Federal Buildings Initiative

Audit Standards Guidelines

Natural Resources Canada
Ressources naturelles Canada

Canada

The Federal Buildings Initiative: Audit Standards Guidelines

Aussi publié en français sous le titre :
L'Initiative des bâtiments fédéraux : Lignes directrices en matière de vérification énergétique

ISBN 0-662-32558-3
Cat. No.: M92-246/2002E

To receive additional copies of this publication, contact:
Energy Publications
Office of Energy Efficiency
Industrial, Commercial and Institutional Programs
Ottawa ON K1A 0E4
Telephone: (613) 995-6950
Fax (613) 947-4121

You can also view or order several of the Office of Energyv Efficiency's publications online.
Visit our Energy Publications Virtual Library at http://oee.nrcan.gc.ca/infosource.
The Office of Energy Efficiency's Web site is at http://oee.nrcan.gc.ca.

Printed on recycled paper

Audit Standards Guidelines

Produced by the
Office of Energy Efficiency
Federal Buildings Initiative

The FBI is a program of NRCan's Office of Energy Efficiency, which is designed to help federal departments and agencies reduce energy and water consumption and greenhouse gas emissions that contribute to climate change.

Contents

The intent of this report is to provide some insight and to act as a guideline toward prescribing an energy audit for your facility.

The report summarizes energy audits by levels: namely yardstick, screening, walkthrough and engineering. A description of each is provided along with sample terms of reference for requesting an audit, sample forms and graphs, approximate costs and time to completion. The report also summarizes the auditing requirements for Natural Resources Canada's (NRCan's) Federal Buildings Initiative (FBI), specifically for energy performance contracting. The report may be taken as a guideline document for energy auditing with NRCan's FBI and Energy Innovators programs.

There are various forms of building audits available to facility managers. Audits may cover the building as a whole or be very specific, covering certain systems or building operations. Audits may also be characterized by the degree of detail provided. Here are a few specific types of audits:

- energy;
- lighting;

Summary of Audit Levels

ENERGY AUDIT	LEVEL	WHEN TO CONDUCT	TIME TO COMPLETE (DAYS)	COST
Yardstick	*Preliminary:* Minimum technical data and analysis, energy demand and use profiles, indication of potential.	Basic data gathering to identify buildings which may or may not have energy-saving potential.	0.5 to 1	$250 to $500
Screening	*Preliminary:* End-use breakdowns, possible energy-saving opportunities, preliminary savings estimates.	Level of audit generally required to prepare Request for Proposal (RFP) for Energy Performance Contracting (EPC).	1 to 3	$500 to $1,500
Walkthrough	*Preliminary:* System type and equipment information, specific savings opportunities identified, preliminary costs and savings.	Prior to bidding on RFP. Conducted and paid for by prospective Energy Service Company (ESCo).	3 to 10	$1,500 to $5,000
Engineering	*Detailed:* Extensive data gathered, modelling, simulation; leads to detailed implementation plan with drawings and specifications.	ESCo that wins contract conducts detailed audit to develop implementation plan.	10 to 50	$5,000 to $50,000

- electrical systems;
- mechanical systems;
- operations;
- maintenance;
- air quality;
- waste management; and
- environmental.

Energy managers use the term "energy audit" to include elements of all these specific audit types. As the term can be quite subjective, it is important to realize that certain types of energy audits have different connotations, especially for individuals that work with buildings on a day-to-day basis. Energy managers also recognize that energy audits may be provided in varying degrees of detail (or levels). This report summarizes four distinct levels of energy audits: yardstick, screening, walkthrough and engineering. Each varies in terms of scope, data requirements, complexity, deliverables, time to complete and cost.

The key to a successful energy audit is identifying its goals and scope as early as possible. The scope, data requirements, complexity and deliverables of each audit level are discussed in Section 4. Section 3 discusses the terms for energy auditing as they relate to the FBI program. Draft terms of reference for requesting an audit are provided in Section 5. Sample forms, worksheets and graphs, which may be used in data collection and as deliverables at specific audit levels, are included in the appendices.

The information contained herein should be used as a guide only. Final specifications for requesting an energy audit for your facility should be reviewed with experienced building technicians or qualified engineers. Care should be taken to request the appropriate level of energy audit for the specific system, building or facility to get to the next decision level, to ensure you get the most for your budget.

The FBI program requires two levels of audit: preliminary and detailed. They are presented below as a point of reference to the overall discussion.

3.1 Preliminary Energy Audit

The preliminary audit includes a review of the facility's energy use profiles and an overall assessment of its systems and operation. The preliminary audit provides a summary of energy use, level of current performance and achievable savings, as well as a preliminary list of energy-saving measures and their estimated costs and benefits. It may also provide estimates of available funding through utility incentive programs. The result of the audit will, in most cases, determine whether or not an FBI project is viable. If it is, then the preliminary audit may be used as the basis for the Request for Proposal (RFP). This level

can be classified as a "screening audit," described in greater detail later.

3.2 Detailed Energy Audit

The detailed energy audit includes a comprehensive analysis of the facility's energy use profiles and an exhaustive description of building systems, their operation and level of performance. It reviews the facility's level of engineering and safety standards and codes for occupant comfort. It provides summary recommendations through an implementation plan for achieving the recognized energy-savings potential. These include detailed descriptions of energy-saving measures, and their installation and operation. Other related components of operator training and documentation, monitoring and maintenance may also be included. The plan provided in the detailed energy audit may be used to track the project.

Energy audits may be broken down into levels of complexity and detail. A search of energy-auditing practices of leading professional associations revealed several approaches. The associations included ASHRAE (American Society of Heating, Refrigeration and Air-Conditioning Engineers), IESNA (Illuminating Engineering Society of North America), AEE (Association of Energy Engineers), CAESCO (Canadian Association of Energy Service Companies) and Power Smart.

Energy audits may be categorized by increasing levels of detail, as follows:

- yardstick;
- screening;
- walkthrough; and
- engineering.

They may be further categorized by scope (covering a single system or technology), energy type or types (electric, gas, oil, etc.) and level of interaction among systems or energy types.

Though the first three are classified as preliminary, each is useful in different situations. The yardstick audit is best used as a general indicator of which facilities may have energy-saving potential. A screening audit generally provides enough detail on the facilities to determine whether or not to proceed to the Request for Proposal (RFP) stage. The walkthrough audit provides more detail than is normally required to write an RFP and is generally used by an energy services company (ESCo) to confirm the findings of the preliminary audit and to develop a preliminary list of energy management opportunities (EMOs). An engineering audit, classified as a detailed audit, is conducted after a contract has been awarded and provides the basis for an implementation plan.

Note that in terms of complying with the requirements of the FBI program, both preliminary and detailed audits are required; the screening audit is the minimum required at the preliminary stage. Prospective ESCos generally conduct a walkthrough audit, at their cost, to confirm the findings of the preliminary audit.

Facility managers who do not pursue the energy performance contracting route should be aware that utilities that provide funding assistance for audits generally require at least the level of detail found in the walkthrough audit.

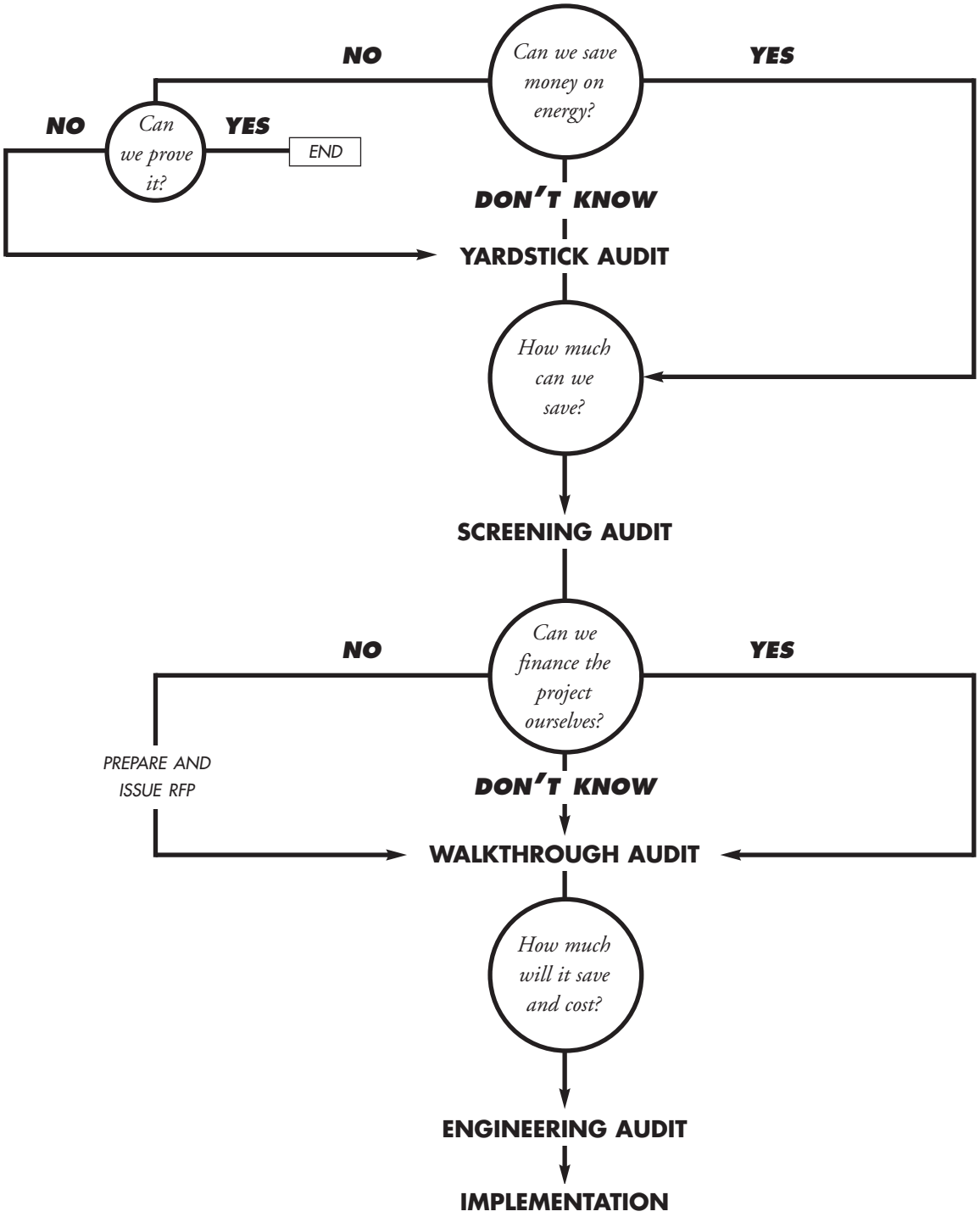
Each of the four types of audits is described on the following pages according to detail, deliverables and costs. The flowchart on page 9 indicates where each level of audit fits into the process of identifying and implementing energy-saving measures in a facility.

4.2 Yardstick Audit

Scope

The yardstick audit is the first step toward reviewing a facility's energy use and energy-saving potential. It is intended to define the building's average energy use in relation to similar buildings. It indicates which season

4.1 Energy Audit Flowchart



dominates the energy profile and with what consistency the load is experienced. It clearly points to areas for further investigation. No measure costing is provided with this level of audit.

Use

Facility managers with little or no baseline information on the energy consumption and demand in their facilities would use a yardstick audit to determine which facilities may have energy-saving potential.

Data Collected

All of the data may be collected at arm's length. This audit provides the minimum amount of technical data, without any details of energy-saving measures, costs or benefits.

Chart I Yardstick Audit Data

DATA	DETAILS
Utility billing data	For each energy type, by month, for the most recent 24 months. Energy units and costs should be provided. These are available from the local utility or the facility's accounting records. Worksheets 1–5 can be used to document this information. Forms 2 and 3 can be used to summarize information.
Building area	Typically net conditioned or net leasable. The architectural drawings or leasing records should provide this data. A history of floor space additions or deletions would also be useful when gauging energy use patterns. Form 1 can be used to document general building information.
Building location annual weather data	Including heating degree-days, cooling degree-days, and wet bulb degree-hours. Other data may include solar radiation and wind speed and direction, but they are not necessary at this stage.
Building energy performance database or reference	Expected energy performance values for specific building types, location and use. Local, provincial, territorial or national databases may be accessed through the local utility, provincial/territorial energy ministry, Natural Resources Canada or Statistics Canada offices.

Chart II Yardstick Audit Deliverables

DELIVERABLE	DESCRIPTION
Building energy performance index (BEPI) in ekWh/m^2/yr. or ekWh/sq.ft./yr.	Form 3 can be used to document this information.
Building energy cost index (BECI) in $/$m^2$/yr. or $/sq.ft./yr.	The costs of all types of energy are combined and divided by the building's area. This provides an average energy cost value for comparison purposes. Form 3 can be used to document this information.
Annual energy profiles by month	Both energy demand and use for different energy types may be tabulated or plotted by month to illustrate a profile. This will indicate seasonal variations. Graph 1 is an example of a monthly plot of total energy use. Graph 2 is an example of a monthly plot of total energy demand.
Summer and winter peak demands	This will be provided for all energy types to determine the dominant season and energy type. This information can be derived from Graph 2.
Data normalization factors	To gauge future changes in building size, energy pricing, building use, operating schedules, weather and other factors.
Estimate of energy savings potential	Comparing the building's BEPI and BECI with the statistical average for the building type, location, and use will indicate any potential energy savings. Although not conclusive, this comparison points in the right direction in most cases. Form 3 can be used to document potential total energy savings.
List of areas of further study based on observations from seasonal peaks, seasonal variations, base load, load factor and power factor	The load and power factors are included in billing data. Load factor indicates the time that the building is at full load and may reveal scheduling opportunities. A cost-saving measure may be identified if a building is being charged for a low power factor.

Time Frame

The time required to perform the yardstick audit is usually not more than a day.

Cost

The cost is in the range of $250 to $500 per audit.

4.3 Screening Audit

Scope

The screening audit represents the level of effort included in the yardstick audit, with additional detail breaking down the energy end-use, technology and operation. The information may be obtained at arm's length without site review. This level of audit helps to better identify and quantify the level of achievable savings through various EMOs without detailing their scope, operation or interaction with other building systems. Very little costing information is provided with this level of audit.

Use

Facility managers who are fairly certain that there are energy-saving opportunities in their facilities and wish to identify and quantify those opportunities would use a screening audit. This level of audit is sufficient for the purposes of issuing an RFP for the FBI program.

Data Collected

It includes all of the data that would be collected in a yardstick audit, plus additional information. All of the data may be collected at arm's length, with the possibility of a short visit to the site.

Chart III Screening Audit Data

DATA	DETAILS
Utility billing data	For each energy type, by month, for the most recent 24 months. Energy units and costs should be provided. These are available from the local utility or the facility's accounting records. Worksheets 1–5 can be used to document this information. Forms 2 and 3 can be used to summarize information.
Building area	Typically net conditioned or net leasable. The architectural drawings or leasing records should provide this data. A history of floor space additions or deletions would also be useful when gauging energy use trends. Form 1 can be used to document general building information.
Building location annual weather data	Including heating degree-days, cooling degree-days, and wet bulb degree-hours. Other data may include solar radiation, and wind speed and direction, but they are not necessary at this stage.
Building energy performance database or reference	Expected energy performance values for specific building types, location and use. Local, provincial, territorial or national databases may be accessed through the local utility, provincial/territorial energy ministry, Natural Resources Canada or Statistics Canada offices.
General description of building systems by end-use, technologies and operating schedules	These may be determined through arm's-length review of technical drawings and operating manuals, including a discussion with the operator. Specific details of each end-use may include types of technologies and the condition and operating schedules of lighting, heating, ventilation and cooling systems. This would be provided in broad terms.

Chart IV Screening Audit Deliverables

DATA	DETAILS
All yardstick deliverables	Expands upon a yardstick audit.
Description of building, building systems and operation	Form 1 and Worksheet 6 can be used to document this information. This may include architectural and mechanical floor plans.
Preliminary end-use breakdown of all energy consumption by use	Form 4 can be used to document this information. Graphs 3–8 are examples of how end-use breakdown can be illustrated (by energy type, total energy, consumption unit and percentage).
Preliminary list of energy management opportunities (EMOs)	Based on typical retrofits and the technologies known to exist in the building.
Preliminary calculations of energy savings and operating benefits derived from EMOs	Should fit with the targeted potential saving derived from the BEPI analysis in the yardstick audit.
Rough estimates of costs	Based on average costs per kWh saved, worked backward to determine probable costs.

Time Frame

The time required to perform the screening audit varies from one to three days.

Cost

The cost is in the range of $500 to $1,500 per audit.

4.4 Walkthrough Audit

Scope

The walkthrough audit represents the level of effort included in the yardstick and screening audits, along with a site visit and interview with the building operator. This audit provides more detailed information and analyses of individual building systems and operation, interaction of systems and first-hand observations of overall building condition. The walkthrough audit provides a complete list of EMOs, with a high level of technical detail and preliminary costing. Final engineering design and budgets are not provided.

Use

This level of audit is generally used by an ESCo interested in responding to an RFP. It enables the ESCo to verify any information provided by the preliminary audit. This level of audit is generally required by utilities that co-fund energy audits.

Data Collected

The data is collected by means of a site visit and discussions with relevant personnel (facility managers and operators). Appendix C (pp. 44–59) contains sample worksheets indicating the level of information.

Chart V Walkthrough Audit Data

DATA	DETAILS
All data in screening audit	Expands upon a screening audit.
Building shape, size, orientation and location	See Worksheet 7 for level of detail.
Building envelope details and condition	See Worksheet 7 for level of detail.
Electrical and mechanical equipment condition and performance, including load inventory	See Worksheet 7 for level of detail. See Worksheets 8–11 for load inventory.
Controls or automation type, condition, status and set-up (programming)	See Worksheet 7 for level of detail.
Operating procedures and approach undertaken and understood by the building operator	Refers to level of responsibility, skill and aptitude of energy management.

Chart VI Walkthrough Audit Deliverables

DATA	DETAILS
All screening deliverables	Expands upon a screening audit.
Complete list of energy management opportunities (EMOs)	Based on typical retrofits and the technologies known to exist in the building.
Detailed calculations of energy savings and operating benefits derived from EMOs	This includes single EMOs as well as combinations, where applicable.
Preliminary engineering designs	For EMO installation and interfacing with other building systems and EMOs.
Preliminary estimates of costs	For all EMOs and combinations of EMOs. Typical measures and average costs per measure are totalled to estimate cost.
Suggestions for improvements in operating procedures	Including training of building operator, improved monitoring systems and better documentation.

Time Frame

The time required to perform the walkthrough audit varies from three to 10 days.

Cost

The cost is in the range of $1,500 to $5,000 per audit.

4.5 Engineering Audit

Scope

The engineering audit includes the information obtained in the yardstick, screening and walkthrough audits, along with detailed engineering alternatives, cost/benefit analyses and summary recommendations. The engineering audit provides the most comprehensive report on the current state of energy managing potential for the building. It may be used to fully understand the building's make-up and operation, as well as its potential for energy management opportunities. This audit provides enough information to constitute a full implementation plan. It will provide the basis for tender documents, scheduling, commissioning and monitoring of savings and costs.

Use

Upon contract award, an ESCo will conduct an engineering audit in order to develop a detailed implementation plan for energy management opportunities.

Data Collected

The ESCo will build upon the data collected in the walkthrough audit. At this level, information gathering is extensive, and each ESCo will have its own method of recording data and observations. Therefore, no sample worksheets or graphs have been included in the appendices.

Chart VII Engineering Audit Data

DATA	DETAILS
All data in walkthrough audit	Expands upon a walkthrough audit.
Site visit(s) and interview(s)	With building operators, building managers, design engineers, service contractors and equipment suppliers to obtain specific information on building systems, operation and interfacing of proposed retrofit systems and operating procedures.
Detailed (as-built) building drawings	If available, including architectural, mechanical and electrical drawings.
Detailed building operation guides	If available, including mechanical, electrical and control systems, and log sheets for heating and cooling plants.
Measurements and monitoring of systems' performance and efficiency	Including heating plant, cooling plant, distribution systems, ventilation systems, HVAC systems, lighting systems and control systems.
Records of building systems' changes and problems in overall operation	Including increasing electrical loads, alterations, additions or use changes, and concerns over indoor air quality, power quality or environmental quality.
Budgeting constraints and information related to available financing or funding	By or for the owner.

Chart VIII Engineering Audit Deliverables

DELIVERABLE	DESCRIPTION
All walkthrough deliverables	Expands upon a walkthrough audit.
Summary discussions of other building operation and design personnel	Interviews and operating logs.
Final calculations of energy savings and operating benefits derived from EMOs	Including computer simulations when used.
Final engineering designs for EMO installation and interfacing with other building systems and EMOs	This may include computer-aided design (CAD) schematics of systems to detail sequence of operation or installation, or of floor plans to detail equipment location and system servicing requirements.
Detailed estimate of all costs associated with the project	For management, tendering, engineering, equipment, installation, commissioning and monitoring costs, and possibly financing, especially through energy savings.

Time Frame

The time required to perform the engineering audit varies from 10 to 50 days.

Cost

The cost is in the range of $5,000 to $50,000 per audit.

4.6 Summary Chart

ENERGY AUDIT	LEVEL	WHEN TO CONDUCT	TIME TO COMPLETE (DAYS)	COST
Yardstick	*Preliminary:* Minimum technical data and analysis, energy demand and use profiles, indication of potential.	Basic data gathering to identify buildings which may or may not have energy-saving potential.	0.5 to 1	$250 to $500
Screening	*Preliminary:* End-use breakdowns, possible energy-saving opportunities, preliminary savings estimates.	Level of audit generally required to prepare Request for Proposal (RFP) for Energy Performance Contracting (FBI program).	1 to 3	$500 to $1,500
Walkthrough	*Preliminary:* System type and equipment information, specific savings opportunities identified, preliminary costs and savings.	Prior to bidding on RFP. Conducted and paid for by prospective ESCo.	3 to 10	$1,500 to $5,000
Engineering	*Detailed:* Extensive data gathered, modelling, simulation; leads to detailed implementation plan with drawings and specifications.	ESCo that wins contract conducts detailed audit to develop implementation plan.	10 to 50	$5,000 to $50,000

This section summarizes the four levels of energy audit in terms of general specifications. Draft terms of reference are listed for both data requirements and deliverables expected and may be used as a starting point by facility managers.

5.1 Yardstick Audit

Data Requirements

The contractor shall obtain the following:

- Utility billing data for each energy type and month for the most recent 24 months. Energy units and costs should be obtained in all cases.
- Building area (typically the net conditioned or net leasable area). The building's architectural drawings, leasing records or direct measurement should be used to source this data.
- Site-specific annual weather data, including heating degree-days, cooling degree-days and wet bulb degree-hours. Other data may include solar radiation and wind speed and direction, if these are major factors in the performance of this type of facility.
- A building energy performance database or reference for similar building types, location and use.

Deliverables

The contractor shall provide the following:

- A building energy performance index (BEPI) – in equivalent kilowatt hours per square metre per year or equivalent kilowatt hours per square foot per year – for each building in the facility. All energy types shall be combined using common units and divided by the building's conditioned floor area.
- A building energy cost index (BECI) in dollars per square metre per year or dollars per square foot per year. All forms of energy costs shall be combined and divided by the building's area.
- Total building annual energy profiles by month for a period of 24 months. Both energy demand and use for different energy types shall be tabulated and plotted by month to illustrate a profile. The contractor shall provide a discussion on seasonal peaks and variations.
- Summaries of summer and winter peak demands. This shall be provided for all energy types, along with a discussion on the dominant season and energy type.
- A summary of energy use data normalization factors as the basis for gauging future changes in building size, energy pricing, building use, operating schedules, weather and any other building energy determining factors.
- An estimate of energy-saving potential using the building's BEPI and BECI with the statistical average for building type, location and use.
- A list of areas for further study based on observations from seasonal peaks, seasonal variations, base load, load factor and power factor, as determined from utility billing data.

5.2 Screening Audit

Data Requirements

The contractor shall obtain the following:

- Utility billing data for each energy type and month for the most recent 24 months. Energy units and costs should be obtained in all cases.
- Building area (typically the net conditioned or net leasable area). The building's architectural drawings, leasing records or direct measurement should be used to source this data.
- Site-specific annual weather data, including heating degree-days, cooling degree-days and wet bulb degree-hours. Other data may include solar radiation and wind speed and direction, if these are major factors in the performance of this type of facility.

- A building energy performance database or reference for similar building types, location and use.
- A general description of building systems by end-use, technologies and operating schedules. These may be determined through an arm's-length review of technical drawings and operating manuals, including a discussion with the building's operator. Specific details of each end-use may include types of technologies, condition and operating lighting, schedules, ventilation and heating and cooling systems. This may be provided in broad terms.

Deliverables

The contractor shall provide the following:

- A building energy performance index (BEPI) – in equivalent kilowatt hours per square metre per year or equivalent kilowatt hours per square foot per year – for each building in the facility. All energy types shall be combined using common units and divided by the building's conditioned floor area.
- A building energy cost index (BECI) in dollars per square metre per year or dollars per square foot per year. All forms of energy costs shall be combined and divided by the building's area.
- Total building annual energy profiles by month for a period of 24 months. Both energy demand and use for different energy types shall be tabulated and plotted by month to illustrate a profile. The contractor shall provide a discussion on seasonal peaks and variations.
- Summaries of summer and winter peak demands. This shall be provided for all energy types, along with a discussion on the dominant season and energy type.
- A summary of energy use data normalization factors as the basis for gauging future changes in building size, energy pricing, building use, operating schedules, weather and any other building energy determining factors.
- An estimate of energy-saving potential using the building's BEPI and BECI with the statistical average for building type, location and use.
- A list of areas for further study based on observations from seasonal peaks, seasonal variations, base load, load factor and power factor, as determined from utility billing data.
- A description of the building, building systems and operation.
- A preliminary end-use breakdown of all energy consumption by use.
- A preliminary list of energy management opportunities (EMOs) based on typical retrofits and the technologies known to exist in the building.
- Preliminary calculations of energy savings and operating benefits derived from EMOs. These should fit with the targeted potential savings derived from the BEPI analysis in the yardstick audit.
- Rough estimates of costs.

5.3 Walkthrough Audit

Data Requirements

The contractor shall perform the following tasks:

- Obtain utility billing data for each energy type and month for the most recent 24 months. Energy units and costs should be obtained in all cases.
- Obtain building area (typically the net conditioned or net leasable area). The building's architectural drawings, leasing records or direct measurement should be used to source this data.
- Obtain site-specific annual weather data, including heating degree-days, cooling degree-days and wet bulb degree-hours. Other data may include solar radiation and wind speed direction, if these are major factors in the performance of this type of facility.
- Obtain a building energy performance database or reference for similar building types, location and use.
- Conduct a site visit and interview with the building operator to obtain specific information, including the following:
  - building shape, size, orientation and location data;
  - building envelope details and condition;
  - electrical and mechanical equipment condition and performance, including load inventory;
  - controls or automation type, condition, status and set-up (programming); and
  - operating procedures and attitudes undertaken and understood by the building operator.

Deliverables

The contractor shall provide the following:

- A building energy performance index (BEPI) – in equivalent kilowatt hours per square metre per year or equivalent kilowatt hours per square foot per year – for each building in the facility. All energy types shall be combined using common units and divided by the building's conditioned floor area.
- A building energy cost index (BECI) in dollars per square metre per year or dollars per square foot per year. All forms of energy costs shall be combined and divided by the building's area.
- Total building annual energy profiles by month for a period of 24 months. Both energy demand and use for different energy types shall be tabulated and plotted by month to illustrate a profile. The contractor shall provide a discussion on seasonal peaks and variations.
- Summaries of summer and winter peak demands. This shall be provided for all energy types, along with a discussion on the dominant season and energy type.
- A summary of energy use data normalization factors as the basis for gauging future changes in building size, energy pricing, building use, operating schedules, weather and any other building energy determining factors.
- An estimate of energy-saving potential using the building's BEPI and BECI with the statistical average for building type, location and use.
- A description of the building, building systems and operation.
- A complete list of energy management opportunities (EMOs) based on typical retrofits and the technologies known to exist in the building.
- Detailed calculations of energy savings and operating benefits derived from EMOs. This includes single EMOs as well as combinations, where applicable.
- Preliminary engineering designs for EMO installation and interfacing with other building systems and EMOs.
- Preliminary estimates of costs for all EMOs and combinations of EMOs.
- Suggestions for improvements in operating procedures, including training of building operator, improved monitoring systems and better documentation.

5.4 Engineering Audit

Data Requirements

The contractor shall perform the following tasks:

- Obtain utility billing data for each energy type and month for the most recent 24 months. Energy units and costs should be obtained in all cases.
- Obtain building area (typically the net conditioned or net leasable area). The building's architectural drawings, leasing records or direct measurement should be used to source this data.
- Obtain site-specific annual weather data, including heating degree-days, cooling degree-days and wet bulb degree-hours. Other data may include solar radiation and wind speed direction, if these are major factors in the performance of this type of facility.
- Obtain a building energy performance database or reference for comparable building types, location and use.
- Conduct one or more site visits and interviews with building operators, building managers, design engineers, service contractors and equipment suppliers to obtain specific information on building systems and operation and interfacing of proposed retrofit systems and operating procedures.
- Obtain and review detailed (as-built) building drawings, if available, including architectural, mechanical and electrical drawings.
- Obtain and review detailed building operation guides, if available, including mechanical, electrical and control systems and log sheets for heating and cooling plants.
- Obtain measurements and monitoring of systems' performance and efficiency, including heating plant, cooling plant, distribution systems, ventilation systems, heating, ventilation and air conditioning (HVAC) systems, lighting systems and control systems.
- Obtain and review records of building systems' changes and problems in overall operation, including increasing electrical loads, alterations, additions or use changes and concerns over indoor air quality, power quality or environmental quality.

- Examine and confirm budgeting constraints and information related to available financing or funding, by or for the owner.

Deliverables

The contractor shall

- Provide a building energy performance index (BEPI) – equivalent kilowatt hours per square metre per year or equivalent kilowatt hours per square foot per year – for each building in the facility. All energy types shall be combined using common units and divided by the building's conditioned floor area.
- Provide a building energy cost index (BECI) in dollars per square metre per year or dollars per square foot per year. All forms of energy costs shall be combined and divided by the building's area.
- Provide total building annual energy profiles by month for a period of 24 months. Both energy demand and use for different energy types shall be tabulated and plotted by month to illustrate a profile. The contractor shall provide an analysis of seasonal peaks and variations.
- Provide summaries of summer and winter peak demands. This shall be provided for all energy types, along with an analysis of the dominant season and energy type.
- Provide a summary of energy use data normalization factors as the basis for gauging future changes in building size, energy pricing, building use, operating schedules, weather and any other building energy determining factors.
- Provide an estimate of energy-saving potential using the building's BEPI and BECI with the statistical average for building type, location and use.
- Provide a description of the building, building systems and operation.
- Provide a complete list of EMOs based on typical retrofits and the technologies known to exist in the building.
- Provide detailed calculations of energy savings and operating benefits derived from EMOs. This includes single EMOs as well as combinations, where applicable.
- Provide preliminary engineering designs for EMO installation and interfacing with other building systems and EMOs.
- Provide preliminary estimates of costs for all EMOs and combinations of EMOs.
- Provide suggestions for improvements in operating procedures, including training of building operator, improved monitoring systems and better documentation.
- Summarize discussions with other building operation and design personnel.
- Provide final calculations of energy savings and operating benefits derived from EMOs, including computer simulations when used.
- Provide final engineering designs for EMO installation and interfacing with other building systems and EMOs. This may include computer-aided design (CAD) schematics of systems to detail the sequence of operation or installation, or floor plans to detail equipment location and system servicing requirements.
- Provide detailed estimates of all costs associated with the project, including management, tendering, engineering, equipment, installation, commissioning and monitoring, and possibly financing, especially through energy savings.

Canada. Natural Resources Canada. "*Dollars to $ense*": *Energy Monitoring and Tracking.* Workshop No. 2. For more information, call (613) 996-6585 or visit the OEE Web site at http://oee.nrcan.gc.ca.

———. *"Dollars to $ense": Spot the Energy Savings.* Workshop No. 3. For more information, call (613) 996-6585 or visit the OEE Web site at http://oee.nrcan.gc.ca.

———. *Energy Audits Software Directory 1997*. Cat. No. M27-01-570E. Ottawa: Minister of Public Works and Government Services Canada, 1997.

———. *Managing Energy Performance Contracts in Federal Buildings,* prepared by Cowan Quality Buildings. Cat. No. M92-84/1994E. Ottawa: The Canadian Association of Energy Services Companies, 1994.

Capehart, Barney L., et al. *Guide to Energy Management*. 3rd ed. Association of Energy Engineers (AEE) Order Code: 0463. Lilburn, GA: Fairmont Press, 2001.

Fardo, Stephen, et al. *Energy Conservation Guidebook*. AEE Order Code: 0310. Lilburn, GA: Fairmont Press, 1993.

Pedersen, Curtis, et al. *Cooling and Heating Load Calculation Principles*. Atlanta, GA: American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE), 1998.

Stein, Benjamin, and John S. Reynolds. *Mechanical and Electrical Equipment*. 9th ed. New York: J. Wiley & Sons, 1999.

Thumman, Albert, P.E., C.E.M. *Handbook of Energy Audits*. 5th ed. AEE Order Code: 0415. Lilburn, GA: Fairmont Press, 1998.

Turner, Wayne C. *Energy Management Handbook*. 4th ed. AEE Order Code: 0477. Lilburn, GA: Fairmont Press, 2001.

United States. American Institute of Industrial Engineers. *Instructions for Energy Auditors*. National Technical Information Services (NITS) Order No. DOE/CS-0135. Washington, D.C.: United States Department of Energy (DOE), 1978.

Wendes, Herbert C., P.E. *HVAC Energy Audit and Balancing Forms Manual*. AEE Order Code: 0367. Lilburn, GA: Fairmont Press, 1995.

Zeits, Ronald A., ed. *CIBO Energy Efficiency Handbook*. Burke, VA: Council of Industrial Boiler Owners (CIBO), 1997.

Appendices (worksheets, forms and graphs)

The following appendices contain worksheets, forms and graphs that may be useful to facility managers for collecting and summarizing energy data on their facilities. The appendices also provide an idea of the format in which certain deliverables may be presented. The list is not conclusive, but it provides a facility manager with a good understanding of the level and format of information required at each audit level.

APPENDIX A Yardstick Data and Deliverables

	Title	Purpose
Worksheet 1	Electricity Worksheet	Record of electricity usage
Worksheet 2	Gas Worksheet	Record of gas usage
Worksheet 3	Fuel Oil Worksheet	Record of fuel oil usage
Worksheet 4	Steam Worksheet	Record of steam usage
Worksheet 5	Water Worksheet	Record of water usage
Form 1	Building Characteristics	Summary of information
Form 2	Current Energy Use Summary	Summary of all energy use
Form 3	Summary of Annual Energy Savings Potential	Summary of BEPI and BECI
Graph 1	Total Energy Use	Summary by month
Graph 2	Total Energy Demand	Summary by month

APPENDIX B Screening Data and Deliverables

	Title	Purpose
Worksheet 6	Building Occupancy Schedule	Record information
Form 4	Components of Annual Energy Use	Summary of end-use
Graph 3	Electrical End-Use Profile	In energy units
Graph 4	Fuel End-Use Profile	In energy units
Graph 5	Electrical End-Use Breakdown	In percentages
Graph 6	Fuel End-Use Breakdown	In percentages
Graph 7	Total Energy End-Use Breakdown	In percentages
Graph 8	Total Energy Use for a Typical Building	Illustrative

APPENDIX C Walkthrough Data and Deliverables

	Title	Purpose
Worksheet 7	Building Information	Detailed record
Worksheet 8	Simple Load Inventories (Lighting, Electrical Heat, Office Equipment)	For known kW
Worksheet 9	Detailed Load Inventories (Current/Voltage Method)	For unknown kW
Worksheet 10	Detailed Load Inventories (Motor Load Method)	For unknown kW or amps/volts
Worksheet 11	Summary of Load Inventories	By use
Form 5	Total Load Inventory	Summary of loads by lighting, HVAC, etc.
Graphs 9.1–9.3	Piqua Mall Analysis – Energy Use – Comparison to Industry – Demand Profile	Progression of data analysis through audit levels

Appendix A

YARDSTICK AUDIT Worksheet 1

Electricity Worksheet

METER NO. _____
LOCATION _____
PROVINCE _____
ENERGY USE PERIOD _____
OPERATION _____

MONTH	CONSUMPTION (kWh)	MEASURES (DEMAND kW)	RATE	BILLED DEMAND	COST	18°C HEATING DAYS	18°C COOLING DAYS	kWh INCREASE OVER PAST YEAR	COST INCREASE OVER PAST YEAR
Jan.									
Feb.									
Mar.									
Apr.									
May									
June									
July									
Aug.									
Sept.									
Oct.									
Nov.									
Dec.									
Total									

YARDSTICK AUDIT Worksheet 2

Gas Worksheet

METER NO. _____
LOCATION _____
PROVINCE _____
ENERGY USE PERIOD _____
OPERATION _____

MONTH	CONSUMPTION (M^3)	RATE	COST	18°C HEATING DAYS	18°C COOLING DAYS	M^3 INCREASE OVER PAST YEAR	COST INCREASE OVER PAST YEAR
Jan.							
Feb.							
Mar.							
Apr.							
May							
June							
July							
Aug.							
Sept.							
Oct.							
Nov.							
Dec.							
Total							

YARDSTICK AUDIT Worksheet 3

Fuel Oil Worksheet

METER NO. _____
LOCATION _____
PROVINCE _____
ENERGY USE PERIOD _____
OPERATION _____

MONTH	CONSUMPTION (LITRES)	RATE	COST	18°C HEATING DAYS	18°C COOLING DAYS	LITRES INCREASE OVER PAST YEAR	COST INCREASE OVER PAST YEAR
Jan.							
Feb.							
Mar.							
Apr.							
May							
June							
July							
Aug.							
Sept.							
Oct.							
Nov.							
Dec.							
Total							

YARDSTICK AUDIT Worksheet 4

Steam Worksheet

METER NO. _____
LOCATION _____
PROVINCE _____
ENERGY USE PERIOD _____
OPERATION _____

MONTH	CONSUMPTION (KG)	RATE	COST	18°C HEATING DAYS	18°C COOLING DAYS	KG INCREASE OVER PAST YEAR	COST INCREASE OVER PAST YEAR
Jan.							
Feb.							
Mar.							
Apr.							
May							
June							
July							
Aug.							
Sept.							
Oct.							
Nov.							
Dec.							
Total							

YARDSTICK AUDIT Worksheet 5

Water Worksheet

METER NO. _____
LOCATION _____
PROVINCE _____
ENERGY USE PERIOD _____
OPERATION _____

MONTH	CONSUMPTION (LITRES)	RATE	COST	18ºC HEATING DAYS	18ºC COOLING DAYS	LITRES INCREASE OVER PAST YEAR	COST INCREASE OVER PAST YEAR
Jan.							
Feb.							
Mar.							
Apr.							
May							
June							
July							
Aug.							
Sept.							
Oct.							
Nov.							
Dec.							
Total							

YARDSTICK AUDIT Form 1

Building Characteristics

BUILDING NAME _____
LOCATION _____
NUMBER OF FLOORS ABOVE GRADE _____
NUMBER OF FLOORS BELOW GRADE _____

GROSS CONDITIONED AREA (m^2) _____

All floor area contained within the outside finished surface of permanent outer building walls, including basements, mechanical equipment floors and penthouses (ANSI Standard Z65.1-1980, "Construction Area"). No exclusions are made for shafts, stairs or atria. Conditioned area is that area provided with heating or cooling to maintain temperature between 10°C and 30°C (ANSI/ASHRAE Standard 105-1984 [Ra90]).

YEAR OF CONSTRUCTION for at least 51% of area _____

BUILDING TYPE (Show approximate % of area by major type. No type <25% of total area.)

_____ Office
_____ Accommodation – Bachelor
_____ Accommodation – Single Family
_____ Accommodation – Multi-Family
_____ Hotel
_____ Primary School
_____ Secondary School
_____ University
_____ Multi-Building Campus
_____ Food Service – Mass Cooked
_____ Food Service – Individually Cooked
_____ Nursing Home
_____ Psychiatric Hospital
_____ Clinic
_____ Active Treatment Hospital
_____ Detention
_____ Greenhouse
_____ Supermarket
_____ General Merchandise
_____ Conditioned Parking Garage
_____ Vehicle Service Garage
_____ Aircraft Hangar
_____ Laboratory
_____ Manufacturing – Describe _____
_____ Warehouse – Non-refrigerated
_____ Warehouse – Refrigerated
_____ Airport Terminal
_____ Railway Terminal
_____ Marine Terminal
_____ Museum/Gallery
_____ Ice Arena
_____ Arena – No Ice
_____ Other Assembly – Describe _____
_____ Other _____

OCCUPANCY PERIOD: Average Hours/Week _____ Average Weeks/Year _____
(Occupancy for at least 51% of the space)

AVERAGE NUMBER OF OCCUPANTS DURING OCCUPANCY PERIOD _____

UTILITY TYPES (Name utilities serving more than 5% of the following end-uses)

Heating _____
Air Conditioning _____
Domestic Hot Water _____
Kitchen _____
Laundry _____
Other Processes _____

SPECIAL LOADS (e.g., pool indoor/outdoor, computer centre) _____

YARDSTICK AUDIT Form 2

Current Energy Use Summary

BUILDING _____
AREA (m^2) _____ (A)
PERIOD: From _____ to _____

ENERGY TYPE	TOTAL ANNUAL USE (365 DAYS)	UNITS	CONVERSION FACTOR TO ekWh	ANNUAL ekWh (365 DAYS)	TOTAL ANNUAL COST
Electricity Consumption					$
Natural Gas					$
Oil No. _____					$
Steam					$
Hot Water					$
Propane					$
Coal					$
Chilled Water					$
Other _____					$
Total				(E)	(C)

Average of 12 months' Peak Electrical Demands (kW): _____(D)

Annual Water Consumption (m^3): _____(W)

ENERGY INDEX:	(E/A)	_____	ekWh/m^2/yr.
DEMAND INDEX:	(D x 1000/A)	_____	watts/m^2
ENERGY COST INDEX:	(C/A)	_____	$/$m^2$/yr.
WATER INDEX:	(W/A)	_____	m^3/m^2/yr.

CONVERSION MULTIPLIERS TO EQUIVALENT KILOWATT HOURS (EKWH)		
Natural Gas	*MCF*	*302.00*
(1000 Btu/m³)	*Cubic Metres*	*10.70*
No. 2 Oil	*Litres*	*10.80*
	Imperial Gallons	*48.90*
No. 6 Oil	*Litres*	*11.90*
	Imperial Gallons	*52.20*
Propane	*Litres*	*7.09*
	Imperial Gallons	*32.20*
Steam (no condensate)	*1000 lbs.*	*293.00*
Coal	*1000 Short tons –*	
	Bituminous	*8.10*
	Subbituminous	*5.50*
	Metallurgical	*7.30*

YARDSTICK AUDIT Form 3

Summary of Annual Energy Savings Potential

BUILDING _____

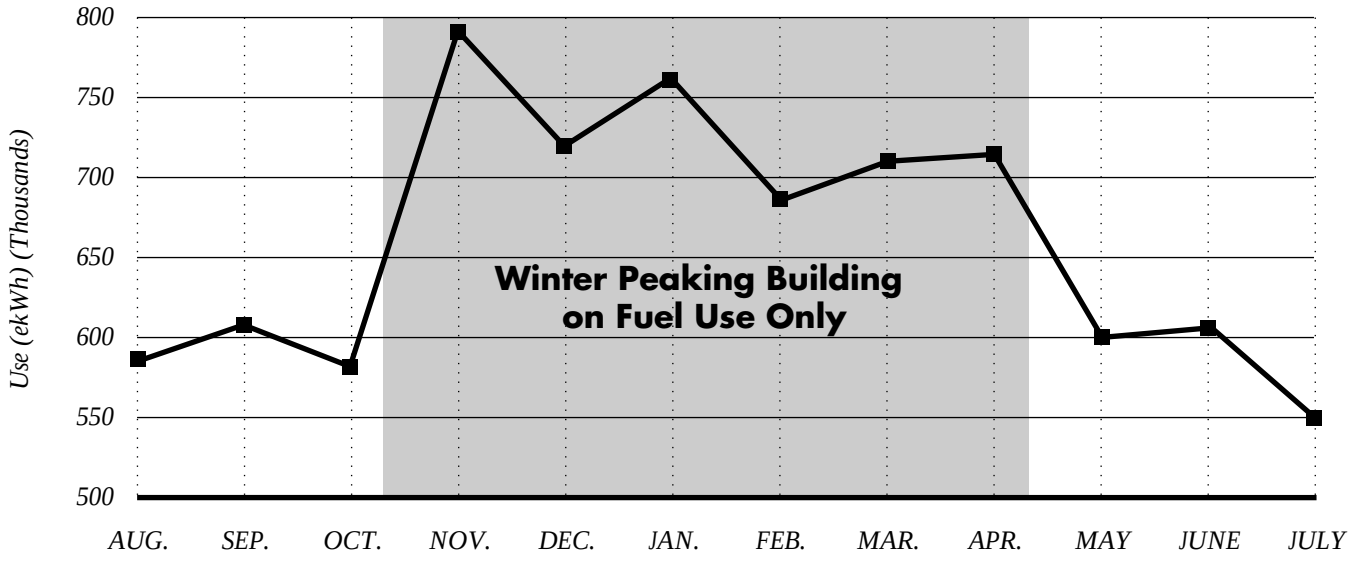
	ELECTRIC DEMAND INDEX (watts/m²)	ENERGY INDICES (ekWh/m²/yr.)			COST INDICES ($/m²/yr.)			TOTAL ANNUAL COST $
		ELECTRICITY	FUEL	TOTAL	ELECTRICITY	FUEL	WATER	
Current Annual Use (C)								
Budget Annual Use [1] (B)								
Savings Potential (C – B)								

[1] *Based on Building Energy Performance Index and Building Energy Cost Index*

YARDSTICK AUDIT Graph 1

TYPICAL OFFICE BUILDING, VANCOUVER

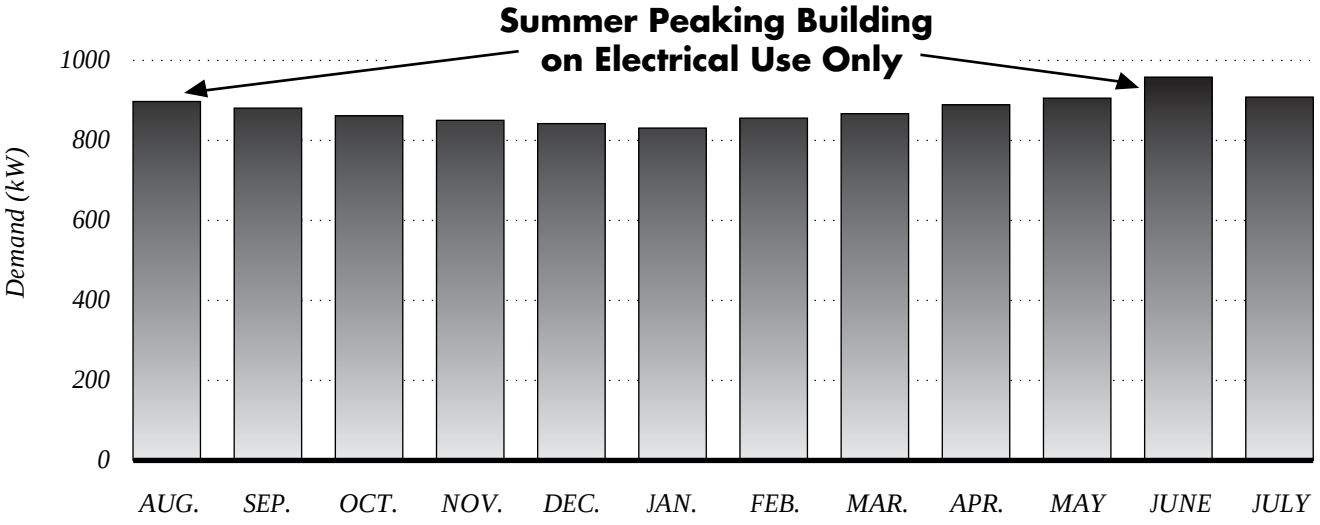
Total Energy Use



YARDSTICK AUDIT Graph 2

TYPICAL OFFICE BUILDING, VANCOUVER

Total Energy Demand



Appendix B

SCREENING AUDIT Worksheet 6

Building Occupancy Schedule

DATE ____________________

PREAPARED BY ____________________

PROJECT NO. ____________________

JOB NAME			WEEKDAYS			SATURDAYS			SUNDAYS/HOLIDAYS		
AREA SERVED	GROSS (m^2)	SYSTEM SERVING	NO. OF OCCUPANTS	OCCUPANCY TIME A.M.	OCCUPANCY TIME P.M.	NO. OF OCCUPANTS	OCCUPANCY TIME A.M.	OCCUPANCY TIME P.M.	NO. OF OCCUPANTS	OCCUPANCY TIME A.M.	OCCUPANCY TIME P.M.

SCREENING AUDIT Form 4

Components of Annual Energy Use

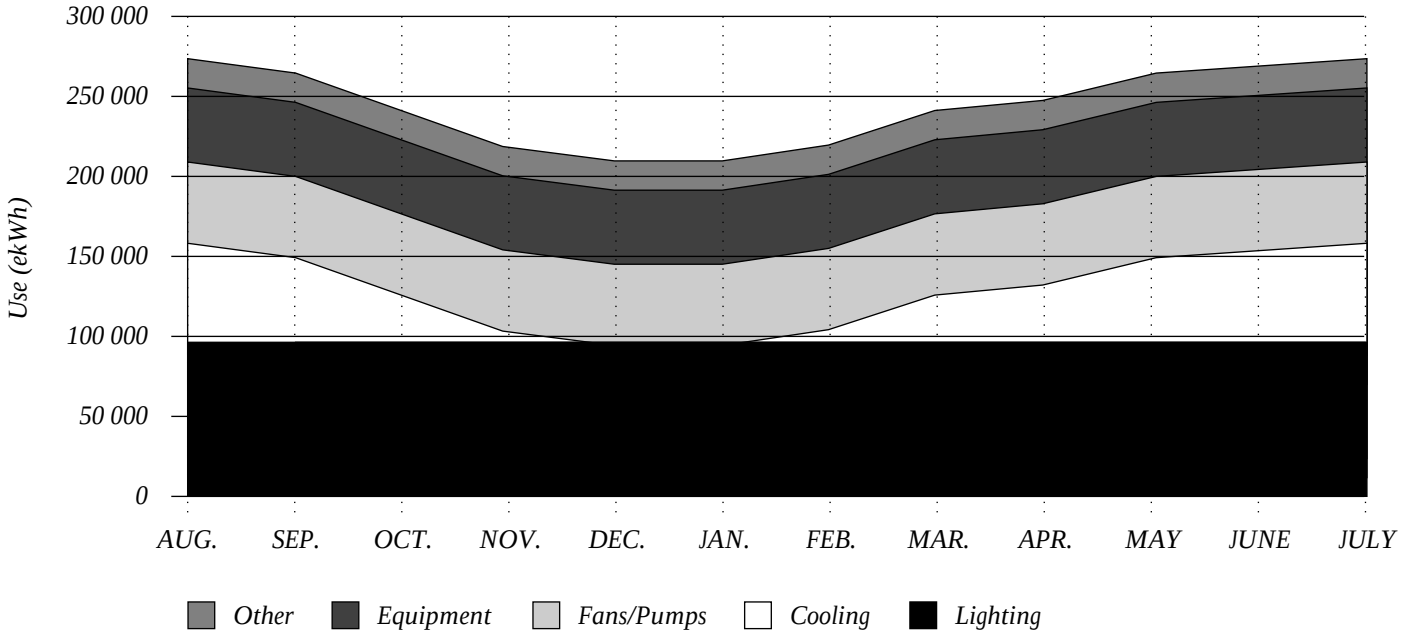
BUILDING _____

	ELECTRIC DEMAND (kW AVG)	ELECTRICITY (kWH)	FUEL (EKWH)	OTHER (EKWH)	TOTAL COST $	% OF TOTAL COST
Space Heating						
Space Cooling						
Fans						
Pumps						
DHW Generation						
Lighting in Conditioned Space						
Lighting Outside Conditioned Space						
Receptacles						
Kitchen						
Laundry						
Lab Equipment						
Conveyance						
Other _____						
Unaccounted						
Total	***Average***				***$***	***100%***

SCREENING AUDIT Graph 3

TYPICAL OFFICE BUILDING, VANCOUVER

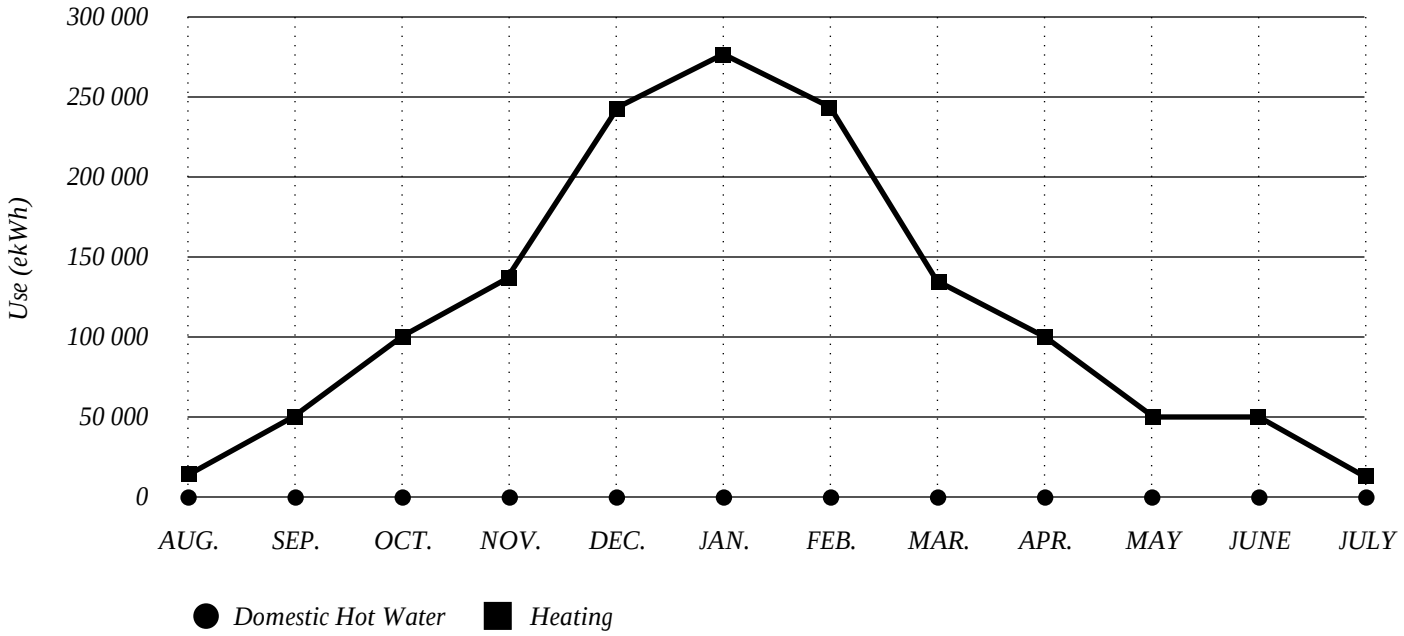
Electrical End-Use Profile



SCREENING AUDIT Graph 4

TYPICAL OFFICE BUILDING, VANCOUVER

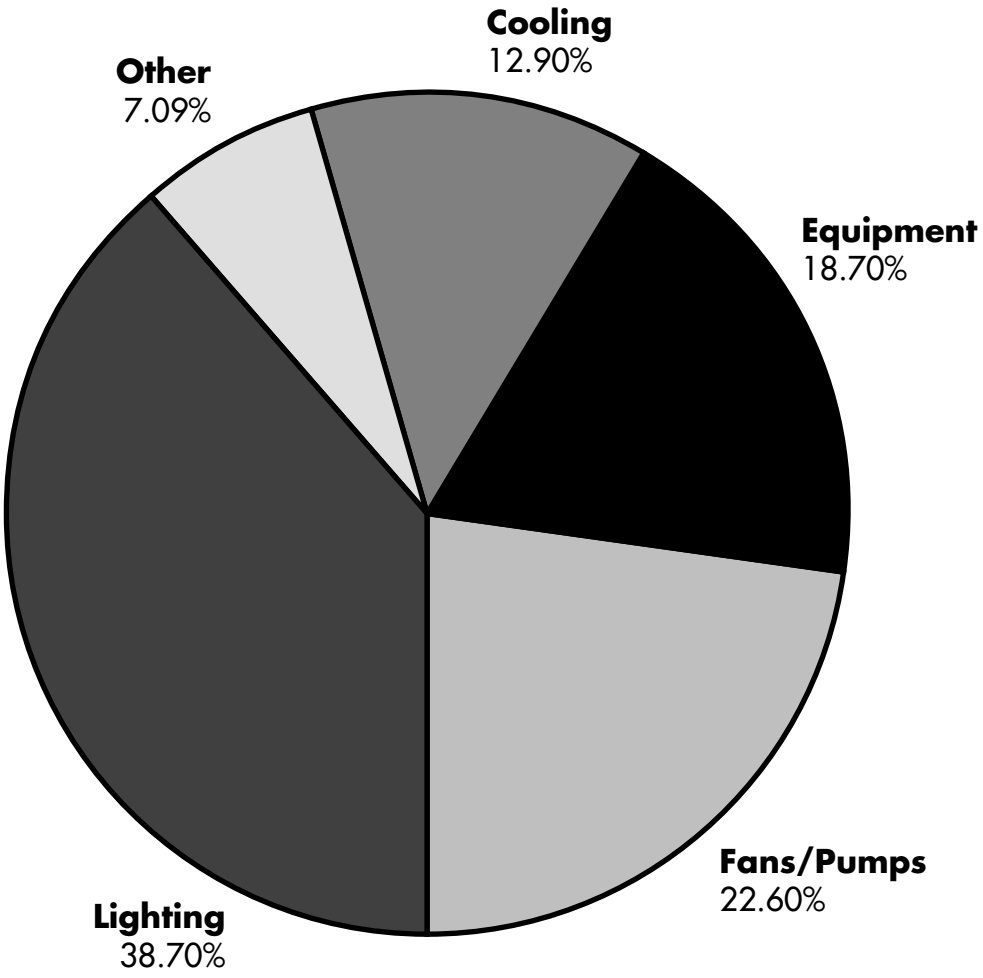
Fuel End-Use Profile



SCREENING AUDIT Graph 5

TYPICAL OFFICE BUILDING, VANCOUVER

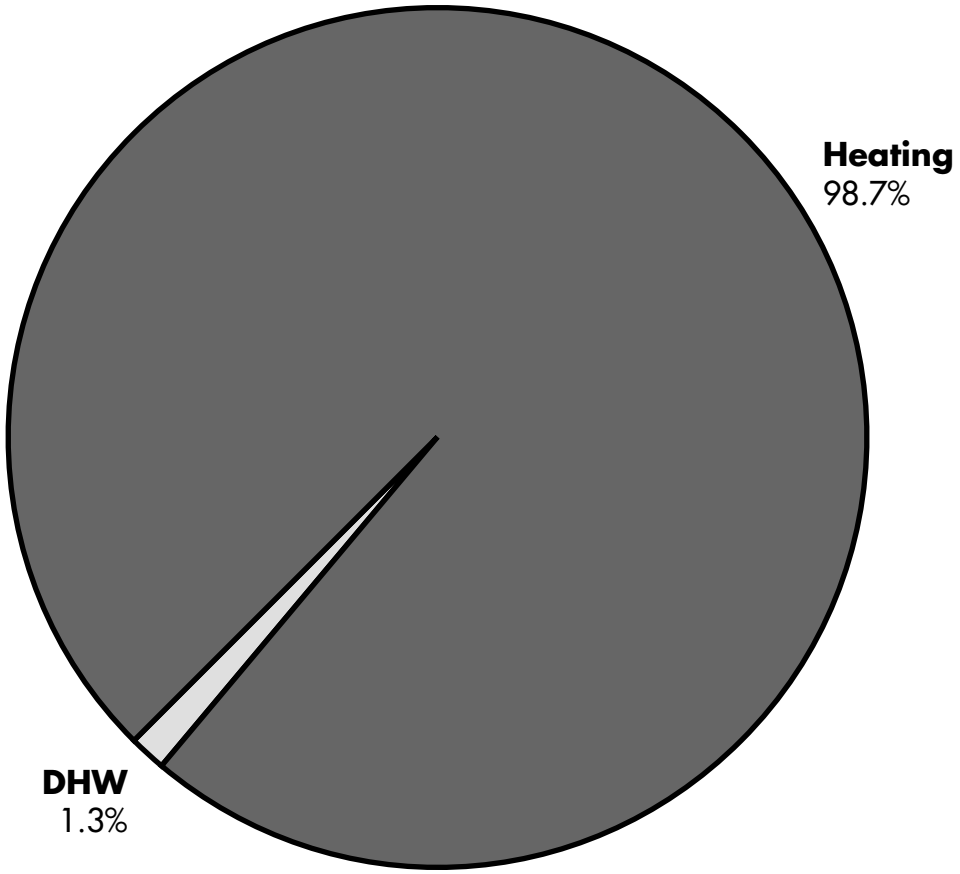
Electrical End-Use Breakdown



SCREENING AUDIT Graph 6

Fuel End-Use Breakdown

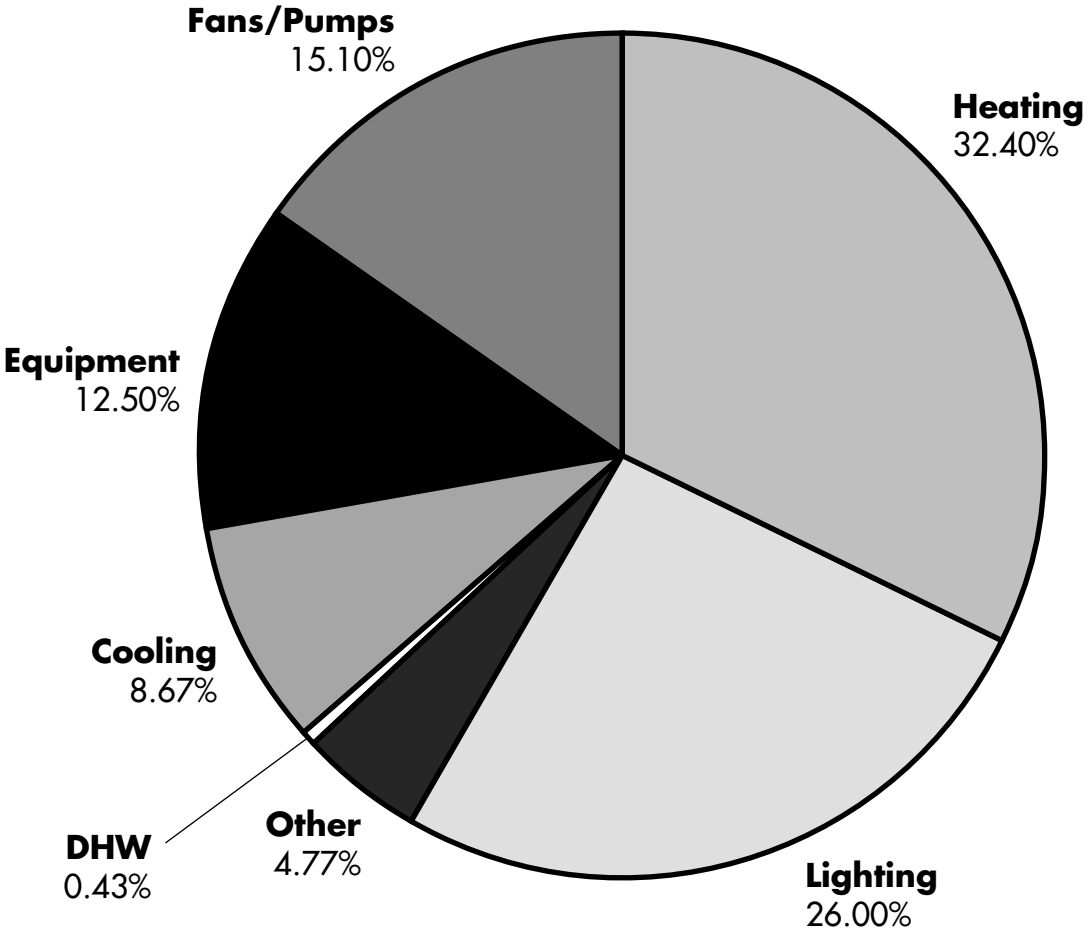
TYPICAL OFFICE BUILDING, VANCOUVER



SCREENING AUDIT Graph 7

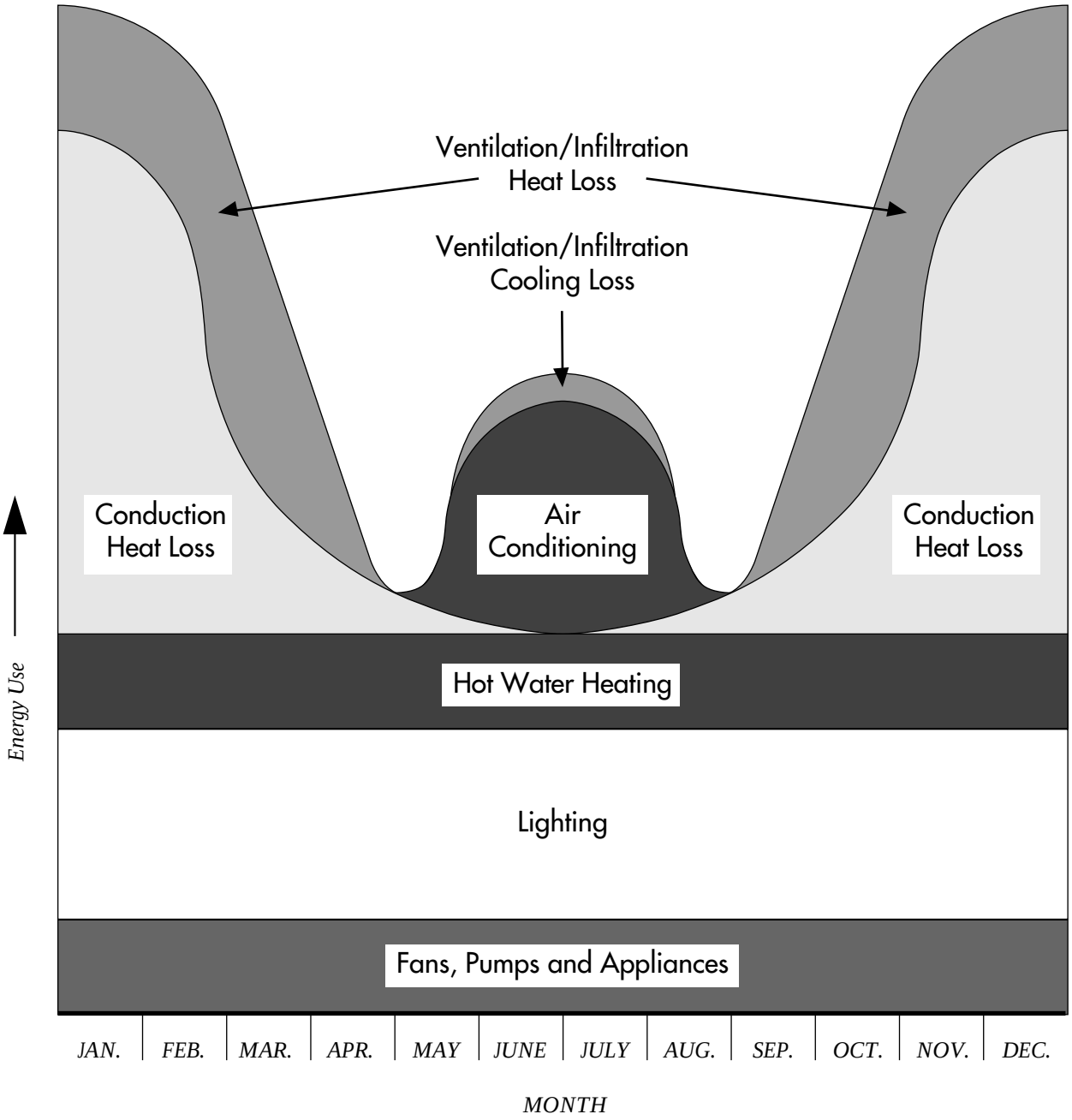
TYPICAL OFFICE BUILDING, VANCOUVER

Total Energy End-Use Breakdown



SCREENING AUDIT Graph 8

Total Energy Use for a Typical Building



Appendix C

WALKTHROUGH AUDIT Worksheet 7

SURVEYED BY _____
SURVEY DATE _____

Building Information

1 General Information

IDENTITY

OPERATION _____

Address _____

Type(s) of occupancy _____

Name of person in charge of energy _____

PHYSICAL DATA

Building orientation _____

No. of floors _____

Floor area, gross, m^2 _____

Net air-conditioned, m^2 _____

Construction type

Walls (masonry, curtain, frame, etc.)
N _____ S _____ E _____ W _____

Roof
Type: Flat _____ Colour: Light _____
Pitched _____ Dark _____

Glazing

Exposure	*Type**	*% Glass/Exterior wall area*
N	_____	_____
S	_____	_____
E	_____	_____
W	_____	_____

** Type: single, double, insulating, reflective, etc.*

Glass Shading Employed Outside (check one)
❑ Fins ❑ Overhead ❑ None ❑ Other _____

Glass Shading Employed Inside (check one)
❑ Shades ❑ Blinds ❑ Drapes, open mesh
❑ Drapes, opaque ❑ None ❑ Other _____

SKETCH OF BUILDING SHOWING PRINCIPAL DIMENSIONS

BUILDING TYPE

All electric _____

Gas % of total energy _____

Oil % of total energy _____

Other _____

BUILDING OCCUPANCY AND USE

	Occupied by* *(No. of people)*	from *(hours)*	to *(hours)*
Weekdays	_____	_____	_____
	_____	_____	_____
	_____	_____	_____
	_____	_____	_____
	_____	_____	_____
Saturdays	_____	_____	_____
Sundays, holidays	_____	_____	_____

Hours air-conditioned Weekdays from _____ to _____; Saturdays from _____ to _____;

Sundays, holidays from _____ to _____

* (Account for 24 hours a day. If unoccupied, enter zero).

2 Environmental Conditions

OUTDOOR CONDITIONS

Winter Day _____ °C dB _____ km/h wind Night _____ °C dB _____ km/h wind

Summer Day _____ °C dB _____ km/h wind Night _____ °C dB _____ km/h wind

MAINTAINED INDOOR CONDITIONS

Winter Day _____ °C dB _____ % r.h. Night _____ °C dB _____ % r.h.

Summer Day _____ °C dB _____ % r.h. Night _____ °C dB _____ % r.h.

3 Systems and Equipment Data

HVAC SYSTEMS: Air-handling systems (check as appropriate)

Perimeter system designation

Single zone _____ Multi-zone _____
Fan coil _____ Induction _____
Variable air volume _____ Dual duct _____
Terminal reheat _____ Self-contained _____
Heat pump _____

Interior system designation

Fan coil _____
Variable air volume _____
Single zone _____
Other (describe) _____

Principle of operation

Heating-cooling-off _____
Air volume variation _____
Air mixing control _____
Temperature variation _____

Interior

Heating-cooling-off _____
Air volume variation _____
Temperature variation _____

4 Air Handling Unit — Supply, Return, Exhaust

System Description _____

_____

Horsepower _____ OSA Dampers Yes ❑ No ❑ M.A. Setting _____°C
Location _____ Area Served _____
Terminal Units: Quantity _____ Type _____

Operations (Start-Stop):	**Start Time**	**Stop Time**
Monday through Friday	_____	_____
Saturday	_____	_____
Sunday	_____	_____
Holiday	_____	_____

Method of Start-Stop Time Clock ❑ Manual ❑ Other ❑

5 Cooling Plant

Chillers: Number _____ Total Tonnage/kW _____
Chilled Water Pumps _____ Total HP _____
Condensed Water Pumps _____ Total HP _____
Cooling Tower Fan(s) _____ Total HP _____
Chilled Water Supply Temperature, Setpoint _____°C

Operations (Start-Stop):	**Start Time**	**Stop Time**
Monday through Friday	_____	_____
Saturday	_____	_____
Sunday	_____	_____
Holiday	_____	_____
Method of Start-Stop	Time Clock ❑	Manual ❑ Other ❑

Months of Operation Per Year _____

Remarks _____
_____
_____

6 Boiler Plant

Boiler: Number _____ Size _____ Type _____
Fuel Used _____
Hot Water Supply Setpoint _____°C Stream Pressure Setpoint _____kg/m^2
Number of Pumps _____ Total HP _____

Remarks _____
_____

7 Rooftop/Unitary Systems

Manufacturer and Model _____

Quantity _____ Location _____

Cooling Capacity _____ Tonnes Total

Heating Capacity _____ Btu Output _____ Btu Input (Gas/Oil) _____

Electric ❑ Gas ❑ Steam/HW ❑

Single Zone Units _____ Multizone Units _____ Number of Zones _____

OSA Damper Control _____ °C

Fans:

	CFM	**HP**
Supply	_____	_____
Return	_____	_____
Exhaust	_____	_____
Operations (Start-Stop):	**Start Time**	**Stop Time**
Monday through Friday	_____	_____
Saturday	_____	_____
Sunday	_____	_____
Holiday	_____	_____
Method of Start-Stop	Time Clock ❑	Manual ❑ Other ❑

8 Exhaust, Air, Makeup Air Systems

Designation	**Location**	**Area Served**	**CFM**	**HP**
_____	_____	_____	_____	_____
_____	_____	_____	_____	_____
_____	_____	_____	_____	_____
		Total	_____	_____

Operating Schedule

_____

_____

_____

All fans (supply, return and exhaust)

Location	**Horsepower**	**Type**	**Method of Operation**
_____	_____	_____	_____
_____	_____	_____	_____
_____	_____	_____	_____

Source of heating energy

Hot water _____ Steam _____ Electric resistance _____ Other _____

Heating plant

Number of Boilers	Rating (MBH)
_____	_____
_____	_____
_____	_____

Boiler type

Firetube _____ Watertube _____ Elec. resist. _____ Electrode _____ Other _____

Fuel used _____ Standby _____

Hot water supply _____ °C, Return _____ °C

Stream pressure _____ kg/m^2

Pumps: Quantity _____ Total HP _____

Room heating units

Type: Baseboard _____ Convectors _____ Fin tube _____

Ceiling or wall panels _____ Unit heaters _____ Other _____

Cooling plant

Chillers: Number _____ Total capacity (tonnes) _____

Type: Centrifugal _____ Reciprocating _____ Absorption _____

Capacity controlled by _____

Chiller operation

Starting controls _____

Stopping controls _____

Chilled water temp. supply _____ °C, return _____ °C

Condensed water temp. _____ in°C _____ out°C

Heat dissipation device

Evaporative condenser _____

Air cooler condenser _____

Cooling tower _____

Condenser/cooling tower fan HP _____

Heat recovery device

Double bundle condenser _____ Other_____

Chilled water pumps _____ Total HP _____

Condensed water pumps _____ Total HP _____

Self-contained units

Type: Through-the-wall air conditioner _____ Other _____

No. of units _____ Basic module served _____

Capacity (tonnes) _____

9 Energy Conservation Devices

Type

Condenser water used for heating _____

Demand limiters _____

Energy storage _____

Heat recovery wheels _____

Enthalpy control of supply-return-exhaust damper _____

Recuperator _____

Other _____

Lighting

Interior lighting type

Watts/m^2: Hallway/corridor _____

Work stations _____

Circulation areas within work space _____

On-off from breaker panel _____ Wall switches _____

Control switching _____

Exterior lighting _____ Type _____ Total kW

Domestic hot water heating

Size _____ Rated input _____ Water temp. _____ °C

Energy sources: Gas _____ Oil _____ Electric _____ Other _____

Other equipment (kitchen, etc.)

Description	Quantity	Size/Capacity in Btu, kW, HP, etc.

10 Operating Schedule

Operation (Start-Stop)

Equipment description	Weekdays	Saturdays	Sundays	Holidays
Refrigeration cycle mach.				
Fans – supply				
Fans – return/exhaust				
Fans – exhaust only				
HVAC auxiliary equip.				
Lighting – interior				
– exterior				
Fan kitchen exhaust				
Elevators				
Escalators				
Domestic hot water heating				
Other _____				

11 Lighting

1. Interior lighting type _____
   Watts/m^2 offices _____ Other _____
   Total install kW _____ Foot candles _____
   On-off from breaker panel? _____
   Wall switch? _____ Control switching? _____
   Operating schedule _____
2. Exterior lighting type _____
   Total kW _____
   Operating schedule _____

1. Remarks _____

12 Utilities

Electric utility _____

Rate schedule _____ Effective _____

Name of rep. _____ Phone _____

Gas utility _____

Rate schedule _____ Effective _____

Name of rep. _____ Phone _____

Water utility _____

Rate schedule _____ Effective _____

Name of rep. _____ Phone _____

Emergency Generators

Number _____ Size _____ kW _____

How started: Manual ❑ Auto switchover ❑

Equipment/System operated _____

_____

_____

Check List

		Due Date	*Date Complete*	*By*
1.	HVAC Survey	_____	_____	_____
2.	Lighting and Misc. Survey	_____	_____	_____
3.	Utility Bill Analysis	_____	_____	_____
4.	Recommendations	_____	_____	_____

Date _____

WALKTHROUGH AUDIT Worksheet 8

Simple Load Inventories
(Lighting, Electrical Heat, Office Equipment)

CATEGORY OF USE _____

DESCRIPTION	QTY (A)	UNIT LOAD (B)	TOTAL kW (C) = A x B	HRS./ PERIOD (D)	kWH/ PERIOD (E) = D x C	ON AT PEAK (Y OR N)	DIVERSITY FACTOR* (F)	PEAK kW (G) = F x C	ON AT NIGHT (Y OR N)	NIGHT (kW)
Total										

** Diversity Factor: Fraction of total load that item contributed to peak demand.*

WALKTHROUGH AUDIT Worksheet 9

Detailed Load Inventories (Current/Voltage Method)

(For loads such as coolers, small motors, appliances; where kW load is not known, nameplate data is known.)

CATEGORY OF USE _____

DESCRIPTION	QTY (A)	VOLTS (B)	AMPS (C)	PHASE (D)	PF (E)	TOTAL kW (F)	HRS./ PERIOD (H) = G x F	ON AT PEAK (Y OR N)	DIVERSITY FACTOR (I)	PEAK kW (J) = I x F	ON AT NIGHT (Y OR N)	NIGHT (kW)
Total												

Total kW = (f) = (a) x (b) x (c) x (d) x (e)

for single phase, use (d) = 1
for three phases, use (d) = 3 = 1.73

WALKTHROUGH AUDIT Worksheet 10

CATEGORY OF USE _____

Detailed Load Inventories (Motor Load Method)

(For motors, if current and voltage have not been measured and kW is not known)

DESCRIPTION	QTY (A)	MOTOR HP (B)	MOTOR LOAD % (C)	MOTOR EFF. % (D)	TOTAL kW (E)	HRS./ PERIOD (F)	kWH/ PERIOD (G) = E x F	ON AT PEAK (Y OR N)	DIVERSITY FACTOR (H)	PEAK kW (I) = G x H	ON AT NIGHT (Y OR N)	NIGHT (kW)
Total												

Total kW = (e) = (a) x *(b)* x *.746* x *(c)* ÷ *(d)*

WALKTHROUGH AUDIT Worksheet 11

CATEGORY OF USE SUMMARY FOR _____
_____
_____

Summary of Load Inventories

(Use this form to summarize simple and detailed load inventories for each category [e.g., HVAC, lighting].)

WORKSHEET	DESCRIPTION	kWh/ PERIOD	PEAK (kW)	NIGHT (kW)
8				
9				
10				
	Total calculated			

WALKTHROUGH AUDIT Form 5

Total Load Inventory

(Summary of all load inventories for all categories, from information on Worksheet 11)

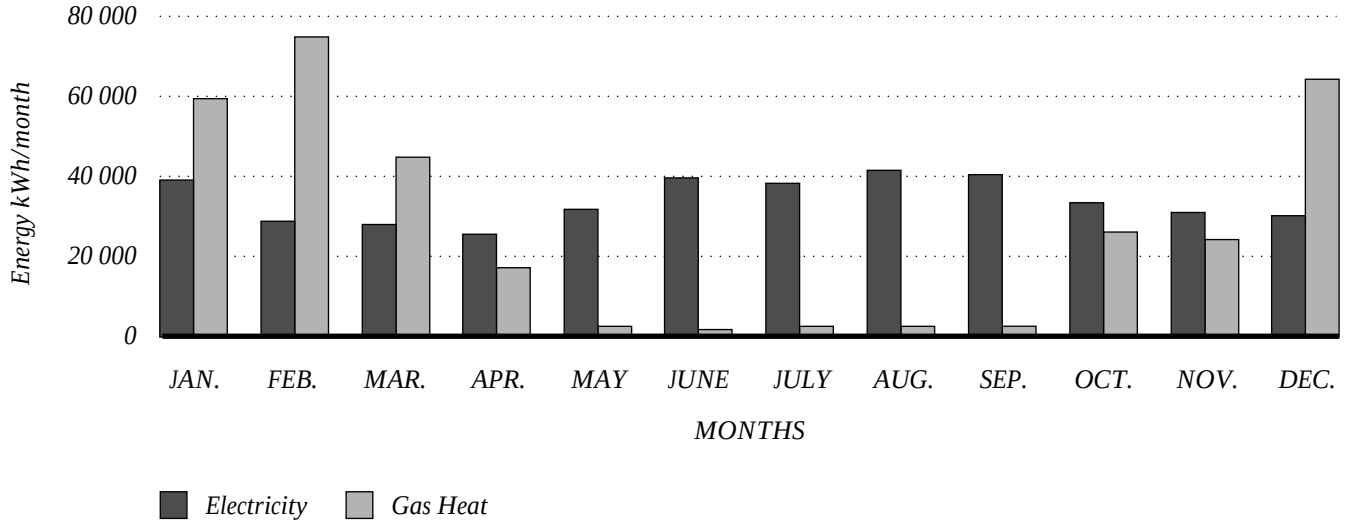
CATEGORY OF USE	CALCULATED DEMAND (kW) (E)	CALCULATED ENERGY (kWH) (F)	CALCULATED NIGHT LOAD (kW) (G)
CALCULATED Demand and Energy			
CALCULATED Night Load			

ACTUAL Demand and Energy (as per utility bills)		

WALKTHROUGH AUDIT Graph 9.1

Piqua Mall Analysis – Energy Use

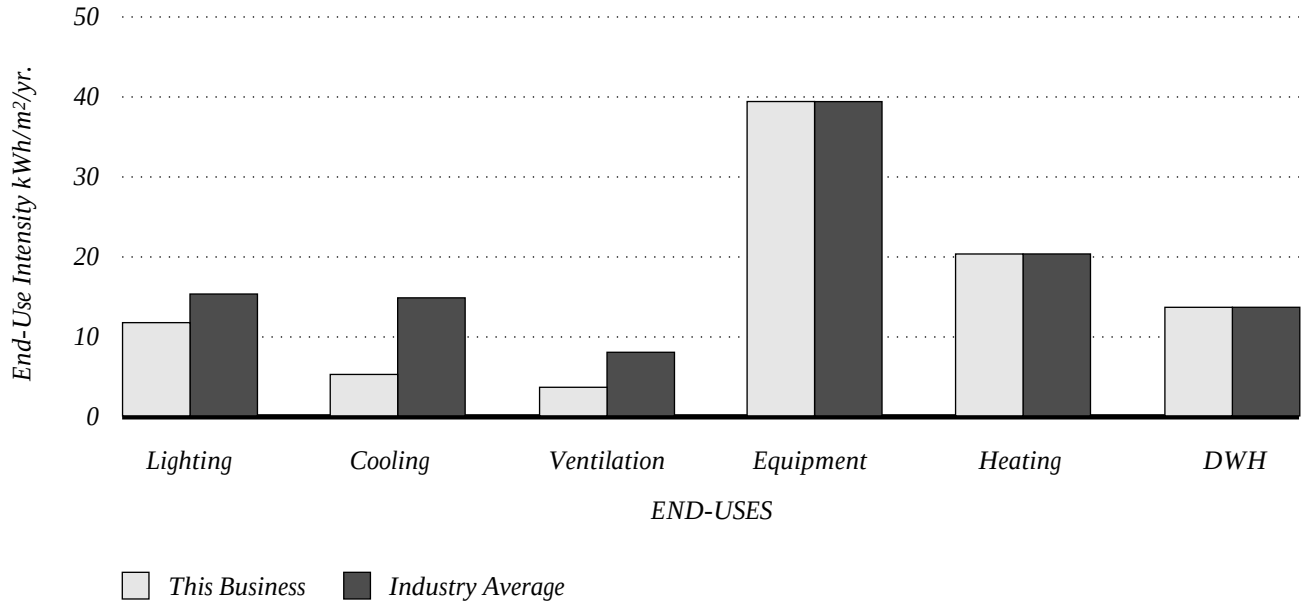
Profile of energy used by type (Yardstick)



WALKTHROUGH AUDIT Graph 9.2

Piqua Mall Analysis – Comparison to Industry

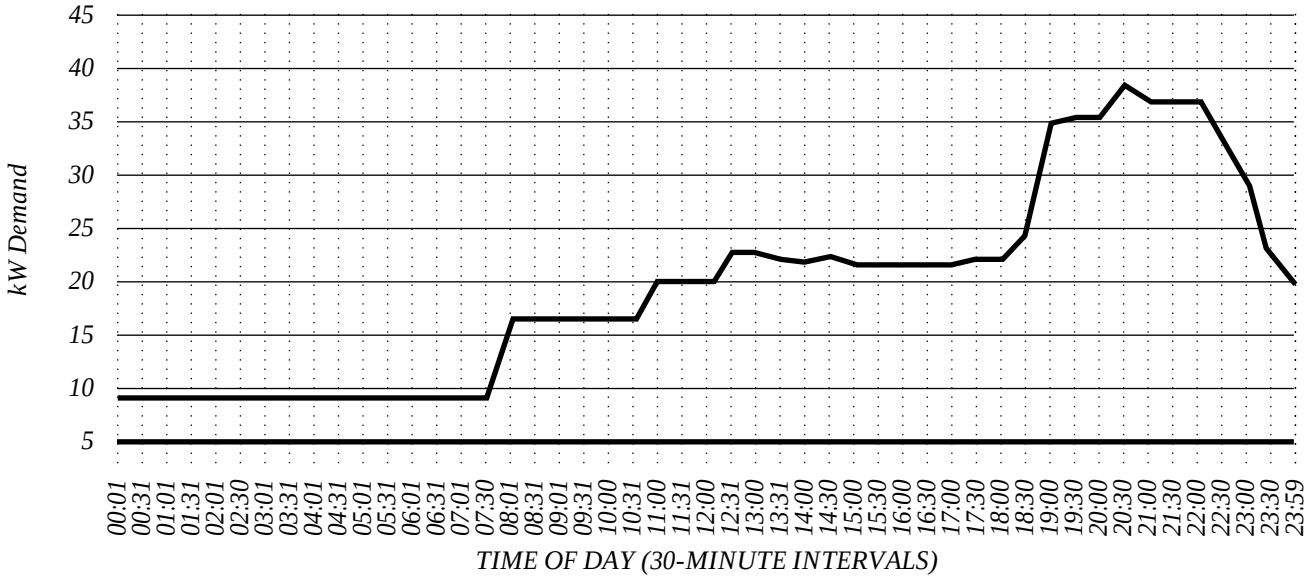
End-use breakdown and comparision to average building (Screening)



WALKTHROUGH AUDIT Graph 9.3

Piqua Mall Analysis – Demand Profile

Demand profile measured over 24 hours (Walkthrough)



Leading Canadians to Energy Efficiency at Home, at Work and on the Road

The Office of Energy Efficiency of Natural Resources Canada strengthens and expands Canada's commitment to energy efficiency in order to help address the challenges of climate change.

Canada