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Chillventa Specialist Forums 2022
Chillventa Fachforen 2022

CONNECTING EXPERTS.

Influence of the Dry Cooler Capacity on the Efficiency of Chillers

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12-10-2022

CONNECTING EXPERTS.

Influence of dry cooler capacity on chiller efficiency

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Agenda:

- Introduction: Chiller & Efficiencies
- Case study, results, energy savings
- Conclusion
- Certification by Eurovent Certita Certification
  -How does it work?
  -Heat Exchangers certification programme

INTRODUCTION: CHILLER & EFFICIENCIES

- Energy efficiency is currently one of the most important subjects in the HVAC&R industry.
- When using a certified chiller with a separately installed condenser or dry cooler, it is very advisable also to use a certified product in order to reach the maximum total energy efficiency.
- Due to correct performance indications, the certified heat exchanger is selected exactly according to the application and fulfills the requirements. The refrigeration unit runs as expected including energy consuming components such as fans.
- Therefore, correct performance indications for heat exchangers are absolutely essential. They influence the energy efficiency of the entire system.

INTRODUCTION: CHILLER & EFFICIENCIES

Liquid Chilling Packages or Chillers

- Machine able to produce chilled water
- Energy Efficiency Ratio (EER):Ratio of the total cooling capacity to the effective power input of the unit
- Seasonal Energy Efficiency Ratio (SEER)
- η_sc (Seasonal space cooling energy efficiency)

INTRODUCTION: CHILLER & EFFICIENCIES

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Use of water-cooled chillers - Efficiency of the solution

An air-cooled chiller: finished product
(no additional system required to reject heat)

A water-cooled chiller:

- Necessary to add a system able to reject heat
- Combination with a dry cooler

+

Efficiency of the solution = Efficiency of the system

INTRODUCTION: CHILLER & EFFICIENCIES

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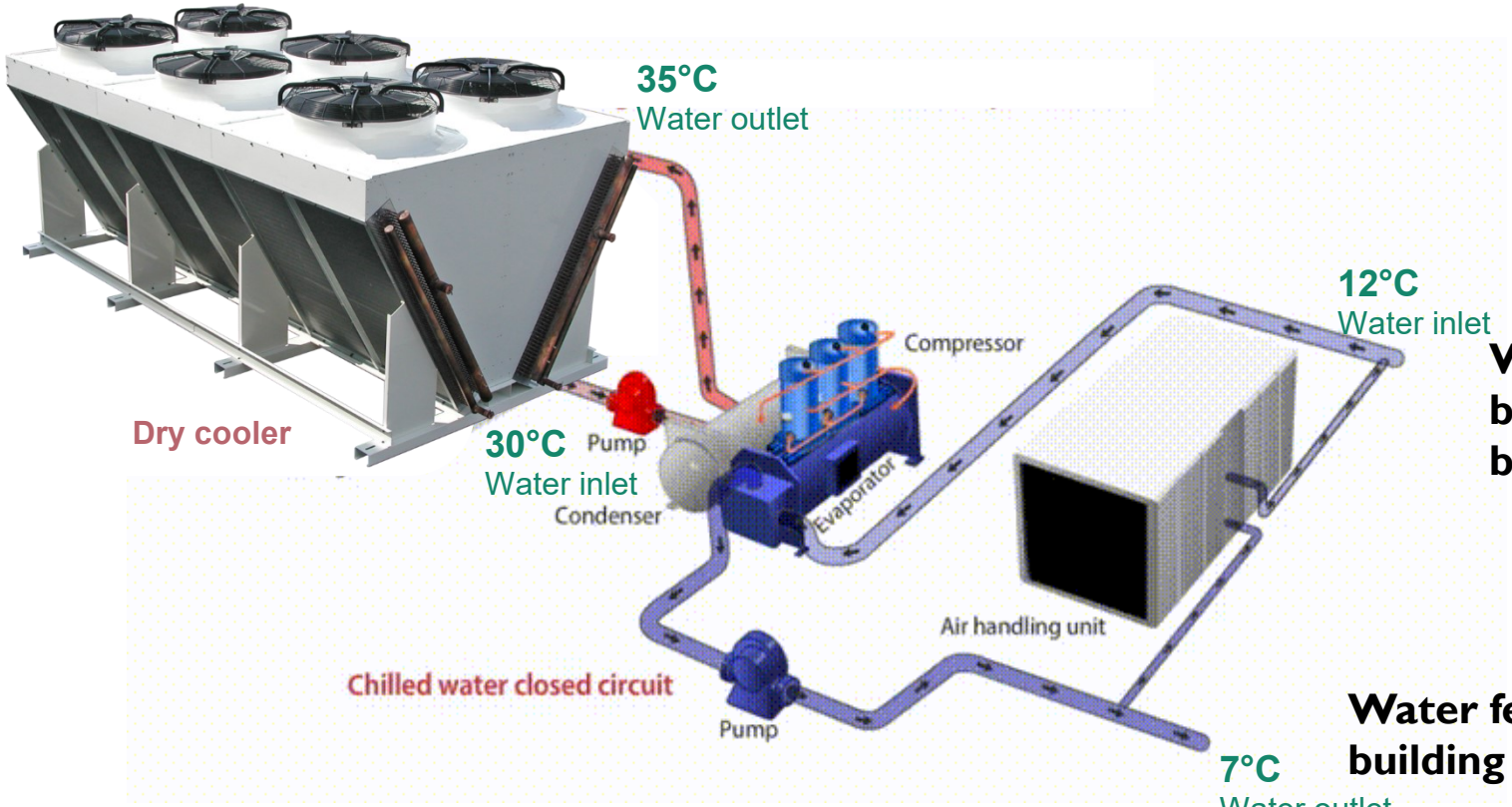
Chillers & Heat Pumps



Water turned back from the building

Water fed to the building

INTRODUCTION: CHILLER & EFFICIENCIES

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How to represent the efficiency of the system

+

EER = Ratio of the total cooling capacity to
(the effective power input of the unit +
power consumption of the dry cooler fans)

Pump power consumption is taken into account during the SEER calculation as per EN 14825.

INTRODUCTION: CHILLER & EFFICIENCIES

Seasonal efficiency of the system

SEER - Seasonal energy efficiency ratio: Overall energy efficiency ratio of the unit, representative for the whole cooling season. The seasonal energy efficiency ratio is calculated as the reference annual cooling demand divided by the annual energy consumption for cooling.

After determining the EER values for each part load for a unit with a dry cooler, SEER can be calculated as per EN 14825:2018.

η_sc - Seasonal space cooling energy efficiency: Ratio between the space cooling demand for the cooling season, supplied by a space cooling unit and the annual energy consumption required to meet this demand.

CASE STUDY

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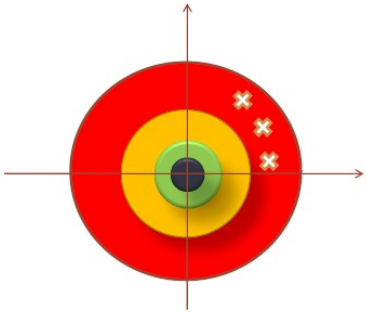
Hypothesis

2 kinds of possible data

- True performance
- Self declaration

self declared data could be anywhere in the data crowd…



Reliability of the data

- Through yearly testing of samples, data certified by Eurovent Certification Company are more transparent comparable and reliable

This study is comparing the behavior of systems

- Chiller + dry cooler certified by ECC
- Chiller + dry cooler **NOT** certified by ECC (assuming capacity gap = -25 %)

CASE STUDY

Conditions and figures

Cooling capacity = 1143 kW

- Chiller water temperature = 7/12 °C
- Dry cooler water temperature = 30/35 °C

Water-cooled chiller combined with dry cooler

- Noise level 60 dB(A) at 10 m
- AC fans

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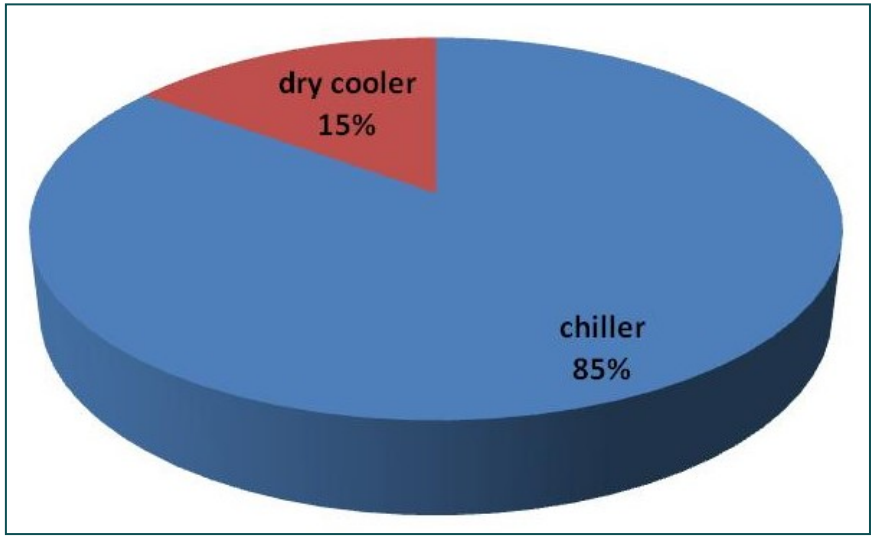
Power consumption of water-cooled chiller + dry cooler



Dry cooler fan power consumption may change in a range between 10 % and 20 % according to the different working conditions.

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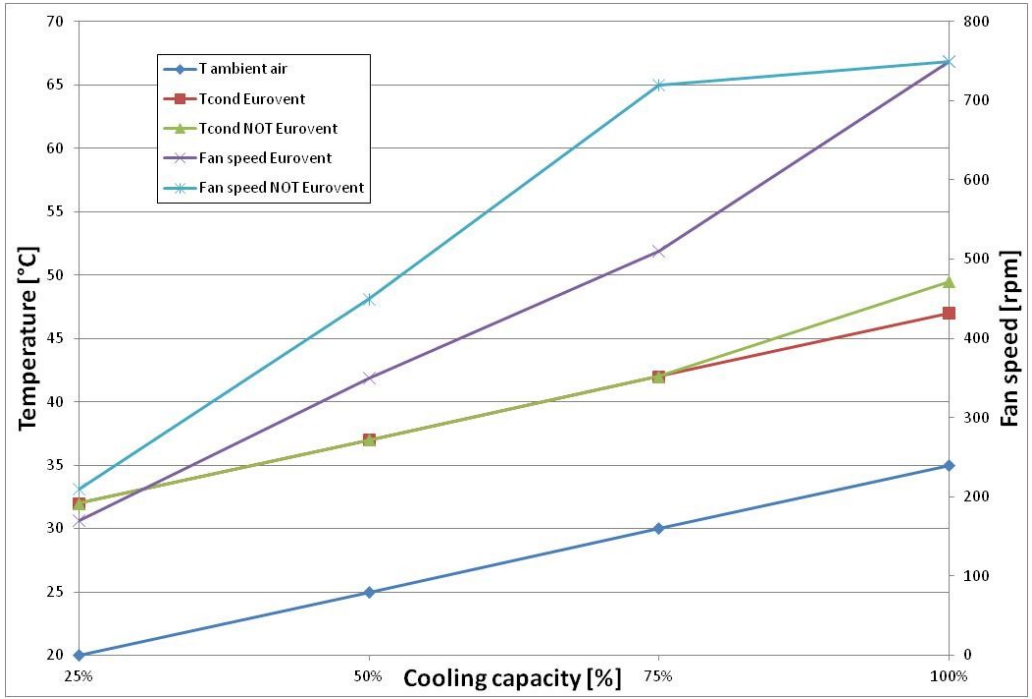
Conditions and figures



Dry Cooler NOT certified requires that chiller works:

- at 100 %: higher condensing temperature
- at 75, 50, 25 %:
  - condensing temperatures are the same
  - fan speed is higher

CASE STUDY

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SEER and eta_s,c calculation of a unit with a **not-certified** dry cooler

SEER

Unit Information		
Heat source	Water-to-water	
Operating mode	Cooling-only	
Application	Air conditioning	
Unit capacity control	Variable	
Water regulation type	FW/VO	
Tdesignc	35	°C
Pdesignc	1143	kW

Calculation Results		
SEERon	3.78	
H_{CE}	600	h
Q_C	685800	kWh
$Q_{...}$	181221	kWh
SEER	**3.78**	
$\eta_{s,c}$	**148.3**	

Unit Performances

Condition	Outdoor HEX	Indoor HEX	Part load ratio	Cooling dem. (kW)	Declared cap. (kW)	Declared EER	C_d	CR	EER_{bin}
A	30/35 °C	12/7 °C	100%	1143.00	1143.00	2.95	0.90	1.00	2.95
B	26/b °C	a/8,5 °C	74%	842.21	846.00	3.45	0.90	1.00	3.45
C	22/b °C	a/10 °C	47%	541.42	537.00	3.95	0.90	1.00	3.95
D	18/b °C	a/11,5 °C	21%	240.63	240.00	4.20	0.90	1.00	4.20

a: With the flow rate as determined during 'A' test for units with a fixed flow rate. See EN 14825 for further details.

b: With the flow rate as determined during 'A' test for units with a fixed flow rate. See EN 14825 for further details.

Auxiliary Power Inputs and Electricity Consumption

Paux modes	Hours	Power input (W)	P x h (kWh)
Ptoc : Thermostat-off	659	0	0
Psbc : Stand by	1377	0	0
Poffc : Off	0	0	0
Pckc : Crankcase heater	2036	0	0

Bin Calculation

Condition	Bin	Outdoor air temp.	Hours	Part load ratio	Cooling dem. (kW)	Cooling capacity of the chiller	EER_{bin}	Annual cooling demand	Annual electricity cons.
	j	T_j	h_j	$pl(T_j)$	$Pc(T_j)$			$h_j*Pc(T_j)$	$h_j*(Pc(T_j)/EER_{bin}(T_j)$
	-	°C	h	%	kW	kW	-	kWh	kWh
	1	17	205	5.26%	60.16	61.80	4.20	12332	2936
	2	18	227	10.53%	120.32	121.20	4.20	27312	6503
	3	19	225	15.79%	180.47	180.60	4.20	40607	9668
D	4	20	225	21.05%	240.63	240.00	4.20	54142	12891
	5	21	216	26.32%	300.79	299.40	4.15	64971	15656
	6	22	215	31.58%	360.95	358.80	4.10	77604	18928
	7	23	218	36.84%	421.11	418.20	4.05	91801	22667
	8	24	197	42.11%	481.26	477.60	4.00	94809	23702
C	9	25	178	47.37%	541.42	537.00	3.95	96373	24398
	10	26	158	52.63%	601.58	598.80	3.85	95049	24688
	11	27	137	57.89%	661.74	660.60	3.75	90658	24175
	12	28	109	63.16%	721.89	722.40	3.65	78687	21558
	13	29	88	68.42%	782.05	784.20	3.55	68821	19386
B	14	30	63	73.68%	842.21	846.00	3.45	53059	15379
	15	31	39	78.95%	902.37	905.40	3.35	35192	10505
	16	32	31	84.21%	962.53	964.80	3.25	29838	9181
	17	33	24	89.47%	1022.68	1024.20	3.15	24544	7792
	18	34	17	94.74%	1082.84	1083.60	3.05	18408	6036
A	19	35	13	100.00%	1143.00	1143.00	2.95	14859	5037
	20	36	9	105.26%	1203.16	1202.40	2.95	10828	3671
	21	37	4	110.53%	1263.32	1261.80	2.95	5053	1713
	22	38	3	115.79%	1323.47	1321.20	2.95	3970	1346
	23	39	1	121.05%	1383.63	1380.60	2.95	1384	469
	24	40	0	126.32%	1443.79	1440.00	2.95	0	0
TOTAL			*2602*					*1090302*	*288285*

CASE STUDY

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SEER and eta_s,c calculation of a unit with a **certified** dry cooler

SEER

Unit Information		
Heat source	Water-to-water	
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Calculation Results		
SEERon	3.97	
H_{CE}	600	h
Q_C	685800	kWh
Q_{CE}	172795	kWh
SEER	**3.97**	
$\eta_{s,c}$	155.8	

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CASE STUDY

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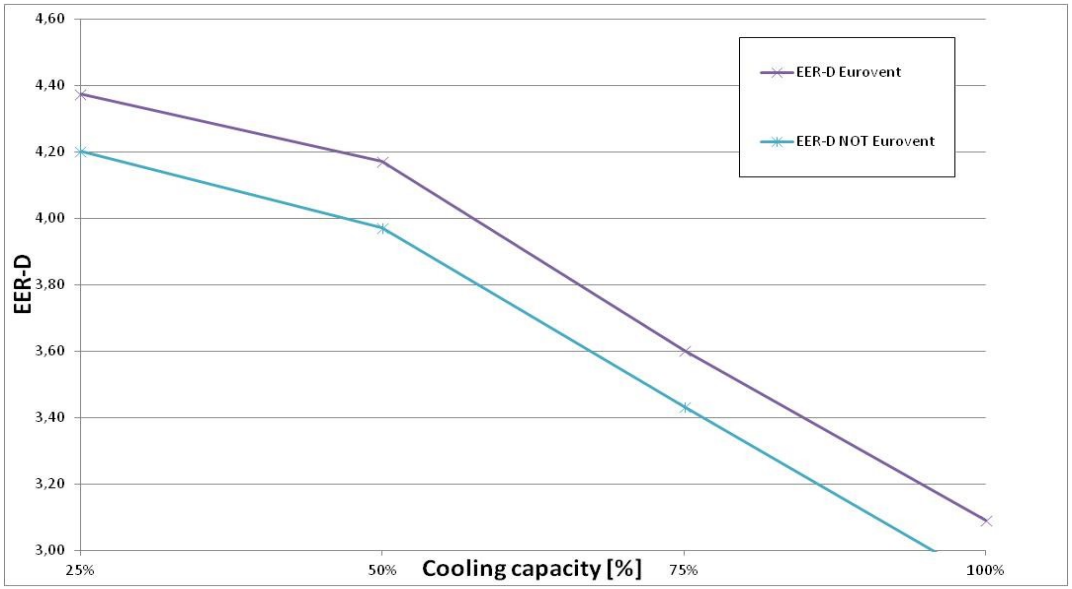
Conditions and figures



- With Dry Cooler **NOT certified**:
  - Fan power consumption is higher
  - System efficiency is lower, specially at high capacity
  - SEER = 3.78
  - η_sc = 148.3
  - Annual cons. = 288 MWh

- With Dry Cooler **certified**
  - SEER = 3.97
  - η_sc = 155.8
  - Annual cons. = 275 MWh

*SEER **+5.03 %** higher and η_sc **+5.06 %** higher !*
*Annual Electricity Consumption **-4.5 %** lower !*

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Energy and € differences

-4.5 % difference

City of NÜRNBERG
(cost 0,30 €/kWh)

Using a product which is certified by ECC can mean a relevant energy saving 4070 € / year

CASE STUDY

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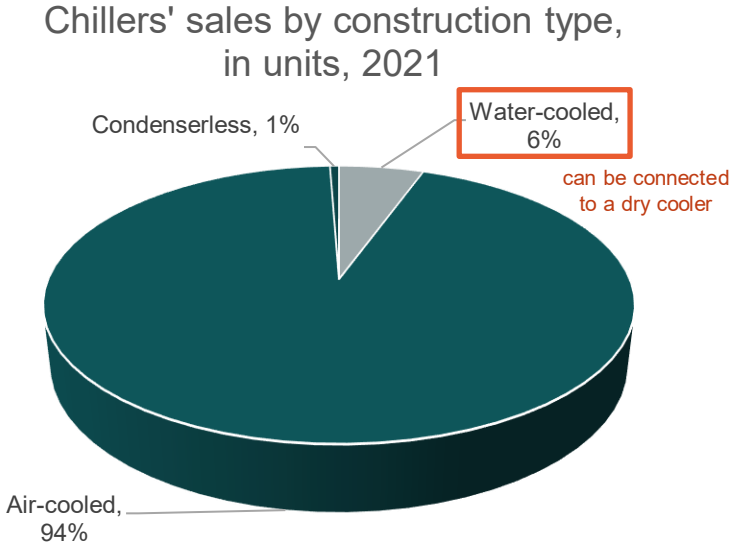
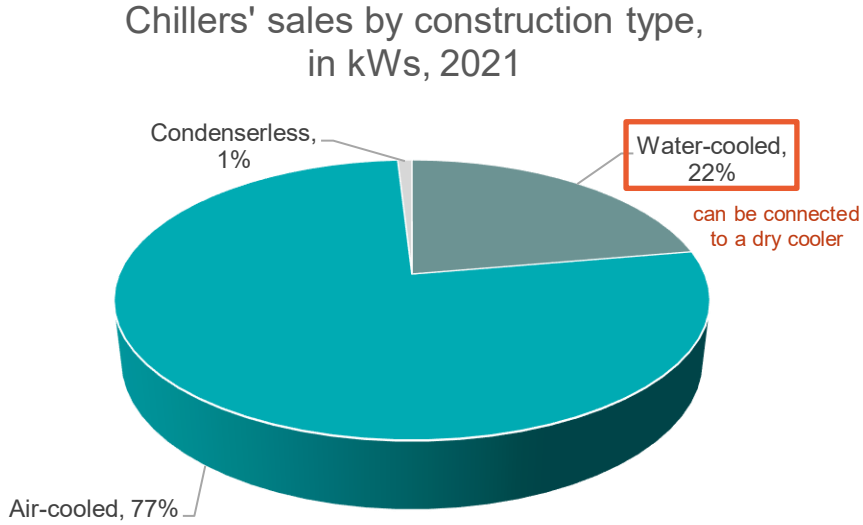
The use of a non certified dry cooler can transform a modern chiller in an old and not efficient unit

CASE STUDY

To put into perspective… 2021 Chiller Market in Europe





You can imagine how much money and energy would be saved if the certified dry coolers are used!!

Key benefits in one glance and best practice

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Easy product selection in HVAC-R

- Direct comparison of competitive products

Good for customer, good for the planet

- New installations as well as retrofitting
- Less energy consumption as the unit runs as expected to achieve the required performance ⇒ reduced product climate and environmental impact as well as electricity costs
- Task incentives for more energy savings (ex: France)

In all cases, the best practice is the following

Good design (avoid oversizing) ⇒ ask for third party certified performances

- Good energy efficiency ⇒ ask for third party certified best classes

Certification by EUROVENT CERTITA CERTIFICATION

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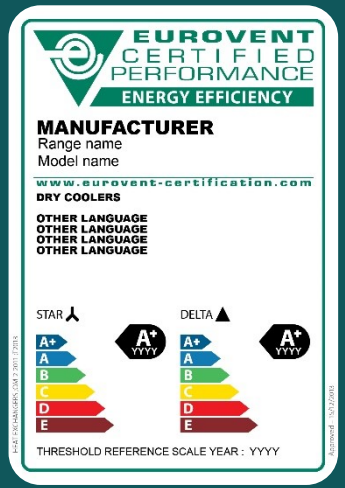
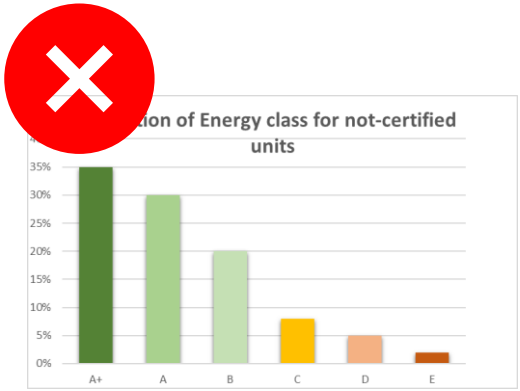
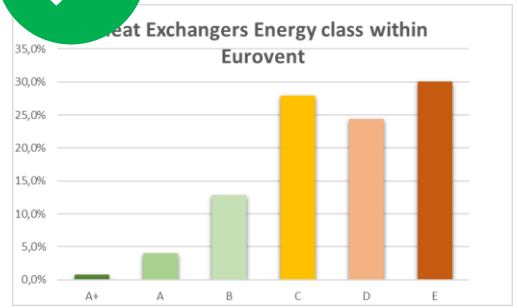
ECC Voluntary labelling for dry coolers

How and by who is labelling prepared?

- Based on European testing standards (EN1048:2014)
- Rating prepared by industry
- We need to cover full range of the market







Meaningful ratings and balanced distribution of classes are the key points

Acc. to Certification Manual art. 318:

A+ < 1 %, A < 5 %, B < 15 %, C < 30 %, D and E > 50 %

Certification by EUROVENT CERTITA CERTIFICATION

Eurovent Certita Certification in numbers

44
Certification programmes

+300K
Certified products

+1800
Tests / year

24/7
Performance data available on website

+2600
Certificates delivered / year

Certification by EUROVENT CERTITA CERTIFICATION

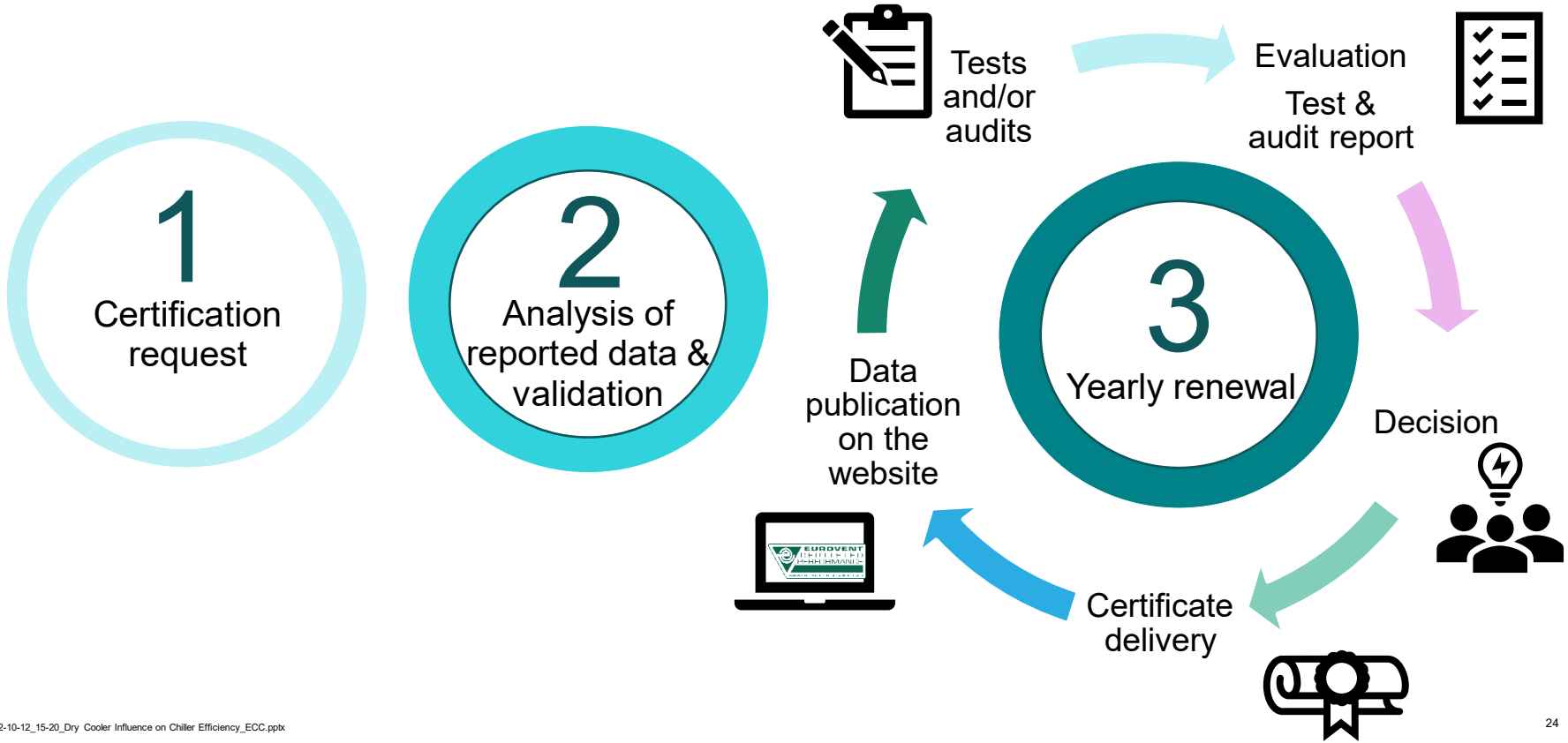
Certification Programmes

44 certification programmes

For buildings and homes

Certification by EUROVENT CERTITA CERTIFICATION

How does it work?



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Zoom on the Heat Exchangers programme

Scope				
Direct Expansion (Dx) Air Coolers using HFC	Dx Air Coolers using CO_2	Air Cooled Condensers	CO_2 Gas Coolers	Dry Coolers.

CERTIFY-ALL PRINCIPLE

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Certification programme for Dry Coolers

Certified performance items for Dry coolers:

- Standard capacity [kW]
- Fan power input [W]
- Energy Ratio R [-]
- Energy class [-]
- Air volume flow [m3/h]
- Fluid side pressure drops [kPa]
- A-weighted sound pressure level [dB(A)]
- A-weighted sound power level [dB(A)]

For dry coolers, the test is carried on according to EN 1048:2014

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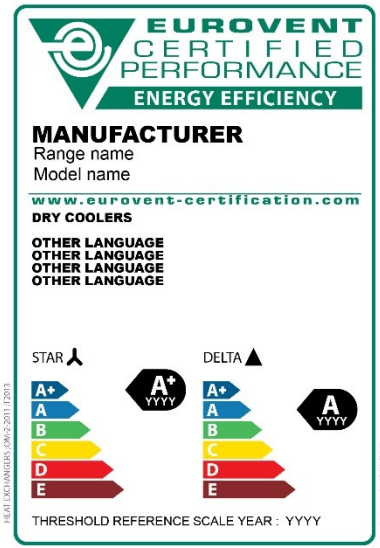
Certification programme for Dry Coolers

$$R_{\text{Dry coolers}} = \frac{\text{Capacity @ DT1} = 15\text{K}}{\text{Fan power cons}}$$

Energy class	Energy consumption	Dry coolers
A+	Extremely low	R≥ 226
A	Very Low	169 ≤ R< 226
B	Low	109 ≤ R< 169
C	Medium	69 ≤ R< 109
D	High	37 ≤ R< 69
E	Very high	R< 37



EN 1048:2014

Thank you for your attention !

Any question?

CONNECTING EXPERTS.