

Building energy estimation methodology



Legal Notice for Standards

Canadian Standards Association (operating as “CSA Group”) develops standards through a consensus standards development process approved by the Standards Council of Canada. This process brings together volunteers representing varied viewpoints and interests to achieve consensus and develop a standard. Although CSA Group administers the process and establishes rules to promote fairness in achieving consensus, it does not independently test, evaluate, or verify the content of standards.

Disclaimer and exclusion of liability

This document is provided without any representations, warranties, or conditions of any kind, express or implied, including, without limitation, implied warranties or conditions concerning this document’s fitness for a particular purpose or use, its merchantability, or its non-infringement of any third party’s intellectual property rights. CSA Group does not warrant the accuracy, completeness, or currency of any of the information published in this document. CSA Group makes no representations or warranties regarding this document’s compliance with any applicable statute, rule, or regulation.

IN NO EVENT SHALL CSA GROUP, ITS VOLUNTEERS, MEMBERS, SUBSIDIARIES, OR AFFILIATED COMPANIES, OR THEIR EMPLOYEES, DIRECTORS, OR OFFICERS, BE LIABLE FOR ANY DIRECT, INDIRECT, OR INCIDENTAL DAMAGES, INJURY, LOSS, COSTS, OR EXPENSES, HOWSOEVER CAUSED, INCLUDING BUT NOT LIMITED TO SPECIAL OR CONSEQUENTIAL DAMAGES, LOST REVENUE, BUSINESS INTERRUPTION, LOST OR DAMAGED DATA, OR ANY OTHER COMMERCIAL OR ECONOMIC LOSS, WHETHER BASED IN CONTRACT, TORT (INCLUDING NEGLIGENCE), OR ANY OTHER THEORY OF LIABILITY, ARISING OUT OF OR RESULTING FROM ACCESS TO OR POSSESSION OR USE OF THIS DOCUMENT, EVEN IF CSA GROUP HAS BEEN ADVISED OF THE POSSIBILITY OF SUCH DAMAGES, INJURY, LOSS, COSTS, OR EXPENSES.

In publishing and making this document available, CSA Group is not undertaking to render professional or other services for or on behalf of any person or entity or to perform any duty owed by any person or entity to another person or entity. The information in this document is directed to those who have the appropriate degree of experience to use and apply its contents, and CSA Group accepts no responsibility whatsoever arising in any way from any and all use of or reliance on the information contained in this document.

CSA Group is a private not-for-profit company that publishes voluntary standards and related documents. CSA Group has no power, nor does it undertake, to enforce compliance with the contents of the standards or other documents it publishes.

Intellectual property rights and ownership

As between CSA Group and the users of this document (whether it be in printed or electronic form), CSA Group is the owner, or the authorized licensee, of all works contained herein that are protected by copyright, all trade-marks (except as otherwise noted to the contrary), and all inventions and trade secrets that may be contained in this document, whether or not such inventions and trade secrets are protected by patents and applications for patents. Without limitation, the unauthorized use, modification, copying, or disclosure of this document may violate laws that protect CSA Group’s and/or others’ intellectual property and may give rise to a right in CSA Group and/or others to seek legal redress for such use, modification, copying, or disclosure. To the extent permitted by treaty or by law, CSA Group reserves all intellectual property rights in this document.

Patent rights

Attention is drawn to the possibility that some of the elements of this standard may be the subject of patent rights. CSA Group shall not be held responsible for identifying any or all such patent rights. Users of this standard are expressly advised that determination of the validity of any such patent rights is entirely their own responsibility.

Authorized use of this document

This document is being provided by CSA Group for informational and non-commercial use only. The user of this document is authorized to do only the following:

If this document is in electronic form:

- load this document onto a computer for the sole purpose of reviewing it;
- search and browse this document; and
- print this document if it is in PDF form.

Limited copies of this document in print or paper form may be distributed only to persons who are authorized by CSA Group to have such copies, and only if this Legal Notice appears on each such copy.

In addition, users may not and may not permit others to

- alter this document in any way, or remove this Legal Notice from the attached standard;
- sell this document without authorization from CSA Group; or
- make an electronic copy of this document.

If you do not agree with any of the terms and conditions contained in this Legal Notice, you may not load or use this document or make any copies of the contents hereof, and if you do make such copies, you are required to destroy them immediately. Use of this document constitutes your acceptance of the terms and conditions of this Legal Notice.



Standards Update Service

CSA C873 Series:15 November 2015

Title: *Building energy estimation methodology*

To register for e-mail notification about any updates to this publication

- go to store.csagroup.org
- click on **Product Updates**

The **List ID** that you will need to register for updates to this publication is **24240.1**

If you require assistance, please e-mail techsupport@csagroup.org or call 416-747-2233.

Visit CSA Group's policy on privacy at www.csagroup.org/legal to find out how we protect your personal information.

CSA C873 Series:15
Building energy estimation methodology



®A trademark of the Canadian Standards Association, operating as "CSA Group"

*Published in November 2015 by CSA Group
A not-for-profit private sector organization
178 Rexdale Boulevard, Toronto, Ontario, Canada M9W 1R3*

*To purchase standards and related publications, visit our Online Store at store.csagroup.org
or call toll-free 1-800-463-6727 or 416-747-4044.*

ISBN 978-1-4883-0105-6

*© 2015 Canadian Standards Association
All rights reserved. No part of this publication may be reproduced in any form whatsoever
without the prior permission of the publisher.*

Contents

Technical Committee on Heating, Ventilation, Air Conditioning and Refrigeration xix

Subcommittee on Building Energy Estimation Methodology (C873) xxi

Preface xxii

C873.0-15, Building energy estimation methodology — Part 0 — Definitions and general requirements for the calculation of energy loads, energy consumption, and source energy for heating, cooling, ventilation, domestic hot water, and lighting in buildings

0 Introduction 3

1 Scope 3

2 Reference publications 4

3 Definitions, abbreviations, symbols, units, and subscripts 5

3.1 Definitions 5

3.2 Abbreviations 11

3.3 Symbols, units, and subscripts 11

4 Use of default values 32

Tables

1 — Symbols, units, and subscripts used in CSA C873.1 2

2 — Symbols, units, and subscripts used in CSA C873.2 13

3 — Symbols, units, and subscripts used in CSA C873.3 17

4 — Symbols, units, and subscripts used in CSA C873.4 21

5 — Symbols, units, and subscripts used in CSA C873.5 22

6 — Symbols, units, and subscripts used in CSA C873.7 26

7 — Symbols, units, and subscripts used in CSA C873.8 28

8 — Symbols, units, and subscripts used in CSA C873.9 31

9 — Symbols, units, and subscripts used in CSA C873.10 31

C873.1-15, Building energy estimation methodology — Part 1 — General balancing procedures, terms and definitions, zoning, and evaluation of energy types

1 Scope 37

2 Reference publications 37

3 Definitions, abbreviations, symbols, units, and subscripts 37

4 Relationship among the Standards of the CSA C873 Series 37

4.1 Variables calculated in other Standards of this Series 37

4.2 Variables calculated in CSA C873.1 and required in other Standards of the CSA C873 Series 39

5 Energy calculation 40

5.1 General 40

5.2 Requirements relating to the energy analysis 40

5.2.1 General 40

5.2.2	Dividing the building into zones	40
5.2.3	Determining the energy loads for each zone	40
5.2.4	Determining the energy loads for heating and cooling by iteration	41
5.2.5	Determining system losses, energy consumption, and source energy	41
5.2.6	Times and periods	41
5.3	Energy load calculation	41
5.3.1	General	41
5.3.2	Lighting energy	42
5.3.3	Energy loads for heating and cooling	42
5.3.4	Energy loads for domestic hot water	43
5.4	Analysis of energy losses due to control and emission, distribution, and storage	43
5.4.1	General	43
5.4.2	Lighting	43
5.4.3	Heating (heating systems and HVAC heating function)	43
5.4.4	Generator cooling for cooling system and HVAC cooling	44
5.4.5	Humidification in HVAC systems	45
5.4.6	Domestic hot-water supply	46
5.4.7	Energy for other process heating or cooling requirements	46
5.5	Calculation of energy consumption (energy use)	46
5.5.1	General	46
5.5.2	Lighting energy consumption	46
5.5.3	Energy consumption for heating and cooling and generation losses	46
5.5.4	Auxiliary energy consumption	49
5.5.5	Energy consumption calculated according to energy types	49
5.6	Source energy	50
6	Zoning of buildings	50
6.1	General	50
6.2	Descriptions	50
6.2.1	Zone	50
6.2.2	Serviced area	50
6.3	Dividing a building into zones	50
6.4	Serviced areas	51
6.5	Determination of geometric parameters	51
7	Assignment of the characteristic values	51
7.1	Characteristic values	51
7.2	General information	52
7.3	Assignment rules for characteristic values	52
7.3.1	General	52
7.3.2	Case 1 — Serviced area and zone are identical	52
7.3.3	Case 2 — Several serviced areas in one zone	53
7.3.4	Case 3 — Several zones in one serviced area	53
8	Determination of system boundaries, areas, and volumes	54
8.1	General	54
8.2	Reference dimensions for determining the thermal envelope area and the gross volume	54
8.2.1	Floor plans (horizontal dimensions)	54
8.2.2	Sections (vertical dimensions)	55
8.3	Other reference dimensions	56
8.3.1	General	56
8.3.2	Energy reference area	56
8.3.3	Storey height	56
8.3.4	Air volume	57
8.3.5	Characteristic length and width	57
8.4	Input parameters for energy calculation	57

9 Calculation approach 57

9.1 General case 57

10 Reporting 59

10.1 General 59

10.2 Mandatory reporting 59

10.3 Optional reporting 59

Annexes**A** (normative) — Mandatory reporting 60**B** (informative) — Optional reporting 64**Tables****1** — Parameters from other Standards in the C873 Series used in this Standard 38**2** — Variables calculated in CSA C873.1 and required in other Standards of the CSA C873 Series 40**Figures****1** — Building floor plan used as an example for determining characteristic values 52**2** — Reference dimensions (floor plan) 55**3** — Reference dimensions (sectional view) 56**4** — Relationships within the balance as calculated according to the CSA C873 Series — General example 58**C873.2-15, Building energy estimation methodology — Part 2 — Energy loads for heating and cooling of building zones****1 Scope** 73**2 Reference publications** 73**3 Definitions, abbreviations, symbols, units, and subscripts** 73**4 Relationship among the Standards of the CSA C873 Series** 73

4.1 Variables calculated in other Standards in this Series 73

4.2 Variables calculated in CSA C873.2 and required in other Standards of the CSA C873 Series 75

4.3 Determination of the energy consumption for various types of mechanical/electrical systems 76

5 Monthly balance calculation method 76

5.1 Principle of balance calculation method 76

5.1.1 Calculation boundaries and calculation period 76

5.1.2 Heat gains and heat losses 77

5.1.3 Utilization of heat gains and heat losses 77

5.2 Equations for calculating the energy loads of a building zone for heating and cooling 77

5.2.1 General 77

5.2.2 Equations for calculating the energy load for heating 78

5.2.3 Balance equations for calculating the energy load for cooling 78

5.2.4 Accounting for weekend and holiday-period operation 78

5.2.5 Monthly values and annual values 79

5.3 Heat losses 80

5.3.1 General 80

5.3.2 Transmission heat losses 81

5.3.3 Ventilation heat losses 81

5.3.4 Internal heat losses 81

5.3.5	Heat losses due to radiation heat transfer	81
5.3.6	Heat storage	81
5.4	Heat gains	82
5.4.1	General	82
5.4.2	Heat gains due to solar radiation	82
5.4.3	Transmission heat gains	82
5.4.4	Ventilation heat gains	82
5.4.5	Internal heat gains	83
5.5	Utilization of the heat gains	83
6	Determination of individual parameters for the monthly balance	83
6.1	Room temperature assumptions	83
6.1.1	General	83
6.1.2	Reference internal temperature for calculating the energy load for heating	84
6.1.3	Reference internal temperature for cooling	85
6.1.4	Temperature of an adjacent unheated or uncooled zone	86
6.1.5	Temperature of an adjacent heated or cooled zone	88
6.2	Conduction heat losses/heat gains	89
6.2.1	Direct conduction to the external environment	89
6.2.2	Conduction through unheated or uncooled spaces to the external environment	90
6.2.3	Conduction to adjacent heated or cooled building zones	90
6.2.4	Conduction through the ground	91
6.3	Ventilation heat losses/gains	91
6.3.1	Infiltration	91
6.3.2	Mechanical ventilation	94
6.3.3	Ventilation in unheated or uncooled zones	97
6.3.4	Air exchange between zones	97
6.4	Radiation heat gains and losses	99
6.4.1	Heat gains due to solar radiation entering through windows	99
6.4.2	Solar heat gains via opaque building elements	100
6.4.3	Solar heat gains via unheated or uncooled sunspaces (glazed annexes)	119
6.5	Internal heat gains and sources of cold	121
6.5.1	Heat gains due to persons	121
6.5.2	Heat gains and losses due to machinery and equipment	122
6.5.3	Internal heat gains/heat losses due to movement of materials	122
6.5.4	Heat gains due to artificial lighting	122
6.5.5	Heat gains and losses due to heating, cooling, domestic hot-water supply, and ventilation systems	123
6.6	Taking into account stored heat between days of usage and non-usage	123
6.7	Utilization factors of heat gains	124
6.7.1	Effective heat capacity (thermal mass)	124
6.7.2	(Thermal) time constant	125
6.7.3	Utilization factor	126
6.7.4	Limit for the utilization factor	127

Annexes

A (normative)	— Shading factors and movable solar protection devices	128
B (normative)	— Maximum heating load in the building zone	135
C (normative)	— Maximum cooling load in the building zone	138
D (normative)	— Calculation of monthly heating and cooling times	146

Tables

1	— Temperature correction factors for various building elements	86
2	— n_{50} design values (default values for untested buildings)	93

- 3** — Default mean monthly supply air temperatures 96
- 4** — Default values for characteristics of glazing and solar protection devices — Operable frames — Aluminum with thermal break 100
- 5** — Default values for characteristics of glazing and solar protection devices — Operable frames — Reinforced vinyl/aluminum clad wood 102
- 6** — Default values for characteristics of glazing and solar protection devices — Operable frames — Wood/vinyl 104
- 7** — Default values for characteristics of glazing and solar protection devices — Operable frames — Insulated fiberglass/vinyl 106
- 8** — Default values for characteristics of glazing and solar protection devices — Fixed frames — Aluminum with thermal break 108
- 9** — Default values for characteristics of glazing and solar protection devices — Fixed frames — Reinforced vinyl/aluminum clad wood 110
- 10** — Default values for characteristics of glazing and solar protection devices — Fixed frames — Wood/vinyl 112
- 11** — Default values for characteristics of glazing and solar protection devices — Fixed frames — Insulated fiberglass/vinyl 114
- 12** — Default values for characteristics of glazing and solar protection devices — Curtain wall frames with thermal break 116
- 13** — Default values for solar radiation absorption coefficients (α) of various surface for the energy-relevant part of the solar radiation spectrum 119

Figures

- 1** — Diagram representing the thermal quantities to be taken into consideration for sunspaces (glazed annexes) 120

C873.3-15, Building energy estimation methodology – Part 3 — Energy loads for conditioning air

1 Scope 151

2 Reference publications 151

3 Definitions, abbreviations, symbols, units, and subscripts 151

4 Interface with other Standards in the CSA C873 Series 151

4.1 Input parameters 151

4.2 Output parameters 151

5 Parameters used in other calculations 153

5.1 General considerations 153

5.2 Supply air volume flow for constant air volume systems 154

5.3 Supply air volume flow for systems with time-dependent or usage-dependent volume flow control 154

5.4 Supply air volume flow for variable air volume systems 154

5.5 Maximum supply airflow rate 155

5.6 Monthly mean supply air temperatures 155

6 Calculation of supply and return fan energy consumption 167

6.1 Constant volume systems 167

6.2 Variable air volume systems 168

6.2.1 Calculation procedure 168

6.2.2 Systems with time-dependent or usage-dependent control of the supply flow 170

6.2.3 Systems with control of the supply flow as a function of the cooling load 170

7 Energy loads for heating, cooling, humidification, and dehumidification of supply air 171

- 7.1 General 171
- 7.2 Determining the energy characteristic values for thermal conditioning of air 172
 - 7.2.1 General 172
 - 7.2.2 Heating energy characteristic values 172
 - 7.2.3 Cooling energy characteristic values 173
 - 7.2.4 Steam humidifier energy characteristic value 174
- 7.3 Economizer 175
 - 7.3.1 Air economizers 175
- 7.4 Calculating monthly loads using the energy characteristic values 176
 - 7.4.1 For constant volume constant temperature and variable volume systems 176
 - 7.4.2 For constant volume variable temperature system 176

8 Maximum loads 181

- 8.1 General 181
- 8.2 Design conditions for outdoor air and return air 181
- 8.3 Calculation of supply air enthalpy 184
- 8.4 Maximum heating load 186
- 8.5 Maximum cooling load 187
- 8.6 Maximum power for steam generation 188

Annexes

- A** (normative) — Energy characteristic values for thermal conditioning of air 189
- B** (normative) — Component usage times 191
- C** (informative) — System types — Schematic diagrams 217

Tables

- 1** — Input parameters 152
- 2** — Output parameters 153
- 3** — Monthly mean supply air temperature for air handling units without cooling installed — NECB Climate Zone 4 156
- 4** — Monthly mean supply air temperature for air handling units without cooling installed — NECB Climate Zone 5 157
- 5** — Monthly mean supply air temperature for air-handling units without cooling installed — NECB Climate Zone 6 158
- 6** — Monthly mean supply air temperature for air-handling units without cooling installed — NECB Climate Zone 7A 159
- 7** — Monthly mean supply air temperature for air-handling units without cooling installed — NECB Climate Zone 7B 160
- 8** — Monthly mean supply air temperature for air handling units without cooling installed — NECB Climate Zone 8 161
- 9** — Monthly mean supply air temperature for air handling units without heating or cooling installed — NECB Climate Zone 4 162
- 10** — Monthly mean supply air temperature for air-handling units without heating or cooling installed — NECB Climate Zone 5 163
- 11** — Monthly mean supply air temperature for air-handling units without heating or cooling installed — NECB Climate Zone 6 164
- 12** — Monthly mean supply air temperature for air-handling units without heating or cooling installed — NECB Climate Zone 7A 165
- 13** — Monthly mean supply air temperature for air-handling units without heating or cooling installed — NECB Climate Zone 7B 166
- 14** — Monthly mean supply air temperature for air handling units without heating or cooling installed — NECB Climate Zone 8 167
- 15** — Water vapour content of returned air 175

16	— Maximum monthly available free cooling hours	178
17	— Ventilation hours of operation monthly free cooling correction factors for in NECB climate zone 4	178
18	— Ventilation hours of operation monthly free cooling correction factors in NECB climate zone 5	179
19	— Ventilation hours of operation monthly free cooling correction factors in NECB climate zone 6	179
20	— Ventilation hours of operation monthly free cooling correction factors in NECB climate zone 7A	180
21	— Ventilation hours of operation monthly free cooling correction factors NECB climate zone 7B	180
22	— Ventilation hours of operation monthly free cooling correction factors in NECB climate zone 8	181
23	— Design parameters for specific outside air conditions	182
24	— Design parameters for return air conditions in the zone	183

Figures

1	— Sections of ventilation ductwork with constant resistance and with variable resistance	169
----------	------------------------------------------------------------------------------------------	-----

C873.4-15, Building energy estimation methodology — Part 4 — Energy consumption for lighting

1	Scope	221
----------	--------------	-----

2	Reference publications	221
----------	-------------------------------	-----

3	Definitions, abbreviations, symbols, units, and subscripts	221
----------	-------------------------------------------------------------------	-----

4	Interface with other Standards in the CSA C873 Series	221
----------	--------------------------------------------------------------	-----

4.1	Input parameters	221
-----	------------------	-----

4.2	Output parameters	222
-----	-------------------	-----

5	Calculations	223
----------	---------------------	-----

5.1	Interior lighting energy consumption	223
-----	--------------------------------------	-----

5.2	Determination of lighting power density	224
-----	-----------------------------------------	-----

5.3	Determination of daylighted and non-daylighted areas	224
-----	------------------------------------------------------	-----

5.3.1	Determination of daylighted area	224
-------	----------------------------------	-----

5.3.2	Determination of primary sidelighted areas	224
-------	--------------------------------------------	-----

5.3.3	Determination of daylighted area under skylights	225
-------	--------------------------------------------------	-----

5.3.4	Determination of daylighted area under rooftop monitors	225
-------	---------------------------------------------------------	-----

5.3.5	Determination of daylighted area under rooftop monitors	226
-------	---------------------------------------------------------	-----

5.3.6	Determination of non-daylighted areas	226
-------	---------------------------------------	-----

5.4	Determination of operating times	226
-----	----------------------------------	-----

5.5	Determination of factor for daylight harvesting	232
-----	-------------------------------------------------	-----

5.6	Sidelighting	233
-----	--------------	-----

5.6.1	Determination of daylight supply factor for sidelighting	233
-------	----------------------------------------------------------	-----

5.6.2	Determination of the mean daylight factor for sidelighting	235
-------	------------------------------------------------------------	-----

5.6.3	Determination of daylight factor for the rough opening for sidelighting	236
-------	-------------------------------------------------------------------------	-----

5.6.4	Determination of the transparency factor	236
-------	------------------------------------------	-----

5.6.5	Determination of the room depth factor	236
-------	----------------------------------------	-----

5.6.6	Determination of the obstruction factor	236
-------	-----------------------------------------	-----

5.7	Toplighting	241
-----	-------------	-----

5.7.1	Determination of daylight supply factor for toplighting	241
-------	---------------------------------------------------------	-----

5.8	Determination of factor for occupancy control and personal control	245
-----	--------------------------------------------------------------------	-----

Annexes

A (normative)	— Determination of daylighted areas	247
----------------------	-------------------------------------	-----

B (normative)	— Calculation of the daylight supply factor when the glare protection is active	251
----------------------	---------------------------------------------------------------------------------	-----

Tables

- 1** — Input parameters 222
- 2** — Output parameters 223
- 3** — Monthly time distribution factors for daytime, $MTD_{day,m}$ 227
- 4** — Monthly time distribution factors for nighttime, $MTD_{night,m}$ 228
- 5** — Annual operating time of space i in zone n during daytime assuming 250 operating days per year, $t_{day,n,i,250}$, for locations with latitude $< 45^\circ$ 229
- 6** — Annual operating time of space i in zone n during daytime assuming 250 operating days per year, $t_{day,n,i,250}$, for locations with latitude 45° to 60° 230
- 7** — Annual operating time of space i in zone n during daytime assuming 250 operating days per year, $t_{day,n,i,250}$, for locations with latitude $> 60^\circ$ 231
- 8** — Calculation of the daylight system control factor for space i in zone n , $C_{DL,ctrl,n,i}$ 232
- 9** — Calculation of the daylight-dependent control system factor for space i in zone n , $C_{DL,ctrl,n,i}$ 233
- 10** — Calculation of the daylight supply factor in the primary sidelighted area when the glare protection system is not active for space i in zone n , $C_{DL,sup,SNA,n,i}$ 234
- 11** — Fraction of the daytime operating hours during which the glare protection system is not active for space i in zone n , $f_{DL,SNA,n,i}$ 235
- 12** — Determination of daylight supply factor for toplighting for space i in zone n , $C_{DL,sup,n,i}$ 241
- 13** — Determination of external daylight factor for space i in zone n , $D_{ext,n,i}$ 242
- 14** — Determination of utilization factor for space i in zone n , $\eta_{R,n,i}$, for dome skylights 243
- 15** — Determination of utilization factor for space i in zone n , $\eta_{R,n,i}$, for non-dome skylights and rooftop monitors 244
- 16** — Factor to account for occupancy-sensing mechanism for space i in zone n , $C_{occ,ctrl,n,i}$ 246

Figures

- 1** — Effect of the angle of elevation of a linear obstruction 237
- 2** — Effect of the horizontal obstruction angle due to an overhang 238
- 3** — Effect of the vertical obstruction angle due to a sidefin 238
- 4** — Schematic of a courtyard 240
- 5** — Notation used to describe the geometry of the upstands of spaces with dome skylights 242
- 6** — Notation used to describe the geometry of non-dome skylights and rooftop monitors 243
- 7** — Schematic of room 245

C873.5-15, Building energy estimation methodology — Part 5 — Energy consumption for heating systems

- 1 Scope** 261
- 2 Reference publications** 261
- 3 Definitions, abbreviations, symbols, units, and subscripts** 261
- 4 Interface with other Standards in the CSA C873 Series** 261
 - 4.1 Input parameters 261
 - 4.2 Output parameters 264
 - 4.3 General energy equations 265
 - 4.3.1 Energy consumption 265
 - 4.3.2 Auxiliary energy 265
 - 4.3.3 Uncontrolled internal heat gains 265
 - 4.3.4 Generator output 266
- 5 Boundary conditions** 266
 - 5.1 Part-load levels 266
 - 5.1.1 Control and emission 266

5.1.2	Distribution	267
5.1.3	Storage	267
5.1.4	Generation	267
5.2	Temperatures	268
5.3	Running times	268
6	Space-heating energy load	270
6.1	Heat control and emission	270
6.1.1	Thermal losses	270
6.1.2	Factors and efficiencies for radiators in rooms with height ≤ 4 m	271
6.1.3	Factors and efficiencies for water-based embedded systems in rooms with height ≤ 4 m	272
6.1.4	Factors and efficiencies for electric heating in rooms with height ≤ 4 m	274
6.1.5	Factors and efficiencies for air heating (HVAC systems) in rooms with height ≤ 4 m	275
6.1.6	Factors and efficiencies for rooms with height > 4 m and ≤ 20 m	275
6.1.7	Auxiliary energy	276
6.2	Distribution	279
6.2.1	Thermal losses	279
6.2.2	Auxiliary energy	280
6.2.3	Uncontrolled internal heat gains	283
6.3	Storage	283
6.3.1	Thermal losses	283
6.3.2	Auxiliary energy	284
6.3.3	Uncontrolled internal heat gains	285
6.4	Heat generation	285
6.4.1	Solar combination systems	285
6.4.2	Heat pump systems	291
6.4.3	Boiler systems	302
6.4.4	Radiant tube heaters and decentralized convection heaters	313
6.4.5	Electric heaters	314
6.4.6	Central gas furnace systems — Energy consumption	314
6.4.7	District heating and local heating	315
6.4.8	Decentralized combined heat and power	317

Annexes

A (informative)	— Characteristic width and length of buildings	318
B (informative)	— Default values for distribution piping characteristics	320
C (informative)	— Estimating the hydraulic power of a pump at the design point	322
D (normative)	— Correction factor for inclination and alignment	324
E (normative)	— Default values for heat pump COP_h	327
F (normative)	— Hour frequencies of outdoor temperatures	332
G (normative)	— Temperature data for heat pump modeling	349
H (normative)	— Calculation procedure for source and sink temperature correction with a set exergetic efficiency	358
I (normative)	— Biomass boiler class definition	360

Tables

1	— Input parameters	262
2	— Output parameters	264
3	— Efficiencies for radiators: Room heights ≤ 4 m	272
4	— Efficiencies for water-based embedded systems (surface heating): Room heights ≤ 4 m	273
5	— Reference thermal resistance of insulation layer below underfloor heating piping	274
6	— Efficiencies for electric heating: Room heights ≤ 4 m	274
7	— Efficiencies for air heating (HVAC systems): Room heights ≤ 4 m	275
8	— Efficiencies for rooms with heights from 4 m to 20 m	276

- 9 — Default values for auxiliary energy for the control system 277
- 10 — Default values for the auxiliary energy of fans for air supply in rooms where $h \leq 4$ m 277
- 11 — Default values for the auxiliary energy of fans and for the control system in room with $h > 4$ m 279
- 12 — Correction factor for heat generators with integrated pump management 281
- 13 — Constants C_{p1} and C_{p2} for calculation of the expenditure factor for circulation pumps 282
- 14 — Factor accounting for the energy contribution in the given month in relation to the annual contribution, f_M 286
- 15 — Default solar collector parameters 287
- 16 — Location factors 288
- 17 — Correction factor for the solar load ratio, f_{slr} 288
- 18 — Correction factor for the temperature level of the space heating, $f_{h,T}$ 290
- 19 — Correction factors to account for deviations in temperature differences in heat pump measurement and operation, $f_{\Delta\theta}$ 297
- 20 — Correction factor for part-load operation of heat pumps with radiators 298
- 21 — Correction factor for part-load operation of heat pumps with surface heating 299
- 22 — Correction factor for part-load operation of absorption heat pumps 299
- 23 — Mean source temperature for ground and groundwater as a function of the average outdoor temperature 300
- 24 — Temperature correction factors for gas-fired boilers 305
- 25 — Temperature correction factors for oil-fired boilers 305
- 26 — Temperature correction factors for biomass boilers 305
- 27 — Part-load factors 306
- 28 — Efficiency factors for gas-fired boilers 306
- 29 — Efficiency factors for oil-fired boilers 307
- 30 — Efficiency factors for biomass boilers 307
- 31 — Radiation loss factors 308
- 32 — Standby loss factors 309
- 33 — Auxiliary energy factors 312
- 34 — Efficiency factor for radiant tube heaters and decentralized convection heaters 313
- 35 — Efficiency factors for central gas furnace systems 315
- 36 — Coefficient B_{DS} as a function of the class of insulation and type of dwelling substation 316
- 37 — Definitions of the classes of insulation 316
- 38 — D_{DS} as a function of the primary temperature and type of dwelling substation 317

Figures

- 1 — Bin hours and energy fractions of the heat pump and the second heat generator (backup heating) in alternate operation 294
- 2 — Bin hours and energy fractions of the heat pump and the second heat generator (backup heating) in parallel operation 295
- 3 — Bin hours and energy fractions of the heat pump and the second heat generator (back-up heating) in partly parallel operation 296

C873.7-15, Building energy estimation methodology — Part 7 — Energy consumption for air-handling and air-conditioning systems

- 1 Scope** 363
- 2 Reference publications** 363
- 3 Definitions, abbreviations, symbols, units, and subscripts** 363
- 4 Calculation procedures, and input and output parameters** 363
 - 4.1 General 363
 - 4.2 Interfaces for heating system calculations 367

- 4.3 Interface with other Standards of the CSA C873 Series 369
 - 4.3.1 Input parameters 369
 - 4.3.2 Output parameters 370
- 5 Energy load for conditioning air 371**
 - 5.1 General 371
 - 5.2 Default values for air-handling unit system components 371
 - 5.2.1 Fans 371
 - 5.2.2 Heat recovery 371
 - 5.3 Energy load for the air-handling unit heating coils 372
 - 5.3.1 General 372
 - 5.3.2 Loss of control and emission for the air-handling unit (air circulation heat losses) 372
 - 5.3.3 Distribution heat loss for the air-handling unit ventilation system (air transport heat losses) 372
 - 5.3.4 Leakage rates 373
 - 5.3.5 Hot-water system temperature for air-handling heating coils 373
 - 5.3.6 Demand time of air-handling unit heating coils 373
 - 5.4 Energy load for the air-handling unit cooling coils 374
 - 5.4.1 General 374
 - 5.4.2 Heat demand for control and emission losses of air to the room 374
 - 5.4.3 Distribution heat gain for the air-handling unit ventilation system (heat gains during air transport) 374
 - 5.4.4 Leakage rates 374
 - 5.4.5 Demand time for air-handling unit cooling coils 375
 - 5.5 Energy load for zone-level air conditioning 375
 - 5.5.1 General 375
 - 5.5.2 Zone-level air-conditioning demand time 375
 - 5.6 Energy load for humidification 376
- 6 Control and emission, distribution, and storage 376**
 - 6.1 Heating plant energy output for air-handling unit 376
 - 6.2 Cooling plant energy output 376
 - 6.2.1 General 376
 - 6.2.2 Cooling plant energy output for the air-handling unit 376
 - 6.2.3 Cooling plant energy output for zone-level air conditioning 377
 - 6.3 Fan energy consumption for zone-level air conditioning 378
 - 6.4 Steam for humidification 379
 - 6.5 Energy consumption for condenser-water and chilled-water distribution 379
 - 6.5.1 Electrical energy demand 379
 - 6.5.2 Hydraulic energy requirement for distribution 383
 - 6.5.3 Expenditure factor for pump operation 388
 - 6.6 Other forms of auxiliary energy (ancillary drives) 390
 - 6.6.1 Pump heating coils 390
 - 6.6.2 Pumps and drives for heat recovery 390
 - 6.6.3 Water humidifier pumps 391
 - 6.6.4 Electrical energy demand for central HVAC unit controls 392
- 7 Energy consumption for cooling and steam plant 392**
 - 7.1 Energy consumption for cooling equipment 392
 - 7.1.1 General 392
 - 7.1.2 Cooling energy output of cooling equipment 393
 - 7.1.3 Energy consumption of compression refrigeration units 394
 - 7.1.4 Energy consumption for heating of absorption chillers 398
 - 7.1.5 Output variables for other Standards in the CSA C873 Series 400
 - 7.1.6 Energy consumption for condenser equipment 401

- 7.1.7 Parameters for calculating the energy consumption for cooling and distribution 403
 7.2 Energy consumption for steam generation 405

8 Energy consumption 405

- 8.1 Cooling equipment 405
 8.1.1 General 405
 8.1.2 Electric energy consumption for compressor-type chillers 405
 8.1.3 Steam for heating absorption chillers 406
 8.2 Steam generation for humidification 406
 8.3 Auxiliary energy consumption for air-handling units and zone-level air conditioning 406
 8.3.1 General 406
 8.3.2 Auxiliary energy consumption for steam supply 407
 8.3.3 Other forms of auxiliary energy and recovered energy consumption 407

Annexes

- A** (normative) — Characteristics for cooling equipment 408
B (normative) — Methods for determining the part-load values of refrigeration 752
C (normative) — Heat sources and sinks 757
D (informative) — Guidelines for calculating the electrical energy demand of cooling-water and chilled-water distribution systems 758
E (normative) — Default values for refrigeration equipment in existing systems 762
F (normative) — External air volume flow and specific power demand of fans in existing systems 763

Tables

- 1** — Demarcation between CSA C873.5 and CSA C873.7 368
2 — Input parameters 369
3 — Output parameters 370
4 — Air-handling unit supply fan default values 371
5 — Default heat-recovery effectiveness values (interface with CSA C873.2 — Usable gains) 372
6 — Minimum utilization factor for demand-oriented space cooling 375
7 — Factors for cooling for air-handling unit (mean annual value) 377
8 — Factors for cooling for zone-level air conditioning (mean annual values) 378
9 — Default values for the specific energy demand of fans for room conditioning 379
10 — Essential parameters for calculating the electricity use of condenser-water and chilled-water networks 380
11 — Specific pressure loss R in kPa/m and additional share of individual flow resistance, z , in pipework 385
12 — Assumed values for pressure losses across components in distribution circuits 385
13 — Operating modes 386
14 — Values of C_{p1} and C_{p2} in relation to the pump operating mode 389
15 — Electrical power for rotor drives 391
16 — Default values for water humidifiers (mean annual values) 391
17 — Overview of refrigeration systems modelled using the characteristic value method 392
18 — Types of part-load control of water-cooled compressor-type cooling equipment evaluated by the characteristic value method 395
19 — Default values for the rated coefficient of performance (COP_c) of cooling for water-cooled chillers 395
20 — Types of part-load control of air-cooled compressor-type chillers evaluated by the characteristic value method 396
21 — Default values for the rated coefficient of performance (COP_c) of cooling for air-cooled compression chillers 396
22 — Types of part-load control of air-cooled zone-level air-conditioning systems evaluated by the characteristic value method 397

- 23** — Rated coefficient of performance (COP_c) of cooling for air-cooled zone-level air-conditioning systems 397
- 24** — Types of part-load control of absorption chillers evaluated by the characteristic value method 399
- 25** — Rated heat ratio, ζ , for single-stage absorption chillers 399
- 26** — Rated heat ratio for direct-fired absorption cooling equipment 400
- 27** — Specific electric input, $q_{R,electr}$, of condenser equipment 402
- 28** — Parameters for evaluating the energy characteristics of indirect cooling systems (chillers) 404
- 29** — Parameters for evaluating the energy characteristics of direct cooling systems (DX units) 404
- 30** — Energy consumption factors for steam generation 405

Figures

- 1** — Heating for the air-handling unit 364
- 2** — Cooling for the air-handling unit 365
- 3** — Cooling for zone-level air conditioning 366
- 4** — Steam generation for humidification 367
- 5** — Procedure for calculating the pump energy demand for condenser water and chilled water 382

C873.8-15, Building energy estimation methodology — Part 8 — Energy consumption for domestic hot-water systems

- 1 Scope** 767
- 2 Reference publications** 767
- 3 Definitions, abbreviations, symbols, units, and subscripts** 767
- 4 Interface with other Standards in the CSA C873 Series** 767
 - 4.1 Input parameters 767
 - 4.2 Output parameters 769
 - 4.3 General energy equations 770
 - 4.3.1 Energy consumption 770
 - 4.3.2 Auxiliary energy use 771
 - 4.3.3 Uncontrolled internal heat gains 771
 - 4.3.4 Generator heat output 771
 - 4.3.5 Energy load 772
- 5 Boundary conditions** 773
- 6 Service hot-water energy load** 774
 - 6.1 Control and emission 774
 - 6.1.1 Thermal losses 774
 - 6.1.2 Auxiliary energy 774
 - 6.2 Distribution 774
 - 6.2.1 Thermal losses 774
 - 6.2.2 Auxiliary energy 776
 - 6.2.3 Uncontrolled internal heat gains 778
 - 6.3 Storage 778
 - 6.3.1 Indirectly heated domestic hot-water storage tanks 778
 - 6.3.2 Electrically heated domestic storage water heaters 780
 - 6.3.3 Gas-fired domestic storage water heaters 782
 - 6.4 Heat generation 784
 - 6.4.1 General 784
 - 6.4.2 Solar systems 784
 - 6.4.3 Heat pump systems 788

- 6.4.4 Electric instantaneous heaters 794
- 6.4.5 Boiler systems 794
- 6.4.6 Direct-fired storage water heaters 801
- 6.4.7 District heating and local heating 802
- 6.4.8 Decentralized combined heat and power 803

Annexes

- A** (informative) — Characteristic width and length of buildings 804
- B** (informative) — Default values for distribution piping characteristics 806
- C** (informative) — Estimating the hydraulic power of a pump at the design point 808
- D** (normative) — Correction factor for inclination and alignment 810
- E** (normative) — Default values for heat pump COP_h 813
- F** (normative) — Temperature data for heat pump modeling 814
- G** (normative) — Calculation procedure for source and sink temperature correction with a set exergetic efficiency 823
- H** (normative) — Biomass boiler class definitions 825

Tables

- 1** — Input parameters 768
- 2** — Output parameters 770
- 3** — Default boundary conditions 774
- 4** — Constants C_{p1} and C_{p2} for calculation of the expenditure factor of circulation pumps 777
- 5** — Factor accounting for the energy contribution in the given month in relation to the annual contribution, f_M 785
- 6** — Default solar collector parameters 786
- 7** — Location factors 786
- 8** — Mean source temperature for ground and groundwater as a function of the average outdoor temperature 792
- 9** — Efficiency factors for gas-fired boilers 796
- 10** — Efficiency factors for oil-fired boilers 796
- 11** — Efficiency factors for biomass boilers 797
- 12** — Radiation loss factors 797
- 13** — Standby loss factors 798
- 14** — Auxiliary energy factors 800
- 15** — Coefficient B_{DS} as a function of the class of insulation and type of dwelling substation 802
- 16** — Definitions of the classes of insulation 803
- 17** — D_{DS} as a function of the primary temperature and type of dwelling substation 803

C873.9-15, Building energy estimation methodology — Part 9 — Energy consumption and source energy for combined heat and power plants

- 1 Scope** 829
- 2 Reference publications** 829
- 3 Definitions, abbreviations, symbols, units, and subscripts** 829
- 4 Interface with other Standards in the CSA C873 Series** 829
 - 4.1 Input parameters 829
 - 4.2 Output parameters 830
- 5 Principles** 830
 - 5.1 Schematic 830
 - 5.2 Annual generator output 831

6 Calculations 832

Tables

- 1 — Input parameters 830
 - 2 — Output parameters 830
-

Figures

- 1 — Schematic of heat-generation plant 831

C873.10-15, Building energy estimation methodology — Part 10 — Boundary conditions of use — Climatic data

2 Reference publications 837

3 Definitions, abbreviations, symbols, units, and subscripts 837

4 Interface with other Standards in the CSA 873 Series 837

- 4.1 Input parameters 837
- 4.2 Output parameters 837

5 Boundary conditions of use — Non-residential buildings 839

- 5.1 General 839
- 5.2 Usage times and operating times 839
- 5.3 Lighting 840
- 5.4 Minimum outside airflow rates 840
- 5.5 Occupancy 840
- 5.6 Domestic hot water 840
- 5.7 Heat sources 841
- 5.8 Indoor conditions 841

6 Climatic data 841

- 6.1 Reference climate — Monthly values 841
- 6.2 Reference climate — Design rating values 854

Annexes

- A (normative) — Detailed occupancy profiles 860
 - B (informative) — Template for recording 993
-

Tables

- 1 — Symbol meanings 838
- 2 — Average monthly solar irradiance and average monthly outside temperature (NECB Climate Zone 4) 842
- 3 — Average monthly solar irradiance and average monthly outside temperature (NECB Climate Zone 5) 844
- 4 — Average monthly solar irradiance and average monthly outside temperature (NECB Climate Zone 6) 846
- 5 — Average monthly solar irradiance and average monthly outside temperature (NECB Climate Zone 7a) 848
- 6 — Average monthly solar irradiance and average monthly outside temperature (NECB Climate Zone 7b) 850
- 7 — Average monthly solar irradiance and average monthly outside temperature (NECB Climate Zone 8) 852
- 8 — Solar irradiance and outside temperature for design load calculations (NECB Climate Zone 4) 854

-
- 9** — Solar irradiance and outside temperature for design load calculations (NECB Climate Zone 5) 855
 - 10** — Solar irradiance and outside temperature for design load calculations (NECB Climate Zone 6) 856
 - 11** — Solar irradiance and outside temperature for design load calculations (NECB Climate Zone 7a) 857
 - 12** — Solar irradiance and outside temperature for design load calculations (NECB Climate Zone 7b) 858
 - 13** — Solar irradiance and outside temperature for design load calculations (NECB Climate Zone 8) 859

Preface

This is the second edition of the CSA C873 Series of Standards, *Building energy estimation methodology*. It supersedes the previous edition published in 2014.

This Series of Standards consists of the following Standards:

- (a) the second edition of CSA C873.0, *Definitions and general requirements for the calculation of energy loads, energy consumption, and source energy for heating, cooling, ventilation, domestic hot water, and lighting in buildings*;
- (b) the first edition of CSA C873.1, *General balancing procedures, terms and definitions, zoning, and evaluation of energy types*;
- (c) the second edition of CSA C873.2, *Energy loads for heating and cooling of building zones*;
- (d) the second edition of CSA C873.3, *Energy loads for conditioning air*;
- (e) the second edition of CSA C873.4, *Energy consumption for lighting*;
- (f) the first edition of CSA C873.5, *Energy consumption for heating systems*;
- (g) the second edition of CSA C873.7, *Energy consumption for air-handling and air-conditioning systems*;
- (h) the second edition of CSA C873.8, *Energy consumption for domestic hot-water systems*;
- (i) the first edition of CSA C873.9, *Energy consumption and source energy for combined heat and power plants*; and
- (j) the second edition of CSA C873.10, *Boundary conditions of use — Climatic data*.

This edition of the CSA C873 Series incorporates the following changes:

- (a) CSA C873.0: Updates to Tables 3 and 9 to align with revisions in CSA C873.3 and CSA C873.10;
- (b) CSA C873.2: Update to Table 3 to align with *NECB (National Energy Code for Buildings in Canada)*;
- (c) CSA C873.3: Replaced **Clause 7** with a formula-based procedure. Added procedure to **Clause 7** for constant volume single zone systems;
- (d) CSA C873.4: Minor modifications to align with *NECB*;
- (e) CSA C873.7 and CSA C873.8: Minor modifications to align with revisions to CSA C873.3; and
- (f) CSA C873.10: Addition of “Outdoor air humidity ratio” into Tables 2–7 to support the formula-based humidification procedure changes in CSA C873.3.

CSA C873.0 provides requirements that are common to some or all of the Standards of the CSA C873 Series. Wherever possible, individual Standards make reference to the relevant clauses in CSA C873.0.

These Standards provide a methodology for assessing the overall energy efficiency of buildings. The calculations enable all energy quantities required for the purpose of heating, domestic hot-water heating, ventilation, air conditioning, and lighting of buildings to be assessed.

CSA gratefully acknowledges that the development of the CSA C873 Series of Standards was made possible, in part, by the financial support of BC Hydro, Manitoba Hydro, the Independent Electricity System Operator (IESO), Efficiency One, Nova Scotia- Department of Energy, Québec Hydro, the Ontario Ministry of Energy, the Canadian Electricity Association (CEA) and Sask Power.

These Standards were prepared by the Subcommittee on Building Energy Estimation Methodology, under the jurisdiction of the Technical Committee on Heating, Ventilation, Air Conditioning, and Refrigeration and have been formally approved by the Technical Committee.

Notes:

- (1) *Use of the singular does not exclude the plural (and vice versa) when the sense allows.*
- (2) *Although the intended primary application of this Standard is stated in its Scope, it is important to note that it remains the responsibility of the users of the Standard to judge its suitability for their particular purpose.*
- (3) *This Standard was developed by consensus, which is defined by CSA Policy governing standardization — Code of good practice for standardization as “substantial agreement. Consensus implies much more than a simple majority, but not necessarily unanimity”. It is consistent with this definition that a member may be included in the Technical Committee list and yet not be in full agreement with all clauses of this Standard.*
- (4) *To submit a request for interpretation of this Standard, please send the following information to inquiries@csagroup.org and include “Request for interpretation” in the subject line:*
 - (a) *define the problem, making reference to the specific clause, and, where appropriate, include an illustrative sketch;*
 - (b) *provide an explanation of circumstances surrounding the actual field condition; and*

(c) where possible, phrase the request in such a way that a specific “yes” or “no” answer will address the issue.

Committee interpretations are processed in accordance with the CSA Directives and guidelines governing standardization and are available on the Current Standards Activities page at standardsactivities.csa.ca.

(5) This Standard is subject to review five years from the date of publication. Suggestions for its improvement will be referred to the appropriate committee. To submit a proposal for change, please send the following information to inquiries@csagroup.org and include “Proposal for change” in the subject line:

- (a) Standard designation (number);
- (b) relevant clause, table, and/or figure number;
- (c) wording of the proposed change; and
- (d) rationale for the change.

CSA C873.0:15

***Building energy estimation methodology — Part 0 —
Definitions and general requirements for the calculation
of energy loads, energy consumption, and source energy
for heating, cooling, ventilation, domestic hot water, and
lighting in buildings***



®A trademark of the Canadian Standards Association, operating as "CSA Group"

*Published in November 2015 by CSA Group
A not-for-profit private sector organization
178 Rexdale Boulevard, Toronto, Ontario, Canada M9W 1R3*

*To purchase standards and related publications, visit our Online Store at store.csagroup.org
or call toll-free 1-800-463-6727 or 416-747-4044.*

ISBN 978-1-4883-0105-6

© 2015 Canadian Standards Association
All rights reserved. No part of this publication may be reproduced in any form whatsoever
without the prior permission of the publisher.

C873.0-15

Building energy estimation methodology — Part 0 — Definitions and general requirements for the calculation of energy loads, energy consumption, and source energy for heating, cooling, ventilation, domestic hot water, and lighting in buildings

0 Introduction

The CSA C873 Series of Standards provides a methodology for assessing the overall energy efficiency of buildings. The calculations enable all energy quantities required for the purpose of heating, domestic hot-water heating, ventilation, air conditioning, and lighting of buildings to be assessed. The CSA C873 Series of Standards also takes into account the interactive effects of energy flows. The methodology outlined in the CSA C873 Series is suitable for determining the long-term energy needs of buildings or parts of buildings as well as for assessing the possible use of renewable sources of energy in buildings. The energy calculation procedure can be used for new or for existing buildings and for retrofit measures for existing buildings.

1 Scope

1.1

This Standard specifies general requirements such as reference publications, definitions, abbreviations, symbols, and subscripts used in the other Standards in the CSA C873 Series.

1.2

This Standard is intended to be used in conjunction with the other Standards in the CSA C873 Series to form a complete Standard.

1.3

In CSA Standards, “shall” is used to express a requirement, i.e., a provision that the user is obliged to satisfy in order to comply with the standard; “should” is used to express a recommendation or that which is advised but not required; “may” is used to express an option or that which is permissible within the limits of the standard; and “can” is used to express possibility or capability.

Notes accompanying clauses do not include requirements or alternative requirements; the purpose of a note accompanying a clause is to separate from the text explanatory or informative material.

Notes to tables and figures are considered part of the table or figure and may be written as requirements.