

Oxford University Physics Department
Computer Room Air Conditioning Upgrades

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HEPiX Fall Workshop 2023 Victoria, BC

Department of Physics



Outline

- Local Computer Room Description
 - Typical electrical power load and PUE
 - Plan to perform upgrade with zero downtime
 - Supplementary A/C & testing
 - The upgrade
 - Tuning & results
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- Begbroke Science Park Computer Room

Physics department local Infrastructure room

- Built in 2007
- Big step up from running racks in old experimental halls
- Traditional air cooled, vented tiles, DX cooling
- 21 rack capacity
- Two 50kW RACU's
- Each rack has two 32A sockets



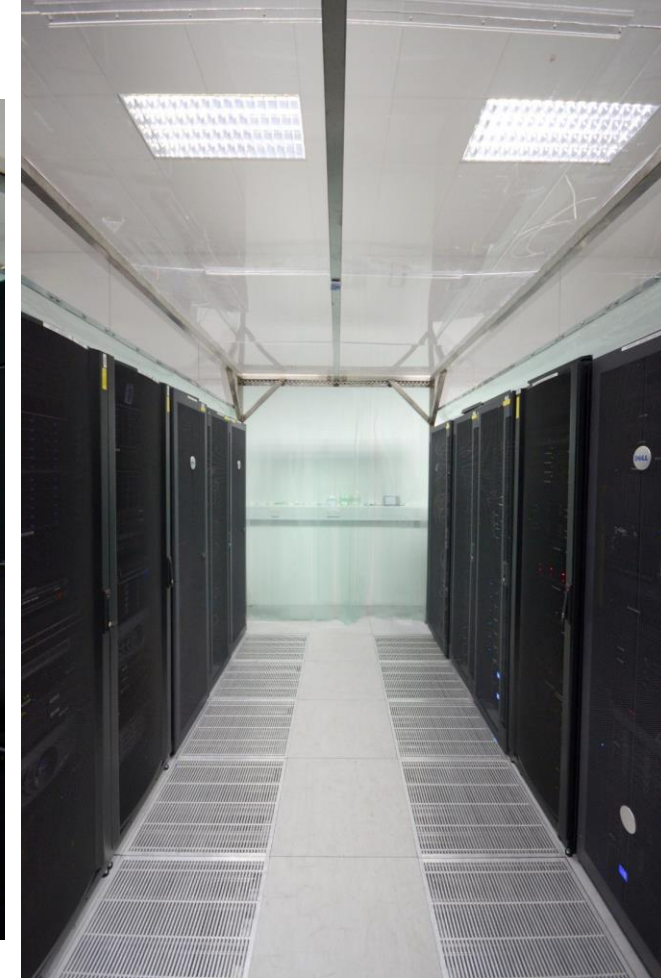
Denys Wilkinson Building
Level 1 Physics Computer Room

Vented Tiles	AOPP	15	8	Central	Vented Tiles	Network Rack	1	RACU								
	Theory	16	9	Central			PP Linux		2							
	Clarendon	17	10	Central			PP Linux		3							
	Clarendon	18	11	AOPP			PP Linux		4							
	Theory	19	12	AOPP			PP Linux		5							
	Astro	20	13	AOPP			PP Linux		6							
	Astro	21	14	AOPP			Central		7							
										RACU						
1	2	3	4	5	6	7	8		9	10	11	12	13	14	15	16



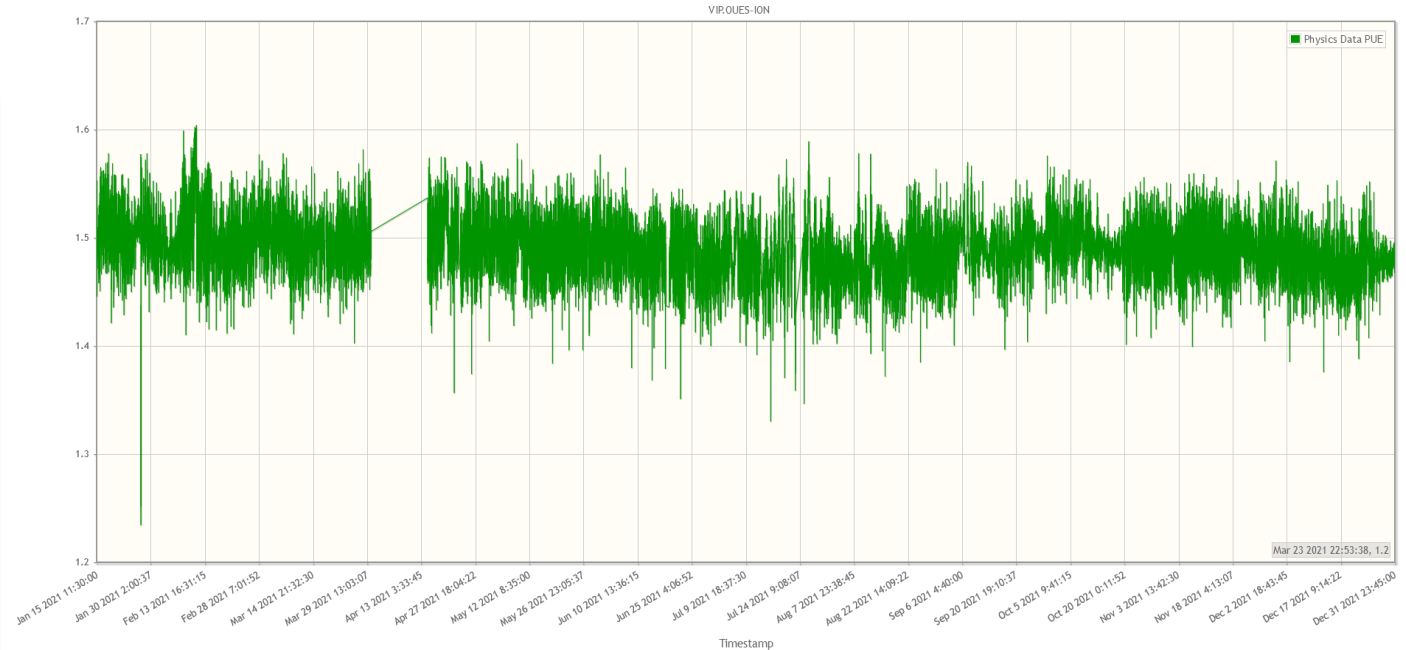
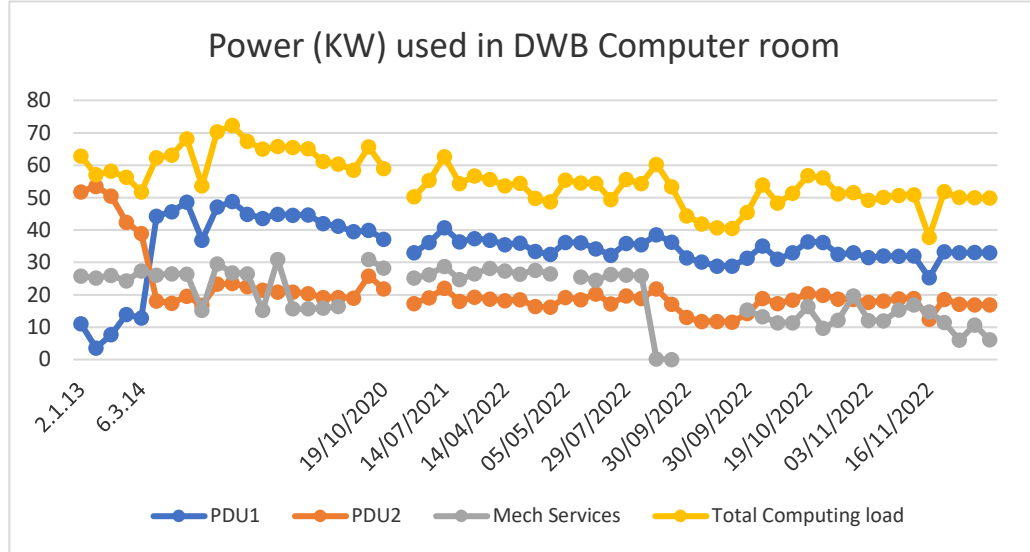
Physics department local Infrastructure room

- Rapidly filled up.
- All rack positions filled
- Enclosed the cold aisles in 2011



Physics department local Infrastructure room

- Load frequently over 50kW, so no redundancy when changing fan belts
- Fans were continuously running so needed to change belts every 6 months to avoid failure.
- Units costly to run, and ~15 years old
- PUE ~1.5



University Estates had a sustainability budget we could apply to have the upgrades funded.

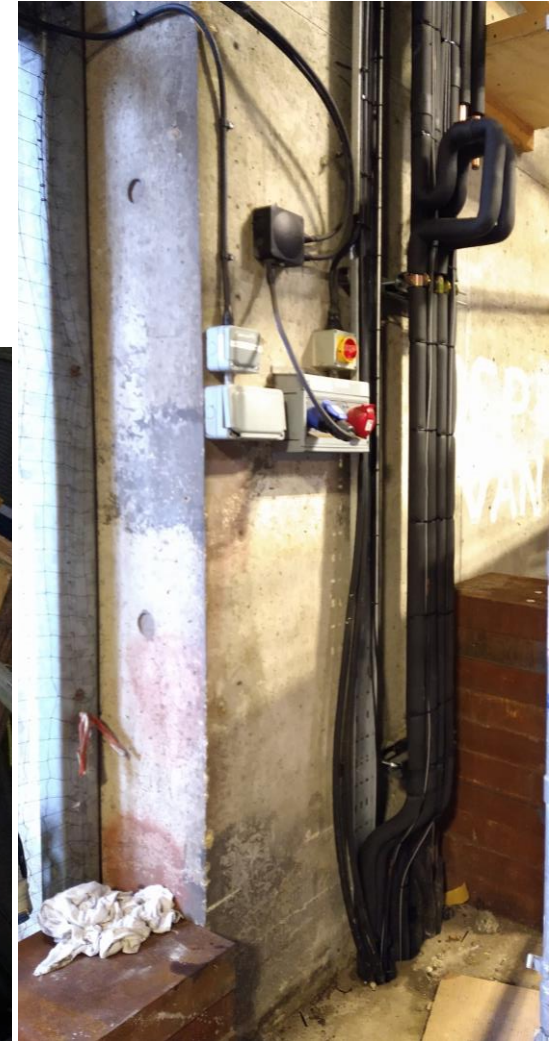
Idea would be to replace the two units with three 45kW units giving better redundancy, increased capacity and the new units should use less power so improve the PUE. Payback period in cost savings over a few years.

First met with Estates in January 2020. Had to get metering installed to measure the PUE to show the potential savings, this was completed in December 2020.

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- University Estates commissioned and funded the project.
- One main Sub contractor to provide the design and A/C units.
 - They sub-contracted out the pipe installation.
 - At one stage they sub-contracted a core drilling company.
 - They sub-contracted the supply of supplementary A/C.
 - Yet another company performed the electrical installation.
- There was no overall project manager so the key stakeholder had to keep a very close eye on what was going on.

Physics department local Infrastructure room – Pipe Installation



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Physics department local Infrastructure room

- Upgrade work started in August 2022
- Had to perform the upgrade without down time.
- Replace one unit at a time and provide supplementary A/C to cover the excess load.

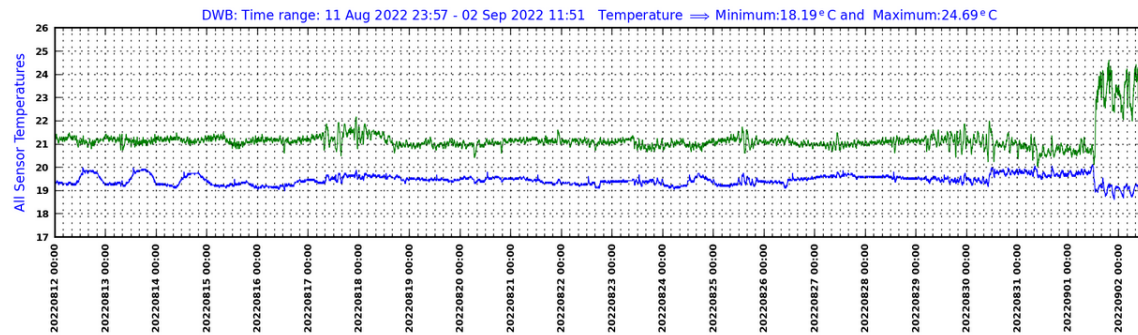
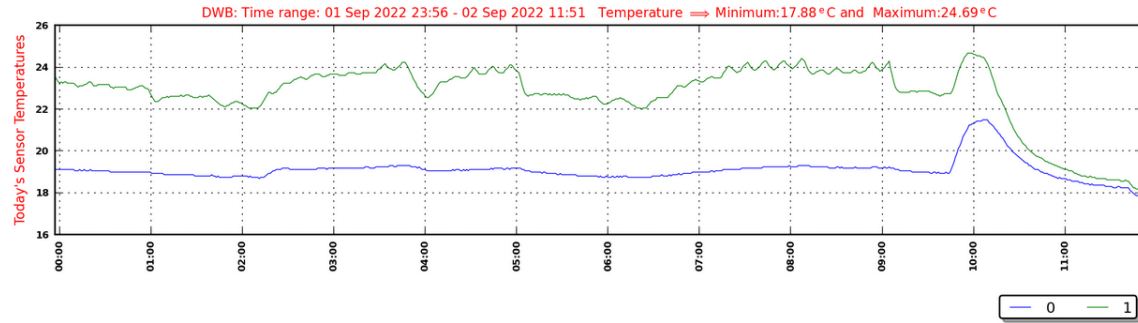


Pictures show the cold air directed into the cold aisles, (Originally directed under floor but insufficient pressure meant it stayed there)

- They proposed rather than supplying 50kW capacity temporary units they could provide 100KW so they could do both units at once.
- I was sceptical that this setup would cope so insisted on testing it.

Physics department local Infrastructure room

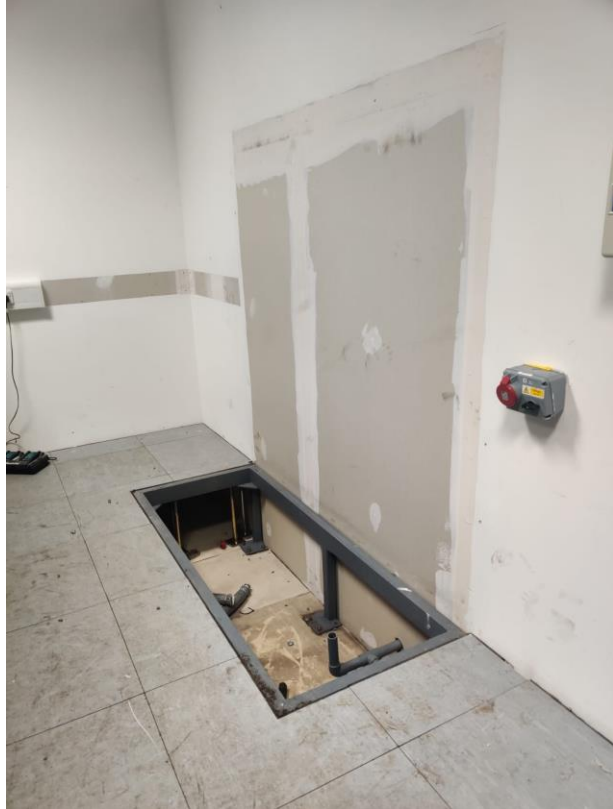
- Tested switching one of our A/C units off. Temperature rose but then stabilised.



- Switching the second unit off resulted in gradual temperature increase as expected.
- Contractors had to revert to the plan of replacing units one at a time.

Physics - local Infrastructure room

- Removed first old unit & external chiller.



Installed two new Smartcool downflow cooling units in the same space and two external units, while running the room on one old unit + the supplementary kit.



Installation of the first 2 of 3 New External Mitsubishi V coil air cooled Condensing Units (Compressor outside). Old unit being degassed.



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- Once the work was complete power savings were immediately noticeable
- New units are more efficient
- They have variable fan speed control (ie not always running at full speed)
- Control setup to maintain a target cold aisle temperature of 23 degrees C using cooling as required.



Pressure control aims for a target under floor pressure. Initially target was 22Pa which was not achievable with the gaps in the tiles.

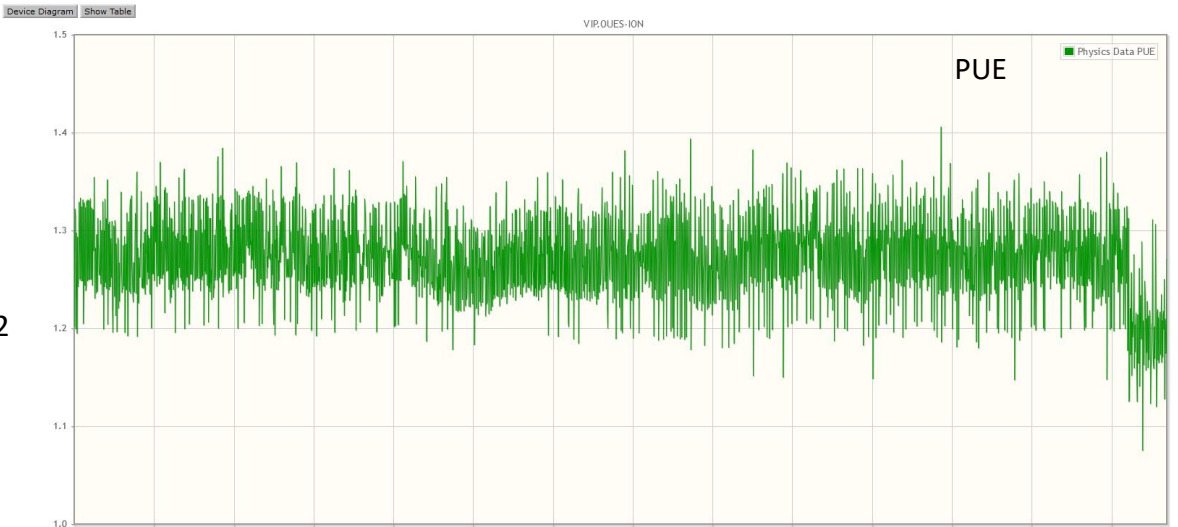
The fans were maxed out running at 89%.

Reducing the target to 15Pa, reduced the Fan speed to 85%.



Physics - local Infrastructure room

- Once missing floor tiles were fixed we could reduce the target to 14Pa, then shut some vented tiles. This helped the under floor pressure stay higher but still provided enough flow and pressure in the cold aisles. This reduced the Fan speed from ~85% to 68%.
- This is close to optimal.
- The PUE is now around 1.19



The end result of this is that the average power taken by the A/C is now around 11kW compared with 25kW for the old units. At today's prices this equates to approximately:

$$14\text{kW} \times 24 \times 365 = 122,640\text{kWh} = \sim \text{£}44,518 \text{ (at } 36.3\text{p/kWh)}$$

So the upgraded should pay for itself in around 3.3 years.

Physics - local Infrastructure room

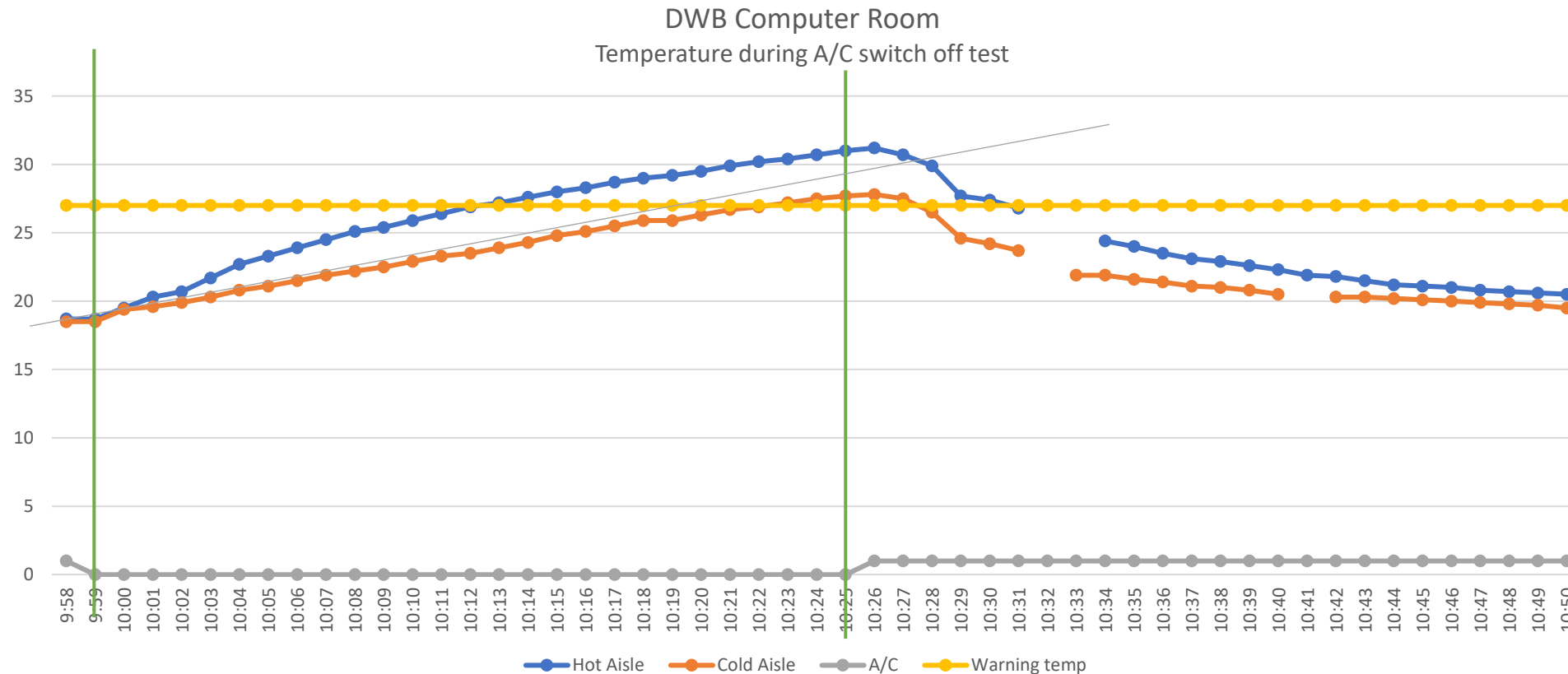
- Originally the electricians wanted to switch off all power including the computer system feeds in order to wire in the new A/C units into the Mechanical Services switch board.
- This was due to the feed coming from a common conduit as shown in the picture on the left below taken during construction in 2007.

Managed to persuade them to route the new cables into the top of the switch board, which could be installed without switching our computers off.



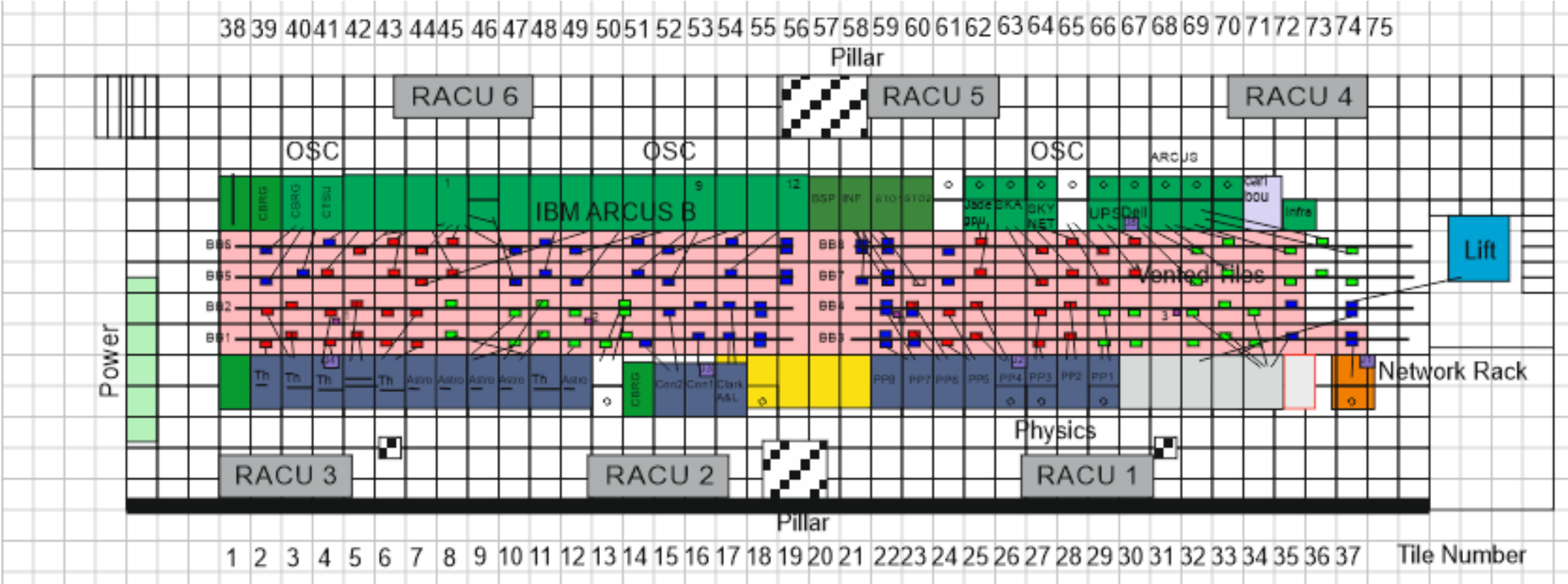
Physics - local Infrastructure room

- Final removal of electrical supply to A/C switchboard would require a power outage.
- Test to see how long the room can survive without A/C when at a reduced load of 38kW.
(Normal average running load is 55kW)
- This showed us we could with preparation allow the electricians to work on the Electrical distribution board for ~25 minutes max. before the temperature got worryingly high.



Begbroke Computer Room

- Much larger room shared with the University Advance Research Computing (ARC) Service
- Physics has 40% of the floor rack spaces.
- Chilled water supplied from the room to six RACUs





Plan

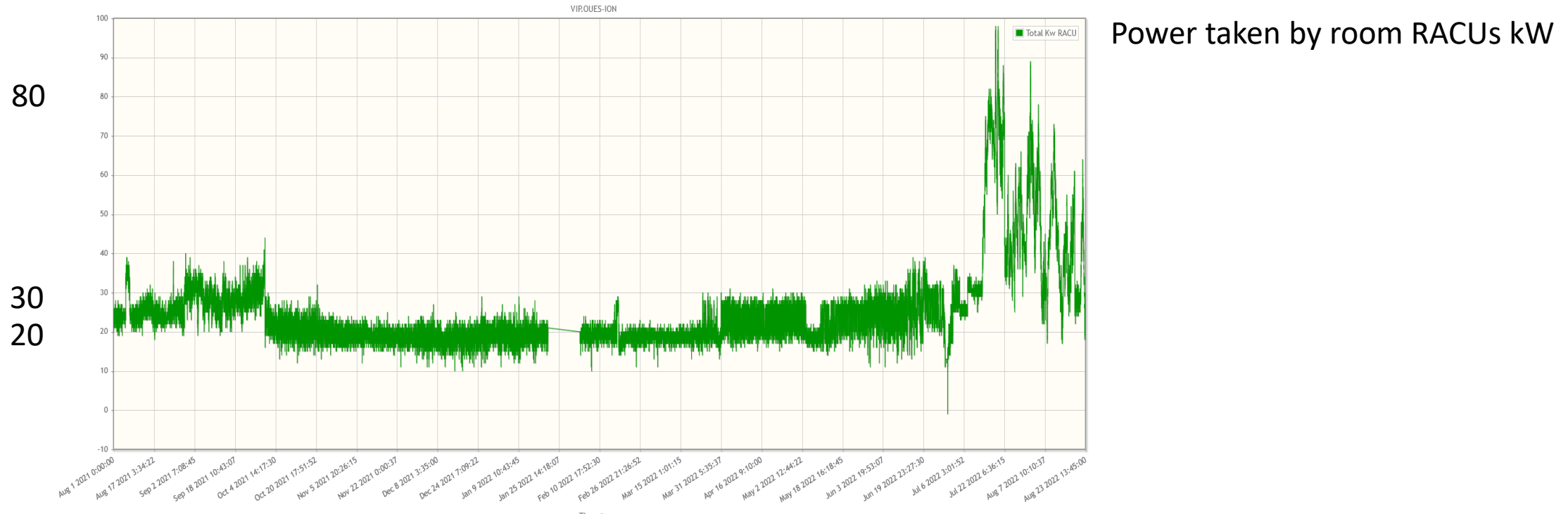
- To replace the six in room RACU's with new ones with
 - Variable speed fans
 - Increased capacity (Each new unit rated approx. 200KW vs old ones 100KW)
 - Possibility for pressure control
 - Existing PUE around 1.5-1.6
- This room had sufficient A/C overcapacity that the units could be replaced one at a time with no worry about over heating in the room.
- Project started on 15th June 2022

Installation



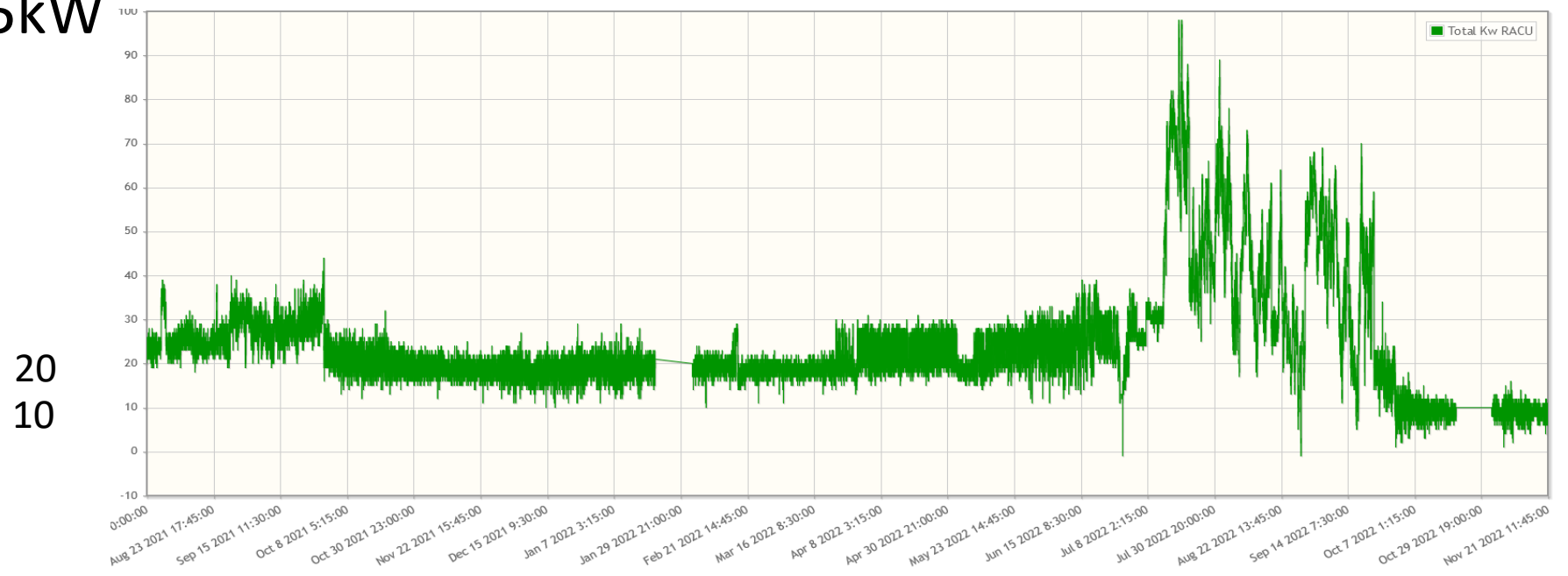
Installation of 6 units completed by August

- But it was noticed that the PUE had increased, due to a dramatic increase in power taken by the RACUs. PUE was up to 1.9-2.0



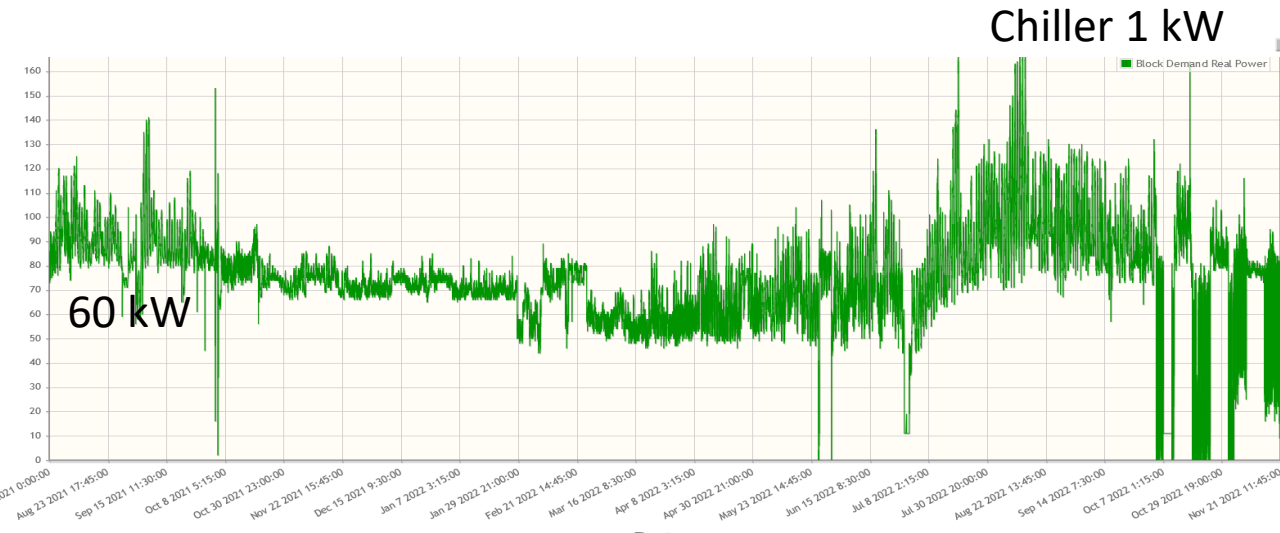
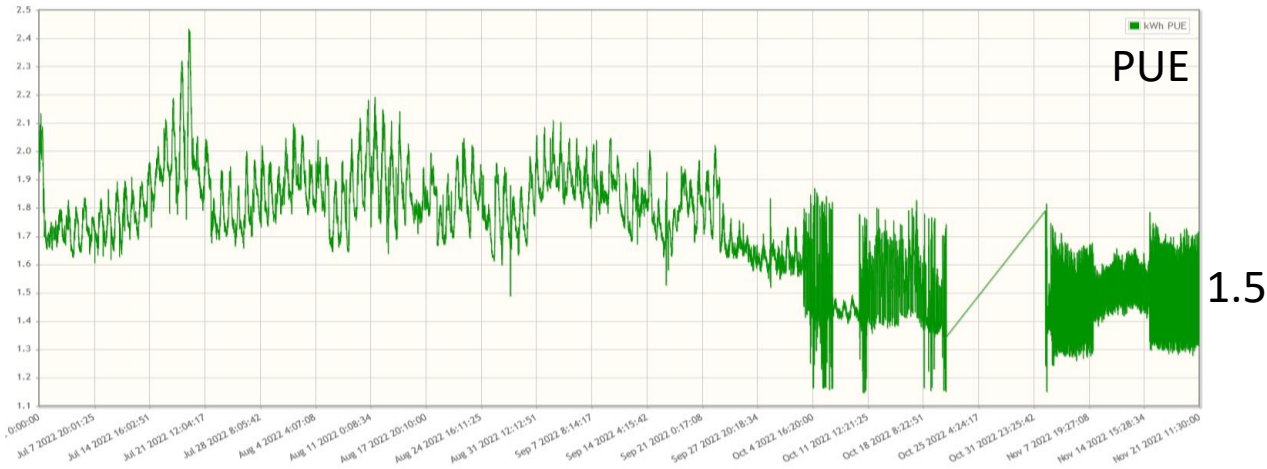
RACU Tuning

- The fans in the units were running way to fast effectively blasting air through the vented tiles.
- Airedale reduced Fan speed 45%→40%→35% on 29/30 Sept 2022
- We found that if the fan speed was reduced too much the units switched off into a state that required an engineer to visit to restart.
- Final configuration resulted in stable power consumption of 10kW vs previous 20-25kW



PUE still not great.

- PUE is back around 1.5 average.
- Big problem is that the power drawn by the Chillers on the roof is a factor of 10 more than the RACUs. (Total ~125kW)
- Further work will need to be done to make an effective improvement.



Some conclusions

- New reliable kit has been installed with no down time.
- Increased resilience and capacity has been achieved.

- Gains can be made by buying new equipment.
- Tuning them to meet the design goals is essential.
- Need to look at the overall picture not just one area.
- Key Stake Holder really needs to be hands on to ensure what is delivered is what was intended.