

# A Successful Data Centre Refurbishment Project

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**Abstract.** Queen Mary University of London (QMUL) has recently finished refurbishing its data centre that house our computing cluster supporting the WLCG project. After 20 years of operation the original data centre had significant cooling issues and increases in energy prices have all driven the need for refurbishment amid growing awareness of climate change. In addition there is a need to increase the capacity (from 150kW) to cope with the expected increased needs to the high luminosity LHC and new astronomy projects such as the LSST and SKA observatories.

A summary of the project is presented covering the project time line and solutions implemented (in row cooling, hot aisle containment, heat pumps and dry air coolers). Experiences and lessons learnt in the design, building and use of the data centre (covering choices in power supply, rack density, storage space, floor type, lighting, monitoring, etc. . .) are discussed. Effects of budget constraints and project rescoping due to inflation are also discussed.

## 1 Introduction

QMUL has recently completed the refurbishment of its on campus research data center. The objective of the refurbishment is to: Support LHC computing and other big data science projects through to 2035; Increase capacity; Improve efficiency; Improve resilience; and reduce environmental impact.

## 2 The Deployed Solution

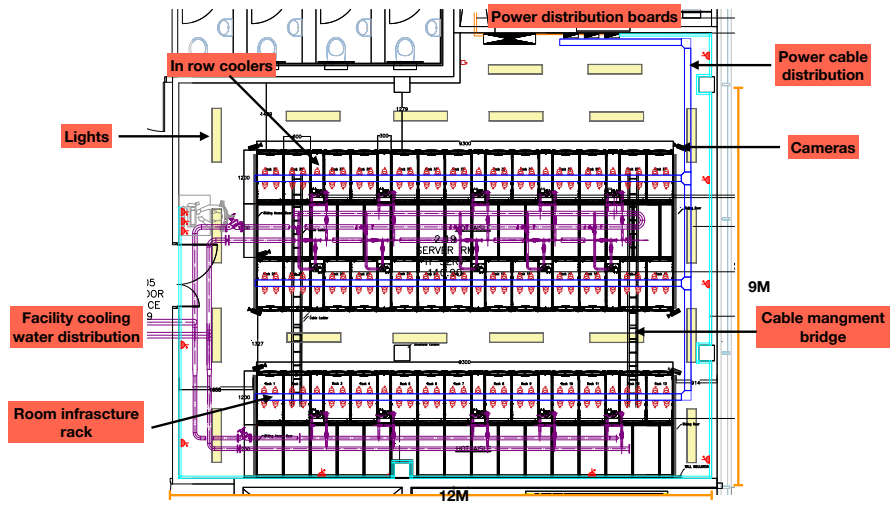
Initial plans, including constraints and justification for the project can be found in [1]. Presented here is the deployed solution.

In the Data Centre (DC) there are 39 racks in three rows of 13 racks each, figure 1 and 2, with a total room cooling capacity of 390kW. Single phase power is provided to each rack with four 32 amp supplies from two separate power supplies. An average power of 10kW per rack with redundancy or up to 20kW is usable without redundancy. Hot aisle containment is used with five in row coolers, providing N+1 redundancy, per row. The cold aisle operates at 26C (Celsius), while the hot aisle is at 45C, this provides optimal efficiency for the coolers [2]. Drop out roof tiles are used to allow the fire suppression system gas to reach all areas of the DC. There is no raised floor, instead all infrastructure, power, cooling water and network cabling, is provided above the rack.

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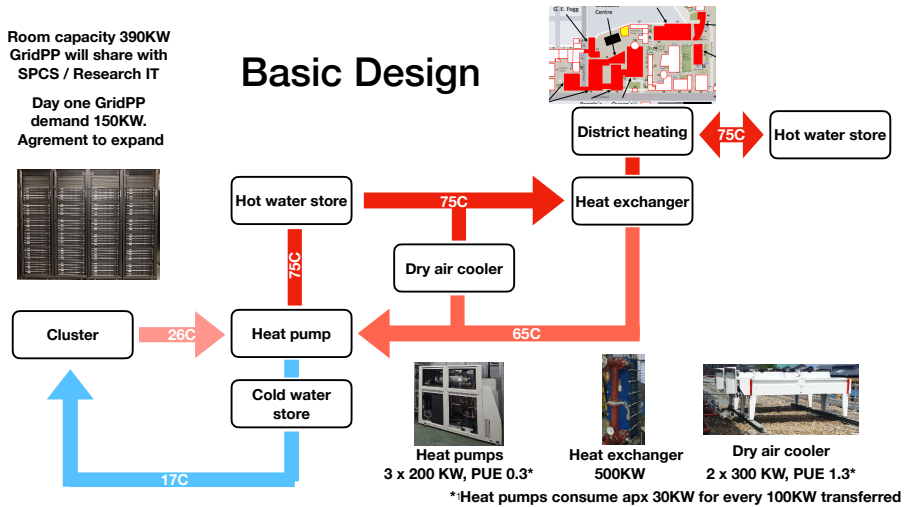
**Figure 1.** A schematic diagram of the layout of the data centre, showing the racks, in row coolers, water cooling circuit and room infrastructure (light and power)



**Figure 2.** Pictures of the actual data centre, showing the racks, in row coolers, water cooling circuit and room infrastructure (light and power)

A chilled water circuit connects to each in row cooler with a input temperature of 17C and output of 23C. The 390kW cooling capacity is provided by three 200kW water source heat pumps (N+1 redundancy), these take the chilled water circuit back to 17C. The water source heat pumps output “high quality” hot water circuit which operates at 75C i.e. the water is hot enough to be efficiently used in a heating circuit. The hot water (75C) circuit feeds into either the district heating system via a 500kW heat exchanger or two 300kW dry air coolers. Note the dry air coolers operate at 75C. This means they can be used all year round but are less energy efficient due to the energy cost of the heat pumps. Year round demand for hot water in

the University should mean there will be minimal use of the dry air coolers. Figure 3 shows a simplified diagram of the cooling circuit.



**Figure 3.** Simplified diagram showing the water cooling circuit for the data centre together with the interface to the district heating system

Schneider electric (APC) kit is used throughout the DC. The APC Data centre expert (DCE [3]) software is used for centralised monitoring and management of the DC but not plant room equipment such as the heat pumps or dry air coolers which are managed by the building management system (BMS). A MODbus connection interfaces between the BMS and the DCE for limited data transfer (selected alarms and energy readings).

### 3 Project Appraisal

Objective 1, Capacity has been Increased by: Adding more usable racks (15 to 38); Upgrading the power supply from 150kW to 390kW. Providing four 32A connections per rack (two previously). The racks were also upgraded to 1200mm deep racks allowing larger server equipment to be installed.

Objective 2, Efficiency has been increased by: Moving from (Computer Room) Air Conditioning (CRAC-refrigerant based) to (Computer Room) air handler units (CRAH-water based). The use of hot aisle containment (expected to be more efficient than no containment / cold aisle containment) [4]. Temperature deltas have been chosen to be the most energy efficient: cold aisle 26C, Hot aisle 45C; In water 17C, out water 23C. LED lighting has replaced fluorescent lights. There is no wide spread use of UPSs.

Objective 3. To improve resilience there are: Two separate power supplies available on each rack; N+1 in row coolers per row; N+1 heat pumps; Alternative heat exhaust options (dry air coolers or heat exchangers for district heating system). There are no backup power generator and no room UPS. In row coolers only have a single power supply.

Objective 4, The environmental Impact has been reduced by: improving efficiency (see above); By using heat recovery. This moves heating from gas to reusing waste heat from the DC which has a lower carbon cost due to increasing renewable contribution to electricity; The use of water instead of refrigerant gas, which can have harmful environmental impacts, for cooling.

## 4 Project Observations

Objectives: Having a clear achievable objectives agreed by users of the facility for the project and used as a reference to make sure what actually happens is aligned with the objectives.

Project management: Vital to getting the project into shape was an experienced project manager, estates not IT, who is familiar with building infrastructure (cooling, electrical, civil).

Financial case: While there were funds available for a modest refurbishment, to build a larger project we had to make the case, both financial and impact, for providing the extra costs associated with expanding the capacity and installing the heat recovery. To do this we use the UK governments green book on project costing [5]. The project was also independently and accurately priced using a quantitative surveyor before going out to tender.

## 5 Data Centre Build Observations

APC was chosen for two main reasons. There was already a large amount of APC kit (racks and PDUs) which could be reused, saving on cost. APC is a recognised name and have had a good experience with their equipment.

Total cooling capacity, 390kW, is limited by space available for the cooling solution in the buildings plant room on the roof of the building. This then placed limits on the design of the DC.

There is no raised floor which brings benefits and problems. A solid concrete floor has no floor loading issues and there are no ramps into the room for equipment to negotiate. All services to the racks, power, cooling water and network, have to come from above the racks.

A large number of lower power density racks was chosen to provide for flexibility in organising in-rack equipment (servers). The lower power density means single phase PDUs can be used.

For reasons of space, cost and need there is no backup power generator and no room UPS. There are two separate power feeds to each rack but only one to the in row coolers which limits the usefulness of the resilience.

Originally there was no area assigned for storage space in the DC. A Non ideal solution was to share space next to the electrical distribution panels.

## 6 Monitoring and Management (BMS, DCE)

The lack of integration of the original cooling of the data centre with the building management system (BMS) required manual checks and resets of the system which typically had to be initiated by the users and could have lag times of days to be acted on by the universities estates management. The new cooling system is integrated into the BMS and this provides monitoring of the state of the system, ability to raise alarms that are seen by the estates management, and also the system performance (energy use and reuse).

In addition it was decided to invest in a dedicated monitoring and management service for the APC equipment in the DC. Using the Data Centre Expert software solution from APC we are able to integrated the management and monitoring of the PDUs, in row coolers, temperature and humidity sensors and video surveillance into one application.

An interface between the BMS and DCE (using a modbus interface) was installed allowing selected alarms and metrics to be exchanged between the two systems.

## 7 Future Concerns

There has not been a great history of long term maintenance in the old DC with a make do and mend approach rather than any proactive care. There is a need to up our game here and develop a long term care plan.

A major concern is the possibility of leaks from pipes above the racks. It does not take too much water to cause problems in a DC. A large number of leak detectors have been installed and included in the monitoring system with alarms.

Modern computing is moving towards high density, high power requirements and liquid cooling. This DC is not designed to handle this type of equipment. This may limit the type of equipment that we can install for GridPP.

## 8 Conclusion

Long term operation required to fully evaluate the success of the project. However there is now enough cooling and power so that all equipment can now be turned on which was not the case before the refurbishment. The objectives of the project have been met. It now rests with the University to make sure the DC delivers what it is capable of, 390kW of power being used by computers and then feed into the district heating system.

## References

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