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Energy Self-Sufficiency in Northampton, Massachusetts

October 1979

Prepared for
U.S. Department of Energy
Assistant Secretary for Policy and Evaluation

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Washington, D.C. 20585

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FOREWORD

In the preface to the National Energy Plan[1/], President Carter states:

> "We can rediscover the ingenuity and the efficiency which have made our nation prosper, rather than deepening our dependence on insecure imports and increasingly expensive conventional energy supplies. We can rediscover small-scale, more creative ways of satisfying our needs. If we are successful, we can protect jobs, the environment, and the basic American standard of living, not only for ourselves but also for our children and grandchildren."

The goal of this study is to begin to rediscover those "more creative ways" of satisfying our energy needs.

The study is set in a New England town of thirty thousand. It starts with an examination of the human and social functions that energy systems must serve, and estimates the end-use energy required to meet those functions. It then considers alternative methods for meeting energy needs using conservation and renewable energy sources that may be locally owned.

Selection of energy systems is based upon explicit criteria that go beyond strict technical and economic criteria. These criteria include:

- increased local energy self-reliance
- environmental protection
- public participation in energy choices
- quality and quantity of energy-related employment
- scale of energy systems development
- local community and economic development
- social costs and benefits of alternative energy systems

These criteria, regarded as externalities in some energy analyses, are central in this study.

Engineering reviews of earlier drafts of this report have made it clear that estimates of efficiency, lead-time for technology development, and other technical or economic factors may be quite uncertain. These uncertainties are probably irreducible, given the immature state of our knowledge and experience with conservation and solar technologies, and how these may be adopted on a wider scale by a pluralistic society. However, the uncertainties in this study, although significant, remain comparable to those of most other analyses of future energy systems, whether at the local, state, or national level.

The purpose of this study is not to present an engineering analysis of a new energy system to be implemented in the next year. Rather it is to begin the process of exploring the potential for conservation and local renewable resource development in a specific community, with the social, institutional, and environmental factors in that community taken into account.

This report has two sections. Section I is an executive summary of the full study. Section II is a detailed examination of the potential for increased local energy self-sufficiency in Northampton, Massachusetts, including current and future demand estimates, the possible role of conservation and renewable resources, and a discussion of the economic and social implications of alternative energy systems.

Chapters 2, 3, and 4 (pp. 15-78) of Section II may be skipped by readers not interested in the particular energy demand profile of Northampton, although the methods used and the emphasis on end use may be of general interest.

This report is preliminary. However, it indicates the range of many of the social, institutional, economic, and technical factors that interact to influence energy policy choices. We publish it now in the hope that it will both broaden and improve the continuing debate on future energy systems.

Allan R. Hoffman

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Advanced Energy Systems
Policy Division

Dick Holt

Dick Holt
Project Director

(1) The National Energy Plan, Executive Office of the President, Energy Policy and Planning, April 1977

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EXECUTIVE SUMMARY

ENERGY SELF-SUFFICIENCY IN NORTHAMPTON, MASSACHUSETTS

I. Introduction

This paper evaluates the potential costs and benefits of a decision made by a small city to become self-sufficient in energy. We have made our question even more specific by focusing on one particular city: Northampton, Massachusetts, and proposing a specific scenario for energy self-sufficiency.

The work summarized here was performed by three undergraduate students and a professor over a period of about 15 months.[1] All of the students were seniors at Hampshire College, and their work was the core of their Division III (senior thesis) work in partial fulfillment of the requirements for graduation. One of our purposes in publishing this work is to encourage students and faculty at other colleges to adapt what we have done to communities in their own area. This can provide both a rigorous introduction to energy analysis for the students and a useful service to the community.

There are several obvious limitations in choosing to base our study on a specific scenerio for a specific city. Every city has its own unique set of supply and demand constraints, and strategies which might work well for Northampton could be impractical or even detrimental for other cities. Another problem is our rather arbitrary and limited definition of "energy self-sufficiency" which accounts only for the energy used locally in the four standard sectors (residential, commercial, industrial, and transportation) and ignores energy required for intercity, interstate, and international transport of goods and people, and the substantial energy content of industrial and agricultural products imported into the city. A third problem is the essential arbitrariness inherent in allowing the political boundaries of a city to determine the size of a self-sufficient unit. There is no historical evidence that considerations of energy supply played any role in the original determination of Northampton's boundaries, so there is no reason to expect that these boundaries define in any rational sense an optimally sized self-sufficient region. Finally, by choosing to examine in detail only one of the vast number of possible ways in which the city might choose to increase its self-sufficiency, we are in danger of giving the impression that there are only two alternatives open to the city: the status quo or our scenario.

Granting all of these dangers and difficulties, we still would argue that a specific study can be a highly useful and enlightening exercise not only for the city studied but for others as well. We believe that many of the problems faced by Northampton are very similar in both scale and quality to those faced by other cities in its population range. For example, urban transportation, inefficient old buildings, and the heavy burden on the economy of imported energy are three problems shared by almost every city, especially in New England.

The choice of a city as our unit as opposed to a county, state, or neighborhood was dictated only partically by convenience. The efforts now being made by Davis, California[2] and Portland, Oregon[3] show that a city does have a signficant amount of political and economic power to affect its energy future. The Davis experiment was one of the factors which initially led us to focus on the city as our unit. Another factor in our decision was the existence of another study in energy self-sufficiency being done on a nearby rural county.[4] Our choice of a small, mainly commercial and residential city nicely complements this study.

Our decision to limit our definition of "energy" to exclude imported goods and non-local transport was dictated to a great extent by limitations on time and research capability, but also by our belief that primary energy production is separable from other kinds of production. It is important to emphasize that our interest in energy self-sufficiency is a practical one and does not derive from an ideological commitment to "total" self-sufficiency. We are not suggesting autarchy or a return to the romanticized ruggedly independent Yankee tradition. It is simply a fact that the vast majority of the energy used in Northampton is not used productively (in the economic sense), and that money which leaves the city's economy to pay for this non-productive energy is not available for productive uses within the city. On top of this there is the real and growing problem of the reliability of supply of primary energy. Cities (and counties) which are completely dependent on external sources of energy have begun to feel like Tom Lehrer's famous "Christian Scientist with appendicitis."[5] It now takes a much more conscious set of faith to plan confidently for the future.

The last problem mentioned above concerned our choice of a specific scenario rather than a more general overview of the various possibilities. We recognize the limitations of this strategy, but on balance feel that the clarity and concreteness achieved by a single choice outweigh the comprehensiveness of a more general approach. We simply caution the reader to keep in mind that many other scenarios are possible, and that we are not asserting that the system we examine in this paper is in any sense the best, or cheapest, or most desirable. It is intended as an example to clarify discussions of options and to illustrate how any given option can be analyzed and compared with others.

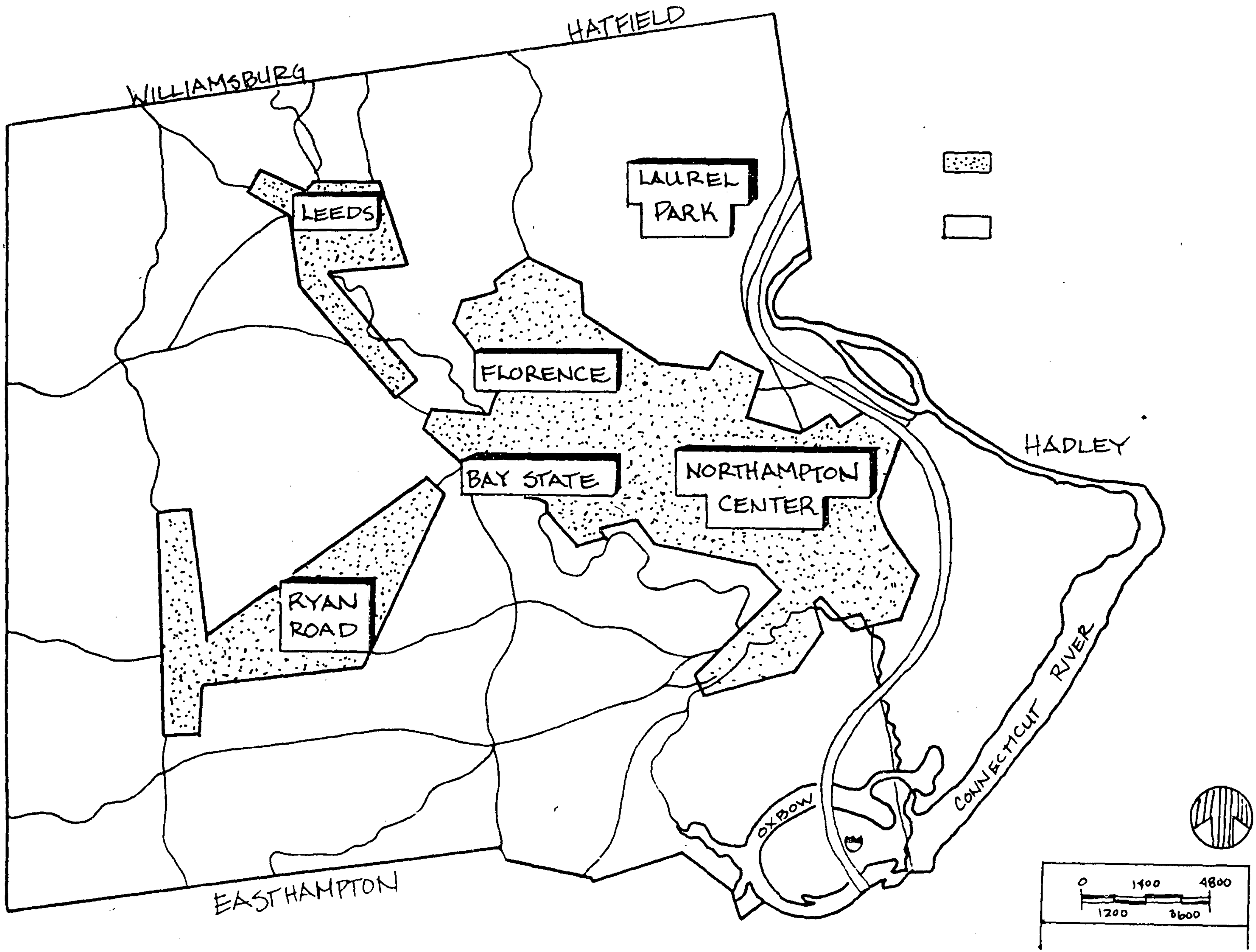
With all of these caveats recorded, the paper proceeds as follows: In Section II we summarize the present energy situation in Northampton and compare Northampton's energy economy with the rest of Massachusetts and the U.S. as a whole. Section III outlines the prospects for energy conservation in the city and recasts the energy use spectrum from the traditional four-sector form to the "end-use" form advocated by many modern analysts.[6] In Section IV we describe our alternative energy supply system and mention some efforts in this direction which have already been undertaken in Northampton. Section V presents an economic and social benefit-cost analysis of the alternative plan relative to the status quo, and in Section VI we present our conclusions and suggestions for future work.

II. Current Energy Use in Northampton

The first step in planning for energy self-sufficiency is to determine the quantities and types of energy currently in use in the city. In our case this was quite straightforward for electricity and natural gas, since the respective utilities (Massachusetts Electric Co. and Bay State Gas Co.) were able to supply us with their sales figures for the year 1977 in Northampton. These figures were also broken down by sector (although the Gas Company combined commercial and industrial sectors) and in the case of electrical energy were also broken down by fuel source (oil, gas, coal, nuclear, hydro).

Oil supply was a bit more difficult to account for, since only about half of the oil used in Northampton is sold by local dealers. Interviews with all local oil companies gave us a good estimate of consumption by residential customers, but only a small portion of the oil used by commercial and industrial customers. Many of the larger oil users purchase bulk quantities of industrial grade fuel oil from out-of-city or out-of-state suppliers. However, we were able to identify these large users (mostly schools, colleges, and public buildings) and obtain data on oil consumption directly from the consumers themselves.

A small but growing source of energy in Northampton is wood. Our data on wood use came from a study done at the University of Massachusetts, Amherst in


HATFIELD
WILLIAMSBURG
LAUREL PARK
LEEDS
FLORENCE
BAY STATE
NORTHAMPTON CENTER
HADLEY
RYAN ROAD
CONNECTICUT RIVER
OXBOW
EASTHAMPTON
0
1200
2400
3600
4800

1977.[7]

Gasoline and diesel fuel consumption were estimated using a figure for total vehicle miles traveled on the city streets supplied to us by the Lower Pioneer Valley Planning Authority and an average mileage rating for vehicles given us by the Massachusetts Energy Office in Boston.

The following is a brief summary of the current (1977) energy supply and demand situation in Northampton. The information is summarized in the system diagram shown in Figure 2 and in Table 1.

General Data: Northampton is located in West-Central Massachusetts on the west bank of the Connecticut River(See Figure 1). It has an area of 35 square miles (22,400 acres) and a population of 30,000,which has stayed very nearly constant since 1950. A typical heating season in Northampton will have 6600 degree days, based on an indoor temperature of 65°F.[8] The terrain of the city is flat near the river but changes into forested hills in the western half. Further to the west are the Berkshire mountains which tend to shield Northampton from the full force o prevailing westerly winds.

Residential Sector: Northampton has 8900 residential units of which 4400 are single family homes and 4500 are in multi-unit structures. The housing stock is quite old, over 70% of the units having been built before 1940. There is one major post-World War II development of several hundred homes located in the southwest portion of the city. The total land area occupied by residences is about 2,000 acres, which is 27% of the developed land area in the city but only 9% of the total area. It should be mentioned that roughly 4000 of the population of Northampton are either college students or inmates of the several large state and federal special schools and hospitals located in the city.

Industrial Sector: Only 41 manufacturing firms are located within the city limits. The two largest industrial firms are the Pro Brush Company which makes toothbrushes and other plastic products and the Kollmorgen Corporation which makes periscopes and other optical equipment. The total industrial workforce in the city is 2400 people, only 20% of the number of employed Northampton residents. The nine largest firms employ 2000 people or 85% of the total. None of the industries is particularly energy intensive, and no industrial process heat is used at temperatures above 235°C.

Commercial Sector: This is conveniently divided into two subsectors: public and private. The public sector consists of 32 establishments including Smith College which itself comprises 101 buildings.[9] Public buildings include schools, hospitals, and both city and county office buildings. The private sector consists of 511 establishments including 296 retail stores, 26 wholesale establishments, and 189 service establishments (e.g., hotels, banks, law offices, etc.).[10] Northampton serves as a commercial center for the many small surrounding communities and has as one of its major ongoing concerns the maintenance and revitalization of its commercial economy.

Transportation Sector: In 1977 there were 19,300 vehicles registered in Northampton of which about 90% were classified as passenger vehicles. Local vehicle travel amounted to some 430,000 vehicle miles per day or 1.57 million per year.[11] Using an average mileage figure of 16.1 miles per gallon[12] we arrive at an estimate of 9.8 million gallons of gasoline and diesel fuel consumed per year. Diesel fuel forms such a small fraction of this that we have simplified our tables by assuming that all the consumption is in the form of gasoline. Energy use in these sectors broken down by fuel type is listed in Table 1. Note that Table 1 lists delivered energy, not primary energy. The full numbers for primary energy use are determined by making allowances

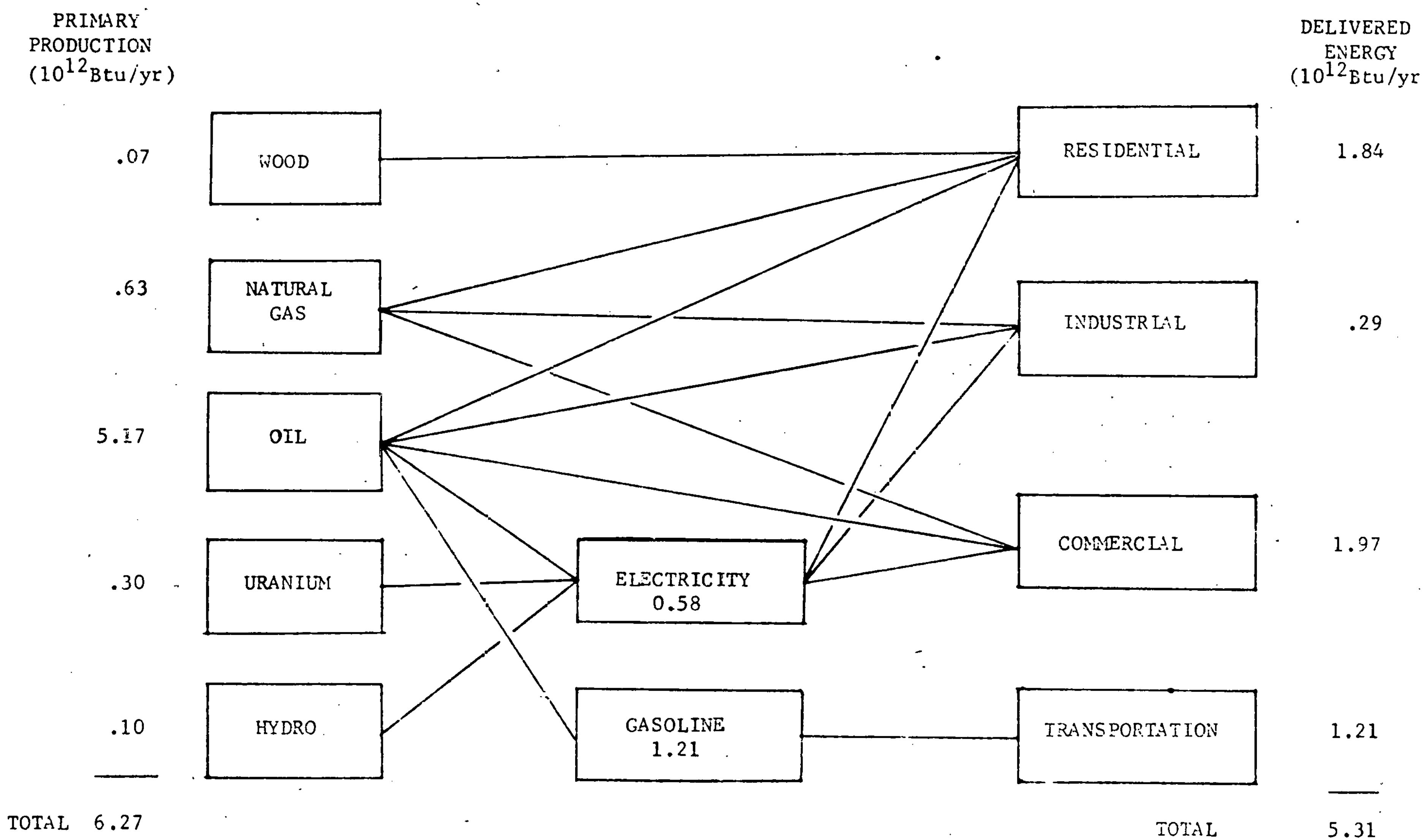


Figure 2

System Chart for 1977 Energy Use in Northampton

Table 1. Energy Consumption by Sector, Northampton, Mass. 1977

	Oil		Electricity		Gas		Wood		Gasoline		Total
	Gallons	Btu	Kwh[a]	Btu	MCF[b]	Btu	Cords	Btu	Gal.	Btu	Btu
	10^6	10^{12}	10^6	10^{12}	10^6	10^{12}	10^3	10^{12}	10^6	10^{12}	10^{12}
Residential	9.0	1.26	56	.19	.30	.32	4.2	.07			1.84
Industrial	0.9	0.12	32	.11	.06	.06					.29
Commercial	10.3	1.44	82	.28	.24	.25					1.97
Transportation									9.8	1.21	1.21
Total	20.2	2.82	170	.58	.60	.63	4.2	.07	9.8	1.21	5.31

a. Conversion losses not included.

b. 1 MCF = 10^3 cubic feet.

for conversion losses in producing electricity and are included in Figure 1. According to Mass. Electric Co. the electricity delivered to Northampton is produced 65% by oil, 17% by nuclear and 18% by hydro. We have assumed 67% conversion losses in the first two and no conversion loss in the last. For simplicity we have assumed no conversion losses in producing gasoline and heating oil from crude oil. The expected errors in our various estimates are large enough to make such refinements unnecessary. This does, however, lead to a systematic underestimate of primary energy consumption.

Several features of Table 1 and Figure 2 deserve emphasis. Certainly the most dramatic feature is the overwhelming dominance of oil on the supply side. Oil accounts for 82% of the primary energy consumption of Northampton, and when it is noticed that 70% of this oil is imported from foreign countries we see that Northampton, like most of New England, is an important contributor to the heavy reliance of our country on OPEC oil.

On the demand side it is interesting to compare the sizes of the various sectors with those of the state of Massachusetts and the country as a whole. These comparisons are made in Table 2, which shows clearly the residential-commercial character of Northampton relative to the state and nation. Presumably the much larger transportation sector for Massachusetts is accounted for by intercity travel and shipping. The very large difference between the local and national industrial sectors attests to the relatively small amount of energy — intensive industry in both Northampton and the entire state.

What does all of this energy cost the people of Northampton? Since we used 1977 figures for energy consumption we have decided to use 1977 prices for energy in calculating energy costs. These are given in the second column of Table 3. Needless to say these prices are quite a bit below current values, but we will save the question of inflation of energy costs until Section V when we compare the two scenarios for future energy use.

The total amount spent on energy in Northampton in 1977 was $25.8 million, or $663 per capita. We have estimated that 12% of this money or $3.1M is respent by the various energy suppliers in Northampton in the form of wages,

Table 2 Comparison of consumption by sector in Northampton, Massachusetts and the U.S.

<table>
<tr><th>Sector</th><th>Northampton</th><th>Massachusetts[a]</th><th>USA[b]</th></tr>
<tr><td>Residential</td><td>34.7%</td><td>29.4%</td><td rowspan="2">37.1%</td></tr>
<tr><td>Commercial</td><td>37.1%</td><td>29.8%</td></tr>
<tr><td>Industrial</td><td>5.5%</td><td>7.0%</td><td>36.7%</td></tr>
<tr><td>Transportation</td><td>22.8%</td><td>32.8%</td><td>26.2%</td></tr>
</table>

a) Data from Energy in Massachusetts, Mass. Energy Office, Boston, Mass. 1978.

b) Data from Statistical Yearbook of the USA (1978), Table No. 1006, p. 607.

Table 3 Breakdown of Energy Expenditures in Northampton, Mass. 1977

Source	Units Consumed	Price per unit	Total Spent on Source ($\$10^6$)
Oil	20×10^6 gal	$ .48/gal	9.6
Gas	$.6 \times 10^6$ MCF	$3.90/MCF	2.3
Electricity Residential	56×10^6 kwh	$ .045/kwh	2.5
Commercial-industrial	114×10^6 kwh	$ .040/kwh	4.6
Wood	4.2×10^3 cords	$50/cord	.2
Gasoline	9.8×10^6 gal	$ .67/gal	6.6
TOTAL			$25.8M

taxes and local purchases of goods and services. Unfortunately, the much larger fraction of 88% or $22.7M leaves the city immediately and does not contribute to the local economy. The magnitude of this loss to the city can be appreciated when it is noticed that $22.7 million is greater than the total payroll of the city's 7 largest industries. There can be little doubt that a system which kept a greater fraction of this money within the city's economy would be highly beneficial and would reduce the historically relentless pressures for commercial and industrial development. A self-sufficient energy system would, in fact, become a major local industry.

III. Conservation and End Use Efficiency

A transition to a self-sufficient energy system will require a considerable capital investment, so it is extremely important to determine first just how much energy is actually necessary. It is now a commonplace fact that a substantial fraction of the primary energy consumed in this country is wasted either because of thermodynamic laws or poor design and construction. We have estimated the difference between primary and end-use consumption for Northampton and find that dramatic improvements in efficiency are possible if some straightforward conservation strategies are implemented, and if the energy sources are better matched themodynamically to the end uses.

Our estimate of end use demand was arrived at by making a few very simple and conservative assumptions. We assumed that electricity is 100% efficient at the point of end use, but only 33% efficient with respect to primary energy. The burning of oil or natural gas for space or water heating or steam production was assumed to be 70% efficient. The burning of gasoline in internal combustion engines was assumed to be 20% efficient in producing useful work from primary fuel.[13] Using these efficiencies we find that of the 6.27×10^{12} Btu/yr consumed in primary energy only 3.33×10^{12} Btu/yr or 53% perform useful "work" at the point of end use.

It should be emphasized that our definition of end use energy for the transportation sector is highly arbitrary. In fact, it is not at all clear how one does define end use in this sector, since the task which the transportation system is intended to perform is very poorly defined. If we set aside transportation and compare primary and end use consumption in the other three sectors we find a primary consumption of 5.06×10^{12} Btu/yr and an end use of 3.09 Btu/yr giving an efficiency of 61%. This still leaves a considerable margin for improvement.

As soon as one begins to think in terms of end use the division into four sectors used in Section 2 becomes much less convenient. The system is clarified by expressing energy use in terms of an end-use spectrum. This spectrum for Northampton is shown in Table 4.

With the end use demand clearly delineated it is now easier to see where conservation efforts are most likely to be effective. By far the greatest potential for savings is in the space and water heating sector which accounts for 73% of end use energy consumption in Northampton.

The Hampshire County Energy Conservation Analysis Project (ECAP) has audited 104 homes in Northampton and found a conservation potential of 44%. Because the initiative for the audits had to come from the homeowner or renter the ECAP audits tended to be focused on middle or upper middle income homes. We feel that this gives us some reason to believe that this figure is conservative. Many of the homes in Northampton are very old and have both substandard insulation and inefficient and poorly maintained heating systems. Of course even greater savings are possible if houses are rebuilt or extensively remodeled to take advantage of passive solar heating. We have decided not to put much reliance on this strategy, since many of the old houses of Northampton have a great historical value, and much of the city's attractiveness derives from these old homes. Eventually, however, they will be replaced, and some new construction will also occur. Clearly the maximal use of passive solar design should be undertaken in any new construction.

Potential energy savings in commercial establishments have been analyzed in a recent report by the Massachusetts Energy Office.[14] This report estimates a potential for 30-50% conservation in typical retail stores while

Table 4

End Use Energy Spectrum for Northampton, Mass. 1977

End Use Category	Temperature (^{o}C)	Primary Consumption (10^{12} Btu)	End Use (10^{12} Btu)	Efficiency	End Use After Conservation (10^{12} Btu)
Space and Water Heating	≤ 85^{o}	3.49	2.40	69%	1.68
Cooking, Laundry, & Miscellaneous Heating	85^{o}-100^{o}	.18	.10	56%	.07
Industrial Process Heat and Steam	100^{o}-235^{o}	.07	.05	70%	.05
Transportation	NA	1.21	.24	20%	.1 - .25[b]
Lighting, Appliances, Machinery, Air Conditioning	∞	1.43	.54	38%	.38
		6.4	3.3	52%	2.28-2.43

a. This total differs slightly from that in Figure 2 because of round-off errors in changing categories.

b. Transportation end use depends strongly on the kind of transportation system chosen by the city. See Section VI.

another study suggests comparable conservation potential in public and municipal buildings.[15]

Finally our own on-site surveys of the nine largest industries in Northampton convinced us that substantial savings are possible in this sector with a moderate investment of capital. We cannot make a reliable quantitative estimate of the conservation potential, since detailed economic data are not available, but we believe they would be at least comparable to those in the commercial sector.

For our projection of conservation potential and future end use demand we have settled on a 30% reduction in end use demand. We feel that this can be easily achieved with a reasonable investment of capital and still allow for a small amount of economic growth. We do not envision any substantial population growth or a great deal of new industry in Northampton's future. If industrial growth does occur, it is highly unlikely that it will be the sort of industry that requires large amounts of energy. We do foresee some commerical growth in the retail and service sectors, but a vigorous conservation program in these sectors would still allow a substantial reduction in overall energy demand.

Again transportation poses a difficult problem in definition. In this sector it is much more difficult to separate "technical fixes" from "lifestyle changes", and we are also much more severely constrained by our insistence on self-sufficiency for the energy used in local transportation. This requirement rules out such palliatives as more efficient autos or gasohol and requires a shift to electrically powered transport. This in turn mandates a dramatic reduction in the use of personal vehicles for local travel and a much heavier reliance on public transportation. We will follow up on this in the next section.

If we assume 30% reductions in low temperature heat demands and a similar reduction in electricity usage for everything except transportation we get the projected end use demand figures in the last column of Table 4.

IV. A Self Sufficiency Scenario

The requirement of local self-sufficiency places very strong constraints on the kind of energy system Northampton could develop. The only local resource which might be tapped for large amounts of energy quickly is the 12,000 acres of woodlands within the city limits. A full harvesting of these woodlands could yield about 170,000 cords of wood and roughly 3.43×10^{12} Btu of energy,[16] less than two years supply at our projected consumption rate. Clearly such a policy would make no sense, although it is comforting to have this standing biomass as a reserve against unforeseen difficulties. For the long term there is no alternative to developing local renewable resources.

The available renewable resources are conservation, sun, wind, hydropower, solid wastes, organic wastes, and biomass. Three of these (conservation, biomass and sewage) are already being used on a small scale to save and produce energy in the city, and proposals for using two others (hydropower and solid wastes) are under study. Some small solar energy facilities have been installed on private and public buildings, mostly for hot water heating, although one small industrial plant in the city relies almost entirely on solar heating. We are not aware of any appreciable use of wind energy inside the city limits. We have already discussed the potential for conservation in the city, and we now discuss briefly the other potential sources.

1. Wind. Northampton is located in the Connecticut Valley down wind of the eastern slopes of the Berkshire Mountains. This location makes it rather poorly suited for any major use of wind energy. Average wind velocities in the area tend to cluster around 8 or 9 mph, well below the 11-13 mph which might make wind generation feasible. There may be some locations in the hills which give better average winds, but these would at best provide only small amounts of power, possibly to homes which are too far from the utility lines to make connection economical.

2. Organic Wastes. The Northampton Sewage Treatment Plant currently operates two digesters for the production of biogas. The digesters produce enough heat to run themselves and to heat several new buildings planned for the facility. Current annual production from the two digesters equals 12000 MCF of gas with a total energy content of $.07 \times 10^{12}$ Btu.[17] However, this represents well under half of the available sewage, the rest of which is disposed of directly into the Connecticut River. In addition to municipal sewage the 3300 acres of tilled agricultural land in Northampton produce a substantial amount of agricultural wastes, some of which could add to the production of biogas. Our conservative estimate for the potential primary energy content of biogas is 0.15×10^{12} Btu/yr. This is best suited for use in the "cooking, laundry, and miscellaneous heating" category.

3. Biomass. As previously mentioned Northampton's boundaries include 12,000 acres of presently unmanaged forest land. Some of this is owned by the city, but much of it is owned privately. A survey referred to earlier suggests that a sustained yield of .5-.7 cords of wood per acre could be harvested for use without any net loss of standing crop.[18] This would provide a renewable resource

of between 6000 and 8400 cords of wood per year, which at a primary energy content of $1.5x10^7$ Btu/cord would provide between $.09x10^{12}$ and $.13x10^{12}$ Btu/yr. We suggest that this be used mostly as a back-up heating source for those homes and buildings which are not connected to the district heating system and therefore must rely on on-site solar heating. Any left over wood can either be stored as a reserve or burned in the solid waste plant described below.

We are not suggesting the use of any currently developed agricultural land for the growing of energy crops. Just as we have become conscious in New England of the extent to which we rely on imported energy, we are becoming more conscious of our heavy reliance on imported food. We feel it would be an error to convert land suitable for the raising of food to energy production. We do, however, urge that the energy potential in agricultural wastes be utilized to the fullest extent possible.

4. Hydropower. The Mill River crosses the northern boundary of the city at an altitude of 370 feet above sea level and drops about 240 feet before it reaches the level flood plain of the Connecticut. The yearly average discharge of the Mill River is about 90 cubic feet per second. The total power in this much water falling 240 feet is 1.83MW, although the inevitable losses reduce the actual potential to just under 1 MW. There are six dams on the river which are not now in use for generating electricity, but which could be equipped with small turbines.

A local engineering firm, Curran Associates, has looked into the economic prospects of renovating these dams and installing generation equipment.[19] They have concluded that the project is not economically viable considered on its own in competition with existing and projected external sources of electricity.

The project would be economical only if significant grants could be obtained from the Federal or State governments. However, the integration of Mill River hydropower into a more general system of local energy generation, and the long term benefits of reliability of supply were not considered in the Curran study. These may or may not tip the balance in favor of development of the project.

5. Solid Waste. Northampton generates 90 tons of solid wastes per day, about 6 pounds per capita.[20] This waste is currently buried in a landfill, but this practice is rapidly becoming unfeasible as good landfill sites are consumed at an ever increasing rate. Recently a proposal to build a solid waste burning plant has been made by the engineering staff at Cooley-Dickinson Hospital in Northampton.[21] The plant would produce electricity and steam for the hospital and cogenerate steam for space heating in the nearby Smith Vocational School and Northampton High School. Based on a comparison with a similar proposal for Rockingham County, New Hampshire,[22] we conclude that 90 tons of solid waste per day could provide 2.4 MW of electricity and a roughly equivalent amount of energy in the form of steam. Whether or not the hospital is the best place for such a plant would depend on a more comprehensive analysis of the entire energy system for the city.

6. Solar Energy. It is evident from the preceding paragraphs that none of the sources mentioned can provide more than a small fraction of the city's energy needs. The only remaining local and renewable resource is the sun. That there is a more than ample supply available can be seen by noting that an average of 150 watts of solar energy is incident on every square meter of Northampton[23] giving a total energy input of 407×10^{12} Btu/yr. or about 65 times the total current primary energy use.

The question then reduces to how to utilize the available solar energy in the most practical and efficient way. This is essentially a question of scale on a spectrum which runs from a single large solar electricity and heating facility serving the entire city to a multiplicity of small, on-site units scaled to the needs of individual buildings or consumers.

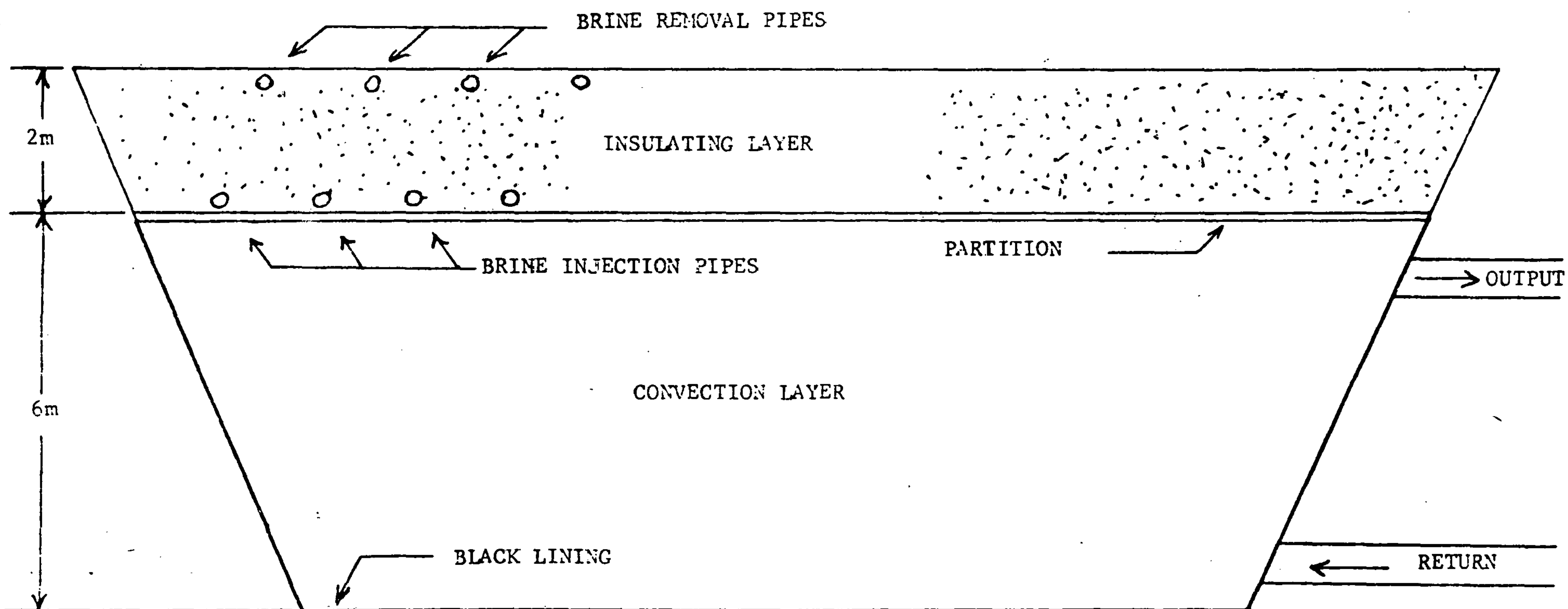
We have no definitive answers to this question but have chosen to explore a system which is intermediate between the two extremes and which seems to be well adapted to the geographic and demographic layout of the city. As we have noted in Section I the great majority of the population and virtually all of the economic activity are concentrated on a small fraction of the land area within the city limits. This suggests to us that the best solar energy system for the city would be one which utilizes portions of the currently unused land for the necessary collection and storage area and distributes low temperature heat through a district heating system which services all but the 2% or so of buildings which are well separated from the developed areas of the city. A promising new technology whic seems particularly well suited to this purpose is the solar pond.

Solar ponds have been explored in practice and in theory most extensively by Rabl and Nielsen[24] and Tabor.[25] There are many possible designs, and we have again had to be rather arbitrary in selecting one particular configuration for our scenario. A detailed comparison of alternative designs would take us too far from the main purpose of this paper.

We use a design proposed by Rabl and Nielsen in which a lower layer of fresh water is insulated from the atmosphere by a layer of water in which an inverted salt gradient is maintained [26] (See Figure 3). The two layers are separated by a transparent barrier made of a material which has enough

Figure 3

Schematic of solar pond design (not to scale).



strength to support the extra weight of the salt on top of it. The salt gradient in the insulating layer is maintained by a system of pipes which circulates concentrated brine to the bottom and fresh water to the top. The fresh water in the convection layer is kept at a temperature of 60°C-80°C and is pumped through the district heating system to homes and other buildings where heat exchangers extract the heat for space heating and domestic hot water.

The total area which must be devoted to ponds is determined by the solar input, the thickness of the insulating layer, various heat loss mechanisms and low temperature heat demand. The depth of the pond determines the thermal mass of the water and therefore controls the amplitude of the yearly temperature fluctuations. Our calculations based on a computerized model of a solar pond show that all low temperature heating needs could be supplied to Northampton with 445 acres (180 ha m^2) of ponds having a total depth of 8.2 meters consisting of a 2.2m insulating layer on top of a 6.0m convection layer.[27] The average temperature of the circulating water would be 69°C (156°F), and it would reach a maximum of 80°C in September and a minimum of 59°C in March. The ponds should be designed so that they are still capable of producing domestic hot water at 52°C (125°F) when the ponds are at their lowest temperature.

It is also possible to produce electricity from the solar ponds by taking advantage of the temperature difference between the hot water pumped out of the ponds and the cool water being returned from the district heating system. A Rankine cycle turbine or expansion engine using freon as a working fluid can be operated between these two temperatures at about 70% of its Carnot efficiency.[28] Waste heat from the Rankine engine is dumped to the return water and therefore put back into the ponds. Incidentally, the electrical energy needed to run the district heating pumps will add less than 300 kw to the total demand of the city.[29]

The availability of cooling water limits the production of electricity by this process, so the output of the generators will be proportional to the heating load. Extra area will have to be added to the ponds to provide for the extra energy taken off as electricity and non-recoverable waste heat. Our estimates are that adding 20ha (50 acres) to the ponds will provide an annual average electrical output of 1.15MW with a winter peak of 2.3 MW.[30] When this is added to the electricity produced by hydropower and solid wastes we get an average output of 4.5 MW. It is clear that other sources of electricity must be created if the projected demand of 15-20 MW is to be achieved.

There would seem to be little alternative to the use of photovoltaic systems for this added capacity. Large banks of photovoltaic cells could be built in conjunction with the solar ponds using the pond water for cooling in a variant of cogeneration. However, the production of more than 10 megawatts of power from photovoltaics in Massachusetts is at present a highly dubious prospect. The abundant biomass, hydropower and wind resources of the larger region encompassed by Hampshire and Franklin Counties would almost certainly be seen as far more practical for Northampton, at least for the foreseeable future.

The new system is summarized in Figure 4. The only aspect of this system which still requires some discussion is the transportation sector. Our estimate of 0.20×10^{12} Btu/yr end use demand for this sector is based on the proposed creation of a public transit system which would replace at least 75% of the local traffic. We have estimated that an electrified system which ran 6000 vehicle-miles per day would

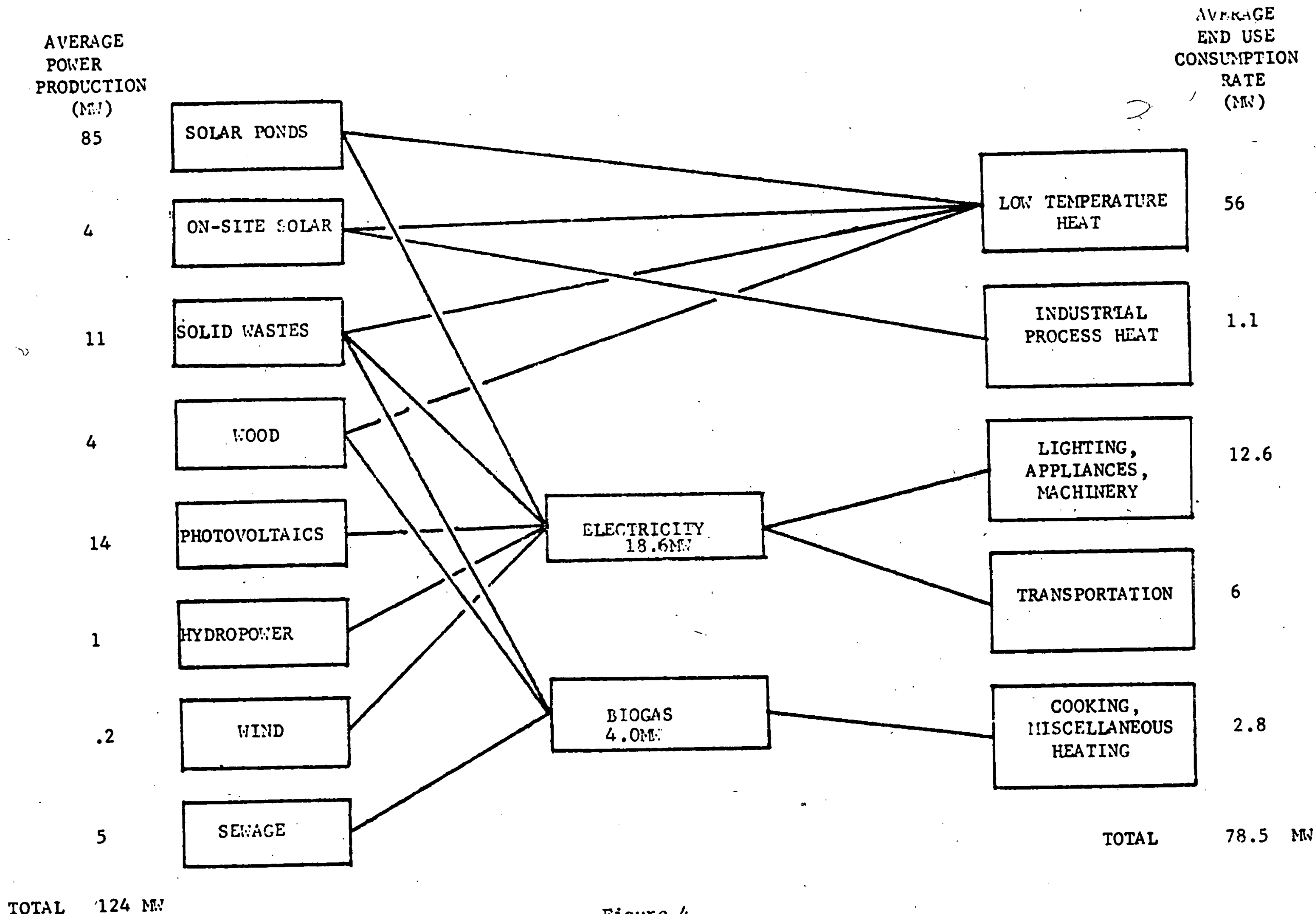


Figure 4

Proposed self-sufficient energy system for Northampton provide more than adequate service at an energy consumption rate of 3MW or 0.09×10^{12} Btu/yr. The balance of 0.11×10^{12} Btu/yr of transportation end use is allotted to commercial and industrial vehicles and some relatively low level of private vehicles use. All vehicles are assumed to be electric.

The requirement of all-electric vehicles in the transportation sector is another doubtful feature of our self-sufficiency scheme. Again it seems likely that the production of liquid fuels from agricultural and woodland sources in the sparsely populated surrounding counties would offer a more economical and convenient solution to the local transportation problem. However, electric public transit does have advantages, and liquid fuels may be needed only for commercial and personal vehicles.

V. Costs and Benfits

A transition to a self-sufficient energy economy will be very expensive. However, this must be put into perspective by keeping in mind that continuation of the use of non-renewable, imported energy sources will also be very expensive, most probably much more expensive in the long run. And it is in the long run that the alternative plan we are suggesting must be judged. We expect Northampton will continue to exist as a city for many years,and a coherent vision of the way the city might produce its energy 50 years from now is not at all inappropriate.

The costs and benefits of energy self-sufficiency are both tangible and intangible: economic, environmental, social and political. Among the local benefits will be increased reliability of energy supplies, more local control over supply and distribution, more money circulating in the local economy, possibly an enhanced sense of community cohesion and political participation, and most likely a lower overall cost for energy. Benefits to the larger economy will include a reduction in imported oil and a reduced pressure on the environment. Among the costs are a massive capital investment for which the payback period may be as long as 20 years, some loss of personal choice in the possible forms of local transportation, and the dedication of a substantial amount of land to the collection and storage of energy,making it unavailable for commercial, residential or industrial development. There will be political costs as well, since companies which now benefit from sales of energy in Northampton will either be displaced by a city energy authority or other companies, or will be forced to shift into other lines of business. Generally, such changes create political tensions, and a commitment to energy self-sufficiency will necessitate a parallel commitment to resolving these tensions.

As usual it is easiest to calculate and compare the strictly economic costs and benefits, although in this case there are great uncertainties in these calculations as well. We urge the reader to keep in mind the very tentative nature of the estimates which follow and to remember that the economic costs and benefits are no more important in principle than the political, social and environmental costs and benefits. They are simply easier to tabulate, while the others must be debated as part of the political process.

In our simplified cost-benefit calculation the benefits are the monies not spent on conventional imported energy sources less the operation and maintenance costs of the alternative system. We discount future benefits with two discount rates: an 8% rate reflecting the ability of the city to borrow money by issuing tax free municipal bonds and an 12% rate reflecting the opportunities for alternative uses of capital by private investors. It is worth noting that the U.S. Office of Management and Budget recommends a discount rate of 10%.[31] This figure was used by the Office of Technology Assessment in its projections of future solar energy applications.[32] The problem of inflation both in the general price level and for conventional fuels has been dealt with by performing the calculations for a number of different assumed general inflation rates and differential rates for energy prices. The inflation rates chosen are 4%, 6.5% and 8% and the differential rates for energy 0%, 2.5% and 5%.

Operation and maintenance costs have been estimated for the entire alternative system at $5.5 million per year. The detailed assumptions which underlie this estimate are given elsewhere.[33] We must also consider the taxes currently paid by energy suppliers to the city of Northampton. These amount to $500,000 per year and would be lost if the energy system were financed and owned by the city (our 8% discount rate scenario). Therefore, we have added this extra annual cost to the 8% scenario but left it out of the 12% scenario.

The numbers in Tables 5a and 5b are the net present benefits in millions of dollars expected from the alternative energy system. These numbers can be compared directly with the total capital cost of the new system, and if the costs of the new system are less than the expected benefits the investment is justified, at least on gross economic criteria. This direct comparison assumes that the new system will be financed and built all in one step, and considering the amount of capital required and the social and economic adjustments which will have to occur, this assumption is not at all realistic. Stretching the financing and construction out in time raises the total capital costs because of inflation, but also introduces the possibility of financing later construction with revenues earned on earlier systems. An accurate analysis of the economics of such a scenario would require a much more elaborate calculation than we have been able to attempt at this stage of our work.

We have made an attempt to get a rough estimate of the total capital costs of our system. We have used the estimates of Curran Associates for the Mill River Hydro Project, Cooley Dickinson Hospital for the solid waste plant, and the city sewage disposal plant for additional biogas digesters. We have made our own rough estimates of the cost of retrofitting buildings, a public transportation system

Table 5a Net Present Benefits of Self-Sufficient Energy System assuming a 12% discount rate (private financing) and a 25 year system lifetime. Numbers are in millions of 1978 dollars.

Inflation Rate \ Fuel Differential Rate	0%	2.5%	5.0%
4.0%	223	297	402
6.5%	281	386	533
8.0%	327	455	637

Table 5b Net Present Benefits of Self-Sufficient Energy System assuming an 8% discount rate (public financing) and a 25 year system lifetime. Numbers are in millions of 1978 dollars.

Inflation Rate	0%	2.5%	5.0%
4.0%	314	445	633
6.5%	415	603	877
8.0%	495	730	1075

and on-site solar equipment and have based our estimate of photovoltaic system costs on projections made by the American Physical Society in its recent study of photovoltaic prospects.[34] Finally, our estimates of solar pond and district heating costs are based on a detailed plan for such a system which is described elsewhere.[35] The result is a total capital cost of $260 million which is only slightly greater than the net present benefits expected from our most conservative scenario; i.e., 4% inflation, no differential rise in energy prices and a 12% discount rate. This suggests to us that the economic prospects of a self-sufficient system are very promising and deserve to be explored in a more detailed manner.

It is important to mention two aspects of the economic benefits from a self-sufficient system which have not been included in the above analysis, but which contribute substantially to the attractiveness of the system. These are the enhanced reliability of energy supply and the multiplier effect operating on money spent locally for locally produced energy. Reliability of supply leads to more certainty in planning and a more stable business climate, and the multiplier effect creates extra income from money which now leaves the city's economy. It is not easy to quantify either of these effects, but one economist has suggested that a multiplier of about 1.6 is reasonable for a city the size of Northampton.[36]

Finally, we may add to these effects the considerable increase in the number of local jobs, especially during the construction of the new system. Currently the energy supply sector of Northampton's economy employs about 170 people.[37] Our alternative system could increase this to perhaps 290 permanent jobs, a 70% increase. Except for the construction phase the energy supply sector will never be a major source of direct employment, but the stimulating effect of money recirculated within the local economy can create jobs in other economic sectors.

VI. Obstacles and Possibilities

We have shown that it is technically feasible and possibly even economically sensible for a city like Northampton to develop a self-sufficient energy system. It remains to ask whether such a scheme makes political sense both in the local context and in its implications for Northampton's relationsips with the county, state and nation in which it is located. There is also the problem of capital formation, probably the single most discouraging obstacle in the path of any community seeking greater self-sufficiency.

The problems of politics and capital formation are deeply intertwined. It is no secret that a move toward self-sufficiency by cities like Northampton would be seen as highly threatening to the utilities which now supply energy to the city. If the idea caught on the entire structure of highly centralized and widely integrated energy networks which has grown up over the past 30 years would be severely undermined. Utilities and major energy companies wield substantial economic and political power and are unlikely to sit quietly while their economic base is systematically eroded.

At the same time these utilities and energy companies could be excellent sources of capital for the transformation if they could be induced to invest in the new energy system or help finance it by loans. The idea of utilities and energy companies expanding into the financing of conservation and alternative energy development is not a new one, but it has not so far been enthusiastically embraced by major energy suppliers. On the other hand, many local oil companies are beginning to branch out into conservation and alternative energy as conservation has begun to reduce their oil sales.

This is useful and should be encouraged, but changes on this level could not provide capital in the quantities needed to make rapid progress toward community self-sufficiency. The real question is whether major corporations can be induced to participate in their own gradual dismemberment, or at least radical transformation. It takes a certain "willing suspension of disbelief" to generate any optimism on this question.

There are, of course, other ways to raise capital. If we stay within the city, we have the possibilities of bond issues, increased taxes, or the formation of a community energy corporation. If we go outside the city, there are the possibilities of State or Federal grants or loans or the (remote) possibility of inducing a major corporation to develop a local energy system as a profit making venture. Again the method of financing has political implications in terms of the degree to which the local energy system will be locally controlled. If genuine local control is a major priority, then most of the capital will have to be raised locally, and this guarantees that the transition will have to take place over a long period of time as revenues from early projects accumulate in sufficient quantities to finance later ones.

Our interviews with local bankers and savings and loan officers showed that there is a relatively high level of energy awareness among them as well as a sense of responsibility toward the local community. Several of them assured us that their organizations would be willing to invest in local energy developments provided that these satisfied their usual criteria for financial soundness and competent management.

The transition to self-sufficiency is then best seen as a long term effort in which the most clearly profitable steps are taken first and used to generate income for later steps. If we examine the system outlined in Section V in this light, a reasonably clear order of priorities emerges.

1. Conservation: As the price of heating oil rises past 90¢ per gallon the economic benefits of major conservation efforts are becoming obvious to a growing number of people. Adding insulation to houses, businesses, public buildings and industries, setting back thermostats, remodeling to take advantage of passive solar heating, installing more efficient heating systems, and other measures are already being undertaken by individuals and firms. The payback periods on many such measures are extremely short, and generally capital can be raised fairly easily in the form of home improvement loans, business loans, etc. The one sector of the economy which needs help in this area are the low income groups and renters. Subsidies or low interest loans can be made to low income people, and city ordinances can be enacted to discourage landlords and businesses from simply passing on higher energy costs to their tenants and customers.

Just how this conservation can be utilized to raise capital for further energy development is problematic. The most obvious measure would be an energy tax which would siphon off some of the savings made by individual consumers. But such a tax is bound to be politically unpopular and would require considerable efforts at education and persuasion on the part of community leaders. It would also have to be associated with a system of rebates or exemptions for low income people to spread the burden more equitably. None of this is impossible, but it would certainly be difficult.

2. Solid waste utilization: The studies which have already been done on the proposed Cooley Dickinson solid waste plant have been quite encouraging. In addition the rapid depletion of available landfill sites makes the development of some alternative disposal system imperative in the near future. All that is needed is capital to finance construction, and this could come in any of several forms. This can also provide the necessary initial local experience with district heating technology.

3. Forest management. The systematic harvesting and sale of wood could provide an immediate and useful contribution to the city's current energy supply. This could be done either by the city through a contract arrangement with a private company or entirely by private enterprise. However, cooperation would have to be obtained from local owners of woodlots, and historically New Englanders have been wary of public control of their private woodlands. In conjunction with this program and the solid waste and biogas facilities, it would also be important to institute a program for collecting the agricultural wastes generated within the city.

4. Biogas: The untreated sewage which is now dumped into the Connecticut River can be tapped for the production of biogas. Efforts could then be made to supply this gas to consumers using the existing utility gas lines. This would require the cooperation of the local gas company, but such cooperative arrangements are now being recognized as potentially advantageous to both parties. Whether or not the city would ultimately generate a sufficient supply of gas to become independent of the utility (thereby requiring that the city also acquire the distribution network) would be a problem for the more distant future.

5. Public transportation: The rapidly increasing price and decreasing supply of gasoline demands that efforts be made either to find substitutes for the private automobile or to find substitute fuels. For the near future the former tactic would seem to promise more immediate benefits, and it follows that an improvement in public transportation service ought to be a high priority. This may or may not be coupled with some restrictions on the use of private vehicles on the city streets.

Such measures will not be entirely palatable to local residents and business people especially given the latter group's running battle with the out-of-town shopping malls. What political pressures do existin the city seem to be oriented toward making driving and parking easier in the downtown area rather than more difficult. There is no easy solution to this problem, but it does seem that continued shortages and price increases for gasoline are bound to make public transit and shopping "downtown" more attractive to a growing number of people. It would seem to be a propitious time for the city commercial interests to begin to plan innovative strategies to take advantage of these developments and woo customers away from the malls.

An important question raised by the prospect of increased public transportation is whether or not it should be electrified. Many factors would contribute to making such a decision, but the controlling factor in the early stages would seem to be the original capital cost of installing an electrified system. A much more detailed analysis of this question than can be done here would be needed before any decision were made on this question.

This initial group of five programs all involve well known and highly accessible technologies. They would make a significant contribution to the energy economy of the city at an initial cost which is not overly large and which promises relatively rapid payback. The group of five which follows are either less well developed or not clearly economically viable at this time. Development of these options would be undertaken slowly and watchfully with every attempt being made to keep options open to take advantage of alternative strategies which may prove to be superior.

- 6. Solar ponds: The many potential advantages of this technology strongly suggest that it be vigorously explored. This would best be done in the form of pilot projects, and Northampton would be as good a place as any to undertake one of these projects. Funding would presumably be in the form of a federal research and development grant. An interesting size to test would be a 15 acre pond capable of supplying low temperature heat to about 300 homes and apartments. If this project turned out successfully, then new ponds could be added as rapidly as capital availability and public acceptance would permit. The question of ownership and management of the ponds and their associated district heating network would be an important political issue which the community would have to resolve early in the program.

7. Local generation of electricity: At the present time only one of the methods of local electricity production we discussed in Section V is close to practicability. This is the solid waste burning project mentioned above in item 2. It could generate about 2.4 MW or about 12% of the current average consumption in Northampton.

The next closest would be hydropower development on the Mill River, but as we have seen this is presently economically doubtful and would in any case make only a minor contribution to the city's electricity needs.

The use of Rankine cycle generators in connection with solar ponds depends on the prior establishment of the feasibility of the ponds as low temperature heat sources. If they turn out to be well suited for this purpose then it should not be much of a problem to add the electrical generating capacity later on. There is no question about the existence of appropriate equipment since suitable generators are already in existence.[38]

The use of photovoltaic cells for the large scale production of electricity must wait upon substantial reduction in costs. Optimism seems to be growing that significant reductions can be achieved, but these will still be some time in arriving even if the optimism is justified.

It seems likely to us that the question of whether or not cities like Northampton will be encouraged to generate their own electricity will be answered by economic and political factors well beyond the control of such small economic and political units. National policies on air and water pollution, nuclear safety and waste disposal, utility regulation, and many others will almost certainly be the controlling factors in determining the options available to Northampton. There is little the city can do at this point except to wait to see what happens and to use its experience with other forms of self-sufficiency to develop the technological, institutional, and economic base which could facilitate the transition to locally generated electricity if it turned out to be warranted.

This list of projects ranges all the way from the immediately practicable and essential to the speculative, hypothetical, and economically dubious. It does, however, form a coherent, internally consistent and technically feasible scenario which Northampton could follow if the people of the city were to decide that a commitment to self-sufficiency was a wise strategy for dealing with the energy crisis. Put very simply the political problems are far more significant and difficult than the technical problems. The many potential benefits of the kind of self-sufficiency we have described in this scenario would seem at the very least to make worthwhile a lively and sustained community discussion of this option in order to get a better sense of the nature and magnitude of the political problems.

VII. Conclusion

We now return to a question raised at the beginning of the paper: is Northampton a sensible choice as an energy self-sufficient unit? The data and arguments developed in this paper do not provide a definitive answer to this question, but they do suggest a number of ways in which the situation might be improved by choosing a larger unit. For example, if the boundaries of self-sufficiency were stretched to include all of Hampshire County, then the wood resource would increase by a factor of 5 from about 0.2 to almost 1.0 cords per capita per year. Of course the full development of this resource would involve a considerably larger expense, since much of the county's forestland is relatively inaccessible, but there is little doubt that for the county as a whole, wood would play a larger role than for the city itself.

Other resources which might prove more practical on a countywide scale are wind, hydro and energy crops. In particular the added agricultural land might allow for some production of alcohol fuels, although the reduction of dependence on imported food should probably take precedence over energy production in claims on good farmland.

These advantages of county-wide self-sufficiency might be offset by the problems of electricity distribution, public transportation and problems of political tension between city and county governments. However, the county does seem the next logical unit to examine in exploring the possibilities for greater use of local, renewable energy sources.

Another important argument against local self-sufficiency is often made by economists. It invokes the well known principle of "gains from trade" to argue that local self-sufficiency in energy production is inefficient when viewed from a wider economic perspective. For example, if Northampton were sitting on top of a bauxite mine it would make sense to import energy and export aluminum.

Unfortunately Northampton has no such advantage. The city has very little industry left and is almost entirely devoted to residential and commercial activities. Therefore, the vast majority of the energy used in Northampton is used for <u>subsistence</u> and not for production. This seems to us to invalidate the gains from trade argument.

In the final analysis the decision on energy self-sufficiency will have to be made by the people of Northampton. Therefore the next stage of our work will be to bring the results of the analysis described in this paper to the attention of the people and political leadership of the city. Obviously more work must be done before a concrete plan is adopted, but the work we have done so far is sufficiently indicative of the range of choices to be made that it can serve as a basis for the extensive political discussion which must precede any change of this magnitude. Energy issues are of urgent concern to a growing number of people, and informed public debate of possible strategies for coping with the energy problem is essential. We believe that studies like this one can make a useful contribution to this debate.

Authors' Note

Three of the authors of this study, Christine T. Donovan, Lucia M. Ford, and Sandra C. Small, are undergraduate students at Hampshire College in Amherst, Massachusetts. The study has been done in partial fulfillment of their Bachelor of Arts degrees at Hampshire. The fourth author, Allan S. Krass, is an Associate Professor of Physics and Science Policy Assessment at Hampshire College. Research conducted for this study during the summer of 1978 was supported by the U. S. Department of Energy in Washington, D. C.

Most importantly, we express gratitude to the people of Northampton who have contributed their time and information to our research. The project would not have been possible without their participation. Richard Holt and Gene Frankel, of the Department of Energy, have offered valuable advice and encouragement throughout our work. Numerous members of the faculty at Hampshire College, particularly Myrna Breitbart, Stewart Shapiro, Stanley Warner, Barbara Linden and Norton Juster, have provided ideas and support for our work. They retained confidence in our ability to work collectively on this project and have added greatly to our enjoyment of the process. Our families and friends, Mod. 87, Apartment 55, and the Olive Street House have inspired and supported us throughout our work. We also thank Julia Bishop for her patience and cheerfulness while typing, Cindy Morgan for her artistic abilities and assistance, and Roger Laviale for his interest in and research on the solar pond concept. Finally, we acknowledge all of the people who have been teachers for us.

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ENERGY SELF-SUFFICIENCY

IN

NORTHAMPTON, MASSACHUSETTS

Introduction

Presently, 98% of New England's energy resources come from outside the region and 80% of the region's total energy imports are derived from foreign sources. This heavy dependence on imported energy has spawned a variety of political and economic problems for New England, most severely experienced during and since the 1973 oil embargo. In response to the energy crisis and its repercussions, New Englanders are educating themselves about energy conservation and appropriate technology. Individuals, neighborhoods, towns, and counties are considering how to supply their own energy needs and become more energy self-reliant.

This study emphasizes energy policy on a local level by examining the prospects for energy self-sufficiency in Northampton, Massachusetts. The intent is to determine if this city of 30,000 people could supply all of its energy from renewable resources located within the city. Relatively small-scale, diversified and technically simple systems are proposed. An inventory of the energy resources which exist in Northampton is presented and possible incentives for their use are examined. The economic and political implications of a shift to alternative energy systems are addressed, and the potential role of groups within the community is discussed.

In order to highlight the opportunities for energy self-reliance in Northampton, a boundary has been drawn in this study which corresponds to the city limits. A scenario for energy self-sufficiency in Northampton is described, but the alternative energy systems presented are only one set of options which could be developed. This study has been considered a case study, designed to facilitate understanding of the general characteristics of energy use and supply in any community.

The importance of a community-level energy strategy rests in the potential for participation on the part of local residents, business-people and government officials. Consequently, this study has been written with the layperson in mind and we have been straightforward about the values and biases which underlie our work. An effort has been made to present information in a format useful to anyone interested in exploring questions related to local and community participation in the production, distribution and financing of alternative energy systems. Since beginning research on this study, we have learned of other groups and communities engaged in similar work. There are exciting projects being developed in areas such as public transportation, neighborhood energy audits, conservation, recycling, solar greenhouses, community gardens, and urban reconstruction using alternative energy. There is a great need for public funding to encourage such projects.

It is only recently that the U.S. Department of Energy has started to fund community level energy studies. DOE is presently funding three related local energy studies: one in the rural area of Franklin County, Massachusetts; the second in a suburban community of Long Island; and the third in downtown Baltimore. These projects are designed to examine the feasibility of alternative energy systems in very different settings, as well as to gauge the economic impacts of their development. Our research was also partially supported by DOE, and the Department has recently funded seventeen communities across the country to undertake Comprehensive Community Energy Management Programs. These studies will entail the examination of each communities' energy objectives, and will involve the determination and implementation of energy management and conservation actions for each community.

This study is divided into three sections. The first chapter serves as a foundation for our project. It outlines the assumptions and social goals used in the study. Part One, An Energy Profile, consists of Chapters Two, Three and Four. This section acquaints the reader with many aspects of Northampton. It examines the city's history, its past and present energy use, and concludes with an economic analysis of present energy expenditures in Northampton.

Part Two, Determining Future Demand, consists of Chapters Five, Six and Seven. It is explained in this section that Northampton can greatly decrease its current energy use by using energy more carefully and efficiently. It is suggested that the city could actually reduce its overall demand for energy without experiencing economic or lifestyle sacrifices.

Part Three, Northampton as an Energy Self-Sufficient Community, consists of Chapters Eight through Eleven. This section examines what natural, economic and political resources the city could utilize in becoming energy self-sufficient. Activities related to alternative energy which are presently going on in the city are described, and possibilities for future action are suggested. Chapter Twelve concludes the study by placing the scenario developed for Northampton within a broader framework. Complex issues involved in the transition to energy self-sufficiency are discussed.

Chapter One

The Politics of Energy Choices

The energy system which has fueled this country's prosperity for the past two hundred years has been based on the availability of abundant and accessible fossil fuels. However, in the past several years, dwindling supplies of oil and natural gas, and the economic and technical instability of nuclear power have forced the United States to reassess its energy choices. The formulation of energy policy is a particularly critical task for New England. A severe climate and lack of indigenous fossil fuel resources make the region heavily reliant on energy imported from other areas. As the cost of energy continues to rise, an increasing amount of money is drained from the New England economy, straining both its present and future viability. Therefore, it is vital that New England take part in the current debate about energy options, and attempt to develop a workable energy policy.

Any national energy policy is likely to require a major social effort, and will have implications for the level and kinds of government intervention, for foreign policy, social equity, environmental protection, and employment patterns. So although the energy problem was once defined as one of maintaining adequate supplies, it has since been broadened to include a reevaluation of the entire technical and sociopolitical structure of the energy system. Questions have been raised concerning the control of energy systems, with particular reference to the concentrations of political and economic power associated with the present system. A sustained discussion has focussed on what resources and energy systems should be utilized.

As the scope of the energy issue widens, there is a deepening awareness that choices about energy reflect social and political values. Decisions which are made about resource use, and the scale, complexity and ownership of energy systems embody social priorities. From this perspective, the energy situation becomes a problem which calls not just for technical expertise, but one which demands widespread and lively debate about fundamental social goals. It is only on the basis of articulated and generally shared social values that various energy schemes can be judged.

This study designs an energy plan which is consistent with a specific social vision, one which is shared by the authors of this study. This vision includes the evolution of an economic and technological system which is environmentally sound, conducive to democratic forms of government, and which guarantees access to the basic necessities of life to all people. These goals are shared by most other Americans, but it is not generally recognized that various technologies can either serve particular social ends or make them difficult, even impossible, to attain. Choosing among technologies is part of the pursuit of a social vision and must be done thoughtfully. At the same time, it is important to recognize that changes in the energy system are necessary, but are not alone sufficient to construct the society which is envisioned.

In this chapter we establish a set of criteria which are based on the social goals described above, and which we feel ought to guide the selection of energy systems proposed for Northampton. Potential energy systems, and the policies necessary to support them, are examined for their socioeconomic consequences, their effects on the political process, and their environmental impact.

Whether explicitly or not, present energy systems embody sociopolitical values through their impact on individuals, communities, and the environment. Awareness of the implicit values is important for an assessment of many current proposals. One energy strategy suggested in various industrial and governmental studies essentially advocates a continuation of existing policies. Energy consumption, according to these forecasts, is assumed to increase at historic (3.5% per year) or near-historic rates. The rapid development of coal resources, and the expansion of nuclear power are expected to substitute for depleting supplies of oil and natural gas. There is a growing literature pointing out the difficulties and dangers in such a course.[1] Many of the inadequacies result from an orientation to energy supply and demand which is based on circumstances now, or soon to be, obsolete.

Conventional energy systems have been constructed in an economic system which treats the environment as an assortment of "free goods". Any damage to the environment which occurs through production or consumption is born socially, while the benefits (in the form of profits or goods) are experienced privately. This "oversight" of the market mechanism is the primary driving force behind policies which maximize the exploitation of nature. Use of the high-impact technologies which characterize many production processes, together with a high level of consumption, and the amplifying effects of population growth, are combining to put pressure on the carrying capacity of the environment. This is most evident in the impending depletion of many natural resources, including fossil fuels. Air and water pollution, and the rising health risks from toxic substances are also visible signs of overstress in the environment.

An energy system based on coal and nuclear power would continue the trend of high-impact technology. There are serious environmental effects associated with the large-scale development of coal resources, including massive strip mining and water shortages in the West, and increased levels of carbon dioxide from the burning of coal.[2] Nuclear power plants, in addition to discharging enormous quantities of waste heat into the atmosphere and bodies of water, have the added risk of environmental disaster which could result from a major breakdown or sabotage. The choice of coal and uranium for our energy supply inevitably entails the sacrifice of environmental standards as well as further erosion of environmental quality.

The present energy system was built in an era of cheap fuel. Before the "energy crisis" of the early 1970's, the price of fuel had fallen relative to the price of labor and capital. Based on a concept of efficiency which includes maximizing output for the least cost of input, the energy system was centralized. Giant, high-technology plants serving large regions were built for their economies of scale in capital and labor. These centralized production facilities "utilize capital and labor efficiently at the expense of increased use of relatively cheap energy"[3]. The huge scale of energy plants, and the vast political and technical infrastructure they require, creates large transaction and distribution costs. With oil and natural gas, there are energy losses at the point of use which occur because of inefficient burners and poorly weatherized buildings. Substantial energy waste results from the unnecessary conversion of fossil fuels to electricity for low temperature heating needs.[4] What was once considered efficient in a very narrow economic sense during a period of diffuse environmental damage and low-cost energy must therefore now be reconsidered.

The cost of replacement energy, that is, the cost of supplying an additional unit of energy, will continue to rise dramatically as less accessible resources are tapped. Any future energy system based on traditional resources will involve massive capital expenditures by the energy-producing sector. The size of coal and nuclear power plants, and the long lead times necessary for their construction, implies that a large amount of capital is going to be concentrated in a few hands for a long time. However in a period of economic problems, market mechanisms may not be able to allocate this capital. Such a situation could prompt the government to ensure the availability of capital for the energy sector.[5] (In fact, the nuclear industry has already benefited from government subsidies in the form of federal insurance, federally-financed research, and low cost uranium enrichment and waste storage arrangements.) Other sectors of the economy, particularly those which are unorganized and weaker in political and economic power than the nuclear lobby (especially social and human services), will lose out in the scramble for societal resources.

To choose an energy future based on nuclear power and coal is to choose to live with increasingly serious environmental effects and economic bottlenecks. The problems of such a strategy include the inevitable weakening of environmental standards, compulsory allocation of scarce resources, the tendency toward self-aggrandizement by the energy producers, and the compromising of health and safety laws for coal miners and nuclear industry workers. The social effects of nuclear power may be even more disturbing. The vulnerability of nuclear power plants to technical failure or sabotage increases the need for elaborate security precautions, and the long-term protection of radioactive wastes demands an unprecedented degree of social stability. As the consequences of a nuclear breakdown escalate, the exercise of civil liberties, dissent and non-conformity become less tolerable.

Many of the unsettling social and political effects of this course of development result from an emphasis on energy systems which are large-scale, technically complex, and which require centralized management. These features have important implications for the allocation of benefits and burdens associated with energy production. For one, centralized energy systems separate both geographically and politically those who bear the impact of energy production (strip mining, air and water pollution, increased cancer rates) from those who receive the benefits of using energy. The conflict inherent in such a situation is evident in the local opposition to nuclear siting procedures and the transportation of nuclear waste. Local autonomy is neglected by the social and geographical remoteness of the authority which operates and comprises the energy infrastructure. Decisions which have political consequences, such as those involving the choice of the location of power plants and the determination of what is "acceptable" risk, are made by an impersonal bureaucracy which stands behind an impenetrable row of technical experts. The underlying values of the industries which produce energy become obscured, and their drive to expand and increase profits goes unchecked.

In addition, with centralized energy systems, control over the production and supply of energy is separated and distant from the people who purchase and use the energy. The political inaccessibility and economic power of a centralized energy structure implies a potential for misuses of power and distribution inequities. It is the poor who suffer most from a lack of control over basic necessities such as energy, and who are most vulnerable to abuses of power.

In short, present energy systems (and many of those planned for the future) force people to depend on "systems they cannot understand, control, diagnose, repair, or modify"[6]. This dependence preempts the political process by leaving a majority of citizens uninvolved in the acts of choosing, initiating, and judging the conditions of major aspects of their lives.

An energy policy based on coal and nuclear power creates reliance on systems which surpass understanding and control, drain the economy of scarce resources, and seriously erode the environment. Such policy is based on projections of future energy needs which are extrapolated from trends occurring in a time of high economic growth and low-cost energy. Continued increases in energy consumption are thought to be not only inevitable but essential to the standard of living, economic health and the quality of life. However, the supposed identity of high energy use with greater social welfare becomes invalid when the systems which supply the energy are environmentally disruptive and socially divisive.

There is another set of values which suggests a reorientation of the energy system by challenging the hegemony of economic and technical motivations in society. The centrality of energy in modern life has given new focus to those dissatisfied with the predominance of a technical scale which denies interaction and flexibility, and which increases the trend toward central authority. It has become increasingly apparent as a high level of material prosperity has been attained that the social ethos created by a narrow economic drive is not necessarily one of social harmony, cooperation, or satisfaction.[7] An alternative framework is developed in our study which includes identifying important social goals and attempting to achieve them "elegantly"[8], with a minimum of resource input, extravagance, and waste. Included in such an energy plan is a commitment to energy systems which are environmentally gentle, which facilitate political access and self-reliance, which are not controlled by "big" business or "big" government, and which are designed to serve human needs over and above narrow technical imperatives.

A reorientation of the energy system would first stress a diversity of solutions. Every region differs in its energy uses, its resource base, its social patterns, and the fragility of its ecosystem. An energy supply system which is small in scale and geographically dispersed would be more adaptable to local resources and conditions than centralized systems are. This type of energy supply system is also inherently quite flexible, both technically and socially.

A sustainable energy system can be built for minimal environmental impact, avoiding air and water pollution and resource depletion. Small-scale systems can be technically diverse, can rely on local resources which are renewable, can be constructed with fewer and simpler components, and can use familiar and environmentally benign technologies.

Small-scale, dispersed energy systems reduce or eliminate much of the waste of the present energy supply structure. Such energy systems are matched in scale and quality to the work requirements, or the end use for which the energy is needed. The scale or size can vary from individual domestic systems to community or district systems.

Small-systems, located at or near the point of use, lower many of the distribution costs and conversion losses which plague centralized systems. A closer fit could be achieved between technical means and social ends. For instance, the incongruity of using a nuclear power plant which produces energy at a temperature of thousands of degrees to heat a home to 68°F would be avoided.

A significant feature of small-scale, dispersed energy systems is their compatibility with a variety of arrangements for ownership and control. Since small energy systems would require much less capital investment than large-scale systems, they are much more appropriate for individual, small group or community ownership. These systems could also foster a decision-making structure which is more decentralized than the current system. Paul Goodman, a political theorist, defines decentralization as "increasing the number of centers of decision-making and the number of initiators of policy; increasing awareness by individuals of the whole function in which they are involved; and establishing as much face-to-face association with decision-makers as possible".[9]

Energy systems which enable political participation must not be too technically arcane, that is, their principles of operation must be readily grasped. This implies that everyone could have a comprehension of the techniques and principles involved, not that each person would necessarily have the skills to build such systems. Less sophisticated management systems could be used to run these systems.

The decentralized control and ownership of energy systems which are small and located in the communities they serve could help to encourage a rejuvenation of local autonomy and community politics. The people living in a community could collectively determine what kind of energy systems to develop, based on their specific energy needs and social patterns, as well as on the level of risks they are willing to bear. These systems could merge the environmental costs of making energy with the benefits of economic and political control over the production, distribution and use of energy. We also advocate that the opportunity for economic control of energy systems be made available to everyone. This goal hinges, to a large extent, on what public policies are taken to implement small-scale, decentralized energy systems.

Conclusion

The two energy scenarios described above diverge significantly.[10] The political, environmental and social costs of a centralized energy path are high. It is "brittle. . . it must fail, with widespread and serious disruption, if any of its exacting technical and social conditions are not satisfied continuously and completely".[11] This approach is likely to be economically troublesome and inconsistent with expectations of personal freedom and civil liberties.

The greatest difference between the two energy paths lies in the diversity available to small-scale, dispersed energy systems. The alternative energy strategy pursued in this study is economically and technically flexible and resilient, politically responsive and resource-conserving. Community-oriented systems are compatible with a wide range of structures for ownership and control. The policies needed to implement such systems are multifaceted, adaptable to the specific social character and energy use patterns of a given community. Most significantly, this alternative energy plan can take form through public meetings, open discussions and local initiative.

Footnotes

1. See Solar Energy in America's Future: A Preliminary Assessment, Stanford Research Institute for ERDA, Division of Solar Energy, March 1977 ; and Nuclear Economics: An Invitation to Ruin, a pamphlet by the Clamshell Alliance ; and A Time to Choose: Final Report, by the Ford Foundation Energy Policy Project, Cambridge: Ballinger Publishing Co., 1974 .

2. Stanford Research Institute, p. xii.

3. Hannon, Bruce. "Energy, Labor, and the Conserver Society", Technology Review, March/April 1977, p. 48.

4. Lovins, Amory. Soft Energy Paths: Toward a Durable Peace, Cambridge: Ballinger Publishing Co., 1977 , p. 28.

5. Ibid.,p. 54.

6. Ibid.,p. 152.

7. Heilbroner, Robert. An Inquiry into the Human Prospect, New York: W. W. Norton & Co., Inc., 1974 , p. 70.

8. Lovins.

9. Stoehr, Taylor, ed. Drawing the Line: Political Essays of Paul Goodman, New York: Free Life Editions, Inc., 1977 , p. 185.

10. Amory Lovins calls these two energy strategies the "hard energy path" and the "soft energy path". As he writes, "the hard path depends on difficult large-scale projects requiring major social commitment under centralized management" (p.54). The soft path "relies on smaller, far simpler energy supply systems" (p.50). It "combines a prompt and serious commitment to efficient use of energy, rapid development of renewable energy sources matched in scale and quality to end-use needs, and special transitional fossil fuel technologies" (p.25). Lovins developed the two scenarios to call attention to the value choices which underlie energy policy. For he says, "Perhaps the most profound difference between the soft and hard paths--the difference that ultimately distinguishes them--is their domestic sociopolitical impact" (p.54).

11. Lovins, p. 51.

PART ONE

An Energy Profile

In order to design an alternative energy future appropriate for Northampton, we have first attempted to learn as much as possible about the city's history, physical layout, current population and government structure. An understanding of these characteristics has been essential to determining current energy use and to suggesting possible alternative energy systems for the city. Chapter Two provides an overview of Northampton from a historical and energy-related perspective. A detailed discussion of the way energy is presently used and supplied in Northampton is presented in Chapter Three. The local economic effects of current Northampton energy expenditures are estimated in Chapter Four, establishing a base on which the economic impacts of the alternative energy systems proposed for Northampton can be compared.

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Chapter Two

A Visit to Northampton - Past and Present

Northampton is a city of 30,000 people located in the central western part of Massachusetts. It encompasses approximately 35 square miles of land which is particularly hilly on the western side of the city. The eastern and southeastern portions of Northampton are bordered by the meandering Connecticut River which has formed an oxbow along a flat section of the flood plain. The soil in the river's floodplain has proven valuable for farming. The Mill River, the other major waterway in the city, runs from the north central part of the city to the south east corner and into the Connecticut River. Northampton is regarded as an urban center by its neighboring rural communities. With a mixture of residences, industries, commercial establishments, and agricultural land, Northampton typifies an old, small New England city.

The Pioneering Years: 1650 - 1850

Northampton was established in 1654 after John Pynchon, a wealthy Springfield resident, purchased common land known as "Nonotuck" from the Nonotuck Indians. The land was renamed Northampton in that year and as the first settlement in Hampshire County, Northampton survived as a nearly self-sufficient agrarian community for the next two hundred years.[1] Agriculture was the chief occupation of Northampton's early pioneers and industry was limited to the production of agricultural tools, wool, and other supplies necessary for the town to sustain itself.

Because it was situated along the Connecticut River, a popular transportation and trade corridor, Northampton attracted many immigrants. During the 19th century, a strong representation of Polish, Irish, Canadian, and Italian nationalities settled in Northampton, until then a predominantly "Yankee" town.[2] In the early part of the 19th century, the availability of jobs in the small but growing mills and factories coupled with the agricultural richness of Northampton were two features that encouraged newcomers to settle there.

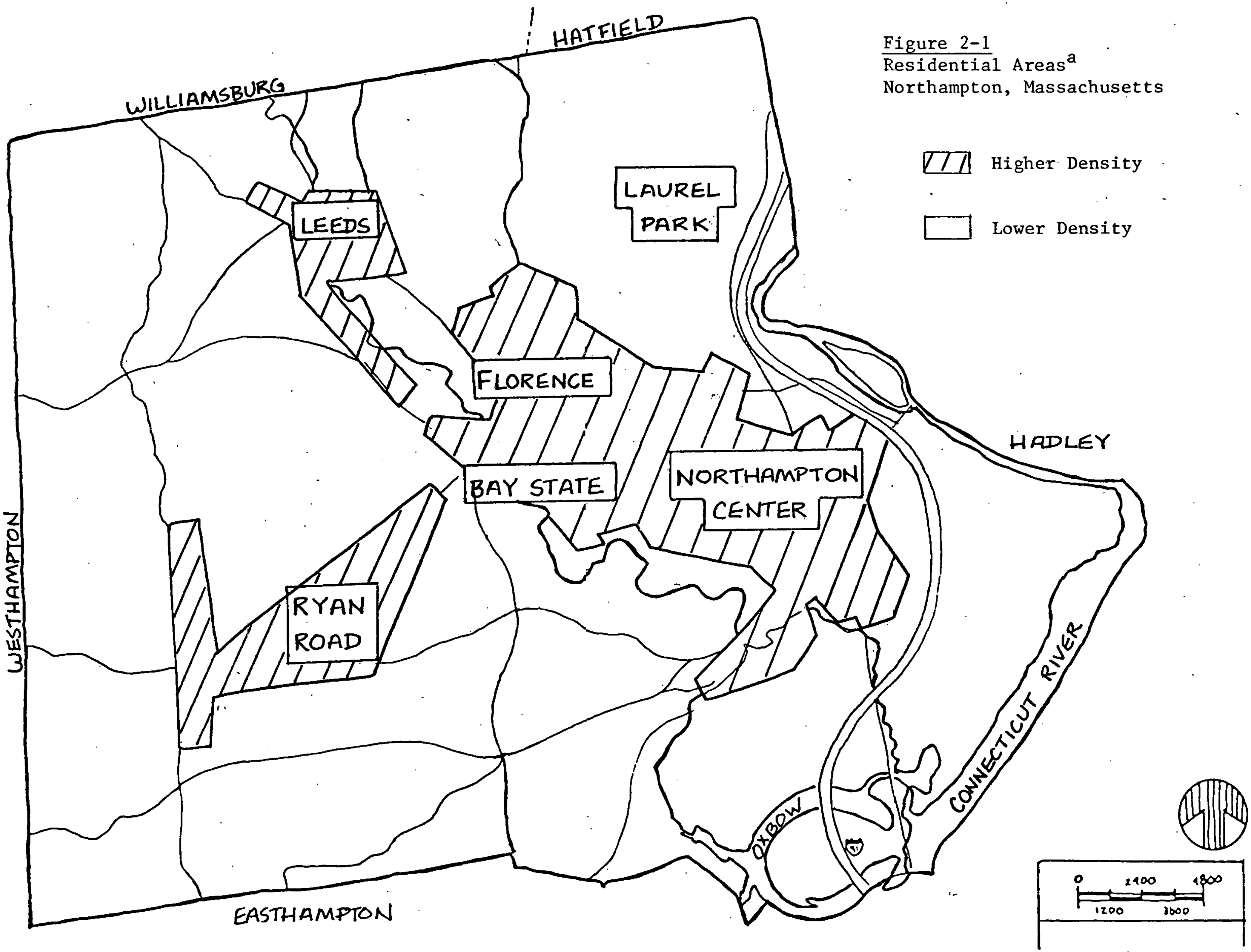
When Northampton was incorporated as a city in the 1830's, it was still very much a New England farming town featuring many small shops and mills and a village atmosphere. But resources such as the Connecticut and Mill Rivers, as well as the introduction of the railroad to the area, produced a climate in which industry would prosper during the mid 19th century.

The History of Energy Use In Northampton

Energy use is a common thread that is woven throughout this overview of Northampton. A summary of the significant changes in energy resources in Northampton's history is necessary before introducing each section.

Wood energy has been a long-standing heating source in Northampton, dating back over 300 years. Wood burning supplied space and water heating and industrial "process heat" to Northampton dwellers. This was true for residences, industries and businesses

Figure 2-1
Residential Areas[a]
Northampton, Massachusetts



[a]Drawing not to scale

which used wood stoves and wood furnaces as their main source of energy into the late 19th century.[3]

With the abundant supply of wood available to Northampton's 17th century settlers, it was only natural that people employed it as a heating source as well as for shelter. However, by the middle of the 19th century, wood had become comparatively scarce. Businesses formed to supply people with wood or coal. First regarded as a service for people who could afford to be more "extravagant", these heating companies continued to supply sources for space heating as wood became less accessible. Somc of the original heating companies are still operating in and around Northampton today as the local heating oil providers.

Domestic oil began to be used in 1930, but it was not widely employed as a heating source until after World War II.[4] Today, almost 60% of Northampton's residential dwellings rely on imported oil to provide space heating needs. Imported natural gas supplies most of the remaining space heating needs, followed by a minimal number of electric and wood heated homes.[5]

All lighting needs were provided by oil and gas lamps into the late 19th century. The downtown area was the first location for electricity. In the early 1900's, electricity gradually spread to the outlying sections of Northampton as the Northampton Electric Lighting Company built more power lines and as the demand for electricity increased.[6] Eventually, the local Northampton Electric Lighting Company became part of the New England Electric Power Company in the 1940's, and in 1961 the local company was bought by a larger public utility, Massachusetts Electric Company.[7] As in the case of the transfer from wood to coal, oil, and gas, we witness the local energy sources being incorporated into a larger, regionally managed power complex.

Housing

During the "industrial boom" of the 1800's, Northampton's population increased steadily. As the city grew, various villages developed within what are currently the city limits. The older villages in Northampton are known as Florence, Leeds and Bay State, all of which were created close to the industries which produced manufactured goods. Neighborhoods such as Laurel Park and the Ryan Road area are newer, post World War II residential areas.

Northampton's history is revealed in the appearance of its houses. Most of the older residential areas are characterized by large houses along tree-lined streets. Approximately 70% of the residences in Northampton were built prior to the 1940's. A substantial number of these were built before 1900.[8] The city thus provides a diverse selection of architectural styles among its 8900 residences. About 4500 dwellings are single family and the remaining 4400 are duplex or multi-family units.[9] The total land area occupied by residences (including apartments) in Northampton is approximately 2000 acres or 27% of all the developed land in the city.[10] (See Figure 2-1)

Industry

Since industries played a fundamental role in the evolution of

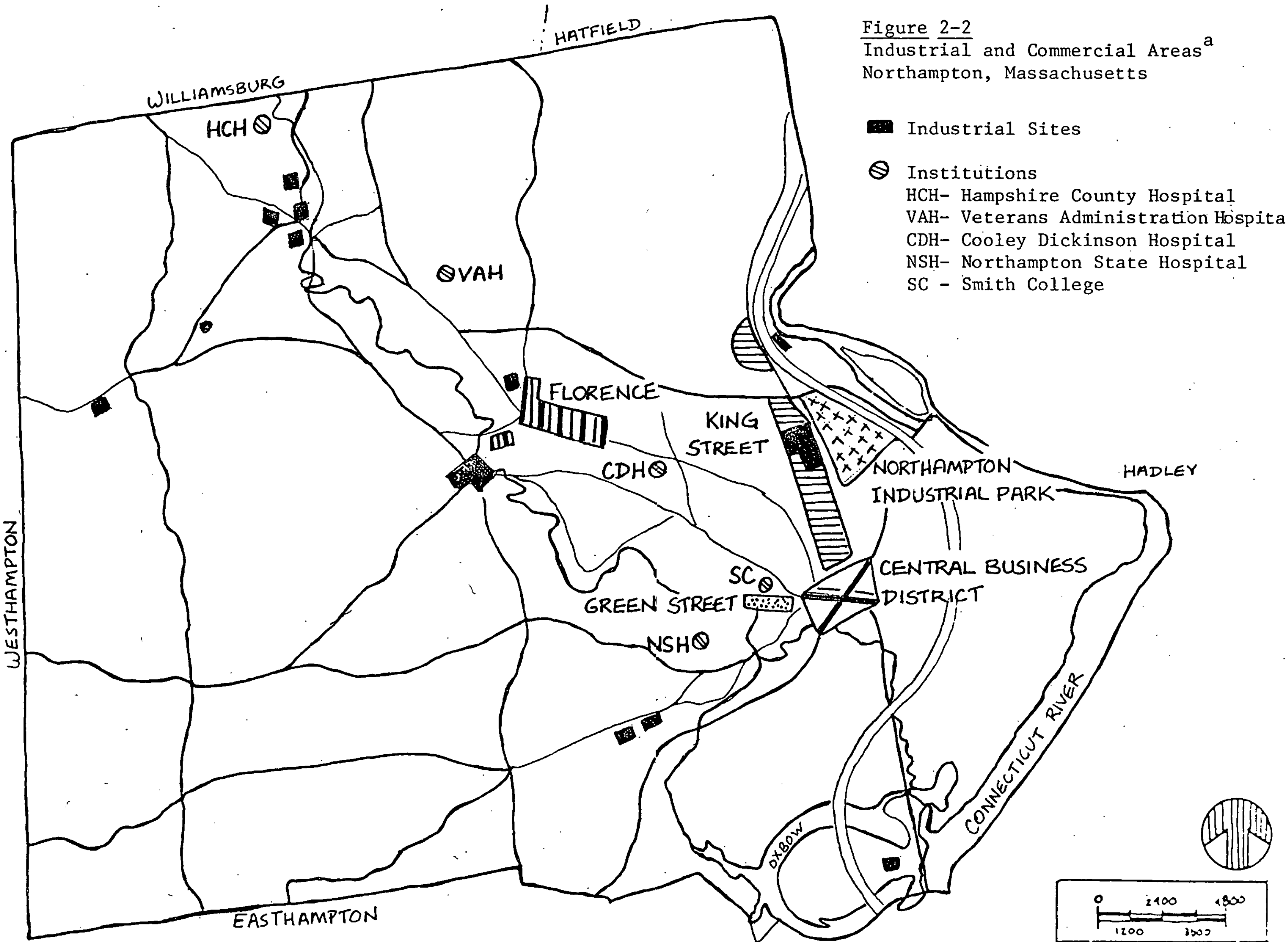
Northampton, it is worthwhile to trace the changes in the types of industrial establishments and their sources of energy since the 1800's. Throughout New England water power was a major source of energy in the first half of the 19th century.

By 1850, 74 factories and small mills were located along the banks of Northampton's Mill River.[11] This concentration of industries close to their power source was not limited to Northampton; it was characteristic of many New England river towns. Around 1860, steam power based on coal began to supplement and gradually replace the water power of the Mill River. A decade later, a major flood seriously damaged dams located on the river, virtually eliminating the use of the River as a power source. With steam power as an energy source, the production of silk buttons, hosiery, caskets, brush and toilet sets and many more specialized products reached its peak during the latter part of the 19th century.

Along with the gradual shift to steam which began in the late 1860's, patterns of industrial (and commercial) ownership began to change. A few locally owned industries incorporated as stock companies, thereby increasing their ownership. The stocks were issued to raise more capital for industrial expansion.[12]

In Northampton, much of the industry was based on local capital which originated from the savings of local merchants and farmers. This meant that most of the profits were recirculated in the Northampton economy. The city's economic base thus remained relatively stable into the early 20th century. The economic stability that was maintained by local capital didnot last for long however, as the number of absentee industrial owners began to exceed local ownership.

Figure 2-2
Industrial and Commercial Areas[a]
Northampton, Massachusetts



[a]Drawing not to scale

As in the case of the Nonotuck Silk Company, Northampton's most prosperous industry, many Northampton industries contracted, eliminated plants and emerged with a smaller number of units. Much of the local capital that supported Northampton industries in the late 19th century could not stand up to outside competition. Many Northampton industries were bought and relocated by outside interests around 1920.[13]

Competition with cheap labor in the Southern states drew many industries out of New England at this time. The use of coal (and later oil, gas, and electricity) also encouraged the shift from the old mill and steam power modes of production. Many industries moved to metropolitan areas where they were closer to larger transportation networks and improved means of distribution.

The number of industrial establishments decreased considerably after 1920. Of the original 19th century manufacturing firms, only a few such as the Daily Hampshire Gazette, Pro-Brush and the Florence Casket Company are still operating. The newer establishments include Coca-Cola, Kollmorgen and the Packaging Corporation of America which can be found along Route 5, along the Mill River or in the vicinity of the north-south highway (Interstate 91) in the sparsely inhabited industrial park.

In 1974, the 41 manufacturing firms represented the third largest sector of employment in the city.[14] Pro-Brush and Kollmorgen are the two largest manufacturing employers and they are also two of the largest energy consumers. Pro-Brush, owned by Standard Oil of Ohio, manufactures tooth brushes, hair brushes and other plastic products, and Kollmorgen produces projection lenses for telescopes and periscopes and other electro-optical instruments primarily under U.S. military contracts. Both firms are controlled by non-resident ownership.

Northampton is not a noticeably industrialized city, especially when compared to Worcester or nearby Springfield. Manufacturers of food, paper, machinery, chemicals, lumber and wood, and a number of other types of relatively small, precision manufacturers are also located in Northampton today. (See Figure 2-2)

Businesses and Services

Energy use in the commercial sector of Northampton has increased as the number and variety of establishments has grown over the years. The commercial establishments of the mid-1800's were largely oriented toward special services or products. Northampton's Main Street and its vicinity were occupied by general stores, drug and grocery stores, harness shops, merchant tailors, tinsmiths, hatters, boot and shoe shops, livery stables, furniture stores, artisan shops, and meat markets.[15] There is not a vast difference between those shops and services and the types available in Northampton today. The shops of the 1800's, however, were apt to be selling more local products rather than marketing boots from South America, mittens from Ireland, and shirts from Taiwan or South Korea.

Past sources of energy in the commercial sector were the same as those discussed in the residential sector. Wood and coal and later, gas, oil, and electricity provided energy to commercial establishments. The types of buildings that comprise the commercial sector in Northampton today can be identified as: schools, office buildings, hospitals, theatres, restaurants, retail stores, churches, wholesale stores, hotels, libraries and all else that cannot be classified as residential or industrial. Owing to the size and use of many of these buildings, the energy demand is often quite large.

It is not possible to identify any single district in the city as "the commercial district." The commericial sector is dispersed throughout the city as are the residences and, to a lesser extent, the industries. But there are four business districts, composed primarily of commercial establishments, and the four districts contain a significant portion of the more than 500 commercial facilities in Northampton.

The largest business district is the downtown, Central Business District located near Main Street. It contains a wide selection of retail stores, small businesses, service industries, and restaurants. Apartments are often located on the upper floors of these old buildings.

One can gain a sense of the character of Northampton by wandering around the Central Business District. There is a distinction between "old" and "new" among the population. This is also reflected in the physical appearance of the buildings. Over the past few years, Northampton's Central Business District has seen very little construction of new buildings. Emphasis has been on the restoration of old buildings. A few entrepeneurs have purchased buildings or commercial space within buildings and rehabilitated them. These restorations (which have taken place with the aid of public and private funds) have helped to enliven the historical and architectural charm of the city. This revitalization has also spawned a young professionalism in the city which compliments the more traditional types of small city business in Northampton.

A second district, Green Street, is located adjacent to the Smith College campus and is composed largely of specialty shops. It is the smallest district of the four.

The village of Florence has its own small shopping area including banks, a post office, retail stores, gas stations, restaurants and a couple of food markets. Florence's commercial identity combined with its residential and industrial establishments has created a strong community within Northampton.

The fourth district is the King Street-North King Street area which offers many supermarkets, three shopping plazas, gas stations, car dealers and automotive services, fast food restaurants, and more. Much of this district was developed during the 1960's and thus its physical appearance stands out when compared to the three older districts. It is typical of the modern commercial "strip" development taking place in cities throughout the United States. Clearly a "non-pedestrian" part of the city, this district was built around and for the use of the automobile. (See Figure 2-2)

A breakdown of energy consumed in each district is not available. It is known, however, that almost 50% of the total electricity consumed in Northampton is used in the commercial sector.[16] A substantial fraction of the heavy electricity use can be attributed to the six main institutions in the city which are included in this sector. Smith College, Cooley Dickinson Hospital, Northampton State Hospital, Hampshire County Hospital, the Veterans Administration Hospital, and the Clarke School for the Deaf are the most conspicuous in their consumption of electricity, oil and natural gas. Smith College, for example, consumed close to two million gallons of oil in 1977, none of which was bought from Northampton oil companies.[17] Cooley Dickinson Hospital's demand for electricity is high because of its constant operation and heavy reliance upon many electrically operated machines.

All six institutions have attempted some energy conserving measures because of rising operating costs and the fact that they house and employ a total of 8000 people.[18] These institutions, combined with the municipal buildings, city schools, service and retail and wholesale establishments, consume a significant portion of the energy supplied to the city.

Agriculture

The role of agriculture has declined dramatically in Northampton over the years. In the 18th and 19th centuries, farming was the mainstay of Northampton's economy as it was in many of the neighboring communities. By the mid 19th century, the manufacturing of tools and clothing on the farm had moved to the local mills and factories. Agricultural production in Northampton then gave way to the industrial boom, and agriculture was slowly pushed out of the city to remain in the smaller outlying communities.

Today, agricultural land makes up approximately 20% of the total land acreage in Northampton.[19] With the expansion of residential, industrial, and commercial areas, and the increase in transportation corridors since 1900, agricultural land has been pushed to the "meadows" on the outskirts of Northampton. Most of this meadowland is part of the Connecticut River floodplain. There is a good chance that the existing agricultural land will be preserved since it can not economically be developed for any other purposes.

Shifts in Energy Sources

It is clear that shifts in energy sources coincide with changes in Northampton's residential, industrial, commercial and agricultural sectors. For instance, the shift from individual to group and corporate ownership of industries and business around 1860 introduced absentee owners to the Northampton community. A shift to "absentee" energy resources also took place at this time. Many of the former water-powered mills and factories in Northampton expanded to steam-powered industries that relied on imported coal. Heating companies formed to sell coal and wood to residential, industrial, and commercial customers. It was no longer the responsibility of a family or a group of neighbors to provide for their home heating needs if they could afford to buy their heat. As the residential, industrial and commercial sectors grew, the amount of agricultural land dwindled. Westward expansion had taken the emphasis off of Northampton as an agrarian community around the mid-19th century as pioneers began farming in the Mid-West.

With less agricultural land and less subsistence farming, Northampton residents had to rely more on imported food supplies and products. All of these changes mark a trend toward larger companies, centralized ownership and a growing dependence on imported capital, natural resources, and food supply.

This pattern is common among many New England communities today. Northampton residents have witnessed drastic changes since the subsistence farming days of the early 19th century. The shifts to imported energy resources and absentee ownership of industries and businesses brought about a decrease in local self-reliance. The centralization and regional management of energy sources (i.e., electrification in the 20th century) became widespread with the increase in population and with the acceptance of the "extravagant" use of energy.

Within the past four decades, New England has experienced many changes: a severe shortage of fossil fuels, the development of nationwide transportation, better access to other region's fossil fuel and natural resources, changes in technology, and the out-migration of businesses and industries. As we have already noted, New England presently depends on imported fossil fuels for a large percentage of its heating sources. It is also important to point out that the average price paid by New England firms for energy is 26% higher than in the rest of the country.[20] Energy prices, along with incentives to relocate in other countries where labor is cheaper, could be reasons why New England has been abandoned by many industries and businesses.[21]

We believe that the best way to solve this problem is to examine critically the current use of energy and suggest ways that conservation and the use of renewable resources might replace the conventional sources of energy in Northampton. The increased consumption and exploitation of foreign fossil fuels and other natural resources cannot continue at its current rate. Regions such as New England have to seriously consider their own renewable energy resource potentials.

Population Characteristics

A brief look at the Northampton population is necessary in order to provide preliminary insight into the demographic and employment patterns which may influence, or be influenced by changes in energy policy. Like many other communities in western Massachusetts, Northampton's population has remained relatively constant for the past 30 years. The 1950 U.S. Census of Population for Northampton was just under 30,000 and in 1975 the Massachusetts State Census recorded slightly above 30,000 residents. The number that we employ for the current population is 30,000 and it will be used throughout this study.[22]

The six institutions in the city represent 15% of the Northampton population.[23] We have assumed that these institutions (including neighboring colleges and universities) are at their peak populations now.

Current Employment and Income

The labor force in Northampton comprises about half of the city's population. With 13,400 people employed and about 600 unemployed in September, 1978, the unemployment rate for Northampton stood at 4.2%.[24] This relatively low unemployment figure can be attributed, in part, to the fact that many college-related services exist in Northampton.

Services, retail trade, precision manufacturers, educational institutions and hospitals are the chief sources of income for those people who work in Northampton. The commercial and industrial firms employ over 9,000 people. The difference between the 13,000 employed Northampton residents and the figure of over 9,000 people employed in local firms indicates that a substantial number of Northampton residents work outside of the city. Service industries represent the largest employment sector in Northampton, followed by wholesaling and retailing. Manufacturing accounts for nearly a quarter of Northampton's total employment.[25]

A breakdown of employment by group is available in the Northampton City Monograph of 1974. Approximately 20% of the labor force are professional and technical workers, 20% are clerical workers, another 20% are service workers, and the remainder of those employed are distributed relatively evenly as managers, proprietors, salespeople, craftspeople, foremen, operatives, and laborers. The potential for conservation and alternative energy exists for many Northampton businesses and industries that employ area residents in these jobs.

In 1974, the median income of Northampton families was $10,180 and the per capita income equaled $3,002.[26] Even though these figures were slightly lower than the state and regional median and per capita incomes, Northampton does not appear "poor" or "depressed." The low income could be related to the large student population, but we have not attempted to verify this. The Northampton economy could face serious problems if it continues to depend on imported energy sources. Higher prices and possible fuel shortages would have obvious negative effects on most activities in the city. It is possible that the development of alternative energy in Northampton could potentially alter the numbers and the types of jobs available in the city.

City Government

City government can play a key role in formulating its own approach to the city's energy problems. City officials could take initiative in proposing an alternative energy plan. Through legislation and publications, conservation could be encouraged. The government could work on many areas from developing energy-efficient building codes to funding alternative energy demonstration projects.

An understanding of the composition of Northampton's city government is necessary before reviewing the city government's role in Northampton's energy situation. The Northampton city government consists of a mayor and nine city councilors, seven of whom are elected by ward, and two of whom are elected at large. Most decision making and appointing of officers is done by the Mayor with the approval of the city council. For some appointments, it is the role of the city council to decide without the vote of the mayor. Examples of these positions include: members of the Board of Public Health, the trust fund committee, the city auditor, the tax collector, and the three city assessors.[28]

The council's committee work is carried on by standing committees established by ordinance: the committees on finance, city property, industry, the fire department, police and traffic, enrollment and elections, rules, orders, ordinances, and claims. The mayor is a member and the chairman of the committees on finance and industry, and he selects the councilors who serve on all eight committees.[29] Work on energy conservation and energy alternatives could be introduced into some of these committees.

The Mayor appointed an ad hoc Energy Commission in February, 1978. The Commission was asked to develop an energy policy and plan for Northampton. Because there were no full-time members, tasks had to be narrowed to a focus on energy conservation and its potential in municipal buildings. After six months of work, William Ames wrote in the Commission's Status Report that "there is a great deal of work to be done in the field of energy conservation, but we are convinced that aggressive efforts to conserve can yield substantial savings of both energy and dollars."[30]

The Energy Commission's preliminary findings have prompted a request by the Mayor for an Energy Conservation Manager to oversee the operation of all city buildings. The Mayor hopes to provide such a position by January, 1980.[31] Until this time, an Energy Conservation Coordinator has been appointed temporarily to organize information on the city's energy use.

Another program in the city includes a feasibility study of the potential for electricity generation from five small dams on the Mill River. This small hydropower study is being done by Curran Associates under a DOE grant.

It is encouraging that there is concern about the energy problem in Northampton, but concern is not sufficient to solve the problem. The provision of energy is an important aspect of everyone's survival and, from the history of energy supply in the city, it seems only to be getting further out of reach of the city's residents, businesses and industries. The results of current patterns of energy use and supply could be very dismal. It is essential that the energy situation in the city be closely examined and specific proposals for change be proposed and implemented.

Footnotes

1. Northampton Chamber of Commerce. Forward Northampton, Brattleboro, VT: Gaylord Brothers, Inc., 1940 , p. 3.

2. Tercentenary History Committee, ed. The Northampton Book, Brattleboro, VT: Alan S. Browne, Inc., 1954 , p. 331.

3. Interview with Richard Whiting, Jr., Whiting Oil Company, Holyoke, Massachusetts, October, 1978.

4. Ibid.

5. See Chapter 3.

6. Interview with Ed Wingfield, District Manager, Massachusetts Electric Company, Northampton, Massachusetts, October, 1978.

7. Ibid.

8. Massachusetts Department of Commerce and Development. City Monograph of Northampton, Massachusetts, Boston: Massachusetts Department of Commerce and Development, 1974 .

9. Ibid.

10. Comprehensive Summary Plan: Northampton, Massachusetts , Boston: Metcalf and Eddy, Inc., 1970-72 , p. 4.

11. Tercentenary History Committee ,The Northampton Book, p. 223.

12. Ibid., p. 234.

13. Ibid., p. 253.

14. City Monograph of Northampton.

15. Tercentenary History Committee, The Northampton Book, p. 84.

16. See Chapter 3, Table 1.

17. Interview with Michael Martin, Smith College Physical Plant, June, 1978.

18. Northampton Chamber of Commerce. Vital and Social Statistics, City of Northampton, 1977, information sheet.

19. MacConnell,William P. Remote Sensing: Twenty Years of Change in Hampshire County, Massachusetts 1952-1972 Bulletin No. 627,Massachusetts Agricultural Experiment Station,University of Massachusetts, Amherst,MA, May 1975.

Footnotes (continued)

20. Massachusetts Energy Office. Wind Report, Boston: Mass Energy Office, October 1978.

21. The cost of energy in Northampton is discussed in Chapter Four.

22. In interviews with city and county planners, it was pointed out that there are differences in the defintion of "resident" in the state and federal census techniques. However, 30,000 was considered an accurate figure.

23. Chamber of Commerce, Vital and Social Statistics.

24. Interview with Murray Leaffer, Division of Employment Security, Boston, Massachusetts, October, 1978. This figure does not include students and others who are considered "out of the labor market," though unemployed.

25. City Monograph of Northampton.

26. Ibid.

27. The price of oil has been predicted to rise by four cents per gallon in the Northampton area this winter according to a Daily Hampshire Gazette article, "As Mercury Falls Oil Price Will Rise" on October 21, 1978.

28. City Clerk's Office, editors. Manual of City Officers, Northampton, MA: Gazette Printing Company, Inc., 1974, pp. 6, 11, 13.

29. The League of Women Voters, ed. This is Northampton, Northampton, MA: League of Women Voters, 1968, p. 29.

30. Interview with Stan Moulton, Daily Hampshire Gazette, Northampton, Massachusetts, September 1978.

31. Ames, William. Energy Commission Status Report, Report to the Mayor and City Council, Northampton, Massachusetts, July 1978.

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Chapter Three

Current Energy Use and Supply

It is customary to divide energy use into four sectors, identified by the types of establishment that consume energy. In this chapter, energy use is examined in each of the usual four sectors: residential, industrial, commercial, and transportation. Estimates of current energy consumption in Northampton are derived from interviews with both the people who use energy and those who supply it, as well as from our own research. An important purpose of this study is to demonstrate that there are significant differences between the amount of energy presently consumed in Northampton and the amount of energy that is actually needed to perform the work that is being done. These differences will be examined closely in Chapter Six once a profile of current energy consumption is developed.

It is useful at this point to define and familiarize the reader with several terms and concepts that are frequently used in discussions of energy and energy use. Energy is usually defined as the capacity, or ability to do work. A widely used measure of energy is the British Thermal Unit or BTU. One BTU equals the amount of heat needed to raise the temperature of one pound of water by one degree Fahrenheit. For discussing large quantities of energy, multiples of the BTU are often used. One million BTU's is denoted by one MBTU, or 10^6 BTU.

Power is the rate of doing work or supplying energy. In other words, power is equal to the energy used to perform work divided by the time it takes to do the work. A common unit of power is the Watt, W, and its decimal multiples are also widely used. One Watt is equal to 3.413 BTU per hour. One kilowatt, kW, equals 1000 Watts and one megawatt, MW, is equivalent to one million Watts. Any unit of energy can be divided by a unit of time to form a unit of power. Similarly, any unit of power can be multiplied by a unit of time to obtain an energy unit.

In this study, the average rates of energy consumption and production in Northampton have been measured in two basic units, BTU per year and megawatts. Megawatts are a particularly convenient unit for Northampton and it must be emphasized that the term applies to all kinds of energy, not just electricity.

There are three major sources of energy used by residences, industries and commercial establishments in Northampton: oil, natural gas and electricity. Wood and coal are used in almost negligible quantities, amounting to only a very small percentage of the city's overall energy use. The transportation sector is fueled by gasoline and some diesel fuel. The amount of diesel fuel consumed by vehicles in Northampton is so small compared to gasoline consumption that it does not warrant special consideration.

Energy use in the residential, commercial and industrial sectors in Northampton is displayed in Table 3-1. The figures listed are based on 1977 sales as estimated by energy companies serving the Northampton area. These figures were checked with our own general estimates

TABLE 3-1: Energy Consumption By Sector, Northampton, Massachusetts-1977

	OIL		NATURAL GAS		ELECTRICITY		WOOD		GASOLINE		TOTAL USED BY SECTOR
	Gallons 10^6	BTU 10^{11}	MCF[a] 10^5	BTU 10^{11}	kWh[b] 10^7	BTU 10^{11}	Cords 10^3	BTU 10^{11}	Gallons 10^6	BTU 10^{11}	BTU 10^{11}
Residential	9.0	12.6	3.0	3.2	5.6	1.9	4.2	.7			18.4
Industrial	.9	1.2	.6	.6	3.2	1.1					2.9
Commercial	10.3	14.4	2.4	2.5	8.2	2.8					19.7
Transportation									9.8	12.1	12.1
TOTAL USED BY FUEL TYPE	20.2	28.2	6.0	6.3	17.0	5.8	4.2	.7	9.8	12.1	53.1

[a]MCF=1000 cubic feet.

[b]Conversion losses not included.

of what the energy needs of each sector currently are. As explained further in the text below, it was difficult to obtain accurate breakdowns for oil and natural gas consumption in the industrial and commercial sectors. The numbers presented for these two sectors are based on our own research concerning industrial and commercial energy use as well as on various sales estimates.

Energy use in the transportation sector is also displayed in Table 3-1. The transportation sector is composed of all vehicles, both publicly and privately owned, that are registered in Northampton. The most recent figures for vehicle registrations available are those for 1977. Energy use for transportation by the residential, industrial and commercial sectors is accounted for in the transportation sector. Questions or assumptions embodied in the numbers presented for each sector in Table 3-1 are discussed more fully below. The table is presented here for the purpose of comparisons among the various sectors.

Residential Energy Use

The residential sector in Northampton is composed of single family, multi-family attached, low-rise and high-rise dwellings. Housing is divided roughly equally between single family and multi-family structures, totalling 4500 and 4400 units respectively.[1] Although it is difficult to generalize about the residential dwellings located in Northampton, it is known that as of 1970 seventy per cent of all the houses and apartments in Northampton were built before 1939.[2] As older homes and buildings, these structures tend to be quite large. They often have many large windows and feature only minimal, if any, roof and wall insulation. According to energy experts, builders, and architects familiar with the Northampton area, Northampton's newer homes and apartments are better insulated than their older counterparts but are often not as well constructed. These structures tend to be less durable overall and are subject to considerable heat loss and drafts.

Information concerning residential energy consumption presented in Table 3-1 comes from sales estimates provided by energy retailers located in the Northampton area. The sales estimates were checked by our group in a lengthy and somewhat elaborate series of calculations concerning the amounts of energy theoretically required by Northampton residences for various heating, cooling, cooking, and electrical needs. A wide variety of information and sources were used in the computations. We particularly relied on figures concerning residential energy use in Boston Residential Energy Consumption, a study published in 1976 by the United States Department of Housing and Urban Development.[3] Information provided by the Massachusetts Energy Office in Boston was also used.[4] The numbers generated by our calculations are summarized in Table 3-2. The total residential energy consumption presented in this table does not equal the similar total in Table 3-1 because of the different techniques that were used to obtain the two figures. However, the agreement between the figures is well within our margin of uncertainty.

It is shown in Tables 3-1 and 3-2 that the total amount of energy

TABLE 3-2: Estimated Residential Energy Use, Northampton, Mass.-1977

Use	Amount BTU 10^{11}	% of Total Used in Residences
Space Heating	14.6	76%
Water Heating	2.4	12
Air Conditioning	.003	<1
Lighting and Appliances	1.5	8
Cooking	.7	4
TOTAL	19.2[a]	100%[b]

[a]This total does not equal the similar total in Table 3-1 because of the different techniques that were used to obtain the two figures. The agreement between the two figures is well within our margins of uncertainty.

[b]These may not add up to 100% because of the rounding-off of numbers.

TABLE 3-3: Industrial Energy Use, Northampton, Massachusetts-1977

	OIL		NATURAL GAS		ELECTRICITY	
	Gallons x 10^6	BTU x 10^{11}	MCF x 10^5	BTU x 10^{11}	kWh[a] x 10^7	BTU x 10^{11}
Nine Largest Industries	.75	1.0	.52	.55	3.05	1.04
Remainder of Industrial Sector	.11	.16	.08	.08	.19	.07
TOTAL	.86	1.16	.60	.63	3.24	1.11

[a]Conversion losses not included.

used in the residential sector in 1977 was about 19 x 10^{11} BTU. It can also be seen that oil and natural gas provided almost 85% of the residential energy needs. This is very similar to the state average of eighty-eight per cent.[5] About three-fourths of the residential energy consumption was used for space heating, with about sixty per cent of all residences relying on oil for home heating.[6] The bulk of the remaining housing units used natural gas for their space heating needs.[7]

Using a population of 30,000, the 1977 Northampton per capita residential energy consumption is about 61 million BTU. This is larger than both the 1973 national per capita residential energy consumption of about 46 million BTU and the 1977 Massachusetts average of 48 million BTU.[8]

Industrial Energy Use

The industrial sector in Northampton consists of about forty manufacturing establishments and eight agricultural establishments.[9] We were not able to rely only on sales estimates provided by energy retailers located in Northampton to determine the amount of energy used by the industrial sector. Estimates available from local oil dealers provided only a portion of the total amount consumed, because many industries, particularly those which use large quantities of oil, purchase industrial grades of oil from distributors located outside of Northampton. Additionally, the gas estimate provided by the gas company serving the Northampton area was a combined figure for both the industrial and commercial sectors.

Determination of energy consumption in the industrial sector was developed in two stages. The first stage involved obtaining specific energy use figures from the nine manufacturing firms which had the largest number of employees and the largest total energy demand. Interviews were arranged with representatives of these firms, and tours were taken of the production areas of each establishment. From the interviews and tours, a general profile was developed of the energy needs and demand of the principal industries in Northampton. In the second stage, the information that had been collected concerning energy use in the nine largest industries was examined and it was estimated what portion of the total industrial energy consumption was represented by those figures. Thus, our assessment of total industrial energy use is based on estimates provided by energy companies, figures available from individual establishments, as well as extrapolations of known data. The results of this research are presented in Table 3-3.

Northampton is not a highly industrialized city. Industries located in the city tend to be relatively small, collectively employing 2360 people, or only 20% of the total number of employed Northampton residents.[10] The nine manufacturing establishments we visited employ about 2000 people, or almost 85% of all industrial employees.[11] It was found, in general, that the production processes used in each establishment are not particularly specialized or excessively energy intensive. With the exception of Pro-Brush, a toothbrush and plastic products manufacturing firm, there is only a small demand for steam generation and the use of high temperature heat appears to be minimal. No industrial users were found who require process heat at temperatures above about 235°C (450°F).

About 750,000 gallons of fuel oil, 10^{11} BTU, were used by the nine largest manufacturing establishments during 1977.[12] Most of the oil was used for space heating with the remainder going to water heating and a small amount to steam generation. A total of 52,000 MCF of gas, or .55 x 10^{11} BTU, was used by six of the firms for either space or water heating and, in one case, for steam generation.[13] Drying ovens used by one firm were also fueled by gas. Electricity consumption in the nine firms totaled just over 30 million kilowatt-hours.[14] This correlates well with the utility company's estimate of 32 million kilowatt-hours for the entire industrial sector. (See Table 3-1) Electricity was used principally for lighting, for air conditioning, and to run machinery. One firm also reported the use of electrically powered compressors in their production line.

As explained above, representatives from the remainder of industrial establishments were not interviewed. From the information collected concerning Northampton's nine largest manufacturing establishments, it seems reasonable to state that the additional Northampton industries probably do not have significantly different energy needs from those already attributed to the nine largest firms. Since it is known that the latter group employs 85% of all industrial employees, we assume that it also uses 85% of the total energy consumed in the industrial sector. This may actually be a conservative estimate since the nine largest firms use about 95% of the electricity used by all industry. It is estimated that about 113,000 gallons of oil, or .16 x 10^{11} BTU, were used by the remainder of the industrial sector in 1977. Gas usage is similarly estimated at 8000 MCF, or $.08 \times 10^{11}$ BTU.

Combining the figures developed in both stages of research, it is found that in 1977 all Northampton industrial establishments consumed 860,000 gallons of oil or 1.16×10^{11} BTU. Electricity consumption was very similar at 32 million kilowatt-hours, or 1.1×10^{11} BTU. The use of gas was somewhat less, with a total usage of 60,000 MCF, or $.63 \times 10^{11}$ BTU. This leads to a total industrial consumption of all fuel types of 2.93×10^{11} BTU, and a per capita industrial energy use of 9.8 million BTU. While the 1973 national per capita energy use in industry is an order of magnitude larger than that for Northampton at 108 million BTU, the 1977 Massachusetts average of 11.4 million BTU is very close to our Northampton estimate.[15] This is reasonable since both Northampton and the state as a whole are recognized as areas that have experienced a significant decrease in industrial activity during the past fifty years.

Commercial Energy Use

The commercial sector is composed of office buildings, retail and other merchandising activities, hotels, motels, schools, hospitals and recreational facilities.[16] The commercial sector is both an important sector to study and a difficult one on which to obtain data. It is important because it includes buildings, particularly public institutions, in which the people who are using energy are not responsible for paying the costs of the energy that is consumed. Careless energy use and unnecessary waste are quite common in commercial buildings. Obtaining data on the commercial sector can be difficult because it is made up of such a numerous and varied group of buildings and establishments.

The commercial sector in Northampton can be divided into four categories: public institutions, retail establishments, wholesale establishments, and service industries. The types of buildings and businesses included in each of these categories are identified in Table 3-4. It was only possible to obtain conclusive figures on energy use in public institutions. Recent interest in decreasing energy costs in public buildings has inspired the city of Northampton to keep accurate records of energy use in municipal buildings. The data collected were provided by municipal employees, Smith College engineers, and past billing records. The Northampton Energy Commission, City Property Committee, Superintendent of Schools, City Clerk and County Planning Department assisted in the research. Staff engineers of individual buildings or institutions were also particularly helpful.

Most of the energy consumption in public institutions was accounted for in the use of oil for space heating. (See Table 3-5.) Just over five million gallons, or 7.1×10^{11} BTU of heating oil were consumed by public institutions in Northampton in 1977.[17] Gas usage for space and water heating reached almost 60,000 MCF, or about $.6 \times 10^{11}$ BTU.[18] Electricity consumption was approximately 21 million kilowatt-hours, or $.7 \times 10^{11}$ BTU.[19] The demand for electricity in this category comes largely from lighting, ventilating and air conditioning needs.

TABLE 3-4: The Commercial Sector, Northampton, Massachusetts-1977

CATEGORY	NUMBER OF BUILDINGS
PUBLIC - Schools, Municipal Buildings, Hospitals, Smith College[a]	32[a]
RETAIL - General Merchandise, Restaurants, Gasoline Service Stations, Food Stores, Retail Stores	296
WHOLESALE - Merchant Wholesalers, Manufacturing Sales Branches and Offices	26
SERVICE AND OTHER - Hotels, Amusement, Legal Services, Finance, Real Estate, Construction, Automobile and Miscellaneous Repair	189
TOTAL	543

[a]Smith College is a private institution but it seems to fit best in the public category of the commercial sector. The college is counted as a single establishment because total energy use figures were available for the 101 buildings that make up the campus.

TABLE 3-5: Commercial Energy Use, Northampton, Massachusetts-1977

	OIL		NATURAL GAS		ELECTRICITY	
	Gallons $\times 10^6$	BTU $\times 10^{11}$	MCF $\times 10^5$	BTU $\times 10^{11}$	kWh[a] $\times 10^7$	BTU $\times 10^{11}$
Public Institutions	5.1	7.1	.6	.6	2.1	.7
Retail, Wholesale and Service Establishments	5.2	7.3	1.8	1.9	6.1	2.1
TOTAL	10.3	14.4	2.4	2.5	8.2	2.8

[a]Conversion losses not included.

It was not possible to acquire compiled estimates of energy consumption for the retail firms, wholesale establishments, and service industries which comprise the remainder of the commercial sector. With the exception of electricity, sales estimates were inconclusive for these categories of the sector. Rather than collect data from the more than 500 establishments included in the categories, we focused on deriving estimates of their energy use from information collected about other Northampton energy consumers. While this method leads to some uncertainty, it has resulted in estimates that are reasonable when compared to state and national figures.

Electricity consumption in the retail, wholesale and service categories of the commercial sector was determined by subtracting the amount used in public buildings from the figure for total commercial use provided by the electric company serving the Northampton area. This results in a 1977 consumption of 61 million kilowatt-hours, or 2.1×10^{11} BTU, in private commercial establishments. (See Table 3-5) An estimate of gas consumption was calculated by subtracting the amount used for industrial purposes and public institutions from the combined sales figure for the industrial and commercial sectors provided by the gas company.[20] This yields a consumption of 180,000 MCF, or 1.9×10^{11} BTU. This estimate may seem high but it must be remembered that there are over 500 establishments accounted for in these categories of the commercial sector, including such large users of gas as restaurants, laundromats and drycleaners.

Developing an estimate of oil consumption in the retail, wholesale and service categories proved to be a relatively complex process. It was first estimated what the total energy needs are for the establishments included in these categories. This was done by using a Massachusetts figure for total energy use per square foot of retail commercial buildings and applying it to estimates of the area of similar buildings in Northampton. A publication examining energy use in retail stores in Massachusetts suggests that total energy use in retail establishments equals about 375,000 BTU per square foot of floor space.[21] While the exact amount may vary among buildings throughout the state and Northampton, this number was accepted as a reasonable estimate of average total energy use in retail, wholesale, and service establishments in Northampton. Using the fact that ninety-six commercial establishments located on the King Street Corridor have a total area of about 660,000 square feet, the area of all private commercial establishments was estimated to be about three million square feet.[22] This number takes into consideration the observation that commercial buildings in the King Street Corridor tend to be newer and much larger than their older counterparts located in other sections of the city. It is calculated from these figures that total energy use for heating, cooling and ventilating in private commercial establishments located in Northampton is about 11.3×10^{11} BTU per year. If estimates of electricity and gas usage are subtracted from this, it is found that about 7.3×10^{11} BTU of energy use are not yet accounted for in these categories. This is equivalent to 5.2 million gallons of fuel oil.

As suggested by the figures presented in Tables 3-1 and 3-5, the commercial sector consumes the largest amount of energy in Northampton. The principle uses of energy in this sector are space heating, ventilation, air conditioning, lighting and, in restaurants, cooking and water heating. The 1977 per capita commercial energy use is 65.7 million BTU in the city. This is greater than both the 1977 state average of 49.1 million BTU and the 1973 national average of 38.2 million BTU.[23] These figures support the hypothesis that Northampton's economy and its energy use are largely oriented around commercial activities.

Transportation Energy Use

The transportation sector in Northampton is composed of all vehicles, both public and private, registered in Northampton. In 1977, this number was 19,300.[24] Vehicles used by residents, industry, city government and commercial establishments are included in this number. About 90% of these are identified as passenger vehicles.[25] According to a study done by the Lower Pioneer Valley Regional Planning Commission and the Department of Public Works, a total of about 430,000 miles per day are travelled by vehicles on roads in Northampton.[26] Unfortunately, it is not known how many of these miles are travelled by vehicles registered in Northampton. In the case of Interstate 91, for example, many of the miles travelled on the portion of highway located in Northampton are probably travelled by vehicles not registered in Northampton. For the purposes of this study, however, it is assumed that the number of vehicles not registered in Northampton that travel into the city equals the amount of Northampton-registered vehicles that travel out of the city to surrounding communities. It is also assumed that the amount of gasoline purchased in Northampton by vehicles not registered in the city equals the amount of fuel purchased outside of the city by vehicles registered in Northampton.

If the total of 19,300 vehicles travel an average of 430,000 miles in Northampton per day, then each vehicle travels an average of about 22.2 miles per day. This leads to a total of 1.57 million miles per year travelled by all vehicles registered in the city. This corresponds to an annual gasoline consumption of 9.8 million gallons using the Massachusetts average efficiency for all vehicles of 16.1 miles per gallon.[27] This is equivalent to a 1977 per capita energy consumption for transportation purposes of 40.0 million BTU. This is somewhat less than the 1977 state average of 54.0 million BTU and less than half the 1973 national average of 88.1 million BTU.[28] However, both the state and national figures include energy used in the long-distance transportation of people, food, merchandise and other commodities. It was not possible to examine in this study the energy used in the non-local transportation of Northampton residents or the goods consumed by them.

Summary

It is possible from the examination of sectoral energy use and supply in Northampton to develop an overview of the total energy consumption in the city. These figures are presented in Table 3-6. It is interesting to note the percentage of the total energy consumption

TABLE 3-6: Energy Use in Northampton, Massachusetts - 1977

	Amount Used[a] BTU x 10^{11}	% of Total Used By All Sectors in Northampton	% of Total Used By All Sectors in Massachusetts[b]
Residential	18.4	34.6%	29.4%
Industrial	2.9	5.5	7.0
Commercial	19.7	37.1	29.8
Transportation	12.1	22.8	32.8
TOTAL	53.2	100%	99%[c]

a Electric conversion losses not included
b From Energy in Massachusetts, Massachusetts Energy Office, Boston, Massachusetts, 1978.
c This column does not add up to 100% because of an "other" category used in the Massachusetts Energy Office publication.

that is used by each sector. Commercial establishments collectively consume the largest portion of energy at 37.1% of the total. The residential sector trails closely at 34.6%. Energy used for transportation represents 22.8% of the total used in the city and industrial energy consumption accounts for only 5.5%. In general, these figures are quite similar to the state percentages developed by the Massachusetts Energy Office also presented in the table.

According to our estimates, the 1977 per capita energy consumption in Northampton is 166 million BTU. This is essentially equal to the 1977 state average of 164 million BTU.[29] The 1973 national average is somewhat larger at 281 million BTU.[30] The difference might be accounted for in specific regional traits, primarily the noticeable lack of energy intensive industries both in Northampton and the state as a whole.

Footnotes

1. Massachusetts Department of Commerce and Development. City Monograph of Northampton, Boston: 1974.

2. Ibid.

3. Hittman, Associates, Inc. Boston Residential Energy Consumption, Washington, D.C.: Final Report, Office of Assistant Secretary for Policy Development and Research, Department of Housing and Urban Development, August 1976.

4. Interviews with various staff members of the Massachusetts Energy Office, Boston, Massachusetts during the summer of 1978.

5. Lee, Henry and Sullivan, Christine B. . Energy in Massachusetts, Boston: Massachusetts Energy Office, May 1978, p. 27.

6. U.S. Department of Commerce, Bureau of the Census. United States Census of Housing: 1972, p. 23-315.

7. Ibid.

8. The national per capita figure is based on information from Robert H. Romer, Energy: An Introduction to Physics, San Francisco: W. H. Freeman and Company, 1976, pp. 600-607. The Massachusetts per capita figure is based on information from Sullivan, Christine B., and Lee, Henry, Energy in Massachusetts, Boston: Massachusetts Energy Office, May 1978, p. 27.

9. This figure is based on our own research, the Monograph, and Census data.

10. Ibid.

11. This information was collected during our interviews with representatives from various industrial establishments.

12. Ibid.

13. Ibid.

14. Ibid.

15. The national per capita figure is based on information from Robert H. Romer, Energy, p. 605. The Massachusetts per capita figure is based on information from Lee and Sullivan, Energy, p. 27.

16. Religious institutions are often included in this sector but we did not examine their energy use. They most certainly represent a very small percentage of the total energy demand in Northampton.

Footnotes (continued)

17. This information was collected during our interviews with representatives from various commercial establishments.

18. Ibid.

19. Ibid.

20. The industrial and commercial sectors consumed a total of 600,000 MCF of gas in 1977 according to an interview with Judy Pelis, Bay State Gas Company, Springfield, Massachusetts in July 1978.

21. Saving Energy and Dollars in Retail Stores, Boston: Massachusetts Energy Office, 1978, p. 2.

22. City Planning Department. King Street Corridor Study Draft, Northampton: 1975.

23. The national per capita figure is based on information from Robert H. Romer, Energy, p. 604. The Massachusetts figure is from Sullivan and Lee, Energy, p. 27.

24. Interview with William Bent, Planner, Lower Pioneer Valley Regional Planning Commission, West Springfield, Massachusetts, July 24, 1978.

25. Ibid.

26. Ibid.

27. Interview with Deborah Schriber, Massachusetts Energy Office, Boston, Massachusetts, October 1978.

28. The national per capita figure is based on information from Robert H. Romer, Energy, p. 606. The Massachusetts per capita figure is based on information from Lee and Sullivan, Energy, p. 27.

29. From information in Lee and Sullivan, Energy, p. 27.

30. From information in Robert H. Romer, Energy, pp. 600-607.

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Chapter Four

Energy, Economics and Employment

The connections among employment, energy use, and energy production have become increasingly important during the past decade. Heated debates are currently going on within government offices, Congressional committees, private corporations, and various interest groups concerning the employment effects of various energy systems. Particular attention is being paid to how changes in energy use and supply might effect employment trends. The issues involved in such debates are complex. They require an understanding of existing employment patterns, predictions of future economic and population growth, and assessments of potential changes in energy use. Unfortunately, the conclusions of the few serious and systematic studies that have been done have often conflicted with one another and have consequently done little to clarify the issues.[1]

This chapter is an attempt to estimate how much money is spent on energy by Northampton consumers and to assess the economic impacts of current Northampton energy expenditures. This process has not involved a detailed quantitative analysis of monetary flows in Northampton. Methods of analysis for such a narrowly defined economy are just now being developed and, consequently, there are few existing models on which we have been able to rely for guidance.[2] However, it has been possible to make reasonable estimates of the amount of money contributed to Northampton's economy from the sale of energy and to estimate how many local jobs might be associated with such sales. By doing this, a base has been established on which to compare the economic and employment impacts of current energy sales with those of the alternative energy systems which we propose for Northampton's future. These comparisons will be presented and discussed in Chapter Nine.

This aspect of research has been approached in three major steps. Starting with figures for total energy use derived in Chapter Three, it was determined how much money was spent to purchase this energy and it was estimated how much of each energy source was purchased from companies located in the city. The second step involved estimating the percentage of sales revenue collected by Northampton energy companies that is respent in the city. This was calculated by examining the proportions of energy companies' budgets that are allocated for local wages, taxes, rent, advertising and maintenance. Finally, the local expenditures were aggregated to assess the total effects on the local economy. In this stage, particular interest was paid to determining the amount of income and the number of jobs generated in Northampton by energy sales.

Fuel Oil

The amount of fuel oil used by the residential, industrial and commercial sectors in Northampton is presented in Table 4-1. It is shown that just over 20 million gallons of oil were consumed in Northampton in 1977. This represents a total expenditure of $9.6 million at 1977 prices. However, unlike other types of fuel, not all of the oil consumed in Northampton is bought from companies based in the city. Many industries and businesses, particularly those which use large quantities of oil, purchase oil from wholesale distributors located in other cities or states. Smith College, for example, purchases

TABLE 4-1: Expenditures on Fuel Oil in Northampton, Massachusetts-1977

	Amount Used Gallons x 10^6	Price $/Gallon	Total Expenditure $ x 10^6
Residential	9.0	.48	4.3
Industrial	.86	.48	.4
Commercial	10.3	.48	4.9
TOTAL	20.2		9.6

most of its oil from a firm located in Connecticut.[3]

As displayed in Table 4-2, only 55% of the total amount of oil used by all sectors in Northampton was purchased from companies located in the city. The 11 million gallons that were bought in the city represent a local expenditure of $5.3 million. The approximately nine million gallons that were purchased outside of the city represent a direct out-flow of $4.3 million from the Northampton economy.

There are about eight fuel oil companies located in Northampton.[4] A majority of local sales is accounted for by the three or four largest firms. Conversations with Northampton oil dealers have indicated that about 80% of the retail price of oil represents the cost retailers must pay to wholesale distributors for the oil.[5] This indicates that about $4.2 million of the $5.3 million of local oil sales represents the cost of the oil and therefore leaves the area immediately. When this is added to the $4.3 million that is spent on the purchase of oil from companies not based in Northampton, it can be seen

TABLE 4-2: Fuel Oil Purchases from Companies Located in Northampton, Massachusetts - 1977

	Amount Purchased From Companies Located in Northampton Gallons x 10^6	Dollar Value of Purchases $ x 10^6 [b]	% of All Fuel Oil Used By Sector Purchased in Northampton
Residential	9.0	4.3	100%
Industrial and Commercial[a]	2.0[a]	.96	18%
TOTAL	11.0	5.3	54.7%

a The industrial and commercial sectors are combined here because we know from oil companies in Northampton that about two million gallons were purchased in the city by the two sectors.

b This is calculated using the $.48 per gallon price quoted to us by local oil dealers.

that almost 90% of all the money spent on oil by consumers in the city does not remain in the local economy.

Of the remaining twenty per cent of local oil expenditures, about one half, or $530,000 is spent on wages. The companies are locally based and appear to employ area residents, so for simplicity it is assumed that all of the wages are those of Northampton residents. The final 10% of sales revenue is spent on a wide variety of items including delivery truck maintenance, taxes, rent, insurance, and advertising. All of these expenditures are assumed to occur in Northampton although it is likely that some of them, insurance for example, involve transactions with firms not located in Northampton.

Natural Gas

Natural gas is supplied to Northampton by Bay State Gas Company, a state-wide firm that services several different regions. Gas travels to Northampton from the Springfield area through a network of underground pipes that serve a total of fourteen cities and towns.[6] Since gas consumed in Northampton represents only a portion of the total that is supplied by the pipeline, specific figures concerning operating and wage costs in Northampton are not available. Economic and employment estimates are extrapolated from figures cited for the entire company in the 1977 annual report.[7]

A standard price for a given unit of gas does not exist. Charges to customers are based on a rate schedule that differentiates between the use to which the gas is put and the total amount consumed. Customers are also billed periodically for fuel adjustment charges that reflect fluctuations in the price the gas company must pay for the gas. Fuel adjustment and rate charges are filed with the Department of Public Utilities. They are quite complicated and are not particularly useful to this discussion, since individual consumers are not being examined. It is possible, however, to compute the average revenue collected by Bay State for each thousand cubic feet (MCF) of gas sold to all sectors. When this is done, it is found that in 1977 the average revenue per sale of each thousand cubic feet of gas was about $3.90.[8] This figure includes whatever periodic fuel adjustment charges were necessary during 1977.

Using the sales estimates that are displayed in Table 4-3 and

TABLE 4-3: Expenditures on Natural Gas in Northampton, Mass.-1977

	Amount MCF x 10^5	Average Revenue $/MCF	Total Expenditure $ x 10^6
Residential	3.0	3.9	1.2
Industrial	.6	3.9	.2
Commercial	2.4	3.9	.9
TOTAL	6.0		2.3

an average revenue of $3.90 per thousand cubic feet of gas, it appears that Northampton gas customers spent about $2.3 million for gas in 1977. The accuracy of this figure was checked by comparing the percentage of total gas sales that Northampton's consumption represents with the percentage of total revenue generated from those sales. Northampton sales account for 2% of all Bay State Gas Company sales.[9] Our figure of $2.3 million represents 1.9% of Bay State's total 1977 operating revenue.[10]

In its annual report, Bay State Gas Company itemizes the amounts of money spent on each of its operating expenses. We calculated the percentages of total revenue that were spent for each budget line in 1977 and applied them to the estimated $2.3 million spent by Northampton customers. This procedure assumes that ratios between sales and operating costs remain constant among the various towns and cities served by Bay State Gas Company.

Since Bay State's headquarters for the Northampton area is located in Springfield, the only operating expenses that would be introduced to the local economy are the local taxes paid on the Northampton pipeline and the wages of any company employees who live in Northampton. Local Northampton taxes account for about $108,000.[11] Although we do not know how many Bay State Gas Company employees reside in Northampton, it is possible to develop a rough estimate of how many people are employed by the company to service Northampton customers. From an employee per customer ratio that we derived from figures included in the 1977 annual report, we calculated that about 21 people are employed to serve Northampton customers. This equals a Northampton wage bill of $214,000 if it is assumed that all 21 employees reside in Northampton and are paid the Northampton median income of $10,180 per year.

Electricity

Electricity is supplied to Northampton by Massachusetts Electric Company, a subsidiary of the New England Electric System. Electric power is distributed to the city through a network, or grid, of transmission lines called the New England Power Exchange. NEPEX serves all of New England, supplying electricity generated from oil, hydropower and nuclear facilities located throughout the region. The complexities of the relationship between Massachusetts Electric Company, its parent company and the regional power grid make it difficult to determine how much money from Northampton electric sales might circulate through the local economy. Dollars generated from electricity sales in Northampton are used partially to pay wages and other operating expenses incurred by the grid as a whole. For example, utility poles used in Boston might be purchased in New Hampshire and paid for with money that was collected in Northampton. Additionally, Northampton based contractors or construction workers might be hired by MassElectric and paid with revenues generated in other cities.

The total Northampton expenditure on electricity was determined in Table 4-4 from sales estimates developed in Chapter Three. Although electricity prices are determined by a rate structure not unlike that of natural gas, general price estimates were available from the utility and used in Table 4-4. Conversations with a utility representative assisted in developing estimates of the proportion of sales dollars that is spent by the utility in Northampton. The two principal ways in which money is spent in the city are property taxes and wages. Massachusetts Electric Company is the single largest tax payer in Northampton. About 3.3% of the approximately $7.1 million collected from electricity sales in Northampton are paid back to the city in the form of property taxes.[13] This represents a total of $234,000, or 2.6% of the $8.9 million 1975 Northampton local property tax roll.[14]

There are thousands of utility employees scattered around Massachusetts who either service Northampton customers or are partially supported by them.[15] However, there are only 43 people presently employed in the Northampton office of the electric company.[16] Assuming that all of these employees reside in the city and that they earn an income equivalent to the Northampton median of $10,180 per year,

TABLE 4-4: Expenditures on Electricity in Northampton, Mass.-1977

Sector	Amount kWh x 10^7	Price $/kWh	Total Expenditure $ x 10^6
Residential	5.6	0.045	2.5
Industrial	3.2	0.04[a]	1.3
Commercial	8.2	0.04	3.3
TOTAL	17.0		7.1

[a]Customers who use large amounts of electricity pay less per unit than those who use small amounts. Prices provided by Massachusetts Electric Company.[12]

$438,000 represents the Northampton wage costs of Massachusetts Electric Company.

Fuelwood

The burning of wood for domestic space heating has traditionally been quite common in New England. It has recently become apparent that an increasing number of homes are relying on wood heat to supplement or replace existing heating systems. This increase has been particularly noted in rural or heavily forested areas. Several studies have been done recently that examine the extent of wood resources in western Massachusetts. Unfortunately none of them has looked in any depth at the economic or employment implications of wood heating systems.

TABLE 4-5: Expenditures on Fuelwood in Northampton, Mass.-1977

Amount Cords $x\ 10^3$	Price $/Cord	Total Expenditure $\$ \times 10^6$
4.2	50	.21

The estimate of current Northampton fuelwood use presented in Table 4-5 is based on research done by a study group at the University of Massachusetts in Amherst.[17] According to an unpublished report produced by the group, about 4200 cords of fuelwood were consumed in Northampton in 1977.[18] Using the group's estimated price of $50 per cord, it appears that a total of about $210,000 was spent on fuelwood by Northampton residents.[19] We assume that all of the fuelwood consumed in Northampton is purchased from dealers located within the city limits.

The operating costs of the wood cutting and distribution process vary according to the scale of operation and the distance that the wood is transported. According to several foresters and wood resource managers in western Massachusetts, fuelwood dealers in the Northampton area tend to be local residents who use the business as a way to supplement other, more regular earnings.[20] Dealers usually cut the wood themselves, relying on family or friends for assistance. Earnings from the sale of wood are seldom reported to the government and do not appear on town tax rolls.

The University of Massachusetts study group determined that from $10-$20 is spent per cord of wood on chainsaw, gasoline, oil and transportation expenses.[21] If an average fixed expense of $15 per cord is assumed, then about 30% of every dollar spent on fuelwood represents the cost of the production and transportation of the wood. In Northampton, we assume that all of these expenses, a total of $63,000, is spent in the local community. The remaining 70% represents profit and any wages that might be paid out. Since many area woodcutters and fuelwood dealers appear to do the work themselves, the estimated $147,000 of profit is considered to be income that could be introduced to the local economy.

Gasoline

There are about thirty gasoline service stations located in Northampton.[22] As explained in the section on transportation energy use, it is difficult to determine how much of local gasoline sales actually represent Northampton based consumption. Using the estimate for Northampton gasoline consumption explained in the section on transportation energy use in Chapter Three, we applied an average price per gallon supplied by the Massachusetts Energy Office to reach a total Northampton expenditure of $6.5 million.[23] (See Table 4-6) Figures available for 1974 indicate that 29 Northampton gasoline service stations sold about $5.2 million worth of gasoline.[24] Allowing for a rise in the price charged per gallon as well as for growth in demand since the gasoline shortage of 1973-74, our 1977 sales figure appears to be a reasonable estimate.

Statistics supplied by the Massachusetts Energy Office indicate that the average increase in price for each gallon of gasoline between

TABLE 4-6: Expenditures on Gasoline in Northampton, Mass.-1977

Amount Gallons x 10^6	Price $/Gal.	Total Expenditure $ x 10^6
9.8	.67	6.5

distributor and retailer is about $.077.[25] Therefore, about 88% of the price charged to the consumer represents the costs paid by retailers for the gas. Of the estimated $6.5 million spent on gasoline in Northampton in 1977, about $5.7 million left the area immediately in order to pay wholesale distributors.

About 12% of the price charged for gasoline is not related to the price paid by the gas stations for the gasoline. Thus, about $780,000 is available in Northampton to pay wages, rent, state gasoline tax, franchise fees, property tax and other operating expenses. According to national figures available in the 1972 U.S. Census of Business, gasoline station payrolls equal about 9.2% of gasoline sales revenue.[26] Assuming that the Northampton breakdown is similar to the national average, about $600,000 is spent on wages by Northampton gasoline stations. This is equivalent to 59 jobs if the Northampton median income is used. For simplicity, it is assumed that all of the remaining $180,000 is spent in the Northampton area on local operating expenses such as property taxes, rent and advertising fees.

Employment and Income Implications

Estimates of total energy expenditures in Northampton and the breakdown between the amounts spent on local wages and other operating costs are collected and presented in Table 4-7. It is important to emphasize the highly approximate nature of these figures. They represent rough estimates of wages and operating costs, and have been developed only to provide a basis for the discussion of the potential employment and income impacts of a shift to alternative, renewable energy sources.

Several important conclusions can be derived from the totals displayed at the bottom of each column in Table 4-7. First, it is now known that $25.9 million was spent in 1977 ($863 per person) on energy consumed in Northampton residences, industries, vehicles, and commercial establishments. It is important to note that $4.35 million of the total spent on fuel oil is purchased from companies not located in Northampton. Therefore, 45% of Northampton oil expenditures have no local employment or economic impacts because the money is spent in other communities.

As the last column in Table 4-7 illustrates, 88.3% of the total amount of money spent on energy in Northampton, or $22.9 million ($763 per person), leaves the city immediately to pay the costs of the production or purchase of the energy. Clearly this large outflow of money from the Northampton economy creates a substantial drain on the local economy. In Chapter Nine, we will consider what would happen if a larger portion of the money spent on energy could be recirculated through the Northampton economy. It is possible that alternative, renewable energy systems could prevent such a drastic drain on local income.

TABLE 4-7: The Breakdown of Energy Expenditures in Northampton, Massachusetts-1977

	Amount Spent on All Energy Purchases 10^6	Amount Respent in Northampton 10^6	Local Wage $ Generated 10^5	Other Local Expenses 10^6	% of Total Not Respent in Northampton
Oil -Local	5.3	1.1	.53	.53	90.1%
-Non-local	4.3	0	0	0	
Natural Gas	2.3	.32	.21	.11	87.4
Electricity	7.1	.67	.44	.23	91.5
Wood	.21	.21	.15	.06	0
Gasoline	6.5	.78	.60	.18	88.0
TOTAL	25.9	3.0	1.9	1.1	88.3%

Note: Numbers displayed in table may vary slightly from the text due to roundings.

It can be seen from Table 4-7 that approximately 12% of the total expenditures on energy, or $3.0 million, is respent in Northampton by energy retailers. This is divided between labor expenses and other operating expenses such as rent, taxes, advertising and maintenance. It was calculated from our estimates of wage costs and employment trends in the various energy companies that about $1.9 million worth of jobs in Northampton are the direct result of current energy sales. By dividing this number by the median income in Northampton, it can be shown that this equals about 170 jobs. In other words, about 170 people are employed in jobs that result directly from the sale of energy in Northampton. (We assume all live in the city but it is possible that some reside in other towns in the Northampton area.) In 1974, 52.9% of the 22,968 Northampton residents sixteen years or older were employed in the civilian labor force.[27] Although we do not know what percentage of these people are actually employed by firms and establishments located in Northampton, we do know that the total amount of Northampton residents employed in civilian jobs equals about 12,000. (It is interesting to note that this is divided fairly evenly between men and women, at 52.9% and 47.1%, respectively.)[28] Thus, it appears that fewer than 1.5% of employed Northampton residents are employed in jobs directly related to energy sales in Northampton.

It has also been determined that about one-third of the $3 million that is respent in Northampton by energy retailers located in the city is spent on non-wage related expenses such as rent, taxes, advertising and maintenance. It is difficult to determine how many jobs are directly and indirectly related to these expenses as they circulate through the local economy. A method similar to that applied to wage costs can be used. However, results of such computations are somewhat less concrete and less indicative of actual employment trends in Northampton than those done on the basis of wage costs. A particularly important impact of these expenditures is on the city's tax rolls. We know from computations concerning tax payments by energy companies to the city that approximately $500,000 was paid in taxes in 1977.[29] It will be important to estimate what effects on the tax base of the city of Northampton could occur as a result of a shift to the development and use of alternative energy systems.

An important prediction of economic theory is that overall spending will tend to increase by more than the initial expenditure as dollars circulate through an economy. This is called the multiplier effect and is defined as the ratio of a change in income to the initiating change in spending that brings it about. While most economic theory addresses the multiplier effect on a national, or macro level, regional economic theory has recently been applying these concepts to regional or localized economies. Hence, it is not enough simply to state that $3 million is spent in Northampton by energy retailers in wage and other expenditures. These dollars have additional impacts on the Northampton economy as they circulate through several 'rounds' of spending.

Multipliers in relatively small or narrowly-defined communities tend not to be very large. This is because a large proportion of the income in such an economy leaves quite rapidly to purchase goods and services not provided by the economy. This is well illustrated by our figures concerning the outflow of dollars from Northampton to pay for energy used, but not produced in the city.

It has been suggested by Craig L. Moore, an economist at the University of Massachusetts in Amherst that about 40% of every dollar of income generated in Northampton is spent in the local economy.[30] This number is based on Moore's studies of various Massachusetts communities as well as of cities and towns located in other states. In his article, "A New Look at the Minimum Requirements Approach to Regional Economic Analysis," Moore examines the relationship between city size and the base and service components of the economies of over 300 cities.[31] He concludes that a city with a population similar to that of Northampton has a multiplier of 1.66.[32] In other words, a dollar spent in Northampton will generate a total of about $1.66 of local income as it circulates through rounds of spending in the economy. This suggests that the total income generated by the amount of money respent by energy retailers in Northampton is $4.98 million, or 19.2% of the amount originally spent by Northampton customers. The total "dollar size" of Northampton can be roughly estimated by multiplying the number of employed residents by the median income earned by each resident. This amounts to about $122 million and although it is known that this is not all respent in the city, it helps to illustrate how small the $4.98 million figure is. In Chapter Nine, similar effects of alternative energy systems will be compared in order to determine whether the multiplier effect and the overall flow of spending could be different in a community more oriented towards energy self-sufficiency.

Footnotes

1. For a comprehensive review of the current debate see, Jobs and Energy Update, Washington D.C.: Environmentalists for Full Employment, 1101 Vermont Ave., N.W., 1978.

2. The method used here was developed after conversations with several economists based in the Amherst-Northampton area.

3. Interview with Michael Martin, Smith College Physical Plant, Northampton, Massachusetts, June 22, 1978.

4. This information is based on our own research during the summer of 1978.

5. This figure is based on our interviews with representatives from oil companies located in Northampton, Mass., October, 1978.

6. Bay State Gas Company Annual Report, 1977. Canton, Massachusetts, pp. 15-16.

7. Ibid.

8. Ibid.

9. Calculated from figures in Bay State Gas Company Annual Report, 1977, pp. 15-16.

10. Ibid.

11. Ibid.

12. Interview with Ed Wingfield, District Manager, Massachusetts Electric Company, Northampton, Massachusetts, June 16, 1978.

13. Interview with Ed Wingfield, October 10, 1978.

14. City of Northampton: Annual Report of Officers-1975, Northampton, Massachusetts: Gazette Printing Co., p. 227.

15. Interview with Ed Wingfield, October 10, 1978.

16. Ibid.

17. Development and Application of Planning Procedures for Assessing the Potential for Using Wood Energy in New England. Unpublished Report Produced by the Fall, 1977 Course, RP 681, Offered by the Department of Landscape Architecture and Regional Planning, University of Massachusetts, Amherst, Massachusetts.

Footnotes (continued)

18. Ibid.,part 3, p. 45.

19. Ibid.,part 3, p. 24.

20. This information was collected during interviews with various area foresters and wood management people.

21. *Wood in New England*, part three, p. 24.

22. Massachusetts Department of Commerce and Development. *City Monograph of Northampton*, Boston: 1974, p. 7.

23. Interview with Deborah Schriber, Massachusetts Energy Office, October 2, 1978.

24. *City Monograph of Northampton*.

25. Schriber, Deborah. ibid.

26. U. S. Department of Commerce, Bureau of the Census, *United States Census of Business: 1972*.

27. *City Monograph of Northampton*.

28. *City Monograph of Northampton*.

29. This figure is based on our calculations of local expenses of Northampton energy companies. We know from our research that in 1977 Bay State Gas Company paid about $108,000 and Massachusetts Electric Company paid about $234,000 in local taxes to the city of Northampton. While we do not know how much gasoline service stations or oil companies paid in the local taxes, we feel it is safe to assume that the total paid by all energy companies is not more than $500,000.

30. Moore, Craig L. "A New Look at the Minimum Requirements Approach to Regional Economic Analysis ", *Economic Geography*, October 4, 1975, pp. 355.

31. Ibid.

32. Ibid., p. 355.

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PART TWO

Determining Future Demand

A commitment to streamlining the patterns and improving the efficiency of energy use in Northampton can stimulate economic growth and enhance the quality of life. In fact, it is demonstrated in the following chapters that it is possible for Northampton to achieve negative growth in its overall demand for energy without experiencing sacrifices or shortages that are often incorrectly associated with a decreased demand for energy. Various factors effecting energy demand in Northampton are examined in Chapter Five. Particular emphasis is placed on examining growth, or in some cases the lack of growth that has been experienced in different segments of the city. A specific and detailed analysis of the way energy is currently consumed in Northampton is presented in Chapter Six. It is demonstrated that there is a significant difference between the amount of energy presently used in the city and the amount of energy that is actually needed to perform the tasks that are being done. In Chapter Seven, the potential for conservation in the residential, industrial, commercial, and transportation sectors of Northampton is estimated. Existing conservation efforts are discussed and future methods of planning for changes in energy use are suggested.

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Chapter Five

Determining Future Demand

Utility companies have always developed predictions of future energy demand. The high capital costs and the long lead times involved in constructing new capacity make it necessary to prepare forecasts of trends in energy consumption. Since utility profits are dependent on installed capacity, there has been an incentive for utilities to encourage present energy consumption and to predict large increases in energy use for the future. In the past, energy demand has been encouraged by extensive advertising, the creation of rate structures which favor large users, and the development of subsidies for builders of electrically-heated homes. The prophecies of high energy consumption became self-fulfilling owing to the efforts of the utilities.

It was not until the energy crisis that state and federal governments seriously questioned the validity and inevitability of utility energy projections. Several studies have recently concluded that the inefficiency of current energy use leaves ample room for both conservation and economic growth and that increases in the standard of living can continue without the high energy growth rates of the past. According to these studies, with a shift in social priorities toward conservation, and a decision to use societal resources more efficiently[1], energy consumption could remain at present levels indefinitely. Society, then, "can decide its energy use, just as an individual does, and attempt to shape the future".[2]

By virtue of its planning and regulatory powers, a city government can greatly influence energy use. There is considerable opportunity for a local government to take initiative in energy conservation and energy self-reliance by incorporating energy-efficient goals into its planning framework. Energy-efficient planning includes a commitment to reducing the demand for energy and improving the efficiency of energy use. It entails local control over the production, distribution, and financing of energy and energy use.[3] In order to achieve such goals, local government can effect changes in land-use and transportation patterns, develop energy-efficient building and site design requirements, support the development of local energy supplies, and encourage public education and demonstration projects.[4] The goals of energy-efficiency and energy self-reliance provide an orientation from which to plan for the future.

In designing an energy plan for Northampton which stresses energy-efficient planning, conservation, and the utilization of local resources, several factors which influence future energy use must be considered. The amount of energy used by individuals and families who live in Northampton can change as a result of shifts in consumer preferences, increases in disposable incomes, and most importantly, energy price levels. The incentives to conservation can be understood by looking at expected trends in individual energy use. Rising energy prices will encourage the use of energy-efficient appliances, the insulation of buildings, and the development of energy awareness by residents of Northampton. In addition to changes in habits of personal consumption, industrial and commercial growth, together with population growth, are also important determinants of future energy use. The vitality of the industrial and commercial sectors has implications for the economic base as well as the energy use of the city, so it is expected that growth in these sectors will be encouraged by the city. It is in these areas that energy-efficient planning, through zoning and building ordinances, and alternative energy models, can have a substantial effect on energy consumption. A commitment to conservation and careful planning can mean no net growth in energy consumption in Northampton, even as the local economy prospers.

Individual Energy Use

Although we view utility forecasts in a critical light, it is still useful to examine the past patterns of energy demand and the future projections of the utility companies which serve Northampton. The important aspects to note are the utilities' expectations of future energy use by individuals.

The last ten to fifteen years has been a situation of no-growth for retail heating fuel in general because of competition from natural gas and electricity. Northampton has maintained its disproportionate reliance on oil for space and water heating, but since 1973 the price of oil has risen from 16¢-18¢ per gallon to over 50¢. An official of one of the larger oil retailers in Northampton stated that oil consumption in the residential sector has dropped by about 20% since 1973. The only way for local heating fuel companies to remain in business has been by purchasing foundering companies and increasing the number of people they serve.[5]

The Massachusetts Energy Office has predicted an increase of 2-3¢ per gallon for home heating oil this winter[6], and a local oil company executive suggested that the price of oil may rise as high as 60¢ a gallon. He believes that by 1985 oil prices may be as high as 80¢ per gallon.[7] Certainly such factors as persistent inflation, continued price increases by OPEC*, and a federal mandate to increase the price of domestic crude oil will only increase the price of home heating oil. It is clear that as prices rise, oil consumption in Northampton will continue to decline as households and businesses turn to stronger conservation measures in an effort to reduce heating bills.

Natural gas is used by 30-40% of Northampton's homes for space and water heating. Table 5-1 illustrates trends in natural gas use by residential customers of Bay State Gas.[8] The figures are aggregated for all of the towns which Bay State Gas serves. It is assumed that Northampton's residential use of gas is comparable to the other areas. As the table depicts, since 1973 the overall trend in residential natural gas consumption has been downward. There have been two exceptions. In 1974, there was an increase in the amount of natural gas used by residential customers, which was probably due to an easing of the previous winter's energy crisis. A particularly severe winter in 1976 apparently increased natural gas consumption by residences. In 1977, the average amount of gas used by households was at a level somewhat below the 1972 figures.

A Bay State Gas Company Annual Report states, "The slack in the

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* As this is written OPEC has just announced a 14.5% increase in the price of crude oil for 1979.

TABLE 5-1: Residential Gas Use by Bay State Gas Customers[a]

Year	1970	1971	1972	1973	1974	1975	1976	1977
Avg. use per residential customer (mcf)	91.1	94.5	97.4	91.2	94.6	93.5	98.5	96.2
Percentage change	---	+3	+3	-6.3	+3.8	-1.2	+5.4	-2.3

[a]Figures derived from Bay State Gas Annual Reports.

economy, coupled with public efforts to conserve energy, and mild weather conditions, have slowed growth".[9] Of course, the weather is unpredictable. A tight economic situation, and increased natural gas prices as a result of curtailments and deregulation pressures, are likely to discourage natural gas usage, and make conservation investments more appealing. In recognition of the inevitability of further declines in residential gas use, Bay State Gas Company concentrates its marketing effort on expanding the number of customers they serve.[10]

According to a Massachusetts Electric official, demand for electricity in Northampton grew from 1965 to 1973 at the rate of 7-8% a year. This growth rate closely parallels the national rate for that period. In 1973, as prices rose, electricity use in Northampton declined by 2.5%. The company's District Manager states that industrial energy use has remained at 1973 levels, while residential and commercial consumption have increased at the rate of 6% per year. For its future projections, Mass Electric has developed a set of estimates

TABLE 5-2: Household Appliance Ownership[a]

% of homes owning	clothes-washers	home food freezers	dish-washers	air conditioners
Northampton	68.9	11.3	15.5	16
United States	90.8	28.5	20.8	35

[a]All figures are for 1969 and are compiled from a variety of sources.[11]

ranging from a 3.5% to an 8% yearly growth rate.[12] The uncertainty of their predictions follows from several factors, including the fact that residential ownership of certain appliances in Northampton is much lower than for the United States as a whole (see Table 5-2 above). The disparity may be due to the large proportion of Northampton's residents who are in the student and institutional populations. These groups would be less likely to purchase as many major household appliances. Overall, future appliance use may increase, but this is difficult to predict quantitatively. Secondly, given the potential for major shifts away from oil and gas, to coal and nuclear based electricity generation for home heating, electricity use may rise.

Oil and gas companies do not foresee individuals and homeowners increasing their energy use. As heating costs soar, individuals will seek to cut down their space and water heating needs as much as possible. The use of residential appliances may expand as there remains considerable market potential. If consumers are aware of the importance of the operating costs of their appliances, they will purchase products which are more energy-efficient. Therefore, even if residential appliance use grows, it need not have significant impact on total energy use in the city.

Growth in Northampton

Estimating population growth in Northampton is central to any determination of future energy needs. People require housing, employment, transportation, and community services, all of which involve the use of energy. Northampton's current population of 30,000 has remained remarkably stable over the last few decades, increasing by only 2% since 1950. A set of population projections for the city has been developed by Metcalf and Eddy, a firm which wrote a Master Plan for Northampton in 1972. They concluded that a probable estimate for Northampton's population in 1990 was around 37,000.[13] Trends since the Master Plan indicate that the figure will probably be lower. A recent projection by the Lower Pioneer Valley Regional Planning Commission predicts a population of 31,500 by 1990 (a 6% increase), and 33,610 people by 2000 (a 12.5% increase).[14] On the basis of these numbers, and a knowledge of Northampton, it is expected that growth in the population of Northampton will be fairly small.

In addition to absolute numbers of people, the age distribution of a community has significant effects on energy use, because of implications for employment patterns and the variety of community services which are required. While growing at a slow rate, by 1990 Northampton's population will be of a younger composition than it is currently. The Comprehensive Summary of the 1972 Master Plan predicts increases in Northampton's population between the ages of 0-14 and

25-44. These increases would reverse the trends of the previous decade for these age groups. At the same time, the Master Plan projects a substantial decline in the older population.[15]

In the past few years, there has already been an influx of students and young professionals, drawn by the revitalization of the downtown area. The growing attractiveness of the city has prompted such descriptions as a recent article in a local paper which was entitled "Northampton's Renaissance: Patrons in Paradise". This article referred to Northampton as a "center of cultural renaissance".[16] If such favorable attitudes and publicity persist, Northampton's population may come to have a more youthful orientation than expected.

The presence of the students and young professionals in Northampton is reflected in the flavor of the revitalization of the central business district. The new, small specialty shops have an appeal to a hip, upper middle-class clientele. The growth of the commercial sector in Northampton also reflects the changing economic base of the city. Northampton's experience is similar to that of many other communities, as there has been a shift away from manufacturing activities which were once the basis of the local economy to an emphasis on services and trade.

From 1967 to 1975, employment in Northampton's service sector grew by over three times, and now represents a third of the total employment in the city.[17] The tremendous growth of the service industries was due mainly to the development of the King Street Corridor which occurred at this time. According to one of the city planners, it is unlikely that King Street will experience any further growth.[18]

Employment in the wholesale and retail trades increased by 18%

from 1967 to 1975, and also represents a third of Northampton's employment.[19] This commercial growth has taken place on King Street, and also to a significant degree through the rehabilitation of Green Street and the Central Business District. Continued growth in the downtown area is constrained by problems of space, parking, and proximity to residential neighborhoods.[20]

Total employment in Northampton grew by about 1500 from 1967 to 1975. The number of people employed in manufacturing in the city decreased by nearly half, and this sector now includes nearly a quarter of Northampton's employment.[21] Even though industrial activity in the city has declined, there is a ninety-acre industrial park which the Redevelopment Authority is vigorously promoting. In the last four years, only one major employer has located in the park.[22] The best prospects for the industrial park are probably light industry, and white-collar firms which might be attracted by the area's educated labor market.[23]

Conclusion

The picture which emerges from the above discussion is interesting to examine for its energy implications. The commercial sector in Northampton uses a large portion of the city's total energy. It is also an area where there is significant energy waste. Although there may be additional commercial growth in the city, strong conservation efforts can eliminate any net growth in energy consumption. The city government, through its zoning and building ordinances, can have substantial impact on the energy-efficiency of this sector, and on the amount, type and location of any further commercial growth.

The industrial sector in Northampton presently uses only a small amount of the energy consumed in the city. The Redevelopment Authority can encourage industries which are not energy-intensive to settle in the Industrial Park. The city could also promote cottage industry within neighborhoods.

The population of Northampton is not expected to increase very much, but a City Planner has suggested that the general housing crunch may effect Northampton.[24] Under these circumstances, energy efficient building codes and planned developments become critical. The city can also design a public transit system to cut down on automobile traffic within the city, and can work to develop a community-scale waste processing operation.

A commitment to improve the efficiency of energy use, and to reduce the demand for energy in Northampton can enable further economic growth and increased electricity use by residences to occur with no net growth in energy consumption. Succeeding chapters explore the current efficiency of energy use in Northampton, the conservation potential in the city, available resources for energy self-sufficiency, and present planning efforts.

Footnotes

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2. Daly, Herman. "Energy Demand Forecasting: Prediction or Planning?", Journal of the American Institute of Planners, January 1976, p. 4.

3. Bureau of Municipal Research. What Can Municipalities do About Energy?, Toronto: March 1978, p. 10.

4. Ibid.,p. 1.

5. Interview with Don Steel, Kimball and Cary Fuel Corporation, Northampton, Massachusetts, November, 1978.

6. Moulton, Stan. "As Mercury Falls, Oil Price Will Rise", Daily Hampshire Gazette, October 21, 1978.

7. Steel, Don. ibid.

8. Bay State Gas Company. Bay State Gas Company Annual Report, Canton Massachusetts: 1974, 1975, 1976, 1977, pps. 22, 18, 22, 15.

9. Ibid, 1975, p. 1.

10. Interview with Judy Pelis, Bay State Gas Company & Subsidiaries, Springfield Division, Springfield, Massachusetts, November 20, 1978.

11. U. S. Department of Commerce, Bureau of Census. U.S. Census of Housing-1972, Washington, D.C.: Superintendent of Documents, 1972, Table 31, p. 23-138. Ford Foundation Energy Policy Project. A Time to Choose, Final Report, Cambridge: Ballinger Publishing Co., 1974, p. 102. Darmstadter, Joel. "Energy Consumption: Trends and Patterns" in Energy, Growth, and the Environment, ed. Sam H. Schurr, for Resources for the Future, Baltimore: John Hopkins University Press, 1972, p. 175.

12. Interview with Ed Wingfield, District Manager, Massachusetts Electric, Northampton, Massachusetts, November, 1978.

13. Comprehensive Summary Plan: Northampton, Massachusetts, Boston: Metcalf and Eddy, Inc. 1970-1972, p.8.

14. Lower Pioneer Valley Regional Planning Commission. Population Projections for Hampshire County, June 9, 1977, West Springfield, Massachusetts.

Footnotes (continued)

15. Comprehensive Summary Plan: Northampton, Massachusetts, p.8.

16. Pendleton, Pen. "Northampton's Renaissance: Patrons In Paradise", Fresh Ink, Volume 2, No. 4, October 19, 1978, pp 1, 6, 7, 14.

17. Division of Employment Security, Occupation/Industrial Research Department. Massachusetts Cities and Towns: Employment and Wages in Establishments Subject to Massachusetts Employment Security Law by Major Industry Divisions, 1967-1975, Commonwealth of Massachusetts, May 1977, p. 103. Employment in the service industries increased from 796 to 3,549.

18. Interview with Peter Klejna, Senior Planner, City Planning Department, Northampton, Massachusetts, December 7, 1978.

19. Division of Employment Security, p. 103. Employment in the wholesale and retail trades increased from 2301 to 2731.

20. Klejna, Peter. ibid.

21. Division of Employment Security, p. 103. Employment in the industrial sector decreased from 3,580 to 1976. Total employment in Northampton in 1975 was 9,373.

22. Pendleton, Pen , p. 14.

23. Klejna, Peter. ibid.

24. Ibid.

Chapter Six

Energy Quality and End Use

In Chapter Three, the amount of energy presently consumed in Northampton by the various sectors was determined. Although results of the calculations were particularly helpful in computations concerning the amount of money spent on energy in Northampton, it is important to further expand the description of energy use in the city. Specifically, the energy profile developed thus far has not taken into consideration that between the time a fuel is first counted at a mine or well and the time the fuel arrives at the point of use, energy is "lost" in the distribution or conversion of the fuel to a useful and convenient form. It is necessary to assign overheads that take into account energy lost in distribution and conversion processes in order to accurately evaluate the amount of "primary" energy.

In addition, this chapter represents an attempt to quantify and be as specific as possible about the different purposes for which energy is used in Northampton. Approaching energy consumption from the viewpoint of the "end use" of the energy, rather than of the fuel types presently used, creates a very different impression of what kinds of energy are actually needed to perform the tasks being done in the city. This approach emphasizes that energy has a "quality" associated with it and that energy systems should be designed to match the quality of energy being used with the heat or work requirements of the tasks that need doing.[1] By examining energy consumption from the end use structure, it can be demonstrated that there is a significant difference between the amount of energy presently consumed in Northampton and the amount of energy that is actually needed to perform the work that is being done.

Primary Energy

The most dramatic losses of energy between primary sources and end uses occur in the generation of electricity, since a considerable loss of thermal energy occurs when chemical or nuclear energy is converted to electrical energy. Although there are other energy losses involved in the distribution or transportation of fuels such as oil and natural gas, these losses have not been incorporated into our analysis of primary energy consumption because they tend to be smaller than other losses and can be difficult to identify and quantify.[2]

When fossil or nuclear fuels are used to produce electricity, about two-thirds of the energy used is lost in conversion and generation processes.[3] Similar energy losses are not involved in hydroelectric generation because hydropower is much more efficient. In Northampton, 82% of the electricity is presently generated from nuclear or fossil fuels, while the remaining 18% is supplied by hydropower.[4] In Table 6-1, the current electricity consumption in Northampton is compared with the total primary energy used to produce the electricity. It is shown that the total primary energy needed to supply the electrical energy used in the city is about 2.6 times

TABLE 6-1: Primary Energy Consumption for Electricity, Northampton, Massachusetts-1977 (10^{11} BTU/year)

	Electricity	Total Primary Energy Used For Elec.
Residential	2.1	5.6
Industrial	1.1	2.9
Commercial	2.8	7.4
Transportation	0	0
TOTAL	6.0	15.9

the amount of electricity that is directly consumed.

The total 1977 Northampton primary energy consumption is presented by sector in Table 6-2. The oil, natural gas and gasoline usage discussed in Chapter Three are presented in the table as direct fuels. The total amount of energy needed to generate the electricity used in Northampton is listed in the column labelled "electricity," and the total primary energy consumed by each sector is listed in the column labelled "total fuel". With the exception of the transportation sector, the primary energy use totals presented in Table 6-2 are considerably larger than the totals presented for each sector in Chapter Three, illustrating the importance of determining primary energy consumption. The total amount of primary energy presently needed to supply all of Northampton's energy demand is almost 64 x 10^{11} BTU per year, or 213 megawatts (MW). This represents a per capita demand

TABLE 6-2: Primary Energy Consumption, Northampton, Massachusetts-1977 (10^{11} BTU/year)

	Direct Fuel	Electricity[a]	Total Fuel
Residential	17.0	5.6	22.6
Industrial	1.8	2.9	4.7
Commercial	16.9	7.4	24.3
Transportation	12.1	0	12.1
TOTAL	47.8	15.9	63.7

[a]Conversion losses included.

of 7.1 kilowatts (kW), or 24.1 x 10^3 BTU, as compared to the national average of about 11.5 kW, or 39.1 x 10^3 BTU. The difference is attributable almost entirely to the absence of energy-intensive industry in Northampton.

Energy Quality

It has only recently become fashionable to emphasize the fact that energy possesses both quantitative and qualitative characteristics.[6] Various types of energy or fuel have different thermodynamic properties, ranging from the lowest quality energy of low temperature heat to the highest quality energy of electricity. A given amount of energy of high quality can generally accomplish more useful work than the same amount of low quality energy. Energy is "wasted" whenever work is done by a higher quality or larger amount of energy than is needed.

Ideally, energy systems should be designed to match the quality of the heat or work generated to that which is required to perform the tasks that are done by the system.

Conventional energy systems have done little to match the appropriate type, or quality of energy with the work being done by the energy. In many cases, premium fuels and electricity are being used for many tasks for which their high energy quality is superfluous, wasteful and expensive. Amory Lovins has compared the tendency in traditional energy systems of creating temperature differences of thousands of degrees when only tens of degrees are actually necessary to "cutting butter with a chainsaw."[7] One of the principal features of the alternative energy scenario developed in this study is the emphasis that is placed on the scrupulous matching of energy quality with energy use.

End Use

In any city or town, many different types of energy are used for a variety of purposes. Some of the uses of energy in Northampton were discussed in Chapter Three. It is essential, however, that this energy profile of Northampton examine more closely the specific functions performed by the energy used in the city. Once this is done, it is much clearer whether energy is required as heat or work, and if as heat, at what temperature. In Table 6-3, the primary energy consumed in Northampton is divided into the various categories of use that apply for each sector. It is shown in the table that with the exception of the transportation sector, space and water heating needs account for a large portion of the energy used by each sector. Items

TABLE 6-3: Primary Energy Consumption by Use, Northampton, Massachusetts-1977 (10^{11} BTU/year)

	Direct Fuel	Electricity[a]	Total Fuel
Residential			
Space Heating	14.3	.74	15.0
Water Heating	2.1	.61	2.7
Lighting, Appliances and Air Conditioning		3.9	3.9
Cooking	.55	.34	.89
TOTAL	17.0	5.6	22.6
Industrial			
Space & Water Heating	1.14		1.14
Lighting, Machinery and Air Conditioning		2.9	2.9
Process Steam & Direct Heat	.70		.70
TOTAL	1.84	2.9	4.7
Commercial			
Space & Water Heating	16.0		16.0
Lighting, Machinery and Air Conditioning		7.4	7.4
Cooking, Laundry and Miscellaneous Heating	.95		.95
TOTAL	16.9	7.4	24.3
Transportation			
All Vehicles	12.1		12.1
GRAND TOTAL	47.8	15.9	63.7

[a]Conversion losses included.

that require electricity such as lights, appliances, machinery and air conditioners account for the bulk of the remaining energy consumption. The grand totals listed at the bottom of Table 6-3 are the same as those listed in Table 6-2.

The next step is to show how much of the primary energy listed in Table 6-3 is actually delivered and used at the various points of use. In Table 6-4, the 1977 Northampton energy consumption is presented according to the various end uses for which energy is needed. The five categories of end use presented in the table are based on the quality, or effective temperature of energy required by the task to be performed. The definitions of these categories are a principal component of this study and the categories will be used during the rest of the study to identify energy use in the city. The amounts of direct fuel and electricity used in each sector for the various end use purposes are listed in the table. The total end use for each category is calculated by adding the amounts of direct fuel and electricity used in each sector and taking into account their overall effectiveness, or efficiency at the site of use.

For direct fuels used for end uses other than transportation, we assume an overall efficiency of 70% since oil and gas-fired furnaces, boilers and water heaters generally operate at 70% efficiency.[8] (This is actually a conservative assumption since many boilers and furnaces are old and not particularly well maintained, resulting in operating efficiencies that are considerably less than the optimum.) An efficiency of 20% is applied to primary energy use in the transportation sector because only one-fifth of the energy supplied to the

TABLE 6-4: Energy Consumption by End Use, Northampton, Massachusetts-1977 (10^{11} BTU/year)

	Direct Fuel	Energy Delivered	Electricity	Total End Use
Low Temperature Space and Water Heating				
Residential	16.4	11.5	.51	12.0
Industrial	1.14	.80		.80
Commercial	16.0	11.2		11.2
TOTAL	33.5	23.5	.51	24.0
Cooking, Laundry and Miscellaneous Heating				
Residential	.55	.39	.13	.52
Industrial				
Commercial	.95	.67		.67
TOTAL	1.50	1.06	.13	1.
Industrial Process Heat				
Direct Heat and Process Steam	.70	.49	negligible	.49
Transportation				
All Vehicles	12.1	2.4[b]		2.4[b]
Lighting, Appliances, Machinery & Air Conditioning				
Residential			1.5	1.5
Industrial			1.1	1.1
Commercial			2.8	2.8
TOTAL			5.4	5.4
GRAND TOTAL	47.8	27.5	6.0	33.5

[a] An efficiency factor of .7 is applied to all uses except transportation. A factor of .2 is used for transportation.

[b] See text and footnote 10 for comments concerning the usefulness and importance of this number.

internal combustion engine presently used in vehicles is actually obtained as mechanical output.[9,10] Electricity is considered to be 100% efficient at the site of use, although considerable losses of energy are involved in the conversion and generation of electrical energy. (This is another conservative assumption since many electrically-powered appliances and machinery lose a considerable amount of energy through waste heat.)

In Northampton, the total end use of energy for space and water heating is 24 x 10^{11} BTU per year, or about 80 MW. Although a small portion of this is presently supplied by high quality electrical energy, the heating of space and water included in this category is a relatively simple process that can be done entirely with low quality heat energy.

Space heating may be described as the task of sustaining the temperature inside a building at a temperature somewhat higher than that of the surrounding environment. Although some climates are colder than others on an absolute scale, the interior of a building is really kept only a few degrees warmer than the exterior environment. Water heating occurs at temperatures slightly higher than those of space heating, but in general the process involved can be similarly viewed as one requiring relatively small changes in temperature. Northampton's use of energy for low temperature space and water heating has been divided into two categories, each identified with a different temperature range. The first category refers to space and water heating to 70°C (158°F). All space heating and most water heating are accounted for by this category. The second category refers to water heating between 70°C and 100°C (158°F to 212°F) and applies to such uses of hot water as restaurant dishwashing. While it is not known exactly how much water heating the second category involves, our research indicates that it is reasonable to assume that it is considerably less than 10% of all space and water heating.

The Cooking, Laundry and Miscellaneous Heating category in Table 6-4 refers to relatively low temperature processes that are used in Northampton by the residential and commercial sectors. The total end use of energy in this category is presently only 1.18×10^{11} BTU per year, or about 4 MW. A small portion of this (about 11%) is currently unnecessarily supplied by high quality electricity.

Water heating, direct heating and steam generation at temperatures above $100^{o}C$ ($212^{o}F$) comprise energy use in the Process Heat category of Table 6-4. The industrial sector consumes most of the processed heat used in Northampton although a few commercial establishments, such as the hospitals and Smith College, do use some steam. It is known from interviews with representatives of various industries in Northampton (most of which are manufacturing firms) that the production processes used in each establishment are not particularly specialized or energy intensive. No industrial energy consumers appear to use heat in their various processes at temperatures above $235^{o}C$ ($450^{o}F$), and there is only a small demand for steam generation. The total end use of energy included in this category is presently only 4.87×10^{11} BTU per year, or 1.63 MW, a small portion of which is presently supplied by electricity.

The end use of energy for transportation in Northampton currently totals 2.4×10^{11} BTU per year, or about 8 MW. (See Table 6-4). While this figure is appropriate to the present discussion of current energy use, it is important to point out that this number will be treated differently from the other end use totals in further analyses of transportation energy needs in Northampton. In Chapter Eight, the miles travelled by Northampton residents for local transportation will be evaluated and a new system using different modes of transportation will be proposed for the city.

Items that require the versatile and high quality energy of electricity are included in the Lighting, Appliances, Machinery and Air Conditioning category in Table 6-4. The total Northampton end use of energy included in this category is quite small at about 5.4×10^{11} BTU per year, or approximately 18 MW. A large portion of this energy is used by the commercial sector for lighting and cooling needs.

A summary of the end use of energy in Northampton is displayed in Table 6-5. The total amount of energy needed to perform the tasks presently being done in the city is 33.5×10^{11} BTU per year, or about 112 MW. This is only 53% of the total primary energy of 63.7×10^{11} BTU per year, or about 213 MW, presently needed to supply Northampton's energy demand. This is a very significant difference and illustrates the importance of examining end use demand.

FIGURE 6-1: Energy Use in Northampton, Massachusetts-1977

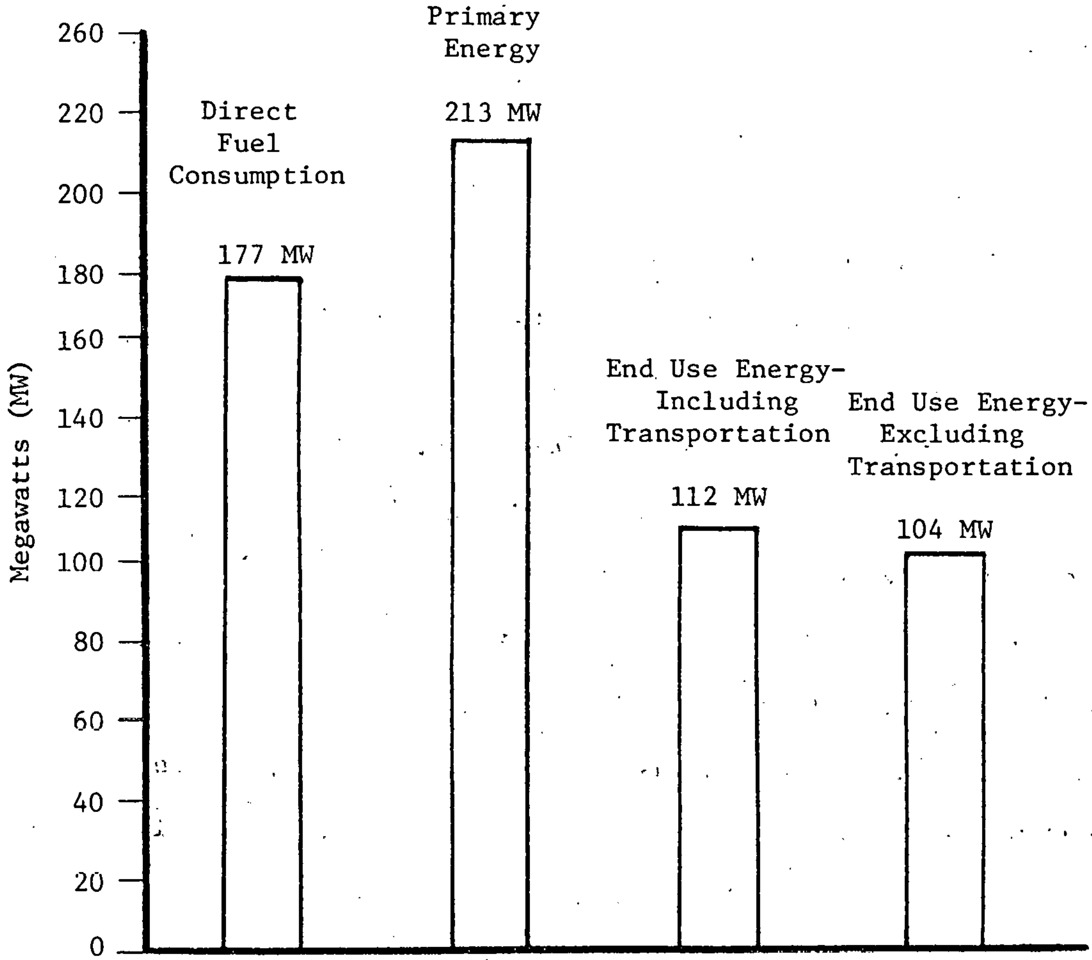

TABLE 6-5: Summary of Energy End Use, Northampton, Massachusetts-1977

	BTU x 10^{11}	MW	% of Total
Low Temperature Heat	24.0	80.2	71.6
Cooking, Laundry and Miscellaneous Heating	1.2	4.0	3.5
Industrial Process Heat	.49	1.6	1.4
Transportation	2.4	8.0	7.2
Lighting, Appliances, Machinery and Air Conditioning	5.4	18.1	16.1
TOTAL	33.5	111.9	99.8%[a]

[a]Rounding errors not corrected.

Summary

Energy use in Northampton has now been examined from a variety of perspectives as displayed graphically in Figure 6-1. In Chapter Three, the amount of energy consumed directly by the residential, industrial, commercial and transportation sectors in 1977 was determined to be 53.2 x 10^{11} BTU per year, or 177 MW. It has been estimated in this chapter that when energy losses involved in electricity generation are accounted for, a total of 63.7 x 10^{11} BTU per year, or 213 MW of primary energy are needed to supply the city's demand for energy. However, by examining end use effectiveness, it has been estimated that only 33.5 x 10^{11} BTU per year, or 112 MW of energy are actually presently used to perform the various end use tasks. Since transportation energy use will be approached from an entirely different perspective in Chapter Eight, transportation end use can be factored out of the 112 MW total presented in Figure 6-1. When this is done, the total 1977 Northampton end use of energy for all purposes except transportation is 31.1 x 10^{11} BTU per year, or 104 MW.

Footnotes

1. The concept of end use energy has been defined and discussed in a number of different energy studies. Amory Lovins is perhaps the person most identified with the concept. His book, Soft Energy Paths: Toward a Durable Peace, Cambridge: Ballinger Publishing Company, 1977, is often cited in discussions of end use energy.

2. For further discussions of the energy losses involved in the distribution and transportation of various fuel types, see R. H. Socolow, The Coming Age of Conservation, Cambridge, England: Energy Research Group, University of Cambridge, February 1977.

3. Lichtenberg, Allan J. and Schipper, Lee, "Efficient Energy Use and Well-Being: The Swedish Example ", Science, Volume 194 (December3, 1976), p.1012.

4. Interview with Ed Wingfield, District Manager, Massachusetts Electric Company, Northampton, Massachusetts, June 16, 1978.

5. National figure based on figures in Robert H. Romer, Energy: An Introduction to Physics, San Francisco: W. H. Freeman and Company, 1976, p. 601.

6. The change in approach to energy use is based on the First and Second Laws of Thermodynamics which state that energy must be evaluated on the basis of its quality, or level of entropy.

7. Lovins, Amory. Soft Energy Paths, Cambridge: Ballinger Publishing Company, 1977, p. 40.

8. Romer, Robert H. Energy: An Introduction to Physics, San Francisco: W. H. Freeman and Company, 1976, p. 163.

9. Ibid., p. 149.

10. While it is useful to this discussion to determine the present end use of energy in the transportation sector, it must be emphasized that we are especially concerned with the miles travelled for local transportation. See Chapter Eight.

Chapter Seven

Planning for Changes in Energy Use: Conservation

Maintaining the current supply of energy to Northampton, even without growth in energy consumption, will continue to be a major drain on the economy of the city. The cars, appliances, and houses that were built in a period of low-cost energy have become too expensive to continue to operate, yet are too expensive to throw away.[1] Conservation is an effective approach to reducing the risky dependence on energy imported from other areas. It is an essential first step toward energy self-sufficiency. The top priority of any attempt to formulate an energy plan is to examine the potential for conservation.

Conservation entails the transfer of a substantial amount of capital from investment in energy supply to investment in conservation measures.[2] Conservation can be thought of as an energy resource because it makes energy available that would have to be generated in some other way. Producing energy through conservation is safer, more reliable, and less expensive than generating energy from any other source.[3]

A recent study entitled New England Energy Policy Alternatives concluded that a strong conservation effort in the region's commercial, residential, and industrial sectors can create as many as 50,000 jobs, increase regional production by $2 billion, and reduce energy costs to the region by $1.4 billion annually. Their findings further indicate that "economically-efficient and attainable conservation measures can reduce New England energy use by almost 30% by 1985.[4] The advantages of conservation have prompted former Governor Dukakis and the Massachusetts Energy Office to declare that "conservation is not only our best energy alternative, but our best economic strategy as well".[5] Conservation is a key feature of the energy policy which has been developed by the state over the past three years.[6]

Several studies have examined the energy use patterns of other industrialized countries in order to assess the potential for conservation in the United States. Sweden, which has a similar per capita income and per capita production of basic industrial commodities as this country, uses only 60% as much energy to generate each dollar of Gross National Product.[7] Adopting some of the conservation strategies of Sweden, including the use of smaller cars, tighter buildings, and the utilization of process heat in cogeneration or district heating systems could reduce energy use in the United States by 30%.[8] These figures indicate the tremendous potential for decreasing energy consumption in this country which could occur without any sacrifice in living standards.

Conservation in the United States can result in substantial energy savings in every sector. Estimates range from reductions of 30-80% of present energy consumption.[9] The lower figure is particularly relevant in the short term, and includes such measures as insulation and more efficient burners, as well as incremental changes in behavior. These measures entail lowering the amount of energy used, or the energy intensity, for any particular good or service. This involves improving efficiencies, substituting other resource inputs for energy, and changing habits and operating procedures.[10]

Conservation is a continuing process, involving energy prices, consumer preferences, government policies, technological developments, and the rate of turnover of capital stock. Over time, conservation means shifting to other goods and services which perform the same task, but which require less energy. Higher estimates of the potential for energy conservation presuppose more efficient energy supply and utilization systems.

Conservation in Northampton

Examining the potential for conservation in Northampton is an integral part of developing an energy plan for the city which is based on energy self-reliance. The previous chapter noted that more efficient supply systems could reduce end use energy significantly by being better matched to the task. In addition to this end use efficiency, this study advocates that a reasonable and feasible conservation effort in Northampton be aimed at reducing energy consumption by 30% in the combined residential, industrial, and commercial sectors. More substantial savings must be made in the transportation sector. These proposals are based on an evaluation of other studies, and a knowledge of energy use patterns and building characteristics in Northampton. This section will discuss current conservation efforts in the city, and suggest areas for major energy savings in the residential, industrial, commercial and transportation sectors.

Residential

Space heating accounts for 76% of the end use energy used in Northampton's residences, while water heating, cooking, lighting, and appliances accounts for the rest. Energy-efficient appliances, low-flow water fixtures, and the use of gas and electric lighters in place of pilot flames, represent significant areas of energy savings for households. Clearly, the focus of a residential conservation program should be in reducing space heating needs. Some conservation in Northampton's residences has already taken place in response to rising oil prices. The Hampshire County Energy Conservation Analysis Project (ECAP) found a conservation potential of 44% in the Northampton homes they audited.[11] In a follow-up survey of the homes that were audited by ECAP, 85% of the Hampshire County respondents had made or were planning to make conservation improvements in their homes.[12]

Although the people answering the ECAP survey generally were not in the low-income category, a large proportion would have been more willing to make conservation improvements if given financial incentives such as tax credits or low-interest loans.[13] For those on low or fixed incomes, the initial costs of conservation are even more prohibitive, and credit is difficult to obtain. It is estimated that 18% of Northampton's population have incomes of less than $5,000.[14] These people often live in structures that need substantial upgrading, and a high percentage of low income people live in rented homes.

The Hampshire Community Action Commission, an advocacy agency for the low-income community in Northampton, runs a fuel assistance and weatherization program for Hampshire County. This year, the group has put together a fuel bank with contributions from local oil companies and banks.[15] While originally designed as a community organizer and advocacy agency,[16] the Hampshire Community Action Commission is often forced to rely heavily on emergency and stopgap measures.

The major impetus for residents to conserve energy is the cost of not conserving. In fact, at the individual homeowner level, investment in conservation may generate a higher rate of return than any other investment available, earning from 20-40% in saved fuel costs.[17] However, several institutional and financial barriers inhibit residential conservation. At this time, no Northampton banks participate in the voluntary state program of low-interest loans for energy conserving home improvements.[18] In addition, many people in Northampton live in rented homes or apartments. They often find landlords unwilling to insulate, yet their leases are too short to provide incentive for them to insulate by themselves.

Individually, then, efforts to conserve energy are hindered by lack of information, financing, and control. It seems clear that a community effort to reduce energy consumption along with a commitment to achieve energy self-reliance would be more effective than actions by single individuals. Action on a neighborhood, tenant organization, or group level facilitates participation and the coordination of individual resources.[19] Information and skill-sharing through tool-loan programs, learning exchanges and workshops are methods for increasing energy awareness and encouraging the adoption of conservation measures.

Groups could either hire technicians or be trained themselves to conduct energy audits. These heat loss surveys would measure the thermal characteristics of buildings, along with the appliance use of the residents and personal consumption habits.

Collective action would also be advantageous financially. Groups could engage in the bulk purchasing of insulation and the joint ownership of major appliances such as snowblowers or lawnmowers. Groups of people may have more access to credit and would find it easier to take conservation steps based on life-cycle costing.[20] Energy-efficient products often entail higher initial cost and lower operating costs, as for example, insulation. Citizen groups could also prod municipal governments into energy-efficient planning and legislation. In short, neighborhood conservation strategies make sense, because they are site-specific, face-to-face, and based on local resources and attitudes.[21]

Industrial

The larger of Northampton's industries are located in old, brick factories which are lined with large windows and which consist of one big working area per floor. The medium sized companies are in newer, one-story flat buildings which resemble warehouses. They have little insulation. Major energy savings can be achieved in the industrial sector through retrofitting existing buildings, replacing worn out equipment with more energy-efficient machinery, increasing waste heat recovery, and cogenerating process steam and electricity.

Most of the industries visited in this study have spent little time and not much money on conservation. A few companies have installed high-efficiency burners and have insulated windows and walls. Most of the industries have concentrated on turning down thermostats, shutting off lights, shutting windows, and turning off idle machinery. We found these industries acutely aware of rising energy costs, but overshadowing their concern was a conservatism, and a predilection for incremental change and the short-term view. Industries are generally unwilling to put any capital investment into energy conservation measures which do not promise very rapid payback.

For example, the National Felt Company has carried out several energy studies. One study examined the feasibility of converting a gas boiler to low-grade oil, while another considered using waste hot water and steam for heating. The latter proposal was rejected because it did not meet the desired three year payback period.[22]

The Packaging Corporation of America makes corrugated containers. Because of exhaust fans and vacuums for scrap materials, the plant loses a lot of heat in the winter. The company has devised an energy quotient to monitor changes in energy used per unit of production. However, there has been no capital investment in energy conservation. The Packaging Corporation is one of 36 similar plants owned by Tenneco and must wait for recommendations by the corporate engineering department.[23]

Pro-Brush, a division of Vistron, is the largest industry in Northampton, employing around 800 people. One official there estimated energy costs are about 8% of the company's operating costs. A conservation committee has succeeded in reducing energy use by about 6%

in the last two years, mainly by installing timers on oil burners, and covering windows with plastic. Pro-Brush is currently expanding its operations into an adjacent building. When asked if they had considered using alternative sources of energy for the building, a representative replied that the company's experts had looked into solar heating, but had not found it to be worthwhile.[24]

Industrial reluctance to invest in conservation can be attributed to several factors. First, energy costs are still low relative to the costs of capital and labor. Furthermore, industrial electricity and fuel prices are based on the average, rather than the incremental or replacement costs of energy. These companies still benefit from an inverted rate structure and they often fail to take into account that energy prices will continue to rise. Perhaps most significantly, their criteria for investment are stringent, and investments in conservation do not demand as high a priority as do product and capacity needs.[25, 26]

Industries generally lack adequate financial incentives to make significant conservation investments. They also lack information on the alternatives and possibilities. One industry spokesman noted that his company was quite willing to conserve, but that they didn't really know what to do.[27]

Commercial

In Northampton, an aggressive conservation program in the commercial sector is important, because this sector already consumes the largest share of the city's total energy use. While most of the energy is used for space heating, this sector also uses a lot of electricity for lighting and cooling. In Sweden's commercial sector, energy use per square meter is estimated to be up to 30% lower than in the United States, even without taking into account the more severe climate of Sweden. This substantial disparity is attributed to differences in insulation, ventilation, building construction standards, and lighting.[28]

Conservation in municipal buildings is important to emphasize because it involves energy use which taxpayers pay for, yet don't control. An audit of 15 state buildings by the Massachusetts Energy Office indicated a conservation potential of 30-40%, given additional capital investment in energy conservation and upgrading of maintenance.[29] A concerted effort to conserve energy is taking place within the municipal buildings and private institutions of Northampton. The city's Energy Conservation Commission has studied energy use in municipal buildings, and performed energy audits on various schools as well as municipal buildings.[30] On the basis of the Commission's recommendations, an Energy Conservation Coordinator has recently been hired with CETA funds, to study energy consumption in all city buildings and develop programs for conservation.

The larger, private institutions such as the four hospitals, and Smith College use large amounts of energy and it is in their best interests to conserve as much as possible. They all have energy conservation committees. Cooley Dickinson Hospital is looking into an alternative source of energy to supply its electricity and heating needs. The Hospital has applied for a grant to study the feasibility of using Northampton's solid waste to generate electricity and heat.[31]

Lighting, cooling, and space heating form the largest portion of energy use in retail stores. Much of the motivation for retail conservation is due to the high percentage of operating expenses represented by energy costs.[32] The Massachusetts Energy Office estimates that savings of 30-50% are possible in many stores.[33]

Lighting efficiency in most stores can be improved substantially with very inexpensive changes. The Massachusetts Energy Office found that the payback period for most lighting improvements is from 6 months to 2½ years.[34] Recommended improvements include switching off unnecessary lights, removing unnecessary lamps, replacing existing fluorescent lamps with reduced wattage, more efficient lamps, and changing from an incandescent light system to a fluorescent system.[35]

The efficiency of space heating and cooling systems can also be improved significantly. The older, smaller stores in the downtown area were built sturdily, but they have little insulation, and often very old heating systems which waste a lot of energy. They do tend to have lower costs per square foot than do the large malls and free-standing stores built since 1950. The Massachusetts Energy Office estimates that most stores can save 20% of their energy costs through such simple, inexpensive measures as maintaining the efficiency of equipment, and adjusting temperature settings. An additional 20-30% energy savings can result from a series of capital improvements.[36]

Unlike the residential sector, which has conserved energy, the commercial sector in Massachusetts has so far not shown much energy awareness or reduced energy waste to any great extent.[37] Last year, energy consumption in the commercial sector actually increased by 4.4%

per degree day.[38] The Massachusetts Energy Office believes that a strong conservation effort in this sector could mean a savings of $75 million in energy costs.[39] Yet, wasteful habits and lack of either knowledge or effective programs have hindered conservation in the commercial sector. An efficient, thorough conservation program for the private commercial sector is difficult to design, and it may be that local efforts, through the Chamber of Commerce, retail associations, and schools could be more successful than state or national attempts.

Transportation

The transportation sector in Northampton uses almost 23% of the energy consumed in the city. Other energy studies consistently demonstrate that the energy efficiency of transportation can be increased substantially. For example, abandoning automatic transmission would save 10% of fuel use in cars, while switching to radial tires would save another 10%. Additionally, reducing a car's weight from 3000 to 1800 pounds would cut down on fuel consumption by 25%.[40]

Beyond improving the efficiency of the private automobile is the possibility for providing alternative modes of transportation, and encouraging city planning which reduces much of the current need for transportation. The potential for conservation in the transportation sector is enormous. More than half of all auto trips in this country are under five miles.[41] The definition of 'necessary driving' is arbitrary, based on land-use patterns which developed around the automobile, and a fervent identification of individual mobility, personal freedom, and even self-esteem.

The four business districts in Northampton are concentrated, with residential neighborhoods spread around them. It is precisely this concentration of activity which would make a public transportation system an attractive, viable, and energy-conserving alternative in Northampton. A model for such a system is described in the following chapter.

Conclusion

Improving the thermal efficiency of Northampton's residences, commercial buildings, and industrial establishments by 30% helps reduce low temperature heating needs in the city to about 55 MW. Improvements in the efficiency of lighting and cooling, particularly in the commercial sector, and in the energy-efficiency of household appliances, reduces the electricity requirements of Northampton to 12.6 MW. The use of gas and electric lighters on stoves rather than pilot flames reduces end use energy needs for cooking, laundry and miscellaneous heating to 2.8 MW. The total amount of end use energy required in Northampton, after conservation and the implementation of a public transit system (transportation energy in Northampton is reduced to 10 MW) is 82.5 MW.

Although the potential for conservation in Northampton is greater than 30%, an end use demand for energy of 82.5 MW represents a clearly attainable and important goal for the city. For a 30% conservation potential in the residential, industrial, and commercial sectors to be reached there is an obvious need to provide financial incentives and information. Also needed are organizations of people, effective programs, and coordinated efforts which can inspire participation.

Footnotes

1. Healy, Robert G. of Conservation Foundation, and Hertzfeld, Henry of Bureau of Economic Analysis, U.S. Department of Commerce. Energy Conservation Strategies, Paper No. 7, undated, p. 5.

2. Gyftopoulos, Elias P., and Widmer, Thos. F. "Energy Conservation and a Healthy Economy", Technology Review, June 1977, p. 36.

3. Darmstadter, Joel and Schipper, Lee. "The Logic of Energy Conservation", Technology Review, January 1978, p. 44, and Hayes, Denis. Energy: The Case for Conservation, Worldwatch Paper No. 4, Worldwatch Institute: January 1976, p. 7. Hayes refers to Roger Sant, former Assistant Administrator of the Federal Energy Commission, who believes that an investment in energy conservation of $500 billion could save twice as much energy as could be produced by a comparable investment in new supplies. (p. 24).

4. New England Regional Commission and Mass Energy Office. New England Energy Policy Alternatives Study, Summary, Massachusetts: October 1978, p. 1. The Mass Energy Office suggests that a 20% decrease in energy consumption in the residential sector of Massachusetts alone could inject $1 billion into the economy by 1985. Lee, Henry and Sullivan, Christine B. Energy in Massachusetts: An Update of Activities and Programs, Boston: May 1978, p. 18.

5. Lee and Sullivan, p. 6.

6. The state received a Federal Grant under the Energy Policy and Conservation Act. Under this Act, the state is required to enact a mandatory and voluntary conservation effort aimed at reducing projected energy consumption in 1985 by 5%. The Mass Energy Office has a budget of $1.7 million and directs over 30 programs. Massachusetts Energy Office, Saving Energy and Dollars in Retail Stores, Massachusetts: 1978, p. 1.

7. Lichtenberg, Allan J. and Schipper, Lee. "Efficient Energy Use and Well-Being: The Swedish Example", Science, Volume 194, December 3, 1976, p. 1001.

8. Ibid., p. 1001. A cogeneration system can utilize waste heat generated by industrial processes to provide electricity and heating needs of buildings. See Chapter Eight for a discussion of district heating systems.

9. Hayes, p. 34. See also Darmstadter and Schipper.

Footnotes (continued)

10. Darmstadter and Schipper, p. 43.

11. Of the audits performed in Hampshire County last year, 104 were done in Northampton.
ECAP, Hampshire County, Northampton, Massachusetts. Interview, June 13, 1978.
The Energy Conservation Analysis Project is a CETA Funded Program, and operates in six counties in Massachusetts. They have succeeded in reducing energy use by 38% in many of the homes they've audited.
Lee and Sullivan, p. 6.

12. Hampshire County ECAP Team. Follow-Up Survey, Summary. Composite for Franklin, Hampshire, Middlesex, and Plymouth ECAP Teams, For Data Received through January 27, 1978, p. 1.

13. Ibid.,p. 3.

14. Chamber of Commerce. Vital and Social Statistics, City of Northampton, 1977, Northampton, Massachusetts: Prepared for "Northampton Day" Dinner at the Hotel Northampton, February 8, 1978.

15. Interview with Pam Murray and Harold Seewald, Energy Program, Hampshire Community Action Commission, Northampton, Massachusetts, October 11, 1978. The average yearly energy expenditure for those receiving fuel assistances was $950 and the average yearly income was $5000 to $6000.

16. Ibid. Community Action Commissions were set up in every county by the Office of Economic Opportunity in the mid-sixties. They operate with federal and state funds and private grants.

17. Hayes, p. 23.

18. Mass Energy Office, List of Banks in Voluntary Low-Interest Loan Program. Received from the Energy Phone.

19. See for example Self-Reliance, No. 16, Washington, D.C.: November-December 1978, "Conservation Strategies that do More Than Save Energy", by David Cawley, pp. 1, 12, 14.

20. Life-cycle costing is the principle of purchasing a product with awareness of the operating costs over the lifetime of the product.

21. Cawley, David, p. 1.

22. Interview with John Chopyk, Engineer, National Felt Company, Northampton, Massachusetts, July, 1978.

23. Interview with John Sutliss, Packaging Corporation of America, Northampton, Massachusetts, July 1978.

Footnotes (continued)

24. Interview with Charles Godrey, Pro-Brush Division, Vistron Corporation, Northampton, Massachusetts, July 1978.

25. Gyftopoulos and Widmer, p. 34.

26. Investment decisions in conservation are made by different groups than investment decisions about the expansion of supply. The Massachusetts Energy Office states that a firm requires a rate of return of 25% to invest in conservation. This is above their rate of return requirements for plant expansion and productivity investments (15%). This biases the market in favor of expanding the supply of energy, since utility companies increase their plant capacity on the basis of an allowed 10% rate of return. Boshier, John F. "Can We Save Energy By Taxing It?", Technology Review, August/September, 1978, pp. 65, 66.

27. Interview with Ray Holly, Quality Control, Coca-Cola Bottling Company of Northampton, Massachusetts, July 1978.

28. Lichtenberg and Schipper, p. 1007.

29. Lee and Sullivan, p. 9.

30. Interview with William Ames, Chairperson, Northampton Energy Commission, Northampton, Massachusetts, July 1978.

31. Interview with Peter Doherty, Veteran's Administration Hospital, Northampton, Massachusetts, June 29, 1978.
Interview with Joseph Fitzgibbon, Engineer, Cooley Dickinson Hospital, Northampton, Massachusetts, June 29, 1978.
Interview with E.M. Hippauf, Chief Engineer, Northampton State Hospital, Northampton, Massachusetts, June 21, 1978.
Interview with Michael Martin, Smith College Physical Plant, Northampton, Massachusetts, June 22, 1978.
Interview with Howard Sanderson, Engineer, Hampshire County Hospital, Northampton, Massachusetts, June 22, 1978.

32. Lighting costs have doubled in the last four years in Massachusetts and will probably double again in the next four to six years. Beyond the monetary incentives, there is a recent amendment to the state lighting code which puts a limit on lighting in new and existing buildings over 10,000 square feet.
Mass Energy Office, Retail Stores, pp. 2,11.

33. Ibid., p. 2.

34. Ibid., p. 13.

35. Ibid., p. 21.

36. Ibid., P. 45.

37 Lee and Sullivan, p. 8.

Footnotes (continued)

38. Ibid., p. 20.

39. Mass Energy Office, Retail Stores, p. 1.

40. Hayes, p. 28.

41. Ibid., p. 29.

PART THREE

Northampton as an Energy Self-Sufficient Community

The problems associated with a decrease of community self-reliance and local autonomy have been suggested throughout this study.[1] While cities are clearly limited in the extent to which they can effect state or national public policy, any city offers unique opportunities for promoting basic, far-reaching changes within its own boundaries. Efforts by a city to increase energy self-reliance, for example, can be aimed at "stabilizing the local economy, reducing living costs, allowing wiser use of local resources, and/or regaining control of basic needs and life support systems".[2] Changes that increase local control over the production, distribution, and financing of energy supply can form the basis for a more politically decentralized society.

A redirecting of energy policy to encourage the development of smaller, more self-reliant units requires an evaluation of the physical, economic and political resources of the local community. The following chapters examine ways in which Northampton's resources could be utilized for the goal of energy self-sufficiency. In Chapter Eight, the renewable energy resources available in Northampton are explored and systems which could be used to supply the city with energy are suggested. Although the designs presented are quite general, they demonstrate various ways that Northampton could be approaching its energy future.

Economic factors are a central consideration in the design of an alternative energy plan. In Chapter Nine, the capital costs of the plan proposed for Northampton are examined and a general cost-benefit analysis is presented. Energy systems which are small in scale and as low as possible in capital costs have been emphasized to enable a variety of arrangements for their financing, ownership, and control. In Chapter Ten, several mechanisms for community ownership and financing of energy systems are described, the purpose being to assure that the economic benefits of the systems accrue to the local community.

It is clear from interviews with members of the Northampton community that it is primarily the citizens who will motivate the implementation of an alternative energy plan. Largely based on these interviews, Chapter Eleven discusses current attitudes toward energy and suggests how various groups in the city can work to encourage energy self-reliance.

In proposing that a small city become energy self-sufficient, numerous questions are raised, particularly concerning the appropriate level at which energy policy should be formulated and implemented. Furthermore, increasing the energy self-reliance of an area involves the interaction of many complex technical, political, and economic factors. Chapter Twelve represents an attempt to place the Northampton scenario within a broader framework, and to consider the many issues raised by this work.

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[1]For example, it has been suggested that the absentee ownership of industries by national and multinational firms can have significant negative effects on a local economy. These impacts include the export of a substantial amount of local profits to areas where the parent companies are based, corporate investment in activities located outside the community, and the lack of a sense of responsibility on the part of the parent companies toward a local community.

[2]Goldberg, David H. Defining Appropriate Technology: A Scenario of Community Self-Reliance. Northeast Regional Appropriate Technology Forum, School of Business Administration, University of Massachusetts, Amherst, October 1975, p. 3.

Chapter Eight

Design Alternatives

The alternative energy systems proposed for Northampton are the result of a careful matching of the available renewable resources with the specific demands for end use energy in the city. All of the alternative energy systems presented for Northampton are based on the use of indigenous resources such as sun, water, solid waste, organic waste, wood and wind. The advantages of using these renewable resources are that, in general, they are inexhaustible, environmentally benign, and low in cost or free. Diversification of energy resources and supply systems is essential because specific end use tasks have varying requirements.

Several criteria have been used in determining the specific design of the energy systems proposed for Northampton. The systems are virtually non-polluting and will not present a serious hazard to the community or environment. It is also hoped that the construction phases will cause little harm to the environment. The energy systems selected are relatively small in scale and can be distributed throughout the city, thereby enhancing opportunities for community control. Moreover, a major priority has been placed on systems which are technologically simple. The systems presented are not excessively complex or specialized, and can be built, operated, and owned by members of the Northampton community.

As explained in Chapters Six and Seven, total end use demand for

TABLE 8-1: Projected Energy End Use, Northampton, Massachusetts[a]

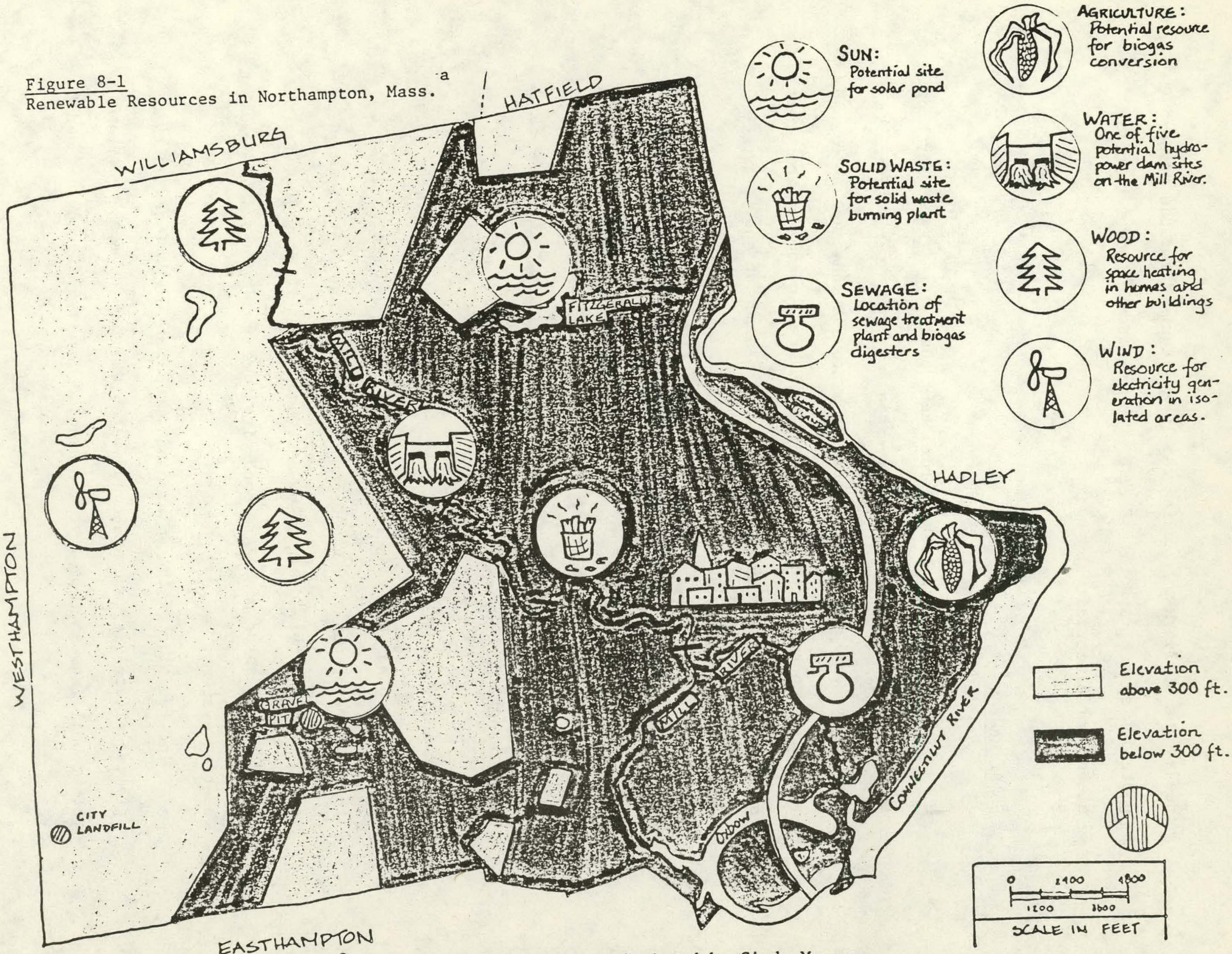
End Use	BTU 10^{11} per year	MW	% of Total
Low Temperature Heat	16.8	56	67.9
Cooking, Laundry, Miscellaneous Heating	.84	2.8	3.4
Industrial Process Heat	.34	1.1	1.3
Transportation	3.0	10	12.1
Lighting, Air Conditioning, Appliances, Machinery	3.8	12.6	15.3
TOTAL	24.8	82.5	100%

[a]After 30% savings through conservation.

energy in Northampton, once a 30% conservation potential is taken into account, is 82.5 MW. The five end use demands are summarized in Table 8-1. An annual demand of 56MW for low temperature heat provides space and water heating in residences, and in most business and industries. The demand for cooking, laundry, and miscellaneous heating is 2.8 MW. Industrial process heat requires the least amount of useful power, 1.1 MW, to provide high temperature heat for the production of goods.

Local transportation has been allocated a generous demand of 10 MW. A description and further discussion of the proposed transportation system occurs later in this chapter. The electricity necessary to supply lighting, air conditioning, machinery and appliance

Figure 8-1
Renewable Resources in Northampton, Mass.[a]



[a] Adapted from a larger map designed by Cindy Morgan

needs equals 12.6 MW. (Adding the 10 MW required for the transportation system, a total of 22.6 MW is the useful power that is needed for electricity.)

Solar Energy

'Solar energy' is such a broad term that it refers to anything from the relatively simple bioconversion of agricultural wastes to the highly complex process of beaming microwave radiation from space satellites to the earth's surface. There are a number of ways that solar energy can be used for electricity production and for space and water heating in Northampton. Two methods examined in this study are solar ponds and on-site solar systems. In Northampton, the average insolation, or the rate at which solar radiation reaches the earth's surface, is equal to 150 watts per square meter.[1]

Solar Ponds

A solar pond is a body of water that is lined with either plastic or concrete and which absorbs the sun's energy and stores it at a temperature of about $70^{o}C$.[2] Some of the advantages of solar ponds are their simple design, low cost and long term storage capacity. In addition, solar ponds are conducive to community based or district heating systems.

The function of the solar ponds proposed for Northampton is to provide electricity and space and water heating for residences and other buildings in the city. We propose that solar ponds be used to provide almost all of Northampton's low temperature heating needs (56 megawatts) as well as a portion of the city's lighting and appliance requirements (1.15 MW). (The remainder of electricity needs will be provided by the solid waste burning plant, the low head hydropower facilities discussed below, and photovoltaic cells.)

The space heating needs of Northampton can be met by pumping water directly from solar ponds through district heating systems. The district heating systems consist of a network of underground pipes which transmit hot water to specific areas of the city.[3] These systems can be very economical and convenient when used in areas of high population and building densities. (Sweden, for example, is in the process of installing district heating systems in many of its major cities.) To supply 100 homes with low temperature heat in Northampton, an average pond area of approximately 10,000 square meters is required.[4] It would take about one year for such a pond to reach a steady state condition. Heat would then be extracted directly from the pond and circulated through a district piping system to supply specific energy requirements.[5]

Electricity can be produced from hot water by Rankine cycle generators. These generators would be coupled to existing power lines or to an underground transmission grid associated with the district heating pipes. The generators use a common refrigerant, such as freon, to produce electricity with either a turbine or an expansion cycle engine.[6] Hot water from the top of the pond would be used to vaporize the refrigerant and cooler water returning to the pond would be used to condense the fluid. This means that the "waste heat" produced by the generating process is recycled to the solar pond, resulting in a net efficiency for the system of about 70%.

There are many variations in the design of solar ponds. Some ponds are composed entirely of fresh water and are lined with black plastic, while others employ a salt gradient insulating layer which provides for better heat retention. Various features have an important effect on the temperature, efficiency, and size of a pond.

A solar pond designed by A. Rabl and C. Nielsen contains two horizontal partitions.[7] (See Figure 8-2) One partition is placed a few centimeters below the surface of the water and can be made of a plastic such as Tedlar. The second partition is placed at a depth of one to two meters, separating the insulation layer of the pond from the convection zone. The bottom of the pond is painted black and lined with a material such as Hypalon, a material commonly used in swimming pools.

As shown in Figure 8-2, the layer of water above the first partition is fresh and the water located between the two partitions, or the insulating layer, is saline. This salt gradient is maintained by pumping a brine solution into the bottom of the insulating layer and pumping fresh water onto the top of the layer at the opposite end. A saline water run-off is located at the top of the insulating layer to keep the water level of the pond the same when maintaining the salt gradient. For an average size pond, Nielsen has shown that the salt gradient is easily maintained and replenishment of the salt is needed only annually.[8]

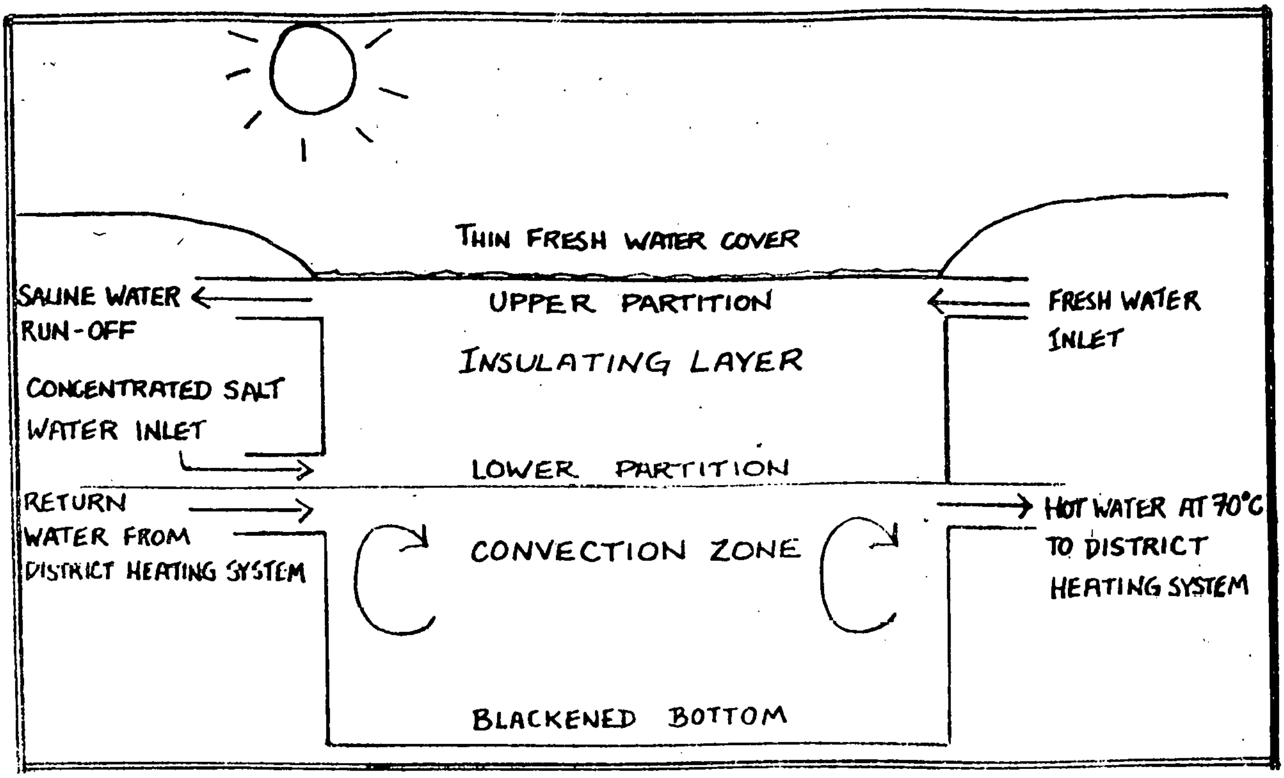
The convection zone contains fresh water. This is to allow direct removal of water into the district heating system, avoiding the corrosive properties of saltwater. Hot water for use in the district heating system is removed at the top of the convection zone and returned at the opposite end of the pond after use. The lower partition must be a stiff material, possibly glass or Kalwal, to overcome instability due to the buoyancy of the fresh water located below the denser saltwater.

As solar ponds become large the cost of the salt needed for the insulating layer becomes a proportionately larger fraction of the total cost of the pond, approaching and possibly exceeding 50%.[9] Theodore Taylor has suggested another scheme in which an inflatable plastic cover is used to insulate the pond.[10] Taylor's estimates suggest that this would be substantially less expensive than salt gradients.

Solar ponds could be located in neighborhoods where there is an open lot of 2.5 acres or more. For example, a solar pond could be situated in what is now an unused gravel pit near Burt's Pit Road in Northampton. It might also be feasible to convert Fitzgerald Lake, a forty acre man-made lake, into a group of solar ponds by emptying it, adding graded partitions, covering the bottom and sides with black plastic liners, filling the ponds with water, and putting some sort of insulating layers on top of the ponds. (See Figure 8-1 for approximate locations.) The issue of safety requires some attention. Fences may need to be constructed around the ponds to prevent unsupervised children and animals from wandering into the area.

We have estimated the land area required for these solar ponds to be approximately 7.9 acres per megawatt for low temperature heat[11]

FIGURE 8-2: Cross Section of a Solar Pond[a]



[a]Based on a design done by A. Rabl and C. Nielsen, drawing not to scale.

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and an extra 50 acres for the 1.15 MW of electricity. A total of approximately 495 acres are needed to supply all of the low temperature heat and electricity demands allocated for the solar ponds.[12] As discussed below some additional land may be needed to supply the balance of the city's electricity demand.

On-Site Solar Energy

Solar ponds can provide hot water at temperatures between 60°C and 80°C. This is adequate for all space heating and for domestic water heating, but some commercial and industrial establishments will require water or steam at considerably higher temperatures. These needs can be met by electric water heaters which would raise the temperature of the input water by the necessary amount. However, in many cases it may be more advantageous to use concentrating solar collectors and high temperature storage facilities to provide process heat in large quantities.

The use of these systems has not been considered in any detail in this plan since they will represent only a small fraction of the city's total energy use. Decisions concerning which systems are most appropriate will occur on the basis of detailed assessments of special needs. These decisions will most likely be made by the individual industries and institutions which require the added capacity.

Another potential use of on-site solar energy involves houses or buildings located in isolated areas where connection with a district heating system is not economical. Such buildings could combine passive or active solar systems with various storage capacities or with a backup energy system, such as wood-burning stoves or furnaces.

The end use demand for on-site solar systems is relatively small. Industrial process heat demand is roughly 1.6 MW. If it is assumed that 5% of the buildings in Northampton will not be connected to the district heating system, then between two and three megawatts of solar capacity are needed for all on-site space and water heating. Therefore, the total demand for on-site solar systems is estimated to be between 3.5-5 MW. For purposes of cost calculations, a value of 4 MW is used in this study.

Solid Waste

The Northampton city landfill currently receives approximately 80-90 tons of solid waste per day, or six pounds per person per day.[13] With this amount of garbage generated in Northampton, it seems logical that it be utilized as a source of energy.[14] Steam for high temperature heat and electricity generation can be produced through the burning of solid wastes. The waste heat from this process can also be reclaimed to meet low temperature heating needs. The features of the solid waste burning plant we propose are based on plans to construct a "refuse to energy plant" at Cooley Dickinson Hospital in Northampton. The plant would burn Northampton's 90 tons of solid waste per day plus another 35 tons or more per day from surrounding communities. A plant of this size could be built on approximately three acres of land.[15]

We have assumed that one-half of the useful energy produced by the plant would be used to supply space and water heating needs, with the remaining half supplying electricity. The useful power potential for the proposed solid waste plant has been calculated from information available in a feasibility study for a solid waste facility in Rockingham County, New Hampshire.[16] In Northampton, the power available for electricity will be about 2.4 MW and a comparable amount of waste heat (2.4 MW) should be available for the district heating system.

Our first choice for a location for the plant is at the proposed site at Cooley Dickinson Hospital. This project would provide the Hospital with its space and water heating needs and some electricity in addition to supplying Northampton High School and Smith's Vocational School with low temperature heat.[17] If for some reason, the Cooley Dickinson plant is not built, an alternative site in Northampton might be sought in the Industrial Park where energy from the plant could be utilized by industries located there.

An advantage of a "refuse to energy" plant is that much less pressure is put on the city landfill. It is well known that many landfills in the communities surrounding Northampton are facing potential refuse disposal problems. Although there will still be a need for the disposal of solid waste residues in the landfill, the amount of residues will be substantially less than the initial solid wastes. Furthermore, the amount of land required for the proposed solid waste burning plant is less than that for a landfill. It may be easier to find a site for an energy recovery plant than to find a site for a new landfill when the need arises. Therefore, the possibility of burning solid wastes from Northampton and from communities surrounding Northampton is an attractive one.

It is important to note that of all the energy sources proposed for Northampton, solid waste burning is apt to be the most polluting form of energy production. In a city such as Northampton where there is very little noticeable industrial pollution, it is likely that the burning of the solid wastes will generate some air pollution. However, the amount of pollution caused by the solid waste plant is less concentrated than that of a typical incinerator because much of the waste heat is being reclaimed to provide space and water heating. In order to restrict the burning of hazardous pollutants, it will be necessary to separate garbage into paper products, ferrous materials, and organic wastes.

Organic Waste

A renewable resource that can be produced from organic wastes is called biogas. Biogas is a mixture of methane and other volatile hydrocarbons mixed with carbon dioxide which, in this case, is produced from municipal sewage. Other organic wastes such as agricultural residues, lumbering residues, and organic material from kitchen garbage disposals can be combined in an anaerobic digester. The specifics of the biogas digestion process vary according to the organic materials that are used, the amount of moisture contained in them, and the temperature in the digester.

The Northampton Sewage Treatment Plant currently operates two biogas digesters. These digesters can produce enough biogas to run themselves and to heat several new buildings planned for the facility.

The useful power from biogas produced at the sewage treatment plant is currently 2.3 MW. (This estimate is based on a total production of twelve million cubic feet of biogas per year.[18]) The potential for increasing the biogas supply exists since only a small portion of the incoming sewage is presently used by the two digesters. With an end use demand for biogas estimated at 2.8 MW, another 0.5 MW (end use) could be produced to meet the end use demand for cooking, laundry, and miscellaneous heating needs in Northampton.

One method of increasing the energy content of biogas is to feed organic wastes such as agricultural residues and perhaps some lumbering residues to the digesters. The amount of agricultural land residues and lumbering residues in Northampton is difficult to quantify since they are not utilized and distributed for biogas conversion at this time. Some 3300 acres of tilled land in Northampton (1500 acres of it being field corn) result in a substantial amount of diffuse crop residues.[19] Only small amounts of lumbering residues are useful because the lignin in wood tends to resist the fermentation process which may result in blocking the digestion of the organic wastes.[20] Therefore, lumbering residues might be better suited for burning in the proposed solid waste plant. After the digestion process has been completed there are often residues that are indigestible. These residues can be sold for use as agricultural fertilizer.

A possibility for increasing the biogas supply in Northampton is to utilize the biogas routinely produced by the solid waste burning plant mentioned earlier. Biogas can also be procured from the decomposition of residues in the city landfill. In addition to the sewage treatment plant, the solid waste burning plant and the landfill could be connected with the pipes that currently supply natural gas to many Northampton residences and buildings.[21] (More extensive natural gas piping could be added when the district heating pipes were installed.) The amount of biogas that could be generated from the proposed solid waste plant and the landfill is unknown. However, these two sources could definitely supplement the biogas supply from the sewage treatment plant.

Wood Energy

With a total of 12,000 forested acres in Northampton it seems essential that a portion of the forest land be carefully managed and harvested.[22] Unmanaged wood lots or areas that are clear cut only hurt the future of wood as an energy source, and can damage the ecology of the forested areas. With a population of 30,000 residing on a land area of 2000 acres, the population is highly concentrated in a small portion of Northampton. This implies that the burning of wood for space heat should probably be restricted in high density areas to limit air pollution. Therefore, wood-burning in large numbers of residences, businesses, or industries is not encouraged in this energy plan except for areas located outside of district heating systems.

Any wood not utilized for the purpose of heating individual buildings can be harvested for burning in the proposed refuse to energy plant. If 5,000 cords of wood were burned in the solid waste plant per year, the useful power available would equal 1.6 MW.[23] If the 1.6 MW is added to the 4.8 MW of power produced by the solid waste burning plant, a total of 6.4 MW could be provided by burning wood and solid wastes. More low temperature heat supplied through district heating by solid waste and wood burning would put less demand on the solar ponds, and reduce the total land area needed for the ponds.

Hydropower

The potential for small hydropower dams on the Mill River in Northampton is currently being examined by a local engineering and planning firm, Curran Associates, Inc. The firm has recently received a grant from the U. S. Department of Energy to study the feasibility of developing low head (under 65 feet) hydroelectric power at five existing dam sites.[24] Methods of generating electric power at the existing sites will be assessed in the study on the basis of the type and size of the units, the capital costs involved in their development, and an estimate of their power potential. The costs and benefits of the potential hydroelectric developments will be evaluated and their environmental impacts will be assessed.[25]

The five existing non-hydroelectric impoundments lie within a 6.5 mile stretch of the Mill River. The river falls 240 feet in this stretch and has an average flow of 94 cubic feet per second (cfs). The maximum flow of the river is 6300 cfs and the minimum flow is 2.2 cfs.[26] The total expected electrical generating capacity is approximated at 1 megawatt.[27] The generating capacity would peak during spring when the flow rate is generally highest. This seasonal increase in generating capacity is helpful because it would supplement electricity production at the solar ponds during a time when the ponds are apt to be operating least efficiently.[28]

The potential for municipal ownership of the hydroelectric stations is being examined as part of the feasibility study. Only one of the five dams is presently owned by the city. Owners of the three private dams have written to the Mayor stating that they are willing to donate the dams and small pieces of adjacent land to the city. The fifth dam is located at Paradise Pond on the Smith College campus. Representatives of the college have stated that they are "keenly interested" in working out an arrangement with the city should it prove reasonable to develop the dam. If the feasibility study is positive, Northampton could soon have a renewable resource operating to supply about 8% of its lighting and appliance needs.

Wind Energy

Wind is another renewable resource that can potentially be harnessed to provide electricity. Prior to implementing any sort of wind energy system, detailed data must be obtained on prevailing wind directions, average wind velocities, and the micro-climate and topographic characteristics of the proposed wind sites.

It was originally hoped that wind power would supply between 1-10 megawatts of electricity to Northampton. Further research revealed a number of reasons why a greater reliance on wind power is unfeasible for the city. Most importantly, the average wind velocities recorded in or close to Northampton have generally been below 11 miles per hour.[29] Such low velocities require that wind generators be excessively large when significant amounts of power are needed. For example, a 1.5 megawatt wind machine is enormous, requiring blade diameters of over 250 feet. The tower height for this type of machine is over 300 feet. If two or three 1.5 megawatt machines were built, they would have to be placed about .7 miles apart from one another. This requires the clearing of significant amounts of forested land and could be very expensive. In addition, there are aesthetic problems associated with placing such large towers close to a small city. Decisions concerning the use of small wind systems will most certainly be made on an individual basis. Although wind does not appear feasible as a major source of energy in Northampton's future, it is possible that small business or home-owned systems will be installed for back-up or for specific appliance and machinery needs.

Photovoltaics

The local production of an adequate amount of electricity is certainly the most difficult task faced by a system based entirely on renewable resources. The combined output of the solid waste facility, solar pond generators, wind generators, and hydropower units averages to 4.5 MW. However our scenario assumes an average demand of 12.6 MW for lighting, machinery, and appliances, and our transportation system may require as much as 6 MW extra capacity (see Transportation).

Therefore, depending on how generous one is in the transportation sector, and on how seriously the efforts at conservation are carried out in the other sectors, we find ourselves short anywhere from 9 to 14 MW of capacity. Photovoltaic generation seems to be the only option remaining within the constraints we have set ourselves.

The best way to use photovoltaics in our system would be in a cogeneration configuration coupled to the solar ponds. Water from the convection layer of a pond can be used to cool the photocells and then pumped back into the pond where the heat can be stored for later use. A substantial area devoted to photovoltaics would therefore reduce the area needed for ponds, thereby mitigating to some extent the high cost of the photocell arrays. If we assume that 60% of the energy incident on the photocells can be dumped into the ponds, then the heat storage rate will be 5 or 6 times the electricity generation rate (at 10% efficiency), and 12 MW of average electrical capacity could in fact provide essentially all of the low temperature heat demand. This would seem to eliminate the need to use ponds as collectors at all and relegate them to pure storage duty. This suggests that the photovoltaic arrays might occupy the same area as the ponds, possibly floating on top of the ponds on insulating platforms. If this eliminated the need for a salt-gradient layer the cost of the ponds would be even more substantially reduced. To explore all of these possibilities is beyond the scope of this paper, so we will simply adopt for our scenario an average generating capacity of 14 MW of photovoltaic cells (1.23×10^8 kwh/yr).

We must also provide for short term storage of electricity if the city is to be independent of the utility grid. A reasonably generous storage capability would be 200 Mwh, which could supply peak demand for at least 8 hours. The transportation system provides an excellent storage facility if batteries and/or flywheels are used. Again this helps to share the capital costs of the storage system between electricity generation and transportation.

Transportation

As noted in previous chapters, the current transportation system relies almost entirely on inefficient private vehicles.

If Northampton is to become truly self-sufficient in its energy supply, it is clear that drastic changes must be made in present transportation patterns. In this study, a preliminary proposal is made for an electric public transportation system and for conversion to the use of electric vehicles for commercial and personal use within the city limits. Problems associated with intercity transportation whether by automobile, train, bus or aircraft should be treated on a regional, state or national basis and are therefore not appropriate for a study of local self-sufficiency.

Since Northampton is a commercial center for the surrounding region, it is in the city's interest to provide a convenient means for people to get to the shopping areas. We estimate that 40 miles of electric bus route would provide convenient and accessible service to a majority of Northampton residents as well as to those living in surrounding towns. The proposed electric bus system could be powered by overhead or underground transmission lines or by batteries. If batteries were used, provision must be made for substantial charging facilities and the use of interchangeable battery packs so that buses are not immobilized for long periods to charge batteries.

At some point, it may prove feasible to use electrically produced hydrogen as a fuel, but until further research increases the efficiency of this process it is less promising than the other options.

The proposed system is illustrated in Figure 8-3. Buses run along the current Pioneer Valley Transit Authority (PVTA) route along U.S. Route 9 from Williamsburg to Amherst. We suggest that the current proposal for a King Street shuttle service (see Chapter 10) be adopted and that another shuttle connect downtown Easthampton with downtown Northampton. Finally, we propose a circle route running along Westhampton Road to Florence Road to Burts Pit Road and Ryan Road and back to Florence Road. This route provides service to the western parts of the city. The total length of this system is slightly less than 40 miles.

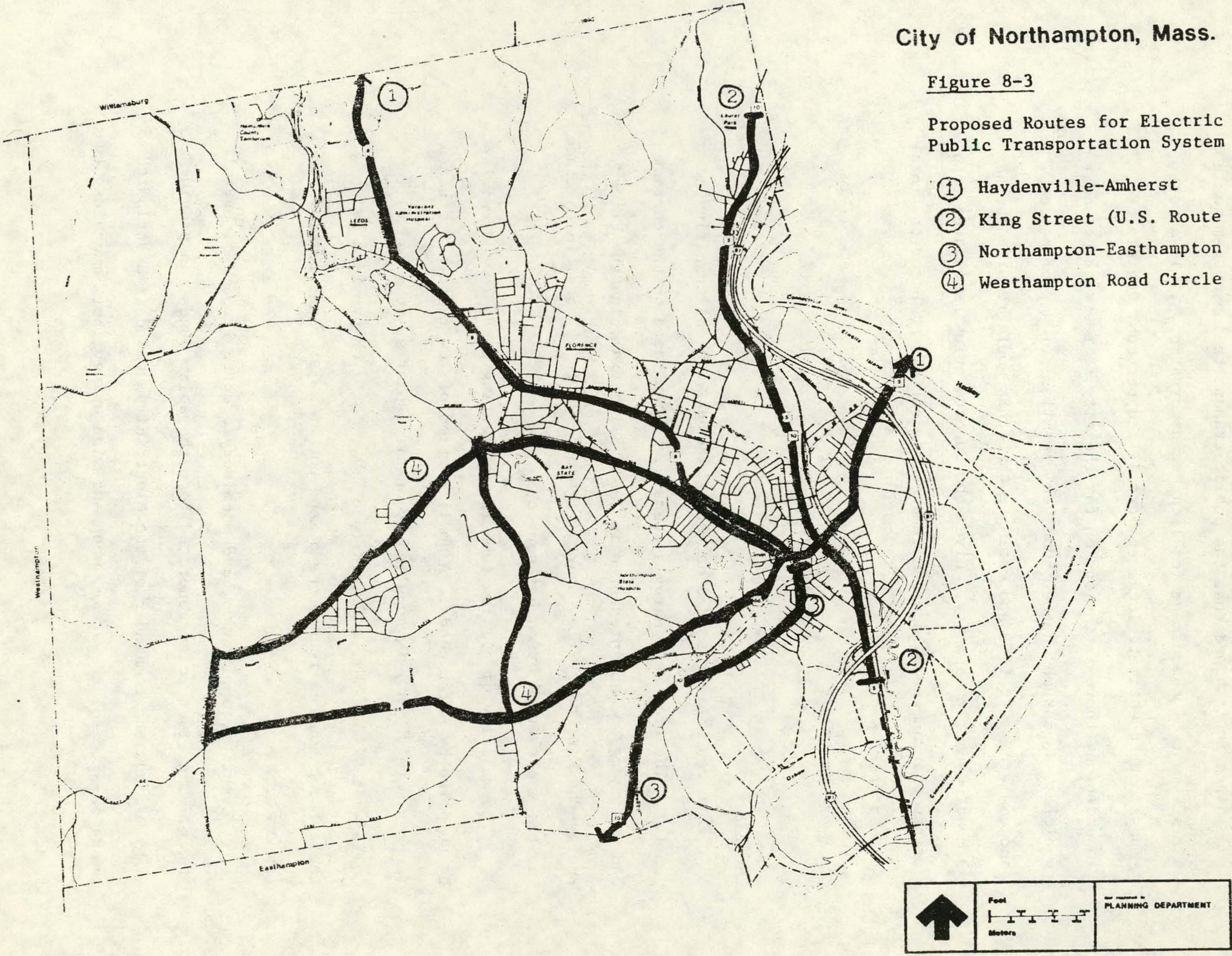
If buses ran every fifteen minutes, from 6 a.m. to 6 p.m. and every 30 minutes from 6 p.m. to 6 a.m., roughly 30 buses would be in service at peak use periods. Allowing time for maintenance and extra buses for emergencies and special events, a fleet of 50 buses should be adequate. It is estimated that the buses will travel 6000 vehicle miles per day, and that the primary energy demand is 4.1×10^4 BTU per vehicle-mile travelled. (This figure is comparable to the efficiency of currently used buses.)[30,31] This equals a total energy demand of 3 MW for the public transportation system. It is believed that this figure is conservative because electrically powered buses are at least as efficient as diesel buses, even if batteries are used as the power source. If a system were adopted which used transmission lines and buses equipped with flywheel storage systems, substantially greater efficiencies and consequently lower energy use would result.[32]

City of Northampton, Mass.

Figure 8-3

Proposed Routes for Electric Public Transportation System

1. Haydenville-Amherst
2. King Street (U.S. Route 5)
3. Northampton-Easthampton
4. Westhampton Road Circle Route



Since it is hoped that the public transportation system would satisfy most of the demand for local transportation, it is almost impossible to estimate local commercial and personal vehicle use. In addition, there is the option for the city to restrict personal vehicles. We assume another 6000 vehicle-miles per day of personal and commercial traffic and estimate that this would require another 3 MW of electric capacity. Given the uncertainties associated with transportation, we allocate a generous amount of MW for the total transportation demand.

Summary

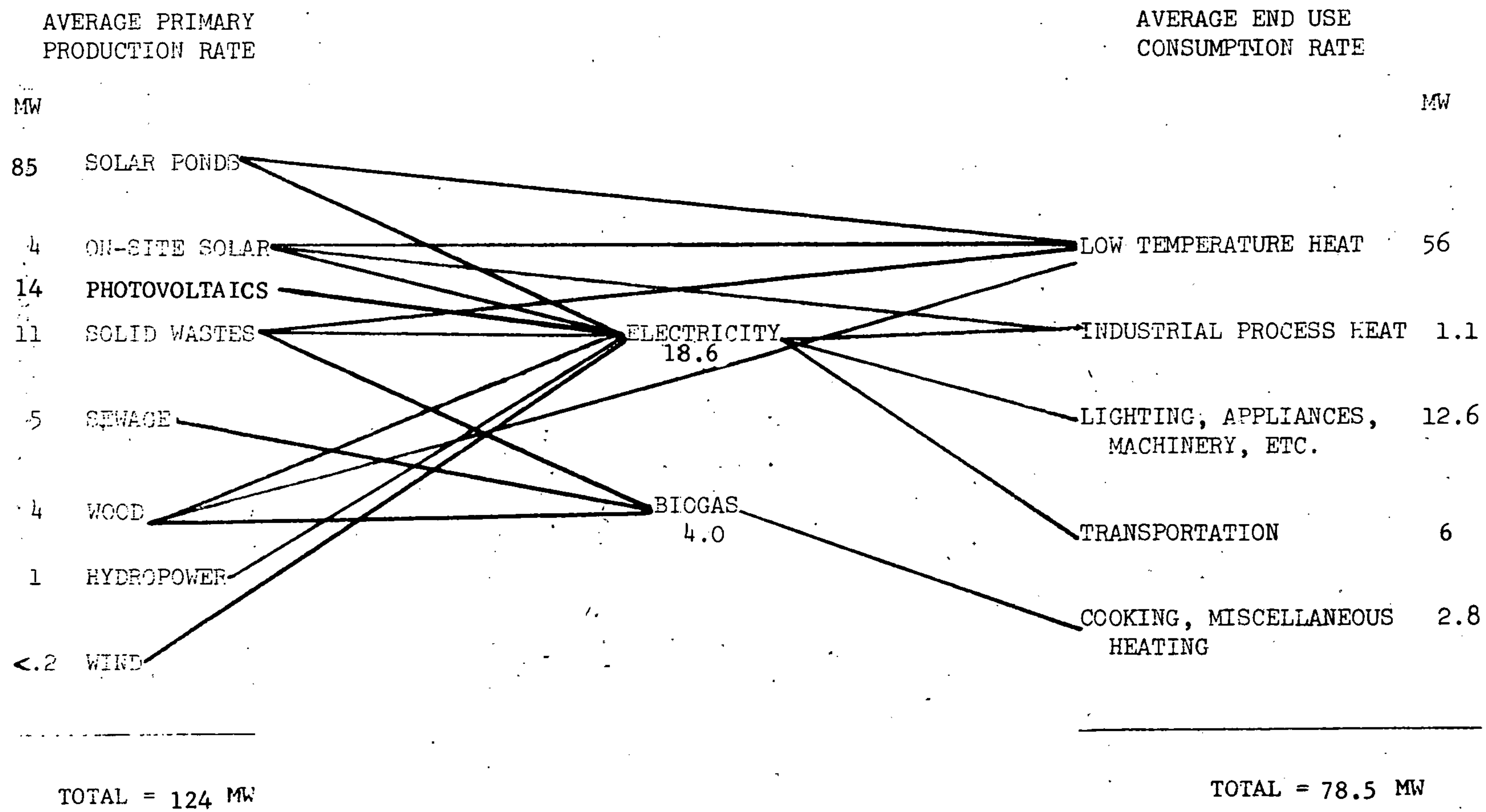
Each renewable resource has been matched with (a) specific end use (s). The proposed energy systems have been based on the current end use energy demand presented in Table 8-1. Examining the Primary Energy-End Use Energy Flow Chart (Figure 8-4), it is possible to trace the tasks performed by each resource.

The majority of all low temperature heating needs (56 MW) will be supplied by solar ponds. A small portion of low temperature heat (approximately 7 MW) is supplied by on-site solar systems (4 MW), solid wastes (2.4 MW), and wood (0.8 MW). The 7 MW provided by these three sources reduce the demand put on solar ponds for low temperature heat.

Lighting, appliances, and machinery require 12.6 MW of useful power. The electricity generated form the solar ponds can provide 1.15 MW, and the remainder of the electricity demand is distributed among on-site solar systems, wood and wind energy (both much less than

Figure 8-4

PRIMARY ENERGY-END USE ENERGY FLOW CHART



1 MW, the solid waste burning plant (2.4 MW), and hydropower (1 MW). The balance of the 12.6 MW and the energy needed for local transportation (6 MW) are supplied by photovoltaic arrays on or near the solar ponds.

The need for industrial process heat (1.1 MW) is met by on-site solar systems and electricity from a variety of sources. The cooking, laundry, and miscellaneous heating requirements for the city (2.8 MW) are provided by biogas production which can take place at the sewage treatment plant (2.3 MW), the solid waste burning plant, and the city landfill.

All of the systems proposed have potential for supplying the energy needs of Northampton. It must be emphasized that this energy plan has been developed as a set of options. Any such plan should be subjected to a more in depth analysis which is unfortunately beyond the scope of this study. We do, however, see these energy systems as very promising, and worthy of the further study needed to assess the costs, benefits, and the specific details of location.

Footnotes

1. Romer, Robert. Energy: An Introduction to Physics, San Francisco: W. H. Freeman and Company, 1976, p. 579.

2. Based on Theodore Taylor's estimates in "Solar Energy Cost Goals" from A Preliminary Assessment for Worldwide Use of Solar Energy, unpublished report, Princeton, NJ, February 10, 1977.
   Earlier experimentation by H. Tabor has shown solar ponds capable of reaching temperatures of 90°C. This appears in "Large Area Solar Collectors for Power Production ", Solar Energy, October 1963, pp. 189-194.

3. Karheck, J., Powell, J., and Beardsworth, E. "Prospects for District Heating in the United States ", Science, Volume 195, March 11, 1975.

4. Taylor, Theodore, "Solar Energy Cost Goals", February 10, 1977. The amount of land area required for solar ponds is presently under experimentation. Taylor estmiates a 10,000 m^2 pond will heat 100 homes , but it is clear that the amount of land area required for a pond depends on the specific design of the pond.

5. District heating pipes containing the heated water connect to each building in the designated neighborhood or district. In the basement of each building, a heat exchanger blows hot air through the building for space heating.

6. Such generators are already being produced commercially by Sun Power Systems in Florida which quotes prices of about $500 per installed kilowatt.

7. Rabl, A. and Nielsen C. "Solar Ponds for Space Heating ", Solar Energy, April 1975, pp. 1-12.

8. Ibid.

9. Ibid.

10. Taylor , "Solar Energy Cost Goals ", February 10, 1977.

11. According to Rabl and Nielsen an area of 140 m^2 of solar pond will supply the needs of a present day house with an efficiency of 25,000 BTU/DD in the Boston area. Boston accumulates about 5800 DD in a typical winter so the total energy which can be supplied in a year by 140 m^2 is 1.45×10^8 BTU. This implies that each square meter of solar pond can supply 1.04×10^6 BTU/year or about 35 watts/m^2. Our own calculations for Northampton ponds allow extraction at the rate of 31 watts/m^2 and a total area of 180 ha or 445 acres. A useful conversion factor is 7.94 acres/MW.

Footnotes (continued)

12. A model calculation shows that adding 20 ha (50 acres) to the ponds will allow the extraction of 1.15 MW average electrical power. This rises to a peak of 2.3 MW in January and falls to very near zero in July when heating demand is a minimum.

13. Interview with Mr. Duseau from Calduwood Enterprises, Northampton, Massachusetts, November 17, 1978.

14. We are concerned that this amount of garbage represents a significant waste of resources and energy, and we recognize that burning certain kinds of trash may not be as economically or environmentally sensible as recycling them. However, a detailed consideration of this option is beyond the scope of this study.

15. Interview with Charles Reed, Cooley Dickinson Hospital, Northampton, Massachusetts, November 1978.

16. Wheelabrator-Frye Inc., Energy Systems. Resource Recovery for Rockingham County and Surrounding Communities: A Feasibility Report and Proposal, Hampton, New Hampshire, April 1978.

17. Interview with Frederick MacInnes, Chief Engineer, Cooley Dickinson Hospital, Northampton, Massachusetts, June 1978.

18. Interview with James Distal, Northampton Sewage Treatment Plant, Northampton, Mass., November 1978.

19. Interview with John Howell, County Extension Service, Hampshire County, Massachusetts, July 1978.

20. Poole, Alan D. and Williams, Robert H. "Flower Power: Prospects for Photosynthetic Energy ", Bulletin of the Atomic Scientists, May 1976, p. 52.

21. The use of utility owned pipes will have to be addressed at some point in the future. It might be possible for the city of Northampton to purchase pipes from Bay State Gas Company.

22. Comprehensive Summary Plan: Northampton, Massachusetts, Boston: Metcalf and Eddy, Inc., 1970-72.

Footnotes (continued)

23. Calculation of useful power from wood burning:

$1/2$ cord of wood $= .4$ ton ---- 20×10^9 joules/ton

16×10^9 joules/cord $\times 5 \times 10^3$ cords

80×10^{12} joules/yr $\div 3 \times 10^7$ joules/sec

$2.6\ MW_{thermal} \times .6$ efficiency factor =

1.6 MW useful power

24. Interview with Robert G. Curran, President, Curran Associates, Inc., Northampton, Massachusetts, July 14, 1978.

25. Ibid.

26. Ibid.

27. This calculation was done to determine the amount of energy being lost per second when 90 cubic feet of water falls 240 feet:

$P = 90\ ft^3/sec \times 7.5\ gal/ft^3 \times 8\ lb/gal \times 240\ ft \times .5$

$= 6.5 \times 10^5 ft\text{-}lb/sec$

$= 1.2 \times 10^3$ hp = 880 kW $\doteq$ 1 MW useful power (an efficiency factor of .5 was included in the calculation)

28. Solar ponds are apt to be operating least efficiently during the winter because a great deal of energy is extracted from the ponds due to increased heating demands.

29. Interview with James Manwell, Mechanical Engineering, University of Massachusetts, Amherst, Massachusetts, November 1978.

30. Romer lists a figure of 1180 BTU/passenger-mile and a maximum load of 35 passengers for local buses. This gives an energy demand of 4.13×10^4 BTU/veh-mi. With 6000 vehicle miles per day we get a demand of 2.48×10^8 BTU/day or 3 MW.

4.13×10^4 BTU/veh-mi. $\times$ 6000 vehicle miles $= 2.48 \times 10^8$ BTU/day

= 3 MW primary energy

If we add another 3 MW for commercial and personal vehicle use we arrive at 6 MW. However we have rounded the transportation energy demand to 10 MW for the sake of simplicity not because we want to encourage an increase in local travel.

31. Romer, Energy: An Introduction to Physics, p. 609.

Footnotes (continued)

32. Flywheels can be used to store energy in the form of rotational kinetic energy and are especially useful in buses which are constantly accelerating and decelerating.

Chapter Nine

The Economics of Energy Self-Sufficiency

An important consideration in the decision of whether to develop an energy system is money. The types of power plants and energy systems which have been built in the United States during the last twenty or thirty years have required both a high level of financial planning and massive capital investments. Since the energy systems proposed in this study are small-scale, simple in design and conservative in their use of natural resources, it is not unreasonable to hope that they are also relatively low in cost. In addition, it is probable that the energy systems will be compatible with a variety of arrangements for ownership and control.

This chapter is an attempt to determine the costs of the alternative energy systems and to examine their economic feasibility. Developing the cost estimates has not involved a detailed financial analysis but rather a general order of magnitude estimate based on information presently available for each system. Conservative assumptions have been used throughout the analysis in order to evaluate the viability of the systems from the least favorable perspective. It is clear that before any of the systems are actually built, extensive and detailed cost analyses will have to be undertaken.

Capital Costs

The overall cost involved in developing an energy system is a function of both the initial construction costs and the annual operating and maintenance costs. In the following discussion, these costs are first determined separately for each system proposed for Northampton, and then combined for an overall cost-benefit analysis. In the breakdown of costs for individual systems, 1978 dollars are used. The effect of inflation on the costs is accounted for in the cost-benefit analysis.

Solar Ponds

Solar ponds are clearly the most capital intensive of all the systems proposed for Northampton. We have suggested a total use of 495 acres of pond area. There is a wide variance in the cost estimates developed by those doing research on the feasibility of solar ponds, depending on whether or not a salt gradient insulating layer is used in the ponds.[1] It was estimated in 1974 that construction costs for a solar pond which uses a salt gradient and serves 20 homes would be about $22.50 per square meter of pond area. This included the costs of earthmoving, wall-facing, labor, sand, partitions, liners,salt, on-site piping, and control equipment.[2] Our own estimates of the costs are considerably higher, approaching $50 per square meter for the ponds we have described. Thus the total construction costs for the 495 acres of ponds equals about $100 million.

Hot water produced by the solar ponds will be distributed to individual residents and buildings through a district piping system. Our estimate of the cost of the piping network is based on data developed by a research group at Brookhaven National Laboratory.[4] The group has estimated the potential costs of installing district heating systems in nine urban regions in the United States. Model systems were constructed for each region, resulting in an average cost for heat supplied to each unit served by the system. Based on figures developed in the Brookhaven study, we estimate the cost for each building served by the Northampton district heating system to be about $2000. This estimate is slightly lower than those suggested for the cities examined by the Brookhaven group because, as suggested by the study, it is expected that piping costs would be significantly lower for cities with populations between 25,000 and 100,000.[5] In addition, the fact that all of Northampton's 30,000 residents live on 2000 acres of developed residential land implies a density of 9600 people per square mile, which is well within the range of population densities considered by the Brookhaven group to be optimal for district heating.[6] If approximately 10,000 buildings in Northampton are linked to the system, the total cost of installing district piping should be about $20 million.

Rankine cycle engines will be used to generate electricity from hot water produced in the solar ponds. With installed capacity for the generators expected to be about 2.3MW and a cost estimate provided by a firm selling the engines of about $670 per kilowatt, a total of approximately $1.7million will be necessary.[7] Although it is hoped that the existing power grid will be used as much as possible, it is anticipated that an investment of about $5 million will be needed for additional power lines and transformers.[8]

The annual operating costs of solar ponds include wages paid for those hired to operate the ponds as well as the actual costs of routine cleaning and maintenance. According to Rabl and Nielson, cleaning and maintenance does not cost more per building served by a pond than does a conventional furnace.[9] If a cost of $50 per year for each building is assumed, then $500,000 is an approximate estimate for annual maintenance costs. Another $100,000 per year is assumed for maintenance of the turbines, although they are virtually maintenance free, and $200,000 per year is allowed for maintenance of the district piping network. Although other research groups have not mentioned how many people would be hired to oversee the daily operation of solar ponds, we propose that two people be hired for each pond. Estimating an average area of ten acres per pond, there would be a total of about sixty ponds. With a payroll of approximately $25,000 per pond, this equals a combined wage bill of about $1.5 million per year.

On-site Solar

It is proposed that on-site solar systems be used for industrial process heat as well as for homes and buildings that are not located in an area served by a district heating system. The total demand for such energy is estimated to be about 4 MW. While the decision of what types of systems to use will be based on cost analyses undertaken by the individual or firm needing the extra installation, the average cost per installed kilowatt is estimated at $1500.[10] This equals a total investment of about $6.0 million. Operation and maintenance costs are assumed to be quite small, at about $600,000 a year.

Solid Waste

Specific cost estimates for the solid-waste burning plant proposed for Northampton were available from an employee of Cooley Dickinson Hospital who is organizing the feasibility study. The capital investment needed for a plant capable of burning from 150 to 200 tons of waste per day is expected to be $4.7 million.[11] This figure includes all construction costs, including labor, building materials and equipment, land, transmission equipment and engineering fees. The anticipated total annual operating cost is $560,000, of which about $200,000 is wages.[12] A significant portion of the payroll includes the cost of collecting the waste in Northampton. Although this is included in our wage estimates, it is not really an additional cost because it is presently being done anyway.

Organic Waste

Two methane digesters are currently in operation at the Northampton Sewage Treatment Plant, producing an amount of biogas equivalent to 2.3 MW. It is proposed in this study that total capacity be increased to approximately 3 MW. We assume that between the purchase of another digester and additional hook-ups to the existing gas distribution system, a total investment of about $2 million will be necessary.[13] According to the 1975 Northampton Annual Report, the treatment plant is presently maintained and operated by a chief operator and three assistants, requiring a payroll of about $50,000.[14] Annual maintenance costs for the plant are about $25,000.[15] Allowing for small increases due to expansion, we expect an annual payroll of about $60,000 per year and yearly maintenance costs of about $40,000. Although these figures are included in our cost estimates, they are not entirely additional costs because the facility already exists and is in operation.

Hydropower

Cost estimates for the five hydropower sites located on the Mill River in Northampton were available from an engineer at Curran Associates Inc. The capital costs involved in retrofitting each of the existing non-hydroelectric impoundments is estimated to be about $7-800,000, and could be considerably more for one of the sites.[16] Therefore, the total construction costs for all five dams is approximately $5 million. We estimate annual maintenance and operating costs to be quite small, perhaps $200,000. It is expected that electricity produced by the dams will be fed into the existing network of power lines.

Photovoltaics

Any cost estimate of a photovoltaic system of the size and type we are considering is bound to be highly speculative. Not only must we wait for the development and mass production of photocells which are substantially cheaper than the present ones, but we should also consider in a much more detailed way than is possible in this broad survey the complex interactions between the photovoltaic arrays and the solar ponds.

In the absence of any firm cost projections we will follow the example of the American Physical Society Study Group[15a] and assume that photovoltaic capital costs can be brought down to 86¢ per peak watt. If we adjust the Study Group's average output value to reflect the shift from the Southwest to New England we find that each peak watt of capacity should produce about 1.5 kwh per year of electricity, so in order to produce 1.23×10^8 kwh/yr we will need 82 MW of peak capacity. At 86¢/W_p this gives a capital investment of $70 million. Operation and maintenance costs of 0.4¢/kwh give a total of just under $0.5 million per year.

There would be added costs involved in using the photovoltaic arrays in a cogeneration mode, but these would be more than compensated for by substantial reductions in the capital costs of the solar ponds. In order to keep our estimates conservative we will assume that these two costs simply cancel out.

For the capital costs of storage we use an estimate of $55 per kwh[15b] for our total storage capability of 200 Mwh. This comes to $11 million, and if battery operated public and/or private transport is used, some of this can be charged off against the transportation sector. Again in the interest of simplicity we will ignore this connection. Operation and maintenance costs will be assumed negligible.

Transportation

The public transportation system described in Chapter Eight consists of about forty miles of bus route (eighty miles round trip). With buses running at fifteen-minute intervals during the day and thirty-minute intervals at night, we estimate that a fleet of about fifty buses will be needed. At a cost of about $100,000 per bus, this represents a total cost of about $5 million.[17] Obviously, roads for the buses already exist, but it will be necessary to construct electric lines and transformers to power the buses. Assuming that the costs of constructing overhead lines is similar to that of regular electricity lines, it is expected that costs will be about $50,000 per mile for the lines and necessary transformers.[18] (If underground lines are used, it will probably be somewhat more expensive.) For forty miles of bus route, construction costs should total about $2 million.

Using battery-powered buses will require a capital investment in batteries and charging facilities. We have not examined the question of whether this would be more or less economical than erecting overhead or underground transmission lines. However, it is important to note that using batteries eliminates the need for aesthetically unpleasant overhead wires.

The payroll costs for the public transportation system will be significant because drivers will be needed for the fifty buses. A staff of repair and maintenance people will also be needed although electric engines require considerably less maintenance than internal combustion engines. We expect annual payroll costs to be about $1 million and yearly repair costs to be about $200,000.

Conservation

Conservation is expected to be one of the biggest sources of energy for Northampton. Although many significant conservation measures require little or no capital investment, it is essential that ample money be allocated to finance those measures which do require money. We assume an average investment of $2,000 per building, or a total of about $20 million for the city.[19] While $1000 or less is probably more than sufficient for most residences, especially multi-unit complexes, many commercial and industrial establishments may require an investment of at least $2000. Conservation efforts will not generally require follow-up maintenance other than that usually needed in residences and other buildings. Although a specific wage bill for conservation efforts pursued in the city has not been estimated, it is hoped that a substantial number of local jobs will be created as the city undertakes a concerted conservation program.

Wood and Wind

The use of wood resources and wind power for energy production in Northampton have been suggested as supplementary sources for the city. While we encourage their use and development wherever possible, it is anticipated that these resources will be used on an individual basis, providing back-up for the other systems. Decisions of how to utilize these sources will be made individually, and are not considered as additional construction or operating costs for the plan as a whole.

Summary of Capital Costs

The construction and operating costs estimated for each of the energy systems proposed for Northampton are collected and presented in Tables 9-1 and 9-2. The total construction cost for the alternative energy plan is estimated to be about $141 million, and annual operating costs are approximated at $5 million. It is important to emphasize the approximate nature of these numbers. They have been developed to facilitate a general economic analysis of the systems and represent a very rough estimate of costs. The systems have been examined as a complete package rather than as a series of projects which might develop over a number of years.

An advantage of using renewable energy systems that are based in the city is the potential for using local labor and materials for their construction and operation. While construction of the new systems and conservation measures should create a significant number of jobs in Northampton, it is recognized that they will be relatively short-term. The number of long-term jobs provided by the systems can be estimated to be 286 if the annual payroll expected for the energy plan is divided by the Northampton median income. This is about 100 more jobs than is currently provided by energy sales in Northampton. (See Chapter Four) This number is not large and it must be pointed out that, in general, the production and supply of energy does not involve

TABLE 9-1: Construction Costs of Proposed Energy Systems, Northampton, Massachusetts-1978 Dollars

	$\$ \times 10^6$
Solar ponds	
construction	100
district piping	20
generators	1.7
distribution of electricity	5.0
On-Site solar	
materials and installation	6.0
Solid waste	
construction	4.7
Organic waste	
digester and additional hookups	2.0
Hydropower	
construction/retrofit	5.0
Photovoltaic arrays	70
Storage	11
Transportation	
buses	5.0
lines and transformers	2.0
Conservation	
construction/retrofit	20
TOTAL	$253M

very labor-intensive activities.

The real benefits of the proposed systems to employment result from the smaller amounts of capital investment which are required to produce a given amount of energy. (See following section of this chapter.) This frees up money for investment in other projects which may have greater effects on employment patterns. In addition, money that would have once left the area to pay for energy may now circulate through the local economy, providing added financial resources for local enterprises.

TABLE 9-2: Annual Operating Costs of Proposed Energy Systems, Northampton, Massachusetts 1978 Dollars

		$ \$ \times 10^6 $
Solar ponds		
payroll		1.5
maintenance,	ponds	.5
	district piping	.2
	generators	.1
On-Site solar		
maintenance		.6
Solid waste		
payroll		.2
maintenance		.36
Organic waste		
payroll		.06
maintenance		.04
Hydropower		
maintenance		.2
Photovoltaics		.5
Transportation		
payroll		1.0
maintenance		.2
TOTAL		$5.5M

Benefits and Costs

The purpose of estimating the capital costs of the alternative energy systems proposed for Northampton is to facilitate discussion of whether it would be advantageous for Northampton to develop and use the systems. The economic advatages and disadvantages of the systems have been evaluated in a simplified version of a cost-benefit analysis.[20] This analysis has been done in strictly economic terms and does not address or evaluate the numerous social and political implications of the energy future described for the city. Such issues are crucial to the ultimate decision of whether or not to undertake the proposed changes, and have been addressed in other parts of our study.

The purpose of doing a cost-benefit analysis is to determine if the revenues collected over and above the operating costs of the systems are at least equal to the expense of building the systems.[21] It has been assumed in the analysis that consumers of energy will be willing to pay as much for energy supplied by the new systems as they would have to spend without the systems. The revenues generated by the new systems can therefore be assumed to equal the amount of money that is currently spent on energy in Northampton. However, in recent years the prices of conventional forms of energy have increased at a rate greater than the 'normal' inflation of other goods and commodities. Since Northampton consumers would have to pay the increased prices in the absence of an alternative system, the revenues used in the cost-benefit calculations are increased by factors which take into account both inflation and differential increases in energy prices.

The anticipated annual operating and maintenance costs of the alternative energy systems are subtracted from the annual revenues that will be generated by the systems to obtain the annual net revenues. These revenues are then "discounted" at a rate determined by the interest rate that would be paid on money borrowed to finance the systems. The discount rate reflects the rate at which capital could be earning income if it were invested in something other than the proposed energy systems. The discounted net revenues are summed over the lifetime of the systems to reach what is described as the net present benefit of the systems. The total construction cost of the systems is compared with the net present benefit to determine whether the proposed energy plan is economically viable.

The process of determining values for each of the factors accounted for in our calculations involves using figures already determined in this study as well as estimating future inflation rates, differential price increases, and interest rates. A series of calculations has been done in order to determine the amount of revenue which would be available under a variety of economic conditions to pay off the costs of the proposed energy systems. It was determined in Chapter Three that about $25.9 million is presently spent on energy in Northampton. An average lifetime of 25 years is assumed for the entire energy plan, although it is likely that many of the individual systems which make up the plan could last considerably longer.

Since it is very difficult to accurately determine what rates of inflation might be experienced during the lifetime of the systems, three different rates were used to accommodate a variety of future projections. The lowest estimate of 4% is a conservative figure which has not actually been experienced in this country for at least ten years. The 6.5% figure is based on projections developed in the Wharton Econometric Forecasting Model for the next ten years.[22] The high estimate of 8% inflation is considerably less than the 11% rate that the United States is presently experiencing. It is quite possible that future inflation will exceed the estimates used in our analysis.

Several differential rates were used to reflect possible increases in the price of conventional energy. The lowest estimate of no differential increase is an extremely conservative figure which is not generally expected to occur in the future. The highest estimate of 5% is one half of a percent lower than a projection developed by the United States Office of Technology Assessment in 1976.[23] The 2.5% rate is the midpoint of the two other figures.

The choice of what interest rate, or discount rate, to use in cost-benefit analysis depends to a great extent on the conditions of ownership and financing that are being examined. Two discount rates were used in this analysis in order to determine how the range of benefits varies with the financial procedures that are used for the systems.* The high rate of 11.5% represents the prime rate of interest currently charged by banks for loans used for private purposes. The lower rate of 6% interest represents the cost of financing if public mechanisms, such as municipal bonds or loans, are used.[24]

The annual operating costs used in the calculations vary slightly depending on whether private or public ownership is being considered. This is because it is necessary to take into account changes in the city's tax base which might occur due to the development of the proposed energy systems. It is assumed for the purposes of the cost-benefit calculations that the amount of local taxes which could be levied on the alternative systems equals that which is presently paid on the con-

*The variety of financial arrangements which could be made for the energy systems is discussed more fully in Chapter Ten.

ventional supply of energy. It was determined in Chapter Four that about $500,000 is presently paid in local taxes by energy companies serving Northampton.

If the alternative energy systems are privately owned and financed, it is reasonable to assume that local taxes will be paid to the city just as they presently are. Therefore, no change will occur in the city's tax base and the annual operating cost of $5 million determined earlier in this chapter can be used in the cost-benefit calculations. If the systems are publicly owned and financed, though, it is possible that local taxes will not be paid to the city. This would represent an annual loss, or cost, to the city of about $500,000. The annual operating cost used in the calculations for public financing includes the $5 million figure as well as the $500,000 which would be lost in local taxes.

The results of the cost-benefit calculations are displayed in Tables 9-3 and 9-4. The numbers listed in the tables represent the amounts of revenue which would be generated by the energy systems described above. If a number listed in the tables is at least equal to the estimated $141 million that it will cost to build the systems, then it makes economic sense to develop the systems. It is shown in Table 9-3 that even under the least favorable conditions of a high rate of interest, no differential increase in the price of conventional fuel types, and only a 4% inflation rate, the revenues collected over the lifetime of the energy systems would justify spending up to $239 million on their construction. This is almost $100 million more than

TABLE 9-3: The Net Present Benefits of the Alternative Energy Systems if Private Financing is Used at a 11.5% Interest Rate, Northampton, Massachusetts - Millions of 1978 $[a]

Inflation Rate \ Differential Rate	0%	2.5%	5.0%
4.0%	233	314	426
6.5%	297	409	568
8.0%	346	484	681

[a]A 25-year lifetime of the systems is assumed, and an annual operating cost of $5.5 million is used.

the estimated construction costs of the systems. Under the most favorable conditions considered in the analysis of 8% inflation, 5% differential increase in energy prices, and a 6% interest rate, it makes sense to invest up to $1.47 billion, or over 6 times the estimated cost of the systems (see Table 9-4).[25]

TABLE 9-4: The Net Present Benefits of the Alternative Energy Systems if Public Financing is Used at a 6% Interest Rate, Northampton, Massachusetts - Millions of 1978 $[a]

Inflation Rate \ Differential Rate	0%	2.5%	5.0%
4.0%	392	571	831
6.5%	529	790	1175
8.0%	640	969	1457

[a]A 25-year lifetime of the systems is assumed, and an annual operating cost of $6.0 million is used.

Conclusion

From a strictly economic perspective, the alternative energy systems proposed for Northampton seem very favorable. Even using the most conservative assumptions, it would cost only slightly more with the alternative systems than it would otherwise. This could result in lower prices per unit of energy, bringing obvious benefits to consumers. In addition, local labor and materials could be used in the construction and operation of the systems and in a conservation program, thereby supporting the local economy.

While it is clear that the amount and circulation of energy expenditures would be very different in an alternative energy future than it is now, it is difficult to actually calculate or quantify the difference. The level at which prices could be set, for example, would vary depending on who owns and finances the energy systems. It has been demonstrated that the overall cost of the energy plan would be less if public mechanisms are used for financing because lower interest rates could be obtained for the projects. In addition, prices which are charged by a private utility include a profit margin. Under a municipal or publicly-owned system, this margin could be eliminated, resulting in lower energy prices.

The overall flow of spending of the revenues collected for energy in this plan also depends on the balance of public and private ownership and financing. It is clear, however, that much of the money which has previously left Northampton to pay for energy imported into the city would remain in the local economy, providing additional resources for local enterprises and strengthening the overall base of the city's economy. Furthermore, this money would have subsequent impacts within Northampton as it circulated through the local economy.

Footnotes

1. See Taylor, Theodore. "Solar Energy Cost Goal", A Preliminary Assessment for World Wide Use of Solar Energy. Unpublished Report, Princeton, New Jersey, February 10, 1977, p. 10, and Rabl, A. and Nielsen, C. "Solar Ponds for Space Heating", Solar Energy, April 1975, pp. 1-12.

2. Rabl and Nielsen, p. 10.

3. A. Krass and R. LaViale, Solar Ponds as Community Energy Systems, in preparation.

4. Karheck, J., Powell, J., and Beardsworth, E. "Prospects for District Heating in the United States", Scien , Volume 195, March 11, 1975, p. 951.

5. Ibid.

6. Ibid.

7. Personal communication, Sun Power Systems, Incorporated, Box 380006, Miami, Florida, 33138, March 1978.

8. The use of existing power lines for power that is not produced by the private utility that owns the lines is clearly a problem that will have to be addressed at some time in the future. It is possible that the city government might be able to negotiate with the utility company.

9. Rabl and Nielsen, p. 10.

10. Willey, W. R. Z. Alternative Energy Systems for Pacific Gas and Electric Company: An Economic Analysis. Testimony before the California Public Utilities Commission 1978, used a price of $1270/kW for on-site solar. We are looking at higher temperatures than he did, but we can also supply it to the collector at 100°C

11. Interview with Charles Reed, Cooley Dickinson Hospital, Northampton, Massachusetts, December 13, 1978.

12. Ibid.

13. As with electricity transmission lines, the use of the existing gas distribution system will have to be negotiated with the gas company.

Footnotes (continued)

14. City of Northampton: Annual Report of Officers - 1975, Northampton, Massachusetts: Gazette Printing Company, p. 375.

15. Ibid.

15a. H. Ehrenreich, Chairman, Principal Conclusions of the American Physical Society Study Group on Solar Photovoltaic Energy Conversion. American Physical Society, New York, Jan. 1979, pp 37-40.

15b. Application of Solar Technology to Today's Energy Needs, U.S. Congress Office of Technology Assessment, Vol I, June 1978, p471.

16. Interview with Jeff Folz, Engineer, Curran Associates, Inc., Northampton, Massachusetts, December 14, 1978.

17. "Handicapped Want UMass Bus ", Valley Advocate, Amherst, Massachusetts, Volume VI, Number 15, November 29, 1978, p. 6A.

18. Interview with Ed Wingfield, District Manager, Massachusetts Electric Company, Northampton, Massachusetts, December 12, 1978. According to Mr. Wingfield, it is difficult to estimate the costs per mile of transmission lines but, at the bottom, it is $35-40,000 per mile.

19. Willey, W. R. Z., Alternative Energy Systems, p. 6, uses a figure of $397 per kilowatt saved. He did not examine industrial or agricultural conservation. Our figure works out to $626 per kilowatt, which seems reasonable since industry and agriculture are included in the estimate.

20. Benefit-cost analysis is traditionally used to evaluate the benefits and costs of a project, weighing them against an appropriate set of societal values and objectives. It is important to stress that significant weaknesses have developed in such analyses. The creation of numerically identified conclusions such as the benefit-cost ratio have encouraged the oversimplification and misuse of the results of such analysis, and have often distracted from much needed discussion concerning the social and political implications of proposed projects.

Footnotes (continued)

21. The equation used in our calculations is:

$$C = R \sum_{n=1}^{N} \frac{(1+k)^n}{(1+r)^n} - O \sum_{n=1}^{N} \frac{(1+j)^n}{(1+r)^n}$$

where C is the amount of capital that can be invested in the systems and still break even, R is the revenue presently spent on energy, k is the total rate at which R will increase based on j, the "normal" rate of inflation and 1, the differential increase in the cost of conventional forms of energy over and above inflation, N is the assumed lifetime of the systems, O is the cost of operating and maintaining the systems, and r is the discount rate on capital.

22. Wharton Annual Model Pre-Meeting Solutions, Philadelphia: Wharton Econometric Forecasting Associates, Inc., September 1978.

23. Office of Technology Assessment. Application of Solar Technology to Today's Energy Needs, Washington, D.C.: Office of Technology Assessment, June 1978, p. 34.

24. Interview with Walter Murphy, City Auditor, Northampton, Massachusetts, December 13, 1978. According to Mr. Murphy, the city currently receives about 6% on its municipal bonds and pays from 3.2% - 5.4% interest on its bank loans. The larger interest rate is the most recent one.

25. It is important to note again that the most favorable conditions allowed in this analysis could be considered by many people to be quite conservative.

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Chapter Ten

Community Ownership and Financing

A significant feature of small-scale alternative energy systems is their compatibility with a variety of arrangements for ownership and control. Since small systems require significantly less capital than those which are larger and technically complex, they are much more appropriate for small group or community ownership. The motivations behind community or group ownership and the financing methods used vary depending on what is deemed desirable and feasible by residents, businesspeople and government officials involved in a proposed development.

There is a long-standing myth in this country that only private enterprise motivated by the profit incentive can operate substantial ventures efficiently and effectively. Yet many public and non-profit groups already own and operate a variety of enterprises, including numerous electric and other utility systems, offering services comparable with and rates lower than those of larger private corporations.[1] For example, there are presently more than 2000 publicly-owned electric utilities operating in the United States.[2] These systems include municipal utilities which are owned and operated by the government of the city or town where the electricity is sold, as well as numerous state or county operated facilities.[3] In addition, there are more than nine hundred electricity cooperatives presently servicing large regions of rural America. These enterprises function separately from local government and are owned by their customers.

Public and cooperatively-owned utilities have shown an average of 30% lower costs for energy than private utilities.[4] Since such systems are motivated not by profit but by a desire to break even and to provide a certain service, they do not have the incentives that private utilities have to set rates at levels other than those consistent with costs and local energy policies.[5] They can consequently spend less, or nothing, on advertising, public persuasion (except for conservation), lobbying, and political donations.

In addition, public and cooperative systems can encourage local control and participatory politics. The management of a small, community owned system is directly responsible to area residents rather than to a parent company or absentee owner. Basic decisions concerning the type and location of energy systems, rate of expansion, placement of transmission lines, and establishment of prices can be made in public meetings or by people elected by the community.

It is possible to envision a wide variety of arrangements which could be made regarding the ownership of alternative energy systems in Northampton. While the specific choices will have to be made by city residents, businesspeople, and local government officials, it is possible to suggest precedents which could be set by various groups within the city.

The city government is one obvious resource which could be utilized in the development of alternative energy. While it is unlikely that the city government will be interested in, or willing to become directly involved in the overseeing of <u>all</u> the systems proposed for Northampton, several systems are particularly conducive to municipal ownership. Sewage treatment and solid waste disposal are services presently operated and financed by the city government. Both the ownership and the financing of future changes or developments in these ventures might best continue under the scope of municipal government. The creation of a public transportation system might also be facilitated most effectively by various public agencies in the city.

Neighborhood-based solar ponds and district heating systems seem particularly applicable to community group ownership. Such systems might be owned by a non-profit community development corporation organized by those served by the system.[6] Ownership could be organized cooperatively with members controlling the corporation themselves by purchasing one share per housing unit or building served. If desired, such groups could become involved in a variety of social, political and cultural activities in the community as well.

Under a neighborhood-based approach to energy systems, attention would have to be paid to the fact that neighborhoods are often defined by specific socioeconomic characteristics. Neighborhoods can vary widely in the amount of economic and political clout they carry in the city as a whole. It would be grossly unjust if the "richer" areas of the city were able to build better energy systems than other areas of the city. It might be necessary to develop a method that assures that financial and other resources are distributed fairly among the different neighborhoods in Northampton.

Community Financing

An alliance between city government and community groups can work to effectively combine the institutionalized power of cities and government agencies with the financial and political intent of community groups. In Northampton, the institutional, real estate, industrial and commercial assets of the city as a whole are resources which might be utilized through the encouragement of, or exercise of powers by the city government. Regulatory or legal mechanisms such as the licensing power of the city and the ability to raise capital through various financial practices can also be used. Although the Northampton city government does not have assets in the form of corporate investments, there is a significant amount of municipally-owned real estate that might be used for some of the energy systems. The city might also consider applying for state and federal grants to help finance the development of the initial energy systems, until their feasibility has been demonstrated to sometimes skeptical private investors. The following is a discussion of various mechanisms which have traditionally been used either in Northampton or in other cities to finance municipal and community group endeavors.

Tax-exempt Bonds

Under present federal laws, bonds issued for various public purposes by city governments, quasi-public agencies and non-profit corporations are tax-exempt. That is, the holder of a bond does not have to pay federal, or sometimes state income taxes on interest received from the bond. The bond market functions as a mutually beneficial relationship between cities and wealthy investors because tax-exempt bonds sell at lower interest rates than taxable bonds with an equivalent risk. However, the recent tightness of capital markets has meant municipal bonds are not receiving as favorable a rate of return as was once associated with them. Northampton currently sells bonds at about 6% interest.[7]

There are two principal types of municipal bonds. General obligation bonds are securely backed by property tax money. These bonds usually require approval by municipal vote since they often involve changes in the tax rates of a city. Revenue bonds are backed by the revenues of the specific project being funded and do not involve changes in property tax procedures. Revenue bonds have traditionally been used to support industrial parks, toll bridges and highways, civic centers and other endeavors in which there is a secure flow of revenue. Such bonds can be used creatively by a city, enabling the municipality to participate or invest in a variety of different enterprises. It is not clear, however, to what extent a relatively radical departure in the use of such bonds would be acceptable to the city of Northampton, the banks and potential investors. There are also many federal tax regulations which must be met when tax-exempt bonds are used, especially in ventures not directly owned by a government entity or not traditionally operated for a public purpose.

A lease back arrangement is usually regarded as a form of revenue bond, but it is guaranteed by city taxes. The city or a public agency writes a contract to make long-term payments on a facility or project. The lease payment is guaranteed by the general revenues of the city, which are essentially tax dollars. Lease back arrangements are often considered to be more secure than revenue bonds, and are usually used for facilities that do not produce revenues, such as new schools or other municipal buildings. It is possible that such arrangements could be devised for an alternative energy system, but it does not seem likely.

An assessment district bond is a form of a local property tax which has conventionally been used for the construction of streets, sewer drainage systems and water systems. The property owners who benefit directly from the improvement are assessed a special tax rate that will pay for the construction. These bonds can usually be issued without a vote unless there is a fifty per cent opposition from property owners.[8]

Tax-exempt Loans

Interest paid on loans taken out by local governments is exempt from income taxes. Instead of issuing bonds on the open market, cities can negotiate these loans with banks. Since many of the technical and time-consuming aspects of bond issuance can be avoided, tax-exempt loans usually have lower interest rates than municipal bonds. If a city borrows money from a bank using its tax-exempt status, it can then lend money to non-profit corporations within the city, essentially passing on the lower interest rate.[9] Northampton presently pays interest ranging from 3.2% to 5.4% on its $12.3 million debt.[10] The higher rate is, of course, the most recent one. It is possible that the Northampton city government could assist community or neighborhood groups in the financing of specific systems by using its tax-exempt status for bank loans.

State and Municipal Guarantees

Much of the high cost of capital involved in private financing is related to individual risk. States and municipalities can effectively distribute this risk by guaranteeing payment of bonds or other debt-financing issued by a quasi-public authority or non-profit corporation. This power can be used to help a community-based group to obtain favorable financing terms by reducing the risk outside investors are asked to assume. This method is often used to enable community ownership of shopping centers, office buildings and industrial parks. The industrial park being developed by the Northampton Redevelopment Authority was guaranteed by both the state and the city under such an arrangement. It is possible that non-profit corporations set up by residents and businesspeople to develop alternative energy systems in Northampton could be guaranteed by the city or by the state.

Local Financial Institutions

Commercial banks and savings and loan associations are often considered as resources for local investment aside from their involvement in tax-exempt bond and loan arrangements. However, banks often invest local savings and profits in ventures that are located outside of the city where the bank is based. It is possible that a municipality could appeal to banks, either on a policy or a financial level, to increase their investments in the local community. This might be particularly true in a city like Northampton where the banks are all locally-based and seem to have a fairly high awareness of their responsibility to the community.[11]

Private Institutions

In any city, as in Northampton, there are apt to be a number of private institutions with significant financial resources which are not being used in any direct ways to benefit the municipality. Churches, private schools, colleges and hospitals usually have reserve funds, pension funds and endowment funds. These funds are frequently invested in corporate securities and public bonds, but they are often used to support investment projects located outside the local community. Such funds could be invested in local, municipally-owned or supported ventures provided they offered a reasonable security and rate of return. Although the institutions may not agree to invest in the early projects of an alternative energy system, they might be willing to participate once the viability of such investments is demonstrated.

Conclusion

It has been suggested that an alliance between the city government and community groups could work to effectively combine the institutionalized powers of the city government with the financial or political interests of community groups. An effective way to begin organizing the people and resources of Northampton might be for representatives of the city government and various community groups to work together on developing a non-profit, community-based energy development corporation.[12] The primary function of the EDC could be to provide technical assistance and financing information to community groups and local government agencies working towards the energy self-reliance of the city. The corporation could serve as a liaison between the city government and community groups, and could help oversee the initial stages of the transition to energy self-sufficiency. The EDC could focus its initial efforts on helping individuals and groups in Northampton to identify areas of the city that are presently well-suited for alternative energy systems. The corporation could begin to develop a much more detailed analysis of existing financial resources in Northampton and could initiate further research on various methods of financing and ownership for the systems.

Footnotes

1. Community Organizing Project. The Cities' Wealth, Washington, D.C.: National Conference on Alternative State and Local Public Policies, 1976, p. 30.

2. Ibid., p. 31.

3. Ibid., p. 31.

4. Ibid., p. 32.

5. There have been problems with public power in the past, ranging from an outright misuse and exploitation of natural resources to a more subtle and unnecessary overencouragement for inefficient and wasteful patterns of energy use. However, these problems may be related to the scale of past systems and are not necessarily inherent in public power. Careful planning could help avoid the problems in the future by encouraging the development of smaller systems and by mandating that they protect the environment and encourage energy conservation.

6. One mechanism that presently exists are federally and locally supported Community Development Corporations. Although CDC's have not specifically been used to support the development of alternative energy systems, they are examples of non-profit corporations which are organized and controlled by the residents of the community in which they operate. They have traditionally been involved in a variety of activities directed toward enhancing the economic base of communities.

7. Interview with Walter Murphy, City Auditor, Northampton, Massachusetts, December 13, 1978.

8. Community Organizing Project, The Cities' Wealth, p. 56.

9. Interview with Walter Murphy, ibid.

10. Interview with Walter Sullivan, Marketing Director, Northampton Redevelopment Authority, Northampton, Massachusetts, December 15, 1978.

11. This is discussed further in Chapter Eleven.

12. For further information on community development, contact: Center for Community Economic Development, 639 Mass Avenue, Cambridge MA .

Chapter Eleven

Citizen Involvement and Public Education

Major changes in energy use and supply can only take place successfully if the Northampton community takes an active part in the shift to renewable resources. Individuals, groups, and institutions have potentially crucial roles to play in facilitating the implementation of an alternative energy plan.

City Government

Although the Mayor is interested in energy issues, he perceives little community concern at the present time. The City Council as a responding rather than initiating body, will attend to a particular issue when there is a "public clamor". At this time, Northampton citizens are not visibly upset about energy problems, and therefore, neither is the City Council. Consequently, the City Council did not support the Mayor's proposal for an Energy Department. The Council has also appeared reluctant to authorize $7,500 for Cooley Dickinson Hospital to perform a feasibility study on its proposed solid waste burning plant.[1] (The study is to be funded by a federal grant matched by money from the local communities who are effected by the plant.)

There are a number of ways in which the city government could guide the community in energy-conserving and alternative energy strategies. An example of a community which has embarked on a significant program of energy conservation, with the leadership of its city council, is Davis, California. Davis, like Northampton, is a city of 30,000 people, and while predominantly a residential community, also has a large population of students. The Davis City Council has enacted a series of measures aimed at reducing energy demand in the city by as much as one-half. Since an energy survey found that 50% of the energy used in Davis was for transportation and 25% was for space heating and cooling, efforts have been directed at these areas.[2]

A primary tool for energy conservation in Davis is the energy-efficient building code. The code is based on regulating heat loss in the winter and heat gain in the summer through a set of prescriptive and performance standards. The code regulates the orientation of buildings, the insulation required, and the amount of glass allowed. Despite the climatic differences, Davis and Northampton currently have the same home insulation requirements in their building codes. Davis even allows for less window and door area in its building code.[3] The 1978 Massachusetts building code, which Northampton is required by law to follow, is a sound one. However, if a city in Northern California has a less severe climate yet follows a more stringent building code than Northampton, it is clear there is significant room for improvement in the Massachusetts code.

The Davis city government has also encouraged developers and builders to use alternative energy systems in new homes. To this end, the municipal government has financed two demonstration solar homes. The houses were built for several purposes: to construct houses which could be 80-90% solar heated and 100% naturally cooled; to utilize high-efficiency appliances and water-conserving fixtures; to use solar hot water heating; to promote the use of natural lighting; to develop a system of landscaping which adds to the thermal performance of the houses; and to keep construction costs as low as possible.[4]

Davis has taken a number of diverse steps to reduce the amount of energy used for transportation. The required width of roads has been decreased and there is an extensive public transit system which uses second-hand British double-decker buses. The city has a system of bikeways, and runs a comprehensive bike safety program. It is estimated that 25% of inner city travel is presently done on bicycles.[5]

The changes which have taken place in Davis could conceivably occur in Northampton and could originate in the Northampton municipal government. If Northampton were allowed to improve upon or be excluded from the state building code, for example, the city could enact its own energy efficient code. The city might also choose to allow property tax exemptions for home improvements that include energy conservation measures and the use of alternative energy systems.

However, long-range energy planning is not presently an objective of the city. Given the general economic situation, the Mayor has suggested that it is important to find inexpensive answers that will yield relatively immediate results. He expressed the hope that the recently hired Energy Conservation Coordinator will retrofit a city building, thereby demonstrating to the City Council and the community as a whole the benefits of conservation efforts.[6] With complaints of excessive local property taxes followed by a "taxpayers' revolt" over the 100% property tax valuation of last fall, the city government is very sensitive to spending the taxpayers' money. Therefore, the "clamor" necessary to stimulate action by the Mayor and the City Council must come from the community.

City Planning

The Northampton City Planning Department can be regarded as an agency in which the long range goals of the city should be addressed. The Planning Department deals with projects related to public transportation, parking, pedestrians, bicycling, housing, zoning, land-use, and the conservation of natural resources. Representatives from the Planning Department serve on the City Planning Board and the Conservation Commission. The planners also work on larger, regional issues through their association with the Lower Pioneer Valley Regional Planning Commission.

The Planning Department is often forced to exercise a regulatory function which leaves it unable to initiate long-range planning in Northampton. One of the planners commented that the department is not given "very clear marching orders" from the Mayor or the City Council regarding planning goals. It was also noted that there is unwillingness on the part of the city government to put money on the line for innovative projects.[7] For the most part, energy considerations are not presently a priority in Planning Department decisions.

Transportation and parking problems in Northampton exemplify the conflicts between long and short term planning, and the neglect of energy factors for more immediate goals. Aside from the fact that many people come from outside Northampton to shop and work, most people who live in the city drive to the Main Street, King Street and Green Street areas. Alternative modes of transportation for inner city customers are presently limited and the distances involved are often too far to be practical for walking. The use of bicycles is one alternative but it is often impractical in bad weather and even somewhat dangerous given the current traffic situation.

Plans for shuttle buses on King Street are in progress at this time. The service promises to help relieve traffic problems along the King Street Corridor (U.S. Route 5), but it may not resolve the congested conditions along Main Street (U.S. Route 9). The provision of bike paths around the central business district is also planned.[8] They should enable easier and safer travel both for bicyclists and motorists. The development of a more comprehensive local public transportation system, such as the one proposed in this study, would be advantageous for several reasons. A system could be implemented that would expand the existing Pioneer Valley Transit Authority (PVTA) service from Williamsburg-Northampton-Amherst as well as the proposed King Street shuttle bus. This could reduce the number of inner city cars entering the central business district, thereby relieving traffic congestion and allowing shoppers from outside areas easier access to the district.

The link between planning efforts and goals of energy-efficiency should be strengthened in order to enable an easing of the traffic situation, as well as to address other community development issues.

The proper time to evaluate energy factors is before capital investments are made in major public works projects. The time and money commitments that accompany planning efforts can either enhance or inhibit opportunities for energy self-sufficiency.

An evaluation of the kinds of issues which involve setting priorities and making difficult trade-offs, could occur in a master plan for Northampton which may be initiated within the next couple of years. One planner interviewed would like the new master plan to develop through the participation of people in Northampton rather than through an outside consulting firm.[9] This could result in a study of the city that addresses some of the long-range goals of Northampton's residents. It is hoped that the Planning Department will receive support from the community and from the city government to undertake innovative planning efforts that include energy concerns.

Businesses

Within the commercial sector, retail establishments represent one of the largest and most diverse segments of the community. In fact, one citizen noted that there seems to be a split between the "old blood" and the "new blood" in Northampton. This has caused some tension within the Northampton business community as well as between businesspeople and city officials. One downtown merchant expressed disappointment that the city government is not working with businesses to solve common problems such as transportation and parking.

An organization which represents the interests of the retail sector is the Chamber of Commerce. According to the executive director, the Chamber serves as an educational tool for the business community. Various committees have been formed within the Chamber, including an Energy Committee which has sponsored several energy conservation audits in the city since 1973.[10]

There are several retail associations within the Chamber of Commerce that exist to share and resolve common problems. District organizations such as the Downtown Merchants' Association, and the Green and West Street Merchants' Association, as well as the Florence Center businesses, could examine the feasibility of alternative energy systems for their areas. Although it has been argued that there is little cohesion in Northampton's business community, the potential for district heating systems in the commercial areas might generate interest among local businesspeople.

There are downtown businesspeople who see Northampton as a special community. One expression of this sentiment may be felt in the new Thorne's Supermarket, a center that strives to combine livelihood and culture in one building. The owners stress the importance of integrating space for dance, art, theater, and music with a mix of retail establishments.[11] The revitalization of the downtown area is an important factor in promoting a sense of community for those who live in Northampton. This commitment should be fostered and could potentially motivate the development of alternative energy systems.

Industries

In interviews with executives from local industries, we found them generally hesitant to invest in alternative energy systems. The same doubts surfaced cosistently. There was a great deal of concern concern about the dependability of such systems, and evidence of their technical and economic success was requested. In addition, the financial incentives to encourage a shift to renewable energy resources were deemed insufficient.[12] Three representatives of local labor unions expressed similar considerations, focusing particularly on the issue of the reliability of the alternative systems.[13]

One practical way to educate the industrial community in Northampton about the fcasibility of alternative energy systems is to publicize instances where they have been used successfully. J. A. Wright and Company, a small building and cabinetmaking firm, has made extensive use of the sun's energy. The building's design incorporates many passive solar construction techniques and has a hot-air solar heating system. The owner informed us that other businesses and industries in Northampton have shown great interest in his heating system and the possibility of retrofitting their own buildings. He has generated a positive response among those in the community who have learned of his solar-based workshop.[14]

Private Institutions

All of the private institutions which were examined have enacted energy conservation measures.[15] We believe that most private institutions in Northampton, such as Smith College, are in good positions to develop alternative energy demonstration projects and models. For one, these institutions are large and have high visibility within the community. Secondly, it has been frequently stressed by city officials and planners that federal and state government funds are currently more limited than they once were. Governments on all levels, then, are looking for public projects to be financed in conjunction with private developers. Cooley Dickinson Hospital's proposal for a solid waste burning plant is an example of a potential model for alternative energy in Northampton. Funds provided by the federal government for the feasibility study will be matched with money contributed by local communities.

Banks

Banks can support and stimulate a shift to renewable energy systems in a variety of ways. Lower interest rates can be offered for home improvement loans which conserve energy. The amount by which rates would be reduced could be based on the effectiveness of the conservation measures that are being financed.[16] Additionally, through its home mortgage service, a bank could encourage people buying homes to invest in conservation efforts by changing the down-payment requirements and the payback terms.[17] Inherent in this lending concept would be the realization that the value of property improvements which increase energy-efficiency will rise as energy costs increase. Banks, as investors can help finance the city or groups within the city during the transition to alternative energy systems. In several interviews with bank officials, we attempted to gauge the level of interest in energy conservation and alternative energy and to assess the attitudes of Northampton's banking institutions toward financing the energy plan proposed in this study.

All of the bank officials interviewed felt energy to be a significant issue, and a few had displayed conservation booklets in their lobbies. In addition, all of the banks had taken various conservation measures of their own, including turning down thermostats and improving lighting efficiency.[18] One bank has also installed a solar water heater on its roof.[19]

Energy conservation, in relation to a bank's service is "essentially a non-issue."[20] While expressing interest in and curiosity about conservation, banks are limited in their behavior by the financial realities of bank operation and market conditions, as well as by predominant attitudes within the banking business.[21] All of the banks have given a few mortgages for homes which included passive solar construction or alternative energy systems. But there are no banks in Northampton which currently offer lower interest rates for home improvement loans which are energy-conserving. The First National Bank of Amherst (which has a branch in Northampton) ran a trial program during most of 1977, offering interest rates for energy-conserving home improvement loans which were 2% lower than the usual rate. According to the Assistant Vice President of the bank, the program was not very popular.[22] His ambivalence was similar to that of other bank officials when contemplating such a program.

Banks have a limited capacity to promote a "primary product."[23] That is, what consumers purchase is of little concern to the bank which lends them money. Bankers do not believe lower interest rates entice customers into investing in conservation measures. However, they do recognize that if such improvements are being considered, a lower interest rate might influence which bank a consumer chooses. Moreover, home improvement loans do not represent a large portion of a bank's business (typically less than 2%), and are not a particularly profitable part of their activities.[24] In addition to competition between banks for the limited number of home improvement loans, there are financial constraints within banks which determine priorities. Particularly during periods of economic crisis, a bank may choose to downplay lending and encourage deposits.

Banks also have a stock portfolio, a portion of which could conceivably be invested in alternative energy systems developed by the city government or by groups within the city. Within Northampton there is a range of opinion concerning a bank's legitimate scope of action, particularly with regard to investment practices. In response to a suggestion that banks invest in the energy plan proposed in this study, all of the bank officials interviewed cited considerations of the financial incentives and risks involved in such investments. Any decision to invest in the city's alternative energy plan would be made by the respective Boards of Investment at each bank and by the State Banking Commissioner.

Attitudes and philosophies concerning the proper role of banks in an alternative energy future varied not so much in content as in emphasis and tone. One banker asserted that a bank's functions are to serve customers and to earn profits. Yet he acknowledged that from a public relations point of view, an investment decision was a different matter.[25] An official of Northampton National Bank stated that his bank would seriously consider the Northampton investment, if the "philosophy" of it were "consistent" with the bank's. The bank might be willing, in this case, to invest in Northampton's energy future at a 7% return and forego an 8% return that could be obtained from a more traditional investment.[26] In fact, all of the bank officials interviewed stressed that their commitment to the community and their sense of social responsibility are factors in decision making.

Banks are not trend-setters in society, but they are acutely aware of their public image and are highly sensitive about their reputations within the community they serve. In any area, there are generally a few banks which are more progressive, and tend to pioneer in offering innovative services. From discussions with Northampton's bankers, we sense that this is true for the city. For the banks in Northampton which are relatively more progressive, there should be encouragement for the development of model programs related to alternative energy. There are several possibilities. For example, a group of banks could set up an energy loan pool, to which each bank would contribute some proportional share of money. The processing costs to each bank, and the risks involved, would thereby be reduced. Secondly, banks could set up low-interest loan programs for large institutions and industrial establishments. Again, the volume of business could offset processing costs, and the institutions could participate in promotion efforts. Thirdly, a bank could develop an energy center as part of its loan and mortgage service. Home-improvement and mortgage services could incorporate energy considerations into their standard practices. Bank personnel could have information on energy tax credits, and on local zoning and building codes. They could have lists of recommended insulation and alternative energy dealers, and could provide technical and reference information to homeowners.[27] Such a center could facilitate the integration of regular banking activity with consumer access to energy-related resources.

Each Northampton bank official interviewed stressed the importance of the bank's relationship with the community. Yet "major bank commitments to this area will probably await the day when large numbers of consumers begin clamoring for conservation devices and related financing, thus legitimizing conservation as a full-fledged business opportunity for banks rather than an object of passive, inconsistent, or token attention."[28] The key to involving the Northampton banking industry in an alternative energy plan is public consensus and pressure.

The Northampton Community

Alternative energy is often a focus for low-income and community organizing groups. This is because, as one member of the Hampshire Community Action Commission noted, "alternative energy dovetails rather nicely with an advocacy approach rather than a service approach."[29] Engaging people in building and controlling alternative energy systems is seen as a way of promoting self-reliance and respect through cooperative self-help efforts.

The East 11th Street Project in New York City is an exciting example of the political, social, and economic benefits of technology which is "appropriate" for people, particularly for the dispossessed of society. In this project, several abandoned tenements have been acquired through a "sweat equity" program and have been reconstructed using solar collectors and windmills as part of a process of reaching self-sufficiency. The group involved is composed of neighborhood organizations as well as members of street gangs. The object of the restoration efforts has been a search for affordable, attractive, self-sufficient, tenant-owned housing. At the same time, the project has instilled a sense of community, has encouraged the sharing of skills, and has helped residents attain a feeling of control over a central part of their lives.[30]

In Northampton, there are several projects underway which address similar goals. For example, there is a solar greenhouse in the Bridge Street Halfway House. There is a community Canning Center which encourages residents to buy and preserve local produce in the summer. People can the food with assistance at the center for a nominal fee. This serves to lower consumer's food costs and helps support local farmers. The Salvo Housing Project, a subsidized housing unit for the elderly, has a solar water heater on its roof.

The Hampshire Community Action Commission is an ideal source for alternative energy projects aimed at the low-income community in Northampton. The intent of this group is to aid in setting up models in low-income neighborhoods, and then to step out, leaving the residents in full control. Recently, the Hampshire Community Action Commission received a grant from the National Center for Appropriate Technology to utilize a solar device as an educational tool in one of Northampton's low-income neighborhoods.[31] The selection of an energy system and the decision of where it will be placed will be made by local residents. It is this type of project which really approaches many of the goals that motivate our alternative energy plan. Unfortunately, as mentioned earlier, the Hampshire Community Action Commission has very limited funds, and they are often forced to deal with emergency situations that could perhaps be served by the United Way or church organizations of Northampton. This would enable the HCAC to concentrate on more far-reaching efforts.

In addition to its relevance for low-income people, alternative energy has become a focal point for those people committed to a rekindling and a redefinition of local politics. These people are concerned with community control for "the simple practical reasons of making life livable and resolving problems which have remained untouched by the movement toward huge, dehumanized scale in social organization, economic organization, and the organization of resources and technology."[32]

As has been discovered in the process of this study, there is keen interest in conservation and alternative energy on the part of many individuals in Northampton. Since many activities occur on an individual and isolated level, the fragmented nature of the efforts prohibits the development of any real momentum. Besides the need for a coordination of individual action and resources, alternative energy needs a higher profile in the community. Such visibility could be encouraged through the media, schools, local clubs, and creative, cultural events which explore energy-related issues. It is also clear from conversations with bankers, industries, and city officials, that only organized group efforts on the part of citizens will stimulate social responsibility in the private sector or encourage foresight in city government. The sense which has emerged from conversations with members of the Northampton community is one of a lack of a social organization or a framework within which the goal of energy self-sufficiency can be articulated and pursued.

The Energy Development Corporation described in Chapter Ten could be an important step in stimulating the necessary coordination and initiative. Such an organization, in addition to serving as a liaison and funding information center, could set up a storefront in the downtown area. This storefront could be a walk-in energy center, which pictorally displayed the principles of energy use and energy conservation, and which exhibited demonstration models of alternative energy systems (perhaps on loan from area stores). The storefront could function as a resource gathering and contact organization, developing a list of people interested in energy issues, or with skills to share. This group could also sponsor field trips to alternative energy sites, organize lectures, facilitate neighborhood energy audits, and generally act as a forum for the gathering energy interests of the community.

Ultimately, the attainment of energy self-sufficiency hinges on the value people place on their community. A commitment to Northampton could have as its source an increasing recognition of the city as a unique, cultural, social, political, and economic entity. A deep sense of community could motivate a reorientation of local politics toward greater community control of services and decision making in which people can participate directly. For politics should live where the people do.[33]

Footnotes

1. Interview with Harry Chapman, Jr., Mayor, City of Northampton, Northampton, Massachusetts, December 13, 1978.

2. See Elements, The. <u>The Davis Experiment</u>, Washington, D.C.: Public Resources Center, 1977, for a description of the many steps Davis has taken.

3. Murphy, Jane. "Building Codes and Energy: Davis, California and Northampton, Massachusetts", unpublished paper, Hampshire College, Amherst, Massachusetts, December 1978.

4. Elements, The, <u>The Davis Experiment</u>, p.13.

5. Flatteau, Edward. "A Tale of Three Cities", Newspaper article, source unknown.

6. Chapman, Harry Jr. ibid.

7. Interview with Senior Planner, City Planning Department, Northampton, Massachusetts, December 7, 1978.

8. Ibid.

9. Ibid.

10. Interview with Paul J. Walker, Executive Director, Greater Northampton Chamber of Commerce, December 13, 1978.

11. Interview with Brinkley Thorne, Thorne's Supermarket, Northampton, Massachusetts, December 13, 1978.

12. See Chapter Seven for further reference.

13. Interviews with James E. Martin, Business Representative, Carpenter's Local #402; Robert E. Murphy, Business Representative, Plumber's and Steamfitter's Local #64; George O'Brien, Business Representative, Electrical Worker's Local #36, Northampton, Massachusetts, December 12, 1978.

14. Interview with Jonathan Wright, J. A. Wright and Company, Northampton, Massachusetts, December 8, 1978.

15. See Chapter Seven for further reference.

16. Real Estate Research Corporation. <u>Innovative Financing: Banks & Energy Conservation</u>, prepared for Department of Energy, May 1978, p.5.

Footnotes (continued)

17. Ibid., p. 66.

18. Interview with Bob Laponte, Assistant Vice President, First National Bank of Amherst, Amherst, Massachusetts, December 12, 1978. The First National Bank of Amherst had Massachusetts Electric perform an energy audit on their building and make recommendations.

19. Interview with Nancy Huntley, Northampton Institute for Savings, Northampton, Massachusetts, December 6, 1978.

20. Real Estate Research Corporation, Innovative Financing, p. 40.

21 Ibid., p. 49.

22. Laponte, Bob. ibid.

23. Real Estate Research Corporation, Innovative Financing, p.1.

24. Ibid., p. 27.
They state that "on an average $1000 loan for 24 months, a bank would have to charge roughly 14.5% annual interest rate merely to break even, before taking account of its desired margin of profit." (p. 29)
At Northampton National Bank, the interest rate for home improvement loans is from 13.32%-13.69%.
Interview with Gary Dill, Senior Loan Officer, Northampton National Bank, Northampton, Massachusetts, December 6, 1978.

25. Interview with Stanley Osowski, Vice President and Treasurer, Nonotuck Savings Bank, Northampton, Massachusetts, December 8, 1978.

26. Dill, Gary. ibid.

27. Real Estate Research Corporation, Innovative Financing, p.71.

28. Ibid., p. 39.

29. Interview with Pam Murray and Harold Seewald, Energy Program, Hampshire Community Action Commission, Northampton, Massachusetts, October 11, 1978.

30. See, No Heat, No Rent: An Urban Solar and Energy Conservation Manual, and Windmill Power for City People, 1977, by the Energy Task Force, 156 5th Avenue, New York, NY.

31. Interview with Pam Murray, Peter Searshma, and Harold Seewald, Hampshire Community Action Commission, Northampton, Massachusetts, December 8, 1978.

Footnotes (continued)

32. Hess, Karl and Morris, David. Neighborhood Power, Boston: Beacon Press, 1975, p. 5.

33. Ibid., p. 10.

Chapter Twelve

Energy Self-Sufficiency in Perspective

It has been shown that the potential for energy self-sufficiency in Northampton is very real. Energy self-reliance appears attractive for a variety of reasons. The use of alternative energy systems can bring practical benefits to the community in the form of continuous energy supply, decreased production costs, and the enhancement of environmental quality. An overall strengthening of the economic base of the community can also occur as energy expenditures circulate through the local economy. Money which once left the area can now be used to pay for local human and physical resources used in the construction and maintenance of the systems.

The effects of energy self-sufficiency are as much social and political as they are technical. The development of alternative energy can include a concern for the decisionmaking process through which the systems are to be developed, who will own and control them, and their compatibility with various social and cultural aspects of the community. Traditional ideas of democracy can be combined with popular interest in and demand for citizen involvement in energy policymaking. Such a participatory approach is based on the belief that people can act responsibly about and take responsibility for important technical and political questions. Elitism and centralization can be minimized, encouraging a wider distribution of economic and political power.

The abilities of different individuals and groups can be shared and integrated as people work toward a common goal. The social and cultural life of the community could be enriched and resources which exist in the community could be better utilized. As plans for self-sufficiency are realized and projects completed, a sense of achievement can develop, inspiring people to continue and pursue their commitment to the community and its overall development.

Increasing the energy self-reliance of a community will take a number of years and will involve the actions of numerous people with diverse interests. The changes require substantial shifts in the style and structure of existing patterns of energy use and supply. For purposes of clarity, this study examined Northampton at the point of total energy self-sufficiency, rather than over the long-term process of achieving energy self-sufficiency. While a more realistic perspective, the transition is also highly complex. It is the process of moving toward self-reliance that can be the most rewarding, yet is the most fraught with complications. Most significantly there is the threat of compromising initial motivations. Over a long period of time, amid the daily nuts and bolts of installing community energy systems, the overall purpose and commitment can be difficult to bear in mind. For example, in the Northampton plan, implementation of all of the solar ponds was examined as a single stage. Under these circumstances, it could be assumed that all electricity lines in Northampton would be purchased from the utility by the city or groups within the city. However, if one neighborhood constructed a solar pond, it would probably sell its electricity to the utility company. With such incremental implementation, there would not necessarily be any alternative structure to the private utility.

There are many obstacles, or barriers, that must be confronted in order to achieve energy self-sufficiency. Many of the changes that will occur will not necessarily be viewed favorably by those effected. Jobs associated with existing energy companies will be lost and although other jobs will be created, they will not necessarily involve the same people. Many conflicts of interest may also occur over specific siting and design features of energy systems. An advantage of a local energy policy is that the range of special interests involved is narrower than that for a national policy and any negative impacts will be felt by a smaller number of people. Members of a community will have to live with the consequences of their decisions and those effected will be able to participate directly in policymaking.

The boundaries for energy self-reliance are not rigid, and it is impossible to be certain about the ideal level for energy self-sufficiency. Is it determined by a political boundary, a geographic region or on the basis of social or cultural identity? There is no absolute measure for the appropriate scale, but the orientation should be focused toward the smallest political unit which can undertake such a task.

Cities are a feasible level from which to promote energy self-reliance because they have a fair amount of political power and organizational strength. Municipalities can raise taxes, amend ordinances, oversee zoning laws, and initiate growth policy. However, a shift to energy self-reliance also depends on the physical size of a city, land-use patterns, the extent of energy-intensive industry, and the distribution of the population.

Consideration of these characteristics in Northampton has resulted in our proposal for developing alternative energy systems such as solar ponds. It is obvious that not every city could opt for this specific type of system because of the different physical and technical attributes of various urban areas. Furthermore, it is probable that every city cannot physically achieve energy self-sufficiency due to a lack of indigenous resources. For those areas which do strive for energy self-reliance, what is important is that the scale be manageable and accessible.

While it is uncertain what the ideal scale for energy self-sufficiency is, it is clear that energy policy should be stimulated at the local level. Obviously the issue of motivation is very complicated, but policy of a national scope often fails because it cannot command the interest or participation of citizens on a day to day basis. Moreover, a national energy policy does not recognize the uniqueness of individual areas or communities.

A community's sense of integrity and interest in utilizing its resources should not override an awareness of the broader context in which the community exists. Provincialism can create jealousies and rivalries between neighboring communities' resource use, trade, and economic disparities, as well as other, more subtle forms of competition. Since energy self-sufficiency will occur in stages, yet as part of a concerted effort, action can be individually oriented, but must also be carefully planned, coordinated, and integrated with what is taking place elsewhere.

What is the proper balance of control and responsiblity between citizens, communities and various government structures? Clearly, government involvement at all levels is necessary; state and federal resources should not be disregarded. An inclusive framework, whether countywide or regional, must be in existence in order to provide a wider perspective for energy self-reliant communities. But the larger units should exist as facilitators and coordinators, rather than as centers and controllers of power.

And so this project ends as a beginning. Further research must be done on specific financing arrangements, on the actual layout of community energy systems and on the factors that determine which systems are optimal for various areas. The most important work, however, cannot be done on paper. What is needed now is action. The impetus for energy self-sufficiency must come from a grassroots level for it depends on citizen action and participation.

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