Retro fitting for Energy Efficiency

Presented by:
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Key Objective

- Stimulate thinking / Initiate debate
- Create a gap for further discussion
- Increase knowledge – Ask better questions

Special notes:
Data discussed indicate trends only
Economy cycles not considered in this discussion
Technologies discussed (CHILLERS / VRV)
Today’s Discussion Points

Identify how to enhance your applied technology solution for best partial load performance

Case study 1 – Modelling Chilled Beam & VRV

Why Integrated Part Load Values (IPLV) are not the best indicators for energy performance!

Case study 2 – Buying an LCD TV

Combining high end refrigerated technologies for best partial load energy performance
Today’s Discussion Points

**Challenge Identified**

**Designers / Energy Consultants**
- Information not good enough for successful energy modelling

**Equipment Manufacturers**
- Hold back Information that Facilitates successful modelling
Professionals at Conference

- Mechanical Consultant / designer
- Architect
- Building owner
- Developer
- Facilities management
- Manufacturer
- Other
Know your Building!

On a scale of 1-9, how would you rate your knowledge on ‘how to best select’ a HVAC plant for maximum energy performance?

- Excellent
- Can optimise Plant performance
- Average
- Still working it out

N = 385
Know your Building!

In your opinion, how much energy is consumed by a HVAC system in a typical office building (as a % of whole building consumption)?

25% 70%

N = 385

HVAC Energy Consumption
Office Bld. Energy Consumption

BCA Class 5 Melbourne

Note: Energy Simulation based on Zone 6 (Melbourne)

- Chiller Plant: 18%
- Heating: 1%
- Fans: 23%
- Lights: 29%
- Misc Power: 24%
- DHW: 3%
- Base Utilities: 2%

40% - Daikin HQ (Actual)
50% - PCA guide book
70% - BCA

Based on actual simulation
20,000m² building & Schedules from BCA

HVAC

Heating, ventilating and air-conditioning (HVAC) plants can account for up to 70% of all energy consumed in a commercial building. A range of strategies exist for maintaining and/or improving the energy efficiency of HVAC systems.
In your opinion, how many hours (represented as a %) does a HVAC plant typically operate at 100% cooling load?

Plant Operation at 100% load?

N = 385
Office Bld. Typical Energy Consumption

Typical Office Building profile

Plant Run hours (%) (2800hrs)

Building Load

Ambient Temp, °C

<1% building load

Typical Representation
A lot of care with selections
Machine characteristics differ
Case Study 1

Designed For 5Star NABERS

- Original design concept Chilled Beam – modelled with IPLV only (cost / serviceability / heating issues)
- VRV option provided
Part Load Values (IPLV) are not the best indicators for good Energy performance.
IPLV Discussion

Real curve based on ARI selection
Software
As load reduces / CDW drops
High COP 13:1

Chiller Capacity %

ARI Relief
What is an **Integrate Part Load Value (IPLV)**?

1. A measurement of chiller energy performance
2. Comparison of chillers in plant rooms
3. **Comparison of chillers at tested / rated points under factory controlled conditions**
4. Provides engineers with an estimation of chiller energy performance
5. **Considers chiller+ pump energy to formulate a result**
6. Not sure!
IPLV Discussion

- Average weighted efficiencies of a single chiller
- With Condenser temperature relief
- Calculate IPLV or NPLV as:

$$0.01 A + 0.42 B + 0.45 C + 0.12 D$$

<table>
<thead>
<tr>
<th>Weightings</th>
<th>CDW inlet</th>
</tr>
</thead>
<tbody>
<tr>
<td>A= COP @ 100%</td>
<td>Load at 29.4°C CDW</td>
</tr>
<tr>
<td>B= COP @ 75%</td>
<td>Load at 23.9°C CDW</td>
</tr>
<tr>
<td>C= COP @ 50%</td>
<td>Load at 18.3°C CDW</td>
</tr>
<tr>
<td>D= COP @ 25%</td>
<td>Load at 18.3°C CDW</td>
</tr>
</tbody>
</table>
There are 4 key reasons why an IPLV is not a great indicator for energy / plant performance!
1. Understand your Climate & Condenser water temperature

Wide operational range
Significant performance characteristics
Geographic considerations
IPLV Discussion

2. Understand your total plant energy consumption

ARI Condenser water relief

IPLV = 9.78

Does not resolve energy consumption

IPLV = 9.78

Source: MCQUAY Selection tools – Centrifugal chiller (6.7degC Evaporator temperature)

Chiller + Ancillaries = Plant COP (4 - 5.5)

Excludes FCU/AHU
3. Test Condition—v– Actual performance

18.3°C Condenser water temperature

6.7°C Chilled water temperature

Design water flows & pressure drop

Voltage +/- 5%

Fouling

Fouling factor (as per specification)

Stable load

50% load point (COP = 6.3)

Source: MCQUAY Selection tools – Centrifugal chiller (6.7°C Evaporator temperature) 1000kW
4. Modelling with incorrect data can cost!

\[ y = -8.332x^2 + 12.155x + 2.2577 \]

\[ R^2 = 0.9997 \]

ARI condenser
Water relief

Condenser water
29 (100%)
23 (10–75%)

1000kWr Chiller with VFD
& condenser water relief
Case Study 2

30HP
Air Cooled VRV HEAT RECOVERY MODE
18DegWB C / 22Deg DB

Caution!!!

50%Cool / 50%Heat

Daikin HQ – 5star
Ambient rating point
Combining refrigerated technologies for excellent energy performance
**Centrifugal – no VFD**

- Low load OK if operation is stable
- Can not unload (PD)
- Surging concerns
Centrifugal – with VFD
Centrifugal – Magnetic Bearing

COP vs Capacity %

- CDW 29.4C
- CDW 22.5C
- CDW 18.3C
- ARI Relief
VRV system (AC) – cooling mode

Cooling mode (energy curve) 385kWr – ex FCU’s

COP vs. kWe

Operation time

<16degC Ambient Temperature 35degC

Simulated NPLV

<table>
<thead>
<tr>
<th>LOAD</th>
<th>NPLV-ARI</th>
<th>NPLV</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1%</td>
<td>0.043</td>
</tr>
<tr>
<td>0.75</td>
<td>42%</td>
<td>2.600</td>
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<tr>
<td>0.5</td>
<td>45%</td>
<td>3.428</td>
</tr>
<tr>
<td>0.25</td>
<td>12%</td>
<td>0.870</td>
</tr>
<tr>
<td>1</td>
<td></td>
<td>6.941</td>
</tr>
</tbody>
</table>
Key Points discussed!

A = COP @ 100%  Load at 29.4°C CDW
B = COP @ 75%   Load at 23.9°C CDW
C = COP @ 50%   Load at 18.3°C CDW
D = COP @ 25%   Load at 18.3°C CDW
Thank you

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