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Additional clarifying considerations on the impact of the revision of the Commission Regulation (EU) 327/2011 on the evaporative cooling industry

Eurovent PP – 2018-04-30

Roadmap

1. The fans installed in the evaporative cooling equipment are not off-the-shelve products
2. Properties of Axial Fans
3. Properties of Centrifugal Fans
4. The fan system cannot feasibly be separated to make fan's efficiency measurements
5. From the efficiency of the evaporative cooling equipment to the fans'efficiency
6. EU energy saving due to Fans' Ecodesign measure: Contribution of the fans installed in evaporative cooling equipment
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The fans installed in the evaporative cooling equipment are not off-the-shelve products

- The installed fans (both centrifugal and axial) are always designed case by case, units by units, according to the climate conditions and to the demanded cooling capacity.
- The diameter of the installed impeller varies with the cell's geometry and with the demanded cooling capacity. The same applies to the fan rotation speed as well as to the blade pitch angles which usually are adjustable (only in the axial fans).
- ***The fans installed in the evaporative cooling equipment are not off-the-shelve products***, they are tailor made products customised case by case, unit by unit, according to the installation's demands and requirements.
- ***The evaporative cooling industry cannot make use of standard pre-assembled fans →*** **<u>it is not possible to follow the fan manufacturers' instructions</u>**

The fans installed in the evaporative cooling equipment are not off-the-shelve products (cont.)

- A ‘fan’ is commonly regarded as a configuration of impeller, stator, electric motor, transmission etc
- In the case of evap. cooling equip., the ‘stator’ is part of the equipment design, which not only includes the fan cowl or fan housing, but also the air movement entering and leaving the fan
- The way the air enters the fan is also of great importance when it comes to fan efficiency. Smooth air entry with little turbulence is desirable, but this is greatly influenced by the integration of the fan in the cooling tower, the type of water distribution, drift eliminators and even the rain density.

The fans installed in the evaporative cooling equipment are not off-the-shelve products (cont.)

There are many factors that influence the performance of a fan in a cooling tower. Inter alia:

- The water flow,
- The type and quantity of packing,
- The type of water distribution,
- The presence and definition of the sound attenuators at the inlets, at the outlets. the types of
- Drift eliminators,
- The use of plume abatement coils.

Fan curves for rotors used by cooling tower manufacturers generated in a lab do not describe the behavior of the same rotor in the actual cooling tower model

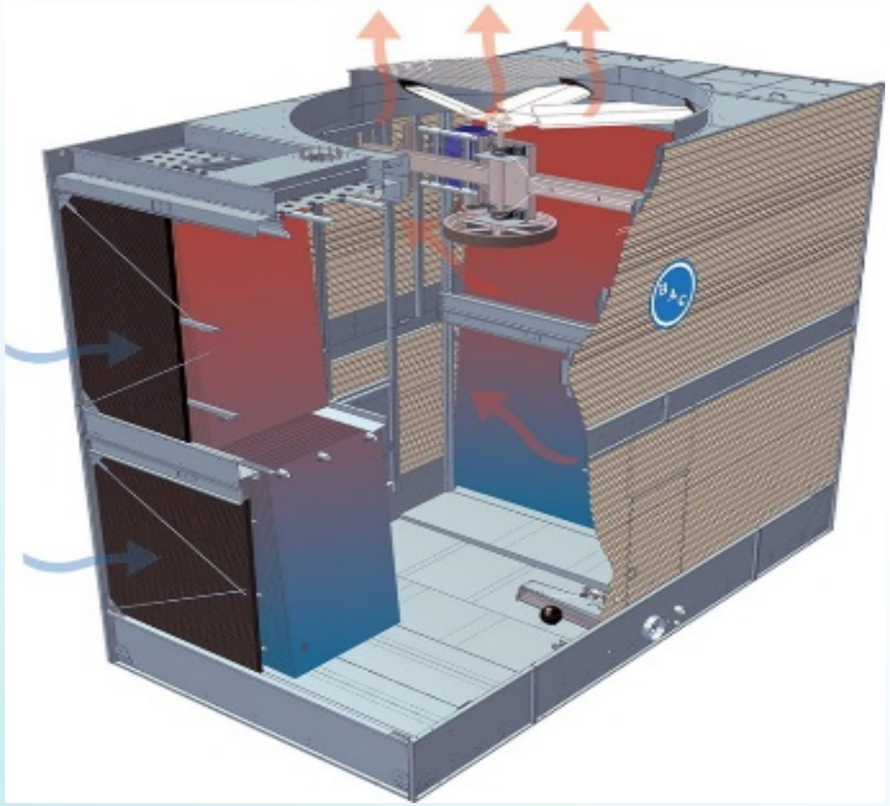
The evaporative cooling manufacturers should test each single fan assembly by themselves, but there is not any CEN standard/technical report addressing how to test fans installed in a cooling tower.

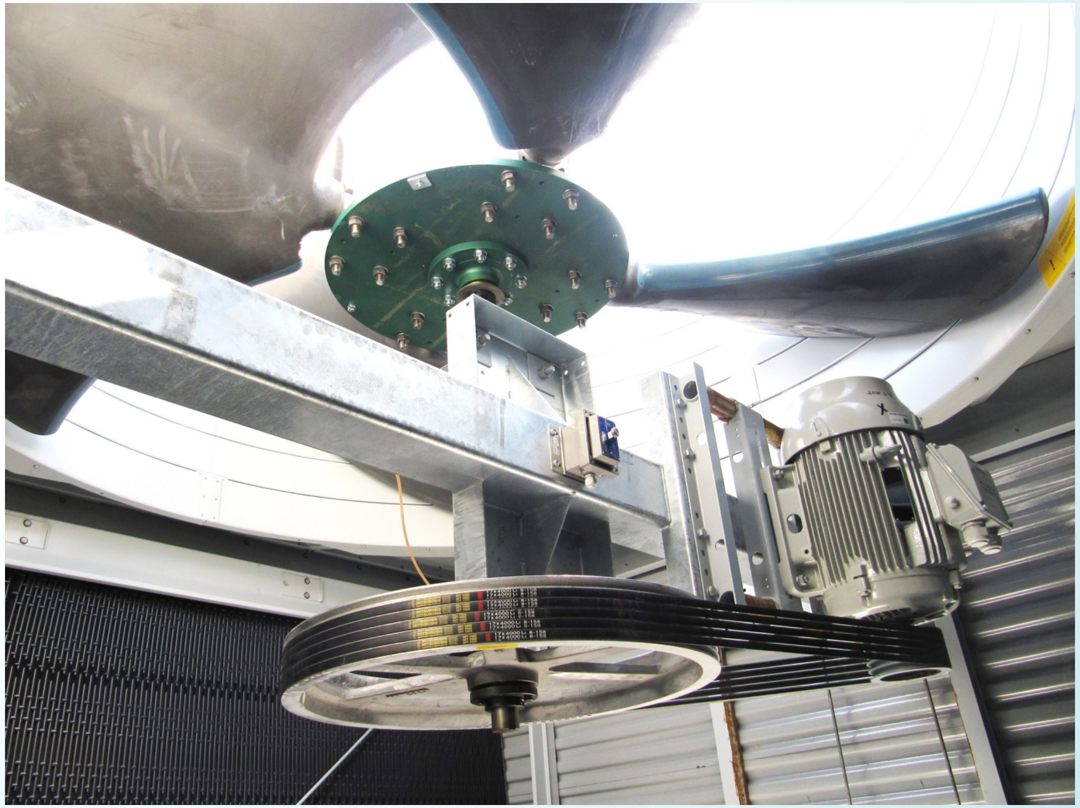
The proposed approach of a scaled testing model does not make any sense: According to the above considerations scaled model is not representative of the efficiency of the final real assembly, and, it is not defined in any CEN standard/ technical report how to test a real evaporative cooling assembly

Properties of axial fans

- The motor/transmission mounting arrangement is always an integral part of the cooling tower structure; the axial fans are always built-in in the evaporative cooling equipment,
- The same applies to belt-driven axial fans where the motor is located on a support which is part of the entire evaporative cooling equipment.

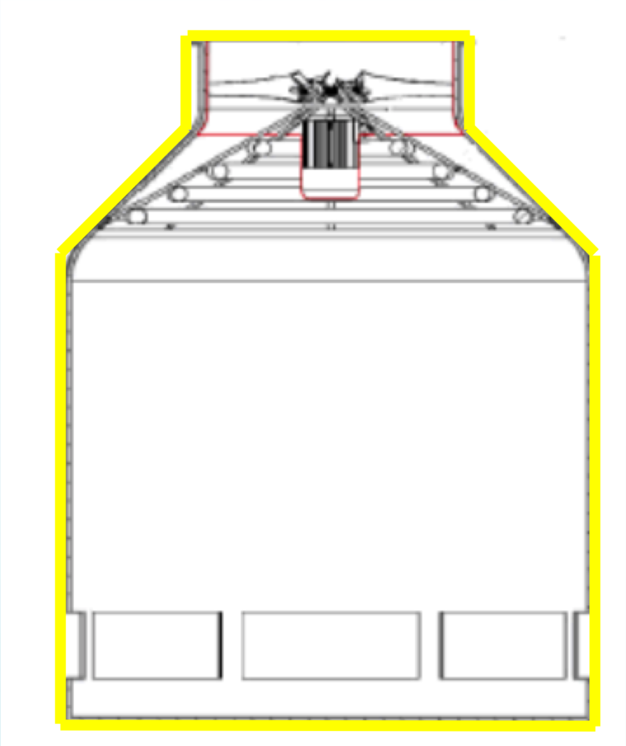
Properties of axial fans (cont.)

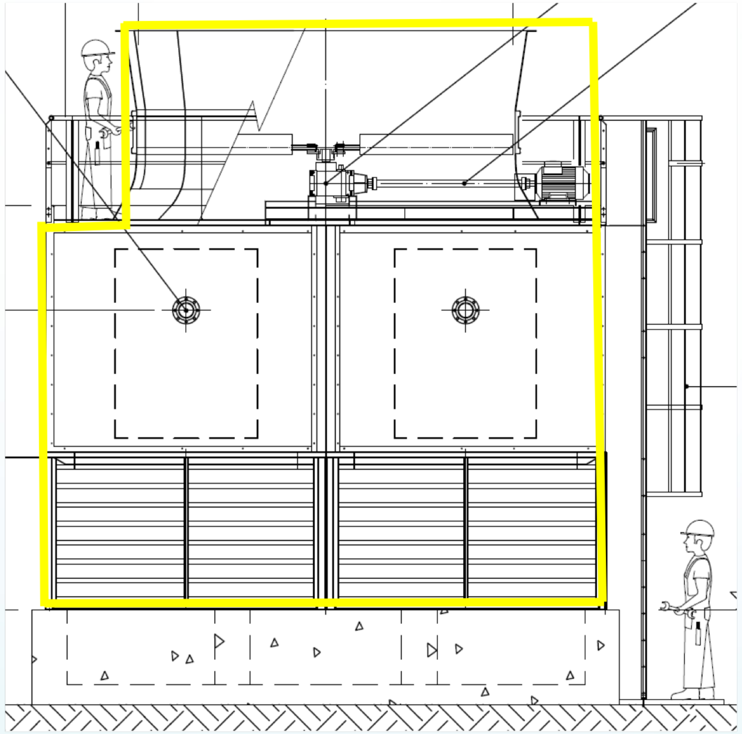


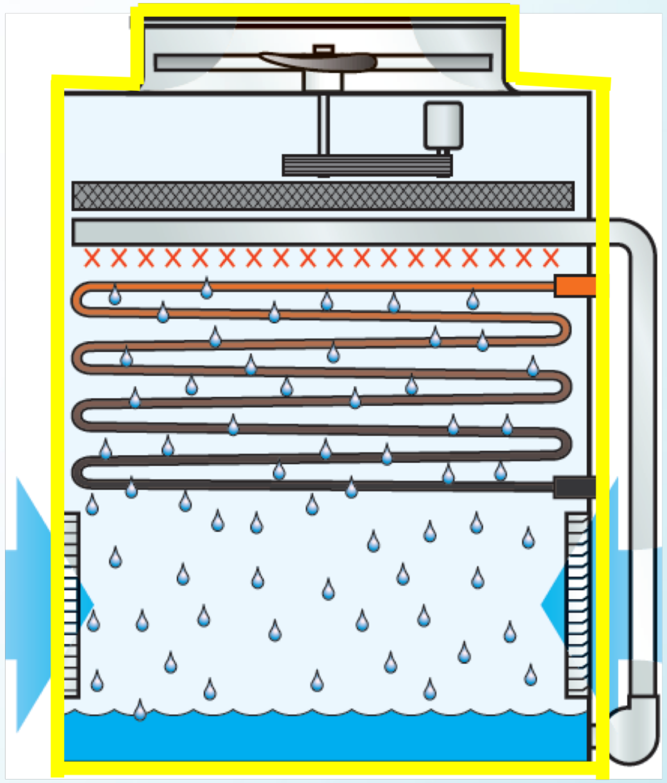


Properties of axial fans (cont.)

Evaporative cooling equipment mounting axial fans: Proposed boundary (yellow) for the defined ‘test fan’



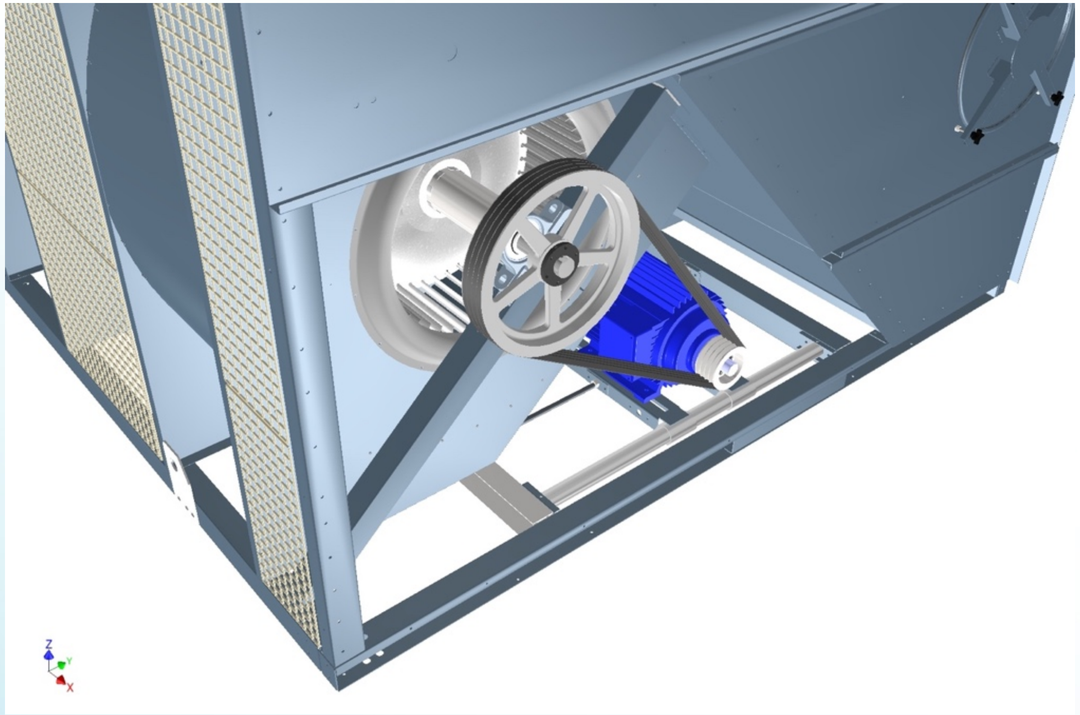




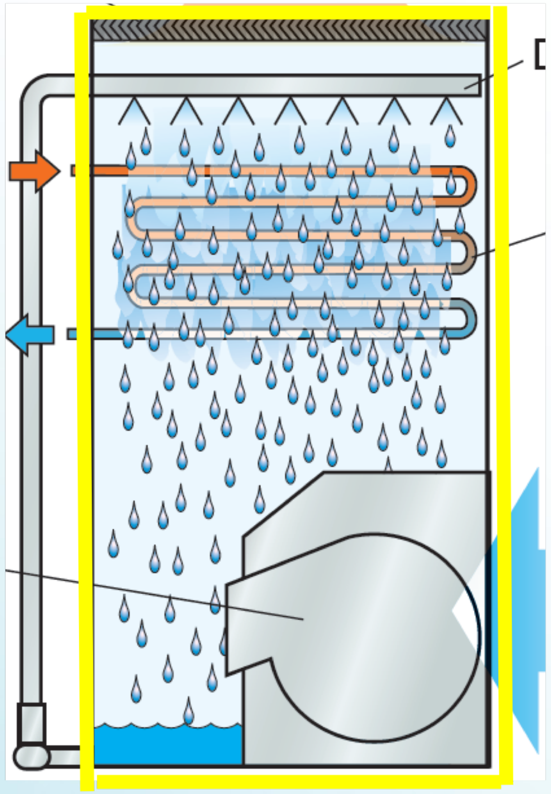
Properties of centrifugal fans

- The centrifugal fans are mainly installed in the forced draft evaporative cooling equipment and they serve as a supporting structure for the heat exchanger installed on top of the fan structure. Centrifugal fans cannot usually be separated by the evaporative cooling equipment.
- The heat exchanger when charged with the cooling tower water or refrigerant, represents the heaviest section of the cooling tower; the fan housing side panels are oversized and positioned under the heat exchanger from floor surface till the underside of the heat exchanger section. Two thirds of the weight of the whole evaporative cooling equipment is positioned above the fan side panels (Example: Cooling capacity of 1 MW→total weight 15.000kg and 10.000kg over the fan side panels).
- In this respect the stator must be always custom-designed in size construction and quantity to support the weight in a structurally safe manner. This principle can neither be compromised nor replaced by an off-the-shelve product, which, as such, is not available on the market. It must be pointed the centrifugal fans are always built-in in the evaporative cooling equipment which constitutes the fans mounting arrangement

Properties of centrifugal fans (cont.)



Properties of centrifugal fans (cont.)



- Evaporative cooling equipment mounting centrifugal fans: Proposed boundary (yellow) for the defined ‘test fan’

The fan system cannot feasibly be separated to make fan's efficiency measurements

- **The critical parts of the fan system** tested to define the fan efficiencies according to the proposed approach **are always incorporated into the physical structure of the cooling tower**
- The majority of the fans for evaporative equipment have a very large dimensions (e.g. large impeller diameters range from **3.96 meter to over 10 meter diamete**r).
- No test facilities in Europe are capable to measure fan efficiencies for such diameters. AMCA International, for instance, has a test facility for fans up to **2.4 meter diameters**. Yet, this facility is located in the USA, making cost-efficient tests unfeasible.

From the efficiency of the evaporative cooling equipment to the fans'efficiency

- **The main purpose of a cooling tower is to cool water, not to move air.** The requested cold water temperature is highly important for the proper efficiency of a process to be cooled, but as the outside temperature is continuously changing, the fan speed is less than 2% of the year at the nominal speed (and optimal fan performance), because the saving on the absorbed power linked to outside temperature is more than 80 times more important than the one on the fan efficiency itself.
- Accordingly, it would be counterproductive in terms of energy saving to operate the tower focusing on fan efficiency first. **Focusing on the efficiency of the cooling tower (according to the Eurovent Recommendation 9/12-2016) is then a key point, compared with the focus on the fan only.**

From the efficiency of the evaporative cooling equipment to the fans'efficiency (cont.)

- Fan efficiency is not the appropriate measure to determine the efficiency of evaporative cooling equipment such as cooling towers. That said, a cooling tower can have an exceptionally efficient fan, but deliver a poor cooling performance. **Unlike other heat transfer technologies, evaporative cooling depends on mixing liquid water with air, which is not directly related to fan efficiency**
- The application of minimum fan efficiency levels leads to a misleading interpretation by the market as it pushes manufacturers to strive for fan instead of maximum cooling efficiencies when developing products.
- ↓lower process temperature = ↑ efficiency =↑Cooling energy **saving**;
- ↑higher process temperature = ↓efficiency =↓Cooling energy **saving.**

From the efficiency of the evaporative cooling equipment to the fans'efficiency (cont.)

- As a result, the heat rejection systems used for cooling applications will be downsized to follow the fan's efficiency approach.
- A downsized heat rejection system would mean an oversized cooling system (e.g. chiller) and a significant increase in terms of energy consumption at the EU level. In fact, it would thwart the efforts in terms of energy saving targets as defined in several EU Ecodesign measures, e.g. Commission Regulation (EU) 2281/2016.
- The above assumption is outlined in the appendix A

EU energy saving due to Fans' Ecodesign measure: Contribution of the fans installed in evaporative cooling equipment

- About 3.850 evaporative cooling equipment have been installed in the EU in 2017. These units account for 2.156.000 kW of installed heat rejection capacity, and for 59.600 kW of installed fan power (**about 4.000 fans**).
- Due to this low number of dedicated fans, **an Ecodesign measure covering the fans used in the evaporative cooling equipment does not meet any EU necessity both in terms of market volume and achievable energy saving**. These fans can only provide a negligible contribution to the energy saving for which this Ecodesign measure is aiming at.

Exemption: proposed text

- ‘This regulation shall not apply to fans which are specified to exclusively transport gases consisting of a mixture of liquid water and air having a relative humidity consistently larger than 90%.
- Loopholes are avoided by using:
  - The ‘mixture of liquid water and air’ = adiabatic saturated air handling equipment is not exempted, neither are humidifiers
  - ‘consistently larger than 90%’ = weather influences for outdoor equipment are not exempted

Market surveillance: Features of axial/centrifugal fans

- In order to avod any loophole in the Regulation, the principal features of the fans (axial and centrifugal) installed in the evaporative cooling equipment are outlined in the following slides (to be intended as for guidance and not as exhaustive)

Market surveillance: Features of axial/centrifugal fans (cont.)

Axial fans

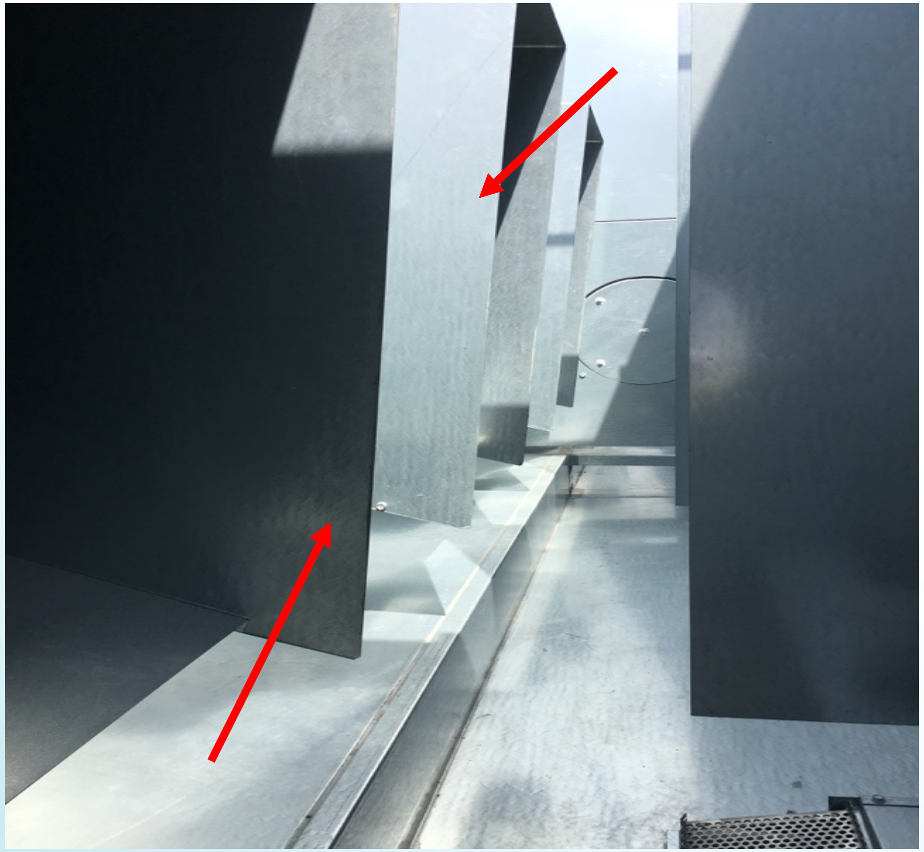
- drain holes in the fan tip
- large tip clearance between fans wheels and housings (this is to prevent structural damages to either fans and housing due to high wind speeds, solar heating, and winter conditions, ice and snow)
- adjustable blade pitch angles
- motor transmission located directly in the saturated air stream (for both directly and indirectly-driven axial fans)
- transmissions using gear boxes typically penetrate the fan cowl and position the motor on top of the fan deck (for directly-driven axial fans)

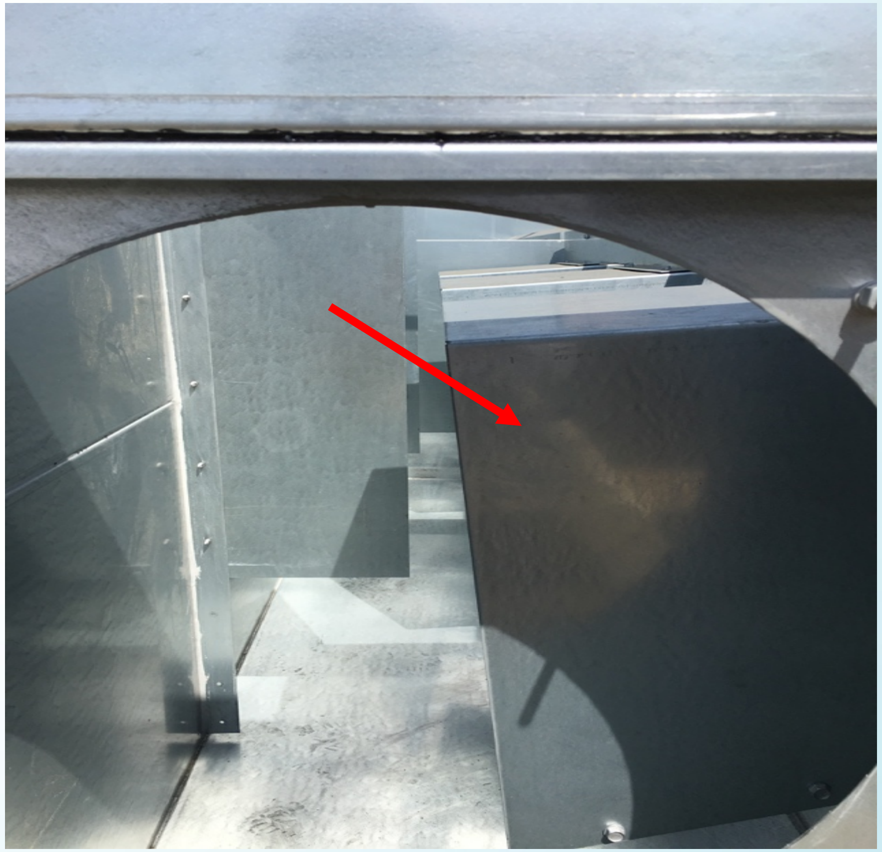
Market surveillance: Features of axial/centrifugal fans (cont.)

Centrifugal fans

- fan housing is a physical support for the heat exchanger
- fan housing side panels are oversized and positioned under the heat exchanger from floor surface till underside of heat exchanger section
- water drain holes in the lowest spot of the fan housing
- fans are equipped with an extended fan nose that serves as protection from the high volume water flood in the wet zone (in red in the next slide)
- fans are positioned in over rotated angle to avoid cooling tower water ingress

Market surveillance: Features of axial/centrifugal fans (cont.)





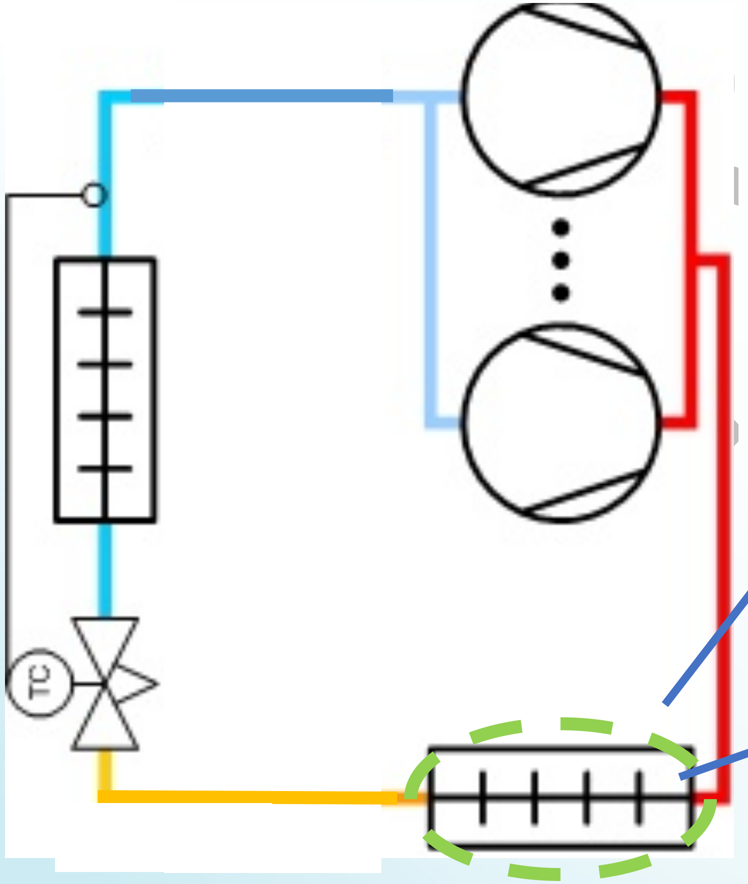
Conclusion

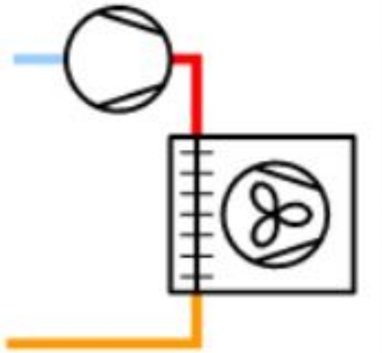
- Due to the low number of dedicated fans, an Ecodesign measure covering the fans used in the evaporative cooling equipment does not meet any EU necessity both in terms of market volume and achievable energy saving.
- If the fan user (evaporative cooling industry) becomes a fan manufacturer, this requires new testing methods, and new testing capabilities. This cannot be economically justified in any way, and even more, it represents a counterproductive impact in terms of the achievable energy saving at the EU level, as mentioned in the above paragraph 2.
- **Eurovent would like to reiterate its call for an exemption of the evaporative cooling equipment**.

Appendix A

Comparison between a dry cooling system and a water cooled system: Energy saving / CO2 emissions analysis

Systems assessed





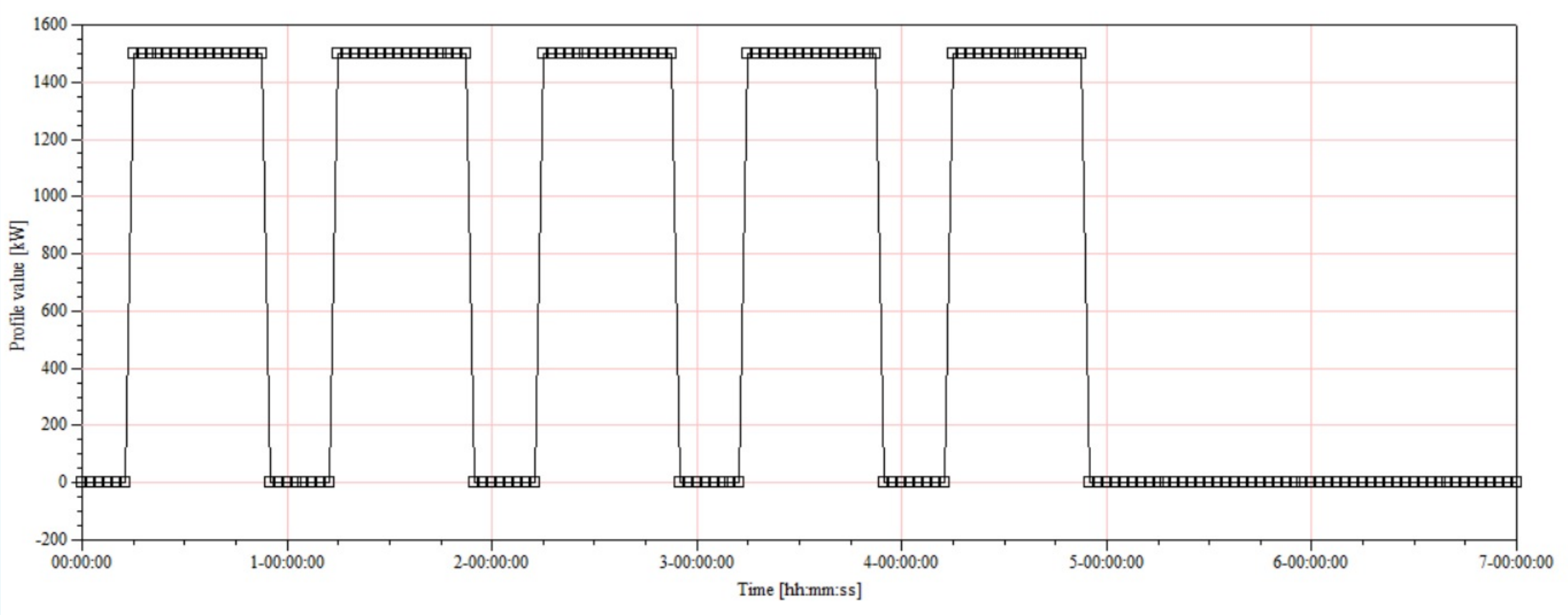
An *air-cooled* process must be intended as a process by which air passes over a coil or channel containing fluid; the heat is transferred from the coil directly to the fluid.

A water-cooled process must be intended as a process that utilizes a spray system to pass water over coils or fill media to reject heat to the atmosphere through evaporation. The spray water itself or the fluid contained in the coil can then be used by a cooling system

1st Assessment (Industrial Application Brussels)

1st assessment							
Air-cooled chiller (monobloc chiller)	Dry bulb temperature: 31,9°C (Brussels)		Industrial load profile	Speed controlled fans: **no**		Condensing temperature 44°C	Evap. In/out temp 12°C/7°C
Open CT	Wet bulb temperature: 22,3 °C (Brussels)	27°C/32°C (4K intermediate heat exchanger)	Industrial load profile	Speed controlled fans: **no**		Condensing temp 32°C	Evap. In/out temp 12°C/7°C

Weekly load profile



System Configuration

System configuration		
	Air-cooled system (reference system)	Water-cooled system
Refrigeration system	Monobloc condensing unit	Open cooling tower, induced draft counterflow, axial fans
Application	Industrial application	Industrial application
Climate	Mild/humid: Brussels Wet bulb. 22,3°C Dry bulb. 31,9°C	Mild/humid: Brussels Wet bulb. 22,3°C Dry bulb. 31,9°C
Load profile	Constant load profile (16 hours per day; 5 days per week)	Constant load profile (16 hours per day; 5 days per week)
Refrigerant	R134a	R134a
Compressors	Screw (Bitzer CSH series) 3xCSH9563-210Y 1xCSH7571-70Y 1xCSH7563-80Y	Screw (Bitzer CSH series) 3xCSH9553-180Y 2xCSH7551-50Y
Compressors' design conditions	(Te=7°C – Tc=44°C)	(Te=7.0°C – Tc=32°)
Inlet/outlet water temp		32/27°C

System Configuration (Cont.)

Suction side		
	Air-cooled system (reference system)	**Water-cooled system**
Cooling capacity	1551,9 kW	1529,1 kW
Total superheat	0°K	0°K
Non-useful superheat	0° K	0°K
Evaporator supply temperature	12°C	12°C
Expansion valve	electronic	electronic
Evaporator DT	5K	5K

System Configuration (Cont.)

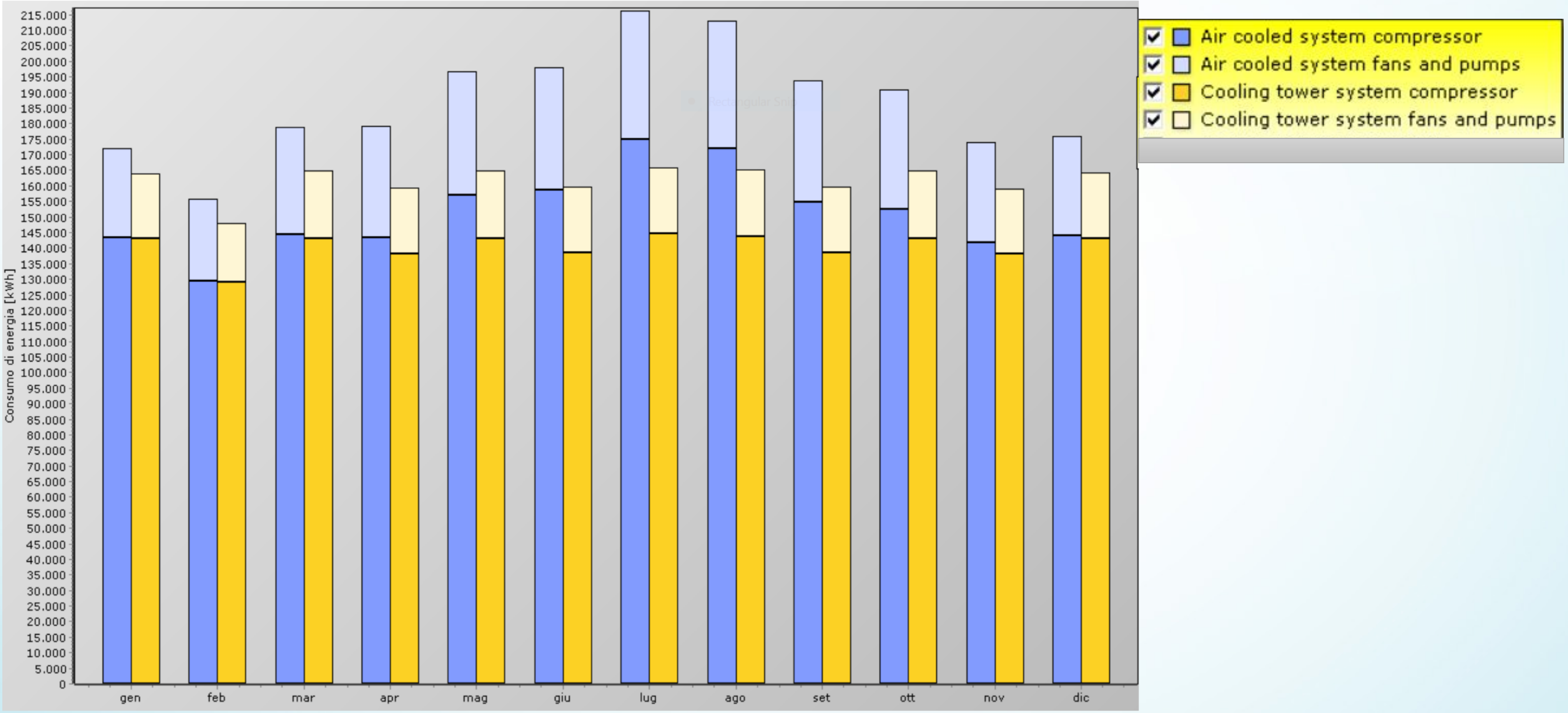
Discharge side		
	Air-cooled system (reference system)	**Water-cooled system**
Condenser capacity	1889,2 kW	1769,0 kW
Condensing approach	12K	4K
Condensing temperature	Tc= Tamb+12K	Tc= Twb+4K+4K (intermedtateHE)
Minimum condensing temperature	20°C	20°C
Design condensing temperature (@ 100% capacity)	44°C	32°C
Subcooling	0 K	0K
Speed controlled fans /pumps	No	No
Fan power consumption @design condition	59,5 kW	22 kW
Pump power consumption @design condition	n.a.	7,5 kW

System Configuration (Cont.)

Economy (Conversions Factor[1])		
	Air-cooled system (reference system)	Water-cooled system
Energy consumption: kWh→kgCO2e	0,40957	0,40957
Water supply: m3→ kgCO2e	n.a.	0,344
Water treatment m3→ kgCO2e	n.a.	0,708

1 https://www.gov.uk/government/collections/government-conversion-factors-for-company-reporting

Assessment of the energy consumption



Assessment of the energy consumption (cont.)

	Air-cooled system (reference)	Water-cooled system
Average COP	**5,77**	**6,77**
Pumps and Fans energy consumption [kWh/year]	206.823	120.488
Compressors energy consumption [kWh/year]	878.776	804.734
Total Energy Consumption [kWh/year]	1.085.599	925.222
Yearly energy saving [kWh]	-	160.377
Yearly energy saving [%]	**-**	**14,8%**

Assessment of the water consumption

According to the calculated condensing capacity, and according to climate conditions the following consumption has been assessed:

- Make-up- water: 10.710 m3/year
- Blow-down water: 3.060 m3/year

Conclusions: kgCO2e emissions assessment

Air cooled system			
	Value [kWh/year]	Conversion factor	Emissions [kgCO2e]
Compressors energy consumptions	878.776	0,40957	359.920,28
Fans energy consumption	206.823	0,40957	84.708,49
Total energy consumption	1.085.599	0,40957	**444.628,77**
Water cooled system			
Compressors energy consumptions	804.734	0,40957	329.594,90
Pumps Fans energy consumption	120.488	0,40957	49.348,27
Total energy consumption	925.222	0,40957	378.943,17
Make-up- water [m^3/year]	10.710	0,344	3.684,24
Blow-down water [m^3/year]	3.060	0,708	2.166,48
Total emissions			**384.793,89**

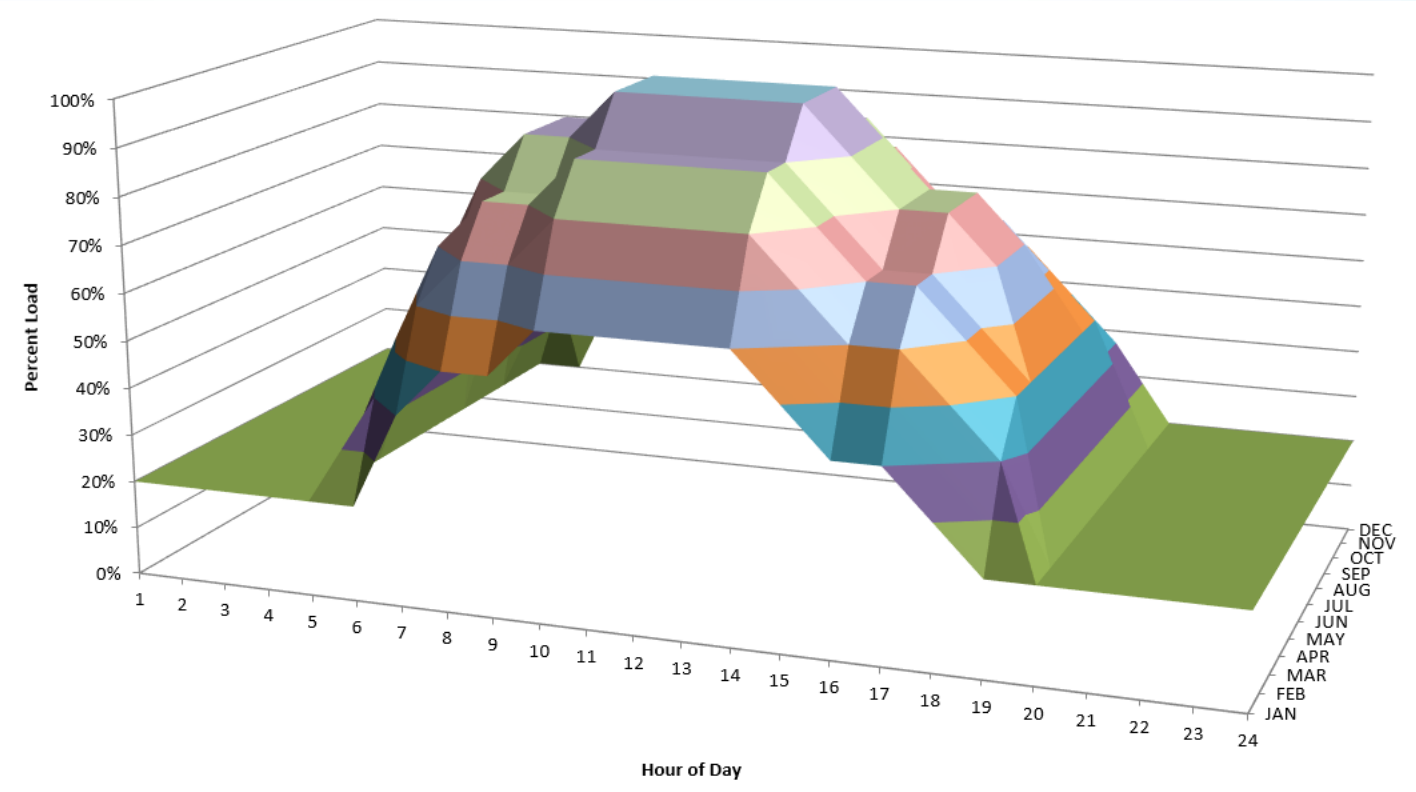
Conclusions: kgCO2e emissions assessment (Cont.)

	Air-cooled system (reference)	Water-cooled system
Total emissions [kgCO2e]	444.628,77	384.793,89
Yearly emissions' saving [kgCO2e]	-	59.834,89
Yearly emissions' saving [%]	**-**	**13,4%**

2th Assessment (HVAC Application Athens)

8th assessment							
Air-cooled chiller (monobloc chiller)	Dry bulb temperature: 35°C (Athens)		HVAC profile 1,5MW 20% fixed	Speed controlled fans: no		Condensing temperature 47°C	Evap. In/out temp 12°C/7°C
Open CT	Wet bulb temperature: 25 °C (Athens)	35°C/30°C (4K intermediate heat exchanger)	HVAC profile 1,5MW 20% fixed	Speed controlled fans: no		Condensing temp 39°C	Evap. In/out temp 12°C/7°C

Yearly load profile



System Configuration

System configuration		
	Air-cooled system (reference system)	Water-cooled system
Refrigeration system	Monobloc condensing unit	Open cooling tower, induced draft counterflow, axial fans
Application	HVAC 20% fix	HVAC 20% fix
Climate	Mediterranean: Athens Wet bulb. 25°C Dry bulb. 35°C	Mediterranean: Athens Wet bulb. 25°C Dry bulb. 35°C
Load profile	HVAC 20% fixed	HVAC 20% fixed
Refrigerant	R134a	R134a
Compressors	14XHGX7/2110-4	12XHGX7/2110-4 1XHGX5/830-4
Compressors' design conditions	(Te=7°C – Tc=47°C)	(Te=7.0°C – Tc=39°)
Inlet/outlet water temp		30/35°C

System Configuration (Cont.)

Suction side		
	Air-cooled system (reference system)	**Water-cooled system**
Cooling capacity	1534,2 kW	1530,3kW
Total superheat	0°K	0°K
Non-useful superheat	0° K	0°K
Evaporator supply temperature	12°C	12°C
Expansion valve	electronic	electronic
Evaporator DT	5K	5K

System Configuration (Cont.)

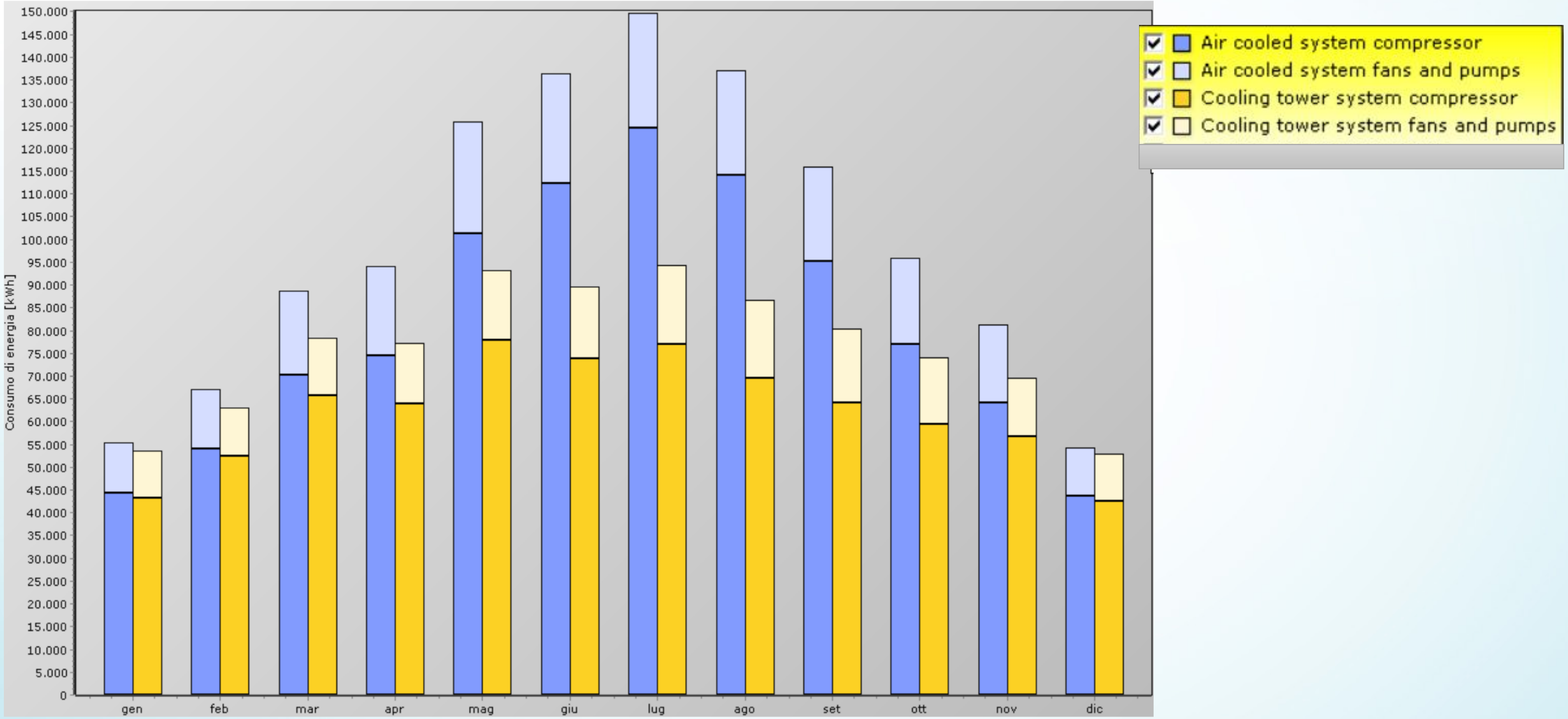
Discharge side		
	Air-cooled system (reference system)	Water-cooled system
Condenser capacity	1862,8 kW	1750,7 kW
Condensing approach	12K	4K
Condensing temperature	Tc= Tamb+12K	Tc= Twb+4K+4K (intermedtateHE)
Minimum condensing temperature	25°C	25°C
Design condensing temperature (@ 100% capacity)	47°C	39°C
Subcooling	0 K	0K
Speed controlled fans /pumps	No	No
Fan power consumption @design condition	64,8 kW	22 kW
Pump power consumption @design condition	n.a.	7,5 kW

System Configuration (Cont.)

Economy (Conversions Factor[1])		
	Air-cooled system (reference system)	Water-cooled system
Energy consumption: kWh→kgCO2e	0,40957	0,40957
Water supply: m3→ kgCO2e	n.a.	0,344
Water treatment m3→ kgCO2e	n.a.	0,708

[1] https://www.gov.uk/government/collections/government-conversion-factors-for-company-reporting

Assessment of the energy consumption



Assessment of the energy consumption (cont.)

	Air-cooled system (reference)	Water-cooled system
Average COP	**4,75**	**6,25**
Pumps and Fans energy consumption [kWh/year]	225.987	166.302
Compressors energy consumption [kWh/year]	975.224	746.136
Total Energy Consumption [kWh/year]	1.201.211	912.438
Yearly energy saving [kWh]	-	288.773
Yearly energy saving [%]	**-**	**24%**

Assessment of the water consumption

According to the calculated condensing capacity, and according to climate conditions the following consumptions have been assessed:

- Make-up- water: 16.380 m³/year
- Blow-down water: 4.680 m³/year

Conclusions: kgCO2e emissions assessment

Air cooled system			
	Value [kWh/year]	Conversion factor	Emissions [kgCO2e]
Compressors energy consumptions	975.224	0,40957	399.422,49
Fans energy consumption	225.987	0,40957	92.557,50
Total energy consumption	1.201.211	0,40957	**491.979,99**
Water cooled system			
Compressors energy consumptions	746.136	0,40957	305.594,92
Pumps Fans energy consumption	166.302	0,40957	68.112,31
Total energy consumption	912.438	0,40957	373.707,23
Make-up- water [m^3/year]	16.380	0,344	5.634,72
Blow-down water [m^3/year]	4,680	0,708	3.313,44
Total emissions			**382.655,39**

Conclusions: kgCO2e emissions assessment (Cont.)

	Air-cooled system (reference)	Water-cooled system
Total emissions [kgCO2e]	491.979	382.655
Yearly emissions' saving [kgCO2e]	-	109.324
Yearly emissions' saving [%]	**-**	**22,22%**

Conclusion

- Yearly energy saving (assumption) 224.575 kWh/unit
- Yearly CO2 emission saving (assumption) 84.579 kgCO2e
- EU installed Evaporative cooling equipment per year (assumption): 3.500
- Achievable savings thanks to evaporative cooling equipment (water cooled chiller as in the Commission Regulation (EU) 2281/2016):
  - **786.012.500 kWh/year**
  - **296.026.500 kgCO2e/year**