FLOWNEX®
SIMULATION ENVIRONMENT

CASE STUDY

DATA CENTRE FREE COOLING ANALYSIS USING FLOWNEX SE

As the demand for data-driven services increase, it is important to ensure the optimal usage of energy in data centres. One way to reduce electricity demand and by extension the costs and carbon footprint of data centres, is by using free cooling methods. Free cooling uses freely available natural resources e.g. water from open-air ponds or ambient air, to provide cooling.

This case study demonstrates how Flownex SE can be used to simulate cooling of a representative data centre using imported weather data, in a transient analysis.

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DATA CENTRES

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CHALLENGE:

Data centres require a significant amount of cooling to maintain the electronic equipment within acceptable temperature ranges. The deployment of free cooling methods can significantly reduce the energy consumption within a data centre. In this analysis a data centre was modelled that is located near a water mass. This water mass could be used for either indirect evaporative cooling or waterside cooling. The primary challenge was to quantify the energy savings that could be achieved by switching the chosen data centre from active cooling to free cooling.

BENEFITS:

Using Flownex SE provided access to the built-in fluid properties (air, water, humid air, refrigerants) and component libraries for fluid flow and heat transfer. This enabled the development of energy performance models in a time-efficient manner, whilst capturing all the relevant heat transfer and fluid flow phenomena. Due to the low computational cost of the models, transient simulations could be conducted over extended periods with relatively short simulation times.

SOLUTION:

The Flownex SE models included the relevant properties of the data centre, as well as the outdoor ambient temperature and humidity conditions for the site, in order to build a model of the performance of the free cooling concepts at different times in a year. The results of the case study show that a >70% reduction in the electricity demand for cooling can be achieved using free cooling. These identified savings can be further used to develop a business case for future implementation at the target site.

"Flownex allowed us to develop detailed thermal models of various free-cooling concepts for our data centre, in a time-efficient manner. The humid-air simulation capabilities of Flownex are well suited to indirect evaporative cooling systems for use in the telecoms sector, which can result in significant energy savings." – *Dr Peter Klein, Senior Engineer, CSIR, South Africa.* "

INTRODUCTION

As the demand for data-driven services increase, it is important to ensure the optimal energy consumption of data centres. One way to reduce electricity costs and by extension the carbon footprint of data centres, is by using free cooling methods. Free cooling uses freely available natural resources e.g. ponds or ambient air, to provide cooling energy. The two free cooling methods investigated in this case study are:

1. Indirect waterside free cooling, using water circulation through a fluid-to-air heat exchanger, and
2. Indirect evaporative cooling, using the humidification of air and an air-to-air heat exchanger.

It is important to note that using indirect free cooling methods ensure that no water needs to enter the data centre, which was one of the constraints for the study.

METHODOLOGY

A network model of the data centre room was created in Flownex that represents a hot aisle/cold aisle configuration with a baseload cooling demand of 66.5 kWth. The volume of air in the isles is represented using the reservoir component, and leakage between the aisles is modelled by added flow components between the reservoirs. The full data centre model can be seen in Figure 1, which incorporates 19 server racks. Compound components were created to model the fluid flow through the server racks and heat loads.

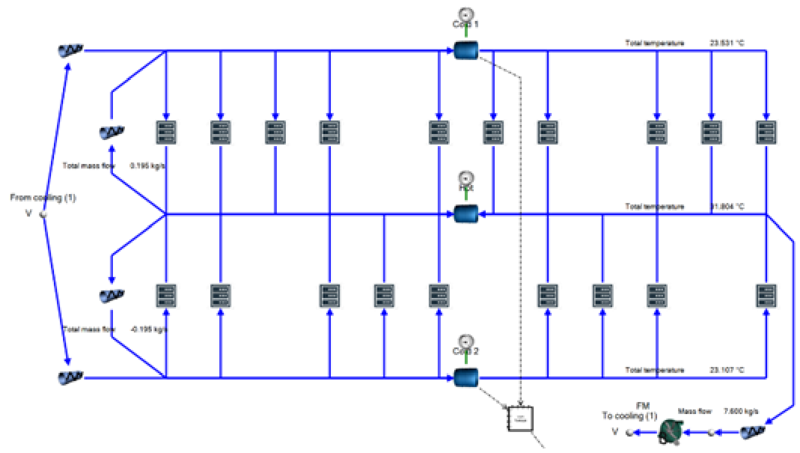

Figure 1: The model of the data centre created in Flownex.

The baseline energy consumption using the in-row coolers was established based on a R410a vapour compression refrigeration cycle model in Flownex. The Coefficient of Performance (COP) of the cycle was calculated to determine the required electricity to meet the cooling demand. The COP for the in-row coolers varied from 3.5 to 7 depending on the outdoor ambient temperature.

To implement the free-cooling solution into the data centre, air is extracted from the hot aisle and ducted to a heat exchanger outside the data centre, where it is cooled. If the free cooling is insufficient to meet the demand, the backup cooling is provided from an R410a refrigeration unit. The Flownex models of the two free cooling concepts of Indirect Evaporative Cooling (IEC) and Waterside Cooling (WC) are presented in Figure 2 and Figure 3 respectively. In the IEC approach, air is drawn from the environment and humidified through water injection. This increases the relative humidity and decreases the air temperature. As the humid air cannot be directly ducted into the server room, it passes through an air-to-air heat exchanger where it cools the hot air from the servers.

In the WC approach, a water-to-air heat exchanger is used to reduce the temperature of the hot air in the data centre. The WC is generally less effective at providing cooling than the IEC, however it does have the advantage of no water consumption from the pond next door, as it is a closed loop pumping system.

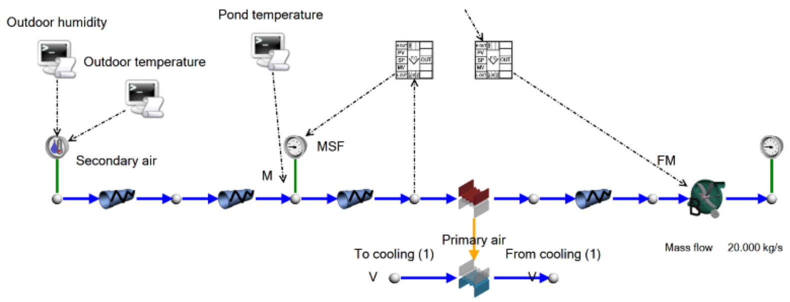

Figure 2: The tested indirect evaporative cooling model.

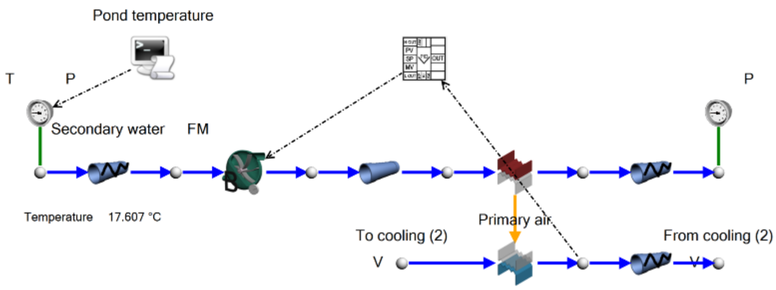

Figure 3: The tested indirect waterside cooling model.

RESULTS AND CONCLUSION

In this case study Flownex aided in the development of a data centre cooling model. The tool allowed the swift and modular development of free cooling technologies in a data centre. A transient simulation was completed using historical weather data as input. The comparison of the savings on active cooling (electricity) in the data centre for the two free cooling methods are shown in Table 1.

Table 1: The electricity savings results from the study.

	Indirect waterside cooling		Indirect evaporative cooling	
	Feb – Mar	Jun – Jul	Feb – Mar	Jun – Jul
Active cooling before free cooling	17.2 MWh	15.5 MWh	15.5 MWh	15.5 MWh
Active cooling after free cooling	4.6 MWh *26.5 %*	0.42 kWh *0.0 %*	1.6 MWh *10.5 %*	38.4 kWh *0.2 %*
Savings by using free cooling	12.7 MWh *73.6 %*	15.5 MWh *100.0 %*	14.2 MWh *91.1 %*	15.5 MWh *100.0 %*

The Flownex models not only provide information about the potential performance savings, but they also allow for the optimal design of the hardware required e.g. pumps, fans, piping, and heat exchangers. This facilitates a smooth transition from performance modelling to solution implementation.