



ENERGY RECOVERY

ENERGY RECOVERY, CALCULATION METHODS

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STANDARDISERINGEN I SVERIGE
SWEDISH STANDARDS INSTITUTION

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ÄR OCH UTGIFTER SVENSK STANDARD SAMT SÄLVER NATIONELLA, EUROPEISKA OCH INTERNATIONELLA STANDARDORGANISATIONER

Changes - Test procedures
Publishing performance of air
and flue gases heat recovery
s

Värmeväxlare - Värmeåterv
aggregat - Provningsmetod
prestationsdata

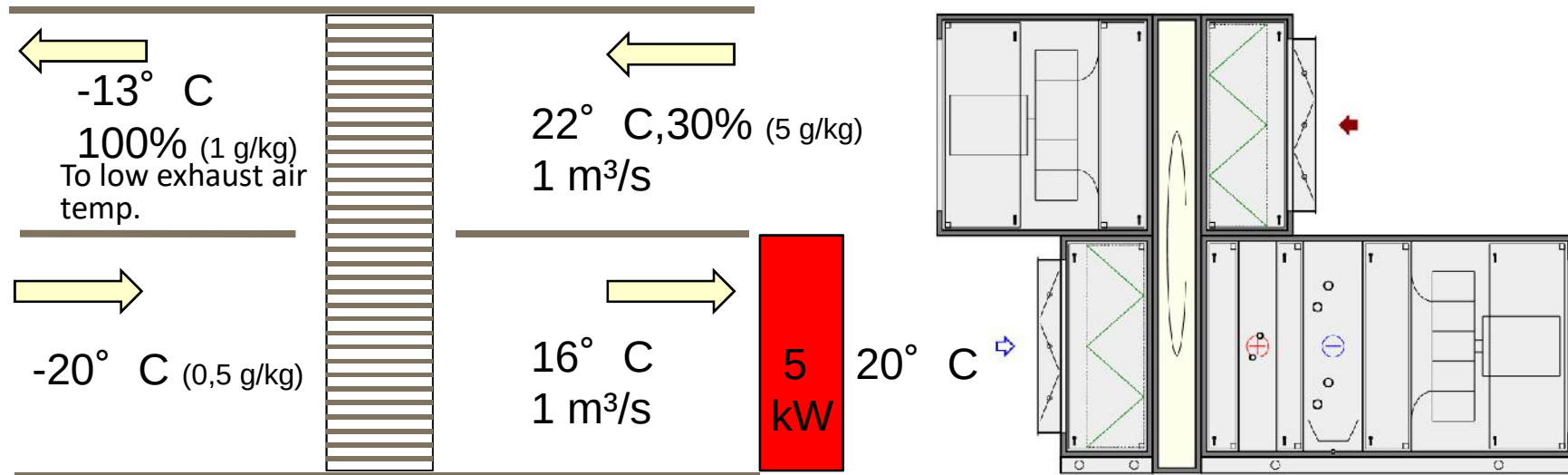
European Standard EN 308:1997 has the
Swedish Standard. This document con-
tains the official English version of EN 308:1997.
Standard supersedes the Swedish Standard
SIS 308:1997.

Europastandarden EN 308:1997 gäller
standard. Detta dokument innehåller
den officiella engelska versionen av EN 308:1997.
Standarden ersätter SIS-ENV 308
1997.

1. Supply air temp. efficiency, for 0°C out doors
2. Supply air dry temp. efficiency (0°C)
3. Supply air temp. efficiency according to EN308
4. Supply air dry temp. eff. equal air flows (Winter dim.)
5. Supply air wet temp. eff. (Winter dim.)
6. Supply air dry temp. eff. (Winter dim.)
7. Supply air temp. efficiency, due to frost protection
 - -27 °C
 - -22 °C
 - -17 °C
 - etc...
8. Exhaust air temp. efficiency
9. Entalpy efficiency
10. Humidity efficiency
11. Sensible, latent efficiency
12. Supply air efficiency, summer
13. Annual temp. efficiency
14. Annual energy efficiency
15. Etc....

- Example of a print out:

1	Batterivärmeväxlare	807175 - 12	
	Batterivärmeväxlaren är vätskefylld och driftsklar		
	Antal rörrader	10	
	Antal kretsar	12	
	Anslutningsnummer	40 utv.	
	Lamellavstånd	2.0	mm
	Luftsidan		
	Tryckfall	249	Pa
	Lufthastighet	2.40	m/s
1)	Tilluftens torra temperaturverkningsgrad (0°C)	63.7	%
2)	Tilluftens torra temp. verkningsgrad vid lika luftflöde (dim. utetemp.)	59.5	%
3)	Årstemperaturverkningsgrad enligt Svensk Ventilation (Kontor m.m.)	64.0	%
4)	Årsenergiverkningsgrad enligt Svensk Ventilation (Kontor m.m.)	83.0	%
5)	Årlig energiverkningsgrad, torra förhållande	80.3	%
6)	Årsenergiverkningsgrad	79.8	%
7)	Tilluftens temp.verkningsgrad, sommar	65.0	%
	Beräknat med hänsyn till avfrostning.		
	Utetemperatur	Tilluftens temperaturverkningsgrad	
8)	-27.0 °C	48.9	%
9)	-22.0 °C	54.5	%
10)	-17.0 °C	61.5	%
11)	-12.0 °C	64.6	%
12)	-7.0 °C	64.0	%
13)	-2.0 °C	63.7	%
14)	3.0 °C	64.2	%
15)	8.0 °C	64.6	%
16)	13.0 °C	65.0	%
17)	18.0 °C	65.3	%



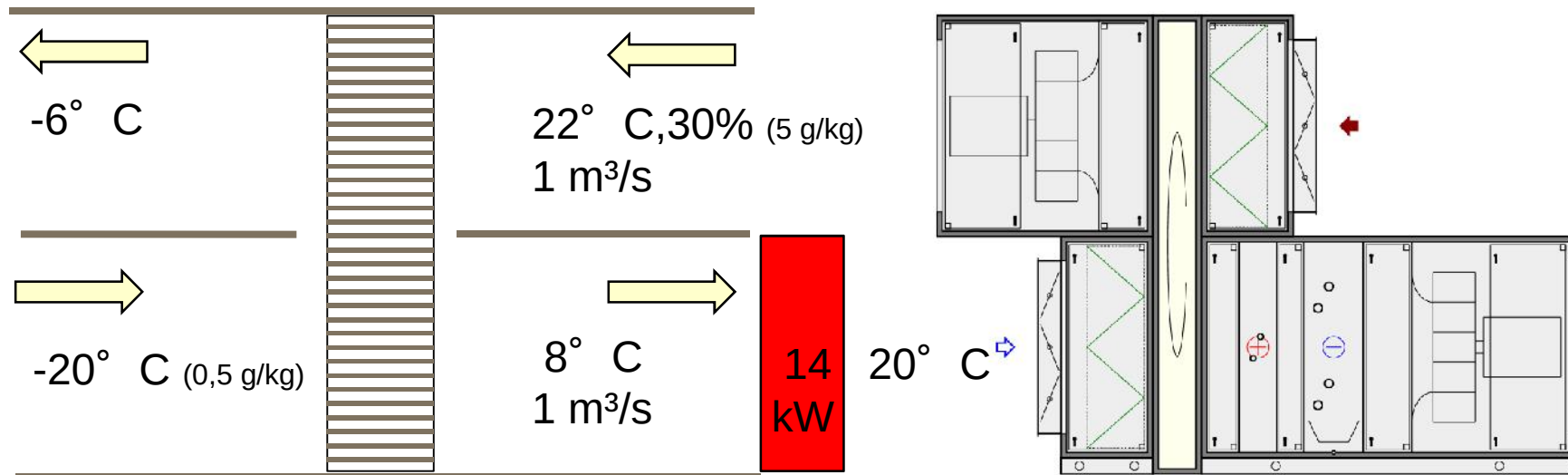
$$\eta = 85\%$$

$$\eta = \frac{t_{\text{supply}} - t_{\text{out}}}{t_{\text{extract}} - t_{\text{out}}}$$

$$\eta = \frac{16 - (-20)}{22 - (-20)}$$

- Is this realistic ?? 4 g/kg of water disappears ?
- Right calculation crucial for sizing the heating coil.
- From energy usage point of view, not important, Stockholm $\leq -16^{\circ}\text{C}$, 0 h per år (MeteoNorm)





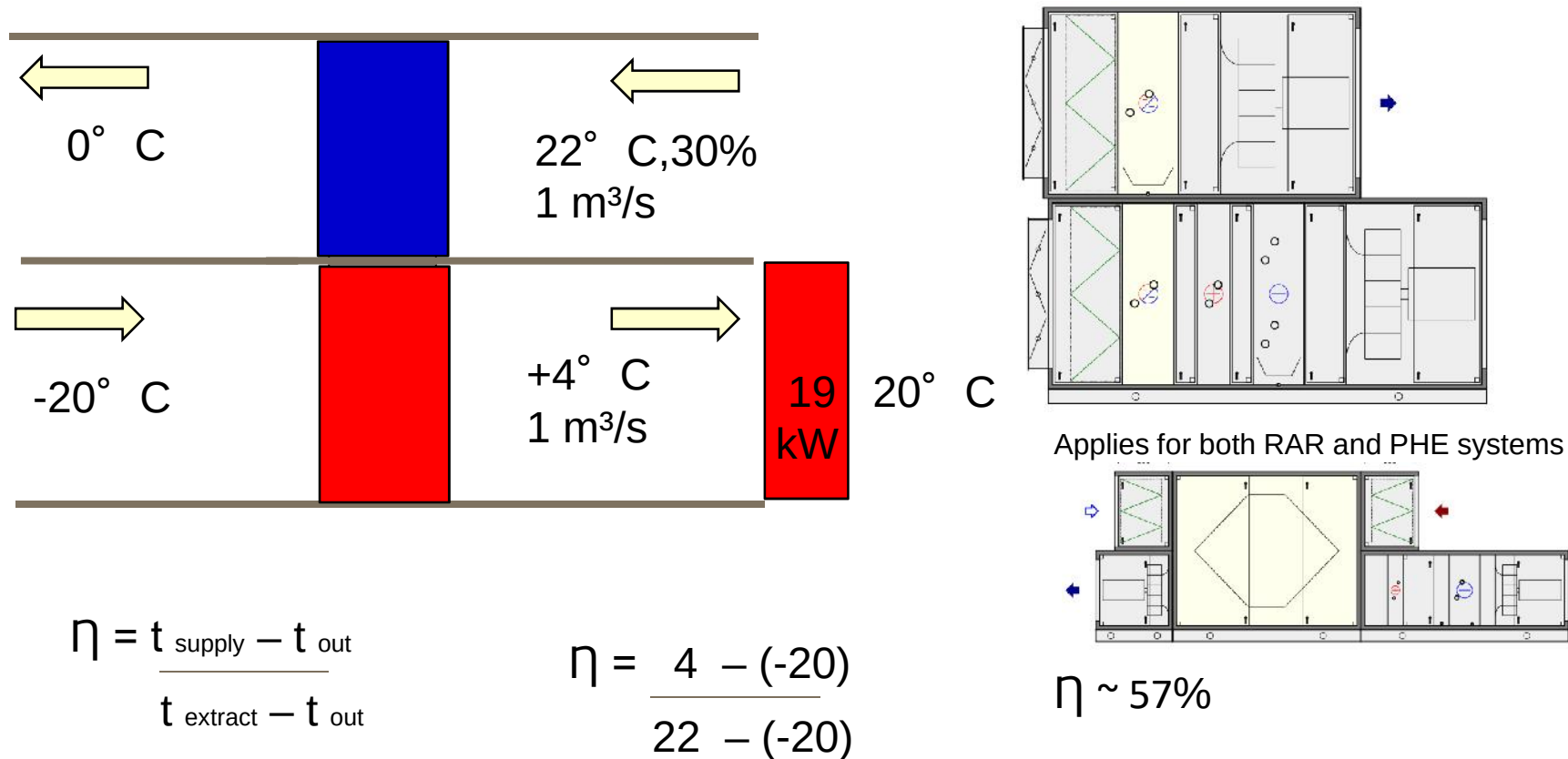
$$\eta = \frac{t_{\text{supply}} - t_{\text{out}}}{t_{\text{extract}} - t_{\text{out}}}$$

$$\eta = \frac{8 - (-20)}{22 - (-20)}$$

$$\eta = 67\% \text{ not } 85\%$$

- To deliver desired air flow, continuously
- To deliver desired supply air temp, continuously
- Calculations/dimensioning for a 'real' conditions, frost protection active if needed.

All other statements/calculations are 'fictive'



For all 'indirect' recovery systems applies:
If extract air is humid, condensation occurs in the recovery system
and exhaust air can not be below < 0° C

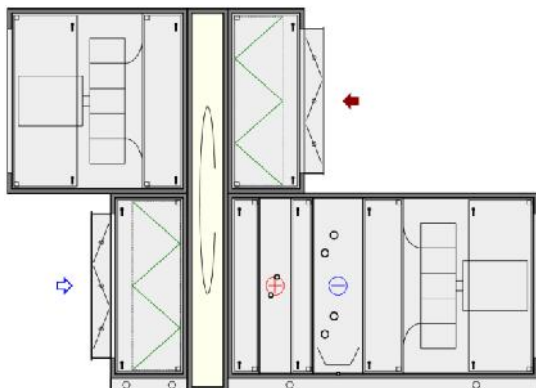
The new high efficient HRS requires an advanced frost protection



When we get frost in the heat recovery we get problems!



The new high efficient HRS requires an advanced frost protection (cold climates $< -10^{\circ}\text{C}$)

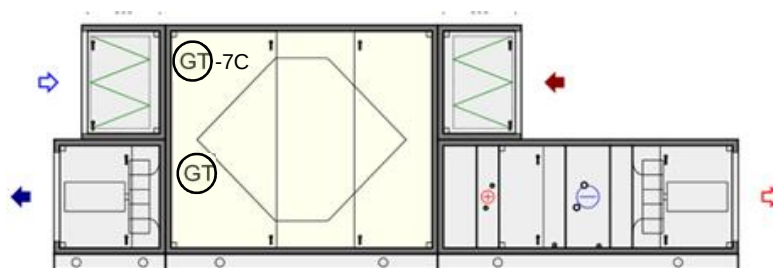


The wheel: no frost protection ?



The plate heat exchanger:

Out door air reg. norm. $\sim -7^{\circ}\text{C}$
or Cold corner

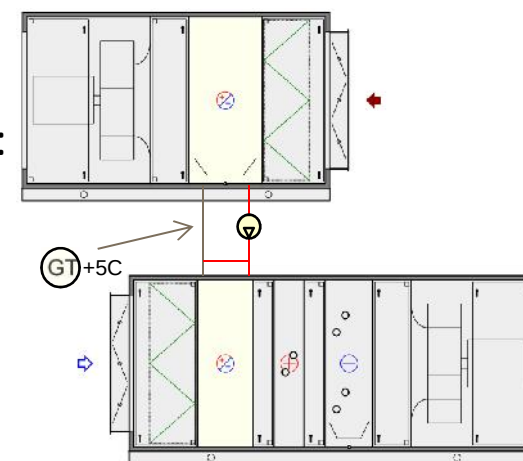


The run around coil system:

Liquid temp. $0...5^{\circ}\text{C}$

Traditional frost protection methods are not good enough anymore:

- Today most HRS are very efficient and the focus on energy savings are of high importance.



The advanced frost protection activates, depending on the need.

Extract air

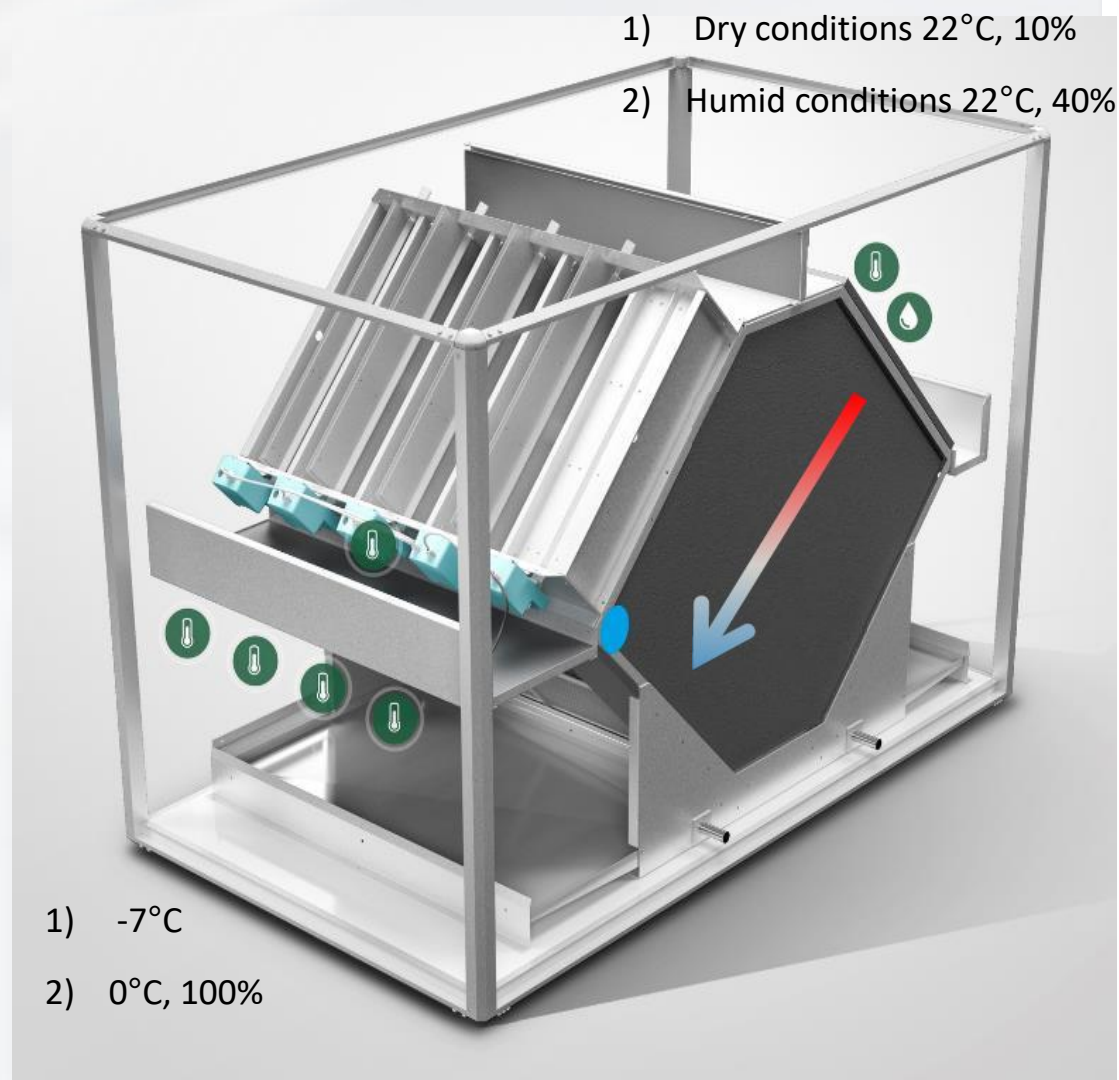
- Temperature
- Humidity

Exhaust air

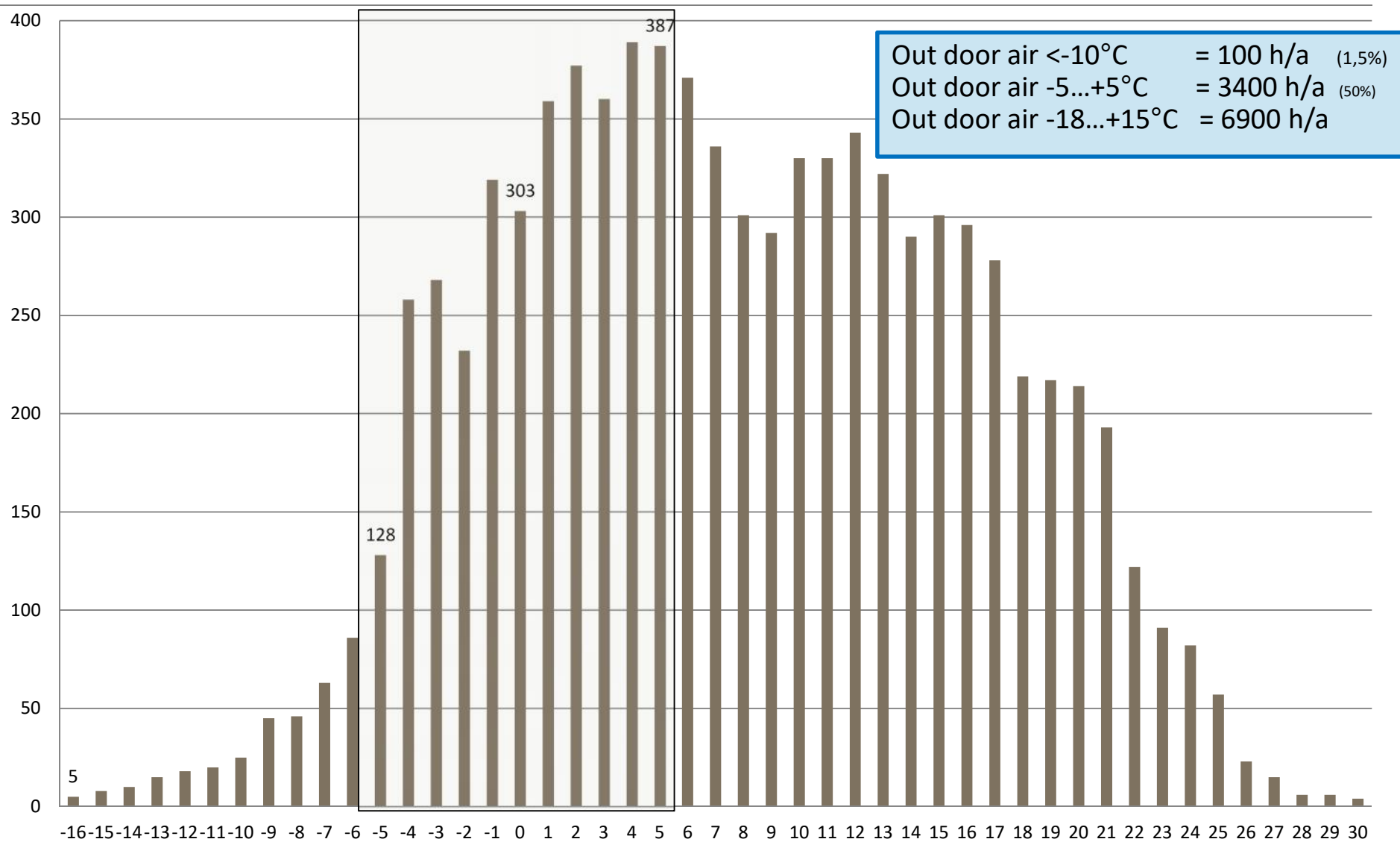
- Temperature (several)

Out door air

- Temperature



For what situation shall I optimize the recovery system ? Stockholm



$$\text{Energy} = \text{Power (kWh)} \times \text{time (h)}$$

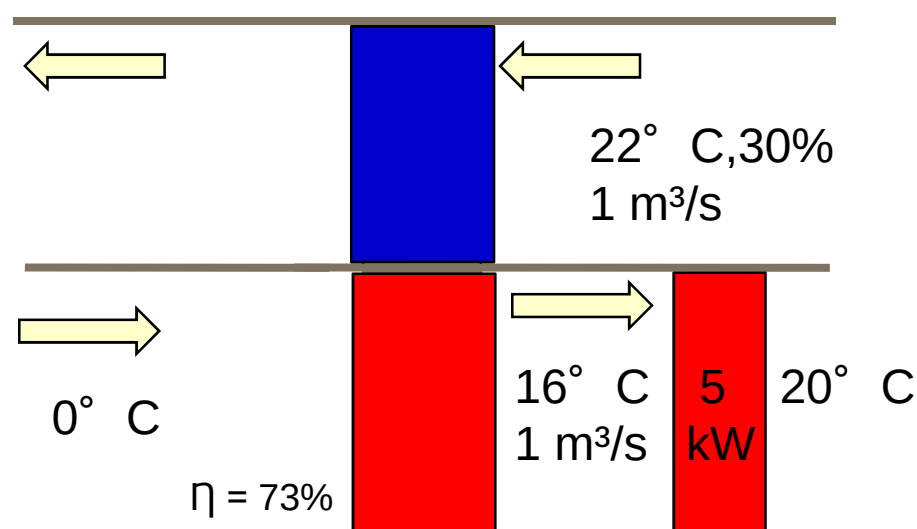
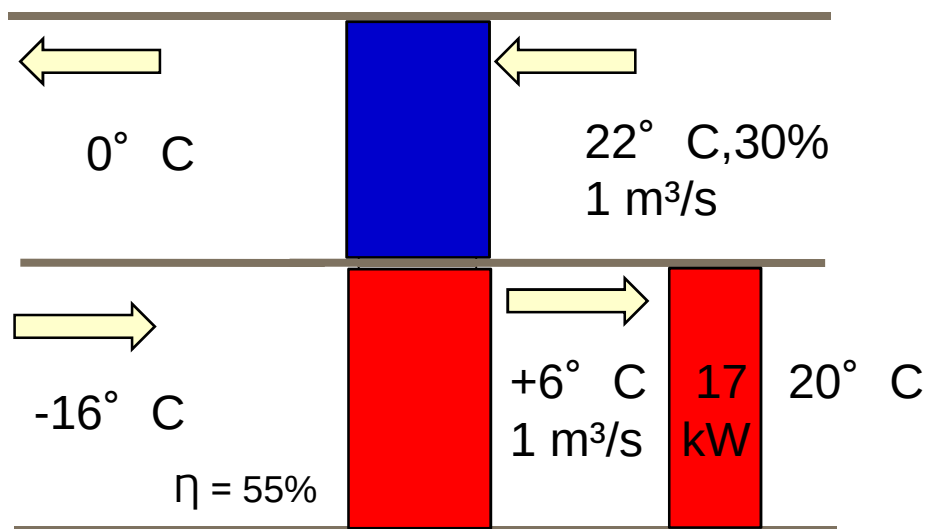
Winter
Heating power: 17 kW (4 times)
Tid: 5 h

0° C out doors, normal cond.
5 kW
303 h (60 times)

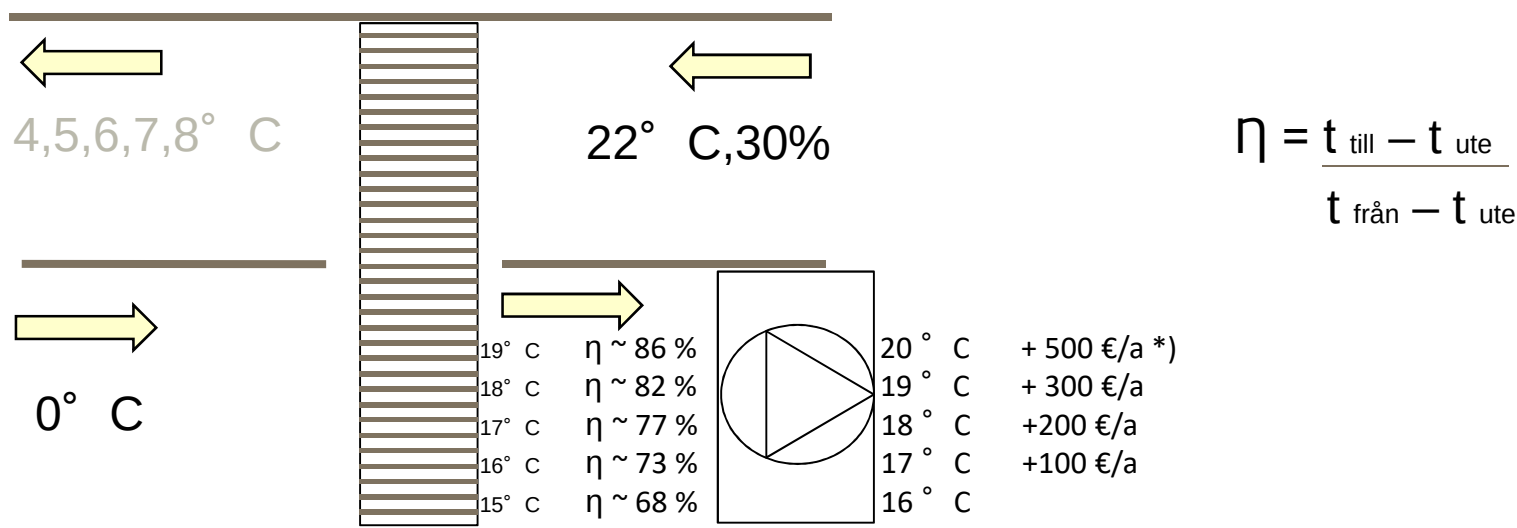
Energy/cost:

85 kWh = 17 €/a

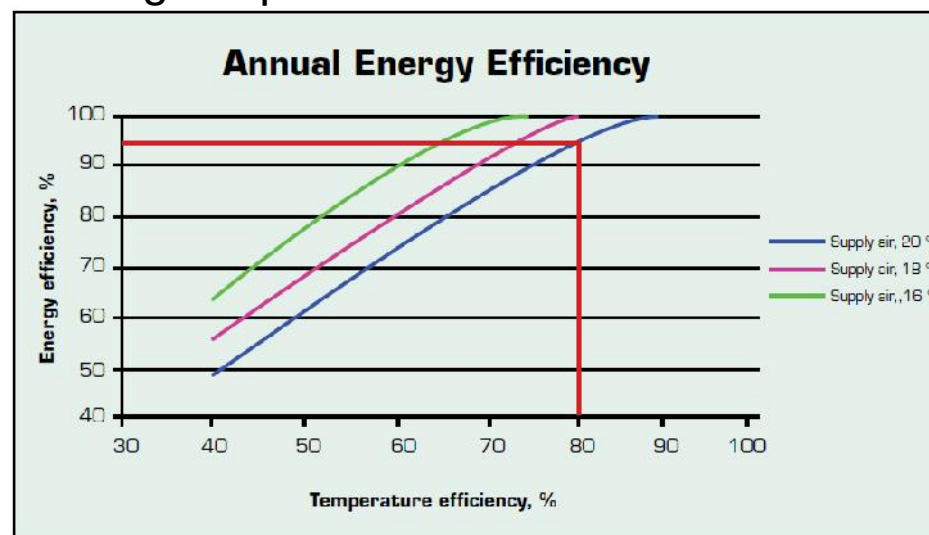
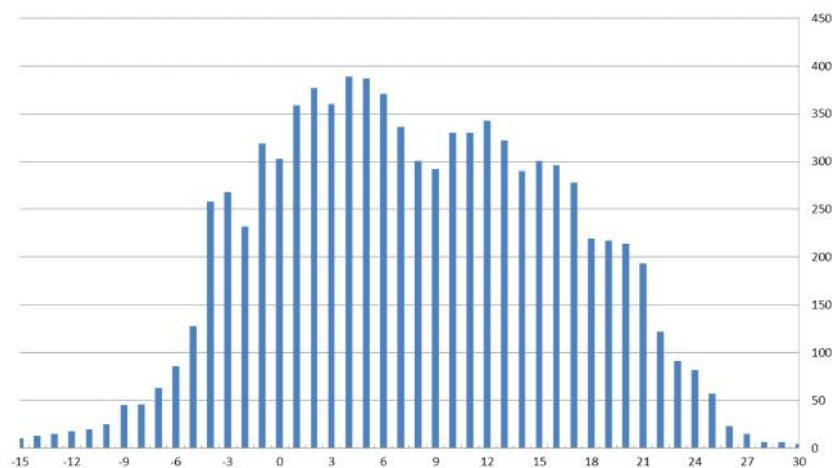
1515 kWh = 303 €/a

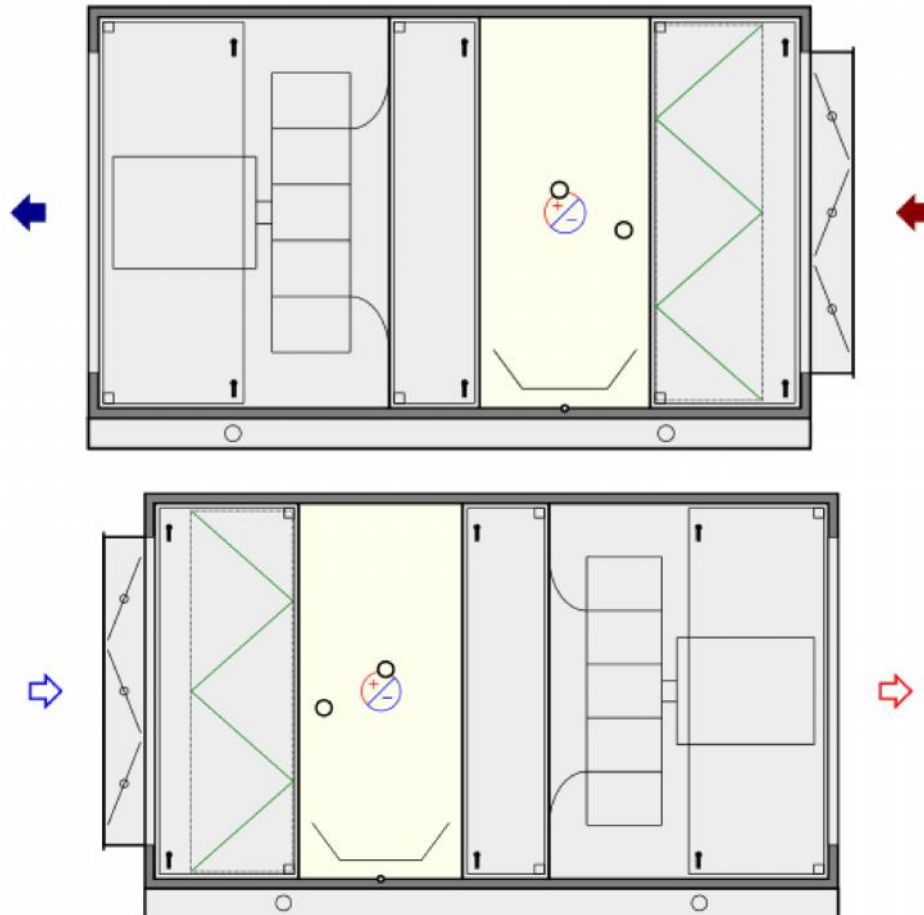


What is the optimum heat recovery system ?



The desired supply air temperature has a huge impact on the choice of the HRS





Temp. eff. EN308: 67,2%

SFPv: 2,11

Annual energy efficiency:

Office, Stockholm

$\eta = 89,1 \%$

Customer:

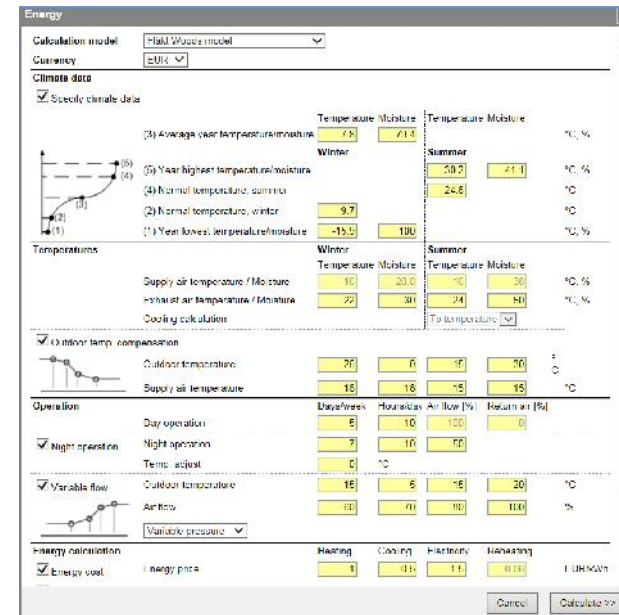
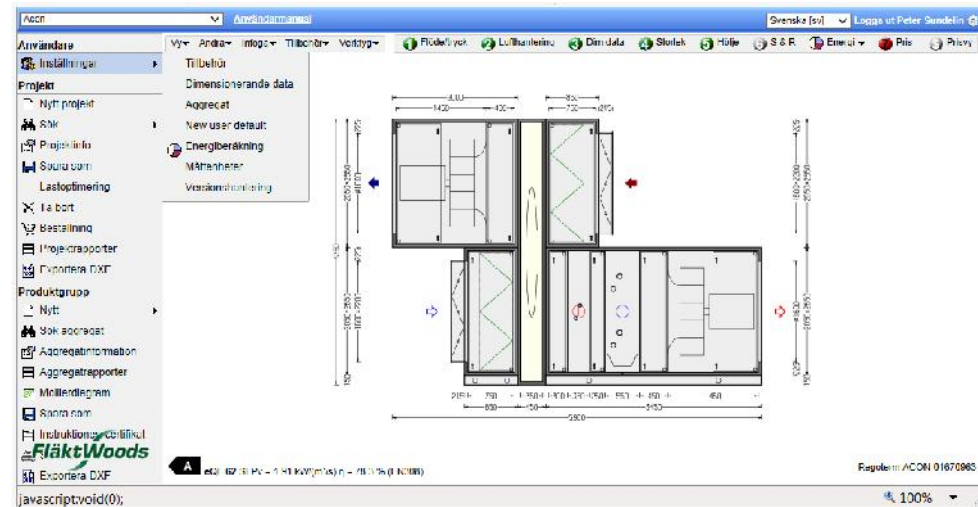
For comparance, Yes but is it
enough ??

Energy consumption ?

Running costs ?

Calculation of annual energy efficiency = $100 \times \frac{Q \text{ energy recovery}}{Q \text{ total heating energy}}$

- Climate data for the whole world (MeteoNorm)
- Possibility to modify climate data
- Several user levels, depending on inputs
- Air temperatures
 - Curve for supply air temp.
 - Cooling to either temp. or humidity
 - Exhaust air winter/summer, both temp and humidity.
 - Supply air for run. night.
- Air flows
 - CAV
 - Average air flow
 - VAV
 - Night
- Pressure loss in duct work
 - Constant/variable pressure
- Energy calculation
 - Energy costs for: Heating, cooling, electricity and reheater
 - CO2 emissions
 - Cost for installed power
 - Energy cost for other equipment (damper/pumps etc.)
 - Water consumption for humidifier
- LCC (Life cycle costs)
 - Operating time, tender sum, rent etc.
- Comparison
 - Comparison between FWG solutions
 - Comparison between FWG and external solutions

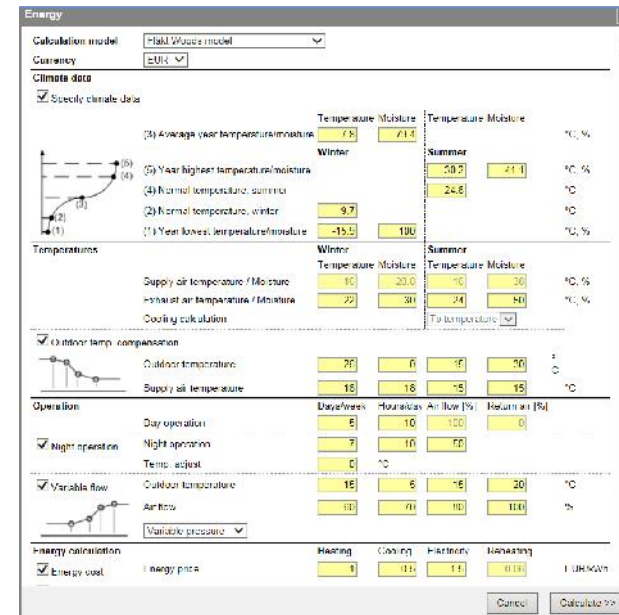
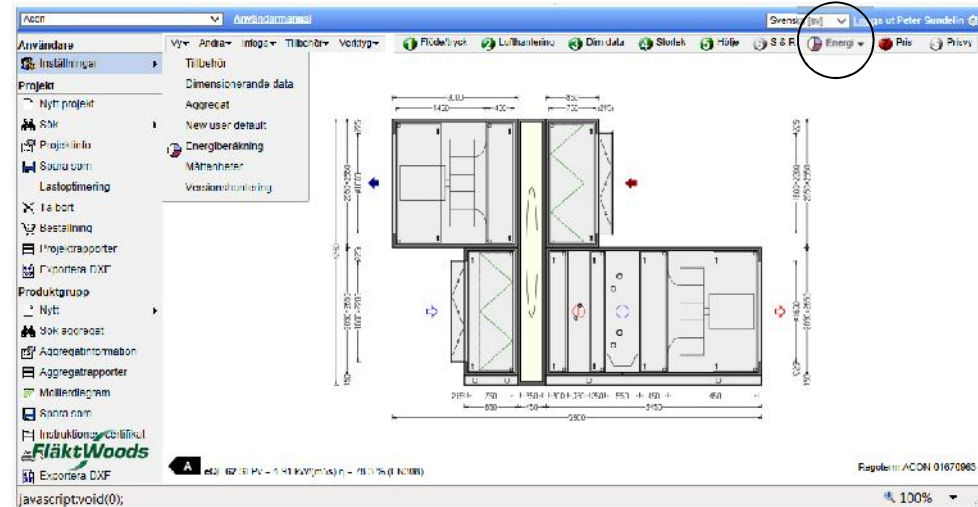


High lights:

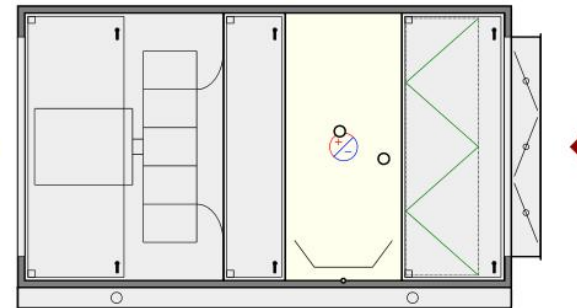
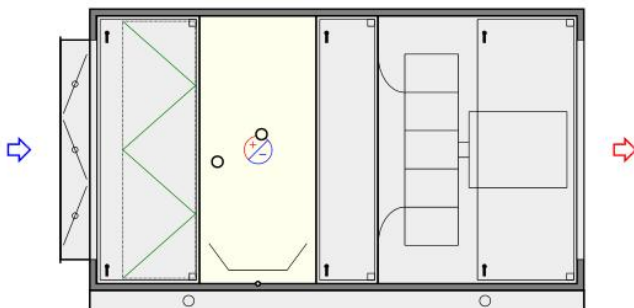
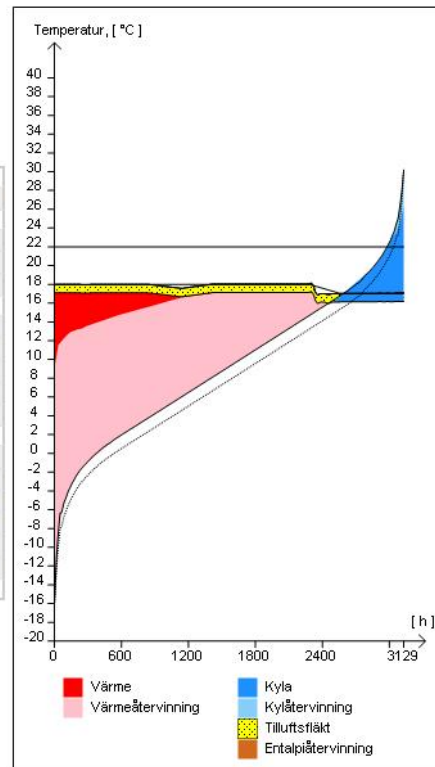
- Climate data for the whole world (MeteoNorm)
- Possibility to modify climate data

Several user levels, depending on inputs

- Air temperatures
 - Curve for supply air temperature
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Årlig energiverkningsgrad		
Årlig energiverkningsgrad	88.2	%
Årlig energiåtervinning		
Värmeåtervinning	281112	kWh
Kylåtervinning	2520	kWh
Tempökning i tilluftsfäkt	26749	kWh
Årligt energibehov		
Värme	37571	kWh
Kyla	29747	kWh
Tilluftsfäkt	33904	kWh
Frånluftsfäkt	33970	kWh
Annan utrustning	3996	kWh
Årlig energikostnad		
Värme	37571	SEK
Kyla	14874	SEK
Tilluftsfäkt	50856	SEK
Frånluftsfäkt	50955	SEK
Annan utrustning	5994	SEK
Summa	160250	SEK
Vatten		



Annual energy efficiency, ECONET, RAR
According to Swedish Ventilation: 89,1% (EN308: 67,2%)

Customer value:

Heating energy: 37,5 MWh
 Heating costs: 3760 €/a

Fan energy : 67,9 MWh
 Electricity costs: 10 180 €/a

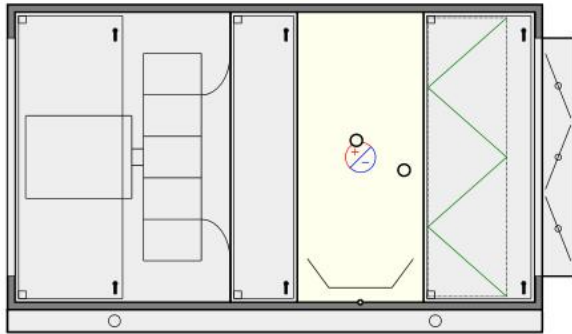
Cooling energy: 29,8 MWh
 Cooling costs: 1480 €/a

Other equipment: 4,0 MWh
 Costs: 600 €/a

(El: 0,15 €/kWh, Heating 0,1 €/kWh, Cooling 0,05 €/kWh)

Total running costs: 16 025 €/a

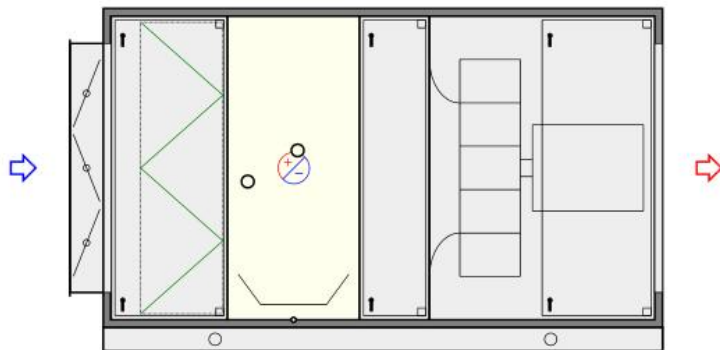
'Real' or project based inputs has a huge impact on the result



Energy/running cost calculation by using ACon

Climate data, Stockholm, Meteonorm ECONET,RAR (EN308: 67,2%)

	Case 1: (SWE Vent)	Case 2	Case 3
Supply air temperature	18°C	18°C/15°C	16°C
Exhaust air temperature	22°C	22°C/24°C	22°C/24°C
Add hum/extract air	+1 g/kg	+1 g/kg	+1 g/kg
Running hours	5 d 06:00-18:00	day 14 h (100% flow) night 6 h (50% flow)	day 10 h (60% flow)
Air flow	CAV	CAV (2 flow)	VAV (60%)
Heating limit	Out door air < +15C	No restriction	No restriction
Energy costs	0,15/0,1/0,05 (electr., heating, cooling)	0,2/0,15/0,065	0,15/0,1/0,05 € kWh



Energy

Calculation model

Fläkt Woods model

Currency

EUR

Climate data

Specify climate data

Sweden

STOCKHOLM

Average year temperature/moisture

7.8

79.4

°C, %

Temperatures

Winter

Summer

Supply air temperature / Moisture

18

20.8

15

38

°C, %

Exhaust air temperature / Moisture

22

30

24

50

°C, %

Cooling calculation

To temperature

Outdoor temp. compensation

Outdoor temperature

-26

0

15

30

°C

Supply air temperature

18

18

15

15

°C

Operation

Day operation

7

14

100

0

Night operation

7

10

50

Temp. adjust

0

°C

Variable flow

Energy calculation

Heating

Cooling

Electricity

Reheating

Energy cost

Energy price

0.15

0.065

0.2

0.06

EUR/kWh

CO₂ - emission

Investment

Economy

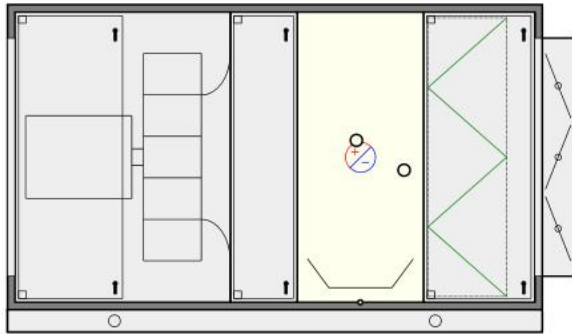
Energy - economy

Cancel

Calculate >>

Annual energy efficiency				
Annual energy efficiency	90.4	%		
Annual energy recovery				
Heat recovery	640665	kWh		
Cooling recovery	2505	kWh		
Temp. rise in supply air fan	46400	kWh		
Annual additional energy				
Heating	68229	kWh		
Cooling	106274	kWh		
Supply air fan	62908	kWh		
Exhaust air fan	63811	kWh		
Other Equipment	6635	kWh		
Annual energy cost				
Heating	10234	EUR		
Cooling	6908	EUR		
Supply air fan	12582	EUR		
Exhaust air fan	12762	EUR		
Other Equipment	1327	EUR		
Total	43813	EUR		
Water				

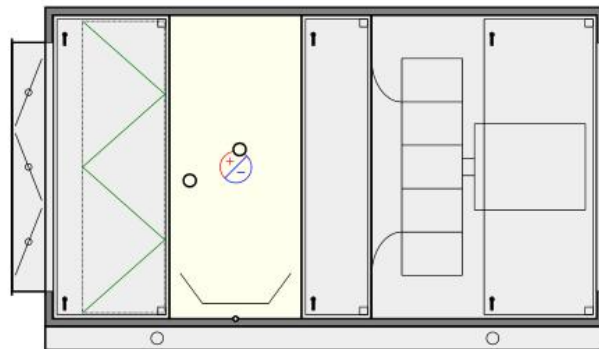
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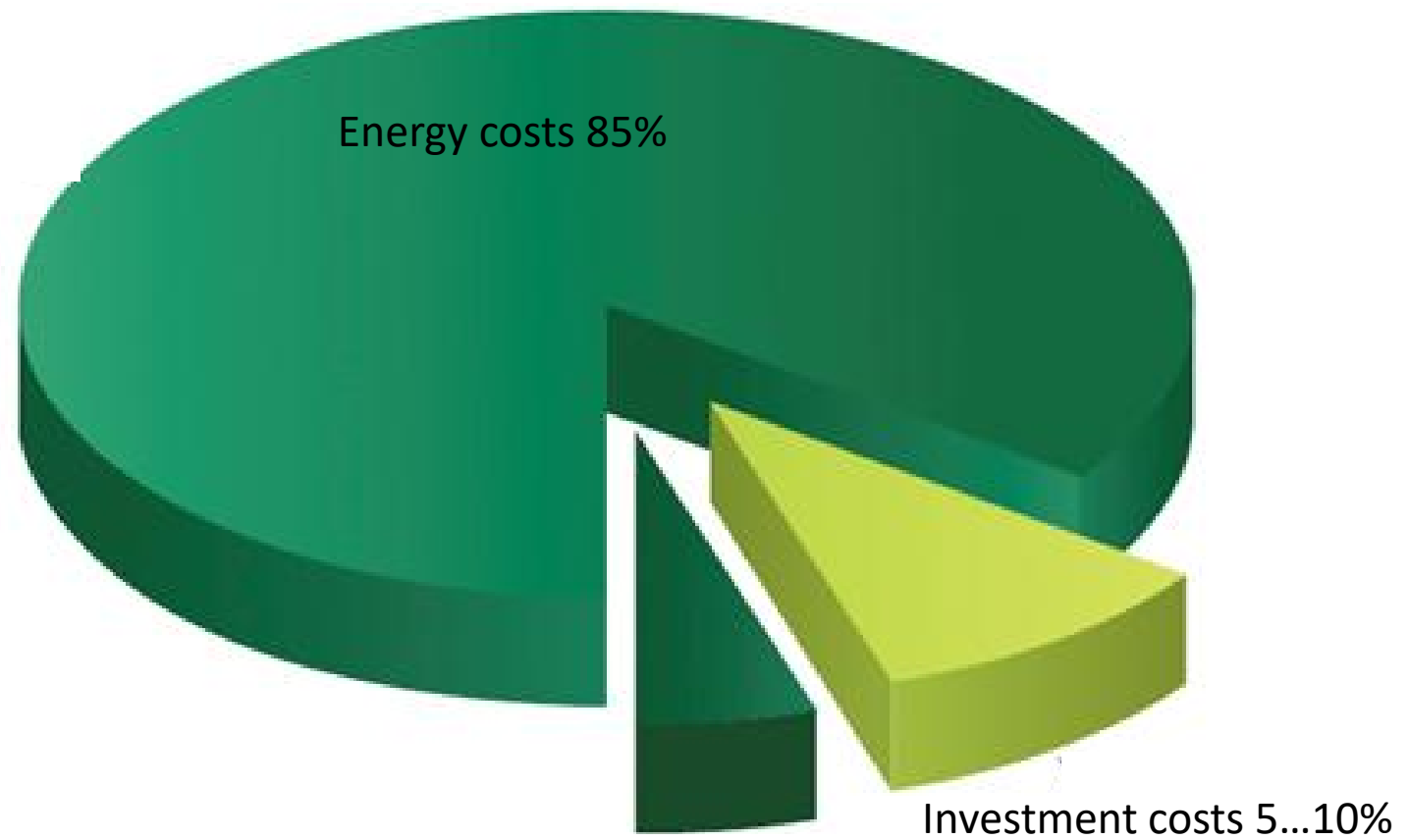
Energy/running cost calculation by using ACon

Climate data, Stockholm, Meteonorm ECONET,RAR (EN308: 67,2%)

	Case 1	Case 2	Case 3
Supply air temperature	18°C	18°C/15°C	16°C
Exhaust air temperature	22°C	22°C/24°C	22°C/24°C
Add hum/exhaust air	+1 g/kg	+1 g/kg	+1 g/kg
Running hours	5 d 06:00-18:00	day 14 h (100% flow) night 6 h (50% flow)	day 10 h (60% flow)
Air flow	CAV	CAV (2 flows)	VAV (60%)
Heating limit	Out door air < +15C	No restriction	No restriction
Energy costs	0,15/0,1/0,05 (electr., heating, cooling)	0,2/0,15/0,065	0,15/0,1/0,05 €/kWh



<u>Total running costs:</u>	Case 1	Case 2	Case 3
	16 025 €/a	43 813 €/a	11 514 €/a
<u>Annual energy efficiency:</u>	89,1%	90,4%	96,6%
<u>AHU cost (investment)</u>	55 000 €		



SFPv and temperature efficiency, yes, but.,.,.,.,

The 'real' truth You get with a
LCC calculation

Annual energy cost

