Admission of Commercial Simulations for Energy Calculation and their Validation in Switzerland

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Keywords: EPB, Standards, Validation, Software, CEN, ISO

Introduction

Switzerland, as a non-EU country, is not obliged to implement Energy Performance of Buildings Directive of the European Union (EPBD). However, in order to eliminate technical trade impediments, the Swiss Association for Standardization (SNV) has been a full member of the European Center for Standardisation (CEN) for a long time. Therefore, the national implementation of European Standards, including those supporting the EPBD (EPB standards), is mandatory in Switzerland. For the construction sector, SNV has delegated all activities in respect of national and CEN standards to the Swiss Association of Engineers and Architects (SIA).

During the last decades of development of the EPB standards, SIA has been an active member of several of the relevant Technical Committees (TC's), including the participation of the author in CEN/TC 371 for the leadership and coordination of the work, responsible for the ventilation and cooling related part.

Standardisation and Energy Regulations

In Switzerland, the energy regulations are competence of the cantons, which leads essentially to 26 different energy regulations throughout the country. Although they have implemented a scheme for the coordination, the so called "sample cantonal energy regulations"

(MuKEn, [1]), this is only a recommendation for the cantons. It has a modular structure and includes one basic "mandatory" module and a collection of voluntary modules. The implementation in the different cantons is different depending on the specific legal basis. In some cases, law changes are necessary, which are discussed in cantonal parliaments and may be subject to referendums, in others decrees can e issued by the cantonal governments.

In the MuKEn and subsequently in the cantonal regulations, SIA standards are referenced wherever they find it suitable. Cantonal experts are also delegated in the SIA standardisation committees. However, not all intentions followed by the SIA are shared by the cantonal regulators. Also, the strategies and behaviour of the regulation bodies vary a lot.

Implementation of the CEN-EPB Standards

Although published already in 2017, the national implementation of the last generation of EPB standards in Switzerland has been completed only recently. The process of creating national elements and/or adopting national standards to comply with the European pendants is complicated and sometimes difficult, but has successfully been completed.

One key element of the implementation is the revised standard SIA 380:2022 "Basis for energy calculation of buildings", which refers to EN ISO 52000-1:2017 "Energy performance of buildings - Overarching EPB assessment - Part 1: General framework and procedures" and implements its basic method of energy balance and substantiates some national specifications. This standard also defines the use of monthly and hourly calculation methods. Whereas the monthly calculation is only admissible for heated only buildings or building parts, the hourly method is imposed for all other cases, but can be used for all buildings. It has to be noted that this is the standards view, not necessarily shared by the energy regulators (see above).

In parallel to the SIA 380 standard, a new standard for the hourly (dynamic) calculation has been developed, collecting all the information from different preceding standards or parts of them in one document and adapting it to the new CEN standards: SIA 380/2:2022 "Energy Calculations of Buildings – Dynamic Method for Determination of Needs, Power and Energy". It refers to a large extent to the CEN standards, but there is one essential deviation: it does not impose a specific method, but admits the use of any method and defines the requirements which these have to fulfil.

The CEN method as defined in the EPB standards is collected in a normative annex as the "standard calculation method". For the building part, this refers to EN ISO 52016-1:2017, with the exception of an own wall model [2] and a more detailed window/shading calculation [3]. For the technical building systems calculations is refers to the respective CEN Standards with only a few exceptions.

The Software Issue

For the first generation of EPB standards and their national implementations, an own software, providing an hourly calculation, had been developed and slowly found its acceptance both in the industry and with some of the regulation bodies: The "SIA TEC Tool". It was based on the EN ISO 13790:2008 and the technical system related standards.

The founding of an upgrade – essentially a new tool – to the new generation of standards turned out to be impossible. Furthermore, one of the initial reasons for an own software, i.e. the expected too small market for commercial tools proved to be wrong. Several other tools have evolved in the meantime.

In the industry, i.e. mainly in the HVAC design offices, there is a motion towards the use of building simulation software for the design (also supported by the increasing use of BIM, resulting in more precise design and respective investment costs). Therefore, these players also push for the use of their simulation tools for energy regulation compliance. In some cases, the regulators accept this, and consistently asked the standardisation body for a validation scheme rather than a new software.

The Validation Scheme

The most prominent condition for the acceptance of a calculation method in SIA 380/2 is to pass the required validation tests. These depend on the intended application of the respective method.

Therefore, a suite of 7 validation tests has been created. The intention of the tests is not only to show that the method provides acceptable results, but also that it covers the required processes of the respective area they cover.

Table 1 shows the matrix of the 7 tests and their embedding in the standards landscape. For the building envelope, international work has been executed for decades, and a part of this has penetrated the standards ▶

Table 1. *Test matrix.*

	Test	EPBD	Standards referenced	Object		
Nr	Verbal Characterisation	Module		Spatial	Technical	
					General	Specific
1	Basic building shell tests	M2-2	EN ISO 52016-1, chapter 7, table 27	Test cell EN ISO 52016-1, clause 7.2.2 (= ASHRAE 140)	--	
2	Type and control of solar protection	M2-8, M9-2	SIA 380/2:2022, clause 2.2.2.3; SIA 387/4:2017, clause 3.4.3	Like test 1, with adaptations (see last column)	--	Fabric screen and adjustable slat blinds
3	Lighting control	M2-7, M9-2	SIA 380/2:2022, clause 2.2.2.4; SIA 387/4:2017, clause 3.4.4	Like test 2	--	Specified lighting system
4	Single zone air conditioning system (air only)	M5-5, M5-6, M5-8	SN EN 16798-7, SN EN 16798-5-1	Example building, auditorium (no window), no heating/cooling emission system	Auditorium air conditioning system, air only	Single zone VAV system, CO_2 controlled; EN 16798-5-1: SYS_TYPE=SINGLE_ZONE; FAC_CTRL=DIRECT; Zone air temp. dependent supply air temp. control; heat recovery: flat plate; frost protection: bypass
5	Complex multi zone air conditioning system with heating coil, cooling coil and humidifier	M5-5, M5-6, M5-8	SN EN 16798-7, SN EN 16798-5-1	Example building, 1st + 2nd floor: 1 open space office, 2 meeting rooms 4 single offices 1 corner group office	Office air conditioning system	Multi-zone VAV system, CO_2 controlled; EN 16798-5-1: SYS_TYPE=MULTI_ZONE Outdoor air dependent supply air temp. control; Heat recovery: rotary heat exchanger
6	Staged ventilation system with pumped circuit heat recovery	M5-5, M5-6, M5-8	SN EN 16798-7, SN EN 16798-5-1	Example building, Restaurant and kitchen	Restaurant ventilation	3 stage air conditioning system; outdoor air dependent supply air temp. control; overflow from restaurant to kitchen (overpressure); heat recovery with pumped circuit, heating and cooling operation.
7	Heating and cooling emission, distribution, storage and generation	M3-5, M3-6, M3-7 M4-5, M4-6, M4-7, M3-8, M4-8	SN EN 16798-9 SN EN 15316-2, SN EN 15316-3, SN EN 15316-5, SN EN 16798-15 SIA 384/3 SN EN 16798-13	All zones from Tests 5 und 6, all ventilation systems from tests 4 to 6.	Cooling emission and distribution (Offices: chilled and heated ceilings, restaurant chilled ceilings) Heating emission and distribution Offices: chilled and heated ceilings, restaurant convectors) Cooling generation; heating generation; own electricity production (PV)	Distribution systems with water tank storage (techn. storage for operation time extension); heating and cooling generation: specific compression chiller/heat pump with dry heat rejection (acting as heat source in heating case); heating generation: bivalent with specific gas fired peak boiler; DHW use via given charging profile; distribution: simplified according to EN 16798-9, Tables 10 to 13:

		Technical systems area											Results		Remarks
		Ventilation			Cooling				Heating				Test	Diagnostic	
Variants	Numb. of Variants	Emission	Distribution	Generation	Emission	Distribution	Storage	Generation	Emission	Distribution	Storage	Generation			
													According to EN ISO 52016-1	--	
SIA 387/4, table 9	4												Solar heat gains; total solar transmission	Radiation on window pane; slat angle	Diagnostic cases for stepwise transfer from test 1: Climate Kloten New window Infiltration Utilisation SIA 2024 Fixed slat angles
SIA 387/4, table 10	12												Lighting energy	Transmitted daylight flow; daylight level on work pane	
	1	x		x	(x)				(x)				Volume flow rate; Supply air temperature; Zone air temperature; fan energy; heating coil energy; cooling coil energy	CO_2 concentration; zone operative temperature latent cooling coil energy	
FAN_CTRL: CONST_PRES / MIN_PRES; heat recovery: hygroscopic / non hygroscopic; humidifier: adiabatic / steam; combinations see sep. table	4	x	x	x	(x)				(x)				Volume flow rate; fan energy; heating coil energy; total cooling coil energy; latent cooling coil energy; total heat recovery; latent heat recovery; heat recovery auxiliary energy; humidification energy	Distribution and AHU leakage and heat losses; Supply air temp.; extract air temp. and humidity; CO_2 conc. (open space office); humidifier aux. energy	
	1	x	x	x	(x)				(x)				Volume flow rate; fan energy; heating coil energy; total cooling coil energy; total heat recovery (heating/cooling); heat recovery auxiliary energy	Latent cooling coil energy; supply air temp.; extract air temp.	
	1				x	x	x		x	x	x		Supplied electric energy for chiller; total extracted heat; auxiliary energy cooling generation; heat delivered from cooling generation to heating use; rejected heat; Supplied electric energy for heat pump; total supplied heat for heating and for DHW; Boiler energy use; auxiliary energy heating generation PV-generation	Electricity supplied from grid; self used PV electricity; exported PV electricity; Divers diagnosis parameters (temperatures, EER, COP)	Result can be seen as total building energy demand. Pre-calculated profiles for zone heating and cooling needs provided.

(ASHRAE 140 and especially EN ISO 52016-1). Therefore, little effort was put on this issue: reference to EN ISO 52016-1 is made, and these tests form test 1. For tests 2 and 3, the same "building" is used, however, a "localisation" suite of adjustments was introduced: local climate data, SIA standards building use data and contemporary glazing and infiltration. Test 2 then focuses on the solar heat gains through the window with two types of shading devices, one of them being blinds with adjustable slats and their control. Test 3 then is for the test of the different lighting control schemes in combination with the test 2 shading devices. The combinations are given in **Table 2**.

For tests 4 to 7, a synthetic example building has been defined (see **Figure 1**). This 3-storey building consists of several thermal zones with different uses and is tailored to the tests implemented on it. A text description as well as digital data such as DXF floor plans and an IFC model are provided.

Tests 4 to 6 all refer to different types of ventilation/air conditioning systems. This may be astonishing and suspect an unjustified emphasis on a specific topic. However, the variety of possible technical solutions in this area is very large, and specific issues wanted to be addressed in the 3 tests. For test 5, different combinations of settings are defined (**Table 3**).

Test 7, finally, is the collection of the energy supplied to and extracted from the ventilation systems from tests 4 to 6 and the thermal zones served by these, with the respective heating and cooling emission, distribution, storage and generation systems. Initially it was planned that this test would be based on the individual results from the candidate software. This was, however, given up to the benefit of pre-defined hourly profiles (originating from the EXCEL files), in order to minimise error propagation and enable the isolation of problems in the area really to be tested.

Also, the emission and distribution systems were simplified, due to their rather small impact, but also to the inability of different software packages to really detailed represent them. The focus is on the generation part, where the detailed technical information of a real heat pump, providing both heating and cooling service, was provided. The information, according to the component standards, especially EN 14825, is given, separately for heating and for cooling operation. So, it is left to the software user to decide how to implement the machine information, possibly by defining separate machines although in reality it is

Table 2. *Combinations for tests 2 and 3.*

Test		Solar protection type	Solar protection control type	Lighting control type
2A	3A	Fabric screen	–	1
	3B			2
	3C			3
	3D			4
	3E			5
	3F			6
2B	3G	Movable slat blinds	1	1
	3H		1	3
2C	3I		2	1
	3J		2	3
2D	3K		3	1
	3L		3	3

Table 3. *Combinations for test 5.*

Test	FAN-CTRL	Heat recovery	Humidifier
5A	MIN-PRES	hygroscopic	adiabatic
5B	CONST-PRES	hygroscopic	adiabatic
5C	CONST-PRES	non-hygroscopic	adiabatic
5D	CONST-PRES	non-hygroscopic	steam

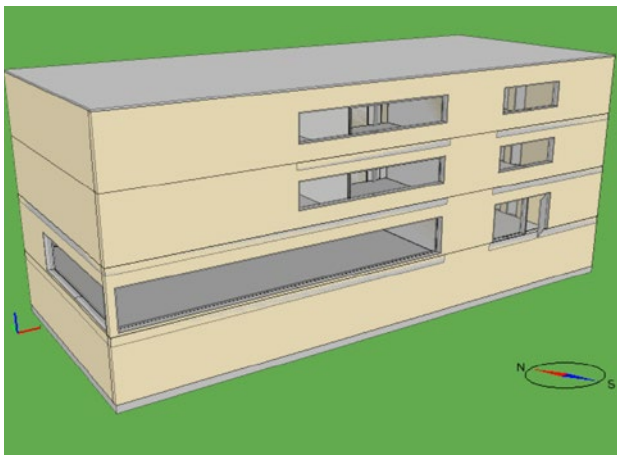

Figure 1. Isometric view of the example building.

only one. The key issue is to cover the cases where both services are provided at the same time. In order to be contemporary, the example building has also a PV production both on the roof and on the south façade (see **Figure 2**).

All 7 tests have been calculated with 4 different software packages: IDA-ICE (the market leader in Switzerland), Energy+, EDSL-TAS and the CEN and SIA spreadsheets. In respect of the latter, an own implementation of the EN ISO 52016-1, enriched with the necessary issues for the Swiss applications, was used for test 1. A special SIA test spreadsheet for the solar gain and lighting calculations was used for tests 2 and 3. For tests 4 to 6, the EN 16798-5-1 and -7 spreadsheets from EPB Center could be applied sequentially. For test 7, the spreadsheets to EN 16798-9 and -13 were applied again sequentially for the cooling part. For the heating part, again a slightly adopted EN 16798-9 spreadsheet was used rather than the one to EN 15316-1 (mostly for the reason of more familiarity to the user), combined with the EN 15316-4-2 spreadsheet for the heat pump. Some adaptions were made to some of these spreadsheets for data collection etc. This proved also the CEN spreadsheets to be fully applicable, and for many of the issues it turned out to generate reference results for the other software.

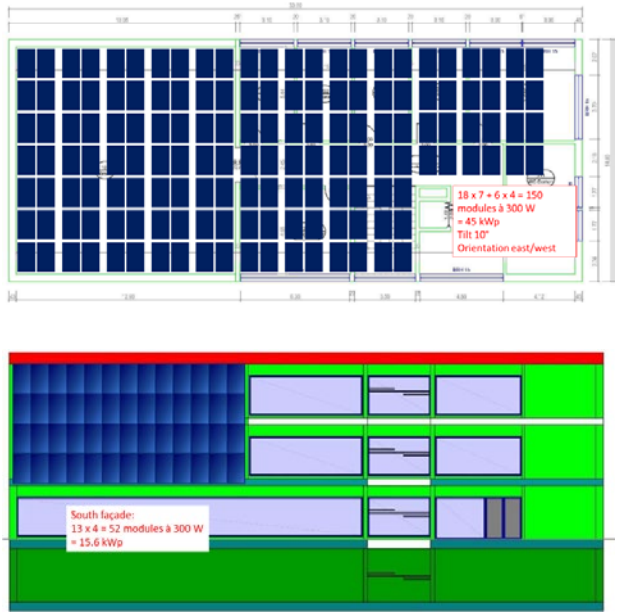

Figure 2. PV production layout on the roof and south façade of the example building.

The results of the 4 programs are used as reference results for the candidate programs. For each test, a specification (text description plus partly schematics in a pdf) an excel sheet is provided to fill in the results. This is protected, so only the parts for data entrance is accessible. The reference program results are used for the decision of "pass/fail" by two means: for the annual values, the average of the four +/- the max. difference of the reference program results defines the acceptable range. In a few cases, one of the reference programs has been excluded from this due to unacceptable deviations. For hourly results, graphical frequency distribution histograms are used, and the criterion is to be in the range of the four reference programs for all values (see **Figure 3** for an example).

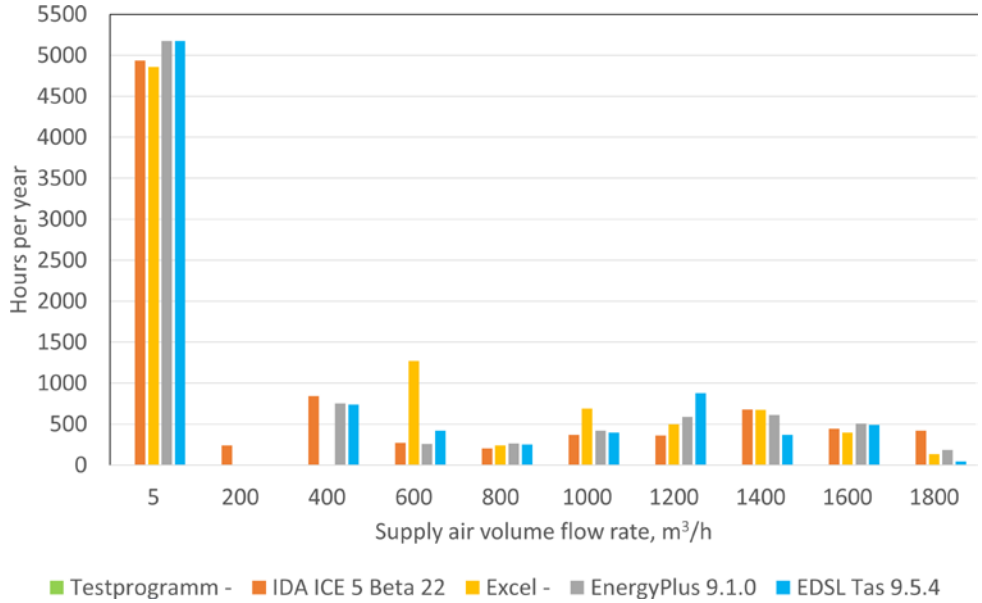

Figure 3. Example of a frequency distribution histogram of the supply volume flow rates of test 4. Note: There is a CO_2 control, except for EXCEL, which uses a work-around based on occupation.

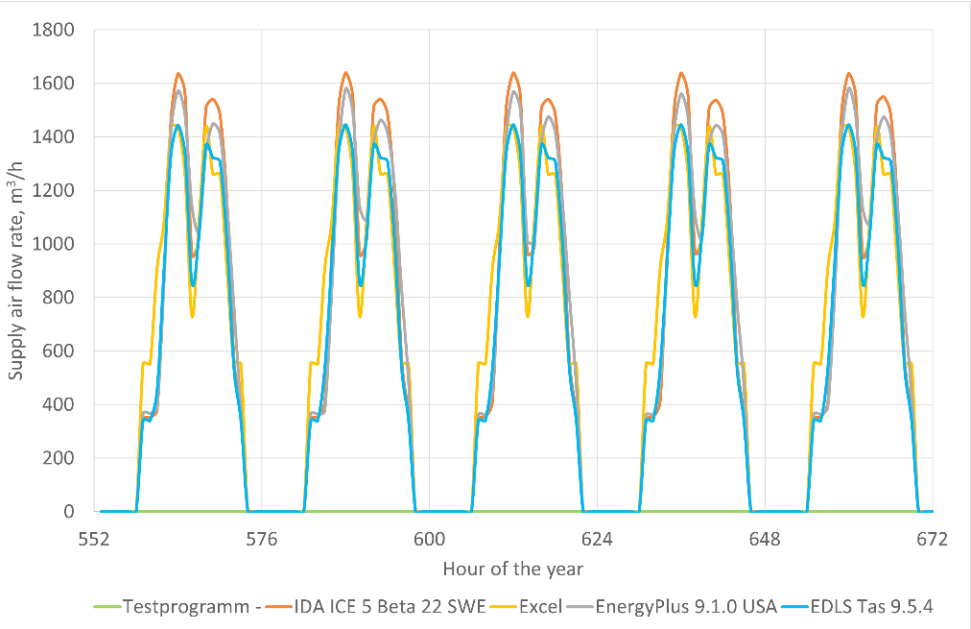

Figure 4. Example of a winter week plot of the supply volume flow rates of test 4. Note: This is only used for diagnosis purposes.

More reference results are shown in the data reporting and analysis sheets, which do not form part of the test criteria, but are given for diagnosis purposes. This includes frequency distributions, but also weekly plots for a winter and a summer week (see **Figure 4** for an example). No such course, however, is used as a test criterion (exception: test 1). For all four reference programs, "application reports" are also provided, where special issues for the implementation of the tests such as difficulties, special solutions and conscious deviations are reported.

Implementation

The document with the description of the test suite, the Technical Report SIA 4010 to the standard SIA 380/2, has been released for publication and will be published as per August 1. 2023. By that time, the tests will be "sharp", i.e. the specifications and the data reporting and analysis sheets will be published on the SIA home page. Several software vendors are already waiting for this moment. The documents for tests 1 to 6 are ready, the one for test 7 is still to be finished at the time of this report. Two reference programs still show unplausible results for some parts.

A technical panel will check the results, give feedback and also respond to questions during the test, where and FAQ document will result from. The test specifications have not been included in the TR SIA 4010 by intention, since from the experience with the reference programs, there might be modifications from further experience. ■

References

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