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Community Energy Audit Guidelines



Canada

Canada Mortgage and Housing Corporation, the Federal Government's housing agency, is responsible for administering the National Housing Act.

This legislation is designed to aid in the improvement of housing and living conditions in Canada. As a result, the Corporation has interests in all aspects of housing and urban growth and development.

Under Part V of this Act, the Government of Canada provides funds to CMHC to conduct research into the social, economic and technical aspects of housing and related fields, and to undertake the publishing and distribution of the results of this research. CMHC therefore has a statutory responsibility to make widely available, information which may be useful in the improvement of housing and living conditions.

This publication is one of the many items of information published by CMHC with the assistance of federal funds.

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COMMUNITY ENERGY AUDIT GUIDELINES

by

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Canada Mortgage
and Housing Corporation

Société canadienne
d'hypothèques et de logement

Honourable Roméo LeBlanc
Minister

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PREFACE

Canada Mortgage and Housing Corporation is concerned to promote the efficient use of energy in housing and its related use in the community. In order to encourage more efficient energy utilization, the Corporation has sponsored a number of research initiatives into the modification of residential construction, the operation of residential heating systems, the development of district heating systems, and the conservation of energy by its inclusion in land use planning strategies. This publication presents the results of a research project concerned with the use of energy at the community level.

Community Energy Audit Guidelines is intended to be an introduction to the process and methods of community energy auditing. It describes the role of the audit, outlines the working principles, describes the major published audit methods, and suggests sources for the data required to carry out an audit. An annotated bibliography is included for those who wish to follow up references made in the text and for those searching for more detailed and specific information.

This publication should be of primary interest to those who are, or could be, involved in the initiation of a community energy audit; an audience which includes municipal officials, community organizations, utilities, provincial and federal officials, and consultants.

Community energy auditing is a relatively new field and the Corporation hopes that this document will serve as an introduction to the techniques of auditing. The terminology in this field is not yet standardized, so this publication has carefully defined its terms, but it is important to realize that they are not in universal use.

The manuscript was prepared by Middleton Associates for the Technical Research Division of the Corporation. A draft was reviewed by a number of municipal officials and consultants from across the country and the Corporation is grateful for their helpful contributions to refining the text.

INTRODUCTION

A community energy audit is an informative and quantitative description of energy supplies and demands within a community. Its general purpose is to serve as a tool in the development, implementation, and monitoring of municipal energy management programs.

The first step in the energy auditing process is to determine what output data are required. Because excessive effort applied to an audit can divert resources and attention away from actual energy saving measures, it is important to be selective when identifying data requirements. Generally, simple audits (energy profiles) will be most appropriate in the current Canadian context. These profiles identify energy consumption by sector of the community and by energy source, but do not normally emphasize subsector, end use, or neighbourhood-level data.

The second step is the selection of an audit method. Two basic approaches are available: the top-down audit and the bottom-up audit. The top-down audit disaggregates energy data relating to the whole community into their component parts. The bottom-up audit aggregates energy data from each component of the community into data for the whole. Utilizing these two approaches, a number of specific methods

have been developed and published; the best documented of these methods are outlined in this publication. It is generally appropriate for a community to utilize selected portions of the various published techniques, rather than to adopt one or another outright.

The third step in a community energy audit is the actual collection of input data. The types of data required are determined by the audit method to be used. For the sake of economy, secondary data collection from sources such as government agencies, energy suppliers, and municipal records is preferable to primary data collection from individual users of energy. Unfortunately, although the range of potential data sources is large, even the collection of secondary input data is often a significant problem.

The final step in the auditing process is the actual calculation of community energy consumption and flows, using the agreed-upon method and the available input data.

In Canada, relatively few communities have, to date, actually undertaken energy audits. Nevertheless, there is some Canadian audit experience and this can be expected to grow significantly in the future.

CHAPTER 1

THE COMMUNITY ENERGY AUDIT

What is a Community Energy Audit?

A community energy audit is an informative and quantitative description of energy supplies and demands within a community. It is a statistical overview of local energy flows, addressing such issues as:

- how much energy is consumed?
- where in the community is it consumed?
- who consumes it?
- what is it used for?
- which energy sources are relied upon?

The community energy audit documents community-wide energy use patterns. The audit does not, by this definition, attempt to predict or project future energy demands or supplies. It looks at "what is", rather than at "what could be".

There are four basic reasons for doing a community energy audit:

1. To stimulate action on energy problems by informing the general public, including municipal officials, about the community's use of energy;
2. To provide data that can be used to identify priority areas for energy-related programs (including conservation action);
3. To provide data that can help estimate the savings in energy and cost of proposed programs; and
4. To provide data that can help monitor and evaluate implemented programs.

A community energy audit can be a valuable **tool** in the development, implementation, and monitoring of programs for municipal energy management. It is a means to an end, **not** an end in itself. Its importance is derived from the importance of the process it supports: municipal energy management.

What is Municipal Energy Management?

There are definite opportunities for major savings of energy (and for the use of renewable energy resources) in all Canadian municipalities. The term "municipal energy management" refers to the process of developing and implementing, at the municipal level, programs and actions that take advantage of these opportunities. This effort is not confined to municipal operations; it involves community-wide programs that foster the efficient use of energy resources. These programs could, for instance:

- a) Introduce bylaws for energy conservation zoning and solar access, and regulations for energy-conscious site development;
- b) Introduce energy as a major factor in the planning process;

- c) Relate to ongoing programs, such as the federal Residential Rehabilitation Assistance Program, in ways that maximize the benefits of conservation;
- d) Encourage innovation concerning energy use in building design;
- e) Identify and provide assistance to groups in the community most vulnerable to increases in energy costs, such as fixed-income households;
- f) Promote public awareness of issues surrounding energy and provide comprehensive services to assist the public's efforts in conservation; and
- g) Promote and demonstrate the use of renewable energy resources and remove barriers to their use.

Why and How Should Municipalities Get Involved?

There are several compelling reasons for municipalities to undertake such municipal energy management programs:

- 1. Municipal areas of jurisdiction, such as land use, local transportation systems, and industrial development, provide many opportunities for energy programs;
- 2. Of all levels of government, municipalities are closest to the people they serve, which, in principle, facilitates effective delivery of programs;

- 3. Conservation programs can enhance the local economy by keeping energy dollars in the community (dollars that would otherwise be "exported" to purchase energy);
- 4. Conservation programs reduce local vulnerability to supply disruptions; and
- 5. Municipal energy management programs benefit the residents of a community by aiding and encouraging their personal conservation efforts.

As a result, a growing number of municipalities are becoming involved in municipal energy management, and, for them, there are numerous possible approaches. For instance, the process of program development could be based primarily upon public involvement, committees of experts, the work of municipal staff, or combinations of the three. In each case, however, the basic **stages** of the process will be similar (Figure 1).

What is the Role of the Audit?

The community energy audit acts as a tool in this process of municipal energy management. The data produced by the audit influence, and are influenced by:

- the identification of program options
- the selection of the preferred programs
- program implementation, and
- program evaluation.

The reason for this multi-faceted role is straightforward — intelligent decision-making on energy must rely upon an understanding of a

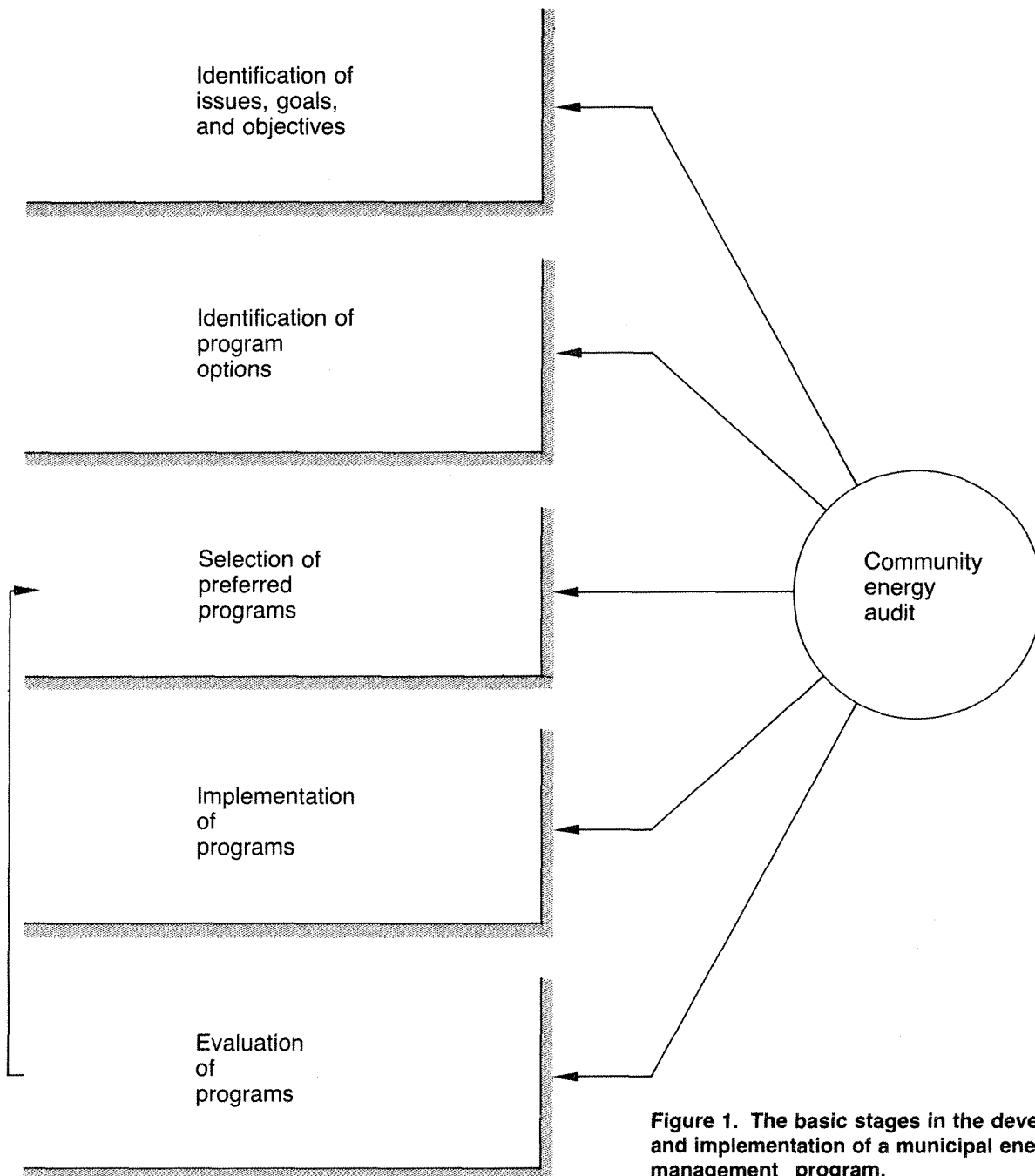


Figure 1. The basic stages in the development and implementation of a municipal energy management program.

community's energy supplies and demands. Otherwise, the management program cannot be assured that it is addressing the highest priority problems, taking full advantage of available opportunities, and taking full account of such criteria as community needs, cost-effectiveness, and social impact.

A lack of data on community energy consumption is **one** of the major barriers to effective programs for municipal energy management. Furthermore, without credible data, it is difficult to make a persuasive case for the adoption of contentious, but legitimate, energy programs. The audit is an effective way to overcome these barriers.

While the audit is an important tool in the process of municipal energy management, alone, however, it is insufficient. An audit without associated action is of limited value.

Who Should Do an Audit?

Communities of any type can be audited: small or large, urban or rural, rapidly growing or stable. The level of effort applied to the audit and the complexity of the resulting data will, of course, vary from community to community. Nevertheless, energy opportunities exist everywhere, and a community energy audit can contribute to the exploitation of these varied opportunities.

Audits can be initiated, and/or undertaken, by a wide range of organizations including municipal staff, community organizations, consulting firms, and university students. Regardless of what institutions are actually involved, the individuals

doing the work will require some basic analytical and mathematical skills. However, since the various published methods (see Chapter 3) provide reasonably detailed "how-to" instructions, the **auditors do not necessarily require highly specialized experience with, or knowledge of, all aspects of the energy field.** All that is required is a willingness to apply the necessary level of effort, as outlined here.

What is Involved in a Community Energy Audit?

The process of community energy auditing involves the collection and analysis of selected input data so as to produce data on community energy flows. The process involves four major steps:

- Step 1: Decide what output data are required (see Chapter 2);
- Step 2: Decide what method to use in order to generate this required output (see Chapter 3);
- Step 3: Collect the necessary input data (see Chapter 4); and
- Step 4: Use this input and the selected method to calculate the desired output data on community energy flows (see Chapter 3).

These steps are closely interrelated. However, for the sake of clarity, they are discussed separately in this booklet.

CHAPTER 2

WHAT OUTPUT DATA IS REQUIRED?

Working Principles

It is essential to be selective when identifying a community's requirements for energy data. Excessive effort applied to an audit can divert resources and attention from actual measures for energy saving. An attempt to produce highly detailed information with absolute rigour is bound to produce extraneous information, to consume an unnecessarily large amount of time and money, and, in any event, to fail. The energy audit is a response to the problem of too little data, but it should not create the opposite problem of too much data. Instead, the character of the audit must be carefully matched to the explicit data needs of the community.

This consideration, and the experiences of a significant number of communities that have undertaken community energy audits, give rise to several working principles. These principles should be remembered during the process of determining output data needs:

1. *The audit is best approached in stages, since the precise data requirements will not be absolutely clear at the outset.* It is generally not useful to begin by attempting to generate all the data that might conceivably be required. It is more effective to generate data for an essential overview first, zeroing in on more detailed information as it is required.
2. *In a changing energy environment, the community energy audit will require updating over time.* New energy programs,

prices, technologies, and problems, may, for instance, create needs for new data in the future. The more complex the initial audit, the more involved any updates are likely to be.

3. *Resources allocated to the audit should be balanced against the resources needed to carry out other elements of the community energy management process.* This will ensure that the audit supports, rather than displaces, efforts in energy management. Thus, in a low budget situation, the requirements for output data should be restricted.

Energy audits should not be confined to a portion of a community's energy use. In fact, the initial **scope** of the audit should generally be broad, examining all energy-consuming sectors and attempting to identify their total energy consumption. This comprehensiveness is, in effect, an attempt to describe the "whole picture" without necessarily attempting (at least initially) to provide great detail or exacting precision in the description. A general understanding of the whole is essential for an integrated understanding of a community's energy problems, opportunities, and options.

The Types of Output

A community energy audit produces several specific types of output data which can be conveniently organized into five categories (Figure 2):

- total community
- major sectors
- subsectors
- end uses
- energy sources.

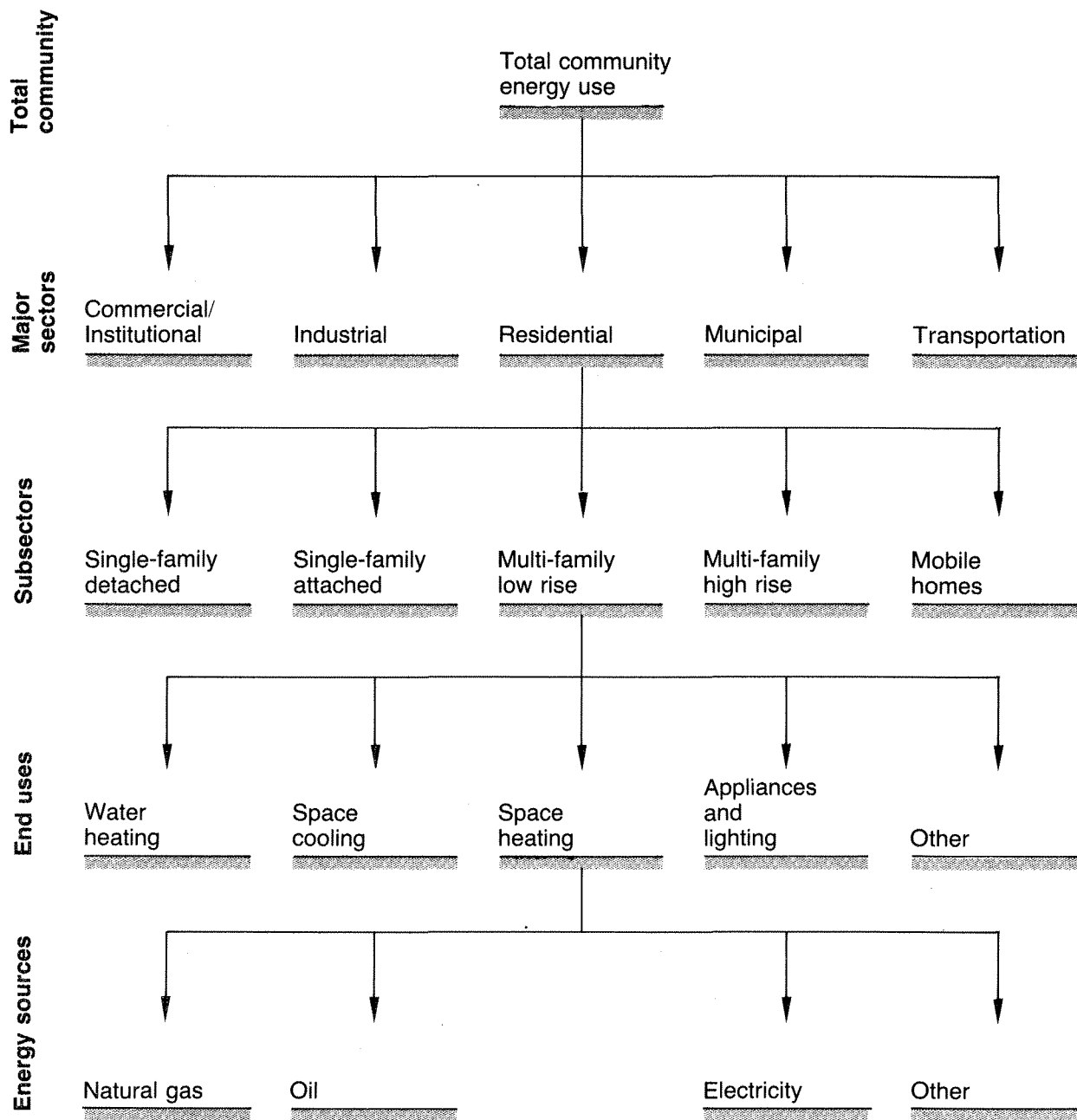


Figure 2. Sample categorization of community energy data.

In Figure 2, the residential sector is highlighted and divided into its subsectors. All sectors, subsectors, and end uses can be subdivided similarly. In Table 1 possible subsectors for the other major sectors are listed. Each subsector can be divided into end uses which can, in turn, be further subdivided into appropriate energy sources. In addition, some community energy audits also attempt to categorize energy use by season, by neighbourhood, or by some other factor.

Taking account of all these possible subdivisions, several hundred pieces of data would be generated by an audit that attempted to "fill all the boxes". Such a comprehensive effort is sometimes called either a "Level 2" or a "Level 3" audit, depending upon the degree of detail involved. Though the Level 3 audit is the more informative in terms of subsectoral, end use, and supply data, there is no clear dividing line between the two levels.

In both cases, the difficulty of carrying out such detailed audits is substantial. Therefore, in keeping with the need for selectivity and the working principles already discussed, the information output of a simpler energy audit is presented in Figure 3. This basic audit is sometimes called a "Level 1" audit or, more commonly, an "energy profile". Such profiles typically involve just three categories of information:

- total community
- major sectors
- energy sources.

Subsectoral and end-use data are not included, except perhaps in selected areas (for instance, some end-use data might be generated for the residential sector, or the transportation sector might be broken down into subsectors). Thus,

the energy profile provides an overview of energy flows, plus limited specific detail. In the current Canadian context, where the vast majority of communities have little or no experience with energy audits, energy profiles have most relevance and should be undertaken first.

The three basic categories of energy profile data (community, sector, and source) need not be aggregated only as shown in Figure 3. The data may also be aggregated to emphasize the community's energy sources rather than its energy uses (Figure 4). The difference is, essentially, one of presentation — the basic data output remains unchanged.

The Nature of the Output — Some Specifics

Specific examples of the actual output data that can be generated by an energy profile are presented in summary form in Figures 5 and 6. The output need not be restricted to such very general data; nevertheless, such an overview is often, by virtue of its clarity, an effective and persuasive aid in the development and explanation of energy programs.

In clarifying the requirements for output data, a number of technical questions may arise. Three of these deserve special mention:

1. The audit as described here is concerned principally with quantities of "secondary energy," i.e., energy as delivered to the consumer. Any data referring to "primary energy" — energy as it is first produced at the wellhead, mine, or hydroelectric facility — is not directly comparable. The difference between primary and secondary

Table 1.

**Subsectors for the commercial/institutional,
industrial, and transportation sectors**

| Sectors | Subsectors |
|--------------------------|---|
| Commercial/institutional | Retail and services Wholesale Office Hotels/motels Hospitals Auditoriums, arenas, theatres Religious, social, cultural facilities Municipal operations ¹ Other |
| Industrial | Manufacturing food, kindred products textiles printing, publishing, fabricated metal products Mining Construction Agriculture ² |
| Transportation | Automobiles Trucks Buses Rail |

¹ If not treated as a separate sector.

² Insignificant in most municipalities.

Note: Many other categorizations are possible.

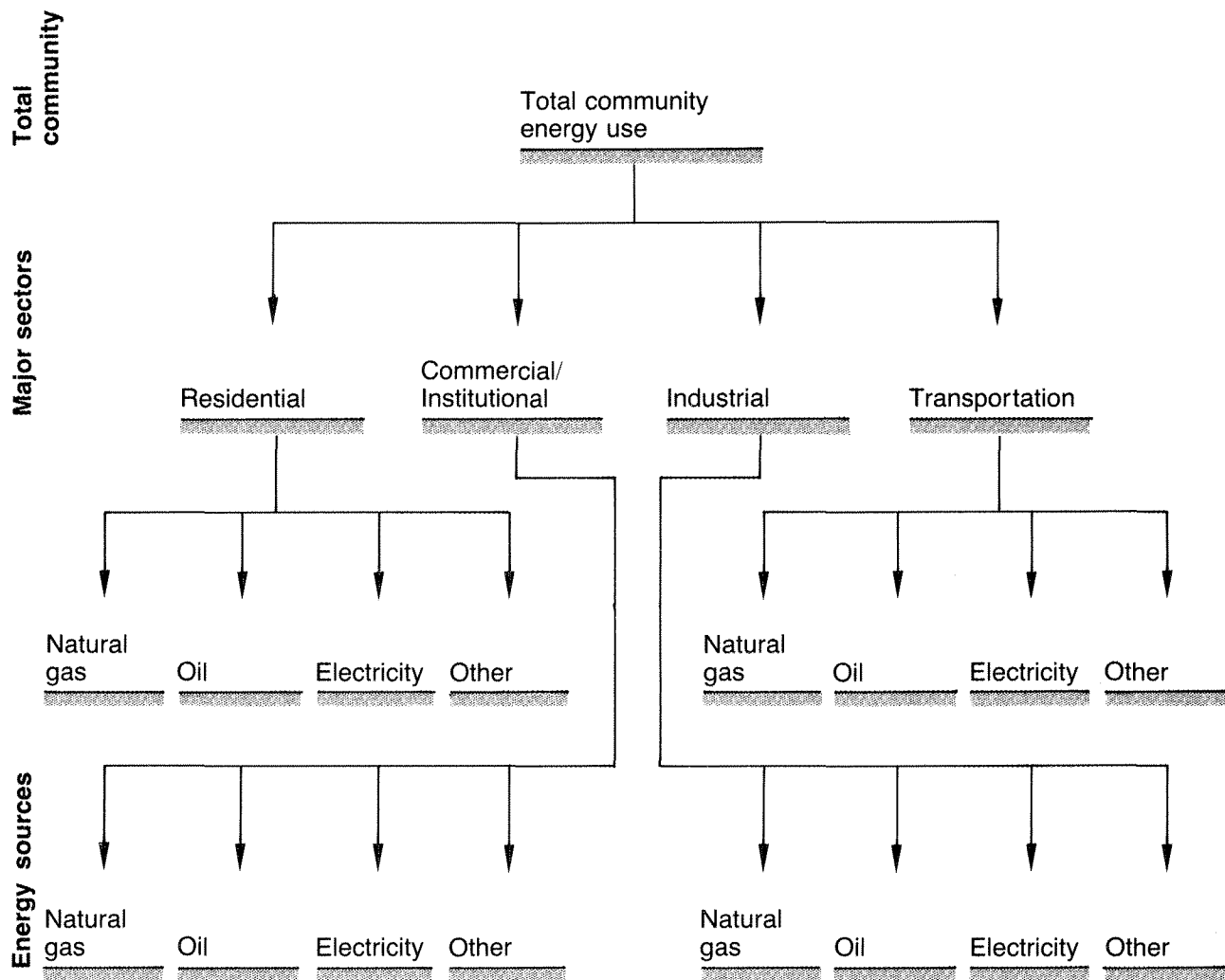


Figure 3. Community energy data generated by an energy profile.

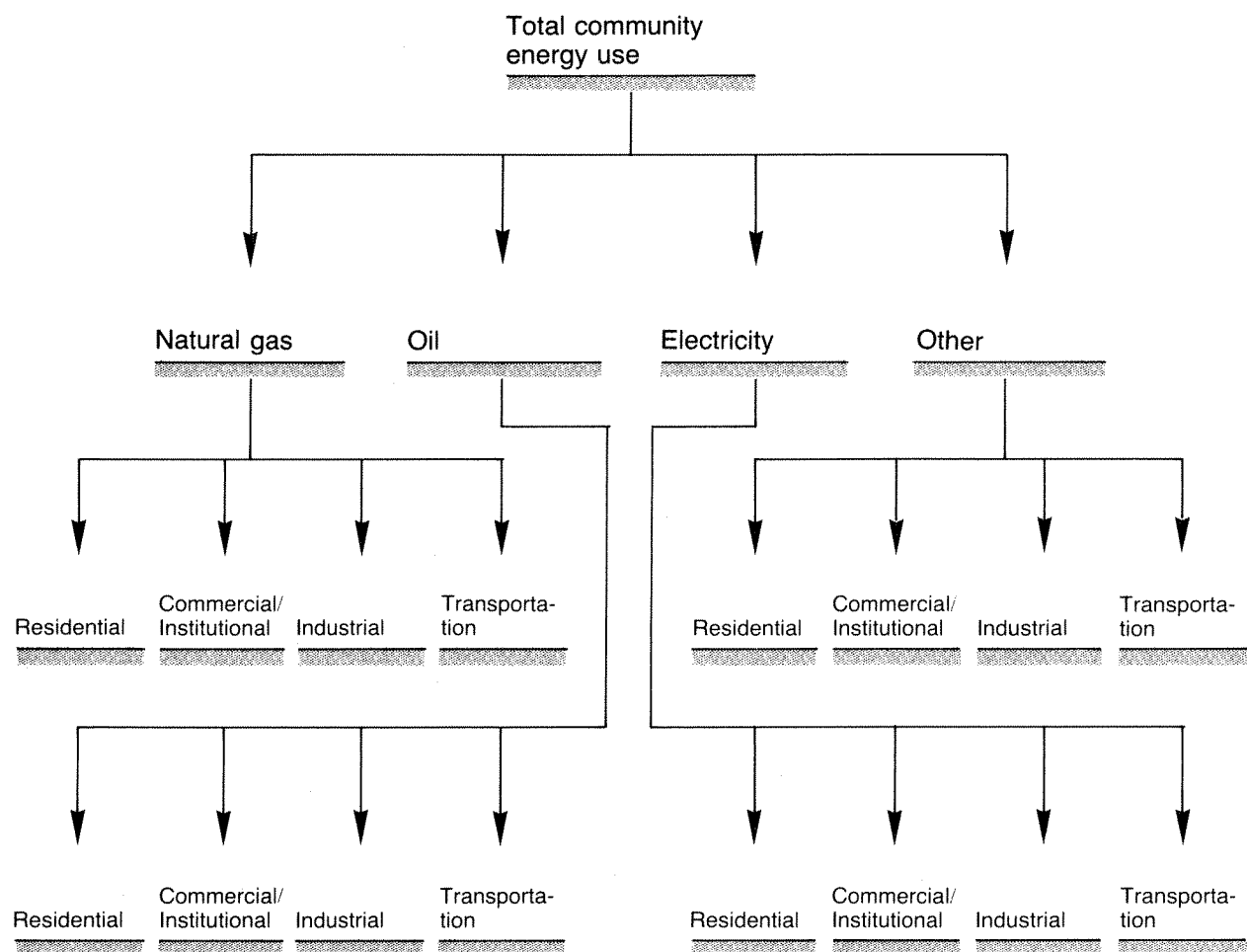


Figure 4. Alternative aggregate of community energy data generated by an energy profile.

energy results mainly from production and transmission losses. The difference is most pronounced in thermal electric plants, where about two-thirds of the primary energy becomes waste heat. This distinction is most likely to be of importance in communities with some sort of facility for energy production.

2. When electrical generating facilities are located in a community, there exists the possibility of double accounting. Essentially fuels used in a power plant are, in part, simply converted to another commercial form of energy (electricity). Thus, from the point of view of the energy auditor, the fuel

in question is not really consumed; it is only transformed.

3. Not all of the energy used by a community is consumed directly in the form of oil, gas, electricity, or other energy supplies. Goods and services imported from outside (food and manufactured products, for instance) often require considerable energy in their production and delivery. As these products are used by the community, their energy content is also, indirectly, consumed. Although such "indirect consumption" may be larger than direct energy use in many communities, it is almost impossible to measure and, thus, its use is generally ignored in community energy audits.

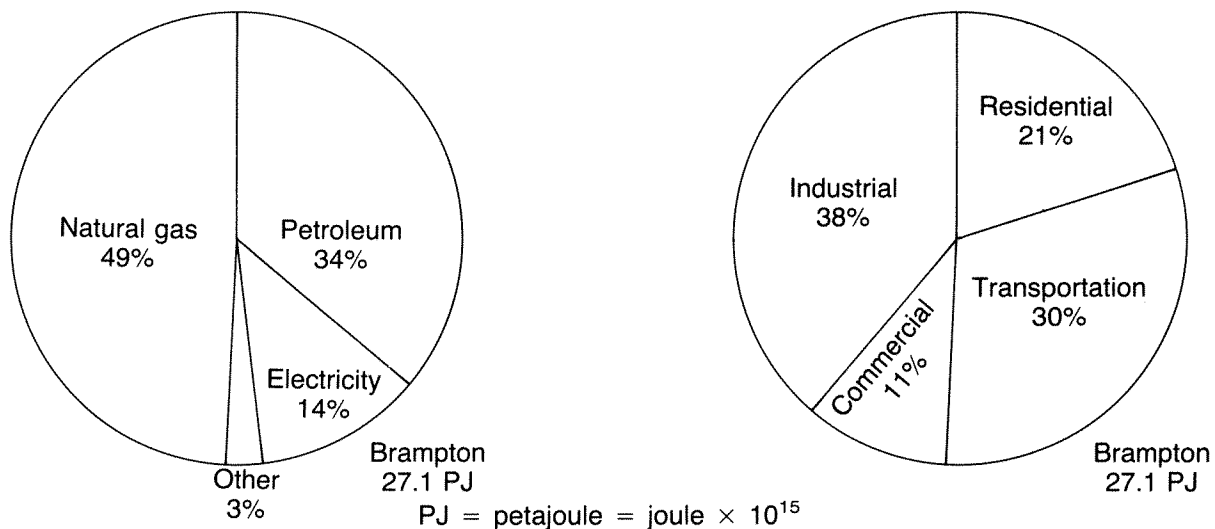


Figure 5. Energy consumption by fuel and by sector for Brampton, Ontario. (Adapted from Local Energy Action Study Team, *Brampton Energy Profile*, with permission.)

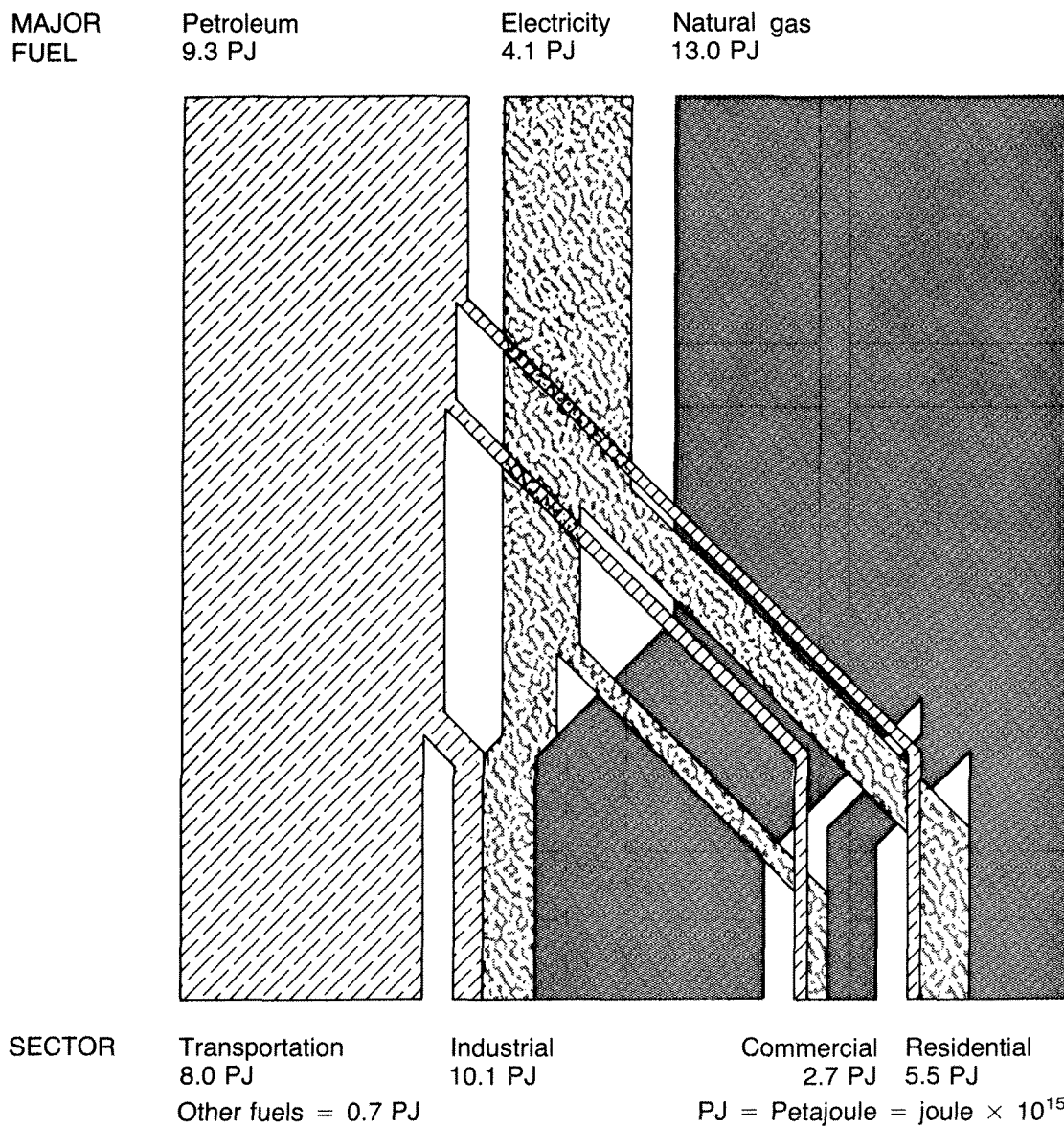


Figure 6. Overall energy use for Brampton, Ontario. (Adapted from Local Action Energy Study Team, *Brampton Energy Profile*, with permission.)

CHAPTER 3

COMMUNITY ENERGY AUDITING METHODS

Two Basic Approaches

Although there are several published methods for the calculation of community energy flows, they are all variations of only two basic approaches: the "top-down" audit and the "bottom-up" audit. Before considering the individual published methods, therefore, it is important to understand the approaches upon which they are based.

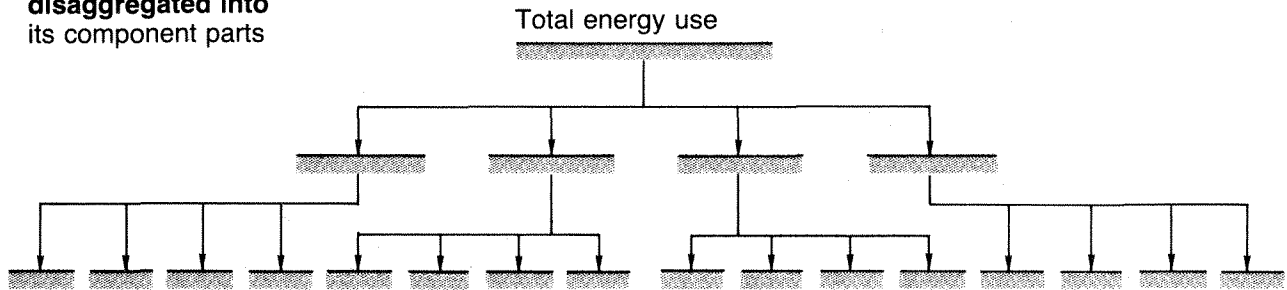
The difference between these two types of audit is, in essence, that the top-down audit **dis-aggregates** energy data relating to the whole community into its component parts (Figure 7A), whereas the bottom-up audit **aggregates** energy data from each component of the community into data for the whole (Figure 7B).

Both the top-down and the bottom-up audits can, in principle, produce output data with any desired level of detail. Thus, regardless of whether a community is undertaking a simple energy profile or an elaborate Level 3 audit, either of the two basic approaches can theoretically be used.

In practice, however, limitations to input data may restrict the full application of either of these techniques. Thus, most community energy audits and most of the published methods are **not exclusively** top-down or bottom-up in character. A given audit might, for instance, rely primarily on a bottom-up approach, but gaps in data might be filled using top-down techniques. Another audit might be essentially top-down in character, but might, nevertheless, utilize bottom-up techniques to cross-check its data. The two approaches are quite distinct, but are not mutually exclusive.

More detailed discussions of the characteristics of top-down and bottom-up audits are provided in Charts 1 and 2 respectively.

- A. Total energy use
disaggregated into
its component parts



- B. Total energy use
aggregated from
its component parts

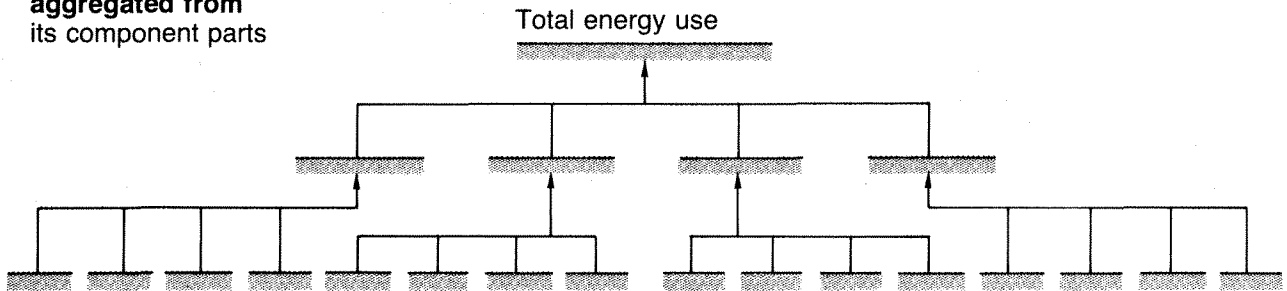


Figure 7. Top-down (A) and bottom-up (B) audits.

CHART 1

TOP-DOWN AUDITS

Basic Approach

The top-down approach involves two basic steps:

- i) Determine total energy use for the entire community (generally by individual energy source).
- ii) Subdivide total energy use into various community components (for instance, different combinations of sectors, subsectors, and end-uses).

Determining Total Energy Use

Information on total energy use (by energy source) for a given community may be available from utilities and fuel suppliers (see Table 2). Comparable information is unlikely to be available from other sources.

Subdividing Total Energy Demands

Depending upon the level of detail required from the audit, it may or may not be necessary to subdivide the figures for total energy use into sector, subsector, and end-use categories. If it is desirable to do so, two possibilities exist:

- i) The utility or fuel supplier providing the data may be able to supply subdivided data.

- ii) If not, the aggregate data may be apportioned among different sectors, subsectors and end-uses.

This process of apportioning involves the estimation of the percentage use attributable to each energy consuming component in the community. A number of assumptions can be used as the basis for this estimation. For instance:

- the proportion of energy use that is applied to a given purpose can be assumed to be the same as in the national, provincial, or regional cases; or
- the proportions can be assumed to be the same as in other comparable communities for which data are available.

These assumptions must be made with *great* caution since, in fact, the use patterns for various fuels vary tremendously from place to place.

The data required to apportion energy use on the basis of these assumptions (data on, for instance, provincial use patterns for a particular energy source) are available from a number of sources (see Tables 3 to 6).

Commentary

Top-down audits generally have the important advantage of requiring less work than bottom-up audits. In addition, they can produce accurate data, if energy suppliers are willing, and able, to release sales information. Top-down data cannot, however, be used to simulate the effects of various policy initiatives as easily as can bottom-up data.

Table 2.

Audit data sources for top-down audit techniques

| Data source | Comments |
|--|---|
| Fuel oil <ul style="list-style-type: none">• Local fuel oil distributors• District sales representatives of large oil companies | <ol style="list-style-type: none">1. Independent dealers are often the most cooperative.2. Local distributors for parent company sometimes do not keep records.3. Confidentiality may be a problem. |
| Electricity <ul style="list-style-type: none">• Electric utility | <ol style="list-style-type: none">1. Most utilities publish Annual Reports and annual statistical reports.2. Service area may not correspond exactly with audit area.3. Billing classifications may not correspond to audit sectors (e.g., highrise apartments may be classified "commercial").4. Sales data in dollars are of limited value due to complex rate structures. |
| Natural gas <ul style="list-style-type: none">• Local gas companies | <ol style="list-style-type: none">1. Same as for electric utility above.2. Head office approval is often necessary prior to the release of information. |
| Gasoline <ul style="list-style-type: none">• Major oil companies• Local gasoline retailers and/or retail associations | <ol style="list-style-type: none">1. Figures are generally not made available because of the competitive nature of business.2. Data may be biased by gasoline purchased but not used in the community (and vice versa). |
| Other (wood, coal, etc.) <ul style="list-style-type: none">• Although these may be locally important energy sources, data are not, in most cases, readily available | |

Table 3.

Audit data sources for the residential sector

| Type of data | Sources |
|--|---|
| Housing Characteristics (type, floor space, age, thermal characteristics, and number of dwelling units) | <ul style="list-style-type: none">• Statistics Canada — census data• Local planning department• Tax assessor records• Local building permit and demolition records• Realtor associations• Energy, Mines and Resources Canada Enersave Program Buildings and Urban Systems Division, Conservation and Renewable Energy Branch• National Research Council of Canada, Division of Building Research• Canada Mortgage and Housing Corporation (CMHC)• Provincial Ministries of Housing/Energy |
| Population (number of occupants, age distribution, and income levels) | <ul style="list-style-type: none">• Statistics Canada — census data |

Table 3 (cont'd)

| Type of data | Sources |
|--------------------------|---|
| Fuels Used, by End Use | <ul style="list-style-type: none"> Statistics Canada <ul style="list-style-type: none"> Census data Standard Industrial Classification printouts Energy, Mines and Resources Canada <ul style="list-style-type: none"> Enersave Program Buildings and Urban Systems Division, Conservation and Renewable Energy Branch |
| Energy Intensity Factors | <ul style="list-style-type: none"> <i>Comprehensive Community Energy Planning, Vol. 1-3; Planner's Energy Workbook; and County Energy Plan Guidebook</i> (US figures) <i>Canada Housing Heating Performance and Improvability</i> (Scanada Consultants for CMHC) Statistics Canada <ul style="list-style-type: none"> Structural Analysis Division Energy, Mines and Resources Canada <ul style="list-style-type: none"> Enersave Home Energy Audit Program |

Comments: The residential sector typically has the best data available for the four major sectors.

Table 4.

**Audit data sources for the commercial/
institutional sector**

| Type of data | Sources |
|--|---|
| Number of Establishments in Each Subsector | <ul style="list-style-type: none"> • Telephone directories • Chamber of Commerce • City business directories |
| Floor Space Data | <ul style="list-style-type: none"> • Real estate market surveys • Tax assessor records • Local planning boards |
| Employment by Subsector | <ul style="list-style-type: none"> • Provincial or Regional Economic Development or Employment Offices • Chamber of Commerce |
| Energy Intensity Factors | <ul style="list-style-type: none"> • <i>Comprehensive Community Energy Planning Vols. 1-3; Planner's Energy Workbook; and County Energy Plan Guidebook</i> (US figures) • Energy, Mines and Resources Canada National Industrial Data Base • Statistics Canada Structural Analysis Division • Provincial Gas and Hydro Utilities Specific regional and/or subsector studies |

Table 4. (cont'd)

| Type of data | Sources |
|--------------|--|
| | <ul style="list-style-type: none"> Provincial Energy Agencies or Secretariats National Energy Audit Program data Energy, Mines and Resources Canada <i>Patterns and Levels of Commercial and Industrial Energy Consumption</i> National Research Council, Division of Building Research |

Comments: The commercial/institutional sector includes a great variety of activities, each one of which is vastly different from most of the others. The relationship between a gas station and a hospital, for instance, is not immediately obvious. As such, energy intensity factors must be highly specific to a given subsector, in order to be meaningful.

Table 5.

Audit data sources for the industrial sector

| Type of data | Sources |
|--|--|
| Names and Addresses of Firms | <ul style="list-style-type: none"> • Regional or city manufacturing directories • Statistics Canada <ul style="list-style-type: none"> Annual Census of Manufacturers • Trade and industrial associations • Chamber of Commerce |
| Subsector Data (employment, fuel-type energy consumption, dollar value added, land area) | <ul style="list-style-type: none"> • Statistics Canada <ul style="list-style-type: none"> Manufacturing and Primary Industries Division CANSIM Section Census of Manufacturers Energy Sector • Federal and Provincial offices of Industry, Commerce and Economics and Inter- governmental Affairs • Local planning departments • <i>Comprehensive Community Energy Plan- ning, Vols. 1-3 and Planner's Energy Workbook</i> (US figures) |
| Energy Intensity Factors | <ul style="list-style-type: none"> • Statistics Canada <ul style="list-style-type: none"> Structural Analysis Division |

Table 5. (cont'd)

| Type of data | Sources |
|--------------------------|--|
| Energy Intensity Factors | <ul style="list-style-type: none"> Provincial gas and hydro utilities <ul style="list-style-type: none"> Specific regional and/or subsector studies Provincial Energy Agencies or Secretariats <ul style="list-style-type: none"> National Energy Audit Programs data Energy, Mines and Resources Canada <ul style="list-style-type: none"> <i>Patterns and Levels of Commercial and Industrial Energy Consumption</i> National Industrial Data Base |

Comments: Energy demands from various firms within the same industry can differ by several hundred per cent. As such, the potential for error in estimating local industrial energy use is large. The Structural Analysis Division of Statistics Canada is attempting to overcome this problem by developing input/output models for 181 subsectors within the commercial and industrial sectors. In communities with only a few industries, this problem might also be overcome by resorting to primary data collection.

Table 6.

Audit data sources for the transportation sector

| Type of data | Sources |
|---|---|
| Vehicle-kilometres of travel by vehicle type and passenger-kilometres of travel | <ul style="list-style-type: none">• Federal and Provincial Departments of Transport• Statistics Canada |
| Number of registered automobiles and trucks | <ul style="list-style-type: none">• Provincial/City Vehicle Registration Offices |
| Bus and rapid transit data (vehicle-kilometres of travel, passenger-kilometres of travel, energy consumption, projections of ridership) | <ul style="list-style-type: none">• Public Transit Authority• School Boards (for school bus data) |
| Energy intensity factors (i.e. average km/L data) | <ul style="list-style-type: none">• Department of Transport• Energy, Mines and Resources Canada |
| | Conservation and Renewable Energy Branch — Transportation Division |

Comments: After the residential sector, data on the transportation sector is generally the most readily available.

CHART 2

BOTTOM-UP AUDITS

Basic Approach

The bottom-up approach involves two basic steps:

- i) Calculate the energy demands for various community components (for instance, different combinations of sectors, subsectors, end-uses, and energy sources).
- ii) Sum these component demands to yield total energy demands and any required subtotals.

Calculating Component Energy Demands

The key is the first of these two steps: calculating the energy demands for the various energy-consuming components of the community. The basic technique is represented by the following equation:

$$\begin{array}{ccccc} \text{Energy} & & \text{Average} & & \text{Actual} \\ \text{demand} & = & \text{energy} & \times & \text{number} \\ \text{for a given} & & \text{demand} & & \text{of "fixed"} \\ \text{com-} & & \text{per "fixed"} & & \text{units"} \\ \text{ponent} & & \text{unit"} & & \end{array}$$

... where "fixed unit" refers to any convenient subdivision of the community component in question. If, for instance, the unit is a single-family house, then:

$$\begin{array}{ccccc} \text{Space} & & \text{Average} & & \text{Actual} \\ \text{heating} & = & \text{space} & \times & \text{number of} \\ \text{energy} & & \text{heating} & & \text{single-} \\ \text{demand} & & \text{energy} & & \text{family} \\ \text{for} & & \text{demand} & & \text{houses} \\ \text{single-} & & \text{per} & & \\ \text{family} & & \text{single-} & & \\ \text{houses} & & \text{family} & & \\ & & \text{house} & & \end{array}$$

If the unit is a passenger-kilometre of travel, then:

$$\begin{array}{ccccc} \text{Energy} & & \text{Average} & & \text{Actual} \\ \text{demand} & = & \text{energy use} & \times & \text{number of} \\ \text{for} & & \text{per} & & \text{passenger-} \\ \text{passenger} & & \text{passenger-} & & \text{kilometres} \\ \text{travel} & & \text{kilometre} & & \text{of travel} \\ & & \text{of travel} & & \end{array}$$

Estimating Parameters

The fixed units chosen (that is, the single-family house or the passenger-kilometre of travel in the above examples) has been referred to as the "estimating parameter" for a given component of total energy demand. The estimating parameters that can be used include:

Residential sector:

(and its subdivisions)
floorspace (m²)
number of dwelling units
number of occupants

Commercial/Institutional sector:

(and its subdivisions)
floorspace (m²)
number of employees

Industrial sector:

(and its subdivisions)
number of employees
dollar-value added
land area (hectares)

Transportation sector:

(and its subdivisions)
vehicle-kilometre of travel
passenger-kilometres of travel

The required data relating to these estimating parameters (the "actual number of fixed units", to use the terminology of the equation) are available from a number of sources (see Tables 3 to 6).

Energy Intensity Factors

The "average energy demand per fixed unit" (as required by the equation) is generally referred to as the "energy intensity factor". Determination of accurate and appropriate energy intensity factors is essential if bottom-up audits are to produce credible data.

The more specific an intensity factor is, the more reliable and useful the overall results will be. For instance, it is preferable to have individual intensity factors for all major types of residential dwellings rather than for residential dwellings as a whole (so long as equally detailed data are available on the "number of fixed units" of each type).

Broadly speaking, two approaches are available for the determination of energy intensity factors:

- i) Rely upon local data, provided by established sources or generated by survey.
- ii) Rely upon non-local data, adjusted to allow for local characteristics. For instance, adjustment may be needed to account for differences between the local and non-local situations with respect to:
 - typical insulation levels
 - heating degree days
 - building operating hours
 - vehicle occupancy rates
 - average travel speed of vehicles.

Data sources for energy intensity factors are outlined in Tables 3-6. In addition, the major published audit methods (see Charts 3 to 5) each provide energy intensity factors together with a number of possible adjustments for local characteristics (although their factors and adjustments are based upon figures for the United States).

Commentary

Bottom-up audits usually require more work and resources than top-down audits, but this extra effort typically produces more detailed results. In addition, the data produced by a bottom-up audit can be manipulated to simulate the effects of various policy initiatives — a definite aid in the development of programs for municipal energy management.

The Published Methods

Top-down and bottom-up are terms that describe basic **approaches** to community energy auditing. For each approach, there is a range of specific methods available, a number of which have been published. The three most detailed of these audit procedures are briefly summarized in Charts 3, 4, and 5 respectively:

- *County Energy Plan Guidebook* (Okagaki and Benson 1979)
- *The Planner's Energy Workbook* (Carroll et al. 1977)
- *Comprehensive Community Energy Planning, Volumes 1-3* (Hittman Assoc. 1978).

The remaining published techniques, which are less comprehensive, or are elaborated in less detail, are not summarized here. The Bibliography provides references to a number of these other options.

Charts 3, 4, and 5 do not describe the basic computations for each method, since these computations are simply elaborations of the top-down and bottom-up approaches already outlined. Instead, the charts identify some of the distinguishing features of each of these published techniques.

CHART 3

AUDIT METHOD FROM COUNTY ENERGY PLAN GUIDEBOOK

Objectives

- i) The *Guidebook* was prepared by the Institute for Ecological Policies, Fairfax, Virginia, (Okagaki and Benson 1979). It is specifically intended to enable non-technical people to produce local energy plans based upon conservation and the development of local renewable energy resources.
- ii) A community energy audit is one part of this process. The intent is to produce an energy profile rather than a highly detailed audit and, as such, the method provided is deliberately more simple than that offered by *The Planner's Energy Workbook* and by *Comprehensive Community Energy Planning* (see Charts 4 and 5).

Cost and Time Requirements

- i) The cost and time requirements are significantly less than in the case of the two methods described in Charts 4 and 5.
- ii) The *Guidebook* is intended for use by volunteers working in their spare time. On this basis, the audit can be expected to cost well under \$5,000 and take from three to six months to complete. Costs and the time requirement can be reduced below these levels by further simplification of the audit.

Resources and Skills Required

- i) The *Guidebook* does not demand resources beyond those that could be applied by interested citizens. Input data needs are less than in the other major published methods.
- ii) The techniques do not require a high level of mathematical expertise.
- iii) The authors consider the expected voluntary input to be the strength of their method, since it implies a high level of interest. Nevertheless, the audit can also be undertaken by municipal staff or others.

Characteristics

- i) The *Guidebook* discusses both top-down and bottom-up approaches but elaborates most on the bottom-up techniques. The user is encouraged to adopt the techniques that make best use of the available input data.
- ii) Energy demands are not broken down in great detail. Few adjustments for the energy intensity factors are provided.
- iii) Only limited effort is applied to determining consumption levels for each energy source. Greater effort is applied to identifying consumption levels for various end-uses. (This emphasis is somewhat different from that suggested in Chapter 2 for the "typical" profile. The difference results from the fact that end-use data can help identify opportunities for renewable energy use.)

- iv) The *Guidebook* is intended for use at the county level, but need not be confined to that level.

Commentary

The *Guidebook* techniques can be used quickly and relatively easily to produce an energy profile. The simplification of method may, in some cases, produce errors that are not recognized because all assumptions are not made explicit, but this is unlikely to be a serious problem. The *Guidebook* has been used by over 150 communities, primarily in the United States.

CHART 4

AUDIT METHOD FROM THE PLANNER'S ENERGY WORKBOOK

Objectives

- i) The *Workbook* was prepared for the US Federal Energy Administration (Carroll et al. 1977). It focuses on procedures for community energy auditing with little reference to a full process of municipal energy management.
- ii) The intent is to help planners and designers to evaluate alternative land-use planning and design programs by relating energy utilization to land use for each major end-use sector.

Cost and Time Requirements

- i) Quantitative statements about time requirements are difficult since the actual applications of the *Workbook* method have been quite varied.
- ii) Specific yet meaningful cost figures are unavailable. The *Workbook* is intended for use by working municipal planners, and, as such, the largest single cost (staff time) is a hidden expenditure.

- iii) In general, however, the cost and time requirements can be expected to be less than those associated with *Comprehensive Community Energy Planning* (see Chart 5) but more than those required by the *County Energy Plan Guidebook* (see Chart 3).

Resources and Skills Required

- i) The *Workbook* has attempted to utilize input data normally available to the land-use planner. The number of types of data required is intermediate between the requirements of the *Comprehensive Community Energy Planning* and the *County Energy Plan Guidebook* methods (and corresponds to the level of detail of the output data produced).
- ii) The *Workbook* is reasonably easy to follow, with fairly detailed directions provided, and does not necessarily demand highly specialized skills (although planners are the major intended users).

Characteristics

- i) The *Workbook* follows the general bottom-up approach (see Chart 2).
- ii) It provides an intermediate level of detail (for instance, 15 subsectors are identified as opposed to 35 in the *Comprehensive Community Energy Planning* method). Similarly, the

number of adjustments for the energy intensity factors falls between the number provided by the two alternative audit procedures.

- iii) The method is not intended for use in communities smaller than several thousand people.

Commentary

The data provided by the *Workbook* are perhaps somewhat dated (published in June 1977). However, the assumptions supporting the data are clearly stated, which allows an assessment of their current and local appropriateness. The *Workbook's* energy intensity factors for the industrial sector are reported to be substantially higher than those actually developed locally by a number of communities. The *Workbook* includes two example applications of the method.

CHART 5

AUDIT METHOD FROM **COMPREHENSIVE COMMUNITY ENERGY PLANNING**

Objectives

- i) The publication presents a comprehensive planning process for municipal energy management, but concentrates on community energy auditing. The audit technique was developed for the US Department of Energy (Hittman Assoc. 1978), and is commonly referred to as the Hittman method.
- ii) It was prepared for use in the US government-sponsored Comprehensive Community Energy Management Program (CCEMP)* and as such was used as an initial guide in 16 US communities.
- iii) The audit method is intended to be comprehensive, and is much more detailed and intricate than the techniques outlined in Charts 3 and 4.

Cost and Time Requirements

- i) The 16 CCEMP communities did not adhere strictly to the Hittman method, and some deviated significantly. Their audits were, furthermore, pilot projects. Therefore, the

* CCEMP was a demonstration program sponsored by the US Department of Energy in the 1970s. It was intended to test the role of local government in energy management.

following CCEMP cost and time information should only be considered to be generally indicative of the scale of the Hittman method.

- ii) The CCEMP communities required from eight to twenty months to complete their audits. Not all of this time was necessarily applied to the actual audit process.
- iii) The cost to those CCEMP communities whose audit relied substantially on Hittman is measured in the tens of thousands of dollars. Because of the wide variation of method, a meaningful and quantitative correlation between community size and cost is not readily apparent.
- iv) Seattle, the community which completed its audit most quickly, provides a specific cost example. Following a supplemented version of the Hittman method, this city of about 500,000 people spent \$187,000 on its energy audit.

Resources and Skills Required

- i) The level of detail contained in the explanatory and procedural material is such that it allows use by individuals who may not have a planning or energy background.
- ii) The method has extensive and often difficult input data needs.
- iii) The output data are also extensive. Computerization was considered necessary by some (but not all) CCEMP communities.

Characteristics

- i) The method follows the general bottom-up approach (see Chart 2).
- ii) Energy demands are broken down into larger numbers of subsectors, end uses, and sources than in the other published techniques (see Charts 3 and 4).
- iii) A greater number of adjustments for the energy intensity factors is provided than is the case in these other methods.
- iv) "Rules of thumb" are provided for purposes of developing data concerning particular estimating parameters (for instance, typical floor areas for various types of commercial establishments).
- v) The method is intended for communities of over 25 000 population.

Commentary

The Hittman audit technique has been evaluated in two reports: *Community Energy Auditing: Experience with the Comprehensive Community Energy Management Program* (Moore et al. 1980) and *The Comprehensive Community Energy Management Program: An Evaluation* (Moore et al. 1981). The method worked best for the residential and transportation sectors and worst for the commercial and industrial sectors. Many of the CCEMP communities found the method and resulting data to be too detailed for their needs. Even with this detail, margins of error were often acknowledged to be large, due to limitations in the input data. Nevertheless, most communities found many of the analytical techniques and much of the information to be useful.

Choosing a Method

Every municipality will have its own auditing requirements and constraints. Given this fact, it is likely that those undertaking audits in Canadian municipalities will adopt only certain elements of the various published techniques. Thus, "choosing a method" does not mean selecting, intact, one of the three methods outlined in Charts 3, 4, and 5. Instead, the task is to identify the most appropriate parts of each of these methods. The result will be a composite, "tailor-made" method designed to suit the local situation.

While this process of identification is highly specific to each audit situation, some guiding principles can be identified:

1. As discussed in Chapters 1 and 2, the character of the required output data should be decided before the audit technique is chosen.
2. The most significant difference between the three published audit procedures discussed in Charts 3, 4, and 5 is in the level of detail they produce. Thus, if the required output data is only as detailed as an energy profile, then the *County Energy Plan Guidebook* method is the most suitable starting point. Conversely, if great audit detail is required, then *Comprehensive Community Energy Planning* can serve as a starting point. *The Planner's Energy Workbook* provides an intermediate level of detail.

3. The method chosen as a starting point can then be modified as required. A number of considerations will influence these modifications, for instance:

- more or less output data, or data of a different type, might be required in one sector
- necessary input data might be unavailable
- available time, money, or skills might not match the requirements of the selected method.

In such cases, more suitable audit techniques can be cautiously borrowed from the other published methods. Alternatively, creative thinking and "hands-on" experience can be used to modify the techniques prescribed by the initial method.

4. The three detailed audit procedures discussed here are predominantly bottom-up in character. If good data for aggregate energy use are available, special consideration should be given to utilizing top-down techniques in the audit, wherever appropriate.

Apart from these general considerations, many other more particular concerns affect the choice of audit method, as noted in Charts 1 to 5. These charts should be referred to in the selection process.

There is much regional variation in Canada with respect to patterns of energy use (due, for instance, to climatic variation and diverse settlement patterns). These differences, in themselves, have few implications as far as choice of basic audit technique is concerned: in principle, the procedures should work almost anywhere. However, there are vast differences in the nature and form of data available from place to place across the country, and this clearly influences the final choice of method.

Wherever it is undertaken, the ideal audit will produce no more, and no less, data than are required. It will rely on available data, skills, and resources and it will not require a disproportionate share of the time and resources

available for purposes of community energy management. No set method will meet these standards, but with an adaptive and creative effort, it is possible to devise an approach that comes very close.

To illustrate, a type of audit technique that has been used in Canada, the method employed in the energy profile for Brampton, Ontario, is outlined in Appendix I. Other methods have been used elsewhere and a number of these are mentioned in Chapter 5 and cited in the Bibliography.

CHAPTER 4

COLLECTION OF INPUT DATA

In the process of energy auditing, the collection of input data (step 3) follows the selection of an audit method and is guided primarily by that choice (since each method has its own unique data needs).

Broadly speaking, there are two types of input data used in energy auditing: primary and secondary. Primary data are new data collected specifically for the energy audit itself, including surveys and actual measurements of energy use. Secondary data, on the other hand, are data that have already been collected, initially for some other purpose (such as census or sales). Sources of secondary data include government agencies, energy suppliers, research establishments, public interest organizations, and universities.

A community energy audit should rely as much as possible on secondary data, because the collection of primary data is expensive, time consuming, and the results are often disappointing. The use of secondary data, on the other hand, is relatively cheap, since somebody else has done much of the work.

Unfortunately, limitations in the availability of secondary data are often severe. Problems include outdated figures, the complete absence of certain types of data, the confidential nature of other types of data, and the fact that data are often organized in formats that are not readily usable. Given these problems, it is valuable if individuals who are familiar with locally available sources of data (representatives of local energy suppliers, for instance) can actively participate in the audit process.

To supplement these various considerations, some potential sources of data for energy auditing are identified in Tables 2 to 6. More specifically, sources that are valuable for top-down audits are listed in Table 2. Tables 3 to 6 are primarily of importance for bottom-up auditing techniques, although many of the sources will also be of value in the apportioning of top-down data amongst various subsectors and end uses. Data sources for the residential sector are listed in Table 3; those for the commercial/institutional sector in Table 4; those for the industrial sector in Table 5; and those for the transportation sector in Table 6.

CHAPTER 5

THE USE OF COMMUNITY ENERGY AUDITS

Of the four basic functions of the completed energy audit, namely to stimulate action, to identify priorities, to estimate savings, and to monitor programs, the first three have been alluded to throughout this publication. The fourth of the audit's functions — the monitoring and evaluation of implemented programs — has been less emphasized but is, nevertheless, of considerable importance. In particular, the audit plays three key roles in the evaluation process:

1. It identifies sources of data and computational techniques that can be used in the measurement of energy impacts;
2. It provides the responsible staff with experience in such activities; and
3. It provides baseline data against which the effects of the implemented programs can be judged.

All these considerations have led, in a number of Canadian municipalities, to the conclusion that a community energy audit could be a valuable aid in both the development and the monitoring of energy management programs. "Hands on" Canadian experience is more restricted than in the United States, but a growing number of audits have been undertaken (Table 7).

Most (though not all) of the effort to date has been at the energy profile level — an overview rather than a highly precise and detailed audit. This is the likely area of most future community energy audit activity in Canada, at least for the foreseeable future.

As more experience is gained, and as input data become more available (as they certainly will, given the growing importance of energy), the task of performing an energy audit will become simpler and the output more useful and precise. Yet even today, the task is manageable and the output data are valuable. The need for well-designed programs in municipal energy management implies an equal need for credible information that an audit can help supply.

Table 7.

Community energy auditing: some Canadian experience

| Place | Year of publication | Undertaken by | Approach | Reference |
|----------------------------|---------------------|---|---|--|
| City of Brampton (Ontario) | 1981 | University students on behalf of City's Energy Conservation Committee | Mixed top-down and bottom-up approach producing a community energy profile | Local Action Energy Study Team, 1981. <i>Brampton Energy Profile</i> |
| Renfrew County (Ontario) | 1980 | Community organization | Mixed top-down and bottom-up approach applied to a decentralized, rural community to yield data somewhat more detailed than a simple profile | Energy Pathways Policy Research Group. Killaloe. 1980. <i>Renfrew County Energy Conservation Project: A Community Energy Study</i> |
| Town of Oakville (Ontario) | 1978 | Consulting firm | Mixed top-down and bottom-up approach producing a community energy profile including some sub-sector and end-use data. Transportation sector excluded | Middleton Associates, Toronto. 1978. <i>Energy Management at the Local Level</i> |

Table 7 (cont'd)

| Place | Year of publication | Undertaken by | Approach | Reference |
|---------------------------------|---------------------|-----------------|---|---|
| Borough of North York (Ontario) | 1979 | Consulting firm | Mixed top-down and bottom-up approach producing a community energy profile, including some subsector and end-use data | Middleton Associates, Toronto. 1979. <i>Urban Form and Energy Conservation</i> |
| Ottawa (Ontario) | 1979 | Consulting firm | Bottom-up approach used for residential sector only. Based on "Canada 2" model of Canadian housing stock | Scanada Consultants Limited, Ottawa & Toronto. 1979b. <i>Ottawa Housing Heating Performance and Improvability</i> |
| Toronto (Ontario) | 1979 | Consulting firm | Primarily bottom-up approach used for commercial and industrial sectors only. Subsector and end-use data provided | MacDonald et al. 1979. <i>Patterns and Levels of Commercial and Industrial Energy Consumption: A Case Study of Metropolitan Toronto</i> |

APPENDIX I

AUDIT METHOD FROM BRAMPTON ENERGY PROFILE

Objectives

The Brampton energy profile was undertaken as a class exercise for graduate students in York University's Environmental Studies Program. It provided both a learning experience and an opportunity to develop and test an audit method. The results were intended to inform community decision-makers, thereby serving as an aid in their efforts to understand the energy situation and establish relevant community programs (Local Energy Action Team, *Brampton Energy Profile*, 1981).

Cost and Time Requirements

The profile was prepared over a three-month period. The project team consisted of four students, a project coordinator, and a supervising professor. The profile was undertaken at no cost to the city of Brampton.

Characteristics

Brampton is a community of 141 000 people. The City has a fairly substantial industrial base. The profile considered community energy consumption by energy source, sector, and, in some cases, by subsector. Problems were encountered with the availability of some input data.

The following techniques were used to determine consumption by energy source:

1. Natural gas sales data for Brampton and region were available. The figures were adjusted downward (on the basis of population) to yield figures for Brampton alone.
2. Electricity sales data for Brampton were available.
3. Fuel oil sales data were available from six of eight local distributors. Figures for the other two were estimated.
4. Gasoline sales were estimated in two separate ways. First, total gasoline sales for Metro Toronto were multiplied by the ratio of Brampton's population to Metro Toronto's. Secondly, data concerning the total number of automobiles registered in Brampton (subdivided into six categories) were available. The figures were multiplied by 20 116 km (12,500 mi.) per car per year and by the appropriate US Environmental Protection Agency litre per kilometre (miles per gallon) figures, yielding an estimate of total consumption.

Bottom-up techniques were used to determine consumption by sector:

1. Residential consumption was estimated based on the number of housing units and average energy consumption figures per unit.
2. Commercial consumption was estimated based on estimated square footage of commercial space and average energy consumption per square foot.

3. Industrial consumption was estimated based on number of employees per industrial group and average energy consumption per employee.

Total consumption (calculated by sector) was compared with total consumption (calculated by energy source), in order to verify the accuracy of the figures.

Results

1. Some of the data generated by the Brampton energy profile are illustrated in Figures 5 and 6.
2. The profile results were presented to the City's Energy Conservation Committee, an

in-house group involving senior municipal staff.

3. The City is now launching a major program in community energy management with significant provincial funding. This program will update and slightly expand the profile, which will then serve as a foundation for the development of a variety of energy programs.

Commentary

The group who carried out the Brampton Energy Profile considers it to be a somewhat preliminary effort, constrained by limited resources. The result, nevertheless, is an informative overview that provides a good basis for future energy-related activity.

ANNOTATED BIBLIOGRAPHY

Carroll, T. Owen. 1976. *The Planner's Energy Workbook: A Manual for Exploring Relationships Between Land Use and Energy Utilization*. Washington: US Federal Energy Administration. • Available from US Department of Commerce, National Technical Information Service, 5285 Port Royal Rd., Springfield, Virginia. • Identifier BNL 50633. • Price US \$12.50. pp. 122.

See Chart 4.

Elmahdy, A.H. *Recorded Energy Consumption in School Buildings*. Ottawa: National Research Council, Building Research Note #180, January 1982. pp. 20.

_____. *Annual Energy Consumption Data on Apartment Buildings*. Ottawa: National Research Council, Building Research Note #181, January 1982. pp. 15.

_____. *Recorded Energy Consumption Data on Office Buildings*. Ottawa: National Research Council, Building Research Note #182, January 1982. pp. 15.

_____. *Annual Energy Consumption Data on Supermarkets in Ontario and Quebec*. Ottawa: National Research Council, Building Research Note #183, January 1982. pp. 8.

Energy Pathways Policy Research Group, Killaloe. 1980. *Renfrew County Energy Conservation Project: A Community Energy Study*. Ottawa: Energy Communications Division, Energy, Mines and Resources Canada, Ottawa, K1A 0E4. pp. 179.

The results of the Renfrew County energy audit are presented (see Table 7), along with a description of the methodology used.

Environmental Action Committee, Notre-Dame-de-Grâce Community Council, Montréal. 1980. *Report of the NDG Community Energy Audit Project*. Ottawa: Energy Communications Division, Energy, Mines and Resources Canada, Ottawa, K1A 0E4. • Free. pp. 20.

An "action-research" project is described in which a questionnaire and various public participation activities were used in lieu of a technical auditing process to generate energy data. The result was not an energy audit in the sense that the term is used here; nevertheless, the overview information produced was considered valuable, as was the action-research process per se.

Hittman Associates Inc., Columbia, Md. 1978. *Comprehensive Community Energy Planning. Volume 1: A Workbook. Volume 2: Appendices. Volume 3: Worksheets*. Washington: US Department of Energy, November 1978. • Available from US Department of Commerce, National Technical Information Service, 5285 Port Royal Rd., Springfield, Virginia. • Vol. 1: Identifier HCP/M0023-01, price US \$14. pp. 156. • Vol. 2: Identifier HCP/M0023-02, price US \$18.50. pp. 254. • Vol. 3 unavailable.

See Chart 5

Inter Technology/Solar Corp, Warrenton. 1978. *Development of a Comprehensive Community Energy Management Plan for the City of Clarksburg, West Virginia*. Washington: US Department of Energy, Division of Buildings and Community Systems. • Available from US Department of Commerce, National Technical Information Service, 5285 Port Royal Rd., Springfield, Virginia. • Identifier ORO-5010-3. • Price US \$23.00. pp. 173.

A general methodology is presented, including an energy audit, for the development of a community energy plan. The methodology is applied to the case of the City of Clarksburg. The methodology and data are not as complete as those cited in Charts 3 to 5 of this book.

Local Energy Action Study Team *Brampton Energy Profile*. Downsview, Ontario: York University Faculty of Environmental Studies. April 1978. Out of print. pp. 46.

See Appendix I.

MacDonald, Robert, Gene Desfor, and Michael Miloff. 1979. *Patterns and Levels of Commercial and Industrial Energy Consumption: A Case Study of Metropolitan Toronto*. Ottawa: Conservation and Renewable Energy Branch, Energy, Mines and Resources Canada, Ottawa K1A 0E4. • Free. pp. 301.

A description is given of the patterns of energy consumption in the Metropolitan Toronto commercial and industrial sectors for 1974, and an assessment is made of methods and data sources for undertaking a municipal commercial energy audit (see Table 7).

Middleton Associates, Toronto. 1978. *Energy Management at the Local Level*. Toronto: Royal Commission of Electric Power Planning. • Out of print. pp. 46.

The objective of this study was to define the role that local governments could play in facilitating energy conservation. The case study approach was used, involving an energy profile for the town of Oakville for which results and methodology are outlined (see Table 7).

_____. 1979. *Urban Form and Energy Conservation*. Ottawa: Ministry of State for Urban Affairs. • Out of print. pp. 99.

The focus here is on patterns of energy use in urban areas. It includes the results and methodology for the North York Energy profile (see Table 7).

Moore, John L., D.A. Berger, C.B. Rubin, P.A. Hutchinson and H.M. Griggs. 1980. *Community Energy Auditing: Experience with the Comprehensive Community Energy Management Program*. Argonne, Illinois: Argonne National Laboratory. • Available from US Department of Commerce, National Technical Information Service, 5285 Port Royal Road, Springfield, Virginia. • Identifier ANL/CNSV-TM-43. pp. 101.

Moore, J.L., D.A. Berger, H.M. Griggs and C.B. Rubin. 1981. *The Comprehensive Community Management Program: An Evaluation*. Argonne, Illinois: Argonne National Laboratory, Dec. 1981. • Available from US Department of Commerce, National Technical Information Service, 5285 Port Royal Road,

Springfield, Virginia. • Identifier
ANL/CNSV-TM-89. pp. 430.

These two reports evaluate and discuss the US CCEMP program. The first focuses especially on the audit component of CCEMP, which was based upon Hittman Associates (*op. cit.*). The CCEMP communities are listed in these two reports. Many have published their audit results, and will make copies available on request.

Municipal Energy Audit: A Practical Guide to the Identification of Energy Expenditures. Ottawa: Conservation and Renewable Energy Branch, Energy, Mines and Resources Canada, Ottawa, K1A 0E4. 1981 • Free. pp. 64.

This study outlines a method for an audit of energy consumption in municipal operation.

Okagaki, Alan, and Jim Benson. 1979. *County Energy Plan Guidebook: Creating a Renewable Energy Future.* Fairfax: Institution for Ecological Policies, 9208 Christopher St., Fairfax, Virginia. 22031. • Price US \$7.50 for individuals, US \$15 for organizations. pp. 184.

See Chart 3.

Pferdehirt, W.P. *An Introduction to Community Energy Auditing.* Argonne, Illinois: Argonne National Laboratory. (In preparation.) pp. 112.

The content and application of the community energy audit are discussed, including its relationship to a full process of municipal energy management.

Scanada Consultants Limited, Ottawa & Toronto. 1979a. *Canada Housing Heating Performance and Improvability.* Ottawa: Central Mortgage and Housing Corporation. • Available from Canadian Housing Information Centre, CMHC, Ottawa, K1A 0P7. • Free. pp. 46.

_____. 1979b. *Ottawa Housing Heating Performance and Improvability.* Ottawa: Ministry of State for Urban Affairs. • Not in print. pp. 21.

Presented here is an approach and some of the necessary data for the modelling of residential heating needs (the "Canada 2" model). Ottawa is used as a pilot case (see Table 7).

Sizemore & Associates, Atlanta, Georgia. 1978. *Methodology for Energy Management Plans for Small Communities.* Washington: US Department of Energy. • Available from US Department of Commerce, National Technical Information Service, 5285 Port Royal Rd., Springfield, Virginia. • Identifier: HCP/M1834-01/UC95d. • Price US \$14. pp. 165.

A methodology is outlined for the development of municipal energy management plans that includes an energy auditing component. The methodology is intended for communities of 10 000 or less, and is tested on LaGrange, Georgia.