Performance guidelines for energy conservation in buildings

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PERFORMANCE GUIDELINES FOR ENERGY CONSERVATION IN BUILDINGS

by J.K. Latta

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DBR Internal Report 443

PREFACE

The National Research Council was asked to coordinate the preparation of a set of guidelines for the design of energy-efficient buildings that could be used by all departments and agencies of the Government of Canada and that could be submitted to an appropriate body for development into a model code for national use. An Interdepartmental Committee, which was formed to prepare the guidelines, decided to develop a performance-type code based on annual energy budgets for various types of occupancies. It was recognized, however, that it would take several years to establish appropriate energy budgets and methods of assessing compliance with such a code. Owing to the urgent need to conserve energy, it was necessary to prepare for immediate use a prescriptive-type document based on ASHRAE Standard 90-75, "Energy Conservation in New Building Design." The Division of Building Research, in consultation with other agencies, analyzed the ASHRAE Standard and proposed certain modifications appropriate for Canadian conditions (DBR Internal Report No. 433).

In 1976 the NRC Associate Committee on the National Building Code established a Standing Committee on Energy Conservation. This Standing Committee has drafted a Canadian Code for Energy Conservation in New Buildings, based largely on the ASHRAE Standard and the modifications proposed by DBR. Following public review, this prescriptive-type model code will be issued by the Associate Committee as a Supplement to the National Building Code.

In the meantime, on the basis of input from the Interdepartmental Committee and its subcommittees, Mr. J.K. Latta, a member of DBR staff, has drafted the text of this performance-type code which has been submitted to the ACNBC Standing Committee. Although further studies are required to establish energy budgets for various occupancies it seemed appropriate to make the draft document available now so that the direction of these studies can be more broadly influenced by the perceived needs of the new code.

In order to help the Standing Committee understand the rationale for various statements in the document, Mr. Latta has prepared the set of notes which appears in the Appendix. In several instances, when lack of information or honest differences of opinion between members of the Interdepartmental subcommittees prevented complete agreement from being reached, he has made a decision personally. Such action was considered to be necessary to expedite the preparation of the draft for review by the ACNBC Standing Committee and is indicated in many instances by the use of the first person singular in the notes.

The contributions of the members of the Interdepartmental Committee and its subcommittees are greatly appreciated.

Ottawa
November 1977

C.B. Crawford
Director, DBR/NRC

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NATIONAL RESEARCH COUNCIL OF CANADA

DIVISION OF BUILDING RESEARCH

DBR INTERNAL REPORT NO. 443

PERFORMANCE GUIDELINES FOR ENERGY CONSERVATION IN BUILDINGS

by. J.K. Latta

Checked by: **Approved by:** C.B.C. **Date:** November 1977

Prepared for: Standing Committee on Energy Conservation of the NRC Associate Committee on the National Building Code

PART 1. ADMINISTRATION

Section 1.1. Scope and Application

*Subsection 1.1.1 Scope

The purpose of this standard is to conserve non-renewable energy resources in Canada by controlling the quantity of primary energy which can be used to generate the delivered energy used within a building. Thus no restrictions are placed upon the use of energy from renewable sources such as the sun, the wind or the tides where such energy is not intermingled with energy produced from non-renewable resources before it reaches a building. All aspects of building design, construction and use which affect the energy needed by a building to enable it to meet the conditions required for the occupancy come within the scope of this standard.

The energy requirements of a manufacturing or other process carried out in the building are not included. This exemption does not cover normal office-type equipment including computers where they occupy less than 10% of the total office space or normal school laboratory and workshop equipment other than in specialist trade schools, and similar ancillary equipment.

*Subsection 1.1.2 Application

1.1.2.1 This standard applies to those buildings containing or intended to contain the following major occupancies:

(a) Offices, provided that 80% or more of the gross floor area is used for normal office functions.

(b) Non-residential schools, generally known as primary or secondary schools.

(c) Residences contained in what are commonly known as apartment buildings or condominium apartment buildings.

(d) Residences contained in detached, semi-detached or row houses, duplexes and triplexes and combinations thereof, whether site built, factory built or mobile.

Section 1.2. Definitions

Subsection 1.2.1 For definitions of words used in this Standard that are not included in this Section reference should be made first to Section 1.3 of the National Building Code of Canada 1977. For the definition of words not found in that section of the Code reference should be made to a standard dictionary.

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* See Appendix - "Notes on Preparation"

*Subsection 1.2.2 The following words and terms in this standard have the following meaning:

Energy budget means the maximum amount of energy that it is permissible, under the terms of this standard, to use in a building during one calendar year. Generally, but not necessarily expressed in terms of MJ/m^2 of gross floor area.

Primary energy means the energy content of a fuel after extraction from the earth but prior to refining, transportation and conversion into delivered energy.

Delivered energy means the energy delivered to the building in a form suitable for use in the building equipment.

Energy weighting factor means the ratio between the quantity of primary energy required to produce one unit of delivered energy when both are expressed in the same units.

A new building means any building for which a building permit is issued on or after the effective date of this standard.

An existing building means any building that is not a new building.

Gross floor area means the aggregate of all floor areas within the outside walls computed by measuring from the inside surface of the outer building wall except where the outer building wall consists of 50% or more of glass the measurement shall be taken from the inside surface of the glass. If the glass surfaces are 50% or more of the outer building wall and are sloping or of any other irregular design the measurement shall be taken from the glass surface nearest to the inside surface of the outer building wall.

Prescriptive requirements means a set of physical characteristics to be possessed by the building and its equipment.

Section 1.3. Abbreviations

Subsection 1.3.1 Abbreviations of Names of Associations

The abbreviations in this standard for the names of associations shall have the meaning assigned to them in this Subsection. The address of such associations are shown in brackets following the name of each association.**

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* See Appendix - "Notes on Preparation"
** To appear in final text of Standard.

Subsection 1.3.2 Abbreviations of Words and Phrases

The abbreviations of words and phrases in this standard shall have the meanings assigned to them in this Subsection.**

Section 1.4. Duties and Responsibilities of the Owner

Subsection 1.4.1 The provisions of Section 2.4 of the National Building Code shall apply as though that Section constitutes part of this standard.

Subsection 1.4.2 New Buildings

*1.4.2.1 At the time of applying for a building permit the Owner shall elect either:

(i) to design, construct and operate his building so as to meet the specified energy budget, or

(ii) to design and construct his building to meet the requirements of Part 5.

*1.4.2.2 An Owner who elects to follow alternative (i) of Article 1.4.2.1 shall submit with his application a statement, in the form prescribed in Part 3, of the estimated energy consumption of the building.

*1.4.2.3 When the gross floor area of the building exceeds 1200 m^2 the estimate of energy consumption required by Article 1.4.2.2 shall be certified by a Professional Engineer as being a sound estimate. For the purpose of this Article, no account shall be taken of internal divisions by fire walls or other means when calculating the gross floor area.

Subsection 1.4.3 Existing Buildings

1.4.3.1 The Owner of an existing building having a gross floor area of more than 1200 m^2 shall within five (5) years from the effective date of this standard either:

(i) modify and operate his building so as to reduce the energy consumption to below the specified energy budget, or

(ii) modify his building to meet the requirements of Part 5.

For the purpose of this Article no account shall be taken of internal divisions by fire walls or other means when calculating the gross floor area.

Subsection 1.4.4 Proof of Energy Consumption

*1.4.4.1 Within five (5) years from the date on which an occupancy

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* See Appendix - "Notes on Preparation"
** To appear in final text of Standard.

permit is issued for the entire floor area of a new building or from the effective date of this standard for an existing building an owner who has elected to meet an energy budget shall submit evidence satisfactory to the authority having jurisdiction that the building is being operated within the energy budget prescribed for the occupancy.

1.4.4.2 Readings of the monitoring equipment specified in Part 4 shall be taken as evidence of the energy consumption of the building.

1.4.4.3 In the event that the measured energy consumption exceeds the prescribed energy budget when it has been adjusted for non standard conditions, following the procedures of Subsection 2.1.2, the owner shall make or have made at his own expense all the changes necessary to reduce the energy consumption to the prescribed amount.

1.4.4.4 While it is anticipated that where a proper energy analysis has been performed and the building has been constructed or modified in accordance with the intent of the design on which that analysis was based, the changes required by Article 1.4.4.3 will be confined to adjustment and tuning of the HVAC equipment and to modifications in the operating procedures,this does not relieve the owner of the obligation to replace all or part of the HVAC system with more efficient equipment or to make changes to the fabric of the building or both if needed to reduce the energy consumption to below the prescribed energy budget.

Section 1.5. Board of Appeal

Subsection 1.5.1

The provisions of Section 2.11 of the National Building Code shall apply insofar as they concern the creation and conduct of a Board of Appeal.

Subsection 1.5.2

1.5.2.1 In addition to the provisions contained in Section 2.11 of the National Building Code for appealing the decisions of the designated official an owner may appeal the requirement to meet a specific energy budget.

1.5.2.2. Since it is not the intent of this standard to force owners to adopt uneconomic measures over the life of the building an appeal against an energy budget may be based on economics.

1.5.2.3 An appeal against an energy budget must be supported by an energy analysis together with such explanation or analysis as is required by the Board to show what energy budget can be met economically.

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* See Appendix - "Notes on Preparation"

1.5.2.4 After considering all information which it considers to be pertinent the Board shall either confirm the prescribed energy budget or set such other less stringent budget as it considers appropriate to the case.

PART 2. ENERGY BUDGETS AND ENERGY WEIGHTING FACTORS

Section 2.1. Energy Budgets

*Subsection 2.1.1 Determination of the Energy Budget

*2.1.1.1 In order to determine the energy budget applicable to his building the Owner shall:

(a) select a test year of weather data from those available for a weather station appropriate to the location of the building, and

(b) for each major occupancy determine

(i) the gross floor area and number of floors occupied by that major occupancy, and

(ii) the pattern of use of the building.

*2.1.1.2 For a new building the energy budget shall be determined by linear interpolation between the values given in Tables 2.1.1.2A to 2.1.1.2D for the conditions which are nearest to those selected or determined as required by Article 2.1.1.1. The energy budget so determined shall be in terms of primary energy.

*2.1.1.3 For an existing building the energy budget shall be determined by linear interpolation between the values given in Tables 2.1.1.3A to 2.1.1.3C for the conditions which are nearest to those selected or determined as required by Article 2.1.1.1. The energy budget so determined shall be in terms of delivered energy.

2.1.1.4 Where a building contains or is intended to contain more than one of the major occupancies covered by this standard an energy budget shall first be obtained for each major occupancy as though it occupied a separate building. These energy budgets shall then be combined in the ratio that the floor area occupied by each major occupancy bears to the total floor area. Areas which serve more than one of the major occupancies shall be proportioned between them in the same ratio of floor areas.

2.1.1.5 Where a building contains one or more major occupancies

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* See Appendix - "Notes on Preparation"

covered by this standard together with one or more major occupancies not covered by this standard that portion of the building occupied by the former shall be considered as a separate building for the purpose of the standard.

TABLE 2.1.1.2A

Forming Part of Article 2.1.1.2

ENERGY BUDGETS FOR NEW OFFICE BUILDINGS MJ Equivalent of Primary Energy / ($m^2 \cdot$ year)							
Number of Floors	Gross Floor Area m^2	Use 1		Use 2		Use 3	
		3000 Degree Days	7000 Degree Days	3000 Degree Days	7000 Degree Days	3000 Degree Days	7000 Degree Days
1	400 or less 600 800 1000 or more						
2	800 or less 1200 1600 2000 or more						
3	1200 or less 1800 2400 3000 or more						
More Than 3	1600 or less 2400 3200 4000 or more						

TABLE 2.1.1.2B

Forming Part of Article 2.1.1.2

ENERGY BUDGETS FOR NEW SCHOOL BUILDINGS MJ Equivalent of Primary Energy / (m^2 · year)						
Gross Floor Area m^2	Use 1		Use 2		Use 3	
	3000 Degree Days	7000 Degree Days	3000 Degree Days	7000 Degree Days	3000 Degree Days	7000 Degree Days
Primary Schools 500 or less 1000 2000 4000 6000 or more						
Secondary Schools 6000 or less 10 000 16 000 22 000 or more						

TABLE 2.1.1.2C

Forming Part of Article 2.1.1.2

ENERGY BUDGETS FOR NEW RESIDENTIAL BUILDINGS HAVING A GROSS FLOOR AREA OF MORE THAN 1200 m^2 MJ Equivalent of Primary Energy/ ($m^2 \cdot$ year)			
Number of Floors	Gross Floor Area m^2	3000 Degree Days	7000 Degree Days
1	400 or less 600 800 1000 or more		
2	800 or less 1200 1600 2000 or more		
3	1200 or less 1800 2400 3000 or more		
More Than 3	1600 or less 2400 3200 4000 or more		

TABLE 2.1.1.2D

Forming Part of Article 2.1.1.2

ENERGY BUDGETS FOR THE HEATING OF NEW RESIDENTIAL BUILDINGS HAVING A GROSS FLOOR AREA OF NOT MORE THAN 1200 m^2 MJ Equivalent of Primary Energy/ ($m^2 \cdot$ year)	
3000 Degree Days	7000 Degree Days

TABLE 2.1.1.3A

Forming Part of Article 2.1.1.3

ENERGY BUDGETS FOR EXISTING OFFICE BUILDINGS MJ Equivalent of Delivered Energy/(m^2 · year)							
Number of Floors	Gross Floor Area m^2	Use 1		Use 2		Use 3	
		3000 Degree Days	7000 Degree Days	3000 Degree Days	7000 Degree Days	3000 Degree Days	7000 Degree Days
1	400 or less						
	600						
	800						
	1000 or more						
2	800 or less						
	1200						
	1600						
	2000 or more						
3	1200 or less						
	1800						
	2400						
	3000 or more						
More Than 3	1600 or less						
	2400						
	3200						
	4000 or more						

TABLE 2.1.1.3B

Forming Part of Article 2.1.1.3

ENERGY BUDGETS FOR EXISTING SCHOOL BUILDINGS MJ Equivalent of Delivered Energy/$(m^2 \cdot$ year)						
Gross Floor Area m^2	Use 1		Use 2		Use 3	
	3000 Degree Days	7000 Degree Days	3000 Degree Days	7000 Degree Days	3000 Degree Days	7000 Degree Days
Primary Schools						
500 or less						
1000						
2000						
4000						
6000 or more						
Secondary Schools						
6000 or less						
10 000						
16 000						
22 000						
22 000 or more						

TABLE 2.1.1.3C

Forming Part of Article 2.1.1.3

ENERGY BUDGETS FOR EXISTING RESIDENTIAL BUILDINGS HAVING A GROSS FLOOR AREA OF MORE THAN 1200 m^2 MJ Equivalent of Delivered Energy/(m^2· year)			
Number of Floors	Gross Floor Area m^2	3000 Degree Days	7000 Degree Days
1	400 or less 600 800 1000 or more		
2	800 or less 1200 1600 2000 or more		
3	1200 or less 1800 2400 3000 or more		
More Than 3	1600 or less 2400 3200 4000 or more		

*Subsection 2.1.2 Adjustment of the Energy Budget for Comparison with the Measured Energy Consumption to Determine Compliance with the Standard

2.1.2.1 Before being compared with the measured energy consumption of the building in use as required by Subsection 1.4.4 the allowable energy budget shall be adjusted for:

(a) the difference between the actual weather conditions to which the building was subjected during the period during which the energy consumption was measured and the weather conditions of the test year chosen following Article 2.1.1.1 to determine the allowable energy budget, and

(b) the difference between the actual hours of operation during the period during which the energy consumption was measured and the pattern of use used to determine the allowable energy budget.

2.1.2.2 The adjustment for the different weather conditions shall be made in the ratio of the degree days below 18°C recorded for the two years at the same weather station.

2.1.2.3 The adjustment for the different periods of occupancy shall be made in the ratio of the products of the hours of occupancy and the floor areas occupied during the two years.

*Section 2.2. Energy Weighting Factors

Subsection 2.2.1

2.2.1.1 The energy weighting factors to be used are those given in Table 2.2.1A.

Table 2.2.1A

Forming Part of Article 2.2.1.1

Type of Delivered Energy	Energy Weighting Factor
Electricity	
Oil	
Natural Gas	
Coal	
Steam	
Hot Water	
Chilled Water	

*See Appendix - "Notes on Preparation"

2.2.1.2 The quantity of primary energy consumed by the building shall be taken as being the sum of the products of the quantities of delivered energy consumed and the appropriate energy weighting factors.

PART 3. PRECONSTRUCTION ESTIMATE OF ENERGY CONSUMPTION

Section 3.1. Preparation of the Energy Estimate

Subsection 3.1.1 General

3.1.1.1 The purpose of the preconstruction estimate of the energy consumption of the building when in operation is to ensure that all aspects of the building, its equipment and mode of operation that affect its energy consumption have been considered at an early stage in the design before irrevocable decisions have been taken.

3.1.1.2 There is no one energy analysis procedure currently available that can be adopted as being the standard procedure for estimating the energy consumption of all buildings in all locations in Canada under all modes of operation. It is therefore left to the Owner to choose an appropriate method of analysis.

3.1.1.3 The method of analysis chosen should include in sufficient detail to permit the evaluation of their effects, all aspects of the building project which affect energy consumption.

*3.1.1.4 Without limiting the generality of Article 3.1.1.3 the method of analysis should cover the following items:

(a) Climatic data

(b) Building data: orientation, size, shape, mass and the air, moisture and heat transfer characteristics

(c) Operational characteristics: temperature, humidity, ventilation, illumination, control mode for occupied and non-occupied hours

(d) Mechanical equipment: design capacity, part load profile

(e) Internal heat generation: lighting, equipment, number of people during occupied and non-occupied periods.

3.1.1.5 It is recommended that for all buildings other than small simple ones, the energy consumption analysis be performed by computer simulation using hourly increments of time for a year of 8760 hours.

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* See Appendix - "Notes on Preparation"

3.1.1.6 For small simple buildings manual methods of analysis such as those given in Chapter 43, Energy Estimating Methods, of the ASHRAE Handbook and Products Directory, 1976 Systems Volume may be used.

Subsection 3.1.2 Climatic Data

3.1.2.1 When the energy consumption estimate is prepared by computer simulation the climatic data used shall be those recorded for the chosen test year (See Article 2.1.1.1) by the Atmospheric Environment Branch of the Department of the Environment.

3.1.2.2 When the energy consumption estimate is prepared by a manual method of analysis the climatic data given for the location in Supplement No. 1 to the National Building Code may be used in lieu of that for a specific test year.

Subsection 3.1.3 Internal Conditions to be Used in the Preparation of Estimate of Energy Consumption

3.1.3.1 When the actual internal conditions which will prevail are known they should be used in the preparation of the estimate of energy consumption, and stated on Form 3.2.1A.

3.1.3.2 When the actual internal conditions which will prevail are not known the values given in Tables 3.1.3A to 3.1.3E may be used. These standard conditions are those used to prepare the energy budgets given in Tables 2.1.1.2A to 2.1.1.2D and in Tables 2.1.1.3A to 2.1.1.3C.

3.1.3.3 The energy budget for the building as determined in Subsection 2.1.1 shall not be adjusted for internal conditions that differ from those given in Table 3.1.3A to 3.1.3E before being compared with the measured energy consumption of the building in use. (See Subsection 2.1.2)

TABLE 3.1.3A*

Forming Part of Article 3.1.3.2

ROOM TEMPERATURES**

Occupancy	Occupied Period		Unoccupied Period	
	Winter	Summer	Winter	Summer
Offices	22°C(72°F)	25°C(78°F)	18°C(65°F)	Not Controlled
Schools				
Primary	22°C	Not Controlled	18°C	Not Controlled
Secondary	22°C	25°C	18°C	Not Controlled
Residences	22°C	Not Controlled	--	--

* See Appendix - "Notes on Preparation"

** Special arrangements may be made for equipment such as computers

TABLE 3.1.3B*

Forming Part of Article 3.1.3.2

ROOM RELATIVE HUMIDITY**

Occupancy	Occupied Period		Unoccupied Period	
	Winter	Summer	Winter	Summer
Offices	30% maximum	60% minimum	Not Controlled	Non Controlled
Schools				
Primary	30% maximum	60% minimum	Not Controlled	Not Controlled
Secondary	30% maximum	60% minimum	Not Controlled	Not Controlled
Residences	Not Controlled	Not Controlled	--	--

* See Appendix - "Notes on Preparation"

** Special arrangements may be made for equipment such as computers

TABLE 3.1.3C

Forming Part of Article 3.1.3.2

MINIMUM VENTILATION RATES

Occupancy	Occupied Period		Unoccupied Period
	Total Air Supply $dm^3/(s\cdot m^2)$ (cfm/sq ft)	Min. Outside Air $dm^3/(s\cdot m^2)$ (cfm/sq ft)	
Offices	1.3 (0.25)	0.5 (0.1)	Nil
Schools			
Primary	2.5 (0.5)	1.3 (0.25)	Nil
Secondary	2.5 (0.5)	1.3 (0.25)	Nil
Residences	0.4 (0.07)	0.2 (0.035)	--

NOTES to Table 3.1.3C:

1. Ventilation rates are per square metre of gross floor area including all occupied spaces less evevator shafts, stair-wells, pipe shafts and vertical duct spaces.

2. The quantity of outdoor air in the total air supply shall be in accordance with the requirement of ASHRAE Standard 62-73 provided that the equipment needed to meet these requirements is specified in the final design and installed in the building.

TABLE 3.1.3D*

Forming Part of Article 3.1.3.2

CONSUMPTION OF DOMESTIC HOT WATER

Occupancy	Consumption of 60°C (140°F) Hot water; L/(person·day) (US gal/person/day)
Offices	4 (1.0) during occupied period
Schools	
Primary	2.25 (0.6) during occupied period
Secondary	7 (1.8) during occupied period

* See Appendix - "Notes on Preparation"

TABLE 3.1.3E* (Forming Part of Article 3.1.3.2)

LEVELS OF ILLUMINATION

Occupancy	Level of Illumination, Lux — Occupied Period	Level of Illumination, Lux — Unoccupied Period
Office Buildings		
(a) Office Areas		
1. Waiting, Reception Rooms	300	
2. Typing Activity	1000 (330 for gen. lighting & less difficult tasks)	
3. Office, Private	330 (900 on desks)	
4. Office, General	330 + task lighting	
5. Conference & Boardrooms	330 (900 for table area)	Nil
6. File Room, Mimeograph, etc.	600	
7. Storage (Live)	200	
8. Storage (Dead)	200	
9. Library, Reading Areas	750	
10. Library, Stacks	320	
(b) Service Areas		
1. Corridors	220	220
2. Stairwells	220	220
3. Washrooms	160 (Fixtures located over washbasins)	
4. Janitor's Closets	160	
(c) Special Areas		
1. Computer Rooms	550	
2. Staff Training	750 (1600 at demonstration area)	Nil
3. First Aid, Waiting	220	
4. First Aid, Examination	550 (1100 at examination table)	
5. Draughting Rooms	330 (1100 at drafting table)	
6. Employee's Cafeteria	550	
7. Kitchen, Food Preparation	750	
8. Kitchen, Serving Area	550	
9. Kitchen, Walk-in Freezers and Storage Areas	160	

* See Appendix - "Notes on Preparation"

Subsection 3.1.4 Periods of Use

3.1.4.1 When the actual periods of occupancy are known they should be used in the preparation of the estimate of energy consumption.

3.1.4.2. When the actual periods of occupancy are not known, one of the standard periods given in Tables 3.1.4A to 3.1.4C may be used. These standard periods of use correspond to the uses given in Tables 2.1.1.2A to D and Tables 2.1.1.3A to D.

TABLE 3.1.4A*

Forming Part of Article 3.1.4.2

Standard Periods of Occupancy for Office Buildings	
Designation	Occupied Period
Use 1	0700-1800 hr Mondays through Fridays 52 weeks per year
Use 2	
Use 3	

* See Appendix - "Notes on Preparation"

TABLE 3.1.4B*

Forming Part of Article 3.1.4.2

Standard Periods of Occupancy for School Buildings	
Designation	Occupied Period
Primary Schools	
Use 1	0800-1600 hr Mondays through Fridays September through June
Use 2	
Use 3	
Secondary Schools	
Use 1	0800-1600 hr Mondays through Fridays September through June
Use 2	
Use 3	

TABLE 3.1.4C*

Forming Part of Article 3.1.4.2

Standard Periods of Occupancy for Residences	
Designation	Occupied Period
Use 1	24 hr/day 365 days/year

* See Appendix - "Notes on Preparation"

Section 3.2. Presentation of the Energy Estimate

Subsection 3.2.1 General Data

3.2.1.1 General data identifying the building, the climatic data used and the major occupancies shall be reported on Form 3.2.1A.

*Subsection 3.2.2 Estimated Energy Consumption

3.2.2.1 The estimated annual amounts of delivered energy to be supplied to and utilized by the building project to satisfy all building project energy requirements shall be reported on Form 3.2.2A, Estimated Building Project Fuel and Energy Consumption, according to the form in which they are supplied to the building project and according to their end use.

3.2.2.2 Where the building project's energy systems are such that some or all of the energy uses in Column A cannot be segregated (heat recovery, total energy, etc.), those categories directly affected may be combined as required in Column B. Such combinations must be indicated on the form.

3.2.2.3 For building projects directly utilizing nondepleting energy, such as solar, wind, etc., the amount of that energy utilized shall be identified and tabulated in Column B6 or B7.

3.2.2.4 The primary energy requirements of the building project shall be calculated on Form 3.2.2B by multiplying Column B total values (line 13) by the appropriate energy weighting factors.

FORM 3.2.1A

Forming Part of Article 3.2.1.1

PRECONSTRUCTION ESTIMATE OF ENERGY CONSUMPTION

PROJECT DESCRIPTION:

ADDRESS:

OWNER:

ESTIMATE PREPARED BY:

CLIMATIC DATA - WEATHER STATION:

- TEST YEAR:

BUILDING DATA - GROSS FLOOR AREA:

- NUMBER OF FLOORS:

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* See Appendix - "Notes on Preparation"

OCCUPANCY DATA

1ST MAJOR OCCUPANCY

- type: - no. of floors occupied:
- floor area occupied: - period of use:
- internal conditions (when not standard)

	Occupied Period		Unoccupied period	
	summer	winter	summer	winter
Temp., ^{o}C R.H., % Ventilation, $dm^3/(s \cdot m^2)$ Lighting, W/m^2				

2ND MAJOR OCCUPANCY

- type: - no. of floors occupied:
- floor area occupied: - period of use:
- internal conditions (when not standard)

	Occupied Period		Unoccupied period	
	summer	winter	summer	winter
Temp., ^{o}C R.H., % Ventilation, $dm^3/(s \cdot m^2)$ Lighting, W/m^2				

... and so on until all major occupancies have been described.

SERVICE AND ANCILLARY AREAS SERVING MORE THAN ONE MAJOR OCCUPANCY

- type:
- no. of floors occupied:
- floor area occupied:
- period of use:
- internal conditions (when not standard)

	Occupied Period		Unoccupied Period	
	summer	winter	summer	winter
Temp., ^{o}C R.H., % Ventilation, $dm^3/(s \cdot m^2)$ Lighting, W/m^2				

FORM 3.2.2A

Forming Part of Article 3.2.2.1

	COLUMN	B1	B2	B3	B4	B5	B6	B7
LINE	A FUNCTION	FUEL & ENERGY SUPPLIED TO SITE						
		LIGHT OIL GJ	HEAVY OIL GJ	NAT'L GAS GJ	COAL GJ	ELEC. GJ		
1	HEATING							
2	COOLING							
3	WATER HEATING							
4	HVAC AUXILARY							
5	LIGHTING							
6	ELEVATORS							
7	COMPUTERS							
8	COOKING							
9	PROCESS							
10	OTHER							
11	OTHER							
12	OTHER							
13	TOTAL							

FORM 3.2.2B

Forming Part of Article 3.2.2.4

	COLUMN	C0	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10
LINE		TOTAL FROM LINE 13	TOTAL PRIMARY ENERGY REQUIREMENTS OF BUILDING PROJECT									
			GJ COAL	GJ NAT. GAS	GJ OIL	GJ U-235	GJ HYDRO	GJ WASTE	GJ SOLAR	OTHER	OTHER	OTHER
14	FUEL OIL											
15	NAT. GAS											
16	COAL											
17	ELEC.											
18	OTHER											
19	OTHER											
20	TOT. RES											

PART 4. MONITORING OF ENERGY CONSUMPTION

Section 4.1. Method of Measuring the Energy Consumption

*Subsection 4.1.1 Buildings Having a Gross Floor Area of More Than 1200 m^2.

4.1.1.1 The quantity of all forms of delivered energy used in the building shall be measured by means of an approved metering system. Meters installed by a Utility Company, such as an electricity or gas supply company, as their normal method of measuring the quantity of energy supplied to the building shall be accepted as an approved metering system.

*4.1.1.2 All oil drawn from bulk storage tanks at the building shall be metered. Where some oil bypasses the conversion equipment and is returned to such tanks the quantity returned shall also be metered. The difference between the two meter readings shall be taken as the quantity of oil consumed in the building.

*4.1.1.3 All steam entering the building shall be metered. The Owner has the option of measuring the energy content of the condensate return; in which case the energy consumed in the building shall be taken as the difference between the energy content of the steam supplied and of the condensate returned.

4.1.1.4 The energy content of hot water and chilled water both as supplied to and returned from the building shall be measured and the energy consumed in the building shall be taken as the difference.

Subsection 4.1.2 Buildings Having a Gross Floor Area of Not More Than 1200 m^2.

4.1.2.1. The quantities of fuel and energy shown on the supply company's invoices may be taken as the quantities used in the building in lieu of quantities metered at the building.

*Subsection 4.1.3 Multiple Building Complexes

4.1.3.1 Where a number of buildings receive all their fuels or energy from a central bulk storage depot or energy generating plant the complex may be considered as one building for the purpose of this standard.

4.1.3.2 In such a complex the fuel or energy consumed in individual buildings need not be measured.

4.1.3.3 The energy budget for the complex shall be determined following the procedures of Subsection 2.1.1 as though the complex was one building.

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* See Appendix - "Notes on Preparation"

Section 4.2. Method of Reporting the Energy Consumption

Subsection 4.2.1 Use

4.2.1.1 The actual floor area occupied by each major occupancy and the aggregate number of hours of use of that area during the reporting period shall be reported on Form 4.2A.

4.2.1.2 Where the area occupied by a major occupancy changes during the reporting period the sum of the products of each portion of the total area occupied by that major occupancy and the hours that that portion is occupied may be entered directly in the table.

4.2.1.3 The allowable energy budget under the actual conditions of use shall be taken as the sum of the values obtained by dividing the design energy budgets for each major occupancy by the product of the floor area and hours of use assumed for design purposes for that occupancy and multiplying the quotient obtained by the product of the actual floor area and hours of use for that occupancy during the reporting period.

Subsection 4.2.2. Weather

4.2.2.1 The energy budget obtained following Article 4.2.1.3. for the building under the actual conditions of use shall be adjusted for the actual weather conditions by being divided by the number of degree days in the design test year and the quotient obtained being multiplied by the number of degree days in the reporting period.

Subsection 4.2.3 Energy Consumption

*4.2.3.1 The quantities of all forms of energy supplied to the building during the reporting period shall be reported on Form 4.2A in the normal units of measurement and then converted to the gigajoule equivalent of delivered energy.

4.2.3.2 The gigajoule equivalent of each form of delivered energy shall be multiplied by the appropriate energy weighting factor given in Section 2.2 to obtain the corresponding quantity of primary energy.

4.2.3.3 The sums of the quantities in gigajoules, of all types of energy used, both delivered and primary, shall be taken as the consumption of delivered and primary energies in the building. The appropriate values shall be divided by the gross floor area for comparison with the allowable energy budget under the actual conditions of use and the actual weather conditions as obtained following Subsections 4.2.1 and 4.2.2 to determine compliance with this standard.

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* See Appendix - "Notes on Preparation"

Form 4.2A

Forming Part of Section 4.2

1. Building Identification - Name - Gross Floor Area
   - Address - Number of Floors
   - Owner

2. Reporting Period: From To

3. Adjustment of the Design Energy Budget for the Actual Period of Use During the Reporting Period

Major Occupancies	Design			During the Reporting Period			Energy Budget Adjusting Factor (c = b/a)	Design Energy Budget MJ/m^2 (d)	Use Adjusted Energy Budget MJ/m^2 (e = d x c)
	Floor Area Occupied m^2	Total Hours of Use	Area x Hr (a)	Floor Area Occupied m^2	Total Hours of Use	Area x Hr (b)			
1st									B_1
2nd									B_2
3rd									B_3
								Total	B_u

4. Adjustment of Allowable Energy Budget for the Actual Weather Conditions

Degree Days		Energy Budget Adjustment Factor	Use Adjusted Energy Budget MJ/m^2	Weather and Use Adjusted Energy Budget MJ/m^2
In Reporting Period D	In Design Year d	$F_w = \frac{D}{d}$	B_u	$B_{uw} = B_u \times F_w$

5. Energy Consumption

Fuel	Meter Readings		Delivered Energy			Energy Weighting Factor	Primary Energy GJ
	Start of Period	End of Period	Quantity	Unit	GJ Equivalent		
Light Oil Heavy Oil Natural Gas Coal Electricity Steam Hot Water Chilled Water Other							
						TOTALS	
						MJ/m^2	

PART 5. ALTERNATIVE PRESCRIPTIVE REQUIREMENTS

This Part will be the same as the Canadian adaptation of ASHRAE 90-75 which is under review by the ACNBC Standing Committee on Energy Conservation in Buildings and which will then be published as the first edition of The Canadian Code for Energy Conservation in New Buildings. As this Committee has not completed its work it has not been included in the draft of the performance standard.

When this performance standard becomes available for publication the then current edition of the Canadian Code for Energy Conservation in New Buildings could be reproduced here either in whole or in part as appropriate. The combined code could then be issued as the Canadian Code for Energy Conservation in Buildings. The word "New" would be dropped from the title since the performance code covers existing as well as new buildings.

APPENDIX

NOTES ON THE PREPARATION OF THE DRAFT OF PERFORMANCE GUIDELINES FOR ENERGY CONSERVATION IN BUILDINGS

by

J.K. Latta

Introduction

The original concept of the performance standard was that an energy budget would be specified for each occupancy and that a building would be designed and operated so as to use no more than this amount of energy. Verification that the design met the budget was to be by means of analysis at the design stage followed by a limited amount of monitoring of the building in use to ensure that it was being operated below the budget.

This concept foundered upon the fact that there is not at present an analytical procedure that will give a unique answer without being overly simplistic and restrictive. (The United States is working toward developing suitable procedures with a massive effort that will take several years.)

A revised concept was then developed that retained the energy budget approach but relied upon post-construction monitoring of the building to establish compliance with the standard. This decision was based upon the premise that a building that is designed to meet a given energy consumption could be brought below this target by suitable tuning of the equipment and operating procedures without needing major changes in the equipment and certainly none to the fabric of the building. Monitoring of the energy consumption would be needed for only a relatively short period to show that the building met the standard although a simple reporting of the energy used thereafter need not be an onerous procedure and would keep the owner and operator aware of changes in energy consumption.

The problem that arises with this approach is that of allowing for the difference between the conditions used for the design of a building and the actual conditions to which it is subjected when in operation. Climatic differences can, in all probability, be allowed for on the basis of degree days. Differences in occupancy periods, patterns and the extent of full or partial occupancy, etc., are not handled so easily but one possible method has been included in the standard.

Since the purpose of the standard is to conserve the non-renewable energy resources in Canada (and the world) the energy budget would be in terms of the Primary Energy needed to generate and distribute the Delivered Energy. The quantity of Primary Energy used would be obtained by multiplying the quantity of Delivered Energy used by a suitable Energy Weighting Factor (Resource Utilization Factor).

Existing buildings (with some exceptions, e.g., houses) would be covered as well as new construction but with a more liberal energy budget which would be in terms of Delivered Energy at the building boundary rather than of Primary Energy.

To keep the job to a manageable size it was decided that only three occupancies -- offices, schools and residences -- would be considered in the first instance. Ultimately all occupancies would have to be covered but this could be by a continuing process of expansion as more information is gathered.

Finally, for those who do not choose to work to an energy budget, the prescriptive requirements of the Canadian Code for Energy Conservation in New Buildings, being prepared by an ACNBC Standing Committee, will be included as an alternative.

The inclusion of this set of prescriptive standards, which may be followed at the discretion of the owner (designer), makes for an easy transition from a prescriptive to a performance standard. An owner or designer who is confident of his ability could opt to meet the performance standard since it gives him the opportunity to be inventive and original. Another owner/designer team less confident or faced with different circumstances could opt to follow the prescriptive standard with which they would already be familiar. By leaving the choice to the owner/designer team the change from one to the other is not forced upon them and can be made when they feel comfortably able to do so. The performance standard could thus be offered to the design profession at an early stage, even though it may be far from perfect, so as to obtain feedback as to how it can be improved.

DETAILED REVIEW

Part 1

Subsection 1.1.1

Energy generated locally from renewable resources has been excluded since it is the easiest policy to administer but it is questionable that this is the desirable thing to do. Locally generated "renewable energy" could replace some nonrenewable energy which would otherwise be needed in the building. The owner is unlikely to install the necessary equipment unless he is forced to or finds it to be to his advantage. He could be forced to do so by either specifically worded legislation or by an energy budget that is so tight that it cannot be met economically any other way. It is, on the other hand, difficult to devise suitable incentives within the framework of a standard such as this. It would be possible to give a direct subsidy to help meet the cost of the equipment or there could be a reduction in rate of taxation in proportion to the percentage of locally generated "renewable energy" that is used. This problem is similar but opposite to the problem of the penalties to be applied to an owner whose building fails to meet the standard.

Subsection 1.1.2

The term "major occupancy" has been adopted since it is defined in the NBC as including the subsidiary occupancies that are an integral part of the principal occupancy. Thus these subsidiary occupancies do not have to be listed.

Subsection 1.2.2

The term "energy weighting factor" was coined before I became aware that ASHRAE used the term "resource utilization factor". The function of the two factors is the same, i.e., to convert the quantity of energy used in the building (delivered energy) into the equivalent quantity of primary energy (the non-renewable energy resources that are to be conserved). However, as proposed by ASHRAE, the resource utilization factors (RUF) "convert energy units of Btu or kW·h supplied to the building project into conventional units of measure (tons, barrels, MCF, etc.) of the resource" whereas the energy weighting factor used in this draft converts the delivered energy in gigajoules into primary energy in gigajoules (see definition of energy weighting factor). Thus the numerical values of the energy weighting factors will be different from those of the resource utilization factors and so the term resource utilization factor should not be used.

The definition of gross floor area has been adapted from DPW Property Management space measurement definition for rentable area to include their building service and accessory areas.

Subsection 1.4.2

1.4.2.1 It was not thought to be necessary to set an arbitrary limit on the size and type of building which could be built following the prescriptive requirements of Part 5. It is unlikely that the owner of a large office building would not elect to meet an energy budget whereas the person building one house almost invariably would go the prescriptive route. The changeover from one system to the other would take place at different levels of size and complexity depending upon the circumstances of the owner. Following the principle of allowing the maximum freedom in design the choice was left to the owner.

1.4.2.2 The reason for requiring a statement of the estimated energy consumption is to ensure that some thought at least has been given to the question at an early stage. An owner who insists on certain design features will be required to consider the consequences of his decision at the design stage and he will not reasonably be able to claim later that he has been placed in an impossible situation. The administrative authority will have some basis for assessing the sincerity of the owner.

1.4.2.3 The requirement for a professional engineer to certify the energy consumption estimate is a further effort to ensure that the problem of energy consumption has been given adequate attention. There is at present no established procedure available by which the estimate can be checked and much of the input to the computation must be made on the basis of the personal judgement of the person doing it. Thus it is essential that the energy consumption estimate be certified as sound by a professionally responsible person.

The cut-off figure of 1200 m^2 will exempt houses and similar small buildings from this requirement. The value is somewhat arbitrary but it is based on a hypothetical small apartment building of three floors with four 100 m^2 apartments on each floor. Even at this size, many designers would employ an engineer.

Subsection 1.4.4

1.4.4.1 The 5-year period is entirely arbitrary; it just seemed to be reasonable. There could be some difficulty in establishing the starting date for this period particularly with large buildings where some parts could be occupied while others are still under construction. The date when the occupancy permit was issued for the last portion of the building has been selected as the starting point.

PART 2

Section 2.1 Energy Budgets

Subsection 2.1.1 Determination of the Energy Budget

There are a great many factors that affect the energy consumption of buildings; some are under the control of the designer and the operator and others are not.

It can be argued that, to be equitable, provision should be made for many of these factors to be taken into account when selecting the budget which applies to any particular building. This would require a fairly involved system for the selection of energy budgets and at present it is not possible to produce such a system with any degree of confidence.

On the other hand, the basic purpose of the Energy Conservation Standard is to reduce the amount of energy that is wasted in buildings. One is tempted to add "to a minimum" to the previous sentence but one can no more define this minimum in the standard than one can take all the variables into account. The absolute minimum is zero, any value higher than that is a function of the design team's expertise, ingenuity and conscientiousness and of the builder's ability to meet their specifications. Thus, the practical minimum will be obtained if one allows a competent design and operating team complete freedom to do its best to reduce the energy consumption. Even with such a team an energy budget is desirable otherwise it may go on forever finding new ways to reduce the consumption by minute amounts. With the practical reality that different design teams have different capabilities and that there are many demands on their abilities when designing a building other than reducing the energy consumption as well as financial limitations a design target in the form of an energy budget becomes more or less indispensable.

Some objection has been voiced to the use of energy budgets on the grounds that once the budget has been met the design team will not make any effort to reduce the consumption still further. Thus a potential saving will be lost. However, the approach has been taken that more energy will be saved if all design teams are required to bring the energy consumption of their buildings below a reasonably low (but not minimal) energy budget than will be wasted because a few teams will not produce even better designs. Furthermore, with an energy budget that is not minimal, it will not be necessary to take into account all the many factors that affect the energy consumption of a building since there will be room for many of them to be compensated for in the design without exceeding the budget.

The difficulties of preparing suitable energy budgets can be divided into two groups. One group can be described as envelope-related and the other occupancy-related.

Envelope-related difficulties are those arising from the transfer of energy into and out of the building through the envelope which is obviously a function, first of all, of the weather. An adjustment for all aspects of the weather that affect the energy consumption of the building is a difficult process but if one accepts that the variations are primarily due to changes in the heating requirements then a simple approximate adjustment can be made using degree days.

Secondly, since the energy budgets are given per square metre of floor area the budgets must be varied in some way to take account of changes in the ratio of floor area to envelope area. This ratio is a function of the size, the number of floors and the shape of the building. With most building sites the designer has only a limited control over these factors since he must meet the owner's requirement while staying within the restraints imposed by building codes and zoning regulations. Without some suitable modification of the energy budget to allow for various sizes and shapes of buildings it could come about that it would be uneconomic to build on some sites. On the other hand the designer has almost complete freedom of choice with items, such as the fenestration, and the amount of insulation, and so he must accept the consequences of his decision in these areas without the benefit of any relaxation in the energy budget.

Occupancy-related difficulties are caused by the needs and duration of the activity being carried out in the building. Further problems arise from differing patterns (profiles) of use, mixed occupancies, and periods of partial occupancy.

Because of lack of knowledge it has not been possible to devise solutions to all these problems that are equitable and easily administered.

However, we may be freezing in the dark from lack of energy before such complete solutions are available if something is not done now and so a partial solution is offered. This takes the form of a tabular presentation of energy budgets which vary with:

1. the three basic occupancies that are being considered at present. The number of tables can be expanded in the future.
2. the size of the building as expressed by gross floor area.
3. the number of floors up to 3, with an overlap in gross floor area.
4. the extent and pattern of use as expressed by three standard uses.

An energy budget that is unique to any given building in any given location with any given occupancy can be obtained by linear interpolation between the tabulated values that are given for the conditions that are nearest to those to which the building will be subjected.

The energy budget values have not been given in the tables since information about them is still inadequate. The method of approaching the problem of generating them has been shown by the work of the Energy and Services Section, DBR, with schools but the details have yet to be worked out. This is a task of considerable magnitude requiring the generation of 366 values to complete the 7 tables as they are set out at present.

It should be noted also that the energy budgets for new buildings are to be given in terms of primary energy and so 184 of the 366 values generated initially in terms of delivered energy will have to be converted into primary energy. This requires that the quantities of the different forms of delivered energy be known which in turn requires that a choice be made as to the type of equipment that is to be installed in the model buildings.

2.1.1.1 It has been left to the Owner (Designer) to select an appropriate test year of weather data since no matter what year is selected or specified the measured energy consumption will always have to be adjusted from the actual weather to that of the test year (See Subsection 2.1.2).

2.1.1.2 As the prime purpose of the standard is to conserve the non-renewable energy resources of the country, energy budgets for new buildings will be given in terms of primary energy.

2.1.1.3 As it does not seem reasonable (nor economic, see Article 1.5.2.2) to require that the complete HVAC system for an existing building be changed, the energy budget for these buildings will be given in terms of delivered energy. No energy budgets are given for existing residential buildings having a gross floor area of 1200 m^2 or less.

Subsection 2.1.2

The only two factors for which adjustments are to be made to the energy budget before comparing it with the measured energy consumption are differences in the weather and in the hours of occupancy. Differences in occupancy profiles cannot be made by simple arithmetic and so are not easy to administer.

The period of occupancy is not easy to establish since both the area in the building that is occupied and the time for which it is occupied can vary widely from day to day.

Residences could be taken as continuous - 24 hr/day. As schools are in most cases operated by some public body, it should be possible to keep track of the usage without great difficulty. There is no such easy method of keeping track of the usage of offices, however, although it is possible that one could be developed for use during the period of energy monitoring only.

Section 2.2 Energy Weighting Factors

The selection of suitable Energy Weighting Factors for the conversion of the Delivered Energy into the equivalent quantity of Primary Energy presents some problems. Should these factors be uniform across the country? Should they be used to encourage the use of one form of energy as opposed to another? How are they to be determined?

These problems must be resolved and the energy weighting factors selected before the energy budgets for new buildings can be settled in terms of primary energy.

PART 3

3.1.1.4 This Article is adapted from ASHRAE 90-75,[1] Section 10, Article 10.3.2.1.

TABLES 3.1.3A to 3.1.3E

General

Originally it was intended that the User Requirements Group[2] would, at an early date, select values for the various conditions inside a building so that they could be used by others in developing the standard (in particular in determining values for energy budgets by computation). Unfortunately, this did not happen and the first set of values was recieved from the Group Chairman in a letter dated 16 November 1976. By this time others doing the computational work had already selected values on their own which differ one from the other and also from these selected by the User Requirements Group. I have therefore selected the values given in Tables 4.3.1.A-E.

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1 ASHRAE 90-75 Energy Conservation in New Building Design.

2 The User Requirements Group was a subcommittee of the Interdepartmental Committee. Their recommendations are contained in the record of work performed under the direction of that Committee.

In making the selection I adopted the philosophy that to make an energy-efficient building it is essential that the designer explore all reasonable means of reducing the energy consumption. The values for the internal conditions which he is required to adopt in the preconstruction energy analysis should not therefore be energy-conserving values set at the limit of conditions that are acceptable to the user and which an energy conscious operator might endeavour to maintain in the building. That is to say, the designer should not be allowed to show a low energy consumption in his analysis at the expense of minimally acceptable internal conditions. He should rather be forced to use less energy conservative values and so have to explore other methods of reducing the energy consumption. The operator of the building would thus have a little leeway to reduce the energy consumption should the design not work out in practice quite as well as anticipated.

Table 3.1.3A Room Temperature

(i) Occupied Period

The User Requirements Group selected values for offices, schools and dwellings of 70°F in winter and 78°F in summer. Sander and Dumouchel[3] used 73°F all year. Jones,[4] in his model for schools, used 72°F all year for secondary schools and 72°F in winter and 78°F in summer but without air conditioning for primary schools. ASHRAE 90-75 gives 72°F in winter and 78°F in summer.

I have selected the ASHRAE values of 72°F and 78°F as being a reasonable compromise and also because it is possible to extend the comfort range to 68°F - 82°F with suitable clothing (User Requirements Group, Appendix A, p. 4).

(ii) Unoccupied Period

For offices and schools the User Requirements Group recommended a set back to 65°F in winter and no mechanical cooling in summer. Sander and Dumouchel, following ASHRAE 90-75, do not use any set back nor does Jones.

I have adopted the User Requirements Group's recommendation since it seems to be desirable to make the designer think about unoccupied period set back and to provide suitable means of achieving it.

Table 3.1.3B Room Relative Humidity

The User Requirements Group recommended humidification to 20% RH and dehumidification to 60% RH with no comment about occupied or unoccupied periods. Sander and Dumouchel use 30% and 60% RH during occupied periods and no control during unoccupied periods. Jones also uses 30% and 60%. ASHRAE 90-75 recommends design conditions of humidification to 30% and

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[3] The work of Sander and Dumouchel in the Technological Research and Development Group of the Department of Public Works (Canada) is contained in the record of work performed by the Large Building Subcommittee of the Interdepartmental Committee.

[4] Jones, L. Calculating Energy Budgets for New School Buildings. To be issued as a DBR Internal Report.

dehumidification to "within the comfort envelope as defined in ASHRAE Standard 55-74[5]---- for minimum total HVAC system energy use" but with provision in the system for operation at other points within the envelope to give minimum energy consumption in operation.

Following the philosophy expressed earlier I have selected the higher figure of humidification to 30% RH in winter and dehumidification to 60% RH in summer for offices and schools with no control over humidity conditions during an unoccupied period. Also no control over humidity in dwellings.

Table 3.1.3C Ventilation Rates

(i) Offices

The User Requirements Group recommended that the minimum requirement of ASHRAE Standard 62-73[6] be used for the occupied period with no ventilation during unoccupied periods. Sander and Dumouchel adopted a minimum outdoor air supply of 0.1 cfm/sq. ft. for offices based upon ASHRAE 62-73 and a minimum air movement (total ventilation?) of 0.75 cfm/sq. ft. which is a DPW standard. ASHRAE 62-73 specifies a total ventilation rate of between 0.15 and 0.25 cfm/sq. ft. for general office spaces but allows for only 33% (or even 15%) of this to be outdoor air provided that the recirculated portion is treated suitably. It has, however, a requirement for a minimum of 5 cfm/person of outdoor air which for general office space equals 0.05 cfm/sq. ft.

Following the philosophy of selecting relatively high standards rather than the lowest acceptable ones, I have adopted for offices the User Requirements Group's recommendations to follow ASHRAE 62-73 for occupied periods but using the maximum value of 0.25 cfm/sq. ft. rather than the minimum (DPW's 0.75 cfm/sq. ft. seems to be excessive) together with Sander and Dumouchel's minimum of 0.1 cfm/sq. ft. of outdoor air. I have also followed the User Requirements Group's recommendation for no ventilation during the unoccupied period for the same reason as for adopting temperature set back - the designer will have to think about it.

(ii) Schools

For schools, Jones used different quantities of outside air ranging from 0 to an extraction rate of 0.67 cfm/sq. ft. (toilet and changing rooms). The minimum air movement (total ventilation?) for classrooms was given as 0.5 cfm/sq. ft. with an outdoor air supply of 0.2 cfm/sq. ft. for primary schools and 0.125 cfm/sq. ft. for secondary schools. He calculates the over-all outdoor air supply rates as being 0.085 cfm/sq. ft. for primary schools and 0.045 cfm/sq. ft. for secondary schools. ASHRAE 62-73 gives between 0.5 and 0.75 cfm/sq. ft. total ventilation for classrooms.

This is a wide range of figures but a total ventilation rate for classrooms of 0.5 cfm/sq. ft. has been chosen in conformity with Jones and the minimum recommendation of ASHRAE 62-73 and the ASHRAE 62-73 absolute minimum for outdoor air of 5 cfm/person has been respected giving 0.25 cfm/sq. ft. This last figure is, however, greatly above Jones' figures for outdoor air.

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5 ASHRAE 55-74 Thermal Environment Conditions for Human Occupancy.
6 ASHRAE 62-73 Standard for Natural and Mechanical Ventilation.

(iii) Dwellings

The User Requirements Group made no recommendations with respect to the ventilation of dwellings. ASHRAE 62-73 recommends between 0.049 and 0.07 cfm/sq. ft. in general living areas and bedrooms in multiple unit dwellings and their minimum requirement for outside air becomes 0.035 cfm/sq. ft. The National Building Code (Subsection 9.33.4) requires that a mechanical ventilation system "be capable of providing at least 1 air change per hour". (It does not require that this be provided continuously.) This requirement applies to buildings of less than 6000 sq. ft. and 3 storeys or less. The Small Buildings Committee[7] required air leakage rates of between 1/4 and 3/4 of an air change per hour but this also is restricted to buildings of 3 storeys or less.

In the absence of any other recommendations the maximum ASHRAE 62-73 recommendation of 0.07 cfm/sq. ft. of total air supply has been adopted together with the minimum requirement for outside air of 0.035 cfm/sq. ft. (i.e., approximately 1.4 air change per hour).

Table 3.1.3D Domestic Hot Water

The User Requirements Group recommended 1 US gal/person/day for offices; 0.6 US gal/student/day in primary schools and 1.8 US gal/student/day in secondary schools. Sander and Dumouchel adopted 320 Btu/sq. ft./year for hot water in offices based on an ASHRAE study. With an occupancy period of 260 days and 100 sq. ft./person (9.3 m^2) this is equivalent to 0.146 US gal/person/day. Even with the greater space allowance of 15 m^2 per person recommended by the User Requirements Group this increases to only 0.265 US gal/person/day i.e., little more than one US quart per person per day. This seems to be rather small, but since it is based upon an ASHRAE study, it should not be rejected out of hand. However, I have adopted the User Requirements Group's figure for offices and schools until suitable evidence is produced to support alternative measures. The use of higher figures also fits with the philosophy of not making the designer's task too easy. Similarly the higher temperature 140°F recommended by the User Requirements Group has been adopted although it can be argued that 100°F is sufficient.

Table 3.1.3E Level of Illumination

The values given for the occupied period are those recommended by the User Requirements Group following a review of Transport Canada guidelines, G.S.A. Recommendations and I.E.S. Standards.

The group made no recommendations about lighting during the unoccupied period but I have assumed that only corridors and stairwells need be lit at that time for the safety and convenience of night watchmen.

Subsection 3.1.4

TABLES 3.1.4A to 3.1.4C

Following from the idea of presenting energy budgets for different periods of use of the same building it is necessary to define these periods

[7] The Small Buildings Committee was a subcommittee of the Interdepartmental Committee. Their recommendations are contained in the record of work performed under the direction of that Committee.

of use. The periods given in these tables together with the internal conditions given in Tables 3.1.3A to 3.1.3E will define the conditions of use to which the building is assumed to be subjected when determining the energy budgets to be entered in Tables 2.1.1.2A and B and Tables 2.1.1.3A and B.

No period was given by the User Requirements Group. Sander and Dumouchel in their model for office buildings selected 0700 to 1800 hr. Mondays through Fridays. This period was selected for offices with no provision for statutory holidays.

Jones used three different occupancy periods for schools depending upon the type of use:

1. 0800-1600 hr on weekdays for a 200-day school year
2. 0800-2300 hr on weekdays for a 200-day school year
3. 0800-2300 hr on weekdays all year

   0800-1600 hr on weekends and holidays all year

In Nos. 1 and 2 the school is closed during the months of July and August. For initial energy analysis one could select any of these three options with an energy budget based on the same occupancy.

No one has specified an occupancy period for dwellings but it seems to be reasonable to assume 24 hr/day all year.

In all probability it would be preferable, if not essential, to define suitable occupancy profiles rather than give hours of occupancy. However, this has not yet been done in a manner suitable for inclusion in a Standard.

<u>Section 3.2</u>

<u>Subsection 3.2.2</u>

These four articles and Forms 3.2.2A and 3.2.2B have been adapted from a draft of the proposed Section 12 of ASHRAE 90-75.

<u>PART 4</u>

<u>Subsection 4.1.1</u>

The division at 1200 m^2 was retained so as to be consistent with the requirement for a P.Eng. to certify the energy consumption estimate. (See Article 1.4.2.3).

4.1.1.2 With heavy oil this may not be a practical method of metering.

4.1.1.3 The heat content of the condensate return is usually small compared with that of the steam supply and so there is not a mandatory requirement for the Owner to install the necessary metering equipment. On the other hand, he has the option to do so if he wishes.

Subsection 4.1.3

The purpose of the standard is to save energy and so it really is of little consequence if one building uses more than some relatively arbitrarily specified amount of energy provided that the balance is restored by another building using less. This provision will allow an Owner to take advantage of easily applied energy saving measures in one building and not force him into expensive measures in another one.

4.2.3.1 The conversion factors to get from the normal units of measurement to the gigajoule equivalents should be specified.