Welcome to BUILD UP

The European Portal for Energy Efficiency in Buildings

Be regularly informed …

30+ relevant new monthly	**20+** events announcements	**20+** publications promoted	Overview articles	Webinars and videos
Be updated with tools, technologies, case studies …	Announce, invite, promote your event	Publish your findings	Be aware of a specific topic every month	Promote, share your activities with the community

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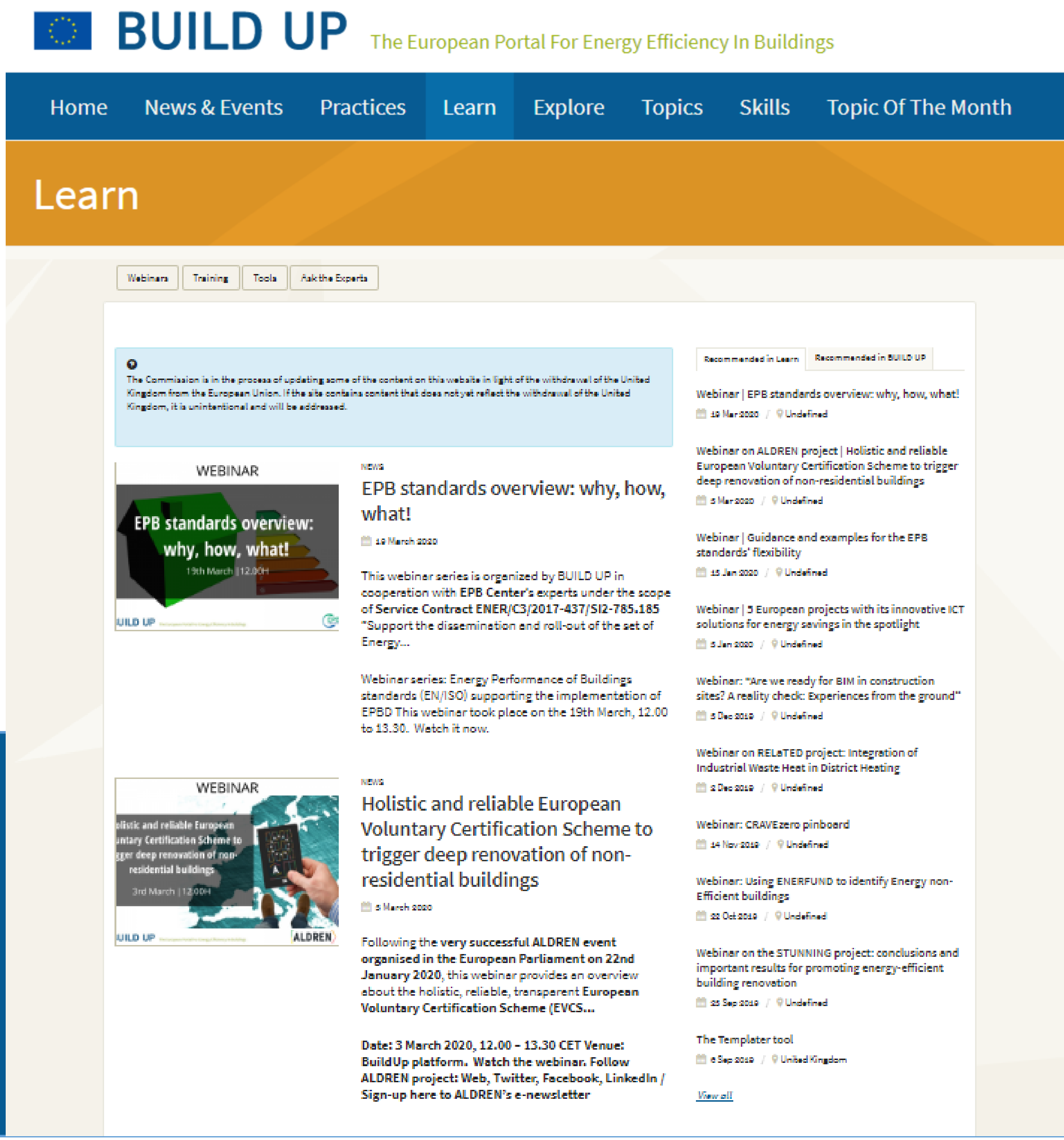

Check our Learn section!

EPB CENTER

BUILD UP The European Portal For Energy Efficiency In Buildings

Webinar 6 – 8th Sept. 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 Dec. 8**, Example calculations with the set of EPB standards – (3) Whole building calculations, from components to overall primary energy

Webinar 10, Tuesday Jan. 19, Example calculations with the set of EPB standards – (4) Energy needs combined with specific systems

EPB CENTER

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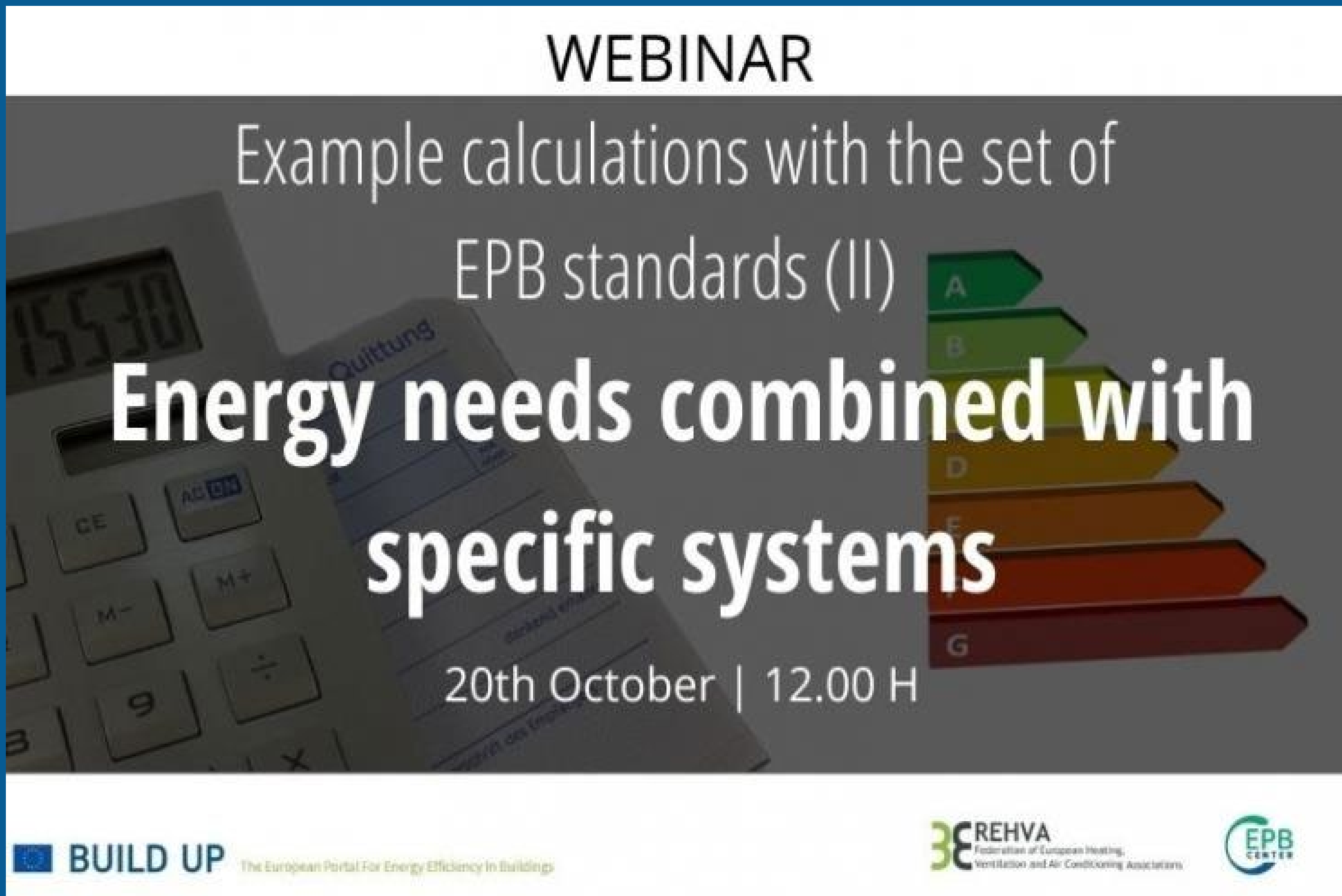

Your service center for information and technical support on the new set of EPB standards

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 project group

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

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This EPB Center is supported 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:Example calculations with the set of EPB standards – (2) Energy needs combined with specific systems
20/10/2020

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: demonstrate which impact of single data or group of data on selected calculation results have
- 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.

Coordination between modules

- Several modules will be tested together to see the effect of interrelation between modules, typically to see the effect of operating conditions.
- A collection of modules will be tested by connecting the spreadsheets. Generating results for particular cases as will be explained by the presenters.

In this 8th webinar we present

specific examples on the energy needs calculation (EN ISO 52016-1) combined with specific systems and a preliminary example of whole building calculations.

- Coupling of the thermal zone (EN-ISO 52016) and heat pump systems (EN 15316-4-2) by Dick VAN DIJK,
- Coupling of the thermal zone (EN-ISO 52016) and natural ventilation (EN 16798-7) methods by Gerhard ZWEIFEL,
- Preliminary examples of whole building calculations by Laurent SOCAL

Thank you!

More information on
the set of EPB standards:

www.epb.center

Contact: info@epb.center

This document has 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

Coupling of the thermal zone
(EN ISO 52016-1)
and heat pump systems
(EN 15316-4-2)

Dick van Dijk

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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: Example calculations with the set of EPB standards – (2) Energy needs combined with specific systems
20th October 2020

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)

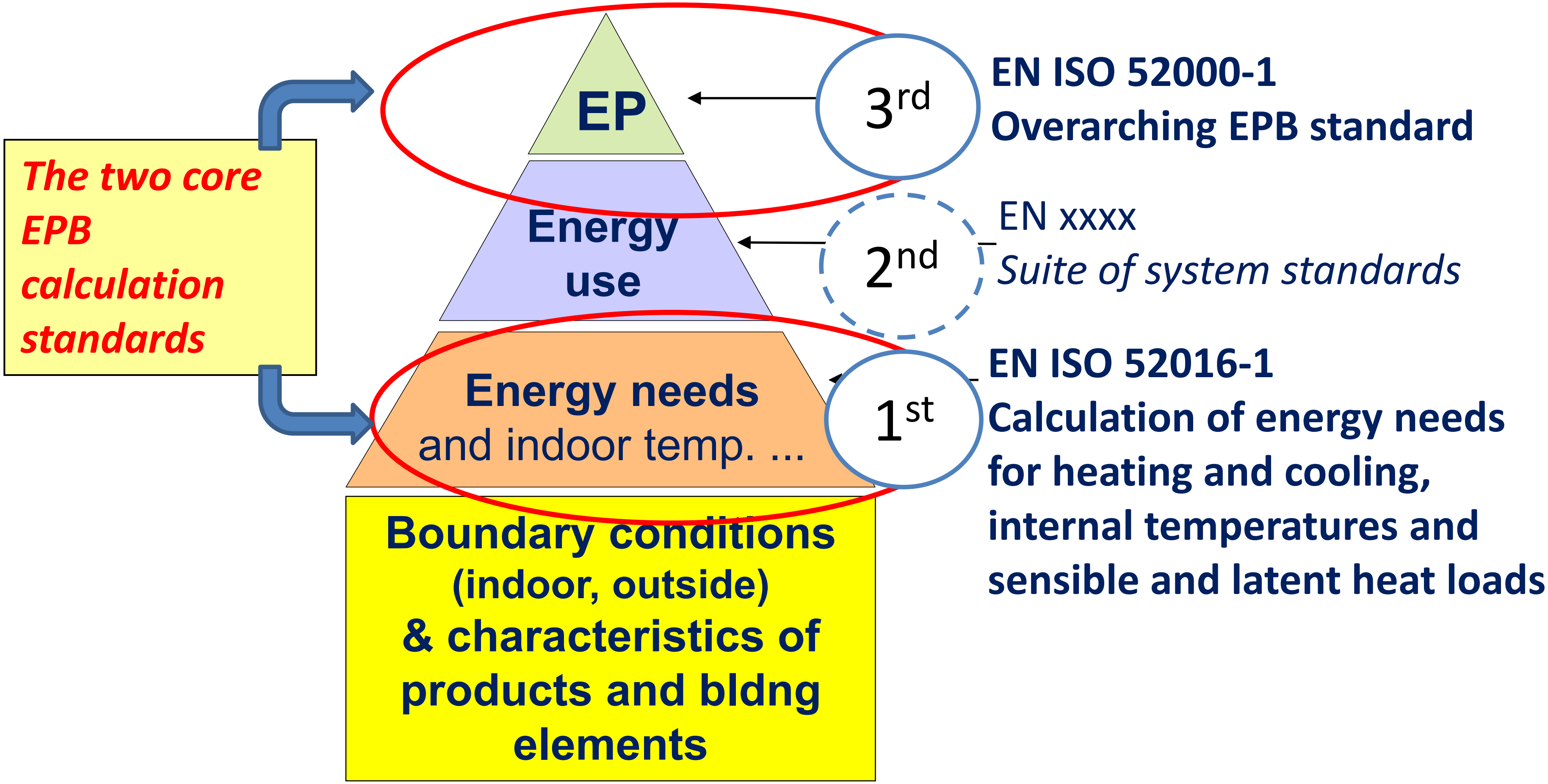
Background information

- For instance:
  - Webinar 2 (March 19): EPB standards overview
  - Webinar 4 (May 26): Hourly versus monthly methods
  - Webinar 7 (Oct. 6): Introduction to the example calculations
- Overview of full series: https://epb.center/support/webinars

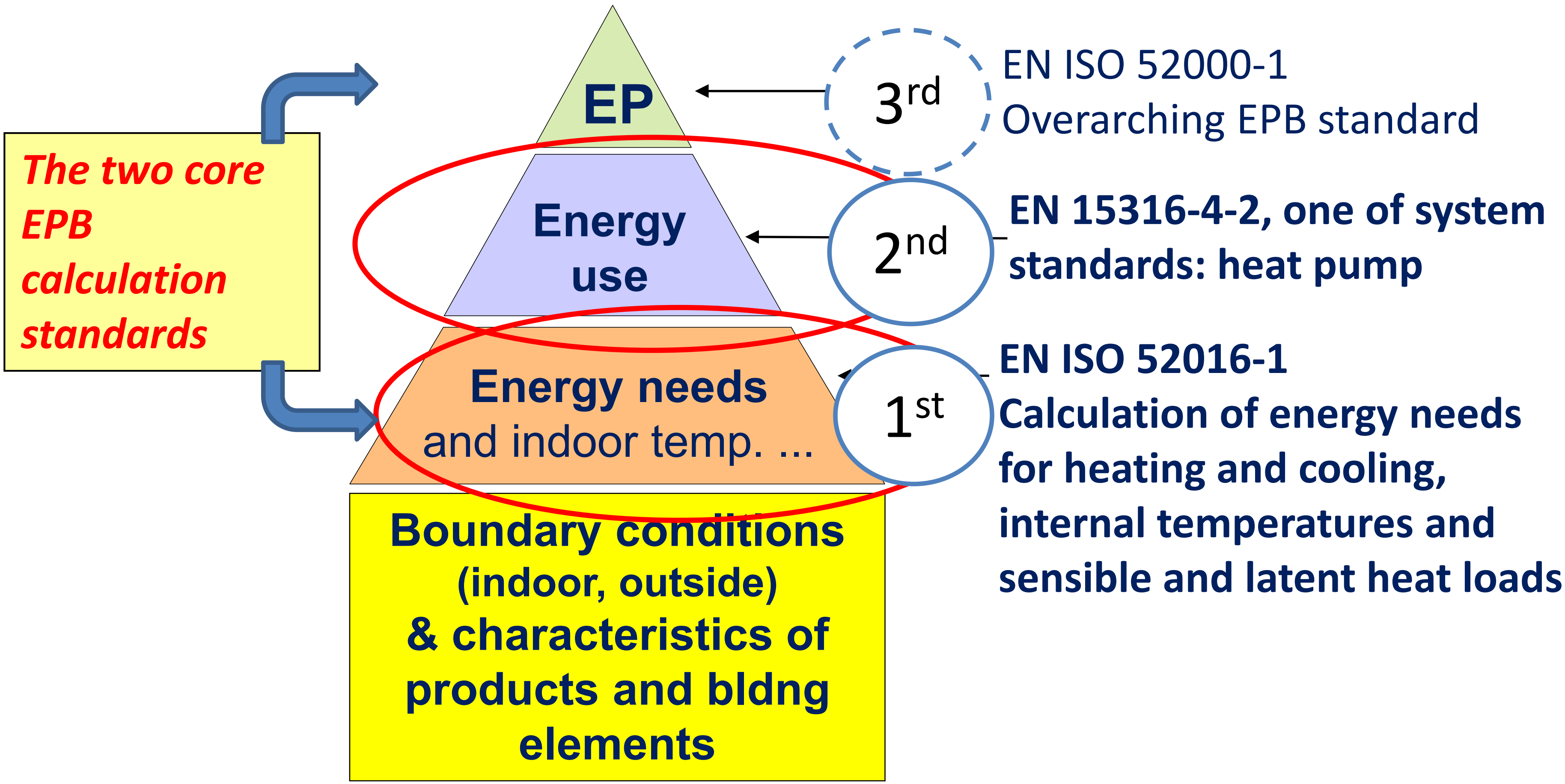
General

- **Energy needs for heating and cooling coupled to systems, general**
- Energy needs for heating and cooling coupled to heat pump system

Previous webinar:
"Set of (about 50) EPB standards.
First question: Where to start with calculation?"



This presentation



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

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
  - E.g. solar and internal gains, varying conditions of use (temperature and ventilation settings), ..

Interested in hourly versus monthly calculations?
Recording of webinar 4

Applied spreadsheet tools
(publicly available or in preparation)

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

EN ISO 52016-1 output

("hourly": only if hourly calculation)

EN ISO 52016-1

Different modes possible:

- **Basic energy loads & needs**
- **System specific loads & needs** *(undersized or absent system, recoverable system heat losses, imperfect control, ..)*
- **System design load**

Hourly sensible and latent heating and cooling load

Hourly indoor (air and operative) temperatures and relative humidity

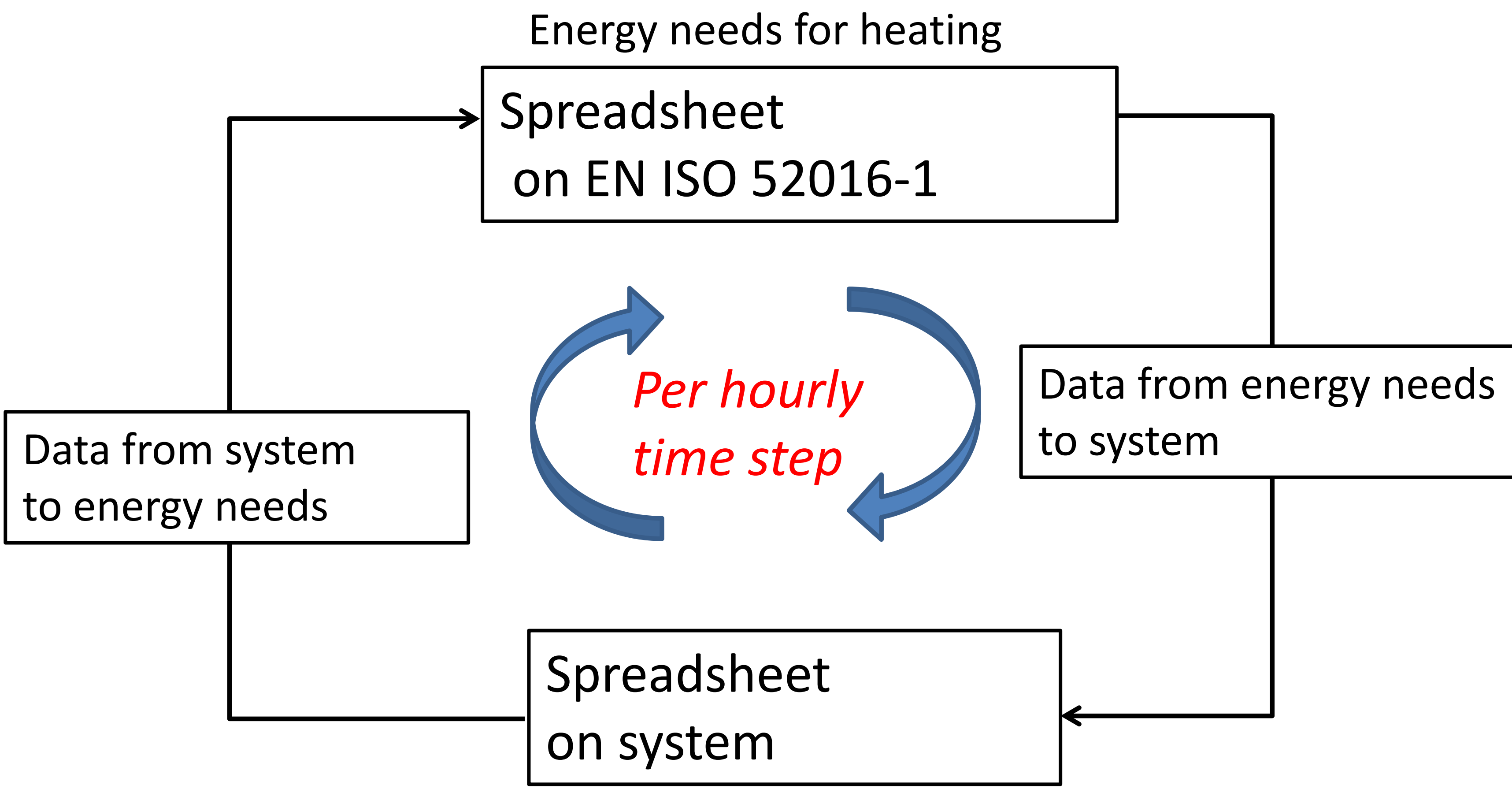
Monthly H&C energy needs

- From hourly calculation
- From monthly calculation

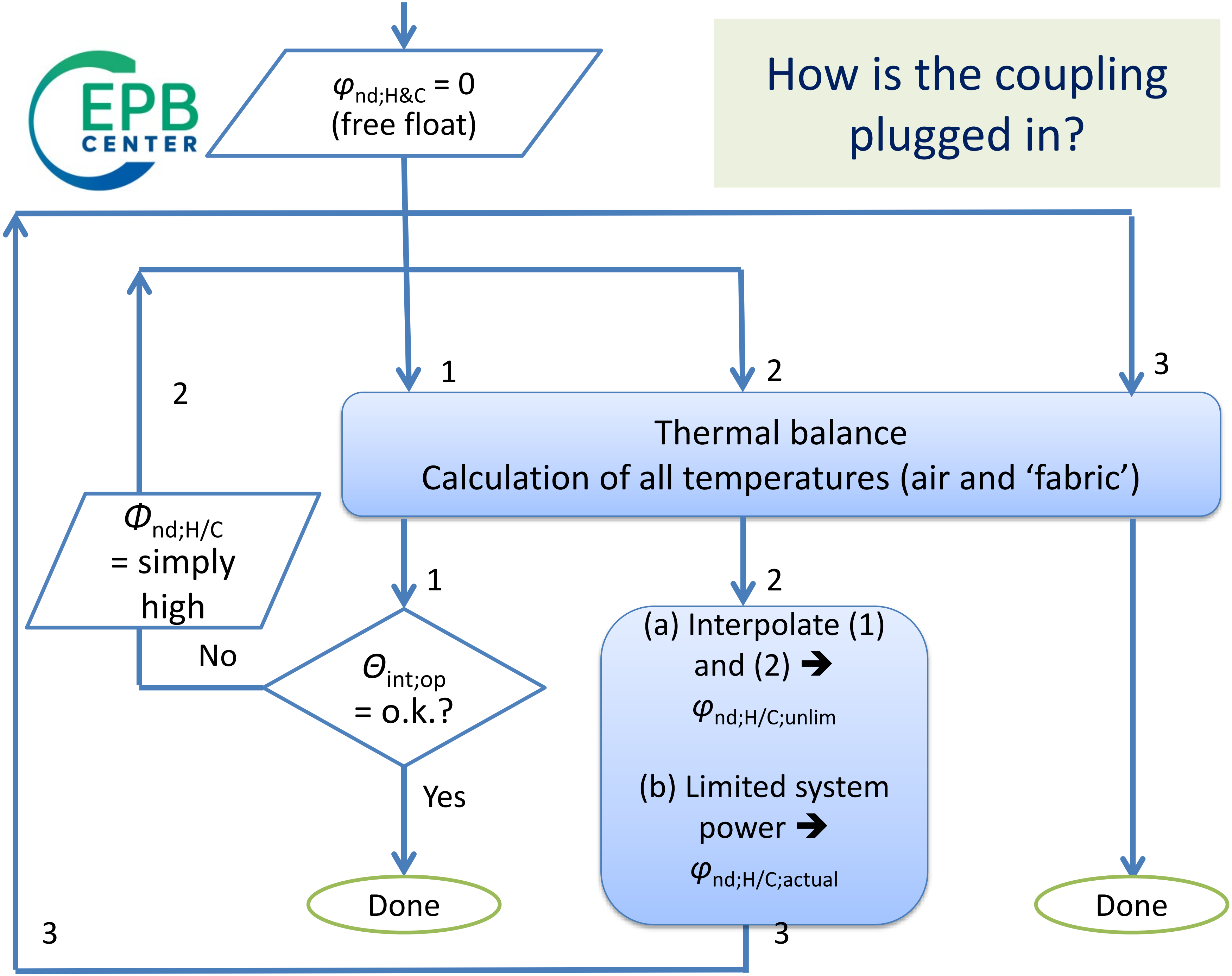
Of course also **statistics**:

- Peak load / Load distrib.curve
- Frequency over- and underheating
- Energy signature
- Key monthly parameters
- ...

How is the coupling working?



How is the coupling plugged in?



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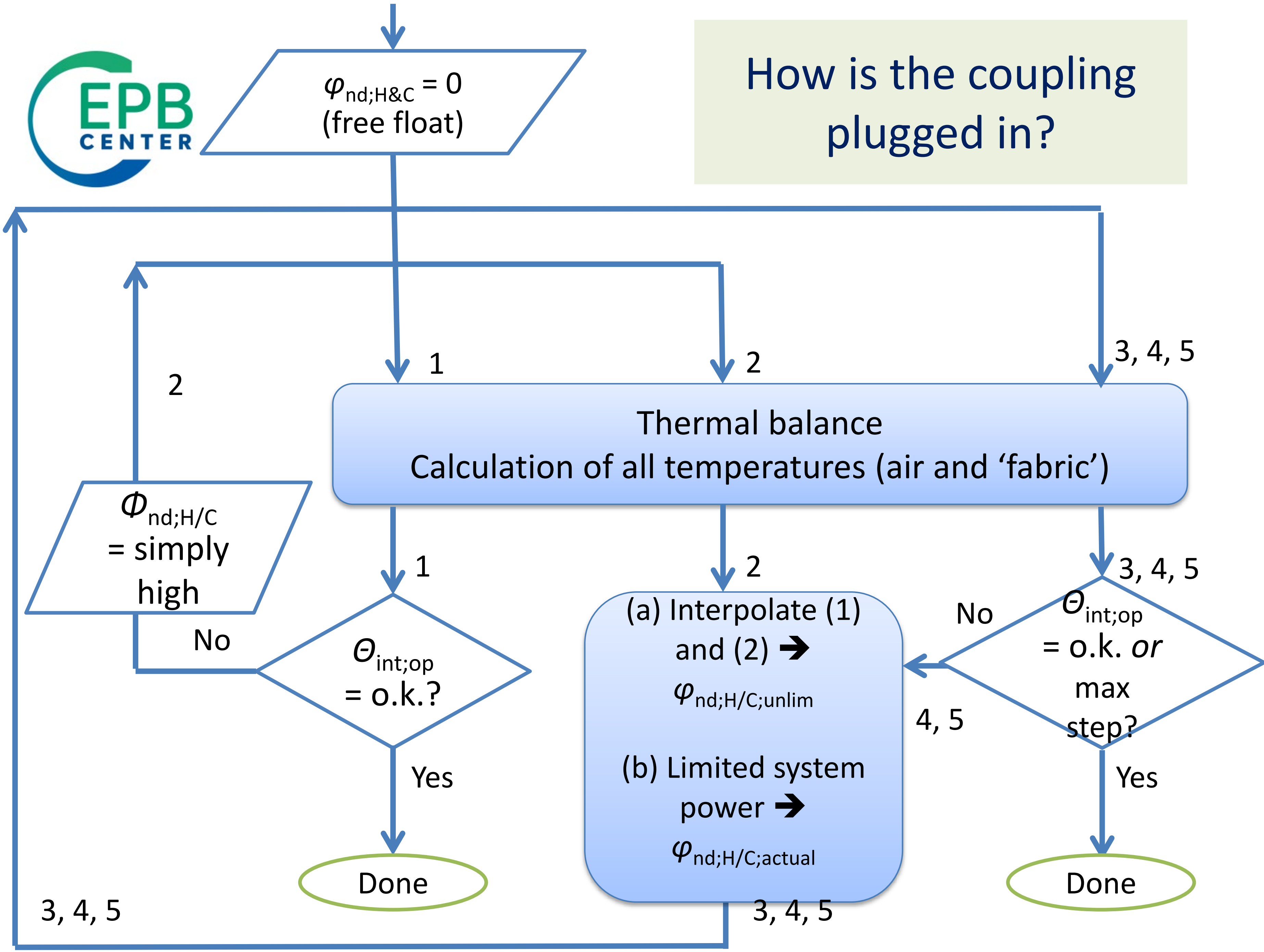
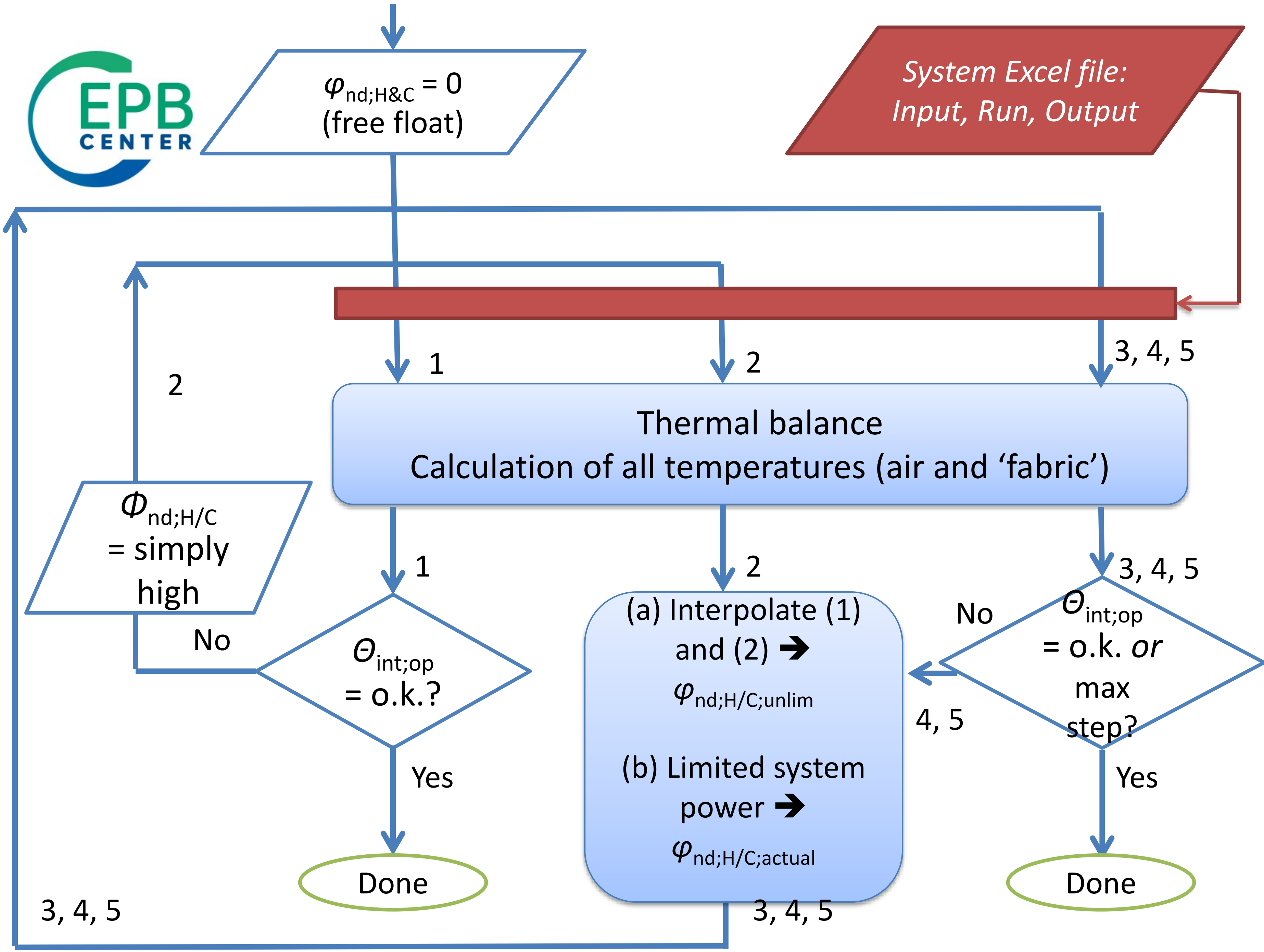


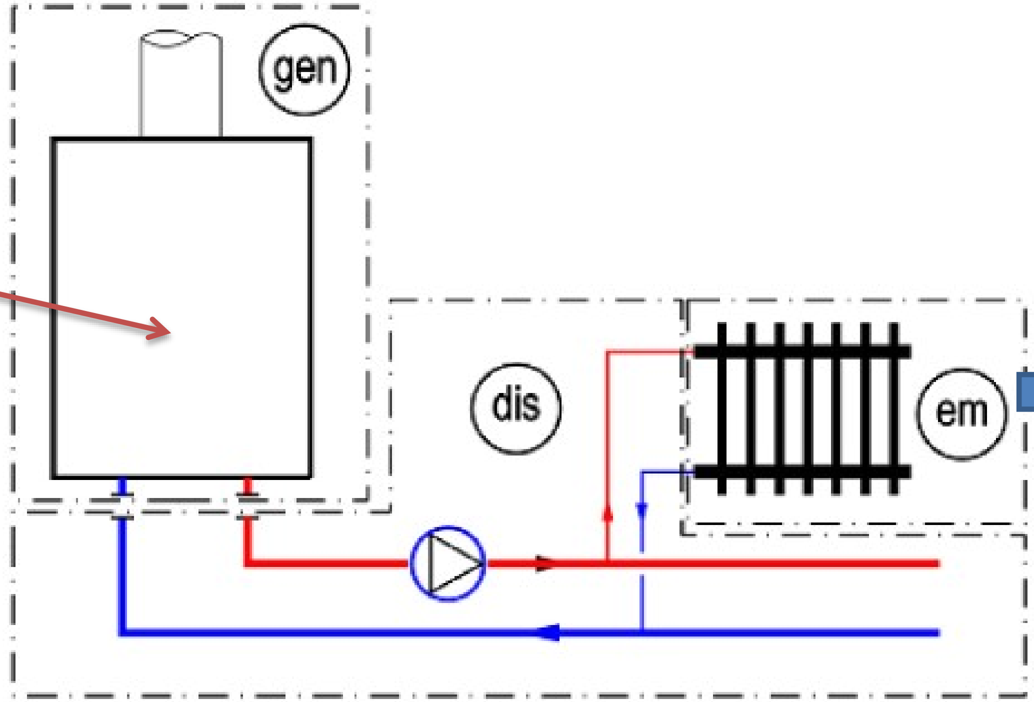

EPB CENTER
$\varphi_{nd;H\&C}$ = 0
(free float)
System Excel file:
Input, Run, Output
1
2
3, 4, 5
2
Thermal balance
Calculation of all temperatures (air and 'fabric')
$\Phi_{nd;H/C}$
= simply
high
1
2
3, 4, 5
No
$\Theta_{int;op}$
= o.k.?
(a) Interpolate (1)
and (2) ➔
$\varphi_{nd;H/C;unlim}$
(b) Limited system
power ➔
$\varphi_{nd;H/C;actual}$
No
$\Theta_{int;op}$
= o.k. or
max
step?
4, 5
Yes
Yes
Done
Done
3, 4, 5
3, 4, 5

Heat pump system

- Energy needs for heating and cooling coupled to systems, general
- **Energy needs for heating and cooling coupled to heat pump system**

Modular system

Heat pump system EN 15316-4-2



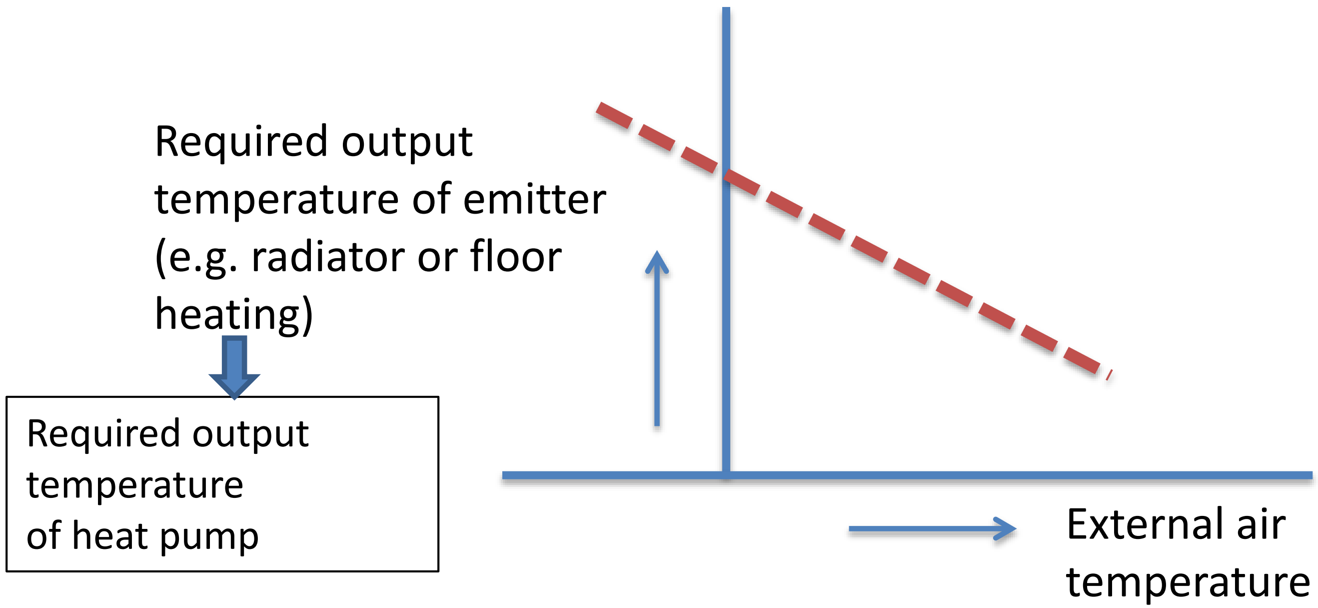
Energy needs for heating and cooling EN ISO 52016-1

gen = generation sub-system EN 15316-x-x
dis = distribution sub-system EN 15316-3 (~ ISO 52032 in prep.)
em = emission sub-system EN 15316-2 (~ ISO 52031)

Emission sub-system

- Partly included in this coupling:

  (more aspects can be added easily)



How is the coupling working: heat pump system?

Energy needs for heating

EN ISO 52016-1

Per hourly time step

- Energy need for heating
- Outdoor temperature (source)
- Required heat pump output temperature

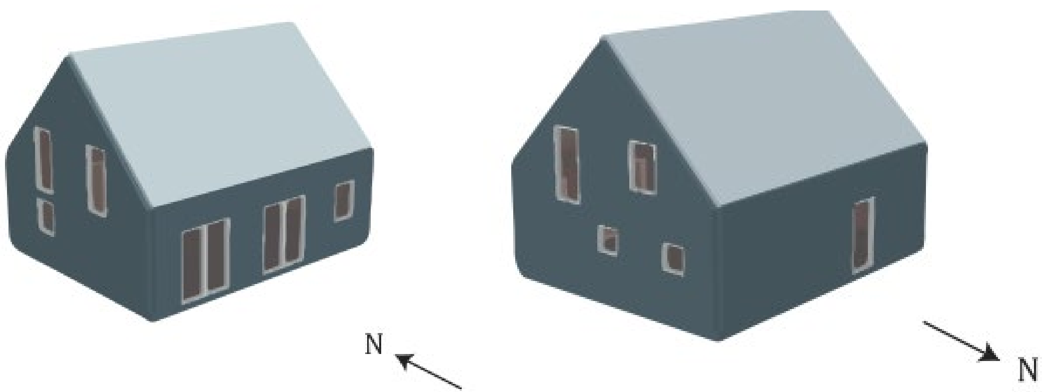
EN 15316-4-2

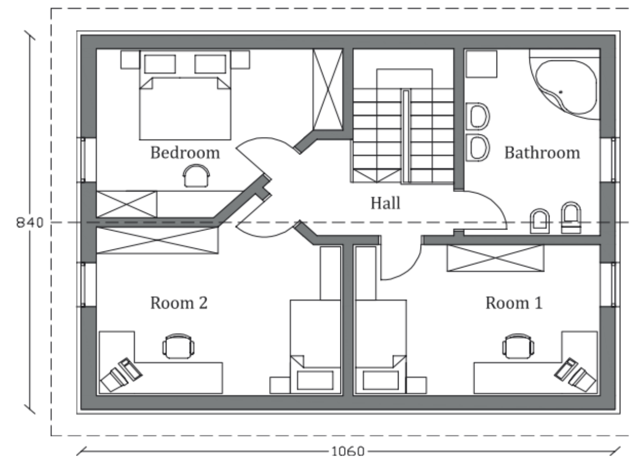
Heat pump system*)

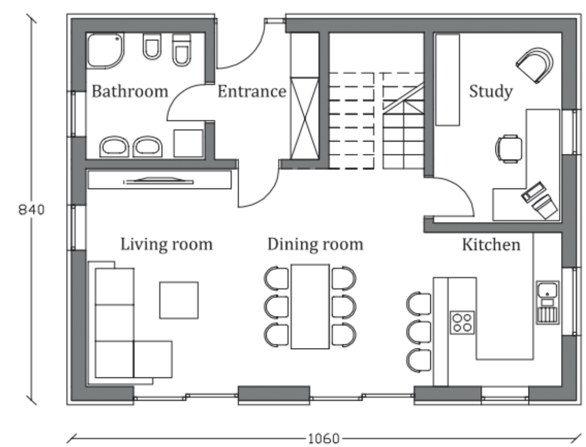
- Energy delivered for heating
- HP system energy use (heat pump, backup, aux.)
- COP of heat pump system
- (Optional other details)

**): incl. auxiliary energy and backup (if present)*

Case study







Single family house

– ISO/TR 52016-2 example

Variations

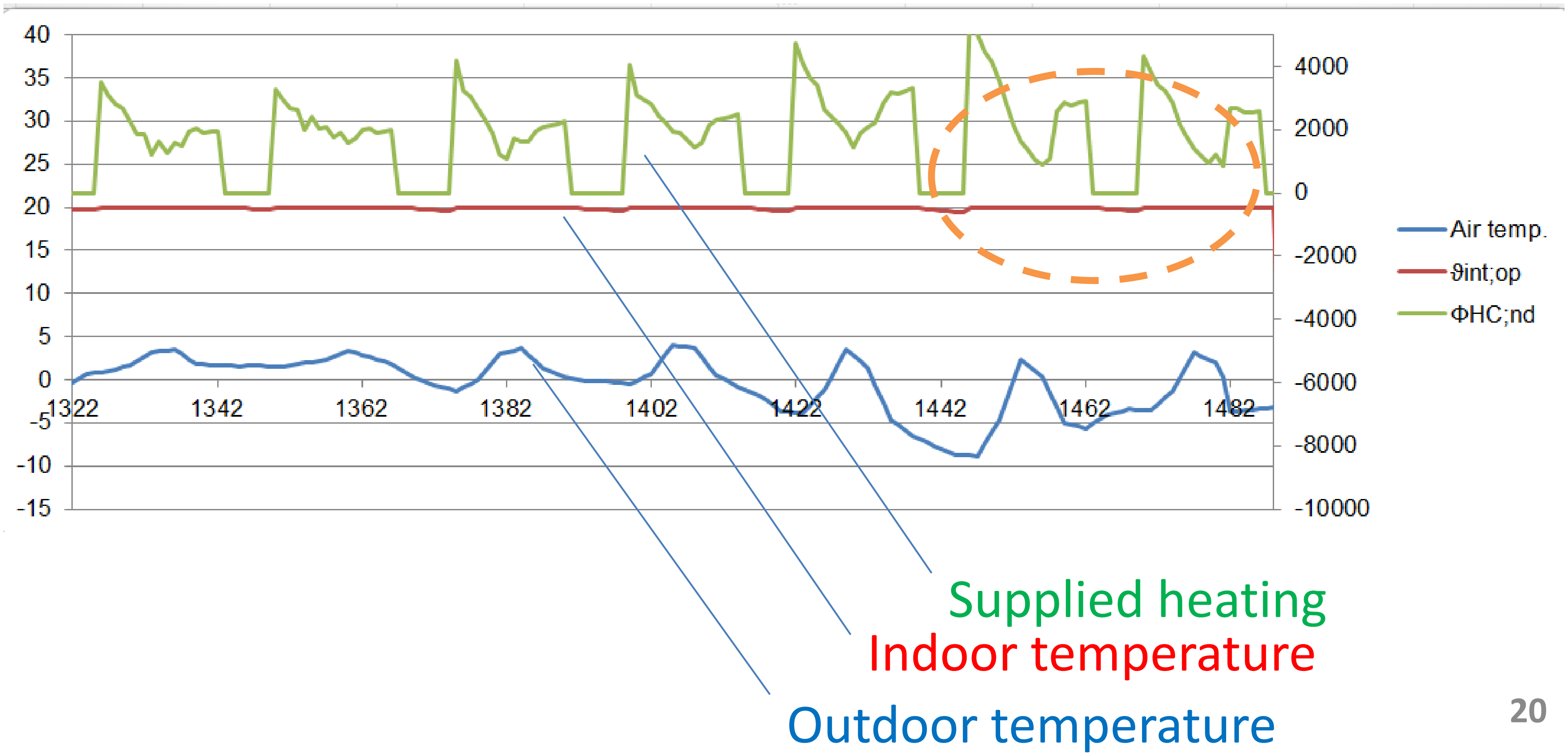
- Hourly calculations
- 3 (European) climates:
  - Oslo, Strasbourg, (Athens)
- Variation in energy needs
- Heat pump system
  - Air-Water
  - Inverter type
  - Variation in capacity
  - With/without (electric) backup

Disclaimer:
The spreadsheet used for heat pump calculation is the most recent update, currently under review

Examples

Illustration of time series of hourly heating needs

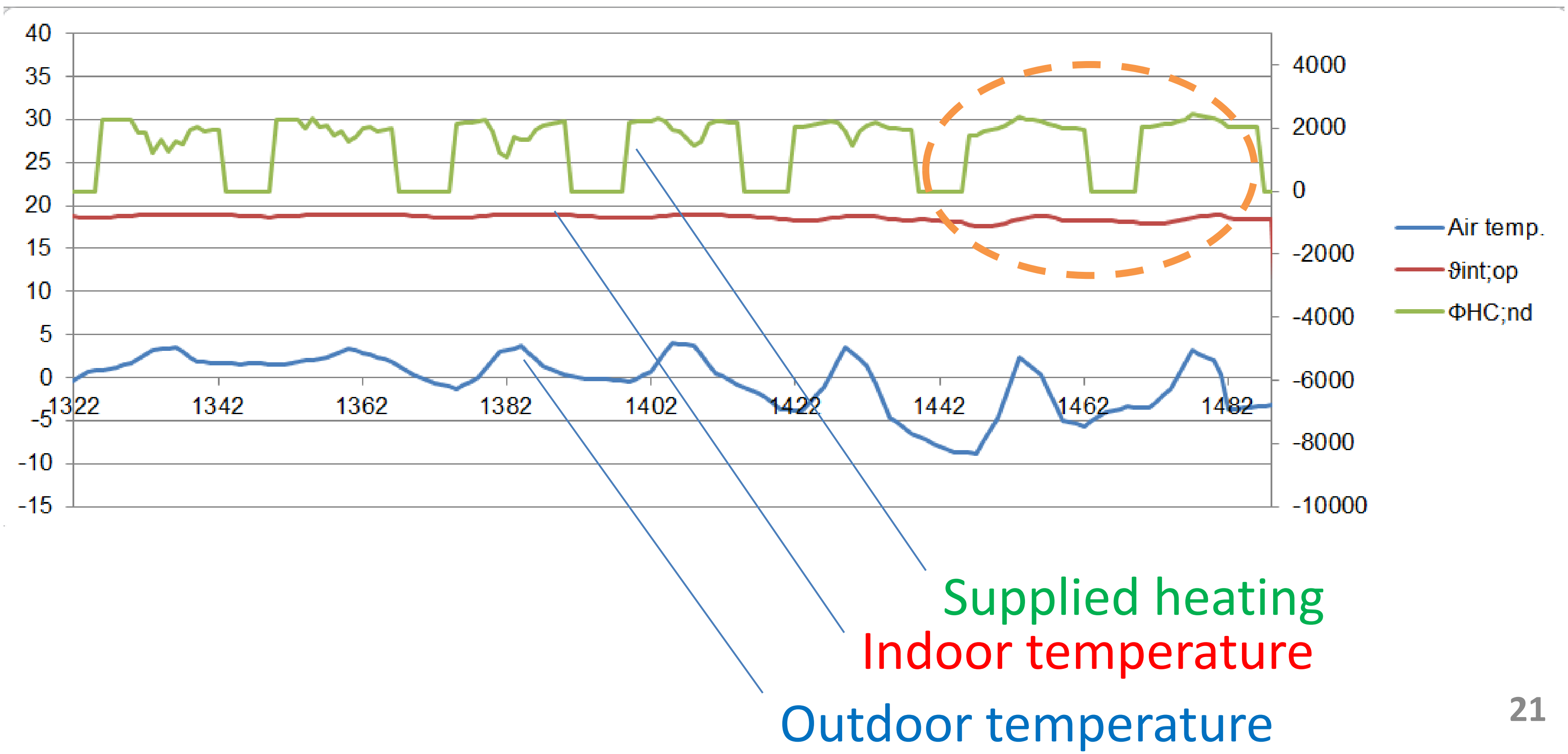
January, Strasbourg



Examples

Illustration of time series of hourly heating needs

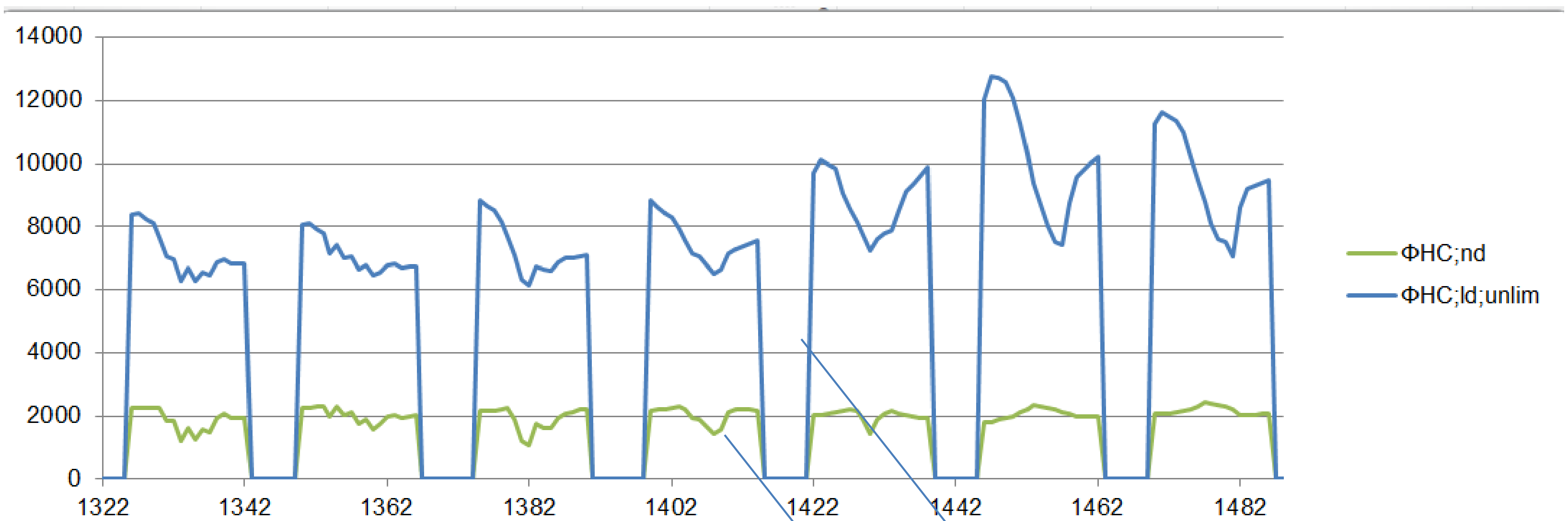
January, Strasbourg / undersized heat pump



Examples

Illustration of time series of hourly heating needs

January, Strasbourg / undersized heat pump



**) Not the same as basic heating needs without system: here, the needs are influenced by insufficient heat supply at previous hours*

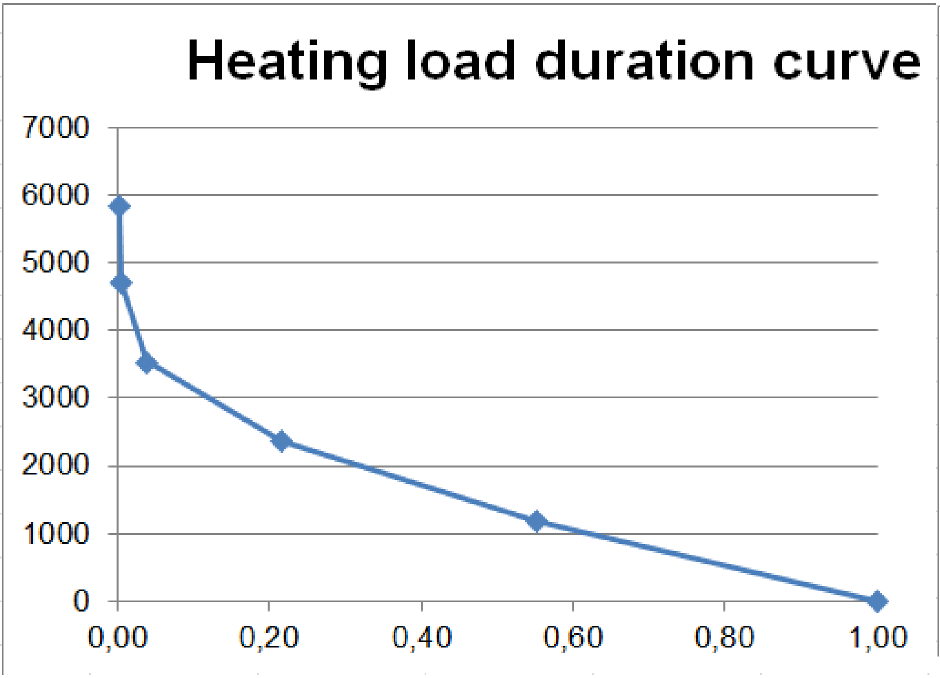
Needed heating *)

Supplied heating

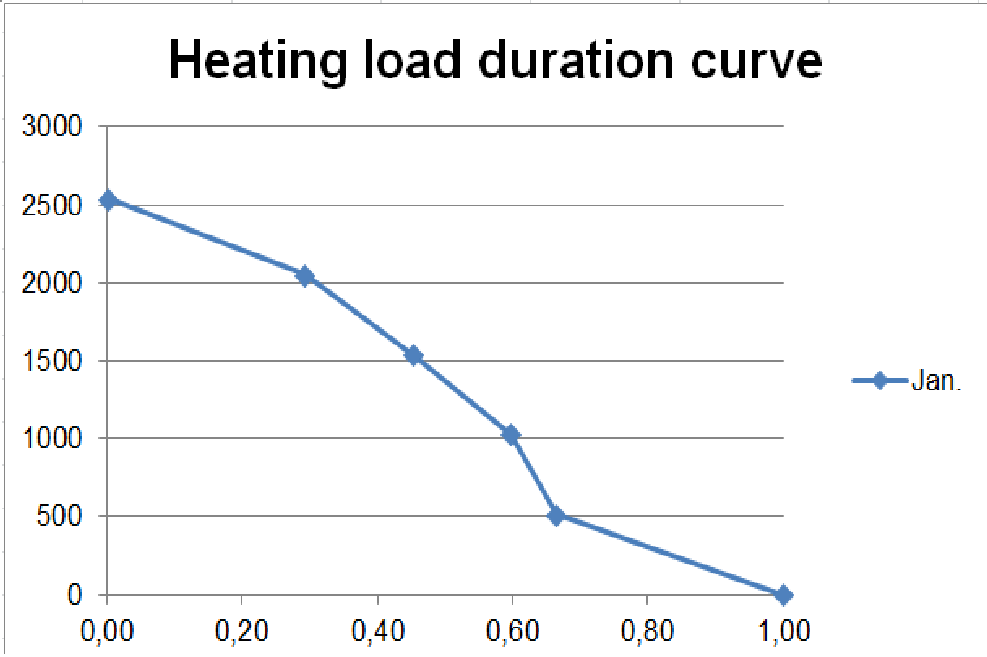
Examples

Illustration of heating load distribution curve

January, Strasbourg



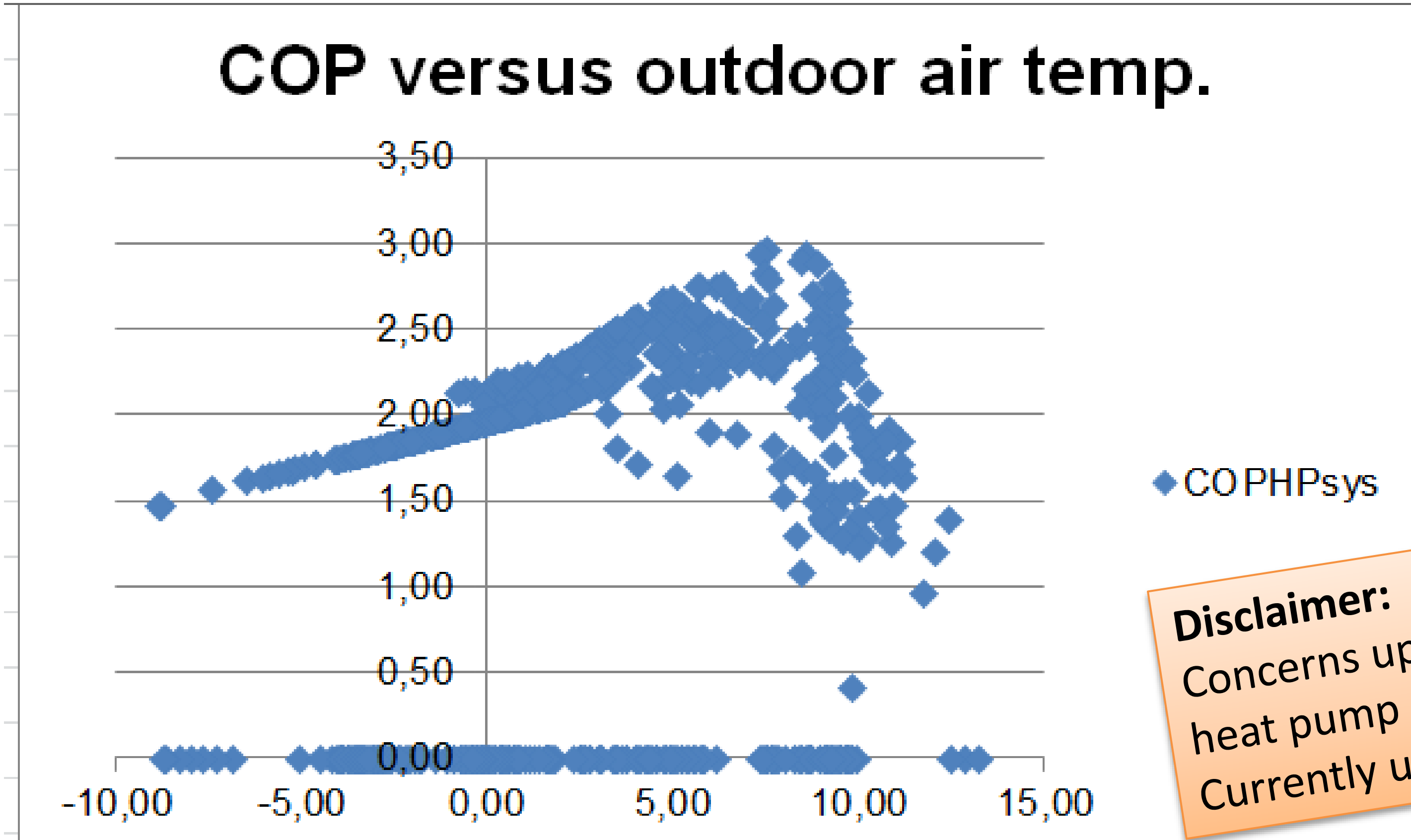
Oversized HP



Undersized HP

Examples

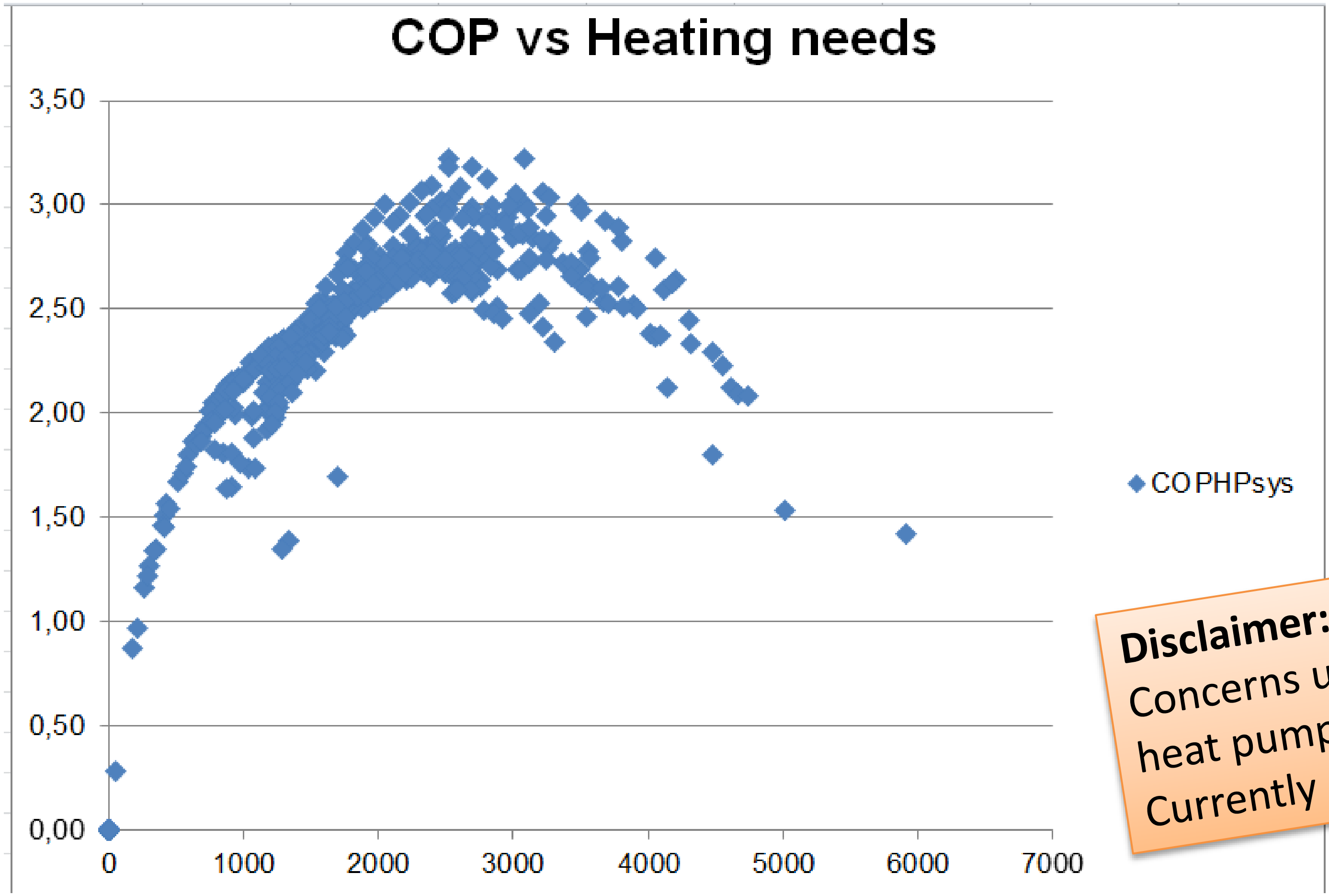
Illustration of Heat pump system performance (COP)
as function of external air (=source) temperature
(plot of hourly values, January - Strasbourg)



Disclaimer:
Concerns updated spreadsheet for heat pump calculation.
Currently under review

Examples

Illustration of heat pump system performance (COP) as function of heating needs (plot of hourly values). January, Strasbourg



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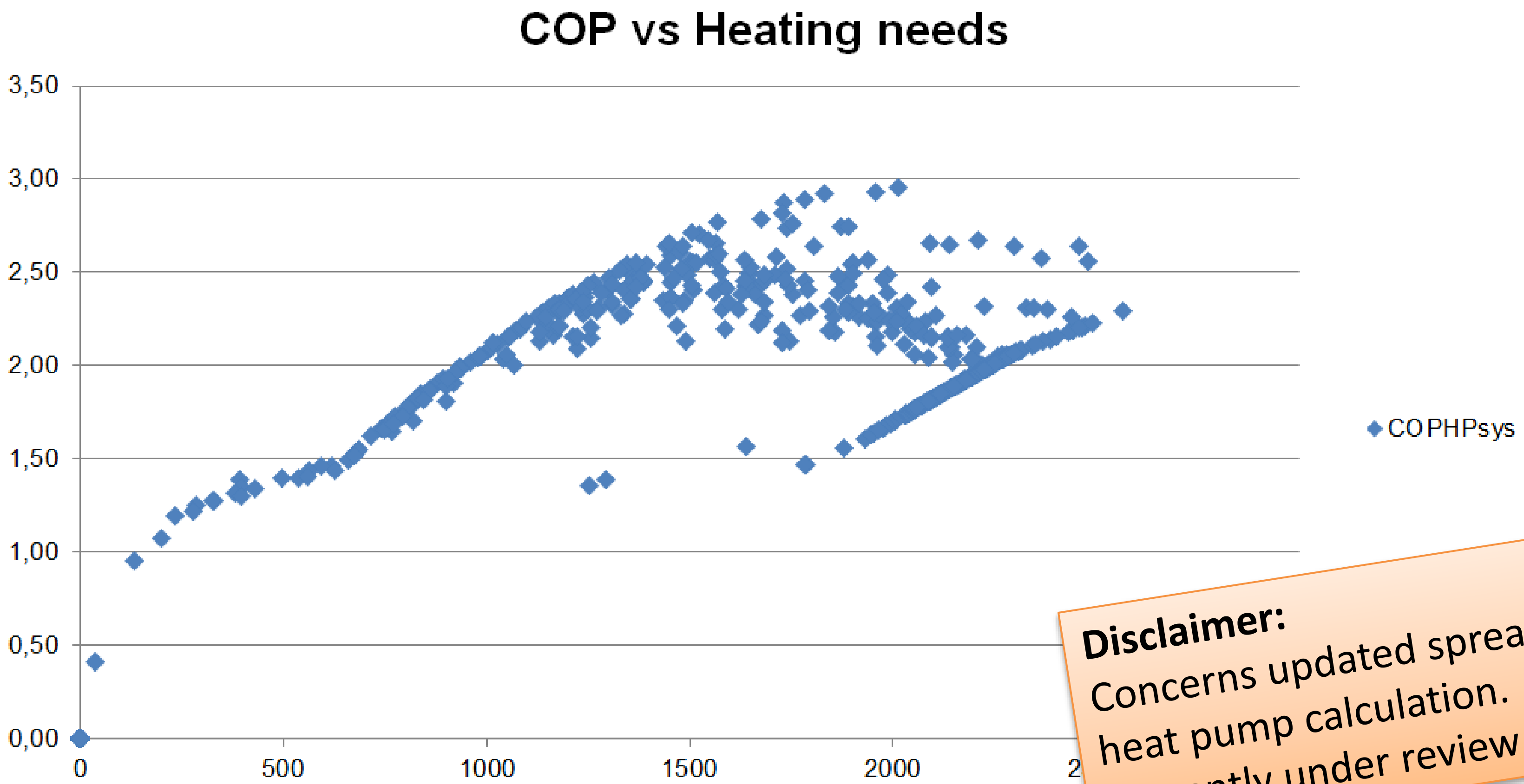
Currently under review

Examples

Illustration of heat pump system performance (COP) as function of heating needs (plot of hourly values). Undersized HP



Disclaimer:
Concerns updated spreadsheet for heat pump calculation.
Currently under review

Conclusion

- **EN ISO 52016-1**: One of the core EPB standards for calculating the overall EPB
- Spreadsheet tool publicly available to perform EN ISO 52016-1 calculations
- Now coupling to specific systems being added, to demonstrate impact of interaction between hourly energy needs and conditions and system performance
  Work in progress
- Why spreadsheets?
  - Fully transparent step-by-step validation and demonstration
  - To show all intermediate results plus references to the formulae in the EPB standard(s)
  - Not for daily practice

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

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

Coupling of the thermal zone (EN ISO 52016-1) and natural ventilation (EN 16798-7) methods

Gerhard Zweifel

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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
- 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

- 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 - Part 7: Ventilation for buildings - Modules M5-1, M5-5, M5-6, M5-8 - Calculation methods for the determination of air flow rates in buildings including infiltration
  - Demo_FprEN_16798-7_2016-02-11.xlsm on https://epb.center/documents/demo-fpren-16798-7/
  - Updated for case study

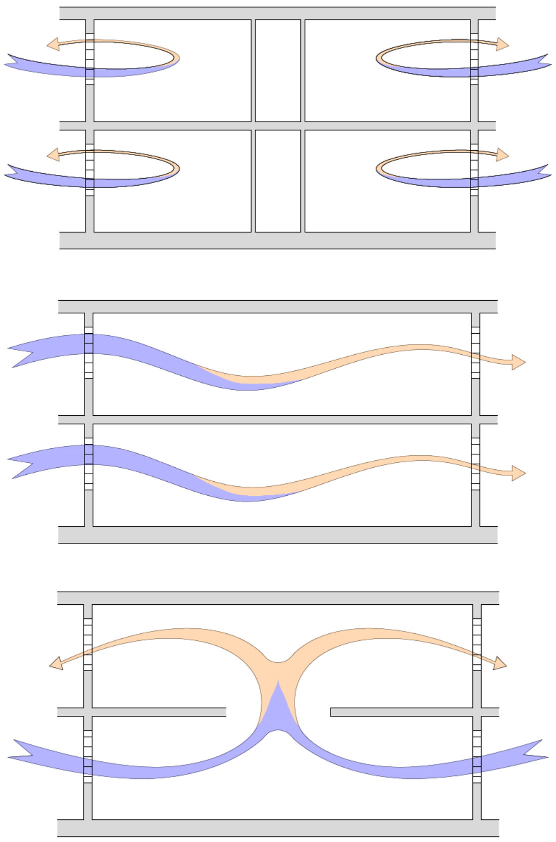
Why coupling of EN ISO 52016-1 and EN 16798-7 spreadsheets?

- EN ISO 52016-1:
  - Ventilation flow rate = input from EN 16798-7
  - In spreadheet: predefined, dependent on occupancy
  - Special ventilative cooling facility
- EN 16798-7:
  - Calculation of air flow rates for natural ventilation

-> Does the flow rate really occur?

EN 16798-7 – relevant contents

- Methods for calculation of air flow rates
  - Entering and leaving through
    - open windows
    - vents
    - leakages
    - passive and hybrid ducts
- Boundary conditions (driving forces):
  - Temperature difference (stack effect)
  - Wind speed
- Different levels of models:
  - Simplified (single formula foe an element)
  - Detailed (iteration to resolve for balance)
- Definition of openings as input, e.g.
  - What size of window(s)?
  - What percentage of area can be opened?
  - Single sided or cross ventilation
  - Height and placement of window(s)
  - Similar for other elements

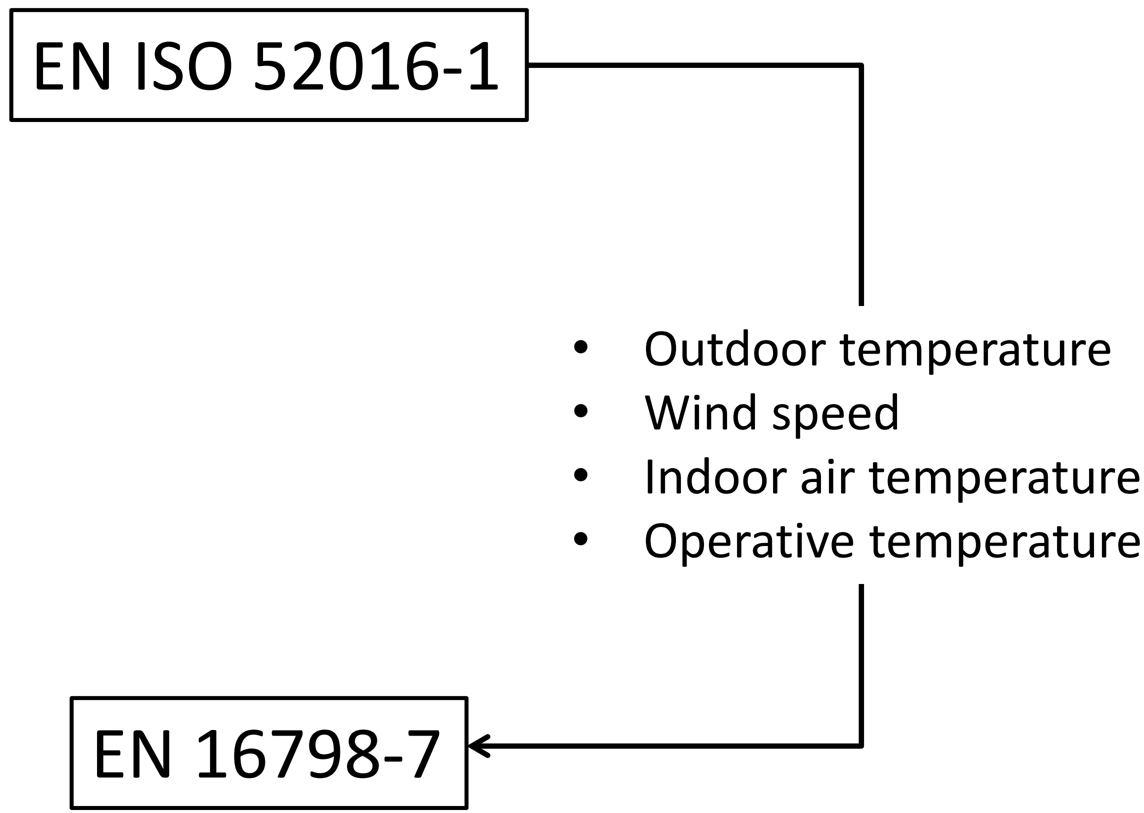


How is the coupling working?

EN ISO 52016-1

EN 16798-7

How is the coupling working?



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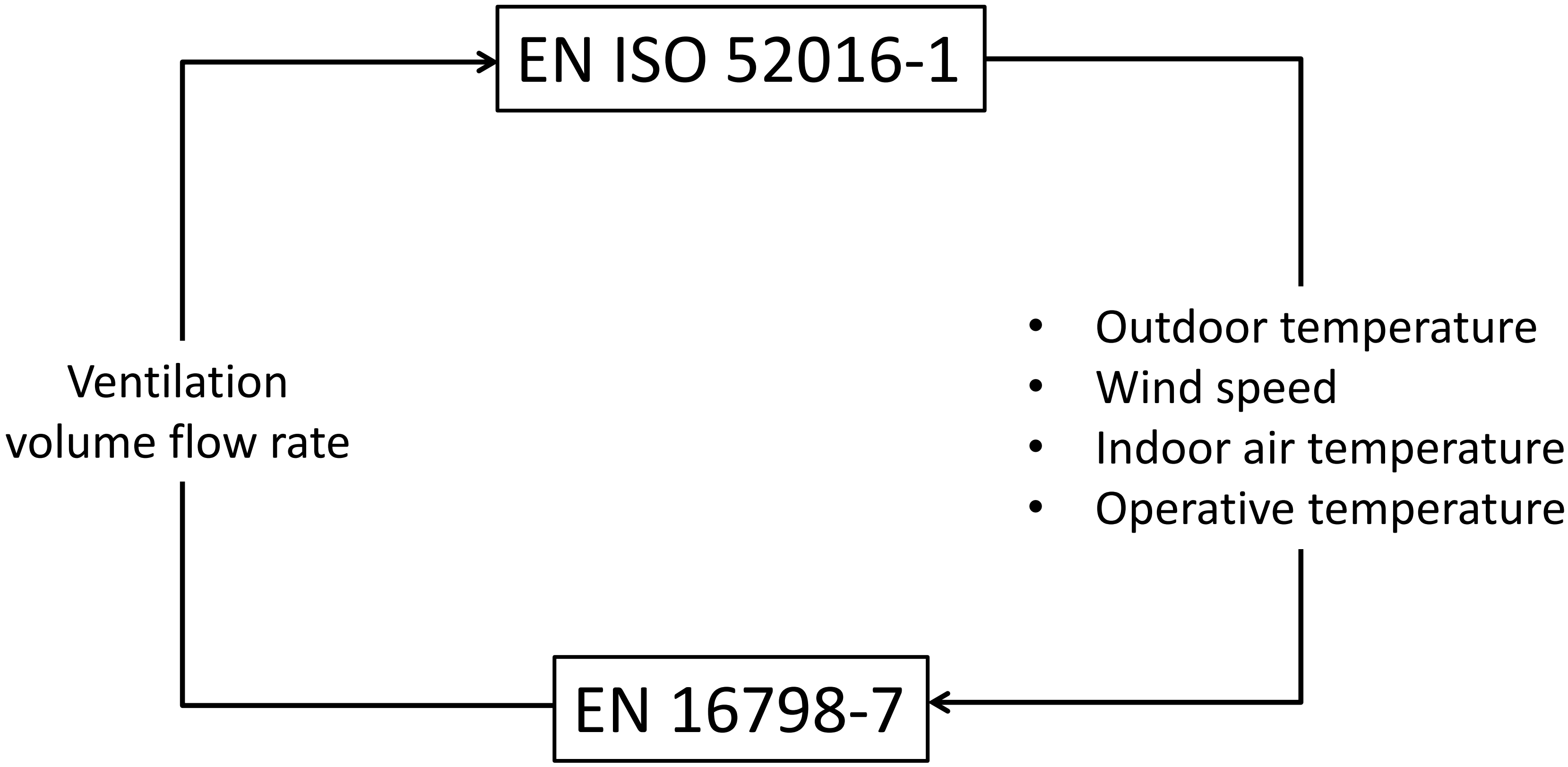

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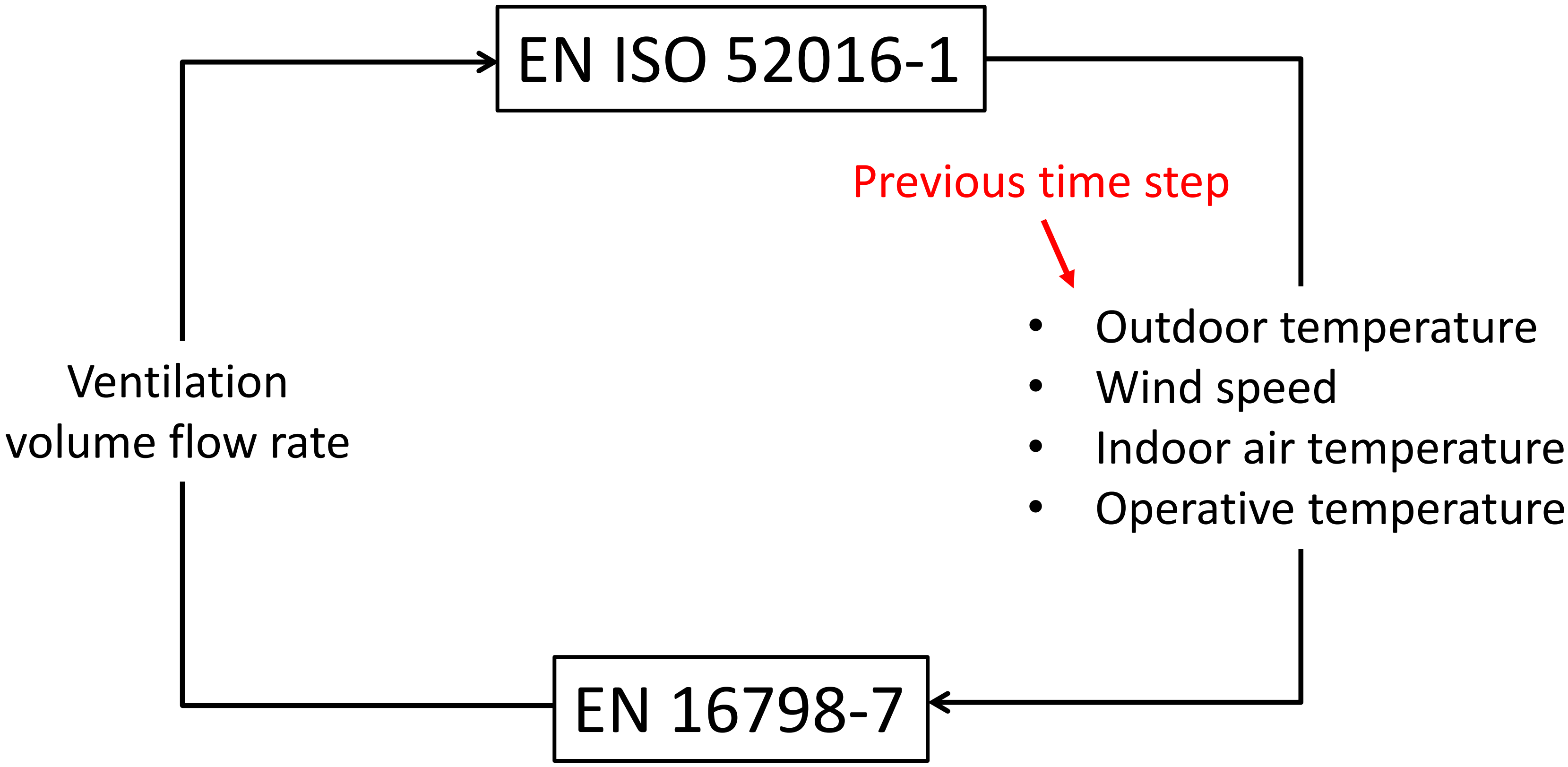

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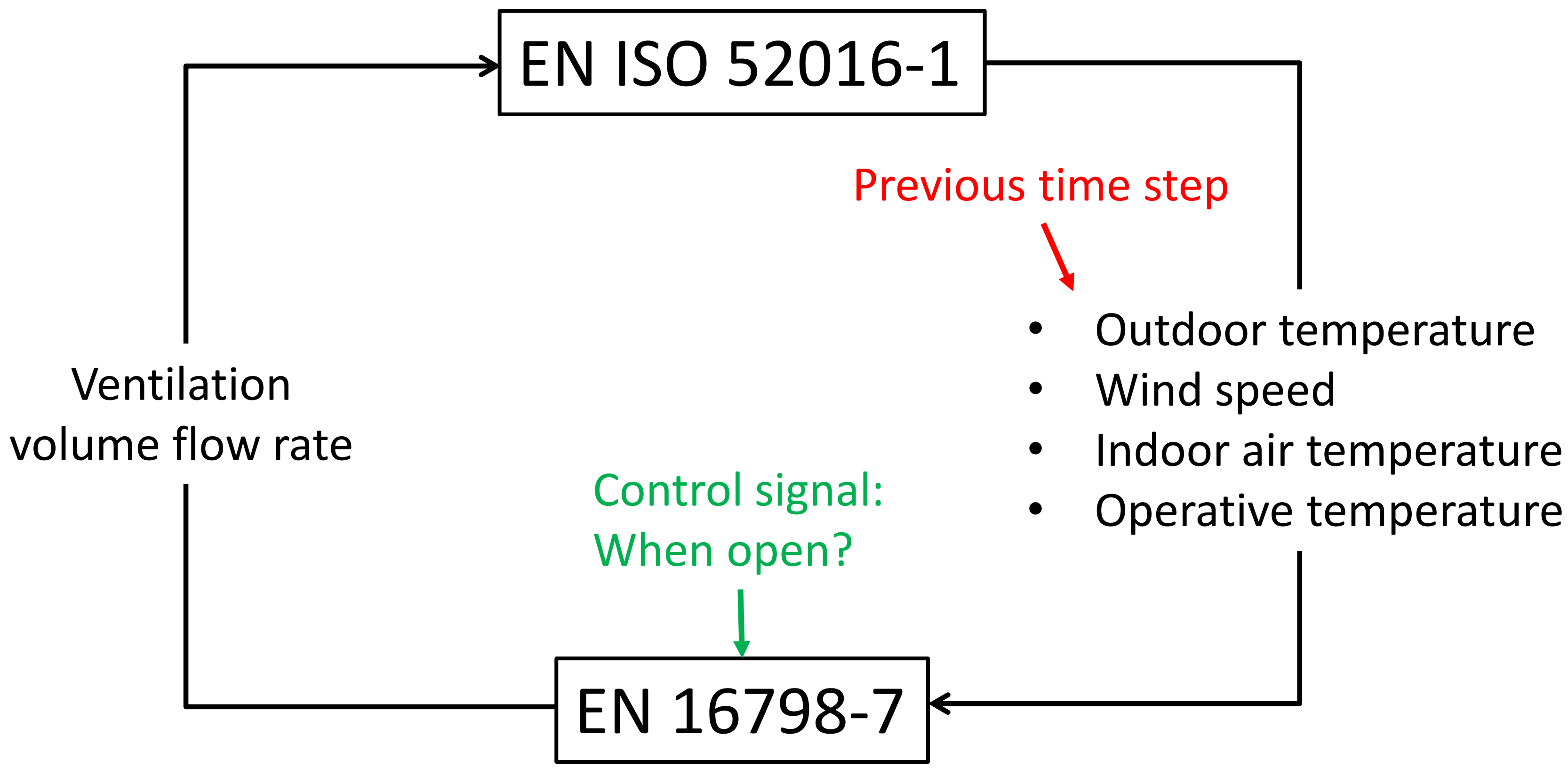

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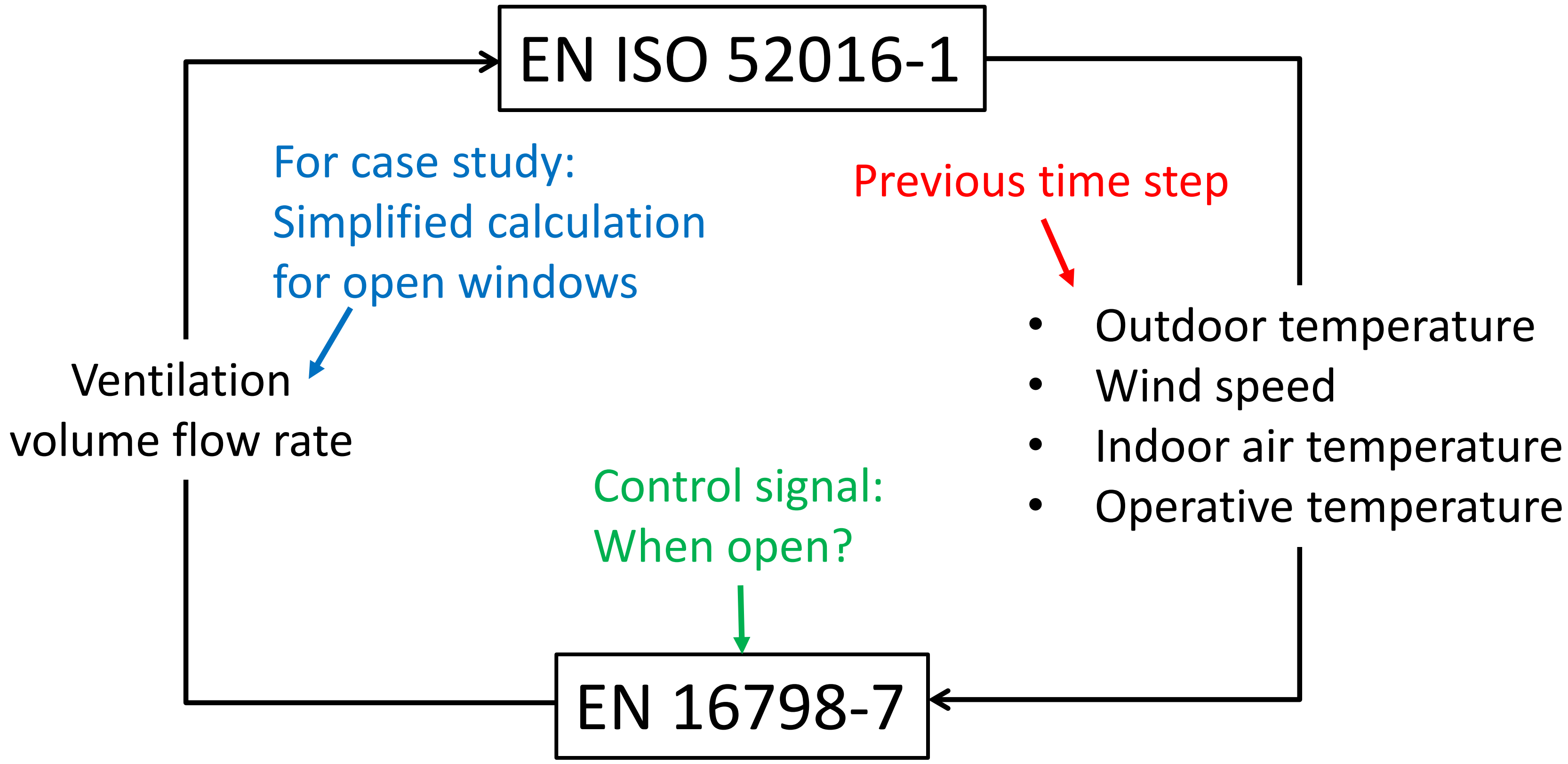
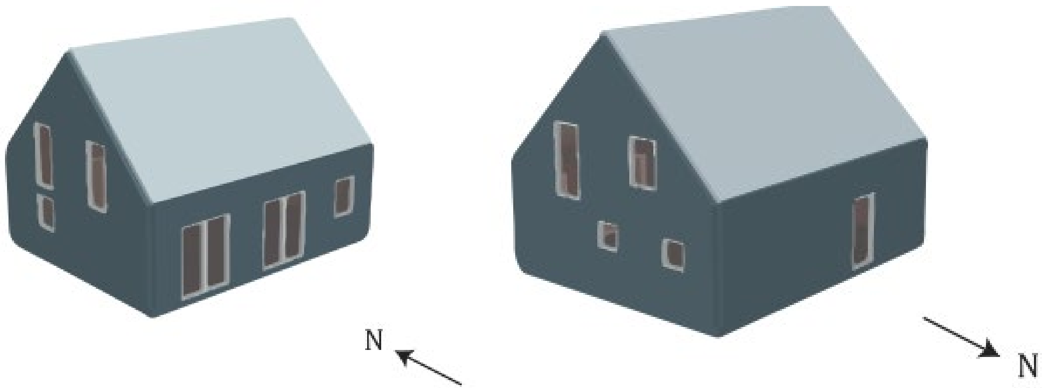
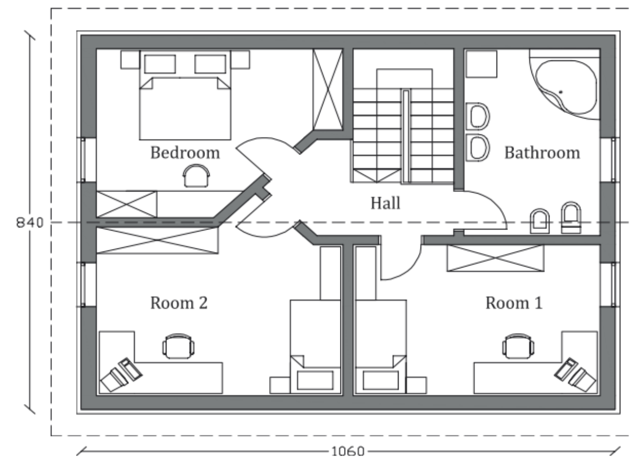
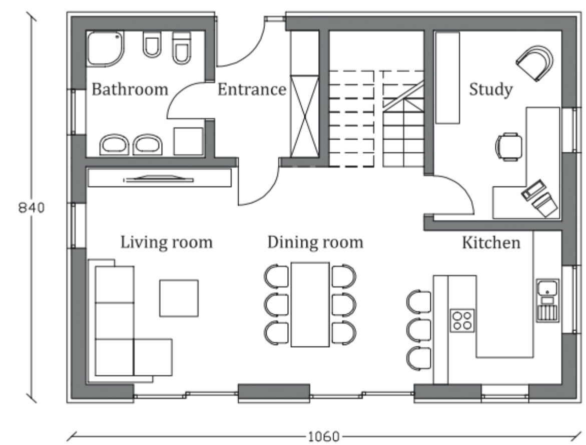


Example calculations







Single family house

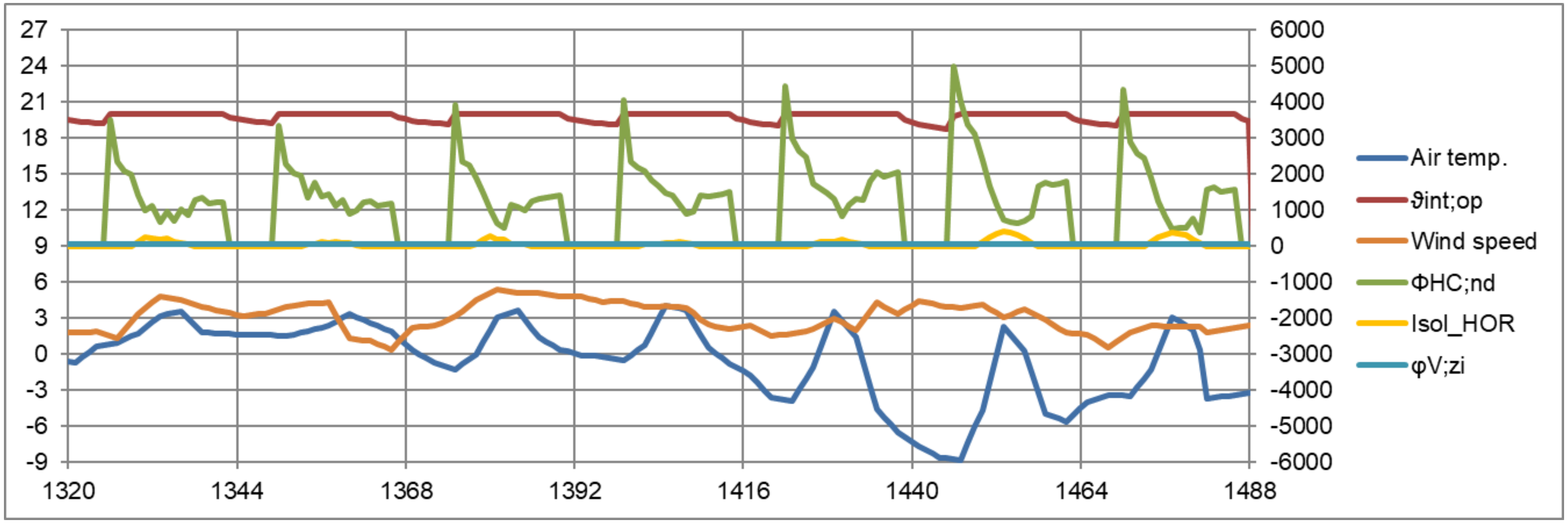
- ISO/TR 52016-2 example

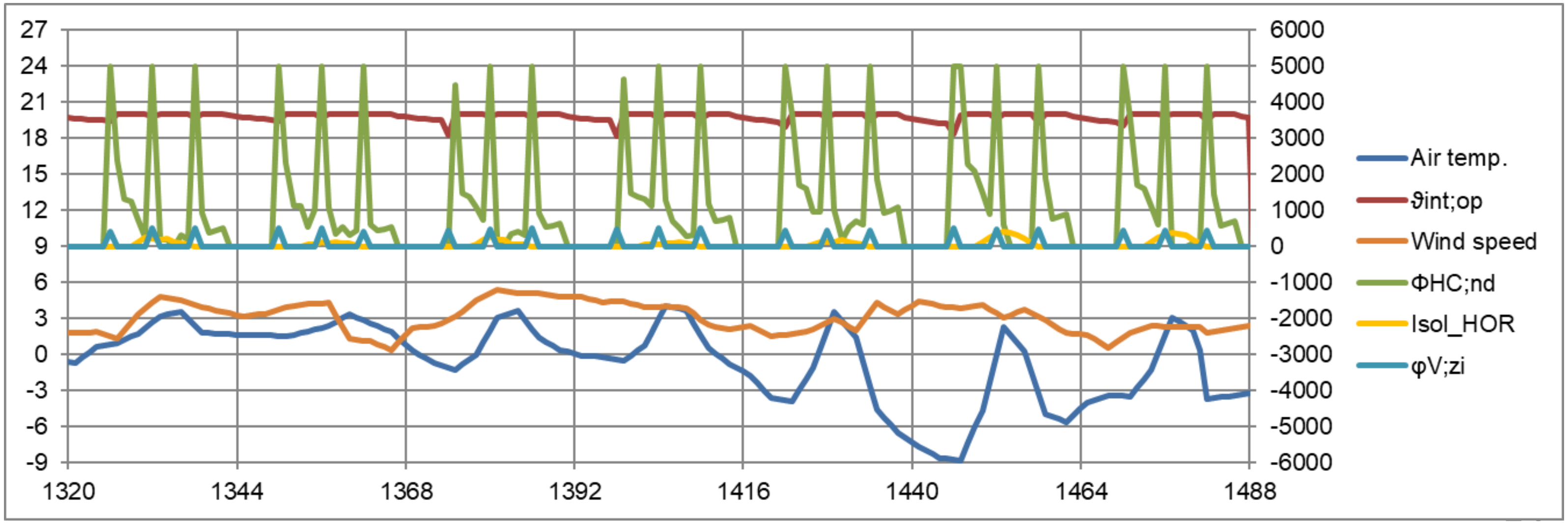
Example calculations

- Climate: Strasbourg
- Ventilation:
  - Cross ventilation, east/west windows, both floors
  - Airing: 3 x daily (6am, 12am, and 6pm)
    - Opening: 15% window area, 30% of 1 h (-> resulting in +/- 1 ACH)
  - Ventilative cooling
    - When outdoor temp. < operative temp.
    - When operative temp > 24°C

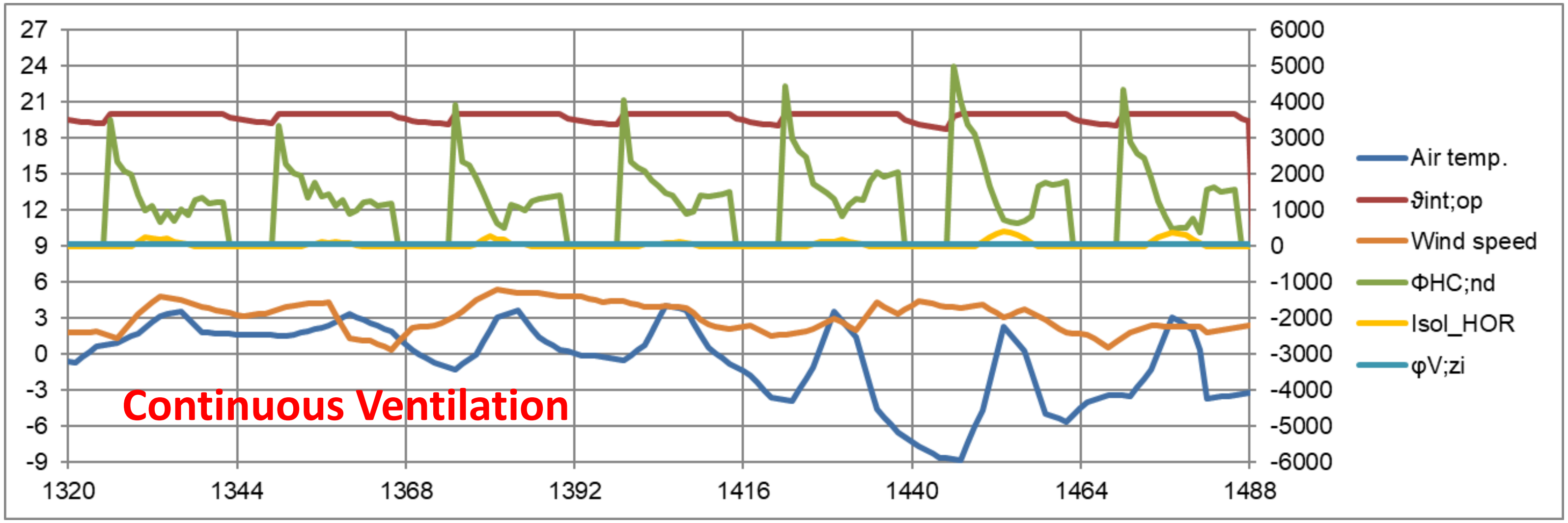
    - > Opening: 15% window area (resulting in max. +/- 5 ACH)

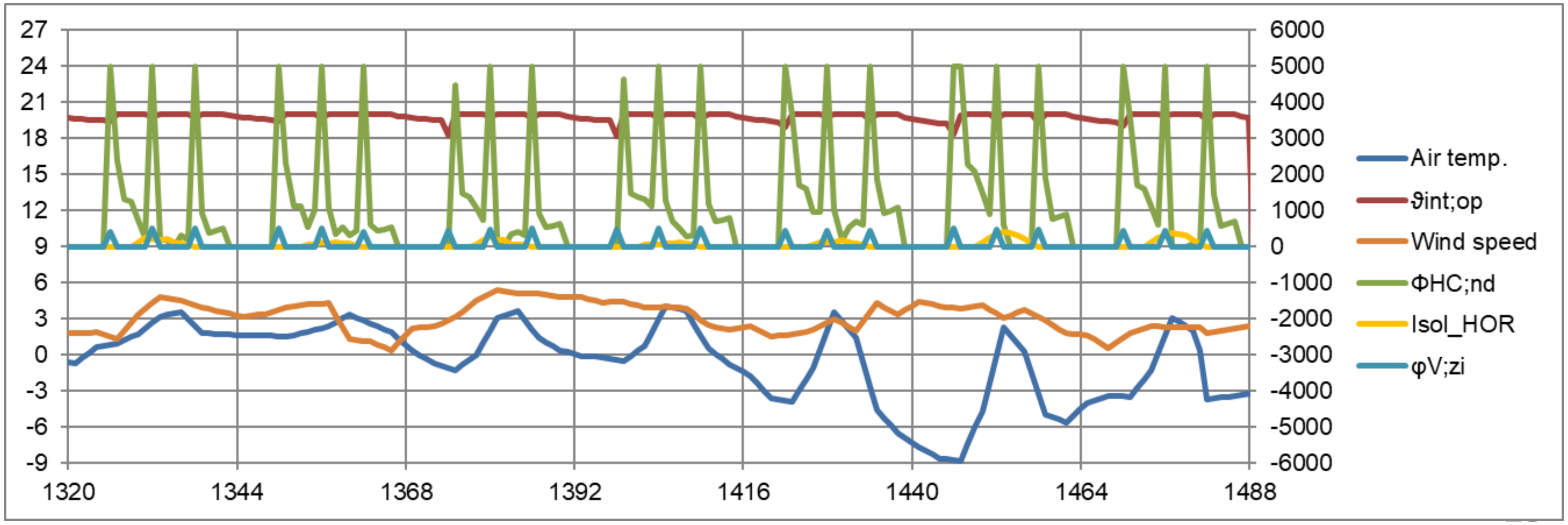
Winter results



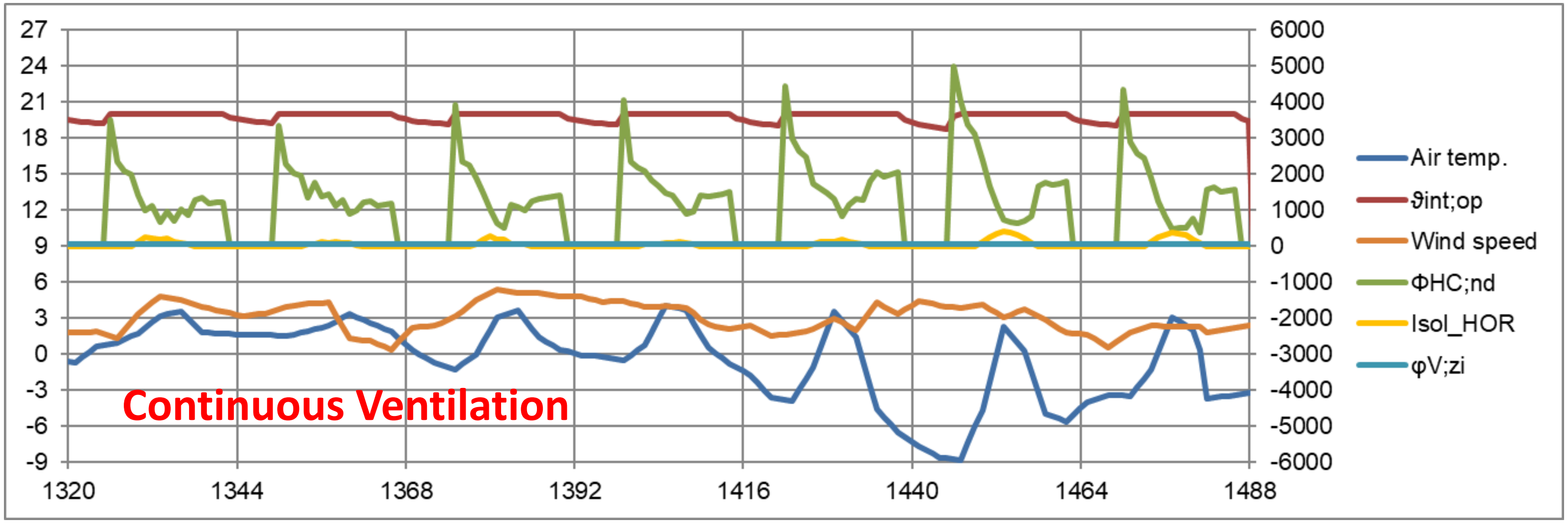


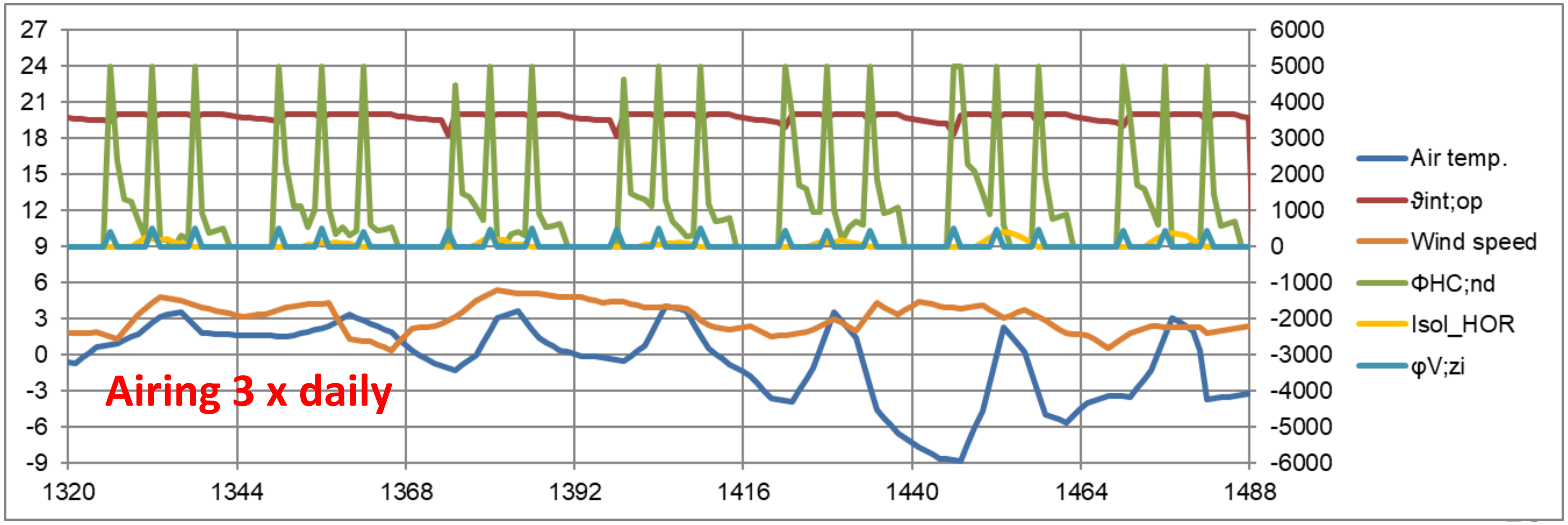
Winter results



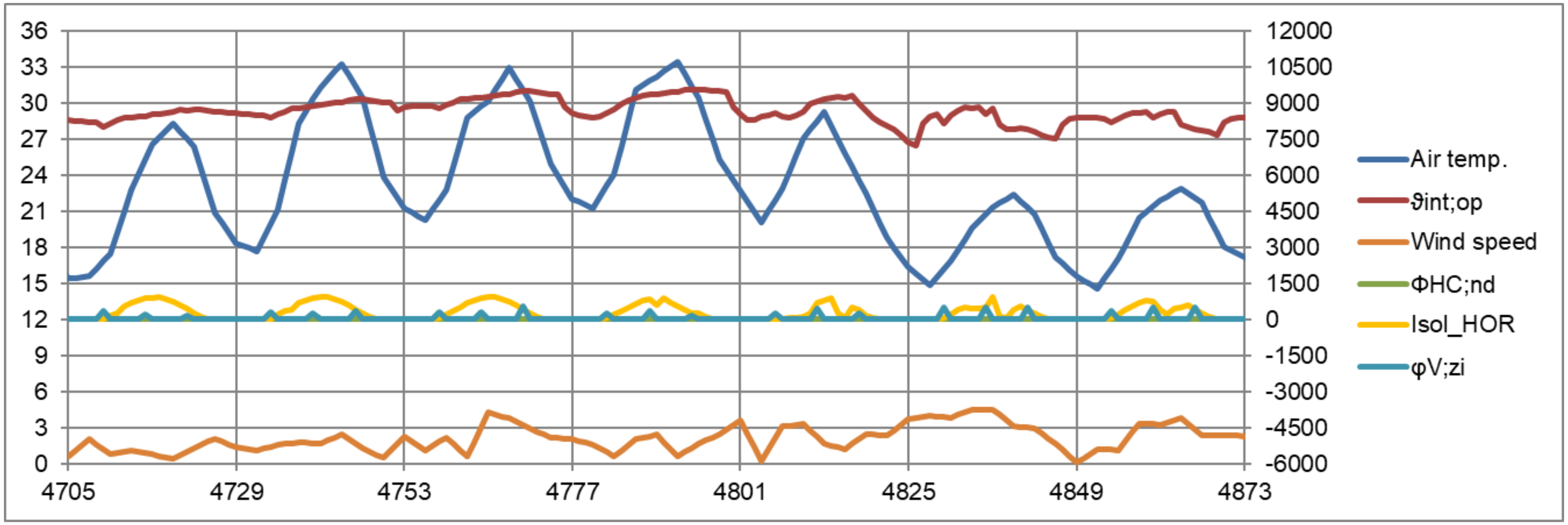


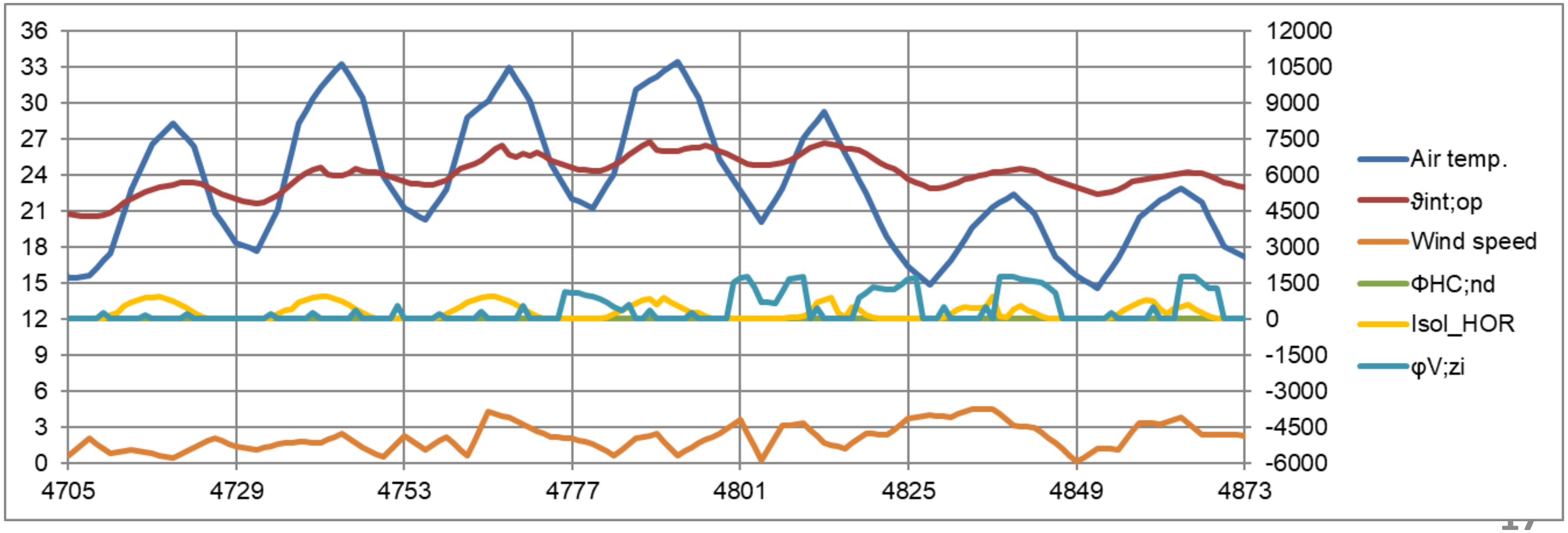
Winter results



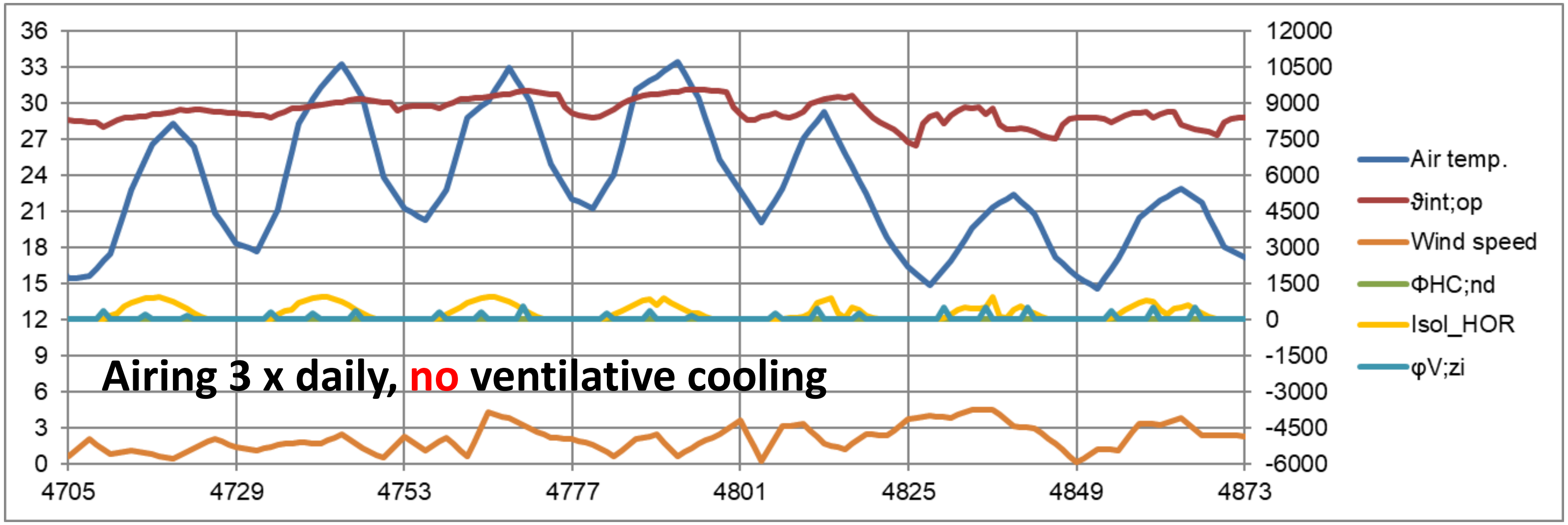


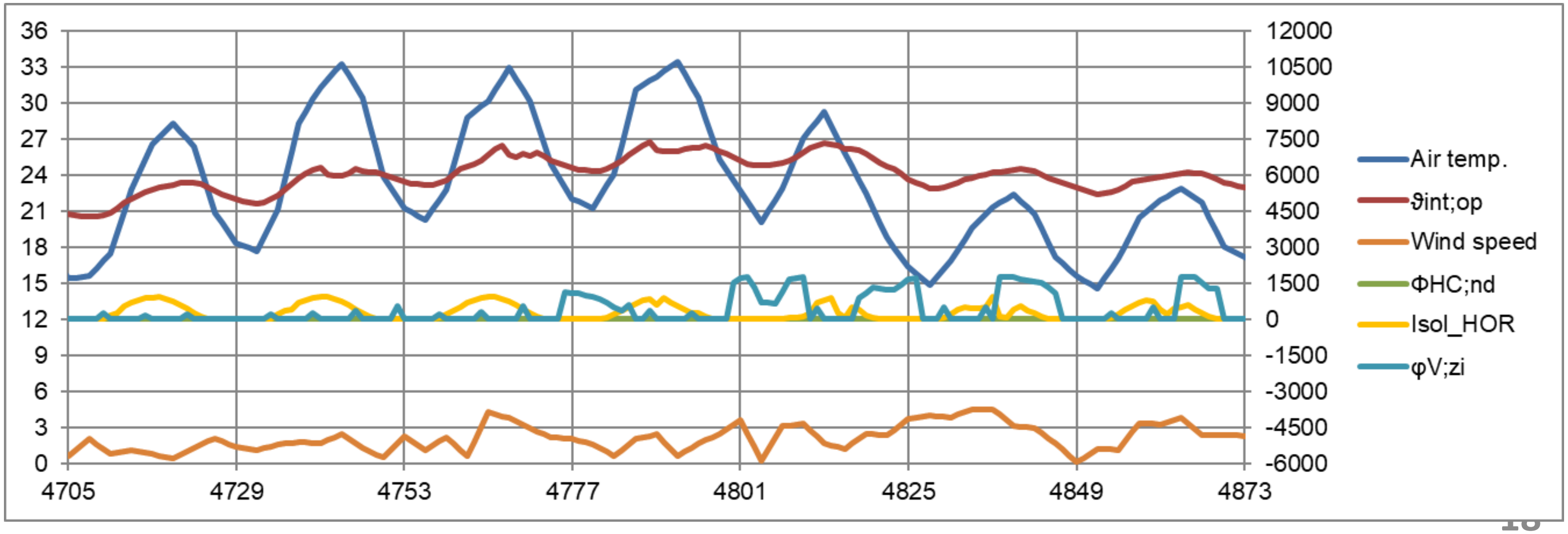
Summer results



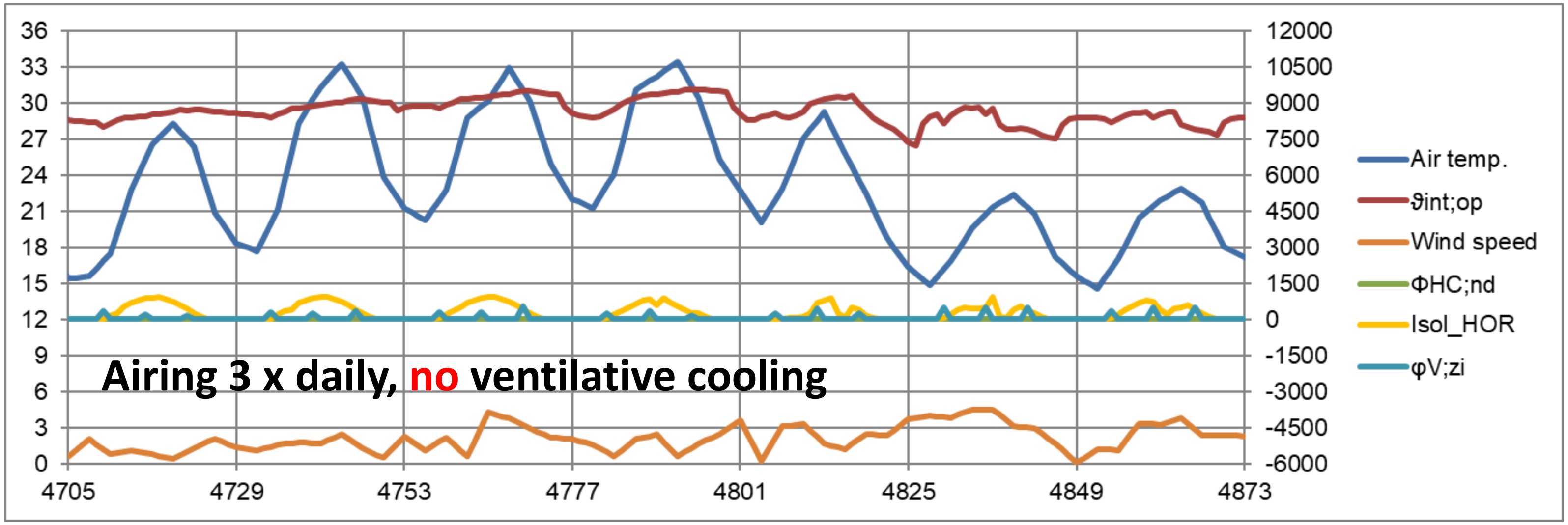


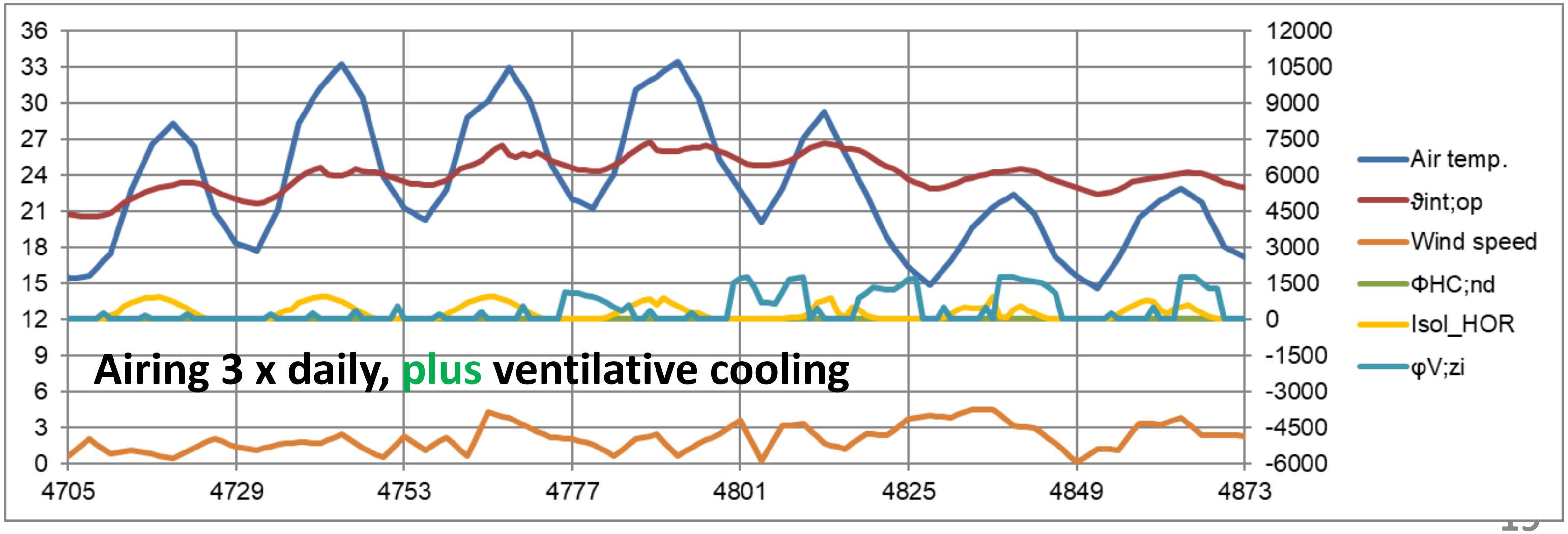
Summer results



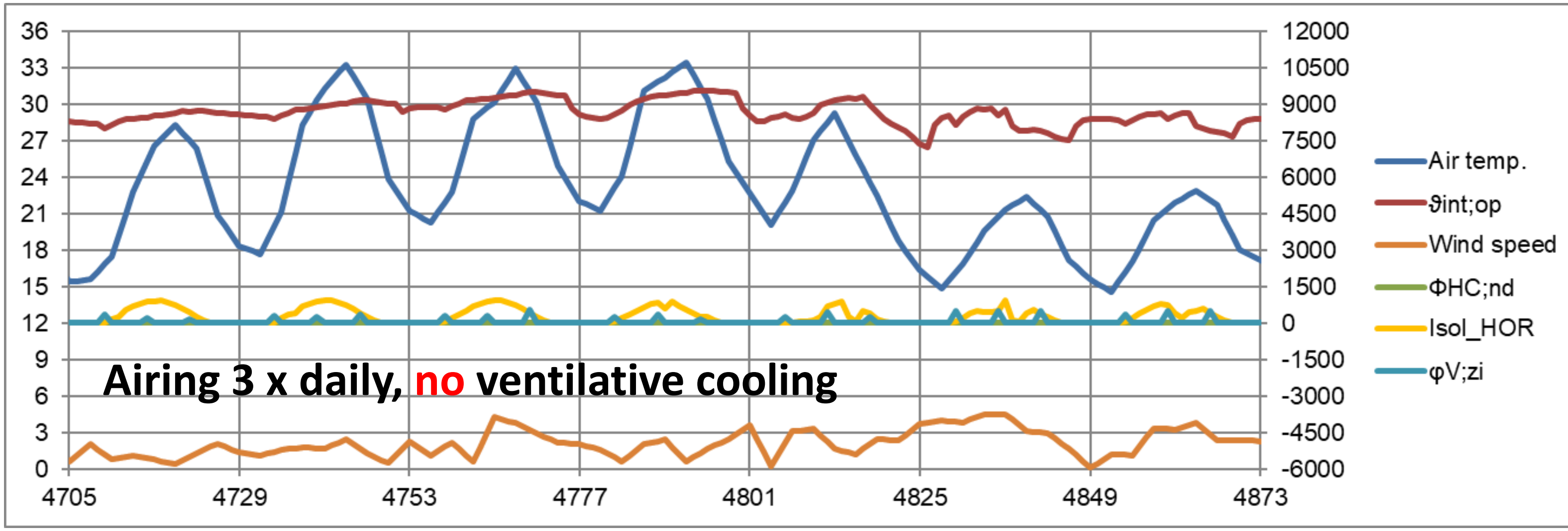


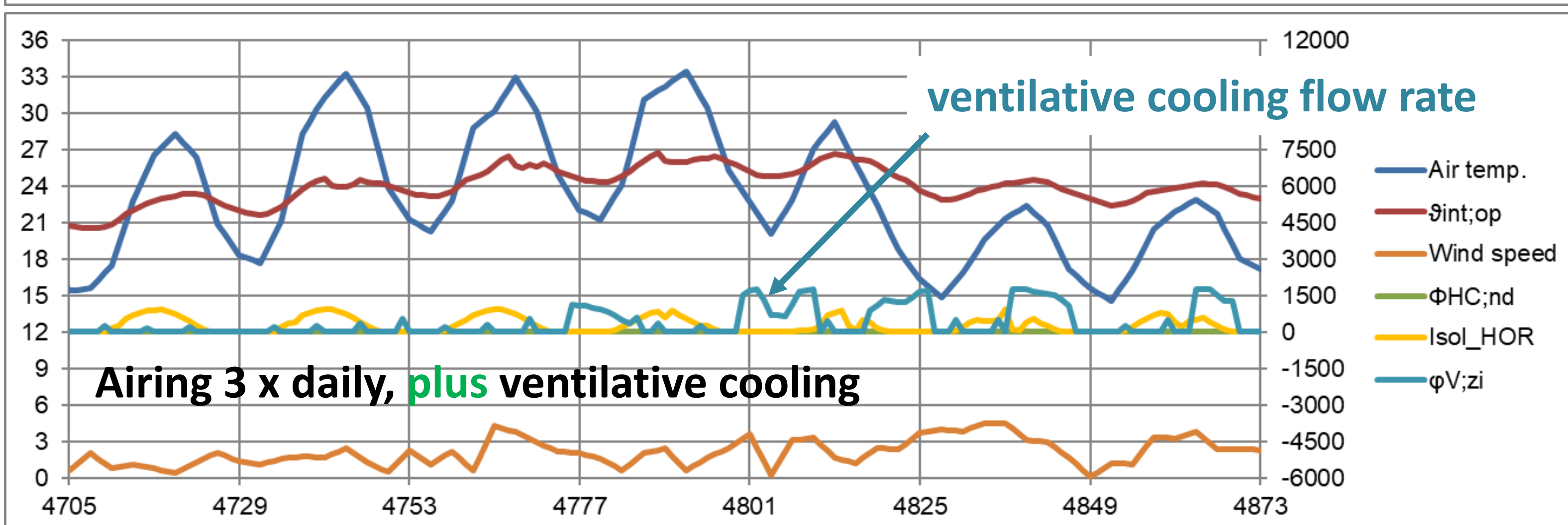
Summer results



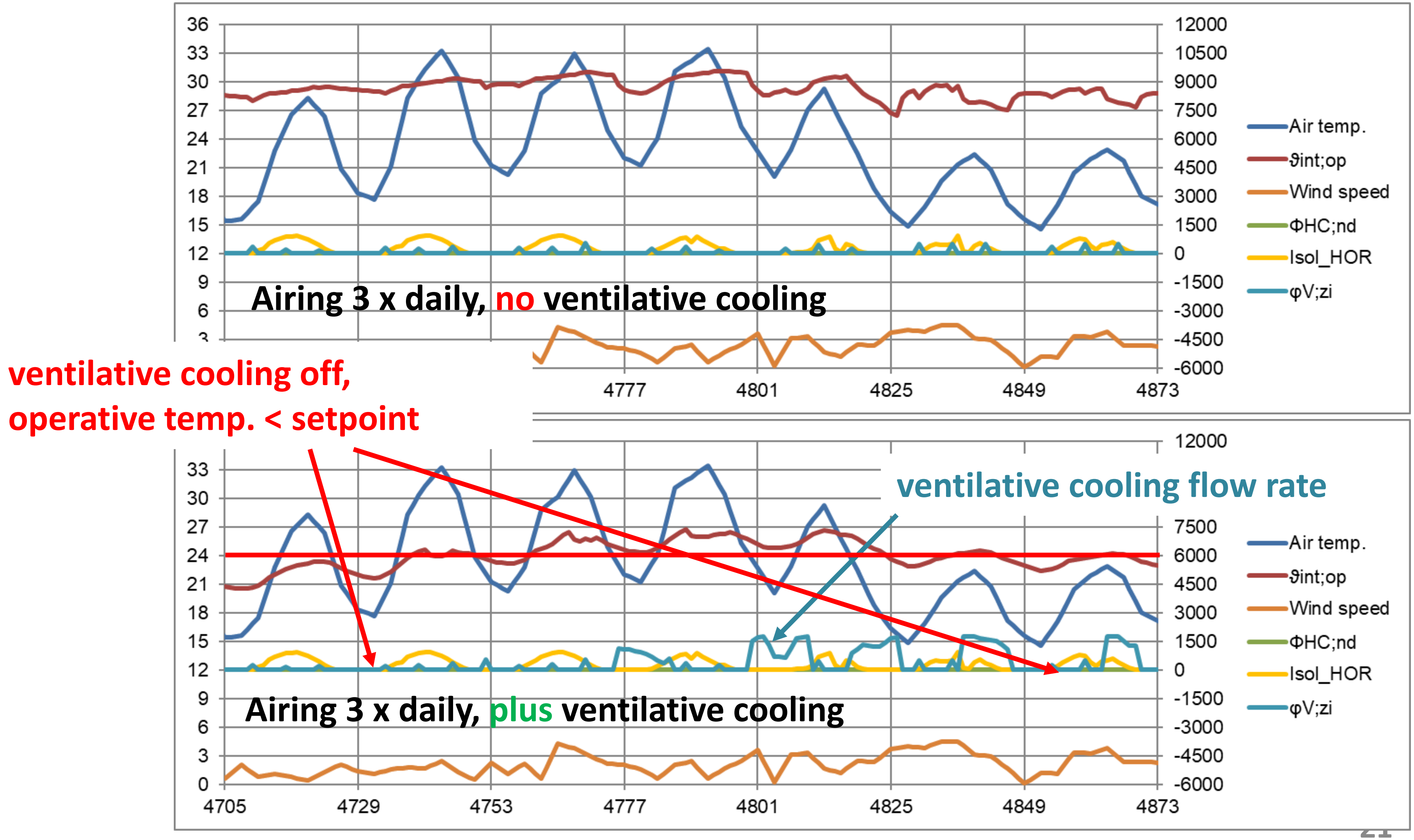


Summer results

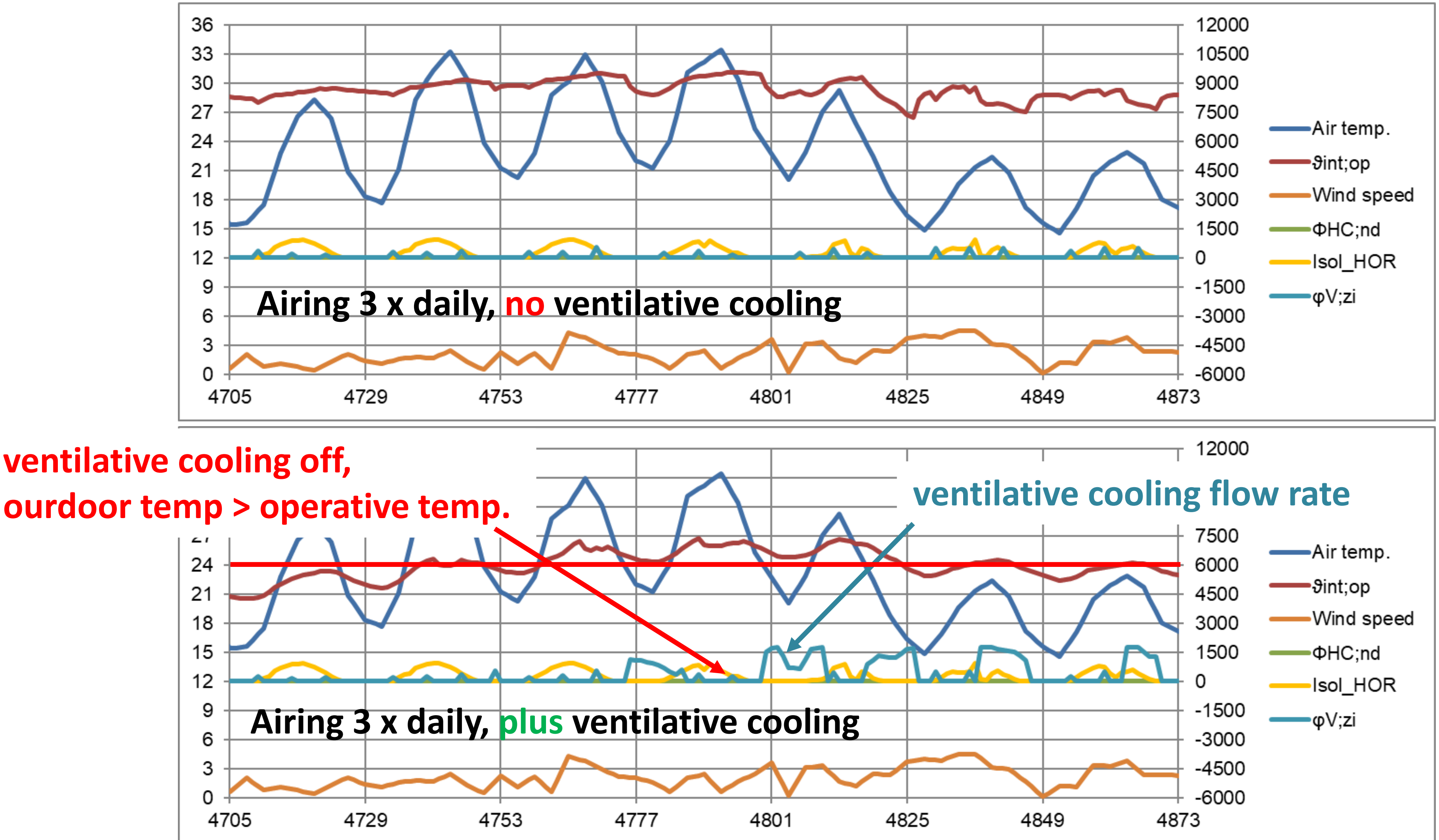




Summer results



Summer results



Conclusion and outlook

- Why spreadsheets?
  - Fully transparent step-by-step validation and demonstration
- Coupling brings in information on flow rates, depending on
  - opening options
  - climatic conditions
  - control options
- Other types of openings (vents, ducts, leakages) could be added to or replace windows
- Example calculation used only simplified calculation
  - Detailed calculation would raise calculation time, since iteration involved (each time step!)
  - > Rather not with EXCEL

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).

EPB CENTER

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

Whole building calculation indicator (EN-ISO 52000-1)

Laurent Socal

socal@iol.it

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 7: Example calculations with the set of EPB standards – (1) Introduction and overarching calculation procedures
6th October 2020

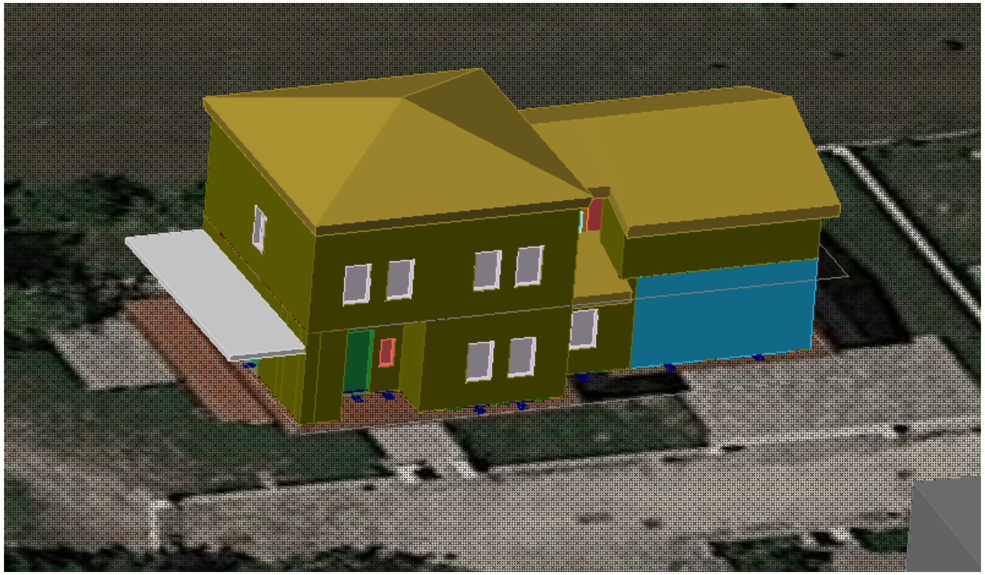
My background

- 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)

The building

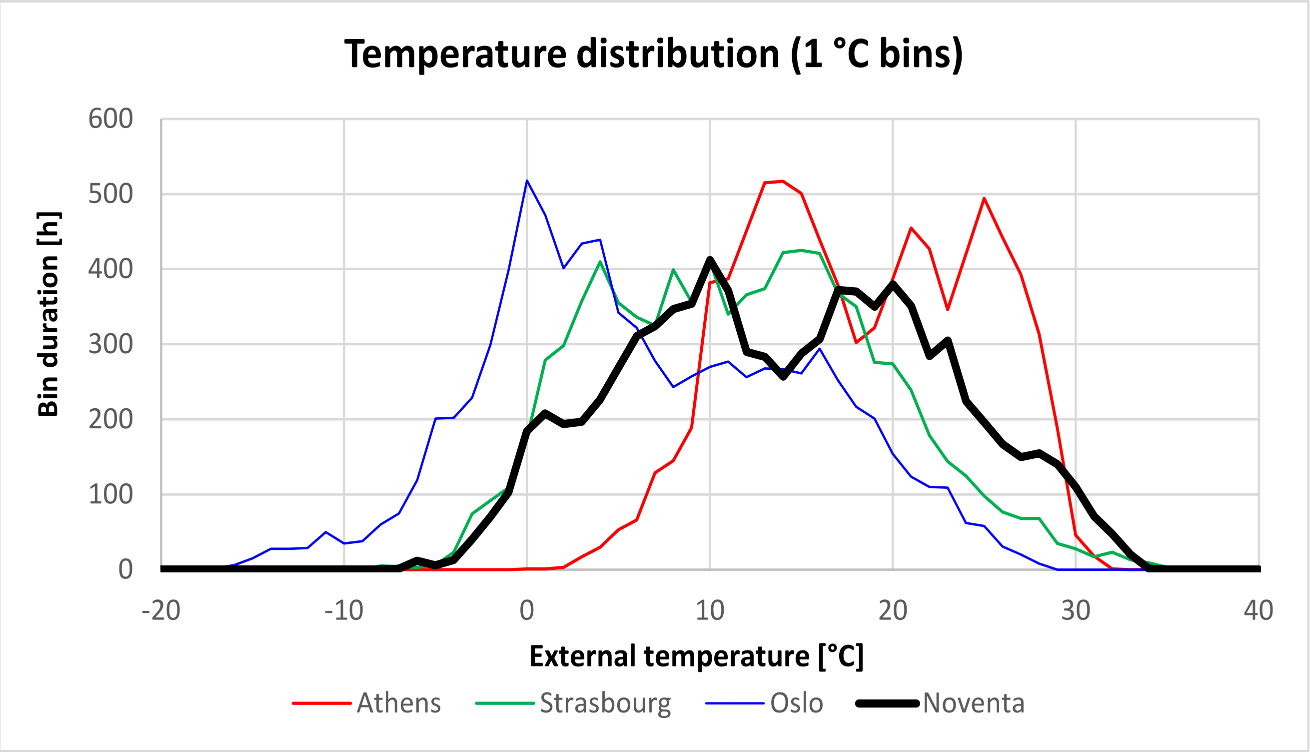
Single family house

180 m^2 floor area
Floor heating
Boiler or heat pump
Thermal solar
Storage 300 l
Optional PV 3kW
Optional battery 5kWh



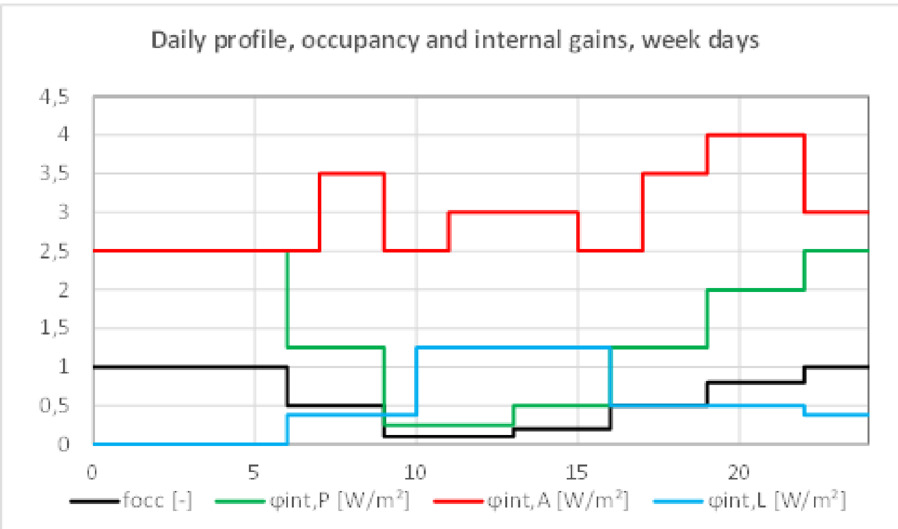
Natural ventilation n = 0,3 n^{-1}

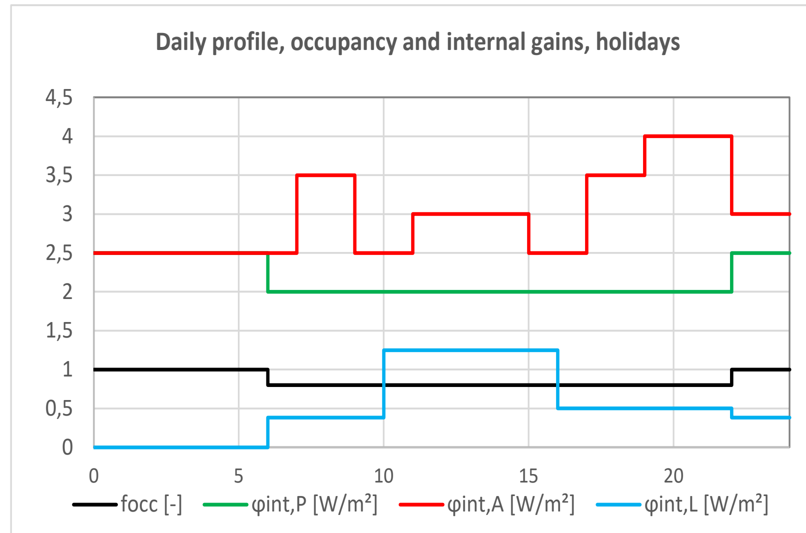
Climate



Generated via TMY and EN ISO 52010

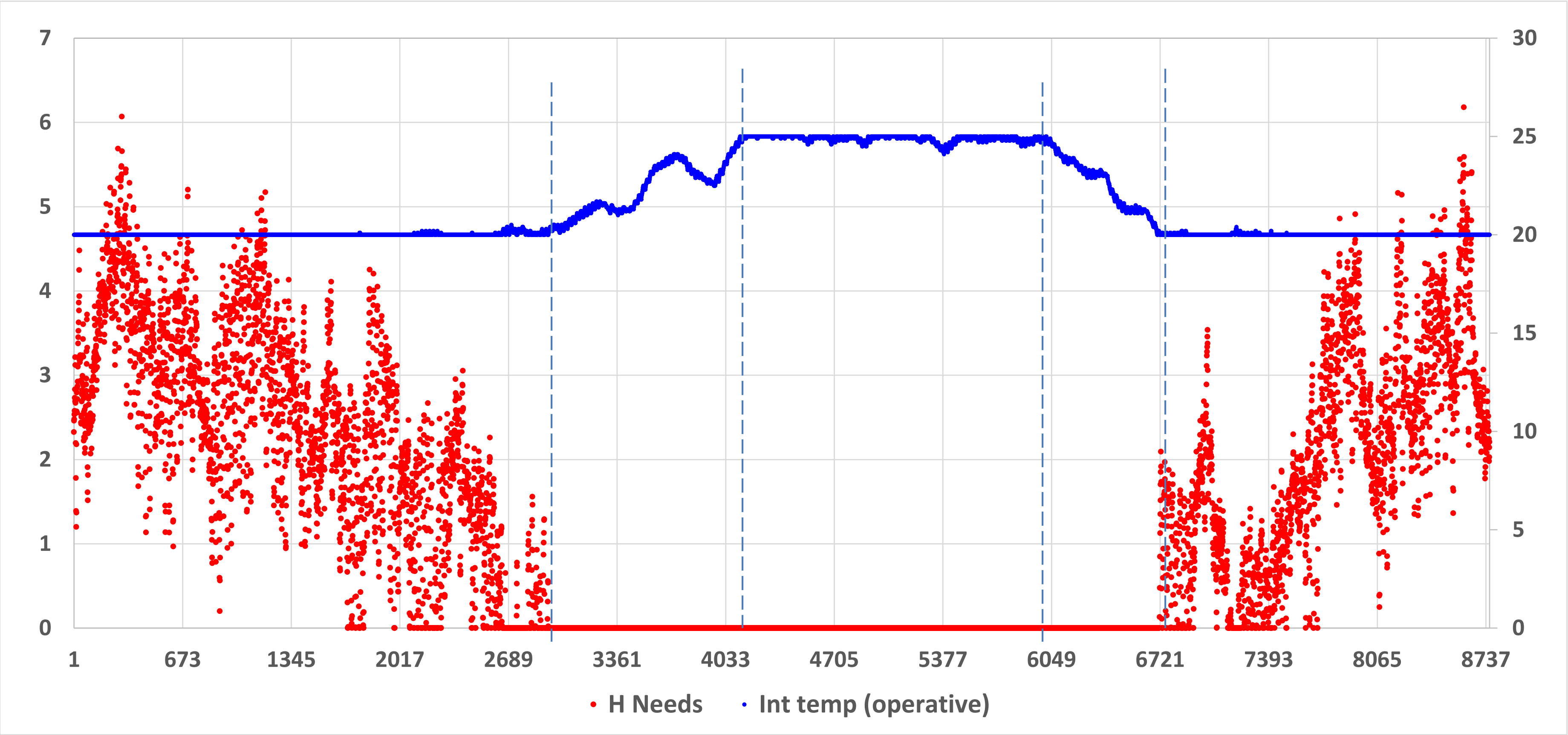
Use profile



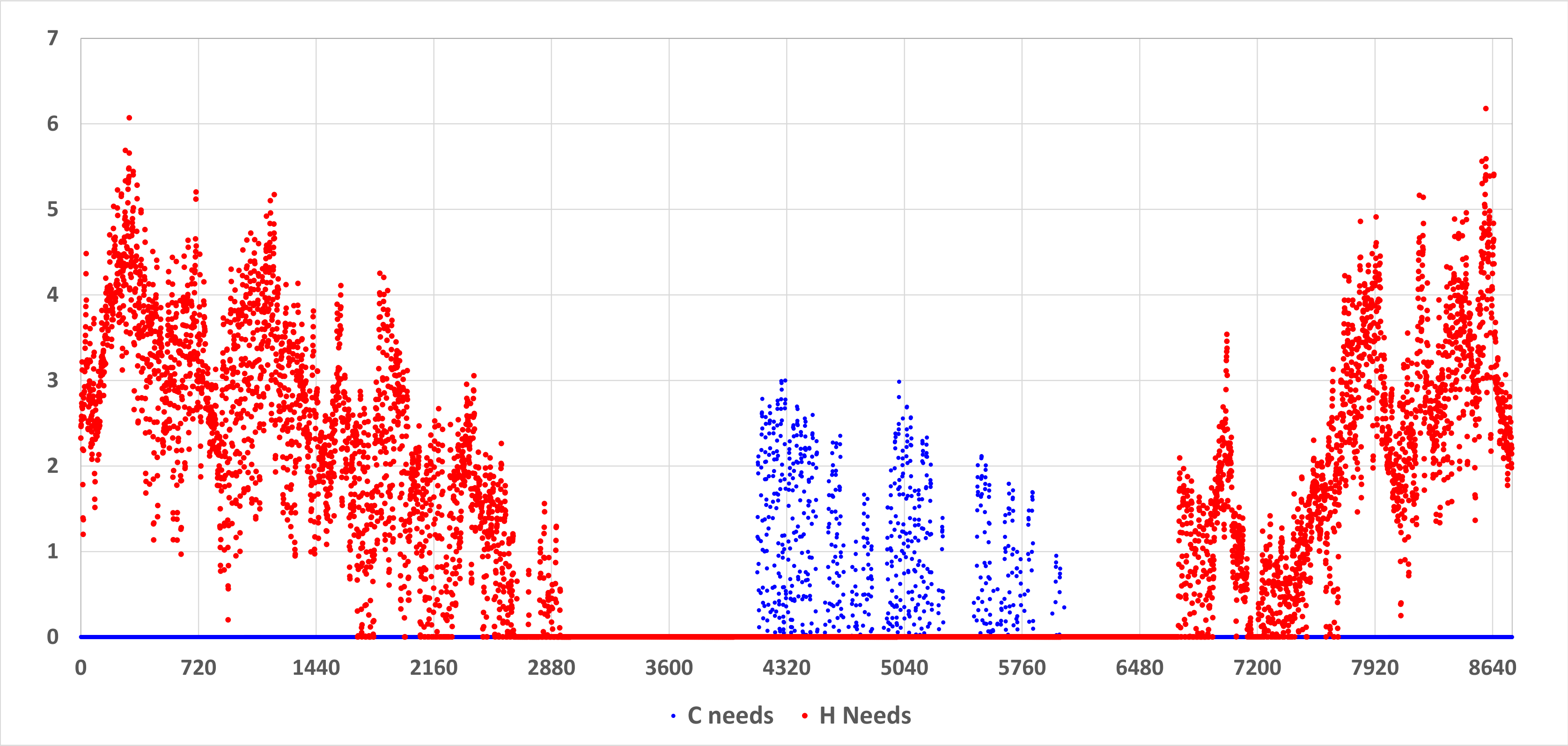


FROM EN 16798-1 – Single family house

Indoor temperature and heating needs

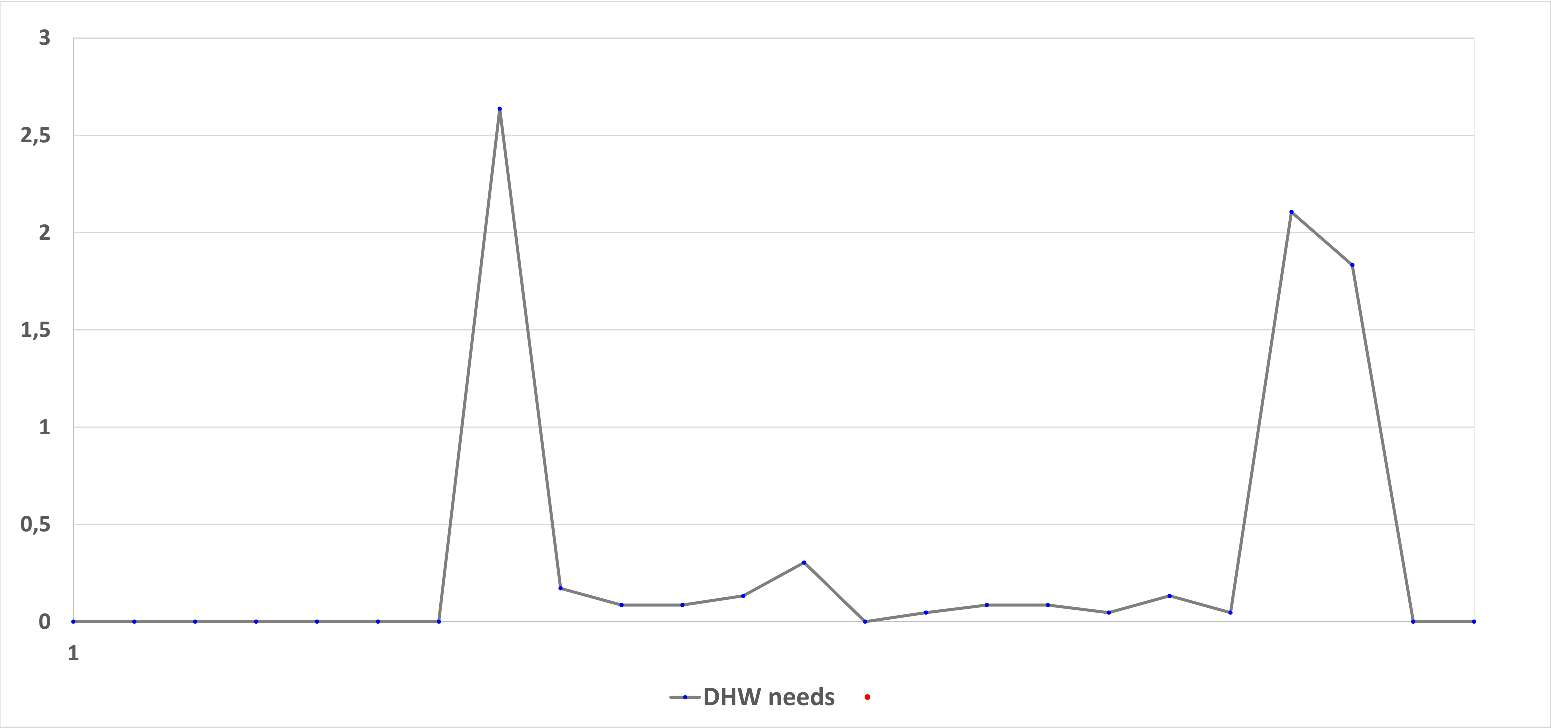


Heating and cooling needs



Software based on EN ISO 52016

Domestic hot water needs



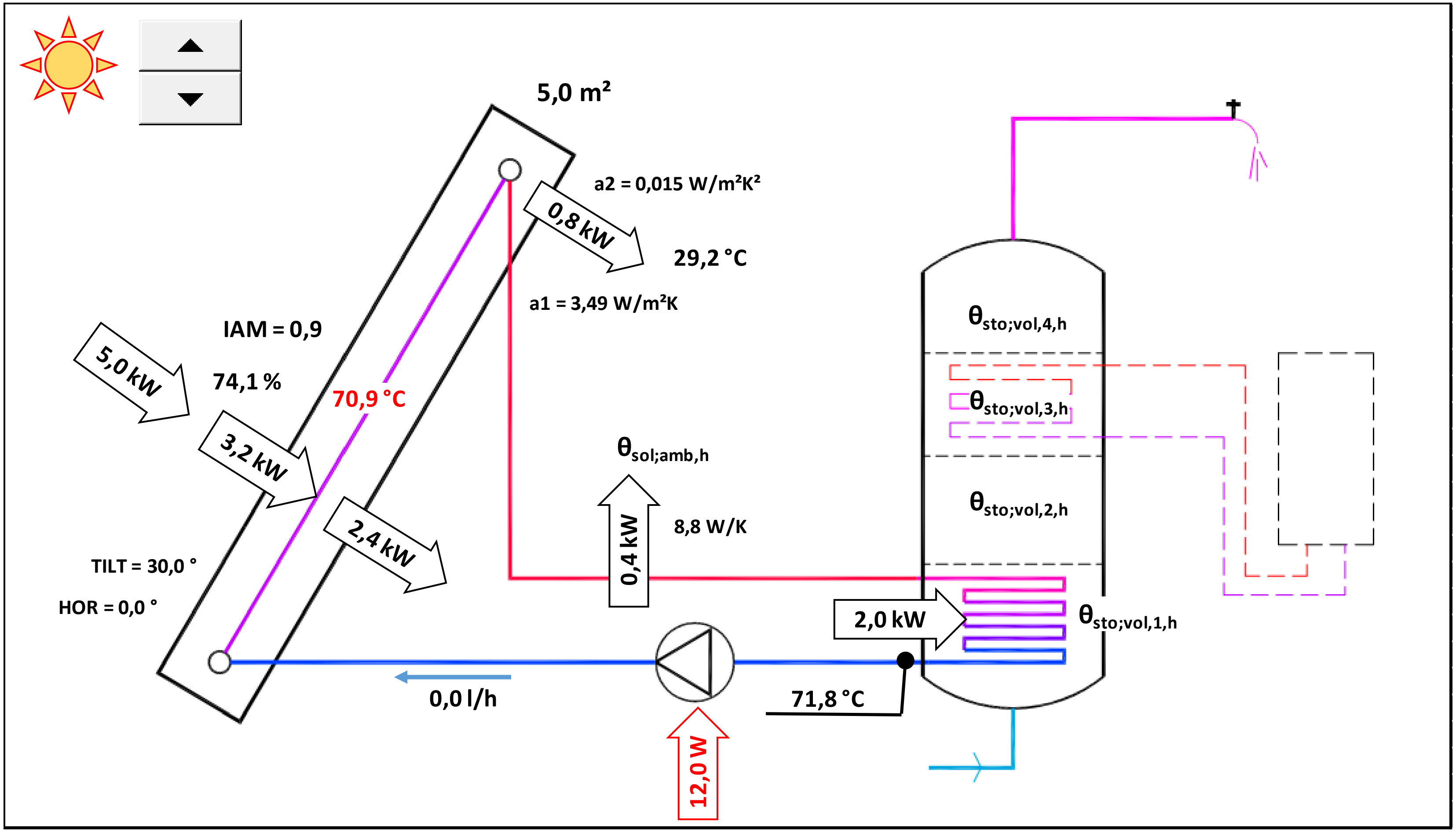
Calculated with EN 12831-3 daily needs and XL profile

Tabulated values of needs

Month	Heating needs	Domestic hot water needs	Cooling needs
	$Q_{H;nd}$	$Q_{W;nd}$	$Q_{C;nd}$
	kWh	kWh	kWh
January	2.552	242	0
February	1.955	218	0
March	1.424	242	0
April	606	234	0
May	12	242	0
June	0	234	228
July	0	242	419
August	0	242	216
September	0	234	7
October	486	242	0
November	1.394	234	0
December	2.212	242	0
Year	**10.640 kWh**	**2.847 kWh**	**870 kWh**
	59,1 kWh/m²y	15,8 kWh/m²y	4,8 kWh/m²y

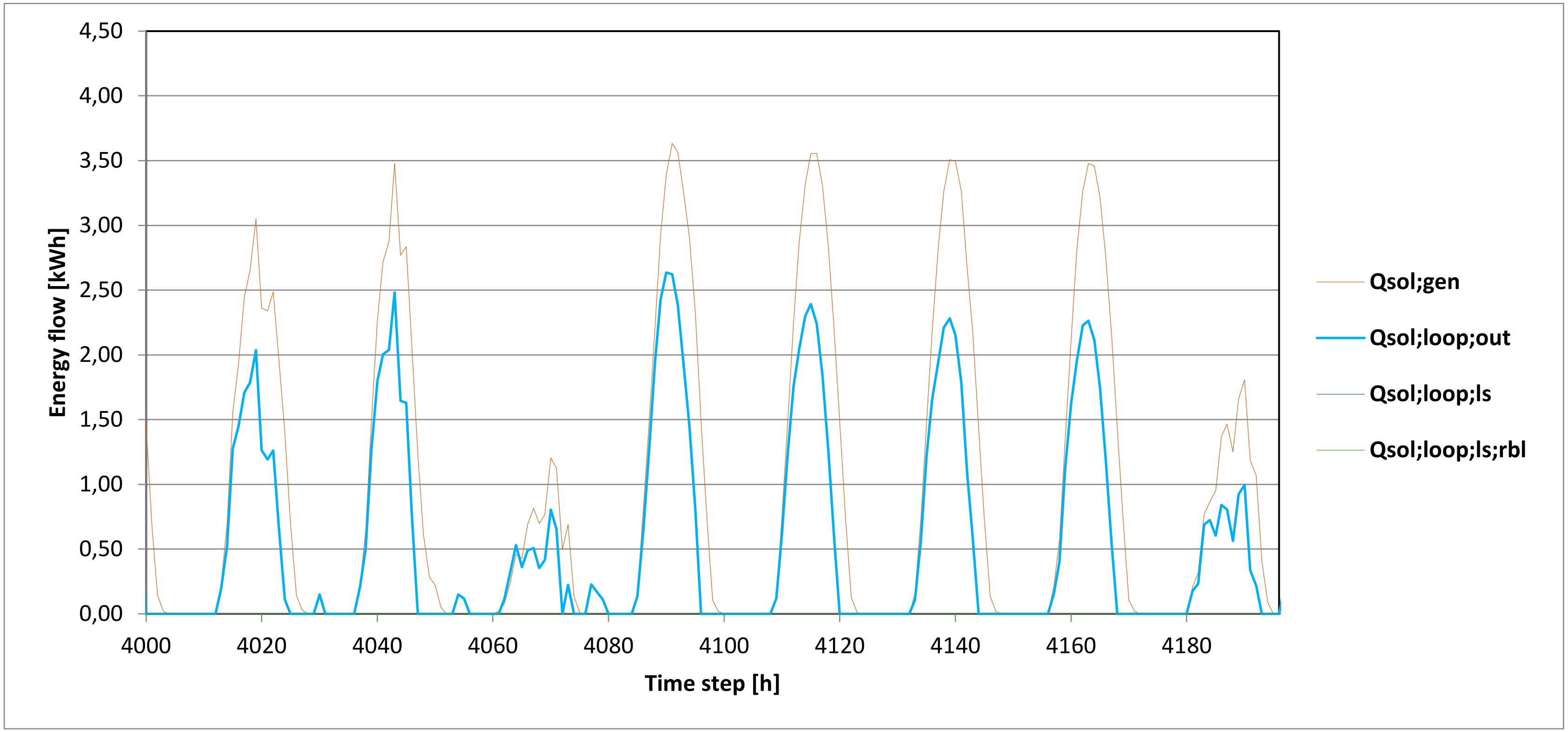
Heating still dominant. If heating improved, domestic hot water may be the highest

Thermal solar coupled with storage



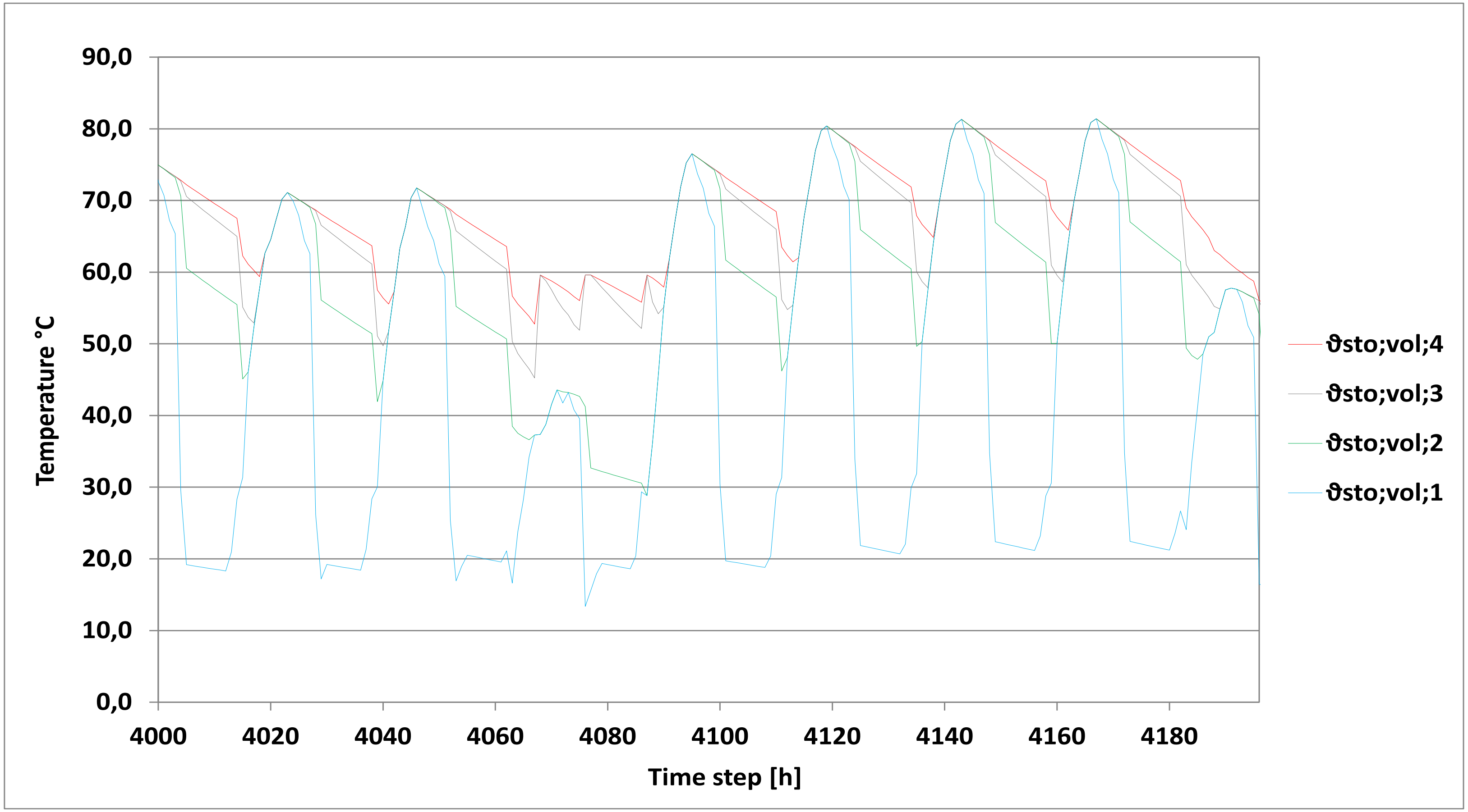
Calculated with EN 15316-4-3 coupled to EN 15316-5

Thermal solar



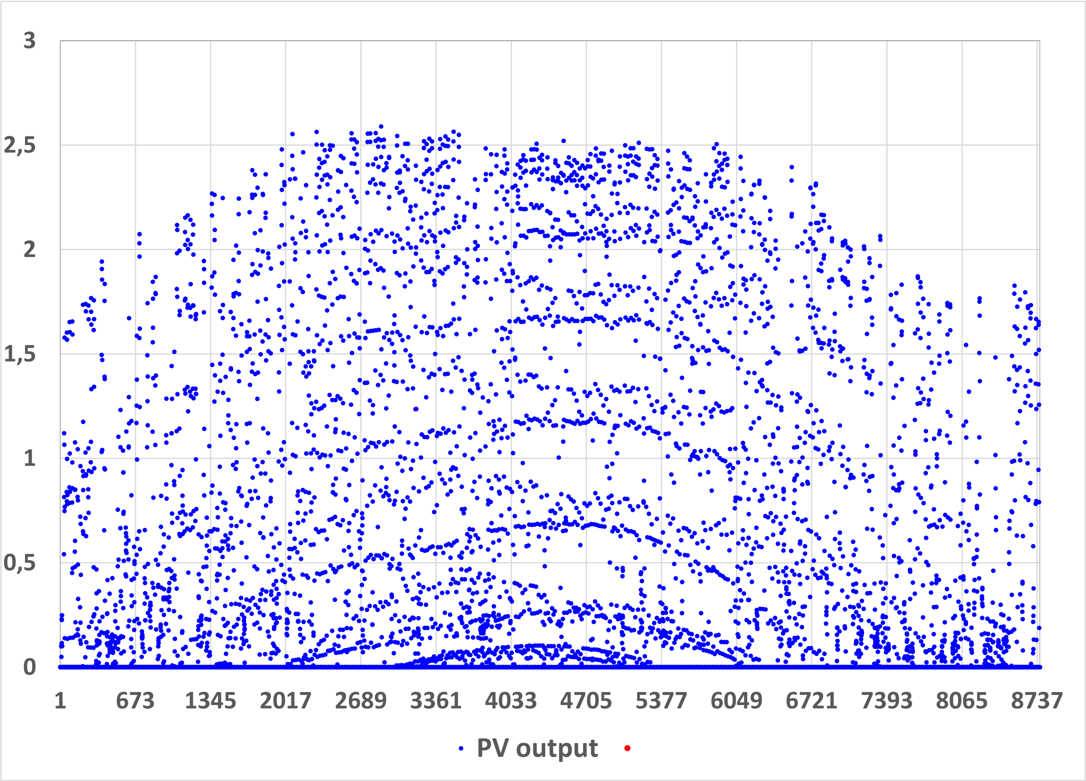
Calculated with EN 15316-4-3

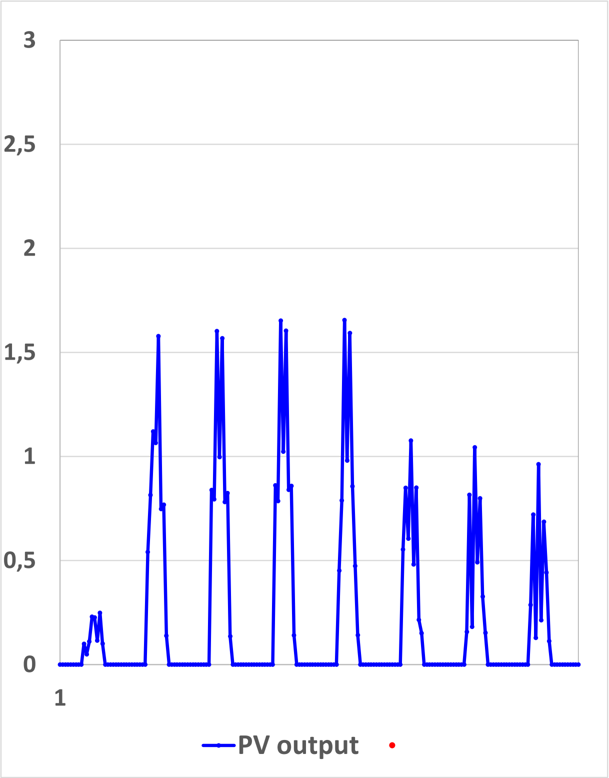
Storage



Calculated with EN 15316-5

Photovoltaic





Calculated with EN 15316-4-3

Potential contribution of REN

PV and thermal solar	Required distribution input	Energy from solar		Energy from back-up	PV electricity production
	$Q_{W;dis;in}$	$Q_{W;sto;in;sol}$		$Q_{W;sto;in;bu}$	$E_{del;el;t}$
	kWh	kWh	%	kWh	kWh
January	356	76	21%	281	166
February	321	111	34%	211	219
March	356	191	54%	164	325
April	344	191	55%	154	463
May	356	236	66%	119	509
June	344	233	68%	112	453
July	356	249	70%	107	553
August	356	243	68%	112	485
September	344	210	61%	134	383
October	356	214	60%	141	305
November	344	127	37%	218	171
December	356	78	22%	278	140
Year	**4.191**	**2.159**	**52%**	**2.033**	**4.175**

Potential is limited by the available surface

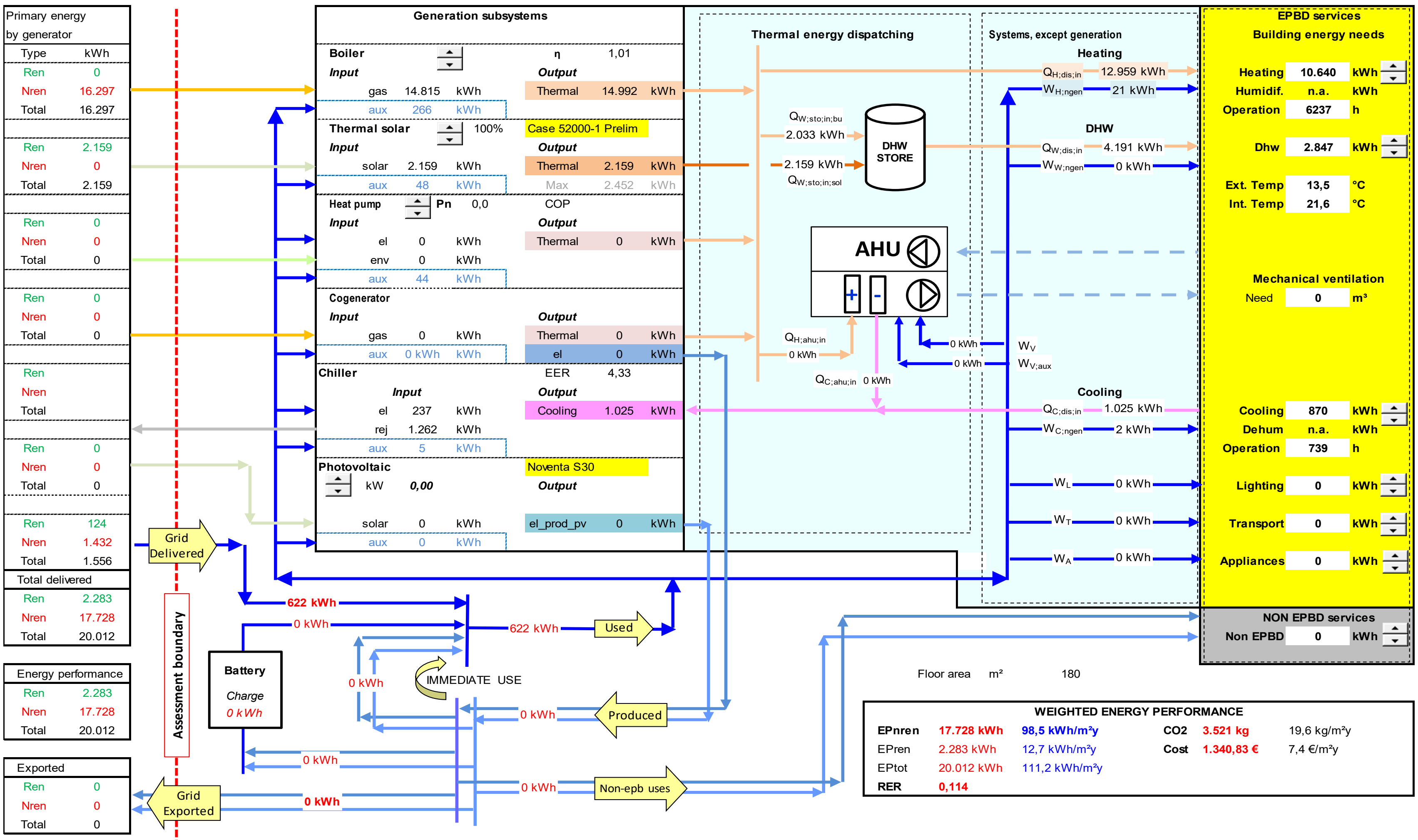
Other systems

Other systems have been estimated with simple equations.

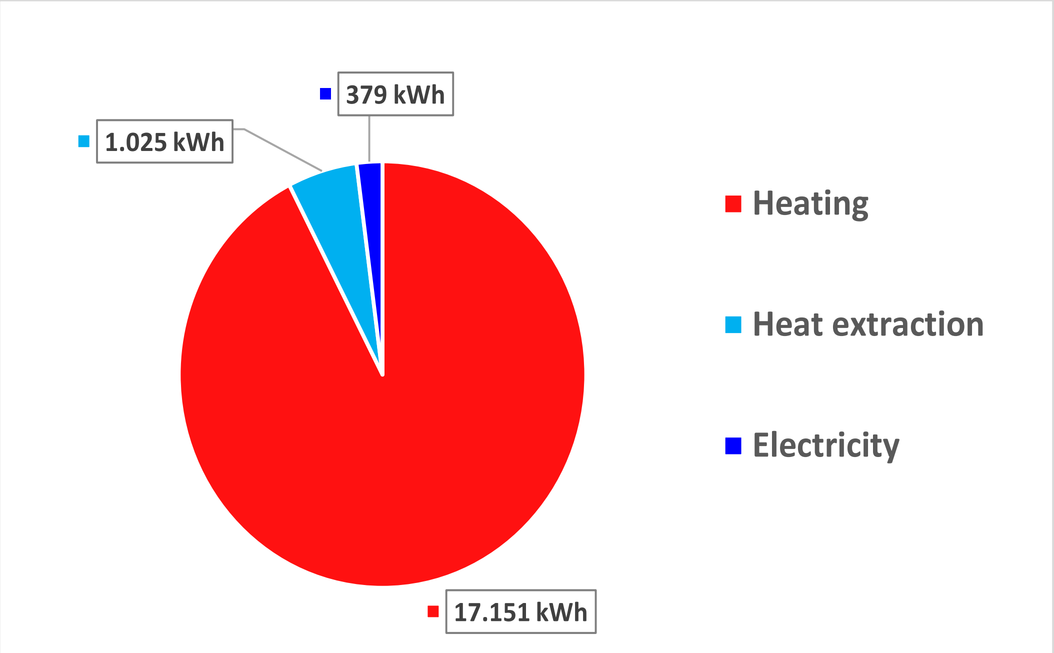
- **Auxiliaries and losses of non generation systems**
- **Temperature of distribution according to outdoor temperature (outdoor temperature reset)**
- **Boiler efficiency depending on water temperature**
- **Constant II principle efficiency for the heat pump = 0,4**
- **AW Heat pump capacity decreasing with outdoor temperature**

→ Reasonable replacement of some of the technical systems standards to show the overall result of some technology options on a realistic hourly pattern

Overall scheme



Required to generation



Climate and building type will influence this basic distribution

Heat can be generated by

- Combustion
- Thermal solar
- Heat pump
- Cogen
- District heating

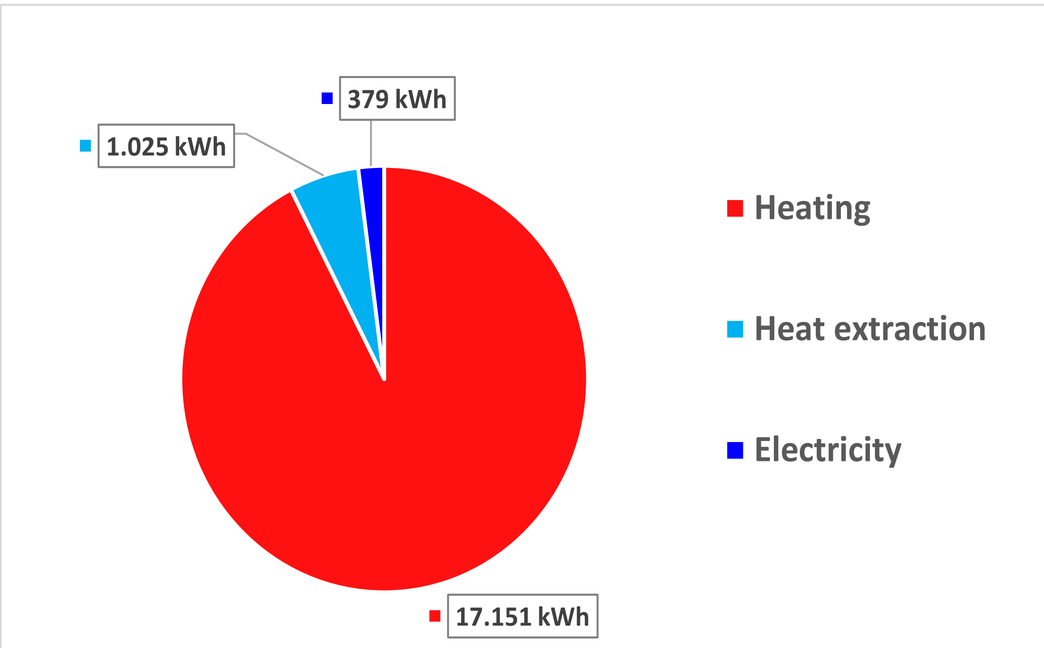
Heat extraction

- Electric heat pump
- Absorption heat pump
- District cooling

Electricity

- Grid
- PV
- Cogen

Required to generation



Available on site renewable sources
2159 kWh thermal solar (d.h.w.)
4175 kWh electricity

The selection of the generators will determine the final share between

- Electricity
- Other fuels

With electricity →
may be produced on-site from renewable sources

With other fuels →
energy performance bound to properties of energy carrier
… but you may still use biofuels

1 - Boiler + TS k_{exp}=0

Weighted energy performance	Non-renewable primary energy	Renewable primary energy	Total primary energy	CO2 emission	Cost	RER
	E_{Pnren}	E_{Pren}	E_{Ptot}	CO_2	Cost	RER
	kWh	kWh	kWh	kg co2	€	
January	3.839	89	3.928	765	284,69	0,02
February	2.932	121	3.053	584	217,61	0,04
March	2.148	199	2.347	428	159,70	0,08
April	1.025	196	1.220	204	76,63	0,16
May	184	239	422	36	14,49	0,57
June	311	249	560	59	29,18	0,44
July	422	275	697	79	41,45	0,39
August	293	257	550	56	27,22	0,47
September	189	213	403	37	15,01	0,53
October	848	219	1.066	169	63,59	0,20
November	2.175	136	2.310	433	161,65	0,06
December	3.364	90	3.454	671	249,63	0,03
Year	17.728	2.283	20.012	3.521	1.340,83	0,11
	98,5 kWh/m²y		111,2 kWh/m²y	19,6 kg/m²y	7,4 €/m²y	

Base case

No exported energy

No influence of parameters

Monthly OK

2 - Boiler + TS + PV k_{exp}=0

Weighted energy performance	Non-renewable primary energy	Renewable primary energy	Total primary energy	CO2 emission	Cost	RER
	E_{Pnren}	E_{Pren}	E_{Ptot}	CO_2	Cost	RER
	kWh	kWh	kWh	kg co2	€	
January	3.790	106	3.897	756	279,45	0,03
February	2.891	136	3.026	577	213,08	0,04
March	2.109	213	2.322	421	155,46	0,09
April	995	206	1.201	199	73,46	0,17
May	164	246	410	33	12,37	0,60
June	166	300	465	32	13,39	0,64
July	192	355	547	37	16,46	0,65
August	167	301	468	33	13,56	0,64
September	170	220	390	34	12,89	0,57
October	827	226	1.053	165	61,39	0,21
November	2.145	146	2.291	428	158,41	0,06
December	3.327	103	3.430	664	245,56	0,03
Year	**16.943**	**2.556**	**19.500**	**3.377**	**1.255,47**	**0,13**
	94,1 kWh/m²y		108,3 kWh/m²y	18,8 kg/m²y	7,0 €/m²y	

Base case and PV

Kexp = 0

Exported energy not accounted

Little contribution of PV also due to time mismatch

2 - Boiler + TS + PV $k_{exp}=0$

Weighted energy performance	Non-renewable primary energy	Renewable primary energy	Total primary energy	CO2 emission	Cost	RER
	E_{Pnren}	E_{Pren}	E_{Ptot}	CO_2	Cost	RER
	kWh	kWh	kWh	kg co2	€	
January	3.685	143	3.828	737	268,02	0,04
February	2.811	163	2.975	562	204,47	0,05
March	2.050	233	2.284	410	149,12	0,10
April	966	216	1.182	193	70,24	0,18
May	152	250	402	30	11,05	0,62
June	128	313	441	26	9,31	0,71
July	122	379	502	24	8,89	0,76
August	129	314	443	26	9,37	0,71
September	154	226	380	31	11,21	0,59
October	794	237	1.031	159	57,74	0,23
November	2.078	169	2.247	416	151,10	0,08
December	3.227	137	3.364	645	234,69	0,04
Year	**16.297**	**2.781**	**19.078**	**3.259**	**1.185,22**	**0,15**
	90,5 kWh/m²y		106,0 kWh/m²y	**18,1 kg/m²y**	**6,6 €/m²y**	

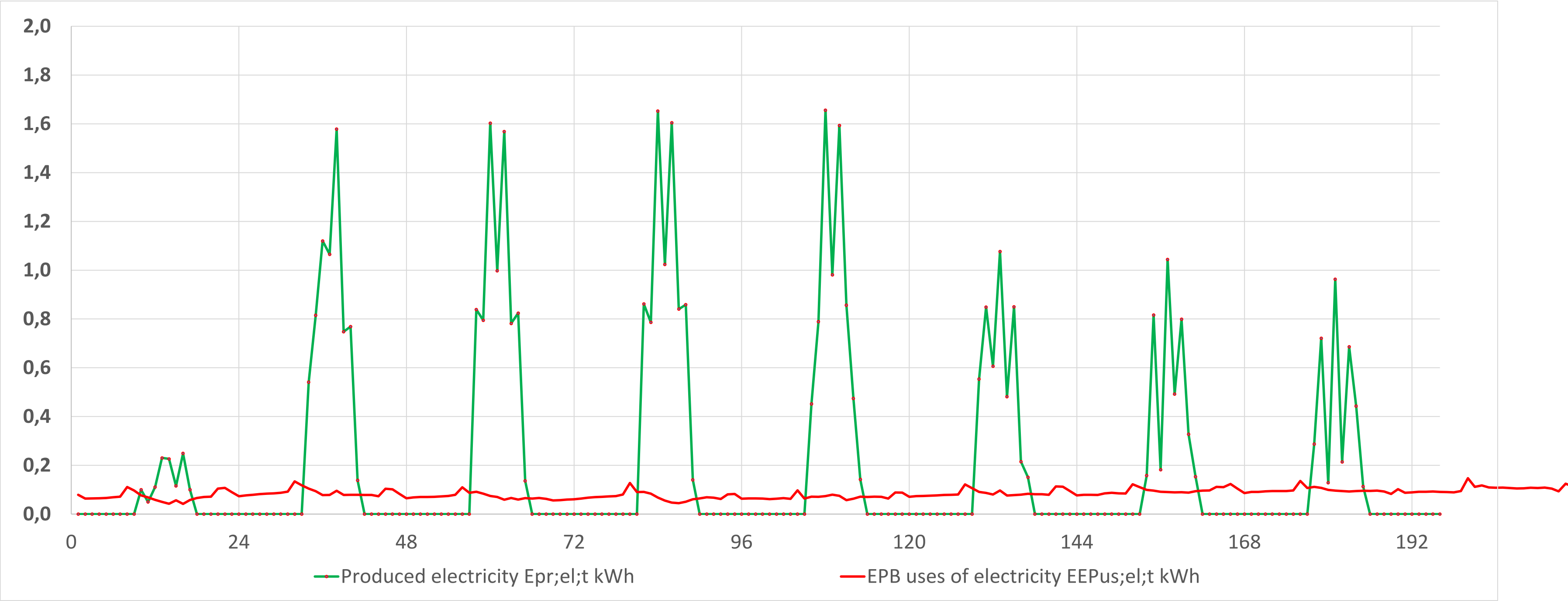
Base case and PV

Kexp = 0

Exported energy not accounted

Monthly calculation based on aggregated hourly imput data = same input

Time mismatch



PV comes in at the wrong time: a lot of PV during the day

Comparison

Hourly

Electricity balance	Electricity required for EPB uses	Electricity produced on-site	Electricity produced and used for EPB uses	Electricity exported to the grid	Grid delivered electricity, t
	$E_{EPus;el;t}$	$E_{pr;el;t}$	$E_{pr;el;used;EPus;t}$	$E_{exp;el;grid;t}$	$E_{del;el;t}$
	kWh	kWh	kWh	kWh	kWh
January	67	166	21	146	46
February	53	219	18	201	34
March	42	325	17	308	25
April	26	463	13	451	13
May	14	509	8	500	5
June	79	453	63	390	16

Monthly

Electricity balance	Electricity required for EPB uses	Electricity produced on-site	Electricity produced and used for EPB uses	Electricity exported to the grid	Grid delivered electricity, t
	$E_{EPus;el;t}$	$E_{pr;el;t}$	$E_{pr;el;used;EPus;t}$	$E_{exp;el;grid;t}$	$E_{del;el;t}$
	kWh	kWh	kWh	kWh	kWh
January	67	166	67	100	0
February	53	219	53	167	0
March	42	325	42	283	0
April	26	463	26	438	0
May	14	509	14	495	0
June	79	453	79	374	0

3 - Boiler + TS + PV k_{exp}=1

Weighted energy performance	Non-renewable primary energy	Renewable primary energy	Total primary energy	CO2 emission	Cost	RER
	E_{Pnren}	E_{Pren}	E_{Ptot}	CO_2	Cost	RER
	kWh	kWh	kWh	kg co2	€	
January	3.456	223	3.678	695	247,43	0,06
February	2.428	297	2.724	492	168,78	0,11
March	1.400	460	1.859	291	87,63	0,25
April	-41	566	525	9	-25,66	1,08
May	-986	646	-341	-177	-97,68	-1,90
June	-732	612	-120	-131	-72,47	-5,09
July	-850	718	-133	-153	-83,23	-5,41
August	-822	645	-177	-148	-81,12	-3,64
September	-692	520	-172	-124	-69,55	-3,02
October	146	463	609	40	-3,78	0,76
November	1.780	273	2.053	361	123,55	0,13
December	3.042	202	3.244	612	218,27	0,06
Year	**8.127**	**5.623**	**13.750**	**1.767**	**412,16**	**0,41**
	45,1 kWh/m²y		**76,4 kWh/m²y**	**9,8 kg/m²y**	**2,3 €/m²y**	

Base case and PV

Kexp = 1

Exported energy is accounted and compensates the use of fossil fuel

All PV is included

No difference with monthly method … until weighting factors are constant

4 – HP + TS k_{exp} = 0

Weighted energy performance	Non-renewable primary energy	Renewable primary energy	Total primary energy	CO2 emission	Cost	RER
	E_{Pnren}	E_{Pren}	E_{Ptot}	CO_2	Cost	RER
	kWh	kWh	kWh	kg co2	€	
January	2.130	2.717	4.847	390	228,84	0,56
February	1.502	2.194	3.695	275	162,34	0,59
March	963	1.774	2.737	176	104,50	0,65
April	440	946	1.386	80	47,80	0,68
May	111	344	454	20	12,03	0,76
June	246	338	584	45	26,71	0,58
July	358	360	719	65	38,92	0,50
August	228	346	574	42	24,79	0,60
September	121	317	438	22	13,19	0,72
October	368	834	1.202	67	39,96	0,69
November	1.053	1.694	2.747	192	114,06	0,62
December	1.759	2.436	4.195	322	189,14	0,58
Year	**9.277**	14.300	23.577	**1.697**	**1.002,28**	**0,61**
	51,5 kWh/m²y		131,0 kWh/m²y	**9,4 kg/m²y**	**5,6 €/m²y**	

Base case with heat pump

Kexp = 0

Heat pump has a better efficiency

6 – HP + PV + TS $k_{exp} = 0$

Weighted energy performance	Non-renewable primary energy	Renewable primary energy	Total primary energy	CO2 emission	Cost	RER
	E_{Pnren}	E_{Pren}	E_{Ptot}	CO_2	Cost	RER
	kWh	kWh	kWh	kg co2	€	
January	1.835	2.819	4.655	336	196,84	0,61
February	1.216	2.293	3.509	222	131,31	0,65
March	741	1.852	2.592	135	80,37	0,71
April	306	992	1.298	56	33,26	0,76
May	70	358	428	13	7,64	0,84
June	84	394	478	15	9,12	0,82
July	113	446	559	21	12,25	0,80
August	92	394	485	17	9,95	0,81
September	95	326	420	17	10,28	0,78
October	285	863	1.148	52	31,00	0,75
November	890	1.751	2.640	163	96,34	0,66
December	1.546	2.510	4.056	283	166,01	0,62
Year	**7.272**	**14.997**	**22.269**	**1.331**	**784,37**	**0,67**
	40,4 kWh/m²y		**123,7 kWh/m²y**	**7,4 kg/m²y**	**4,4 €/m²y**	

Base case with heat pump and PV

Kexp = 0

Heat pump has a better efficiency.

PV contributes partially

Heat pump is running continuously, could be intermittent to improve performance

7 – HP + PV + TS $k_{exp} = 1$

Weighted energy performance	Non-renewable primary energy	Renewable primary energy	Total primary energy	CO2 emission	Cost	RER
	E_{Pnren}	E_{Pren}	E_{Ptot}	CO_2	Cost	RER
	kWh	kWh	kWh	kg co2	€	
January	1.747	2.850	4.597	320	188,38	0,62
February	997	2.369	3.366	182	110,33	0,70
March	215	2.035	2.249	39	30,05	0,90
April	-626	1.316	691	-114	-55,85	1,91
May	-1.059	751	-309	-193	-100,41	-2,43
June	-797	701	-97	-146	-75,15	-7,25
July	-914	803	-111	-167	-85,96	-7,23
August	-887	734	-153	-162	-83,70	-4,80
September	-760	623	-137	-139	-71,47	-4,55
October	-334	1.078	744	-61	-28,23	1,45
November	659	1.831	2.490	120	74,22	0,74
December	1.436	2.548	3.984	263	155,49	0,64
Year	**-325**	**17.639**	**17.315**	**-56**	**57,70**	**1,02**
	-1,8 kWh/m²y		**96,2 kWh/m²y**	**-0,3 kg/m²y**	**0,3 €/m²y**	

Base case with heat pump and PV

Kexp = 1

Heat pump has a better efficiency.

PV contributes totally

Time mismatch between electricity production and use is hidden by Kexp=1

7 – HP + PV + TS k_{exp} = 1

Weighted energy performance	Non-renewable primary energy	Renewable primary energy	Total primary energy	CO2 emission	Cost	RER
	E_{Pnren}	E_{Pren}	E_{Ptot}	CO_2	Cost	RER
	kWh	kWh	kWh	kg co2	€	
January	1.747	2.850	4.597	320	188,38	0,62
February	997	2.369	3.366	182	110,33	0,70
March	215	2.035	2.249	39	30,05	0,90
April	-626	1.316	691	-114	-55,85	1,91
May	-1.059	751	-309	-193	-100,41	-2,43
June	-797	701	-97	-146	-75,15	-7,25
July	-914	803	-111	-167	-85,96	-7,23
August	-887	734	-153	-162	-83,70	-4,80
September	-760	623	-137	-139	-71,47	-4,55
October	-334	1.078	744	-61	-28,23	1,45
November	659	1.831	2.490	120	74,22	0,74
December	1.436	2.548	3.984	263	155,49	0,64
Year	**-325**	**17.639**	**17.315**	**-56**	**57,70**	**1,02**
	-1,8 kWh/m²y		**96,2 kWh/m²y**	**-0,3 kg/m²y**	**0,3 €/m²y**	

Base case with heat pump and PV

Kexp = 1

Heat pump has a better efficiency.

PV contributes totally

Negative energy performance and RER>1, that's normal

8 – HP + PV + TS + BAT k_{exp}= 0

Weighted energy performance	Non-renewable primary energy	Renewable primary energy	Total primary energy	CO2 emission	Cost	RER
	E_{Pnren}	E_{Pren}	E_{Ptot}	CO_2	Cost	RER
	kWh	kWh	kWh	kg co2	€	
January	1.765	2.852	4.616	324	189,18	0,62
February	1.054	2.367	3.421	193	113,68	0,69
March	477	1.979	2.456	87	51,67	0,81
April	43	1.111	1.154	8	4,64	0,96
May	0	393	393	0	0,00	1,00
June	0	430	430	0	0,00	1,00
July	4	496	501	1	0,48	0,99
August	1	439	440	0	0,15	1,00
September	0	369	369	0	0,00	1,00
October	87	951	1.038	16	9,44	0,92
November	733	1.821	2.554	134	79,32	0,71
December	1.459	2.550	4.009	267	156,55	0,64
Year	**5.623**	**15.760**	**21.382**	**1.030**	**605,10**	**0,74**
	31,2 kWh/m²y		118,8 kWh/m²y	**5,7 kg/m²y**	**3,4 €/m²y**	

Base case with heat pump and PV and battery

5 kWh

Kexp = 0

The battery allows the building to use its own produced electric energy

$K_{exp}=0$

Var	Calc	Gen	PV	TS	K	Bat	E_{Pnren}	E_{Ptot}	CO_2	Cost	RER
#							kWh/m²y	kWh/m²y	kg/m²y	€/m²y	-
1	h	Boil	No	Yes	0,0	No	98,5	111,2	19,6	7,4	0,11
2	h	Boil	Yes	Yes	0,0	No	94,1	108,3	18,8	7,0	0,13
2	m	Boil	Yes	Yes	0,0	No	90,5	106,0	18,1	6,6	0,15
2	m-m	Boil	Yes	Yes	0,0	No	92,2	107,1	18,4	6,8	0,14
4	h	HP	No	Yes	0,0	No	51,5	131,0	9,4	5,6	0,61
5	h	HP	Yes	No	0,0	No	46,7	127,8	8,6	5,0	0,63
5	m	HP	Yes	No	0,0	No	30,8	117,4	5,6	3,3	0,74
5	m-m	HP	Yes	No	0,0	No	40,4	123,7	7,4	4,4	0,67
6	h	HP	Yes	Yes	0,0	No	40,4	123,7	7,4	4,4	0,67
8	h	HP	Yes	Yes	0,0	Yes	31,2	118,1	5,7	3,4	0,74

Key

- **Var** **Variant number**
- **Calc** **Calculation type h = hourly m = monthly m-m monthly with matching factor**
- **Gen** **Generator type, Boil = boiler HP = Heat pump**
- **PV** **Photovoltaic Yes/No (3 kW)**
- **TS** **Thermal solar Yes/No (52% coverage of domestic hot water)**
- **K** **Value of K_{exp} 0,0/1,0**
- **Bat** **Battery Yes/No (5 kWh)**

All cases

Var	Calc	Gen	PV	TS	K	Bat	E_{Pnren}	E_{Ptot}	CO_2	Cost	RER
#							kWh/m²y	kWh/m²y	kg/m²y	€/m²y	-
1	h	Boil	No	Yes	0,0	No	98,5	111,2	19,6	7,4	0,11
2	h	Boil	Yes	Yes	0,0	No	94,1	108,3	18,8	7,0	0,13
3	h	Boil	Yes	Yes	1,0	No	45,1	76,4	9,8	2,3	0,41
4	h	HP	No	Yes	0,0	No	51,5	131,0	9,4	5,6	0,61
5	h	HP	Yes	No	0,0	No	46,7	127,8	8,6	5,0	0,63
6	h	HP	Yes	Yes	0,0	No	40,4	123,7	7,4	4,4	0,67
7	h	HP	Yes	Yes	1,0	No	-1,8	96,2	-0,3	0,3	1,02
8	h	HP	Yes	Yes	0,0	Yes	31,2	118,1	5,7	3,4	0,74

Key

- **Var** — **Variant number**
- **Calc** — **Calculation type h = hourly m = monthly m-m monthly with matching factor**
- **Gen** — **Generator type, Boil = boiler HP = Heat pump**
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- **TS** — **Thermal solar Yes/No (52% coverage of domestic hot water)**
- **K** — **Value of K_{exp} 0,0/1,0**
- **Bat** — **Battery Yes/No (5 kWh)**

Conclusion

52000-1 parameters impact energy performance.

The most impacting choice is that on $\mathbf{k_{exp}}$ → see videos for details

https://epb.center/documents/short-video-exported-energy-explained/

Building envelope is a required good starting point.
Then, the achievable performance range depends on the generation technology

Timing is more and more important → hourly calculation

https://epb.center/documents/short-video-impact-calculation-interval/

The several indicators, combined with the parameters in EN 52000-1, give different results, different information and may be sensitive to different features
→ the choice of parameters shall be fully transparent for comparability
… and one can repeat the calculation with any set of parameters for EN ISO 52000-1

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:

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Q&A

Submit your question!