Hybrid cooling of a container for telecommunication equipment

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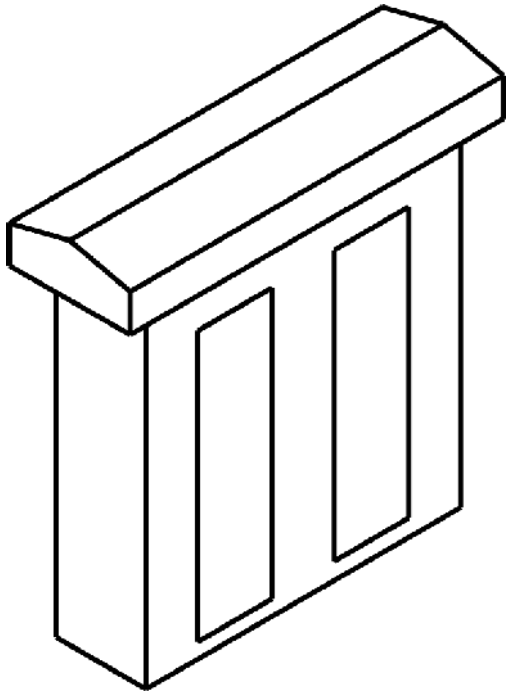
Conventional container

The objective was to improve the design of a typical container for telecommunication equipment.

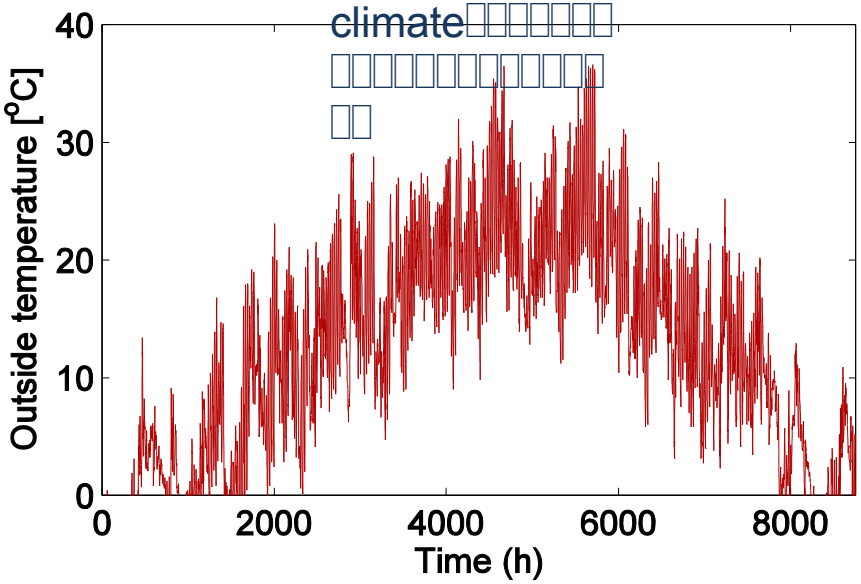


- 3,3 m length × 0,8 m width × 2,4 m height
- completely sealed envelope with the insulation
- a split-system used for cooling
- 25 – 50% of the total annual energy consumption is used for cooling (from the literature)
- the same container design usually gets replicated to many locations and to different sizes of telecommunication equipment

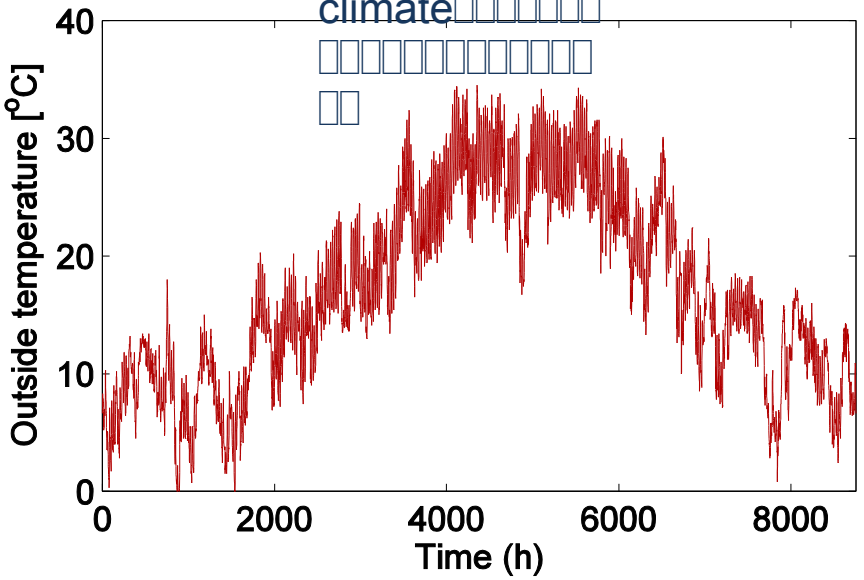
Potential for energy savings

Due to a relatively mild climate, there is a good potential for energy savings using passive cooling.

Zagreb climate□□□□□□□□□□□□□□□□□□□□



Split climate□□□□□□□□□□□□□□□□□□□□

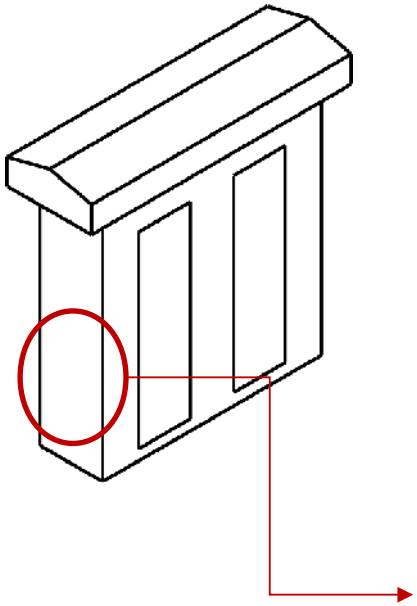


- The highest annual temperature□ in Zagreb is 36,6oC and 34,5oC in Split.
- The highest allowable temperature inside the container is 45oC.
- Project internal loads are 2,2 kW.

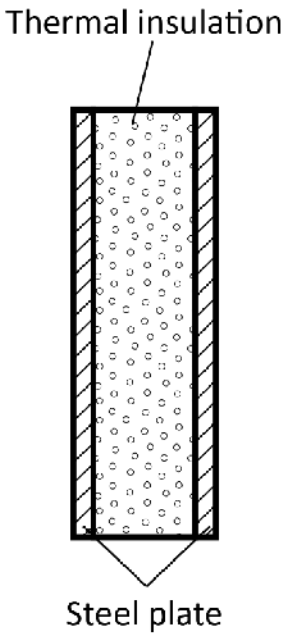
□ Data for a typical meteorological year, published by the *Croatian Meteorological and Hydrological Service*

Performance analysis

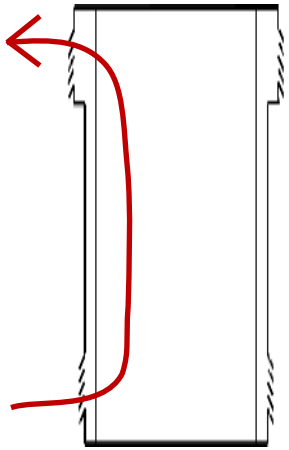
Analysis 1: Three envelope designs were compared based on the annual energy consumption for cooling.



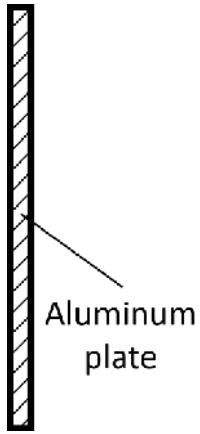
Design A
(base case)



Design B



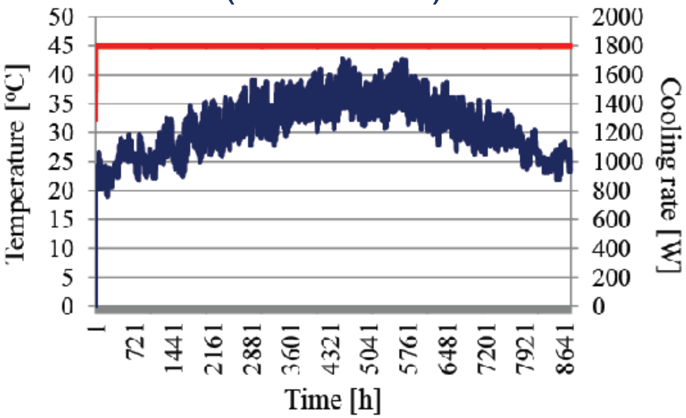
Design C



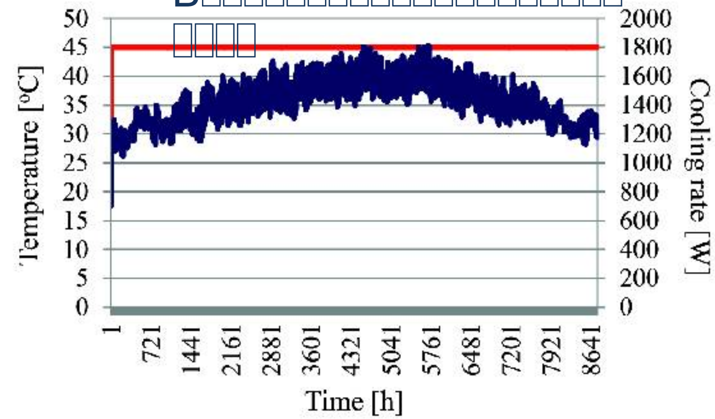
Performance analysis

The container with the uninsulated envelope (Design C) consumes 3,7 times less electricity for cooling (annually) than the base case.

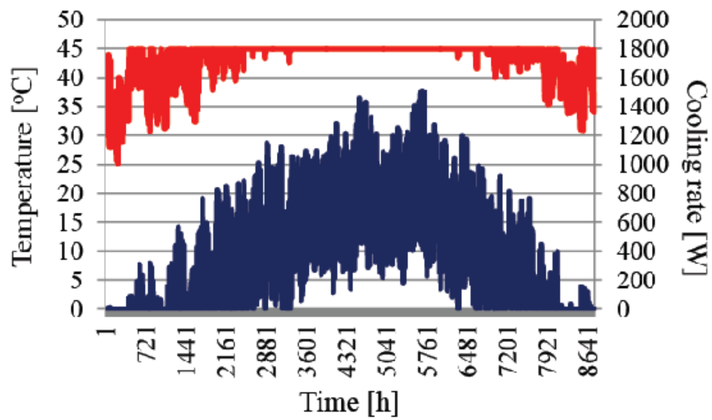
Results for Design A (base case)



Results for Design B



Results for Design C



— temperature

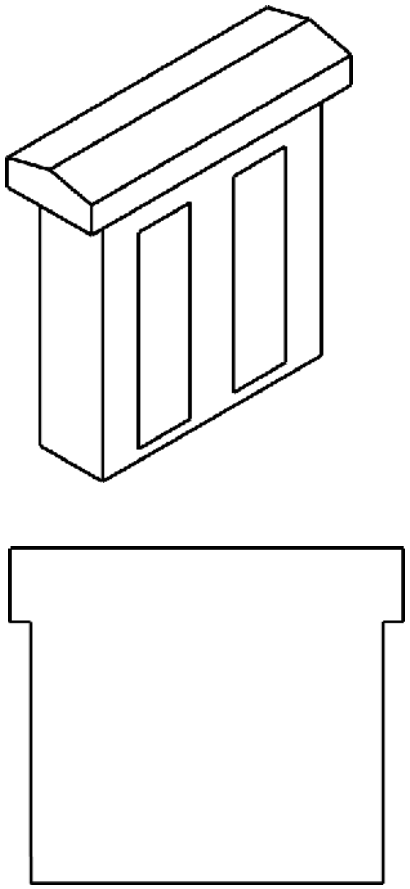
— split-system cooling rate

Assuming the still air inside the double-skin envelope.

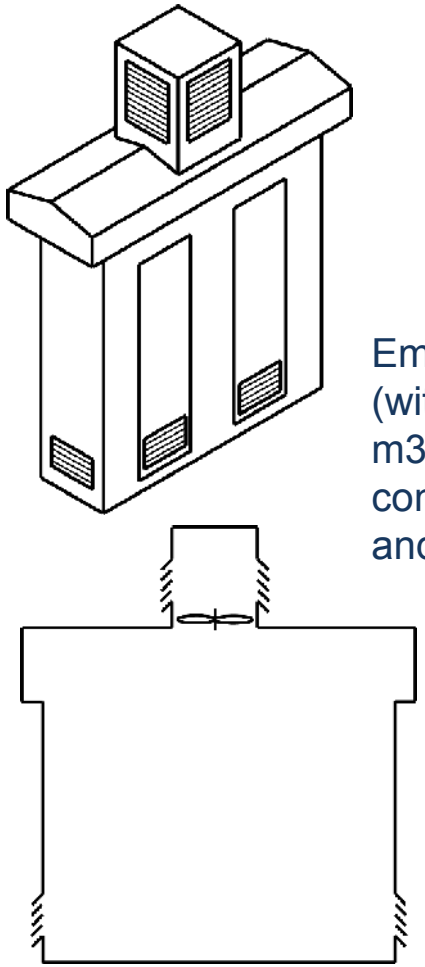
Performance analysis

Analysis 2: An axial fan was used for cooling.

Conventional design



Proposed design

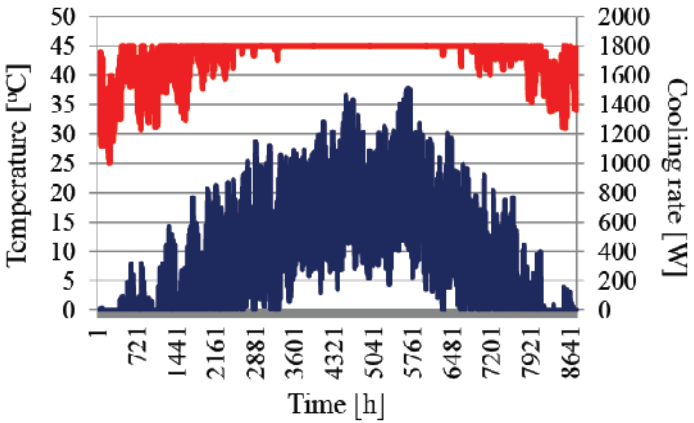


Employs an axial fan (with flow rate of 1000 m3/h and electricity consumption of 30 W) and grilles for ventilation.

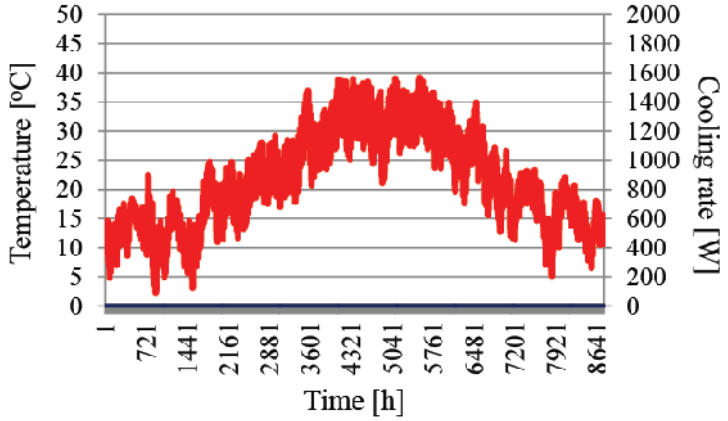
Performance analysis

The container with the uninsulated envelope and axial fan for cooling consumes 20 times less electricity for cooling (annually) than the base case.

Results without fan



Results with fan



- temperature
- split-system cooling rate

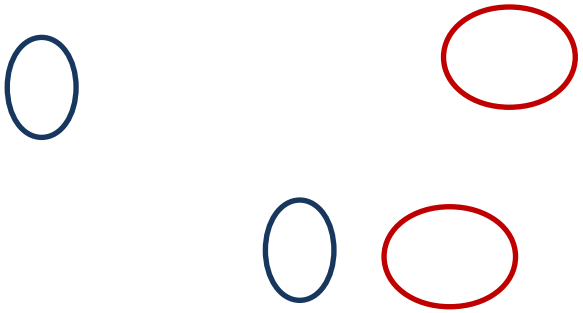
It is estimated that the fan would work about 250 days annually (for Zagreb climate).

Assuming the COP of 3.

Performance analysis

Analysis 3: Natural ventilation was used for cooling.

- Only buoyancy-driven natural ventilation was considered.
- The objective was to find number of hours for which *T*inside < 45oC.
- The set of coupled equations was solved using the combination of TRNSYS and MATLAB.

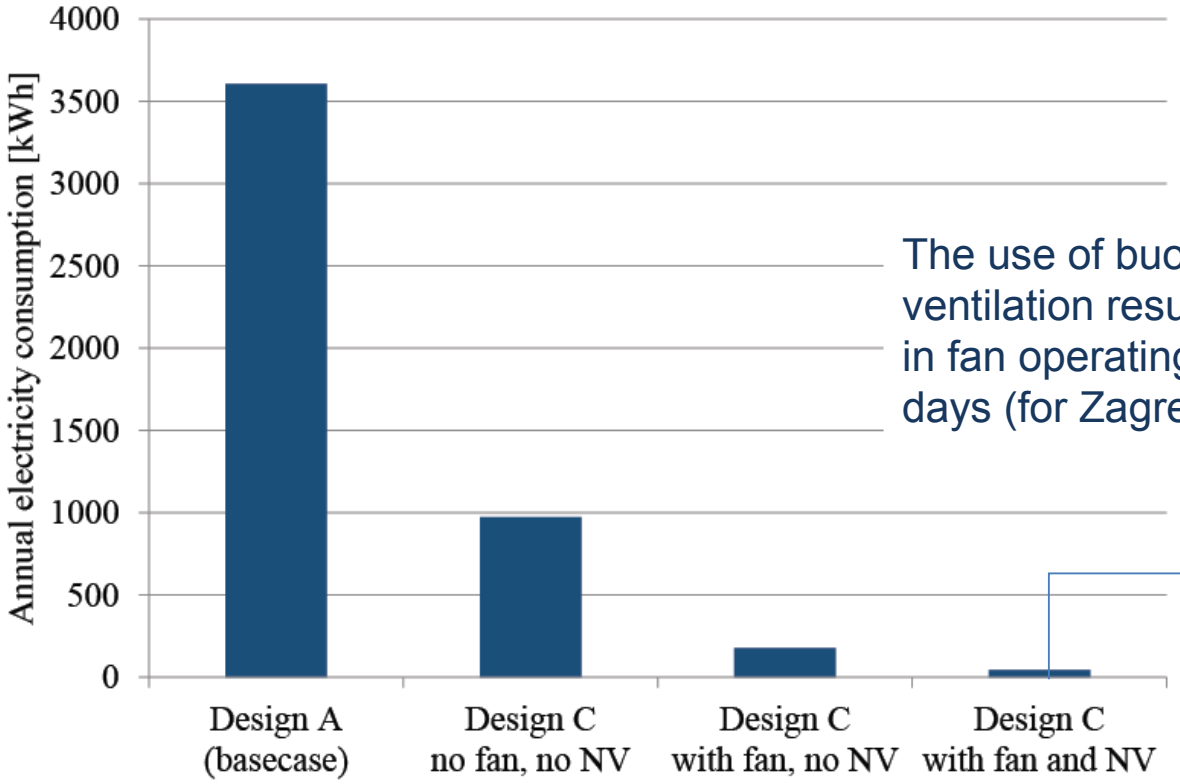


A … opening area [m2]
Cd … discharge coefficient □□□ [-]
H … container height [m]
Tinside … temperature inside container [K]
Toutside … temperature outside container [K]
V … airflow due to buoyancy [m3/s]

□□□□□ **Idel'chik, I.E.**, *Handbook of Hydraulic Resistance*, Jaico Publishing House, Mumbai, India, 2005.

Potential for energy savings

The container with the uninsulated envelope and hybrid cooling (natural ventilation + axial fan) consumes 82 times less electricity for cooling (annually) than the base case.



The use of buoyancy-driven natural ventilation resulted in the reduction in fan operating days from 250 to 61 days (for Zagreb climate).

Assuming the COP of 3.

Prototype – container „Velebit”

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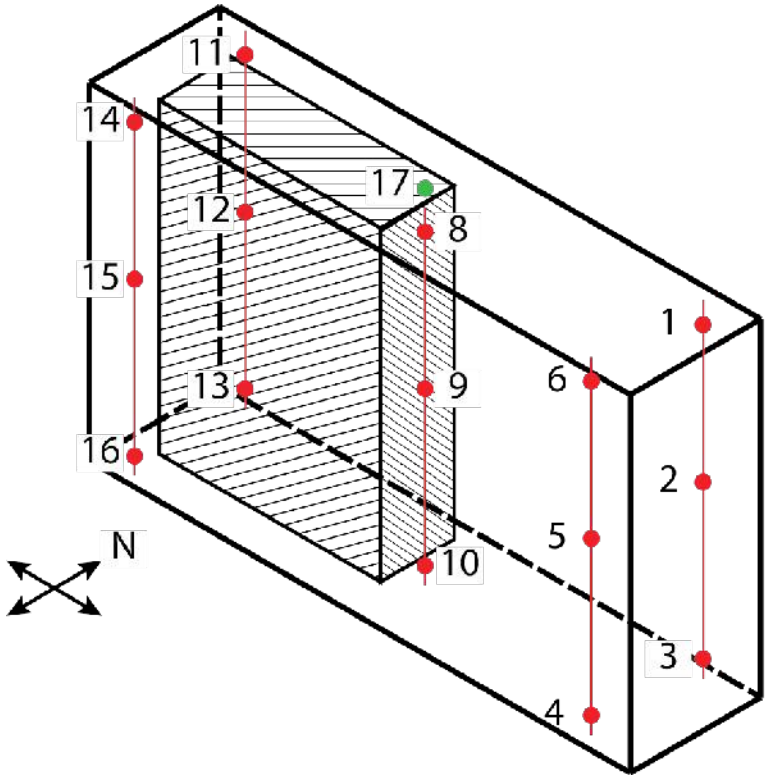
- Project internal loads were 2,2 kW.
- Installed internal loads were 0,6 kW.

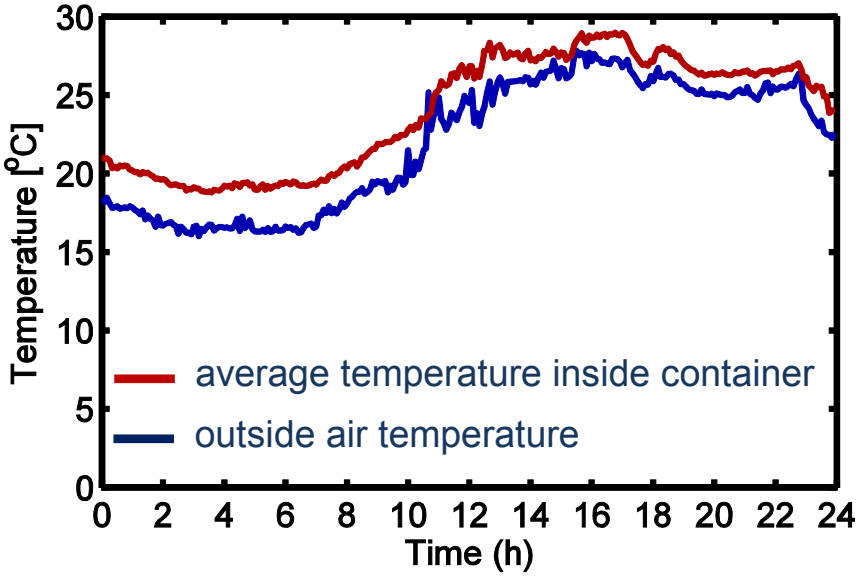
Experimental measurements

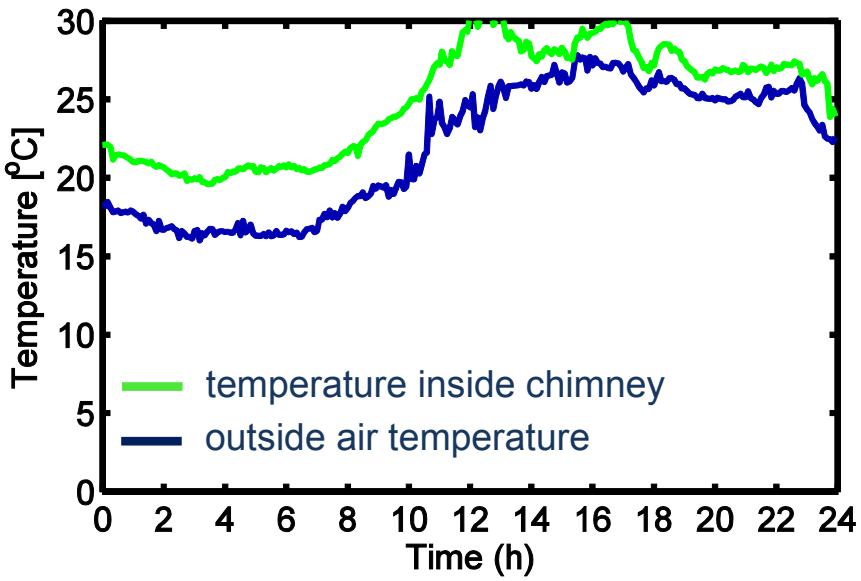


Experimental measurements

Temperatures and fan working hours were measured from 01.08.2014. until 17.09.2014. (with internal loads of 0,6 kW)

Temperature measurement results for 13. 08. 2014.



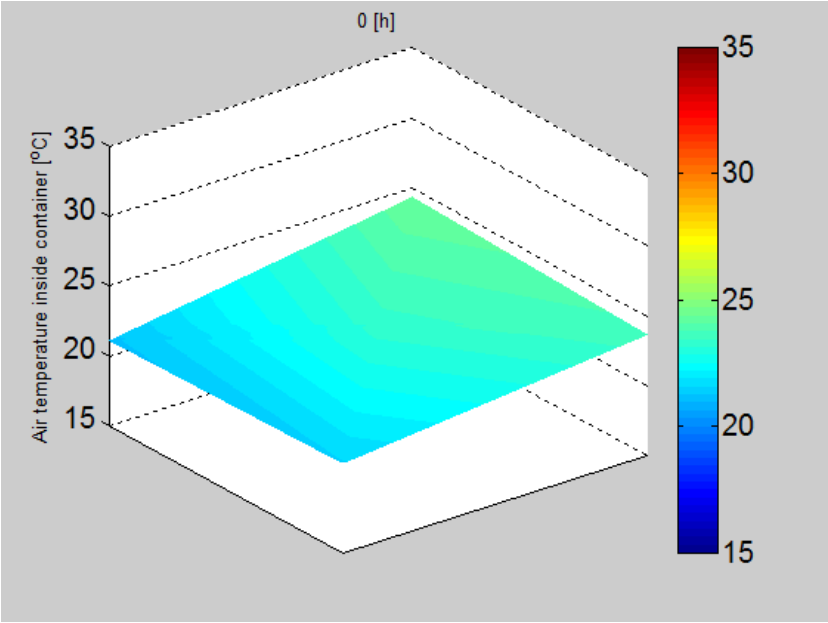


- The fan control was set to turn on the fan at 40oC.
- The fan did not turn on even during hot summer days.

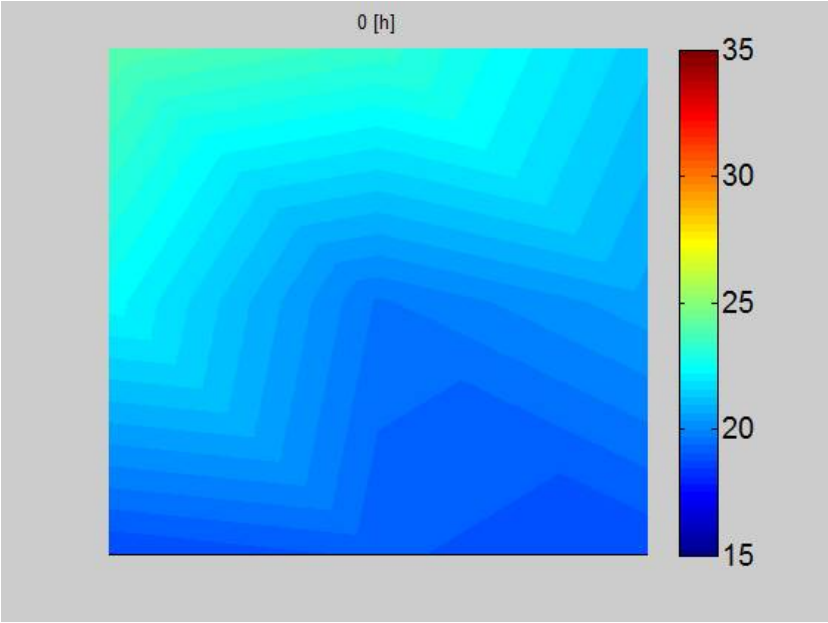
Experimental measurements

Measurements showed that the temperature field is very non-homogeneous in both horizontal and vertical plane.

Horizontal plane in the middle of the container (for 13. 08. 2014.)



Vertical plane in the middle of the container (for 13. 08. 2014.)



Summary and future work

- The research evaluated the hybrid cooling potential of a typical container for telecommunication equipment.
- The base case was a typical container with completely sealed envelope and a split-system for cooling.
- The proposed designed was the container with an uninsulated envelope and hybrid cooling (natural ventilation + axial fan).
- The proposed designed consumes 82 times less electricity for cooling (annually) than the base case.

FUTURE WORK

- Validate the model using experimental measurements.
- Evaluate flow rates due to natural ventilation.
- Consider replacement of the fan and grilles.

The authors would like to gratefully acknowledge the support of *Hrvatski Telekom*, part of the *Deutsche Telekom* Group, for this research.

Thank you!

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