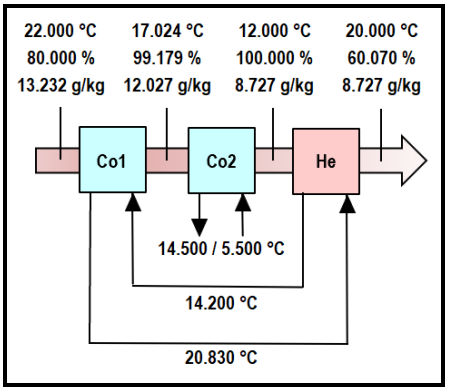
Greenhouse air conditioning

For the cooling and dehumidification of greenhouses, www.certhon.com from Holland installs intelligent, cost-saving ***energy systems using the pure air circulation process***, for which on Certhon Mr. John van der Sande can be addressed.

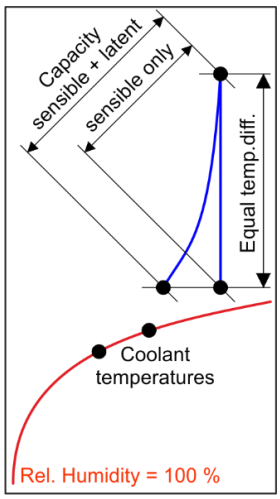
Warm moist air is extracted above the plants, ***cooled, dehumidified and reheated***. The treated air is then blown in again under the plants.

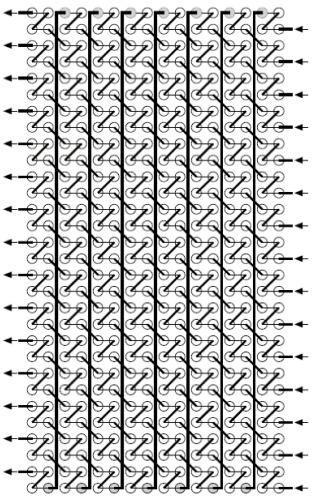
An energy-saving heat recovery system is used, for which we were able to supply all the needed software components.

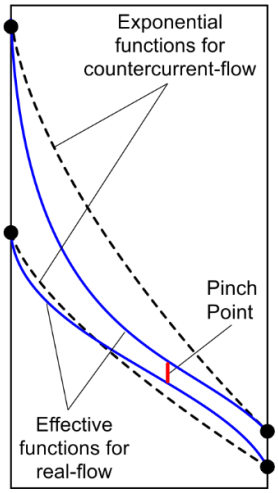
The calculation of the heat exchangers for the energy recovery system places great demands on accuracy, because the mean logarithmic temperature differences are only around 1K.
This only works with our internal hydraulic heat exchanger tube connection, developed in 1985, with a maximum proportion of counterflow, which must be able to be vented and drained in the installation position. In particular, it should be noted, that after the second cooler, 100% of the separated condensate must be removed, otherwise ***Sisyphus sends his best regards***.



When it comes to cooling humid air, opinions on latent performance vary widely. Only those who calculate the cooling process with finite elements, can determine exactly, how the cooling process works. The exponential temperature curve in the diagram on the right must be forgotten, since only sensible power can be dissipated at the beginning and latent power only towards the end. ***The exponential temperature curve deforms.***







The calculation of such an energy recovery system, which we call ***CCSU***, can be seen as an example on the following pages.

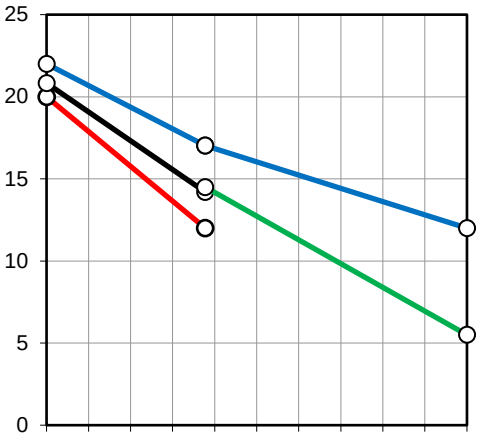
Dehumidifying		Co1	Co2	He	Co1+Co2
Capacity	kW	271.080	447.059	271.080	**718.139**
Surface reserve	%	2.544	6.054	2.511	
Present surface	m2	5983.345	2393.338	5983.345	
Temp. in	°C	22.000	17.024	12.000	
Rel. humidity in	%	80.000	99.179	100.000	
Abs. humidity in	g/kg	13.232	12.027	8.727	
Temp. out	°C	17.024	12.000	20.000	
Rel. humidity out	%	99.179	100.000	60.070	
Abs. humidity out	g/kg	12.027	8.727	8.727	
Velocity	m/s	1.947	1.907	1.912	
Pressure drop	Pa	179.943	85.454	148.572	

Definition		
Height over sea level	m	0.000
Pressure	hPa	1013.250
Temp.	°C	20.000
Rel. humidity	%	40.000
Supply air	m3/h	100000.000

25 V% Et.glycol		Co1 / He
Temp. in	°C	14.200
Temp. out	°C	20.830
Volume flow	m3/h	38.054
Pressure drop total	kPa	260.749

Water		Co2
Temp. in	°C	5.500
Temp. out	°C	14.500
Volume flow	m3/h	42.681
Pressure drop	kPa	31.021

Co1 = 37.748 % **Co2 = 62.252 %**



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Poeldijk, 8.2.2022
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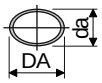
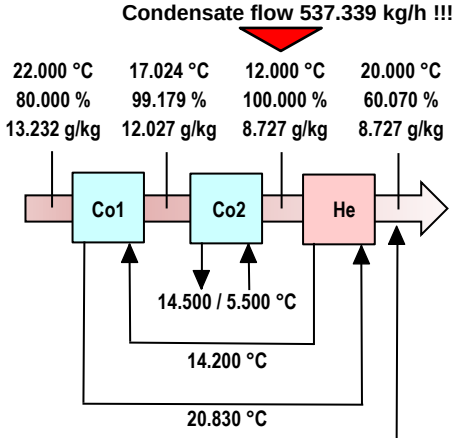
Plant
Object
Position

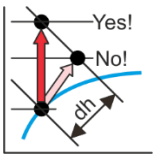
Software by www.zcs.ch

Technical data		Co1	Co2	He
Tubes blank	Piece	0	0	0
Int. vent./drains	Piece	9	0	9
Tube rows on the depth	Piece	20	8	20
Tube rows on the height	Piece	60	60	60
Number of circuits (NC)	Piece	60	80	60
Volume	l	1451	606	1451
Weight	kg	3135	1308	3135
Connections	G	4"	4"	4"
Frame height	RH	2480	2480	2480
Frame width	BT	6292	6268	6292
Frame depth	RT	870	380	870
Finned height	LH	2400	2400	2400
Finned width	LB	6000	6000	6000
Frame on top	RO	40	40	40
Frame on bottom	RU	40	40	40
Frame in front	RV	30	30	30
Frame on back (~69/69/69)	RN	69	69	69
Collector covering	AD	223	199	223
Fin spacing	LT	3.000	3.000	3.000
Fin thickness	LD	0.200	0.200	0.200
Tube diameter	DA	16.400	16.400	16.400
Tube diameter	da	16.400	16.400	16.400
Tube thickness	S	0.400	0.400	0.400
Tube interval on the height	S1	40.000	40.000	40.000
Tube interval on the depth	S2	34.641	34.641	34.641
Tubes	---	Cu	Cu	Cu
Tubes	---	smooth	smooth	smooth
Tubes	---	staggered	staggered	staggered
Tubes	Type	circular	circular	circular
Collector	---	Cu	Cu	Cu
Connections	---	Rg7	Rg7	Rg7
Fins	---	Al	Al	Al
Fins	---	smooth	smooth	smooth
Frame	---	AISI 304	AISI 304	AISI 304
Protection	---	without	without	without
Protection	---	---	---	---
Price	**EUR**	**42711.00**	**18065.00**	**42711.00**

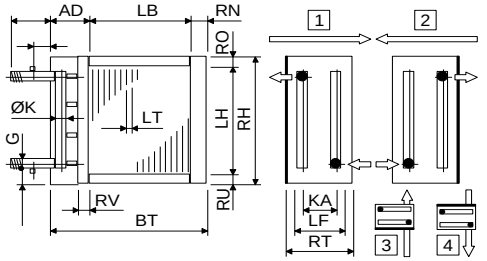


Wire mesh droplet eliminator (Demister)
Drop eliminator: Pressure drop > 100 Pa ?!?
Condensate flow 537.339 kg/h !!!





If the temperature and humidity at the outlet are not maintained, the droplet eliminator must be checked for sufficient pressure loss!



Delivery:	5-6 weeks
Validity:	12 weeks
Condit.:	net, prepaid address
Payment:	30 days net

Co1: 40/35/16-20R-60T-6000A-3.0PA-60C-Cu/Al/AISI 304

Capacity	kW	271.080	------ sensible:	169.635
Surface reserve	%	2.544	latent:	101.445
Present surface	m2	5983.345	frost:	0.000
Required surface	m2	5834.929		
k-coeff.	W/m2K	38.871	---------- ffi:	5.000E-05
Average temp. diff. (63.67 %)	K	1.195	ffa:	5.000E-05

Air humid		Inlet	Outlet	Definition
Height over sea level	m			0.000
Pressure	hPa			1013.250
Temp.	°C	22.000	17.024	20.000
Rel. humidity	%	80.000	99.179	40.000
Abs. humidity	g/kg	13.232	12.027	
Density humid	kg/m3	1.186	1.208	
Enthalpy humid	kJ/kg	55.764	47.583	
Volume flow humid	m3/h	101876.212	99968.848	100000.000
Mass flow dry	kg/h	119278.084	119278.084	
Condensate flow	kg/h		143.722	
Surface temperature	°C	21.248	15.209	
Velocity	m/s	1.965	1.928	
Pressure drop (dry 154 Pa)	Pa		179.943	

25 V% Et.glycol		Inlet	Outlet	Selection
Temp.	°C	14.200	20.830	17.241
Density	kg/m3			1038.614
Spec. heat	kJ/kgK			3.724
Heat cond.	W/mK			0.471
Viscosity	Pas			2.018E-03
Volume flow	m3/h			38.054
Velocity	m/s			0.922
Pressure drop	kPa			130.443

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Plant
Object
Position

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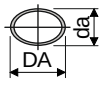
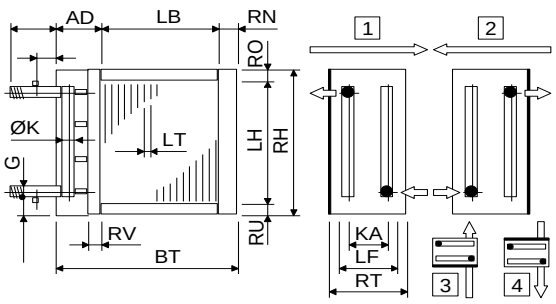
Technical data

Tubes total		Piece	1200	Tubes:		Cu
Tubes blank		Piece	0	Tubes:		smooth
Int. vent./drains		Piece	9	Tubes:		staggered
Tube rows on the depth		Piece	20	Tubes:		circular
Tube rows on the height		Piece	60	Collectors:	1.27 m/s	Cu
Tube coupling in series		Piece	20	Connections:	1.27 m/s	Rg7
Number of circuits (NC)		Piece	60	Fins:		Al
Volume		l	1451	Fins:		smooth
Weight		kg	3135	Frame:	2.0 mm	AISI 304
Connections	G	---	4"	Protection:		without
Frame height	RH	mm	2480	Protection:		---
Frame width	BT	mm	6292	Air flow direction:		horizontal
Frame depth	RT	mm	870			
Finned height	LH	mm	2400			
Finned width	LB	mm	6000			
Finned depth	LF	mm	693			
Frame on top	RO	mm	40			
Frame on bottom	RU	mm	40			
Frame in front	RV	mm	30			
Frame on back (~69mm)	RN	mm	69			
Collector-Diameter	K	mm	108			
Collector covering	AD	mm	223			
Collector distance	KA	mm	734			
Fin spacing	LT	mm	3.000			
Fin thickness	LD	mm	0.200			
Tube diameter	DA	mm	16.400	Delivery:		5-6 weeks
Tube diameter	da	mm	16.400	Validity:		12 weeks
Tube thickness	S	mm	0.400	Condit.:		net, prepaid address
Tube interval on the height	S1	mm	40.000	Payment:		30 days net
Tube interval on the depth	S2	mm	34.641	**Price net:**		**EUR 42711.00**





Co2: 40/35/16-8R-60T-6000A-3.0PA-80C-Cu/Al/AISI 304

Capacity	kW	447.059	------ sensible:	170.233
Surface reserve	%	6.054	latent:	276.826
Present surface	m2	2393.338	frost:	0.000
Required surface	m2	2256.711		
k-coeff.	W/m2K	49.103	---------- ffi:	5.000E-05
Average temp. diff. (95.98 %)	K	4.034	ffa:	5.000E-05

Air humid		Inlet	Outlet	Definition
Height over sea level	m			0.000
Pressure	hPa			1013.250
Temp.	°C	17.024	12.000	20.000
Rel. humidity	%	99.179	100.000	40.000
Abs. humidity	g/kg	12.027	8.727	
Density humid	kg/m3	1.208	1.231	
Enthalpy humid	kJ/kg	47.583	34.090	
Volume flow humid	m3/h	99968.848	97726.907	100000.000
Mass flow dry	kg/h	119278.084	119278.084	
Condensate flow	kg/h		393.617	
Surface temperature	°C	15.428	7.889	
Velocity	m/s	1.928	1.885	
Pressure drop (dry 62 Pa)	Pa		85.454	

Water		Inlet	Outlet	Selection
Temp.	°C	5.500	14.500	10.768
Density	kg/m3			999.640
Spec. heat	kJ/kgK			4.191
Heat cond.	W/mK			0.581
Viscosity	Pas			1.278E-03
Volume flow	m3/h			42.681
Velocity	m/s			0.775
Pressure drop	kPa			31.021

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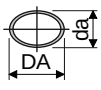
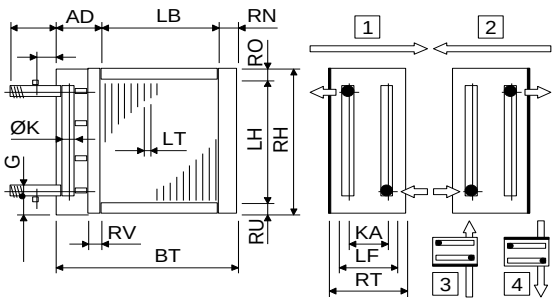
Plant
Object
Position

Software by www.zcs.ch

Technical data

Tubes total		Piece	480	Tubes:		Cu
Tubes blank		Piece	0	Tubes:		smooth
Int. vent./drains		Piece	0	Tubes:		staggered
Tube rows on the depth		Piece	8	Tubes:		circular
Tube rows on the height		Piece	60	Collectors:	1.42 m/s	Cu
Tube coupling in series		Piece	6	Connections:	1.42 m/s	Rg7
Number of circuits (NC)		Piece	80	Fins:		Al
Volume		l	606	Fins:		smooth
Weight		kg	1308	Frame:	2.0 mm	AISI 304
Connections	G	---	4"	Protection:		without
Frame height	RH	mm	2480	Protection:		---
Frame width	BT	mm	6268	Air flow direction:		horizontal
Frame depth	RT	mm	380			
Finned height	LH	mm	2400			
Finned width	LB	mm	6000			
Finned depth	LF	mm	277			
Frame on top	RO	mm	40			
Frame on bottom	RU	mm	40			
Frame in front	RV	mm	30			
Frame on back (~69mm)	RN	mm	69			
Collector-Diameter	K	mm	108			
Collector covering	AD	mm	199			
Collector distance	KA	mm	243			
Fin spacing	LT	mm	3.000			
Fin thickness	LD	mm	0.200			
Tube diameter	DA	mm	16.400	Delivery:		5-6 weeks
Tube diameter	da	mm	16.400	Validity:		12 weeks
Tube thickness	S	mm	0.400	Condit.:		net, prepaid address
Tube interval on the height	S1	mm	40.000	Payment:		30 days net
Tube interval on the depth	S2	mm	34.641	**Price net:**		**EUR 18065.00**





He: 40/35/16-20R-60T-6000A-3.0PA-60C-Cu/Al/AISI 304

Capacity	kW	271.080		
Surface reserve	%	2.511		
Present surface	m2	5983.345		
Required surface	m2	5836.775		
k-coeff.	W/m2K	34.487	---------- ffi:	5.000E-05
Average temp. diff. (95.82 %)	K	1.347	ffa:	5.000E-05

Air humid		Inlet	Outlet	Definition
Height over sea level	m			0.000
Pressure	hPa			1013.250
Temp.	°C	12.000	20.000	20.000
Rel. humidity	%	100.000	60.070	40.000
Abs. humidity	g/kg	8.727	8.727	
Density humid	kg/m3	1.231	1.198	
Enthalpy humid	kJ/kg	34.090	42.271	
Volume flow humid	m3/h	97726.907	100468.580	100000.000
Mass flow dry	kg/h	119278.084	119278.084	
Velocity	m/s	1.885	1.938	
Pressure drop	Pa		148.572	

25 V% Et.glycol		Inlet	Outlet	Selection
Temp.	°C	20.830	14.200	17.390
Density	kg/m3			1038.562
Spec. heat	kJ/kgK			3.725
Heat cond.	W/mK			0.471
Viscosity	Pas			2.010E-03
Volume flow	m3/h			38.052
Velocity	m/s			0.922
Pressure drop	kPa			130.306

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Plant
Object
Position

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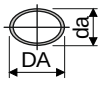
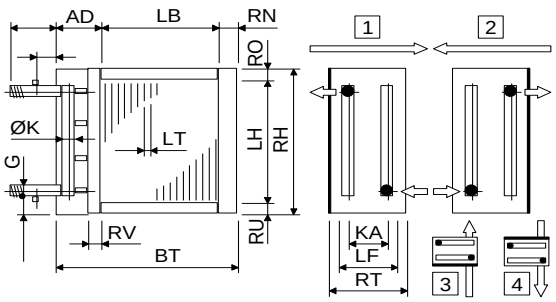
Technical data

Tubes total		Piece	1200	Tubes:		Cu
Tubes blank		Piece	0	Tubes:		smooth
Int. vent./drains		Piece	9	Tubes:		staggered
Tube rows on the depth		Piece	20	Tubes:		circular
Tube rows on the height		Piece	60	Collectors:	1.27 m/s	Cu
Tube coupling in series		Piece	20	Connections:	1.27 m/s	Rg7
Number of circuits (NC)		Piece	60	Fins:		Al
Volume		l	1451	Fins:		smooth
Weight		kg	3135	Frame:	2.0 mm	AISI 304
Connections	G	---	4"	Protection:		without
Frame height	RH	mm	2480	Protection:		---
Frame width	BT	mm	6292	Air flow direction:		horizontal
Frame depth	RT	mm	870			
Finned height	LH	mm	2400			
Finned width	LB	mm	6000			
Finned depth	LF	mm	693			
Frame on top	RO	mm	40			
Frame on bottom	RU	mm	40			
Frame in front	RV	mm	30			
Frame on back (~69mm)	RN	mm	69			
Collector-Diameter	K	mm	108			
Collector covering	AD	mm	223			
Collector distance	KA	mm	734			
Fin spacing	LT	mm	3.000			
Fin thickness	LD	mm	0.200			
Tube diameter	DA	mm	16.400	Delivery:		5-6 weeks
Tube diameter	da	mm	16.400	Validity:		12 weeks
Tube thickness	S	mm	0.400	Condit.:		net, prepaid address
Tube interval on the height	S1	mm	40.000	Payment:		30 days net
Tube interval on the depth	S2	mm	34.641	**Price net:**		**EUR 42711.00**





Economy: Dehumidifying		
Height over sea level	m	0.000
Pressure	hPa	1013.250
Temp.	°C	20.000
Rel. humidity	%	40.000

Definition
Supply air

Cold recovery		Dehumidifying
Efficiency	**%**	**37.748**
Capacity	kW	271.080

Cold recovery		Cooler
Present surface	m2	5983.345
Surface reserve	%	2.544
Temp. in	°C	22.000
Temp. out	°C	17.024
Volume flow humid	m3/h	100000.000
Pressure drop	Pa	179.943
Fan efficiency	---	0.700
Fan power	kW	7.141

Cold recovery		Heater
Present surface	m2	5983.345
Surface reserve	%	2.511
Temp. in	°C	12.000
Temp. out	°C	20.000
Volume flow humid	m3/h	100000.000
Pressure drop	Pa	148.572
Fan efficiency	---	0.700
Fan power	kW	5.896

Cooler: additional		Cooler
Present surface	m2	2393.338
Surface reserve	%	6.054
Temp. in	°C	17.024
Temp. out	°C	12.000
Volume flow humid	m3/h	100000.000
Pressure drop	Pa	85.454
Fan efficiency	---	0.700
Fan power	kW	3.391

25 V% Et.glycol		Cold recovery
Volume flow	m3/h	38.054
Pressure drop Cold recovery	bar	1.304
Pressure drop Cold recovery	bar	1.303
Pressure drop Hydraulics	bar	2.000
Pressure drop Total	bar	4.607
Pump efficiency	---	0.800
Pump power	kW	6.088

Water		additional
Volume flow	m3/h	42.681
Pressure drop	bar	0.310
Pressure drop Hydraulics	bar	1.000
Pressure drop Total	bar	1.310
Pump efficiency	---	0.800
Pump power	kW	1.942

Economy		Dehumidifying
Gross useful ratio with CC-System	kW	271.080
Need of energy with CC-System	kW	24.457
Net useful ratio with CC-System	kW	246.623
Coefficient of performance (COP)	**---**	**11.084**

Economy		Dehumidifying
Volume flow humid Total	m3/h	100000.000
Need of energy with CC-System	kW	24.457
Specific Recovery Power (SRP)	**Ws/m3**	**880.457**

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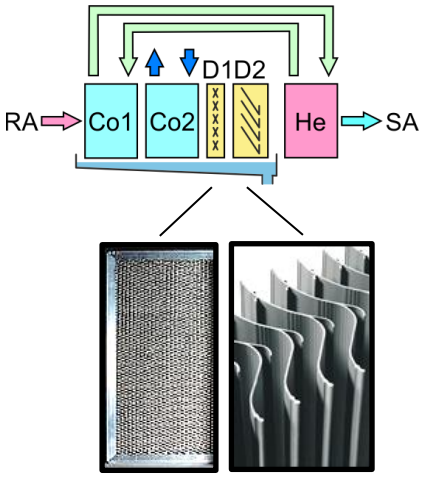
Software by www.zcs.ch



If there is a purely recirculating air operation and a lot of moisture has to be extracted from the air, part of the performance can take place via cold recovery. The rest, for example, has to be cooled with cold water from 6 to 12°C, which results in high operating costs.