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COMPREHENSIVE COMMUNITY PLANNING FOR ENERGY MANAGEMENT AND CONSERVATION

FIRST
INTERIM REPORT
HIT-693
VOLUME I - TECHNICAL REPORT

April 1977

Prepared Under
U.S. Energy Research and Development Administration
Contract No. EC-77-C-10-0023

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HITTMAN

ADDENDUM

This addendum, to Report HIT-693, "Comprehensive Community Planning for Energy Management and Conservation" (First Interim Report), has been provided to summarize the comments made by the project Evaluation Panel on the content and format of the report, and the overall progress and direction of the study. The comments discussed in this Addendum were made at the project Evaluation Panel meeting, which was held on April 12, 1977. Attendies at that meeting are listed in Attachment 1.

Overall, the Evaluation Panel members' opinions of the report were very favorable. The general opinion of the Panel members was that the report was very comprehensive, and that the amount of work exhibited was substantial, in view of the time elapsed thus far on the contract. The group, however, did provide a thorough and critical review, and from that review several comments/suggestions were made which will assist the project team in focusing the remaining work, and assuring that the end products of the study will have a high degree of utility for their intended users.

In this Addendum, the major comments of the Evaluation Panel members are discussed in four sections: General Comments, Comments on the Community Characterization Procedure, Comments on the Energy Analysis Procedure, and Comments on the Application Framework. Within each of these sections, each major comment is stated in summary form, and the project team's response is then provided.

A. General Comments

Several comments were made which did not relate to any particular technical section of the report, but rather to the project as a whole. These are discussed below:

COMMENT: The report should more strongly reflect the perspective of a practicing planner.

RESPONSE: An extensive interaction with the "user community," to provide review and feedback on the utility of project outputs, has been scheduled as an important phase of the project. As indicated in the original Project Work Plan, this activity is accomplished in Work Area 400, Assessment and Refinement. Specifically, the project team has decided to identify a sample of community planners which may be typical users of the project's outputs, and to consult with these individuals to determine what the precise nature of their work is, what their primary requirements are in the area of energy analysis capability, and for what types of applications would they be most likely to use the project's outputs. In the course of this consulting activity, first skeleton drafts or summaries of the project outputs will be developed. Subsequently, a user panel will be convened to review and comment upon the format, structure and content of the planned outputs. This activity will be accomplished during the month of May.

COMMENT: The length and complexity of this report would intimidate its users and possibly deter from its usability.

RESPONSE: This comment is more germane to the development of user documentation than to this first interim report. It should be recognized that this report is oriented for the client, ERDA, rather than for the ultimate users. As such, it is basically an expository document, designed to show the full range of factors considered. It is intemded that actual user outputs will be significantly briefer, and structured such that, depending on the user's particular application, much of the detailed information can be avoided.

COMMENT: Community growth and development is essentially a marginal process, and the majority of applications to which the methodology would be put would involve a planner trying to assess the energy impacts of competing marginal development alternatives. On the basis of this, the project, and the report, should emphasize the analysis of marginal impacts rather than comprehensive planning.

RESPONSE: The methodology provides amply for both marginal impact analyses and comprehensive planning. In the report, six typical applications of the methodology are presented. Of these, three are marginal impact assessment schemes. If, in the course of the upcoming user interviews, it becomes obvious that marginal impact assessment is the overwhelmingly most likely use of the tools, then the project outputs will be modified to place additional emphasis on marginal approaches and less on comprehensive ones. Furthermore, the project team will consider separately binding that portion of the methodology which deals with marginal impact assessment, in a smaller user manual, for the purpose of increasing its accessibility.

COMMENT: The methodology for energy impact assessment was very complex, and as such, the cost of making the assessment may be larger than the value of any energy savings obtained through using the methodology.

RESPONSE: The issue of complexity in this report has been previously addressed. As stated above, this report is not intended as a user document, but as an exposition of concepts for the client. Obviously, user manuals will be ultimately developed, and will emphasize simplicity and ease of use. Furthermore, in connection to the question of the cost of impact assessment, and the relationship of those costs to the value of energy resources saved, it is unlikely that the cost of impact assessment would be greater than that of the resulting energy savings, because the impact assessment is a one-time cost, while the energy savings are recurrent through time. In addition, it should be noted that the real cost of several energy forms is rising, and is predicted to continue rising, at a faster rate than the cost of the labor required to perform the analysis.

COMMENT: Consideration should be made of the cost of making the energy impact assessments prescribed in the methodology, and specifically, to what degree would making such assessments increase the cost of development or construction.

RESPONSE: All efforts are being made to keep the methodology steps, at the planner level, very simple and straightforward. When the final methodology is fully developed, and testing completed, quantitative statements about its impact on the cost of development may, and should, be made.

B. Comments on the Community Characterization Procedure

The following comments were made which were specifically related to the Community Characterizations Procedure (CCP):

COMMENT: Use of the CCP may require the obtaining of secondary data from sources not familiar to the users.

RESPONSE: In the development of user manuals, whenever data input is required, suggestions will be included regarding generally where and how the data may be obtained. It is not expected that familiarity with data sources will become a problem, however, as the methodology is being developed specifically to use data from sources with which planners are familiar.

COMMENT: In using the Physical Characterization Procedure, which presents average values for estimating parcel level land use descriptions on the basis of more gross measures, the inaccuracy introduced by using such averages may be larger than the energy impacts which this methodology is intended to measure.

RESPONSE: Whenever a mean, or average value is presented in the CCP, three other types of information will be presented with it. First a description of the parameter, and how it is calcualted, will be presented. From this, the user may re-construct the parameter with data specific to his locality. Second, the source of the parameter will be cited, and the sample from which the parameter was estimated will be described. From this, the user may determine to what degree his community is like, or unlike, those communities from which the parameter was calculated. Third, a range of accuracy will be associated with parameters given, such that the user may know, quantitiatively, what degree of error was introduced by using the parameter. Where this qualifying information is not available, numerical parameter values will not be provided, so that no false sense of accuracy will be introduced. The validity of this approach will, of course, be evaluated during the Assessment and Refinement phase and the Test and Evaluation phase.

C. Comments on the Energy Analysis Procedure

The following comments, and their discussion have been presented with respect to the Energy Analysis Precedure:

COMMENT: There appears to be a major ambiguity in the problem as stated by ERDA, and that this ambiguity is confusing the direction of the project. Specifically, the lack of definition of target communities has forced the development of tools which have broad applicability. But, to attempt to provide something which is somewhat useful for all communities may result in a product which is highly useful for none. Furthermore, the emphasis placed on tools for use by ATMES, ACUCS, and other ERDA research programs appears to be inconsistent with the overall goal of assisting practicing planners.

RESPONSE: The project team, in response to ERDA previous comments, is continuing to place emphasis on the development of the methodology and analytical tools for use at the planner level. At the energy analyst level, emphasis is continuing to be placed on the demand estimating techniques. These two areas of emphasis are reflected in the fact that the full scale test of the methodology on a real community will be done at the planner level. The demand profiles, while they will be individually verified, will not be field-tested in aggregate during this phase of the project. This is due, in part, to the fact that a full scale test of the profile generating algorithms requires full computerization of the procedure, which is beyond the scope of this phase of project.

COMMENT: Due to work currently under way at the National Laboratories, at ERDA, and among ERDA's various contractors, it would be redundant and unnecessary for this project to attempt developing energy balance algorithms, or algorithms which simulate energy supply and distribution networks.

RESPONSE: As ERDA has previously expressed, a central need of their overall research program is for good methodologies to estimating community energy demands. Other researchers, however, have already accomplished more work on the simulation of supply systems and the balancing of supplies and demands than could be accomplished using the resources of this project which are available for that task. Thus, it has been decided to concentrate efforts of this project on developing the demand-side methodologies.

D. Comments on the Application Framework

The following comments and discussion relate specifically to the Application Framework, as presented in the First Interim Report:

COMMENT: When considering an action alternative, option, or policy, the practicing planner would first make a "quick" implementability assessment, then make a detailed quantitative impact assessment, and finally make a thorough implementability assessment. It was suggested that the AF incorporate the quick implementability assessment as one of the initial steps.

RESPONSE: This comment will be brought to the attention of the practicing planners in the forthcoming round of consultations, and if it proves to be the case, the AF will be modified accordingly.

COMMENT: The list, or "catalog," of energy conservation options for planners should be organized to reflect the particular areas where the planner has leverage or control.

RESPONSE: This approach will be taken in structiuring the user manuals.

COMMENT: Along with each conserving option specified, the unit energy savings impacts should also be given, to allow very "quick and dirty" analyses of potential energy savings.

RESPONSE: This data will be provided, on a per-unit affected basis, wherever possible.

COMMENT: The presentation of the methodology in any type of user manual should include a series of worked out examples for typical applications.

RESPONSE: This approach has always been planned, as part of the user manual development, and this comment reaffirms the validity of that plan.

COMMENT: The project team should consider deleting all decision aids in the AF, such as the method for preliminary selection of alternatives, and the method for ranking, comparing and selecting from among those alternatives which had been evaluated. The rationale for this was that practicing planners already had ways of making decisions, and would regard our methods as somewhat presumptuous. Thus, the implication was that the project team should concentrate on accurate impact assessment and de-emphasize decision-making aids.

RESPONSE: The Evaluation Panel did not achieve a concensus opinion on this point. Some felt that the decision making aids were important, though the specific form of the aids presented in the report may require some refinement. The outcome of the discussion was to leave them in the report until the user consultation, then let the users comment on their utility. It was also agreed to de-emphasize the precise form or techniques presented, and to concentrate simply on the need for the activity, in one form or another. Reference was also made to the extensive literature on multi-attribute decision making tools which currently exists.

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The views and conclusions contained in this document are those of the authors and should not be interpreted as necessarily representing the official policies of the U.S. Government.

ACKNOWLEDGEMENTS

The studies reported in this document have been a team effort, in the truest sense. The highly interdisciplinary nature of this project is such that no single organization could do it alone. At every step, close coordination between engineering, social science, financial, and planning experts has been imperative. For this reason, Hittman Associates, Inc. gratefully acknowledges the cooperation and participation of all the project team members.

The project team which has performed this work has included Hittman Associates, the prime contractor, three organizations which have served as subcontractors, and four organizations which have served as consultants. The subcontractors have been:

Real Estate Research Corporation, Inc.
RTKL Associates, Inc.
Mathtech, Inc.

The consultants have been:

Fuel and Energy Consultants, Inc.
American Society of Planning Officials
Environmental Law Institute
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In addition to the members of the project team, Hittman Associates wishes to acknowledge the guidance and support provided by the ERDA Community Systems Branch personnel, including Messrs. Isiah Sewell and Steven Carros, as well as the project technical monitor, Mr. John Tschanz of Argonne National Laboratory.

ABSTRACT

This document is the first interim report of work performed under the Comprehensive Community Planning for Energy Management and Conservation project. This project has been supported by the Energy Research and Development Administration, Office of Conservation, Community Systems Branch. This report documents results of the first four months of effort on this project.

The objective of the project is to develop a methodology which will enable community planners and/or energy analysts to evaluate the impact of proposed planning measures on the energy use and supply patterns existing in the community. To do this, the project team is developing an overall methodology, and two major analytical tools which are used within that methodology. The overall methodology contains guidelines for examining existing energy usage and supply patterns in the community, defining community energy goals, and identifying action alternatives which are capable of achieving those goals. Once action alternatives are identified, the two analytical tools are used to evaluate the alternatives. The first analytical tool, the Community Characterization Procedure (CCP), enables the user to estimate the likely impact of proposed alternatives on the physical makeup of the community. The second analytical tool, the Energy Analysis Procedure (EAP), enables the user to quantitatively analyze the impact which anticipated physical changes will have on the energy usage and supply patterns existing. When the physical and energy impacts of proposed alternatives are determined, the methodology then provides the user with guidelines for assessing the implementability of alternatives, ranking and comparing them, and making a final selection of action items.

This report presents the results of a survey of current knowledge, which has been done prior to initiating conceptual work on the development of the products mentioned. It also presents the results of the initial conceptual efforts.

In the development of the overall methodology, the conceptual work reported here includes preliminary work on providing guidelines for performing a baseline community energy use audit, developing and selecting community energy goals, identifying and classifying possible action alternatives, assessing their implementability, and comparing and ranking them.

In the development of the Community Characterization Procedure, this report presents a preliminary method to classify and describe a community's physical makeup, which bridges the gap between land use categorization and energy analysis. It also presents a preliminary description of how community

decision making processes operate, and a description of how their operation may ultimately (or immediately) affect energy use patterns. It further presents preliminary concepts on how the planner, through an analysis of the various decision making processes, may develop an estimate of the possible range of physical impacts associated with an action alternative which is being considered.

In developing the Energy Analysis Procedure, this report presents the preliminary selection of energy using activities which will be included in the analysis procedure. It presents preliminary concepts on how the energy use patterns associated with each activity will be quantified, and how these quantitative patterns will then be summed up to represent the overall community energy use patterns.

The remaining ten months of effort on this project will include completion of the conceptual development, data collection, conceptual and field testing, user assessment, and the development of recommendations for future research.

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I. INTRODUCTION

Land and energy supplies are two of mankind's most fundamental resources. Land provides the base from which all of man's activities arise. Energy is the driving force for those activities. The way land is used has a direct impact upon the way energy is used. This fact has been thoroughly documented through research, though it has long been obvious to any commuter who drives an automobile forty-five miles to work each day. In recent years, as certain energy forms have become scarce, and as all energy forms have become more costly, man has been forced to take a serious look at all of his activities, and scrutinize them in terms of the efficiency with which they use energy. In doing so, one fact has become painfully clear: throughout the course of modern history, due to the fact that energy has been relatively inexpensive, man has arrayed his activities over the land in such a way that a large, and ever-increasing, amount of energy is required to support those activities. Little can be done to change the past. The energy efficiency of specific activities can be improved in a variety of ways, and measures to induce those improvements have been developed, and, in some cases, implemented. But the actual spatial arrangement of activities is fixed. Thus, the main opportunities for reducing energy use through the spatial arrangement of activities lie in the redevelopment of previously developed areas, and in the wise development of previously undeveloped areas. Both of these functions normally fall within the responsibility of community planners and decision makers. Planners plan, or propose, the spatial arrangement of activities (or activity types). Decision makers, such as mayors, city councils, city managers, etc., normally review the proposals of planners, and with the input of various citizen groups, either adopt or reject the plans proposed. If the array of human activities upon the land is to be fashioned in a way which lends itself to a more efficient utilization of energy, then it will be necessary to endow community planners and decision makers with an understanding of the relationships between land use and energy use. In the broadest sense, this is the purpose of this study.

A. Objectives

As mentioned above, in the broadest sense, the objective of this study is to provide community planners and decision makers with an appreciation for the energy use implication of various land use patterns. The approach to this task is a pragmatic one. The study and its products will provide some basic information which will be educational to planners and decision makers, but its main thrust will be to provide usable, practical tools which can be used to evaluate the energy use implications of land use alternatives. Development and use of such tools will allow more energy-efficient urban spaces to be designed for the future, and will allow planners to include energy use considerations in their overall comprehensive planning processes.

This study represents one part of ERDA's overall energy conservation research program. The overall program involves conservation research in the areas of building design and use, transportation, and industrial processes. The Community Systems Branch of ERDA is directly responsible for initiating and funding this research.

On a more specific level, this study has been initiated in order to develop three major products. These products are:

- An overall methodology which community planners, decision makers, or energy analysts can use to incorporate energy considerations into the planning process;

- A pair of analytical tools to be used as part of the methodology developed. The first of these tools is one which enables its user to develop estimates of the changes in the community's physical composition, structure, and form which would ensue from various planning actions; and

- The second of which would enable its user to estimate the changes in energy use patterns which would result from the changes in physical composition, structure or form described above.

In producing these three major outputs, it is intended that this research will serve several purposes. These are:

- It will provide a useful methodology for energy and land use planning, which will include analytical tools which may be used at a rather general level for purposes of policy decisions and the evaluation of energy conservation programs.

- It will provide the same methodology and analytical tools, which may also be used at a very detailed level, to provide information which would enable the design or optimization of utility systems, or the detailed evaluation of policies or programs designed to achieve a community's energy use goals.

- It will build upon previous work in this field, and provide a basis for further work.

- It will provide a useful research tool for the other research projects under the ERDA Community Systems Branch.

- It will allow and enable communities to identify and quantify their energy conservation potential, and thus demonstrate the validity or applicability of other ERDA Community Systems research outputs (such as the Advanced Coal Using Community Systems project, the Advanced Technology Mix Energy Systems project, or the Community Annual Cycle Energy Systems project), thus aiding in the commercialization of these RD&D outputs.

With these products and goals in mind, the following section presents an overview and description of the study's products and their interrelationships.

B. Products and Interrelationships

1. Potential Users and Their Needs

For the purpose of this research, three classes of users have been identified. These classes are:

- Communities which have small planning staffs with generalized capabilities, and which have little resources or expertise to be applied to energy planning.
- Communities which have large, sophisticated planning staffs and considerable resources to devote to energy planning
- The ERDA research community, which, in its overall research activities, is involved in the development of numerous concepts for community energy supply systems, and which is in need of a reliable method to estimate community energy demands.

Each of these user groups has needs, which, in theory, will be served by the products of this research. The following is a brief summary of the needs of each of the three user classes identified.

a. Small Communities. The first class of users described above are small communities with small planning staffs and relatively small budgets for energy planning. Such communities would typically be those with 25 to 50 thousand people. Based on the resources, level of expertise, and level of complexity of such communities, it is felt that their main need would be to have a methodology which included the analytical capability to:

- Take stock of existing energy use patterns, in terms of annual use of each major energy form, in the community;

- Use the results of this "energy audit", in conjunction with other inputs and constraints, to identify a set of broad energy-related goals for the community;

- Develop a series of action alternatives which will be capable of achieving the stated goals;

- Examine each alternative and determine what the physical impacts of its implementation would be on the community;

- Estimate the resulting energy use patterns, and their differences from the community's "baseline" energy use patterns; and

- Weigh the advantages and disadvantages of each possible action, as the basis for a final action plan for achieving the energy goals stated above.

b. Large Communities. The second user class described was large communities. This category of community may have a reasonably diversified planning staff and may already have developed a sensitivity to energy issues. Based on the complexity, resources, and expertise in such a community, it is felt that this class of community would make the best use of a methodology which included the analytical capability to:

- Develop a baseline energy use picture of the community at a very detailed level, including hourly energy demands for each end use of energy;

- Use this baseline, and other information, to develop goals and action alternatives, just as the smaller communities might do, but at a more detailed level;

- Estimate the physical impacts of alternative actions;

- Estimate the energy use patterns of the community if the action alternatives were implemented; and

- Weigh the advantages and disadvantages of actions considered, and develop an action plan for achieving their goals.

The similarities between the two sets of needs for the large and small communities are apparent. This is because the processes used are basically the same, differing mainly in the level of detail of inputs and outputs, and the level of alternative or actions which may be analyzed. For the small community, the methodology would have the analytical capability to estimate annual energy use by energy type. For the large community, hourly profiles for each energy using activity would be produced, and these would be matched up against supplies on an hourly basis (except for gasoline used in transportation), and the resulting primary energy use information would be reported. This implies a wider range of action alternatives which may be considered. These may include:

- Complete energy system analysis
- Peak load management schemes
- Development of municipal utility systems
- Development of integrated industrial parks
- Waste heat recovery and utilization
- District heating and/or cooling systems

c. ERDA Research Community. The final class of users identified above was the ERDA research community. This group includes the complete range of researchers in the Federal government, the national laboratories, and the various contractors which are currently engaged in community energy systems research. Many of these are currently researching alternative, advanced, or optimized energy supply technologies for use at the community level. A major need of these projects is an accurate, reliable technique for predicting hourly system energy demands, based on community descriptions and climatic variables. These hourly demands are needed to:

- Optimize the design of community energy supply system;
- Demonstrate the commercial applicability of the technologies developed; and
- Identify the potential for energy storage, fuel substitution, and other energy management schemes.

With these users and user needs in mind, the following section states and describes the anticipated products of this research.

2. Description of Products

a. Preliminary Concepts. The energy use patterns within a community result from the interaction of a variety of factors. Broadly stated, the energy use patterns depend on the amount and types of activities which exist in the community, and the climatological and topographical environment in which these activities are undertaken.

The climatological and topographical environment is not easily modified. The amount, arrangement, and types of activities, however, is, to some degree, controllable. Community energy planning, then, must concentrate on ensuring that the amount, arrangement, and types of activities in the community are such that efficient utilization of energy is achieved. A major goal of this research, then, is to provide planners and decision makers with an understanding of the relationships between the amount, type, and arrangement of activities, and the energy use patterns which they cause.

In approaching this task, the amount, type, and arrangement of activities (which, together with climate and topography, determine energy use) have been conceptually viewed as depending on two classes of variables. These classes are called physical variables and behavioral variables. Physical variables are those which indicate the types of facilities, structures, or equipment present in the community. Behavioral variables incorporate the full range of decision making processes which govern both the amount and kinds of facilities, structures, or equipment which are present, and the manner in which these facilities, structures, or equipment are used.

Two examples will serve to clarify these concepts. In an existing community, there exists a mix of housing types. These housing units are heated and possibly cooled by a mix of equipment types. Furthermore the residents of the community have certain travel patterns, which are accomplished by using a certain mix of transportation equipment. Clearly, the energy needed to live and travel depends on the types of housing, heating and cooling equipment, and transportation equipment. But the energy needed to live and travel depends also on the behavioral patterns in the community. The thermostat settings, the amount of ventilation used, or the travelling habits govern the use of energy to the same degree as the mix of physical facilities or equipment does. Thus, it can be seen that for the existing community, energy use depends on physical and behavioral variables as well as climate and topography.

If the existing community is viewed from a more dynamic perspective, it becomes clear that energy use patterns of the future depend on the same classes of variables. Future energy use will depend on the physical variables at that time, such as the mix of housing types, heating and cooling equipment, and transportation equipment present at that time. It will also depend on the behavioral variables at that time, i.e., how the physical facilities and equipment are used. But the way in which the mix of facilities and equipment in the future differs from that of the present also depends on a set of behavioral variables. These include the decisions to locate and build houses of various types, decision to purchase autos of various types, or decisions to locate and build industrial facilities of various types.

Summarizing this discussion, then, it can be stated that energy use at any time depends on physical variables, such as the mix of facilities and equipment, as well as behavioral variables, or decisions to operate. Furthermore, energy use at some future time depends on how the physical variables will have changed by that time. This implies considering behavioral variables associated with growth, or decisions to develop. Consideration of decisions to develop will help define the physical variables in the future. These physical variables, in conjunction with the decisions to operate in the future, will determine energy use in the future.

To place these concepts in the context of community energy planning, it can be stated that to determine the energy use patterns of the existing community, the planner must consider physical variables and behavioral variables associated with decisions to operate. When community energy goals are determined, and action alternatives are specified to achieve those goals, then the planner must evaluate the energy patterns associated with the community's form as impacted by the action alternatives proposed. To do this the planner may be required to assess both physical and behavioral impacts. Furthermore, in assessing the behavioral impacts, the planner may have to address both those associated with operation and those associated with development. It is anticipated that the products of this study will provide the user with guidelines to assess both physical and behavioral impacts of proposed actions, and from these, to assess the changes in energy use patterns which would result.

As mentioned in the previous section, the anticipated products of this research are three. The first is an overall methodology which would enable planners, decision makers, or energy analysts to evaluate the probable energy use implications of various land use patterns. The second and third are analytical tools to be used within the methodology. Together, they provide the methodology with its analytical capability. One of these tools is a primarily qualitative procedures which enables its user to characterize the existing physical and behavioral patterns within the community, and also enables its user to estimate the probable changes in the community's physical and behavioral structure which may result from actions proposed. The other tool is a primarily quantitative procedure which enables its user to estimate the changes in energy use patterns which would result from the physical and behavioral changes anticipated. The following paragraphs briefly describe each of these products.

b. Generalized Description of Energy Planning Methodology. Figure 1, below, shows a schematic illustration of a generalized methodology for energy/land use planning. As the

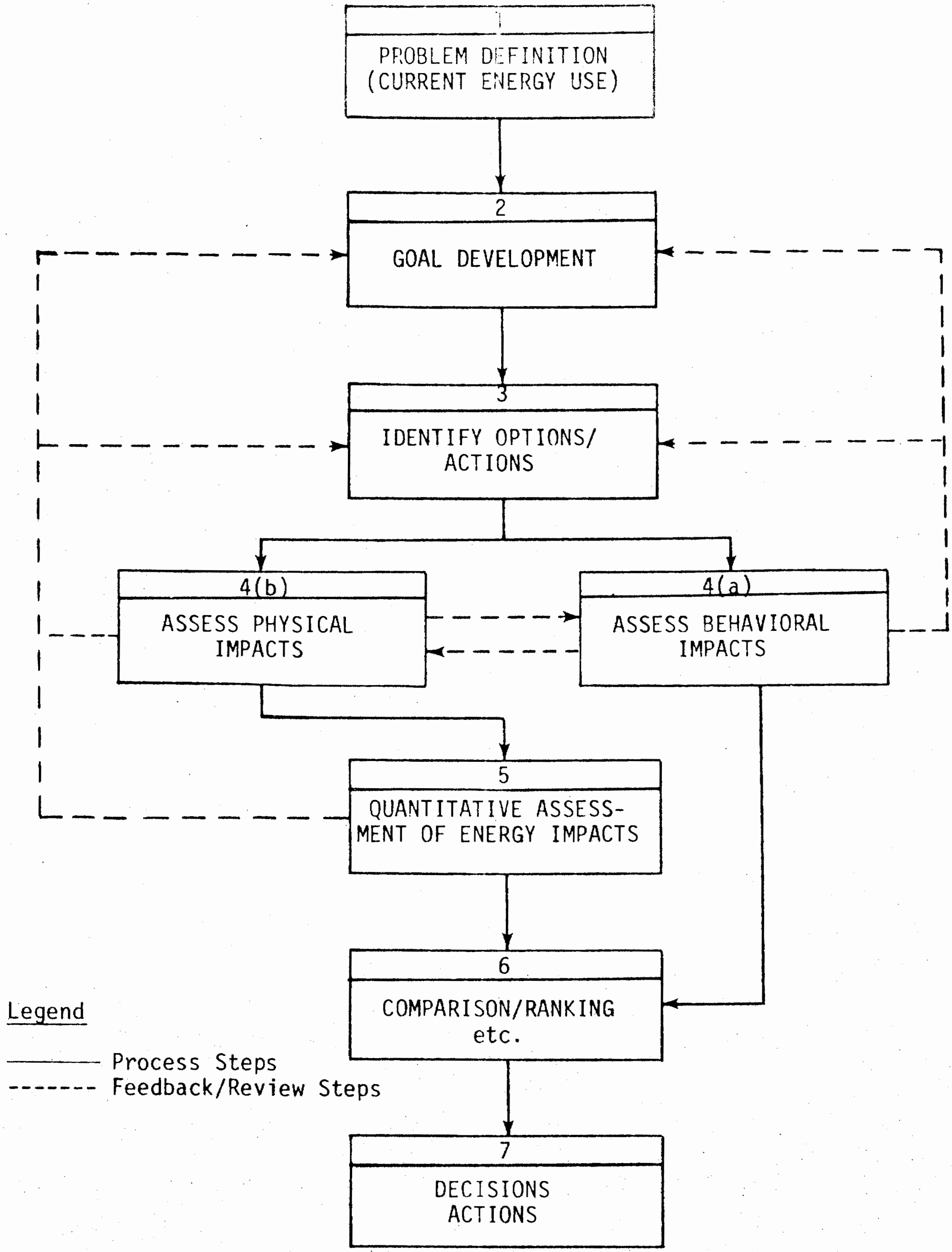


Figure 1. General Description of Energy Planning Methodology

figure shows, the process begins with an evaluation of current energy use patterns. This evaluation helps define and focus the problem. The next two steps involve the development of goals, and the identification of action alternatives to achieve those goals. Goals are defined here as rather broad statements of intent or policy. Typical goals might be:

- To reduce overall energy use in the community,
- To alter the mix of energy forms used in the community,
- To make improved use of power generating capacity (i.e., reduce peak demands, or improve load factor).

Action alternatives on the other hand, are defined here as fairly specific statements of intended actions. These might include:

- Modify zoning and density specifications of all unused land such that all future residential construction would be multi-family residences,
- Modify building codes such that all new residential construction would require R-13 insulation in the walls, and R-20 in the roofs;
- Require that lighting in municipal buildings be reduced by 50 percent during unoccupied hours;
- Increase the real estate assessment rate and/or tax rate on new single family detachec residences by 25 percent each.

As Figure 1 shows, the next step in the process woulc be to assess the physical and/or behavioral impacts of the action alternatives selected. From the example actions listed above, it can be seen that the actions listed would probably have both classes of impacts. The zoning and density changes would have the direct physical impact of modifying the future mix of housing types. It would also have some effects on the marketplace by essentially "outlawing" single family detached residences.

These market effects would eventually translate into physical effects. For example, the zoning change would alter the mix of housing units, but in the longer term, it may also reduce the growth rate of housing in general. The change in real estate assessment and/or tax rates would have nc direct physical impact, but would effect the decision to purchase (a behavioral, or market, mechanism), and this would ultimately translate into physical impacts. Based on this discussion, it can be seen that the methodology must provide some way of:

- Tracing the direct physical impacts of measures undertaken,
- Tracing the direct behavioral impacts of measures undertaken,
- Tracing the interaction between physical and behavioral impacts, and the ultimate physical manifestation of these interactions.

Once the measures considered have been translated into a reasonable range of likely physical impacts, the methodology must be capable of assessing the energy use impacts associated with the physical changes specified. This procedure is basically a set of engineering type calculations which must be made by the planner. The energy used will be a function of a number of physical and behavioral parameters, including construction practices, life styles, local climatic and topographic conditions, etc. When these calculations are completed, the planner will have an idea of the energy use associated with the revised "picture" of the community, which he created by tracing the impacts of some proposed actions.

The final steps in the methodology are the comparison, ranking, and decision-making steps. Here the planner would compare the energy use patterns of the community, as modified through the implementation of some action alternatives, with that of the "baseline" or unmodified case. If several alternatives were being considered, the comparison against baseline conditions would be made for each. Taking the energy impacts into consideration, along with other goals and constraints which the planner must consider, the planner would then rank the options and develop an action agenda.

It should be noted that Figure 1 also indicates several "feedback" steps. The assessment of physical impacts may cause a re-evaluation of the goals or actions selected. The assessment of behavioral impacts may also cause a re-thinking of goals and actions, and it may also bear upon the comparison and ranking. The quantitative assessment of energy impacts may likewise necessitate a re-evaluation of the goals and actions.

Based on the above discussion, it can be stated that the methodology to be developed has three main parts. These are:

- A procedure for determining the most likely range of physical impacts resulting from proposed actions

- A procedure for assessing the energy use patterns of the community based on its physical description

- An applications framework within which these two procedures would operate. This application framework mainly consists of guidelines for developing goals and actions, and guidelines for performing the ranking, comparison, and ultimate selection of actions for implementation.

One of the central concepts of this project is that, due to the variety of users and their needs, certain of the tools will be developed such that they are operable at either of two levels. One level, called the "planner level" is fairly coarse and only includes annual energy use, while the second level, called the "energy analyst level" is quite detailed and includes hourly energy demands and supplies. Keeping this in mind, a precise statement of the project outputs can be made.

c. <u>Community Characterization Procedure</u>. The first major output of this project will be an analytical tool referred to as the Community Characterization Procedure (CCP). This procedure will be a rational way of describing the physical and behavioral structure of the community. Its main function will be to provide the user of the methodology with a way to take action alternatives, such as a change in the tax structure, and determine what the most likely range of physical impacts from that change will be. This is a crucial link, since the energy impacts of any action can only be determined once the likely physical impacts are specified. This procedure will be capable of operating at both the planner level and the energy analyst level, with the major difference being the level of detail required for inputs, and the accuracy and detail of the outputs. A detailed discussion of the CCP, and its operation at either level, is presented in Chapter II, Section C.

d. <u>Energy Analysis Procedure</u>. The second major output of this research will be an analytical tool referred to as the Energy Analysis Procedure (EAP). This procedure, also, will be developed to be operated at either the planner level or the energy analyst level. When operated at the planner level, it treats the community as an aggregation of land uses, referred to as parcels. A parcel is a particular land use type (such as a single family detached residence), which may incorporate a number of energy-using activities. Associated with each parcel is an energy intensity factor (EIF), which is basically the average annual energy use associated with each parcel, or land use type. The EIFs will, of course, be location specific. But in general, the energy use on an annual basis will be found as the sum of products of the number of each type of parcel and the EIF of the parcel type.

At the energy analyst level, the EAP operates quite differently. At this level, energy use is considered to a degree more specific than the parcel. In the analyst mode, the EAP uses the End Use Mode (or EUM) as the fundamental unit of disaggregation. The end use modes are specifically defined ways of using energy. An end use mode is defined by the specification of four parameters. These include the parcel, activity, equipment, and energy form. The parcel, as described above, is the land use type on which energy is used. The activity is the actual functional use of energy, such as space heating, lighting, etc. The equipment specifies the means of end use conversion, such as oil-fired furnaces. The energy form, finally, is the actual energy form used at the end use point - i.e., electricity, oil, gas, coal, etc. For each EUM the EAP, when used at the energy analyst level, provides an algorithm which generates a year long, hourly profile of energy demand for one typical occurrence of that EUM. After all these profiles are generated, the EAP then employs statistical techniques to amplify the profile for a single EUM to a profile which represents the yearly demand of all EUMs of that type in the community. From all the amplified EUM profiles, the EAP will aggregate the profiles over each energy form, to develop an aggregate profile for each energy form used. It should be noted here, that for analysis purposes, it may be desirable to aggregate the amplified profiles in some intermediate way before aggregating over energy forms. For instance, it may be desirable, from a policy standpoint, to aggregate over land use categories, such as residential, commercial, industrial, etc. This would be accomplished easily by various summations. On the basis of this, the EAP will ultimately report the energy requirements for the community. The structure and operation of the EAP, at each of the two levels, will be described in more detail in Chapter II, Section D.

e. <u>Application Framework</u>. The third major product of this research is referred to as the Application Framework. This is the methodological framework in which the two analytical tools (the CCP and the EAP) are used. This framework will consist of a set of guidelines for the user to follow in terms of performing a baseline community energy audit, developing energy goals, developing a set of actions for evaluation, preparing the statement of action alternatives for input to the CCP, evaluating the action options in light of the outputs of the EBP and CCP, ranking and comparing the action alternatives, and making the final selection of actions for implementation. Unlike the two analytical tools, the application framework is not developed for use at two levels. It is felt that the activities in the areas of goal development, option identification, result evaluation, option ranking, and selection are all reasonably similar at the planner level and the energy analyst level. Thus, the application framework will be used similarly for either level of application, and only the CCP and EAP components will change, based on the level of application.

To summarize the description of the products presented in the preceeding pages, then, it is anticipated that the study will result in one methodology for energy/land use planning. This methodology will incorporate three parts: the Community Characterization Procedure, the Energy Analysis Procedure, and the Application Framework. The methodology may be applied at either of two levels, a planner level, or an energy analyst level. When applied at the planner level, the methodology makes use of the Application Framework, and uses the CCP in a very general way, producing impact predictions at the parcel level, which are then used by a simplified version of the EAP, which contains annual energy intensity factors, to calculate energy use impacts on an annual basis. When used at the energy analyst level, the Application Framework is again used, and the CCP is used in a detailed manner, to produce physical impacts which are translated into end use modes for use by the detailed EAP to calculate hourly energy demand, hourly energy supply, and primary energy requirements. At both levels, the Application Framework, then, assists the user in interpreting and evaluating the analytical results, and ranking and selecting actions for implementation. It should be noted here that at the energy analyst level, the EAP will require the use of a digital computer.

In Chapter II a detailed discussion of the CCP, the EAP, and the Analytical Framework are presented.

C. Technical and Management Approach

To accomplish this work, a technical work plan was developed which consisted of eight technical work areas. Each of these work areas represents a major area of effort which follows a systems analysis approach to achieve the project objectives. A series of tasks is delineated within each work area. These tasks detail the procedure to be used in accomplishing the objectives of each work area. The following is a brief summary of the technical objectives and approaches in each work area.

1. Major Work Areas

The research has been divided into eight technical work areas, which are groupings of technical tasks. The work areas and associated tasks include:

a. Work Area 100 - Survey of Current Knowledge. The purpose of Work Area 100 is to delineate the state-of-the-art of community energy planning. This work area sets the foundation for the remainder of the project. The two tasks within this work area include a survey of the literature (Task 110) and a series of contacts with knowledgeable people in the field (Task 120).

b. Work Area 200 - Concept Definition. The objective of Work Area 200 is threefold:

- Conceptualization of a procedure to characterize a community for energy analysis purposes (Task 210);
- Conceptualization of a procedure to allow for the quantitative determination of community energy demand and supply requirements (Task 220); and
- Conceptual development of the application framework for using the analytical tools developed.

This work is central to the remainder of the project. The conceptual formulation of the Community Characterization Procedure (CCP) and the Energy Analysis Procedure (EAP) will be further refined, analyzed, and evaluated throughout the remainder of the project. Within this work area the critical variables will be identified (Task 230) and data requirements will be defined (Task 240).

c. Work Area 300 - Data Collection. Work Area 300 includes tasks related to the development of data collection procedures for the CCP, EAP, and the Application Framework (Tasks 310 and 320). Representative data will be collected for calibration and application purposes in Tasks 330, 340, 350, and 360. The collection of this data will be based on the results of Tasks 310 and 320. It should be stressed that this data will be used for preliminary testing and data will be obtained only from easily accessible sources.

d. Work Area 400 - Assessment and Refinement. Work Area 400 provides for the preliminary testing and assessment of the CCP and EAP. Subsequent to the preliminary testing, a cross section of planners will be contacted regarding the feasibility of the CCP, EAP, and Application Framework (Task 440 and 450). Based on the results of this user assessment, the CCP and EAP will be refined and modified.

e. Work Area 500 - Test and Evaluation. The purpose of Work Area 500 is to perform a full test and evaluation of the Energy Analysis Procedure (EAP) and a further check on the Community Characterization Procedure (CCP). In this Work Area, field testing of the EAP will emphasize its use at the planners level. In order to develop a fully tested methodology ready for use by practicing planners this site-specific test will be made. At the energy analyst level, profiles will be be individually verified, but the aggregated community-wide demand profiles will not be field tested until the entire system is computerized. It is anticipated that this will be done under a later phase of this project. This work area includes a task related to selecting a test site (Task 510) and collection of test data (Tasks 520 and 530).

The CCP will be tested and evaluated in Task 520. The EAP will be tested and evaluated within Tasks 540 and 550. Another user assessment of the EAP will be conducted at the conclusion of this Work Area. In the course of testing the analytical accuracy of the CCP and EAP, the user's opinions of the Application Framework will be solicited.

f. Work Area 600 - Mathematical Formulation. The purpose of Work Area 600 is to develop a mathematical representation of the Energy Analysis Procedure suitable for later development into a computer program by the consulting team in Phase II of this effort.

g. Work Area 700 - Identification of Future Research Needs. Work Area 700 will identify the necessary next steps to implement the CCP, and EAP, and the Application Framework. These steps include the proposed demonstration and application of the tools, and their further evaluation.

h. Work Area 800 - Packaging and Dissemination. Work Area 800 will focus on the development of user manuals for the CCP, EAP, and Application Framework, and a procedure for disseminating the information developed in this project to allow for the further demonstration and application of these techniques.

2. Phasing and Scheduling

ERDA has placed a high priority upon receiving the outputs of this research project. This is evidenced by two factors. First, the issuance of a Program Opportunity Notice (PON) has been scheduled to coincide roughly with the availability of the energy planning methodology which will be produced in this project. Second, several other ERDA research programs, mainly concerned with community energy supply systems, have been notified that the development of hourly community energy demands was to be accomplished in this project, and that this demand simulation technique would provide demand profiles for testing their supply-side products.

This priority has placed some very severe time constraints on this project. The period of performance is fourteen months, with about twelve months to complete all technical work. The project schedule is shown in Figure 2.

In connection with the project schedule, it should be pointed out that certain tasks, though shown on Figure 2 as having a well defined duration, are actually ongoing efforts throughout the course of the project. This comment applies especially to Work Area 100. While the majority of the literature review was accomplished during the first nine weeks of the project, further literature review will occur throughout the course of the effort, as pertinent sources are identified. In order to assure the ultimate usability of the research tool developed for the planner, early considerations will be given to possible forms of packaging and dissemination (Work Area 800) based upon preliminary testing and evaluation (Work Area 500) of selected planners. Likewise, in Work Area 700, future research needs will become apparent throughout the course of the project, and will be noted. During the actual scheduled period for this task, however, the research needs identified will be accumulated and presented in a report format.

3. Priorities Established

In view of the time constraints placed on the project, ERDA has seen fit to establish a priority on the project outputs. This priority statement has basically asserted that the highest priority will be placed upon developing the methodology at the planner level. This implies priority on the development and testing of the Application Framework, the CCP to a coarse level, and the EAP version which operates

COMPREHENSIVE COMMUNITY PLANNING FOR ENERGY MANAGEMENT AND CONSERVATION -

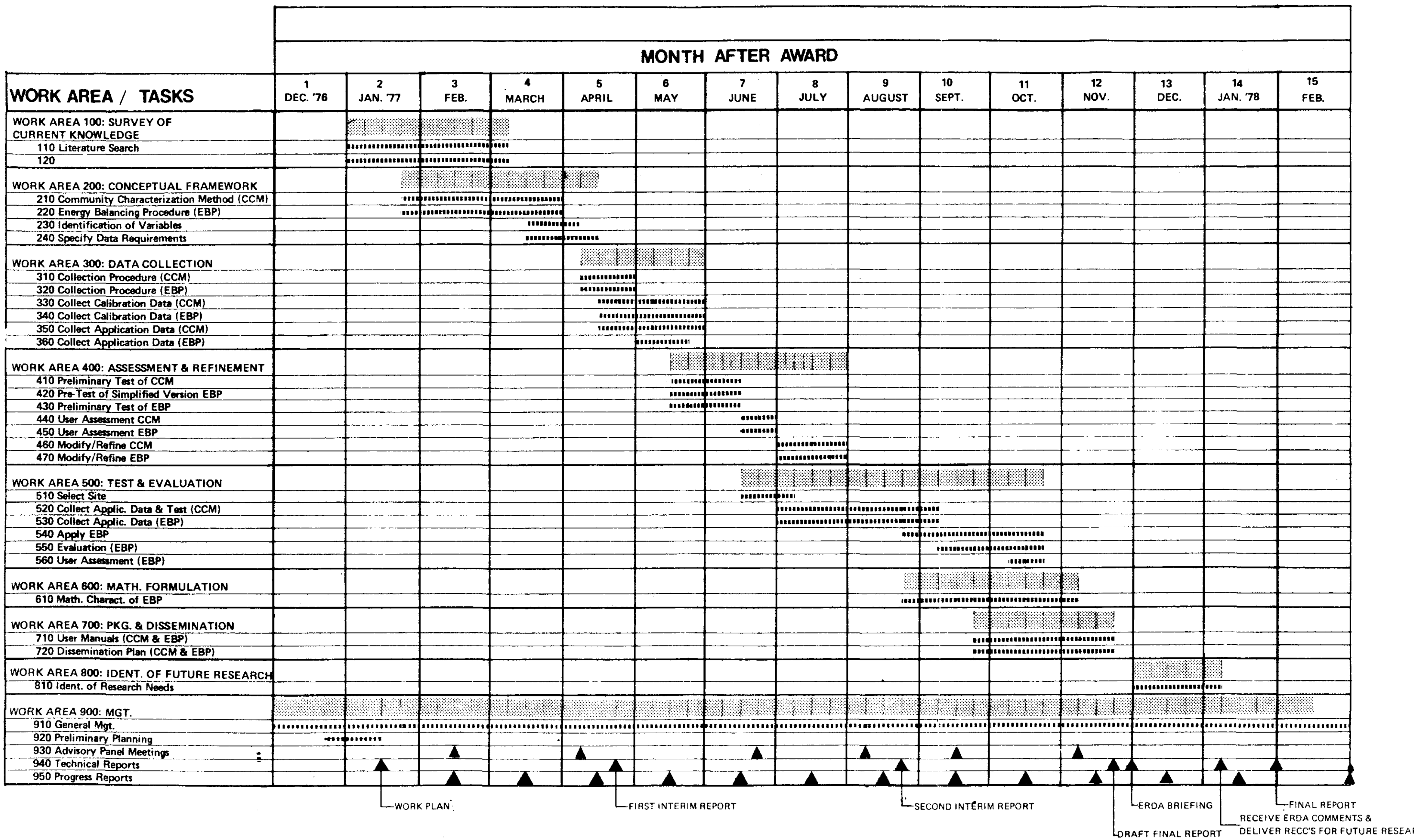


Figure 2 Project Schedule

on the basis of annual energy intensity factors. This emphasis is primarily based on the fact that ERDA has announced their intention to issue a Program Opportunity Notice in 1978, for communities to demonstrate this methodology, and thus it becomes imperative that the methodology be fully developed and ready for implementation by the scheduled date.

Beyond the emphasis on the planner level methodology, ERDA has further expressed the position that in the development of the methodology at the analyst level, and with respect to the EAP at that level, priority should be placed upon the development of the demand-side simulation algorithms. This position is due to the fact that numerous other ERDA projects are researching various facets of the supply side, and this project is intended to provide demand estimating techniques for those projects. Finally, within the demand side of the detailed EAP, ERDA has expressed the position that the major emphasis should be placed on developing techniques for estimating demands for land uses in the residential, commercial, institutional, and transportation categories, with lesser emphasis on the demands for land uses in the industrial category.

With respect to the testing of this project's outputs, ERDA's priorities have necessitated a full scale test of the methodology at the planners level. The testing of the EAP at the energy analyst level will be limited to verification of individual EUM demand profile generating algorithms. The testing of aggregated demand profiles, which requires computerization of the complete system, will be performed under a later phase of this project.

D. Preview of This Report

This report includes the complete results of the Survey of Current Knowledge (Work Area 100), and the partial results of the Concept Development (Work Area 200). In general, the Survey of Current Knowledge showed that little work had been done which is directly applicable to this project. The results of the survey of current knowledge are presented in Appendix A. This appendix is augmented by Appendices B, C, and D, which present a bibliography of materials reviewed, a complete set of abstracts of materials reviewed, and a set of summaries of personal contacts made, respectively.

Chapter II presents the results of the Concept Development work accomplished to date. The chapter is organized into six sections. The first two are overview and introductory material. The third, fourth, and fifth each address the conceptual work accomplished on each of the major products - the CCP, the EAP, and the Application Framework.

II. CONCEPTUAL FRAMEWORK

A. Introduction

In the preceeding chapter, it was stated that this project will result in the development of a methodology for community energy planning. This methodology will consist of three major parts, which include the Community Characterization Procedure (CCP), the Energy Analysis Procedure (EAP), and the Application Framework (AF). As of this writing, these three products have all been developed, in concept. The purpose of this chapter is to provide detailed conceptual description of each part, and to demonstrate how they will work together, and how they will be used by their ultimate users, the practicing community planners and/or energy analysts.

This chapter is organized into five sections. Section A, the Introduction, provides a general overview of the manner in which the project team has viewed the community as an energy using system. Section B, Overview and Description of Products, defines each of the study's products. It also defines two levels at which the methodology may be applied - a very detailed level, and a more general level. It also describes five generic classifications of uses for the study's products. Finally, it discusses how the various study products may be applied to each of the five application classes at either of the two levels of use. Having thus set the foundation by describing the products and their uses, the remaining three sections provide detailed conceptual discussions of each major product.

Section C provides a conceptual discussion of the Community Characterization Procedure. This section includes a description of the method for characterizing the physical composition of the community, as well as a method for characterizing the major decision-making, or behavioral processes which, in part, govern the community's physical composition.

Section D provides a conceptual discussion of the Energy Analysis Procedure. This section provides a full discussion of how the EAP will be developed for application at the detailed level. It concludes with a discussion of how the EAP will be used at the general level, and how these two levels are related.

Finally, Section E provides a discussion of the Application Framework, outlining the methodological steps that the user must follow to use the CCP or the EAP, at either the general or detailed level.

In approaching this research project, the project team has attempted to analyze a community as an energy-using system. Figure 3, below, shows a schematic representation of energy use in a community, and its determinants. The left side of this figure shows the interplay between general community characteristics, such as size, type, location, or climate, and the community's institutional, or behavioral arrangements. These two factors influence one another, and both of them influence the specific physical and behavioral characteristics of the community and its residents. Moving across the figure to the right, it shows that the specific, detailed physical and behavioral characteristics of the community, in turn, give rise to a large set of end uses of energy. These various end uses of energy can be combined into common groupings, or end-use sectors, such as residential, commercial, industrial, transportation, and municipal. Each end use within a sector has its own particular energy demand characteristics, aggregate annual energy use, and efficiency of end-use conversion. But while the number of end uses is large, at any point in time, they reduce to a small number of aggregate energy demands, one for each major energy form used in the community. As the figure shows, in fact, the multitude of end-use demands present in a community combine for any particular time, to form aggregate demands for electricity, gas, oil, coal, steam, and other energy forms used, which must somehow be met. The way they are met is referred to as the energy balance. In any community, energy balance exists when, for a particular point in time, all the community's demands for the various energy forms available are met by the community's existing primary conversion and distribution (PC&D) systems. These PC&D systems, as shown, may include electrical generating stations, arrangements with electric power grid, coal and oil vendors, gas pipeline companies, etc. Each of these PC&D systems, in turn, receives energy resources from somewhere else, and converts/distributes their supply throughout the community to the various end uses. Each PC&D system has an associated efficiency of conversion, and efficiency of distribution. These efficiencies combine with the efficiency of end-use conversion to form an overall system efficiency for each mode of end-use activity.

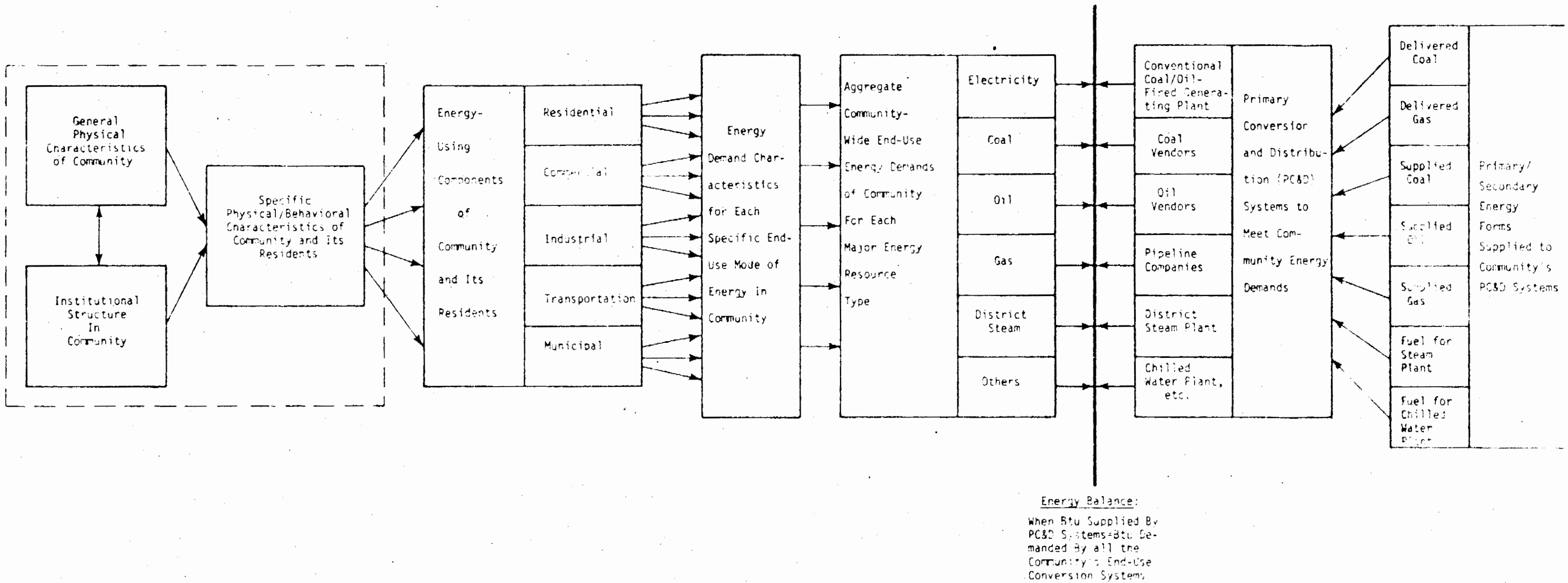


Figure 3. Schematic Representation of Energy Use in a Community, and Its Determinants

Summarizing the conceptual framework set forth in Figure 3, then, it is believed that, in most cases, general community characteristics (type, form, scale, climate, etc.), interact, with institutional factors in the community. The product of their joint interaction, and of their own separate influences, is their physical expression, the mix of structures, services, and activities which make up the community. Once the mix of community physical characteristics (number of homes, number of miles of highway, etc.), and of community behavioral characteristics (number of vehicle-miles travelled, number of gallons of water used per capita per day, etc.) is determined, then the disaggregated energy demands for the community are fixed, and so must be the aggregated demands. Energy Balance, at any time, is achieved by the PC&D systems, which supply the community's demands, on a dynamic basis. Total energy requirements of the community, then, consist of the energy inputs to the PC&D systems. The most salient feature embodied in this conceptualization is the belief that, besides climate, the main determinants of energy use in a community are the number and mix of end uses present, the behavioral characteristics of the residents, and the PC&D systems used to meet the demands. In particular, it is felt that the various decision-making processes, and other non-physical factors do not, in themselves, directly influence energy use, but rather they influence the number and mix of end uses, and the behavior of the residents, and these parameters, in turn, determine the characteristics of community energy use.

With this conceptual framework in mind, the role of planners in achieving community energy goals can be considered. As energy resources become more scarce and more costly, it becomes incumbent on those individuals whose decisions determine land use patterns to take the energy impact of a proposed land use alternative into account. Wise energy utilization cannot be the only criteria on which such decisions are based, and, in fact, it can be, at best, just one more in a list of competing goals, such as preserving a tax base, keeping citizen taxes down, maintaining a community economic base, minimizing environmental degradation, etc. But if planners and decision makers are to consider the energy implications of their decisions, even only as one of many competing goals, then it is necessary that they be provided with the tools and procedures to do this. Developing such tools and procedures is the main objective of this research, and this chapter discusses the concepts which are necessary to develop them.

B. Overview and Description of Products

1. Generalized View of Community Energy Planning Process

As stated in Chapter I, the main objective of this work is to develop an integrated methodology which will enable community planners, analysts, or decision makers to integrate energy use considerations into the planning process. In general, the methodology to be developed was schematically represented in Figure 1. This figure is repeated here for the convenience of the reader. In the version presented here, however, the methodological steps are numbered for ease in interpreting the discussion which follows.

In reviewing the methodology depicted in Figure 1, it becomes apparent that there are a number of applications to which it may be put. These applications have been broken down into six generic categories for ease of exposition. The categories are:

- Baseline Application - This application is one in which the user merely wants to develop a quanti-tative assessment, or "audit", of the existing energy use patterns in the community. Assuming the user has a detailed physical description of the community in hand, the methodology is "entered" at the conclusion of Step 4b. The description of the physical components of the community are used, in conjunction with the tools for performing quantitative energy evaluation, in step 5, to calculate the desired energy use parameters.

- Physical Change - This application is one in which the user is faced with the problem of assessing the energy-use implications of a proposed action which can be stated in very explicit physical terms. An example of such an action would be the proposal to demolish some particular dilapidated commercial area, and construct, in its place, a low-rise apartment complex. In this application the user would begin by performing the baseline application, as described above, to determine the baseline, or existing, energy use patterns. Then he would develop a revised physical description of the community, which would incorporate the proposed charges. To do this, the user would use the guidelines provided in Step 4b of the methodology. When the revised description was completed, the description of the "revised" community would be used, along with the guidelines or procedures

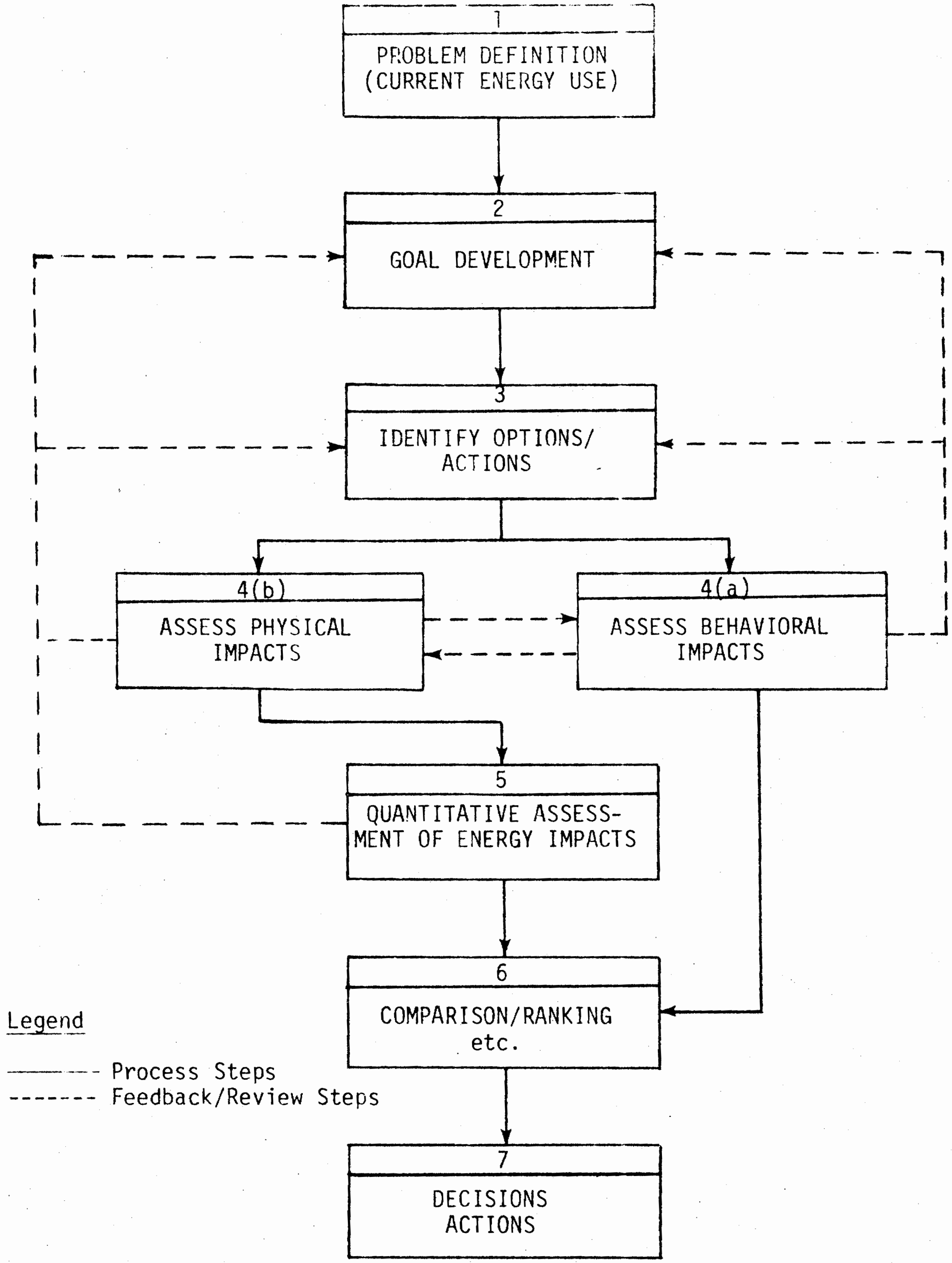


Figure 1. General Description of Energy Planning Methodology

specified in step 5, to calculate the energy use parameters of interest. The energy use patterns of the "revised" community would then be compared with those of the "original" community, and the changes would be noted.

- Behavioral Change - This application is similar to the previous one, except that in this case the user would be attempting to assess the energy use implications of some proposed action which was not capable of being stated in very explicit physical terms. An example of this type of action might be a proposal to re-zone some large amount of land from light industrial to residential. Assuming the land in question is undeveloped at the time, the problem the user faces is that of assessing the energy implications of two alternative, but unspecified, development scenarios. To do this, the user would, again, begin by performing the first application, the baseline assessment of current energy use patterns. Then, assuming the light industrial zoning pattern, the user would enter the methodology at step 4a, and work within steps 4a and 4b until a "likely" development scenario could be stated in physical terms. This physical description could then be used in step 5 to calculate the energy use parameters of interest. When this is completed, the user would then assume the residential zoning pattern, and would enter the methodology at step 4a again. Again, the procedures in step 4a and 4b would be used until a "likely" development scenario could be stated in explicit physical terms. This physical description of the community would then be used with the procedures provided in step 5 to calculate the energy use parameters of interest. When completed the user would compare the energy implications of the two development scenarios, and use the information gained to assist in his decision.

The three applications of the methodology described above share the common feature that in each, the user is merely trying to determine the energy use patterns associated with three classes of actions - the status quo, a physical change, or a behavioral change. In none of these was the change to be evaluated motivated out of any particular energy-related concerns. They were simply possible land use scenarios which might arise in the course of his everyday activities, and he was attempting to consider their energy-use implications. There exists, however, a broader type of application of this methodology. This broader class is one in which the user is attempting to formulate some type of community-wide energy conservation or management program, and wishes to use this methodology to assist him. There are two generic applications which fall into this category. These are described below.

- Option Evaluation - This application assumes that the community planners and/or decision makers are somewhat sensitized to the energy use/land use issues, and that they have already done the baseline application, established a set of goals, and identified a series of action options which must be considered. The problem, then, is that based on some constraints, such as budget, staff, time, or others, all of the actions identified cannot be implemented, and the user must select, from all of those identified, that sub-group which will be recommended for implementation. The object of using the methodology here, then, is to assess which actions may have the highest potential for achieving the community's stated goals. In this application the user would enter the methodology at the conclusion of step 3. He would work through the behavioral and physical impact steps (4a, b) and the energy evaluation step (5) to develop the energy parameters of interest. Furthermore, he would repeat this procedure for each action option being considered, and at the conclusion he would use the procedures in step 6 to compare, rank, and ultimately select the options which appear most favorable.

- Comprehensive Energy Planning - In this application, it is assumed that the community has little or no sensitivity to land use/energy use issues. For such communities, the methodology is used in its entirety. The user would enter the methodology at step 1, performing the baseline community energy audit. Based on the results of that step, and other goals of the community, the user would develop a set of energy-related goals for the community to strive for. In step 3, the user would consider a broad range of action alternatives, and from these, would make a preliminary selection of those which appear good enough to warrant detailed evaluation. This group of action alternatives which is chosen in step 3 may consist of alternatives which can be expressed in terms of direct physical impacts, alternatives which act upon the behavioral, or decision-making processes in the community, or some combinations of these two classes. Using the procedures in steps 4a and 4b, the user would translate the alternatives selected into likely physical impacts. Once this is done, quantitative evaluation of the associated energy impacts would be possible, per the procedures in step 5. In step 6 the implementability of each would be reviewed, and a comparison and ranking of alternatives would be made. Finally, in step 7, final selections would be made, and an action agenda would be prepared. Thus, using the methodology described, the planner would be able to begin with little or no energy related policies, programs, or goals, and work through a rational procedure to arrive at an integrated action plan capable of achieving a set of energy goals, and being in harmony with other, non-energy goals which may have been previously established.

There is one further application of this methodology which merits discussion. As stated in Chapter I, one class of users of this methodology is the ERDA research community. To accommodate the needs of this group, a Research Application has been defined. It is described below.

- Research - In this application, the user is an energy systems analyst. The user's needs are to determine some very detailed information about the characteristics of the demand for various energy forms which arises from a specified community configuration, be it real or hypothetical. In this application the user would enter the methodology at step 4b and either begin with, or develop, a detailed physical description of the community and its various energy using systems. From this, the user would move to step 5, where the energy use patterns would be calculated, in a very detailed fashion, for the specified community configuration. The energy use patterns thus calculated would be used for the purpose of testing, designing, or optimizing an energy supply system to meet the energy needs of the community.

The discussion of the methodology and its components and applications here, thus far, has been at a very generalized level. The remaining parts of this section will focus on more detail, both in terms of the actual tools to be used, and the applications to which they may be put. It is useful, at this point, to review the six classes of applications developed above. These classes will be used repeatedly throughout this chapter.

2. Description of Products

As discussed briefly in Chapter I, it is felt that the range and diversity of potential users of this methodology are sufficiently wide that it is useful to develop it such that it may be used either at a general level (referred to as the "planner level") or at a very detailed level (referred to as the "energy analyst level"). The main distinctions between the two levels are in the areas related to energy analysis, which is predominantly the function of the Energy Analysis Procedure (EAP), and the behavioral/physical evaluation, which is predominantly the function of the Community Characterization Procedure (CCP). For example, at the planner level, it is felt that the user would most likely be interested in describing the community in terms of some large aggregations of land uses, and determining estimates of annual energy use, possibly by fuel type. On the other hand, at the energy analyst level, the user may be interested in describing the community at a very detailed level, possibly even down to specific sites, and then evaluating the hourly energy demands of all major energy-using activities which occur on a site. In the more operational areas, however, such as goal development and option identification, the two levels of application are very similar. On the basis of this type of comparison it has been determined that the CCP and the EAP should be developed to operate on two levels, depending on the needs of the user. The Application Framework, however, operates generally the same on either level.

Table 1, below, provides a comparison between the generalized planning methodology depicted in Figure 1, and the outputs of this project. As Table 1 shows, the three major outputs of this project are:

- Application Framework - this includes five parts, which are:
  - the community energy audit method
  - guidelines for energy goal selection
  - guidelines for development of action alternatives
  - a procedure to assess the implementability of actions; and
  - a procedure to compare, rank, and select action options.

TABLE 1. COMPARISON OF GENERALIZED ENERGY PLANNING METHOD AND PROJECT OUTPUTS

Steps in Generalized Energy Planning Method	Project Outputs
1. Problem Definition	• Application Framework, Step 1 - Provides guidelines for performing a community energy audit and interpreting the results.
2. Define Goals	• Application Framework, Step 2 - Provides guidelines for identifying and selecting goals.
3. Identify Options/Actions	• Application Framework, Step 3 - Provides a series of action alternatives for consideration, and a method for making preliminary selection.
4a. Assess Behavioral Impacts	• Community Characterization Procedure, Step 1 - Provides a method to assess the behavioral impacts of actions considered.
4b. Assess Physical Impacts	• Community Characterization Procedure, Step 2 - Provides a method to assess the physical impacts of actions considered.
5. Quantitative Assessment of Energy Impacts	• Energy Analysis Procedure - Provides a method to assess the energy use patterns of a community of known physical composition.
6. Comparison, Ranking and Final Selection	• Application Framework, Steps 4 and 5 - Step 4 provides a method to assess the implementability of action alternatives considered. Step 5 provides a method to rank the alternatives, based on energy impact and implementability, and make a final selection of alternatives for recommendation and action.

- Community Characterization Procedure - this procedure allows the user to assess the physical impacts of proposed actions

- Energy Analysis Procedure - this procedure allows the user to evaluate energy use parameters associated with communities for which the physical description is known.

In the following part of this section, the various products will be developed in more detail. In order to do this, the discussion is separated into two parts, one which applies to each of the two proposed application levels, the planner level and the energy analyst level.

3. Community Energy Planning Methodology - Planner Level

Figure 4, below, depicts the Community Energy Planning Methodology (the Methodology) as it would be used at the planner level. In this figure, the generalized energy planning methodology of Figure 1 has been re-stated in terms of the particular outputs of this project, and has been somewhat expanded to show some of the sub-components of the CCP and the EAP. The methodology, used at the planner level, consists of the CCP and the EAP. The methodology, used at the planner level, consists of ten elements, described below. In this description the abbreviations AF, CCP, and EAP are used to denote the Application Framework, Community Characterization Method, and Energy Analysis Procedure, respectively.

- AF-1: Energy Audit - In this step, the user would use the first part of the AF to perform a baseline energy audit of the existing community.

- AF-2: Goal Development - In this step, the user would go through an exercise wherein the results of the baseline energy audit were used to identify existing or potential energy problem areas for the community. Guidelines for doing this would be provided in AF-2. Subsequently, AF-2 presents the user with a range of energy related goals for consideration, and a set of guidelines for selecting those goals.

- AF-3: Option Identification - In this step, the user is presented with a broad range of energy conservation/management options and a method for making preliminary selections among those options, to identify a set which merits further analysis.

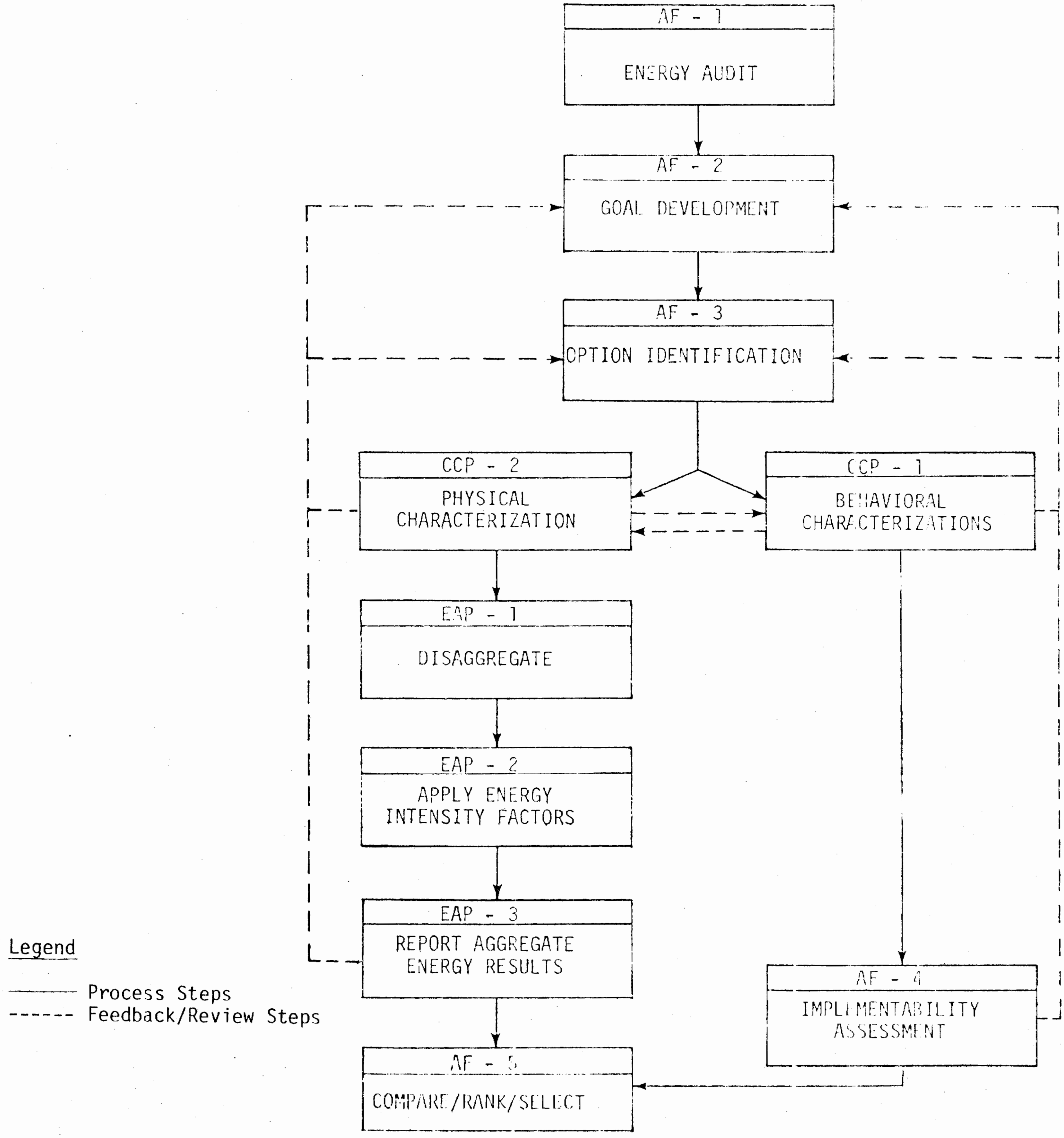


Figure 4. Community Energy Planning Methodology - Planners' Level

- CCP-1: Behavioral Characterization - In this step, the user is provided with a description of the various decision-making processes in the community, and a method for identifying which decision making processes may be affected by each of the options considered, in addition to identifying the participants in the decision processes, and the likely range of physical impacts which may ensue from each option considered.

- CCP-2: Physical Characterization - This step allows the user to refine and standardize the assessment of likely physical impacts of the options considered. It provides a method of classifying land uses at very general or very detailed levels. The most detailed of these is the "parcel" level, which refers to a particular land use on a particular site. Ultimately, the impacts of options must be expressed in terms of changes in the number or mix of parcels in the community. Where impacts cannot be specified at the parcel level, the Physical Characterization procedure enables the user to estimate parcel-level impacts from those which may be stated at a more general level.

- EAP-1: Disaggregation - In this step, the number of each type of parcel in the community is disaggregated. Due to the fact that energy impacts must be calculated by energy form, it is necessary to separate parcels (such as sites occupied by single family detached residences) into groupings which use the same energy forms for the same activities. Once this is done the energy use parameters can be calculated.

- EAP-2: Application of Energy Intensity Factors - In this step, an Energy Intensity Factor (EIF) is applied to each of the sub-groupings of parcels developed. Besides being specific to the type of parcel and the energy form used, the EIFs are also dependent upon physical factors such as the local climate and energy using characteristics of the parcel in question (for a residence these might include floorspace, exterior surface thermal properties, etc). The EIFs provide annual energy use information for each parcel type. The result of this step is a disaggregated estimate of annual energy use for all parcel types, further broken down by energy forms used.

- EAP-3: Aggregation - In this step, the user sums the disaggregate annual energy use figures calculated. These may be summed in a variety of ways, depending on the user's needs. If energy use by energy form is desired, than the summation is done over all categories except energy form. Alternatively, total energy use may be calculated by summing over all categories, or energy use by parcel type may be calculated. Obviously the previous disaggregation steps enable a wide variety of aggregation possibilities to be considered.

- AF-4: Implementability Assessment - In this step, the user is provided with a method to qualitatively assess the implementation potential of each option being considered. This assessment includes consideration of the governmental mechanisms involved, the time required for implementation, and the likely costs of implementation.

- AF-5: Comparison, Ranking, and Selection - In this step, the user is provided with a method to compare and rank the options which have been evaluated. This method involves a weighted scoring technique, and takes both energy impacts and implementability into consideration.

From this description, it can be seen how, at the planner level, the various parts of the AF, CCP, and EAP are interrelated. Table 2, below, provides, for each of the methodology elements above, a summary of their key inputs and outputs.

In using the methodology at the planner level, it will not always be necessary to go through all the procedural steps outlined above. Certain applications of the methodology allow a significant degree of "short circuiting" of methodological elements, while still yielding the desired results. In the previous discussion of the generalized methodology, six generic classes of applications were presented. In order to illustrate use of the Community Energy Planning Methodology at the planner level, these six applications are re-described here, in terms of the project outputs. For each application, a copy of Figure 4 is provided. However, steps required for each applicatior are shown in bold-face lines.

Table 2. SUMMARY OF INPUTS AND OUTPUTS FOR METHODOLOGY STEPS - PLANNER LEVEL

Methodology Element	Inputs	Outputs
AF-1	• Community physical description • Energy Intensity Factors	• Annual energy use by energy form
AF-2	• Energy use patterns • Political constraints • Non-energy goals	• Energy goals
AF-3	• Energy goals • Action suggestions	• Preliminary selection of action options (alternatives) for further analysis
CCP-1	• Behavioral Context: government decision making, market decision making, consumer decision making • Relationship of behavioral factors to community physical form	• Roughly defined physical impacts • Implementability data (time, cost, governmental powers required)
CCP-2	• Physical descriptions at various levels of land-use specification	• Physical description at the parcel level,
EAP-1	• Physical description at parcel level	• Physical description of community with parcels disaggregated to sub-groups by major energy forms used
EAP-2	• Sub-groupings of parcels • Energy intensity factors • Local climatic data • Specific physical descriptors of energy using activities	• Annual energy use by sub-groupings of parcels (i.e., parcel type-energy form combinations)
EAP-3	• Annual energy use by sub-groupings of parcels	• Aggregated annual energy use, by energy form, by parcel type, etc.
AF-4	• Implementability data (time, cost, governmental powers required)	• Implementability factors
AF-5	• Implementability factors • Energy impacts • Local priorities	• Comparison and ranking of alternatives, • Final selection for recommended action

- Baseline Application - Figure 5 shows the methodology applied in the baseline application. As the figure shows, the application begins with the physical description of the community. This would most likely be supplied by the user. It then goes through the disaggregation step, applies the energy intensity factors, and reports out aggregate results at whatever level of aggregation is most appropriate.

- Physical Change Figure 6 shows the application of the methodology to a situation in which the energy impacts are to be determined which would result from an action which could be explicitly stated in physical terms. As Figure 6 shows, the action statement is used as input by the CCP. The CCP allows the planner to assess the impacts, on a parcel level, and these become input to the EAP, where they are disaggregated, the EIFs are applied, and the results are re-aggregated and reported out.

- Behavioral Change - In this application, a change is made which is directly application to one or more of the decision-making processes in the community. The change is specified and the methodology is entered at CCP-1, the behavioral characterization. By CCP-1 and CCP-2, the behavioral change is translated into a range of parcel-level physical impacts. These are used by the EAP, and energy impacts are reported out.

- Option Evaluation - Figure 8 shows how the methodology would be used for this application. Since this application is based on some overall intent to develop an energy management program, more of the Application Framework steps are needed. This is in contrast to the previous two applications, where the goal was to merely determine the energy impacts of isolated actions. As the figure shows, the methodology is entered with the specification of options for evaluation, at the conclusion of step AF-3, and the methodology is worked through until the energy parameters are available from step EAP-3.

- Comprehensive Energy Planning - Figure 9 shows the most general application of the methodology at the planner level. In this application the user begins with the energy audit step, proceeds through AF-2 and AF-3, identifying goals and options, and then applies the CCP to determine

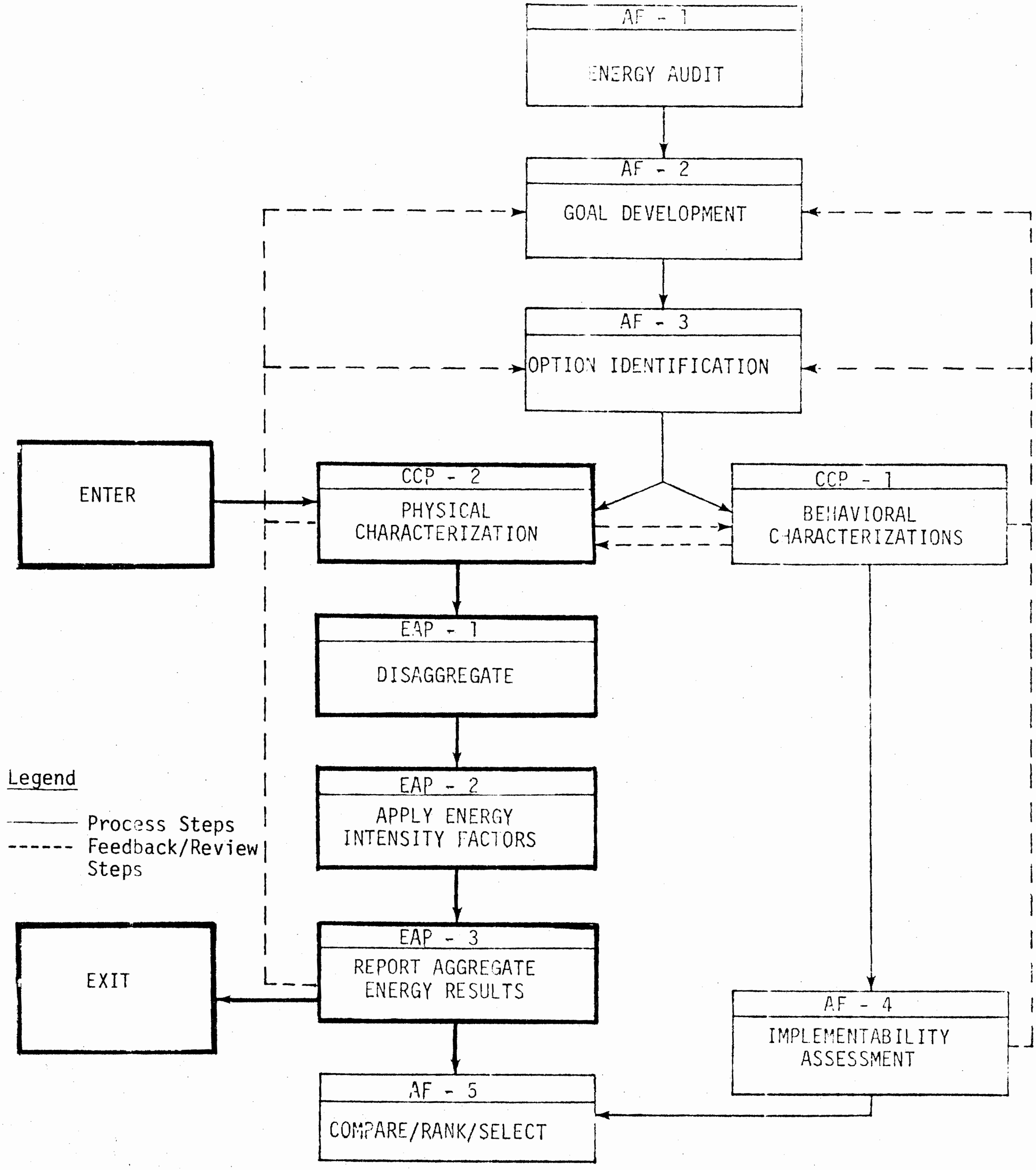


Figure 5. Baseline Application - Planner Level

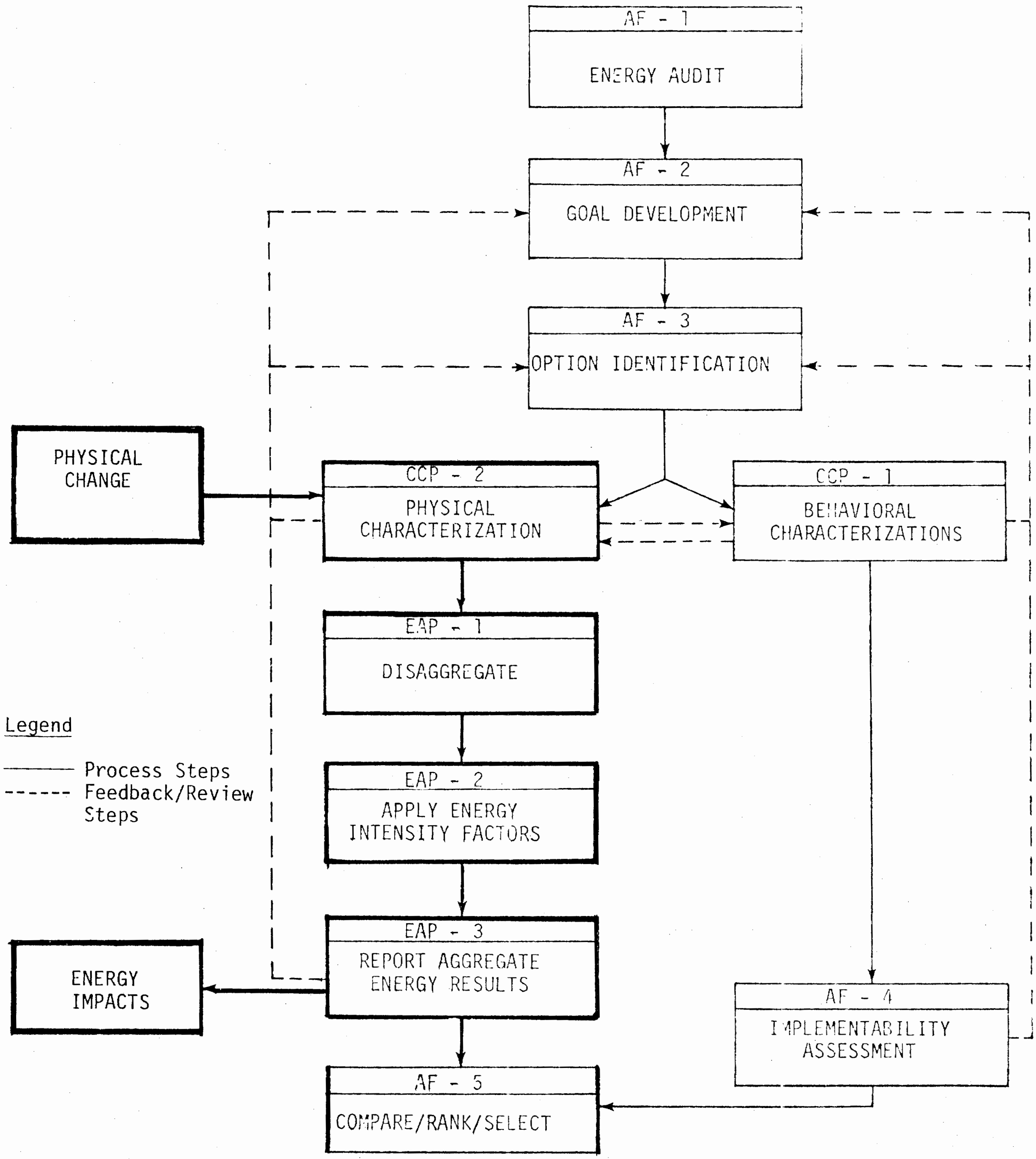


Figure 6. Physical Change - Planner Level

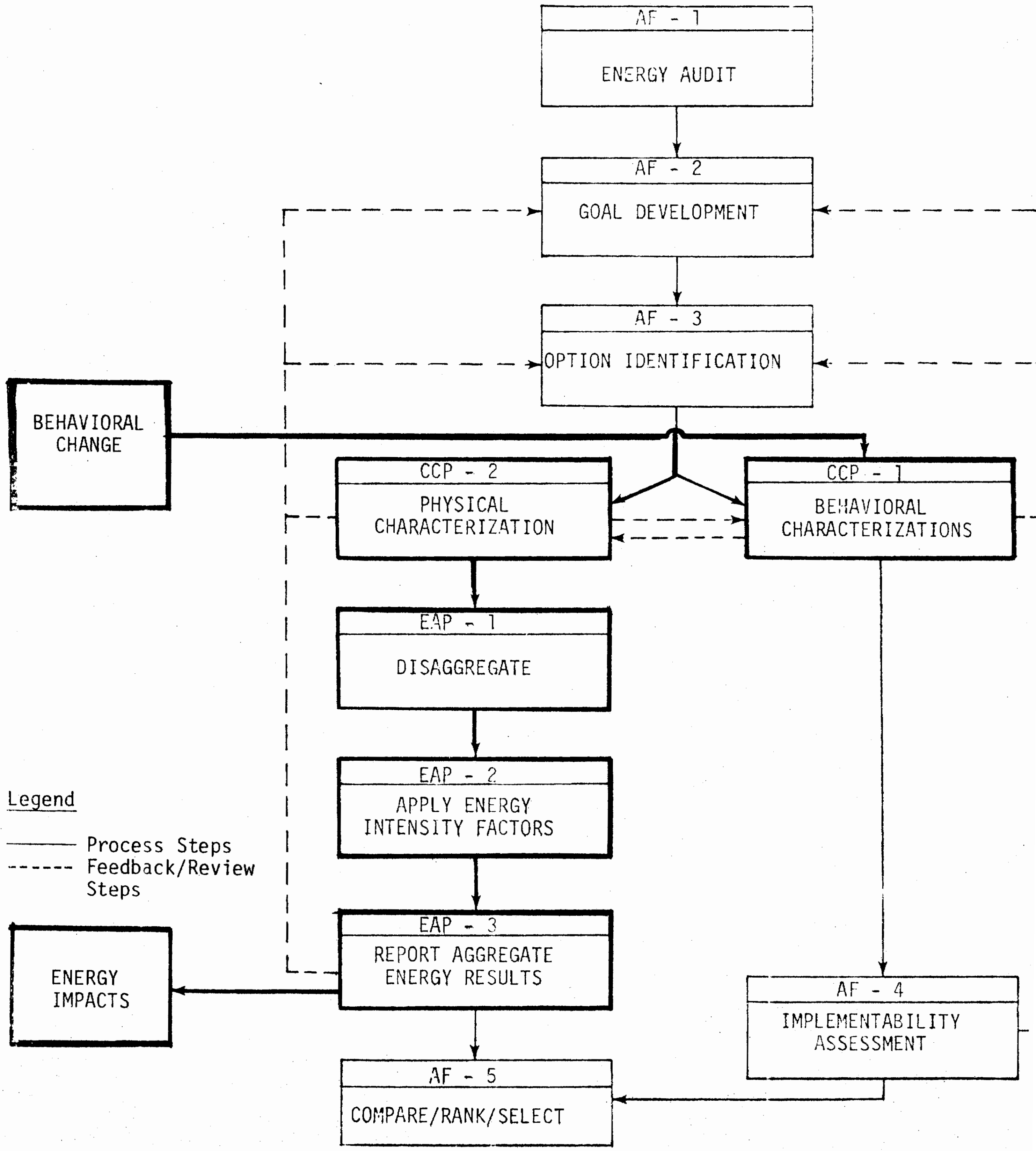


Figure 7. Behavioral Change - Planner Level

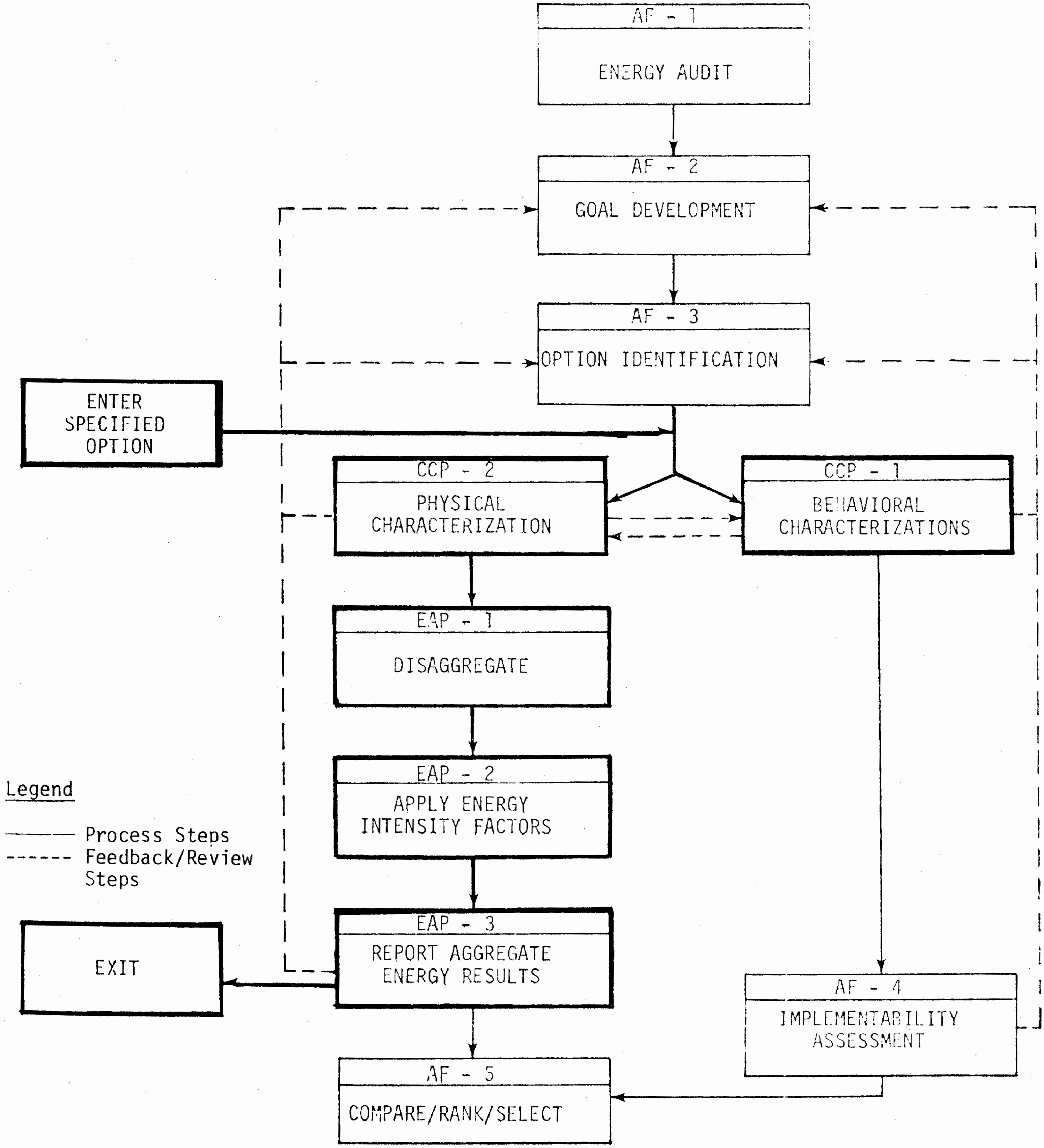


Figure 8. Option Evaluation - Planner Level

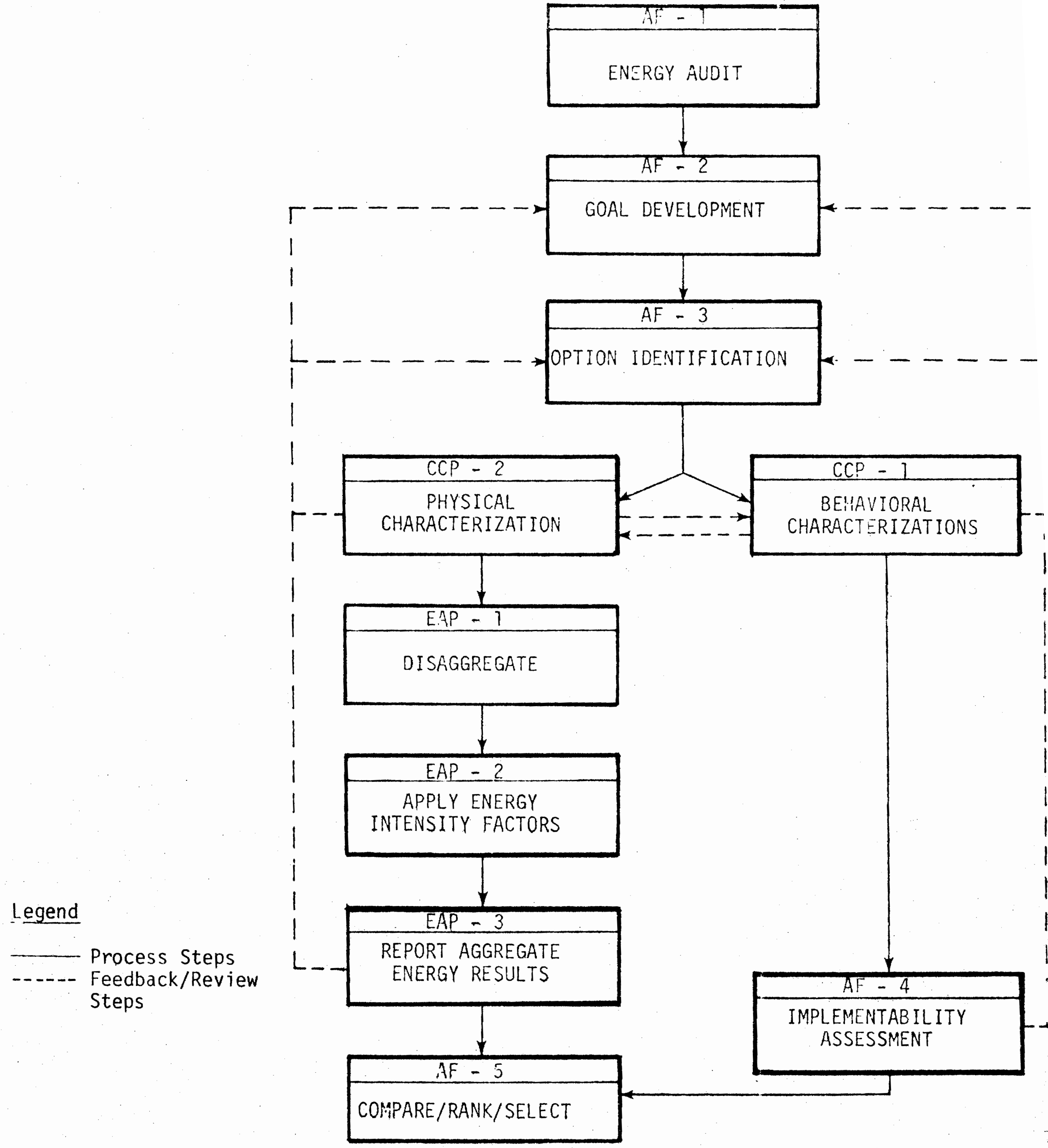


Figure 9. Comprehensive Energy Planning - Planner Level

physical impacts at the parcel level. From this step the EAP is applied, and after energy impacts are calculated, AF-4 and AF-5 are used to assess the implementability and to compare, rank, and select.

o Research Application - The research application is not described here, as it is felt that this application requires a level of analytical detail beyond that which is available when using the methodology at the planner level.

Based on the discussions presented above, it can be seen that the methodology, when applied at the planners level, is capable of providing a useful planning tool, which can evaluate a wide variety of options, and which will be useful for a broad range of communities. For certain communities, however, the planners level of detail will be insufficient for their needs. When more detailed information is needed, then the methodology may be used at the energy analyst level. This level is described below.

4. <u>Community Energy Planning Methodology - Energy Analyst Level</u>

For uses which require a level of analytical detail beyond that which is achieved by using the methodology at the planner level, this section describes its use at the energy analyst level. Just as in the previous section, this section describes the use of the methodology at this level by first describing the overall methodology, noting inputs and outputs for each step, and then illustrating its use for various applications with a series of illustrations and descriptive test.

Figure 10, below, shows a schematic representation of the methodology as applied at the energy analyst level. The steps in the methodology are described here. Note, again, that in the figure and in the following text, the appreviations AF, CCP, and EAP refer to Application Framework, Community Character-ization Procedure, and Energy Analysis Procedure, respectively.

(a) AF-1: Energy Audit - This step is the same basic activity as was described in the previous section (methodology used at planner level). The only dif-ference is that the audit at the energy analyst level involves specification of energy using activities to a greater level of detail, and it also provides more detailed information on energy demand patterns.

(b) AF-2: Goal Development - This step is the same as was previously described.

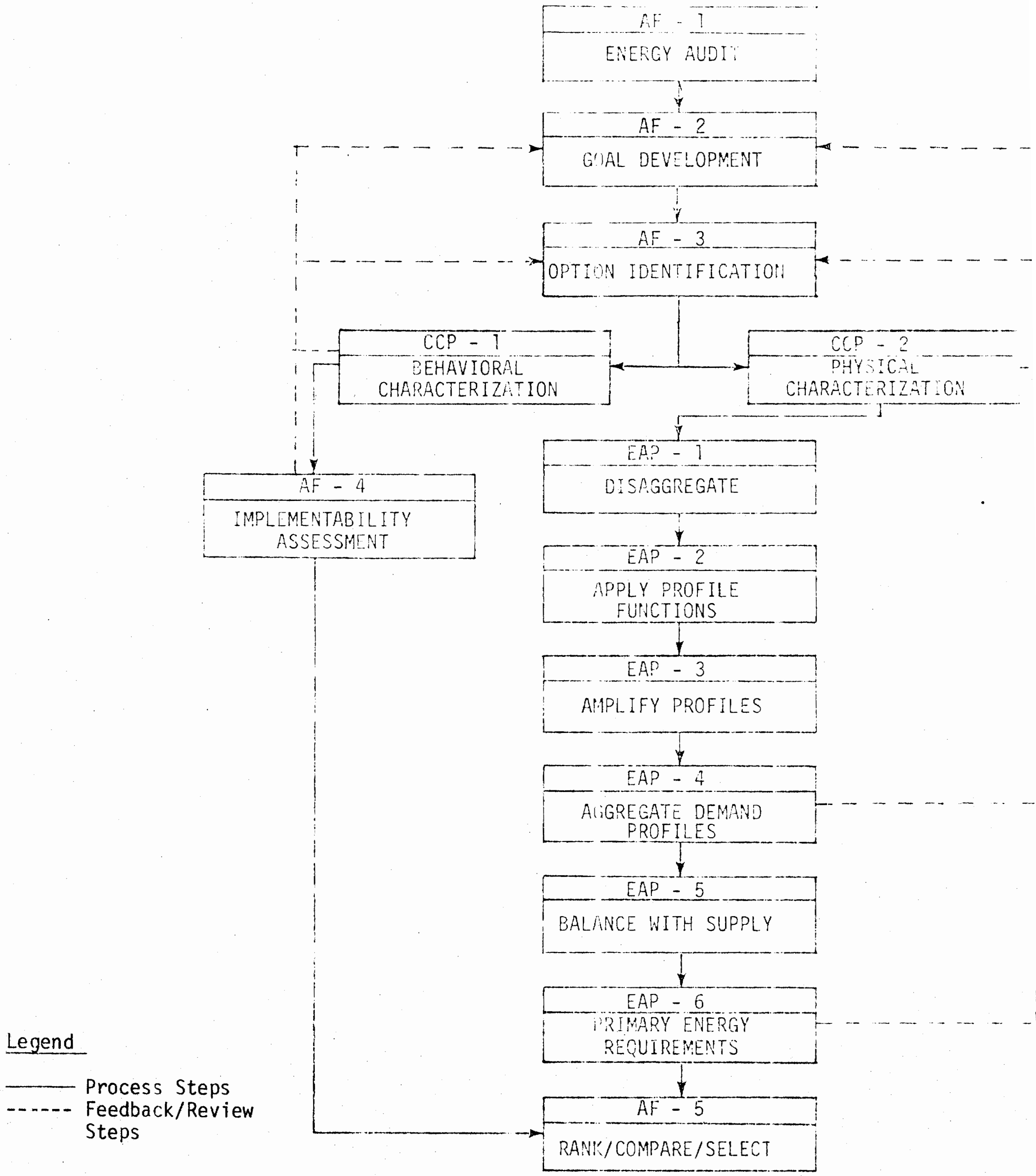


Figure 10. Community Energy Planning Methodology - Energy Analyst Level

(c) AF-3: Option Identification - This step is generically the same as it was in the preceding sections. The major distinction is that with the expanded analytical capabilities of the energy analyst level, the range and types of options which can be evaluated is broader. In particular, at the energy analyst level, various classes of energy supply and distribution technologies may be evaluated, as well as energy storage, peak load shifting and shaving, and other demand (as opposed to consumption, or use) management strategies.

(d) CCP-1: Behavioral Characterization - This step operates in generally the same way, and produces generally the same outputs, as was described in the preceeding section. Again, its main difference at the energy analyst level is that the user would most likely use it in a more comprehensive manner.

(e) CCP-2: Physical Characterization - As in the preceeding section, this step allows the refinement and standardization of the physical description of the impacted community. It enables the user to estimate all physical impacts in terms of parcels, for use by the EAP. Where Step CCP-1 cannot specify parcel-level impacts, step CCP-2 provides methods to estimate them based on higher level impact specification.

(f) EAP-1: Disaggregation - At the energy analyst level, the EAP treats each major energy using activity in the community separately. Each of these activity classes is refereed to as an End Use Mode (EUM). The EUM is defined as a specific energy using activity which is associated with a specific type of parcel, which uses a specific energy form, and which is accomplished by using a specific type of end-use conversior equipment. For each parcel type specified by Step CCP-2, the disaggregation step, then, must determine which, and how many EUMs there are.

(g) EAP-2: Application of Unit Profile Generating Functions _ For each type of EUM in the community, the EAP generates a year long, hourly energy demand profile. This profile is specified in two parts - a demand rating, and a percentage profile. The demand rating specified the kW or Btu/hr demand of the highest point on the profile, and the percentage profile specifies the demand at all other points (hours) as some percentage of the rating. For each EUM in the community, this step provides a function which uses the physical characteristics of the EUM, in conjunction with general physical characteristics of the community, and general activity and energy usage patterns of its residents, to generate this profile.

(h) EAP-3: Amplification of Profiles - In step EAP-2, it was stated that profiles were generated for each type of EUM in the community. In this step, the profiles generated for one occurrence of each EUM, are increased, or amplified, to represent all occurrences of each EUM which occur in the community. This amplification is done using a statistical technique which takes account of the diversity factors in the loads.

(i) EAP-4: Aggregate Demand Profiles - In this step, the amplified demand profiles for all EUM types in the community are aggregated. This is done over fuel types (energy forms) to develop the total demand profile for each major energy form used in the community. Depending on user needs, this aggregation may be done over various land use categories, activity types, or other ways to yield specific information needed.

(j) EAP-5: Balance With Supply - In this step the aggregate demands for each energy form are balanced, on an hourly basis with the available supplies. This is accomplished by a linear programming allocation scheme. The result of this step is a set of output requirements for the community's primary conversion and distribution facilities.

(k) EAP-6: Specify Primary Energy Requirements - In this step, the outputs of primary conversion and distribution systems are being used, in conjunction with the physical/engineering characteristics of these facilities, to determine the primary fuel requirements necessary to meet the energy output requirements.

(l) AF-4: Implementability Assessment - This step is the same at the energy analyst level as it is at the planner level.

(m) AF-5: Comparison, Ranking, Selection - This step is the same at the energy analyst level as it is at the planner level.

In the context of using the methodology at the energy analyst level, it should be noted that the complexity of the EAP, at this level, is such that it is only practical to use this tool in a computerized mode. It is anticipated that the EAP will be computerized during the second phase of this project.

Table 3, below provides a summary of the inputs and outputs of the various steps in the methodology, as applied at the energy analyst level.

Similar to the planners level, there are six classes of applications which have been defined for the methodology at the energy analyst level. Furthermore, as before, it is not necessary for the user to work through all the methodological steps to perform each of the applications specified. The following text and figures illustrate each of these applications, and how the methodology is used to accomplish each. As before, the figures are shown with only the necessary steps drawn in bold face lines.

(a) Baseline Applications - This application is shown in Figure 11. In this application the user may enter at either of three positions. If the community description is known at the EUM level, the user may enter after step EAP-1, and begin by applying the profile generating functions. If the community description is available at the parcel level, the user enters at step EAP-1, and begins with the disaggregation exercise. Finally, if the community description is known, wholly or partially, at some level more general then the parcel level, the methodology is entered at step CCP-2, where the physical characterization procedure is used to the parcel level. The user works through all the EAP steps, and exits after step EAP-6.

(b) Physical Change - This application is shown in Figure 12. In this application, the user must have the physical change specified at least to the parcel level. The methodology is entered prior to step EAP-1. The parcel-level inputs are disaggregated and the energy impacts are calculated in steps EAP-2 through EAP-6. The results are reported from step EAP-6.

(c) Behavioral Change - This application is shown in Figure 13. In this application, the methodology is entered at step CCP-1. The CCP is used to predict likely physical changes resulting from behavioral changes. These physical changes are specified at the parcel level. Steps EAP-1 through EAP-6 are used to develop energy impacts. Results are reported out of step EAP-6.

(d) Option Evaluation - This application is shown in Figure 14. In this application, the user enters the methodology with a proposed energy conservation/management option in mind. As the option may be of

TABLE 3 . SUMMARY OF INPUTS AND OUTPUTS
FOR METHODOLOGY STEPS - ENERGY ANALYST LEVEL

Methodology Step	Inputs	Outputs
AF-1	• Community description, in terms of EUMs • Local physical and climatic factors affecting energy use	• Hourly loads for all EUMs, and energy forms
AF-2	• Same as Table	• Same as Table
AF-3	• Same as Table	• Same as Table
CCP-2	• Same as Table	• Same as Table
EAP-1	• Community physical description-parcel level	• Community physical description-EUM level
EAP-2	• List of EUMs in Community • Climatic data • Other physical and behavioral factors	• Unit demand rating for each EUM type • Unit percentage profile for each EUM type
EAP-3	• EUM unit profiles • Probabilities of usage for each EUM • Climatic data	• Amplified EUM profiles
EAP-4	• Amplified EUM profile	• Aggregated profiles, by energy form or other levels of aggregation as needed
EAP-5	• Energy form-specific demand profiles • Supplies available • Supply constraints	• Allocation of supplies
EAP-6	• Supply system output requirements • Physical/engineering characteristics of supply facilities	• Primary energy requirements
AF-4	• Same as Table	• Same as Table
AF-5	• Same as Table	• Same as Table

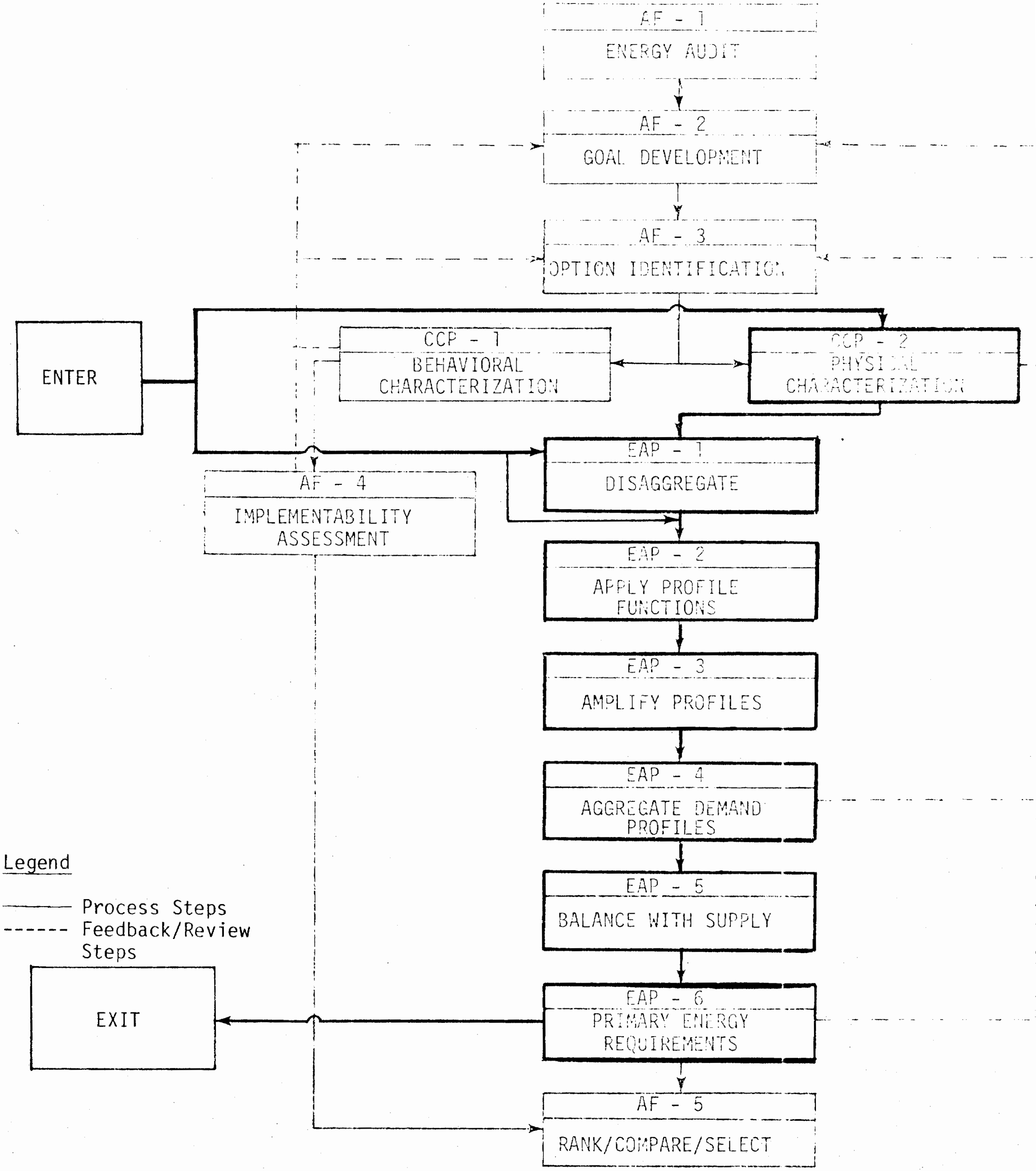


Figure 11. Baseline Application - Energy Analyst Level

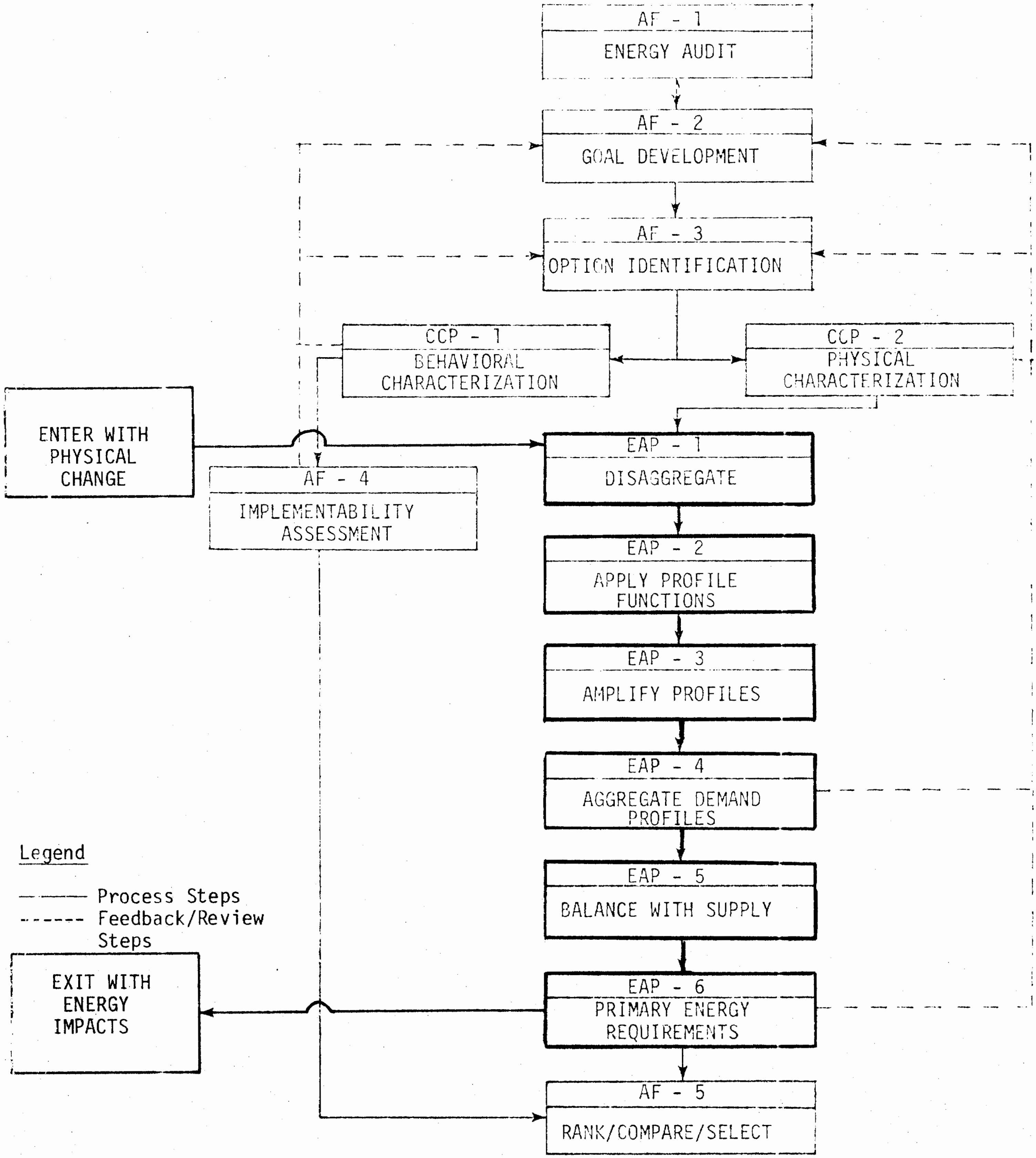


Figure 12. Physical Change - Energy Analyst Level

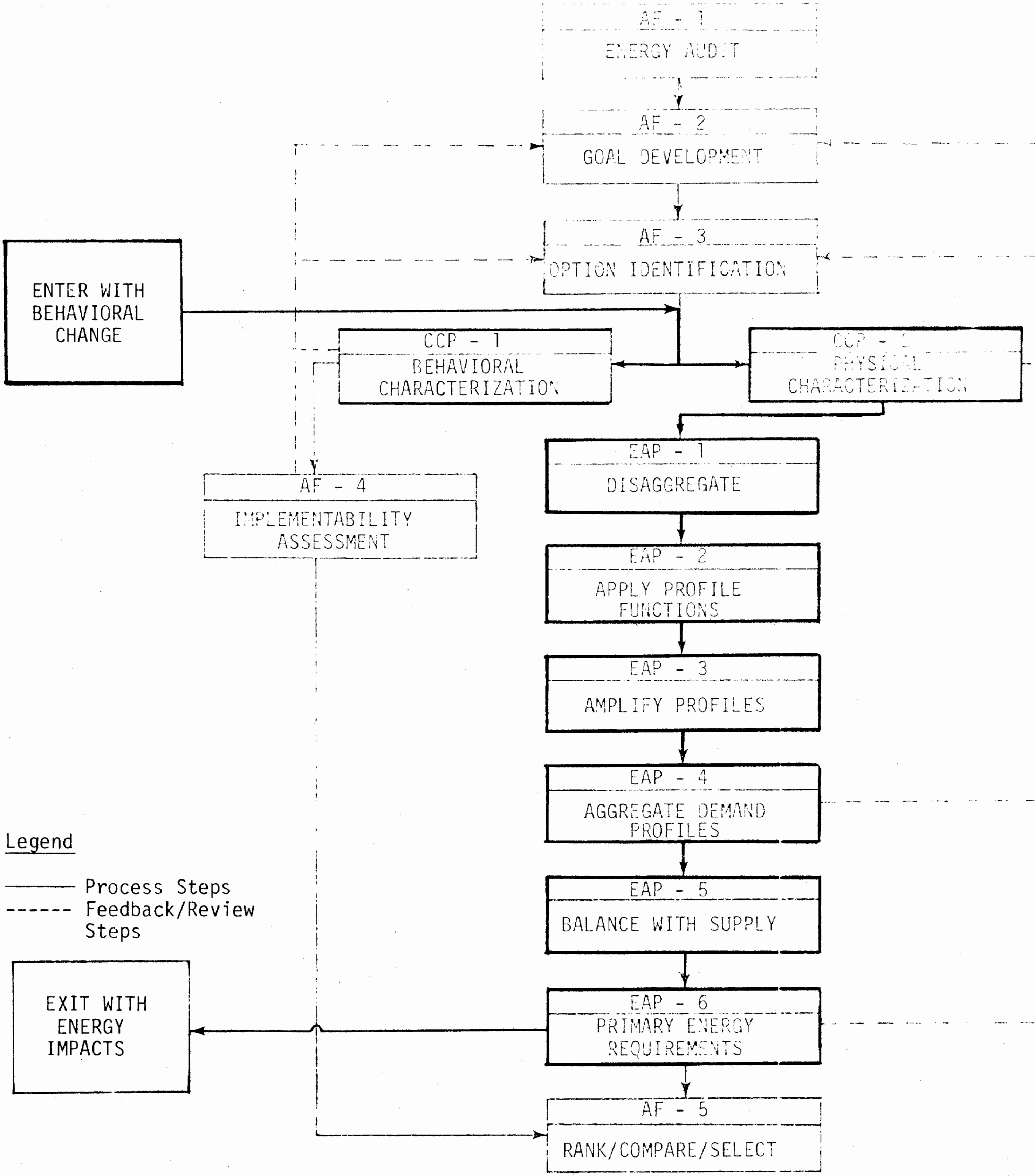


Figure 13. Behavioral Change - Energy Analyst Level

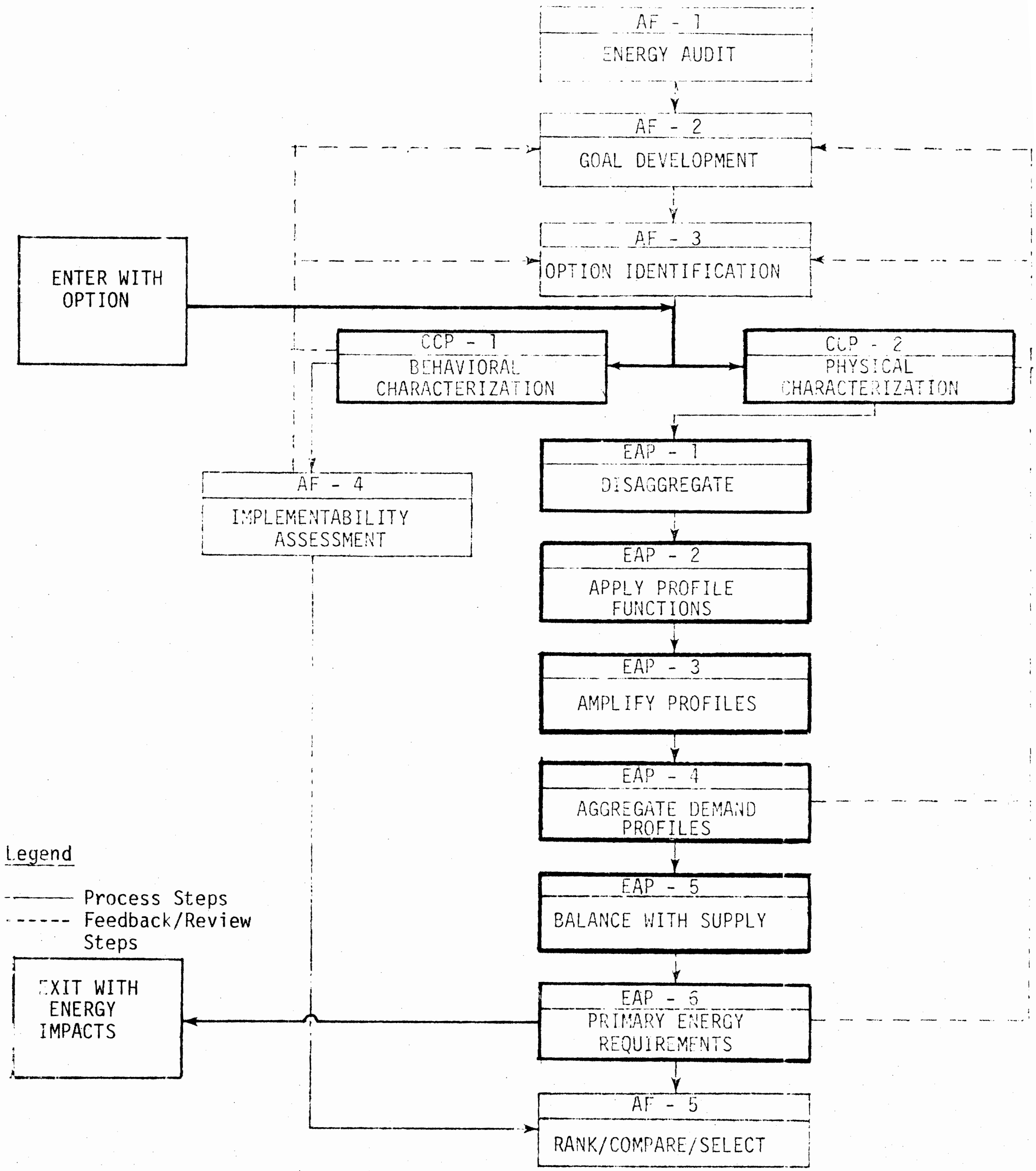


Figure 14. Option Evaluation - Energy Analyst Level

either a behavioral or a physical nature, the user must enter prior to steps CCP-1 and CCP-2. In these steps, the impacts of the option, at the parcel level, are specified or estimated. The user then works through steps EAP-1 through EAP-6 and the energy impacts are reported out of step EAP-6.

(e) Comprehensive Energy Planning - This application is shown in Figure 15. In this application, the full methodology is used. The user enters the methodology at AF-1 where the baseline energy audit is done. From there he proceeds to identify and select goals, in step AF-2, and to make a preliminary selection of action options in step AF-3. The physical impacts of these options are estimated in step CCP-1 and CCP-2, then the associated energy impacts are developed in steps EAP-1 through EAP-6. The implementability of each is assessed in step AF-4, and the implementability and energy impacts are used in step AF-5 to compare, rank, and select from among the options evaluated. As shown in Figure 15, there are a number of places through out the methodology where feedback/review may be required. These feedback loops allow the user to redefine goals or reselect options for evaluation based on the outcome of various methodological steps.

(f) Research Application - This application is shown in Figure 16. In this application the objective is to estimate the hourly energy demands of a specified (real or hypothetical) community. Since maximum accuracy is required, the user enters with a description of the community's physical composition at the EUM level. The methodology, therefore, is entered at the start of step EAP-2. From the EUM specification and other physical and climatic data particular to the community, the energy demand profiles are generated in steps EAP-2 through EAP-4. The aggregated load profiles are reported out from step EAP-4.

5. Summary

As this section has stated, the product of this research is one methodology. This is comprised of an Application Framework and two analytical tools. The methodology may be applied at either of two levels, depending on the needs and resources of the user. The major difference between the two levels of application of the methodology is that for each level of application, a different version of the analytical tools is used. In the planner application, the framework is used with a simplified CCP and EAP. In the analysts application, the detailed AAP and EAP are used.

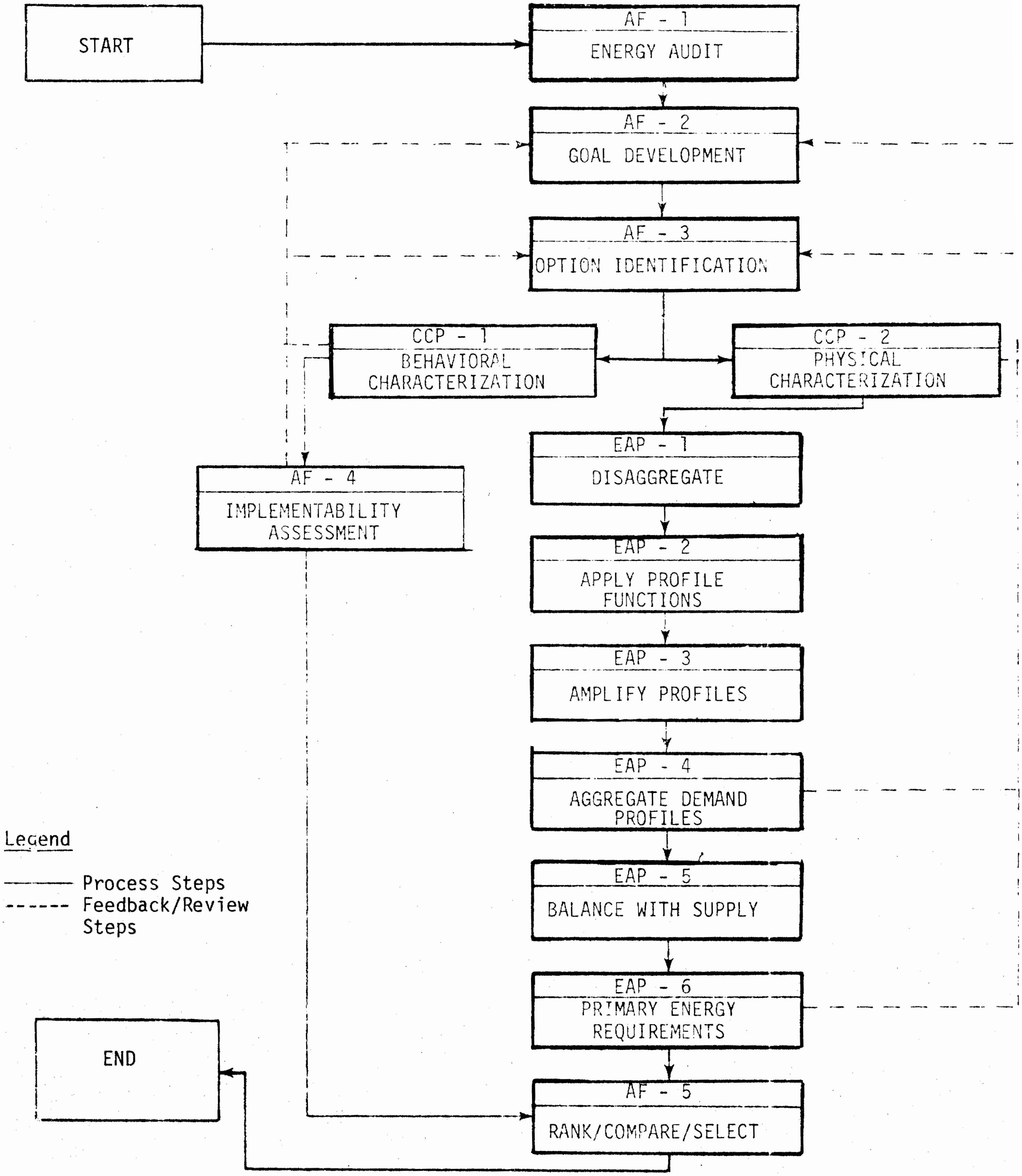


Figure 15. Comprehensive Energy Planning - Energy Analyst Level

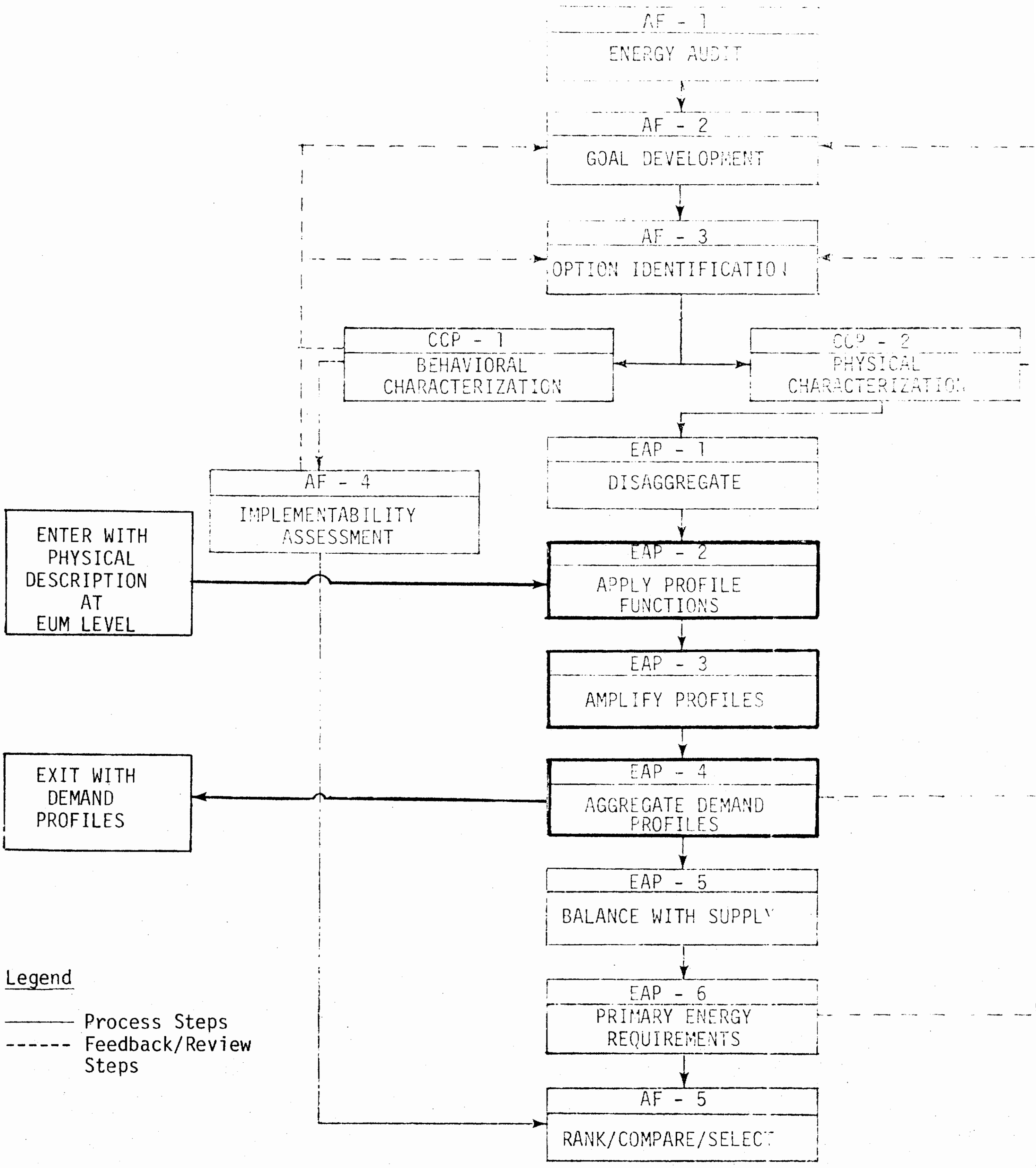


Figure 16. Research Application - Energy Analyst Level

The balance of this chapter provides detailed descriptions of the CCP, the EAP, and the Analytical Framework. In the sections for the CCP and EAP, both the planner and the energy analyst levels of application detail are discussed.

C. Community Characterization Procedure

1. Overview

a. Precedents. There have been various efforts to provide comprehensive descriptions of both the physical and behavioral characteristrics of a community, but none is directly relevant to the particular purposes of this project. That is, the classification scheme that is required for this project will be uniquely designed to meet the purposes of this project, as defined in the previous section. This is not to state that previous attempts at classification of elements of community have not been reviewed and utilized in the development of this particular framework, for such was, in fact, the case. Rather it is to point out that the particular purpose and design of this project required an attempt to characterize the various components of land use, activity, and behavioral processes unlike previous efforts.

b. Major Components. As discussed previously, there are two major components to the community characterization procedure: physical characterization and behavioral characterization. In addition, there are a set of procedures that are used as part of the application of both characterization. Those components are described in the following sections.

c. Uses of the Community Characterization Procedure. In general, the community characterization procedure is intended to provide a means for either the planner or energy analyst to describe both physical and behavioral aspects that impinge upon or influence energy conservation and community planning. These purposes may be more explicitly stated as the capability to:

- Describe decision-making processes and patterns of development in a community;
- Analyze those processes and patterns of development in a systematic fashion to determine how energy use may be altered by physical and behavioral changes;

- Evaluate a variety of energy conserving actions, other actions and policies, and broad community goals, in terms of changes in energy use and behavioral impacts, which these actions, policies, or goals might cause.

In more specific terms, the Community Characterization Procedure is intended in itself to describe and analyze present patterns of energy end-uses, as determined by present patterns of physical and behavioral characteristics (as in the "Baseline Application" described in the previous section); it is necessary to undertake, at a minimum, an analysis of physical characteristics in order to make any statement of how energy is presently used in the community. Furthermore, depending on a variety of assumptions or parameters, various other applications are linked into the Community Characterization Procedure and depend upon it to derive both changes in energy demands and to determine likely behavioral impacts; both of these pieces of information are necessary to proceed with decision-making and evaluation based, in part, on energy-conservation and management in the community.

d. Overview of Community Characterization. In order to explain how the Community Characterization Procedure was derived, and to further develop how it may be used for both analytical and evaluative purposes, a series of assumptions that underlie the framework will be stated:

(1) One major assumption underlying this project is that all physical forms or activities can be translated into energy end-uses in a direct way; therefore, for every physical parameter that may be expressed there is corresponding expression of energy demand.

(2) Physical aspects may be alternatively defined as land uses and commensurate activities, and may further be seen as the products or results of development processes.

(3) Physical forms or land uses may be further defined as consisting of three components -- natural or site conditions, structures and infrastructure networks, and activities or operations. These distinctions are made to differentiate among land use references as follows:

- As natural or environmental attributes of a site or geographical area;

- As functional uses of a site or geographical area, where functions are determined by the type or structure or infrastructure on the land;

- And as type of activity that occurs on the land and within structures.

For example, residential land uses/activities may be taken to refer to land committed to residential uses, residential structures themselves, household operations, or activities that occur on the land.

(4) Another major assumption underlying this project is that a direct relationship between behavioral and physical characteristics cannot be stated. The relationships between physical forms or characteristics of the community and the decision-making processes and behavioral patterns that create and operate those forms are too complex, too interrelated, and too numerous to account for in a simple yet fully descriptive manner. As will be seen, the approach in this project, then, is to provide a common framework that may be used for sorting out the relationships between behavioral processes and physical products resulting from those processes. The common framework will consist of a well-defined set of descriptors of behavioral characteristics, which will be used as a checklist organizing the process of decision-making, development and operation, for descriptive purposes, and which may then be further refined for analytical and evaluative purposes.

(5) In arraying the behavioral characteristics, the implicit assumption is made that the particular forms and activities in a community are the result of processes of both market and nonmarket behaviors. Economic decisions may be tracked or understood in the context of market behavior -- therefore business behavior is oriented to obtaining a profit or rate of return on investment; government decisions are directed to delivery of a level of services and facilities as demanded by consumers within the constraints of public budgets; and households are motivated by cost considerations of a similar nature. In addition, noneconomic decisions or changes

must also be accounted for, so that natural events, personal preferences, and political choices, for example, are also taken into account in decision-making processes.

(6) Although the number of relationships between behavioral and physical aspects, and among behavioral characteristics themselves, is large, the primary focus of this project is on the community planner and public decision-making. Therefore, the set of behavioral factors is directed more toward -- but not exclusively upon -- the governmental dimension of behavioral characteristics.

The relationships that have been described underlying this project are summarized on Figure 17, and may be simply stated:

- Energy end-uses are determined directly from the physical characteristics of a community, including attributes of land, structures, and activities.
- Energy end-uses are determined indirectly by behavioral processes or characteristics that affect physical forms and therefore energy end-uses.
- Behavioral characteristics are determined by a number of factors, but the public policy and action aspect is of particular importance, for this is the arena in which the community planner has greatest influence.

2. Physical Characterization

a. Definition. Energy use is directly related to the physical form of a community. In order to analyze energy use patterns, the physical characteristics of the community must be described in some detail. For the purposes of this study, this analysis is referred to as a "physical characterization."

The purpose of the physical characterization is:

- to facilitate the conversion from land-use categories to land-use parcels, which can be converted into end use modes for energy analysis;
- to relate land-use categories to changes in the behavioral patterns in the community.

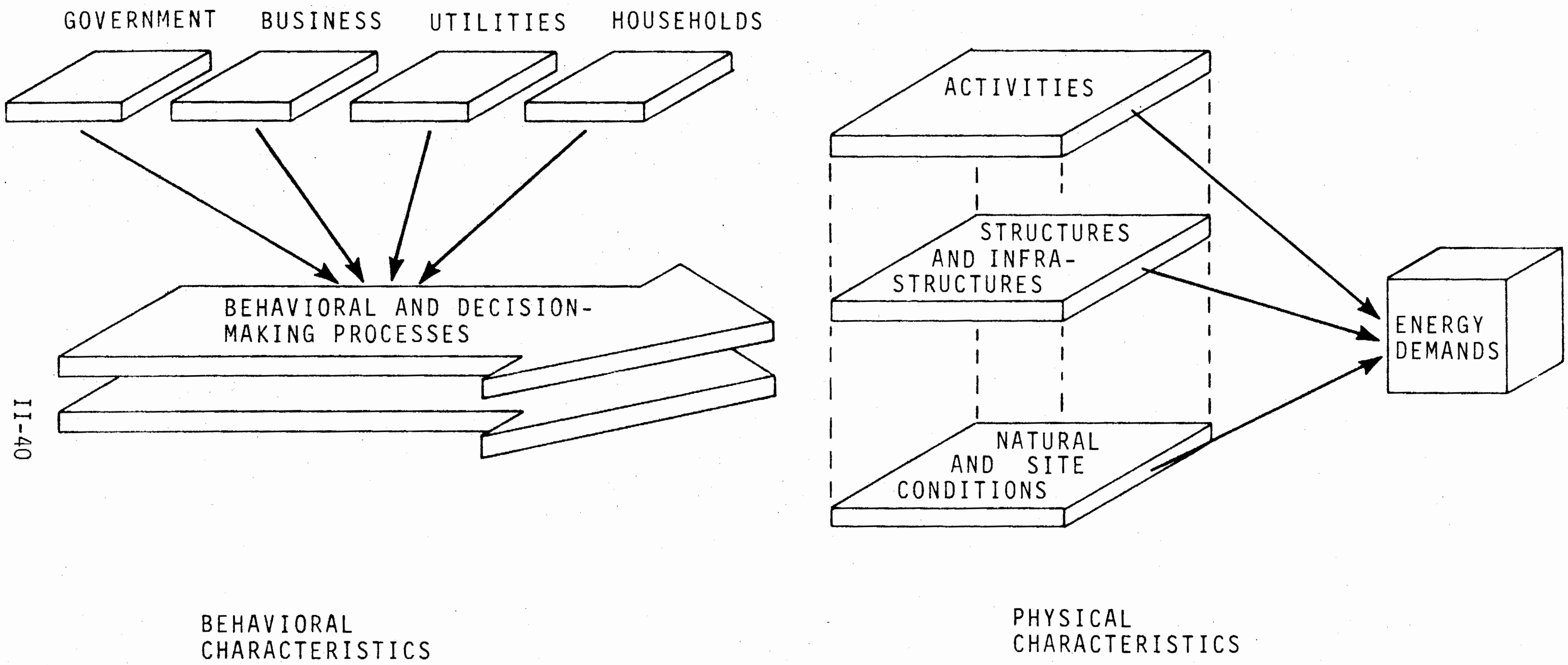


Figure 17. Schematic of Major Components of Community Characterization Procedure

The physical characterization must be discussed in sufficient detail to contribute to the overall framework of the community characterization and to be useful to the practicing planner on a variety of levels to achieve these two purposes, thus this section proposes a physical characterization procedure which can be operated at five levels of detail -- metropolitan, community, district, zone, and parcel. A method is provided for analyzing a community at any of these levels, and for converting gross land-use tabulations to the most detailed level (parcel) where energy analysis can begin.

So that the community planner or energy analyst may either assess energy use or evaluate alternative energy conservation methods, the community must be considered according to the four main factors constituting its physical characteristics. In order of importance from a conceptual point of view, these are land-uses, natural conditions, circulation, and urban form. Further, each of these factors has elements which are of conceptual priority. These are discussed below.

(1) Land Use. Land use categories refer to the types of activities serving and expressing human needs. Inasmuch as buildings accommodate these activities, various structural types are associated with land use; although in some cases the land may purposely be preserved from development, as in the case of open space. Major land use categories that correspond to human activities such as living, working, shopping, and recreating are residential, industrial, commercial, institutional, transportation, open space and active recreation, and agricultural. These categories represent a distillation of several existing codes in current use*, and are a compilation deemed more appropriate to energy considerations than these existing codes, which frequently, for example, itemize manufacturing types in detail inappropriate to energy consumption analyses.

(2) Natural Conditions. Natural conditions are the support system and paramaters for all physical community development; the primary parameters of human settlement development are defined by such things as the climate, water orientation, topography, and landscape (vegetation type, density, maturity) of a

* *Standard Land Use Coding Manual, U.S. Urban Renewal Administration and Bureau of Public Roads, Washington, D.C., 1965, pp. 29-31; and Standard Industrial Classification Manual, U.S. Bureau of the Budget, Washington, D.C., 1957. From "Land Use Studies," in Principles and Practice of Urban Planning, Shirley Weiss, p. 111-112. (Ed., Goodman and Freund).*

community. These factors may be mediated to facilitate certain types of human development, but they may never be altogether controlled or ignored (as has been demonstrated in recent history by the documented detrimental effects of air and water pollution, for example). Natural conditions are variably controllable through natural resource management.

Water resources and orientation are significant descriptive factors of a community but different types have varying impacts on energy use.

Of the four natural conditions, climate is the least flexible parameter, inasmuch as it may only be controlled, though not altered, at the micro (or building) level. (Although metropolitan area climate control, in the form of a space bubble, has been proposed, it is not realized yet.) The presence of a large area of water -- an ocean, lake, or bay -- will be a micro-climatic influence affecting energy use for heating and cooling, for example. Also, its adjacency to a site limits extensive land development; or it may provide a power source (as for hydroelectric energy production), if available in an appropriate form. Likewise, topography is a parameter which is a more easily controlled variable than climate or water orientation, because land configurations may be changed more readily, although not without affecting other natural conditions (water, vegetation). Finally, vegetation characteristics, although water and climate-dependent, can be altered, probably the most easily of the four natural factors.

Natural conditions differ from land use in that they are discriptions without value in terms of a relationship to people, their needs and activities.

(3) <u>Circulation</u>. Because it comprises several semi-independent and overlayed networks, circulation is the most complex factor affecting community physical form from an energy standpoint. In the case of transportation, this network serves people directly; utility distribution of gas, electricity and water serve people indirectly, as does waste collection, either solid waste or waste water.

(4) <u>Urban Form</u>. Urban form refers to the patterns of development which characterize a community, including both the vertical and horizontal configuration of structures and spaces. As human settlements have grown to be increasingly complex (and strived for physical permanence and continuity), the urban area, including the

city as its vital center, has become the focus of not the norm for discussing land-use relationships. Indeed, recent land use studies document the urban annexation of rural lands, including open idle, forest and crop land.

Thus, although current urban uses of land occupy only 16.4 percent of the total land area, these uses are both intense and increasingly influential on cross-sector development. The deployment of uses, including clustering, as in Planned Unit Development, and Mised-Use Development, are examples of current planning practices that affect urban form, and indicate trends which suggest the necessity for including urban form as a dynamic factor that characterizes a particular community's physical form.

b. Objectives. A number of objectives were established for the choice of physical descriptions. To provide continuity between established physical planning approaches and current efforts to assess a community for energy use and potential conservation, every effort has been made to selectively incorporate terms and classifications familiar to the practicing planner. Additional criteria for the choice of factors and categories also require that they have an available data base, and that the factors be energy-consumption indicators. Inasmuch as existing data sources may be heterogeneous, a further objective of the physical characterization process is to provide the community planner with a conversion method, which will render mixed data directly applicable to an energy analysis. Thus, for example, where residential land use is often described by number of dwelling units, denoting number of occupants; figures commonly used to describe commercial land uses are in square feet of floor space. Equivalencies for number of dwelling units, which can be converted to energy end-use modes are provided in Table 4 Physical Characterization-Levels of Analysis. Also, these conversions may be worked out from the most general or aggregate level of characterization to the most specific level.

Factors which are not primary energy indicators are eliminated or deemphasized. An example is the four digit Standard Industrial Classification code, originally developed for statistical review by various Federal agencies. These breakdowns are not all applicable to energy-use analysis, because this classification provides a level of detail which is too cumbersome for community-wide energy analysis. Furthermore, all land use categories are included in the list of physical characteristrics, so that a comprehensive descriptive basis will both match current energy analyses by sector, and provide a meaningful departure point for considering

TABLE 4. PHYSICAL CHARACTERIZATION-LEVELS OF ANALYSIS

METRO	COMMUNITY	DISTRICT	ZONE	PARCEL
	Central City	Central Business District	Subdivision, (by type)	Residential
			R-1, R-2, R-3, etc.	Single family detached
			Single/multi family	Single family attached
	Suburban Fringe	Industrial District		Multi-family low-rise
			Employment	Multi-family high-rise
		Planned Unit Development	Office	Mobil homes
			Industrial (M-1,M-2,...)	
			Government	
				Commercial
		CBD Fringe	Shopping (B.1,B.z...)	retail : small
				retail : large
		Urban neighborhood	Medical (Inst.)	retail : regional
				restaurants
			Campus	wholesale
		Suburban Neighborhood		office low rise
			Parks-Open Space	office high rise
		Beltway "Ring"		auditoria and arenas
				hotel - motel - low rise
				" " high rise
				Institutional
				hospitals
				schools
				Public Administration
				religious, social
				cultural, museums
				Transportation, circulation
				roads, r.o.w.s
				parking
				terminals
				Open Space
				preserves (land, water)
				park
				Special uses
				industry (by type)
				agriculture

future development options. If, for example, open space were to be excluded, as it might be perceived as entailing no (or insignificant) energy use; the current total energy-use figures for a community would only correspond to a partial area. Also, energy-use requirements for future development of the open space (infrastructure siting, operation and maintenance, building and transportation system construction and maintenance) could not be calculated.

c. Levels of Analysis. Urban planners practice their professions in an environment that requires anticipating long-range trends while at the same time making detailed day-to-day decisions. Charged with the responsibility to project the changing needs and form of the city over the long term future, planners must take a "broad-brush" approach to master planning. Simultaneously, however, planners must also make recommendations on detailed land-use, transportation, and public service alternatives, as well as review construction plans proposed by private land owners. Planners, therefore, must analyze issues on a number of different levels of detail.

In addition, planners must rely on available data resources for most of their work. Only on large specialized assignments - usually when outside funding is available -do planners have the ability to collect significant amounts of new data or to do original research. Existing data may be spotty and may have been collected for specific purpose which restricts its usefulness. Available data also included standard information sources such as the census. In summary, data will be available from a variety of sources, but will vary in terms of accuracy, applicability, timeliness and level of detail.

In order to accommodate analysis and data at different levels of detail, the physical characterization of the community must be designed to operate for different levels of analysis. These levels of analysis should permit:

- Analysis of the community using data which varies in detail and source.
- Analysis of the community in a rapid, overview manner as well as for more thorough study.
- Analysis of a community using available data and providing estimated values where necessary to complete the characterization.

For the purposes of this study, the physical characteristics of the community are arranged in such a manner as to allow planning professionals to make energy decisions at a variety of scales. For example, Comprehensive Master Planning is carried out typically at the scale of the entire community, while zoning or site plan reviews will effect a small segment of the community or perhaps only a single site. In order to permit aggregations of land uses into manageable and useful categories, the following list of levels for analysis has been developed:

- Metropolitan. Describes clusters of communities. This level of analysis is beyond the scope of the current study.

- Community. Describes a self-contained municipal jurisdiction within largely contiguous political boundaries, and containing a full range of land uses. Community types include Central Cities Suburban Fringe Cities.

- District. Describes aggregations of mixed uses on multiple sites such as a Central Business District, Office/Industrial employment districts, Planned Unit Developments, or sectors of cities such as CBD Fringes, Urban Neighborhoods, "Beltway" developments, etc.

- Zone. Homogenous uses on single or multiple sites such as Industrial Parks, Subdivisions (Residential), Campus developments, Shopping complexes, etc.

- Parcel. Describe a single homogenous use on a single building parcel, such as a single-family residential unit, small office building, or shop. This level provides the necessary breakdown of variables for conversion to EUMs, dealt with in subsequent sections. Table 4 shows the five levels of analysis and types of land uses, under each category.)

The following sections describe each of these levels of analysis.

(1) Metropolitan Level of Analysis. A metropolitan area generally includes a major central city and a cluster of suburban communities. Analysis of major urban concentrations, particularly those involving multiple political jurisdictions is undertaken by various state, county, or regional planning agencies. The intent of this study is to provide planning tools which can be applied to smaller communities which may or may not be a part of a large urban area. The characterization of entire metropolitan areas is considered beyond the scope of the study.

(2) Community Level of Analysis. The term community is used here to describe a municipal jurisdiction. For this study, methodology will be developed to characterize communities in the 25-50,000 population range. Communities of this size are considered to be sufficiently large to demonstrate the characterization process without encumbering the process with undue complexity. Either a suburb or a self-contained community pertains. In addition, cities in this population range generally have a planning history as well as access to a planning staff. Therefore, it can be expected that a data resource will exist as well as a functioning planning organization to make use of the methodology.

The political boundaries of the city are chosen as the boundaries of the characterization in order to reflect the area over which a local planner has influence. In addition, nearly all data is collected and compiled on the basis of defined boundaries.

At the community level, a planner may have several concerns which can be addressed by the characterization:

- A planner can learn to what degree his community is typical of other communities. The characterization should provide basic measures drawn from a variety of cities which a local planner can use to evaluate his community. In this way, a very rough approximation of the basic elements of the community can be estimated.

- Rapid estimations of physical characteristics can be made for "broad brush" analysis. For example, assessing the impact of major changes on the entire community.

- At the community level, a planner can incorporate data which is available and specific to his community, thereby modifying generalized community data which is supplied in the characterization. For example, a small community which includes a major regional use such as a college campus, a steel mill or a regional park, will produce physical data dissimilar to the average town of its size. For these communities, the local planner can make the characterization more specific by adding in special local conditions, while at the same time retaining estimations of other land uses provided by the characterization.

A breakdown of land uses at the scale of the entire community, from which the planner can convert to the parcel level, is provided on the parcel chart. (Table 14. Parcel Measurements for Data Conversion.)

(a) Types of Communities. For the purposes of this study, two types of communities have been identified - Central Cities and Suburban Fringe Cities. Experience has shown that communities which are independent of other communities have a somewhat different mix of land use and other physical characteristics.

- Central Cities. A Central City will be defined as a community which is dominant in its region. The city may provide services which support outlying or rural development but does not rely on other communities for basic needs such as employment, shopping or living area.

  Among smaller communities (25-50 thousand population range), the boundaries of the city generally will include a full range of land uses. The characterization will consider land uses in the following categories:

  - Residential - single-family detached residences.

  - Residential - two family attached units.

- Residential - multifamily apartments or condominiums.

- Commercial areas including stores, shops and other forms of retail activity.

- Light industry including warehouse and distribution as well as light manufacturing and processing facilities.

- Heavy industry including major manufacturing and processing facilities.

- Circulation including streets and highways and railroads.

- Parks, and other public open space.

- Public and semi-public property including schools, other public facilities and institutional, religious and cultural facilities.

For each type of community, land use guidelines are provided on the basis of area (acres, sq. mi., etc.) or by population.

- Area measures for Central Cities: Research indicates that land use proportions for typical Central Cities have been found to reasonably consistent. Table 5, Typical Land Uses for Central Cities, provides guidelines for planners to define land use quantities. Using these proportions, and lacking any more city specific data, a planner can roughly estimate expected land use breakdowns for his community. In order to relate the analysis directly to his application, the planner should add into the process any features which make his community unique or atypical. These breakdowns may be converted to the parcle level using the chart provided. (Table 14, Parcel Measurements for Data Conversion.) The data in this and the following

TABLE 5. TYPICAL LAND-USES FOR CENTRAL CITIES BY AREA

Use	Percentage of Developed Area	Percentage of Total Area
Residential Single family	31.81	75% Developed
Residential Two family	4.79	
Residential Multifamily	3.01	
Commercial	3.32	
Light Industry	2.84	
Heavy Industry	3.60	
Railroad	4.86	
Streets	28.19	
Parks & Recreation	6.74	
Public and Semi Public	10.93	
Vacant (Incl. water)		25% Undeveloped
Total	100%	100%

SOURCE: Adapted from Land Use in American Cities, H. Bartholomew, Harvard University Press, 1955; and Recent Land Use Trends in 48 Large American Cities, Niedercorn and Hearle, Rand Corp., 1963.

three tables may be limited by its age, and the size of the community being studied; and may also need to be further defined in work area 300, through more research into existing sources, or locally through a market analysis.

Working from a population base, the tabulations in Table 6, Typical Land Uses for Central Cities by Population, provide land use breakdowns for typical Central Cities.

Working from a population base, planners can estimate land use for existing communities or project future land-use needs for growing areas.

- Suburban Fringe Cities. Suburban fringe cities are communities which are functionally and/or economically tied to other communities. The most common type of Fringe City is the "Bedroom Community" which is located in proximity to a large city or within a major urban concentration. Fringe Cities typically are lower in density overall than Central Cities and have higher proportions of low density residential and industrial uses.

  The following tables represent data collected for communities which are recognizable, independent entities in large urban areas but which are not so specialized as to be unique examples. For instance, communities which have unusually large areas of industrial, educational or residential land uses can be recognized. For these cities, the tabulated data must obviously be modified locally.

TABLE 6. . TYPICAL LAND USES FOR CENTRAL CITIES BY POPULATION

Use	Acres of Developed Area per 100 Persons
Residential - Single family	2.10
Residential - Two family	0.33
Residential - Multifamily	0.21
Commercial	0.20
Light Industry	0.25
Heavy Industry	0.33
Railroad	1.94
Streets	0.46
Parks	0.75
Public and Semi Public	
Total	6.89

SOURCE: Adapted from Land Use in American Cities, H. Bartholomew, Harvard University Press, 1955; and Recent Land Use Trends in 48 Large American Cities, Niedercorn and Hearle, Rand Corp., 1963.

- Area Measures for Suburban Fringe Cities. The data in Table 7 provides area breakdowns for typical suburban fringe cities. Table 8 illustrates typical land use in Suburban Fringe Cities based on population.

(3) District Level of Analysis. To obtain a more precise physical characterization than can be achieved at the community level, a planner can work at the "District" Level. The term district is used to define an area of the community which has definable boundaries and contains certain dominant land uses. Districts can also describe aggregation of mixed land-uses on multiple or single large sites. Examples of districts are:

- Central Business Districts
- Office/Industrial Employment Districts
- Planned Unit Developments
- Urban Residential Neighborhoods
- Suburban Neighborhoods
- "Beltway" Developments

This characterization will permit a planner to subdivide his community into districts and to calculate land use and often physical quantifications based on the District Level of detail. Advantages of the District Level of analysis are that the community can be characterized in a more specific way than at the overall community level while at the same time using general data and readily available estimating.

Ideally a community could be completely divided into districts for which data could be analyzed. In practice, however, it is expected that the District Level of analysis could be combined with other levels of analysis to characterize the community. Although the District Level includes the six types cited above, for illustrative purposes, the CBD has been selected to show the analytic process, because the CBD is a crucial sector.

(a) Central Business District. The Downtown is the most readily identifiable District in any community. For characterization purposes, it is also perhaps the most difficult area to describe due to the multiple overlapping land uses. The CBD is often considered to have two sectors: the CBD core and the CBD frame. The core-frame concept permits separation of the CBD into areas including dense center and a second area which includes the less dense areas surrounding the center.

TABLE 7. TYPICAL LAND USES FOR SUBURBAN FRINGE CITIES BY AREA

Use	Percentage of Total Developed Area	Percentage of Total Area
Residential - Single family	36.18	
Residential - Two family	3.31	
Residential - Multifamily	2.49	
Commercial	2.54	
Total Industrial	7.86	75%
Railroad	4.65	
Streets	27.67	
Parks	4.37	
Public & Semi Public	10.93	
Total	100.00	
Vacant		25%
Total		100%

SOURCE: Adapted from Land Use in American Cities, H. Bartholomew, Harvard University Press, 1955; and Recent Land Use Trends in 48 Large American Cities, Niedercorn and Hearle, Rand Corp., 1963.

TABLE 8. TYPICAL LAND USES FOR SUBURBAN FRINGE CITIES BY POPULATION

Use	Acres of Developed Area per 100 Persons
Residential - Single family	3.14
Residential - Two family	0.29
Residential - Multifamily	0.22
Commercial	0.22
Industrial	0.69
Railroad	0.40
Streets	2.40
Parks	0.38
Public & Semi Public	0.95
Total Developed Area	8.69

SOURCE: Adapted from Land Use in American Cities, H. Bartholomew, Harvard University Press, 1955; and Recent Land Use Trends in 48 Large American Cities, Niedercorn and Hearle, Rand Corp., 1963.

The following tables indicate the most easily identifiable characteristics of the core and frame (Tables 9, 10, and 11).

- Land Use in the CBD. The primary land users in the CBD are Retail, Commercial, Office and Transportation. In order to characterize these factors it is necessary to provide a general methodology for calculating quantities.

  The following data may be limited by its age, the size of the community studied, and may also need to be further defined in Work Area 300, through more research into existing sources, or locally through a market analysis.

  The following data is provided to assist the planner in estimating land use in the CBD:

  - Retail Space. Retail sales have been found to occupy approximately 30 percent of available downtown floor space. Since shopping activities are almost exclusively first floor uses (except in the case of multistory department stores) this proportion is a rough approximation of downtown land coverage.

  - Office Uses. Office uses occupy approximately 33 percent of CBD flospace. Offices may be single or multistoried structures and therefore total floor area must be divided by average building height to determine ground coverage.

  - Transportation. Space for auto circulation and storage (streets and parking) can vary greatly depending upon size of community and the value of downtown land area. Estimates of space needs range between 25 and 35 percent of CBD land area.

TABLE 9. GENERAL PROPERTIES OF THE CBD CORE

Property	Definition	General Characteristics
Intensive land use	Area of most intensive land use and highest concentration of social and economic activities within metropolitan complex	Multistoried buildings Highest retail productivity per unit ground area Land use characterized by offices, retail sales, consumer services, hotels, theaters, and banks
Extended vertical scale	Area of highest buildings within metropolitan complex	Easily distinguishable by aerial observation Elevator personnal linkages Grows vertically, rather than horizontally
Limited horizontal scale	Horizontal dimensions limited by walking distance scale	Greatest horizontal dimension rarely more than 1 mile Geared to walking scale
Limited horizontal change	Horizontal movement minor and not significantly affected by metropolitan population distribution	Very gradual horizontal change Zones of assimilation and discard limited to a few blocks over long periods of time
Concentrated daytime population	Area of greatest concentration of daytime population within metropolitan complex	Location of highest concentration of foot traffic Absence of permanent residential population
Focus of intracity mass transit	Single area of convengence of city mass transit system	Major mass transit interchange location for entire city
Center of specialized functions	Focus of headquarters offfices for business, government, and industrial activities	Extensive use of office space for executive and policy making funct ons Center of specialized professional and business services
Internally conditioned boundaries	Excluding natural barriers, CBD boundaries confirmed only by pedestrian scale of distance	Pedestrian and personnel linkages between establishments govern horizontal expansion Dependency on mass transit inhibits lateral expansion

SOURCE: Horwood and Bonce, Studies of the Central Business District and Urban Freeway Development, Washington

TABLE 10. GENERAL PROPERTIES OF THE CBD FRAME

Property	Definition	General Characteristics
Semi-intensive land use	Area of most intensive non-retail land use outside CBD core	Building height geared to walk-up scale Site only partially built on
Prominent functional subregions	Area of observable nodes of land utilization surrounding CBD core	Subfoci characterized mainly by wholesaling and stocks, warehousing, off-street parking, automobile sales and sevices, multifamily dwellings, intercity transportation terminals and facilities, light manufacturing, and some institutional uses
Extended horizontal scale	Horozontal scale geared to accommodation of motor vehicles and to handling of goods	Most establishments have off-street parking and docking facilities Movements between establishments vehicular
Unlinked functional subregions	Activity modes essentially linked to areas outside CBD frame, except transportation terminals	Important establishments linkages to CBD core (e.g., intercity transportation terminals, warehousing) and to outlying urban regions (e.g., wholesale distribution to suburban shopping areas and to service industries)
Externally conditioned boundaries	Boundaries affected by natural barriers and presense of large homogeneous areas with distinguishable internal linkages (e.g., residential areas with schools, shopping, and community facilities)	Commercial uses generally limited to flat land Growth tends to extend into areas of dilapidated housing CBD frame uses fill in interslices of central focus of highway and rail transportation routes

TABLE 11. PRIMARY DIFFERENCES BETWEEN CBD CORE AND CBD FRAME

Factor	Primary Characteristics in CBD Core	Primary Characteristics in CBD Frame
Land utilization	Intensive	Semi-intensive
Site utilization	Fully built on	Partially built on
Building types	Similar	Dissimilar
Growth	Upward	Outward
Business linkages	Internal	External
Parking space	Very limited	Generally adequate
Transportation mode	Pedestrian	Vehicular
Transportation foci	Intercity	Intercity
Boundary determinants	Internal fac factors	External factors

SOURCE: Horwood and Bonce, Studies of the Central Business District and Urban Freeway Development, University of Washington Press, Seattle, Washington, 1959.

- CBD Land Use Mix. The data presented below, and that in Table 12, allow the user to estimate typical CBD developments in a small community. These sector breakdowns provided may be similar to the parcel level of analysis. Further breakdown required for conversion to the parcel level of analysis is provided in the parcel level-of-analysis chart. (Table 11, Parcel Measurements for Data Conversion.)

Average size of CBD as a proportion of total city size	.70%
Average ground floor building area as a percentage of CBD land area	60%
Average total height of building (this factor x floor area equals total building area)	1.5 to 2.0

(b) Other District Level Functions. The central business district was selected for illustration because data was readily available. Data required for analyzing other district level functions such as industrial/employment areas, urban neighborhoods or planned unit developments has not been obtained. Further research is needed to determine the availability, accuracy and suitability of information. Of particular importance for this project are employment and residential sectors. It is suggested that characterization of these functions at the district level may be accomplished on a nonsite specific basis. For example, industrial employment data is available from the Census of Business and could be directly converted into floor area and acreage volumes. A further breakdown required for conversion to the parcel level of analysis is provided in Table 14, Parcel Measurements for Data Conversion.

(4) Zone Level of Analysis. The term Zone is intended to describe homogenous uses on definable tracts of land. Examples are Residential areas of like density, Industrial Parks, Shopping Complexes, or Campuses.

TABLE 12. AVERAGE MIX OF LAND USE BY FLOOR AREA

Retail Business	
Auto related	3.9
Variety	9.5
Miscellaneous	5.3
Food	
Restaurant	1.8
Other	2.1
Clothing	4.2
Household	5.3
Office	
Financial	3.0
Service Trade	4.1
Headquarters Office	5.0
General Office	12.7
Other	7.8
Miscellaneous	
Lodging	11.7
Residential	3.4
Public & Semi Public	11.6
Industrial	1.5
Wholesale	1.8
Vacant	5.5

SOURCE: Raymond E. Murphy, The Central Business District, Aldine, Atherton, NY, 1972.

Zones are familiar land use categories for planners since most cities use "zoning" to control land development. Zoning classifications specify areas which permit only uses of certain types and sizes to be developed. While nonconforming and under-utilized parcels of land occur frequently in cities, zoning is a reasonably accurate tool for measuring quantities of various land uses. In addition, examination of zoning for undeveloped land indicates the likely future use of that land barring unexpected rezoning.

Most city planning departments have a general knowledge of the amount of land in the community which is zoned for various uses. Also known is the percentage of land which has been developed as well as that remaining undeveloped. In addition, planners often understand the degree to which the allowable building densities can be achieved on a specific parcel. For example a planner will know from local experience that a development usually yields 1.6 dwelling units per care in an R-10 zone which requires 10,000 square foot lots.

If the planning department does not have zone data available, it can be obtained reasonably quickly by taking quantities off maps and zoning documents. Local knowledge of existing conditions must be used to make judgments as to the selection of zones and use of data which is obtained. It is intended that analysis at the zone level should be more detailed than at the community or district level, but less detailed than the parcel level which may required field investigation and surveys to assemble detailed data.

The key zones for analysis are Residential, Commercial, Industrial, and Office. The following example, in the industrial sector, illustrates the method which can be utilized for zone level analysis.

(a) <u>Industrial Land Use Estimation</u>. For industrial land uses estimations at the zone level it is necessary to establish the approximate mix of industrial types within the city. The number of workers, as well as land area requirements, vary considerably by type of industry.

Table 13 permits conversion of data for industrial uses and can be entered for employment, site size, or building area, which are parcel level factors. Further data required to obtain parcel level breakdown is provided by the parcel level chart. (Table 14, Parcel Measurements for Data Conversion). In Table 13 separate columns are maintained for central area

TABLE 13. TYPICAL INDUSTRIAL LAND USES

2 Digit SIC Code		Site Size x 1,000 sq. ft.		Ratio of Building Area to Site Area		Employee Density/Acre	
		Central	Outlying	Central	Outlying	Central	Outlying
20	Food	36	90	40%	45%	40	20
23	Apparel	30	150	60%	30%	105	51
24	Lumber	45	300	70%	6%	100	3
25	Furniture	20	50	80%	31%	44	24
26	Paper	50	400	72%	40%	40	32
27	Printing	10	50	133%	30%	164	94
28	Chemicals	500	1,000	36%	10%	6	6
30	Rubber	30	80	67%	45%	50	21
32	Stone Products	150	500	50%	8%	33	3
33	Primary Metal	100	600	55%	30%	18	11
34	Fabricated Metal	60	200	50%	20%	25	12
35	Machinery	15	80	50%	30%	48	28
36	Elect. Machinery	20	175	70%	60%	50	35
37	Transportation	1,100	2,500	50%	10%	36	8
	Average	80	375	50%	15%	30	10

SOURCE: Industrial Potential of the Central City, Urban Land Institute, 1973.

TABLE 14. PARCEL MEASUREMENTS FOR DATA CONVERSION

Land-Use Category		Population	Hand Coverage	Quantity	Site Conditions
Residential	Single-Family Detached, Low Density	# Residents	#Acres	#Units	
	Medium Density	Tenants	#Acres	#Units	
	High Density	Tenants	#Acres	#Units	
	Single-Family Attached	Tenants	#Acres	#Units	
	Multi-Family Low-Rise	Tenants	#Acres	#Units	
	Multi-Family High-Rise	Tenants	#Acres	#Units	
	Mobil Homes	Tenants	#Acres	#Units	
Commercial	Retail: Small	# Employees +	#Sq. Ft.		
	Large	# Employees +	#Sq. Ft.		
	Regional	# Employees +	#Sq. Ft.		
	Restaurants	+#Patrons	#Sq. Ft.	Seats	
	Wholesale	+#Patrons	#Sq. Ft.		
	Office Low-Rise	# Employees	#Sq. Ft.		
	High-Rise	# Employees	#Sq. Ft.		
	Auditoria and Agena	+#Patrons	#Sq. Ft.	Seats	
	Hotels/Motels Low-Rise	+#Guests	#Sq. Ft.	#Rooms	
	High-Rise	+#Guests	#Sq. Ft.	#Beds	
Constitutional	Hospitals	+#Patients	#Sq. Ft.		
	Schools	+#Students	#Sq. Ft.		
	Religous/Social	+#Members	#Sq. Ft.		
	Cultural/Musems	+#Patrons	#Sq. Ft.		
Transportation	/Circulation		#Miles	#Spaces	
	Roads Rights-of-way		#Acres	#Spaces	
	Parking		#Sq. Ft.		
	Terminals	# Employees	#Miles		
	Utilities Rights-of-way				
	Service Stations (lift stations, treatment plants)	# Employees	#Aq. Ft.		
Open Space	Land/Water Preserves		#Acres		
	Parks		#Acres		
Special Uses	Industrial	# Employees	#Sq. Ft.		
	Agricultural	# Employees	#Acres		

industrial facilities and for outlying industries. The variance between columns illustrates two factors: higher downtown land densities and older industrial development patterns vs. newer lower-density patterns. The values given should be regarded as a range of possible values that can be modified to reflect specific applications.

(b) Other Land Uses for Zone Level Analysis. For purposes of the conceptual stage of this report, the industrial sector has been analyzed. Other land uses for which zone level analysis will be detailed include various densities of housing, office and commercial uses, medical facilities, public facilities, educational complexes, and recreational uses. For each use a conversion table will be developed in order to permit data to be compared in a uniform manner. The preceding discussion of industrial uses indicates the manner in which other land uses will be treated. This analysis will be completed as data collection proceeds during the succeeding work area.

(5) Parcel Level of Analysis. A parcel involves only a single building with a single, or homogenous use, and represents the most detailed level of analysis being undertaken in this characterization of the physical community. Data at the parcel level may be estimated, or is available by survey.

Because parcels are individual units, such as a single-family detached dwelling, a shop, store, school, or hospital, data from surveys is already available for various sectors. U.S. census data for example, is based on dwelling unit, and therefore provides residential sector data at the parcel level.

In order to operate at the parcel level, a planner may either estimate land use quantities based on available data, or undertake field inspections and surveys to obtain precise data. Of all levels of analysis, the parcel level is the only one that permits the use of detailed site-specific data.

The evaluation of the energy needs of all land use requires the preparation of data at the parcel level, since parcel level data can be converted directly to energy end use modes. Parcel level data can be estimated using procedures outlined for other levels of analysis.

Table 14 illustrates land use conversion measurements which allow the user to compare land-use data using uniform data measurements.

Table 14 will provide conversion factors for use in the following ways:

- To convert bulk land use to parcel level analysis- i.e., number of acres of housing to total units to population size, etc.

- To convert land use to building area- i.e., total acres of commercial area to total square feet of commercial building to breakdown by type of shop.

- To convert activity measures to building area- i.e., total number of hotel rooms to square feet of hotel building or total numbers of students to number of classrooms to total building area.

- To estimate volume of building area for city size- i.e., approximate number of hospital beds or fire or policy facilities to size of facilities.

d. Summary. The physical characterization is intended to provide a community data base, in the proper format to facilitate energy analysis. The procedure for translating the physical characterization into energy use measures is described later in the interim report. The key output of the physical characterization is a tabulation of land uses at the parcel level in sufficient detail to meet energy analysis requirements.

Since planners are not generally expected to have complete parcel-level land-use data available, and since gathering the data at that detail may be precluded by time and cost constraints in average communities, the method of estimating land uses is provided in the physical characterization step. This estimating method permits the planner to work at a variety of levels of analysis, incorporating available data where appropriate and arriving at an acceptable approximation parcel-level land uses for the subject city.

In addition, the physical characterization can be used to reflect changes in the behavioral aspects of a community, and to permit energy analysis of those changes. This is described in the following section.

3. Behavioral Characterization

The physical characterization that was outlinec in the previous section permits very detailed specification of the characteristics of a community; the only limitations to full and comprehensive description seem to be the lack of data, or the costs of accumulating data. In that case, less detailed procedures will be used, but the problems will still be in terms of data accumulation, and not conceptual difficulties.

In the case of behavioral characterization, data quality and availability is also a problem. But a more fundamental problem exists as well, namely, the limits on conceptual thinking that are required for the analyst or planner to utilize the behavioral characterization procedure. In other words, since the intent of the behavioral characterization is to establish a generalized framework into which the numerous and complex relationship between physical and behavioral factors are arranged, less precision will be possible in specifying behavioral characteristics than can be achieved in specifying the physical ones.

The components of the common framework are described in the following sections, in a general manner. As will be seen, it is also possible, and useful for purposes of this analysis, to divide the community into six major land use categories. More detailed background information on each of the six categories is presented in Appendix E; this information may be used in carrying out a specific application of the methodology and is useful for orientation to the entire process of behavioral characterization. The Summary to this section will provide tables that provide the overall framework and key components that are required for use when the behavioral characterization is used in actual application.

a. Class of Decisions. The primary structure in behavioral characterization is to divide the sets of decision-making processes into two basic groups: the decisions to construct or to develop and the decisions to operate or to maintain. These types of decisions are sufficiently different to warrant separate attention; the differences do not lie so much in the energy end-use aspect as in the fact that different types of decisions, different participants, and different sectors are involved in the two sets. The distinction therefore becomes analytically useful for fulfilling all the purposes of behavioral characterization listed above.

b. Sectors and Participants. There are a variety of participants in the processes of development and operation, as indicated in the summary tables. As will be discussed in following sections, the most important participant from the perspective of this project is the community planner involved in public decision- or policy-making. Before isolating on that key participant, it is first necessary to array and link all other participants, and to understand how decisions from each perspective are made.

It is convenient to separate decisions, therefore, into four sectors:

(1) Government sector: The decisions made by public officials are important as a group for three reasons -- the most obvious of which is that this is the arena in which community planners operate. It is also an important set of decisions because of the widespread impacts of public policies, regulations, and decisions in all other sectors, and because of the same reason, in part, that utility decisions are isolated -- that capital improvement decisions affect the pace and direction of development, and therefore have considerable energy end-use implications.

(2) Business (market) sector: The decision to invest, to locate, to operate facilities or to provide goods and services have implications for community development and operation. The decision to develop is especially important for developers, builders, the design professions, and financial institutions. The decision to operate, on the other hand, is important in manufacturing processes, as well as in business operations in general.

(3) Utility sector: Normally, such decisions would not be separated from business decisions in general, but because of the particular focus of this project -- namely to orient to energy end-uses, and because of the impact of utility decisions in providing services to undeveloped fringe areas and the resulting impacts on the direction and pace of growth, separate consideration of this set of decisions was warranted.

(4) Household sector: The full range of consumer decisions are of course fundamental to the determination of both physical and institutional factors of community development and operation. Whether expressed as to decisions to buy, to

locate, to maintain, or to consume, there are strong impacts that can be traced to physical expressions of the community, which in turn create energy demands.

c. Factors or Determinants. In addition to identifying and sorting out participants, sectors, and types of decisions, there are various factors that impinge upon the decision-making process. Such factors influence or constrain the nature of those decisions, and therefore have an indirect impact on physical characteristics and further upon energy end-uses. The types of determinants or factors that might be found are generically stated in Table 15.

d. Prototypical Sequence of Events. Once all the components of the behavioral pattern or decision-making process have been defined, it is possible to array those components in prototypical sequences, which display the series of events that occur in the development and operation of specific types of land used, accounting for both structures and activities. This sequence can then be seen as a way of displaying the variety of participants, types of decisions, and determinants in a consistent manner. Once this entire process is understood -- and expressed as a sequence of events -- it will allow display of the behavioral interrelationships, the relationships between behavioral and physical characteristics, and how those relationships will be altered by energy conservation measures or by comprehensive community planning for energy purposes. The sequence of events has been developed for only decisions to develop; decisions to operate and maintain are on-going and not amenable to description in a sequential manner.

Because of the variety of factors, motivations, and determinants that operate in a different manner in public and private sector decision-making, it is useful to derive two prototypical sequences of events; these sequences are presented in Tables 16 and 17.

e. Summary. The components of the behavioral or decision-making processes are summarized on the following sets of tables. This information refers to material presented in the Appendix E as well as in this section. The information is intended to both summarize the description of behavioral characterization and to allow a means of identifying further information for actual applications. The first set of tables (Tables 18-29), refers to development decisions; the criteria or determinants of development decision-making is found in the following tables, referenced in the main table. Each table is subdivided into the major land use categories that are used in this project, and which are the subject of further background information in the Appendix E. The second set of tables (Tables 30-35), refers to operations decision-making, and likewise includes a general reference table, followed by a series of tables with factors or determinants of operational decisions.

TABLE 15. GENERIC FACTORS OR DETERMINANTS OF DECISION-MAKING/BEHAVIORAL CHARACTERIZATION

- Natural Hazards (e.g., storms, earthquakes)
- Physical Geography and Geology
- Existing Land Uses, Values and Ownerships
- Infrastructure Investments (e.g., transportation, sewers, utilities)
- Economic Feasibility (i.e., makretability, profitability)
- Fiscal Feasibility (government cost-revenue balance)
- Development Regulations (e.g., zoning, environmental regulations)
- Legal Constraints (e.g., taking i-sue, state/local jurisdictional problems)
- Political Constraints (e.g., intergovernmental relations, growth concerns)
- Size of Population/Economy and Growth Rate
- Labor Force Characteristics
- Socioeconomic Characteristics
- Transportation Characteristics
- Consumer Preferences

TABLE 16. PROTOTYPICAL PUBLIC-SECTOR DEVELOPMENT SEQUENCE

1. Forecast population, housing, employment transportation, and other long-term trends

2. Allocate population, housing, and employment changes to sub-areas, such that location of increased demands can be isolated

3. Inventory present levels of service and facilities, so that existing capacity can be determined and so that upgraded or replaced facilities can be supplied as well as anticipated additional facilities.

4. Determine need/demand that must be met

5. Develop service and facility standards to conform to anticipated needs

6. Identify particular projects in specific locations, with schedule of when demands will occur

7. Derive projection of costs of projects

8. Develop short- and long-term projections of availability of funding from variety of sources: tax revenues, other revenues, bonded indebtedness, user assessments, intergovernmental grants and loans, etc.

9. Compare demands for facilities and services against availability to provide facilities from public revenues

10. Submit plan for review by cognizant departments or appropriate local, state, Federal agencies; submit plan to executive for review with budget

11. Submit plan for approval to legislative authority (city council, with possible intermediate reviews by planning commission)

12. Authorize plan and budget by legislature

13. Develop detailed work plan and design specifications

14. Hold public hearings and conduct administrative review

15. Advertise and let bids; negotiate contract

16. Undertake construction

TABLE 17. PROTOTYPICAL PRIVATE-SECTOR DEVELOPMENT SEQUENCE

1. Select a metropolitan area, reflecting market characteristics from a regional perspective

2. Select a specific community, based on the assessment of government services, market socioeconomic characteristics, zoning, utility availability, land write-down potential

3. Select a specific site based on site amenities: reputation, ambience, transportation available, and surrounding land uses

4. Conduct a market study and analysis of financial feasibility

5. Conduct an engineering study of the site, determining types and costs of services, identifying environmental problems, and site preparation costs

6. Acquire land by option or direct purchase

7. Conduct site and unit design plans

8. Seek local government approval; embark upon negociation. Attain approval

9. Assess public services

10. Confirm utility service and obtain sewer/water connections

11. Arrange short-term financing and guarantee of long-term financing

12. Undertake construction

13. Begin marketing program

14. Complete sales/leasing activity and occupy units

TABLE 18. DEVELOPMENT PROCESS

Land Use Category	Sector/Participants	Role of Planner: Direct	Role of Planner: Indirect	Table Which Details the Factors/Determinants in the Decision Process
Residential	Government: Planner Building Dept Engineer Public Works Zoning Assessor	Zoning Subdivision review Utility hookups	Tax incentives	Table 19
	Business: Developer Contractors Architects Legal Financial	Building codes		Table 20
	Household: Consumer			Table 21
Commercial	Government: see residential Business: see residential	Zoning Building codes Land	Tax incentives Land write-down	Table 22 Table 23
Industrial	Government: see residential Business: see residential	Zoning Building codes	Tax incentives Low-cost city services Land write-down	Table 24 Table 25
Governmental	Government: executive branch legislative body planner engineer public works treasurer		Advisory Capital budgeting	Table 26
Transportation	Government: Federal/State DOT Interstate Commerce Environmental Agencies City/state engineers Planners Zoning Attorneys Executive Branch		Advisory	Table 26

TABLE 18. DEVELOPMENT PROCESS (CONTINUED)

Utilities	Government: State/Federal Power Commissions Courts Planners Zoning	Zoning Environmental review	Table 27
	Utilities		Table 28

TABLE 19. RESIDENTIAL DECISION-MAKING: GOVERNMENTAL CRITERIA

Community Level:	Growth orientation, including managed growth and nongrowth Zoning and general plan Housing type: Preferences - Single family Multifamily Planned unit development
Site/Project Specific Level:	Zoning changes Type of housing, with implications for Income levels and School enrollment Environmental impacts Water pollution Damage to physical/bio processes Wildlife, vegetation Air pollution Hazards Earthquake, erosion, landslide, fire Health and safety Transportation Public transit Existing roads/routes: Capacity Energy On-site (heating/cooling) Off-site (transportation to work, shopping) Sprawl Influence on growth: extent and direction Fiscal impact Delivery of services versus tax revenues Design features and facilities Architecture and natural land forms Day care, handicapped, bicycle paths Parking Open space Capacity of existing services/facilities Sewers - sanitary Sewers - storm Water supply Water treatment Police Fire Schools Solid waste treatment Hospitals Recreation

TABLE 20. RESIDENTIAL DECISION-MAKING BUSINESS CRITERIA

Community Level: Market Characteristics

- Growth trends
- Competition
- Housing demands
- Absorption rates by type
- Socioeconomic characteristics

Local Government Characteristics

- Growth orientation, including managed and nongrowth
- Environmental controls
- Urban renewal land availability
- Review procedures
- Tax rates
- Quality and availability of public facilities/services

Financial Characteristics

- Mortgage availability
- Interest rates
- Terms
- Cost of materials, land, labor

Site Characteristics: Area Reputation

Proximity to Transportation Networks

- To public transit
- To employment
- To shopping

Sewer/Water Hoopups
Health/Safety Hazards
Site Preparation Costs

(Generally, the developer weighs those factors which will affect the marketability of his product as well as his profit picture.)

TABLE 21. RESIDENTIAL DECISION-MAKING: HOUSEHOLD CRITERIA

Price

Location and attributes
- Proximity to employment
- Proximity to transportation
- Schools
- Shopping
- Churches
- Social relationships
- Recreational facilities

Features of development
- Amenities in unit
- Parking

Taxes/Homeowner fees

Financing
- Down payment
- Interest rate
- Prepayment charges
- Term
- VA - FHA loan availability

Energy/Utilities
- Availability
- Type
- Cost

Potential for appreciation

Perception of neighborhood

TABLE 22. COMMERCIAL DECISION-MAKING GOVERNMENT CRITERIA

Community Level:	Growth orientation, including managed growth and non-growth Zoning and general plan Shopping center type: regional, community and neighborhood
Site/Project Specific Level:	Zoning change Type of center or office, with implications for sales tax potential and property tax potential

Criteria:	Environmental impacts
	  Water pollution
	  Damage to physical/bio processes
	  Wildlife, vegetation
	  Air pollution
	Hazards
	  Earthquake, erosion, landslide, fire
	  Health and safety
	Transportation
	  Public transit
	  Existing roads/routes: Capacity
	Energy
	  On-site (heating/cooling)
	  Off-site (trips generated to center or office)
	Sprawl
	  Influence on growth: extent and direction
	Fiscal Impact
	  Diversity of services versus tax revenues
	Design features and facilities
	  Architecture and natural land forms
	  Parking
	  Open space, landscape, plazas
	  Signs
	  Setbacks

TABLE 22. COMMERCIAL DECISION-MAKING GOVERNMENT CRITERIA (CONT'D)

Capacity of existing services/facilities

- Sewers - sanitary
- Sewers - storm
- Water supply
- Water treatment
- Police
- Fire
- Solid waste treatment

TABLE 23. COMMERCIAL DECISION-MAKING BUSINESS CRITERIA

Community Level:	Market Characteristics - Growth trends - Absorption rates - Lease rates - Competition - Community functional character (office) - Socioeconomic characteristics - Expenditure patterns (retail)
	Local Government Characteristics - Growth orientation - Environmental Controls - Land write-down potential - Tax structures - Quality/availability of public facilities/services
	Financial Characteristics - Mortgage availability - Interest rates - Terms - Cost of materials, land, labor
Site Characteristics:	Prestige of Area
	Land Assemblage Potential
	Proximity and Access to Major Transportation Routes - To residential concentrations - To public transportation
	Visibility
	Sewer/Water Hookups
	Cost of Site Preparation

TABLE 24. COMMERCIAL OFFICE DECISION-MAKING GOVERNMENTAL CRITERIA

Community Level:	Industrial Attitudes Zoning and General Plan Industrial Type: light, moderate, heavy
Site/Project Specific Level:	Zoning Change Type of Industry - Impact on adjacent land use - Manufacturing operations Type-of-Structure - Property tax potential - Employment potential
Criteria:	Environmental Impacts - Water pollution - Damage to physical/bio processes - Air pollution - Noise pollution Hazards - Earthquake, erosion, landslide, fire - Health and safety Transportation - Public transit - Existing roads/routes: Capacity - Railroad capacity - Airport capacity Energy - On-site (heating/cooling) - Off-site (transportation to work) Fiscal Impact: Diversity of services versus tax revenues Design Features and Facilities - Architecture - Setbacks - Parking - Open space, landscape, plazas - Signs Capacity of Existing Service/Facility/Utilities - Sewers - sanitary - Sewers - storm - Water supply - Water treatment - Police - Fire - Solid waste treatment

TABLE 25. INDUSTRIAL DECISION-MAKING: INDUSTRIAL CRITERIA

Market Factors

- Demand for Good's Provided
- Transportation For Good's Produced
- Distribution of Good's Produced

Raw Materials

- Materials
- Water
- Transportation

Factors of Production (importance will vary by Industry type)

Transportation

- mode (rail, waterway, truck)
- cost
- reliability of service

Manpower

- available skilled/unskilled
- wages
- productivity

Energy

- fuel type (coal, oil, natural gas, electricity: purchased or generated)
- costs/industrial rates
- reliability (long term contracts/guarantees)

Allied industries

- proximity to adjunct/complementary industries

Location & Land Attributes

- Topography
- Soil, geological structure
- Vegetation
- Size, shape (room to expand)

TABLE 25. INDUSTRIAL DECISION-MAKING: INDUSTRIAL CRITERIA (CONTINUED)

Proximity to:

- manpower
- transportation
- services (city)
- support services (business/commercial)

Costs

- Land cost
- Construction costs
- Labor costs (construction and operation)
- Finance costs
  - interim
  - long term
- Taxes and fees
  - assessment
  - rates
- Compliance Costs
  - number of reviews/permits
  - duration of reviews
  - legal costs
  - opportunity costs

General Government/Citizen Attitudes

- "business climate"
- availability of local incentives
- environmental regulations

TABLE 26. GOVERNMENTAL DECISION-MAKING: GOVERNMENT CRITERIA

Community Level:	Population Growth Rate Demographic Characteristics Economic Base, including type and level of employment; labor force characteristics Jurisdictional Arrangements and Local Authority (number, types, and responsibilities of municipal, school, and other units of local government) Financial conditions, including assessed value of property, tax structure, and level of bonded indebtness Politcal climate and local preferences Federal and state grants and loan programs
Site/Project Specific Level:	Present comprehensive plan Zoning and building codes Capacity and existing facilities and services Area-specific service demands Environmental impacts water pollution Damanage to physical/bio processes Wildlife/vegetation Air pollution Local traffic conditions, including parking and congestion

TABLE 27. TRANSPORTATION DECISION-MAKING
TRANSPORTATION CRITERIA

Inventory of present transportation facilities, including level of service

Projection of future transportation demands

Projection of future transportation facilities needed

Present pattern of modal choice

Present pattern of trips, both by length and purpose

Costs of acquisition, construction, reloaction and displacement

Costs of maintenance and operation

Availability of bonded indebtedness

Availability for grants and loans for capital projects

TABLE 28. UTILITY DECISION-MAKING GOVERNMENTAL CRITERIA

Federal/State Level:	Projected Population/Business Growth Direction/Location of Growth Current Energy Demands Projected Energy Demands and Needs Sources of Generating Fuel
Local Level:	Zoning Environmental Impacts - Water pollution - Thermal pollution - Damage to physical/bio processes - Destruction of wetlands - Air pollution Hazards - Health and safety - Earthquake, erosion, landslide Energy - Type of energy generating fuel - Potential for local energy supply Fiscal Impact - Delivery of services vs. tax revenues - Employment potential Capacity of Existing Services/Facilities - Sewers - sanitary - Water supply - Water treatment - Solid waste treatment - Police - Fire

TABLE 29. UTILITY DECISION-MAKING: UTILITY CRITERIA

Community/Regional Level: Environmental Factors

- Availability of land, water
- No major structural fault
- Adequate drainage, subterrain structure
- Wind patterns, noise
- Snowfall, rainfall, flooding
- Waste removal
- Transportation access
  - (For nuclear plants)
  - thermal pollution
  - radiation standards
  - population density

Community/Regional Level: Economic Factors

- Rate structure
- Utility rating (ability to sell bonds and stocks)
- Cost of construction
- Cost of environmental control equipment
- Cost of borrowing
- Cost of delays in construction
- Distance from service area or market

Community/Regional Level: Socio/Political Factors

- Population trends
- Employment trends
- FPC, State Commission hearings
- Public hearings (to consider impact on environment)
- Local zoning approval
- Decisions about rate increases
- Approval to sell bonds/stocks
  - For nuclear facilities: requires approval from AEC

TABLE 29. UTILITY DECISION-MAKING: UTILITY CRITERIA (CONTINUED)

Site/Project Specific Level: Cost Factors

Capital costs and interest during construction
Operation and maintenance costs
Taxes, insurance, depreciation
Interim equipment replacement

Site/Project Specific Level: Environmental Considerations

Compatiability with existing and planned adjacent land use
Ability to return the site to its natural state at plant retirement
Visual image
Construction impact on physical and biological environment
Multiple use of reject heat and facilities
Multiple use of site property

Site/Project Specific Level: Feasibility

Technology available
Existance of potential sites
Community acceptance
Plan cost-effective:
- Adequate rate structure
- Adequate financing sources
- Minimal application process

Site/Project Specific Level: Risk

Plant exposure
Safety and damage
Regulatory process makes proposed plant too costly
Rejection of site or facility by environmental groups blocking quick approval by Regulatory Commissions

TABLE 30. OPERATIONS PROCESS*

Land Use Category	Sector/Participant	Role of Planner: Direct	Role of Planner: Indirect	Factors Determinants
Residential	Residential: Household	-Housing Codes	- Educational - Tax incentives - Financing incentives	Table 31
Commercial	Business: Owners Tenants	-Health/fire codes	- Tax incentives - Financing incentives	Table 32
Industrial	Business: Owners Tenants	-Health/fire codes	- Tax incentives	Table 33
Government:	Government: All municipal departments and agencies		-Advisory -Capital budgeting	Table 34
Transportation:	Government: Departments of transportation Public works		-Advisory	Table 35
Utilities:	Government: State/Federal Power Commissions Utilities			N/A

* Utilities were not considered to be participants in operating decisions because their impact is indirect - through cost of energy.

TABLE 31. RESIDENTIAL DECISION-MAKING HOUSEHOLD OPERATIONS CRITERIA

Financial

- Costs of operating - maintaing of utilities
- Cost of rehabbing
- Cost of public transportation vs.
- Cost of private transportation - investment, insurance, fire

Market Factors

- Change in home values in neighborhood
- Perceptions of activity and improvement in other homes
- Socioeconomic Turnover

Personal Factors

- Time involved in maintenance
- Efficiency of appliances
- Convenience of private transportation
- Prestige of some transportation modes
- "Conservation conscience"

TABLE 32. COMMERCIAL DECISION-MAKING BUSINESS OPERATIONS CRITERIA

Financial (profit)

- Cost of operating/maintaining of utilities
- Cost of rehabbing - plant and equipment
- Cost of maintaining inventory/supplies vs. more frequent reordering
- Cost of extending service/operating hours
- Cost of expanding staff

Benefits

- Increased sales/profits
- Increased viability of office/retail center
- Improved market position - ability to attract tenants
- Potential for lease increases (for owner)

Market Factors

- Perceptions of viability in the surrounding area
- Perceptions of maintenance in neighborhood

TABLE 33. INDUSTRIAL DECISION-MAKING INDUSTRIAL OPERATIONS CRITERIA

Parameters

- Type of product manufactured
- Industrial process
- Governmental regulations

Financial

- Cost of fuel and internal space control
  - rehabbing (time, inconvenience, financing)
  - utilizing manpower vs. machinery
  - maintaining an inventory of supplies
- Increased productivity/profit by upgrading
- Decreased costs of lowered temperatures
lighting moderations

TABLE 34. GOVERNMENT DECISION-MAKING GOVERNMENT OPERATIONS CRITERIA

Delivery of Services/Facilities
- Quality of services
- Convenience of services
- Satisfaction among recipients
- Smooth functioning of city

Financial
- Costs of services: maintenance and staff
- Cost of construction of facilities
- Constraints of local revenues:
  - Sales tax
  - Property tax
  - Grants
- Balance of municipal services vs. fiscal position of the city

TABLE 35. TRANSPORTATION DECISION-MAKING - TRANSPORTATION OPERATIONS

Variables
- Level of traffic on various networks
- Condition of roads
- Prevailing wage schedules
- Relationship of road within entire network
- Costs of repair materials
- Climatic effects
- Use of public transportation

Revenues
- Income of toll roads
  - gasoline tax
  - property tax
- Overall budget limitations for maintenance

4. Procedure for Application

The two major components of the community characterization procedure have been described in the two previous sections. The methodology for applying or using the procedures is described in this section. The procedure is oriented to the planner and energy analyst, and consists of a set of sequential steps which the user must follow.

a. Physical Characterization Procedure. The step-by-step procedure used in developing and carrying out the physical characterization is illustrated in Figure 18. Each step is summarized as follows:

- Step One: Assess Community Context. The community context describes the socio-economic and institutional factors which condition and influence community patterns of development. As part of the procedure for application, the planner or analyst brings to bear considerable background information on the community itself. This step does not have any format set of procedures and is merely intended to serve as a means of beginning to define and specify further analytical steps. Table 36 lists typical elements that will be known to the planner or analyst in the community and that will be useful in structuring further steps.

- Step Two: Specify Level of Analysis. The planner or analyst will define whether the particular application or analysis relates to a metropolitan level, a parcel or site level, or some combination of intermediate levels.

- Step Three: Specify Level of Application. The user of the methodology must determine if the planners or analyst's mode of application is appropriate for the analysis to be undertaken. This choice is conditioned by the availability of data, the provision of analysis required, and tye types of conclusions that would be required for decision-making.

- Step Four: Specify Land Uses and Activities. The user of the methodology must also make a series of decisions as to whether all land uses and activities, or some, are to be the subject of investigation. These land use and activity sectors were defined in the previous sections. The type of analysis and extent of data will, of course, vary with number and dimensions to the sectors of analysis.

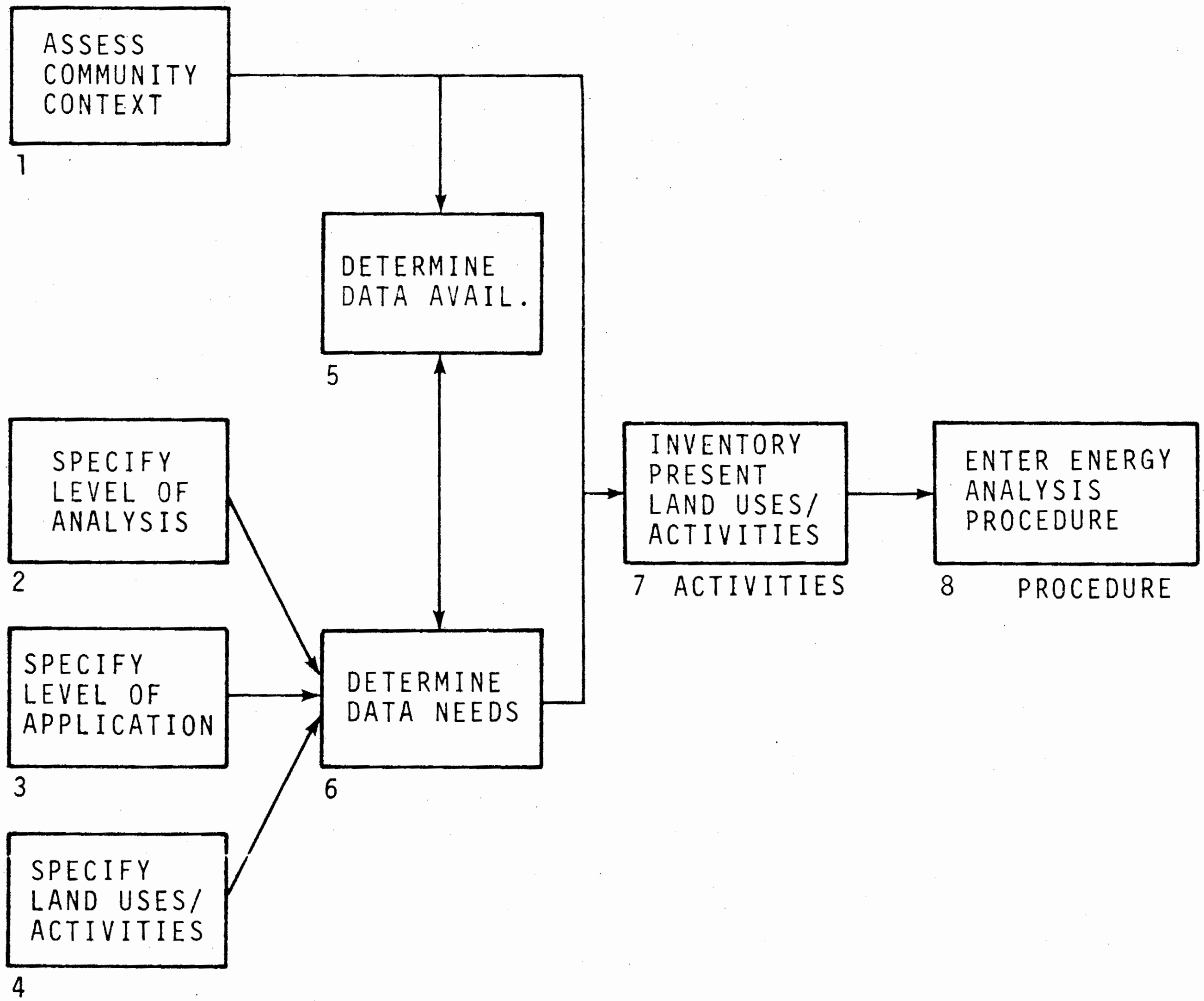


Figure 18. Physical Characterization Procedure

TABLE 36. COMMUNITY CONTEXT

Demographic Factors

- population size, composition
- population age distribution
- racial, ethnic distribution

Socioeconomic Factors

- income distribution
- education
- religion
- occupation

Employment

- employment by reputation
- unemployment
- dependency ratio

Employment Structure

- employment by sector
- wages
- industrial
- commercial
- retail

Institutional Factors

- General type
- Number of departments, agencies
- Formal role of

Financial Factors

- Banks, S&L's, capacity and policies
- Tax revenues
- Other revenues
- Budget balance/flexibility

Associated Factors

- Labor union
- Consumer group
- Political parties
- Environmental group
- Other acquired interests

- Step Five: Determine Data Availability. Based in part on the general knowledge of the community and the context of the analysis, the availability of data for the analysis will be determined.

- Step Six: Determine Data Needs. The first analytical step in the procedure--once the preliminary decisions have been made to structure the analysis--consists of deriving a specific set of requirements that are appropriate to the specifications of the analysis as defined by the previous steps. In this process, gaps and deficiencies in the data will be identified. Such gaps and deficiencies may be filled if required by the analysis.

- Step Seven: Inventory Present Land Uses and Activities. The essential step in the procedure is to prepare an inventory of land uses and activities, according to the decisions and specifications stated in previous steps. The user of the methodology may directly enumerate these physical characteristics at the necessary level of analysis. However, in many communities this may prove to be an enormous if not impossible task. An alternative approach would be to make use of the conversion tables presented in section 2 above, on Physical Characterization which will allow the users of the methodology to develop reasonably precise and reliable estimates of the characteristics of land uses and activities. Such conversion factors permit the user to define the requisite information for analysis of energy demands from commonly known sources such as number of residential units, density, floor areas, community land areas, and othe information. Other approaches are also possible, and are summarized in a later section. It must be pointed out, however, that one key factor is the specification steps that lead up to the inventory; by means of those steps the requirements for data may be limited to make the task more manageable. The more detailed is the specification of land uses and activities, the more manageable this step will be.

- Step Eight: Enter Energy Analysis Procedure. Once the inventory of land uses and activities has been compiled according the stated specifications, the shift into analysis of energy demands is apparent. Those steps are covered in a later section of this chapter.

b. Behavioral Characterization Procedure. The step-by-step procedure that is used in developing and carrying out the behavioral characterization is illustrated in Figure 19. Each step is summarized as follows; it should be noted that the end of the behavioral characterization procedure is the initiation of the physical characterization procedure, and that the two are linked:

- Step One: Specify Behavioral Change (Optional). In order for the common framework to be oriented to a particular set of issues or concerns, it is necessary to define a particular behavioral change. Although it may be possible to present limited statements on the behavioral framework without a particular change, the types of statements may be so generalized and non-specific that the exercise of behavioral characterization may prove either too unwieldly or too diffuse for analytical purposes. Therefore, the methodology usually begins with the specification of a behavioral change which the user seeks to trace through the system to determine its ultimate effect on energy end-uses and other community impacts.

- Step Two: Assess Community Context. In a manner similar to physical characterization, the user of the methodology draws upon and refers to the general knowledge of the community to a considerable extent. The user takes account of local conditions that will certainly influence and determine the behavioral impacts of a specific change that is under investigation.

- Step Three: Select Mechanism(s) Involved. Based on the specification of the behavioral changes and drawing upon the knowledge of the community context, the user of the methodology determines which particular tool or mechanism available to the planner for public decision-makers. A preliminary list of such mechanisms is provided in Table 37.

- Step Four: Identify Type of Decision. The specified change will affect either development decisions, operational decisions, or both. Since much of the structure of the common analytical framework depends on distinguishing among these types of decisions, the user of the methodology must specify which set is relevant.

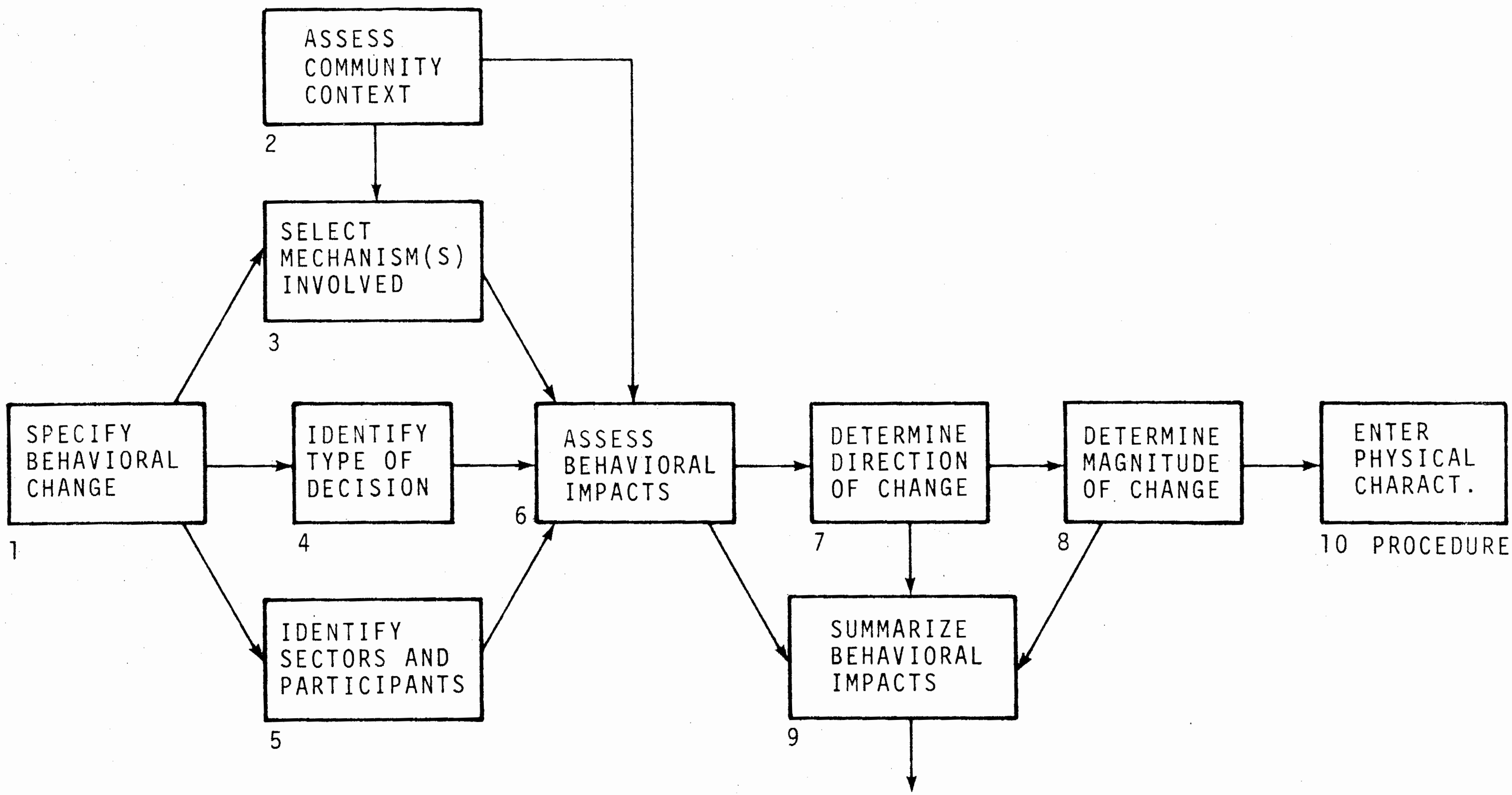


Figure 19. Behavioral Characterization Procedure

TABLE 37. BEHAVIORAL MECHANISMS (USED BY PLANNER/ PUBLIC OFFICIAL TO INFLUENCE COMMUNITY DEVELOPMENT AND OPERATION)

1. Regulatory Powers

   Zoning

   Permits
   Traffic Regulations

2. Review and Approval

   Subdivision Review
   Environmental Review
   Design Review
   Official Historic/Preservation/Coastal Zone

3. Fiscal and Economic

   Capital Improvements Program Budget
   Annual Operations Budget
   Tax Structure - Property
                   Interest
   Tax Assessments
   Tax Rates
   User Assessments
   Fees and Other Revenues

4. Eminent Domain

   Subsidies and Grants
   Bonds
   Pond Amortization
   Loan Guarantees

5. Planning

   Master Plan
   Facility Siting and Design Planning
     (Capital Improvements)

6. Information/Education

   Demonstration
   Education
   General Persuasion

- Step Five: Identify Sectors and Participants. The nature of the behavioral changes and the type of decision affected will allow the user to identify which sectors, participants, and land use/activity categories are involved. The background material in general, and the summary tables (Tables 18 and 30 in Section 3 above) should prove useful guides to specifying these aspects of the analysis.

- Step Six: Assess Behavioral Impacts. Information gathered and specification made by the user in the five previous steps of the procedure all assist in determining the behavioral impacts of the specified change. This assessment of impacts involves two closely related activities, and the result of these activities is to define both physical changes--which can be further analyzed through the physical characterization procedure and ultimately translated into changes in energy demands--and changes or implications that occur within the behavioral dimension itself. This latter set of changes will allow judgements as to the implementability of the proposed change under investigation.

  The first activity within the impact assessment requires the user to consider the behavioral change from a wide variety of perspectives, and to speculate on the types of changes that would result from such a change. This is a difficult task and does not lend itself to precise structuring and rigorous analysis. It would require, for example, the user to think through the change from the perspective of the local government official, the developer, and the consumer, noting where changes in both behavioral and physical factors would occur. The background information presented in Appendix E is intended to provide some of the types of considerations that must be made. More directly related are the lists of factors or criteria presented in the Summary to Section 3, (Tables 18 and 30). In many instances, elements of a market analysis will have to be performed, so that implications of the proposed change in the behavioral patterns can be traced through development and operational decision processes. A prototypical market study that can be applied to a wide variety of land uses and activities is presented in Figure 20, to assist the analyst in capturing the thought process that is required for further analysis.

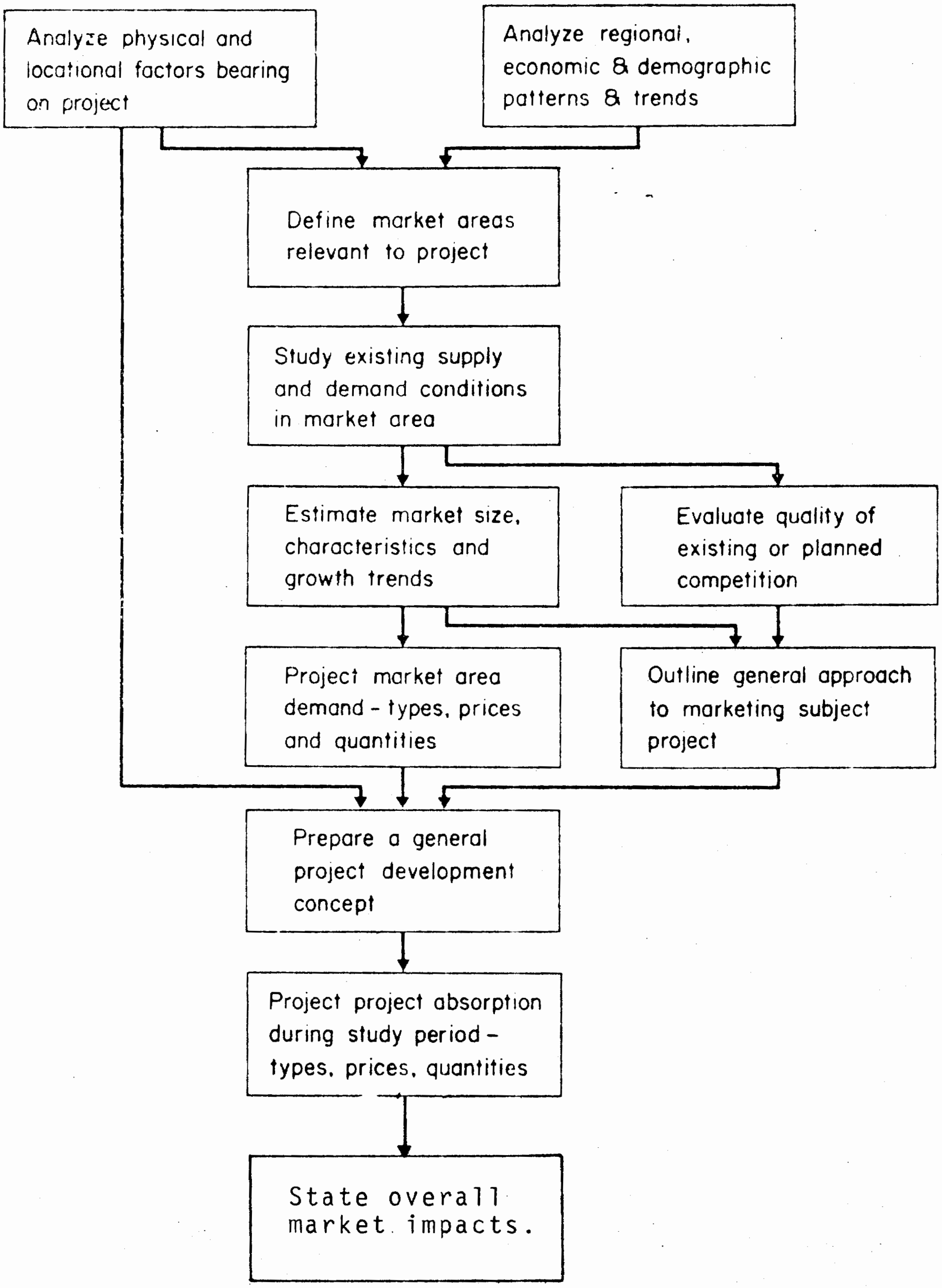


Figure 20. Prototypical Elements of Market Analysis

The second activity is more rigorous and lends itself to more precise analytical procedures. Once the user of the methodology is determined the types of changes that can occur, those changes are explicitly and systematically recorded in a series of checklists, in which an array of possible impacts are considered and which can capture those instances in which impacts may be associated with the specific behavioral change.

At this point, two sets of tables or worksheets will be utilized. The planners or energy analysts will identify--using their own subjective judgement, which in turn is rooted in community content-specific information, the impacts of the proposed change. The first table (Table 38) captures behavioral impacts; this table must be used first, since the second set of tables (Tables 39-44) is dependent in part upon information in the first table. The table is used in the following manner:

- The user scans the preliminary list for behavioral changes that will correspond to the change. Because of community-specific characteristics, the user can quickly eliminate those which are not relevant, and may even add additional factors that are suggested by his knowledge of local conditions.

- The next step is to indicate whether or not a particular impact is relevant, and if so, indicate by a positive answer. As stated, in making such judgements, the user will have to adopt various perspectives.

The second set of tables is much more detailed, and is the means of capturing direct physical changes that result from the behavioral change, being analyzed, as well as physical changes which result from behavioral changes which result from the particular behavioral change being analyzed. These "second order" behavioral changes should be apparent from the positive responses in the behavioral table; this means that each such positive answer in the behavioral table should be analyzed in the physical tables to determine how other physical changes may indirectly result from behavioral changes).

TABLE 38. BEHAVIORAL IMPACTS: SOCIOECONOMIC AND INSTITUTIONAL WORKSHEET

Impact Type	Impact	Direction	Magnitude
Demographic			
Population growth			
Population composition			
by age group			
by sex			
by family type			
by race/ethnicity			
Economic			
Housing Supply/Cost			
Employment - permanent			
Employment - temporary			
Dependency ratios			
Land values			
Sector value added			
retail			
commercial			
industrial			
service			
Wages			
Occupational Structure			
white collar			
sales/service			
blue collar			
Institutional (Community Government)			
Revenues			
tax assessment			
fees			
Service Costs			
water, sewer, storm sewer			
transportation			
police, fire, health			
schools, health care, mental health, health, corrections			
Sociopolitical			
Community stability			
Business climate			
Socioeconomic status			
Equal opportunity			
Political realignment			
Travel times/frequency of trips			
Congestion			
Health and welfare			
Public safety			

TABLE 38. BEHAVIORAL IMPACTS: SOCIOECONOMIC AND INSTITUTIONAL WORKSHEET (CONTINUED)

Environmental

- Air quality
- Water quality
- Unique features
- Land degredation
- Visual attractiveness
- Noise levels

TABLE 39. PHYSICAL IMPACTS: RESIDENTIAL WORKSHEET

Impact Type	Impact Direction	Magnitude
Development		
1. Increase/decrease number of acres		
2. Increase/decrease number of dwelling units		
3. Increase/decrease rate of dwelling units		
4. Other mix of dwelling units		
5. Other site design		
6. Increase density		
7. Other amenities		
8. Other site improvements Utilities Sewer water Transportation		
9. Other trip generation factors		
Operation		
1. Other systems use		
2. Other appliance use		
3. Remodel or rehabilitation		
4. Deteriorate (non-maintenance)		
5. Maintain (structure/systems)		
6. Other trip generation factors		
7. Retrofit systems		

TABLE 40. PHYSICAL IMPACTS: COMMERCIAL WORKSHEET

Development	Impact	Direction	Magnitude
0. Cease			
1. Increase/decrease number of acres			
2. Increase/decrease square footage of building area			
3. Increase/decrease site coverage (floor area ratio)			
4. Increase/decrease building height			
5. Increase/decrease pace of construction			
6. Alter site design (layout)			
7. Alter amenities (landscaping, buffering, graphics, etc.)			
8. Alter mix of tenants			
9. Alter building design			
10. Alter building materials			
11. Increase/decrease number of parking spaces			
12. Increase/decrease number of stores, shops			
13. Alter site improvements			
Utilities (gas/electric)			
Water/sewer			
Drainage system			
Internal circulation			
External (off-site) road improvements			
14. Increase/decrease size (sq ft) of parking spaces			
15. Retrofit			
Operation			
1. Alter mix of tenants			
2. Alter size of tenant spaces			
3. Change from one source of fuel to another			
4. Remodel or rehabilitate			
5. Maintain/not maintain systems			
6. Enclose open plazas or malls			
7. Meter individual tenants/do not meter			
8. Change hours of business			

TABLE 41. PHYSICAL IMPACTS: GOVERNMENT WORKSHEET

	Impact	Direction	Magnitude
Development			
0. Cease			
1. Increase/decrease acreage devoted to public facilities			
2. Increase/decrease square footage of public office space			
3. Accelerate/slow down pace of facility construction			
4. Increase/decrease floor area ratio (coverage)			
5. Change site design (layout)			
6. Increase/decrease building height			
7. Alter mix of services to be offered			
8. Alter amenities			
9. Alter building design (layout)			
10. Alter building materials			
11. Increase/decrease number of parking spaces			
12. Increase/decrease size of parking spaces			
13. Retrofit			
14. Provide/do not provide new facilities in growth areas			
15. Extent/do not extend water and sewer lines to growth areas			
16. Provide/do not provide incentives for inner city revitalization or redevelopment			
17. Size facilities to serve present needs only/size in anticipation of future demand			
Operations			
1. Purchase smaller public vehicles			
2. Change size of vehicle fleet			
3. Maintain/do not maintain vehicle fleet			
4. Switch to alternate heating/cooling fuel source			
5. Remodel/rehabilitation facilities			
6. Increase/decrease hours of operation (e.g., library)			
7. Change from seasonal to year round operations (e.g., schools)			
8. Offer more services/reduce services			
9. Change frequency of service delivery (e.g., mail delivery, trash collection)			
10. Maintain/do not maintain utility lines			
11. Increase/reduce service standards (e.g., require tertiary sewage treatment)			
12. Adopt new technologies			

TABLE 42. PHYSICAL IMPACTS: INDUSTRIAL WORKSHEET

	Impact	Direction	Magnitude
Development			
0. Cease			
1. Increase/decrease number of acres			
2. Increase/decrease square footage of building area			
3. Increase/decrease floor area ratio			
4. Increase/decrease building height			
5. Increase/decrease pace of construction			
6. Alter site design (layout)			
7. Alter amenities			
8. Alter building design			
9. Alter building materials			
10. Increase/decrease number of parking spaces			
11. Increase/decrease size of parking spaces			
12. Alter site improvements			
Utilities (gas/electric)			
Water/sewer			
Drainage system			
Internal circulation			
External (off-site) road improvements			
Rail access			
13. Retrofit			
Operation			
1. Alter type of manufacturing process			
2. Increase/reduce labor intensiveness			
3. Increase/reduce water use			
4. Change from one source of fuel to another			
5. Increase/reduce number of production work shifts			
6. Install new technologically advanced equipment			
7. Maintain/not maintain production machinery			
8. Maintain/not maintain mechanical and electrical systems			

TABLE 43. PHYSICAL IMPACTS: UTILITIES WORKSHEET

	Impact	Direction	Magnitude
Development			
0. Cease			
1. Build new generating capacity			
2. Increase/do not increase capacity of transmission lines			
3. Increase/do not increase storage capacity			
4. Extend/do not extend service lines			
5. Provide/do not provide further connections (hookups)			
6. Increase/decrease number of acres in r.o.w, storage, generating stations			
7. Convert to new power generating sources			
8. Increase/decrease pace of exploration, source development			
9. Alter design of new generating facilities			
10. Require new safety precautions			
11. Require new environmental protection devices			
Operations			
1. Maintain/do not maintain lines and and facilities			
2. Remodel/rehabilitate			
3. Operate below design capacity			
4. Operate at excess of design capacity (overload)			
5. Curtail peak period service to certain customers			
6. Shift fuel supplies			
7. Store at capacity/do not store at capacity			
8. Allocate power for primary users			

TABLE 44. PHYSICAL IMPACTS: TRANSPORTATION WORKSHEET

	Impact	Direction	Magnitude
Development			
0. Cease			
1. Reduce/increase road lengths			
2. Reduce/increase road widths (change in lane miles)			
3. Alter road construction materials			
4. Alter road design standards			
5. Select alternate locations or routes			
6. Speed up/slow down pace of road improvements			
7. Install/do not install street lighting			
8. Install/do not install curbing and and sidewalks			
9. Limit/do not limit access points (curb cuts)			
10. Install/do not install traffic signals, signs, turn lanes			
11. Install/do not install bicycle paths			
12. Designate/do not designate bicycle paths			
13. Designate/do not designate bicycle routes on existing streets			
14. Build/do not build fixed rail rapid transit lines			
15. Acquire/do not acquire additional buses or rail cars			
16. Increase number and length of airport runways			
17. Expand terminal facilities			
18. Develop new shipping ports, expand existing ports			
Operation			
1. Change speed limit			
2. Maintain/do not maintain road surface in an adequate manner			
3. Limit road usage by trucks and trailers			
4. Formulate/do not formulate new mass transit routes			
5. Change scheduling and frequency along existing transit routes			

TABLE 44. PHYSICAL IMPACTS: TRANSPORTATION WORKSHEET (CONTINUED)

6. Remodel transportation terminal facilities (air, rail, bus, port)
7. Encourage/discourage location of new or expanded terminal facilities and yards
8. Maintain/do not maintain condition of existing equipment, lines, tracks, terminals, etc.

- <u>Step Seven: Determine Direction of Change</u>. Two further elaborations of step six are required.

  Upon identification of the presence or absence of an impact related to a specified change the user must make a determination as to the direction of the change on each factor scored with a "yes" notation. The precise meaning of "direction" is factor determined. For a change in wages, direction refers to "higher" or "lower." For a change in a factor such as "size of tenant spaces," direction refers to "more" or "less." In all cases the user will make an assessment of direction in terms appropriate to the characteristic under consideration. Such determinations will be made for each "yes" item and noted in the column provided on the work sheets.

- <u>Step Eight: Determine Magnitude of Change</u>. To this point in the analysis the user's activity is directed to narrowing choices and making determinations based upon his or her own expertise, knowledge of the community and upon the lists provided in the above tables. Each stage in the analysis supposes a greater degree of specificity and less and less reliance upon subjective judgements. In order to link behavioral characteristics of a community, and ultimately to link community characteristics to energy consumption parameters, the planner must attach quantitative measures to the impacts. This process requires that the user address each previously identified impact from a quantitative perspective. The measure involved will vary from factor to factor. For a change in wages (to continue the example from 7 above) the user will have to translate direction into dollar values. for "size of tenant spaces," the user will have to express the change in square feet. For particularly difficult factors, the user may have to specify a range of possible values.

- <u>Step Nine: Summarize Behavioral Impacts</u>. User decision in steps 7 and 8 yield a summary chart of impacts which identifies those factors which are affected by the specified change, the direction of the change in those factors and a quantitative measure of the magnitude of the impacts associated with change being analyzed.

- Step Ten: Enter Physical Characterization Procedure. As indicated, the quantified changes identified in step 8 are inputs to the physical characterization procedure. In effect, this will consist of a set of impacts with specific values that can be related directly to the community physical characteristics, so that the specified change is translated into its land use effects.

5. Summary

The community characterization procedure that has been outlined--and consisting of both physical and behavioral characterization with a set of procedures for using the characterizations--will function at the analyst level. The fundamental requirement is fairly extensive data requirements and sufficient resources available for such data collection and analysis. The methodology will also be applied at the planners level, but, of course, with much less precision; it may be adequate, however, for purposes of evaluation and decision-making, and therefore is of considerable use.

a. Data Requirements. The data requirements for the community characterization procedure will vary considerably with the types of applications, the types of use, and the level of analysis. There are several approaches that may be taken for accumulating data, which are suggested as various ways to compile the extensive data needs of the methodology. These approaches would include:

- Direct measurement in which all variations are the subject of empirical investigation and extensive detailed data are accumulated. (This may be the case with the analyst's mode of operation).
- Direct measurement within a well-conceived sample that would be representative of the range of types of data that might be considered.
- Investigation of a number of values, in sequential order, so that the desired information may be zeroed in on.
- Investigation of the boundary conditions, such that the total range of variation is known and identified, with the actual cases lying somewhere within the boundaries.

Regardless of the approach used, there are also differences in the types of information needed for the Physical and Behavioral Characterizations. For the physical dimensions of the community, common sources would include land use inventories, master plans, zoning maps subdivision plats, or other maps, and census data and other economic data for levels of activities. The sources and uses of data are fairly rigorous and straight-forward, in this case.

On the other hand, the behavioral characterization does not have such precise and rigorous requirements, and depends on certain qualities among the users of the methodology; such qualities would include the following:

- Knowledge of the community context (as discussed)
- Carefully thought-out subjective judgements
- Willingness to speculate rather freely on the impacts or results from rather uncertain and perhaps; ill-defined changes; such speculation will not only have to determine the resistance or absence of change, but must be further translated into both direction and magnitude of change
- Ability to perceive changes from a variety of perspectives

If these qualities are present, then the user may, in fact, do what was intended for the behavioral characterization--namely to sort out the varied relationships that exist among behavioral factors, and the roles that behavioral factors play in determining the varieties of urban forms, physical aspects, and levels of activity in community development and operation.

D. Energy Analysis Procedure

1. Overview

In this section, a detailed conceptual description of the Energy Analysis Procedure (EAP) is presented. This procedure will be used, either at a detailed or a general level, to assess energy impact of planning alternatives.

The foundation of the energy analysis capability of this methodology lies in the detailed, or energy analysis version, of the EAP. The simplified, or planner's version, of the EAP is based heavily on the theory and structure of the detailed EAP. The organization of this chapter reflects this emphasis. Part 1 presents an overview of the EAP and its components. Part 2 presents a discussion of how the unit demand profiles will be generated for each EUM in the community, including a description of the various sub-models which are used in the EAP to generate yearly profiles for each EUM. Part 3 describes the theory behind the procedure for amplifying unit EUM profiles to reflect a profile for all occurrences of each EUM in the community. Part 4 describes how the amplified EUM profiles may be aggregated over energy forms, or any other variables of interest. Part 5 discusses the manner in which energy supplies are allocated among the demands, and how the primary energy requirements are calculated. These five parts complete the conceptual description of the EAP.

In Part 6 of this section, attention is turned to the EAP as it would operate at the planner level. Since this is a much simpler theoretical procedure, it is treated completely in one Part. Part 7 provides a summary of the conceptual discussion of the EAP.

In the preceding section on Community Characterization, it was stated that the object of the Physical Characterization procedure was to provide a complete description of all the land in the community, according to a variety of land use types, or parcels. Methods were described which would enable the development of parcel-level specifications from several broader classes of land uses. In this section the same theme is contained. The community is viewed as a patchwork of parcels. The parcels furthermore, are grouped into six major land use categories, according to the generic classes of activities which take place on the parcels. These land use categories are residential, commercial, institutional, transportation and circulation, open space, and special uses. Table 4, in the preceding section, details the parcel types contained in each land use category. In this section, the land use categories stated are used as the major organizational framework for the calculation of energy demands. Within each land use category are a variety of reasonably similar parcel types. Upon each type of parcel, certain characteristic energy using activities take place. Since energy use is physically related to activity rather than land use, it is necessary, for energy analysis, to define the major energy using activities associated with each parcel type.

At the energy analyst level, this definition of energy using activities is achieved by the concept of the End Use Mode (EUM). An EUM is a specific activity which takes place on a specific type of parcel. Furthermore, the definition of an EUM specifies the energy form used for the activity and the end use conversion equipment used for the activity. For example, for the parcel type called single-family detached houses, there would be a separate EUM for those which accomplished space heating by using electricity with a heat pump, and a separate one for those which accomplished space heating with electricity using electric resistance heating. Needless to say, the energy demand profile for each of these would be different. Furthermore, since the EUMs for each parcel type must include all major energy using activities associated with that parcel (or land use), it has been decided to include transportation as an energy using activity associated with each parcel. This is based on the realization that each parcel type is capable of generating trips of various lengths, types, and modes. Thus, in Part 2, on the definition of EUMs and the development of unit profiles, most parcels are described in terms of the on-site energy uses (or EUMSO, and their transportation related energy uses (or EUMs).

At the energy analyst level, it is necessary to develop an hourly, year long, energy demand profile for each type of EUM. In this report, "energy demand" is used in its strict technical sense, i.e., the time derivative of energy use. Whenever "energy use" is used, it is also used in the strict technical sense, meaning the integral of the energy demand curve over some time period. The term "energy consumption," which flies in the face of the First Law of Thermodynamics, is not used at all. To develop the unit demand profiles for each EUM, the technique has been employed of using a demand rating and a percentage profile. The demand rating is a single number which represents the highest demand level an EUM may achieve. The percentage profile, then, presents, for each hour, the fraction of that demand rating which is demanded in each hour.

At the planner level, the EAP deals not in energy demand, but in annual energy use. Activities are not separated to the detail specified in the EUM characterization. At this level, the parcels are merely disaggregated by the variety of energy forms they use, even if these energy forms are used for several activities on each parcel. The energy use is calculated using an annual energy use rate, called an Energy Intensity Factor (EIF). Most parcel types have more than one EIF, but fewer EIFs than EUMs (indicating the more general level of detail in the planner mode). For instance, for the parcel type called single-family residences, one sub-group is all-electric homes. There would be one EIF for these parcels, denoting the annual kWh per dwelling unit. Another likely group would be single-family residences which have gas space heating and cooling, and use electricity for all other activities. These would require one EIF for the gas usage (combining heating and cooling) and a separate EIF for the electrical usage (incorporating all other uses). With the various sub-groups of parcels thus defined, the total annual energy use in the community is just the sum of products of parcel sub-group sizes by EIFs for each sub-group.

Before embarking on a discussion of the details of the EAP, it is necessary to address one more preliminary point. That is the transition from the CCP outputs to EAP inputs.

In both the detailed EAP and the simplified EAP, the first step (see Figures 4, and 10, above) is a disaggregation step. At the planner level, this disaggregation takes the user from parcels to sub-groups of parcels for which EIFs are defined. At the energy analyst level the disaggregation is from parcels to EUMs. In either case, the methodology will provide the user with the choice of three ways to handle the problem. These are:

(a) Available secondary data may be supplied by the user (e.g. census data)

(b) Primary data may be developed by the user for the purpose of applying the methodology (this may be necessary for some land use categories, such as commercial and industrial, where no known secondary data exists to make some of the transitions required)

(c) The user may opt to use default values which will be built into a "data disaggregation" which will be a part of both the simplified and the detailed EAP. In developing this "automatic" disaggregation, the project team will rely on available secondary data. In some cases, these will be national averages; in some cases they may be regional averages; and in some cases, where data is extremely scarce, they may be based on very small and localized survey samples. In all cases, however, the default values provided will be referenced, such that the user may adjudge the applicability of the defaults to his particular situation and make a determination whether or not primary or secondary data collection is necessary or justifiable.

With these preliminary concepts, caveats, and definitions established, the following pages describe the theory and workings of the Energy Analysis Procedure.

2. Analysis of Energy Use for Specific End Use Modes

This section describes the manner in which hourly demand profiles will be developed for the various EUMs in the community. It is organized into parts which reflect the six major categories of land uses used in the study, namely, residential, commercial, institutional, transportation and circulation, open space, and special land uses. Within each part, the EUMs considered are grouped into on-site energy using activities, and transportation-related energy using activities. Finally, within each of those groupings, the discussion is organized into the specification of end use modes, the development of energy demand ratings and unit profiles, the accuracy/reliability expected, and the data requirements.

a. Residential Land Uses. Residential land use parcels familiar to the community planner were defined in the previous section. The five parcels identified there (single-family detached, single-family attached, multifamily low-rise, multifamily high-rise and mobile homes) have been broken down further into eight categories for detailed analysis of energy use. In addition, the end use modes have been divided into two categories: on-site and transportation energy uses.

(1) On-Site Energy Uses

(a) Specification of End Use Modes. On-site energy end use modes associated with residential land uses have been identified in Table 45. All specific combinations of parcel, activity, equipment and energy form were not listed in this table for reasons of brevity. However, for each activity the individual EUMs can be derived by using the combinations of parcel, equipment, and energy source listed in the row with that activity. Eight parcels have been identified: single-family detached (SFD) houses of (1) one floor, (2) two floors, and (3) all others, single-family attached (SFA) houses with (4) two units per structure (duplexes), and (5) more than two units (town-

Parcel	Activity	Equipment	Energy Form
*SFD - 1 Floor SFD - 2 Floor SFD - Other **SFA - 2 Units SFA - More Than 2 Units Multifamily Low-Rise Multifamily High-Rise Mobile Homes	Space Heating	Furnace/Hot Air, Furnace/Steam, Furnace/Hot Water. Room Heater Heat Pump, District Service	Electricity, Utility Gas, Fuel Oil or Kerosene, Coal or Other Fuels, Steam, Hot Water
*SFD - 1 Floor SFD - 2 Floor SFD - Other **SFA - 2 Units SFA - More Than 2 Units Multifamily Low-Rise Multifamily High-Rise Mobile Homes	Space Cooling	Window Unit, Heat Pump, Absorption, Central Electrical, District Service	Electricity, Utility Gas, Steam, Hot Water, Chilled Water
*SFD - 1 Floor SFD - 2 Floor SFD - Other **SFA - 2 Units SFA - More Than 2 Units Multifamily Low-Rise Multifamily High-Rise Mobile Homes	Domestic Water Heating	Furnace Combination, Individual Heater, District Service	Electricity, Utility Gas, Fuel Oil or Kerosene, Coal or Other Fuels, Steam, Hot Water
*SFD - 1 Floor SFD - 2 Floor SFD - Other **SFA - 2 Units SFA - More Than 2 Units Multifamily Low-Rise Multifamily High-Rise Mobile Homes	Home Appliance Use	Numerous Appliances	Electricity, Utility Gas

*SFD = Single family detached housing unit
**SFA = Single family attached housing unit

TABLE 45. RESIDENTIAL END-USE MODES

houses, quadraplexes, etc), (6) multifamily low-rise structures (four floors or less), (7) multifamily high-rise buildings (more than four floors), and (8) mobile homes. At the energy analyst level, this type of disaggregation should be possible. In some cases, less detailed information may be available. In this case, Census of Housing data should be utilized to disaggregate the single-family attached and detached units into parcels. This may require the use of community level census data, or, in some locations, state or regional information.

Four activities have been specified to represent on-site residential energy uses: space heating, space cooling, domestic water heating, and appliance usage (including lighting). Each of these activities can be carried out by a variety of equipment and energy forms most likely to be used for each activity have been listed to the right of the activity name in Table 45. Numerous combinations are available here, such as, space heating with a hot air furnace fueled by oil, gas, electricity or coal. Obviously, certain combinations may never appear in the real world or be so few in number as to be insignificant (such as coal fuel space heating in mobile homes). The steam, hot water, and chilled water energy forms are, of course, only associated with district heating or cooling services. The home appliance activity is a combination of numerous appliances. The number and type of these appliances will be dependent on parcel type.

(b) <u>Development of Energy Demand Ratings and Unit Profiles</u>. Of the four activities listed in Table 45, two (space heating & space cooling) are very strongly weather dependent. Therefore, the hourly profiles of unit energy use for each space heating and cooling EUM will be determined from weather data. There are numerous procedures for calculating hourly energy use for these activities. Most of them are complex computer models which require specific building structural, thermal, equipment, and utilization data, and hourly weather data. However, recently a procedure has been developed for determining heating and cooling energy use which requires no computerization.

This procedure was developed by using a dynamic, time response building energy analysis model (similar to the Post Office program) to first compute the components of heating and cooling loads (such as, conduction through walls and roof, infiltration, solar radiation gain through glass, etc.), and then to relate the variations in these load components to variations in building or climatic characteristics (thermal conductance of walls, rate of infiltration air, window area, heating degree days, etc). Then parametric variation of building characteristics and climatic data were used to determine changes in heating and cooling component loads. From this analysis, algorithms were developed relating building and climatic characteristics to component loads. Total heating and cooling energy uses can be computed for any time period using a series of graphs and equations used to determine individual component loads and combining all components. The existing algorithms are geared toward determining energy use on a monthly basis. Data requirements of this procedure are specific to the time period of analysis. The data reqired for monthly analysis is much reduced from that required by the computerized model used in development. However, development of hourly load profiles will necessitate the use of more detailed climatic data.

Modification of this procedure will be required to make it more useful in determining hourly energy use profiles. With the supplement of an hourly weather tape, this procedure can be computerized rather easily. The weather tape can provide hourly dry bulb temperature, solar gain, and wind speed for use in computing hourly heating loads. In addition, the hourly wet bulb temperature data would be utilized (in conjunction with dry bulb) to compute discomfort index on an hourly basis for computation of infiltration cooling loads. The correlations incorporated in the existing procedures should be independent of the change in time periods (hours vs. months); nevertheless, validation of these correlations is necessary.

The current form of the existing procedure is applicable only to certain types of residential structures, specifically, single-family detached houses, townhouses, and a barracks/dormitory-type structure. However, there is no reason to believe that the methodology could not be applied to all other residential parcels, with limited modification effort.

For these weather dependent activities, the energy demand rating (the capacity of the heating or cooling equipment) could be determined from a building survey. However, the typical size of equipment could be determined by computing the energy use for the structure/parcel at the ASHRAE design point (Ref. 3). Once a demand rating has been determined, a unit, or percentage, profile of energy use for an entire year can be determined by dividing each hour's heating or cooling energy use by the capacity, or demand rating, of the appropriate equipment.

The energy demand rating and unit profiles for the other two activities in residential buildings (domestic water heating and appliances) are more directly related to the activity of the occupants. These can be approximated by use of profiles similar to those in Figure 21. These profiles are based on typical observed data (Ref. 2), and define energy demand as a fraction of total energy demand rating. Demand ratings can be established for each parcel type based on a survey of the community or use of Census and other regional data sources.

Typical profiles of unit demand for hot water and appliances will be incorporated in the EAP. However, since some energy management alternatives may impact such profiles, the model will provide the flexibility to permit the user to modify these profiles, or to substitute others which more accurately represent the community in question.

(c) Accuracy/Reliability. The existing algorithm for residential heating and cooling energy use has been tested on several buildings with a resulting error of only about five percent between calculated and actual usage (Ref. 4). These tests have been on a scattering of buildings, not with a statistically significant sample. Tests are still being conducted by the U.S. Army Construction Engineering Research Laboratory. In addition, the algorithm developed for office buildings (using a similar procedure) has also been tested, with results indicating a similar level of accuracy.

The use of weather tapes in the procedure can be a source of inaccuracy for two reasons. First, because these tapes are only available for locations with National Weather Service recording stations, analysis of many communities would require adoption of a weather tape from a nearby community. Variation in weather between a community and the nearest weather station may be significant in some cases, however, it is believed that the vast majority of communities could be studied with considerable confidence. The second source of error in the application of weather tapes is in the variation in temperature and wind speed within the community. Typically, National Weather Service recording stations are located at airports, which are normally located on the outer edge of a community. Temperature recordings are often significantly and consistently different between downtown and the airport. Similar variation is also common throughout the community. However, since this energy use analysis is for the entire community, the impact of these variations is expected to be less than might occur for individual building analyses.

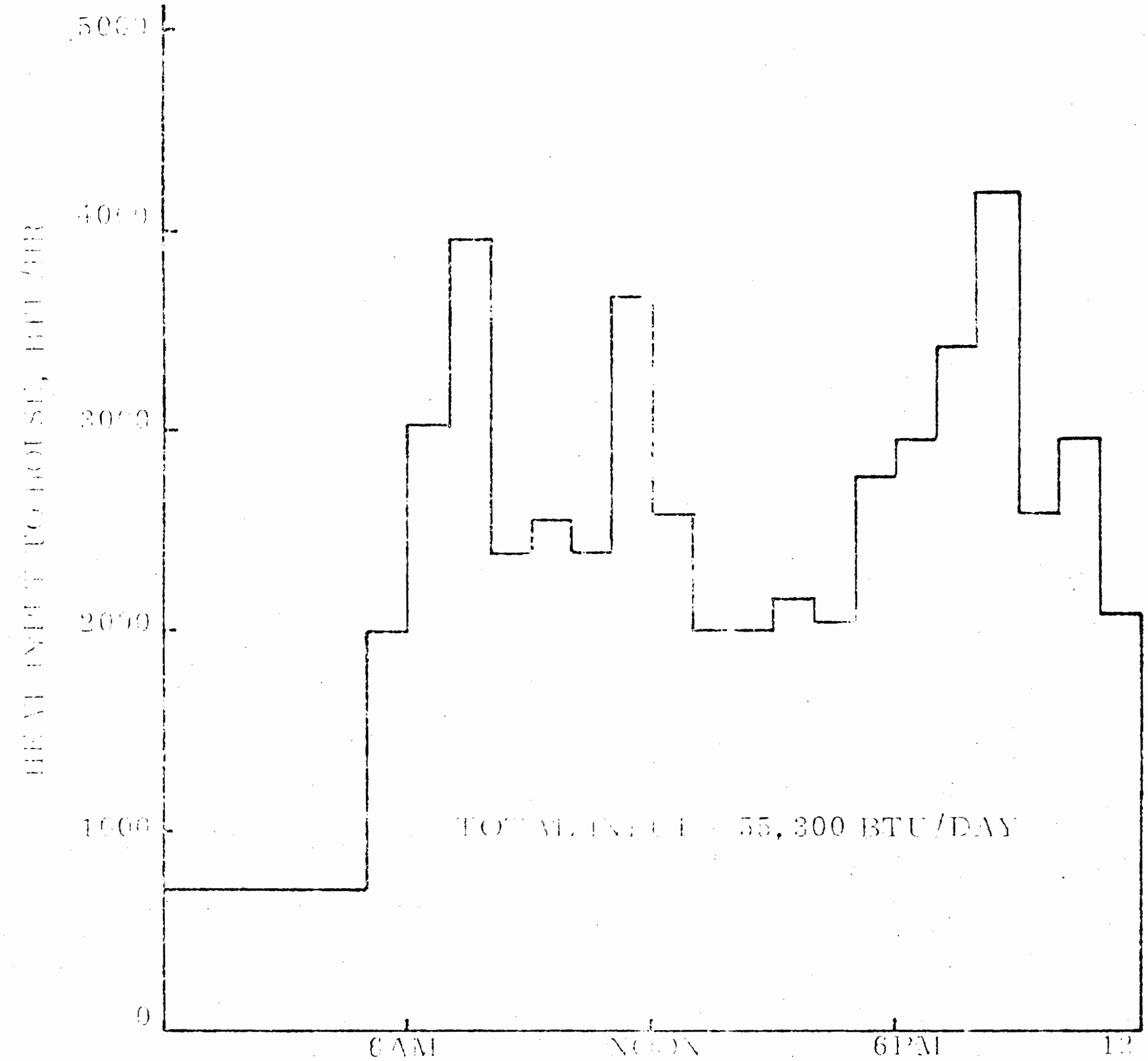


Figure 21. Profile of Average Daily Heat Input to Characteristic House Due to Use of Appliances

The accuracy of water heating and appliance profiles incorporated into the model would be very questionable if applied to the analysis of one building, since lifestyle parameters such as these tend to vary significantly. However, as applied to the community analysis level, their reliability is higher, since the variations would probably average out. In addition, any survey data collected within the community of study would certainly be more reliable than typical data supplied.

(d) Data Requirements. The heating and cooling algorithms have significant data requirements, including the following for each parcel type:

- Overall thermal resistance of building walls and roof
- Window/glass area of building
- Number of doors
- Number of occupants
- Thermal resistance of floor
- Type of under floor space; basement, crawlspace, or slab-on-grade
- Floor area (living space)
- Exterior wall area
- Presence of storm windows and storm doors
- Type of heating and cooling equipment and fuel
- Type of water heating fuel
- Type of fuel for appliances (some may be gas)
- Local ground temperatures

With this data provided for a typical housing unit of each parcel type, hourly energy use profiles could be determined using an hourly weather tape.

Domestic hot water demand rating and energy use profiles would be dependent on the number of occupants and the number of hot water-using appliances in the dwelling.

Appliance demand ratings are, of course, derived from the number, type, and size of appliances in the residence. The energy use profile will be dependent on the number of residents.

(2) Transportation Energy Uses. The transportation energy use within a community will be developed by analyzing the following travel activities:

- Home-based travel
- Nonhome-based travel
- External travel
- Truck travel

The project team has proposed analyzing the home-based travel at a disaggregate level or parcel level, and has proposed analyzing the nonhome-based travel, external travel and truck travel on a community wide basis rather than on an individual parcel basis.

The project team has proposed this difference in analysis procedure for the following reasons:

- Home-based travel accounts for the largest proportion of urban travel.

- Home-based travel activities have been studied in finer detail than the non-home-based, external, and truck travel activities.

Home-based travel activities will be analyzed as part of the residential parcels. Home-based travel includes all travel purposes with either end of the trip located at home.

The nonhome-based travel, external travel, and truck travel will be discussed within the section on commercial parcels.

Table 46 presents data regarding trip purposes for several urban areas.

TABLE 46. TRIP PURPOSES BY PERCENT OF TOTAL INTERNAL TRAVEL

City	Home-Based Work	Home-Based Non Work	Non Home-Based	Truck
Philadelphia	27	39	19	15*
Detroit	28	33	24	15*
St. Louis	27	40	20	13*
Baltimore	26	37	26	11*
Hagerstown	23	46	27	4

SOURCES: "A System Sensitive Approach for Forecasting Urbanized Area Travel Demands", Alan M. Vourhees & Associates, prepared for U.S.D.O.T., 1971.

Hagerstown/Washington County Transportation Study, Maryland Department of Transportation, July, 1976.

(a) Specification of End Use Modes. The energy consumption for home-based travel in a community will be derived by starting with land use characteristics and the travel behavior associated with those land uses. Travel characteristics for the land uses (i.e., trip generation, trip length, etc.) can be obtained using national averages, actual values, values obtained from travel or land use simulations, etc. For urban areas having a population of 50,000 or more where comprehensive transportation is a requirement for Federal transportation funding, the input data for the parameters used in the EUM's should be available.

Thus, an individual EUM for transportation has to be defined for each residential parcel. The EUM would include a range of activities (travel purposes), equipment (vehicle type), and energy (gasoline, electric, etc.).

Obviously, if too disaggregate approach is taken in describing the full range of travel activities and available equipment and energy forms, the number of resulting EUM's would be impossible to efficiently manage. On the other hand, if too aggregate approach is taken, it would not be possible to obtain the required detail needed for energy impact analysis. The next section presents the initial listing of transportation EUM's. As the data collection phase proceeds within the study, it may be determined that this list will have to either be collapsed or disaggregated further because of either data availability and/or specification requirements.

Home based trips are considered produced at the residence of the trip maker whether the trip begins or ends at the residence. Thus, the EUM that includes home based travel activities will only appear under the residential sector.

The automobile inventory has been tentatively divided into three weight categories to allow the inclusion of different energy intensity factors. This classification has only been proposed for gasoline powered vehicles. For electric and diesel powered automobiles, only one automobile weight classification is proposed.

Only one bus and rail transit classification is presently proposed. Based on future data collection efforts, it might be necessary to develop a finer classification to account for energy intensity differences. For the bus mode, this may include school bus and conventional bus. For the rail transit mode, this may include light rail, streetcar and/or rapid rail.

Energy form descriptions include:

- Gasoline
- Diesel
- Electric

The EUMs have been constructed to not only allow the analysis of conventional modes, but also to allow the inclusion of new technology such as the electric vehicle. Table 47 defines the transportation EUMs for the residential sector. The parcel column has been left blank in both columns. This has been done for two reasons. First, the activity, equipment and energy from descriptions are the same for each parcel within the residential sector. Thus, in the interest of presentation simplicity, all the possible EUM permutations were not presented. For example, a complete listing of residential EUMs would expand Table 47 by including under parcel: (1) single-family detached, (2) single-family attached, etc., and then repeating the complete list of activity, equipment, and energy descriptors. The second reason the parcel column has been left blank is related to a computational consideration. The primary effect of the parcel descriptor is on trip generation rates. While default values (national values) will be provided for each residential parcel dependent on the analytical procedure used by a given community, the residential trip generation may not be stratified by parcel. The EUMs could then be formulated by using the aggregated residential EUM without considering individual parcels, or a different disaggregation scheme could be used.

Again, it should be stressed as the conceptual phase continues it may be indicated that the residential EUMs should be aggregated to a greater degree or the non-residential EUMs should be further disaggregated.

(b) Development of Energy Demand Rating and Unit Profiles. The total energy used per unit of time for any EUM can be expressed as follows:

$$TE = f(EF, TC)$$

where:

TE = Total Energy Per Unit of Time

EF = Energy Factor (Energy/Mile)

TC = Trip Characteristics (VMT) for a given parcel

TABLE 47. END USE MODES

CATEGORY	PARCEL	ACTIVITY	EQUIPMENT	ENERGY
Residential		Home to Work	Compact Auto	Gasoline
		Home to Shop	Compact Auto	Gasoline
		Home to Other	Compact Auto	Gasoline
		Home to Work	Intermediate Auto	Gasoline
		Home to Shop	Intermediate Auto	Gasoline
		Home to Other	Intermediate Auto	Gasoline
		Home to Work	Standard Auto	Gasoline
		Home to Shop	Standard Auto	Gasoline
		Home to Other	Standard Auto	Gasoline
		Home to Work	Auto	Diesel
		Home to Shop	Auto	Diesel
		Home to Other	Auto	Diesel
		Home to Work	Auto	Electric
		Home to Shop	Auto	Electric
		Home to Other	Auto	Electric
		Home to Work	Bus	Gasoline
		Home to Shop	Bus	Gasoline
		Home to Other	Bus	Gasoline
		Home to Work	Bus	Diesel
		Home to Shop	Bus	Diesel
		Home to Other	Bus	Diesel
		Home to Work	Bus	Electric
		Home to Shop	Bus	Electric
		Home to Other	Bus	Electric
		Home to Work	Rail Transit	Diesel
		Home to Shop	Rail Transit	Diesel
		Home to Other	Rail Transit	Diesel
		Home to Work	Rail Transit	Electric
		Home to Shop	Rail Transit	Electric
		Home to Other	Rail Transit	Electric

The Energy Factor (EF) can be fuel specific (i.e., Gasoline/vehicle-mile, Electricity/vehicle-mile, etc.).

An energy intensity factor will be supplied as part of the algorithm for each EUM. The EF is based on a number of factors as detailed in Table 48. In theory, a new EF should be used for each variation in trip length, speed, auto occupancy, etc. Average EF factors will be supplied for each EUM for use in energy calculation. A procedure, it is hoped, will be developed to allow the user to vary the EF if different conditions exist in his community, if a different mix of vehicle types exist, etc.

Tables 49, 50, 51, and 52 indicate the EFs for various modes of travel under different conditions. Using data such as this, a set of EFs will be developed for different modes under varying conditions.

Land use densities and policies, transportation system and policies and technology will all have an effect on trip characteristics including the trip generation (TG), trip length (TL), Modal split (M) and auto/ vehicle occupancy rates (O). Inputs for these variables can come from national averages, actual values noted from empirical studies, or the results of travel models being employed by the community. As mentioned above, communities of 50,000 population or more usually have an analytical capability to generate this information.

The trip characteristics (TC) are a function of several variables as indicated in Table 53.

The formulation shown at the beginning of this section indicates that the total energy will be calculated by a unit of time. It is proposed, that for gasoline or diesel equipment/energy form, this unit of time be on a daily basis.

The unit of time for electrical equipment/energy form will be on an hourly basis.

The project team has concluded that for petroleum use in the transportation sector daily use would be sufficient to satisfy all expected requirements. In most cases, the primary variation is between weekday and weekend.

TABLE 48. ENERGY FACTORS

EIF= f (Operating Conditions, Vehicle Type)

Operating Conditions = f(V,S,G,A,FT,S/G,A/D,P,I,L,TL,T)

Where:

V	=	Traffic Characteristics (Volume)
S	=	Speed
G	=	Profile of Guideway (grade)
A	=	Alignment (curvature)
FT	=	Facility Type
S/G	=	Number of Stop/Go Cycles
A/D	=	Number of Slowdowns
P	=	Surface Conditions
I	=	Idling Time
L	=	Load Factor - Additional Weight
TL	=	Trip Length/Phase of Operation
T	=	Temperature

Vehicle Type = f (Y,W,AC,TU,TI)

Where:

Y	=	Year of Production
W	=	Vehicle Weight
AC	=	Number of Accessories
TU	=	State of Tuning
TI	=	Type of Tire

TABLE 49

VEHICLE GASOLINE CONSUMPTION ON FREEWAYS (1974)

AVERAGE SPEED (MPH)	CONSUMPTION - GALLONS PER MILE (1)								
	65	60	55	50	45	40	35	30	25
SUBCOMPACT AUTOMOBILE	.0497	.0453	.0420	.0395	.0379	.0371	.0358	.0354	.0356
COMPACT AUTOMOBILE	.0667	.0608	.0563	.0531	.0504	.0498	.0481	.0475	.0478
STANDARD AUTOMOBILE	.0825	.0752	.0696	.0656	.0623	.0616	.0594	.0587	.0591
2 TON LIGHT DUTY TRUCK	.0999	.0851	.0740	.0663	.0608	.0577	.0522	.0549	.0554
6 TON SINGLE UNIT TRUCK	.1437	.1347	.1259	.1200	.1158	.1148	.1147	.1152	.1173
20 TON GASOLINE TRUCK	.3500	.3554	.3332	.2799	.2985	.2968	.2963	.2970	.3052
25 TON DIESEL TRUCK	.2339	.2382	.2289	.2188	.2102	.2094	.2076	.2056	.2062
MIXED VEHICLE(2)	.0927	.0864	.0801	.0743	.0716	.0707	.0687	.0683	.0690

(1) DATA BASED ON TYPICAL ROADWAY SEGMENTS WHICH REFLECT VARIOUS CURVES, GRADES, STOPS PER MILE, TRAFFIC DENSITIES, ETC.

(2) DATA BASED ON VEHICLE MIX OF 83.04% AUTOMOBILES, 6.81% TWO TON TRUCKS, 3.26% SIX TON TRUCKS, 3.29% TWENTY TON TRUCKS, 3.60% TWENTY-FIVE TON TRUCKS. THE AUTOMOBILE MIX IS 58%, 30%, AND 12% FOR STANDARD, COMPACT, AND SUBCOMPACT, RESPECTIVELY.

SOURCE: BLOOM, KENT, <u>TRANS-URBAN COMPUTER MODEL (OPGAS)</u>, FEDERAL HIGHWAY ADMINISTRATION, U.S. DEPARTMENT OF TRANSPORTATION, WASHINGTON, D.C., APRIL, 1973

SOURCE: Characteristics of Urban Transportation System, DeLeuw, Cather & Co., USDOT, May 1975.

TABLE 50. ENERGY INTENSIVENESS FOR AUTOMOBILES AND BUSES

Energy intensiveness for automobiles and buses, 1974-1980

Vehicle type	Gross weight (1000 lbs.)	Trip length (statute miles)	Average trip hrs @ MPH	Fuel type[1]	Vehicle statute miles/gal	Number of seats		Specific energy, stop/start: Seat-miles/gallon		Specific energy, stop/start: BTU's seat-mile	
						Available (full load)	1972 Actual aver. oper.	Available (full load)	1972 Actual aver. oper.	Available (full load)	1972 Actual aver. oper.
Urban, subcompact auto	2.0-2.4	10.0	.24/25	Gas	24.0	4.0	1.6	96	38.4	1,302	3,255
Urban, compact auto	2.5-3.4	10.0	.24/25	Gas	18.0	5.0	1.6	90	28.8	1,389	4,340
Urban, standard auto	3.5-4.4	10.0	.24/25	Gas	14.4	6.0	1.6	86.4	23.0	1,447	5,435
Urban, luxury auto	4.5-6.0	10.0	.24/25	Gas	9.0	6.0	1.6	54	14.4	2,315	8,681
Urban, bus	(18.5 empty) 20.3-3-26.0	13.0	1.25/ 10.3	Diesel	3.6-4.0	50	12	180	48	771	2,891
Intercity, bus	(28.7 empty) 45.0	100.0	1.81/55	Diesel	6.0	46	19.4	276	116.4	503	1,192
Intercity, subcompact auto	2.0-2.4	100.0	1.81/55	Gas	30.0	4.0	2.0	120	60	1,042	2,083
Intercity, compact auto	2.5-3.4	100.0	1.81/55	Gas	22.5	5.0	2.2	112.5	49.5	1,111	2,525
Intercity, standard auto	3.5-4.4	100.0	1.81/55	Gas	18.0	6.0	2.6	108	46.8	1,157	2,671
Intercity, luxury auto	4.5-6.0	100.0	1.81/55	Gas	13.0	6.0	3.0	72	36	1,736	3,472

[1]Gasoline = 125 X 10^3 BTU/gal, Diesel = 138.8 X 10^3 BTU/gal.

SOURCES: U.S. Department of Transportation, Energy Statistics, U.S. Government Printing Office, Washington, DC as reported in the Transportation Energy Conservation Data Book, Oak Ridge National Laboratory, October 1976.

TABLE 51. ENERGY INTENSIVENESS FOR TRUCKS, 1974-1980

Vehicle type	Cargo density lbs/ft^3	Maximum payload in tons	Trip length (statute miles)	Average trip time hrs @ MPH	Type of fuel	Vehicle statute miles/gallon	Specific energy stop/start cycle	
							Ton-miles per gallon	BTU's/ton mile
Urban, truck	20-100	8	10	.4/25	Gas	8	64	1,953
Urban, truck	20-100	8	10	.4/25	Diesel	12	96	1,446
Urban, truck	10-30	3.1	10	.4/25	Gas	8	25	5,040
Intercity, truck	20-100	25	100	1.8/55	Diesel	5	125	1,110
Intercity, truck	15	14.3	100	1.8/55	Diesel	4.8	69	2,023

SOURCES: U.S. Dpartment of Transportation, Energy Statistics, U.S. Government Printing Office, Washington, DC as reported in the Transportation Energy Conservation Data Book, Oak Ridge National Laboratory, October, 1976.

TABLE 52. ENERGY INTENSIVENESS FOR PASSENGER TRAINS, 1974-1980

Vehicle type	Gross weight (1000 lbs)	Trip length (statute miles)	Average trip time (hrs)	Fuel type	Vehicle statute miles/gal	Number of seats	Specific energy stop/start cycle: Seat-miles gallon	Specific energy stop/start cycle: BTU's/ seat-mile
Urban train	79	0.75	0.02	Electric	37,600 BTU/mi	50-60	106	1320
Metroliner	1050	75	1.0	Electric	0.83	382	318	440
New Tokaido line	2000	140	1.4	Electric	0.4	1400	305	427
Standard diesel	1200	50	0.75	Diesel	0.66	360	240	583

SOURCES: U.S. Department of Transportation, Energy Statistics, U.S. Government Printing Office, Washington, DC as reported in the Transportation Energy Conservation Data Book, Oak Ridge National Laboratory, October, 1976.

For electrical consumption, hourly PROFILES will be described for urban rail (electric) transit and for electrical auto/bus/truck vehicles.

TABLE 53. TRIP CHARACTERISTICS

TC = f(TG, M, O, TL, S)

Where: TG = Trip Generation

TL = Trip Length

M = Mode Split

S = Speed

As mentioned at the beginning of this section, if an urban area does not have the data required for calculating the unit profiles or VMT, default or national average values will be supplied.

The following pages present figures and tables that indicate the sources and types of data that can be supplied.

- Vehicle Miles of Travel - Table 54 presents one approach to obtaining VMT by urban area. This table indicates that within urban areas of similar size travel per capita increases with capacity per capita.

- Trip Generation - A considerable amount of effort has concentrated on developing good trip generation data, especially at the residential trip end.

  Table 55 presents trip generation for residences. The table was taken from a source which presents a comprehensive listing of trip generation rates for several land use classifications.

  Regression equations for trip generation have been developed on a national level that could also be used by an urban area that does not have specific generation information.

TABLE 54. VMT/POPULATION RELATIONSHIPS

VEHICLE MILES OF TRAVEL PER CAPITA RELATED TO POPULATION AND HIGHWAY SYSTEM SUPPLY

Capacity Index *	POPULATION GROUP (000) 50 to 100	100 to 250	250 to 500	500 to 1000	1000 & over	All Urban Areas
Less than 75	7.04	8.06	8.70	7.45	9.44	7.83
75 - 150	8.89	10.10	10.60	11.20	10.50	9.80
Over 150	11.00	10.93	11.98	14.37	12.96	11.37
All Capacity Classes	9.00	10.01	10.66	11.26	10.40	9.61

* Assumes Freeway Capacity = 5 x Surface Arterial Capacity

$$\text{Capacity Index} = \frac{\text{(5 (Freeway Miles) + Surface Arterial Miles)}}{\text{Population (00)}}$$

SOURCE: Kassoff, H., and Gendell, D.S., "An Approach to Multi-Regional Urban Transportation Policy Planning," as reported in "A System Sensitive Approach for Forecasting Urbanized Area Travel Demand," Alan M. Vorhees & Associates, 1971.

TABLE 55. TRIP GENERATION RATES

SUMMARY OF TRIP GENERATION RATES

Land Use/Building Type: Single Family Housing — ITE Land Use Code: 210

Independent Variable—Trips per: Person

			Average Trip Rate	Maximum Rate	Minimum Rate	Correlation Coefficient	Number of Studies	Average Size of Independent Variable/Study
Average Weekday Vehicle Trip Ends			2.5	4.8	1.2		107	1890
Peak Hour of Adjacent Street Traffic	A.M. Between 7 and 9	Enter	0.1				25	
		Exit	0.2				26	
		Total	0.2				95	
	P.M. Between 4 and 6	Enter	0.2				26	
		Exit	0.1				26	
		Total	0.3				94	
Peak Hour of Generator	A.M.	Enter	0.1				26	
		Exit	0.2				26	
		Total	0.2				97	
	P.M.	Enter	0.2				28	
		Exit	0.1				26	
		Total	0.3				96	
Saturday Vehicle Trip Ends			2.7				37	
Peak Hour of Generator		Enter	0.2				21	
		Exit	0.1				21	
		Total	0.3				31	
Sunday Vehicle Trip Ends			2.4				32	
Peak Hour of Generator		Enter	0.1				19	
		Exit	0.1				19	
		Total	0.3				30	

Source Numbers: 1, 4, 5, 6, 7, 8, 11, 12, 13, 14, 16, 19, 20, 21, 24, 26, 34, 35, 36, 38, 40, 71, 72

ITE Technical Committee 6A-6—Trip Generation Rates

Date: 10-1-75

SOURCES: Trip Generation, Institute of Transportation Engineers Informational Report, 1976.

Table 46 presented some examples of the different trip purposes.

- Trip Length - Trip length is a function of:

    - The size and physical structure of the urban area

    - The transportation system

    - The social and economic patterns

  Table 56 and Table 57 are examples of work that can be used in developing default values for an urban area that does not have this information.

- Automobile Occupancy - Table 58 presents information on automobile occupancy.

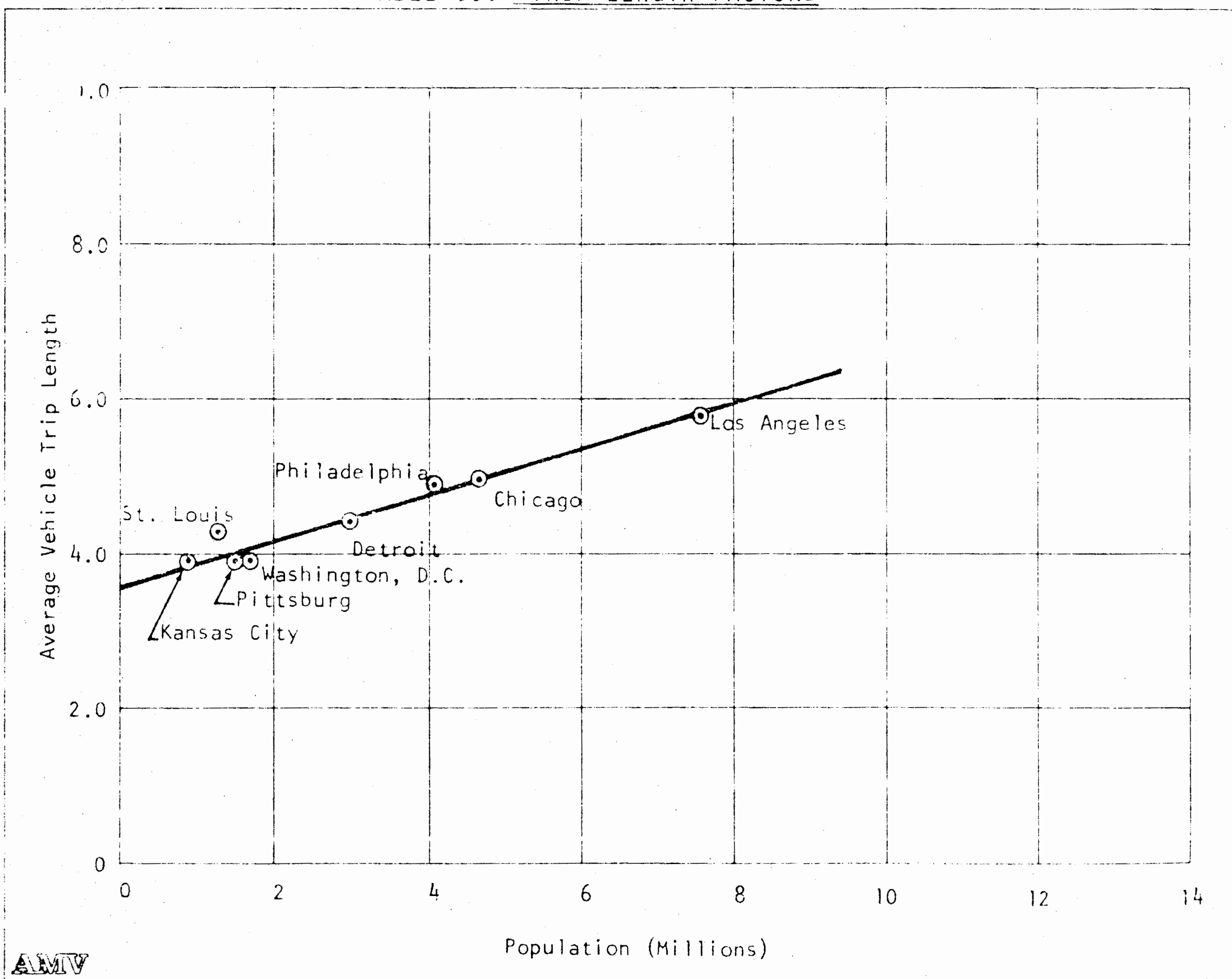
Within the remaining conceptual work and the data collection effort, work will continue in defining default values for all important transportation variables.

It should be pointed out again that in most cases (especially for those urban areas with a population greater than 50,000) the urban area will have this information.

(c) Reliability/Accuracy. First, the accuracy relates to the number of EUMs. As mentioned previously, if every possible EUM combination could be defined and modeled a fairly refined and accurate representation could be made. However, if this approach was followed not only would the number of EUM's be impossible to manage, but it is uncertain whether the data exists to support this refinement. The level of EUM detail proposed tends to balance these factors. As more experience is gained, the detail may vary.

The second factor that effects accuracy is the energy factors. The more accurate the EFs reflect the conditions found in the community the more accurate the calculations.

TABLE 56. TRIP LENGTH FACTORS



SOURCE: Wilbur Smith & Associates; "Transportation and Parking in Tomorrows Cities," 1965, as reported in "A System Sensitive Approach for Forecasting Urbanized Area Travel Demand,"

TABLE 57. TRIP LENGTH FACTORS AND CONSIDERATIONS

Work Trips

1. Size and physical structure:

   (a) If an urban area grows by extending its present population and employment density patterns, the change in the average work trip length (time) will probably be proportional to the fourth root of the population change.

   (b) If an urban area grows largely by the filling in of unused land while maintaining its same density pattern, there will be no material change in work trip length (time).

   (c) If an urban area develops by concentrating additional population and employment in the downtown area and/or in other sections of the metropolitan area, the average work trip length (time) will probably decline. Various studies have shown that this decline could vary from 5 to 10 percent.

2. Network speed:

   (a) Changes in the average work trip distance (miles) will be directly proportional to the square root of changes in peak-hour network speed.

   (b) Changes in the average work trip duration (minutes) will be inversely proportional to the square root of changes in peak-hour network speed.

3. Socio-economic factors:

   (a) A more heterogeneous distribution of income in an urban area could reduce trip length by as much as 10 percent, but with present social attitudes this is not likely to happen.

   (b) Changes in existing historical and social patterns could change trip length by 5 percent, but it appears from the data investigated that these changes occur very slowly.

Nonwork Trips

1. Size and physical structure:

   (a) Nonhome-based trip lengths will change at about the same rate as work trips, whereas social-recreation trip lengths will change as the 0.7 power of the work trip length.

   (b) Shop trip length is not likely to change unless unanticipated changes occur in retailing practices.

   (c) Truck trip length is not likely to change unless commercial and residential land-use patterns change.

2. Network speed:

   (a) Shop and truck trip length does not appear at this time to be related to changes in average network speed.

   (b) Changes in the average social-recreation trip distance appear to be directly proportional to the cube root of changes in off-peak network speeds.

   (c) Changes in the average social-recreation trip duration (minutes) appear to be inversely proportional to the cube root of changes in off-peak network speeds.

   (d) Nonhome-based trip distance (miles) will be directly proportional to changes in network speeds provided there is no radical change in CBD travel.

3. Socio-economic factors:

   (a) More heterogeneous distribution of incomes within an urban area could increase social-recreation trip lengths as much as 10 percent, but would have little impact on other types of nonwork trips.

   (b) Changes in existing historical and social patterns could change nonwork trip lengths as much as 10 percent, but, as in the case of work trips, these changes are not likely to occur very rapidly.

SOURCE: Factors and Trends in Trip Lengths, National Cooperative Highway Research Program, Report 48, Alan M. Voorhees & Associates, 1968.

TABLE 58. AUTO OCCUPANCY

Place of residence	Major purpose of trip													
	Earning a living			Family business				Educational, civic, and religious	Social and recreational					All purposes
	To and from work	Related business	Total	Medical and dental	Shopping	Other	Total		Vacation	Visits to friends or relatives	Pleasure rides	Other	Total	
	Occupancy - Occupants per trip													
All incorporated places	1.4	1.6	1.4	2.0	2.0	1.9	1.9	2.6	*	2.3	2.8	2.6	[illegible]	[illegible]
All unincorporated areas	1.4	1.7	1.5	2.3	2.1	2.0	2.1	2.5	*	2.3	2.5	2.6	2.4	2.0
All places and areas	1.4	1.6	1.4	2.1	2.0	1.9	2.0	2.5	3.3	2.3	2.7	2.6	2.5	1.9
	Occupancy - Passenger miles per vehicle-mile													
All incorporated places	1.5	1.6	1.5	2.1	2.2	2.2	2.2	2.4	*	2.7	3.2	3.0	2.9	2.2
All unincorporated areas	1.6	2.0	1.7	2.9	2.3	2.2	2.4	2.6	*	2.6	2.5	2.9	2.8	2.2
All places and areas	1.6	1.7	1.6	2.6	2.2	2.2	2.3	2.5	3.3	2.7	3.0	3.0	2.9	2.2

* Data insufficient for analysis.

SOURCE: Based upon unpublished table D-8 from the Nationwide Personal Transportation Survey conducted by the Bureau of the Census for the Federal Highway Administration, 1969-1070 as reported in the Nationwide Personal Transportation Study, Report No. 1, April, 1972.

The third factor that effects the accuracy of the formulation relates to the trip generation, trip length, and other travel characteristics used in the energy consumption formulation. Presently, the formulation is constructed to use average values obtained through a default option or from a travel model. Accuracy could be improved if, for example, trip speeds are represented as distributions in the formulation rather than single values. However, to be effective the EF would have to vary in accordance with speed.

(d) Data Requirements. The primary requirements for developmental data includes the derivation of Energy Factors (EF) and average or default values for each of the variables contained in the energy consumption formulation. The level of EUM detail will be very dependent on the ability to derive these values for specific cases.

For the user, the primary requirements relate to describing the number of EUM's for each category. Beyond this, the user can use the default values or supply locally generated values. It is assumed that for most areas a fairly complete data base will exist related to travel conditions and they could be used for input.

For calibration purposes data will be required on gasoline/diesel sales in a community. The availability and accuracy of the data has not yet been determined. The data to calibrate the electrical energy use for rail transit can be obtained from the transit organizations presently running these operations throughout the country.

b. Commercial Land Uses. Commercial land uses familiar to the community planner have been defined in the previous section. In addition to the parcels identified there, food stores have been defined as a separate retail parcel because of the particular equipment loads unique to this type of store. Energy end use modes are identified for both on-site and transportation activities, and the concepts for development of an energy analysis procedure as it relates to these end use modes are discussed in the following sections.

b. Commercial Land Uses. Commercial land uses familiar to the community planner have been defined in the previous section. In addition to the parcels identified there, food stores have been defined as a separate retail parcel because of the particular equipment loads unique to this type of store. Energy end use modes are identified for both on-site and transportation activities, and the concepts for development of an energy analysis procedure as it relates to these end use modes are discussed in the following sections.

(1) On-site Energy Uses

(a) Specification of end use modes. The energy end use modes associated with commercial land uses are identified in Table 59. As in Table 45 for residential end use modes, all specific combinations of parcel, activity, equipment, and energy source are not listed. However, all combinations, or EUMs, can be derived from the horizontal row groupings of parcel, activity, equipment and fuel. Ten parcels have been identified which should be utilized at the energy analyst level. Only the food store and the mall-type retail categories differ from the planner's available disaggregated data base. This additional data will probably require a limited survey of buildings.

Seven activities within the commercial land use category have been identified. Two of these are limited to a few parcels in terms of significant energy use. Food preparation is significant only in restaurants and hotels and motels. Food storage is a significant activity in food stores, as well as restaurants, hotels and motels. A third activity, space cooling, is not considered to be significant in one parcel type - warehousing. All other activities (space heating, water heating, lighting, and other appliances) are considered in all parcels.

Equipment is a very important factor in commercial building heating and cooling. The multitude of distribution system types in commercial buildings (see Table 60) with vastly different efficiencies is a major problem in determining energy use. Some systems will use two or three times as much energy as another to meet the same heating or cooling loads (Ref. 1). In addition, the percentage of outside air used in heating or

TABLE 59. COMMERCIAL ZONE ENERGY END-USE MODES

Parcel	Activity	Equipment	Energy Form
Food Stores Small Retail Large Retail Mall-Type Retail Restaurants Warehousing Low-Rise Office High-Rise Office Low-Rise Hotel/Motel High-Rise Hotel/Motel	Space Heating	Furnace/Boiler, Heat Pump, Distributed Electric Resistance, District Service (See Table 60 for HVAC Systems)	Electricity, Utility Gas, Fuel Oil (Distillates) or Kerosene. Residual Fuel Oil, Coal or Other Fuels Steam, Hot Water
Food Stores Small Retail Large Retail Mall-Type Retail Restaurants Low-Rise Office High-Rise Office Low-Rise Hotel/Motel High-Rise Hotel/Motel	Space Cooling	Window Unit, Electric Central, Absorption, Heat Pump, District Service (See Table 60 for HVAC Systems)	Electricity, Utility Gas, Steam, Hot Water, Chilled Water
Food Stores Small Retail Large Retail Mall-Type Retail Restaurants Warehousing Low-Rise Office High-Rise Office Low-Rise Hotel/Motel High-Rise Hotel/Motel	Domestic Water Heating	Furnace/Boiler Combination, Heat Pump, Individual Water Heater, District Service	Electricity, Utility Gas, Fuel Oil (Distillate) or Kerosene, Residual Fuel Oil, Coal and Other Fuels, Steam, Hot Water
Food Stores Small Retail Large Retail Mall-Type Retail Restaurants Warehousing Low-Rise Office High-Rise Office Low-Rise Hotel/Motel High-Rise Hotel/Motel	Lighting	Fluorescent, Other	Electricity
Restaurants Low-Rise Hotels/Motels High-Rise Hotels/Motels	Food Preparation	Ranges and Ovens, etc.	Electricity, Utility Gas, Other
Restaurants Low-Rise Hotels/Motels High-Rise Hotels/Motels Food Stores	Food Storage	Refrigerators, Freezers	Electricity, Steam, Utility Gas, Hot Water, Chilled Water
Food Stores Small Retail Large Retail Mall-Type Retail Restaurants Warehousing Low-Rise Office High-Rise Office Low-Rise Hotel/Motel High-Rise Hotel/Motel	Other Appliances	Other Electrical Appliances (Various and special for each parcel)	Electricity, Gas

TABLE 60. HVAC SYSTEMS

NUMBER	DESCRIPTION
1	Single Zone Fan System with Face and By-pass Dampers
2	Multi-Zone Fan System
3	Dual Duct Fan System
4	Single Zone Fan System with Sub-Zone Reheat
5	Unit Ventilator
6	Unit Heater
7	Floor Panel Heating
8	Two-pipe Fancoil System
9	Four-pipe Fancoil System
10	Two-pipe Induction Unit Fan System
11	Four-pipe Induction Unit Fan System
12	Variable Volume Fan System and Optional Reheat
13	Constant Volume Reheat Fan System

(c) Accuracy/Reliability. The existing algorithm for heating and cooling in office buildings has been tested on only a few buildings, however, the results of these tests have indicated a margin of error of less than ten percent (compared to actual energy usage). Here too, tests are still being conducted by the U.S. Army Construction Engineering Research Laboratory. However, errors in commercial buildings can be expected to be greater than in residential structures if approximations are required in the assignment of HVAC systems. A good sample survey of system types and amount of outside air utilized will tend to keep error margins small in this area.

As discussed in the residential land uses section preceding, the inaccuracy of weather tapes applies to commercial buildings as well.

(d) Data Requirements. The heating and cooling energy algorithms have the same data requirements as those listed for residential users, plus the following additions.

- Schedule of the occupants in building is as important as the number of total occupants.

cooling system ventilation can vary widely with any system used. This factor can be a major component of building energy use. Therefore, the analyst cannot reliably determine energy use in the commercial land use category without identifying, in some way, the types and mix of heating and cooling equipment utilized and some approximation of ventilation air typical in the study community. All other equipment selections for other activities will have relatively less significance with respect to energy use in these buildings. Energy source should also be identified in the survey of commercial buildings, or from utility company information.

(b) Development of Energy Demand Ratings and Unit Profiles. Energy demand ratings associated with commercial land uses will be based on a unit square foot of floor space for all EUMs (with the possible exception of the hotel and motel group which would be on a per room basis). Those demand ratings and use profiles dependent on weather data will be derived in a fashion similar to that described in the preceding section on residential land uses. The same methodology for heating and cooling algorithms will be utilized in application to commercial buildings. The existing algorithm is currently applicable to office buildings and food stores. Development work will be required to fashion the procedure to other types of commercial buildings.

Occupancy and operational schedules are more important in commercial than in residential buildings. Also, energy conservation and management alternatives will include variation of operating schedules in commercial establishments. The flexibility to alter these schedules will be provided in the energy use profile algorithm.

The other activities associated with commercial land uses are also dependent on the occupancy and operations schedules, including: lighting, water heating, food preparation, and other appliance usage. Only the food storage activity is somewhat independent of these schedules. The unit profiles for these activities will be developed as a function of building occupancy or operational level, based on typical buildings of each type. The flexibility to alter these profiles or substitute others will be available to the user.

- The type of HVAC system is very important. In addition, the percentage of circulation air which is supplied from outside the building must be specified.

- Type of lighting and lighting usage schedule.

All other data requirements for appliances, lighting, and other equipment is similar in type to those described in the residential land use section.

(2) Transportation Energy Uses. As discussed under the residential category, the transportation energy use within a community will be developed by analyzing the following travel activities:

- Home-based travel
- Nonhome-based travel
- External travel
- Truck travel

Home-based travel was considered under the residential category and energy use was determine on a parcel basis. The energy use for nonhome-based travel, external travel, and truck travel will be established using community wide statistics. The procedure is discussed under the commercial sector even though it covers travel that is also related to the other parcels.

(a) Specification of End Use Modes. Table 61 defines the transportation EUMs for the nonresidential based trips - nonhome based travel and truck travel.

Table 62 defines the transportation EUMs for external travel.

(b) Development of Energy Demand Rating and Unit Profiles. As discussed under the residential section, the total energy used per unit of time can be expressed as:

TE = f(EF, TC)

TE = Total Energy per Unit of Time

EF = Energy Factor

TC = Travel Characteristics (VMT) per unit of time.

TABLE 61. TRANSPORTATION END USE MODES

SECTOR	PARCEL	ACTIVITY	EQUIPMENT	ENERGY
Non-residential		Non-Home Based	Auto	Gasoline
		Non-Home Based	Auto	Electric
		Non-Home Based	Auto	Diesel
		Freight	Light Truck	Gasoline
		Freight	Light Truck	Diesel
		Freight	Light Truck	Electric
		Freight	Heavy Truck	Gasoline
		Freight	Heavy Truck	Diesel

TABLE 62. TRANSPORTATION END USE MODES

SECTOR	COMPONENT	ACTIVITY	EQUIPMENT	ENERGY
External		External	Auto	Gasoline
		External	Auto	Diesel
		External	Bus	Gasoline
		External	Bus	Diesel
		External	Truck	Gasoline
		External	Truck	Diesel

Energy Factors for different transportation modes were discussed previously under the residential sector and examples of these factors were given in Tables 49, 50, 51, 52.

A set of EFs will be developed for different modes under varying conditions.

The data related to trip characteristics expressed as vehicle miles of travel (VMT) for nonhome-based travel, truck travel, and external travel should be available in areas of 50,000 population or greater.

For those communities that do not have the data, default values will be supplied.

Much of the information related to VMT, trip length, auto occupancy, etc. presented under the residential category is applicable to those purposes.

Mean percentage values for the three purposes being considered as a percentage of total vehicular trips will be presented. (See Table 46 in the residential sector.

Also, a study prepared for the Department of Transportation is the development of the Transportation Resource Allocation Study (TRANS) developed trip generation equations for the nonhome based travel or national statistics. Information was also developed in that study to calculate other travel purpose trips.

(c) Reliability/Accuracy. See the residential sector for a discussion on reliability.

(d) Data Requirements. See the residential sector for a discussion on data requirements.

c. Institutional Land Uses. The classification of land uses within this very broad category is not very detailed. Some of the land uses in this category are large energy users on a unit basis, such as hospitals, but this entire category represents a small portion of the community's total energy use. Generalization and approximation within this category, therefore, has a reduced impact on the calculation of total community energy use.

Within this land use category are building types which are sometimes municipally owned and/or operated. These buildings have a special significance to community energy-use planners, since the activities within these buildings can be readily controlled by government action. Although these municipal buildings are described in terms of end use modes no differently than non-public buildings of the same type, they will be identified in the model input and output in order to emphasize this immediate control to the user.

As in the preceding sections, energy end uses have been divided into two categories: on-site and transportation energy end uses.

(1) <u>On-site Energy Uses</u>

(a) <u>Specification of EUM</u>. On-site energy end use modes associated with institutional land uses are identified in Table 63. Specific end use modes are combinations of any parcel, activity, equipment and energy source on a horizontal row. Nine parcels have been listed; the two most significant ones in most communities are schools and hospitals. Public office buildings may also be important energy users in some communities. These offices will be handled in the Energy Analysis Procedure just like other office buildings in the commercial section, preceding, except that their energy uses will be listed separately for the convenience of the user.

Seven activities have been identified for energy use in these facilities: space heating, space cooling, water heating, lighting, food preparation, food storage and special. This last category is a catchall for special energy uses peculiar to these rather diverse parcels.

The equipment and energy forms utilized in the EUMs are similar, in general, to those in the commercial land use category. The exceptions are in the special energy use activities associated with these EUMs.

(b) <u>Development of energy demand ratings and unit profiles</u>. Energy demand ratings for these EUMs will be based on different units of measure because of their diversity. Energy use per hour per unit square foot of floor space will be the basis for energy demand ratings for: museums and libraries, social halls, reli-

TABLE 63. INSTITUTIONAL END USE MODES

Parcel	Activity	Equipment	Energy Form
Hospitals Police/Fire Stations Public Office Buildings Schools Religious Institutions Social Halls Auditoriums and Theaters Museums and Libraries Arenas (in door)	Space Heating	Furnace/Boiler, Heat Pump, Distributed Electric Resistance, District Service (See Table 60 for HVAC Systems)	Electric, Utility Gas, Fuel Oil (Distillate) or Kerosene, Residual Fuel Oil, Coal or Other Fuels, Steam, Hot Water, Chilled Water
Hospitals Police/Fire Stations Public Office Buildings Schools Religious Institutions Social Halls Auditoriums and Theaters Museums and Libraries Arenas (in door)	Space Cooling	Window Unit, Electric Central, Absorption, Heat Pump, District Service (See Table 60 for HVAC Systems)	Electricity, Utility Gas, Steam, Hot Water, Chilled Water
Hospitals Police/Fire Stations Public Office Buildings Schools Religious Institutions Social Halls Auditoriums and Theaters Museums and Libraries Arenas (in door)	Water Heating	Furnace/Boiler Combination, Heat Pump, Individual Water Heater, District Service	Electricity, Utility Gas, Fuel Oil (Distillate) or Kerosene, Residual Fuel Oil, Coal and Other Fuels, Steam, Hot Water
Hospitals Police/Fire Stations Public Office Buildings Schools Religious Institutions Social Halls Auditoriums and Theaters Museums and Libraries Arenas (in door) Stadia	Lighting	Fluorescent, Other	Electricity
Hospitals Schools Arenas (in door) Stadia	Food Preparation Food Storage	Ovens, Ranges, etc. Refrigerators, Freezers	Electricity, Utility Gas, Other
Hospitals Polic/Fire Stations Public Office Buildings Schools Religious Institutions Social Halls Auditoriums and Theaters Museums and Libraries Arenas (in door)	Special	Particular to the Parcel	Electricity, Utility Gas, Fuel Oil (Distillates) or Kerosene, Residual Fuel Oil, Coal or Other Fuels, Steam, Hot Water, Chilled Water

gious institutions, police and fire stations, and public office buildings. Schools will use the number of students as a measure, while hospitals will use the number of beds available for patients. Arenas, stadia and auditoriums and theatres wil use seating capacity as a unit measure for demand rating.

Demand ratings must be determined for each of these EUMs from survey of existing facilities and their energy use. This will entail a significant data collection task.

Unit profiles of space heating and cooling activities will be determined using algorithms similar to those discussed in the residential and commercial sections. Profiles for other activities will be closely associated with the occupancy and operational schedules of most of the parcels (e.g., auditoriums and theaters).

(c) Accuracy/Reliability. The energy use by space heating and cooling activities can be assessed in these EUMs with a confidence level similar to commercial structures. The other activities can be evaluated with reliability, also, if the proper data is provided by the user. For instance, to assess the lighting energy at a stadium, the number of events which take place at the stadium at night is a critical input. Special activities will probably be the most difficult to evaluate. The accuracy of the EAP in institutional facilities is heavily dependent on the user providing good, detailed data.

However, energy use by this entire land use category is expected to be a small portion of the total community's energy use. Therefore, a significant error in the assessment of a small portion of the total energy results in a small error at the community level.

(d) Data Requirements. The data required for use of the heating and cooling energy algorithms is similar to that required in the commercial land use category. Other data requirements are primarily the identification of schedules of operation or occupancy. School schedules, religious and social events are significant factors in determining hourly end use profiles for these EUMs.

The task of data collection on this project for the institutional land use category should be concentrated on two parcels: hospitals and schools. Other parcels (with the exception of public office buildings which will be handled like any other office building) are either small energy users, or are very community specific (schedule of events, etc.), or both. For community specific data, the user will be required to provide the data. The procedure must provide guidance on what data to collect and how to use it.

(2) Transportation Energy Uses. See the commercial sector for a discussion related to transportation energy use.

d. Transportation, Circulation. As was mentioned in section C which discussed physical characterization, this particular land use is the most complex factor affecting community physical form. This is because it is comprised of many networks of activities such as roads, utility lines and rights-of-way, solid or wastewater collection routes, as well as network junctions or staging areas such as parking facilities or terminals, waterworks or waste treatment plants. It should be pointed out that the transportation land use does not include what the layman might expect, and that is use of vehicles such as cars, busses, trucks, rapid transit, and the like. As discussed in previous sections, for the purposes of this study, transportation is considered as an activity which is associated with certain trip-generating parcels, such as residences, businesses, etc. It is not treated under this land use category, as no unique trips are generated by land uses in this category.

Fiscal accountability, within this end use category, is also complex in that the parcels in this land use are owned by either private enterprise or governmental authorities. This poses a problem unless the government or municipally operated parcels can be identified. This identification will be necessary in order to assess policies affecting the government controlled parcels. Although municipally operated parcels span several land use categories, they will be able to be identified within each land use category for ease in implementing policies at the municipal level. These policies are usually of the immediately implementable type and are of considerable importance to the planner.

(1) Specifications of EUMs. Table 64 lists the EUMs applicable to the Transportation Circulation land use category, from the Parcel to the Energy form. It should be noted that utility lines and similar rights-of-way are listed as EUMs although they in themselves do not use energy. They are included so that a complete accounting of land uses within a community may be obtained.

(2) Development of Unit Profiles. Each of the EUMs listed in Table 64 will be discussed in detail by parcel. Specific description of the EUM will be given including a description of its demand rating and its demand profile over time.

(a) Water Works. Besides the normal heating, cooling, and domestic hot water production demands which apply to all buildings, the Water Works specializes in water pumping along with other activities such as dry feeding, flocculating, mechanical mixing, air compressing, and miscellaneous electrical services. No matter what the activity (except miscellaneous services) the equipment prime movers for the activity are all electric motors of varying sizes. Thus, equipment is specified as motor horsepower and the EUM's demand rating will be a function of the total motor horsepower at a given Water Works. This function is given by the equation.

Demand Rating (kW) = Motor Horsepower (HP)x .746 (kW/HP)

The motor horsepower for any treatment facility is easily taken off the plans and schematics for the facility. These should be accessible to the planner through his city engineers' office.

Because motor horsepower reflects both motor and specific pump efficiencies, it matters not whether the pumps are impellor, propellor, centrifugal, or otherwise. Demand profiles of the Water Works will closely parallel the communities water demand profile. Typically, as water is demanded, the head is lowered. This lowered head of water triggers the pumps to fill the reservoir and thus the demand for energy. The size of reservoirs is greatly from location to location and thus the reliance on pumps varies. It is because of this that water consumption was not chosen as the indicator of energy use. Water

TABLE 64. END USE MODES ASSOCIATED WITH LAND USES IN THE TRANSPORTATION, CIRCULATION CATEGORY

	Parcel	Activity	Equipment	Energy
a	Water Works	Pumping	Motor Horsepower	Electricity
b	Water Works	Dry Feeding	Motor Horsepower	Electricity
c	Water Works	Flocculating	Motor Horsepower	Electricity
d	Water Works	Mechanical Mixing	Motor Horsepower	Electricity
e	Water Works	Air Compression	Motor Horsepower	Electricity
f	Water Works	Misc. Services		Electricity
g	Waste Water Collection	Pumping	Motor Horsepower	Electricity
h	Waste Water Treatment	Pumping	Motor Horsepower	Electricity
i	Waste Water Treatment	Mechanical Mixing	Motor Horsepower	Electricity
j	Waste Water Treatment	Sludge Processing	Motor Horsepower	Electricity
k	Waste Water Treatment	Sludge Processing	Reactor	Natural Gas
l	Waste Water Treatment	Sludge Processing	Incinerator	Natural Gas
m	Waste Water Treatment	Misc. Services		Electricity
n	Roads	Street Lighting	Incandescent Filament	Electricity
o	Roads	Street Lighting	Sodium Vapor	Electricity
p	Roads	Street Lighting	Mercury Vapor	Electricity
q	Roads	Street Lighting	Fluorescent	Electricity
r	Solid Waste Disposal	Sanitary Land Fill	Motor Horsepower	Electricity
s	Solid Waste Disposal	Composting	Motor Horsepower	Electricity
t	Solid Waste Disposal	Incinerating	Motor Horsepower	Electricity
u	Solid Waste Disposal	Incinerating	Furnace	Gas
v	Solid Waste Disposal	Incinerating	Furnace	Oil
w	Terminals	Space Heating	Unspecified	Various
x	Terminals	Space Cooling		
y	Terminals	Water Heating		
z	Terminals	Lighting	Fluorescent	Electricity
aa	Terminals	Other		Electricity
bb	Parking Facility	Lighting	Fluorescent	Electricity
cc	Utility Right-of-way			

Works of similar water output could have considerably different energy demand ratings.

(g) Waste Water Collection. As with the Water Works, Waste Water Collection involves pumping. Whether the system involves positive pressure or vacuum drag, the prime mover is an electrical motor and motor horsepower determines the demand rating. Again, motor horsepower power should be easily accessible from the city engineers' office. Depending on the location of the waste treatment plant, the demand profile for the collection pumps will lag the water demand profile by a certain amount.

(h-m) Waste Water Treatment. A wastewater treatment plant is in much the same way described as the water works. There are pumping requirements and mixing requirements. Beyond these there are sludge processing requirements such as centrifuging, and vacuum filtration to separate the sludge from the water. These are also governed by motor horsepower and utilize electricity. Once the sludge is separated, it can be burned in an incinerator or oxidized in a reactor. In both cases natural gas is the form of energy which must be supplied. Depending on where the Waste Water Treatment Plant is located, the demand profile could vary considerably from the water usage profiles.

(n-q) Roads. The only energy used by these rights-of-way is in the form of lighting. Streets are lighted by four types of lamps, incandescent, sodium vapor, mercury vapor, and fluorescent. The distinction is made because of the relative efficiencies of each lamp. Demand profiles will usually vary as dusk to dawn varies annually and by region. The profile may also depend upon cloud cover and other weather factors if a community's lights are triggered by outside photoelectric cells.

(r-v) Solid Waste Disposal. Sanitary landfills are not usually energy intensive with the exception of the tracked vehicles necessary to move the fill and earth. However, some landfills utilize shredders and grinders or some other sort of hammermill to homogenize the composition of the fill before it is covered. Compactors are also used when space is of concern. Both these types of processing utilize electricity although the compactor could be a gas driven hydraulic arrangement. Demand profiles will usually be uniform throughout the business day, but could peak if deliveries are not carefully planned.

Composting is generically more energy intensive than landfills but produces a useable product while reducing the volume of waste to be disposed. Primary equipment consists of a conveyor system for moving the waste from one point to the other, a shredder/grinder to reduce the size of the waste to a consistent quality as well as increase surface area to facilitate composting, a digestor which oxidizes the waste, and a magnetic separator. All of these equipment utilize electrical energy. The demand ratings are again defined as a function of motor horsepower. Demand profiles are relatively uniform as typical composters have a holding area for incoming solid waste and an inventory usually exists.

Solid waste can also be incinerated. Although the solid waste itself combusts, the process is aided by auxiliary fuels such as gas or oil to keep the temperatures high. Besides the furnaces, electrical power is used to transport the waste at various stages. As before, the demand rating is a function of motor hosepower. Demand profiles are also uniform and are similar to composting.

(w-aa) Terminals. As was stated earlier, terminals can be considered rodes of the network. Their energy use is similar to those types of buildings described in the commercial land use category. In fact, the algorithms developed in the commercial category will apply completely to terminals.

(bb) Parking. A parking facility is similar in concept to the terminal, although parking is not considered a building. The only energy used in parking is for lighting. This is generally fluorescent, but the other types used in general street lighting could apply. As with street lighting, a dusk to dawn profile could exist, but in parking garages, a more uniform profile might also be the case since the only light available is through artificial means.

(cc) Utility Right-of-way. These parcels are of the type that typically demand no energy, but are included so as to give the planner a complete set of descriptions for the community.

(3) Reliability of Accuracy Expected. In general, the accuracy of the algorithms will be a function of the accuracy of the input data. If national averages or default values are used, the accuracy obtained will be guided by the amount that the community differed from that average. The accuracy will also depend upon specific characteristics of the individual EUMs. The following paragraphs discuss these specifics.

(a-f) Water Works. Water usage fluctuates according to climate and time of day. Accuracy will depend upon determining these factors at a given location. Demand rating accuracy, given the correct amount of motor horsepower, is exactly accurate.

(g) Waste Water Collection. These parcels are subject to the same accuracies as (a-f).

(h-m) Waste Water Treatment. These parcels are subject to the same accuracies as (a-f).

(n-q) Roads. If the number of street lights can be determined then their demand can be calculated exactly. Demand profiles will be accurate to the degree of input accuracy.

(r-v) Solid Waste Disposal. Energy use is largely dependent upon the specific content of the waste. The more the content varies from the design value of the plant, the more the energy use will vary.

(w-aa) Terminals. Less work has been done in this parcel than for parcels in the Commercial/ land use category. Accuracies should be consistant with those described in the Institutional Land Use Category.

(bb) Parking Facility. These parcels are subject to the same accuracies as (n-q).

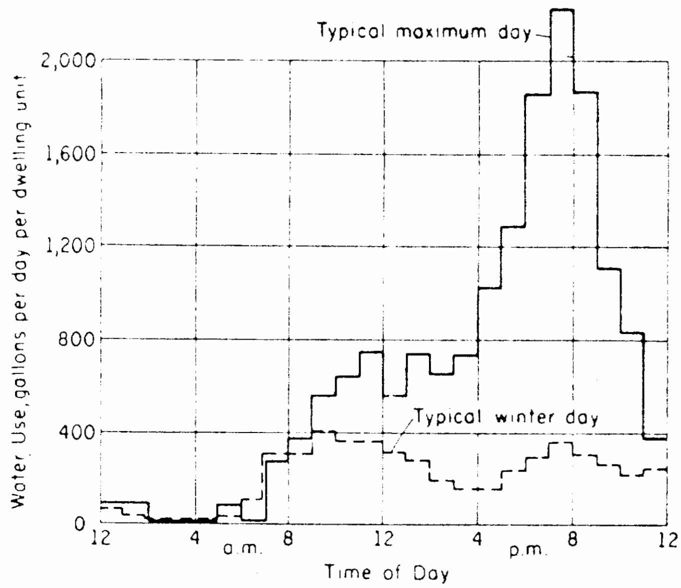
(cc) Utility Rights-of-way. There are no accuracies involved in these parcels since generically no energy is used.

(4) Developmental Data Requirements, Locational Calibration, and Parametric Use. Each EUM will be addressed in two parts. The first part being the demand rating, and the second part being the demand profile.

(a-f) Water Works. Whenever motor horsepower is given, the conversion is .746 Kilowatts per horsepower. Hourly profiles will vary according to time of day, location and size of service. Profiles, however, peak in the morning around 10 and in the evening around 8. The Residential Water Use Research Project (RWURP) has generated many profiles which reflect various conditions. Figure 22 depicts the range of water demand on maximum and minimum days from the RWURP.

These profiles will be used until they can be refined by more data during the demonstration and PON phases. Verification and calibration will be accomplished by comparing daily and monthly water works records with those estimated by the physical parameters. A preliminary check reveals that water works plants keep records of power usage consistent with the EUM breakdown and should be easily verified. Figure 23 shows what type of information is available on a process flow diagram while Figure 24 is typical of energy accountability at the water works. As the accounting ledger, Figure 24, shows, the usage and dollar value of energy is generally available for a variety of the specific activities which constitute the EUMs in this land use category.

(g) Waste Water Collection. Pumping for wastewater collection is based upon motor horsepower and will be handled as stated above. Hourly profiles will be more difficult to obtain because many stations have a small holding tank and pump only when at a certain level. The profile is also extensively dependent upon the sewer location. Initially, sewage collection profiles will be based on water usage with peaks in the morning and evening with local verification expected to contribute heavily to the summary of the profile. Luckily, the power consumed by the pumping station is small and so the impact may be also.



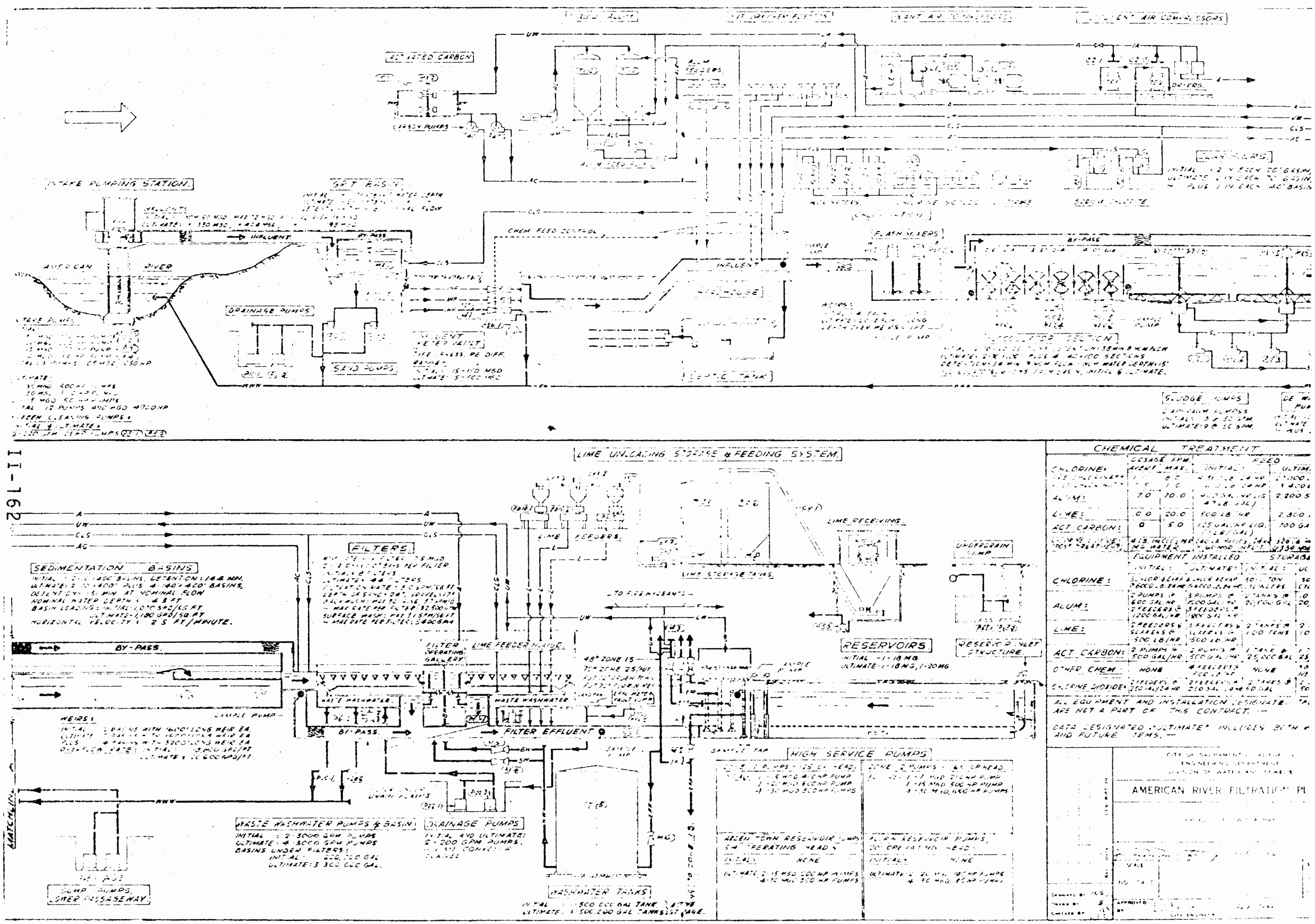
Daily water-use patterns, maximum day and winter day. (Courtesy of the Residential Water-Use Research Project of The Johns Hopkins University and The Office of Technical Studies of the Architectural Standards Division of The Federal Housing Administration.)

Figure 22. Daily Water-Use Patterns

(h-m) Waste Water Treatment. The discussion above on the Water Works (a-f) applies here. Demand profiles will be verified from actual data in the demonstration phases.

(n-q) Roads. Incandescent wattage spans a considerable range and thus the demand rating will be the average. The figure will be verifiable at the planners level and should be updated to reflect the local area's inventory. All other types of lamps are fairly narrow in range of wattage although the local verification still applies. Hourly profiles will vary between locales but is generally dusk to dawn on cycle. Verification of the community level is facilitated by the fact that street lighting billing is a separate entity.

(r-v) Solid Waste Disposal. Demand ratings for incinerating will be based upon the capacity of the solid waste disposal site. This may vary, but a range will be established which would cover the sizes encountered. With the exception of incinerating, all demands are based upon motor horsepower and will be handled as described above.


ACTIVATED CARBON
INTAKE PUMPING STATION
AMERICAN RIVER
INFLUENT
SET. BASIN
DRAINAGE PUMPS
SAND PUMPS
SEPTIC TANK
FLASH MIXERS
CLARIFIERS
SLUDGE PUMPS
CHEMICAL TREATMENT
LIME UNLOADING STORAGE & FEEDING SYSTEM
LIME FEEDERS
LIME RECEIVING
LIME STORAGE TANKS
SEDIMENTATION BASINS
FILTERS
BY-PASS
WEIRS
FILTER OPERATING GALLERY
LIME FEEDER HOUSE
WASTE WASHWATER
FILTER EFFLUENT
RESERVOIRS
INITIAL - 1 - 18 MG
ULTIMATE - 1 - 18 MG, 1 - 20 MG
RESERVOIR INLET STRUCTURE
UNDERDRAIN SUMP
HIGH SERVICE PUMPS
WASTE WASHWATER PUMPS & BASIN
DRAINAGE PUMPS
WASHWATER TANKS
SUMP PUMPS UNDER PASSAGEWAY
CHLORINE:
ALUM:
LIME:
ACT. CARBON:
EQUIPMENT INSTALLED
OTHER CHEM.
CHLORINE DIOXIDE
ALL EQUIPMENT AND INSTALLATION DESIGNATED ARE NOT A PART OF THIS CONTRACT.
DATA DESIGNATED "ULTIMATE" INCLUDES BOTH AND FUTURE ITEMS.
CITY OF SACRAMENTO, CALIFORNIA
AMERICAN RIVER FILTRATION PL
MATCH LINE

CITY OF HOMETOWN
DEPARTMENT OF UTILITIES
HOMETOWN, U.S.A.

HOMETOWN WATER PURIFICATION PLANT

Cost of Operation for the Month of ________ 19__

Total Amount of Water Treated (Gallons)	________
Total Amount of Water Pumped to City (Gallons)	________
Total Amount of Water Used for Washing Filters (Gallons)	________
Average Gallons Treated per Day	________
Maximum Gallons Treated per Day	________
Minimum Gallons Treated per Day	________
Per Cent Wash Water Used	________
Hours Plant in Operation	________
Cost of Chemicals:	
____ lbs. Aluminum Sulphate @ $____ per hund.	$________
____ lbs. Lime @ $____ per hund.	$________
____ lbs. Chlorine @ $____ per hund.	$________
____ lbs. Activated Carbon @ $____ per hund.	$________
____ lbs. ________ @ $____ per hund.	$________
Total Cost of Chemicals	$________
Cost of Chemicals per Million Gallons Filtered	$________
Cost of Power:	
Pumping Water to City	$________
Pumping Raw Water	$________
Pumping Wash Water	$________
Dry Feed Machines	$________
Flocculator	$________
Mechanical Mix	$________
Air Compressor	$________
Lights and Sand Pump (Approx.	$________
Total Cost of Power for Month	$________
Cost of Power per Million Gallons Pumped to City	$________
Labor	$________
Incidental (Approx.)	$________
Total Cost of Plant Operation	$________
Cost of Operation per Million Gallons to City	$________

Figure 24. Monthly Accounting Ledger

in (a-f). Hourly profiles will be on a shift basis with some reduction for start up and shut down. Verification is possible on the local level for both demand rating and profiles.

(w-aa) Terminals. Data requirements and verification will be similar to those developed in the Institutional Land Use section.

(bb) Parking Facility. This parcel has similar concerns to those which were covered in (n-q).

(cc) Utility Rights-of-way. There are no present data requirements for this parcel.

e. Open Space. The fifth land use category addressed in this study is open space. Parcels within this category include preserves, parks, undeveloped land, water covered land, etc. There have been no EUMs associated with these parcels. This category has been included mainly to allow the user to develop a complete specification of the community's land.

It should be noticed, in this context, that in the analysis of options, one large class of options to be considered is methods of developing currently undeveloped land. In such a case, this land would be "converted," for analytical purposes, to parcels which do have EUMs. However, in that situation, the subject land would be transferred to a different land use category.

f. Special Land Uses. This land use category includes parcels which do not fit into any of the other categories. The most important of these, from an energy use perspective, is industry. Some work has been done to date on establishing annual energy usage on a non fuel specific basis for two digit SICs. Little to no work has been done in determining fuel specific hourly profiles for two digit SICs. During the data collection phase gathering, this data will be attempted. Because there is little or no data from which to build on and thus increase the accuracy, these initial data gatherings should be supplemented by further efforts including further PONs and other demonstration opportunities.

3. Demand Profile Amplification and Aggregation Method

a. Nature of the Problem. The focus of Energy Analysis Procedure (EAP) is on the End Use Modes (EUM). An EUM, here, refers to the generic type of energy demand at the lowest level of aggregation. For instance, the energy demand for domestic hot water in any single family detached dwelling unit by an electric water heater is an EUM. The tentative number of EUMs listed for consideration in EAP is somewhere in the area of 400 to 500 for the community sizes of interest to the this project.

In a community of 50,000, for example, there may be thousands of SFD units with electric water heaters. The development of load profiles for every water heater is impractical and certainly unnecessary because of the main characteristics of EUM is the homogeneity of all the end uses within the mode. In other words, every end use within any EUM is typical of the end uses within that mode. This implies that the load profile for a typical end use within an EUM can be amplified to represent all the end uses collectively. The problem would have been very simple if all end uses within each EUM had identical demands at every point in time. Street lighting is a good example of this case. The total load is the sum of all the connected loads (the lights). This case is, however, an exception. In almost all other cases energy demands from various end uses within an EUM do not necessarily coincide in time. The clothes drying load is a simple example. All the SFD units with similar clothes dryers do not necessarily use their dryers at the same time. Hence, the demand from end uses in general have a random coincidence in time. Consequently, simple amplification, as in the case of street lighting, is no longer valid. A capability for amplification of any EUM load profile is an integral part of EAP. The following is a review of alternative methods of load profile amplification. The methodology selected for inclusion in EAP will be discussed in more detail later in this section.

b. Methods of Profile Amplification

(1) Econometric Approach. In an econometric approach the amplified load profile is estimated directly using historical data. The weather model used by utility companies is a good example. In a weather model the system weather sensitive load (cooling load) is related to the air conditioning saturation level and weather data (see Appendix A, Section F). In general, for any EUM the amplified load profile can be related to the number of end uses, the connected loads, and the use pattern. The functional relationships may be evaluated by statistical methods.

(2) Diversity Factor. Diversity factor is a constant multiplier which represents the extent to which demands from various end uses coincide. It is the ratio of amplified load to the sum of connected loads. A diversity factor of one (1) corresponds to 100 percent coincidence of demands from all end uses. For other cases the factor is less than one. Diversity factor, in a sense, is the percent frequency of observation of demand from a given end use at a particular time. The product of the diversity factor and demand is the expected (or average) load for the end use. A plot of expected load over an appropriate time cycle (a day or a week) is an average load profile generally referrred to as a diversified profile. In practice, the diverisified load profile for any EUM is obtained by averaging a sample of observed demand profiles. The typical load profile is then directly multiplied by the number of end uses to obtain the amplified load profile. This methodology has been used in engineering models. For instance, the Energy System Optimization Program, (ESOP), developed for the MIUS Community Conceptual Design Study, applies diversity factor to base electric load profiles.

(3) Probabilistic Approach. The demand profile of any EUM is the time history of application of the respective end use equipment. Since the incidence of the demand is random, the demand at any point in time is a random variable. In a probabilistic approach the amplified load is derived as the sum of random demands from all end uses within any given EUM.

Among the various amplification methods, the econometric approach is not applicable to EAP because:

- it requires substantial aggregated data for each EUM, which generally do not exist,
- an econometric model is only valid for the particular group of end uses for which the model is evaluated,
- model coefficients require re-evaluation of any significant change in the characteristics of the explanatory variables.

The latter implies that the class of econometric models are not suitable for evaluation of conservation measures required from the CCP.

The method of diversity factor was also rejected because the probabilistic method is superior and does not require undue excess efforts. The demand of an EUM at any arbitrary time is a random quantity due to the randomness inherent in application of end use equipment. The method of diversity factor gives only a point estimate for the amplified load while a probabilistic approach leads to the probability distribution of the amplified load. Indeed the diversity factor method can provide only part of the information that can be obtained via a probabilistic approach.

It should also be emphasized that a random model can be easily transformed to an expected value model by freezing every variable at its mean value. Therefore, one can easily go from a probabilistic model of amplification to a diversified load model, but the reverse is not always possible. The probabilistic model of load amplification is discussed in the following section.

c. <u>Probabilistic Model of Load Profile Amplification</u>. The EUM demands, except for some industrial processes, are discrete loads, in general, independently and randomly distributed over some appropriate time cycle. For example, consider the heating load of a commercial building in a given winter day. The load profile is described by the intermittent operation of the heating equipment in response to the change of temperature in the building. Another example is the clothes drying load of a household. It will occur as a discrete load for the period of the dryer cycle at various times during the week. In the first example the use pattern of the heating equipment is described by the building heat losses. In the second example the use pattern is described by the way the household operates. In general, the load profile of a single end use at any arbitrary time, t, can be represented by a random variable z(t) such that

$$z(t) = cx(t) \qquad (1)$$

In equation (1), c is the connected load (or rated input) of the end use equipment and x is the indicator function describing the use pattern of the equipment. x, in general, is a random variable which takes on values between zero and one. If the end use equipment operates only as on or off, then x is indeed a zero-one variable. If the equipment is operated at various load levels (e.g., a kitchen range) then x takes on the percentage of the maximum load.

Since there are numerous EUMs for the purpose of bookkeeping it is necessary to define the following indices:

Symbol	Definition
s	Index of parcel type, e.g., single family detached dwelling units, multi-family low rise, shopping centers, etc.
j	Index of activity, e.g., heating, cooling, domestic hot water, street lighting, etc.
r	Index of equipment type, e.g., heat pump, resistance furnace, etc.
k	Index of end use equipment size (or rate of input), e.g., small size dryer, window air conditioner, large freezer, etc.
f	Index for energy form, e.g., oil, gas, electricity
m	Index of end uses within any feasible combination of r and k. In other words, m keeps record of the end uses within any EUM, e.g., if there are 100 forty-gallon electric water heaters in SFD dwelling units, then for this group of end users m = 1, 2.....100.

Using these indices then equation (1) can be written as

$$z^f_{sjrkm}(t) = c^f_{jrk} \cdot x_{sjrkm}(t) \qquad (2)$$

where z is the energy demand from end use m, for the activity j, end use equipment of type r, size k, and fuel type f, utilized in parcel s, at time t. c is the rated input of fuel type f to end use equipment of type r and size k in the activity j. x(t) indicates the state of the load (on or off) for end use m.

The load profile for the activity j, in all parcels of type s is then obtained by summing the demand profile from all end uses over equipment types and sizes, where z is the energy demand from end use m of equipment size k in equipment type r for activity j in parcel s for fuel type f at time t. Then the demand for fuel type (f) in activity j in parcel s at time t is:

$$Z^{f}_{sj}(t) = \sum_{r} \sum_{k} \ldots \sum_{m} c^{f}_{jrk} \cdot x_{sjrkm}(t) \qquad (3)$$

Equation (3) is the random model of load profile amplification for any EUM. Clearly the total load profile for all fuels (Btu equivalent) can be obtained by using appropriate conversion factors and summing the equation over index f. In equation (3) x is a random variable for or combinations of parcels, activities, equipment types and sizes, and fuels, therefore, Z is a random variable. The probability distribution associated with random variable is derived next.

d. Probability Distribution Function of the Amplified Load Profile. The additive form of equation (3) suggests application of characteristic functions for encoding the probability distribution of z. Characteristic functions as transform functions have unique convolution properties for addition of independent random variables. That is, the characteristic function for the sum of n independent random variables is the product of their characteristic functions. Let Φ (u) represent the characteristic function for random variable x, then if

$$y = x_1 + x_2 + \ldots + x_n \qquad (4)$$

where all x's are independent random variables the characteristic function for y, $\Phi_y(u)$ can be written as

$$\Phi_y(u) = \Phi_{x_1}(u) \cdot \Phi_{x_2}(u) \ldots\ldots \Phi_{x_n}(u) \qquad (5)$$

The probability distribution for y then is obtained by inversion of its characteristic function $\Phi_y(u)$. The characteristic function for any random variable x is defired as follows

$$\Phi_x(u) = E\left[e^{iux}\right] \qquad (6)$$

$$= \int_{\infty}^{\infty} e^{iux} f(x)\, dx$$

where i = -1, E is the expectation operator and u is the variable of the transform. Note that f(x) is the probability density function for random variable x. Inversely, the probability density function for random variable x is is uniquely defined by its characteristic function. That is

$$f_x(x) = \frac{1}{2\pi} \int_{\infty}^{\infty} e^{-iux} \, \Phi_x(u) \, (du) \qquad (7)$$

Hence f(x) can be obtained by integrating equation (7). In some cases f(x) may be obtained by inspection from tables of Fourier transforms. Mathematically complex characteristic functions can be inverted numerically with the aid of Fast Fourier Transform (FFT) routines.

Applying the characteristic function to equation (3) yields:

$$\Phi_{Z^f_{sj}(t)}(u) = \prod_r \prod_k \prod_m \Phi_{x_{sjrkm}(t)} (c^f_{jrk} \cdot u) \qquad (8)$$

where

$$\Phi_{x_{sjrkm}(t)}(c^f_{sjrk} \cdot u) = e^{iuc^f_{sjrk}} \cdot \Phi_{x_{sjrkm}(t)}(u) \qquad (9)$$

Therefore, if the probability distribution for x(t) is known, then the probability distribution for the amplified load Z(t) can be derived from equation (8).

$X_{jsm}(t)$ is identically distributed for all m's (homoseneity of EUM). Using this property, equation (8) is reduced to

$$\Phi_{Z^f_{sj}(t)}(u) = \prod_r \prod_k (e^{uic^f_{rjk}})^N \cdot \left(\Phi_{x_{sjrk}(t)}(u)\right)^N \qquad (10$$

$\Phi_{x_{sjrk}(t)}(u)$ is the characteristic function for use pattern of a typical EUM and N is the number of such EUMs.

e. <u>Validity and Precision of the Model</u>. The random model of equation (3) is a precise representation of the amplification process. The model provides a complete description of the EUM demands. This includes:

- Probability distribution of peak load
- The mean value of the hourly demand

- Variance (or standard deviation) of the hourly demand

- Confidence interval on the amplified load profile for any specified level.

Of course no model is more accurate than its input. The precision of the results, therefore, will depend on the accuracy of the c's and x's. Conceptually, there is no restriction on the number of c's and x's, however, to reduce the problem to a manageable size it is required to represent a range of equipment having close rated inputs with an average input rate. Also for some EUM, the load can vary between 0 percent to 100 percent (e.g., gas stoves). In such case again the range of part loads is approximated by a few points, e.g., off, low, medium, and high. These approximations could result in slight errors in the final distribution. This is a kind of trade-off between precision and resource requirements. The user may decide on level of precision required. Also, application of characteristic function implies statistical independence of the x's. This, in general, is a valid assumption since the end use equipment within each mode is operated independently of each other.

f. Data Requirements. In the random model of load profile amplification, equation (3), all c's and x's are input information. Since x's are random variables, in fact their probability distributions are the required inputs. The c values may be provided by the CCP, input exogenously by the user or included in the EBP as default options. The probability distribution for x's in general are internal to the EAP. Of course the user will have the option to input the distributions exogenously.

Since the EAP is designed for communities with sophistication, or the ERDA research programs, the c's are expected to be provided by the user for precision purposes. The data in any case can be compiled from the following sources:

- Census reports

- Trade associations

- Direct survey

Also the probability distribution for x can be derived from:

- Sample of measured profiles

- Published use pattern profiles

- Typical load profiles (if the corresponding c is known)

- Survey of use pattern

- Informed judgement

The model developed here has a unique advantage over other amplification methods evaluating conservation measures. Here, the end use equipment are separated from the use patterns. The impact of hardware oriented conservation measures (e.g., more efficient equipment) can be evaluated directly by changing the c values. The impact of software oriented measures, e.g., lower thermostat setting, can be evaluated by changing the probability distribution of relevant x's. Of course, simultaneous effects of more efficient equipment and energy saving practices can be measured by perturbation of corresponding c's and x's.

g. Illustrative Example. Application of the methodology is illustrated here by a very simple example. Assume that the residential sector of a community under consideration consists of 50 SFD units each equipped with a 4KW clothes dryer with a forty minute cycle time. The question is, what is the load profile for clothes drying in this residential sector? Using equation (3), then

$$Z(t) = \sum_{m=1}^{N} c \cdot x_m(t) \qquad (11)$$

where s, j, and k indices were dropped for clarity of illustration, and all dryers are of the same size. In equation (11), c is 4 KW, N=50, and the probability distribution for x is plotted in Figure 25. The latter is based on a typical drying load profile from a study by Detroit Edison Company in 1960 (Figure 26). Using discrete time intervals of one hour, the probability distribution for x is given by

$$P[x(t) = 1] = p_x(t) \qquad (12)$$

$$P[x(t) = 0] = 1-p_x(t) = q_x(t)$$

where $p_x(t)$ is plotted in Figure 25. The characteristic function for random variable x then, is:

$$\Phi_{x(t)}(u) = \sum_{x=0}^{1} e^{iux(t)} \; p_x(t) \qquad (13)$$

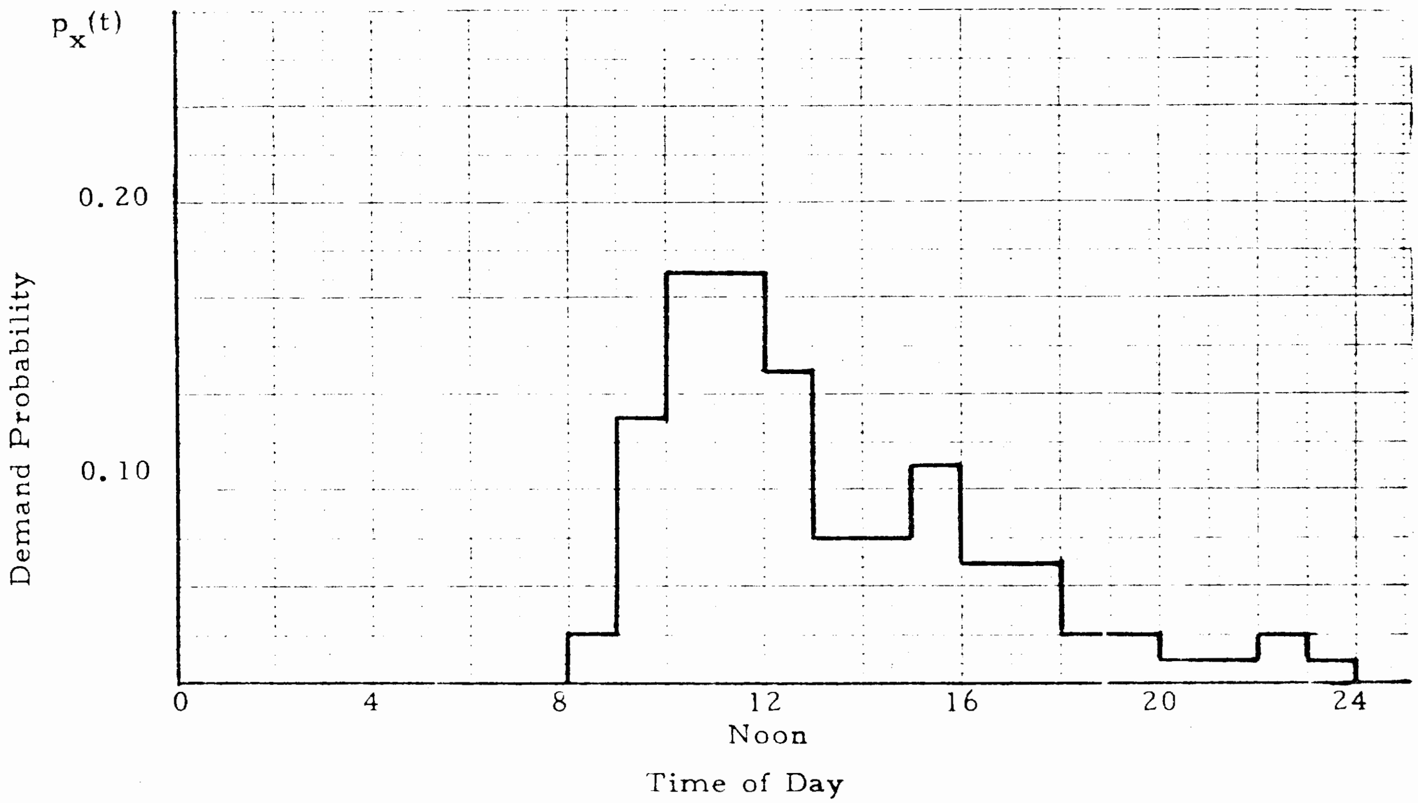


Figure 25. Probability Distribution of Clothes Drying Load on a Typical Weekday (for a Typical User)

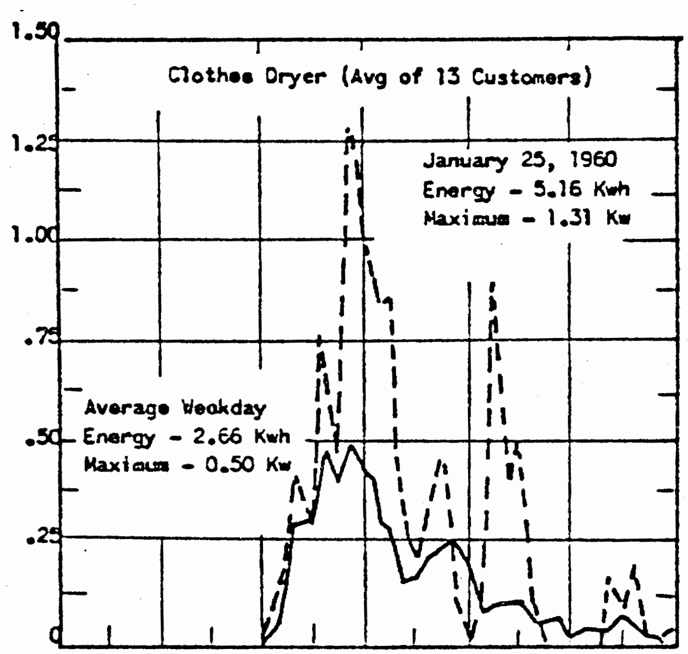


Figure 26. Clothes Dryer Load Profile for Day of Maximum Demand and Average Weekday of Coldest Week, 1959-1960

Source: MATHTECH, ACUCS Draft Report, Task 1b, October 1976 or

$$\Phi_{X(t)}(u) = p_X(t)e^{iu} + q_X(t) \qquad (14)$$

using equation (14) in equation (10) yields,

$$\Phi_{Z(t)}(u) = \left[p_X(t) \cdot e^{iu4} + q_X(t)\right]^{50} \qquad (15)$$

Equation (15) is the characteristic function of a binomial distribution.

Hence, the probability distribution for Z(t) is given by:

$$P[Z(t) = 4.K] = \frac{50!}{(50-K)\ K!} [p_X(t)]^{K} [q_X(t)]^{N-K} \qquad (16)$$

for K = 0, 1, 2,...N

The probability distribution for Z(t) are summarized in Table 65. Figure 27 illustrates the probability distribution of Z for two time periods, 10 to 12 a.m. and 4 to 6 p.m. From Figure 27 the following information can be calculated:

- o $E[Z(t)] = 34$ KW for $10 \leq t \leq 12$ a.m.
- o $\sigma^2_Z(t) = 28.22\ KW^2$ for $10 \leq t \leq 12$ a.m.
- o $P[Z(t) \leq 60]$ .98 for 10 $t \leq 12$ a.m.

The latter indicates that the change of peak load exceeding 60 KW at any time between 10 to 12 a.m. is less than 2 percent.

Figure 28 illustrates the 95 percent confidence interval for the amplified load. The mean value of the hourly demand is plotted in Figure 29. The shaded area represents the average daily energy demand for clotnes drying for all 50 households collectively.

TABLE 65. PROBABILITY DISTRIBUTION FOR CLOTHES DRYING LOADS OF 50 SFD UNITS ON A TYPICAL DAY

LOAD KW

TIME OF DAY	0	4	8	12	16	20	24	28	32	36	40	44	48	52	56	60	64	68	72	76	MEAN	STANDARD DEVIATION
8-9	.364	.371	.186	.061	.014	.003	+	+													4	1.98
9-10	.001	.018	.055	.109	.158	.180	.167	.130	.086	.050	.025	.011	.004	.001	+	+					22	4.42
10-11	+	+	.005	.015	.036	.069	.105	.136	.149	.143	.120	.089	.059	.035	.019	.004	.002	.001	.001	+	34	5.31
11-12	+	+	.005	.015	.036	.069	.105	.136	.149	.143	.120	.089	.059	.035	.019	.004	.002	.001			34	5.31
12-13	.001	.007	.026	.062	.108	.149	.167	.157	.126	.088	.054	.029	.014	.006	.003	.001	+	+			26	4.76
13-14	.045	.145	.226	.231	.173	.102	.049	.019	.007	.002	+	+									12	3.36
14-15	.045	.145	.226	.231	.173	.102	.049	.019	.007	.002	+	+									12	3.36
15-16	.009	.044	.107	.170	.197	.179	.133	.083	.044	.020	.008	.003	.001	+	+						18	4.05
16-17	.077	.202	.261	.220	.136	.066	.026	.008	.002	.001	+	+									10	3.08
17-18	.077	.202	.261	.220	.136	.066	.026	.008													10	3.08
18-19	.364	.371	.186	.061	.014	.003	+	+													4	1.98
19-20	.364	.371	.186	.061	.014	.003	+	+													4	1.98
20-21	.605	.305	.075	.012	.001	+	+	+													2	1.41
21-22	.605	.305	.075	.012	.001	+	+	+													2	1.41
22-23	.364	.371	.186	.061	.014	.003	+	+													4	1.98
23-24	.605	.305	.075	.012	.001	+	+	+													2	1.41

+ Less than 10^{-4}

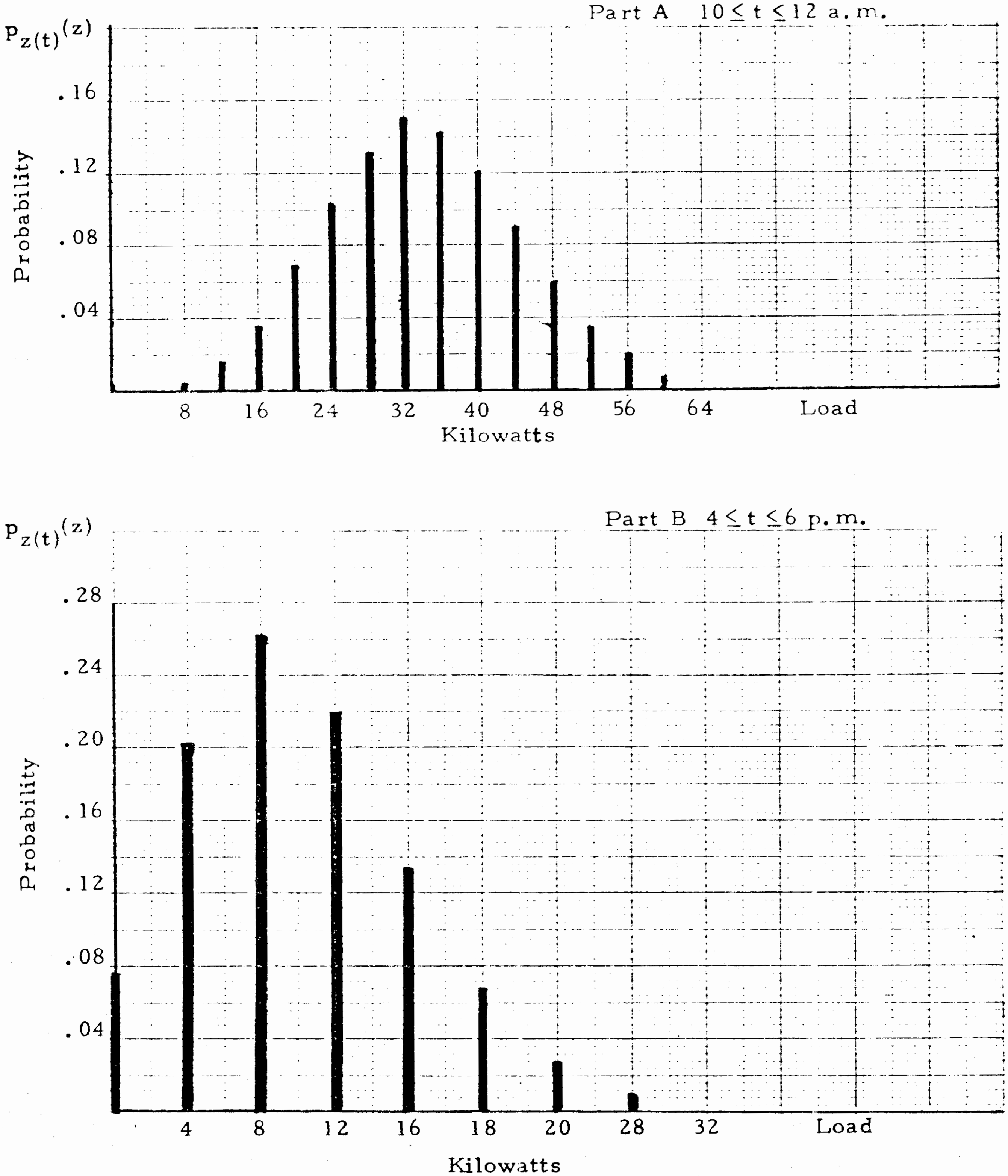


Figure 27. Probability Distribution of Clothes Drying Load for 50 SFD Units on a Typical Weekday

Figure 28. 95% Confidence Internal for Daily Amplified Clothes Drying Load

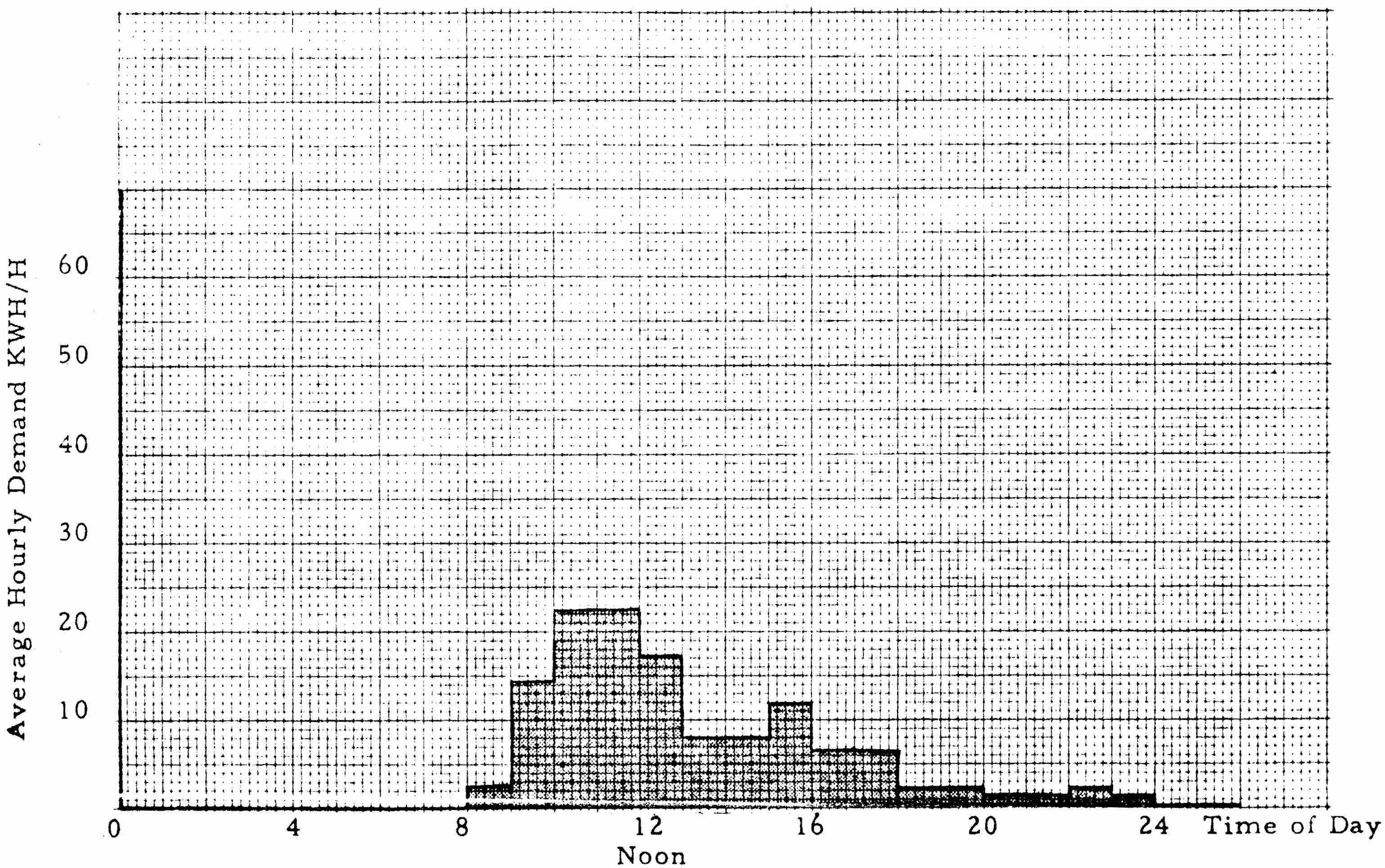


Figure 29. Hourly Profile of Average Amplified Demand for Clothes Drying
(A Typical Weekday)

h. Load Profile Aggregation Model. Aggregation, conceptually, is the same as the amplification process. In fact, amplification is a special case of aggregation where the end uses are homogeneous. The objective of aggregation is to determine the collective demand profile of sets of EUMs. Aggregation may be applied to EUMs within a single zone, a group of zones or the communit as a whole. The methodology developed for amplification is also valid for aggregation process. If the desired level is a land use category, S, then the demand by type of fuel is given by

$$Z_S^f(t) = \sum_s \sum_j \sum_r \sum_k \sum_m c_{jrk}^f \; x_{sjrkm}(t) \qquad (18)$$

where s is the index of the land use category of interest. All subscripts are as defined earlier.

Clearly the summation of equation (18) over all land use categories will give the total community load profiles by type of fuel, i.e.

$$Z^f(t) = \sum_S Z_S^f(t) \qquad (19)$$

Note that aggregation can be obtained for any subsets of community EUMs by summation of appropriate EUM demands from equation (2).

The aggregated demand, Z, (in equations 18 and 19) in general, is a random variable and its associated probability distribution can be derived using operational transform techniques (characteristic function) similar to the amplification model. Hence, the characteristic function for the aggregated demand profile of a land use category (equation 18) is given by

$$\Phi_{Z_S^f(t)}(u) = \prod_s \prod_j \prod_r \prod_k \prod_m \Phi_{x_{sjrkm}}(t)(c_{jrk}^f \cdot u) \qquad (20)$$

In aggregation process some of the EUM load profiles may be deterministic, such as process loads, street lighting profiles, etc. In such cases, without any of generality, the indicator function x(t) has a probability of one (certainty) for the interval that the end use equipment is in operation. In fact, for any EUM, if the probability distribution of x's are not available, the x's can be treated as deterministic functions at their mean values, or the mean value of corresponding z(t) from equation (2) can be used directly in equations (3), (18) or (19). This features of the model provides the EAP with a flexibility to perform the analysis at various levels of information and precision. The extreme case is to freeze all x's at their mean values, which reduces the model to a diversified load aggregation (or amplification) model.

i. Model Application. The aggregation model developed in Section h provides a mathematical framework for going from load profiles at EUM level to those of land use categories, zones, districts and the community. The model indeed has the capability to trace the impact of energy conservation measures through the homogenous as well as the non-homogeneous communities. The effect of fuel substitution can be evaluated by shift of the EUMs which then is upgraded to the level of community. The impact of conservation and fuel substitution measures are measured in terms of:

- average reduction in peak demand
- average hourly and daily energy savings
- variance (and standard deviation) of conserved demand and energy consumptions
- confidence interval on the profile of energy savings.

The model can evaluate the effects of both energy saving innovations and practices separately and/or simultareously. The measures can be evaluated one or many at a time.

j. Validity and Limitations of the Model. The only assumption underlying the model is that individual pieces of end use equipment are operated independently of each other. This is a necessary condition for the application of the characteristic functions. If some of the end uses are operationally dependent (e.g., clothes dryer often is used following the washer), then such dependent variables have a joint probability distribution and correspondingly a joint (multivariate) characteristic function should be used for the convolution process. Although this does not pose any problem conceptually, for a large number of dependent variables the model may become mathematically complex and computationally cumbersome. Fortunately, among the EUMs considered for inclusion in the EAP, those with random characteristics are for practical purposes independent. While, in general, the model can be expanded to consider dependencies, the dependent variables can always be frozen at their expected values to preserve the validity of the analysis.

k. Data Requirement. The data requirements for the aggregation model is generally the same as that of the amplification model which was discussed in a previous section.

4. Energy Analysis Procedures - Use at the Planner Level

The proceding portions of this section have provided a detailed discussion of the conceptual foundations of the detailed Energy Analysis Procedure (EAP). This procedure allows its user to simulate all the basic modes of energy end use in the community, and from that simulation, to develop hourly demand profiles for each end use mode, as well as add up the profiles to determine cumulative energy use profiles at a variety of aggregation levels. When calibrated and tested, this will provide a powerful tool for community level energy analysis.

It is realized, however, that all users of the overall methodology developed in this research will not have a need for detailed hourly demand information. In particular, a large class of users of the methodology, whose interest is in rather broad policy decisions, may find that reasonably reliable indicators of annual energy usage associated with various physical or behavioral measures is sufficient information for their needs. For these users, referred to previously as the "planner level," a simplified version of the EAP is necessary. This simplified version should fully utilize the theory embodied in the detailed EAP, but should differ by degree of data detail required for use, degree of technical training required for the user, and degree of detail in the output. The following pages describe how such a simplified version of the EAP is currently conceived.

a. Precedents. Of recent and useful concern is the BNL/SUNY Project on Land Use and Energy Utilization.(5) In this study, Energy Intensity Factors link physical land use activities to energy demands. Other recent studies which either utilize or calculate energy intensity factors include:

- Reading the Energy Meter on Development(6)
- Development of a Comprehensive Community Energy Management Plan, City of Clarksburg, W.Va. (8)
- Metropolitan Development and Energy Consumption(8)
- Energy Management in Municipal Buildings (9)

- Seattle's Electric Energy Conservation Long-Term Program and Some Implications for R&D (10)

- Portland Energy Conservation Project (11)

Each of these studies and virtually every study which links energy demand to a physical entity, utilizes some form of an energy intensity factor. On the simplest physical level or the equipment level, the energy intensity factor is its demand rating, e.g., an electric motor rated at 1.5 kW. It is known for a fact that when the motor is turned on it will demand 1.5 kW. On the other hand, if the energy demand of a parcel were needed, an energy intensity factor would be an aggregate of the many variables which affect a parcel's demand. By specifying a broader physical category a corresponding increase in range or accuracy results in the specification of an energy intensity factor.

b. Method Selected

(1) Rationale. The simplified EAP must be responsive to a majority of the planner's everyday policy decisions. In order to be able to do this the simplified EAP must utilize everday available data. More than that, the simplified EAP must use this everyday available data in an uncomplicated way. On the other hand, the simplified EAP cannot be so simple or uncomplicated that it would inadequately, respond to the planner's questions.

Discussion with planners, reviews of the literature, and drawing on the project team's expertise has led to the decision that the simplified EAP should be at the parcel level of land use. It is between this level and the zone that the planner most frequently operates and it is between this level and the activity that meaningful energy assessments can be made.

(2) Use. The main focal point in the simplified EAP is formatted in Table 66. The vertical axis lists the parcels while the horizontal specifies final specific energy use. Energy Intensity Factors (EIF) will be developed for each combination of parcel and final specific energy use in the table. In all parcels except in the Industry and Transportation land use categories, the preponderance of energy consumption is in heating and/or cooling the structure. EIFs for heating and cooling are especially sensitive to the following factors:

- Annual heating and cooling degree days

TABLE 66. ENERGY INTENSITY FACTORS FOR PARCELS

Parcel	Unit	Electrical Heating (Btu/DD/Unit)	Oil Heating (Btu/DD/Unit)	Gas Heating (Btu/DD/Unit)	Other Heating (Btu/DD/Unit)	Electrical Cooling (Btu/DD/Unit)	Other Cooling (Btu/DD/Unit)	Electrical Non-Heat/Cool (Btu/Unit)	Non-Specific Energy Use (Btu/Unit)
Single Family Detached	dwelling unit								
Single Family Attached	dwelling unit								
Multi-family Low-Rise	dwelling unit								
Multi-family High-Rise	dwelling unit								
Mobile Homes	dwelling unit								
Retail: Small	ft^2								
Retail: Large	ft^2								
Retail: Regional	ft^2								
Restaurants	seat								
Wholesale	ft^2								
Office Low-Rise	ft^2								
Office High-Rise	ft^2								
Auditoriums and Arenas	seat								
Hotel-Motel High-Rise	room								
Hotel-Motel Low-Rise	room								
Hospital	bed								
School	ft^2								
Public Administration	ft^2								
Religious, Social	ft^2								
Cultural, Museum	ft^2								
Roads	miles								
Parking	space								
Terminals	ft^2								
Service Stations	ft^2								
Preserves	acre								
Parks	acre								
Industry	employee or $ Value Added								
Agriculture	acre								
Transportation	vehicle mile travelled								

- R value of exposed surfaces
- Size of structure

The EIFs are normalized to Annual Degree Days so that the planner only has to look at Figures 30 and 31 to determine for his locale the mean annual total heating/cooling degree days. Exterior surface R values and the size of structure vary between regions of the country. Because of this, a total of eleven (11) tables of the same format as Table 66 will be developed to reflect the different types of structures in the following metropolitan areas:

- Atlanta
- Baltimore
- Boston
- Chicago
- Denver
- Houston
- Los Angeles
- Miami
- Minneapolis
- San Francisco
- St. Louis

These metropolitan areas have been thoroughly studied (12) and data is available detailing thermal characteristics of exterior surfaces and area variations.

For the planner to use the simplified EAP, the following steps should be taken:

- Determine the number of units within a parcel that apply to such fuel specific energy use
- Determine the metropolitan area which most closely approximates the planner's community

Figure 30. Mean Annual Total Heating Degree Days (Base 65 F)

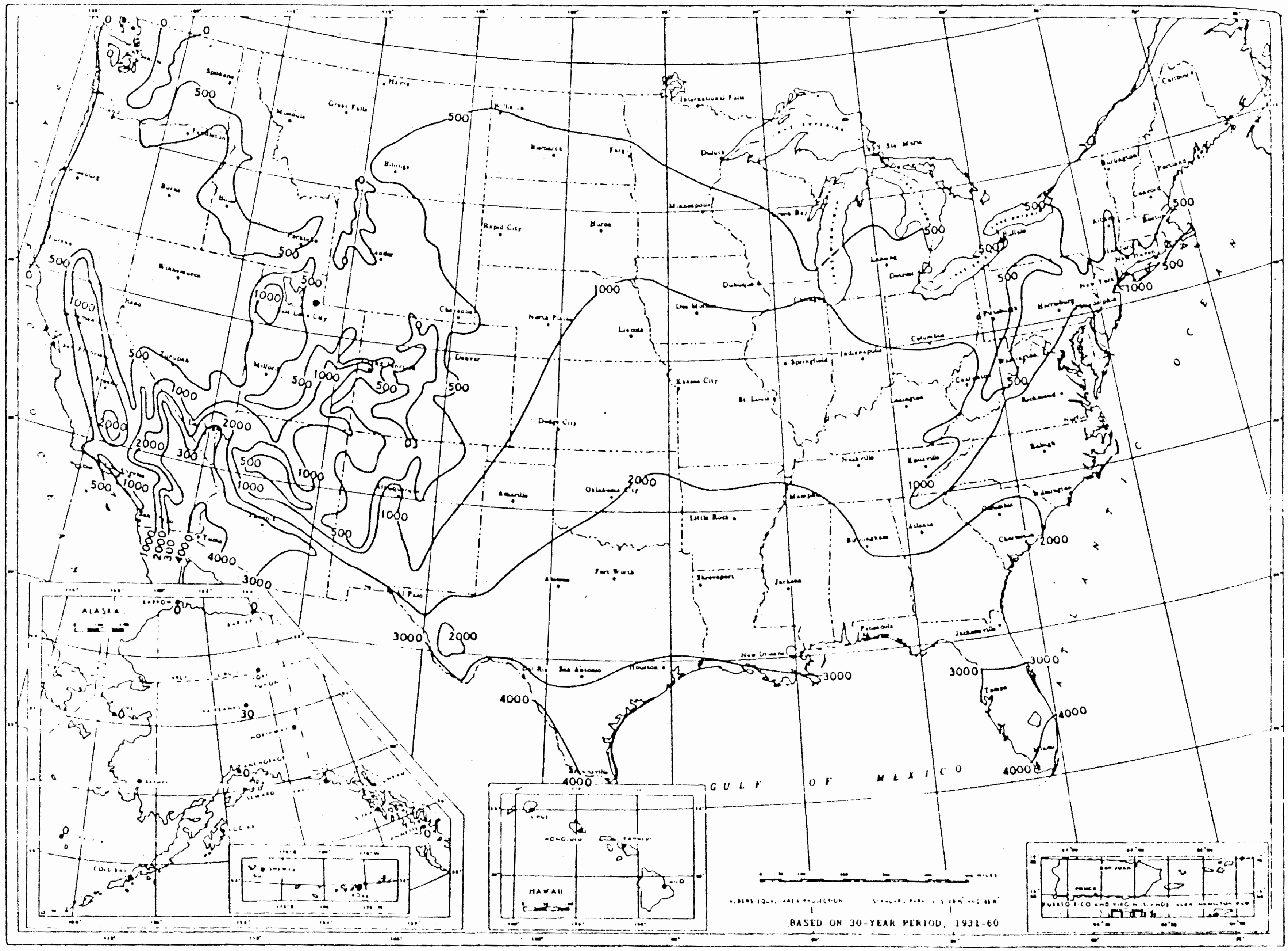


Figure 31. Mean Annual Total Cooling Degree Days (Base 65 F)

- Determine from Figures 30 and 31 the near annual total heating/cooling degree days

The annual energy consumption for all parcels can then be calculated by equation (1).

$$E = (EIF) \times P \times D \quad (1)$$

where E is the total annual energy consumption for all units within a given parcel category.

P is the total number of units within a given parcel category.

EIF is the energy intensity factor.

D is the mean annual tool heating or cooling degree days where applicable.

The energy consumed annually by a community is then the sum of all the E's calculated for every parcel.

Industry energy consumption and the associated EIF determination will closely parallel the BNL/SUNY report's classification scheme (5). This scheme aggregates industry by two digit SICs using a cluster analysis technique into five groupings:

- Light Industry
- Medium Industry
- Mining and Metals
- Paper and Chemicals
- Synthetics

In order for the planner to associate specific local industry with these five groupings a table will be provided which relates the two digit SIC to the five groupings.

Annual transportation energy consumption can be calculated by multiplying the transportation EIF by community level annual vehicle miles traveled (VMT).

(3) Data Requirements. EIFs for parcels in the Residential land use category will be primarily obtained and generated from existing data on residential structures. Additional data may be obtained from the literature cited above.

EIFs for parcels in the Commercial land use category will again be primarily generated from internal data (NECAP and BEAM models). This is possible because building characteristics are essentially the same as residential with the exception of specialized equipment. As was stated above, for the Industrial category, the groupings of BNL/SUNY will be utilized to characterize the parcels. Every city with a population over 50,000 is required to have a transportation plan and therefore would have annual VMT data. VMT data for smaller cities must be determined in the data collection phase.

c. Relationship to Theory Developed for Detailed EAP. The main thread in the fabric of not only the EAP but also the simplified EAP, and the CCP is the Physical Characteristics Table 4 in section II.C.1 which details the planner's domain from the Metropolitan level through the Parcel level. The simplified EAP and the detailed EAP are so similar that the only differences are those of detail of application, not approach. Whereas the EAP demand ratings are applied at the Activity/Equipment level, the simplified EAP energy intensity factors are applied to the parcel level. Where the EAP reflects hourly energy profiles, the simplified EAP reflects yearly energy use. They both are fuel specific, the EAP being more detailed than the simplified EAP. Transportation is an EUM within each parcel in the EAP, however, it is a separate entity in the simplified EAP.

5. Summary

The preceding pages have described the conceptual features of the EAP. Both the EAP and the CCP will be used by the planner within an overall Application Framework. The following section describes the nature and conceptual content of that framework.

E. Application Framework

1. Overview

Energy and land use planning share a number of features which are common to all planning exercises, at all levels. These include such activities as problem definition, goal development, option identification, etc. The methodology developed here includes steps of this nature. Due to their generality, they remain unchanged when one moves from the planner application to the energy analyst application.

In this section, the major portions of the Application Framework specific to energy/land use planning are described. The tasks described here are not unfamiliar to the planner/user (with the possible exception of an energy audit). The procedure discussed for each task is only one method for performing the task, and is presented only for illustrative purposes. It is not intended that this procedure be interpreted as the only method. Because of 'planners' familiarity with goal definition, alternative selection, and ranking, many planners will, and should feel free to, use their own procedures.

2. Community Energy Audit

An energy audit provides a community decision maker with increased sensitivity to and knowledge of energy concerns in the community. It serves two primary purposes; to document and quantify the energy situation in the community, and to familiarize the decision maker with the elements of the community that exhibit existing or potential impact on energy use. The following types of data will be identified in the audit:

- Number of existing units in the various land use classifications (number of single family homes, square feet of commercial area etc.)
- Patterns of existing infra-structure development (roads, sewer and water lines, etc.)
- Community configuration, and physical characteristics (climate, community classification, etc.)
- Fuel specific energy use in the community by land classification (what percentage of the energy needs in single family residences is met by natural gas, electricity, etc.)

This data may be sufficient to document the existing energy situation in the community, however, energy patterns may only be identified by examining future energy use in the community to determine possible problems in energy availability and opportunities for energy management and conservation. For this reason the following types of data must also be included in the energy audit.

- Planned community development by land use classification
- Planned infra-structure development
- Anticipated supply patterns
- Existing legislative and regulatory framework

The community energy audit serves as an introduction to an energy management and conservation program (see Figure 1) It is therefore imperative that the methodology employed encompass all information necessary for analysis on both a quantitative level (derived from the EAP) and a qualitative level (derived from CCM). The proposed procedure for conducting a community energy audit entails collection and analysis of data that will provide the planner with a complete assessment of existing and future energy use in his community.

a. Precedents. Numerous communities have completed some form of baseline energy analysis employing various levels of sophistication. Some of the programs developed have centered upon methods of attaining raw data (actual Btu used annually by sector and fuel type etc.), while others deal extensively with a methodology for analyzing such data. Few studies address both areas with an equal degree of comprehensiveness, therefore these elements are separated in the subsequent discussion.

(1) Methods of Data Collection. Various techniques have been developed to collect community baseline energy data. The most comprehensive and reliable of these involves an actual community survey where each building's energy use is monitored, and traffic volumes are assessed.

This approach was utilized in The Development of a Comprehensive Community Energy Management Plan for the City of Hobbs New Mexico. Extensive surveys were conducted in the residential, industrial and commercial segments of the community. The resulting data was detailed and accurate, but this approach is beyond the resources available for most communities.

In the BNL/SUNY study on Land Use and Energy Utilization (5) a concise methodology is provided for a community to conduct an extensive baseline energy study. Characterization of energy end use by fuel type is provided for a variety of land uses. This study provides much of the necessary framework for an energy management program but it utilizes a sophisticated land use model to identify physical characteristics of the community based on an invariant decision-making framework. This does not provide the flexibility desired for evaluation of non-physical as well as physical parameters/alternatives in a community.

In the development of A State Energy Management Plan for North Carolina, a program is utilized to develop a statewide energy management plan. An extensive analysis of baseline energy supply and demand data for both present and future situations with associated environments, economic and social impacts of the projections is provided.

The conceptual framework of this study is similar to the study in question, however, it is relevant at the state level and not as specific or detailed as is desired for a community level program.

The Portland Energy Conservation Project defines energy use patterns and conservation potentials for the City of Portland. The report relies heavily upon census data to determine energy use patterns and analyzes consumption patterns on an annual basis only. Similarly, other planners could utilize such data sources in their assessment of baseline use patterns in the residential, commercial/industrial, municipal and transportation sectors.

(2) Methods of Conducting Quantified Data Analysis. Numerous methods exist to quantify the energy conservation potential of various alternatives. These involve a variety of numerical formulations that determine the community total energy conservation potential due to some alternative from the number of individual components affected. Some of the methods utilized are described below.

In a study completed for the Massachusetts Department of Community Affairs entitled Energy Management in Municipal Buildings, a procedure is developed for local officials to evaluate the economic value of energy management/conservation measures.

Energy use is established in five Massachusetts buildings to be used as standard structures for evaluation of energy conservation measures. A workbook approach is given for assessing energy conservation potentials. This report is limited in application to the municipal government sector, however this is relevant to one portion of the CCP project.

An excellent conceptual basis for community level energy management and conservation is presented in Development of a Comprehensive Community Energy Management Plan. This methodology comprises the essential steps that must be taken by a community, however, the analysis requires a strong engineering background, and often computer facilities. This type of analysis not available to the small community planner and is thus not applicable to the planning technologies to be developed in this project. However, such sophisticated analysis procedures are relevant for the energy balancing procedure for detailed research.

(3) Qualitative Analysis of Energy Alternatives. Few studies have really attempted to provide a rational framework for analyzing the qualitative or non-physical factors of energy alternatives. Studies that have addressed this type of issue include the following.

In a report prepared for the Regional Planning Commission of Jefferson, Orleans, St. Bernard and St. Tammany Parishes in Louisiana by Urban Transportation Planning Associates, Incorporated, entitled A Proposal for Implementation of An Energy Conservation Management Plan for New Orleans, Louisiana, SMSA. A valid picture is presented of the numerous public and private organizations that must be involved in the establishment of a successful program. This report documents the steps leading up to the development of a management plan and the costs associated with such a plan. They recommend the establishment of an Energy Conservation Management Planning Organization to be comprised of various committees representing energy users (commercial committee, industrial committee, and tourism committee, etc.) and energy suppliers (committee on existing energy sources, committee on potential energy sources). Each of these committees would be comprised of experts in the field who would recommend and assess alternatives for energy conservation and management. The primary strengh of this approach lies in the great public participation and the assurance that regional needs will be addressed. The fundamental weakness exists in the lack of any attempts to quantify alternative actions and assess their energy impacts. This quantification is expected to be accomplished by the experts involved in the various committees is solely dependent on their expertise.

b. Audit Method Chosen. The method of conducting a baseline energy survey is crucial to the remainder of the study. Although all factors addressed in the survey may not be quantifiable, or even necessary, to arrive at an assessment of the existing community, they are essential to the process of goal and alternative selection and final ranking of alternatives. Specific data requirements and the methodology for conducting the audit are detailed in the previous sections describing the energy analysis procedure and the Community Characterization Procedure. The EAP is the primary quantitative tool, and the CCP the primary qualitative tool, that the planner will use in conducting a community energy audit. It is anticipated that both the EAP and the CCP will be simplified to correspond with the technical and analytical resources available to a planner.

The user of the framework will enter the CCP at a variety of levels. The planner may be able to collect community data at the parcel level for residential development, however the commercial development may only be designated on the district level. The CCP will provide a method to translate available levels of data to the parcel level. Once the community has been defined at the parcel level the user may begin the EAP to complete a quantified analysis of community energy use. Specific details of both the EAP and CCP are provided in previous sections.

The audit must also provide a framework for planners to identify the existing community regulatory and governmental framework. The community decision maker will be required to identify the powers and decision makers indicated in Table 67. This information may be gained through study of the local codes and governmental organization charts. It is anticipated that in many instances the planner will be totally familiar with this information, however it must be documented to assist in the latter processes of goal development and alternative selection.

c. Interpretation of Audit and Usefulness for Decision Makers. At the completion of the baseline energy analysis process the user should have a understanding of energy use in his community and the land use class in the community with the greatest energy impact. If the planner were not to take the process any farther he would have begun the fundamental process of recognizing energy consumption patterns in the community and integrating

TABLE 67. DATA COLLECTION SHEET FOR COMMUNITY DECISION MAKING PROCESS

Regulatory Powers

- zoning
- legislation
- building codes
- permits
- traffic regulation
- rail regulations

Review and Approval

- subdivision review
- environmental review
- design review
- special historic/preserve/coastal zone

Fiscal and Economic

- capital improvements program budget
- annual operating budget
- tax structure property
  inter-Government
- tax assessments
- tax rates
- user assessments
- fees
- subsides and grants
- bonding
- bond amortization
- loan guarantees

Eminent Domain

Planning

- master plan
- facility siting and design

Information/Education

- demonstration
- education

TABLE 67. DATA COLLECTION SHEET FOR COMMUNITY DECISION MAKING PROCESS (CONT'D)

COMMUNITY POWER DELEGATION

(Indicate names and phone numbers of community Decision Makers)

Legislative	Executive	Administrative
city, town or city council ________	commissioners ________	Director of Public Works ________
commissioners ________	mayor ________	City/County Administrator ________
aldermen ________	executive ________	Planning/Zoning Director ________
selectmen ________	other ________	

Voluntary Boards - Commissioners

Board of Zoning Appeals ________

Special Conservation Commissions ________

Historic District Commissions ________

Others ________

energy considerations into the planning process. However, in order to complete a comprehensive analysis of the community energy situation the data must be intepreted and refined.

A strength of the community energy audit is that it provides an analytical framework that will guide the planner into the proper channels for goal selection. This is true whether the audit is conducted at the energy analyst level, providing data necessary for complete use of the EAP; or at the planner level, providing data necessary for completion of the simplified EAP. As illustrated in Table 68 a series of analytical questions will be provided at the completion of the energy audit to assist the user in the intepretation of the data collected. The level of detail provided by the energy audit method chosen determines the level of detail needed for an intelligent response to the analytical questions. For this reason it is anticipated that the analytical questions will be directed to the specific user, whether that user is the community planner/decision maker or the energy researcher/analyst.

As may be seen, the energy analysis provides the framework for the subsequent formation of goals and alternatives. For only when a planner knows the existing form of his community will he be capable of formulating the direction that he wants that community to take. The analysis also provides the fundamental procedures that will be used to analyze alternatives for the community and their impact on the total energy scenario of the community. The audit should also serve to identify all the data necessary for analysis, procedures that will be included in the remainder of the study.

3. Goal Development

Goal development comprises the rationale for any planning process. In no instances, however, is the planner afforded the luxury of selecting a goal that is mutually exclusive, impacting no other segments of the community. The process of goal formulation and selection inherently involves the analysis of conflicting community ideals. Each community decision maker is faced with the responsibility of ensuring the optimum quality of life for all the residents of the community. As a result there must be trade-offs made between the goals developed relating to various aspects of community life. A community decision maker may be operating with a wide variety of goals including protecting the ecology of the community, providing an alternate mix of housing

TABLE 68. INTERPRETATION OF ENERGY AUDIT

Research/Analyst Level

Data necessary:

- detailed load factors
- hourly profiles by fuel type

Factors to identify:

- What fraction of energy forms are substituable?
- Is there significant seasonal variation in energy use?
- Is there significant time-of-day variation in energy use?

Community Decision Maker Level

Data necessary:

- yearly energy used by land use classification
- yearly energy used by fuel type
- planned community development
- projected energy supply patterns

Factors to identify:

- Does a specific land-use category use a major percentage of energy in the community?
- Does a specific fuel-type provide a major percentage of the energy needs in the community at large?
- Does a specific fuel-type provide a major percentage of the energy needs in a specific land use category?
- Assuming future growth rate to correspond with planned community development will there be significant increases in energy demand by sector, fuel type or in the community at large in the next year, 5 years, 10 years, 20 years?
- Do projected energy supply figures match projected energy use?

for all residential needs, and assuring adequate energy supplies for the community. These goals may often be diametrically opposed, an example being a community that wants to assure an adequate energy supply and is considering a coal-fired power plant, but also wants to maintain a high environmental quality. Trade-offs of this nature are inherent in the planning process.

Increasingly, the planning community is realizing that thoughtful planning has the potential to effect long term energy use patterns. This realization has highlighted the necessity for community planners to consider energy related goals. Such goals involve a wide range of considerations and may or may not involve an overall reduction in energy use. Recent fuel-specific energy shortages have highlighted the need for a management tool that will enable community decision makers to respond to such a shortage in the manner that is least detrimental to the community at large. The cost of energy producing facilities, and the delays associated with the siting process have highlighted the need to utilize existing facilities to the maximum extent possible, eliminating peak consumption periods that drain the system temporarily and increase the pressure for a new plant. Issues of this nature serve to underscore the types of goals that a planner may wish to address when utilizing this methodology. Any methodology that addresses energy conservation must be able to accomodate both energy conservation goals and energy management goals in a community.

Energy planning decisions have a long term impact upon the future energy situation in a community. Energy goals must be formulated carefully to alleviate or lessen current and anticipated energy problems. They must also be structural so as to incur minimum conflict with other established community goals. Therefore, the most important, but often neglected step in any energy planning is the evaluation and establishment of energy goals.

This section will present a systematic approach to the process of goal selection including:

- Identification of possible goals.
- Evaluation of goals vs. energy problems.
- Preliminary selection of goals.
- Examination of energy goals vs. other community goals.
- Final selection of goals.

a. Identification of Possible Goals. A number of possible energy-related goals were considered in the formulation of the final list of goals. Many were discarded immediately due to the fact that they were outside the realm of the planner's decision making powers. An example of this would be goals that apply directly to the development of an innovative technology. This would include such projects as developing a more efficient solar collector or increasing automobile fuel economy. While these comprise valid energy-related goals they are too far beyond the scope of the planner to be included in this study. The goals developed for possible consideration are broad, generic categories that relate to energy management and conservation. They encompass areas to be addressed by either the energy analyst or the community decision maker and include:

(1) Reduce overall community energy use

(2) Change timing of consumer demand (reduce peak loads)

(3) Substitute energy types in the community

(4) Improve load factors

(5) Lower unit cost of energy

The listing of goals has several advantages. First, they are concise and expressed in terms which any planner will be familiar with, and will have considered in the development of the baseline energy consumption analysis. Second, they provide an excellent criteria for a preliminary limiting and selection of related alternatives. The final listing of goals encompasses all aspects of community energy management and conservation that a community decision-maker may wish to consider.

b. Evaluation Of Goals Versus Energy Problems. The goals chosen for incorporation in the analytical framework directly relate to specific energy problems. Each goal corresponds to an energy problem that was detailed in the community energy audit. Table 69 indicates the types of relationships that may be documented between energy goals and problems. The problems are considerations that were addressed in the intepretation of the community energy audit and will comprise the framework for preliminary selection of community energy goals.

TABLE 69. RELATIONSHIP BETWEEN GOALS AND ENERGY PROBLEMS

Goal	Energy Problem
Reduce overall community energy consumption	Projected energy supply does not meet projected community demand
Change timing of consumer demand (reduce peak loads)	Excessive hourly demand for energy.
Substitute energy types in the community	Projected energy supply of a specified fuel type does not meet projected community demand
Improve load factors	Excessive seasonal demands for energy
Lower unit cost of electricity	Consumer complaints

c. Preliminary Energy Goal Selection. The preliminary selection and evaluation of goals is entirely a community specific process. Through the completion of the baseline energy evaluation, communities will have gained a sensitivity to the overall energy needs and concerns in their community. These needs and concerns form the basis of the goal selection process and are specified by the planner at the completion of the energy audit. The series of generic questions that the community decision-maker answers concerning energy in the community provide the framework by which the community situation may be translated into preliminary goals. As an example, a northern midwestern community that has documented through the baseline energy evaluation the fact that 80 percent of their heating requirements are met by natural gas would immediately recognize the need for shift in fuel type and select the goal of shifting fuel types. A community that has experienced many summer "brown-outs" during the periods of highest energy use may consider the goal of load management. A community that has no desire to expand their current supply facilities (due to an over riding environmental or economic concern) may choose a goal of energy conservation. It must be noted that the goal of energy conservation does not necessarily mean that total energy use will decrease over time, but only that the incremental change will be less than with no conserving alternatives employed.

d. Identification and Resolution of Conflicts Between Energy-Related Goals and Other Community Goals. A community decision-maker must acknowledge the fact that even the most well defined energy goals may conflict with other community goals. Therefore conflicts must be identified, and if possible a resolution of the conflicts must be established. Table 70 provides a method for a planner to rank the impact of, and correlation between, energy related and non-energy related community goals. The community decision-maker will identify the community goals and assess the impact that proposed energy-related goals will have. A strong positive impact would mean that the energy goals are compatible with existing community goals. A negative impact indicates that conflicts do exist.

In order to resolve the possible conflicts the community decision-maker may choose one of several courses of action including:

- Modification of one or both goals
- Deletion of one goal
- Assigning higher priority to one goal

TABLE 70. IMPACT OF ENERGY RELATED GOALS ON OTHER COMMUNITY GOALS

Other Community Goals \ Energy Goals	Reduce overall community energy consumption	Change timing of consumer demand	Substitute energy types in the community	Improve load factors	Lower unit cost of electricity
Improve community economic base					
Maintain ecological balance					
Improve environ-mental quality					
Provide mix of residence-types					
Provide social mobility					
Provide increased recreationa/ educational opp.					

Negative Impact

- weak
= moderate
≡ strong

Positive Impact

+ weak
++ moderate
+++strong

If it is possible to resolve the conflict, or if no conflict exists it may be asserted that the energy-related goals are compatible with community goals and merit furhter consideration.

At this point the planner may establish his final listing of goals. This listing will reflect both the energy problems identified through generic questions in the energy audit, and the goals compatibility with other community goals.

4. Identification and Preliminary Selection of Action Alternatives

Once a community decision maker has identified the goal(s) that correspond to the anticipated energy concerns in the community, a variety of alternatives may be employed to accomplish the goal(s). A limiting process is necessary at the onset of alternative selection, to eliminate those alternatives that would have the least impact on a specified community. This process is nonquantifiable in nature, and serves to channel the decision makers selections into those alternatives that are best suited to his goals and community situation. Each alternative will be evaluated based upon three limiting factors, goal selected, land use category affected, and level of implementation. This preliminary selection process is necessary due to the limited supply of resources (manpower and dollars) available to a community decision maker to conduct an energy management and conservation program. Any alternative chosen for detailed analysis will require a certain expenditure of such resources, thus, it is useful for the user to go through a preliminary selection of alternatives prior to using either the CCP or EAP for more detailed evaluation.

a. Precedents. There are a number of categories that have been used to accomplish a primary limitation of alternatives. One possibility would be to select those energy using activities which the community decision maker feels would have the maximum energy management and conservation potential in his community. Once the specific mode is chosen (space heating, private transportation, etc.) only the alternatives that affect such a mode will be considered. This method could be advantageous if the goal of the planner was to shift fuel types in the community, and had established the fact that a specific activity used a large percentage of a specific fuel in the community. However, the other goals would not be addressed at all in this method, and so it has been rejected for this study.

Another method of selecting alternatives would involve a general land use classification (single-family detached, etc.) and an analysis of only those classifications which the decision maker has identified as having a significant impact upon the energy use patterns within the community. This method has considerable merit, and yet ignores the aspects of implementability that could immediately negate the affects of any alternative considered. This approach was utilized in the Brookhaven Study (5), in which the lower land use model was utilized to establish the community characterization.

In some cases, alternatives have been addressed solely on their level of implementability. An alternative could fall under any one of the powers of the local government (taxation, zoning, etc.). Again, while this is one aspect of the selection process, if this was used exclusively it would ignore the other considerations that are necessary in a preliminary selection of alternatives.

b. <u>Major Types of Alternatives Provided in the Methodology</u>. The methodology developed will be capable of analysing a wide variety of alternatives that exist for energy management and conservation. A preliminary listing of alternatives relating to various land use classifications follows. While the alternatives may appear in more than one classification this is necessary due to the fact that it is anticipated that the user will base his alternative selection on one or more land use classfication in the community.

- <u>Residential Land Uses</u>

  -lower air infiltration rates in space heating
  -heat pump
  -envelope zoning
  -landscaping and shading
  -setback requirement
  -building code revision
  -prohibit use of outdoor gas lights
  -outlaw heated pools
  -encourage "solar clothes" drying
  -reduce indoor temperature
  -price controls on fuels
  -daylight savings time
  -zoning for multifamily units
  -large roof areas (for solar)
  -develop new multifamily housing units adjacent to places of existing employment and services

- improve proximity of housing at related income levels to employment
- redevelop older housing units
- introduce alternative transport modes
- develop multiuse facilities
- total energy systems
- selective energy systems
- local solar energy
- local wind and water power
- energy conservation zones
- energy use disclosure at time of sale or lease
- standards for improved appliance efficiency
- solar water heating
- tax credits/penalties
- insulation improvement
- individual electrical meter of multifamily housing
- optimize lighting energy use
- improved central air conditioners
- heat pipes
- heat wheels
- electro-chemical sources
- automated temperature control
- increased metering and automation
- double glazing
- improve physiological thermodynamics (keep doors tight and well insulated)
- no sliding glass doors
- attic eave and ridge vents
- radio-controlled electric water heat load management system
- time of use metering
- gasoline rationing
- area transportation restrictions
- one day a week driving ban
- mandatory carpooling
- gas tax
- vehicle tax
- carpool program
- vanpool program
- subsidized transit
- improve transit service
- improve transit security
- expand transit fleet
- weatherstripping
- caulking
- publish pamphlets
- publish posters
- sponsor oratorical contests
- sponsor essay contests
- sponsor seminars
- sponsor workshops
- turn off lights

- Commercial Land Uses

-curtail office hours
-daylight savings
-change operating hours
-halt escalators and elevators
-eliminate unnecessary lighting
-discontinue use of electrical office equipment
-eliminate decorative and advertising lighting
-decrease ventilation air
-revitalize existing town centers
-encourage multiuse facilities
-total energy systems
-energy use disclosure at time of sale or lease
-standards for improved appliance/equipment efficiency
-solar water heating
-tax credits and penalties
-individual metering
-optimize lighting energy use
-improve central air conditioning
-heat pipes
-heat wheels
-automated temperature control
-double glazed windows
-telecommunications
-public information programs

- Institutional Land Uses

-decrease ventilation air
-revitalize existing recreation facilities
-create new, local recreation facilities
-total energy systems
-public information programs
-change operating hours
-halt escalators and elevators
-eliminate unnecessary lighting
-eliminate decorative and advertising lighting
-revitalize existing town centers
-encourage multiuse facilities
-standards for improved appliance/equipment efficiency
-solar water heating
-optimize lighting energy use
-improve central air conditioning
-heat pipes
-heat wheels
-automated temperature controls

- Transportation and Circulation Land Uses

  -reduce street width
  -improve street surfacing
  -utility rate structure revisions
  -reduce quantity of urban streets
  -district heating and cooling plants
  -integrated utility systems
  -solid waste heat recovery
  -use of solid waste to generate steam
  -steam distribution system improvement
  -preferential traffic control
  -right turn on red
  -syncronization of traffic lights
  -preferential parking
  -parking supply increase or decreases
  -parking tax
  -parking bans
  -congestion tolls
  -park and ride facilities
  -consolidate routes and terminals
  -construct new highway facilities
  -construct new transit facilities
  -construct new parking facilities
  -public information programs

- Special Land Uses

  -increase motor loads
  -reduce friction in motors
  -industrial lighting
  -processing heating
  -internal climate
  -resistance welders
  -weatherstripping
  -caulking
  -intensify industrial uses in prescribed areas
  -encourage multiuse facilities
  -tax credits and penalties
  -energy cascading
  -heat pipes
  -heat wheels
  -public information programs

c. Preliminary Selection Criteria. At each step in the alternative identification process, there is an inherent selection process. In order to enter the process, the planner must have selected the goal(s). This goal selection immediately creates a package of alternatives that may be selected to apply to the community.

By further delineating the goals by land use classification, the planner is again limiting the applicable alternatives. The knowledge of which classification to choose would be based upon the baseline energy data collection phase of the application framework. In this phase the planner would have developed a picture of the land use classification(s) that have the greatest potential for the achievement of the goals. For example, a community that wanted to shift the type of fuel used in the community from a specific scarce fuel type to a more available resource may have discovered that the commercial classification of the community used 90 percent of that scarce fuel. In order to optimize the effectiveness of the alternatives the planner would deal specifically with alternatives relating to this sector. Again, the planner could select a "package" of alternatives from the overall set of alternatives that apply to the community. Each alternative will be listed on a page designated for the specific goal it fulfills and the applicable land use category. The user will then be able to select only the pages relating to the specific goal and land use category he wishes to analyze without considering extraneous material.

A further delineation of alternatives involves the method of implementation. An alternative may either be mandated (through legislation, building code revision, etc.), encouraged (through tax incentives, preferential treatment, etc.), or the government may sponsor educational programs to acquaint the public with the energy management and conservation opportunities associated with a given alternative. (A sample data sheet is provided in Table 71). While all alternatives may not be implementable at each of these levels, they comprise a valid delineation for preliminary selection of alternatives. A community decision maker will be familiar with the basic constraints imposed upon the community and will be able to assess the possible success of an alternative that must be mandated, encouraged, or requires public education.

It must be stressed that while the municipal area is not specifically delineated in this classification it is comprised of elements in each land use classification. Municipal facilities and services often offer the maximum potential for energy conservation by virtue of the fact that they are under direct government control. While any alternative affecting municipally controlled land uses must be analysed for a wide variety of social and economic acceptability factors, the government may conduct internal housekeeping in a relatively unconstrained manner. For this

TABLE 71. SAMPLE DATA SHEET FOR PRELIMINARY ALTERNATIVE SELECTION

Goal ____________________
Land Use Classification ____________________

Level of Implementation / Alternatives	Mandate	Encourage	Educate

reason, preliminary programs may be comprised solely of alternatives relating to governmental facilities and operations. Advantages of this approach include:

- The governmental sector has high visibility and extensive publicity may be generated to underscore the potential importance of alternatives.
- The governmental sector is comprised of activities affecting all land use classifications and is thus an excellent area to test the validity of alternatives.
- The governmental sector may stress the cost/benefit attributes of a given alternative by incorporating such factors in their operating and capital budget.

It is highly recommended that alternatives selected be applied to the governmental sector of the community to underscore their importance and validity.

At the completion of this phase the planner will have a finite listing of alternatives to subject to a more rigorous quantitative analysis. Those alternatives will be consistent with the planners goals, the existing community situation, and the decision-making framework of the community.

5. <u>Evaluation</u>

In evaluating the options identified and selected, the CCP and EAP will be used.

When applying the methodology at the planner level, the simplified CCP approaches will be used to generate parcel level physical impacts, and then the simplified EAP will be used, with its energy intensity factors, to assess the energy impacts.

When applying the methodology at the analysts level, the detailed CCP will be used to generate parcel level impacts. After that, the detailed EPA will be used, with its profile generating functions, to analyze energy supplies and demands on an hourly basis.

Both detailed and simplified versions of the CCP and EAP have been described previously in this report.

6. Implementability Assessment

The quantitative assessment of energy alternatives is only one aspect of the ultimate ranking and final selection of goals. No matter how "good" an alternative may be in terms of compliance with desired goals its ultimate value is highly dependent upon ease of implementation. A variety of governmental predispositions and powers exist that affect the implementability of given alternative. Given a specified budget, a specified supply of manpower, and specified governmental powers, alternatives must be assessed in terms of their implementability in a given community as well as their energy savings potential. A methodology will be provided here to assess the implementability based upon these three constraints. This process will allow the planner to make a selection of action alternatives based on both energy impacts and implementability considerations.

a. Precedents. A variety of methods have been developed to rank the barriers associated with implementation of a given policy. Few of these studies, however, deal with a workbook type approach whereby the user actually assesses the implementability in his own community. This is due to the fact that most barrier studies have dealt with a limited number of policies on a national basis and hence actually rank the variables associated by a specific policy. The method to be developed here will allow a given community to access their own situation and assign appropriate weights to the associated barriers. This is necessary due to the lack of uniformity in communities and their differing decision making processes.

Although studies have not been completed with direct applicability to this topic existing studies do highlight the types of considerations that must be addressed in any assessment of implementation. The types of considerations to be made include community decisional framework, existing legislative/ regulatory powers, the community resource availability. All of these factors are totally community-specific and must be presented in a manner applicable to each case.

b. Community Decision Making Factors Considered. One aspect of the community baseline energy survey involved an identification of the existing decision-making framework in the community. This includes the identification of existing regulatory powers including zoning, taxation, etc.; and the existing organizational framework to determine methods of implementation available to the community. This will provide the planner with an adequate overview of the existing community decision-making structure to assess the community decision-making process. A complete copy of a sample data sheet for this element was presented in Table 67.

c. Method Selected. Due to the extreme variances among communities, the method utilized will require each community to assess their own situation. General considerations to be addressed in the ranking include existing governmental framework, financial resources available, and time and manpower required to implement the desired alternative. The community decision-maker will rank the communities resources in each category to arrive at a final measure of implementability, as detailed in Table 72.

(1) Existing Governmental Framework. The data sheet included in the community energy audit identifies for the decision-maker the existing governmental powers in the community. Each alternative will involve the exercise of one of these powers, be it a tax incentive/penalty, zoning change, or any other method of implementation. If an alternative is proposed for which no governmental power exists to implement it, then the alternative is immediately disgarded. The exception to this is an alternative designed to change the governmental structure, in which case this factor is ignored. The user will assign a value to this category in the following manner. If the governmental power exists in the community to implement the alternative a score of 1 is assigned. If the power does not exist a score of 0 is assigned, and the user may proceed to evaluate the subsequent alternatives.

(2) Financial Resources Available. The community decision-maker must assess the cost to the government of implementing a given alternatives and determine if funds are available to assure implementation. The alternative's financial demands and the available community budget will be scored on a scale of zero (0) to three (3). A score of zero reflects a situation where the cost of implementation is far outside of the financial resources available In this situation the user may assume that the alternative is unimplementable and begin an assessment of other alternatives. A score of three indicates that the financial committment is well within the community's budget and the alternative should be considered more fully. Other scoring values (one and two) indicate situations that are within the range of possibilities, but may require substantial resource committment.

TABLE 72. IMPLEMENTABILITY ASSESSMENT

Implementability Scores / Alternatives	Existing Governmental Framework Provides the Power To Implement-* Yes=1 No=0	Implementation Cost Score 0 - outside of community committment possibility 3 - Well within community committment possibility	Implementation Manpower Score 0 - outside the community committment possibility 3 - well within community committment possibility
1			
2			
3			
4			

*This factor must be ignored if the alternative involves the creation of new

(3) Manpower Resources Available. The final factor affecting implementability is whether existing manpower is available to implement a given alternative. The level of effort required to implement a given alternative would include the following considerations:

- Duration of the alternative (will manpower be required over an extended period of time or only during initiation?)

- Complexity of the alternative (Are massive amounts of technical inputs required or can persons provide the labor?)

- Target land use category (How many units will be affected and must be addressed?)

- Inter-relationships with other governmental agencies (Can the manpower be shifted, or will a liason person be required?)

These types of factors will determine the manpower requirements of an alternative which will be compared with existing manpower resources. Again, a scale of zero to three will be employed for each user to assess the manpower available. A score of 0 indicates that in no instance will the required manpower be available, a score of 3 that the manpower requirements are well within the community capability.

(4) Final Implementability Assessment. Each variable affecting implementability will be considered to arrive at a final implementability factor. A simple multiplication will be completed to determine the implementation factor as follows:

Governmental Power Score		Implementation Cost Score		Implementation Manpower Score		Implementation Factor
	x		x		=	

The final implementation factor encompasses range of zero to nine, with nine indicating that the alternatives is highly implementable and zero indicating that the alternative is unimplementable. The user may then rank the alternatives under consideration based upon the implementation factor.

7. Ranking and Selection Method

The final ranking and selection of alternatives will be based, to a large extent, upon the planner's individual committment to the energy related goals. It is will allow a planner who wants only to see some results of the program without actually meeting the goals to implements those programs that have the least barriers to implementation and deemphasize energy impacts. Conversely a planner who is willing to implement any alternative with significant impact on the goal no matter what the difficulty to implement may be can emphasize the energy impacts. But the planner who wants to implement a program that will provide the most effective and efficient action possible, that will use a minimum of manpower and dollar resources and still answer the requirements of the goal will be allowed to assess all factors.

This tool encompasses all of the information developed in the framework. Portions of the baseline energy survey, community characterization methodology, the energy analysis procedure and the implementability factor will be combined to form a final ranking of the optimum alternatives, and final policy package for a given community.

a. Precedents. Methodologies have been developed to evaluate the relative energy savings of various alternatives. These methodologies have, however, inevitably ignored the related factors that determine how many units will actually be affected by a given conservation option, and what types of social and political considerations will impact the effectiveness of alternatives. This firal ranking and evaluation process encompasses barriers studies, policy studies and energy use studies to formulate one concise tool to measure the effectiveness of energy management and conservation alternatives.

b. Method Selected. The method of final selection and analysis of alternatives must be complex enough to present a valid picture of the actual worth of an alternative to a community. It must also be simple enough to require a minimum amount of calculations and time from a planner. While portions of both of these goals must be sacrified in arriving at a methodology it is felt that the proposed method will best serve the needs of the planner. No new data is required in this process. When data is called forward from other portions of the framework specific table references will be given.

A planner's level of committment to energy management and conservation goals will determine the final ranking of alternative. A weighting factor is provided to ensure that the final ranking reflects this committment. The procedure presented here involves the planner making a selection among alternative based upon their energy impacts, as calculated in the evaluation step, and their implementability factors, as developed in the preceding section. These two factors, implementability and energy impact, are used in a weighted ranking scheme, where the users subjective priority on implementability versus energy impacts is used to provide the weighting. The procedure is executed by using Table 73 as a work sheet. Prior to using this procedure, the user must have the following information at his disposal.

- A listing of the alternatives being considered;
- A list of the alternatives ranked on the basis of their energy savings;
- A list of the alternatives, ranked on the basis of their implementation probability; and
- A subjective opinion of his relative priority between energy impacts and implementability.

The procedure is used in the following manner:

- First, enter the alternatives names in the first column of Table 73;
- Second, enter the energy impact rank in the second column of Table 73 (1=most favorable impact);
- Third, decide the level of priority associated with energy impacts, and enter this value at the head of the third column (1=high priority, 2=moderate priority, 3=low priority);
- Fourth, multiply the values in column 2 by the priority level (weight) assigned to energy impacts, and enter the weighted energy impact scores thus developed in the appropriate positions in column 3;

TABLE 73. WORKSHEET FOR WEIGHTED RANKING AND FINAL SELECTION OF ALTERNATIVES

1. Alternative	2. Energy Impact Rank	3. Weighted Energy Impact Score Priority =	4. Implementability Rank	5. Weighted Implementability Score Priority =	Final Score (3+5)

- Fifth, enter the implementability rankings in column 4;
- Sixth, enter the priority placed on implementability at the head of column 5 (again 1=high priority, 2=moderate, 3=low);
- Seventh, calculate the weighted rank for each alternative and enter it in the appropriate position in column 5;
- Eighth, add the weighted energy impact rank (column 3) to the weighted implementability rank (column 5) and enter the sum of these in column 6;
- Ninth, select the alternatives with the lowest scores in column 6.

The final product of this phase will be an ordering of alternatives that reflects their energy impacts and their likelihood of success. From this ranking a planner will be able to select the highest ranked alternatives tht best address his goal for actual implementation in his community.

8. Summary of Framework

When the framework is followed in totality the community decision maker will have a complete picture of existing and future energy supply and demand factors in his community, alternate methods of achieving his specific energy-related goal, and a feeling for the magnitude of the energy factors involved in the community.

A primary strength of the methodology is that a user may apply it for any level of data that he wishes. The (impact of one specific subdivision) may be analyzed or the entire community may be studied to determine the complex relationships of the various sectors. The tool provides universal application to an area that will soon take a position in the planning process equivalent to the economic and environmental considerations of today.

a. How the Framework Will be Used. A planner will enter the framework under one of two conditions. The planner will have either a genuine commitment to study energy conservation and management in the community, or will be confronted with a specific problem in the community (such as a fuel-specific energy shortage) that needs to be dealt with. No matter what the planners rationale for using the framework, the methodology will remain the same.

First, a baseline energy survey will be conducted to familiarize the planner with all the parameters affecting energy and energy policy decisions in his community. Next, goals will be formulated based upon the patterns uncovered in the survey. From these goals a series of specific alternatives will be developed to achieve the desired results. These alternatives will be subjected to a quantative and qualitative evaluation to determine their ultimate energy impact potential. A final ranking and selection will take place and the planner will have begun the actual implementation of an energy management and conservation program.

b. Anticipated Format. It is anticipated that the framework will be presented in a two volume, workbook format. The first volume will contain the conceptual background material and a complete explanation of the methodology. This volume will be as clear and concise as possible providing a step by step approach to the framework.

The second volume is anticipated to be a looseleaf format. Tabbed sections will separate data needed by goal, sector and region. In this way the planner can assemble only that data which will be needed to complete the analysis and will not be hampered by extraneous materials. Also the looseleaf format will allow a specific page to be removed for easy reference or to take along for data collection purposes. While the second volume will be rather massive this format will allow the planner to arrange a pachet of community-specific material that will be available for future analysis and information.

c. Useability Parameters. The framework has been carefully designed to conform with the planners realm. Definitions in data are consistently made in terms that the planner is most familiar with. Calculations are kept as simple as possible to allow any lay person to utilize the framework. Data sources will be identified for all information needed and they are sources which the planner is used to working with and has a clear understanding of.

A minimum of manpower is required to employ the framework and in the event that the planner simply has no staff to complete the analysis a variety of lay personnel may be called in to complete the study. For a small community this approach may actually be the optimum approach as it would involve citizens in the process and foster increased community interest in the program. Groups that could be contacted to assist would include various civic groups (Joycees, League of Women Voters, Kiwanis, etc.), senior citizen groups, high school and college groups, or a community task force could be developed comprised of representatives of all of these types of groups. This approach has considerable merit as it would immediately take the goals and considerations into the community and increase the likelihood of implementation of alternatives and the overall success of the program.

d. Unresolved Conceptual Issues. Several areas of consideration in the development of a comprehensive framework for energy management and conservation are unresolved at this junction in the preparation of the framework. The primary concern is that these areas do not impact energy management or conservation in a community to a great degree, and the inclusion of these factors in the framework could serve to complicate the process without adding significant information. However these considerations could be included in the proposed methodology with minor modifications.

The areas that are not fully analyzed in the framework include broad socio/economic and geographic factors. These areas are extremely difficult to categorize or quantify and will be observed throughout the actual development of the framework to assess the importance of their inclusion.

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