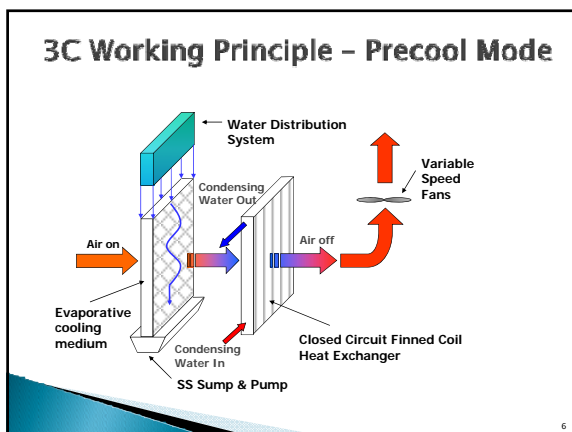
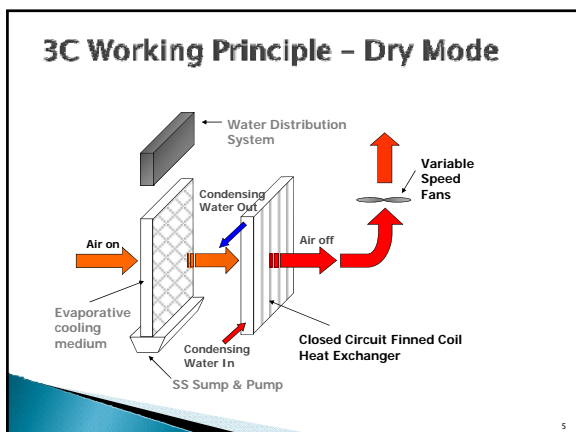
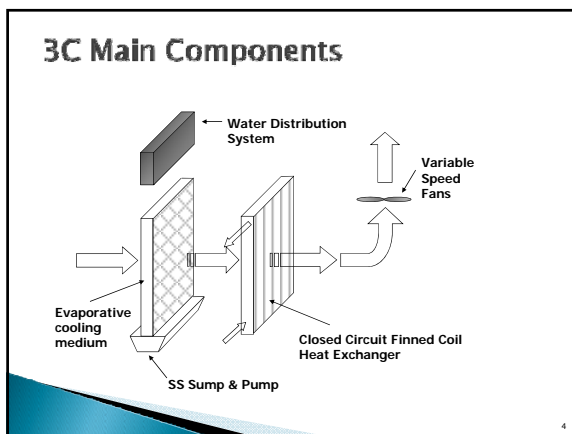


AIRAH – NSW

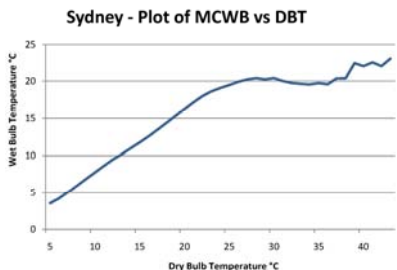
FAN ENERGY & WATER USAGE ESTIMATOR
for
ADIABATIC 3C FLUID COOLERS

- ## Main Topics
- ▶ Adiabatic 3C fluid cooler – working principle
 - ▶ 3C-FEWUE Model – main elements
 - ▶ Life Cycle Cost Comparison
 - ▶ Demonstrate Model

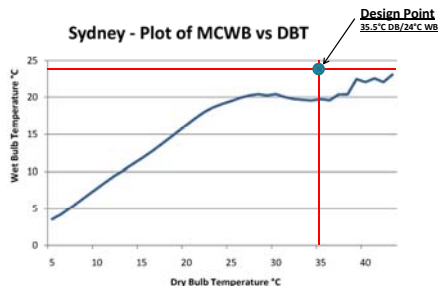
- ## Why develop FEWUE Model?
- ▶ Estimate precisely 3C fan energy consumed for different locations (climates) & cooling load profiles
 - ▶ Estimate accurately annual water usage and usage patterns
 - to assist in sizing of rain water harvesting tanks
 - ▶ Provide accurate data for life cycle cost calcs



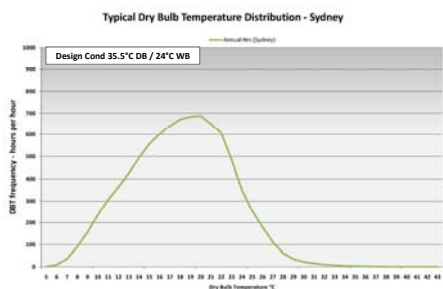
Climate Data for Sydney



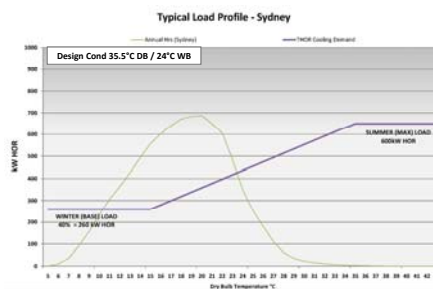
Typical Design Cond- Sydney



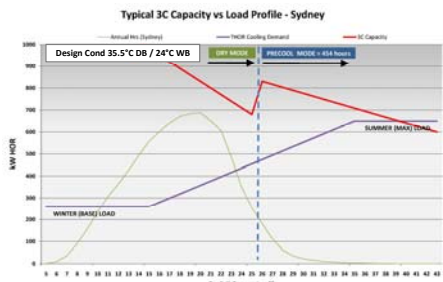
Dry Bulb Temp Frequency- Sydney



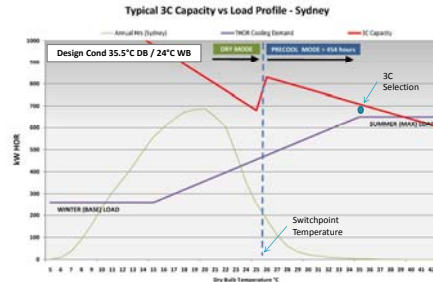
Simple Load Profile- Sydney



Typical 3C Capacity vs DBT



3C Selection based on Max Conds



3C-FEWUE Model

- ▶ Match the 3C capacity to cooling load – vary the fan speed
- ▶ Fan power \propto fan speed³
- ▶ At higher DBTs – initiate precooling + fan speed control
- ▶ Water usage is dependent on: –
 - DB & WB conditions
 - Air flow rate through pads
 - No. of hours of precooling

3C-FEWUE Model

- ▶ Excel 2007 Spreadsheet – Macro-enabled
- ▶ Version 1.2 – Australia only (uses CSIRO ACADS-BSG reference year climate data)
- ▶ Version 2.0 – International (uses ASHRAE Climatic Data for Design & Standards)

3C-FEWUE Main Interface

- ▶ Three (3) sections
 - Input section
 - Output section
 - Charts



Input section

- ▶ Divided into three (3) parts
 - Location selection
 - 3C Model selection
 - Water temperature control / unit cost for utilities

The screenshot shows the 'Input Data' section of the model. It includes a table for 'Input Data' with fields for Location (Sydney), Design Ambient (DBT 35.5 °C, WBT 24.0 °C), Thermodynamic Switchpoint Temp (25.7 °C), Annual Precooling Hours (368 hrs), Cycles of Concentration (9.0), and 3C Unit Model (HS1-100). It also shows 'Maximum HOR entered' (600) and 'kW HOR' (600). Other parameters include Design Condenser EWT (35.0 °C), Variable Condenser LWT for ARI Relief (29.5 °C), Condenser Water ΔT (°C), Fan Motor (2.8 kW), Pump Motor (0.4 kW), Air Flow per Unit (83.6 m³/s), Elec Unit Charge \$/kWh (0.10), Rated Unit Capacity (655.5 kW HOR), Water Cost \$/cu.m (1.00), and Economic Switchpoint Temperature (22.0 °C).

HOR Load Input sheet

Input Heat Rejection Load Data

3C Operating Time

No. of Days per Week: 7

No. of Weeks per Year: 52

Months	Day-time Load	Night-time Load
Jan	600	
Feb	600	
Mar	600	
Apr	400	
May	370	
Jun	260	
Jul	260	
Aug	260	
Sep	325	
Oct	400	
Nov	460	
Dec	530	

Return

Variables

- Number of days per week
- Number of weeks per year – between 48 & 52 to cater for summer shutdown
- Allowance for variable loads between summer/ winter and trans-seasonal
- Monthly daytime heat rejection loads
- Monthly night-time loads

Output Section

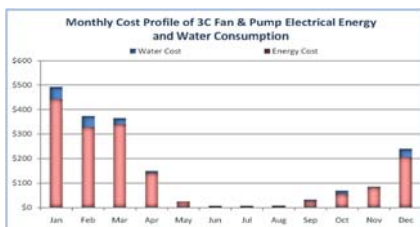
- ▶ Divided into three parts
 - Fan & pump electricity usage in kWh
 - Water usage in litres
 - Fan energy and water usage costs

Output Data

Month	Electricity		Water		Costs		
	Fans & Pump kWh	Water Use litres	Used litres	Total litres	Energy \$	Water \$	Total \$
Maximum Usage on Peak Day (Worst Case Day)	254	9254	1,137	35,143			
Monthly Usage	Jan: 4,435	43,065	5,462	49,347	443.09	49.35	492.44
Feb: 3,267	41,061	5,133	46,194	326.74	46.19	372.93	
Mar: 3,395	22,467	2,704	24,371	199.52	24.38	224.90	
Apr: 3,391	7,509	909	8,718	199.07	8.72	207.79	
May: 226	0	0	0	22.57	0.00	22.57	
Jun: 164	0	0	0	5.38	0.00	5.38	
Jul: 51	0	0	0	5.09	0.00	5.09	
Aug: 62	0	0	0	6.20	0.00	6.20	
Sep: 248	5,472	684	6,156	24.81	6.16	30.97	
Oct: 342	11,644	1,405	13,099	34.24	13.02	47.26	
Nov: 405	2,293	287	2,580	40.53	2.58	43.11	
Dec: 2,013	29,626	3,676	33,302	204.31	33.06	237.37	
Annual Usage	14,518	163,979	26,372	188,352	11,492	5183	12,010

Charts – first chart

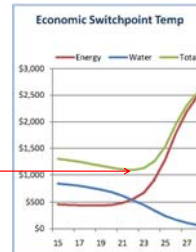
- ▶ Bar chart displaying visually the costs
- ▶ Red bars - monthly fan energy cost
- ▶ Blue bars - monthly water usage costs



Charts – second chart

Line chart displays Economic Switchpoint Temperature (ESPT) by calculating cost of energy and water at various SPTs

- ▶ Red line - energy cost at various SPT
- ▶ Blue line - water cost at various SPTs
- ▶ Green line - Total costs (sum of the red & blue)
- ▶ Lowest operating cost = ESPT



ESPT Calculation

- ▶ Once Location and Unit Selection data inputted, then press CTRL+SHIFT+Z to activate the Macro
- ▶ ESPT will appear when macro completes calcs

ESPT Calculator Tab

Tabular display of fan energy consumption & water usage and associated costs at various SPTs to identify lowest operating cost

Economic Switchpoint Temperature Calculator

Supt Temp °C	Energy kWh	Water litres	ESPT		Total
			Energy \$6.10	Water \$1.00	
15	4,357	847,656	\$455.72	\$847.66	\$1,303.37
16	4,483	828,585	\$448.28	\$828.58	\$1,276.86
17	4,621	806,522	\$442.13	\$806.52	\$1,248.67
18	4,376	772,172	\$437.56	\$772.17	\$1,209.73
19	4,371	734,727	\$437.06	\$734.73	\$1,171.79
20	4,471	688,456	\$447.09	\$688.46	\$1,135.55
21	4,832	618,519	\$483.25	\$618.52	\$1,101.77
22	5,596	532,958	\$559.62	\$532.96	\$1,092.58
23	6,788	447,887	\$678.79	\$447.89	\$1,126.68
24	9,216	338,716	\$921.64	\$338.72	\$1,260.36
25	12,926	240,317	\$1,292.58	\$240.32	\$1,532.90
26	17,988	154,985	\$1,798.79	\$154.98	\$1,953.78
27	21,974	111,414	\$2,197.36	\$111.41	\$2,308.77
28	24,802	68,077	\$2,480.25	\$68.08	\$2,548.33
					\$1,092.58

Version 1.2 Constraints

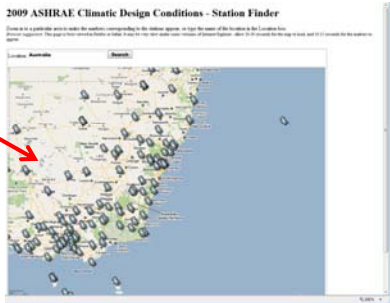
- ▶ CSIRO ACADS-BSG reference year climate data is very dated (over 30 years old)
- ▶ Only relevant to 10 locations in Australia - main centres only
- ▶ ACADS-BSG newsletter continues to highlight frustration with DCCEE (51 months) to release up-to-date corrected climate data

FEWUE – Version 2.0

- ▶ ASHRAE Climatic Data for Design & Standards
- ▶ Access to climate data from 5,564 weather stations around the world
- ▶ Climate data is relatively up-to-date (ranging from 1991 to 2006)

268 Weather Stations in Australia

Weather station locations in SE Australia



FEWUE Output changes

Replace months of the year - with temperature intervals

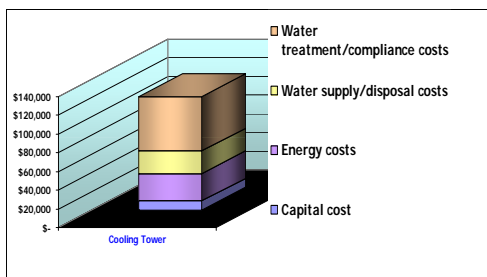
Muller 3C Fan Energy & Water Usage Estimator [3C-FEWUE_AU]
Based on ASHRAE Climatic Data for Design and Standards (Research Project 343)

Output Data

Parameter	Value	Parameter	Value	Parameter	Value
Location	Seville	AC Unit Model	100-1000	Design Condition (DBT)	35.0 °C
Design Ambient	DBT 35.0 °C	No. of Units Running	1	Design Condition (WBET)	25.0 °C
WBET	24.0 °C	No. of Fans per Unit	16	Variable Condenser (DBT for All: Retail)	35.0 °C
Thermodynamic Subpoint Temp	23.7 °C	Fan Model	1.0	Condenser Water (DBT)	30.0 °C
Annual Precooling Hours	454 hrs	Pump Model	0.0		
Cycles of Concentration	0.0	Air Flow per Unit	0.0 m³/s	Site Unit Charge (\$/kW)	0.10
Summer Load	THDR 100 kW	Rated Unit Capacity	653.0 kW (100%)	Water Cost (\$/cu.m)	1.00
Winter (Base) Load	THDR 200 kW				
Climate Subpoint Temperature	°C	Electricity Subpoint Temperature (with by adding 0.7% + 0.17T + 0)	24.0 °C		

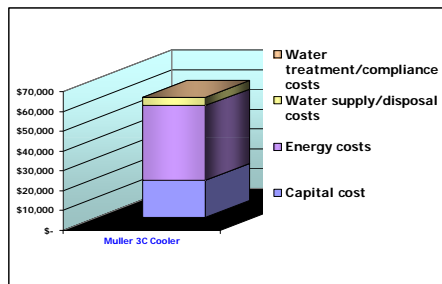
Temperature Interval	Electricity			Water			Costs		
	Power Load	Use & Purty	Water Usage	Water	Total	Energy	Water	Total	
35°C - 30°C	448	0	0	0	0	0.00	0.00	0.00	
30°C - 25°C	20	0	0	0	0	0.00	0.00	0.00	
25°C - 20°C	40	0	0	0	0	2.00	0.00	2.00	
20°C - 15°C	200	200	0	0	0	20.00	0.00	20.00	
15°C - 10°C	811	3,476	0	0	0	147.62	0.00	147.62	
10°C - 5°C	0	0	0	0	0	0.00	0.00	0.00	
5°C - 0°C	0	0	0	0	0	0.00	0.00	0.00	
Annual Usage	1,219	3,702	0	0	0	170.62	0.00	170.62	

Typical Cooling Tower - 15 year LCC



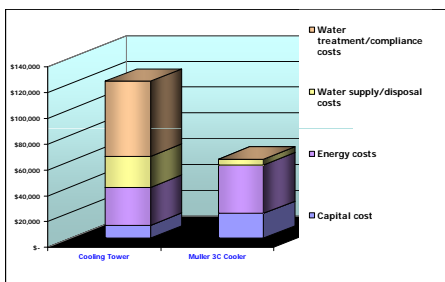
27

Muller 3C - 15 year LCC



28

Compare Cooling Tower with 3C



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Demonstration

[3C-FEWUE_Model](#)