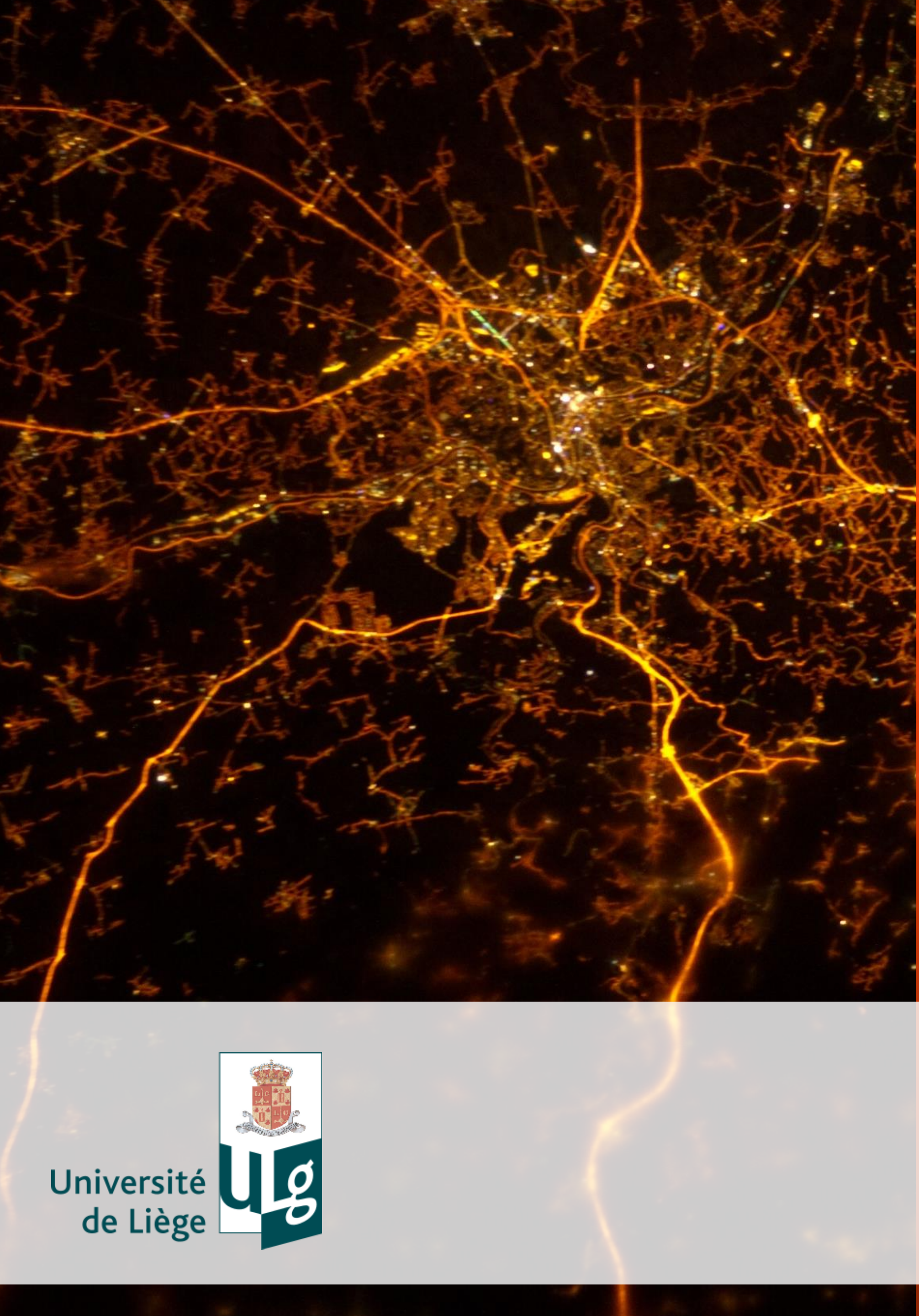

TOWARDS NZEB GOAL FOR NEWLY BUILT OFFICE BUILDINGS IN EUROPE USING HIGH TEMPERATURE COOLING.

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Introduction

- In the design phase of a building, many HVAC systems options are available to satisfy the basic requirement related to its use.
- High efficiency requirements are imposed to the HVAC equipments through strong regional regulation such as the EPB Directive:
  - ➢ It requires minimum efficiency of HVAC equipments in the market.
  - ➢ In addition, voluntary certification schemes like the Eurovent Certification provide support by introducing the certification of products.
- Current technologies in the market have now only a small window of opportunity for improvements still open (Brelih & Seppänen, 2012).
- With the nearly zero energy goal for all newly constructed buildings in Europe after 2020, it seems very likely that the design of the future building should rely on today's technology to meet these targets.
  - ➢ The integration of High Temperature Cooling (HTC) and Low Temperature Heating (LTH) in buildings brings a fresh perspective in this context.

Contents

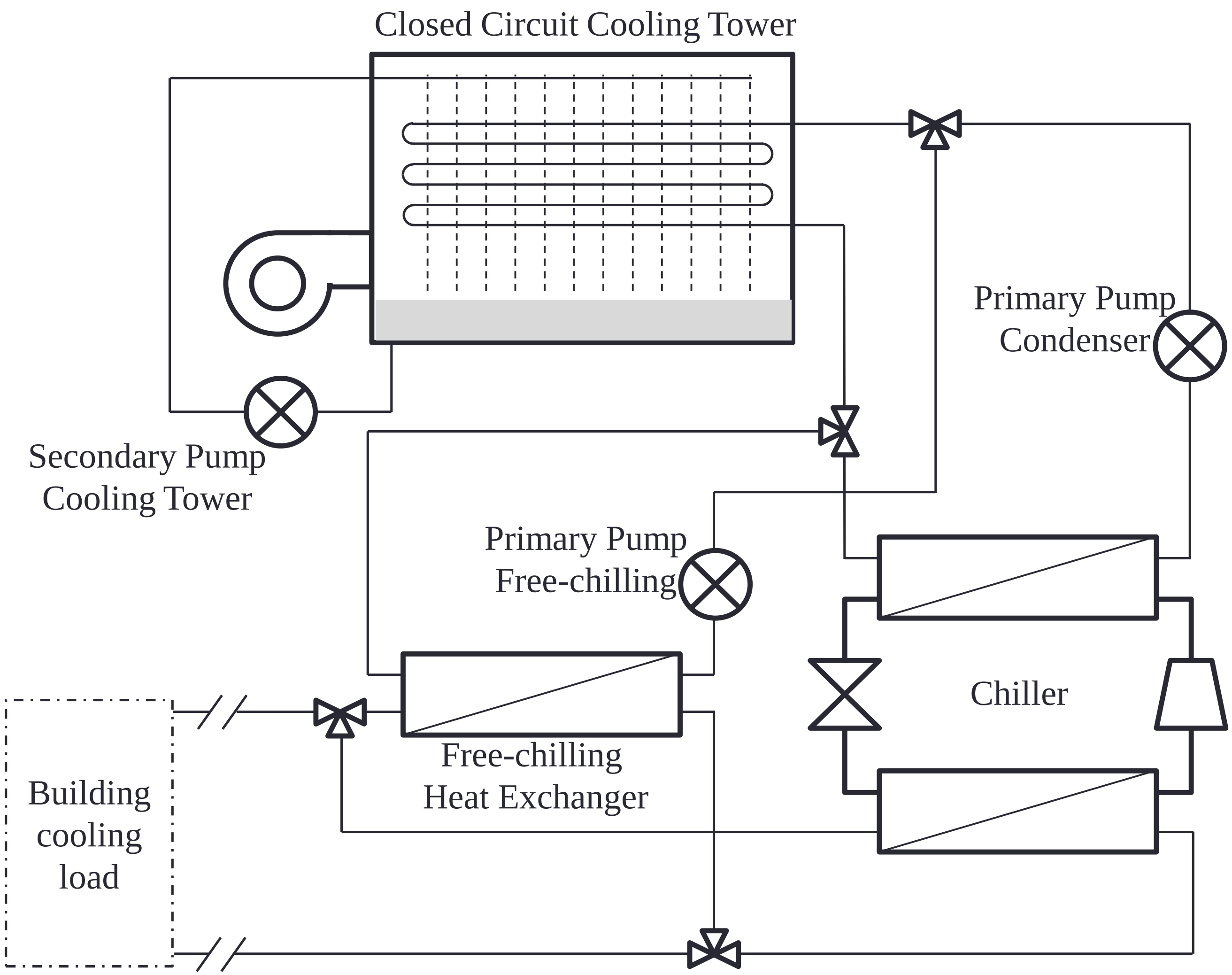
- Sensitivity analysis of a primary system to the chilled water supply temperature.
  - The system is composed of a water cooled chiller with a cooling tower and a free-chilling heat exchanger.
  - The analysis of the system is based on semi-empirical model tuned with manufacturer data at full and part load in large range of operation.

  Objective: Assessment of the impact of the chilled water temperature on the primary system performance

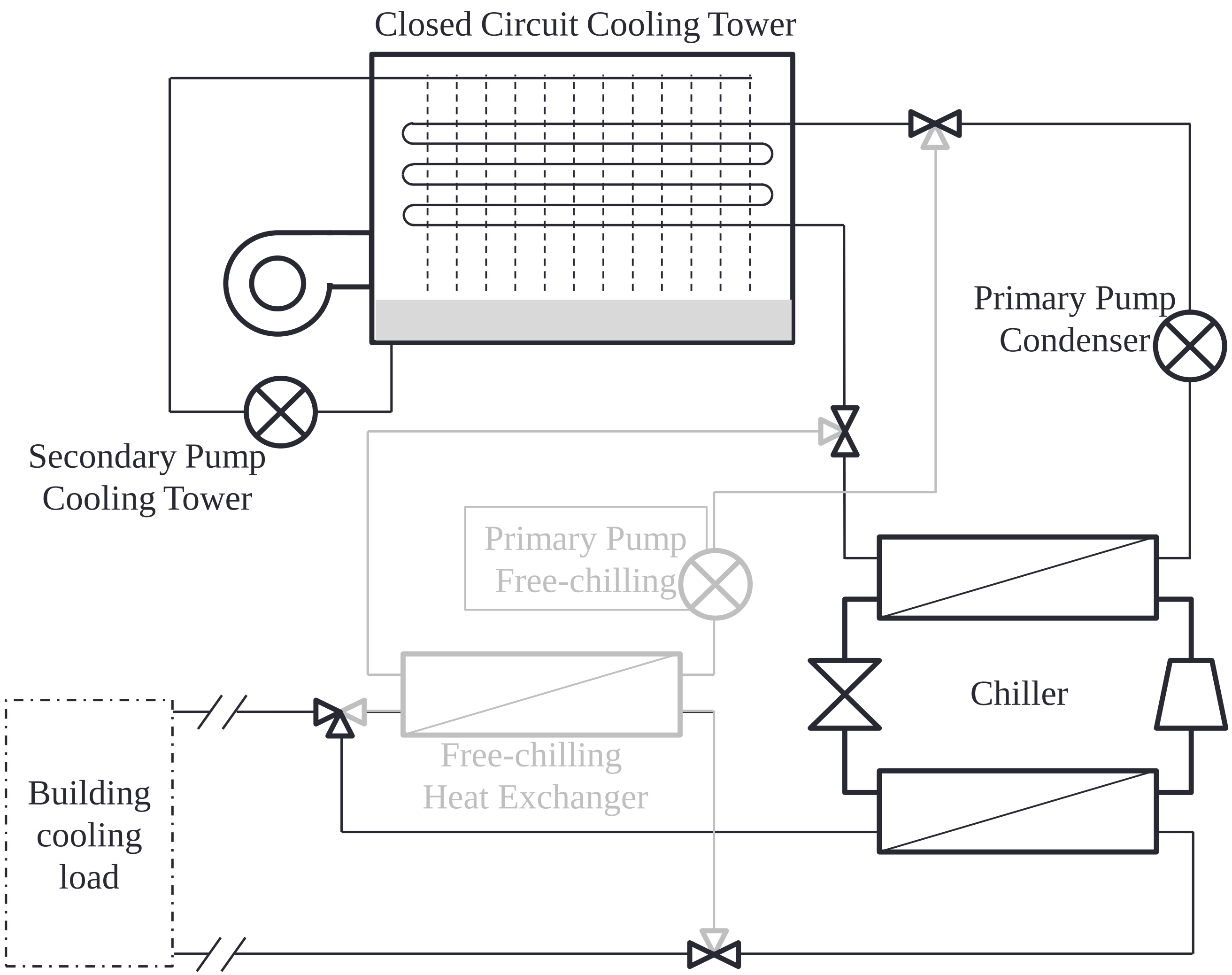
- Sensitivity analysis is extended to the whole HVAC system
  - Integrated in a high efficiency newly built office building
  - Considering the distribution, the emission and the ventilation.
  - Full year simulation.

  Objective: Assessment on the impact of chilled water temperature on the system performance and give guidenlines on the sizing and the control of such system in the frame of nearly zero energy building.

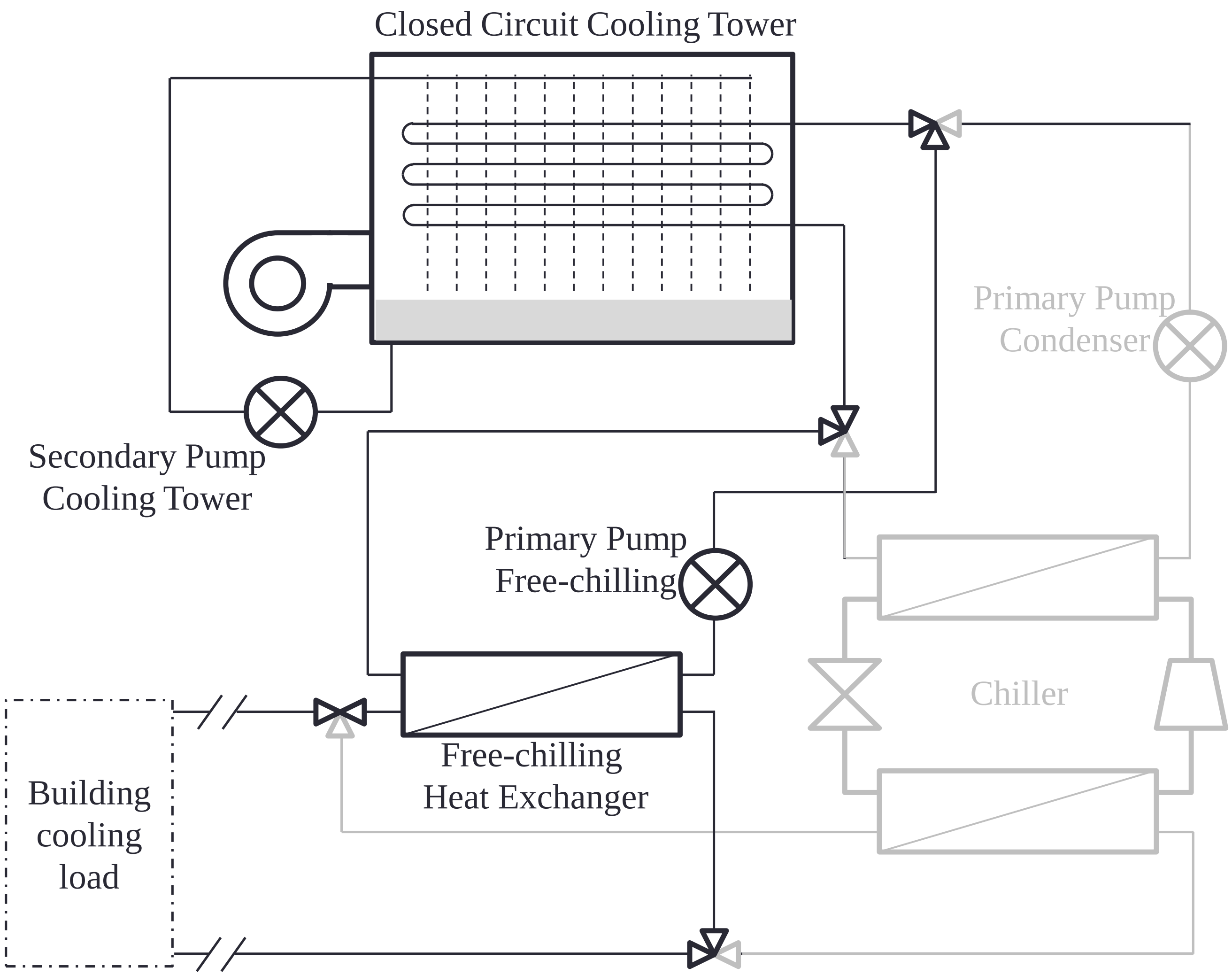
Cooling plant schematic



Cooling plant schematic: Standard operation



Cooling plant schematic: Free-chilling operation



Cooling plant sizing

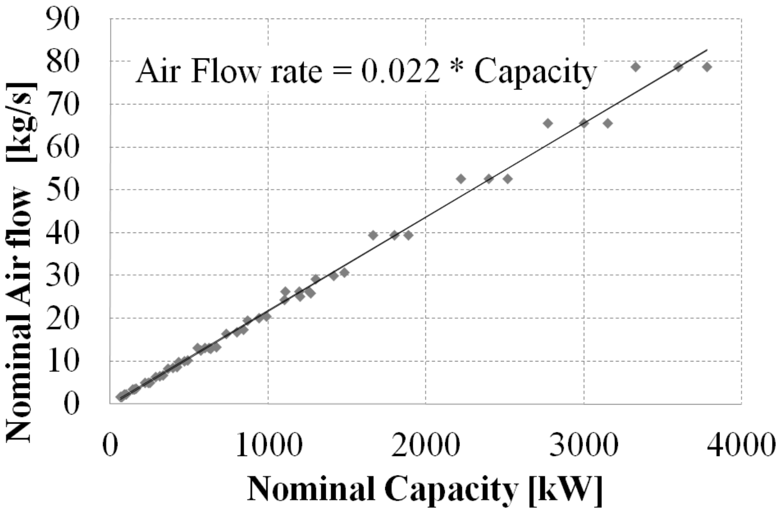
- The sizing of the cooling tower capacity is based on the:
  - Cooling capacity of the evaporator (design cooling load of the building),
  - Chiller energy efficiency ratio (EER),
  - Cooling tower oversizing factor.

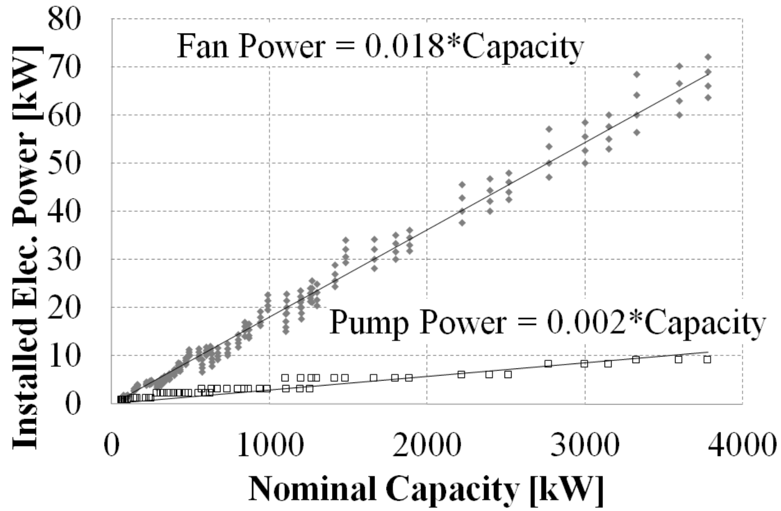
$$\dot{Q}_{ct,n} = \dot{Q}_{ev} \cdot (1 + 1/EER_{chiller}) \cdot f_{ct,oversizing}$$

$$\dot{M}_{a,ct,n} = 0.022 * \dot{Q}_{ct,n}$$

$$\dot{W}_{fan,ct,n} = 0.018 * \dot{Q}_{ct,n}$$

$$\dot{W}_{pump,2,ct,n} = 0.002 * \dot{Q}_{ct,n}$$

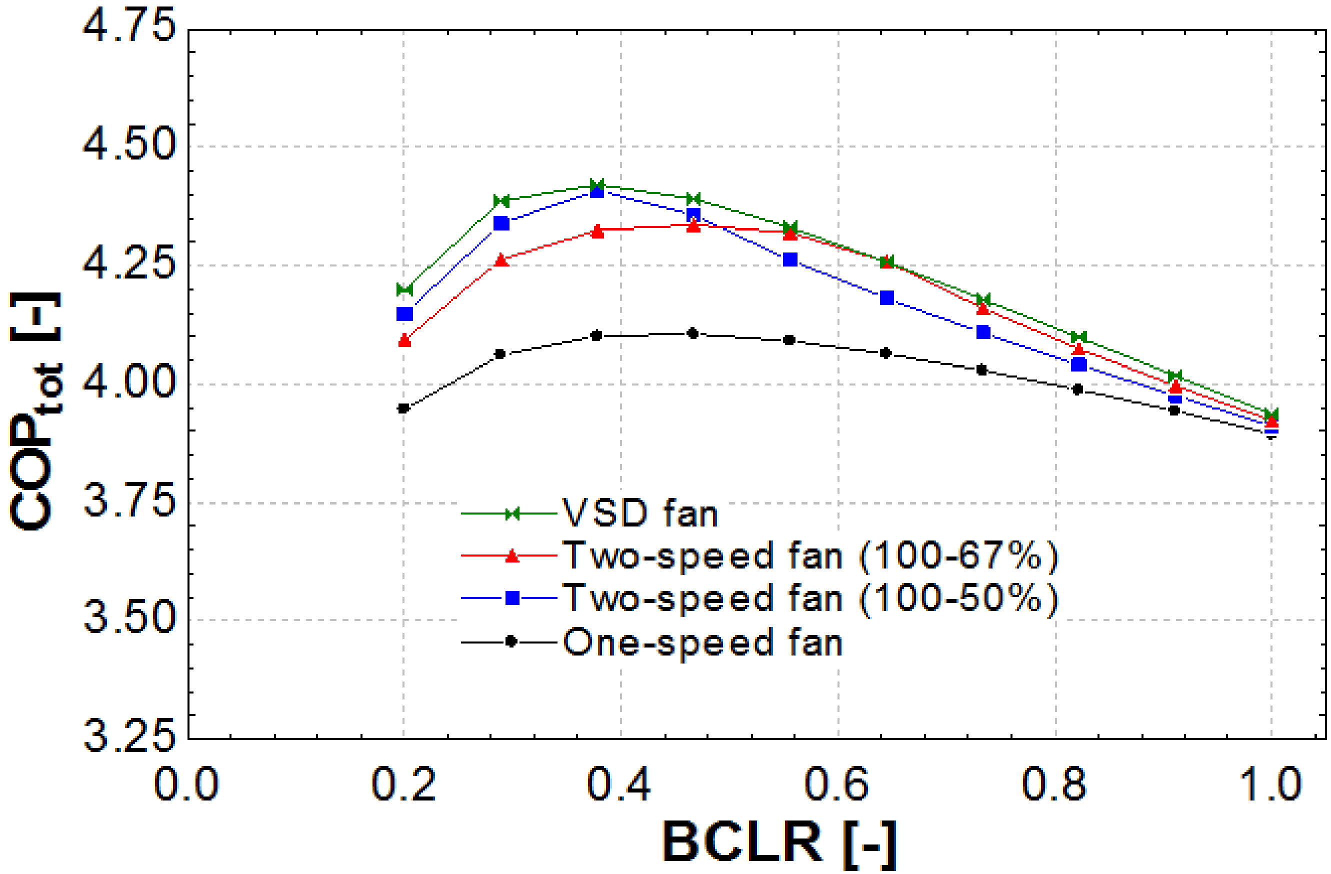




Cooling plant sizing

	Unit	Value
Cooling capacity at evaporator/condenser	kW	366.30/445.86
Cooling capacity at cooling tower (oversizing factor)	kW	512.42 (1.15)
Cooling capacity at free-chilling heat exchanger	kW	146.55 (0.40)
EER ($t_{ev,ex}$=7°C and $t_{cd,su}$=30°C)	-	4.62
Condenser nominal water flow rate	kg/s	21.29
Condenser nominal pressure (water-side)	kPa	17.50
Condenser pump nominal power	kW	3.10
Free-chilling heat exchanger primary side water flow rate	kg/s	3.50
Free-chilling heat exchanger primary side pressure drop	kPa	7.35
Free-chilling primary pump nominal power	kW	0.56
Cooling tower		
Supply wet bulb temperature	°C	22.00
Air flow rate	kg/s	11.30
Fan nominal power	kW	9.20
Exhaust water temperature	°C	30.00
Global UA-value	kW/K	41.82
Nominal pressure drop in standard/f-ch. Mode	kPa	62.00/28.49
Secondary cooling tower pump nominal power	kW	1.10

Cooling plant sensitivity to fan speed control at different BCLR



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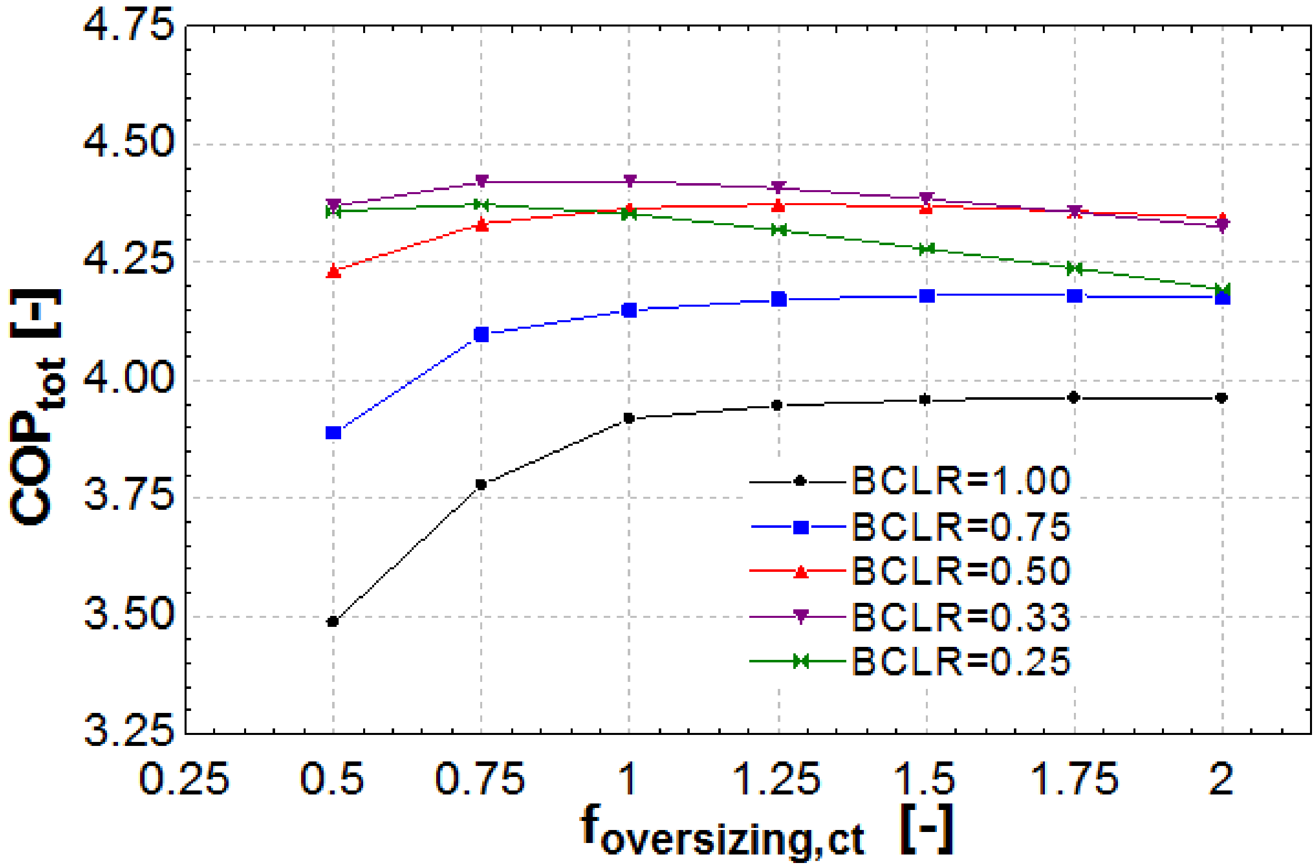
Cooling plant sensitivity to CT sizing at different BCLR



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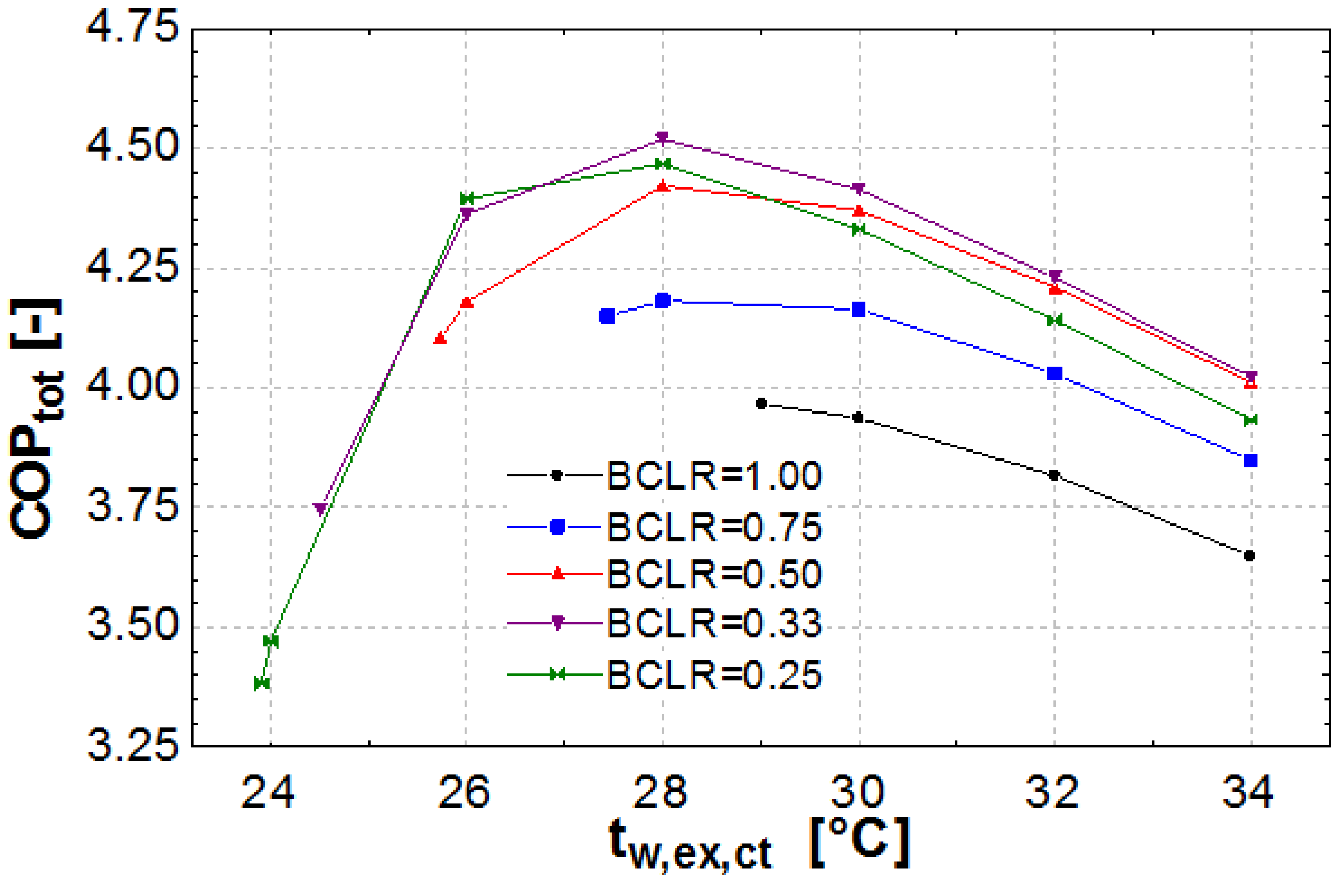
Cooling plant sensitivity to CT exhaust water temperature at different BCLR



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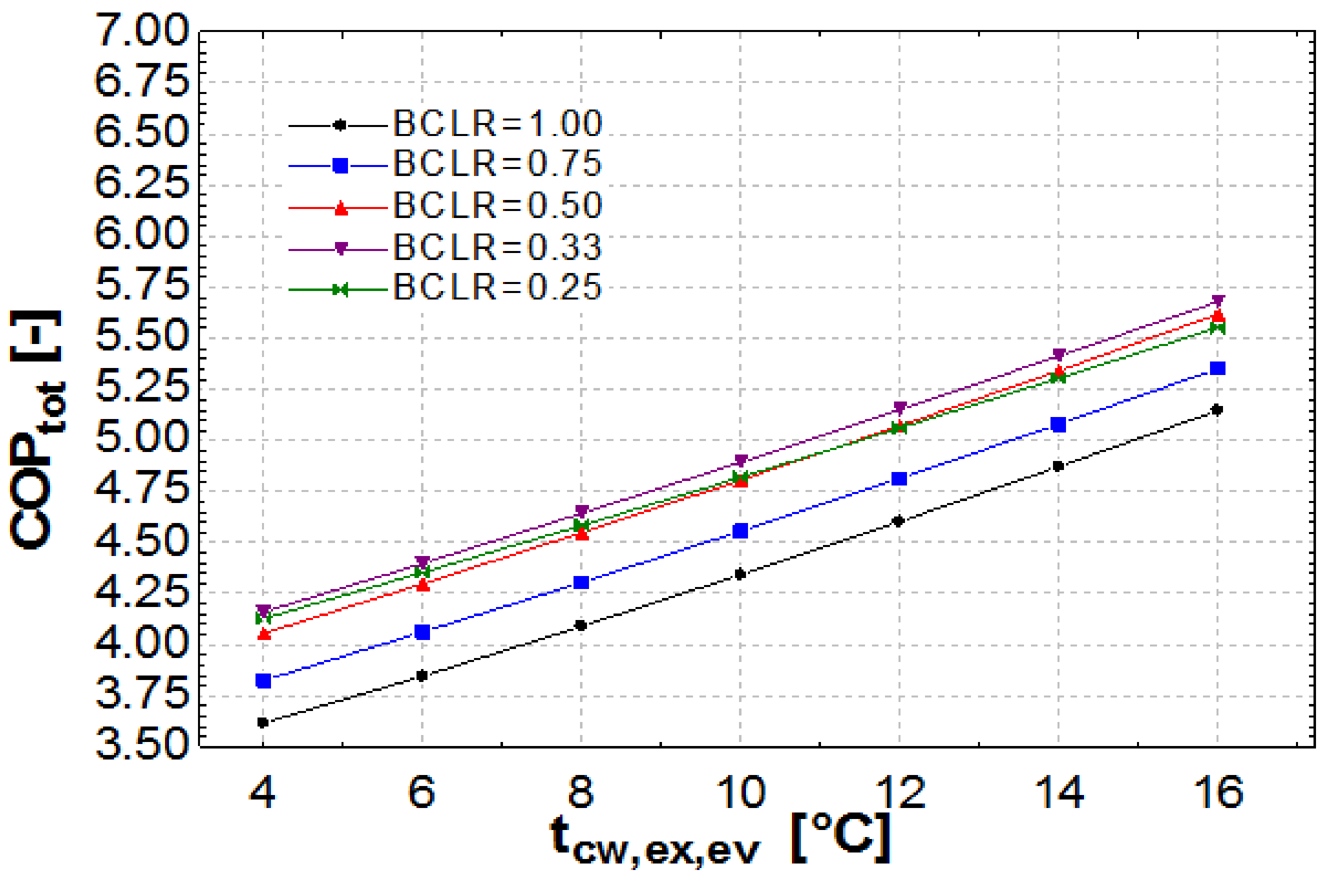
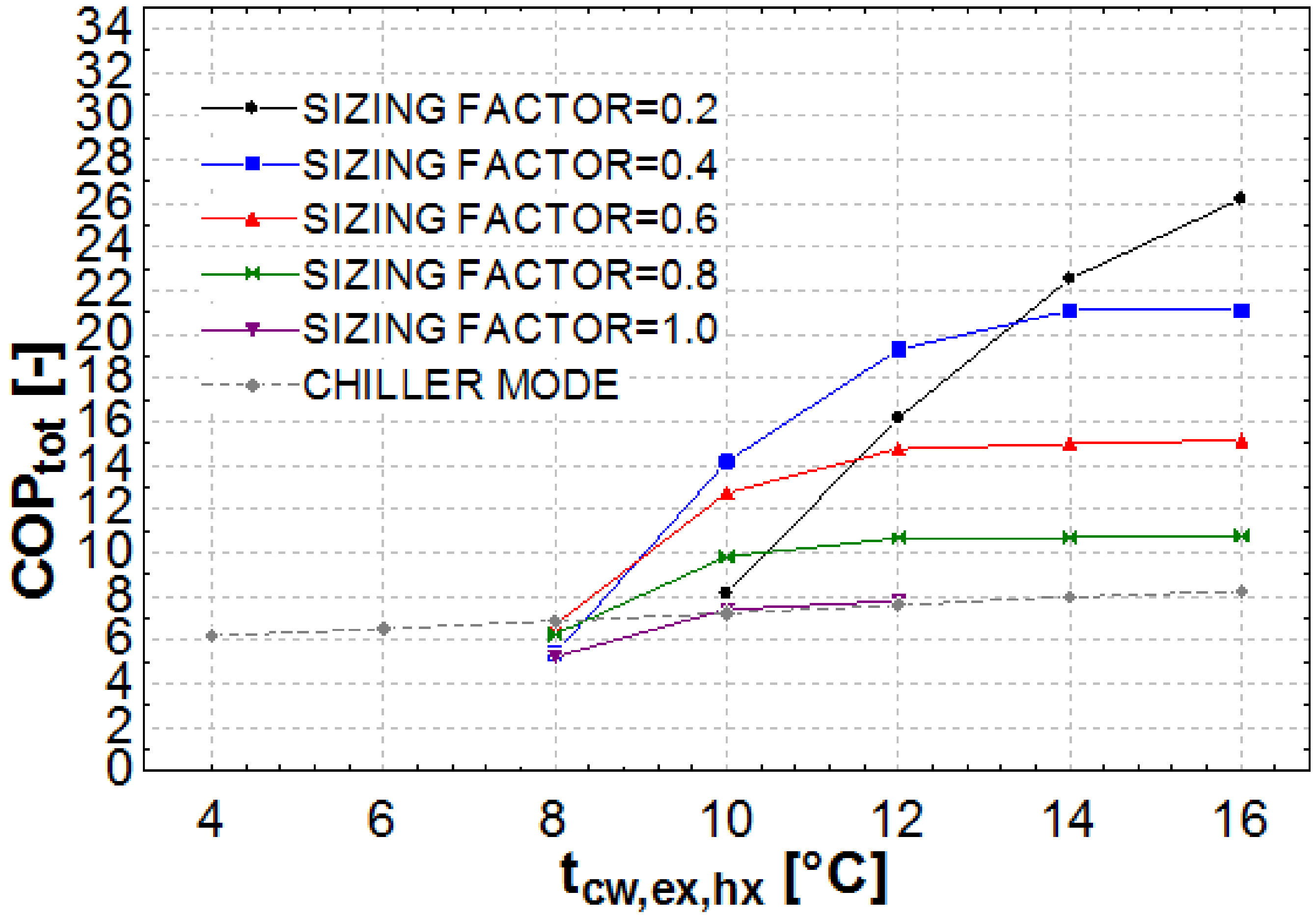
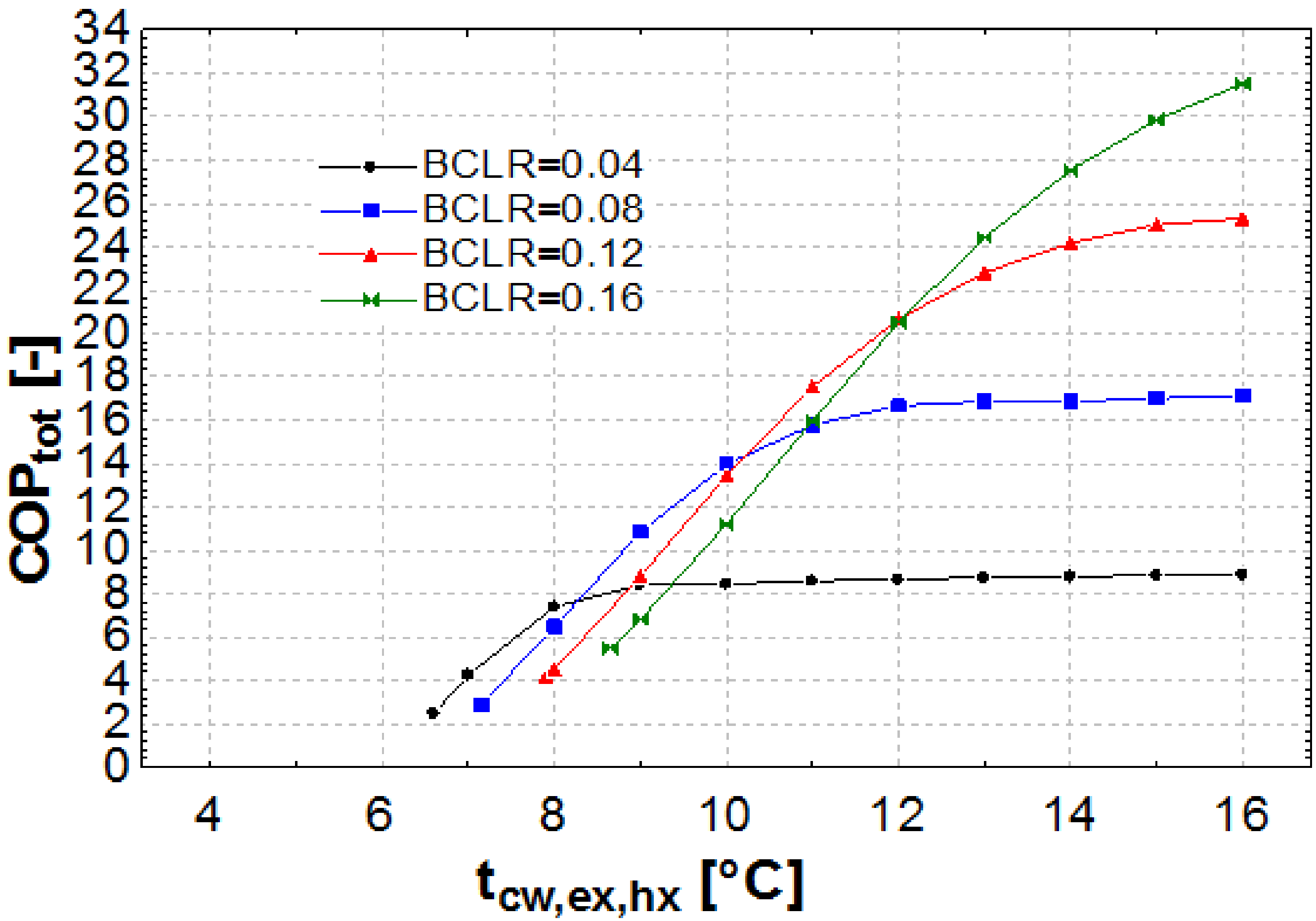
Cooling plant sensitivity to evaporator temperature at different BCLR



Cooling plant sensitivity to free-chilling sizing at different water temperature leaving the hx, at BCLR=0.1 and T_{out}=5.5°C/RH=50%



Cooling plant sensitivity to water temperature leaving the free-chilling hx at different BCLR and T_{out}=10°C/RH=50%



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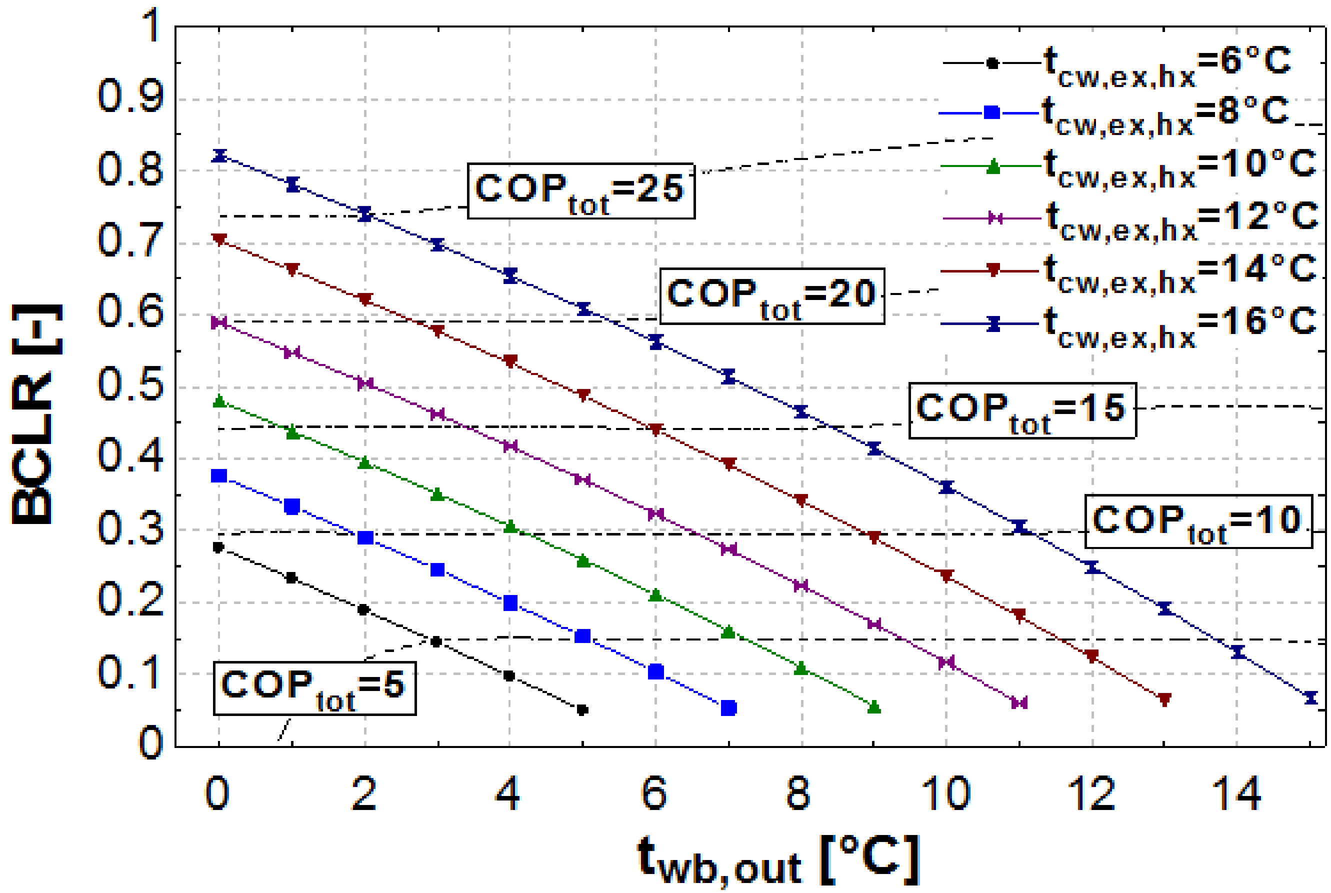
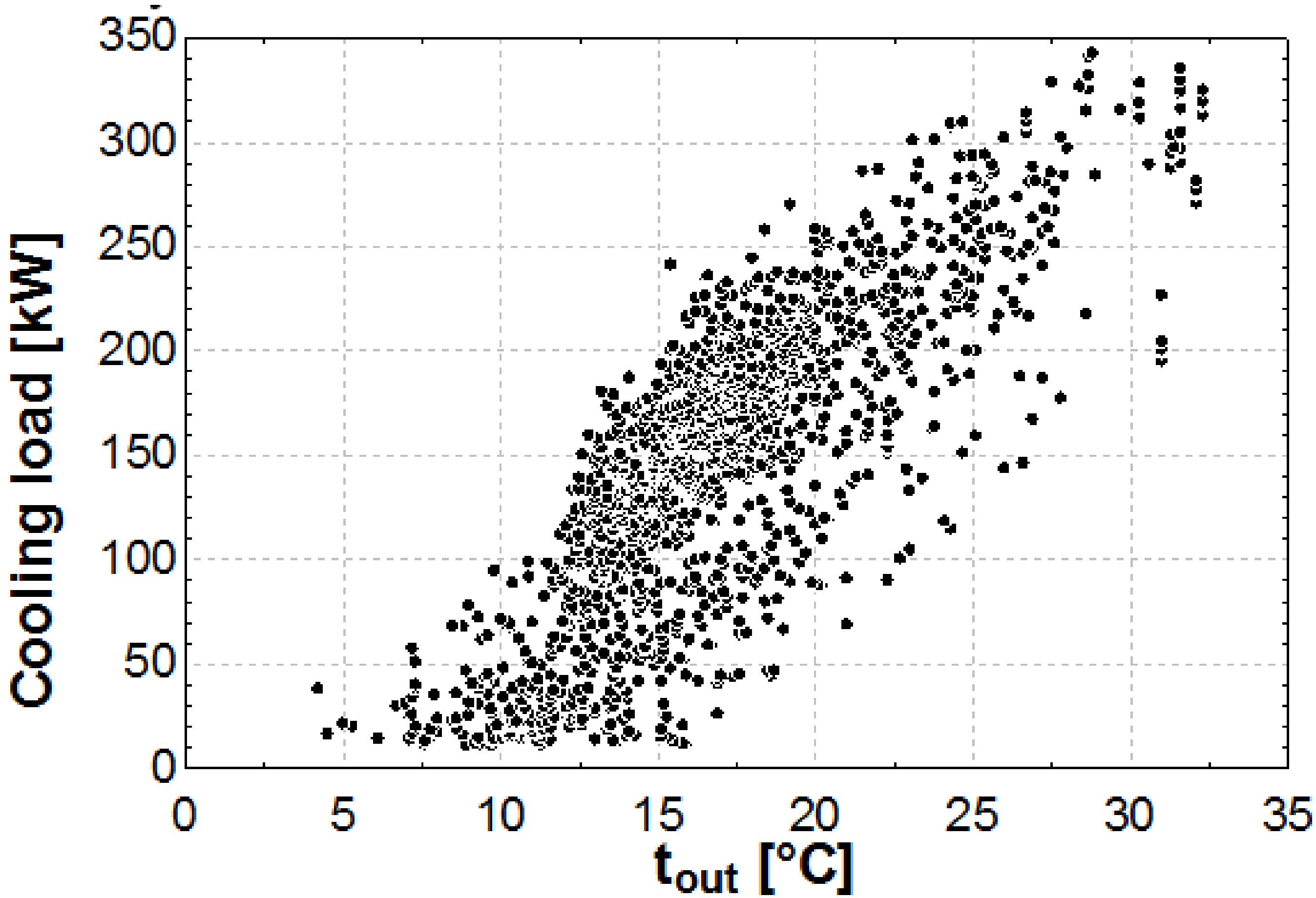
Free-chilling cooling capacity as a function of the outdoor wet bulb temperature and for different water temperature leaving the free-chilling hx



Full year performance: Reference building hourly cooling load



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Full year performance: Influence of free-chilling, water temperature control and CT exhaust water temperature control

- The system performance is gradually improved with the:
  - enabling of the free-chilling mode,
  - control of the water temperature with a heating curve link to the outside temperature,
  - control of the cooling tower exhaust water temperature with a heating curve link to the outside wet bulb temperature.
- These scenarios show important improvement of the performance of the system with an increase of 21.3% of the system performance giving a reduction of 17.6% of the plant electrical consumption.

	Elec. cons. [MWh]	COP_{avg} [-]
Scenario 0: no free-ch. and t_{cw}=6°C	49.113	4.54
Scenario 1: with free-ch. and t_{cw}=6°C	48.893	4.56
Scenario 2: with free-ch and $t_{cw}=6+0.2*(32-t_{out})$	45.429	4.90
Scenario 3: Scenario 2 and $t_{ct,ex}=9.8+0.86*t_{wb,out}$	40.455	5.51

Conclusions and Acknowledgement

- From the results of the present study, a wide range of improvement possibilities are offered when working at high temperature cooling.
- The proper sizing of the system components and the impact of their auxiliaries consumption on the total system performance is crucial.
- The climatic location and the specific load profile of the concerned building should be taken into account in the sizing phase but even more in the definition of the control of the system most sensitive parameters.

The authors are grateful to the Walloon Region who funded this research in the frame of IEA EBC Annex 59 project.

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