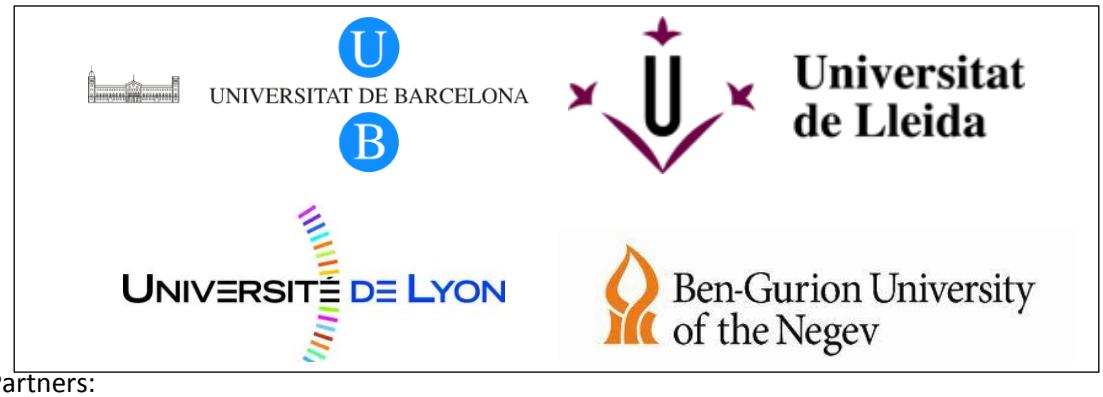
INNOSTORAGE – USE OF INNOVATIVE THERMAL ENERGY STORAGE FOR MARKED ENERGY SAVINGS AND SIGNIFICANT LOWERING CO_2 EMISSIONS

Beneficiaries:



Partners:

D7.2 - Report on Staff Exchanges

	Name and Institution	Date
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Contents

1 Objectives

This report comprises the results of two secondments realized at the same time by Prof. Ingrid Martorell and Prof. Marc Medrano, both from the University of Lleida (UdL), in Spain. They both visited Dr. Frank Bruno, at the University of South Australia for one month in July 2015. The objectives of the two secondments were:

1. To enhance the collaborations between the two institutions with a long term perspective.
2. To develop a research work on the effect of real tariff prices, PV generation and emergency thermal storage on data centres industry, both in Catalonia and South Australia.

2 Introduction

Data Centers (DC) are a type of energy consuming building with unique demand characteristics, which have grown in the recent year in size, complexity and energy density. This is due to the rapid growth of cloud computing, supercomputing and Internet use. As they are becoming an important player in the total energy consumption of the building stock in the world, industry and researchers are currently studying different strategies for reducing their energy use. Although there is considerable amount of recent scientific literature on the energy efficiency of data centers, there is no study addressing the impact of real time-of-use electric rates and PV implementation on the energy bill for two regions in the world with similar climates but different utility rates structure, one in Europe (Catalonia) and one in Australia (South Australia). There is as well scarce literature analysing thermal storage options for data centers in emergency situations.

3 Description of work

The work done in the research stay has consisted in starting the different tasks associated with this project, having in mind a scientific paper as the final outcome. Thus, the work to be done is summarized as follows as a list of tasks:

- Design paper structure, defining the scope, the DC size (case study), and what to include in every section.
- Search and analyse previous literature work on the topic, trying to identify original contributions to the scientific community.
- Collect and analyse typical hourly power profiles for data centers, based on load profiles and the type of data processed in the DC.
- Collect and analyse time of use (TOU) updated electric rates for industrial consumers (high voltage), both in Catalonia and in South Australia.
- Design the right calculation tool for processing hourly data and demand and power (TOU) costs and determine the annual electricity DC bills.

- Select the right plotting tools for showing the complexity of the TOU rates in a visual way.
- Dimension and assess the effect of PV farms implementation in the DCs of Barcelona and Adelaide on the electric bills.
- Define and analyse the emergency TES cases, both for cold water tank and for PCM.
- Discuss results and write conclusions.

4 Materials and Methodology

This is an analytical work, based on electric TOU rates of two different regions of the World, DC power profiles, weather data, PV performance, and TES data. The tools used for addressing this work are literature citation software (Zotero), spreadsheets, mathematical solvers (EES), plotting tools and text processing tools.

5 Results

During the four weeks at UniSA we have been able to move forward in several tasks of the project. The work done is summarised as follows:

1. Design paper structure, with what to include in every chapter.
2. Formatted Excel files for estimating total annual electricity costs, taking into account both the hourly power profile of the DC and the TOU rates, both for Spain and SA, and both for Web and Data centers power profiles (see Figures 1 to 4)

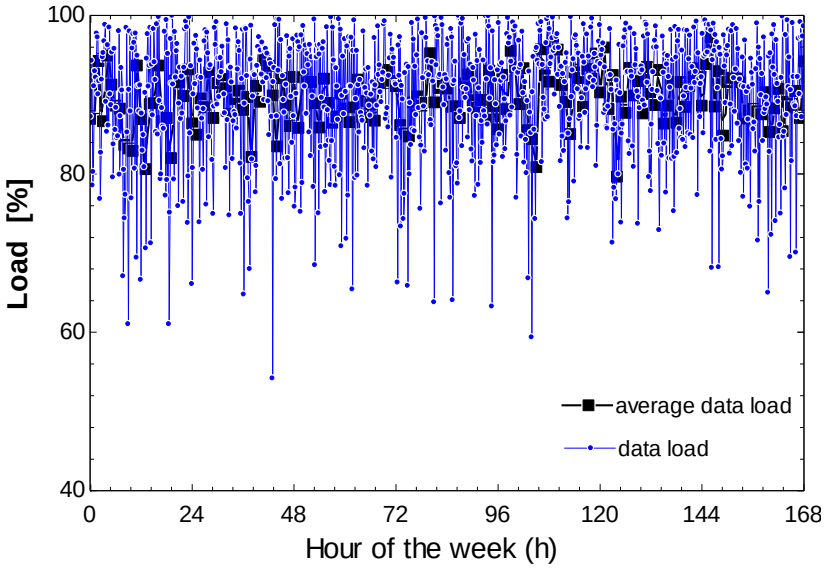

Figure 1: Detailed and averaged values for a high performance computing (HPC) data center load in a typical week.

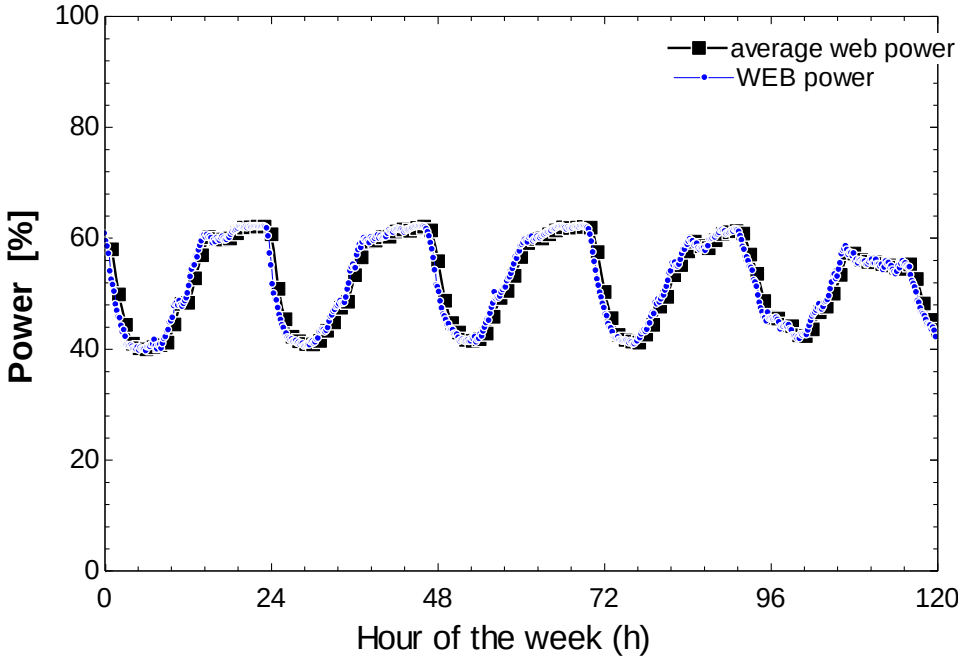

Figure 2: Detailed and averaged values for a web-serving data center power IT consumption load in a typical week.

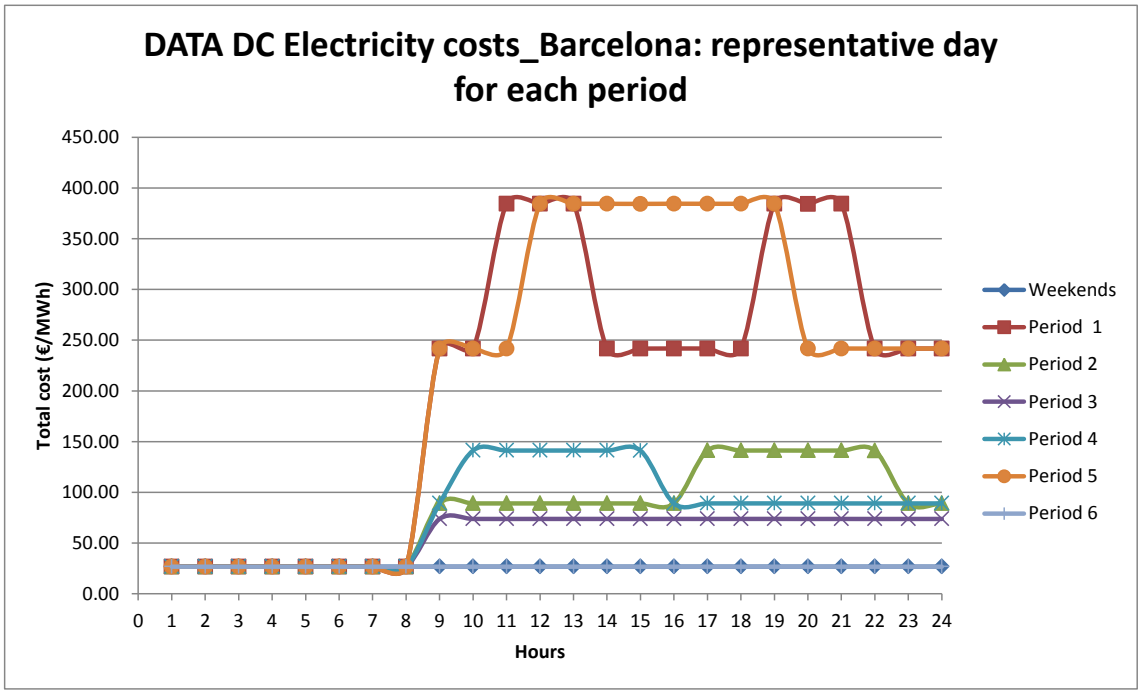

Figure 3: Hourly change in cost per MWh for the 7 different periods of the high voltage industrial Spanish electric tariff.

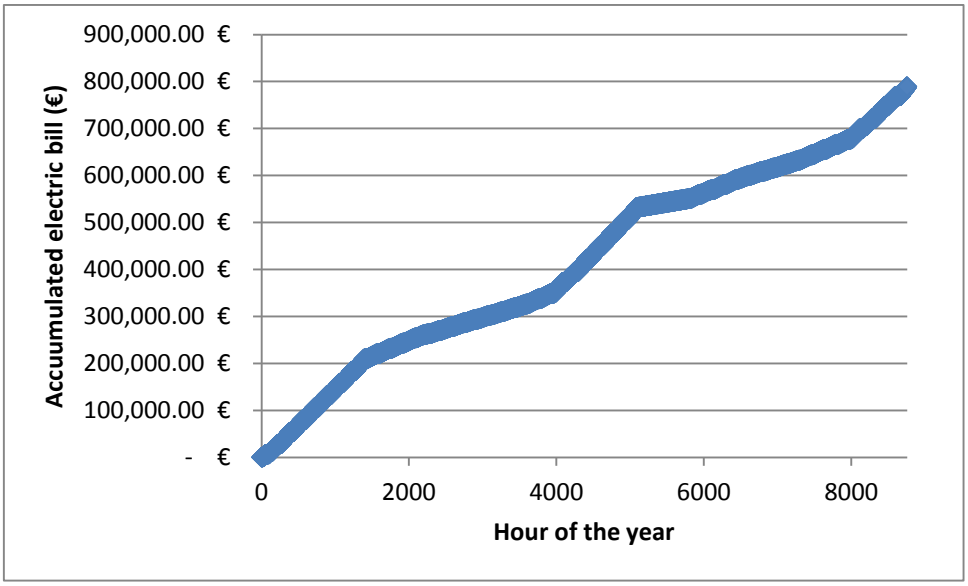

Figure 4: Accumulated electricity costs for a data center in Barcelona.

- Two Excels for Spain, one with tariffs for a particular retailer and one for official BOE network charges, corrected by a factor to have a reasonable final cost per MWh.
- One Excel file for SA, using rate structure for SA net supplier and correcting the final cost value based on a real cost estimation given by an energy broker at SA for our particular case of a data center.
- The same 3 files for data power DC profile (almost constant power).

3. Generated some preliminary plots for Spain and SA on Electricity cost profiles (contour plots, some daily profiles for Spain and SA). Need to decide which ones are more illustrative and clear for the paper (Figure 5).

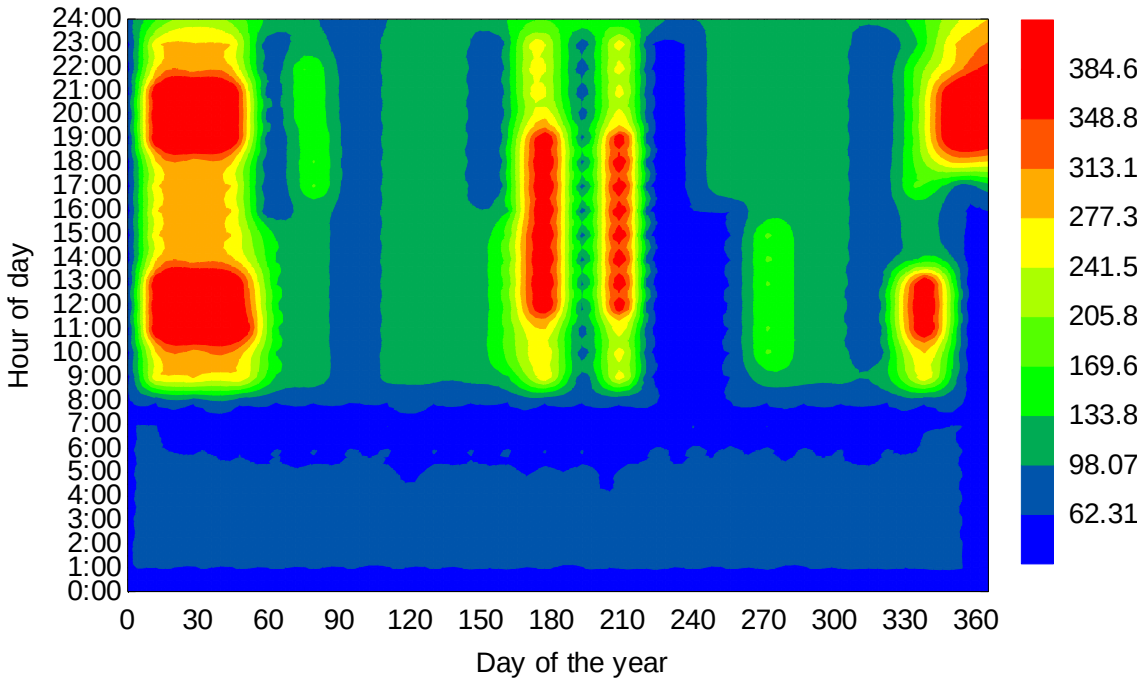

Figure 5: Contour plot for time of use effective cost of electricity in Barcelona, applying the high voltage industrial Spanish electric tariff

4. Generated two basic PV pre-dimensioning cases for Barcelona and Adelaide (Figure 6), using PVsyst software, with nominal power of 562.5 kW (electric power used by cooling equipment). Only average daily values, no hourly values so far.

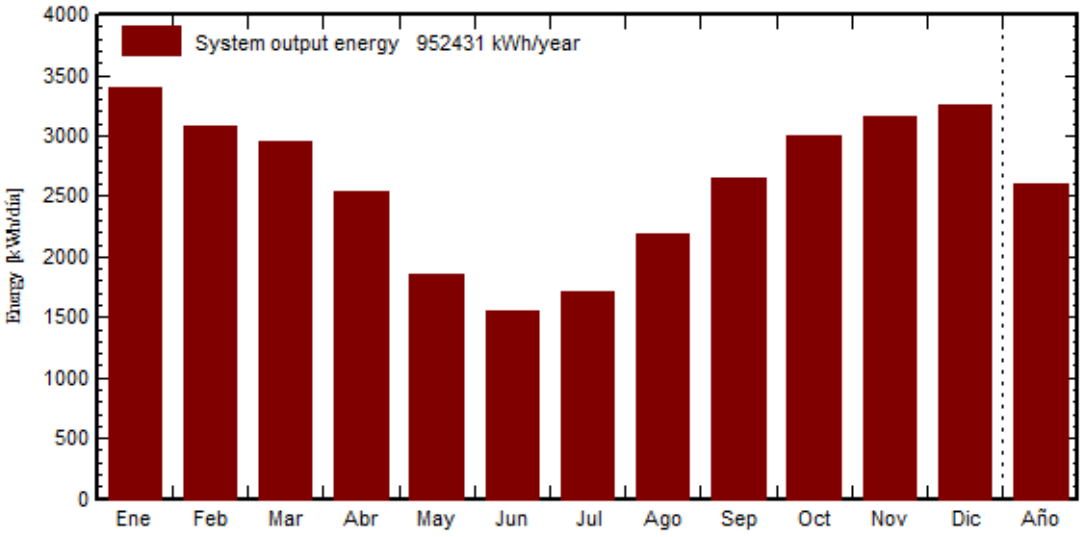

Figure 6: Annual and monthly output energy for a 560 kW peak PV farm in Adelaide, next to the DC, supplying the electricity needs of the DC cooling equipment.

5. Done first basic model (Figure 7) for emergency TES case with cold water tank. Assumed perfect mixing in tank and no thermal inertia in IT room (Figure 8). First step for more complex model. Explained to Steven Lee, who will start now working on a model for the PCM case, using variable HX effectiveness for their tube-in-tank PCM storage.

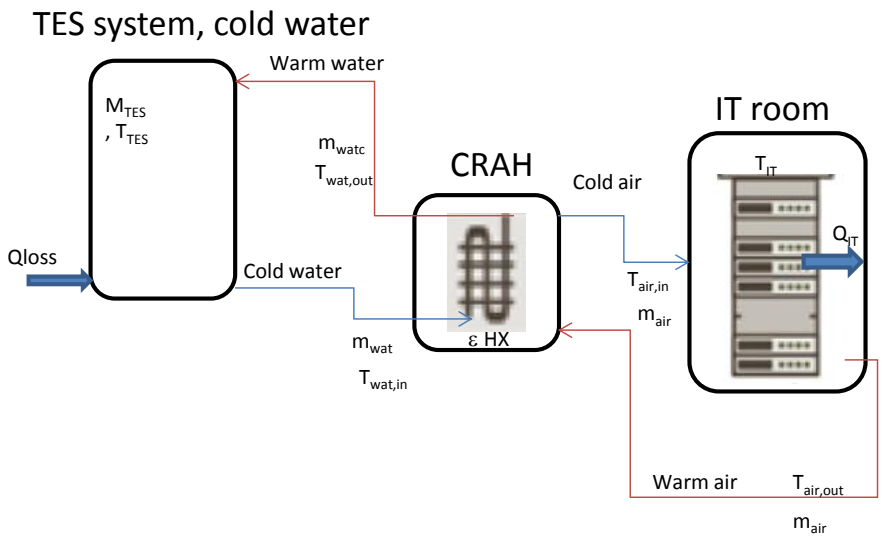

Figure 7: Block diagram for cooling the IT room of a DC in an emergency case, using TES.

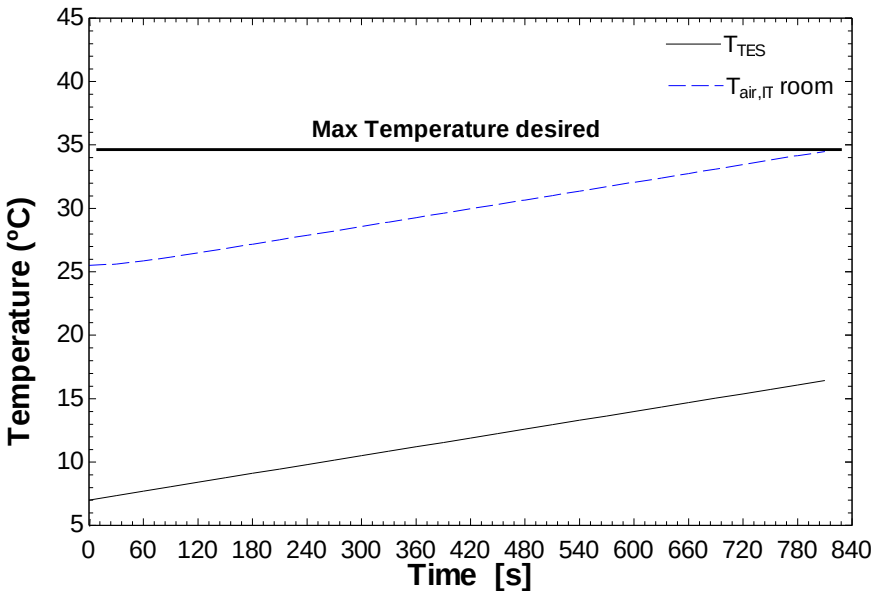

Figure 8: Dynamic evolution of TES temperature and IT room temperature during an emergency case.

6. Collected and read references and included in Zotero, for rapid bibliography generation (see “References” section below).

As the stay was relatively short, several tasks could not be finished there and we will be working on them in the following months. The pending tasks are:

- Decide which daily profiles (for cost of electricity for a data center profile, both for Spain and for SA) are more visual and interesting for the paper.
- Generate other plots for the first tariffs part of the paper (i.e. accumulated elec cost with time for the two cities and for the two types of DC, etc.)
- Dimension PV array installation for HVAC electric needs (chillers, fans, pumps, etc.) and calculate hourly electricity production for Barcelona and Adelaide in a more accurate way.
- Perform more detailed analysis of dynamics of emergency case with cold water tank, at least including some basic stratification model.
- Perform dynamic model for PCM TES tank, including model of Frank Bruno and Steven Tay for the PCM power behaviour with melting. Decide if the time for emergency should be the same in the PCM design, or larger, as once the PCM has totally melted the exchanged power will be much lower than in the sensible water case.
- Perform profitability analysis for PV savings and for alternative to emergency cold tank (i.e. upgrade UPS capacity or estimate cost losses when IT room down).
- Write the paper.
- Include an acknowledgment section for the Innostorage funding.

6 Outcomes or future work

As stated above, the initial work realized by the two secondments will be continued and finished in the following months, with the collaboration of the researchers at UniSA. We expect to elaborate a good quality journal paper to be published in a prestigious scientific journal. The links and personal interactions we developed in the stage will certainly be beneficial for future collaborations and joint projects.

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8 Assessment

8.1 Assessment by Marc Medrano

This secondment gave me the great opportunity to experience other ways of conducting research and organizing a research team, share and exchange ideas and knowledge with researchers with different cultural and geographical references as mine, and develop personal relationships than will be useful for future collaborations. This has been indeed an enriching experience and I would like to express here my gratitude to the Innostorage Programme for granting me this interesting research stay at the University of South Australia, with Pr. Frank Bruno.

8.2 Assessment by Ingrid Martorell

This secondment has been an unique experience to interact with researchers from another university and start a collaboration that hopefully will not finished with this project. I had the privilege of exchanging research ideas with Pr. Frank Bruno and his team. It was also very interesting to start collaborating with Dr. Steven Tay who will participate actively in one of the tasks of the research work we started at UniSA. I want to thank the Innostorage Programme for the opportunity of conducting this research stay at University of South Australia.