

INDUSTRIAL TRAINING

Marta Codina Gessé, Universitat Politècnica de Catalunya (UPC)

25/1/2016

The industrial training was performed in the Catalonia Institute for Energy Research (IREC) from September to December, under the supervision of Dr. Eduard Oró.

The developed tasks could be classified in two main parts:

- Literature research
- Interactivity with TRNSYS

For this reason, the structure of this report is in two sections.

1 Literature research

The starting point was the performance of an exhaustive search of information, since I had no knowledge about the topic of research. For this reason, I read about 50 scientific articles and I wrote down an state-of-the-art.

The research group, with which I collaborate, are experts about the implementation of energy efficiency strategies into data centers. In that sense, they have a deep knowledge about thermal energy storage (TES). However, they are interested to add some components into their strategies about electrical energy storage (EES). And also, during my master thesis work, it is expected that I optimize one real system of energy from a UPC data center. Hence, the basic lines to look for information was:

- Data center
- TES
- EES
- Optimization framework

In the following subsections, I am going to give a general overview about these topics.

1.1 Data center

Data centres are facilities used to house computer systems and associated components aim for performance, reliability and security 24 hours a day the 365 days a year, transforming them into a highly energy demand infrastructures.

During the last years, the rapid increase of cloud computing, high-powered computing and the vast growth in Internet use have aroused the interest in energy consumption and carbon footprint of data centres. Nowadays, the energy consumption of the data centre industry represents the 2 % of the total energy consumption worldwide and it's expected to growth.

Actually, up to half of the total energy consumption in a state of the art infrastructure is attributed to cooling which in turn produces vast amounts of waste heat. Energy consumption of data centres can be unnecessarily high due to poor airflow management, reliability drives the dimensioning of the infrastructure, inadequate localisation of cooling devices, etc

1.2 Thermal Energy Storage

The Thermal Energy Storage consists on a tank where the heat is stored, because it contains some fluid in a specific conditions, typically it is water. But depending on the heat storage, there are three methods of TES; sensible, latent and chemical heat storage. And also, depending on the store time can be either short or long term storage; daily or seasonal.

The key point is to ensure that the fluid meets the specific conditions when, from an energy point of view it is more favorable, and then, store it at those conditions. It allows us to spend energy at the best moment, for example, during an off-peak electricity price, or when the weather conditions are appropriate for lower power consumption.

This device is integrated, mainly in the cooling system.

In this study, water is used as sensible storage material as it is cheap and available in many locations, has the best thermal properties, and possesses good long term stability. And also, this study only focuses on using short term storage.

1.3 Electrical Energy Storage

EES has an important role to increase the potential use of renewable energy and to reduce the operational costs of data centres. However, actually the high cost of this technology is still a barrier; but it is also expected that in the near future the cost of the batteries will drastically decrease due to a rapidly accelerating rate of technological development.

The different types of EES could be classified depending on the response time:

- long-duration (min): PHS, CAES, lead-acid, NaS, Ni-Cd, VRFB, Fe-Cr.
- medium duration (min-s): CAES (aboveground), lead-acid, NaS, ZEBRA, Li-ion, VRFB, Zn-Br, Fe-Cr, Ni-Cd, hydrogen.
- short duration (s): Flywheel, lead-acid, Li-ion.

The integration of this device in any electrical system will represent an important energy improvement.

1.4 Optimization framework

In order to predict the economic and energy impact of different strategies it is necessary to model the system. In that sense, many researchers have been investigated and proposed many different numerical models for data centres which can be divided in CFD models, their own development models and building and energy simulation models.

On one hand, due to the complex and system specific nature of CFD models and the difficulties in obtaining accurate input variables, CFD analysis can often include inaccuracies, besides being highly time consuming. Same phenomenon happens with own development models, it's difficult for others to play with them.

On the other hand, energy modelling is utilized on buildings for two main purposes: design and optimization of buildings and Heating, Ventilating and Air Conditioning (HVAC) systems and determination of the baselines and potential retrofit energy savings in existing buildings. These dynamic numerical models are able to predict the energetic behaviour and the economic analysis of data centres within a common sense time consuming. In particular, this study will use TRNSYS.

In the near future, during my master thesis study, I will work with GenOpt, an optimization framework from TRNSYS, combined with Matlab [1].

2 Interactivity with TRNSYS

As I said, I worked with TRNSYS (Transient System simulation tool). It is an extremely flexible graphically based software environment used to simulate the behavior of transient systems. While the vast majority of simulations are focused on assessing the performance of thermal and electrical energy systems.

To become familiar with this software and providing the line to follow during my thesis (the optimization of the system described in [2]), I build two different systems with:

- Two chillers
- Three chillers

The first model (figure 1), is the simpler one, which contains only 2 chillers.

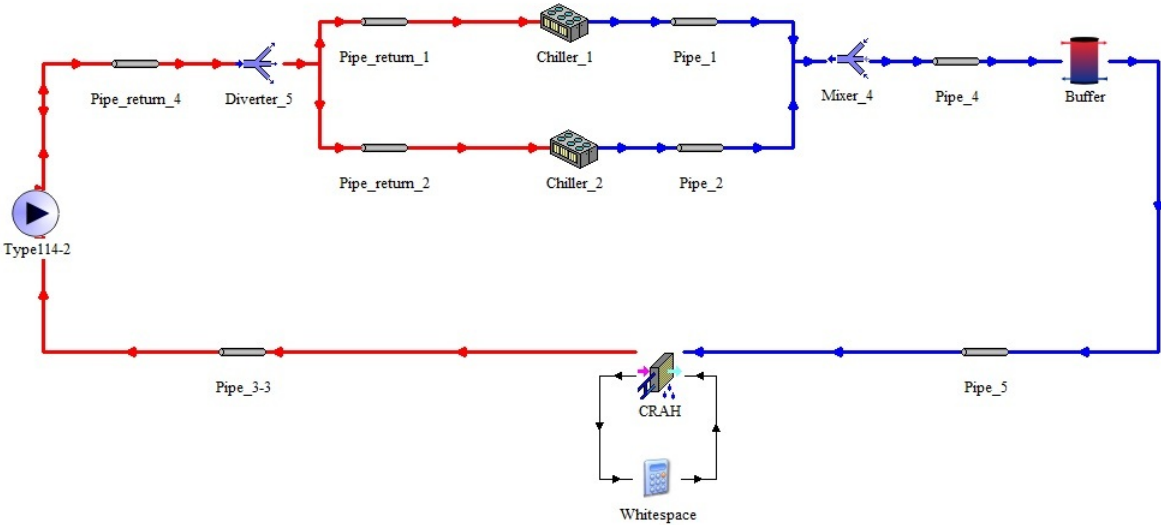


Figure 1: Data center model using 2 chillers.

The second model (figure 2), includes a new chiller into a subsystem, where a TES tank is located.

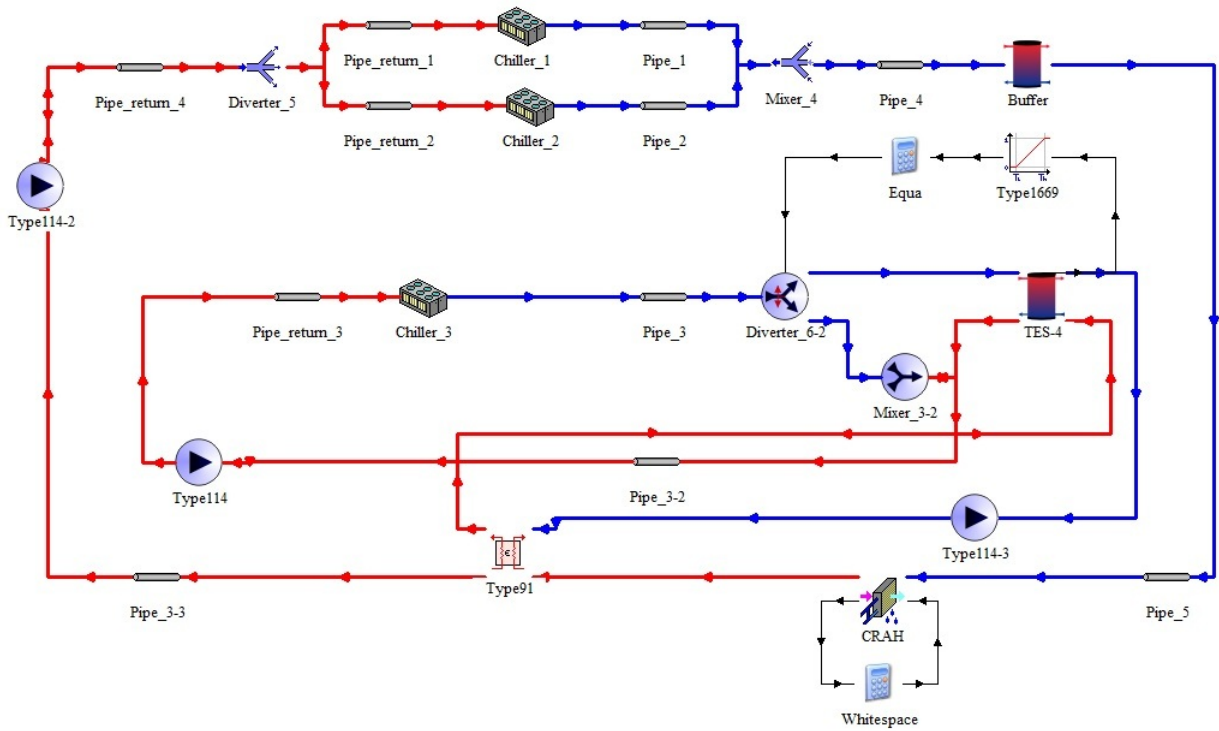


Figure 2: Data center model using 3 chillers; the new chiller is part of the subsystem, where is the TES.

The last model was verified in [2], but to check that I rebuild it correctly, I compared three graphs from the temperature and relative humidity in the whitespace. The data from the first plot are obtained from real data acquisition in UPC facilities (figure 3), the second one (figure 4), shows the corresponding results obtained from the simple model (figure 1), and the last one (figure 5), corresponds to the results from the model with 3 chillers (figure 2).

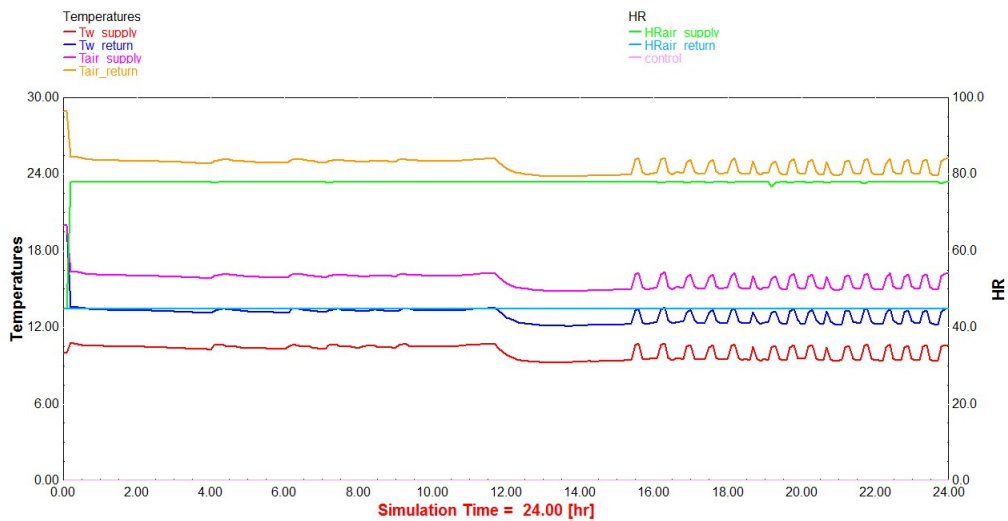


Figure 3: Temperature and relative humidity conditions in the whitespace from real data center.

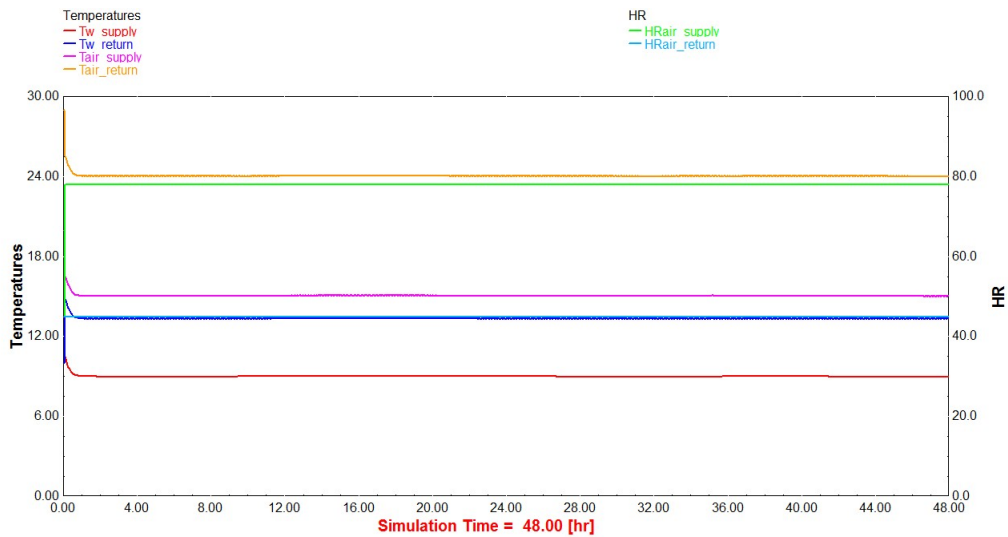


Figure 4: Obtained weather conditions, into the whitespace, with the 2 chillers model.

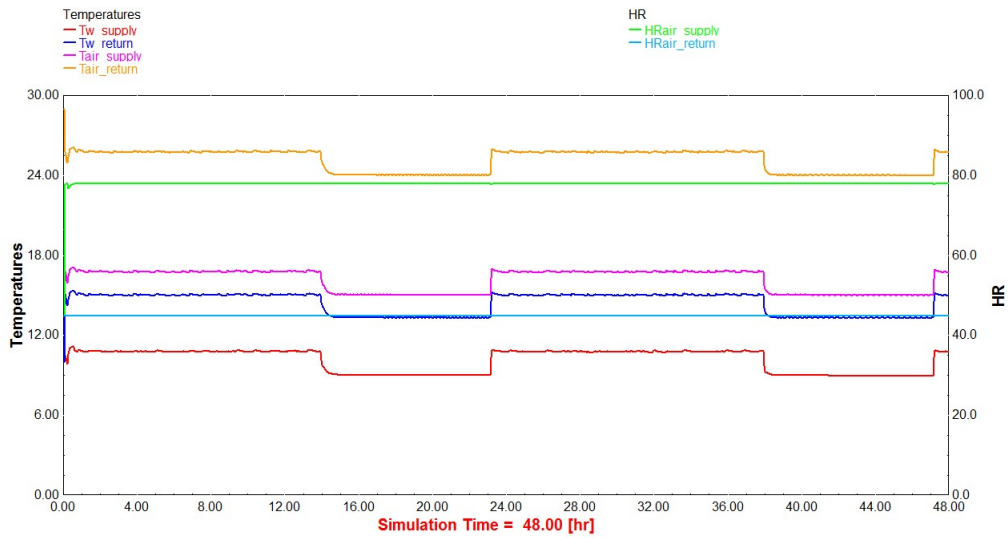


Figure 5: Obtained weather conditions, into the whitespace, with the 3 chillers model.

As it is possible to see, both models behave correctly, according to the real data.

Finally, remark that the model with the subsystem containing the TES device was validated before my work [2]. I build the same system to understand it in a deeper way to become familiar with the software and the topic of research.

In the near future, I am ready to optimize some parameters of the system and improve the energy efficiency strategy.

References

- [1] ASADI E., GAMEIRO DA SILVA M., HENGGELER ANTUNES C. and DIAS L., *A multi-objective optimization model for building retrofit strategies using TRNSYS simulations, GenOpt and MATLAB*, Building and Environment 56 (2012) 370-378.

- [2] ORÓ, E. and SALOM J., *Energy model for thermal energy storage system management integration in data centres*, Energy Procedia 73 (2015) 254-262.