Geothermal

Guide to a **COMMUNITY HEAT PLAN**

A Geothermal
Energy Application

March 1982

MASTER

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GUIDE TO A GEOTHERMAL HEAT PLAN: A Geothermal Energy Application

Serial No. 3

March 1982

WAOENG--82-04

DE82 020591

STATE OF WASHINGTON
John Spellman, Governor

Published by

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U.S. DOE

Richland Operations Office

Grant No. DE-FG51-79-R0 00079

In conjunction with the
Oregon Department of Energy

Prepared by

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5006 Commercial St. S.E.

Salem, OR 97302

under Contract No. 80-19-01

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ENERGY UNIT CONVERSION FACTORS

The common unit of energy measure in this guide is the British Thermal Unit (Btu). To convert between other energy units, use the following factors:

To Convert	Into	Multiply By
Barrels, oil	gallon	42.0
Cubic feet, natural gas	therms	0.01
Cubic feet, natural gas	Btu	1,020
Gallons, No. 2 oil	Btu	138,700*
Gallons, No. 4 oil	Btu	145,000*
Gallons, No. 5 oil	Btu	148,000*
Gallons, No. 6 oil residual	Btu	149,700*
Gallons, kerosene	Btu	135,000*
Gallons, gasoline	Btu	125,000*
Gallons, diesel oil	Btu	138,700*
Horsepower-hours	Btu	2,544
Horsepower-hours	kWh's	0.7457
Horsepower	Btu/min.	42.4176
Horsepower (boilers)	Btu/hr.	33,479
Kilowatt-hours	Btu	11,600
LPG (Gallon)	Btu	95,500
M(1,000)CF natural gas	Btu	1,000,000
S(Standard)CF natural gas	Btu	1,031
Steam	Btu	1,390
Therms, natural gas	Cubic feet	100
Therms, natural gas	Btu	100,000
Tons, refrigeration	Btu/hr.	12,000

*These are average values. Since exact Btu content varies with type and source, contact supplier when extreme accuracy is essential.

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This brochure is a condensed version of the *Guide to a Community Heat Plan: A Geothermal Energy Application*, published June, 1981, by the Washington State Energy Office, WAOENG-81-19.

1. INTRODUCTION

1.1 BACKGROUND

Energy use within a community and the nature of the community's built environment are closely interrelated. The relative abundance of energy resources, the level of technology for their conversion into useful energy, and various geographical and political factors determine the availability and cost of energy. This, in turn, influences the size and shape of communities, and the mixture and density of their land-uses. Conversely, the land-use patterns which develop require a certain level of energy input in order for the community to function.

Until recently, inexpensive and abundant energy supplies permitted communities to develop physically with little or no regard for energy-efficiency. As a result, the built environment of many communities are now low in density and sprawled in spatial form, creating demands for inordinately high levels of increasingly expensive energy supplies.

In response, it is suggested that community planners can initiate policies and practices to improve the energy-efficiency of their cities. While considerable attention has been focused on improvements through weatherization and similar conservation measures, there are additional measures available for accomplishing longer-range efficiencies on a community-wide scale. Such improvements can take the form of: more efficient land-use patterns, which require lower amounts of energy inputs for such functions as space heating and transportation; and more efficient designs for infrastructure, which will facilitate the introduction of alternate energy resources and technologies, such as geothermal district heating.

Of a community's energy needs, a majority are usually required for heating purposes, including space and domestic water heating and industrial process heating. This can be seen in the flow of energy through the state of Washington, in Figure 1, indicating the amount of energy used by each community sector; and in Table 1, where the predominant heating requirements in two of these sectors are shown. Thus, it is suggested that improvement of a community's energy-efficiency in the future will depend in large part on orderly and timely plans for managing its heat supplies and demands.

The formulation and implementation of a heat plan should be an important part of a community's overall energy and development strategies. Such a thermal plan should be concerned with the following objectives:

- Systematic monitoring of current and forecasted heat supplies and demands (in atlas form).
- Conservation of heat through more rational and efficient land-use and building standards, and utilization technologies.

Figure No. 1

FLOW of ENERGY THROUGH WASHINGTON, 1979

Shown in Trillion Btu

Source: Hinman et al., 1980

Table No. 1

COMMUNITY SECTOR ENERGY END-USE
 (Percent of Total Consumption)

Energy End-Use	Residential Sector				Energy End-Use	Commercial Sector			
	Single Family		Multi-Family			Office Building		Retail Store	
	Climate		Climate			Climate		Climate	
	1	2	1	2		1	2	1	2
Heating	60	53	48	51	Heating	34	33	28	39
Cooling	-	16	11	15	Cooling	5	15	11	9
Water Heating	18	12	17	14	Water Heating	1	1	1	1
Appliances	19	17	15	12	Lighting & Power	19	11	44	36
Lighting	3	2	9	8	Fans & Aux- iliaries	41	40	16	15
Climate 1 = 4,000-5,500 Heating Degree Days									
Climate 2 = 5,500-7,000 Heating Degree Days									

Source: Mathematical Sciences, 1979

- Development of alternate heat resources, such as geothermal, cogeneration, waste recovery, and solar.
- Optimizing of the heat requirement and locational matches between heat sources and users.
- Integration of heat supply and demand planning with other traditional community planning sectors, such as housing, transportation, and employment, in order to make thermal energy a key determinant in community development processes.
- Reduction of the net heat requirements of the community through the cumulative effects of the heat plan.

This guide has been written to assist Washington communities with the formulation and implementation of such a thermal plan. The guide was originally commissioned to develop techniques for identifying prospective geothermal energy users in communities. Previous studies indicate that as many as 80 cities in Washington may have potential for utilizing low and moderate-temperature geothermal resources (Allen & Shreve, 1980). While the guide does emphasize geothermal considerations, its scope has been widened to acknowledge the role of other alternative heat resources in a community's thermal planning.

1.2 HEAT PLAN OVERVIEW

The approach selected for the guide is a two-part process, where heat resources and end-uses are first characterized in a heat atlas, and then acted upon according to goals and strategies embodied in a heat plan. The purpose of the atlas is to systematically monitor a community's thermal supplies and demands, and to catalog them in the same manner as other community development sectors, eg. land-uses and public works. In turn, the heat plan contains thermal goals and implementation measures based on conditions and opportunities revealed in the atlas.

The purpose of this guide is to introduce the concept of a heat plan, so that local officials may become familiar with thermal considerations and determine which options deserve further study and action. The guide is not intended as a comprehensive, in-depth analysis of every thermal option, nor is it meant to indicate feasibility of the options discussed. Local officials should obtain technical assistance during preparation of the heat plan in order to determine the feasibilities of site-specific options.

Two limitations of the guide which should be noted are the use of heat load estimation methodologies and consideration of space cooling. A heating load is the amount of energy consumed for heating purposes. In the case of estimating such loads the guide stresses the need for local heating data; however, recognizing that actual heat load information is often difficult to obtain, it may be necessary to use an estimation methodology. It should be noted that several alternative methodologies are available in the literature, and local planners may wish to review these before selecting

an approach for their communities. However, regardless of which methodology is chosen, it should be applied only when actual heat load data is unavailable, and only then for purposes of preliminary evaluation.

With regard to space cooling, although it represents a major energy end-use in certain communities, inclusion of cooling options was beyond the scope of the guide. However, communities with sufficiently warm climates should consider including space cooling loads and resources in their thermal planning.

1.3 DEFINITION OF THE STUDY AREA

The area to be considered for a heat atlas and plan should be defined by geographic and climatic parameters. An appropriate geographic boundary is usually the community's urban growth or service boundary. By using this established boundary the atlas and plan will be consistent with existing community data and related plans for land-use and public facility development. An atlas base map should be prepared according to the selected boundary.

A major factor affecting heating characteristics in the study area will be its climatic conditions. Heating demands are based largely on climate, and an identification of these factors will facilitate further work on the atlas and plan. The following climatic parameters can be identified from records of the U.S. Weather Service office nearest the community:

Longitude and latitude
Topography and elevation
Distance and direction to ocean
Prevailing wind patterns and velocities
Average and extreme temperatures

Average precipitation
Average and extreme humidity
Solar radiation averages
Heating and cooling degree days
(Amounts of time that occur above
and below a reference temperature,
usually 65°F)

In addition, a thorough literature search for any previous energy studies in the area should be made through appropriate government and academic agencies. Often times useful information may already be published, or sources of such information may be collected in earlier works.

RELATIONSHIP of COMMUNITY STRUCTURE and ENERGY USE

(After Owens, 1979)

2. THERMAL RESOURCES

The thermal resources of the community represent the first half of the heat atlas. Such heat supplies will include those conventional fuels already in use, and those alternate energy resources which have potential for utilization. The purpose of this portion of the atlas is to identify which specific thermal fuels and resources are or could be available to the community; in what quantities, qualities, and locations they occur; and what their likely future prices will be. This fuel and resource inventory will also indicate the types of alternate energy technologies which must be integrated with community infrastructure, such as a network of district heating pipelines.

2.1 CONVENTIONAL HEATING FUELS

Many communities are only slightly aware of their present usage of conventional heating fuels. However, this usage can equal 40 to 60 percent of a community's energy flow, and as such it represents an important baseline for thermal energy planning. The prices and market shares of conventional fuels will have a direct effect on incentives for conservation and conversion to alternate heat resources.

Thus, the availability, cost, and market shares of conventional fuels should be identified and described according to the characteristics listed in Table No. 2. Information sources will include local utility officials and fuel distributors, and possibly previous energy studies in the area.

The information collected should be periodically updated, particularly cost and inflation data. From these updates a chronological profile of conventional fuel use can be assembled, and progress in conservation or displacement of these fuels can be measured over time.

In addition, the information-gathering contacts with local utilities and fuel distributors should serve to: express the community's interest in thermal planning; encourage the participation of the utilities and distributors in such planning; and establish lines of communication and coordination for future community action.

The results of the fuels inventory should be plotted and tabulated on the atlas base map.

2.2 GEOTHERMAL RESOURCES

The geothermal resources available to the community should be characterized as completely as possible. Unfortunately this task is often made difficult by a paucity of reliable site-specific data. In addition, the expertise required to assemble such data is highly technical, and therefore, not readily available to many communities. However, local officials can perform certain preliminary steps which will help increase their awareness of the resource's nature and occurrence, and also facilitate further professional assessment work.

Table No. 2

CONVENTIONAL HEATING FUELS INVENTORY

<u>Fuels to be Inventoried</u>	<u>Data to be Collected for Each Fuel</u>
• Electricity	• Number of distributors
• Fuel Oil	• Total annual energy sales
• Natural gas	• Estimated market share
• Propane or bottled gas	• Service area boundaries
• Steam	• Current unit cost
• Wood	• Conversion to million Btu (MBtu) cost
• Coal	• Estimated cost inflation rate
	• Conversion efficiency

The assessment of low and moderate-temperature direct-use resources is generally concerned with the following major characteristics of the resource: areal location, depth of aquifers, temperature, flow rate, and fluid quality. It is the nature and occurrence of these characteristics in or near the community which should be documented in the heat atlas.

The geographic scope of resource assessment should extend beyond the principal study area boundary, in order to allow for piping of geothermal fluids from outlying, but nonetheless promising, resource sites. Previous studies have indicated that a range of 5 to 15 miles is presently economical for hot water piping to large-scale heat loads (Lund et al., 1980; Pierdehirt & Kron, 1980).

First, a thorough literature search should be performed for any geological, hydrological, or possibly geothermal research already conducted in the area. Sources for such literature will include academic and government agencies with responsibilities in the fields of geology, water resources, and energy. If available, such literature may provide useful background information on local geology and ground water conditions. Also, the authors of such literature will already be familiar with the area, and if available, may be able to assist the community in further assessment work.

Next a geologic map of the community should be prepared on the atlas base map. Such a map may be available in geological literature, or through nearby college geology departments. At a minimum it should display rock classifications and major lineaments of the area. This information will provide a preliminary reconnaissance of the community which can be interpreted and refined by a professional geologist to focus on promising resource areas.

Another useful assessment task which can be performed by local officials is the collection of water well, and if present, spring records for the area. These records should be available through local water resource agencies, and can be helpful in tentatively describing hydrological conditions. Information collected on wells and springs from these records should include: location, depth, bottom-hole temperature, and flow rate. The locations should be plotted on the geologic map, thus forming a preliminary geohydrological picture of the community.

A considerable amount of evaluation will remain to be accomplished before the community's resources can be most effectively developed and utilized. At this point professional assistance will be required to complete a detailed assessment program.

The results of an assessment program should provide two major inputs for the heat atlas: the areal location of geothermal production reservoirs; and the amount of beneficial heat which can be recovered from such reservoirs. The location, capacity, and disposal requirements for these reservoirs in relation to heating loads should become prime determinants in the community's growth and thermal planning processes.

The conversion efficiency of recovered thermal energy determines the amount of beneficial heat available for direct or heat pump use. This efficiency is represented by the amount of temperature drop which occurs during utilization; or in other words, the amount of beneficial heat actually withdrawn from the recovered thermal energy. Table No. 3 provides conservative estimates of areal beneficial heat according to varying resource temperatures and conversion efficiencies.

These and similar methodologies in the geothermal literature are available for initially analyzing the thermal potentials of a community's geothermal resources (see Muffler, 1979; Lund et al., 1980; Lienau, 1981). These estimated values may be used in the heat atlas until detailed resource assessment work can provide actual values.

2.3 COGENERATION & WASTE HEAT RESOURCES

The availability of cogenerated thermal energy from power plants, and recovered waste heat from industries should also be documented in the atlas. When constructed or retrofitted for thermal cogeneration or waste recovery, these types of facilities can often make significant contributions to a community's heat supplies. Such resources would often be used to operate hot water or steam district heating systems, perhaps as a peaking supplement to geothermal resources.

An inventory of potential cogeneration and waste heat facilities should be conducted as given in Table No. 4. In addition to power plants, selected industries which may have waste heat or cogeneration potential are:

Paper	Other food
Aluminum	Glass
Refined petroleum	Other manufacturing
Misc. paper products	Light metal fab
Pulp	Shipbuilding
Industrial chemicals	Dairy
Saw mills	Motor vehicles
Plywood	Electric machinery mfg.
Cement	Heavy metal fab
Steel	Finished chemicals
Canned food	Grain
Frozen food	Nonelectric machinery mfg.
Dried food	Printing
Meat	Furniture
Misc. wood products	Industrial equip. mfg.
Nonferrous metals	Textiles
Beverages	

The inventory should extend beyond the study area boundary in order to reflect piping feasibilities from outlying facilities. The range of 5 to 15 miles used previously should also be applicable here.

Table No. 3

ESTIMATES OF AREAL BENEFICIAL HEAT FOR LOW & MODERATE-TEMPERATURE
GEOTHERMAL RESERVOIRS

Resource Temperature °F (°C)	Wellhead Temperature °F (°C)	Retrofit ¹			New Construction ¹		
		ΔT in °F (°C)	Areal Beneficial Heat (10 ⁹ Btu/yr/mi ²)		ΔT in °F (°C)	Areal Beneficial Heat (10 ⁹ Btu/yr/mi ²)	
220 (104)	200 (93)	50 (28)	375		100 (56)	750	
200 (93)	180 (82)	40 (22)	300		80 (44)	600	
180 (82)	160 (71)	30 (17)	225		60 (33)	450	
160 (71)	140 (60)	20 (11)	150		40 (22)	300	
140 (60)	120 (49)	15 (8)	112.5		30 (17)	250	
120 ² (49) ²	100 (38)	15 (8)	112.		15 (8)	112.5	
100 ² (38) ²	80 (27)	15 (8)	112.5		20 (11)	150	
80 ² (27) ²	60 (16)	10 (6)	75		10 (6)	75	

¹ Estimates reflect greater efficiency of conversion of new construction designed specifically for geothermal, in comparison to existing structures which require retrofitting.

² Heat pump range; recent equipment developments may increase the ΔT.

Source: Lund et al., 1980.

Table No. 4

COGENERATION & WASTE HEAT INVENTORY

Resource Type

Data to be Collected

Power Plants:

Name, location, and operating utility
Prime mover type
Fuel
Operating mode (baseload, cycling, peaking)
Present or planned generating capacity (MWe)
Potential thermal capacity (10^6 Btu/hr)
Retrofitted generating capacity (MWe)
Start-up or retirement date

Industries:

Name, location, standard industrial classification
Age
Annual, seasonal, and daily operating hours of plant
Fuel(s) purchased (type and amount)
Plant heating system type(s)
System capacities and usage
Amount of exothermal/liquor recovery
Amount of heat losses (gas and water streams, cooldown)
Amount of recoverable loss (quantity and temperature)
Time-based availability of waste heat

Incinerators:

Name, location, operating entity
Capacity (tons/day)
Potential heat production (10^6 Btu/hr)
Start-up or retirement date

In addition, solid waste incinerators are not commonly in use yet, and therefore, will likely have to be approached as a planned rather than existing heat resource. Local solid waste officials should be consulted about such plans.

An actual determination of cogeneration or heat recovery feasibility for each facility will require a detailed engineering and economic analysis. The intent of the atlas inventory is only to identify such facilities and plan for such detailed analyses.

The results of the inventory should be plotted on the atlas base map.

3. THERMAL RESOURCES

The thermal load of a community, as used in the guide, is the thermal energy required to meet its space, water, and industrial process heat demands. These heat demands represent the second half of the atlas, and are organized by sectors of residential, commercial, institutional, and industrial uses. The objective of this portion of the atlas is to establish a baseline of existing thermal loads and a projection of future thermal needs, which can then be matched with the heat supplies and resources identified in Section 2. A principal objective is the identification of heat users in each sector who have a favorable potential for utilizing alternate heat resources, particularly geothermal energy.

3.1 RESIDENTIAL HEATING LOADS

The residential sector will often account for a majority of a community's heat consumption, and thus, should play a major role in thermal planning.

Because it is usually impractical to audit the exact load of every residence in the community, a method of estimating loads by dwelling type or floor space is required. The literature provides several approaches, based largely on local climatic conditions and building design temperatures. It should be noted that most of these methodologies provide estimates of end-use energy consumption, rather than fuel consumption. This is because different heating systems, with varying efficiencies, will consume different amounts of fuel to provide the same end-use heating effect. If possible, energy consumption estimates should be spot-checked against actual fuel consumption records. Once selected, an estimating methodology should be applied in a full load survey of the residential sector.

The residential load survey consists of four major components: current population and housing data; present energy consumption rates; future projections of population, housing, and energy consumption; and residents' attitudes and perceptions regarding energy improvements and costs. The type of approach used in gathering this information will vary according to the size of the community, the resources available to prepare the atlas, and the level of detail desired in the results.

The specific residential information which should be collected for existing housing is given in Table No. 5. Note that air conditioning questions have been included in order to acknowledge communities where the climate is warm and the cooling load is significant.

As shown in Figure No. 2, the results of the survey should be plotted on an atlas base map to describe the location and characteristics of current and projected residential loads.

Table No. 5

RESIDENTIAL HEATING LOAD SURVEY

Housing Data Required for each Dwelling Unit

Location (block number, census tract number)
Lot size (sq. ft.)
Dwelling type (single, multiple)
Owner or renter occupied
Age of dwelling
No. of residents
Dwelling size (sq. ft.)
No. of rooms
No. of stories
Primary construction materials
Type of foundation (slab, crawl space, basement)
Type of insulation and weatherization (ceiling, roof, walls, floor, doors, windows)

Heating (& Cooling) Data Required for each Dwelling Unit

Type of main heating system (central air, resistance, radiator, heat pump, stove)
Fuel (electricity, natural gas, fuel oil, propane, wood)
Age of system
Location of system in structure
Condition of system
Frequency and cost of system maintenance
Typical room temperature settings
Energy usage (total annual and peak hourly)
Present unit cost of fuel
Air conditioning (type, fuel, percent of building, age, location in structure)
Water heating (type, fuel, age, location in structure)

Public Opinions to be Sampled

Is there an energy crisis? Why or why not?
Have previous energy improvements been made to the home? Specify.
Is there awareness of alternative sources of heat?
Is there a willingness to consider retrofitting to a district heating system or another alternate heat source?
Under what financial circumstances would retrofit occur (maximum expense, desired payback, tax credits)?

3.2 COMMERCIAL HEATING LOADS

The community's commercial sector should be surveyed in the same manner as residences were. Information sources will remain largely the same, as will the specific data to be collected. Commercial building data should be available through local planning and building agencies, assessor records, and aerial photographs. Energy consumption data may be available through local utilities, previous area-wide studies, or individual businesses. In the case of major commercial establishments, such as shopping centers or high-rise office buildings, previous energy audits may be available. Also, the methodologies cited earlier may be utilized for estimating heating loads by building type and floor space.

As in the case of residential loads, a definitive survey of the commercial sector will likely require field interviews or similar polls to collect comprehensive heating data and sample business opinions towards energy matters.

Commercial heating data requirements are the same as those given for residences in Table No. 5. The results of this survey should be plotted, together with projected commercial growth, on an atlas base map.

3.3 INSTITUTIONAL HEATING LOADS

The atlas of heating loads should continue with the community's institutional buildings. For purposes of the atlas, institutional buildings are defined as public or quasi-public facilities open to the community at large. Examples include: government administration buildings, public and private schools, hospitals, churches, fraternal meeting halls, and public swimming pools.

Institutional buildings should be given particular attention in the atlas because they are often excellent candidates for district or other alternate heating. This is due to: their commonly large heating loads; their high visibility in the community as demonstration sites; their publicly-supported heating costs, usually creating sentiment in favor of cost-saving improvements; and their eligibility for certain types of financing which is not available to the private sector.

The major considerations and approach to collecting institutional heating data are similar to the residential and commercial sectors. Building data should be readily available through managing entities, and energy data through previously cited sources. The collection of information for this sector should be facilitated by previous energy audits, which have now been performed for many schools, hospitals, and government buildings. Copies of previous audits should be obtained from each major institution or the energy agency which performed them.

A complete survey of all institutions, supplemented by audits where available, should be performed according to the data requirements given earlier in Table No. 5. The survey results should be plotted on an atlas base, along with proposed institutional loads.

3.4 INDUSTRIAL HEATING LOADS

The community's industrial sector should be surveyed in the same manner as other sectors, except that process heat loads should be added to space and water heating as prospective geothermal or alternate heat targets.

Whereas the industrial cogeneration and waste heat survey performed in Section 2.3 identified potential heat suppliers, this industrial load survey is aimed at potential alternate heat consumers. The earlier survey can be expanded to include all industrial space and process loads in the community. The information to be collected for these industries is given in Table No. 6. Upon its completion, survey results should be plotted on an atlas base map.

3.5 COMPOSITE HEAT MAP

The final step in the atlas is to aggregate the community's heat resources and its four load sectors into a composite heat map of the community. Such a composite map is shown in Figure No. 3 representing a geographical and quantitative inventory of the community's heat resources and needs.

In addition to the geographic relationships of these heat supplies and loads, a factor that should also be analyzed is the time-based relationships of these heat supplies and loads. In other words, in terms of cogenerated or waste heat, what seasons and hours of the day would peak output be available; or in terms of heating loads, do the residential and commercial peaks occur simultaneously with institutional and industrial peaks? These time-based relationships, shown in simplified form in Figure No. 4, will have considerable impact on the size and costs of energy supply systems, and should be included with geographic criteria in making improvements in the community's energy efficiency.

At this point the atlas portion of the heat plan has been completed, and can be used as a baseline or benchmark for the community's thermal initiatives to build on.

Table No. 6

INDUSTRIAL HEATING LOAD SURVEY

Plant Data Required for each Industry

- Standard industrial classification (SIC) number and number of employees
- Location (block number, census tract number)
- Property size (sq. ft.) and plant coverage (percent of property)
- Age of plant
- Type of industrial process or product
- Plant size (sq. ft. and cubic ft.)
- Amount of plant space heated (sq. ft. and cubic ft.)
- Primary construction materials
- No. of stories
- Height of ceilings
- Building heat loss characteristics
- Annual and daily operating hours

Heating (& Cooling) Data Required for each Industry

- Type of main heating system
- Fuel(s)
- Age and condition of system
- Location of system in plant
- Frequency and cost of system maintenance
- Additional operational costs
- Temperature requirements for each process step
- Energy usage (total annual and peak hourly) for each process and space
- Present unit cost of energy
- Air conditioning (type, fuel, age, location, energy usage)
- Domestic water heating (type, fuel, age, location, energy usage)
- Other heat uses (specify)

Industry Opinions to be Sampled

- Willingness to utilize alternate heat resources according to technological, economic, and financial parameters.

FIGURE No.4

CONCEPTUAL TIME-BASED HEAT SUPPLIES & LOADS

4. THERMAL PLANNING

The atlas' description of heat resources and loads should now be consolidated in order to formulate a community thermal plan. This plan should seek to conserve or displace conventional heating fuels through the development of geothermal and other alternate heat resources, and by effectively matching such resources with existing and projected heating loads. The heat plan should be integrated with other community goals and strategies, so as to make thermal efficiency a key determinant along with other traditional factors in community development decisions.

The thermal planning process should include goals and strategies for: further heat resource assessment; converting individual users to geothermal or other alternate heat; evaluation of district heating feasibilities; and integration of thermal considerations with related public policies.

4.1 RESOURCE ASSESSMENT

As noted earlier, the full assessment of a community's thermal resources, particularly geothermal, will usually exceed the scope of the heat atlas, which in turn, must initially rely on tentative estimates of resource availability and capacity. However, such estimates must eventually be replaced by detailed site-specific assessment work, in order for major policy and investment commitments to be made to a resource.

Based on the preliminary results of the atlas, a community should establish specific goals and strategies for:

- Prioritization of resources for assessment, given their estimated heat potentials and locations in relation to heating loads;
- Determination of which community organizations will be responsible for assessment work, given the legal and financial circumstances of the community;
- Identification of likely funding sources for assessment work, given competing demands for scarce monies;
- Determination of the most appropriate assessment techniques, given local resource characteristics and assessment budgets;
- Formulation of the most feasible schedule for assessment work, given technique and funding constraints; and
- Establishment of land-use designations for resource areas that are protective and/or conserving of resource access and supplies.

The results of this assessment work should replace or supplement the atlas' preliminary estimates.

4.2 INDIVIDUAL HEAT USERS

The second component of a community's thermal plan should be goals and strategies for converting individual heat users from conventional fuels to geothermal or other alternate resources. Goals for such conversions should be set for each sector (residential, commercial, institutional, industrial), and for both existing and new types of construction.

The achievement of these goals will depend on identification of the most prospective geothermal or other alternate heat users in each sector. A suggested approach is a screening and ranking of the users surveyed in each sector of the atlas, resulting in a rank-ordered listing of those users estimated to have the best prospects for conversion to an alternate energy.

Such screening and ranking should be based on four major factors: heating load characteristics; retrofitting characteristics; cost-effectiveness of the conversion in relation to conventional energy costs; and user attitudes towards alternate energy conversions. The atlas' heating load surveys were designed to provide the information needed for such screening and ranking. Table No. 7 describes the screening factors and the attributes desirable for favorable ranking.

The screening and ranking for cost-effectiveness is a critical step in the targeting process, and should be based on specific local cost data and professional assistance whenever possible. The literature provides several approaches for estimating cost-effectiveness when detailed professional analysis is not possible. A suggested approach for evaluating geothermal potentials is the comparison of first year costs for geothermal energy versus conventional fuel, and a comparison of twenty-year levelized costs for both geothermal and conventional (Lienau, et al., 1981; after Pierdehirt & Kron, 1980). This approach requires the following calculations:

- Estimation of geothermal capital, operation and maintenance costs;
- Computation of current costs per unit of geothermal heat;
- Computation of current costs per unit of heat from conventional fuel; and
- Computation of the 20-year levelized cost per unit of heat for both geothermal energy and conventional fuel.

This cost comparison should be applied to the top-ranked users in each sector. It should be noted that the methodology applies to retrofitting existing buildings, and geothermal heating systems which appear cost-effective in this case will be even more attractive for new construction.

The resulting list of targeted users in each sector should form the basis of a marketing program for geothermal or other alternate conversions. These users should be contacted in the order of their ranking and be encouraged to evaluate geothermal or

Table No. 7

INDIVIDUAL USER SCREENING & RANKING CRITERIA

<u>Screening Factor</u>	<u>Desirable Ranking Criteria</u>
Heating Load:	Large amount of annual energy use High load factor
Retrofit Requirements:	Heating water designed for warm/hot water Heating system requiring minor or moderate changes to accept warm/hot water System located in ground floor or basement Older system with low present value System in poor operating condition requiring replacement
Cost-Effectiveness:	Lower cost of geothermal energy compared to conventional fuel Lower cost of geothermal O&M compared to conventional O&M Lower cost of geothermal equipment compared to conventional replacement
User Attitudes:	Conscious of energy crisis Previous energy improvements made Aware of geothermal potentials Willingness to consider retrofit under typical geothermal financial parameters

other alternate heat resources. An information and referral service should be offered, as well as technical assistance if possible. Local officials may also want to consider other direct incentives, such as building or zoning code modifications which facilitate geothermal or other alternate conversions, and local tax credits for such conversions (see Section 4.4.2).

4.3 DISTRICT HEATING

The third component of a community's thermal plan should initially be an evaluation of district heating potential, and if favorable, then a detailed feasibility study, followed by goals and strategies to build and operate a district heating system.

For the purposes of this guide, district heating is considered to be the centralized supply of heat, from one or more sources, to a group of buildings and/or processes. Heat sources can include geothermal energy, cogenerated and waste heat, conventional boilers, and solar collectors; services can include space and water heating, industrial process heating, and sometimes space cooling.

In the individual user section the community's efforts were aimed at altering demands for conventional fuels, whereas district heating is a thermal option which communities can employ to influence energy supplies, and thus achieve even greater levels of fossil fuel conservation and renewable energy utilization. Other district heating advantages include: greater efficiencies and lower heating costs from geothermal or other renewable energies; improved air quality (from displaced fossil fuel emissions); increased certainty of supply (compared to fluctuating fossil fuel supplies); and support for related policies such as neighborhood stabilization, economic development, and compact urban growth.

Much of the information needed for an assessment of district heating potentials has already been collected and organized in the heat atlas. There are a variety of approaches in the literature to evaluate district heating prospects, and local officials should review these to determine which is most appropriate to local conditions. The approach suggested here is based on previous guides for local officials (Lienau, 1981 ; after Pferdehirt and Kron, 1980). It is important to remember that such a district heating evaluation is not a detailed feasibility study, but rather an indication of whether such a study should be performed.

Major considerations in this evaluation include: the presence of a sufficiently cold climate (usually greater than 4,000 heating degree-days); the proximate location and suitable capability of the community's geothermal or other alternate resources in relation to the locations of its heating loads; and the presence of sufficiently high hourly and annual demands per unit of land area, so as to make distribution costs feasible and maximize system utilization.

The approach suggested for evaluating district heating potentials include: the identification and characterization of thermal zones, using the sector surveys from Section 2; the selection of a conceptual system design and budget, based on the heat

resources identified in Section 1 and the loads inventoried in Section 2; and a cost comparison of district heating versus conventional fuels, as described in Section 4.2 for individual users.

4.3.1 Identification of Thermal Zones

The composite heating load map from Section 3.5 should be used for estimating the thermal load density and load factor in each of the sectors.

Thermal load density is defined as the thermal load per unit of land area (expressed as Btu/hr/acre), and load factor is the ratio of total annual energy use to the total annual possible if the peak were supplied continuously for the year (see Lienau, 1981 for estimation methodology). The resulting estimates should be plotted on the composite heating map, showing total annual and peak hourly loads for each sector, and their thermal load densities and load factors. In addition, the time-based occurrence of peak loads developed in Section 3.5 should be plotted on a histogram as shown in Figure No. 4.

This comprehensive load map should then be screened to identify thermal zones, which are groups of contiguous neighborhoods which can be combined to achieve the thermal load densities and load factors required for district heating. Values of desirability in load densities, based on Swedish and U.S. studies, are given in Table No. 8 (Wahlman, 1978). Based on U.S. studies, a minimum feasible load factor for district heating is suggested to be 15% (Higbee, 1981). The tabulation of these estimates for a conceptual zone is shown in a worksheet in Figure No. 5.

These thermal zones will represent potential district heating market areas and should be further screened according to the following criteria: the zone should be reasonably close to a geothermal production field or other alternate heat resource, and have an unobstructed route between them; the combined peak load of the zone should equal a large portion of the thermal capacity of the zone's designated heat resource; the zone should either be the site of major new construction, or if not, retrofitting requirements for existing heating systems should be economically favorable; and the individual users in the zone should indicate a willingness to connect to district heating. This last criteria should be addressed by market analysis techniques subsequent to confirmation of the proposed system's engineering and economic feasibility.

The zones remaining after this screening should be mapped as shown in Figure No. 6, along with alternate heat resources. The matching of these thermal resources and zones will then allow a conceptual district heating design and cost estimate to be prepared.

Table No. 8

DESIRABILITY OF THERMAL LOAD DENSITIES FOR DISTRICT HEATING

<u>Type of Land-Use¹</u>	<u>Thermal Load Density² (MBtu/hr/acre)</u>	<u>Desirability for District Heating</u>
Downtown; high rises	> 0.97	Very favorable
Downtown; Multi-storied	0.70-0.97	Favorable
City core; commercial buildings and multi-family apartments	0.28-0.70	Possible
Two-family residential	0.17-0.28	Questionable
Single-family residential	< 0.17	Not possible

¹Land-use types are categorized to indicate general groups of desirability; local land-uses may have differing thermal load densities and district heating desirabilities; for example, improvements in distribution economics may make certain single-family areas eligible for district heating.

²Based on diversified peak hourly load.

Source: Wahlman, 1978

DISTRICT HEATING THERMAL ZONE WORKSHEET

THERMAL ZONE NO. (From Figure 16) 3 LAND AREA 71.85 acre

LAND-USE/BUILDING TYPE	ZONAL FLOOR SPACE (ft ²)	BUILDING TYPE HEATING LOAD FACTOR (Btu/hr/ft ²)	PEAK HEATING LOAD (10 ⁶ Btu/hr)	ANNUAL ENERGY USE (10 ⁹ Btu/yr)
RESIDENTIAL Low-density Moderate-density High-density COMMERCIAL INSTITUTIONAL INDUSTRIAL	2,116,666 N/A	33 Specific to process types	69.85	129.52
THERMAL DENSITY = $\frac{1.08}{1.08} \times 10^6 \text{ Btu/hr/acre}$ LOAD FACTOR = <u>0.21</u>	SUBTOTAL PEAK HEATING LOAD (PHL) = $69.85 \times 10^6 \text{ Btu/hr}$ TRANSMISSION & DISTRIBUTION LOSSES (+11% of PHL) = $7.67 \times 10^6 \text{ Btu/hr}$ TOTAL ZONAL PEAK HEATING LOAD (PHL) = $77.52 \times 10^6 \text{ Btu/hr}$		SUBTOTAL ANNUAL ENERGY USE (AEU) = $129.52 \times 10^9 \text{ Btu/yr}$ TRANSMISSION & DISTRIBUTION LOSSES (+11% of AEU) = $14.23 \times 10^9 \text{ Btu/yr}$ TOTAL ZONAL ANNUAL ENERGY USE (AEU) = $143.75 \times 10^9 \text{ Btu/yr}$	

(After Lienau, 1981; Pferdehirt & Kron, 1980)

4.3.2 Selection of Conceptual Design & Estimation of System Costs

Geothermal district heating systems are typically composed of: production, and sometimes injection, wells; wellhead and circulating pumps; distribution pipelines; heat exchangers (either central or single-building units); in-building heating systems; district system controls; and possibly heat pumps and peaking boilers to augment geothermal or other alternate resources as discussed above. These components can be arranged in a variety of configurations depending on local circumstances. The literature contains considerable information on system design (Anderson et al., 1979; Lienau, 1981; Ryan, 1981), and professional engineering advice should be sought in evaluating these options and selecting a conceptual design.

Once a design is selected its construction and operating costs can be estimated. Cost components for a geothermal system will typically include the following items:

Capital construction

- Well field development (siting, drilling, restoration)
- Wellhead and circulating pumps
- Optional peaking station
- Major transmission pipelines
- Lateral distribution pipelines
- Heat exchangers
- In-building retrofits
- System controls

Annual operation and maintenance

- Pumping electricity
- Well field maintenance
- Optional peaking fuel and station maintenance
- Pipeline maintenance
- Exchanger and control maintenance
- Debt Service

Cost estimates for these items will be extremely site-specific, although the literature does provide certain rule-of-thumb approaches (Lienau, 1981; EG&G Idaho, 1980). Local officials should utilize professional engineering assistance in developing these cost estimates.

4.3.3 Cost Comparison of Conventional Fuel vs. District Heating

The next step in evaluating district heating potentials is to compare energy unit costs, as was done with individual users in Section 4.2. The calculations described in Section 4.2 should be applied to the district heating case, and compared to the cost of the most predominant conventional fuels in the target thermal zones.

The result should be a comparison of first-year and twenty-year levelized costs for district heating versus conventional fuels. Where either first-year or levelized costs indicate a notable advantage for district heating, consideration should be given to conducting a detailed engineering, economic, and marketing analysis.

Such further consideration, assuming the initial evaluation is favorable, should be embodied in an overall development plan for district heating consistent with other thermal plan elements. Major considerations in formulating such a plan should be: a detailed verification of heat resources and loads; a similar confirmation of engineering and economic feasibilities, including the marketability of district heating; an analysis of growth trends in the community in order to forecast heat demands over time, and to plan accordingly for resource development and system sizing; institutional and environmental barriers to district heating; a determination of the most appropriate entity to construct and operate a system; and the enlistment of community support for a system through public involvement in the planning process (Allen, 1981).

4.4 RELATED GOALS & STRATEGIES

At this point, the major components of the heat atlas and plan have been completed. What remains to be accomplished is the formulation of supporting goals and policies to integrate the heat plan with related community actions.

These goals and strategies can be grouped into five areas as follows:

4.4.1 Institutional Responsibilities

Community action will require a clear assignment of institutional responsibilities among the various organizations which should be involved in thermal planning. Responsibilities for overall management, coordination, financing, and technical implementation should be distributed among local government units, energy utilities, private developers, and civic groups as deemed most appropriate by the community. These entities should form a team which can move towards common goals, especially a broad base of citizen support for energy improvements in the community.

4.4.2 Thermal Integration with Community Planning & Development

As noted at the outset of the guide, a primary objective of thermal planning is directing the community's built environment into a more energy-efficient size and shape, and allocation of land-uses. Thus, the community's controls over growth and redevelopment should include measures or criteria which conserve thermal energy and facilitate the introduction of alternate energy systems such as district heating. These policies should be embodied in the community's comprehensive plan, zoning and subdivision ordinances, and capital improvement program, as requirements and/or incentives for supporting the heat plan.

Such additional thermal planning measures can include the following examples:

Residential Land-Uses

- Designate multi-family uses to increase heat loads near heat resource sites, major institutional and commercial uses, and along district heating pipeline corridors.
- Increase allowable dwelling densities to achieve district heating load density requirements (see Table No. 9).
- Employ energy conserving siting standards which require or reward: common-wall construction; two-story dwellings; below-grade floors; wind-screening; passive solar orientation; and deciduous landscaping.
- Allow alternative uses such as home occupations, or small rentals in large single-family structures, to increase residential load densities and load factors.

Commercial Land-Uses

- Designate major commercial areas near heat resource sites, other large heating loads, and along district heating pipeline corridors, so as to minimize distribution requirements.
- Prohibit strip or linear commercial development which decreases load densities and increases distribution requirements for district heating.
- Employ energy conserving maximum limits on building height and bulk.

General Land-Use

- Designate areas near heat resource sites as priority growth or redevelopment targets.
- Discourage annexation and development of energy inefficient strips or fringe areas which contribute to sprawl and low densities; encourage in-filling of vacant interior lands in targeted thermal zones.
- Allow mixed-use zoning of various land-uses, so as to increase load densities and load factors, particularly in targeted thermal zones.
- Require or reward subdividing which clusters structures so as to increase load density and minimize energy distribution requirements.

The application of these measures to a conceptual community is shown in Figure No. 7.

4.4.3 Environmental & Resource Protection

The development and utilization of alternate heat resources should be consistent with community policies for environmental protection, and thermal plans must take into account areas or issues which have environmental sensitivity. In addition, the energy resources themselves will often require environmental protection to insure their long-term productivity.

In the case of geothermal utilization, the community should identify concerns and guidelines for the following environmental issues: release of airborne and water-borne effluents; noise; subsidence and induced seismicity; ground water impacts; and flora and fauna impacts. In addition, if large-scale use of geothermal reservoirs were to become a community goal, the long-term productivity of the resource should be protected by a reservoir monitoring and management program.

4.4.4 Public Information & Alternate Heat Marketing

The success of any community endeavor depends in large part on sufficient citizen awareness and involvement. This is especially true in the case of new programs, such as thermal planning, where public familiarity is low and support must be created through educational outreach efforts. General information can be disseminated through: neighborhood associations, merchant groups, local building designers and contractors, and the media. In addition to familiarizing the general public with thermal planning and alternate energy concepts, such outreach should be specifically targeted at prospective alternate heat users in order to achieve utilization goals. Likely targets will include: public and quasi-public institutional buildings; major industries; large commercial or residential projects under single ownership; and areas of redevelopment or new growth.

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