

## **Appendix F**

### **Comparative analysis of air conditioning systems proposed for CMRI**

For the purpose of this submission we have chosen to compare one of the styles of traditional air conditioning and one of the newer, more energy efficient design. There are many variants of each and in the case of the energy efficient design there are further efficiencies that could be adopted eg co and tri generation, geothermal etc but initial assessment sees this extra step as not being cost effective, due to the large increase in cost, complexity, failure risk, higher maintenance and downtime costs in the event of failure and much longer payback.

It is important to note that the air conditioned areas of the facility are not all simply open plan office space but a mixture of critical environment laboratories and non critical office spaces. As such the critical plant must handle not just temperature but active humidity control, unlike simple open plan systems which have no such control, except by virtue of cooling coil selection.

#### **Type 1 Traditional**

This consists of central plantroom housing cooling towers, chillers, gas boilers, including pumps and heat exchangers, which in turn reticulate chilled, heating and condenser water to serve floor by floor plantroom based multizone air handlers, zone reheaters, electric humidifiers and condenser water package units. Floor air handlers serving labs would combine laboratories ie not individual air handlers per lab space.

These air handlers then deliver conditioned zone air to sub zone VAV boxes, each with VAV heating water coil reheaters and thence to the space to seek to match the significantly varying loads in what may be adjacent spaces. Outside air cycles would be included but no extra airside heat recovery as this becomes problematic with humidity controlled spaces and parasitic heat loadings in laboratories. Assumes water cooled computer room PAC's.

High humidity control would be achieved by lowering the chilled water temperature and overcooling and reheating the supply air then trim with space VAV and reheaters. 100% supply and 100% spill from animal house areas would be included. The total system would be controlled by a configured BMS.

#### **Type 2 Improved energy efficient**

For the business critical areas eg labs and animal house, this consists of heat reclaim VRV air cooled condensers, gas VRV condensers, heat pump desiccant dehumidifier and evaporative pad humidifier pre-treatment of decoupled outside air, airside heat recovery of animal house spill air, individual zone space specific above ceiling VRV fan coil units, in some cases multiple systems serving the one space for redundancy purposes with significant percentage outside air cycles. Lesser number of elements of the total system would be controlled by a configured BMS eg VRV system and heat pump desiccant dehumidifier would be self controlled systems. Assumes air cooled computer room PAC's.

#### **Background**

The energy cost estimates are based on projected space usage and not on historical data for the smaller existing facility. The savings quoted are based on commercial energy rates (averaging 13 c/kwhr incl time of use demand for electrical and average 3.8c/kwhr for gas). The current actual energy cost is much less as it is being supplied from the hospital grid. It is assumed this favoured position may not proceed in the long term.

The energy savings and payback justify the initiatives proposed, however the CO2 savings are significant and reduction of carbon footprint should become a driving factor instead of raw payback.

**Table 1 Air conditioning comparison table**

<b>Air conditioning comparison</b>	<b>Base</b>	<b>Proposed</b>
	<b>Type 1 Traditional</b>	<b>Type 2 Energy efficient</b>
System description	Central chillers, boilers, cooling towers, floor by floor air handlers serving multiple labs, VAV zoning with reheat, ceiling return air. Water cooled computer PAC's	Air cooled heat reclaim VRV, outside air de coupled and treated desiccant dehumidifier/evaporative humidifier, animal house airside heat recovery, individual space VRV fan coils
<b>Assessment criteria</b>		
Fit for purpose ie satisfy minimum Client room data sheets	Yes	Yes
Standards and Codes compliance	Yes	Yes
Minimising Legionella risk.	Cooling tower legionella risk	No legionella risk, due to all air cooled plant.
Future flexibility to add and modify existing systems.	Yes by tapping into spare chilled water/ heating water/condenser water tapings at each floor	Yes via VRV tapping points and spare chilled water/ heating water tapings at each floor.
Business critical areas plant capacity under higher than design ambient conditions	Not available	Available via dual VRV' fan coils and separate condenser sets
Plant failure risk and redundancy in business critical spaces, due to failure or maintenance	Available in chiller/boiler and pump sets only but not at air handling and zone level	Built in feature. Redundancy available from condensers to final space air handlers
Ability to maintain tight humidity control in labs and specialist rooms	Not possible due to combined labs and common ceiling return air. No direct dehumidification except by virtue of coil selection	Built in feature
Ability to maintain laboratory, specialist room pressure differentials	More difficult with a combined laboratory system	Easier due to individual lab systems
Plant ability to isolate areas to save energy	Not possible	Built in feature down to 50% in labs
Ability to fire isolate and smoke exhaust individual lab areas.	Not possible	Built in feature
Ability to do maintenance without access to the space	Possible except zone VAV's	Possible for roof condensers and dehumidifiers but not possible with above ceiling fan coil units.
Plant initial capital cost (minus redundancy)	Base	similar
Extra cost for plant redundancy (lab and animal house) in airside, chilling, heating, dehumidification, domestic hot water (calorifier)	Base	Extra \$500,000
Plant annual energy costs differential	Base	Approx 35% energy and CO <sup>2</sup> saving Saving \$450,000 P.A.
Plant maintenance cost	Base	Similar
Plant controls and reliance on BMS	High	Much less reliance on BMS as VRV/desiccant dehumidifier are standalone. More reliance on motorised dampers to provide pressure and space decontamination capabilities
Plantroom and service riser spatials Translated to cost to build	Base	Saving of approx 400 sqm in floor plantrooms spread over floors. Central plantroom similar except spread over stages. Risers similar. Estimate cost saving at \$5,000/sqm plantroom may be \$2,000,000

## Background to Table 1 above - Air conditioning

Detailed calculations from BEAVER and Munters modelling\* (Based on air conditioned area 20,131 sqm)

\*No humidity control comparison undertaken

Assuming the traditional system includes the latest high efficiency chiller (at both full and part load) and comparing with VRV (without desiccant dehumidifier control), both systems are approx same energy based on simple temperature control (excluding humidity control in the animal house or laboratories). The part load turndown coefficient of performance of multiple smaller inverter driven VRV compressors plus the smaller fans due to reduced ductwork runs, sees a slight energy reduction advantage over the

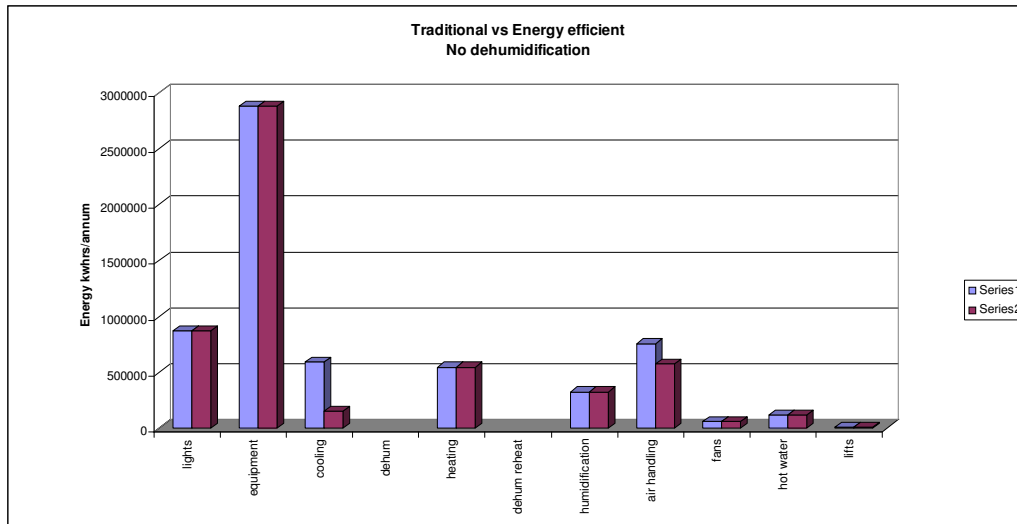


Fig 1 No high humidity control comparison

traditional plant system.

In these simple terms there are no significant benefits of central plant or VRV from an energy viewpoint, if high humidity control is not desired.

The capital cost of the traditional plant, whilst initially estimated as similar (assuming common systems are ignored eg fume/amenity/dangerous/carpark etc), becomes much higher due to the significant extra cost of creating floor by floor plant rooms (something not required by the energy efficient system) would penalise the traditional system.

Ignoring the addition of humidity control (either overcool and reheat or desiccant dehumidifier technologies), neither the traditional simple cooling coil or VRV will control high humidity at all times, except by virtue of coil selection, probably achieving 50% maximum around 15% of the time when dehumidification was required. Neither would control a 28 CDB and 99% RH day.

Both control low humidity, traditional by electric steam generators or the energy saving alternative of evaporative pads.

### Heat recovery issues.

Adding 75% efficient sensible heat recovery to either the traditional or VRV systems serving the labs has been modelled and due to the expected higher than normal constant space loads (freezers etc) the heat recovery becomes an actual parasitic load for around 50% of the year and outside say 5C off ambient is even more.

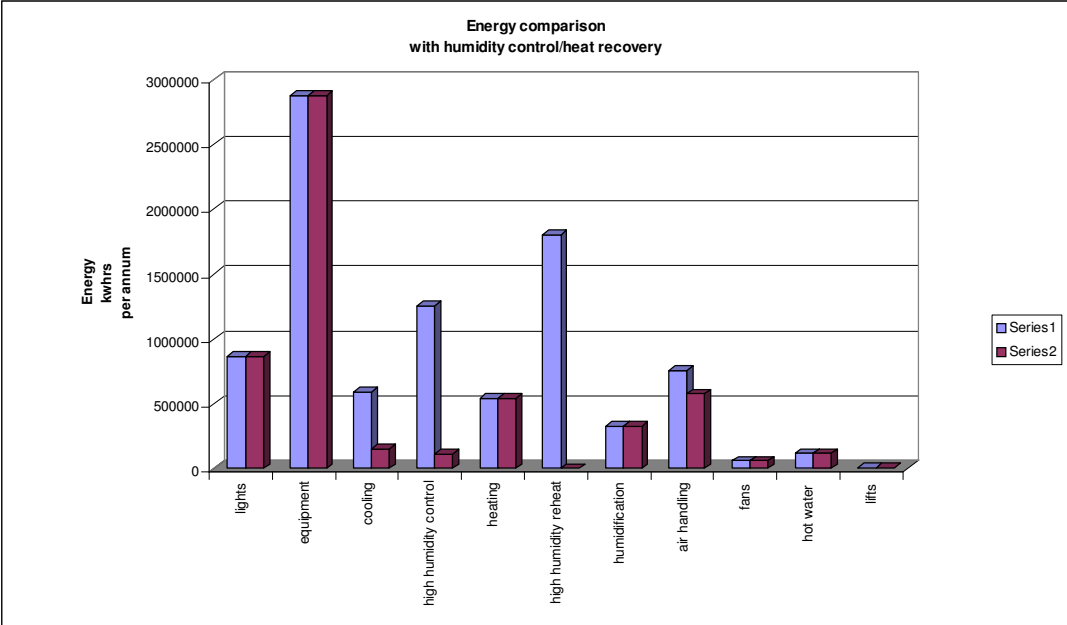
Given humidity control is required in the labs then this heat recovery adds unfavourable ambients at times. Turning the heat recovery off at these times reduces the impact and cost effectiveness, ie installing a system that largely is then turned off most of the time.

Given the varying fume exhausts any benefits become even less. It is therefore not recommended to add heat recovery on the lab areas. The labs will benefit from the addition of desiccant dehumidifiers to decouple the outside air and to allow the CMRI to offer selective humidity controlled lab spaces.

The 100% animal house systems exhibit different space load characteristics which more so lend themselves to selective heat recovery. Ignoring any humidity control requirement, heat recovery can be efficient from a sensible heat viewpoint (reduces energy by 17%), but critically heat recovery becomes a parasitic load when seeking to pull out moisture for 50% of the year, mostly in summer and warm moist days.

As a background, of the total annual 8760 hrs, there would be around 4000 dehumidification hours required (to achieve 24CDB/50%RH) 80% of these hours are below 24CDB is no passive assistance from any traditional cooling coil. In effect 36% of the year a normal coil is of no value as a humidity control device and the humidity would rise (forcing energy consuming overcooling and reheating on a traditional system). In fact heat recovery would negate energy savings when using a traditional overcool and reheat system. Whilst this varies depending on the base space heat loads, which varies from labs to animal house, by comparison the dehumidification desiccant wheel can be stopped to counter this issue and work in conjunction to optimise the heat recovery (animal house only).

Hence desiccant plus heat recovery are recommended on the animal house.



**High humidity control issues.**

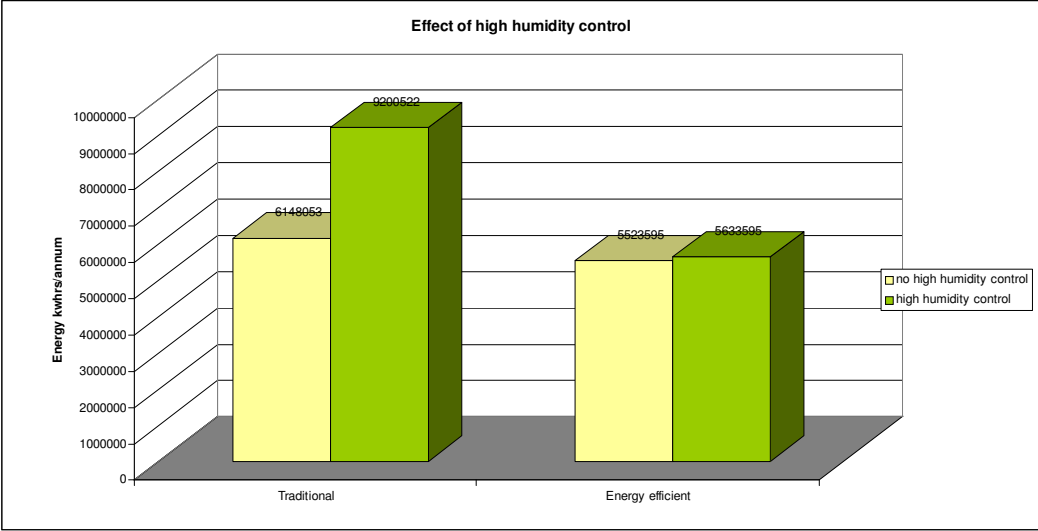
Assuming both the labs and animal house requires control of high humidity and further assume this would be done either:

- A traditional solution by 6 row coils and lower chilled water temperatures, then boiler based reheating or
- The alternative heat pump desiccant dehumidification with booster chilled water and heating water used for all humidity removal control,

when the installed cooling coils cannot provide sufficient dehumidification eg outside air 24C DB and 99% RH, then the relative energy savings of desiccant dehumidification, over the traditional overcool and reheat, can be modelled.

It should be noted that this desiccant system becomes the main air handler and allows a chilled water AHU as backup. Hence the extra capital cost is less by about \$50,000 in the animal house system.

In summary the savings of implementing a VRV and desiccant dehumidifier vs traditional chiller air handler using overcool and reheat, would be 3,500,000 kWhrs/annum which equates to reducing the carbon footprint by a significant 2,600 tonnes of CO<sup>2</sup> annually and \$450,000 annual saving. In effect a 35%% carbon footprint reduction



**System recommendation**

Based on the following comparison table and in consultation with CMRI, the type 2 energy efficient design philosophy is proposed to be further investigated as the appropriate balance between energy efficiency, carbon footprint reduction, cost and ability to satisfy the business critical functions of the CMRI.