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The European Portal for Energy Efficiency in Buildings

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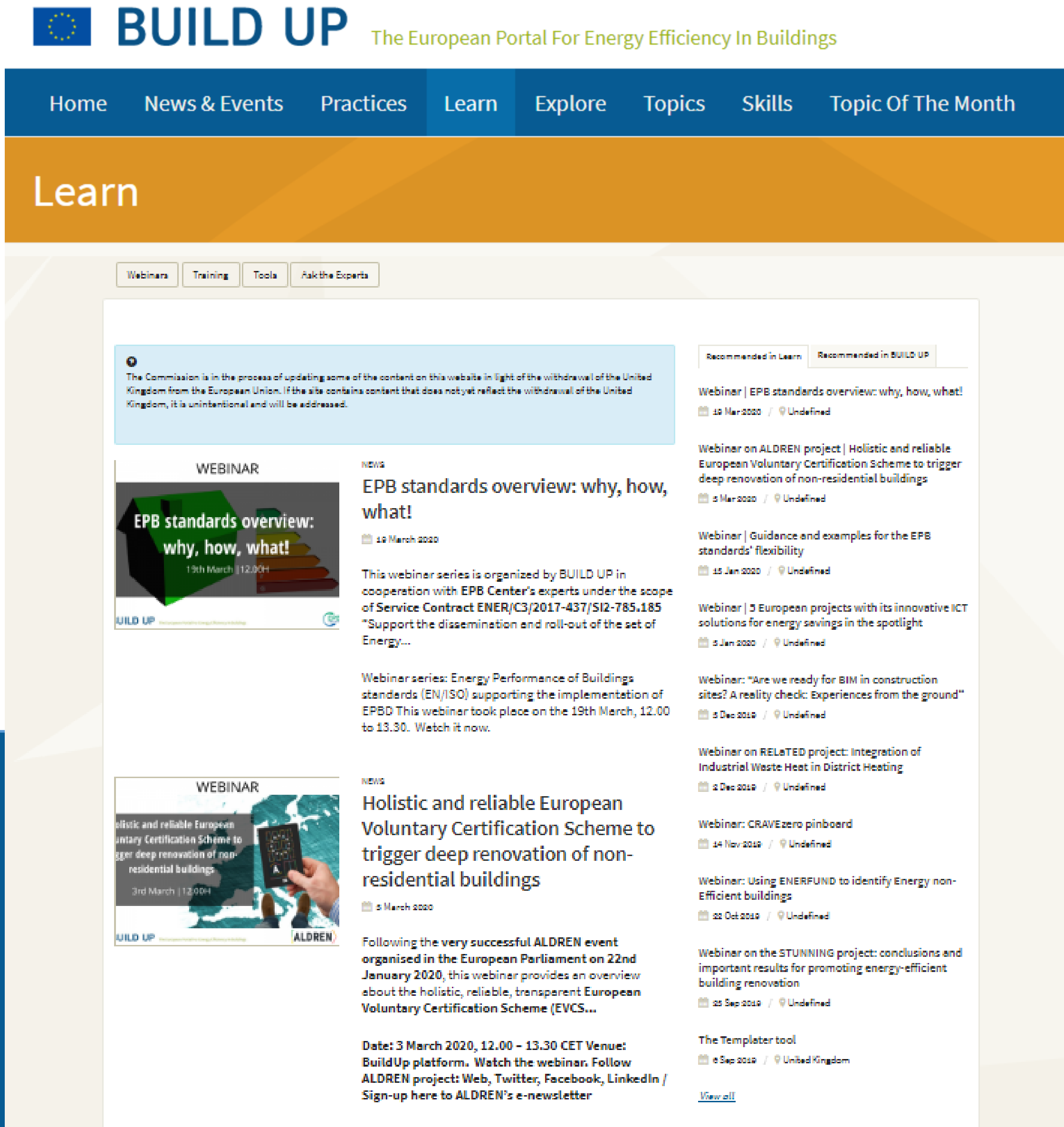


Check our Learn section!

Webinar 6, Sept. 8 2020– Heating systems in the EPB standards

Webinar 7, Tuesday Oct. 6, Example calculations with the set of EPB standards – (1) Introduction and overarching calculation procedures

Webinar 8, Tuesday Oct. 20, Example calculations with the set of EPB standards – (2) Energy needs combined with specific systems

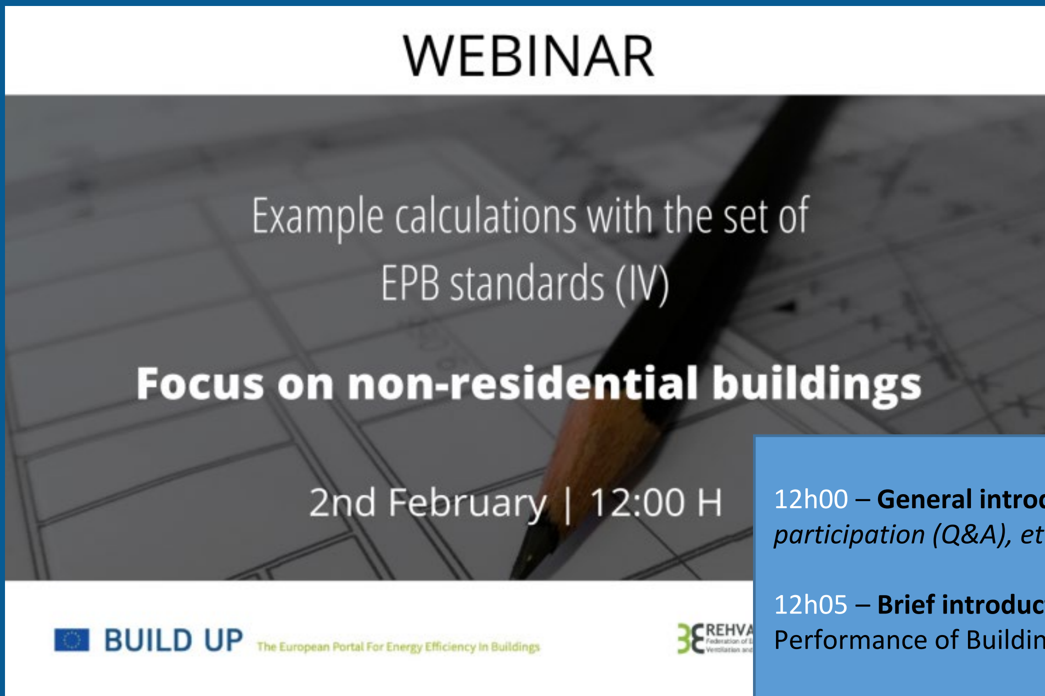
Webinar 9, Tuesday Jan. 19, Example calculations with the set
standards – (3) Whole building calculations, from components
primary energy

Last one!

Webinar 10, Tuesday Feb. 2, Example calculations with the set of EPB standards – (4) Energy needs combined with specific systems

EPB CENTER

BUILD UP The European Portal For Energy Efficiency In Buildings



12h00 – **General introduction** by the moderator *(overview, practical information on participation (Q&A), etc.)*

12h05 – **Brief introduction,** by Jaap HOGELING, Chairperson CEN/TC 371, Energy Performance of Buildings project group, European Committee for Standardization (CEN)

12h10 – **Specific features of the calculation of energy needs for heating and cooling for non-residential buildings,** by Dick VAN DIJK, EPB expert, EPB Center

12h20 – **Integrated application of the EPB standards on energy needs, ventilation and air heating and cooling; demonstration,** by Gerhard ZWEIFEL, EPB expert, Professor emeritus Lucerne University of Applied Sciences and Arts

12h45 – **From component to overall energy performance** – the modular approach, by Laurent SOCAL, independent EPB expert

13h00 – Moderated **Q&A**

Your service center for information and technical support on the new set of EPB standards

Energy Performance of Buildings standards (EN/ISO) supporting the implementation of the EPBD

Jaap Hogeling
Manager international standards at ISSO
Chair CEN/TC 371 Energy Performance of Buildings
Member ISO/TC 163/WG 4: Joint Working Group (JWG) between ISO/TC 163 and ISO/TC 205: Energy performance of buildings using holistic approach
j.hogeling@isso.nl

The EPB Center is supported by the EU-Commission Service Contract ENER/C3/2017-437/SI2.785185

Start 21 September 2018 for 3 years

www.epb.center

BUILD UP Webinar series
Webinar 10 – Example calculations with the set of EPB standards – (4) Focus on non-residential buildings 02/02/2021

My background

- CEN/TC 371: Energy Performance of Buildings, chairperson since 2004
- Project leader of the EU Mandate/480 to CEN regarding the development of the set of EPB standards.
- Participation in 5 CEN/TC’s and 2 ISO/TC’s related to Energy Performance of Buildings
- Manager international standards at ISSO, Rotterdam, the Netherlands
- Initiator of EPB Center (an initiative of ISSO and REHVA)
- Fellow of ASHRAE and REHVA

The goal of example calculations is to demonstrate:

- the **functionality** : to demonstrate that the calculation works with practical cases and available features to describe energy performance of buildings and HVAC installations
- the **sensitivity** of the calculation procedure: what is the impact of single data or group of data on selected calculation results
- the **usability**: demonstrate the data input (avoiding unnecessary input complexity) , description of practical system configurations, show useful results .

of individual calculation modules and of the whole building calculation procedure.

In this 10th webinar we will focus on EP calculation for non-residential building case

The EPB Center experts : Mr. Dick van Dijk, Professor emeritus Gerhard Zweifel, Mr Laurent Socal will focus on the following:

- Dick van Dijk will demonstrate how the EN ISO 52016-1 is suited for residential and non-residential buildings alike.
- Gerhard Zweifel will demonstrate the integrated application of the EPB standards on energy needs, ventilation and air heating and cooling;
- Laurent Socal will illustrate the modular approach from component to overall energy performance

EPB calculation standards as tools

- The EP calculation standards are great tools.
- The presentations will demonstrate that using **hourly** calculation methods **correctly**, you can extract a lot of useful information to decide on the best building and system design by comparing different possible solutions.

Thank you!

More information on
the set of EPB standards:

www.epb.center

Contact: info@epb.center

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Your service center for information and technical support on the new set of EPB standards

Specific features of the calculation of energy needs for heating and cooling for non-residential buildings

Dick van Dijk

dick.vandijk@epb.center

This project is facilitated by the EU-Commission Service Contract ENER/C3/2017-437/SI2.785185

Start: 21 September 2018 for 3 years

BUILD UP Webinar series
Webinar 10: Example calculations with the set of EPB standards – (4) Focus on non-residential buildings,
2nd February 2021

My background

- EPB Center expert (> 2017)
- Involved in initiation, preparation and coordination of set of EPB standards (2012-2017)
- Co-convenor of ISO Joint Working Group on the overall set of EN ISO EPB standards, in collaboration with CEN

  ISO/TC 163 & ISO/TC 205, CEN/TC 371
- Convenor of ISO Working Group responsible for few key EPB standards:

  Energy needs heating/cooling, Climatic data, Partial EP indicators (ISO/TC 163/SC 2/WG 15)

EPB standard EN ISO 52016-1: *heating and cooling needs and indoor temperatures*

- Today: some answers to questions:
  - Is it only suited for residential buildings?
  - What can the demo spreadsheet be used for?

Available at website

- Basics of the hourly calculation method in EN ISO 52016-1
- Main feautures of the spreadsheet, now with illustrations
- Illustrate use of different climates and use patterns
  - Current spreadsheet and work in progress
- Link to systems (briefly)

Remember:
EN ISO 52016-1: parallel hourly and monthly calculation methods

Hourly calculation of
- energy needs for heating and cooling
- both sensible and latent heat
- indoor temperatures
- heating and cooling load

Same input data and boundary conditions

Monthly calculation of energy needs for heating and cooling
- using national correlation factors to take into account dynamic effects
  - E.g. solar and internal gains, varying conditions of use (temperature and ventilation settings), ..

Remember:
EN ISO 52016-1: parallel hourly and monthly calculation methods

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Extra output:
- Monthly characteristics

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Hourly calculation of
- energy needs for heating and cooling
- both sensible and latent heat
- indoor temperatures
- heating and cooling load

Same input data and boundary conditions

Extra output:
- Monthly characteristics
- Can be used as basis for generating or validating **correlation factors** for monthly method

Monthly calculation of energy needs for heating and cooling
- using national **correlation factors** to take into account dynamic effects
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Monthly calculation of energy needs for heating and cooling
- using national **correlation factors** to take into account dynamic effects
  - E.g. solar and internal gains, varying conditions of use (temperature and ventilation settings), ..

Interested in hourly versus monthly calculations?
Recording of webinar 4

Hourly calculation method in EN ISO 52016-1

- Similar to building simulation tools:
- Overall energy balance is calcuated each hour
  - Dynamic heat transfer through each (opaque or transparent) building element
  - Interaction with solar and internal gains, with outdoor climate, with indoor air
  - ➔ calculation each hour: energy load for heating or cooling on basis of min. and max. temperature
    - Similar for latent heat: (de)humidification load on basis of min. and max. humidity
  - All construction elements interact:
    - Mutually
    - with indoor air
    - With incident solar radiation

Similar as building simulation tools

- Detailed model, similar as for building simulation tools
- Quick illustrations: “resistance-capacitance“ model:
  - Each construction element divided into *N* nodes (~ [*N*-1] layers)
  - Per thermal zone: If *M* construction elements: *M* x *N* nodes plus indoor air node
  - At each hour: ➔ *M* x *N* interrelated energy balance equations solved to obtain the temperatures at all nodes and the heating and cooling load
- Alternative equivalent models are allowed

Illustration:

Illustration: Model of construction element

Nr of layers , each with thermal resistance, capacitance, absorptance of solar radiation (if transparent), etc. (fig. from CEN ISO/TR 52016-2)

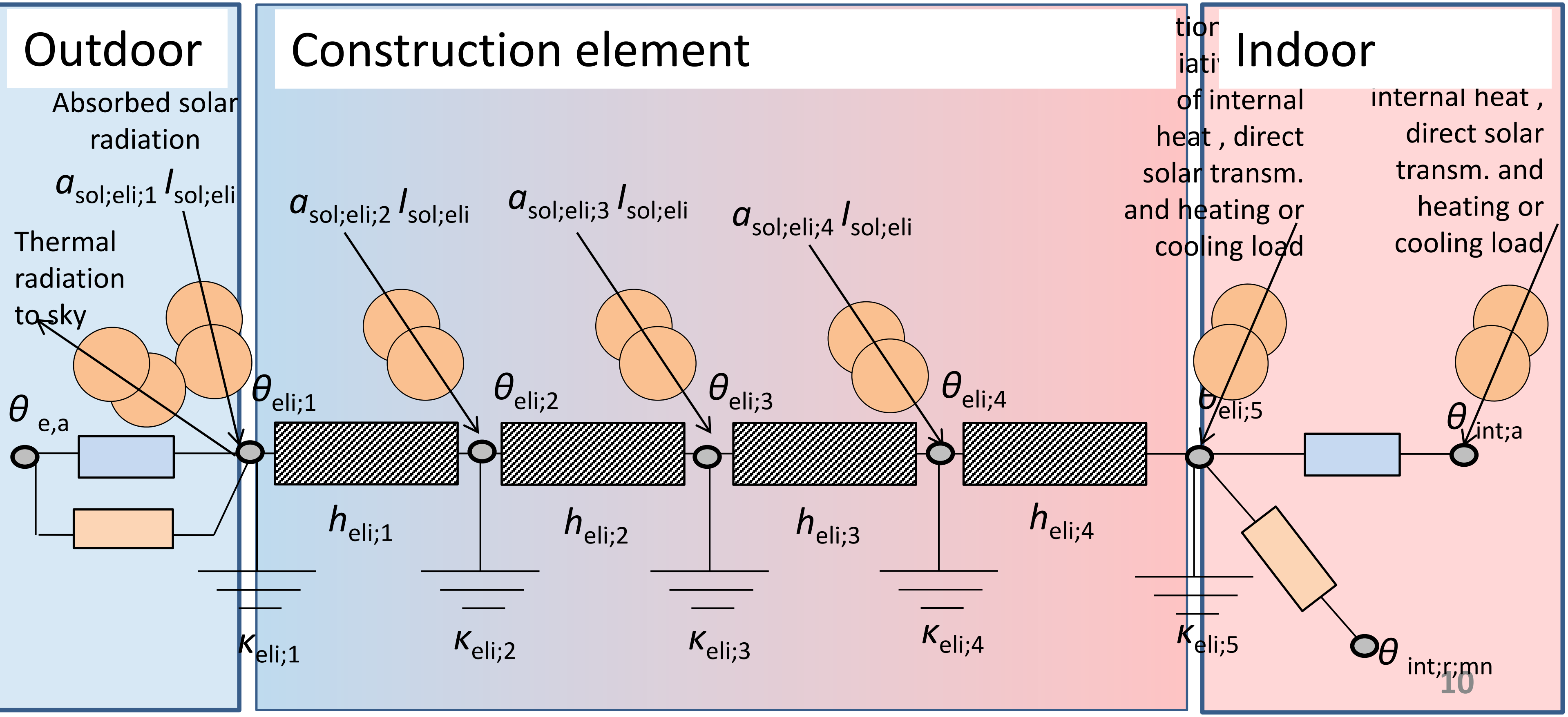
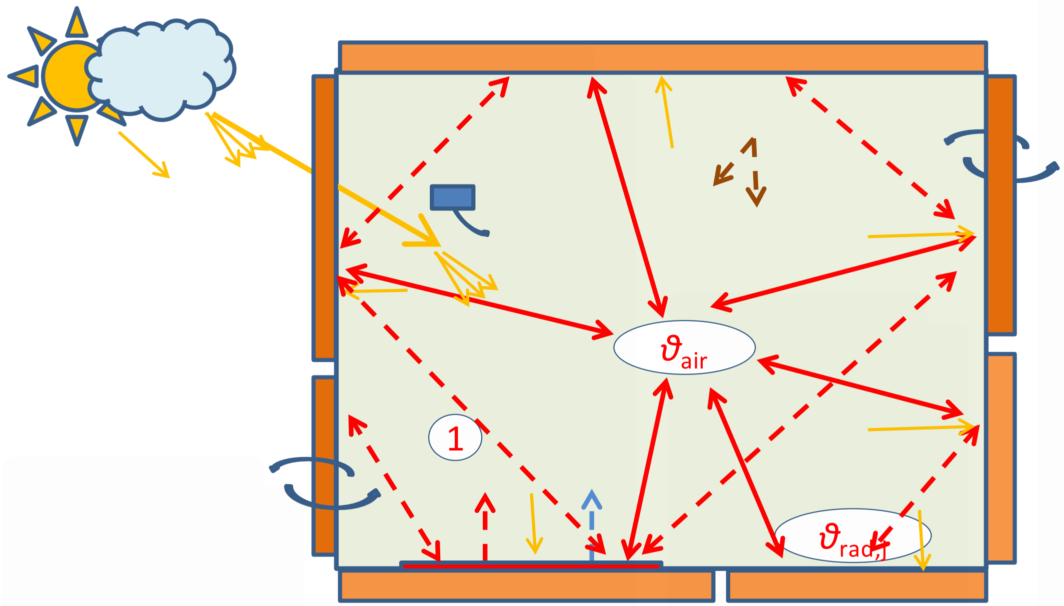


Illustration: Inside thermal zone

Interaction between all construction elements and indoor air



Building construction element (black box)

Convection heat exchange

Thermal radiation heat flow

Air infiltration and ventilation air flows; vent.system

Solar radiation

Internal heat gains and recoverable system losses

H & C system emission

Multiple thermal zones possible, based on (national) zoning rules

Alternative modelling allowed

- Alternative modelling techniques are allowed
- (national choice, acc.to template in Annex A)

Table A.10 — Alternative choices in modelling (see 6.5.5.2, 6.5.6.3.1 and 6.5.7.1)

Description	Choice	If choice is No, describe or give reference to the applied alternative method
Use the method in 6.5.5.2 to calculate the actual temperatures and loads	Yes/No	*<free text>*
Use method in 6.5.6.3.1 for the calculation of the thermal (longwave) radiation exchange	Yes/No	*<free text>*
Use method in 6.5.7.1 for the conversion of physical properties of building elements into properties per layer (node)	Yes/No	*<free text>*
NOTE In case of one or more "No", the procedures are validated using the validation cases in 7.2, as described in that subclause.		

Different from most building simulation tools

- Model is **tailored** to the needs (= assessing energy performance):
  - No more input data needed from user than monthly method
    - Standard hourly climatic data and use patterns supplied nationally/regionally
    - Model simplified where possible:
      - E.g.: layers inside construction (but: national choice!)
- Model is fully **transparent** and unambiguous:
  - All equations are spelled out
  - All results are traceable
  - ➔ Can also easily add or expand with innovative technologies
- **Modular** set up of all EPB standards:
  - Each input / output is clear
  - ➔ Can also check interconnectivity with other modules

  Now: time to introduce the spreadsheet

Spreadsheet on each individual EPB standard

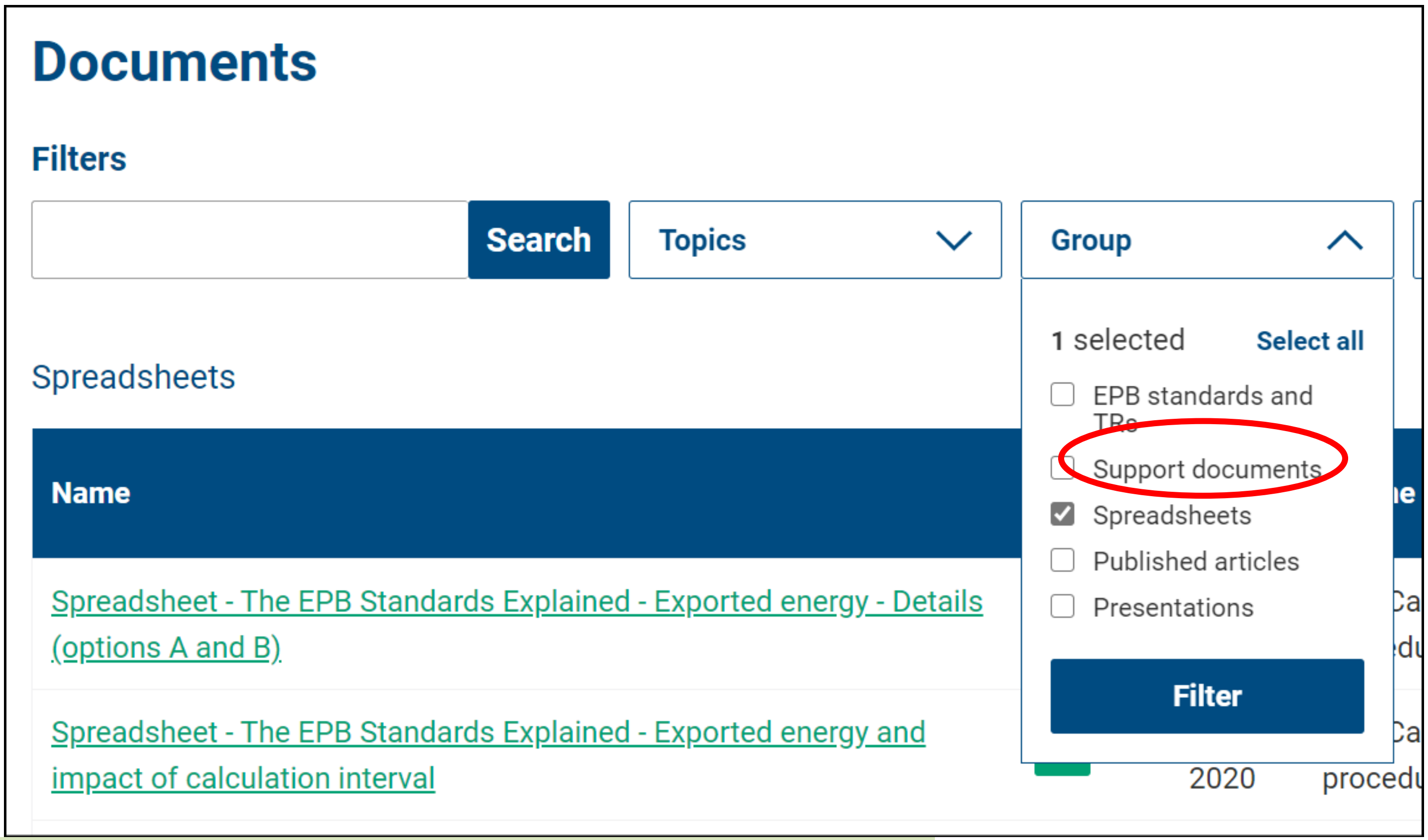
- To demonstrate and validate each EPB standard
- Highest priority: technically correct and **transparent**
  - ➔ where possible: all intermediate results are shown
  - At each step of calculation: references are given to the corresponding clause or formula in the standard
  - Clear input & output ➔ shows interconnections with other EPB standards (modules)

Spreadsheet on each individual EPB standard

- To demonstrate and validate each EPB standard
- Highest priority: technically correct and **transparent**
  - ➔ where possible: all intermediate results are shown
  - At each step of calculation: references are given to the corresponding clause or formula in the standard
  - Clear input & output ➔ shows interconnections with other EPB standards (modules)
- (!) spreadsheet ≠ corresponding standard:
  - Spreadsheets have some limitations
    - Not intended for daily practice to assess EPB
    - Lower priority: user friendliness and performance (speed)
    - Some 'practical' limitations on choice of input data
    - Some special features not included (e.g.: multi-zone calculation, attached unconditioned spaces, ..)

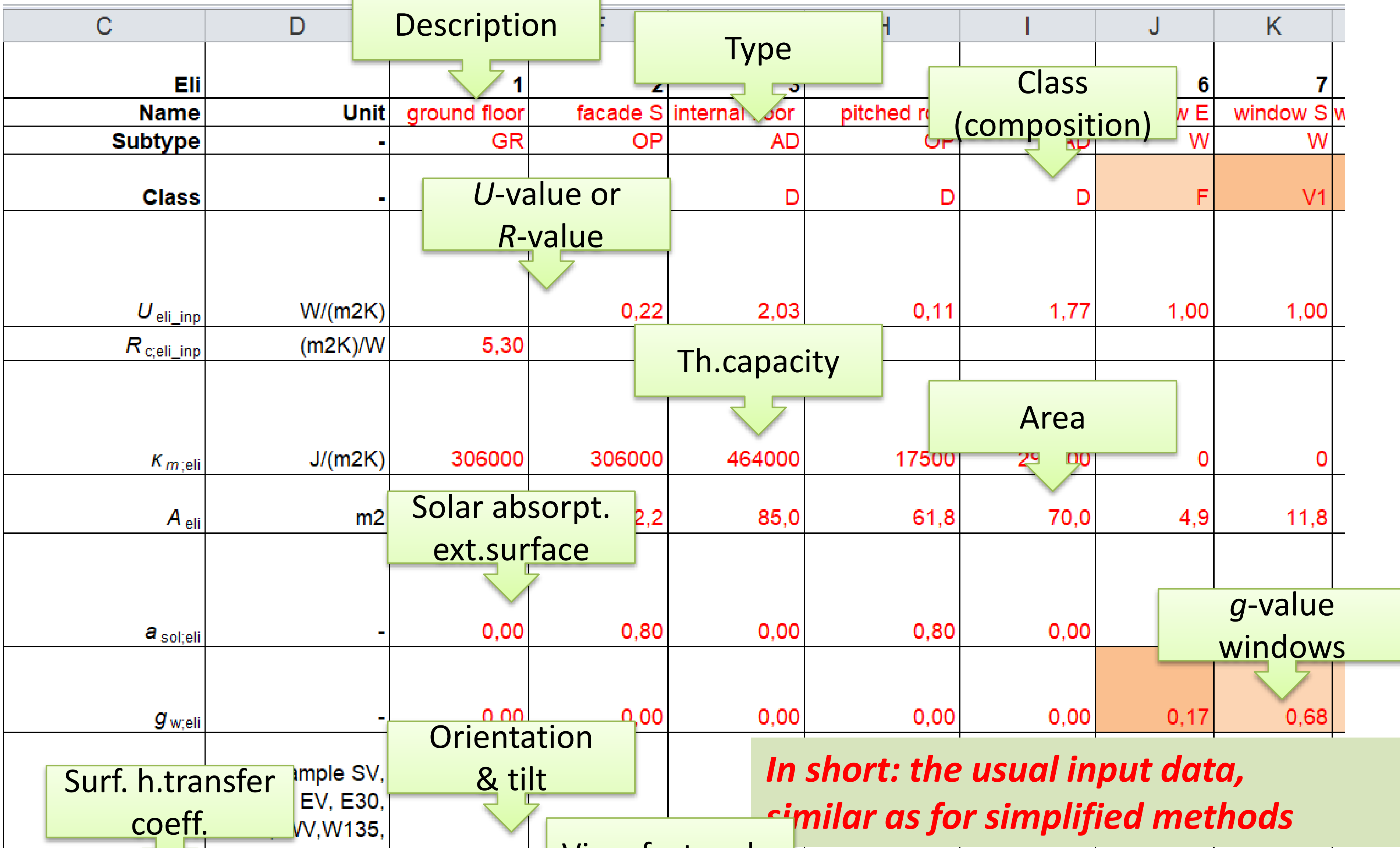
Demo spreadheet on EN ISO 52016-1

- Published Nov.2019



Update in preparation

Sheet with input for each construction element



In short: the usual input data, similar as for simplified methods

Sheet with other 'static' input

For instance:

- Area
- Volume
- Thermal capacity
- Temperature setpoints
- Humidity setpoints
- Internal heat gains
- Air flow rates *(if not input from ventilation standards)*
- Correlation factors for monthly method
- ...

In short: the usual input data

Set points and schedules, currently 3 levels

Just some examples

Heating set point, 3 levels

2	°C	22
1	°C	19
0	°C	15

2: high comfort required

1: moderate comfort required

0: low comfort required

Cooling set point, 3 levels

2	°C	26
1		32
0	°C	99

Internal heat gains, 3 levels

Constant internal heat flow rate during all hrs	$q_{int;tot;24x7}$	W/m^2	1,70
Extra internal heat flow rate during moderate comfort hrs	$q_{int;tot;comf1}$	W/m^2	1,60
Extra internal heat flow rate during high comfort hrs	$q_{int;tot;comf2}$	W/m^2	2,00

Just some examples

Also latent heat load/needs (moisture)

Humidity set points

$\varphi_{\text{int;set;HU;}ztc\text{;}t}$	%	25
$\varphi_{\text{int;set;DHU;}ztc\text{;}t}$	%	60

Assumed moisture production inside thermal zone

Moisture production during all hrs	$G_{\text{int;24x7}}/A_{\text{use}}$	kg/(m^2.s)	0,000000392
Extra moisture production during moderately occupied hrs	$G_{\text{int;occ1}}/A_{\text{use}}$	kg/(m^2.s)	0
Extra moisture production during highly occupied hrs	$G_{\text{int;occ2}}/A_{\text{use}}$	kg/(m^2.s)	0

Sheet with use patterns, weekly schedules

Just some examples

Hour | Occupancy level | Comfort level | Operation 1 level | Operatio level

Work day | Week end | Work day | Week end | Work day | Work day

Weekly schedules	Used for internal heat and moisture gains			Used for temperature control and ventilation			Not yet used! 1=not yet used.; 2=on			Not yet u 1=not yet use
	Occupancy level	Occupancy level		Comfort level	Comfort level		Operation level	Operation level		Operation level
Hr of day	Weekday (Mo-Fri)	Weekend (Sat+Sun)		Weekday (Mo-Fri)	Weekend (Sat+Sun)		Weekday (Mo-Fri)	Weekend (Sat+Sun)		Weekday (Mo-Fri)
1	2	2	1	0	0	1	0	0	1	0
2	2	2	2	0	0	2	0	0	2	0
3	2	2	3	0	0	3	0	0	3	0
4	2	2	4	0	0	4	0	0	4	0
5	2	2	5	0	0	5	2	0	5	2
6	2	2	6	0	0	6	2	2	6	2
7	[illegible]	1	7	2	0	7	2	2	7	2
8	[illegible]	2	8	2	2	8	2	2	8	2
9	[illegible]	2	9	2	2	9	2	2	9	2
10	0	1	10	2	2	10	2	2	10	2
11	0	1	11	2	2	11	2	2	11	2
12	0	1	12	2	2	12	2	2	12	2
13	0	1	13	2	2	13	2	2	13	2

→ Sheet with hourly input

ust some examples

Hourly data full year

hour

Occupancy level

Comfort level

Operation level

Ventilation

Internal heat

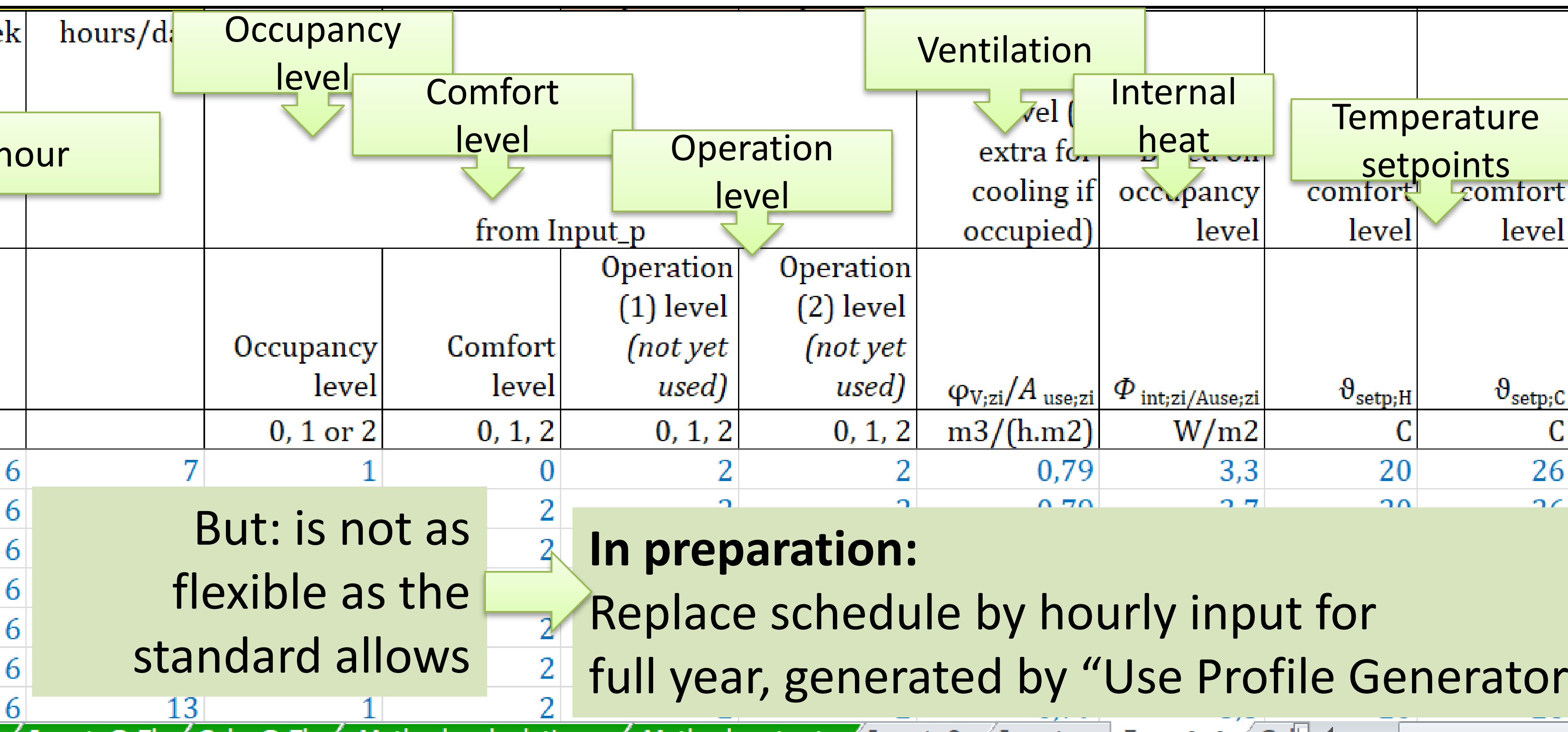
Temperature setpoints

ek	hours/d			from Input_p		vel (extra for cooling if occupied)	B… occupancy level	comfort level	comfort level
		Occupancy level	Comfort level	Operation (1) level *(not yet used)*	Operation (2) level *(not yet used)*	$\varphi_{V;zi}/A_{use;zi}$	$\Phi_{int;zi/Ause;zi}$	$\vartheta_{setp;H}$	$\vartheta_{setp;C}$
		0, 1 or 2	0, 1, 2	0, 1, 2	0, 1, 2	m3/(h.m2)	W/m2	C	C
6	7	1	0	2	2	0,79	3,3	20	26
6	8	2	2	2	2	0,79	3,7	20	26
6	9	2	2	2	2	0,79	3,7	20	26
6	10	1	2	2	2	0,79	3,3	20	26
6	11	1	2	2	2	0,79	3,3	20	26
6	12	1	2	2	2	0,79	3,3	20	26
6	13	1	2	2	2	0,79	3,3	20	26

→ Sheet with hourly input

Just some examples

Hourly data full year



But: is not as flexible as the standard allows

In preparation:
Replace schedule by hourly input for full year, generated by “Use Profile Generator”

Use Profile Generator
(1) Select which profile, from database

USER PROFILE:

Residential: detached house			**10**
Source data sheet	**RES_Det_house**		
Zone area	m^2	50	

BASE PARAMETERS	**Value**	**Unit**
Hour at day, START	0	hour
Hour at day, END	24	hour
Breaks, inside range	0	hours
Days/week	7	days
hours/day	24	hours
hours/year	8760	hours
Occupants	45,2	m^2/pers
Occupants [Total]	2,8	W/m^2
Occupants [Dry]	1,9	W/m^2
Appliances	2,4	W/m^2
Lighting	0	

(being) developed by
Mr Laurent Socal

Profiles based on EN 16798-1 (is another EPB standard)

plus customized data sets

Use Profile Generator

(1) Select which profile from database

USER PROFILE:

Residential: detached house			10
Source data sheet	RES_Det_house		
Zone area		m²	50

BASE PARAMETI

Hour at day, STAR
Hour at day, END
Breaks, inside ran
Days/week
hours/day
hours/year
Occupants
Occupants [Total]
Occupants [Dry]
Appliances
Lighting

CO_2 production	0,44	g/m²h
Min T,op in unoccupied hours	16	°C
Max T,op in unoccupied hours	32	°C
Min T,op	20	°C
Max Top	26	°C
Ventilation rate [min]	0,5	l/sm²
Ventilation rate for CO_2 emission	0,16	l/sm²
Max CO_2 concentration [above outdoor]	500	ppm
Min. relative humidity	25	%
Max. relative humidity	60	%
Lighting. illuminance in working areas	0	lux

(being) developed by
Mr Laurent Socal

Use Profile Generator
(1) Select which profile from database

(being) developed by
Mr Laurent Socal

USER PROFILE:

Residential: detached house ▾ | **10**

Source data sheet **RES_Det_house**

Zone area m² 50

BASE PARAMET
Hour at day, STAR
Hour at day, END
Breaks, inside ran
Days/week
hours/day
hours/year
Occupants
Occupants [Total]
Occupants [Dry]
Appliances
Lighting

CO2 production	0,44	g/m²h
Min T,op in unoccupied hours	16	°C
Max T,op in unoccupied hours	32	°C
Min T,op	20	°C
Max Top	26	°C
Ventilation		
Ventilation		
Max CO2 co		
Min. relativ		
Max. relativ		
Lighting. illu		

Domestic hot water Calculated average

Tapping profile selection ERP - XL

Reference data for dhw needs Cold water temperature 15

Results for dhw Yearly needs 2.847

Daylight saving time Starts at hour 1995 ends at

Use Profile Generator
(2) Generate hourly values

Hourly data full year

TOTAL DATA

Appliances gain

Persons gains

Vapou

CO2

Temperature setpoints

p	W	W	W	W	g/h	g/h	°C	°C	°C	°C
0,88	60	13	112	76	56	18	20	20	26	26
0,88	60	50	112	76	56	18	20	20	26	26
0,88	84	50	112	76	56	18	20	20	26	26
0,88	84	50	112	76	56	18	20	20	26	26
0,88	96	50	112	76	56	18	20	20	26	26
0,88	96	50	112	76	56	18	20	20	26	26
0,88	96	50	112	76	56	18	20	20	26	26
1,11	72	38	140	95	71	22	20	20	26	26
1,11	72	38	140	95	71	22	20	20	26	26
1,11	60	0	140	95	71	22	20	20	26	26
1,11	60	0	140	95	71	22	20	20	26	26
1,11	60	0	140	95	71	22	20	20	26	26
1,11	60	0	140	95	71	22	20	20	26	26
1,11	60	0	140	95	71	22	20	20	26	26
1,11	60	0	140	95	71	22	20	20	26	26

Use Profile Generator
(2) Generate hourly values

Hourly data full year

TOTAL DATA

Appliances gain | Persons gains | Vapou | CO2 | Temperature setpoints

p	W	W	W	W	g/h	g/h	°C	°C	°C	°C
0,88	60	13	112	76	56	18	20	20	26	26
0,88	60	50	112	76	56	18	20	20	26	26
0,88	84	50	112	76	56	18	20	20	26	26
							20	20	26	26
							20	20	26	26
							20	20	26	26
							20	20	26	26
							20	20	26	26
							20	20	26	26
							20	20	26	26
							20	20	26	26
							20	20	26	26
							20	20	26	26
1,11	60	0	140	95	71	22	20	20	26	26
1,11	60	0	140	95	71	22	20	20	26	26

Work in progress:

Combine data to make the data fit as hourly input for specific EPB standard. Such as for spreadsheet on EN ISO 52016-1

Use Profile Generator
(2) Generate hourly values

Hourly data full year

TOTAL DATA

Appliances gain | Persons gains | Vapou | CO2 | Temperature setpoints

Occ nu | ht | s | nt m for

p	W	W	W	W	g/h	g/h	°C	°C	°C	°C
0,88	60	13	112	76	56	18	20	20	26	26
0,88	60	50	112	76	56	18	20	20	26	26
0,88	84	50	112	76	56	18	20	20	26	26
							20	20	26	26
							20	20	26	26
1,11	6				71					
1,11	6				71					

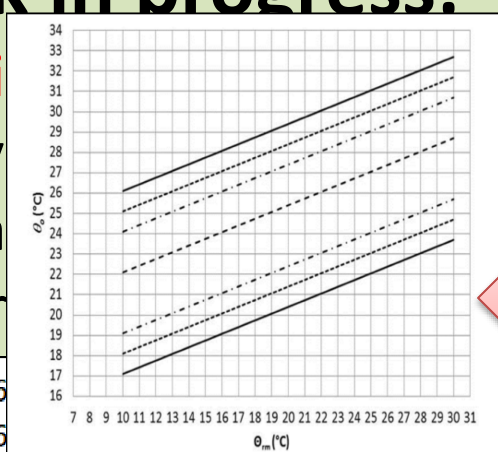
Work in progress:

Combi e data

hourly PB sta

Such a

for spr



Also in preparation

for spreadsheet on EN ISO 52016-1:

Hourly **adaptive temperarure setpoint**

(based on EN 16798-1, or customized)

For resid.bldngs and offices with operable windows without mech.cooling)

Again: sheet with hourly input

Just some examples

Hourly data full year

Variable properties of windows (e.g. movable solar shading)

Very transparent where to add control or input from other EPB standards

V1	V1	V2	V2
$1/R_{c;window}$	$\tau_{sol;window}$	$1/R_{c;window}$	$\tau_{sol;window}$
W/m2K	-	W/m2K	-
1,21	0,10	1,36	0,40
1,21	0,10	1,36	0,40
1,21	0,10	1,36	0,40
1,21	0,68	1,36	0,40
1,21	0,68	1,36	0,40
1,21	0,68	1,36	0,40
1,21	0,68	1,36	0,40

Variable max. system power

Variable ventilation properties

$\varphi_{V;zi}$	$\varphi_{V;sys;zi}$	ϑ_{sup}	$x_{a;sup}$	$\Phi_{H;nd;avail}$	$\Phi_{H;sys;ls;rbl}$	$\Phi_{H;nd;avail}$
m3/h	m3/h	C	/kg dry air	W	W	kWh
0				4789	55,4	4,789
0				4758	53,8	4,758
0				4726	52,6	4,726
1099,795				3798	58,9	3,798
0				4677	57,7	4,677
0				1755	58,9	1,755
0				2216	58,9	2,216

Sheet with hourly climatic data

Hourly data full year

Output file for Excel sheet on ISO 52010-1	
Date:	Date: 2020-10-05
Time start -> end:	17:40:37 -> 17:42:11
Configuration file (workbook):	Demo_ISO_52010-1_Config_V2.0_TMY_Example_calcs_8 es_2020-10-05.xlsm
Climatic input data file (workbook/sheet):	Demo_ISO_52010-1_Input_TMY_Athens_2020-08-19_18-1 17.xlsx/data
Station data------:	
Station name:	Athens
Station note(1):	JRC TMY, selected months, years: 1 = 2 = 2012; 3 = 2013; 4 = 2011; 5 = 2009; 2009; 7 = 2013; 8 = 2011; 9 = 2009; 10 2007; 11 = 2012; 12 = 2012;
Station note(2):	Selected period 2005-2014
Station note(3):	None
Latitude (degr.):	37,976
Longitude (degr.):	23,736
Elevation (m):	96
Timezone (hr):	1

Sheet with hourly climatic data is direct copy of output from spreadsheet on EN ISO 52010-1 *(conversion solar radiation from hor. measured to any orientation and tilt)*

EPB CENTER

Sheet with hourly climatic data

Just some examples

Hourly data full year

Wind

Sun position

Temp.

Moist.

Solar, total and diffuse, per orient. & tilt

					Identification of orientation & tilt ->				Id:	NV	NVd	EV	EVd
					ent.) angle, degrees, S=				amma:	180	180	90	90
					Tilt angle, degrees from horiz. ->				Beta:	90	90	90	90
ay/week	Week	Air temp.	Wind speed	Wind dir.	Air pressure	Air moist. content	Solar alt	Solar azim	Grnd refl.	Isol_tot	Isol_dif	Isol_tot	Isol_dif
-	-	Degr. C	m/s	Degrees	Pa	g/kg	degrees	degrees	-	W/m2	W/m2	W/m2	W/m2
1	9	16,27	3,61	198	99549	7,965	36,27155	-35,06	0,2	155,2551	155,2551	155,2551	155,2551
1	9	15,94	3,94	185	99490	8,205	28,27438	-49,8479	0,2	134,9824	134,9824	134,9824	134,9824
1	9	15,61	4,26	173	99431	8,432	18,47831	-61,9823	0,2	92,20507	92,20507	92,20507	92,20507
1	9	14,68	3,91	182	99408	8,382	7,588008	-72,3108	0,2	42,94607	42,94607	42,94607	42,94607
1	9	13,74	3,55	190	99384	8,301	0	-81,659	0,2	0	0	0	0
1	9	12,8	3,2	199	99361	8,196	0	-90,7868	0,2	0	0	0	0

Just some examples

Sheet with hourly output

Hourly data full year

Internal gains

Incident solar radiation on each construction element

Time dependent interim output

	<simplified to only 1 H_ve>		$I_{sol;eli}$	**Incident** solar radiation, per element eli, per m2 (W/m2)							
	H_{ve}	$\Phi_{int;zi}$	1	2	3	4	5	6	7	8	
	W/K	W	W/m2	W/m2	W/m2	W/m2	W/m2	W/m2	W/m2	W/m2	W/
3	39,86945667	555	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,
4	39,86945667	555	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,
5	39,86945667	555	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,
6	39,86945667	555	30,14	30,14	87,89	70,04	30,14	285,92	30,14	30,14	30,
7	39,86945667	495	76,53	76,53	114,32	276,76	76,53	625,47	76,53	76,53	76,
8	39,86945667	495	168,02	168,02	106,79	490,80	168,02	754,22	168,02	106,79	106,
9	39,86945667	495	302,20	302,20	127,73	674,84	302,20	717,21	302,20	127,73	127

Sheet with hourly output

Just some examples

Hourly data full year

Time dependent interim output

Internal gains

Incident solar radiation on each construction element

<simplified to only 1 H_ve>

$I_{sol;eli}$

Incident solar radiation, per element eli, per m2 (W/m2)

H_{ve}	$\Phi_{int;zi}$
W/K	W
39,86945667	555
39,86945667	555
39,86945667	555
39,86945667	555
39,86945667	495
39,86945667	495
39,86945667	495

Needs

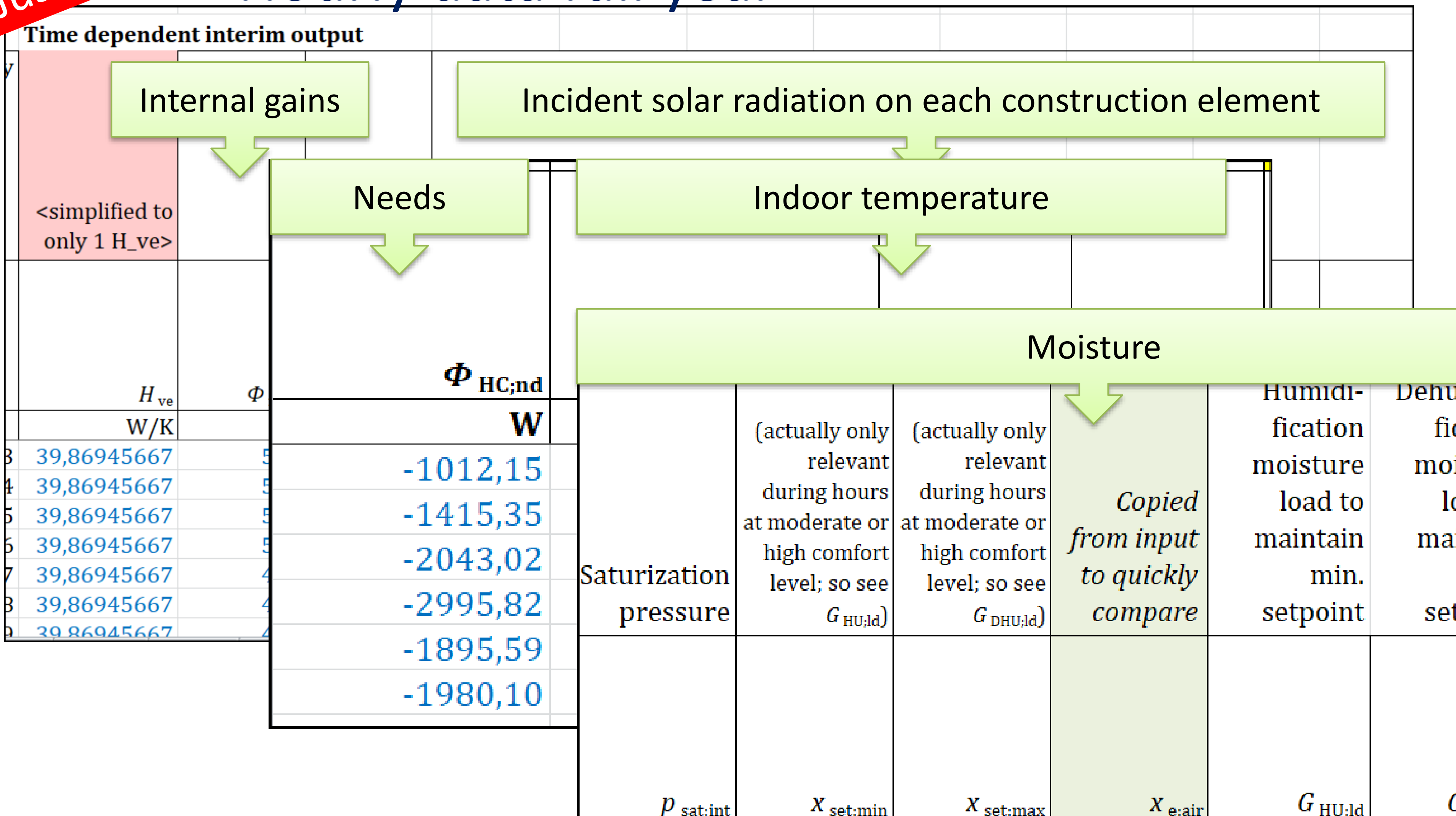
Indoor temperature

$\Phi_{HC;nd}$	$\vartheta_{int;op}$	$\vartheta_{int;a}$	$\vartheta_{int;rm}$
W	C	C	C
-1012,15	26,00	25,95	26,05
-1415,35	26,00	25,92	26,08
-2043,02	26,00	25,87	26,13
-2995,82	26,00	25,79	26,21
-1895,59	26,00	25,83	26,17
-1980,10	26,00	25,83	26,17

Sheet with hourly output

Just some examples

Hourly data full year



Just some examples

Sheet with monthly output

Summary and statistics per month

Heating load distribution

Number of hours/month with operative temperature exceeding specific limit

s > fraction X of max power					Base	Number of hrs with $\vartheta_{int;op}$ below:						Bas
0,8	0,6	0,4	0,2	0	**20**	18	16	14	12	10	8	**2**
-3756	-2817	-1878	-939	0	$\vartheta_{int;op}$							$\vartheta_{int;o}$
0,00	0,00	0,00	0,00	0,92	0	0	0	0	0	0	0	
0,00	0,00	0,00	0,00	0,67	0	0	0	0	0	0	0	
0,00	0,00	0,00	0,00	0,67	0	0	0	0	0	0	0	
0,00	0,00	0,00	0,00	0,99	0	0	0	0	0	0	0	
0,00	0,00	0,02	0,07	1,00	0	0	0	0	0	0	0	

Monthly method

Monthly calculation & output

Just some examples

Example: sheet for **heating**

H.need if no intermitt. | Solar and sky rad. | Gains | Intermittency correction | Time const. | Losses | Balance ratio

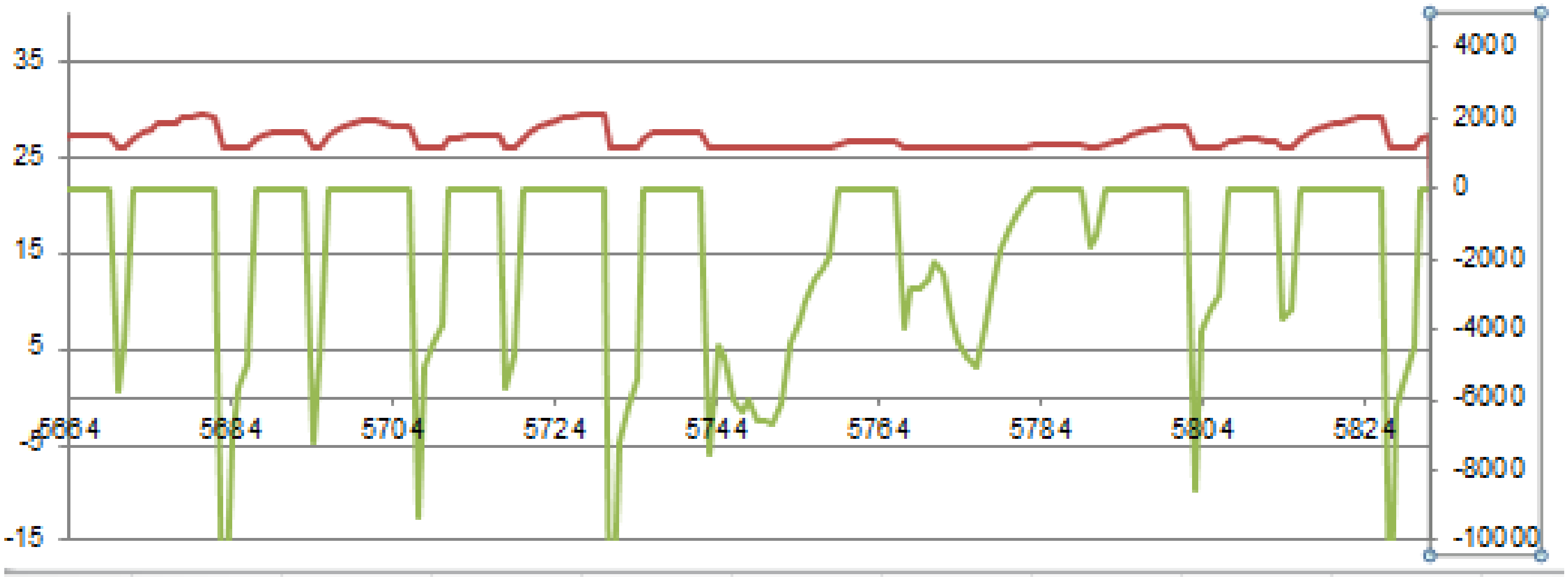
contin.H	added...	Excl.sky rad	Sky rad	incl minus sky rad			contin.	Intermittency			Night s...	
6.6.4.4	6.6.10.4	6.6.8	6.6.8	6.6.8	6.6.7	6.6.4.4	6.6.10.2	6.6.11.3	6.6.11.3	6.6.11.3	6.6.11.3	6.6...
$Q_{H;ht;cont}$	τ_H	$Q_{H;sol}$	Q_r	$Q_{H;sol}$	$Q_{H;int}$	$Q_{H;gn}$	$\gamma_{H;gn;cont}$	$d\vartheta_{float}$	$\Delta t_{H;red;y}/\tau_H$	$d\vartheta_{H;red;mn;y}$ without lower limit	$d\vartheta_{set;H;low;y}$	$\Delta t_{H;re...}$
kWh	h	kWh	kWh	kWh	kWh	kWh	-	-	-	-	-	
685	89,2	1100,8	51,6	1049,2	353,7	1402,9	2,05	1,00	0,08	1,00	1,00	
793	89,2	1083,7	51,6	1032,1	353,7	1385,8	1,75	1,00	0,08	1,00	1,00	
810	89,2	945,2	46,6	898,6	319,4	1218,0	1,50	1,00	0,08	1,00	1,00	
581	89,2	1442,1	51,6	1390,6	353,7	1744,2	3,00	1,00	0,08	1,00	1,00	
515	89,2	1370,3	49,9	1320,4	342,3	1662,7	3,23	1,00	0,08	1,00	1,00	
73	89,2	1406,3	51,6	1354,7	353,7	1708,4	23,48	1,00	0,08	1,00	1,00	
-266	89,2	1422,7	49,9	1372,8	342,3	1715,0	-6,44	1,00	0,08	1,00	0,00	
-481	89,2	1490,2	51,6	1438,7	353,7	1792,3	-3,73	1,00	0,08	1,00	0,00	

Sheet with graphical output

Just some examples

Examples from earlier presentations:

Examples of hourly data



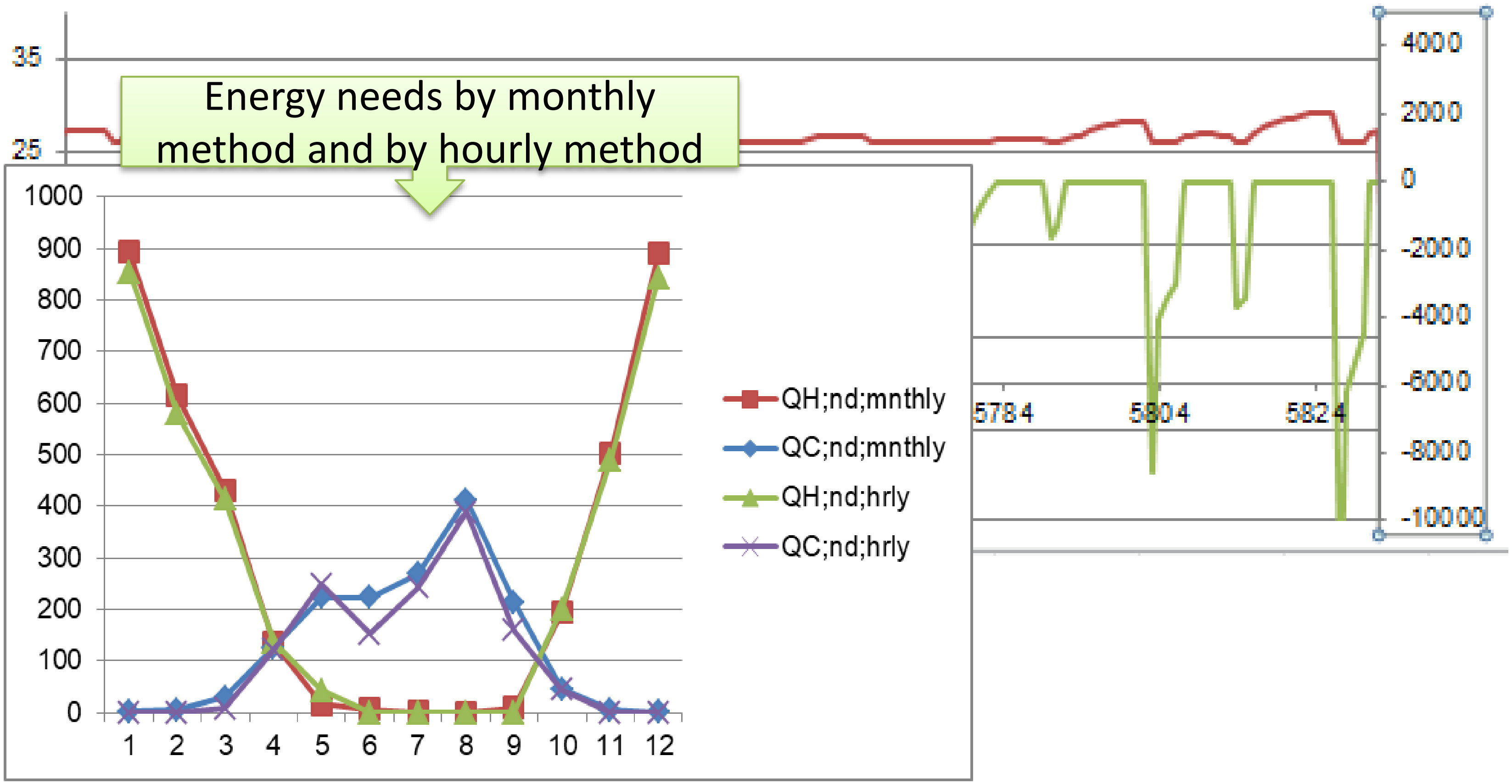
Sheet with graphical output

Just some examples

Examples from earlier presentations:

Examples of hourly data

Energy needs by monthly method and by hourly method

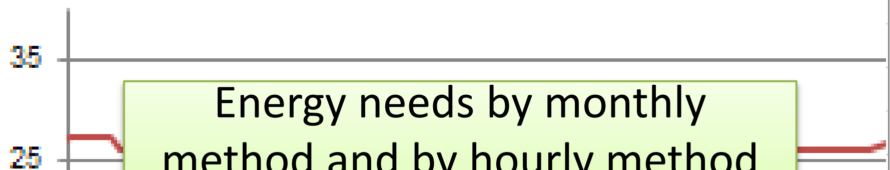


Sheet with graphical output

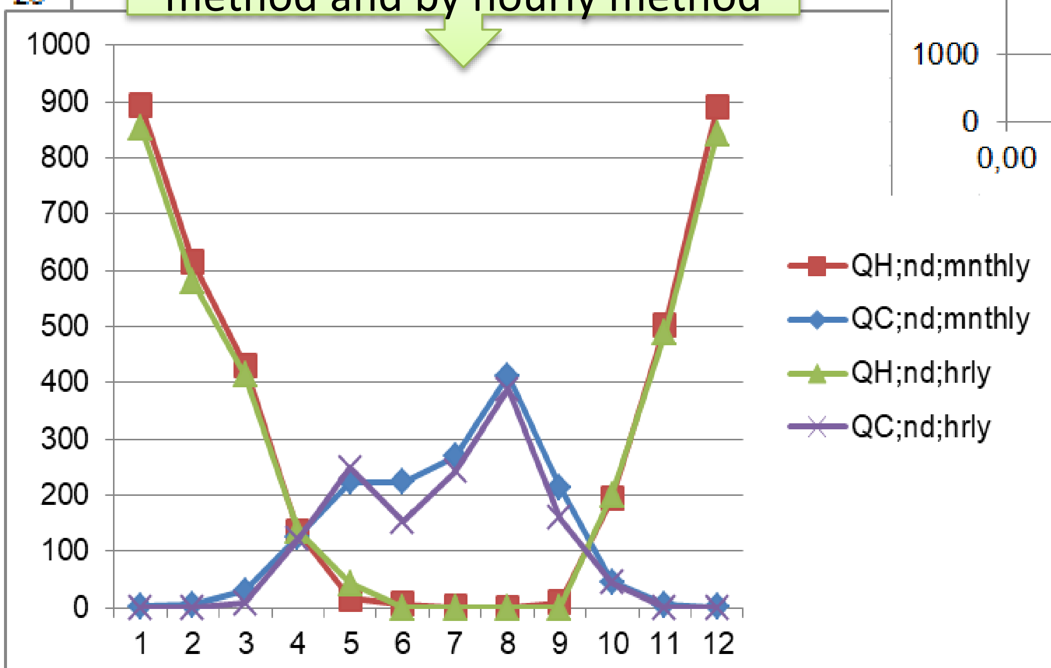
Just some examples

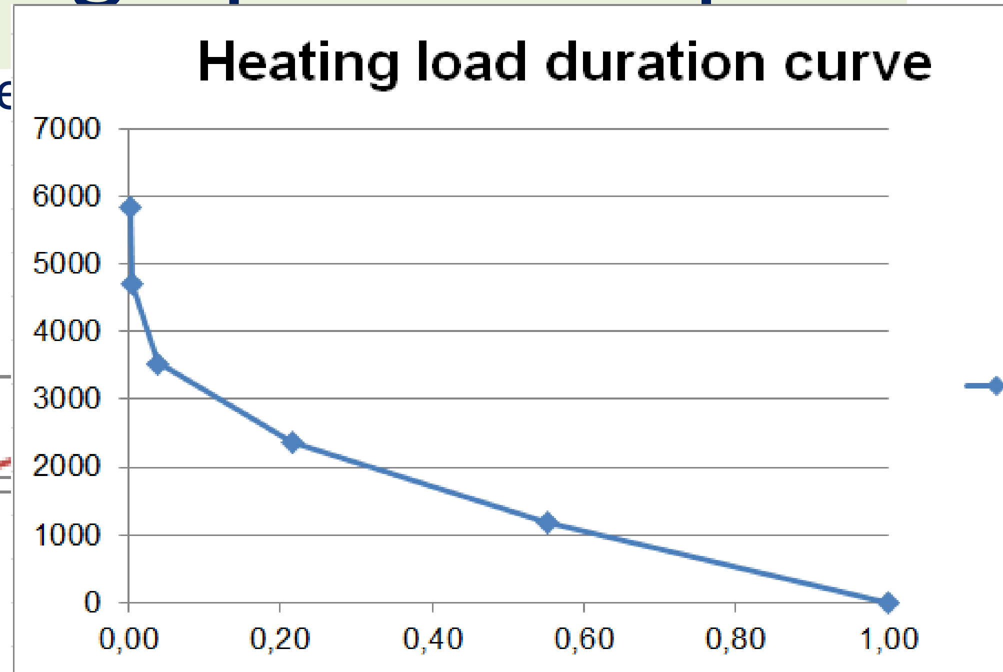
Examples from earlier pre

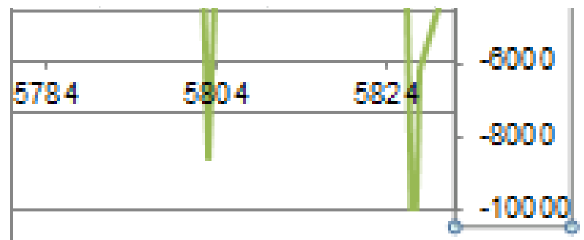
Examples of hourly data



Energy needs by monthly method and by hourly method



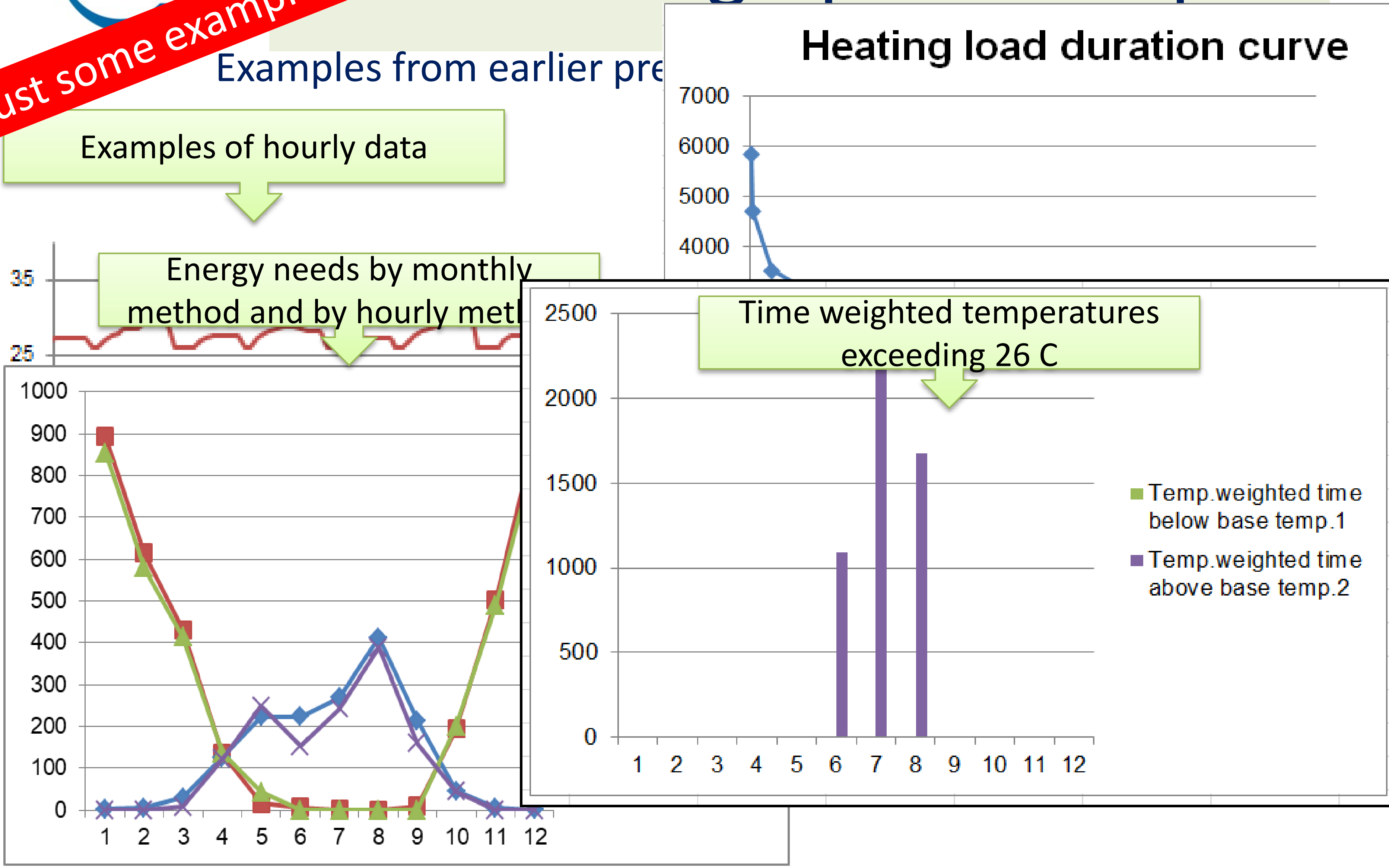




Sheet with graphical output

Just some examples

Examples from earlier pre



Conclusion on **EN ISO 52016-1**:

One of the core EPB standards for calculating the overall EPB

- Illustrated that
  - The **hourly calculation method** is pure **physics** & **dynamic** → comparable to building simulation tools
  - But **tailored** to the needs:
    - No more input for user than monthly method
    - Fully traceable
  - Fit for various climates and use patterns: residential and non-residential
- Also illustrated:
  - Spreadsheet features and further developments for demonstration and testing: **transparent**, also in interconnection between standards (modules)
- Note: **monthly method** is also an option in EN ISO 52016-1, but requires extra care

Thank you!

EPB Center is also available for specific services requested by individual or clusters of stakeholders

More information on
the set of EPB standards:

www.epb.center

Contact: info@epb.center

Parts of this document have been produced under a contract with the European Union, represented by the European Commission (Service contract ENER/C3/2017-437/SI2-785.185).

Your service center for information and technical support on the new set of EPB standards

Integrated application of the EPB standards on energy needs, ventilation and air heating and cooling; demonstration

Gerhard Zweifel

gerhard.zweifel@hslu.ch

This project is facilitated by the EU-Commission Service Contract ENER/C3/2017-437/SI2.785185

Start: 21 September 2018 for 3 years

BUILD UP Webinar series

Webinar 8: *Calculations with the set of EPB standards (II) - Energy needs combined with specific systems*

20 October 2020

My background

- Professor emeritus, Lucerne University of Applied Sciences and Arts (HSLU) (≤ 2019)
- EPB Center expert (> 2017)
- Involved in initiation, preparation and coordination of set of EPB standards (2012-2017)
- Convenor of CEN Working Group responsible for system related EPB standards:

  Ventilation/cooling

  CEN/TC 156/WG 21
- Member of ISO Joint Working Group on the overall set of EN ISO EPB standards, in collabora-tion with CEN, and some related working groups

  ISO/TC 163 & ISO/TC 205, CEN/TC 371, ISO/TC 163/SC 2/WG 15/16

Involved standards and spreadsheets

- EN ISO 52016-1: Energy performance of buildings - Energy needs for heating and cooling, internal temperatures and sensible and latent heat loads - Part 1: Calculation procedures
  - Demo_XLS_on_ISO_52016-1_2019-11-20b.zip on https://epb.center/documents/demo-en-iso-52016-1/
  - Updated for case study
- EN 16798-7: Energy performance of buildings — Ventilation for buildings — Part 7: Calculation methods for the determination of air flow rates in buildings including infiltration (Modules M5-5)
  - Demo_FprEN_16798-7_2016-02-11.xlsm on https://epb.center/documents/demo-fpren-16798-7/
  - Updated for case study
- EN 16798-5-1: Energy performance of buildings — Modules M5-6, M5-8, M6-5, M6-8, M7-5, M7-8 — Ventilation for buildings — Calculation methods for energy requirements of ventilation and air conditioning systems — Part 5-1: Distribution and generation — method 1
  - Demo_EN_16798-5-1_2019-09-20f.xlsm on https://epb.center/documents/demo-en-16798-5-1/
  - Updated for case study

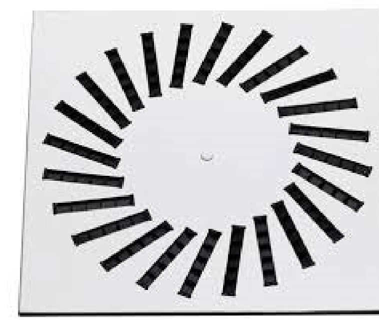
Why coupling of EN ISO 52016-1, EN 16798-7 and EN 16798-5-1 spreadsheets?

- EN ISO 52016-1:
  - Calculation of required heating/cooling energy needs
  - Calculation of room temperatures based on really supplied/extracted heating/cooling energy
- EN 16798-7:
  - Calculation of required air flow rates and/or supply air temperatures for mechanical ventilation
  - Based on EN ISO 52016-1 required heating/cooling energy need
    - > Transformation of energy needs in flow rates/supply temperatures
- EN 16798-5-1:
  - Calculation of air flow rates and/or air temperatures really supplied for mechanical ventilation
  - Based on required air flow rates and/or supply air temperatures from EN 16798-7

> Effects of limited capacities and/or operational deviations from actual needs!

EN 16798-7 – relevant contents

- Effects of mechanical ventilation «emission», i.e.
- the determination of
  - required air flow rates
  - required supply air temperatures
- to
  - fulfill the indoor air requirements (based on EN 16798-1)
  - cover the energy needs for heating/cooling in cases when to be covered by ventilation/air conditioning system



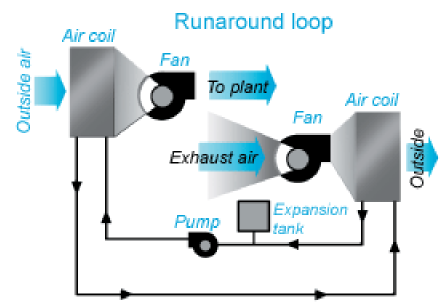
Technically:

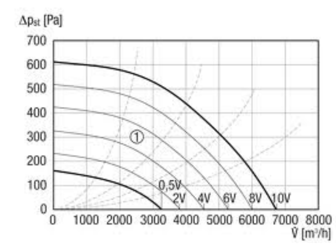
- Air terminal devices
  - VAV boxes
- nothing
  - just transformation of calculated values

EN 16798-5-1 Contents

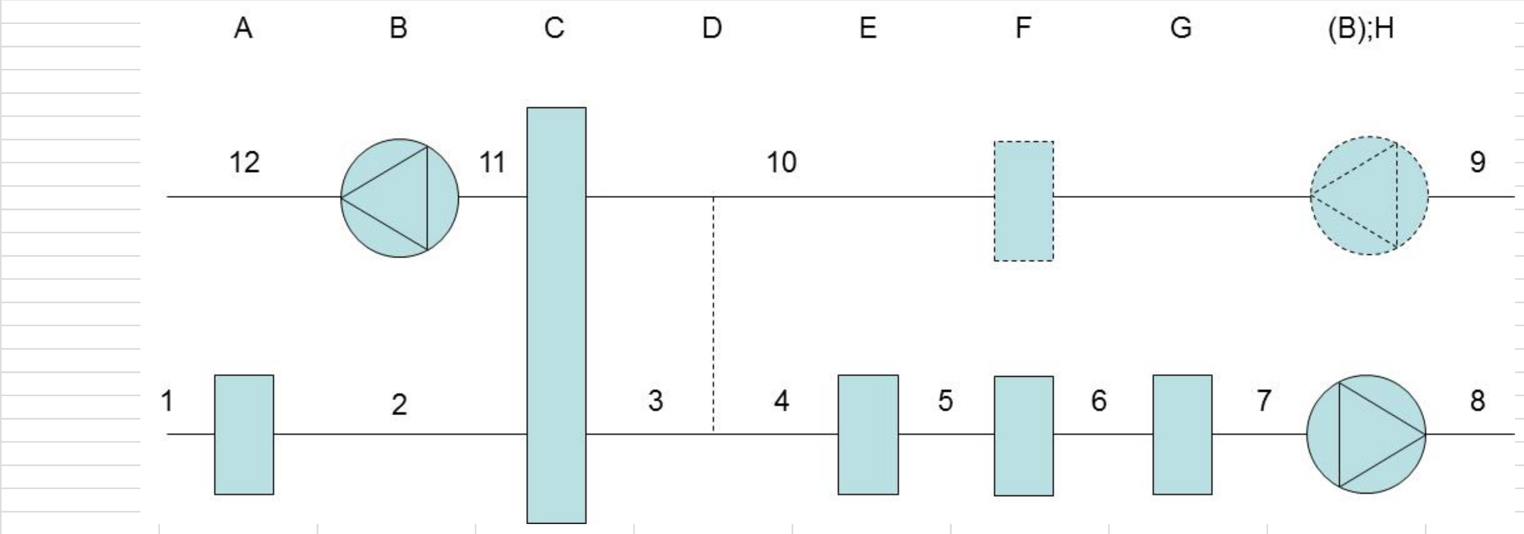
- Air flow rate control types
- Supply air temperature control types
- Heat recovery:
  - Types:
    - flat plate
    - Rotary
    - Pumped circuit

    Connection to product standards (EN 308, 13053)
  - Humidity recovery
  - Control
  - Frost protection
  - Auxiliary energy
- Recirculation control
- Fan control
  - Single zone / multi zone systems
  - Big impact on fan energy
  - Link to product standards
- Ground preheating / -cooling
- Humidification / dehumidification
- Adiabatic cooling





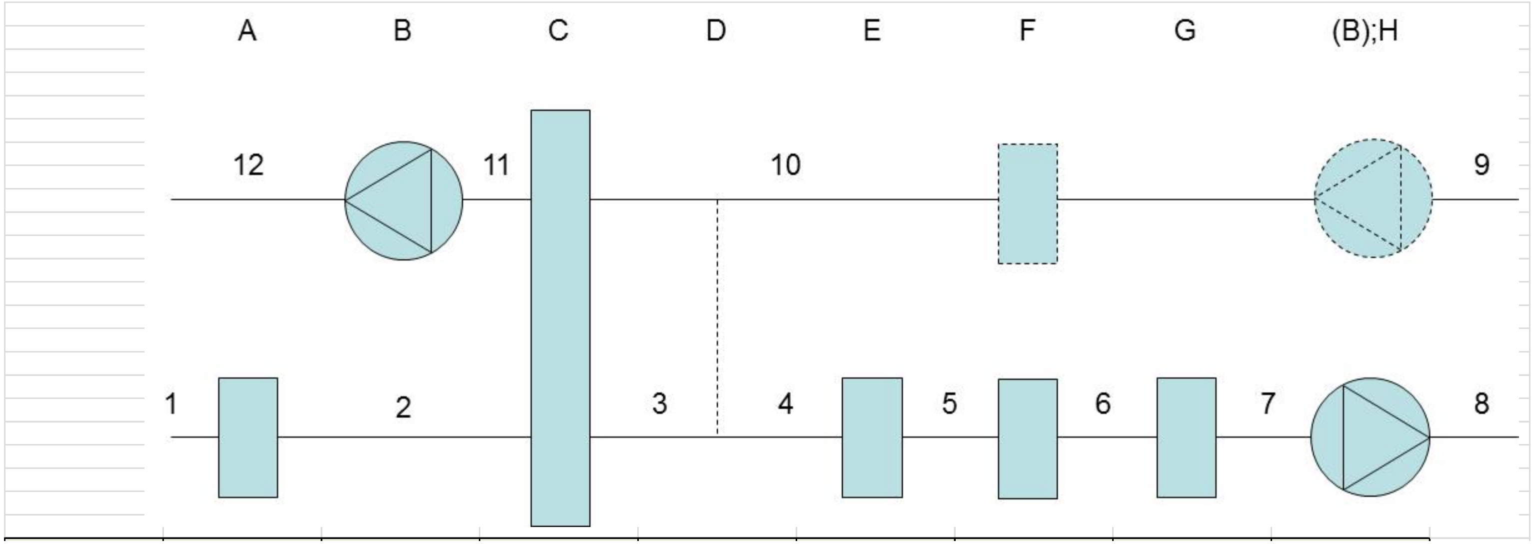
EN 16798-5-1 Spreadsheet



Key	Treatment stage
A	Frost protection / ground preheating/-cooling
B	Exhaust air fan
C	Heat recovery
D	Recirculation
E	Cooling / dehumidification
F	Humidification
G	Heating
H	Supply fan

Key	Air type	Subscript
1	Outdoor air	ODA
2	Preheated outdoor air	ODA;preh
3	Supply air after heat recovery	SUP;hr
4	Supply air after recirculation	SUP;RCA
5	Supply air after cooling/dehumidification	SUP;C
6	Supply air after humidification	SUP;hu
7	Supply air after heating	SUP;rh
8	Supply air entering the distribution system	SUP;dis;in
9	Extract air leaving the distribution system	ETA;dis;out
10	Extract air entering the heat recovery / recirculation	ETA;hr;in
11	Extract air after heat recovery	ETA;hr;out
12	Exhaust air	EHA

EN 16798-5-1 Spreadsheet

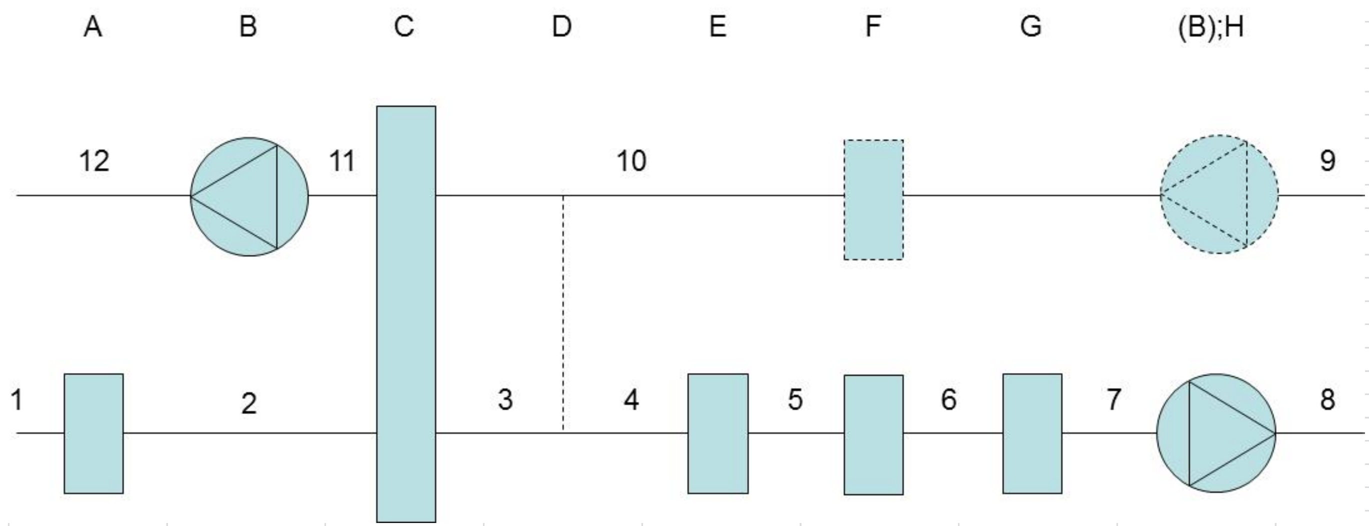


Very comprehensive spreadsheet

- > 150 equations
- Vast number of options
- Vast number of combinations
- Characterisation of components

-> need for a user friendly interface, as seen on next slide

EN 16798-5-1 Spreadsheet



General	A	B	C	D	E	F	G	H
Volume flow rates	Frost protection / ground preheating/-coo-ling	Exhaust air fan	Heat recovery	Recirculation	Cooling / dehumidification	Humidification	Heating	Supply fan
Detailed								
Air handling unit localosation	Ground air preheating and -cooling	localisation	Heat recovery type			Humidifier type		Fan motor localisation
NC	NONE	UP_HR	ROT_HYG	yes		CONTACT		OUTS_AIR
Supply air temperature control	Frost protection type		only for FLAT_PLATE and ROT_HYG	Recirculation control		humidifier control		System type for variable air volume flow rate fan energy calculation
ODA_COMP	PREH		Residential	VARIABLE		ON_OFF		SINGLE_ZONE
Control of the volume flow rate	Control of the frost protection		Control of the heat recovery device			humidification energy carrier		Control of the fan
ODA_COMP	INDIRECT		SPEED			HUM_CR_EL		DIRECT
System type						Adiabatic cooling		localisation
else						no		UP_HR

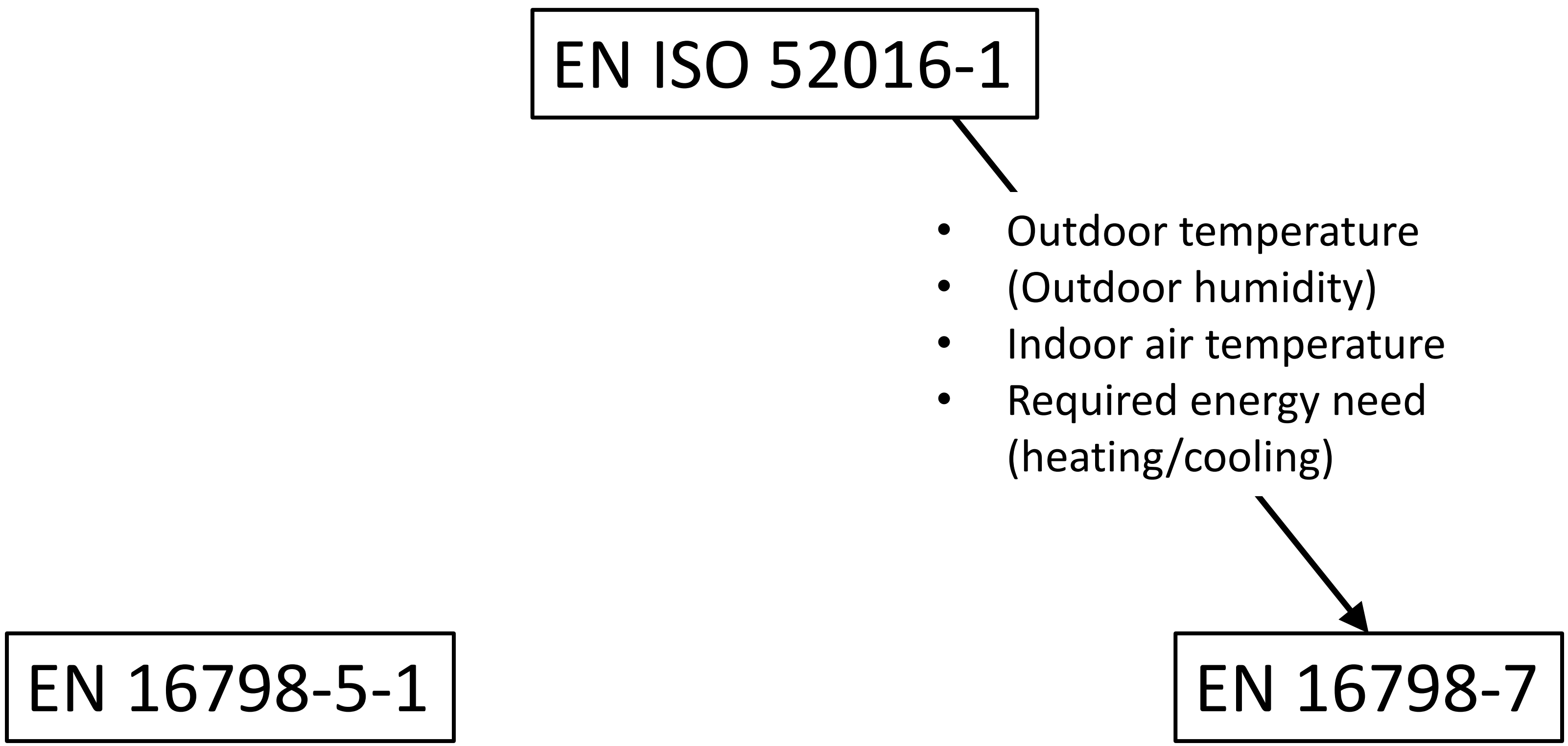
How is the coupling working?

EN ISO 52016-1

EN 16798-5-1

EN 16798-7

How is the coupling working?



How is the coupling working?

EN ISO 52016-1

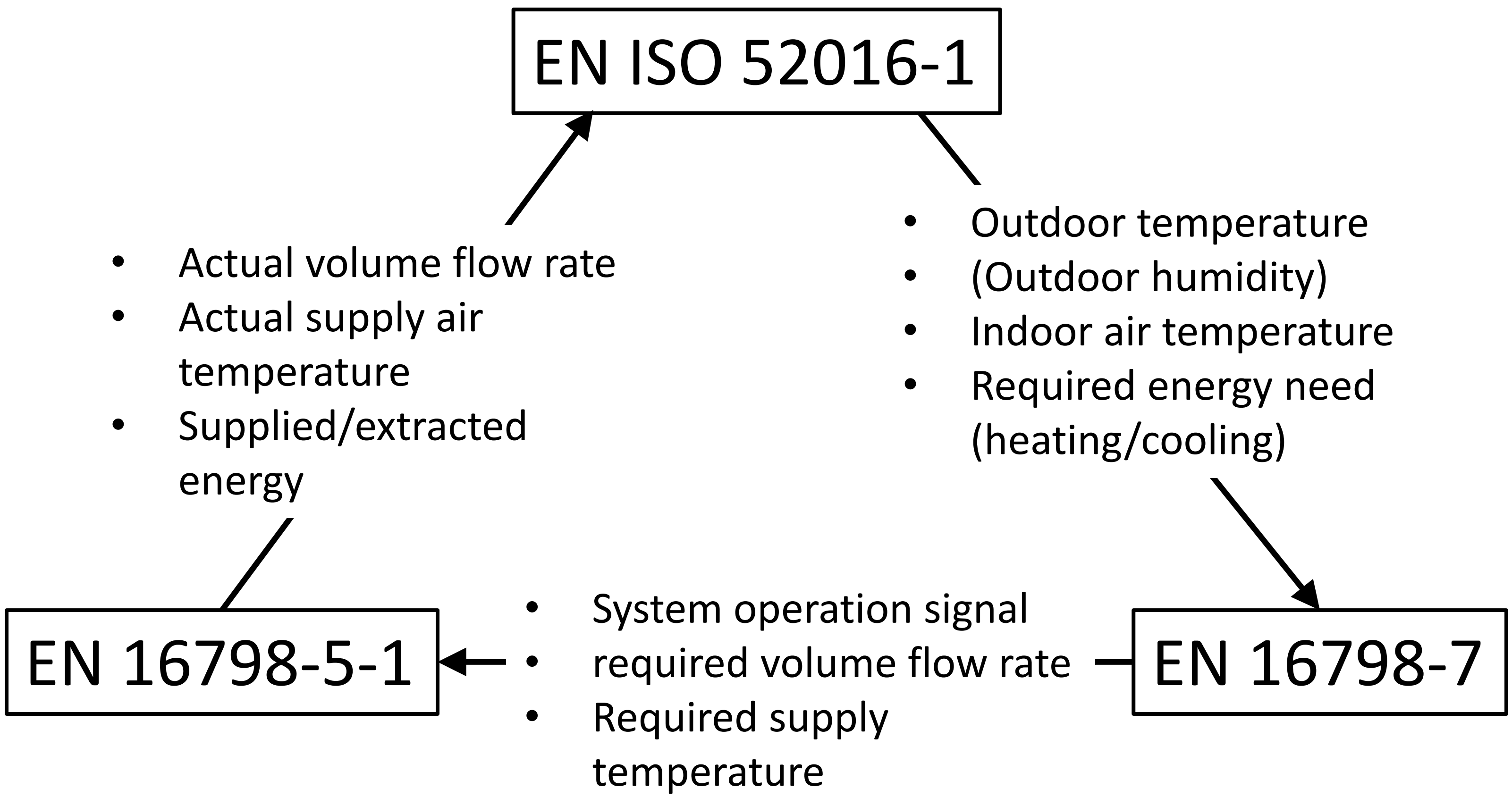
- Outdoor temperature
- (Outdoor humidity)
- Indoor air temperature
- Required energy need (heating/cooling)

EN 16798-7

- System operation signal
- required volume flow rate
- Required supply temperature

EN 16798-5-1

How is the coupling working?



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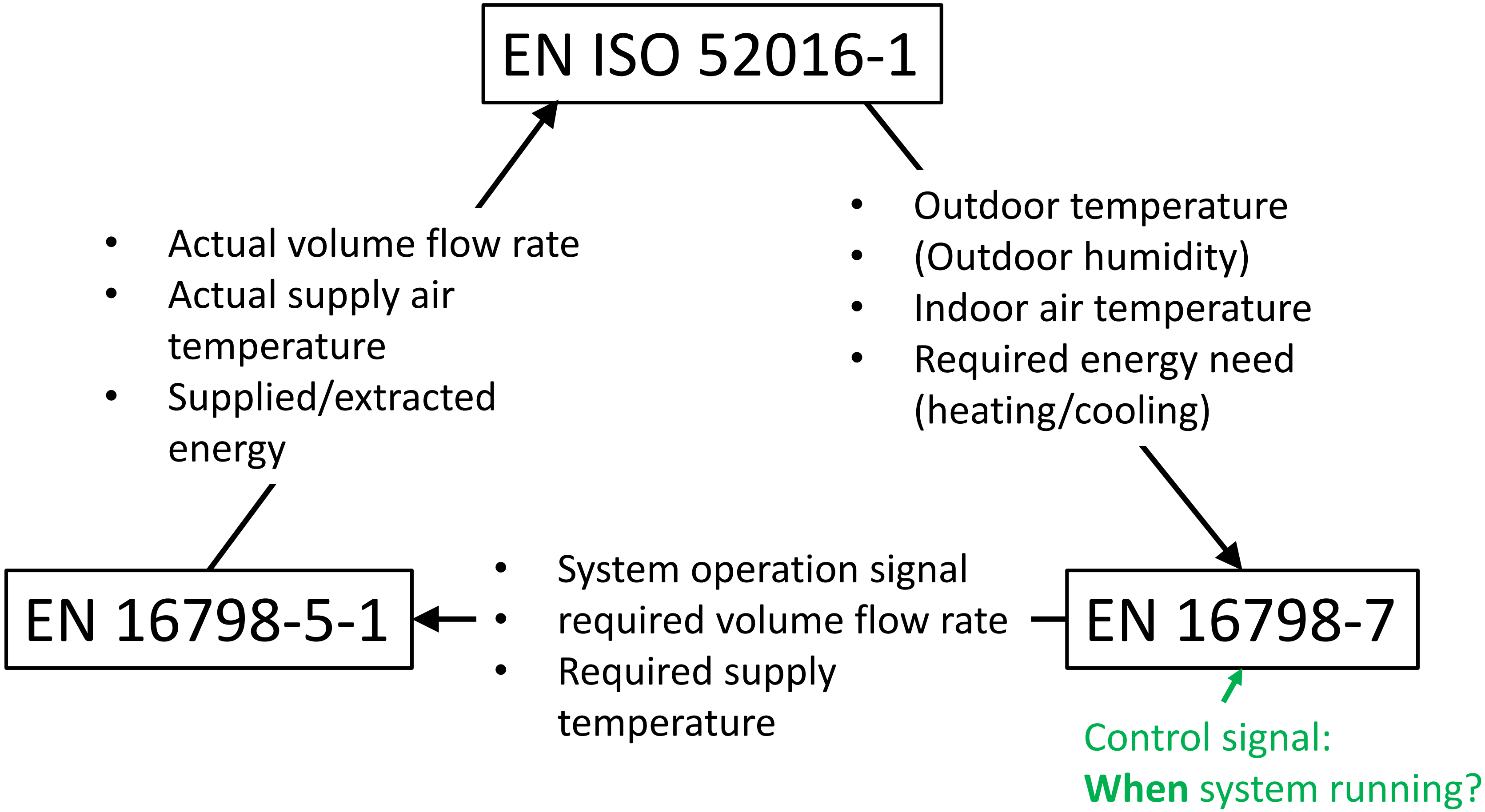

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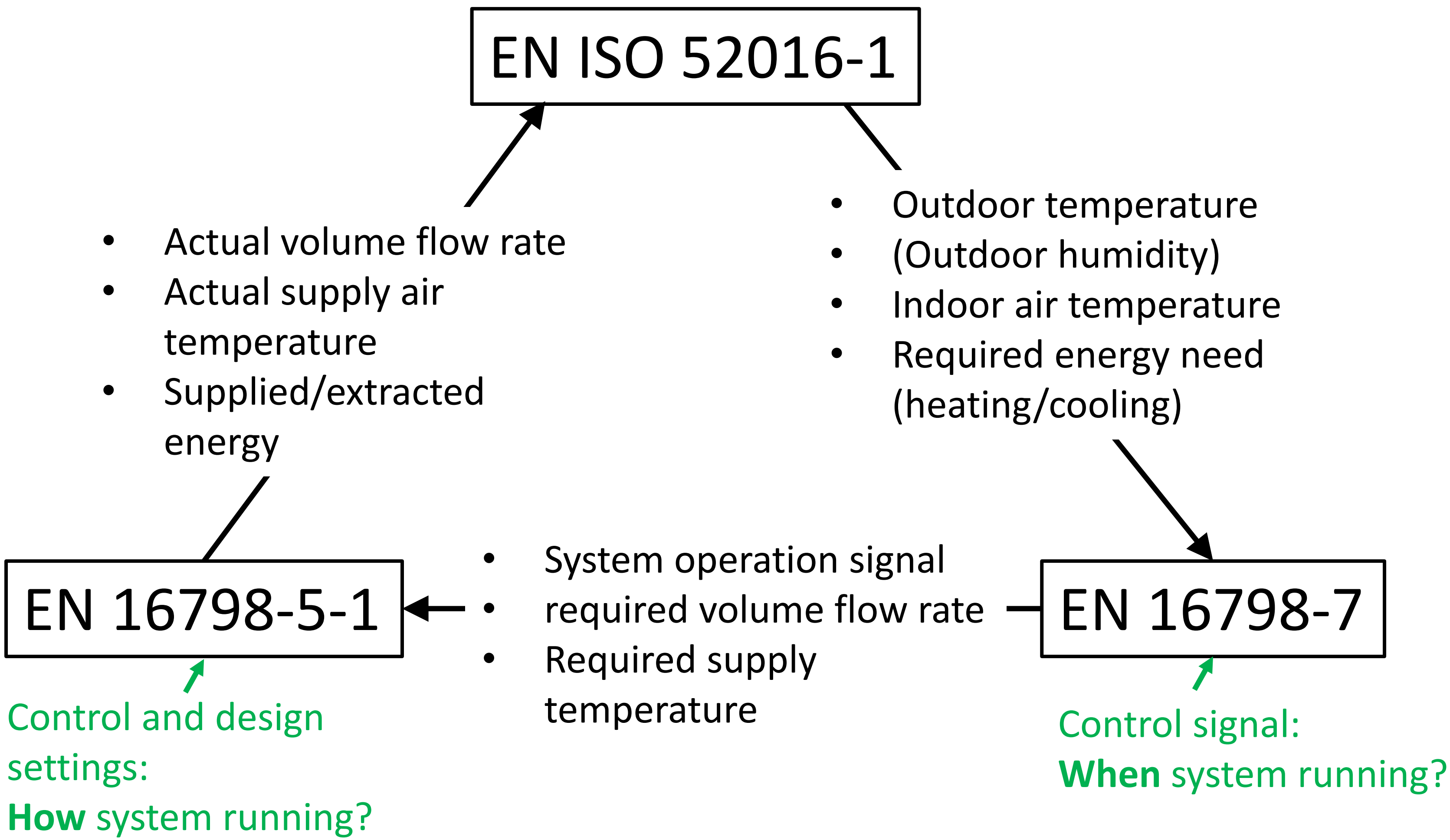

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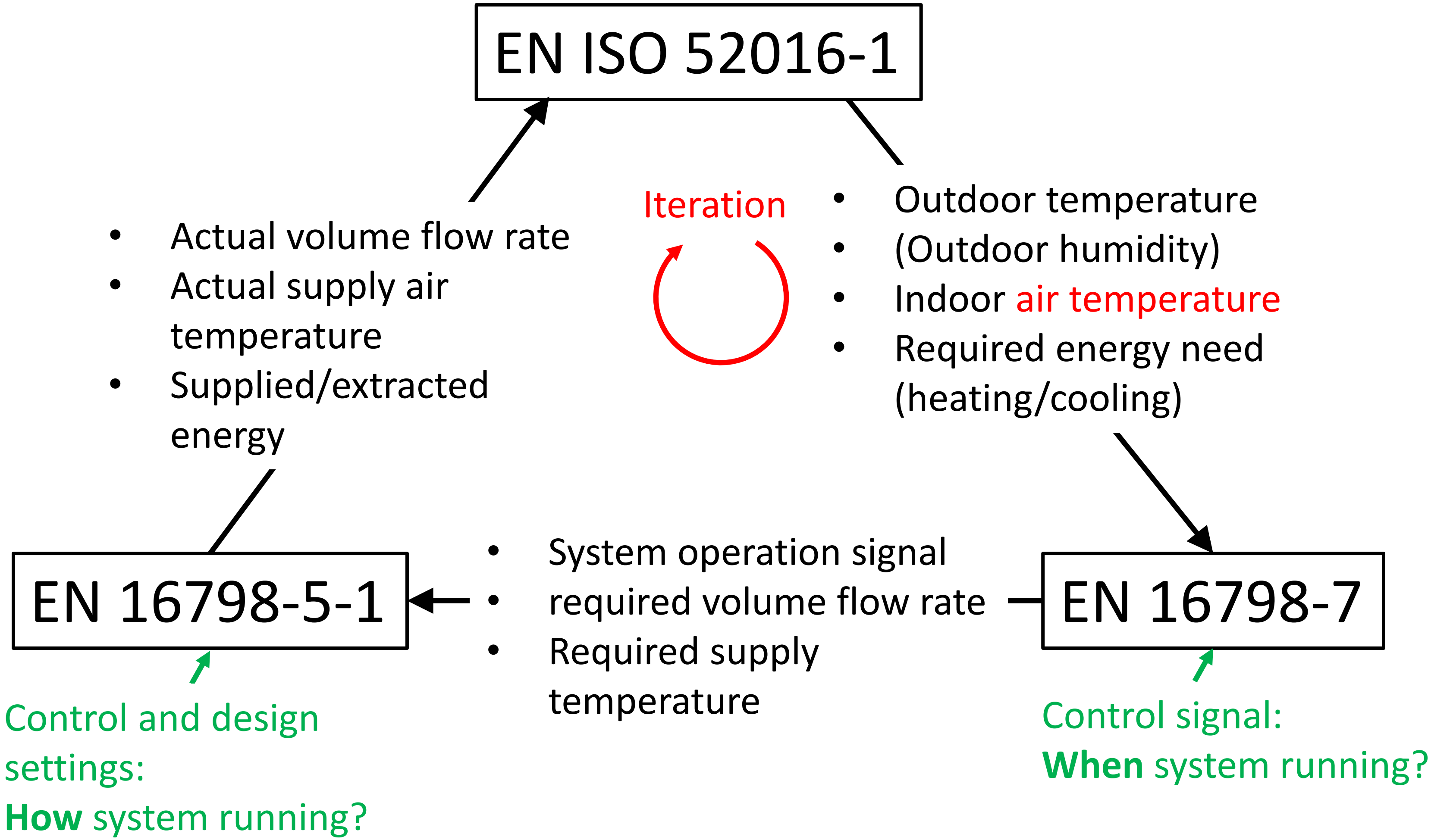

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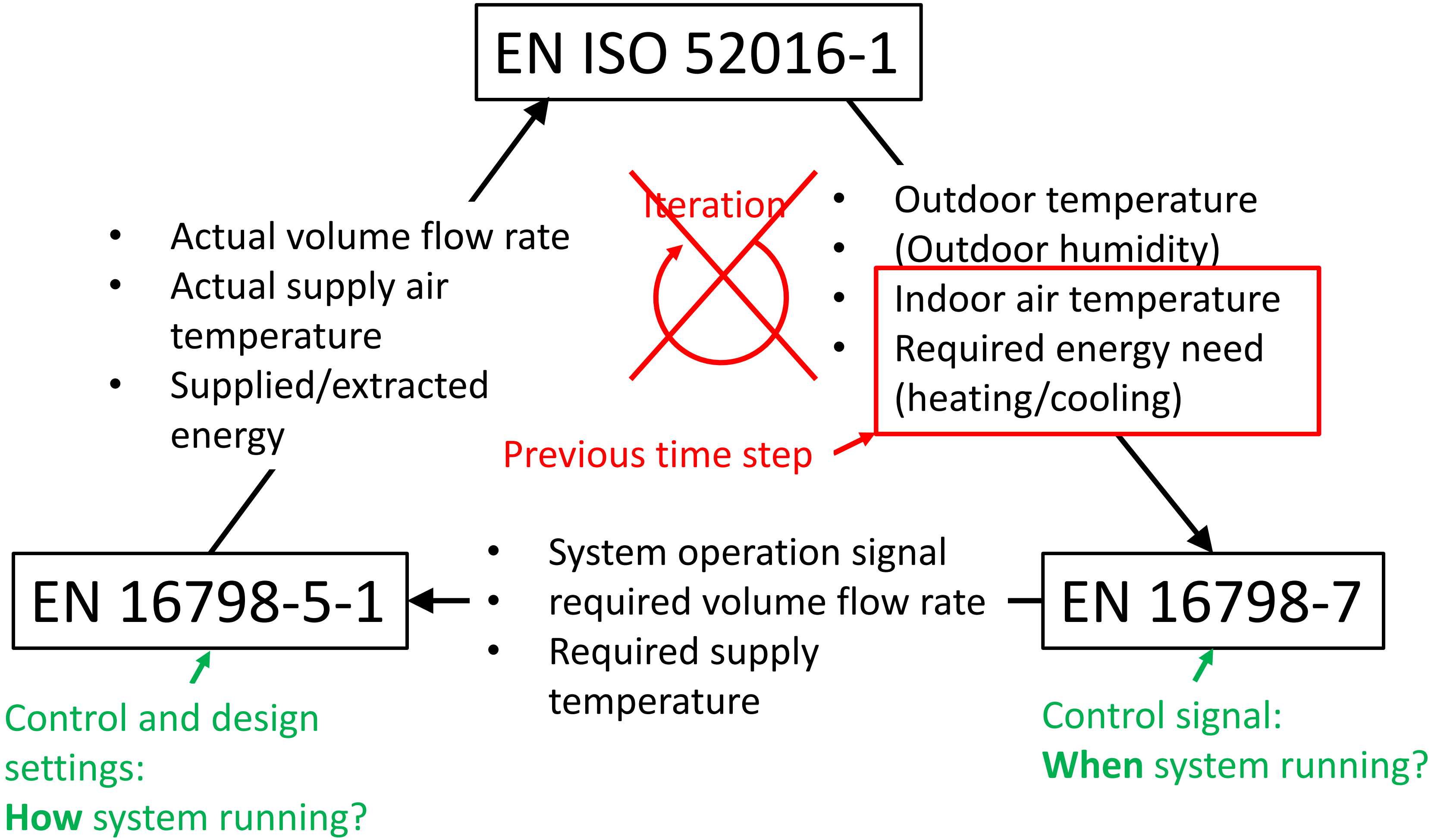
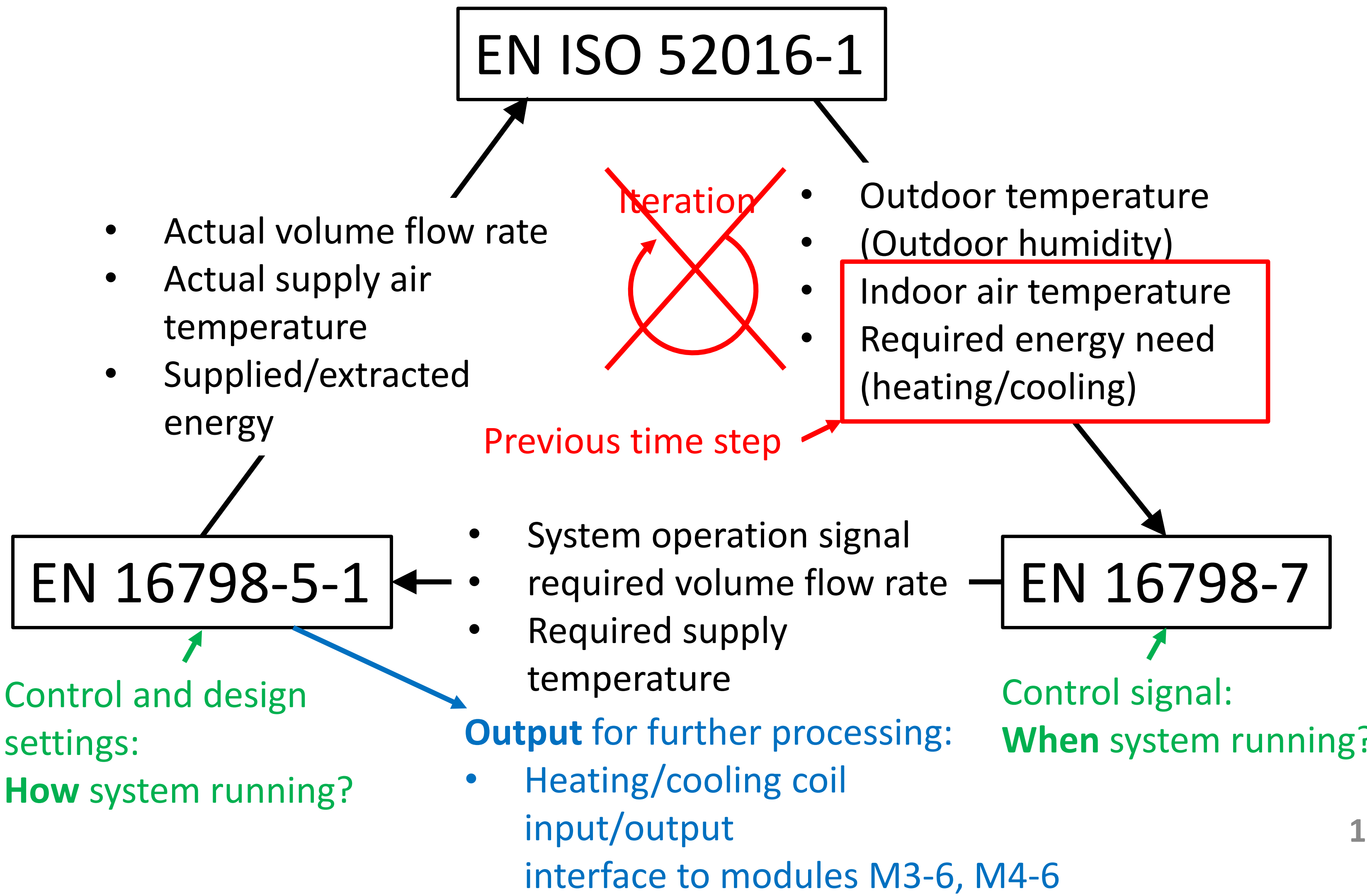


How is the coupling working?

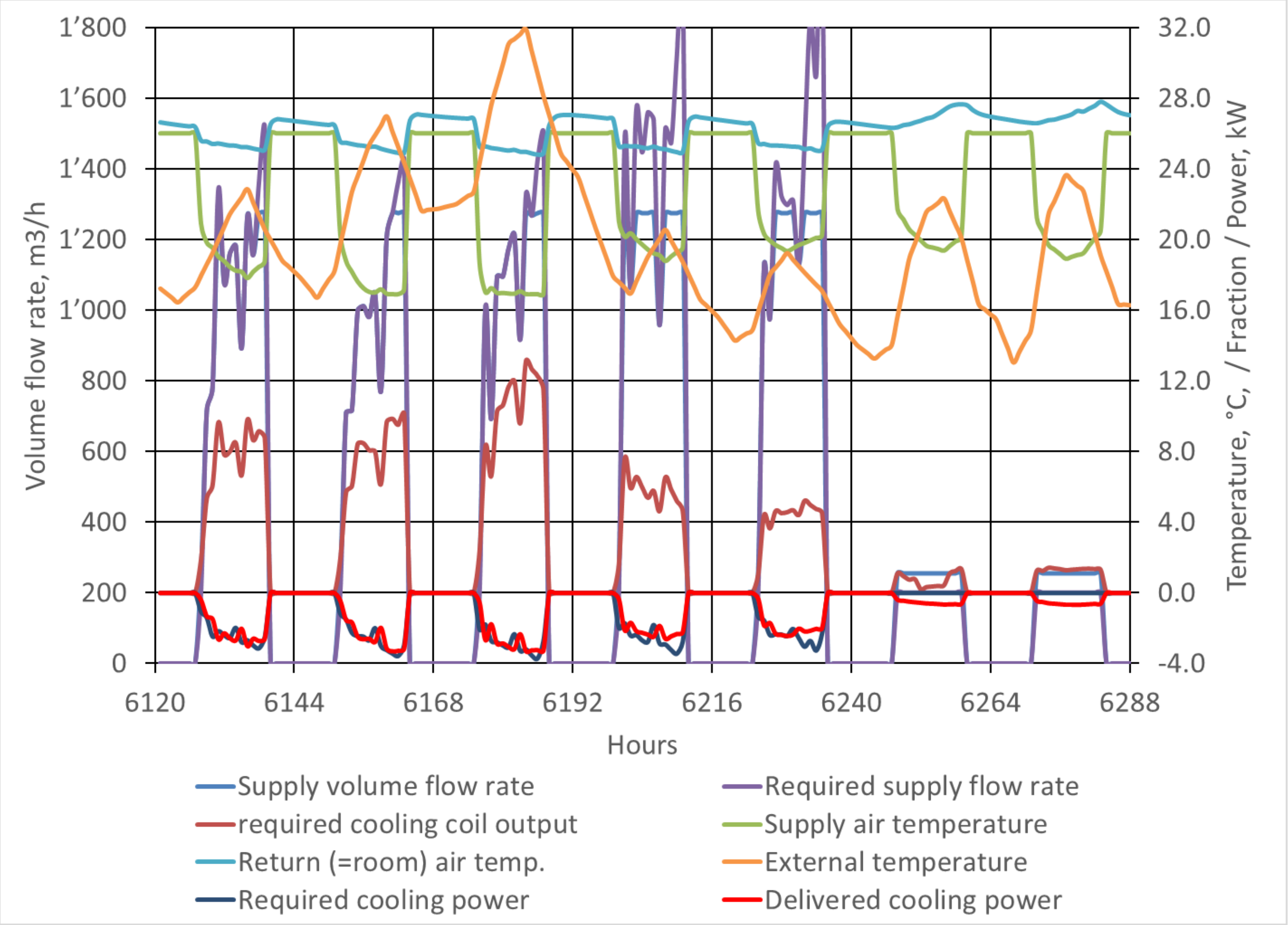


Example calculations

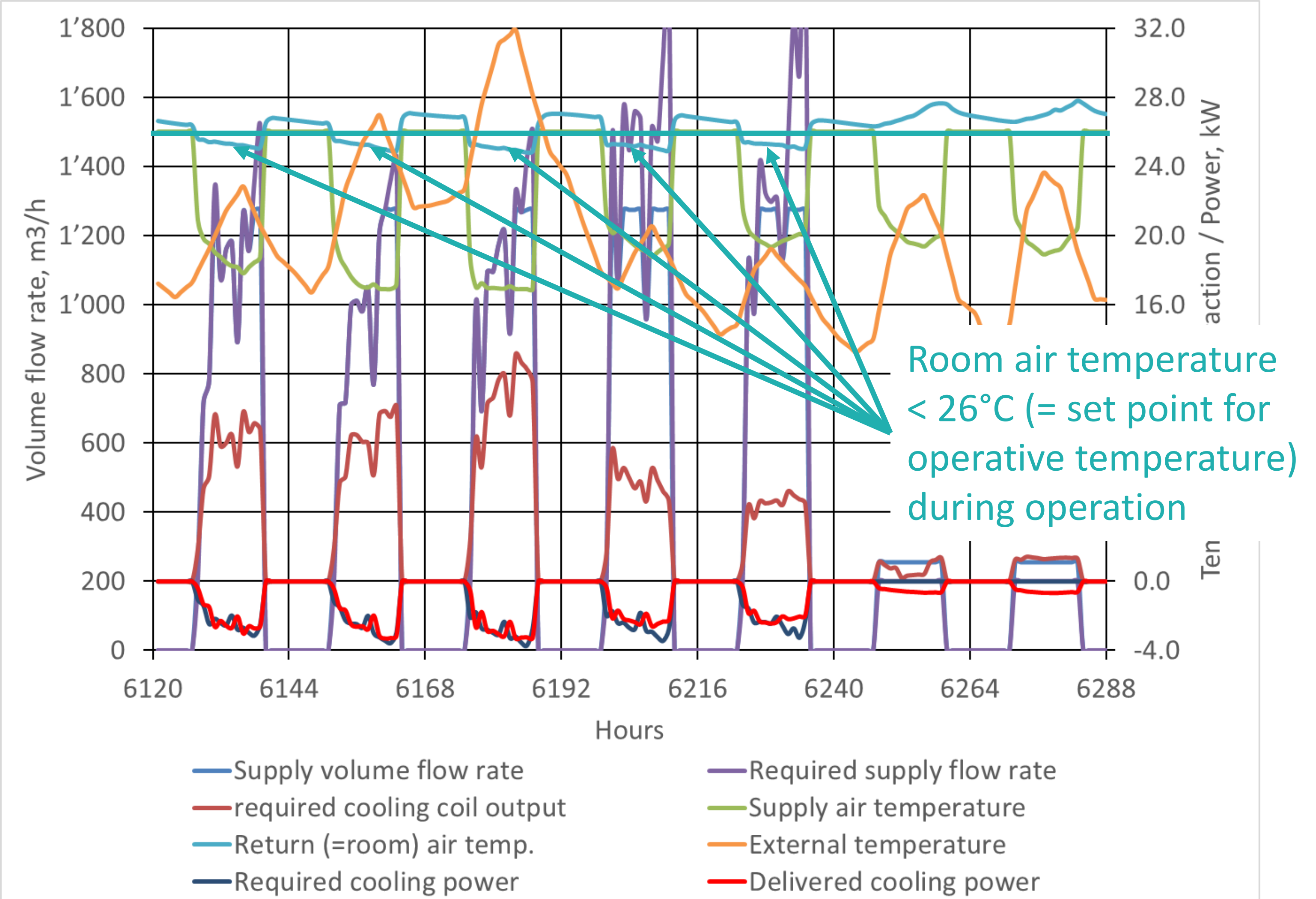
- Climate: Strasbourg
  - Two periods
    Summer: 3 weeks August (last week analysed)
    Winter: 3 weeks January/February (last week analysed)
- «Building»: 150 m^2 landscape office, single space
- Ventilation system: 2 cases
  1. Variable volume (VAV) system
     - Volume flow rate controlled according to energy needs
     - Supply temperature pre-defined (outdoor-dependent curve)
  2. 2 stage ventilation system
     - Volume flow rate pre-defined (controlled according to outdoor air requirements)
     - Supply temperature controlled according to energy needs

➢ note: load based control of both is «bad control» (unless clearly sequential)
  - Not possible in EN 16798-5-1 standard/spreadsheet

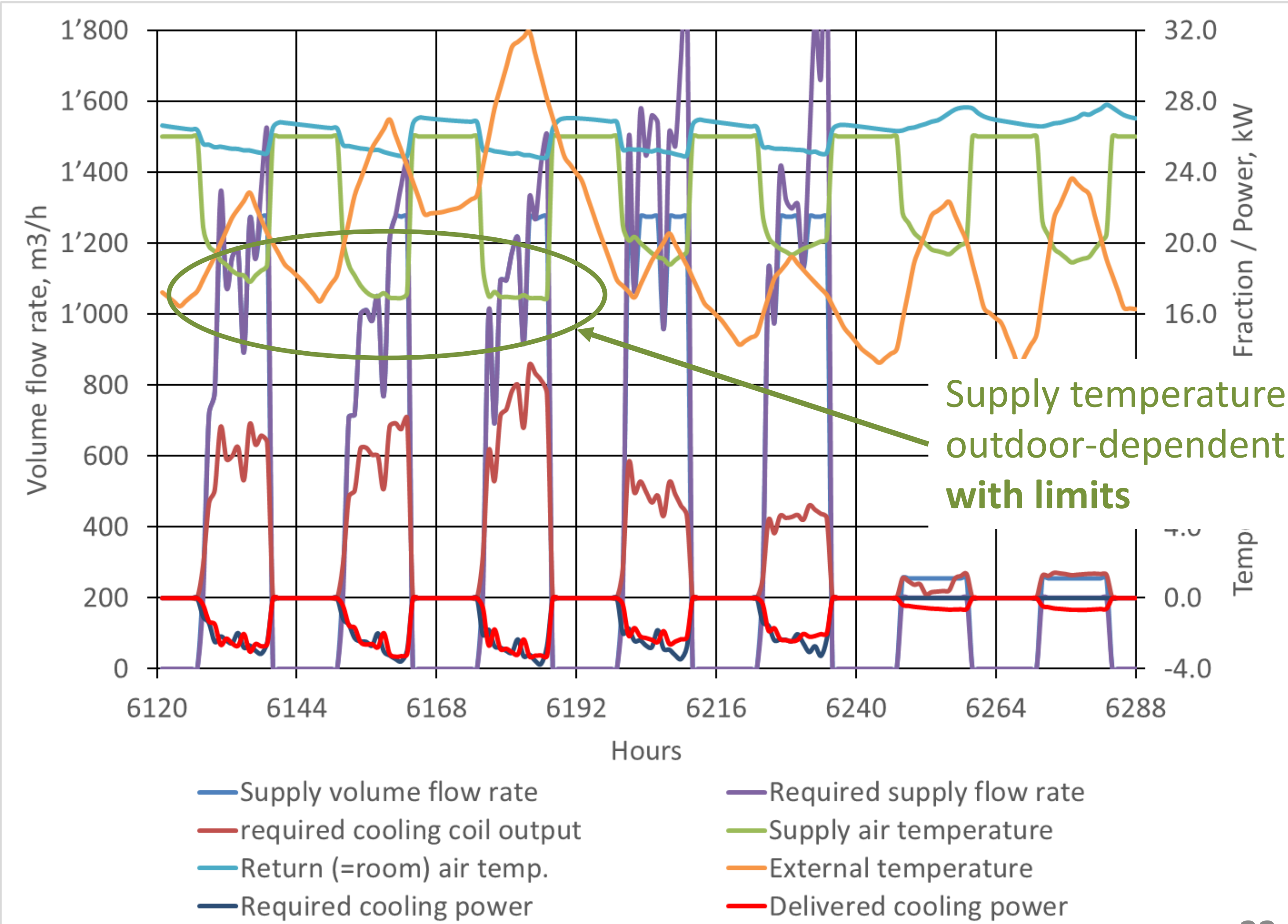
Summer results case 1



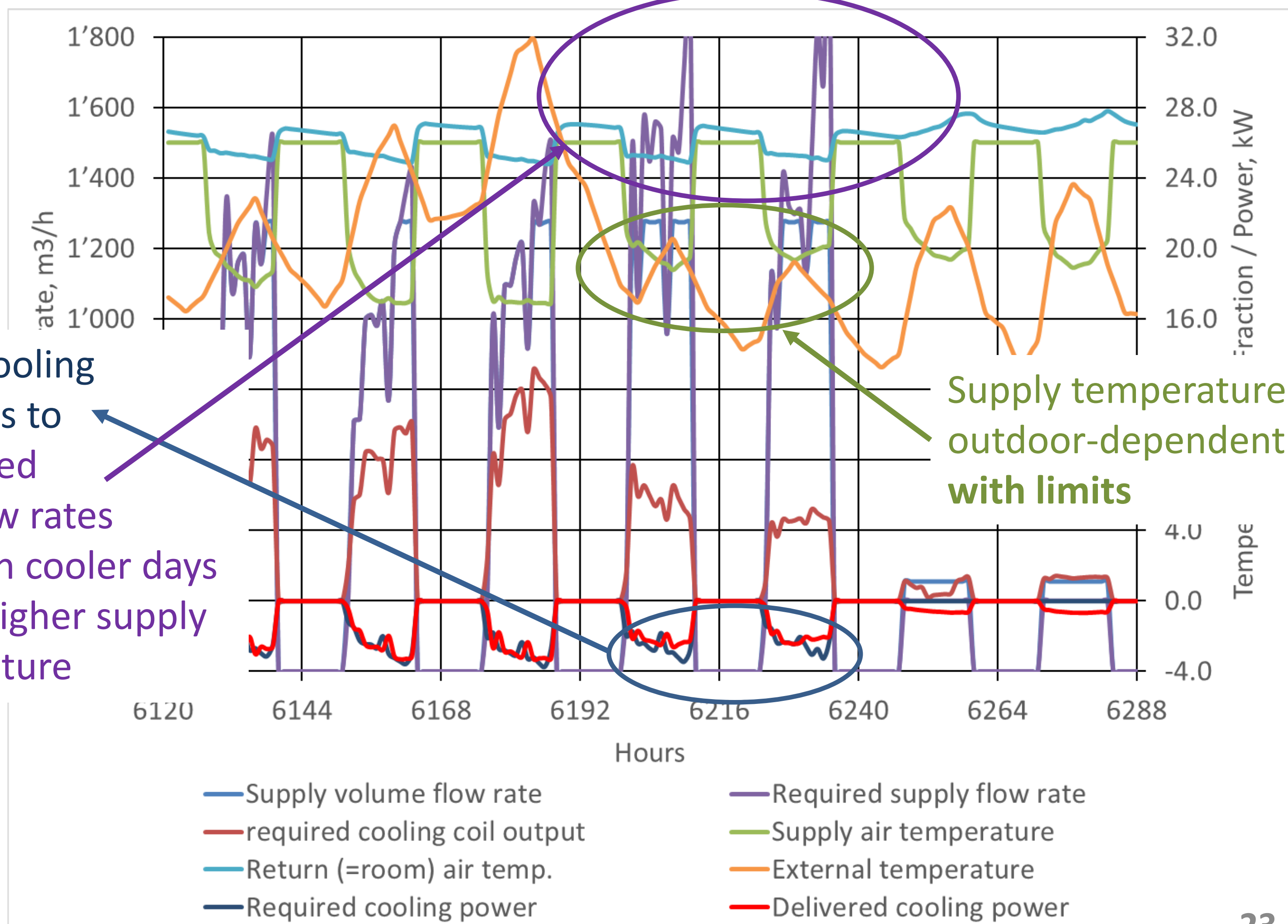
Summer results case 1



Summer results case 1



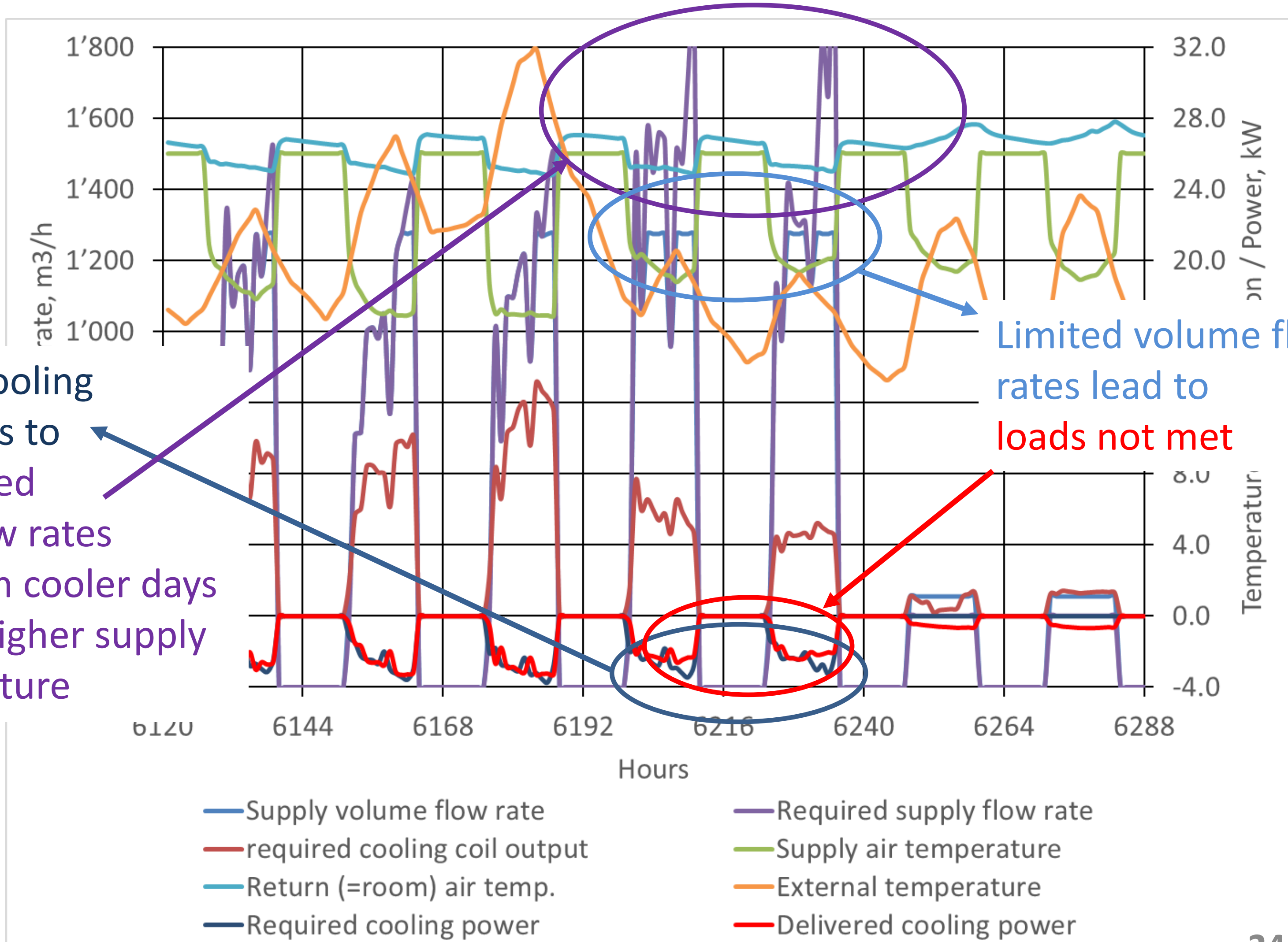
Summer results case 1



Required cooling power leads to high required volume flow rates
-> higher on cooler days due to higher supply temperature

Supply temperature outdoor-dependent **with limits**

Summer results case 1



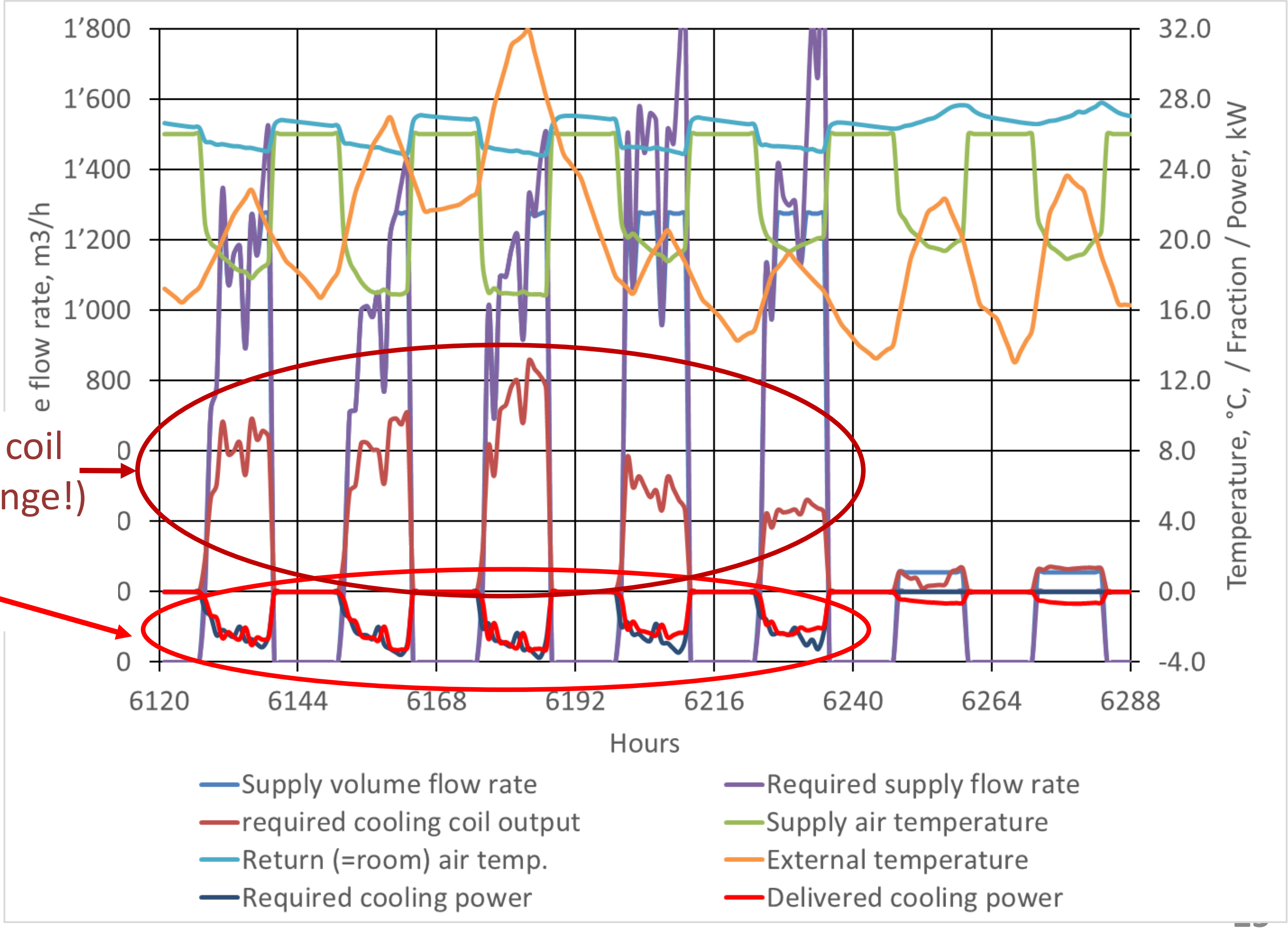
Required cooling power leads to high required volume flow rates
-> higher on cooler days due to higher supply temperature

Limited volume flow rates lead to loads not met

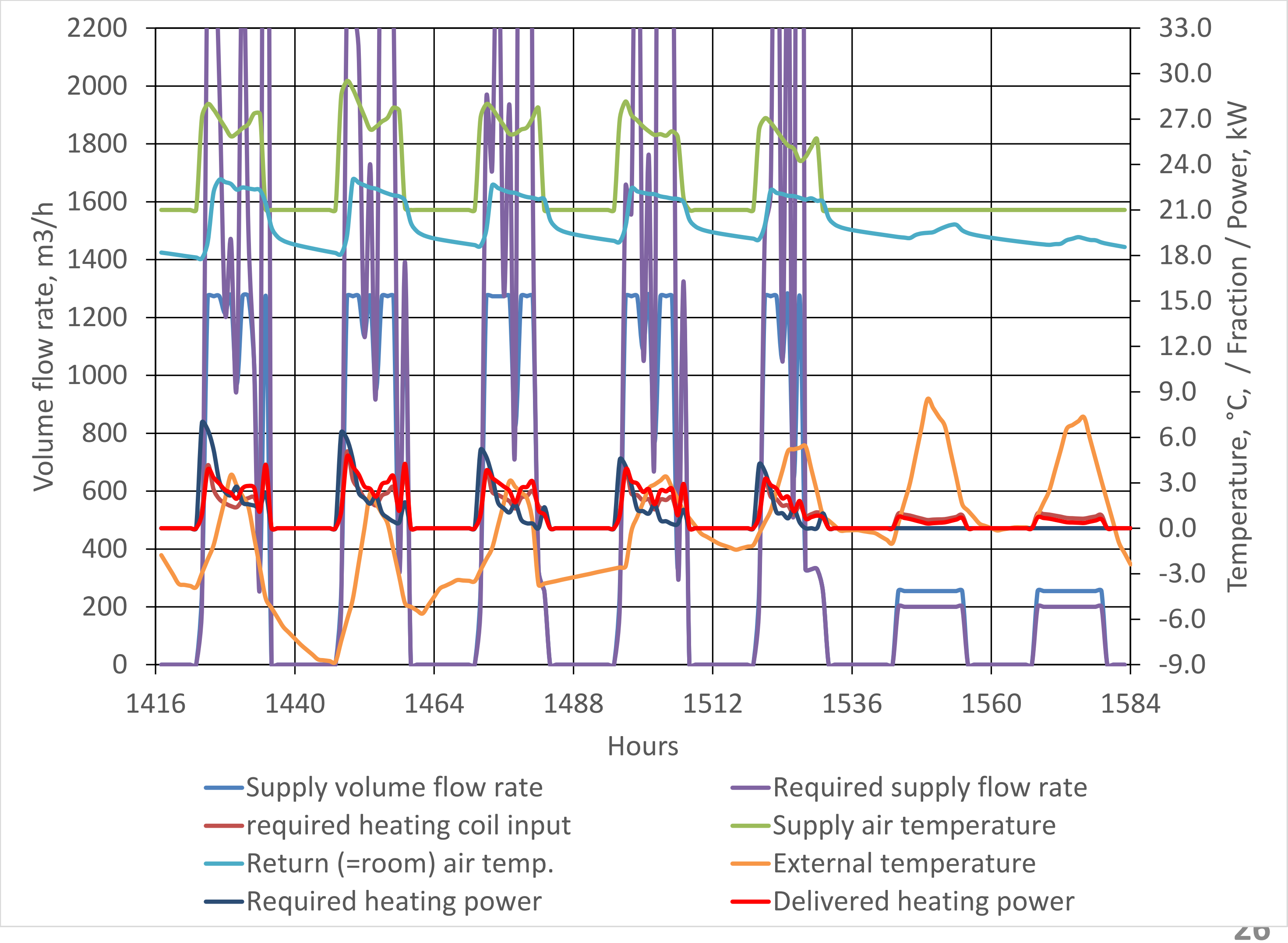
Summer results case 1

Output: cooling coil power (sign change!)

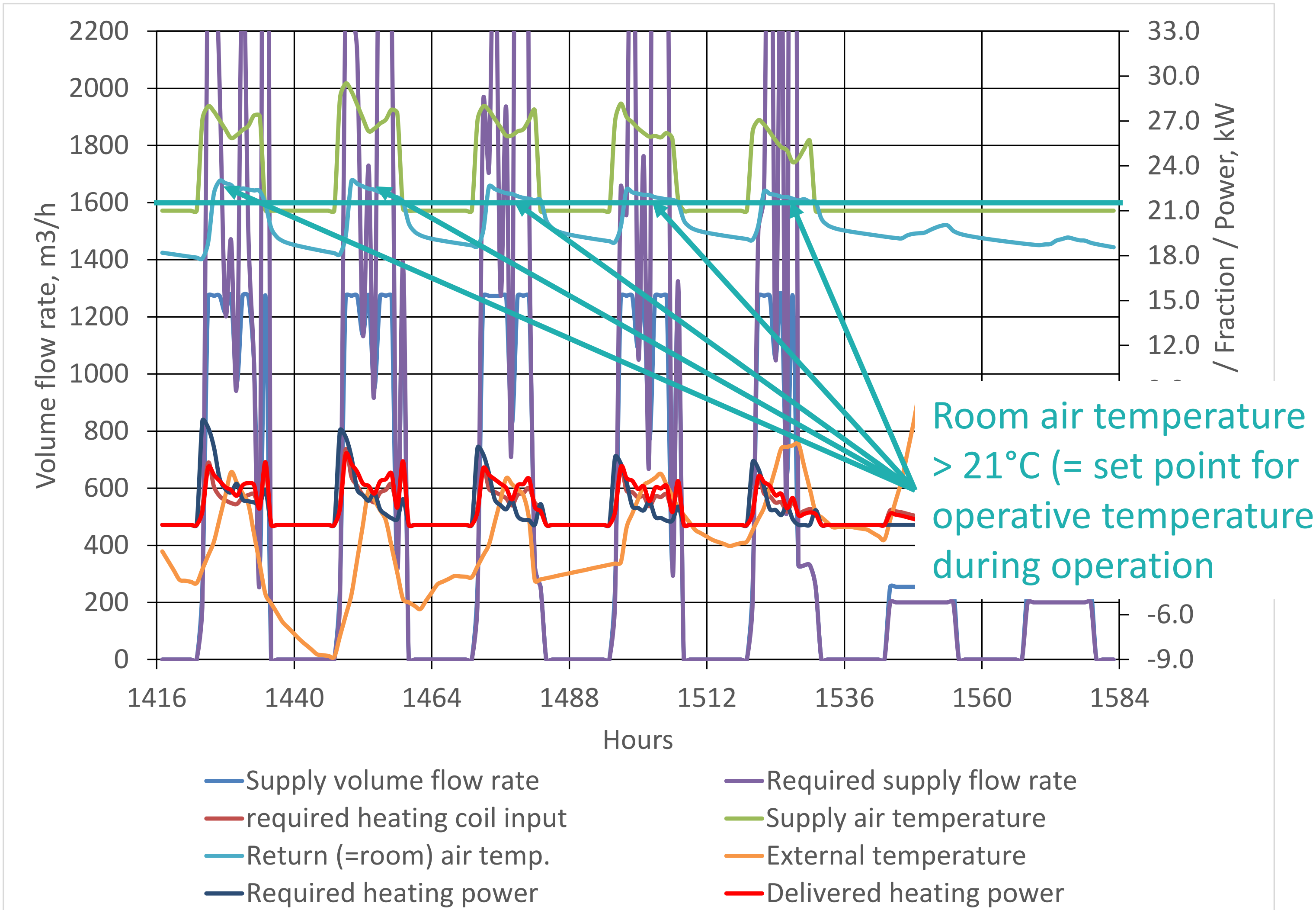
different from zone need



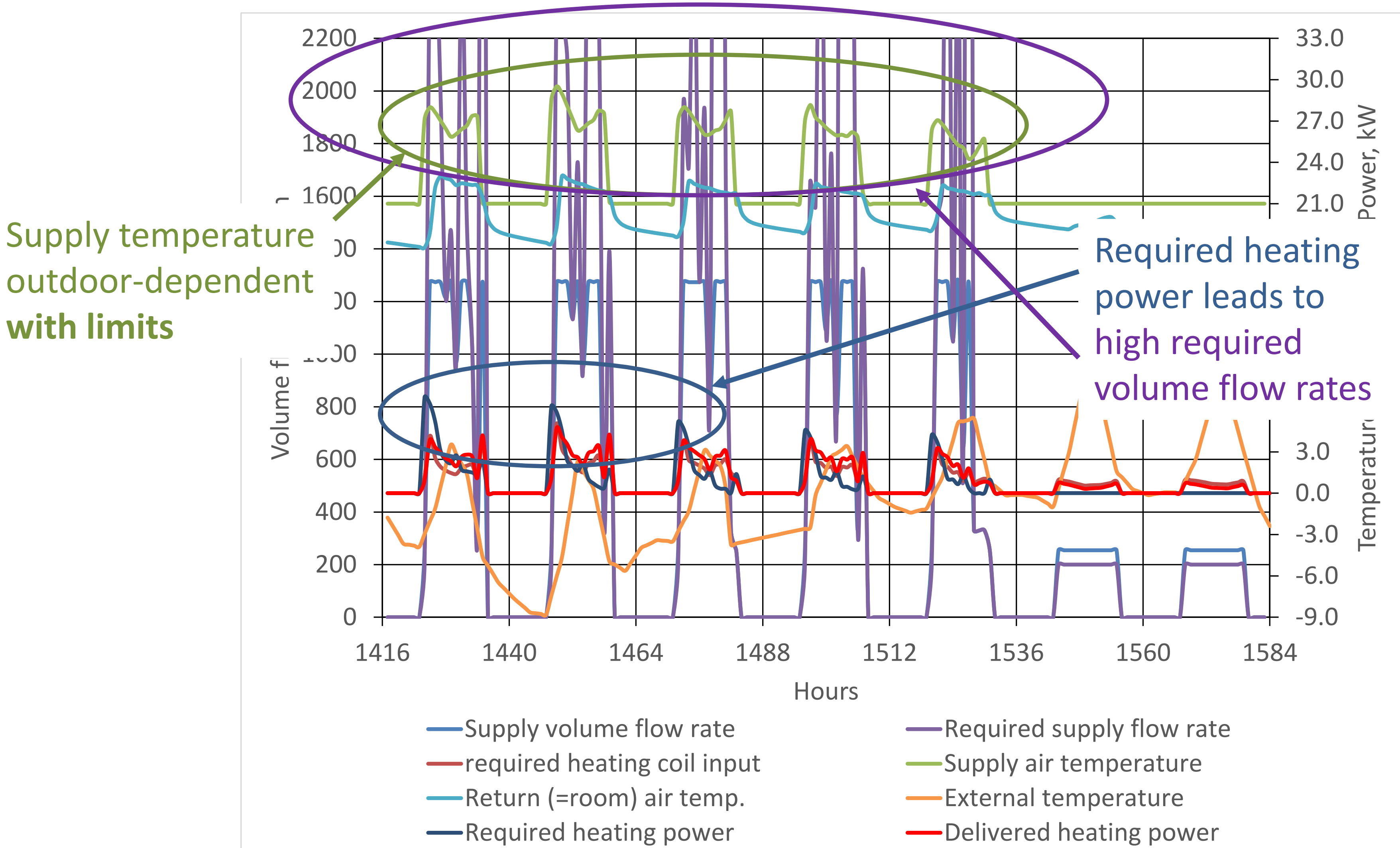
Winter results case 1



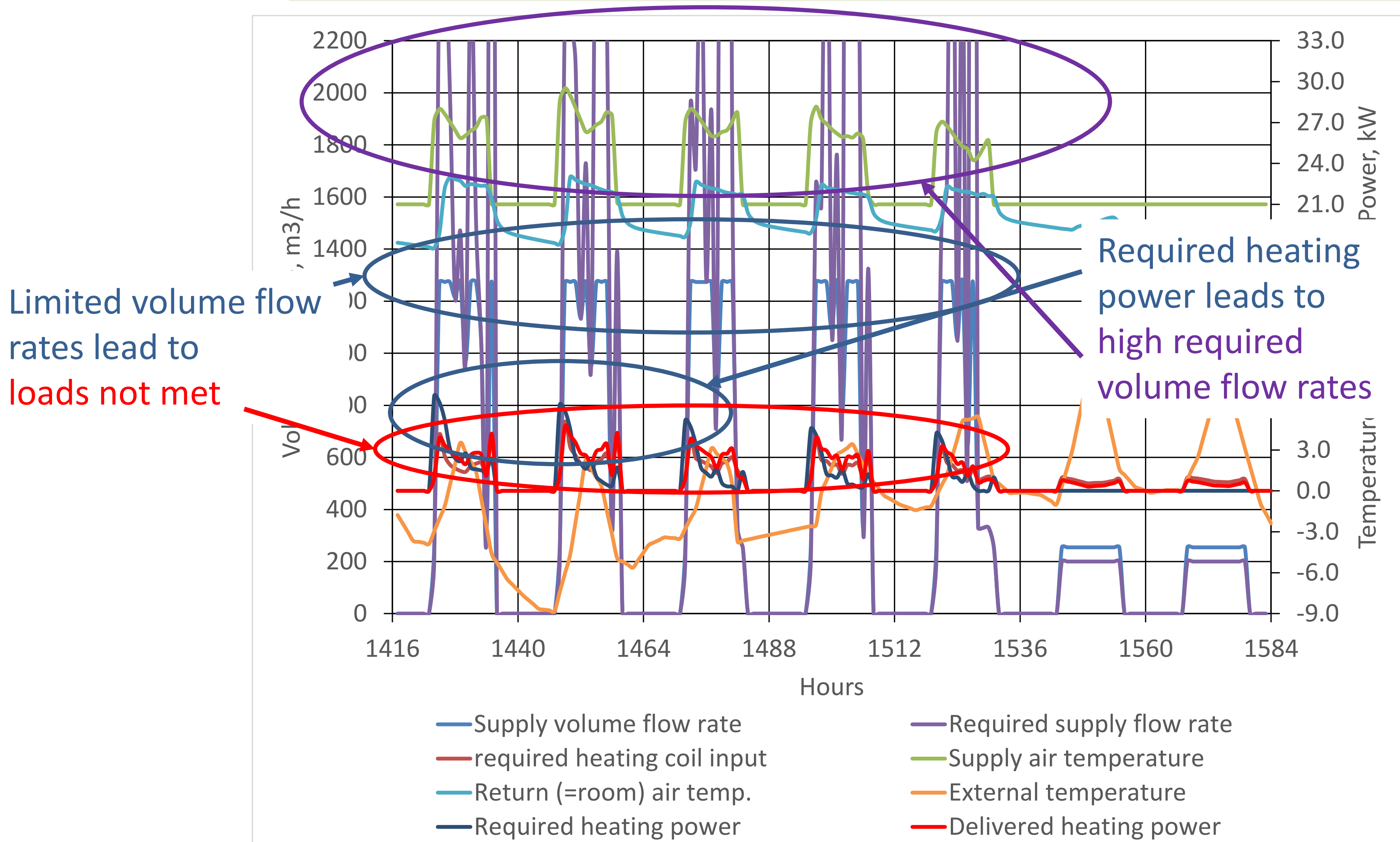
Winter results case 1



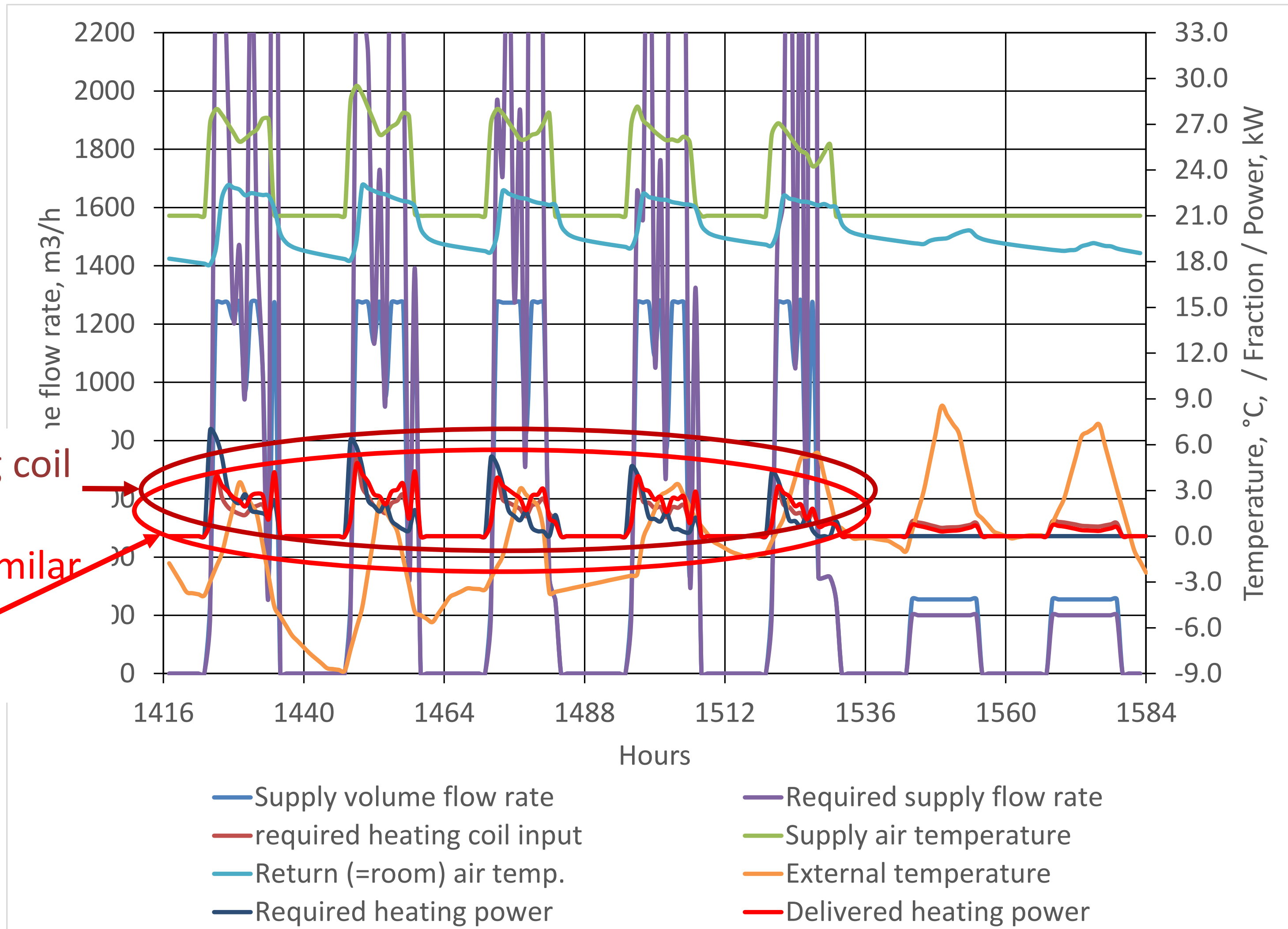
Winter results case 1



Winter results case 1

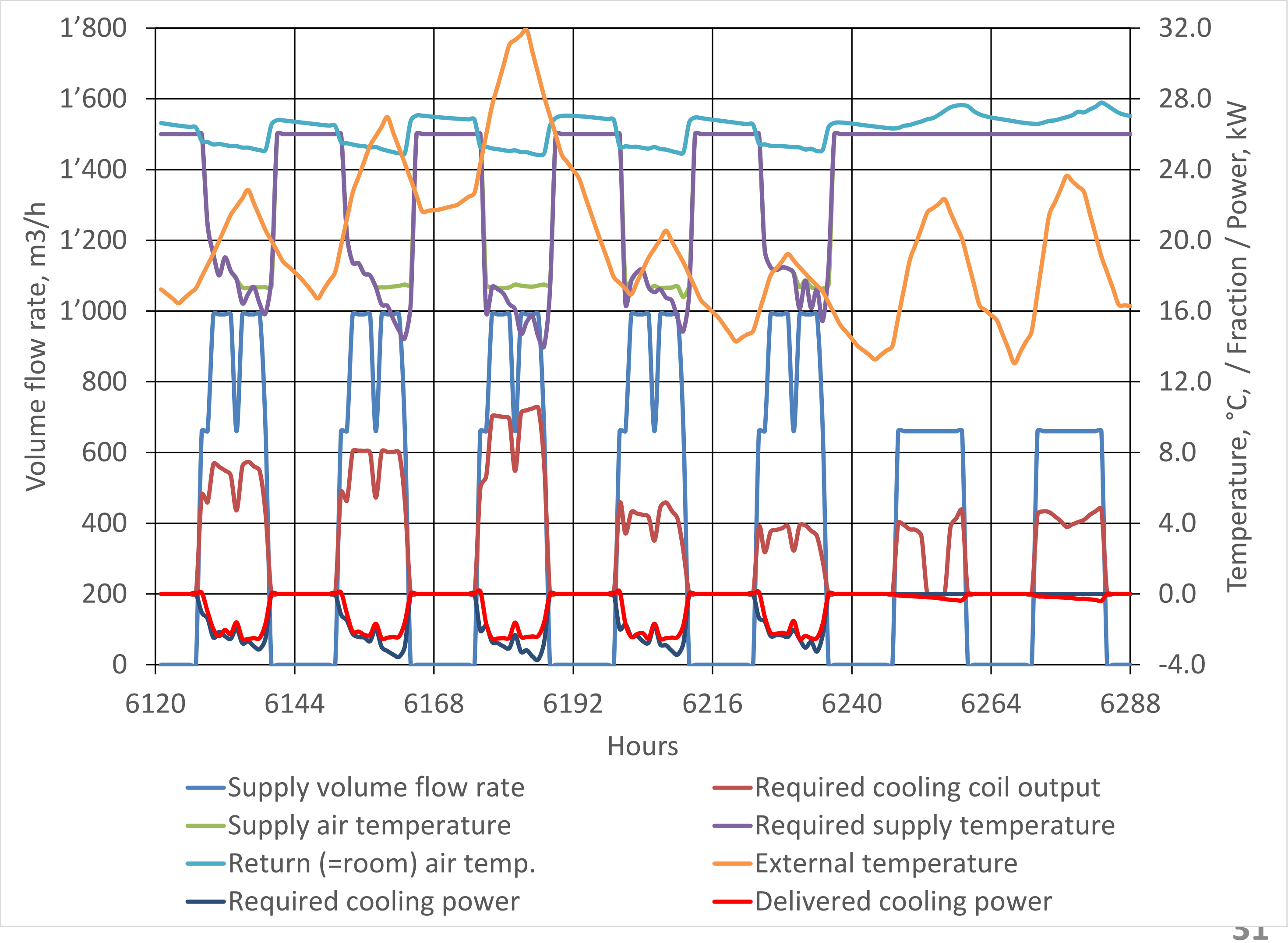


Winter results case 1

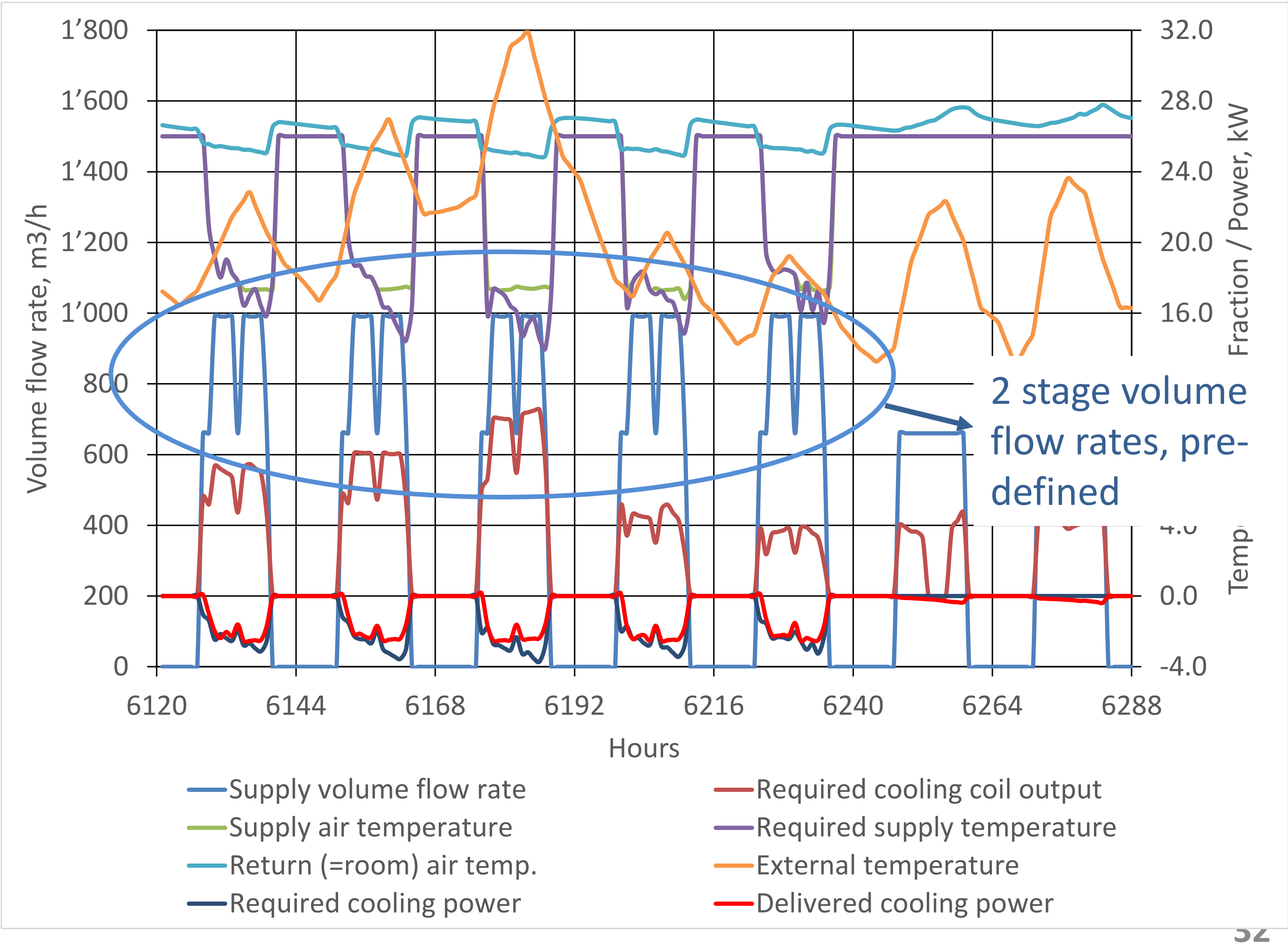


Output: heating coil power
different, but similar to zone need
(heat recovery)

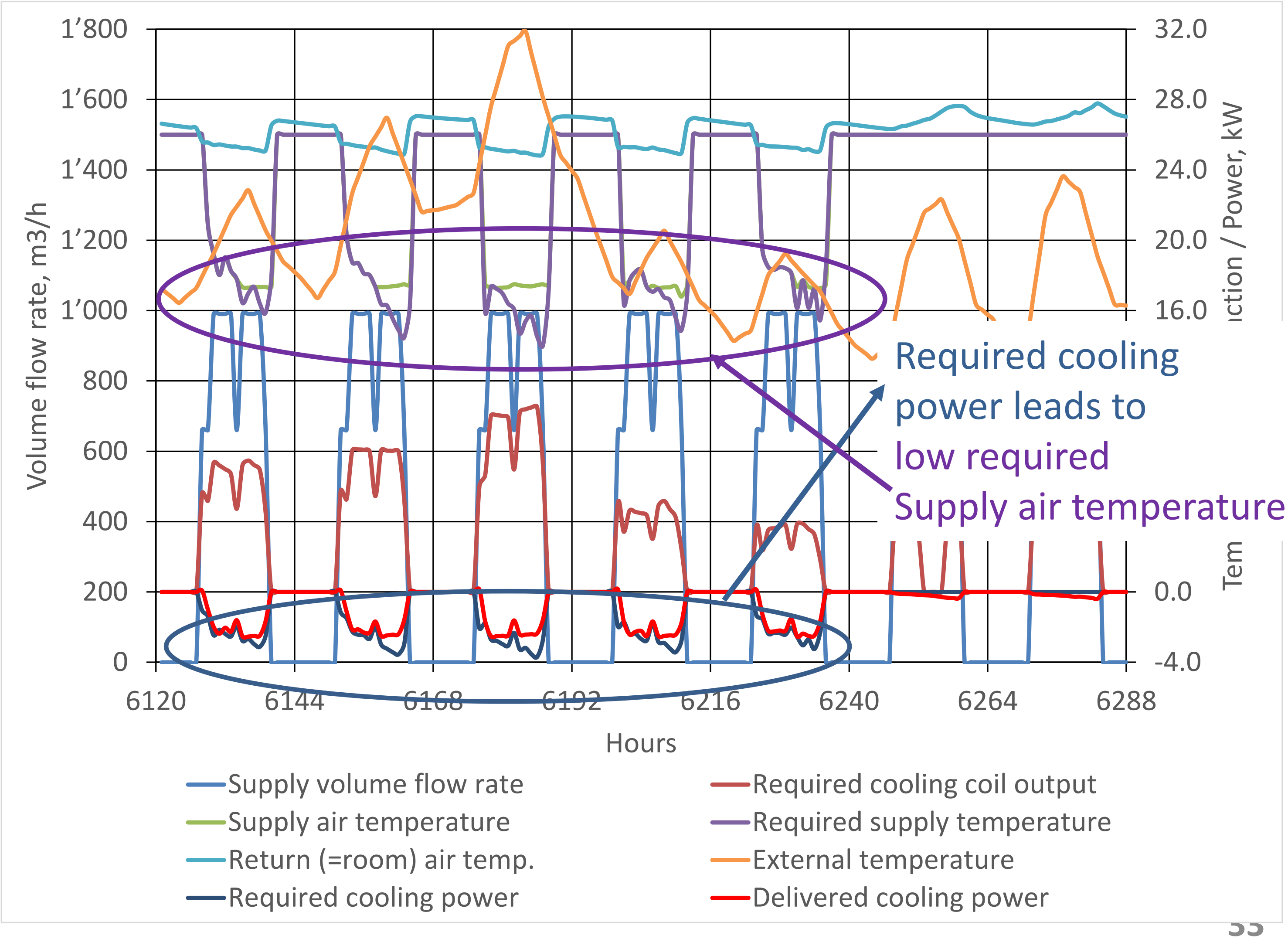
Summer results case 2



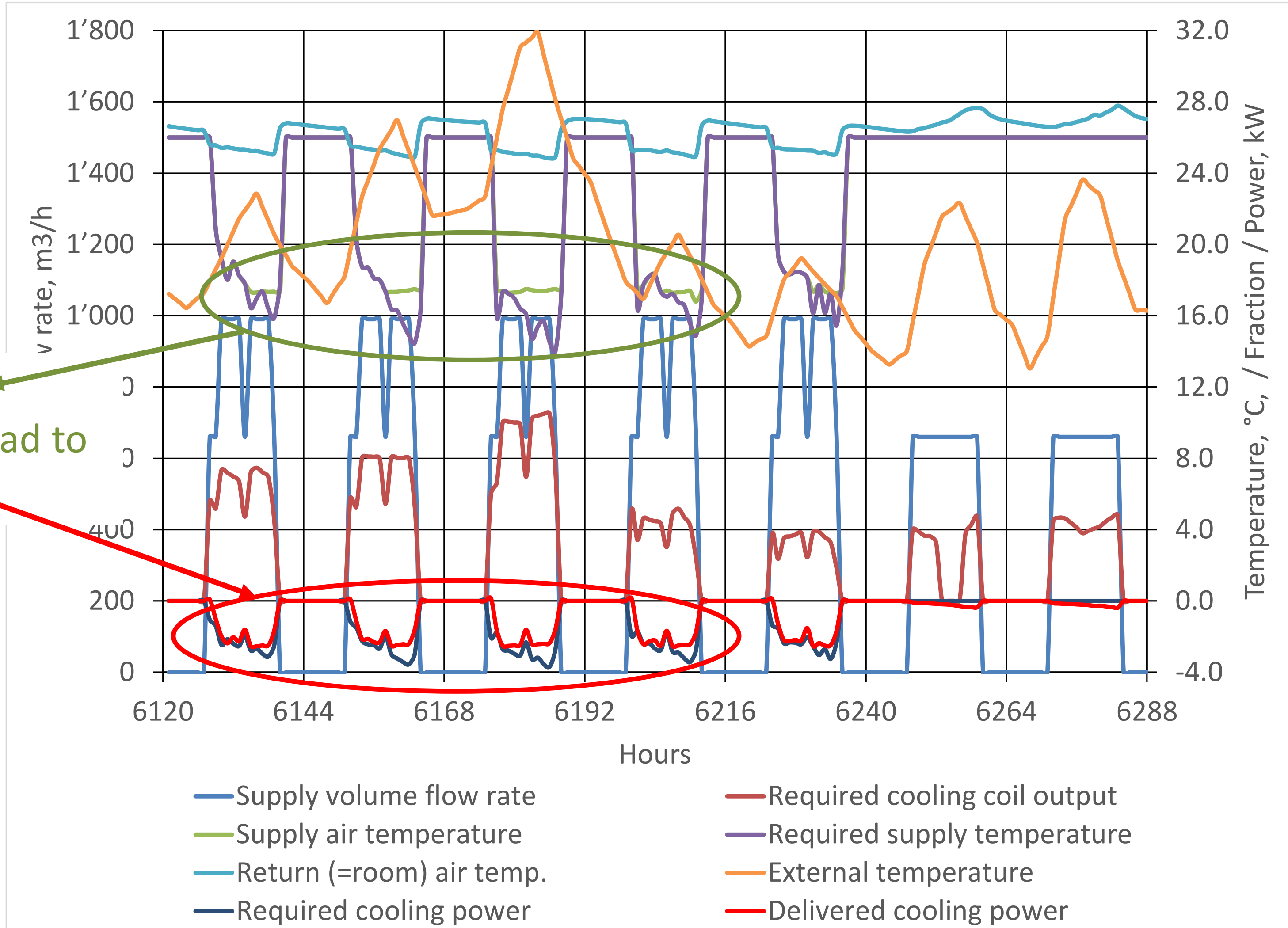
Summer results case 2



Summer results case 2

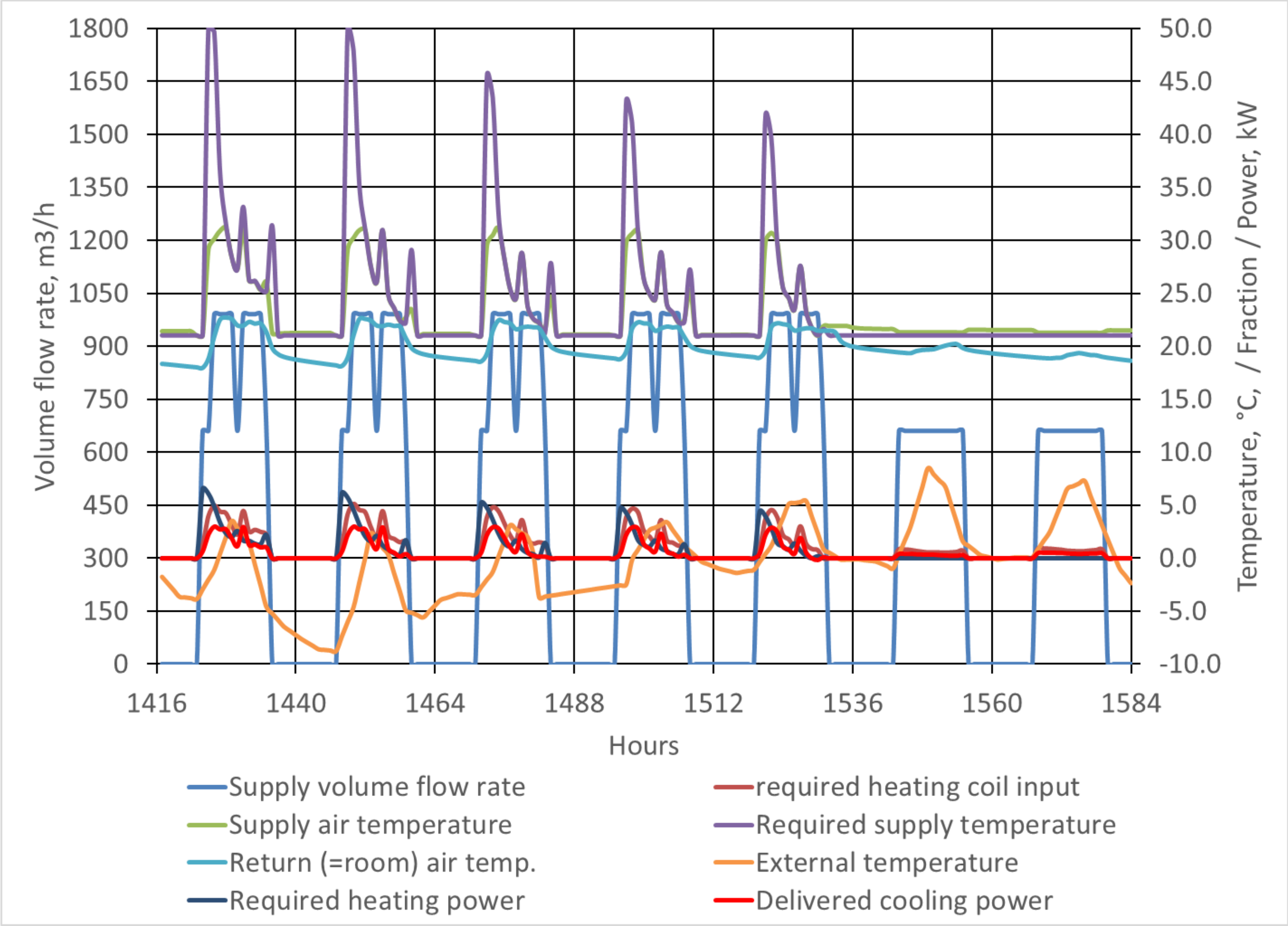


Summer results case 2

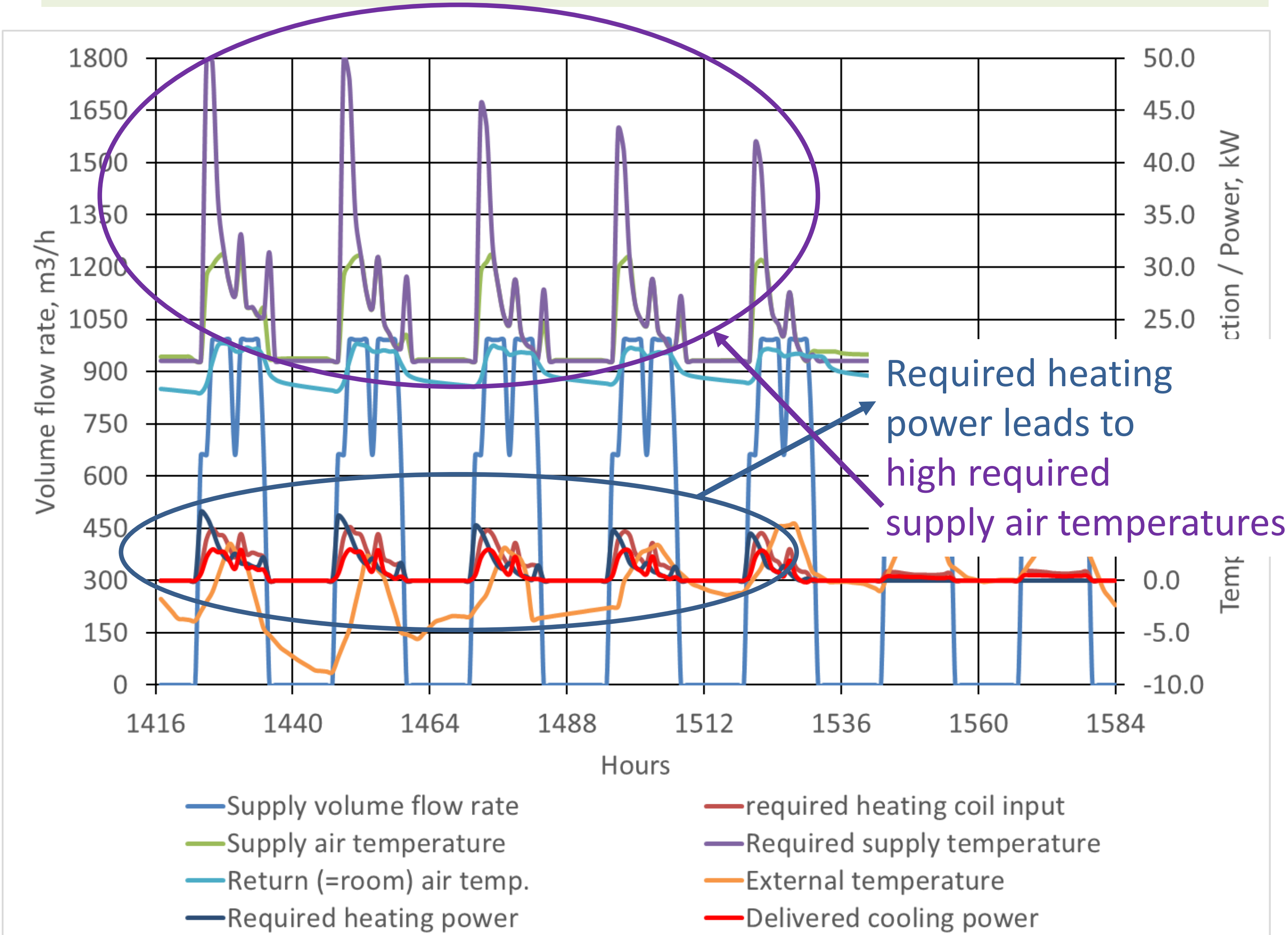


Limited supply temperatures lead to loads not met

Winter results case 2

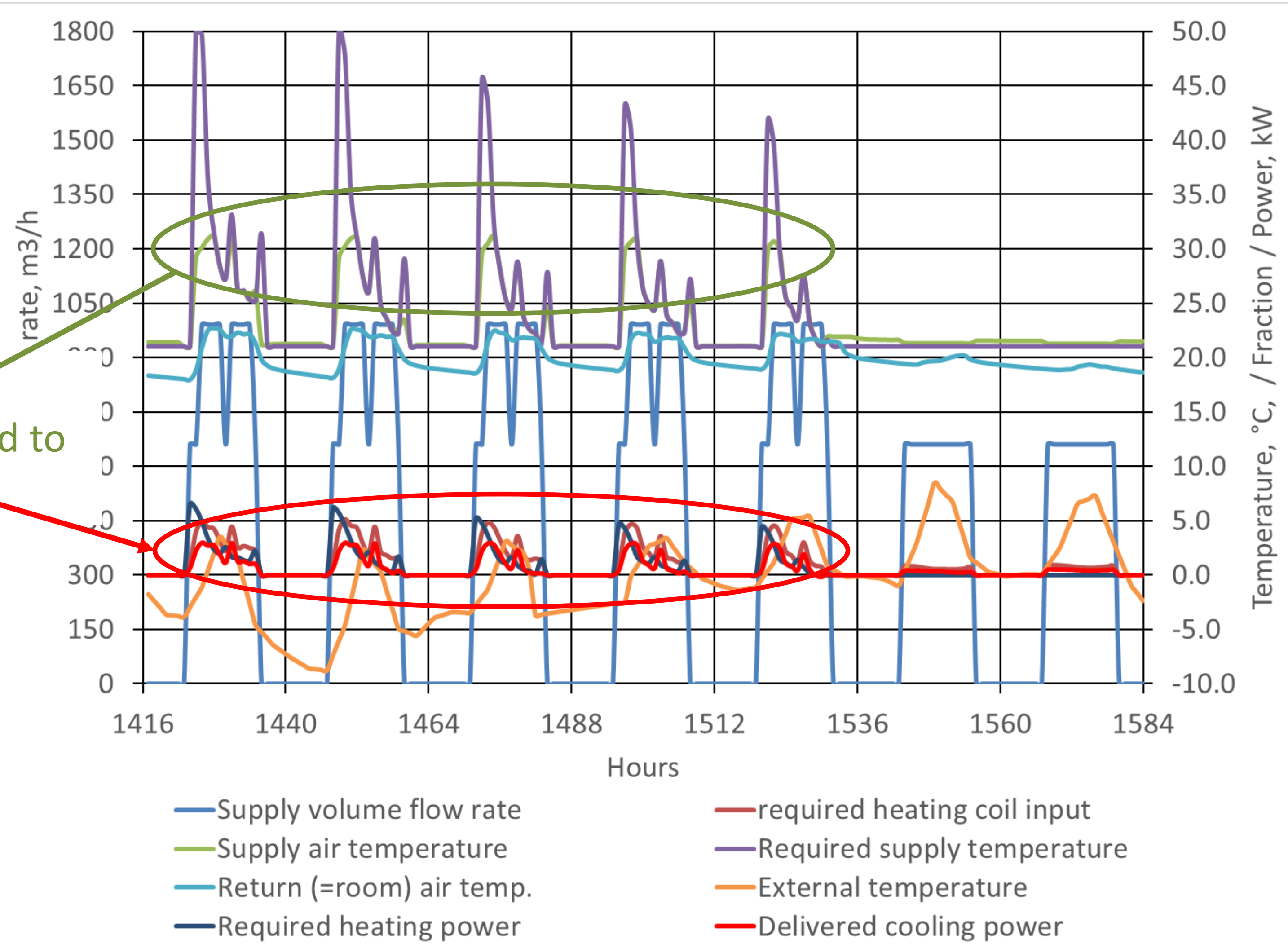


Winter results case 2



Winter results case 2

Limited supply temperatures lead to loads not met



Conclusion and outlook

- Why spreadsheets?
  - Fully transparent step-by-step validation and demonstration
- Coupling shows the correct function of the chain
  EN ISO 52016-1 – EN 16798-7 – En 1679851,
  for ventilation-based space conditioning
- Different operational design and control options
  - Pre-set supply air temperature with load-controlled volume flow rate
  - Pre-set volume flow rates with load-controlled supply air temperature
- Further aspects not analysed in results shown, but partly included
  - E.g. dehumidification

Thank you!

EPB Center is also ‘available’ for specific services requested by individual or clusters of stakeholders

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Parts of this document have been produced under a contract with the European Union, represented by the European Commission (Service contract ENER/C3/2017-437/SI2-785.185).

Your service center for information and technical support on the new set of EPB standards

From component to overall energy performance – the modular approach

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Start: 21 September 2018 for 3 years

BUILD UP Webinar series
Webinar 10: Example calculations with the set of EPB standards
Focus on non-residential buildings
2nd of February 2021

My background

- Various professional experience as installer, designer, commissioning, software analysis, standardisation and training activity related to the HVAC sector.
  Also working in the industrial sector (pharma) on environmental (IPPC) and energy issues (energy audits, energy management systems)
- Convenor of the Italian mirror group on heating systems
- Task leader for the development of several EN standards,
  - ***EN 15378-3*** *on measured energy performance*
  - ***EN 15378-1*** *on the inspection of heating system*
  - ***EN 15316-4-8*** *on local and radiant heaters*
  - ***EN 14336*** *installation and commissioning of heating systems*
- Active member of CEN/TC 228 WG4 and WG1
- Involved in the preparation and coordination of the set of **EPB standards** under **Mandate 480** (2012-2017)
- **EPB center expert** (> 2017)

How to balance ?

The availability of large amounts of cheap energy is the foundation of our life quality…

… but the consequences of energy use is a concern.

We want all sorts of comfort services in an NZEB …

… but we want to use as little as possible resources.

We want to prove that new designed buildings will require few resources for a standard use and also to display this for any existing building, maybe before and after renovation …

… so we need to calculate the "energy performance" of all sorts of buildings and systems for all EU climates …

… but we want to keep it as simple as possible

So we would like…

A calculation method that is:

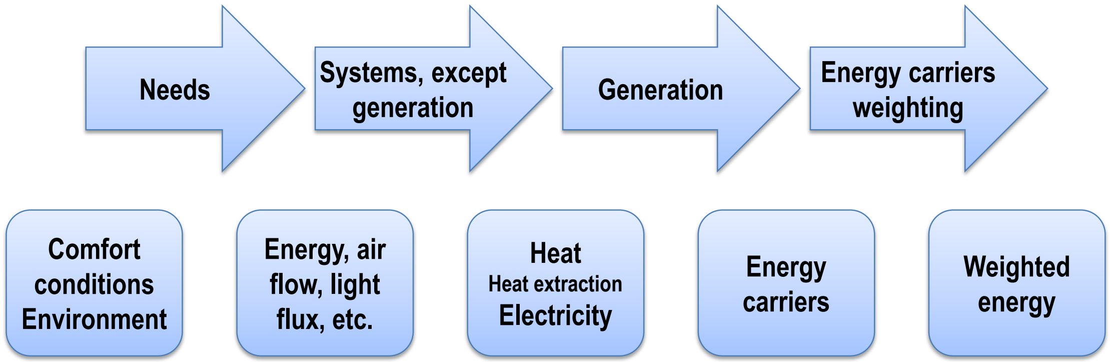
- **Functional**: it works with all types of buildings and systems
- **Sensitive**: it reacts to all the available options and encompasses both new and old technologies to support a correct renovation evaluation
- **Usable**: it has clear data input, it is adaptable to context, and it provides suitable results for its scope, compliance with requirements and energy performance display

… that is: **comprehensive**, **traceable**, **realistic, adaptable …**

… but also **simple, short**, **compact**, **easy to read** and **software proof**, …

Modularity

Modularity allows to combine simple items to build or describe a complex system. Here is an example from Webinar 7:



You start from the needs: some can be reduced (insulation) others can't.
Technical systems, up to generation, loose some energy and use auxiliary energy
Generators provide heat, heat extraction and electricity using energy carriers
Energy carriers are weighted to provide the energy performance

Then you can explode each step into a number of "modules"

Systems → subsystems

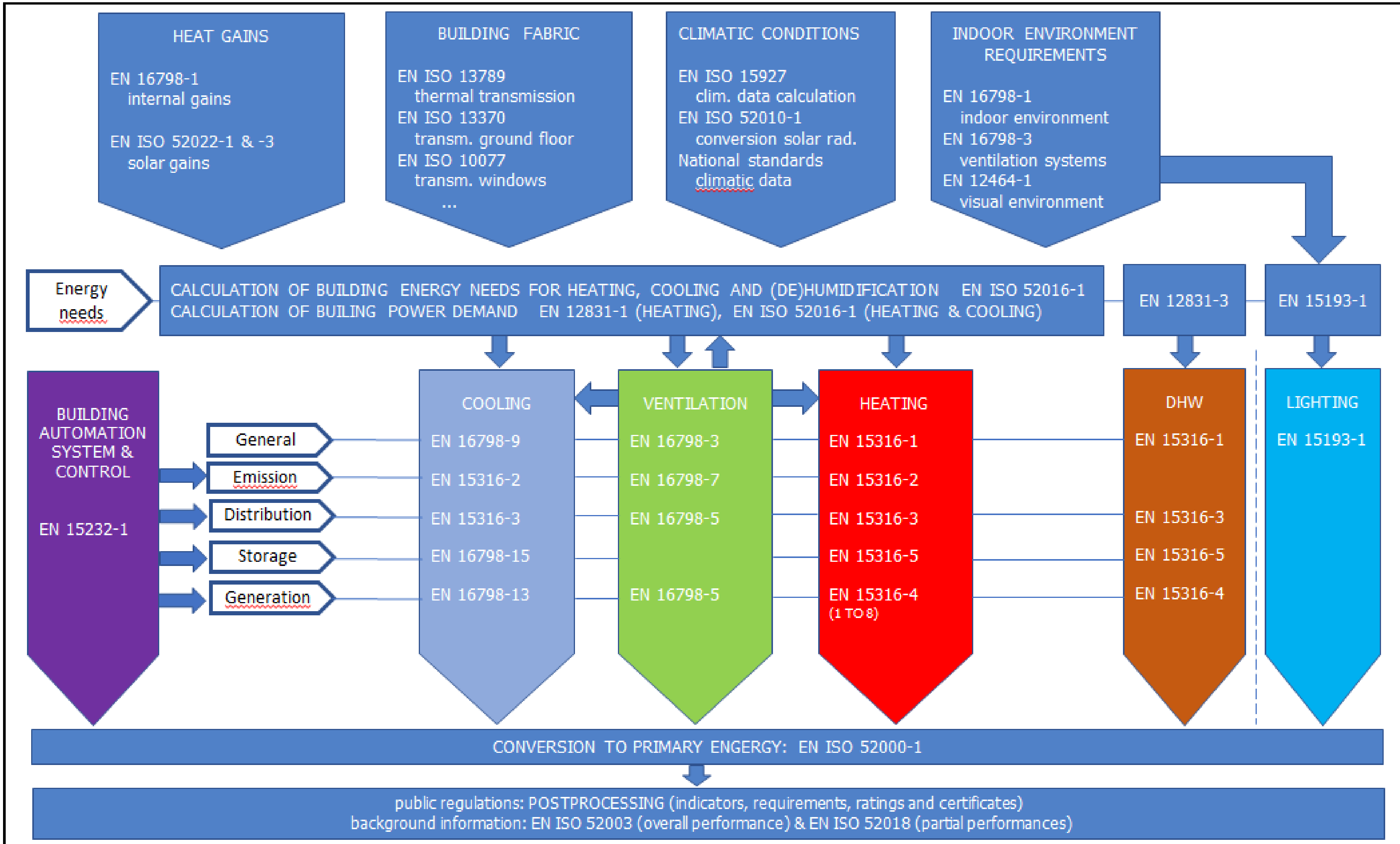
Generation → type of generators

Then repeat for all services

An overview of all modules was given in WEBINAR 2

The result...

presented at webinar 1, Feb 4, 2020)



Which modularity ?

Modularity is a real advantage when «modules» have similar properties and internal organization so that:

- If you know one, you (nearly) know all of them
- You can easily replace one with another one for e.g.
  - another type of generator
  - a default / special module (EN / national)

CEN-TS 16629 «detailed technical rules» specifies the common properties of all modules

Common properties of «EN EPB modules»

- **Organisation of the contents of the standard and of the related TR**
- **Annex A / annex B mechanism**
- **Structuring of the input data**
  - **Product data** (local)
    - product description (qualitative, standardized selection properties);
    - product technical data (quantitative, standardized technical properties);
  - **System design data** (application case properties, local);
    - process design data;
    - control type;
  - **Operating conditions** (connection with structure)
  - **Constants** and **other data**
- **Structure of the accompanying Excel → connection**

Structure of each module

Module input (at each time step) | **Module input (only once at start)** | **Module output data (at each time step)**

Operating conditions (at each time step)

Input	Symbol	Unit
Detailed « real » connections		
- Return water temperature		
- Required flow temperature		
Main connection		
- Required energy output		
Control signals		
- Heating		
- DHW		
Building connections		
- Room temperature		

Selection properties
(vocabulary prISO 16757)

Data preparation

User interface
Product characteristics
- Boiler use (e.g.heating, DHW)
- Fuel (e.g. gas, oil)
- Boiler type (e.g. condensing y/n)

System design data
- Localisation (e.g. heated space y/n

Database

2.1a Product **description** (qualitative)
Boiler use, Fuel, Boiler type
> **Boiler selection**

2.1b Product **technical** characteristics (quantitative)

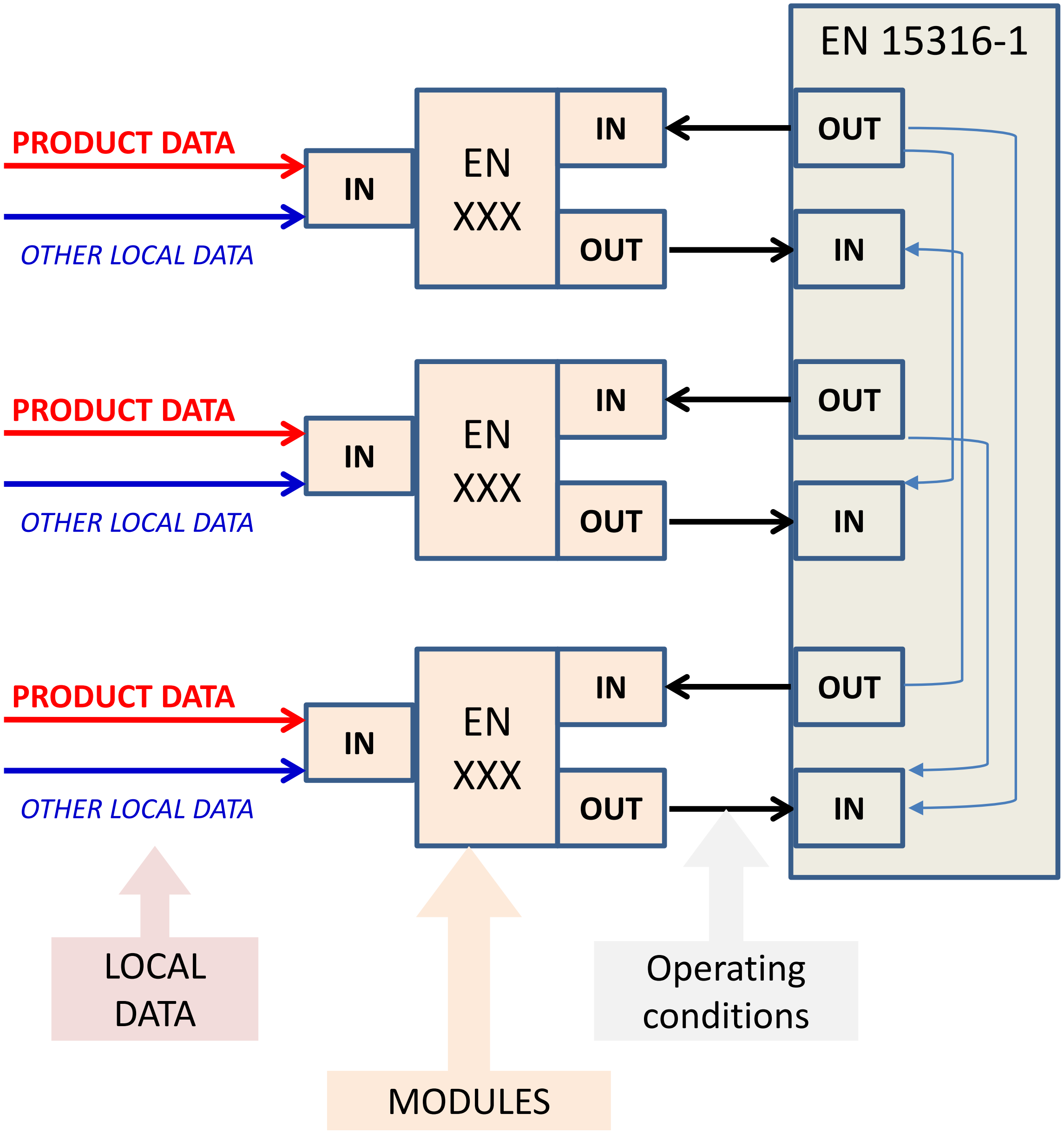
Boiler power output
Gen. output intermediate load
Efficiency
generator efficiency at full load
Gen. efficiency intermed. load
Temperatures
Max running temperatures

2.3 System **design** (including control)

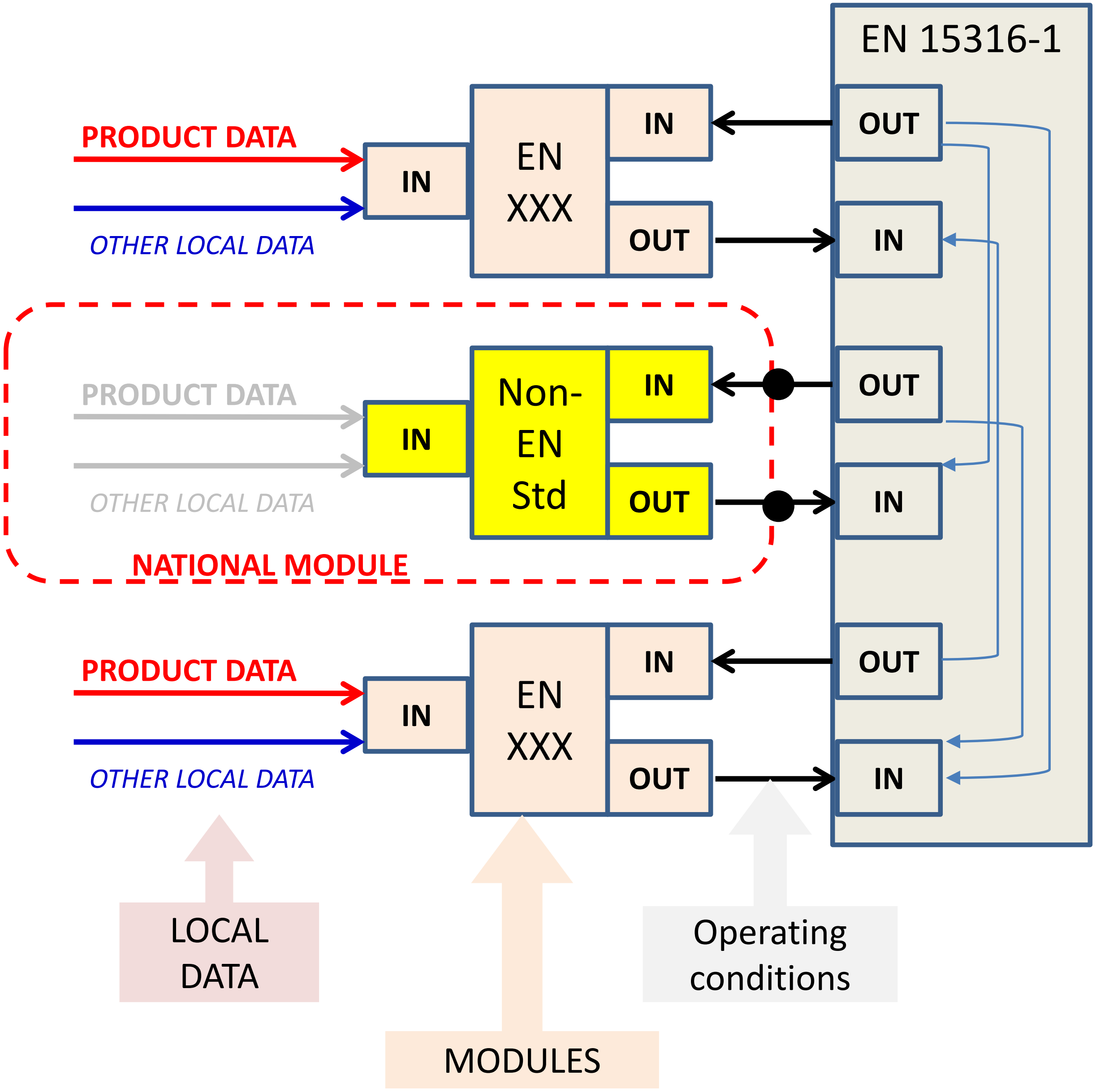
Module calculation procedures (at each time step)

Output	Symbol	Unit
Main connection		
- Actual energy output		
- Recoverable losses		
Overarching standard		
- auxiliary energy		
- energy input		
Other ouptut		
- Performance indicator		

- MODULAR STRUCTURE
  General part + modules
- Calculation modules
  1 XLS per module
- Each calculation module requires
  - Interconnection values (i/o to the structure operating conditions)
  - Product data (local data)
  - Other local data about specific application (like localisation, indoor/ outdoor installation info)



- **Thanks to the modular structure you may even connect a non EN standard**
- … but the I/O structure has to be respected
- Needed info can be found both in the accompanying XLS and in the specific I/O clauses in the EN standard



Facilitating input

Product data				
Product description data				
Condensing boiler	*BLR_COND*	*BLR_COND*		BLR_COND_NO
Fuel	*BLR_FUEL*	*BLR_FUEL*		BLR_FUEL_OIL
Product technical data				
generator output at full load;	Φ_{Pn}	*Phi_Pn*	kW	60
generator efficiency at full load;	$\eta_{gnr;Pn}$	*eta_gnr_Pn*	%	**92,0**
generator output at intermediate load;	Φ_{Pint}	*Phi_Pint*	kW	18
generator efficiency at intermediate load;	$\eta_{gnr;Pint}$	*eta_gnr_Pint*	%	**90,0**
stand-by heat loss at test temperature difference $\Delta\theta_{i,test}$;	$\Phi_{gnr;ls;P0}$	*Phi_gnr_ls_P0*	kW	0,72
power consumption of auxiliary devices at full load;	$P_{aux;gnr;Pn}$	*P_aux_gnr_Pn*	kW	0,32
power consumption of auxiliary devices at intermediate load;	$P_{aux;gnr;Pint}$	*P_aux_gnr_Pint*	kW	0,06
stand-by power consumption of auxiliary devices;	$P_{aux;gnr;P0}$	*P_aux_gnr_P0*	kW	0,015
auxiliary power when the generation system is inactive	$P_{aux;off}$	*P_aux_off*	kW	0
minimum operating boiler temperature.	$\vartheta_{gnr;min}$	*theta_gnr_min*	°C	50
Recoverable fraction of stand-by losses	$f_{gnr;env}$	*f_gnr_env*	-	0,5
correction factor of full-load efficiency;	$f_{corr;Pn}$	*f_corr_Pn*	-	0,04
correction factor of intermediate load efficiency;	$f_{corr;Pint}$	*f_corr_Pint*	-	0,05
generator average water temperature at test conditions for full load;	$\vartheta_{gnr;test;Pn}$	*theta_gnr_test_Pn*	°C	70
generator average water temperature at test conditions for intermediate load;	$\vartheta_{gnr;test;Pint}$	*theta_gnr_test_Pint*	°C	50
difference between mean boiler temperature and test room temperature in test conditions;	$\Delta\vartheta_{test;P0}$	*deltatheta_test_P0*	°C	50
part of the auxiliary energy recovered	$f_{rvd;aux}$	*f_rvd_aux*	-	0,75
part of the nominal electrical power not transmitted to the distribution sub-system	$f_{rbl;aux}$	*f_rbl_aux*	-	0,25

Input data required to define a boiler

Aggregation of data

Standard boiler, CE marked

- Old atmospheric boiler, before 1994
- Standard boiler, CE marked
- Condensing boiler
- ...
- Other default boilers

Qualitative data

Quantitative data

Old atmospheric boiler, before 1994

Standard boiler CE marked

Condensing boiler

BLR_COND_YES
BLR_FUEL_GAS
60
95,8
18
99,8
0,69
0,32
0,06
0,015
0
0
0,5
0,2
0,2
70
30
50
0,75
0,25
15
0,7

BLR_COND_NO
BLR_FUEL_GAS
60
88,6
18
86,8
0,99
0,32
0,06
0,015
0
50
0,5
0,04
0,05
70
50
50
0,75
0,25
15
0,7

BLR_COND_NO
BLR_FUEL_GAS
60
84,0
18
79,0
0,40
0,60
0,05
0
0
50
0,5
0,04
0,05
70
50
50
0,75
0,25
15
0,7

It's not only energy

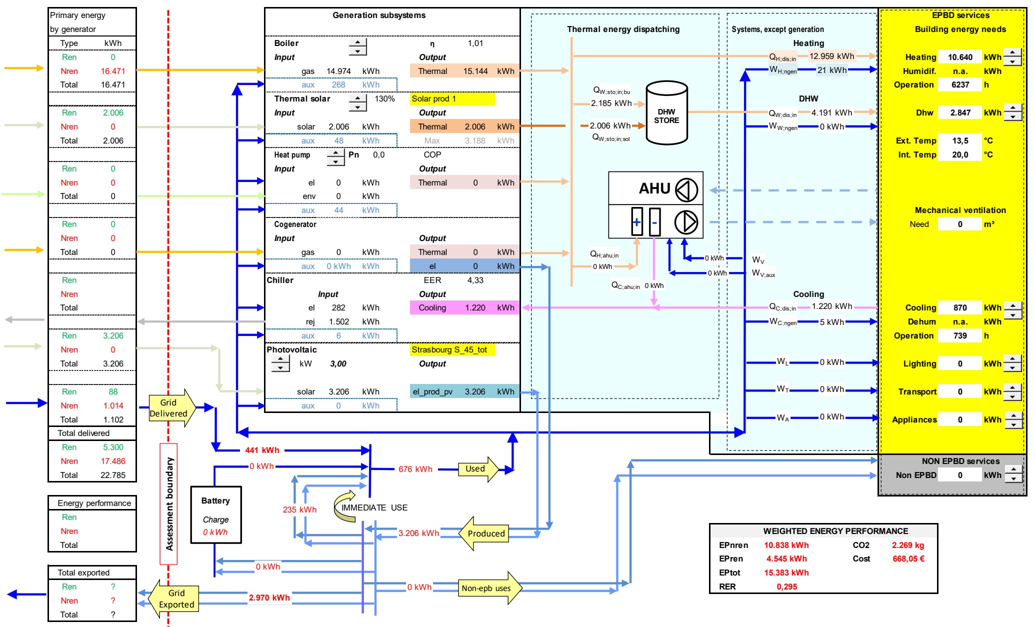
- In the past:
  - needs → systems → delivered energy
  - the «connection» was only energy → simple streamline
- Now
  - The connection is also operating temperature
  - There might be several generators (priorities)
  - There are interactions between building and systems (heat losses)
  - There are connections between systems for various services (heat recovery from chiller to provide domestic hot water)

You have just seen the interaction between energy needs and ventilation systems, with only a few possible control options

The real challenge…

It’s relatively simple to deal with each module…

… the real challenge is having them work together smoothly.



Webinar 7

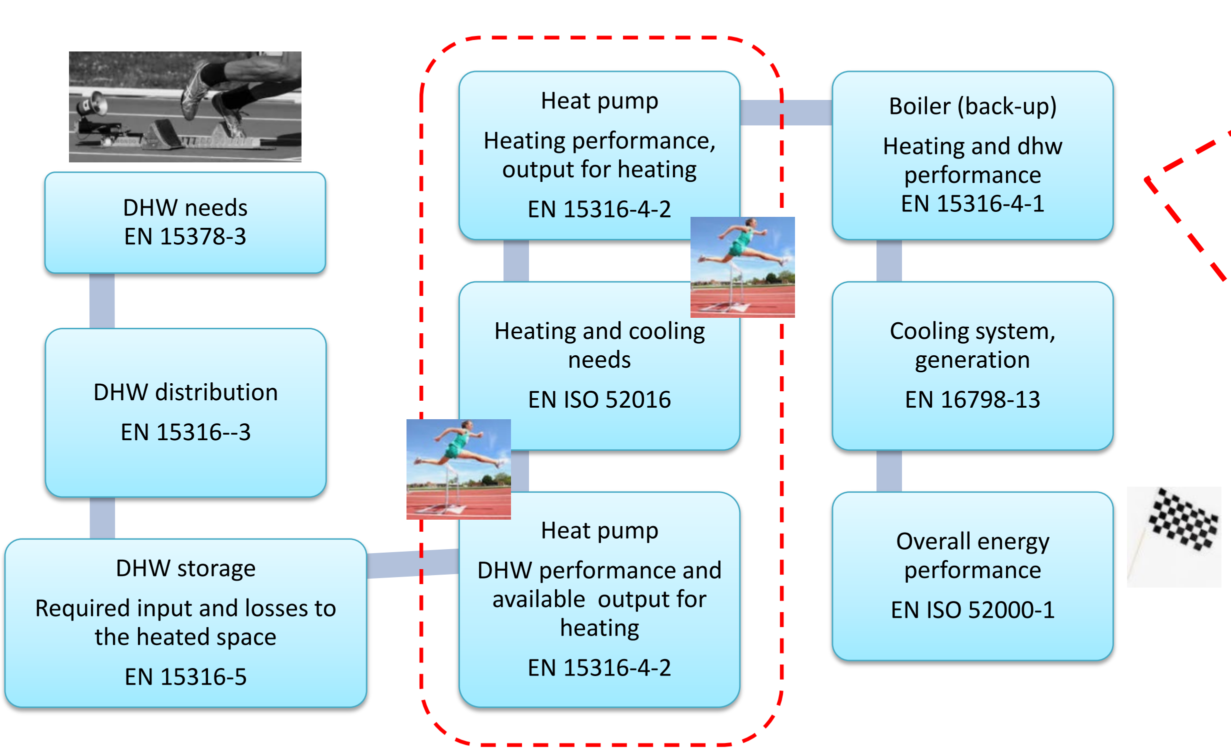
An example of a simple overall structure

There is only one building zone

Not shown: there are relevant interactions that by-pass the indicated energy flow

The real challenge…

It's relatively simple to deal with each module…
… the real challenge is having them work together smoothly.



Webinar 9

The calculation order has to be carefully designed to avoid iterations

Not shown: there might be several thermal zones and serviced areas

But don't be afraid…

There is a front-end and a back-end

- **Front-end**: is seen by those who actually do the calculation and use the method. Their concern:
  - Describing the configuration of the building and systems
  - Inputting the data about all building elements and system components
  - Describing the operation of the building and systems
  - Understanding the calculation and the indicators
- **Back-end:** for those who design the method. Their concerns:
  - Structuring the modules and their input and output so that it is easy to combine them and link them to catalogues and data-bases
  - **Defining a calculation structure that is software proof and easy to adapt to actual building and system configuration**

Conclusion

Modern buildings and systems are more and more various and complex and interactions between building envelope and technical systems are more and more relevant and both ways

A clear modular structure allows to adapt the calculation to the actual case

It's a real challenge to define a general structure to connect all modules in a smooth way: concern for standard developers

The structure issue is not seen by the end user: the flexible structure allows him to describe a large variety of situations.

Thank you!

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Q&A

Submit your question!