasibility materials on all components of the waste-to-energy system, including all subsystems for energy conversion and/or transfer, transport, and application, should be submitted.

5. Environmental Assessment

A project may be subject to local, county, state, and/or national environmental statutes. Provide an assessment of the applicable environmental regulations for the proposed site and utilization. The successful completion of all applicable environmental requirements should be specified as tasks and milestones in the overall project development plan.

6. Legal Requirements

Provide substantiation that all legal requirements have been met or are scheduled and integrated into the development plan. These include, but are not limited to, resource rights, water rights, zoning regulations, local and state licensing, disposal permits, local noise abatement requirements, and other such regulatory permits or certifications necessary for the project's implementation and operation.

7. Economic Feasibility Assessment

An economic feasibility assessment of the project which includes all project costs and estimating assumptions, cash flow, capital amortization, internal rate of return, discounted cash flow, both with and without the UDAG funds requested, should be submitted. The assessment should also include a market study for the end product of the project. The market study should address such items as the project unit cost and price and demand compared to other energy sources. Information on building stock and related heating systems to be serviced by the energy end product should be provided. Letters of intent or similar evidence that customers in the proposed and product service area will use the new energy supply at the marketing study prices should be submitted to indicate that the project is economically viable.

8. Technical Consultants

Charlotte Rines, Program Manager
Department of Energy
Forrestal Building
Room 1F069
Washington, D.C. 20585
(202) 252-9397

Donald K. Walter, Chief
Department of Energy
Forrestal Building
Room 1F088
Washington, D.C. 20585
(202) 252-9397

APPENDIX J

Recycling or Reclamation Facilities or Systems

1. Project Description

Describe the proposed recycling or reclamation system including a description of the site, the facilities and equipment; and the method of collection and subsequent processing of the recovered materials as well as the transportation system to be utilized in moving the materials to market. In addition, the description should provide an overview of the benefits to be derived by the community including energy savings, employment potential and materials recovered. The description should explain how the proposed project is related to the overall materials management plan for the community.

2. Development Plan

Provide a time-phased integrated development plan for all phases of the project with key milestones identified. The expansion potential of the system should be discussed.

3. Economic Feasibility Assessment

Provide an economic feasibility assessment which includes all project costs and estimating assumptions, cash flow, capital amortization, and internal rate of return, both with and without the UDAG requested. Since the project is dependent on the marketability of the materials recovered, analysis of the market demand shall be presented.

4. Environmental Assessment

A project may be subject to local, county or state environmental statutes and/or the national environmental protection laws. Provide assessment of the applicable environmental regulations for the proposed facility and or program. Include in the development plan all tasks and key milestones denoting the successful completion of environmentally associated requirements.

5. Legal Requirements

Provide substantiation that all legal requirements have been met or are scheduled and integrated into the development plan. These include but are not limited to local and state requirements, including but not limited to, licensing, zoning and other such regulatory permits necessary for the projects' implementation and operation.

6. Technical Consultant

Dr. Harvey Yakowitz
Office of Recycled Materials
National Bureau of Standards
Department of Commerce
Washington, D.C. 20234
(202)921-2621

APPENDIX K

Solar Thermal Energy Systems

1. Introduction

Solar thermal energy systems collect or concentrate heat from the sun to produce hot water or steam. The basic types are flat plate, parabolic trough, disk, and central receiver collectors. The commercial applications which appear most feasible at present are community district heating systems and process heat applications in industries such as food processing, chemicals, enhanced oil recovery, brick, clay, and glass manufacturing, textitle manufacturing, and laundries which use large volumes of heated water or steam.

2. Project Description

Provide a description of the solar thermal resource, the proposed utilization project, how the solar thermal energy will be used (i.e., generate steam, space heating, etc.) and the magnitude of the project (i.e., total steam power (psi) generated; number, type, size of industrial process). The compatibility of the solar thermal resource and the proposed utilization should be discussed and should include temperature, peak power requirements of the application, and flow, temperature, and capacity estimates for the solar thermal resource.

3. Development Plan

Provide a time-phased integrated development plan for all phases of the project with key milestones. The development plan should cover all aspects of the project including investigations and field operations to further explore and define the solar thermal resource, construction of all surface plants, equipment procurement, pipelines, and utilization facilities. Tasks and milestones should also be establishedfor completion of associated phases of the project such as completion of an Environmental Impact Statement (if required), and their integration into the construction schedule. The expansion potential of the system without Federal financial subsidies and the scarce fuel savings, beyond the segment for which UDAG funding is sought, should be estimated.

4. <u>Resource Data</u>

Provide data sufficient to describe the solar thermal resource and compatibility with the project. Systems must be sized according to the best match between energy requirements and systems capacity at peak demand.

5. <u>Environmental Assessment</u>

A project may be subject to local, county, or state environmental statutes and/or the National Environmental Protection laws. Provide an assessment of the applicable environmental regulations for the proposed site and utilization. Include in the development plan all tasks and key milestones denoting the successful completion of environmentally associated requirements.

6. <u>Legal Requirements</u>

Provide substantiation that all legal requirements have been met or are integrated into the development plan. These include, but are not limited to appropriate zoning; compatibility with existing zoning, including access to sunlight; regulatory requirements; permits, licenses and approvals required.

7. <u>Economic Feasibility Assessment</u>

Provide an economic feasibility assessment which includes all project cost and estimating assumptions, cash flow, capital amortization, and internal rate of return, both with and without the UDAG requested. The economic feasibility should include a market study for the end product of the project. The market study should address such items as the product unit cost, price and demand, compared to other energy sources. For purposes of consistency, economic feasibility assessments must be based upon the Dickenson methodology.* In addition, the feasibility assessment should include a comparison of life-cycle cost between one standard site, i.e., Albuquerque, N.M., and the proposed site. Subsystems cost estimates are also required, including collectors, structure, piping, mechnical and electrical components, controls, instrumentation, and site preparation.

*Dickenson, W.C. and K.C. Brown, <u>Economic Analysis of Solar Industrial Process Heat Systems</u>, Lawrence Levermore Laboratory, VCRL 52814, August 17, 1979.

8. Technical Consultants

David Moore
Program Manager
Solar Heating & Cooling
Demonstration Program
Office of Policy Development
and Research
Department of Housing & Urban
Development
451 7th Street, S.W.
Washington, D.C. 20410
(202)755-6900

Walter Schimmel
Systems Analysis Division 4723
Sandia National Laboratories
Albuquerque, New Mexico 87185
(505)844-9904

APPENDIX L

Photovoltaic Manufacturing Facilities

1. Introduction

Photovoltaic energy systems involve the direct conversion of sunlight into electricity, silently and with no internal moving parts. At present, the two approaches that have established technical feasibility are flat plate arrays and concentrating collectors. While technical feasibility is a demonstrated fact, the current high cost of systems confines their use to small-scale, remote applications. To achieve significant fuel displacement, photovoltaic systems must be capable of producing electricity at a cost competitive with utility-generated electricity from conventional sources.

The objective of the Department of Energy is to reduce system costs to a competitive level in both distributed and centralized grid connected applications. DOE's current module price goals for commercially available hardware in 1980 dollars for both flat plate and concentrating modules are:

Module Price (1980 $)	Commercially Ready
$2.80/peak watt	1982
$0.70/peak watt	1986
$0.15-0.40/peak watt	1990

HUD is interested in organizations which will build photovoltaic manufacturing facilities in distressed cities, counties, or pockets of poverty. DOE will support HUD in the evaluation of submitted proposals and is particularly interested in organizations that can meet or exceed these price goals.

2. Project Description

A narrative description of the manufacturing process should be submitted. The applicant should fully discuss the input material; the output product in terms of size, power, module efficiency, quantity, price per module and price per watt; the initial plan characteristics in terms of size, land area, manufacturing area, facilities cost and equipment costs; and the operating plant characteristics. The description should explain why a UDAG is necessary for the project.

3. Development Plan

Provide a time phased, integrated development plan for all phases of the project with key milestones identified. The expansion potential of the facility should be discussed.

4. Engineering Design

A complete engineering design of the plant should be submitted in a form suitable for evaluation by the Solar Array Manufacturing Industry Costing Standard (SAMICS), available through the Jet Propulsion Laboratory for flat plate and Sandia Laboratories for concentrator modules.

5. Environmental, Occupational Health and Safety, Legal

The project may be subject to local, county, state, or Federal environmental and worker occupational health and safety statutes. An assessment of applicable environmental and occupational health and safety regulations should be made. Evidence that all legal requirements have been met or are scheduled and integrated into the development plan should be provided. These include but are not limited to local and state licensing, zoning, and other such regulatory permits required for the project's implementation and operation.

6. Economic Feasibility Assessment

Provide an economic feasibility assessment which includes all facility cost and estimating assumptions, cash flow, capital amortization, and internal rate of return, both with and without the UDAG requested. A business plan, including an analysis of the market demand should be presented. The market study should address such items as the product unit cost, price and demand, compared to other energy sources.

7. Technical Consultants

Dr. William Callaghan
Jet Propulsion Laboratories
4800 Oak Grove Drive
Pasadena, California 91003
(213)577-9517

Dr. Donald Schueler
Sandia Laboratories
Albuquerque, New Mexico 87115
(505)264-4041

Dr. Leonard Magid
Department of Energy
600 E Street, N.W.
Washington, D.C. 20585
(202)376-1958

APPENDIX M

LOW AND MEDIUM BTU GASIFICATION FACILITIES

1. Introduction

Low and medium BTU gasification involves the generation of combustable gas using heat processes from a variety of fuels such as coal, agricultural wastes, timber wastes, urban refuse and other organic materials. Low BTU gasification systems are relatively simple in design and maintenance and produce gas with a heating value of less than 200 BTU per cubic foot. Medium BTU processes are more expensive and complex and produce gases with heating values between 200 and 600 BTU per cubic foot.

2. Project Description

The project description shall be a narrative discussion of the project including the background, current activities, future plans and potential as relevant to the project. The project description shall be complete to the extent that, without supporting material, the reader will be knowledgeable about the project.

3. Development Plan

Sufficient information shall be presented to determine the technological feasibility of the proposed project. The assessment shall provide a rationale for the process selection and analyze the uncertainties surrounding the commercial application of the process. Included in this section should be the following information:

a process flow diagram;
energy and mass balances;
major equipment requirement;
site layouts;
supporting raw material resources (ie: fuel, water, power);
design, procurement and construction schedule.

4. Economic and Financial Analysis

This section should analyse the financial and economic feasibility of the proposed project to produce synthetic gas at competitive prices. The analysis would be expected to include: total capital requirements including appropriate breakout of the capital components; income and cash flow projections; risk analysis of the economic incentives affecting all technical, cost, environmental, timing and raw material estimates; and a sensitivity analysis of the project economics to changes in the various major factors of the project (ie: project size, feedstock cost, DCF, interest rates, capital requirements, etc.)

5. Market Analysis

The analysis should typically include market composition, size and the pertinent competitive market factors, both current and future, that are important to the project.

6. Siting

An analysis of rationale for the selected site should be included.

7. Environmental, Health, Safety and Socioeconomic Assessment

An examination of those issues that are likely to have the most impact on the permitting and scheduling of the proposed facility should be included. Specifically, the effort should result in being able to: (1) determine whether the proposed facility can meet and on what time schedule, Federal, State and local statutory and regulatory requirements; (2) identify the principal regional and local concerns which might arise if the facility were constructed; (3) ensure that environmental, health, safety, and socioeconomic considerations are an integral component of all subsequent planning and decisions.

8. Technical Consultants

Coal Gasification

Mr. Edward C. Luthy
U.S. Department of Energy
Resource Applications
Office of Low/Medium BTU Coal Gasification
12th & Pennsylvania Avenue, N.W.
Mail Stop 3344, Room 3446
Washington, D.C. 20461
(202) 633-9195

Biomass Gasification

Mr. Gary Schiefelbein
Pacific Northwest Laboratory
Box 999
Richland, Washington 99352
(509) 375-2140

Appendix B

ROCHESTER GAS AND ELECTRIC CORPORATION RESPONSE TO STAFF QUESTIONS PURSUANT TO COMMISSION ORDER IN CASE 27566

Rochester Gas and Electric Corporation

Response to Staff Questions Pursuant
to Commission Order in Case 27566

Q. 1 Why has the steam system lost so many customers?

(a) Did they go out of business?

(b) Did they shift to alternate fuels?

(Fuel type and cost of conversion)

(c) Have the uptown and downtown systems been affected similarly?

Rochester Gas and Electric Corporation

Response to Staff Questions Pursuant
to Commission Order in Case 27566

A. 1 (a) The attached four lists of customer losses and one of customer gains over the period July 1970 through March 1980, will provide an answer as to the reasons the number of steam customers has decreased from 472 to 308 over this decade. During the early 1970's the primary loss of customers was due to demolition by urban renewal and building owners, whereas in the more recent years the losses are due to the increasing costs of steam. Certain of the demolitions resulted in new customers coming on the system such as Lincoln First Tower. In the Southeast Loop and South Avenue Ramp Garage demolition areas, only one new customer was gained, this being Manhattan Square Park with an annual use of 374 "M". Many owners of old, uninsulated buildings faced with the cost of upgrading the structure and heating system found using the land for automobile parking lots more lucrative. Some owners cannot afford demolition and are unable to sell or rent their buildings. Such buildings stand vacant. A resume of losses follows.

	LOSSES TO CONVERSIONS	LOSSES DUE TO DEMOLITION URBAN RENEWAL	LOSSES DUE TO DEMOLITION BUILDING OWNERS	OTHER LOSSES	GAINS
1970	3	8	2	1	1
1971	2	10	9	0	4
1972	2	9	8	0	5
1973	0	2	10	1	0
1974	2	5	5	1	2
1975	2	8	5	2	6
1976	5	2	5	2	3
1977	10	4	2	5	1
1978	12	1	7	4	1
1979	17	2	1	3	0
1980	6	1	0	1	0
TOTAL	61	52	54	20	23

Steam Customers Converted to Other Fuels

Customer	Address	Date	Annual "M" Lbs.	Comment
Women's Ed. & Ind. Union	86 North St.	6/70	530	Gas
Molly Matlow	354 State St.	10/70	190	Gas
American Excelsior *	8 Cairn St.	10/70	610	Gas
North American Molding *	325 Mt. Read Blvd.	1/71	720	Gas
Vern & Nels Restaurant	454 Main St. W.	5/71	90	Gas
J. Antonelli Stores	291 East Ave.	1/72	2,800	Gas
Silver Dry Cleaners	350 State St.	8/72	125	Oil
D. Schiano	442 Main St. W.	11/74	140	Unknown
Midtown Holdings	77 Chestnut St.	12/74	100,000	Converted air cond. to electric drive
133 East Ave. Corp.	133 East Ave.	3/75	700	Oil
Asphaltic Concrete Co.*	155 McKee Rd.	3/75	1,400	Oil
McCurdy & Co.	285 Main St. E.	1/76	43,500	Oil - converted to gas 2/78
National Casket Co.	142 Exchange St.	2/76	1,800	Oil
D.G.& S. Realty	250 Mill St.	2/76	1,500	Oil
Dixie Wig	170 Main St. E.	3/76	90	Electric
Harmin Jewelers	172 Main St. E.	4/76	98	Electric
Perticone & Kaplan	241 Alexander St.	1/77	2,546	Oil
Frank Perticone	253 Alexander St.	3/77	6,796	Oil
Dencor Dev. Corp.	8 Prince St.	4/77	4,310	Oil
Staub Cleaners	951 Main St. E.	4/77	8,880	Oil - has applied for gas
384 East Ave. Inc.	384 East Ave.	7/77	1,612	Oil
J. B. Davie Co.	178 Water St. N.	9/77	816	Oil

Steam Customers Converted to Other Fuels

Customer	Address	Date	Annual "M" Lbs.	Comment
Shantz Assoc.*	20 Symington Place	9/77	858	Oil
Halpar Tool *	20 Symington Place	9/77	1,077	Oil
Eastwood Assoc.	111 Clinton Ave. N.	11/77	513	Electric Heat Pump
J. E. Kennedy	30 Scio St.	11/77	882	Oil
111 East Ave. Inc.	111 East Ave.	1/78	12,000	Oil - has applied for gas
R. Gordon (Reynolds)	16 Main St. E.	2/78	5,948	Oil - has applied for gas
50 Chestnut Plaza	50 Chestnut St.	3/78	11,500	Oil - has applied for gas
Arcade Sandwich Shop	16 Main St. E.	4/78	288	Electric Water Heater
G & G Cheese	107 North St.	5/78	35	Gas
Kaplan and Perticone	237 Alexander St.	5/78	493	Oil
Tom Izzo	21 Stillson St.	5/78	260	Electric
Mario Cerame	80 Main St. W.	6/78	1,140	Gas
Jewish Veteran's Memorial Home	70 Grove St.	7/78	661	Gas
Joseph F. Consul	21 Stone St.	9/78	51	Gas
Wm. Eastwood & Sons, Co.	29 East Ave.	9/78	168	Gas
Donatelli, Inc.	23 Stillson St.	9/78	222	Electric
Hauser Machine Co.	117 Platt St.	1/79	455	Gas
Hoffend Rochester Decorators	186 N. Water St.	1/79	230	Gas
U of R Eastman School of Music	26 Gibbs St.	3/79	21,205	Gas & Oil
Jasco Tools, Inc.	195 St. Paul St.	4/79	446	Gas
Rich Coffee *	20 Symington Place	4/79	221	Gas
Uhlen Carriage Co.	416 St. Paul St.	4/79	386	Gas

Steam Customers Converted to Other Fuels

Customer	Address	Date	Annual "M" Lbs.	Comment
City of Rochester	78 Browns Race	5/79	783	Electric
J. Gukey Assoc.	146 Broad St. W.	5/79	154	Gas
Farash Const. Co.	155 Broad St. W.	9/79	4,371	Gas
Rochester Chamber of Comm.	55 St. Paul St.	9/79	6,574	Gas
Caldwell Manufacturing	64 Commercial St.	10/79	1,761	Gas
Walblatter	418 St. Paul St.	11/79	1,209	Gas
Rochester Drugs	320 Goodman St. N.	11/79	3,585	Gas
Genesee Valley Club	421 East Avenue	11/79	4,744	Gas
Bonds	10 Gibbs St.	12/79	2,370	Gas
Bethel Full Gospel	339 East Avenue	12/79	4,910	Gas
Gurell Associates	233 Alexander St.	12/79	538	Gas
Association for Blind	422 Clinton Ave. S.	1/80	3.128	Gas
Builders Exchange	65 College Ave.	1/80	1.063	Gas
Monroe High School	164 Alexander St.	2/80	24,445	Gas
Norry Co.	370 East Ave.	2/80	2,497	Gas
Marc Four Bowling *	588 West Ave.	3/80	491	Gas
Monroe Laundromat	270 Monroe Ave.	3/80	566	Gas

*Station 9 district. All others are Station 3 & 8 district.

Customers Lost to Urban Renewal and U.D.C. Activities
(All Station 3 & 8 district)

Last Customer	Address	Date	Annual "M" Lbs.	Comments
Morris Epstein	36 Monroe Avenue	2/70	2,770	Demolition Southeast Loop
Louis J. Camarella	40 Monroe Avenue	2/70	180	Demolition Southeast Loop
Lew Yick	16 Monroe Avenue	8/70	300	Demolition Southeast Loop
Jerry Apple	22 Monroe Avenue	9/70	725	Demolition Southeast Loop
S.E. Loop Field Office	276 Clinton Ave. S.	10/70	1,745	Demolition Southeast Loop
S.E. Loop Urban Renewal	215 Clinton Ave. S.	10/70	4,250	Demolition Southeast Loop
Security Trust Company	103 Main Street E.	12/70	4,100	Building vacant.
Security Trust Company	43 S. Water Street	12/70	950	Building vacant
S.E. Loop Urban Renewal	225 Chestnut St.	3/71	1,700	Demolition Southeast Loop
S.E. Loop Urban Renewal	202 Chestnut St.	3/71	1,300	Demolition Southeast Loop
3 Hour Laundry	200 Clinton Ave. S.	5/71	2,750	Demolition Southeast Loop
Dick's 43 Restaurant	43 Stone Street	5/71	240	Demolition South Ave. Ramp
I. Gordon Realty Corp.	39 Stone Street	5/71	510	Demolition South Ave. Ramp
Elizabeth Clark	26 South Avenue	5/71	450	Demolition South Ave. Ramp
John C. Moore	67 Stone Street	5/71	2,550	Demolition South Ave. Ramp
Ryan & McIntee, Inc.	207 Chestnut St.	9/71	400	Demolition Southeast Loop
Roch. Iron & Metal	309 St. Paul St.	9/71	700	Demolition Upper Falls U.R.
Artco Coverall	395 St. Paul St.	10/71	6,200	Demolition Upper Falls U.R.
John Lenzi	12 Saratoga	2/72	2,760	Demolition Brown Square
Lee Mor Stores, Inc.	113 Main St. E.	3/72	260	Vac. - Canal Town Cause
Uhlen Carriage	18 Ward Street	3/72	570	Demolition Upper Falls U.R.
City of Roch. (Firehouse)	165 Chestnut St.	4/72	870	Demolition Southeast Loop
Patchen Post, Inc.	185 Chestnut St.	5/72	230	Demolition Southeast Loop
Hollycroft Apts.	400 Broad St. E.	7/72	2,200	Demolition Southeast Loop
Chesterfield Apts.	393 Broad St. E.	8/72	6,125	Demolition Southeast Loop

Customers Lost to Urban Renewal and U.D.C. Activities

Last Customer	Address	Date	Annual "M" Lbs.	Comments
Inez Wishman	211 East Avenue	12/72	1,280	Demolition Southeast Loops
Lilac Laundry	1 Cork Street	1/72	9,700	Fire-Demolition U.F.U.R.
City of Rochester	137 Chestnut St.	7/73	1,400	Demolition Southeast Loop
City of Rochester	143 Chestnut St.	7/73	925	Demolition Southeast Loop
Auto Club of Roch.	190 Chestnut St.	2/74	615	Demolition Southeast Loop
City of Rochester	185 East Avenue	6/74	425	Demolition Southeast Loop
City of Rochester	205 East Avenue	6/74	500	Demolition Southeast Loop
City of Rochester	158 Clinton Ave. S.	6/74	2,100	Demolition Southeast Loop
City of Rochester	2 Broadway	10/74	1,500	Demolition Southeast Loop
Marfil Prop., Inc.	237 East Avenue	2/75	250	Demolition Southeast Loop
Thomas Haney	235 East Avenue	8/75	200	Demolition Southeast Loop
Zissi Kerxhalli	241 East Avenue	8/75	350	Demolition Southeast Loop
F. R. Sheehan	253 East Avenue	9/75	225	Demolition Southeast Loop
Louric Realty	105 Main St. E.	9/75	450	Unoccupied Caused by Canal Town Indecision
Louric Realty	15 South Avenue	9/75	450	Unoccupied Caused by Canal Town Indecision
Bausch & Lomb Co.	47 Bausch Street	10/75	5,500	Partial Demolition U.D.C.
Bausch & Lomb Co.	635 St. Paul St.	12/75	206,000	Vacant
Executors of Roch.	245 East Avenue	4/76	337	Demolition Southeast Loop
City of Rochester	229 East Avenue	5/76	768	Demolition Southeast Loop
Rudolph Schmidt & Co.	33 South Avenue	1/77	722	Demolition/Canal Town
Willsea Works	371 St. Paul St.	5/77	2,138	Vacant Upper Falls
Action for a Better Community, Inc.	255 East Avenue	10/77	646	Vacant - To be demolished
Monroe Board of Elec.	140 Fitzhugh St. N.	11/77	0	Demo - New City Hall
Columbia Bank & Loan	426 Main St. East	5/78	1,564	C of R Cultural Center Development
Scio Swan Corp.	455 Main St. East	1/79	1,647	Vacant Cultural Dist.
City of Rochester	191 East Ave.	6/79	1,470	Demo - Southeast Loop
St. Vincent Press	136 North St.	3/80	272	Vacant Cultural Dist.

STEAM CUSTOMERS TERMINATED
VARIETY REASONS

CUSTOMER	ADDRESS	DATE	"M" Lbs.	COMMENTS
P. Pizzingrilli	18½ St. Paul St.	6/70	513	Building vacant
Suss Leaf State Cor.	39 State St.	11/73	4,700	Building vacant
A.B.C. Billiards	373 Main St. E.	10/74	525	Building, tenant moved
B.Y.G. Corp.	72 Franklin Street	4/75	1,000	Building vacant
City of Rochester	67 Mortimer St.	8/75	925	Ramp Garage - Now Unheated
269 Lyell Realty	165 St. Paul St.	8/76	783	Building vacant
City of Rochester	1 Falls Street	10/76	8,431	Building vacant
35 East Avenue Corp.	35 East Avenue	5/77	434	Building vacant
Rochester Stationery	497 State St.	6/77	1,430	Building vacant
Arnold Kolvalsky	184 St. Paul St.	6/77	306	Building vacant
M&M Stathz Bldg.	163 St. Paul St.	9/77	1.650	Building vacant
Dorhelmar Corp.	67 South Avenue	12/77	1,687	Building vacant
City of Rochester	250 South Avenue	4/78	3,075	Building vacant
Odd Fellows Union	11 Clinton Ave. N.	5/78	727	Building vacant
Weston	53 Canal St.	5/78	640	Building vacant
Toth Cleaners *	545 West Avenue	6/78	453	Building, tenant moved
Axtec	175 St. Paul St.	6/79	183	Building vacant
City of Rochester	225 Clinton Ave. S.	11/79	5,332	Building vacant
Bond Stores	288 Martin St.	12/79	30,663	Factory vacant
Hickey-Freeman	90 Canal St.	1/80	3,230	Building, tenant moved
		TOTAL-TO-DATE	65,688	

*Station 9 district. All others are Station 3 & 8 district.

Steam Served Buildings Demolished by Owners

Customer	Address	Date	"M" Lbs.	Comment
Rol-Sal Restaurant	19 Clinton Ave. N.	6/73	240	Parking Lot
Eastman Kodak Company	19 Otsego St.	6/73	1,900	Parking Lot
Eastman Kodak Company	21 Otsego St.	6/73	365	Parking Lot
First National City Bank	381 Main St. E.	7/73	775	Parking Lot
Regent Theatre	65 East Avenue	10/73	2,000	Parking Lot
Eastman Kodak Company	232 Mill Street	1/74	225	New Holley Pump
Martina & Paramount	35 Clinton Ave. N.	1/74	2,000	Parking Lot
Bryan Drug House	92 Main St. W.	3/74	280	Fire - Vacant Lot
Roscoe Realty	95 Frankfort St.	10/74	425	Fire
Bourjois, Inc.	33 Capron St.	11/74	6,900	Parking Lot
Clinton Avenue Restuarant	29 Clinton Ave. N.	4/75	200	Parking Lot
Wax-Rite Products	116 Fitzhugh St. N.	5/75	950	New City Hall
Rochester Stationery	8 Jay St.	8/75	3,500	Parking Lot
Croci Ippolito	93 Jay St.	9/75	300	Parking Lot
Clintstone Properties	47 Clinton Ave. S.	11/75	1,200	Parking Lot
R.I.T.	55 Plymouth Ave. S.	1/76	3,831	Demo-Rebuilt-Gas
Powers Ramp Garage	20 Fitzhugh St. N.	7/76	752	Parking Lot
Mill Street Parking	255 Mill St.	9/76	110	Parking Lot
Ainslow Apts.	56 Chestnut St.	10/76	3,252	Parking Lot
Rochester Jobs, Inc.	61 Jay Street	12/76	242	Parking Lot
Chamberlain Rubber	53 Scio St.	1/77	2,271	Fire - Vacant Lot
Edwin Cohen	71 State St.	11/77	600	Parking Lot
Gunther Kranz	104 Clinton Ave. N.	1/78	246	Fire
Elbow Room	252 State Street	2/78	765	Fire - Parking Lot
Fladd-Luig Co.	30 Platt Street	5/78	304	Vacant to be dem.
M&J Rubens	103 State St.	7/78	375	Parking Lot

Steam Served Buildings Demolished by Owners

(All Station 3 & 8 district)

Customer	Address	Date	Annual "M" Lbs.	Comment
Marine Midland	33 Exchange St.	6/70	2,100	Parking lot
Sams Valet	127 Clinton Ave. S.	10/70	80	Parking lot
Central Trust	21 Clinton Ave. S.	3/71	2,850	For Lincoln First
Woolworth	211 Main St. E.	3/71	3,010	For Lincoln First
Three Sisters	219 Main St. E.	3/71	835	For Lincoln First
W. H. Gorsline	385 Main St. E.	6/71	575	For Lincoln First
133 S. Clinton Corp.	133 Clinton Ave. S.	11/71	3,350	Parking lot
Monroe City Jail	180 Exchange St.	12/71	6,000	Parking lot
Monroe City Garage	160 Exchange St.	12/71	1,660	Parking lot
Monroe City Garage	168 Exchange St.	12/71	3,600	Parking lot
McFarlin Clothing	195 Main St. E.	4/71	3,125	For Lincoln First
Inez Wishman	202 Court St.	5/72	900	Parking lot
Inez Grassi	149 Clinton Ave. N.	7/72	4,450	Fire - Vacant Lot
Levis Music Store	412 Main St. E.	8/72	655	Parking lot
School of Holy Childhood	215 Andrews St.	9/72	1,100	Parking lot
Jewelery & Diamond	90 East Ave.	9/72	135	Parking lot
First National City Bank	80 East Ave.	11/72	210	Parking lot
First National City Bank	11 Gibbs St.	11/72	1,100	Parking lot
Horton Headquarters	66 East Ave.	11/72	0	Parking lot
Michael Crandal	84 East Ave.	6/73	50	Parking lot
George Perrotta	7 Gibbs St.	6/73	90	Parking lot
2nd Church Christ Scientist	88 East Ave.	6/73	120	Parking lot
W. H. Gorsline	72 East Ave.	6/73	780	Parking lot
Wilson Sinclair Co.	182 Commercial St.	6/73	800	Parking lot

CUSTOMER GAINS

Customer	Address	Date	Annual "M" Lbs.
Holiday Inn	120 Main Street E.	9/70	22,930
American Laundry Mach. *	70 Glide St., Bldg. A3N	1/71	5,804
" " " *	70 Glide St., Bldg. 2	1/71	13,727
S. C. Toth *	545 West Avenue	4/71	453
Artco Laundry	331 Main St. W.	8/71	7,582
Clintstone Properties	31 Clinton Ave. S.	2/72	32,592
City of Rochester	305 Monroe Ave.	3/72	1,979
McFarlins Store	26 Clinton Ave. S.	4/72	544
Central Trust Bank	20 Clinton Ave. S.	6/72	760
General Ser. Admin.	100 State St.	11/72	13,809
Lipani Bakery	522 Plymouth Ave. N.	6/74	1,666
Rochester Area TV	280 State St.	10/74	1,432
Shepherd Showcase	12 Commercial St.	4/75	295
Crossroads Apartments	125 St. Paul St.	5/75	27,355
Corpus Christi Church	864 Main St. E.	9/75	2,026
Manhattan Square Park	130 Chestnut St.	9/75	374
Medical Associates	1 Strathallen	10/75	499
General Plating	850 St. Paul St.	12/75	2,648
Vilmaz Baris	48 St. Paul St.	1/76	395
1st Federal Sav. & Loan	38 Main St. E.	11/76	12,057
Lincoln First Bank	26 Clinton Ave. S.	12/76	7,470
Genesee Brewing Co.	587 St. Paul St.	12/77	4,083
Mixing Equipment Co.	69 Cascade St.	1/78	812

*Station 9 district. All others are Station 3 & 8 district.

Steam Served Buildings Demolished by Owners

Customer	Address	Date	"M" Lbs.	Comment
Eastman Kodak Co.	395 State St.	8/78	467	Vacant Lot
Eastman Kodak Co.	407 State St.	8/78	997	Vacant Lot
DHW Properties, Inc.	116 North St.	11/78	336	Vacant to be dem.
St. Patricks Church	453 Plymouth Ave. N.	7/79	816	Parking Lot

Rochester Gas and Electric Corporation

Response to Staff Questions Pursuant
to Commission Order in Case 27566

A. 1. (B) Fuel type of conversion is answered under reply given in 1 (A). A list of some recent costs of conversions follows. It is noted that we experienced some reluctance by customers/owners to divulge cost data. Also, costs include, in certain instances, other work on the building heating systems. For instance conversion of Caldwell Manufacturing includes changing from a steam to a hot water heating system. A breakdown of this cost is not available.

CUSTOMER	ANNUAL USE "M" LBS.	DATE OF CONVERSION	APPROXIMATE COST OF CONVERSION
J. J. Gukey Associates, Inc. 146 Broad Street East	154	5/79	$ 3,500
Farash Construction 155 Broad Street East	4,371	9/79	$ 75,000
Rochester Chamber of Commerce 55 St. Paul Street	6,574	9/79	$ 55,000
Caldwell Manufacturing Co. 64 Commercial Street	1,761	10/79	$ 68,000
Rochester Drugs 320 Goodman Street North	3,585	11/79	$ 25,000
Genesee Valley Club 421 East Avenue	4,744	11/79	$ 55,000
Guy Bondi 10 Gibbs Street	2,370	12/79	$ 20,000
Bethel Full Gospel Church 339 East Avenue	4,910	12/79	$ 22,000
Gurell Associates 233 Alexander Street	538	12/79	$ 7,500
Association for the Blind 422 Clinton Avenue South	3,128	1/80	$ 28,000
Builders Exchange 65 College Avenue	1,063	1/80	$ 18,000
Monroe High School 164 Alexander Street	24,445	2/80	$240,000
Norry Company 370 East Avenue	2,497	2/80	$ 25,000
Marc Four Builders 583 West Avenue	491	3/80	$ 8,000
Monroe Laundromat 270 Monroe Avenue	566	3/80	$ 5,800

Appendix C

COMPUTER SIMULATION PROGRAM TO MODEL THE PRESSURE-FLOW RELATIONSHIP OF STEAM DISTRIBUTION SYSTEMS

(Stoner Associates, Inc., Carlisle, Pennsylvania)

Users Guide

GAS STEADY STATE (GASSS)

PREFACE

This publication provides a detailed description of the Gas Steady-State Piping System Program (GASSS). GASSS is a digital computer program which can be used to determine the balanced steady-state pressure-flow relationship for an isothermal gas network system composed of pipelines, compressors, and regulators. The program was designed using modern equation-solving techniques to provide fast convergence of the model equations, resulting in a low-cost simulation.

This edition of the *GASSS Users Guide* supersedes and obsoletes all previous editions.

GASSS is a gas network analysis program developed by Stoner Associates, Inc., Box 86, Carlisle, Pennsylvania 17013.

Neither National CSS, Inc., nor Stoner Associates, Inc., assumes responsibility for any errors that may occur during the operation of this program, or errors in interpreting the results of this program.

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GASSS is a trademark of Stoner Associates, Inc.

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Because the equation of state has been included in the integration, this equation should be valid for the flow of dry, saturated steam having any pressure drop, or any length of pipeline.

In the evaluation of the friction factor, Reynold's Number is computed from the following equation:

$$\text{Reynold's Number} = \frac{Q}{3.14\ 75\ D\ \gamma}$$

The viscosity of the steam should be read as a system variable on the fifth line of system variable input. An average value for the viscosity of dry saturated steam in the 100-300 psi range is .0000137 pounds/ft.-sec.

Association of variables with NCE input positions:

- X1 – pipeline diameter.
- X2 – pipeline length in feet or miles.
- X3 – Darcy-Weisbach friction factor, default value can be used.
- X4 – pipe roughness in inches, default value can be used.
- X5 – equivalent length multiplier

If the Moody diagram switch of line 5 of the input data is on, the friction factor will be computed as a function of Reynold's Number and relative roughness. If the switch is off, then the friction factor read through the X3 variable will be used throughout the flow balancing computation. When using the GASSS program for the solution of steam problems, the fourth line of the data file should contain SUPOFF. On the fifth line, only the base pressure, default friction factor, default roughness, viscosity and Moody switch are effective. An example steam system analysis is included in Section 8.

MUNICIPAL STEAM SYSTEM EQUATION

Designator Characters 'FS'

A pressure-flow equation has been provided for the analysis of municipal steam systems in which the flow unit is pounds of steam per hour or thousands of pounds of steam per hour. When this equation is used, the flow unit designator of LB/HR or MLB/HR, respectively, should be used on line 2 of the input data file along with a pressure unit of PSIG.

The equation used is developed from the flow equation for a compressible gas in which the gas is assumed to be dry, saturated steam, where the relationship between density and pressure is of the following form:

$$\rho = \frac{P^{.946}}{343.4}$$

The basic differential flow equation is as follows:

$$dP + \frac{f \rho V^2}{2D} dx = 0$$

which, when combined with the mass flow rate equation $Q = \rho AV$ results in a differential equation of the following form:

$$\rho dP + \frac{f Q^2 dx\, 5280.}{(32.2)(3600.^2)2.DA^2 (144.)}$$

If the relationship for density from the above equation of state is used, and the equation integrated with respect to P and x, a flow equation of the following form results:

$$Q = D^{2.5} \sqrt{\frac{(32.2)(3600.^2)(2.)(9.88)}{(1.946)(343.4)(16.)(144)(12.)(L)(5280.)}} \sqrt{\frac{P_1^{1.946} - P_2^{1.946}}{f}}$$

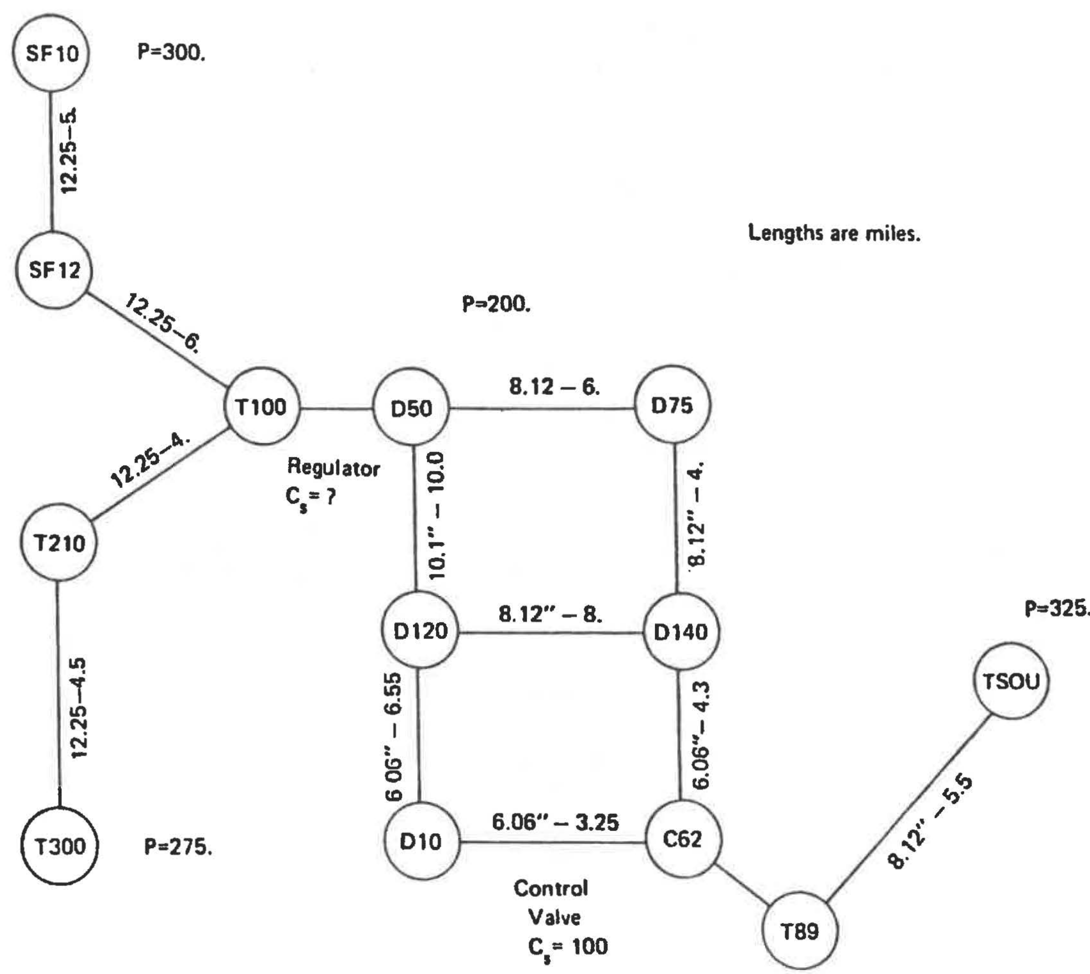
where

- Q = steam flow rate in pounds/hour.
- D = diameter of the pipe in inches.
- L = length of the pipe in miles.
- P_1 = pressure at the upstream point, psia.
- P_2 = pressure at the downstream point, psia.
- f = the Darcy-Weisbach friction factor, determined from a Reynold's Number relative roughness equation.

EXAMPLE 4 – ANALYSIS OF A STEAM DISTRIBUTION NETWORK

GASSS is useful for analyzing the steady-state pressure-flow relationship for a municipal steam system. The following example shows the use of the Fundamental Steam Equation, the use of the Fisher Regulator to determine a valve sizing constant, and the use of this element as a control valve. The Fundamental Steam Equation is a friction factor type equation with a Darcy-Weisbach friction factor determined as a function of Reynold's Number. The equation of state for dry saturated steam is used in this flow equation. The example also uses the GASSS load generator to establish the loads on the network.

The following schematic depicts the sample steam system. There are three supply points to the system, nodes SF10, T300 and TSOU. The sources of steam at these three nodes have a pressure of 300 pounds, 275 pounds, and 325 pounds, respectively.



The core of this system is a lower pressure limited system. The pressure at node D50 must be set at 200 pounds. This pressure is controlled through the regulator from node T100 to D50. Also a control valve from node T89 to C62 cuts the pressure from the TSOU source. The pipeline diameters and lengths are given on the schematic. For a given loading condition described later, it is desired to know what will be the pressures in the distribution system and the quantity of steam required from each of the three sources as well as the regulator sizing coefficient for the regulator from T100 to D50. The problem file, or input data file, for this problem is shown below. The loads are not shown as these will be provided by the load generator.

```
10.50.30 printf stsampl data tl

 SAMPLE STEAM SYSTEM -- MULTIPLE FEED  REGULATOR AND CONTROL VALVE
MLB/HR  PSIG
MILES
SUPOFF
14.73,520.,.6,500.,1.,.02,.0006,.0000137,0,
.1,.1,.05,10.,5.,.1
20
1,1,1,
SF10 SF12 FS    12.25,5.,
SF12 T100 FS    12.25,6.,
T100 T210 FS    12.25,4.,
T300 T210 FS    12.25,4.5,
T100  D50 FI S  5000.,32.,20.
 D50  D75 FS    8.12,6.
 D75 D140 FS    8.12,4.
D140 D120 FS    8.12,8.
D120  D50 FS    10.1,10.
D120  D10 FS    6.06 6.55
 D10  C62 FS    6.06 3.25
D140  C62 FS    6.06 4.3
 T89  C62 FI    100. 32. 10.
TSOU  T89 FS    8.12 5.5
ZZZZ
SF10 300., 0.,S
SF12 500.,S
T100 400.,S
 D50 200.,
 D75 200.,S
D140 ,S
D120 200.,S
T210 500.,S
T300 275., 0,S
 D10 200. S
 C62 200. S
 T89 300. S
TSOU 325.   100. S
ZZZZ
```

The loads for this problem are to be generated using the GASSS load generator. The supplementary load file that accompanies the above problem file is shown below. This is the file STSAMPL LOADS.

```
10.56.18 printf stsampl loads

  LOAD FILE FOR SAMPLE STEAM NETWORK
  STEAM LOADS ARE MLB/HR
   COL 1  WINTER BASE LOAD
   COL 2  WINTER LOAD/DEG FOR TEMP BELOW 65 DEG F
   COL 3  LOAD AT EACH NODE TO ACCOUNT FOR CONDENSATE REMOVAL
   COL 4  SUMMER BASE LOAD
   COL 5  SUMMER LOAD/DEG FOR TEMP ABOVE 65 DEF F (AIR COND)

SF12    5.0   0.15   1.20    3.0   0.30    0.0    0.0    0.0    0.0    0.0
T210    8.0   0.18   1.30    4.0   0.25    0.0    0.0    0.0    0.0    0.0
T100    4.0   0.05   2.00    2.0   0.10    0.0    0.0    0.0    0.0    0.0
 D50    0.0   0.01   0.50    0.0   0.05    0.0    0.0    0.0    0.0    0.0
 D75   16.0   0.21   0.80   10.0   0.50    0.0    0.0    0.0    0.0    0.0
D120   12.0   0.15   0.90    6.0   0.45    0.0    0.0    0.0    0.0    0.0
D140    8.0   0.11   0.60    3.0   0.25    0.0    0.0    0.0    0.0    0.0
 D10   10.0   0.09   0.80    5.0   0.40    0.0    0.0    0.0    0.0    0.0
 C62    4.0   0.12   0.50    2.0   0.34    0.0    0.0    0.0    0.0    0.0
 T89    0.0   0.0    2.00    0.0   0.0     0.0    0.0    0.0    0.0    0.0
```

The first seven lines of this file are title information in which it is convenient to describe the contents of each column. In this case, a very simple use of the load generator is envisioned and by using only five of the possible ten columns, both winter and summer loads can be generated. In this sample, only the first three columns will be used to generate a winter loading condition for a 60 degree day condition. Column 3 is a constant load at each node to account for condensate removal from the drip at each node. Column 1 is a wintertime base or firm load. To establish the load for a 60 degree day, it is necessary to multiply column 2 by 60 and add the result of that multiplication to column 1 plus column 3. To generate a summertime load, the user would multiply column 5 by some number of degrees and sum column 3, 4, and the result of a multiplication of column 5 to obtain the load. The following terminal session shows the above-mentioned use of the load generator and the solution of the problem.

```
11.09.51 attach gasss
GASSS    ATTACHED AS 192,(T)

GASSSV3 5/06/74 RUN ON 05/20/74

MONITOR COMMAND ??edit
```

Attach GASSS and request the editor.

```
 EDITOR FOR GASSS FILES
INPUT FN FT stsampl
loads
```

Edit the file STSAMPL (filetype of DATA assumed).
Enter the load generator.

```
 LOAD GENERATOR FOR GASSS
 INPUT FN FT stsampl loads
```

Request the file STSAMPL LOADS.

```
 LOAD FILE FOR SAMPLE STEAM NETWORK
 STEAM LOADS ARE MLB/HR
  COL 1  WINTER BASE LOAD
  COL 2  WINTER LOAD/DEG FOR TEMP BELOW 65 DEC F
  COL 3  LOAD AT EACH NODE TO ACCOUNT FOR CONDENSATE REMOVAL
  COL 4  SUMMER BASE LOAD
  COL 5  SUMMER LOAD/DEG FOR TEMP ABOVE 65 DEF F (AIR COND)

 COLUMN  6 IS THE FIRST COLUMN WITH ALL ZERO VALUES.
 THERE ARE      10 NODES IN THE LOAD FILE
L c2=c2*60.
L q=c1+c2+c3
L qn=q
 FOLLOWING NODE NAMES ARE IN THE PROBLEM FILE LIST BUT
 ARE NOT IN THE LOAD FILE LIST
"SF10"
"T300"
L q
 RETURNING TO NODE ENVIRONMENT
p 20
SF10     300.0        0.0  S 0.0       0.
SF12     500.0 S    -15.20   0.0       0.
T100     400.0 S     -9.00   0.0       0.
 D50     200.0       -1.10   0.0       0.
 D75     200.0 S    -29.40   0.0       0.
D140       0.0 S    -15.20   0.0       0.
D120     200.0 S    -21.90   0.0       0.
T210     500.0 S    -20.10   0.0       0.
T300     275.0        0.0  S 0.0       0.
 D10     200.0 S    -16.20   0.0       0.
 C62     200.0 S    -11.70   0.0       0.
 T89     300.0 S     -2.00   0.0       0.
TSOU     325.0      100.00 S 0.0       0.
file stmtemp bin
```

Title information prints after the file has been read.

Multiply column 2 by 60 degrees.

Sum columns 1, 2, and 3 to produce the loads. Merge the load generator vector into the problem file vector QN.

Return to the node environment.

Print a sufficient number of nodes to examine the generated load.

File the problem file to STMTEMP BIN.

```
MONITOR COMMAND ?? run          <-- Request the Solution Program.

 GAS STEADY STATE.

 INPUT FILE? stmtemp bin        <-- Input file is STMTEMP BIN.

OUTPUT FILE? out

PROBLEM TITLE:

SAMPLE STEAM SYSTEM -- MULTIPLE FEED  REGULATOR AND CONTROL VALVE

RUN ON: 05/20/74 AT 11.13.36


SYSTEM IS TIED TOGETHER AS ONE UNIT


 *** PROBLEM SUMMARY ***

  13 NODES
  14 NCES
   1 UNKNOWN NCES
   9 UNKNOWN PRES
   3 UNKNOWN FLOWS

 BALANCING STARTED

  SOLUTION COMPLETED IN  14 ITERATIONS

  OUTPUT SEGMENT: COMMAND READY SYMBOL=*

*sour     <-- Solution has been completed. Produce
              a listing of the source nodes on the
              user's terminal.


    SOURCE NODES FOR:
SAMPLE STEAM SYSTEM -- MULTIPLE FEED  REGULATOR AND CONTROL VALVE
RUN ON 05/20/74 AT 11.13.36


 NODE     PRESSURE      FLOW(MLB/H)
T300      275.00           48.35 S
SF10      300.00           63.32 S
TSOU      325.00           30.13 S
```

*full ← Request full output at the user's terminal.

```
  FULL NCE RESULTS FOR:
SAMPLE STEAM SYSTEM -- MULTIPLE FEED  REGULATOR AND CONTROL VALVE
RUN ON 05/20/74 AT 11.13.36

FROM  TO    F-P    T-P    TYPE    MLB/H    PARAM.      REMARKS
D120  D10   121.S   89.S FS        6.29    6.060 RN=  321955.F=0.0157
D120  D50   121.S  200.  FS      -36.93   10.100 RN= 1133452.F=0.0132
D140 D120   105.S  121.S FS       -8.75    8.120 RN=  333892.F=0.0153
D140  C62   105.S  126.S FS       -6.52    6.060 RN=  333616.F=0.0157
SF10 SF12   300.   275.S FS       63.32   12.250 RN= 1602174.F=0.0126
SF12 T100   275.S  256.S FS       48.12   12.250 RN= 1217586.F=0.0129
TSOU  T89   325.   275.S FS       30.13    8.120 RN= 1150062.F=0.0135
T100 T210   256.S  261.S FS      -28.25   12.250 RN=  714742.F=0.0136
T100  D50   256.S  200.  FIS      67.37    332.0
T300 T210   275.   261.S FS       48.35   12.250 RN= 1223307.F=0.0129
 D10  C62    89.S  126.S FS       -9.91    6.060 RN=  506687.F=0.0150
 D50  D75   200.   105.S FS       29.34    8.120 RN= 1119779.F=0.0135
 D75 D140   105.S  105.S FS       -0.47    8.120 RN=   18101.F=0.0269
 T89  C62   275.S  126.S FI       28.13    100.0

 NODE INFORMATION
NODE    PRESSURE     FLOW(MLB/H)
D120     121.49 S       -21.90
D140     105.10 S       -15.20
SF10     300.00          63.32 S
SF12     275.02 S       -15.20
TSOU     325.00          30.13 S
T100     255.96 S        -9.00
T210     260.70 S       -20.10
T300     275.00          48.35 S
 C62     126.37 S       -11.70
 D10      88.63 S       -16.20
 D50     200.00          -1.10
 D75     105.05 S       -29.40
 T89     274.63 S        -2.00
```

*q

```
  OUTPUT COMPLETED FOR:
SAMPLE STEAM SYSTEM -- MULTIPLE FEED  REGULATOR AND CONTROL VALVE
```

In the above simulation results, RN is the Reynold's Number of flow in each particular pipe. F stands for the friction factor. Note that the regulator sizing coefficient is 332 and that the control valve T89 to C62 is passing 28 MLB/HR.

Appendix D

PRELIMINARY HEAT BALANCE FOR RETROFITTING UNIT #12 TURBINE FOR COGENERATION

(C. H. Thiele, ORNL Consultant)

Rochester Gas and Electric Company Retrofit of Unit #12

The turbine-generator is a General Electric, 75,000 KW machine with a tandem compound, double flow reheat turbine and a hydrogen cooled generator. Turbine auxiliaries include a 45,000 sq ft surface condenser, two circulating water pumps, three condensate pumps and a two element, two stage steam jet air ejector for removal of noncondensibles from the condenser.

Steam for the turbine is supplied by a Combustion Engineering, Inc., controlled circulation reheat-type steam generator. The unit is designed for a main steam flow of 560,000 lb/hr of steam at 1825 psig and 1055°F at the super heater outlet, and a reheater flow of 441,000 lb/hr of steam with reheat of 1005°F. Auxiliaries consist of three mills and feeders, one forced draft fan, two regenerative air preheaters, electrical precipitator, one induced draft fan, one constant speed and one variable speed boiler feed pump, Bailey meter pneumatic combustion control, and a 234 ft exhaust stack.

Unit #12 is wholly separate from the existing units in the station as to steam, feedwater, and condensate piping systems of the main turbine cycle. The unit system being rigidly followed and cycle interconnections omitted. The three high pressure closed feedwater heaters are located in the cycle after the boiler feed pumps with the last high pressure heater taking its extraction before the turbine crossover. The three low pressure heaters are in one divided shell and mounted in the condenser neck. The system does not include an extraction stage deaerating heater. Deaeration of the condensate is done in the condenser.

The turbine consists of a high pressure section, an intermediate section, and a double-flow low pressure section. Extracting heating steam from the high pressure or intermediate sections could cause an unbalance in the tandem arrangement. There is no problem in the balanced divided flow of the low pressure section.

Steam expansion takes place in successive pressure stages, each stage being comprised of stationary nozzles carried in a diaphragm and a row of buckets secured to the rotor. There are ten stages in the high pressure element, eleven stages in the intermediate pressure element, and four stages in each section of the low pressure element. Steam for feedwater heating is extracted from stages 6, 10, 15, 18, 21, and 23.

The condenser has a steam capability of 371,000 lb/hr with a heat rejection of 988 Btu/lb of steam with 36,300 gpm circulating water at 53.7°F and exhaust pressure of 1.05 in. Hg, absolute.

Steam Extraction for Process or Heating

Unit #12 cogeneration could be provided for at one of the following steam sources:

1.	Throttle steam	500,500 lb/hr	1815 psia	1050°F
2.	Hot reheat	395,629 lb/hr	291.1 psia	1000°F
3.	Cold reheat	395,629 lb/hr	323.5 psia	630°F
4.	Stage 6	35,285 lb/hr	626.7 psia	776°F
5.	Stage 10	44,391 lb/hr	323.5 psia	630°F
6.	Stage 15	20,683 lb/hr	111.0 psia	730°F

Stage 10 and the cold reheat are the same. The throttle steam and hot reheat with temperatures at 1000°F or above would require heat exchangers with costlier materials suitable for the high temperatures.

For the conditions of stage 15, assuming a suitable flow could be obtained and consolidating main steam and reheat flow into throttle flow for simplification, the following heat balance diagram and calculation show the apportionment of one pound of steam between electric and steam (Fig. D.1).

A. 100% electric generation	Btu/lb
1. Steam to turbine [500,000 (1510.9-472.53) + 395,629 (1525.47-1330.5)] ÷ 500,500 + 472.53	1665.0
2. Loss to condenser (1043.4 - 59.7)	983.7
3. Used by the turbine	681.3

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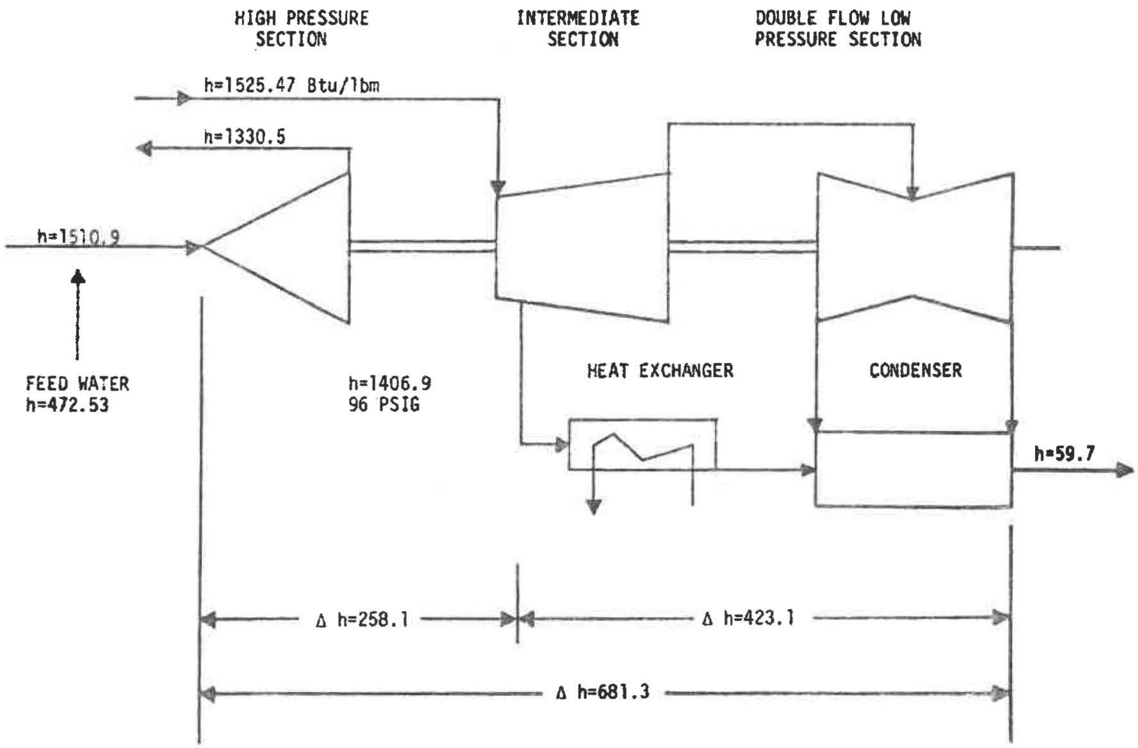

Fig. D.1. Heat balance for the cogeneration option for Unit #12.

B. Electric and steam

		Btu/lb
1.	Steam to turbine	1665.0
2.	Available to electric	681.3
3.	Available used by electric (1665 - 1406.9)	258.1
4.	Available used by steam (681.3 - 258.1)	423.2
5.	Percent available used by electric (258.1 ÷ 681.3)	37.9
6.	Percent available by steam (423.2 ÷ 681.3)	62.1
7.	Condenser loss charged to electric (983.7 x .379)	372.8
8.	Condenser loss charged to steam (983.7 x .621)	610.9
9.	Total charged to steam (62%)	1034.1
10.	Total charged to electric (38%)	630.9

Cogeneration reduced the cost of both electric and steam by recovering the steam send out that would be lost in 100% electric generation. There is some sacrifice in electric generating capacity, but substantial energy conservation.

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