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"Transcritical CO_2 Refrigeration Systems for Building Cooling and Heating Reduce Energy and Cooling Water Consumption, Emissions and the Legionella Danger."

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Issues

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- Energy Consumption
- Cooling Water Consumption
- Global Warming Resulting From Energy Consumption
- Legionella Disease
- Global Warming Resulting From HFC/HCFC Fugitive Gases
- The Kigali Amendment to the Montreal Protocol
- How can CO_2 Help?

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Figure 1: World's First Hybrid CO_2 Gas Cooler/Evaporative Condensers Installed at a Job Site in Sydney

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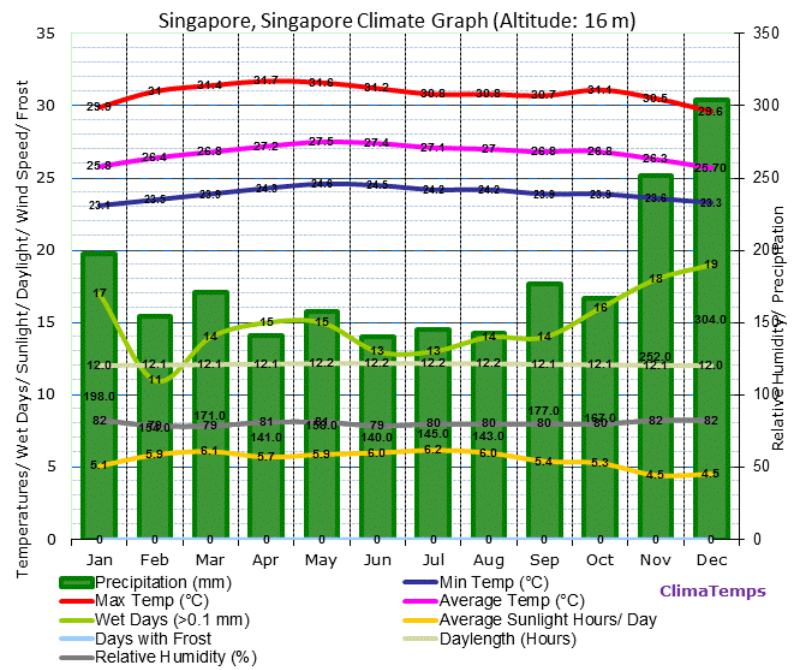
Figure 2. Singapore Annual Climate & Temperature Summary



Source: www.climatemps.com

Climate Variable	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Average Max Temperature °C (°F)	30 (86)	31 (88)	31 (89)	32 (89)	32 (89)	31 (88)	31 (87)	31 (87)	31 (87)	31 (88)	31 (87)	30 (85)	31 (88)
Average Temperature °C (°F)	26 (78)	26 (80)	27 (80)	27 (81)	28 (82)	27 (81)	27 (81)	27 (81)	27 (80)	27 (80)	26 (79)	26 (78)	27 (80)
Average Min Temperature °C (°F)	23 (74)	24 (74)	24 (75)	24 (76)	25 (76)	25 (76)	24 (76)	24 (76)	24 (75)	24 (75)	24 (74)	23 (74)	24 (75)
Average Precipitation mm (in)	198 (8)	154 (6)	171 (7)	141 (6)	158 (6)	140 (6)	145 (6)	143 (6)	177 (7)	167 (7)	252 (10)	304 (12)	2150 (85)
Number of Wet Days (probability of rain on a day %)	17 (55)	11 (39)	14 (45)	15 (50)	15 (48)	13 (43)	13 (42)	14 (45)	14 (47)	16 (52)	18 (60)	19 (61)	179 (49)
Average Sunlight Hours/ Day	5h 05'	6h 26'	6h 05'	5h 54'	5h 54'	6h 12'	6h 11'	6h 00'	5h 36'	5h 17'	4h 36'	4h 32'	5h 39'
Average Daylight Hours/ Day	12h 02'	12h 04'	12h 06'	12h 08'	12h 10'	12h 11'	12h 11'	12h 09'	12h 07'	12h 05'	12h 03'	12h 02'	12h 00'
Percentage of Sunny (Cloudy) Daylight Hours	43 (57)	54 (46)	51 (49)	49 (51)	49 (51)	51 (49)	51 (49)	50 (50)	47 (53)	44 (56)	39 (61)	38 (62)	47 (53)
Sun altitude at solar noon on the 21st day (°).	68.5	77.6	87.8	79.5	71.2	67.9	70.8	79.2	88.2	77.4	68.5	65.2	75

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Figure 3. Consumer Energy Share in the EU.

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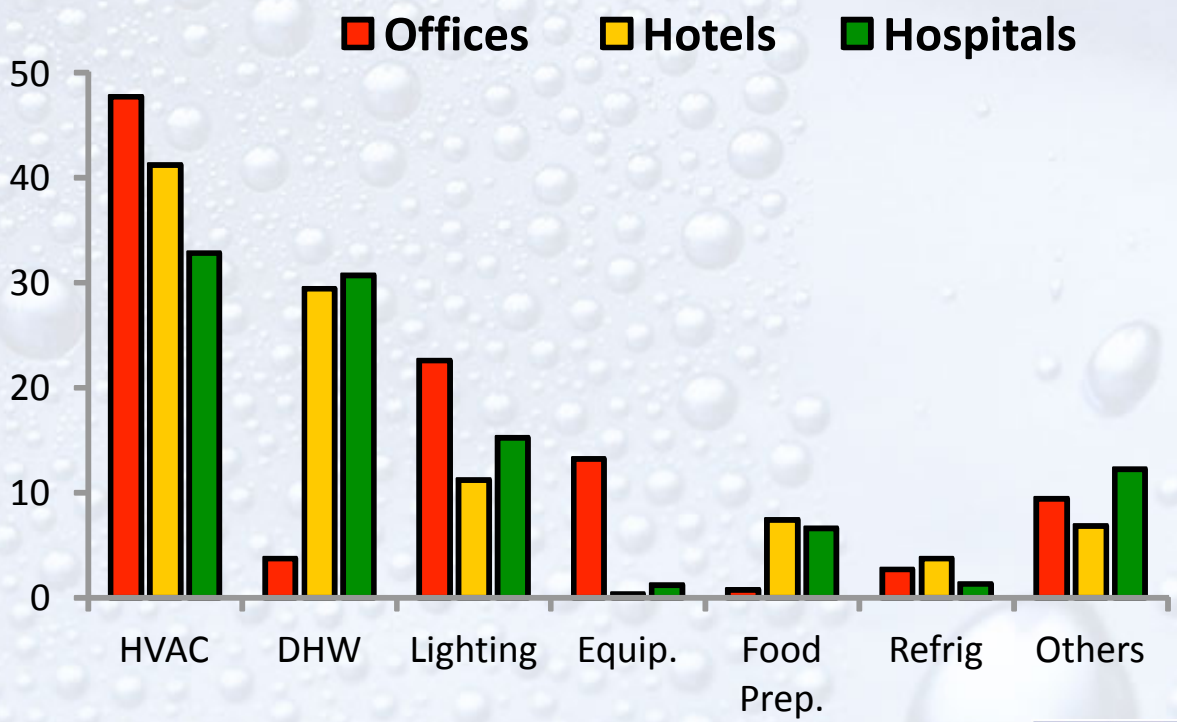

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Figure 4 & 5: Coefficients of Performance (COPs) of a Commercially Available Semi-Hermetic Transcritical CO_2 Compressor at 75, 80 and 100 bar Discharge Pressure at 5°C Evaporating Temperature, Including Heating COPs to Heat Water from 25°C to 60°C

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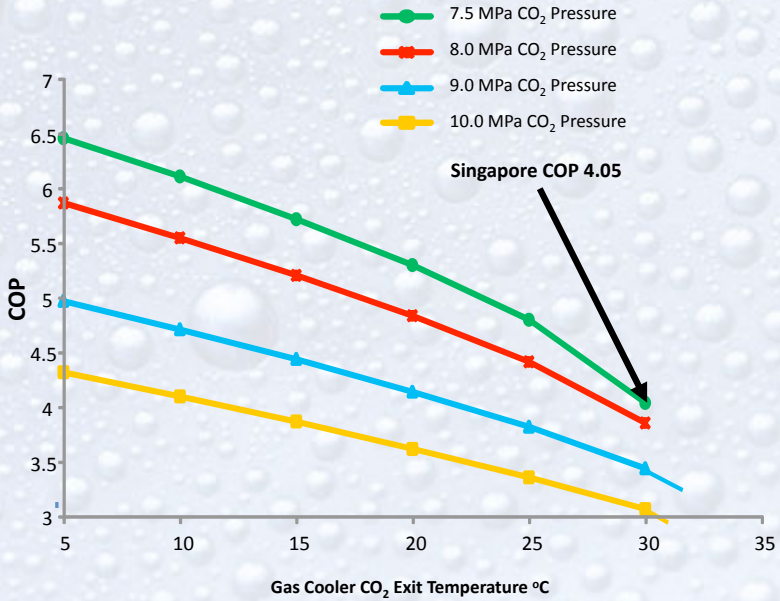

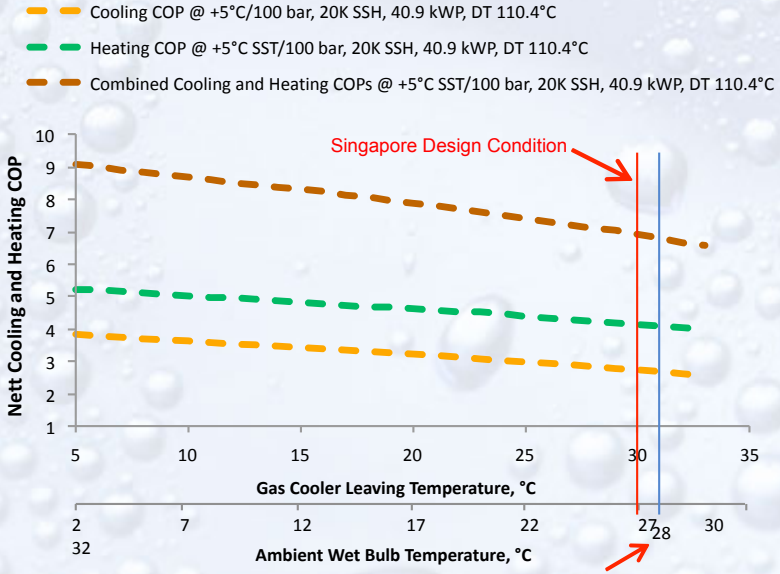

LEGEND

COP = Coefficient of Performance
SST = Saturated Suction Temperature, °C
SSH = Suction Super Heat, °C

kWP = compressor power consumption
bar = compressor discharge pressure
DT = compressor Discharge Temperature, °C

K = degree Kelvin for temperature difference
°C = Degree Celsius

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Figure 6. Heat rejection profile based on a commercially available transcritical CO_2 compressor at 5°C sat. suction, with 5 K useful suction superheat and 5°C CO_2 liquid temp.

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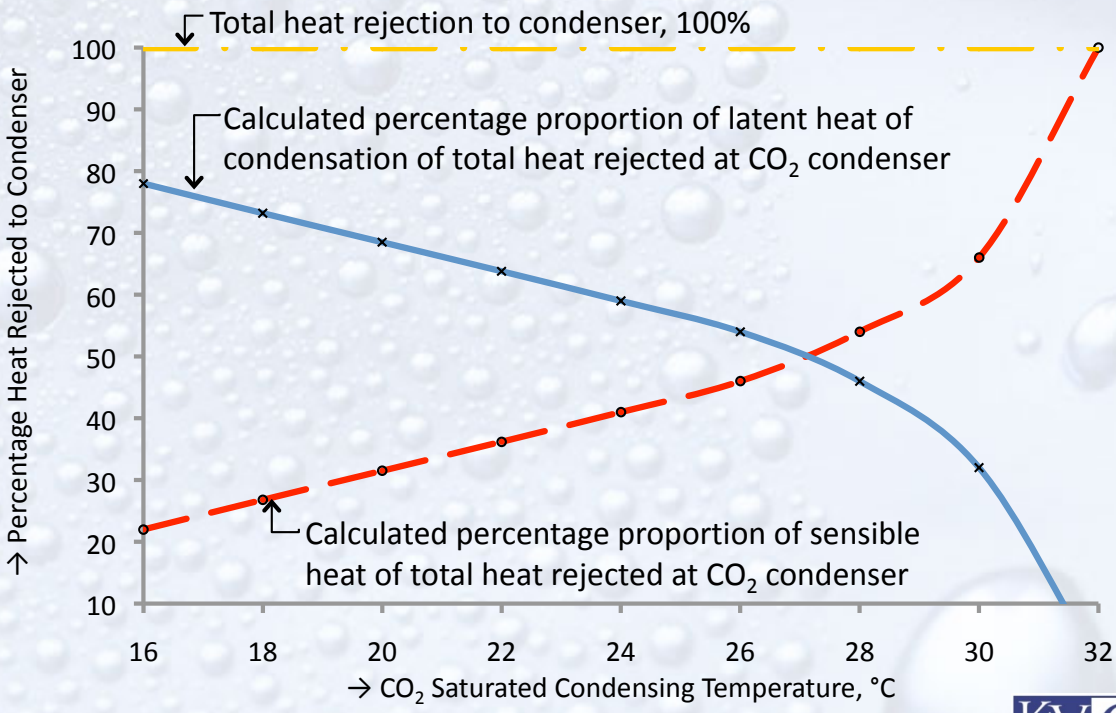

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Figure 7: Schematic of a Conventional Central System with Water Chiller & Cooling Tower.

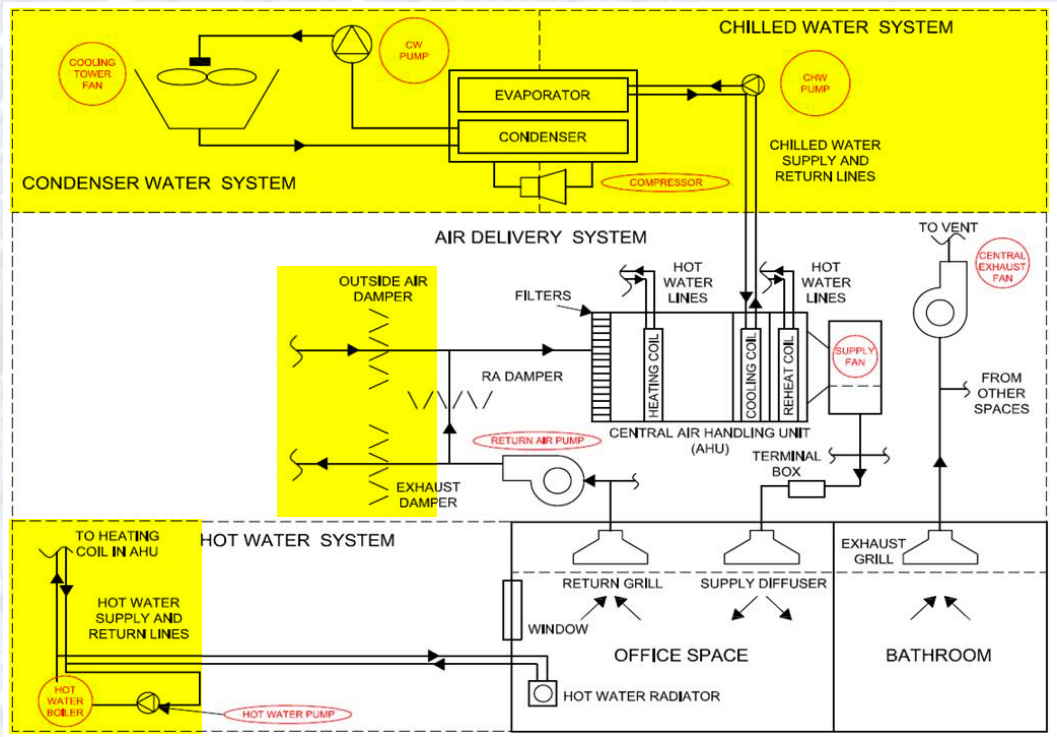

Figure 8: Schematic of a Central System with CO_2 Cooled Water Chiller, Exhaust Air Energy Recovery and Water Heating.

NB: Evaporative Condenser/Gas Cooler in Lieu of Cooling Tower.

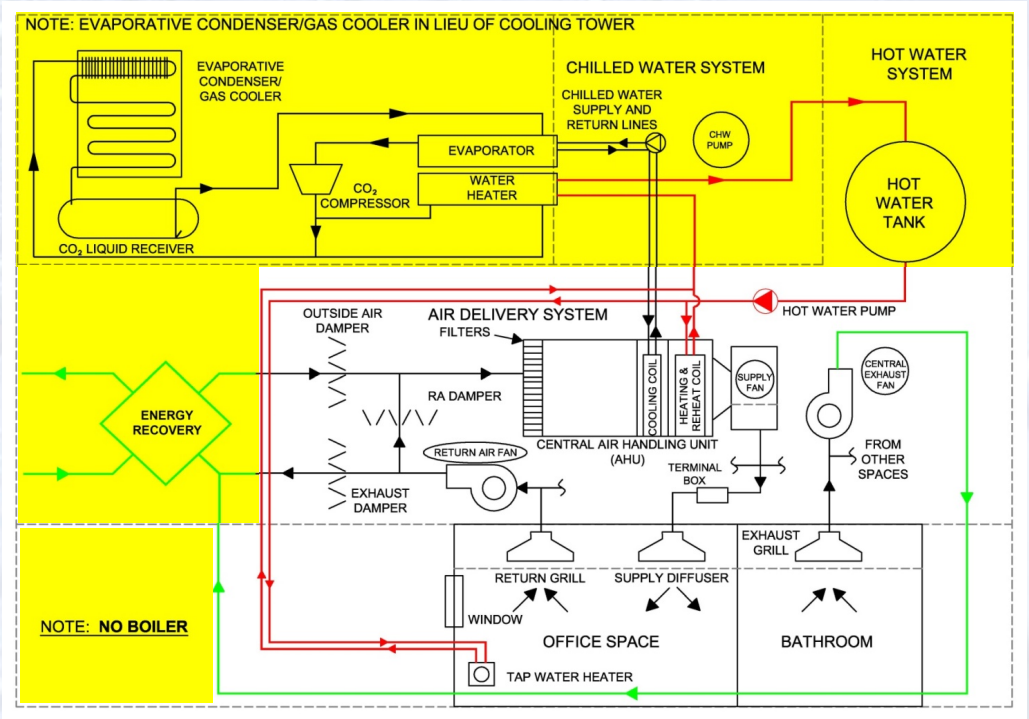

Figure 9: Melbourne Hospitals Reduction in Energy Consumption when Retrofitting CO_2 Cooling and Heating to Existing Hospitals & Equipping New Hospitals with Transcritical CO_2 Cooling & Heating Systems.

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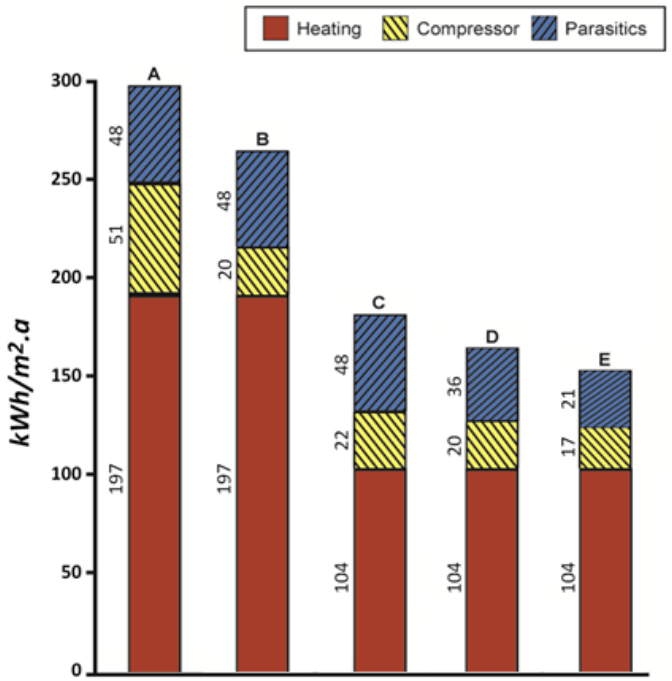

Source – "A" Existing Situation.

Legend:
A = Existing Situation in Office Buildings in Melbourne
B = Retrofit CO_2 Compressor
C = Retrofit CO_2 Heat Recovery
D = Slow Down Fans
E = New Building with Pumped CO_2 and Slow Fans

Energy Consumer	A	B	C	D	E	Remarks
Parasitics	48	48	48	36	21	
Compressor	51	20	22	20	17	
Heating	197	197	104	104	104	Gas
Total	296	265	174	160	142	
Reduction KWh/m².a	-	31	122	136	154	
Reduction %	-	10.5	41.2	45.9	52.0	

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Figure 10: Specific Cooling Water Consumption per kW Heat Rejection of Pure and Hybrid CO_2 Evaporative Condensers in Singapore

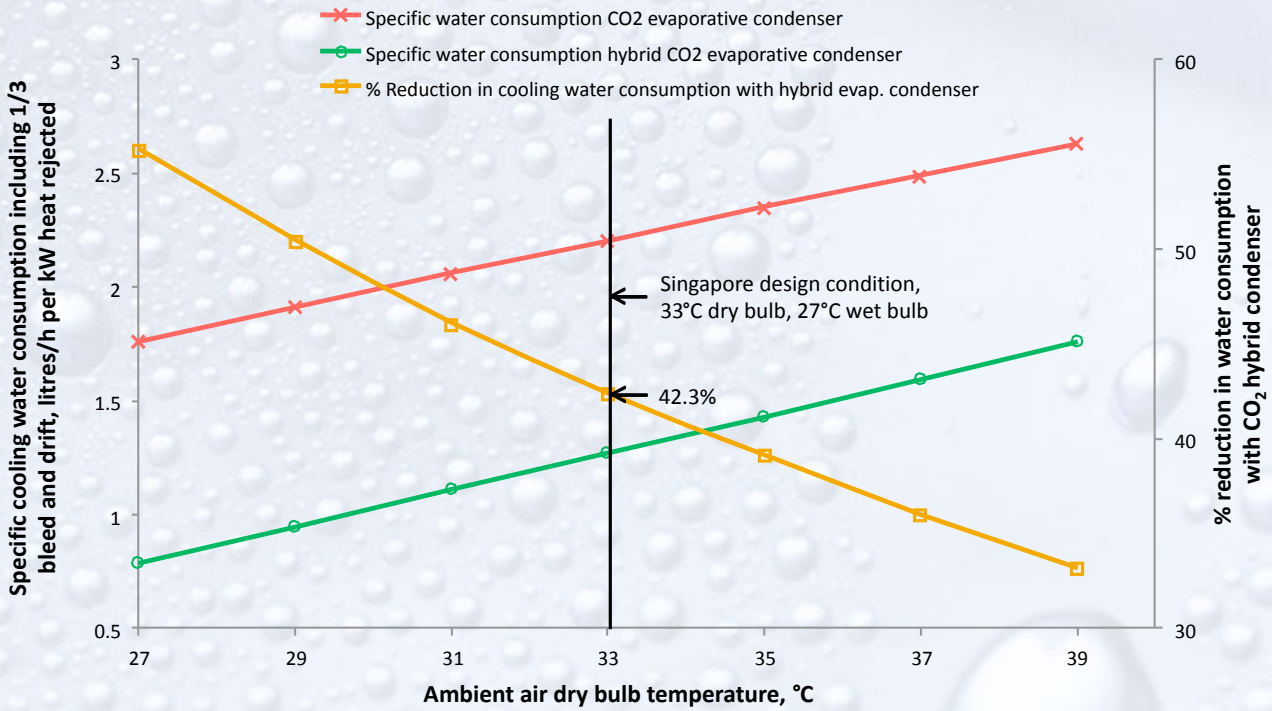

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Figure 11: Inefficient energy use with split HCFC/HFC systems for heating and cooling in high-rise buildings

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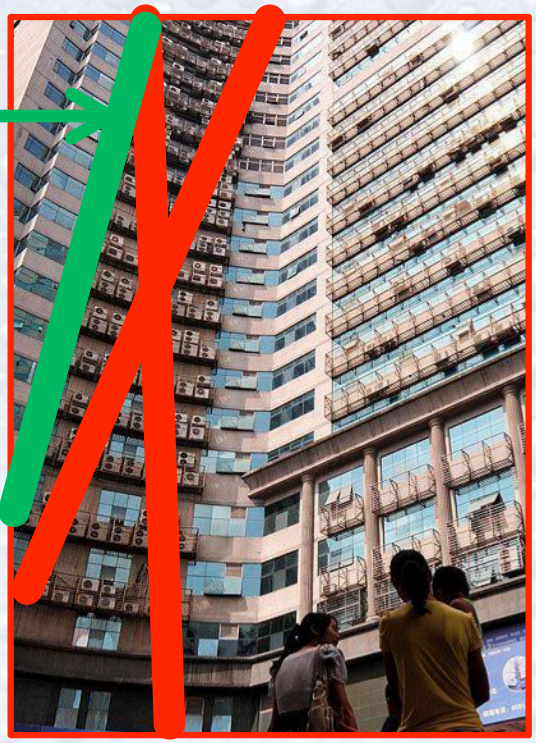
Hot and Chilled Water supply and return for heating and cooling from CO_2 refrigeration system.



Heating and cooling water measurement station

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Figure 12: Asia Marine Products SDN BHD Malaysia. Refrigeration Units and Air Sock Layout.

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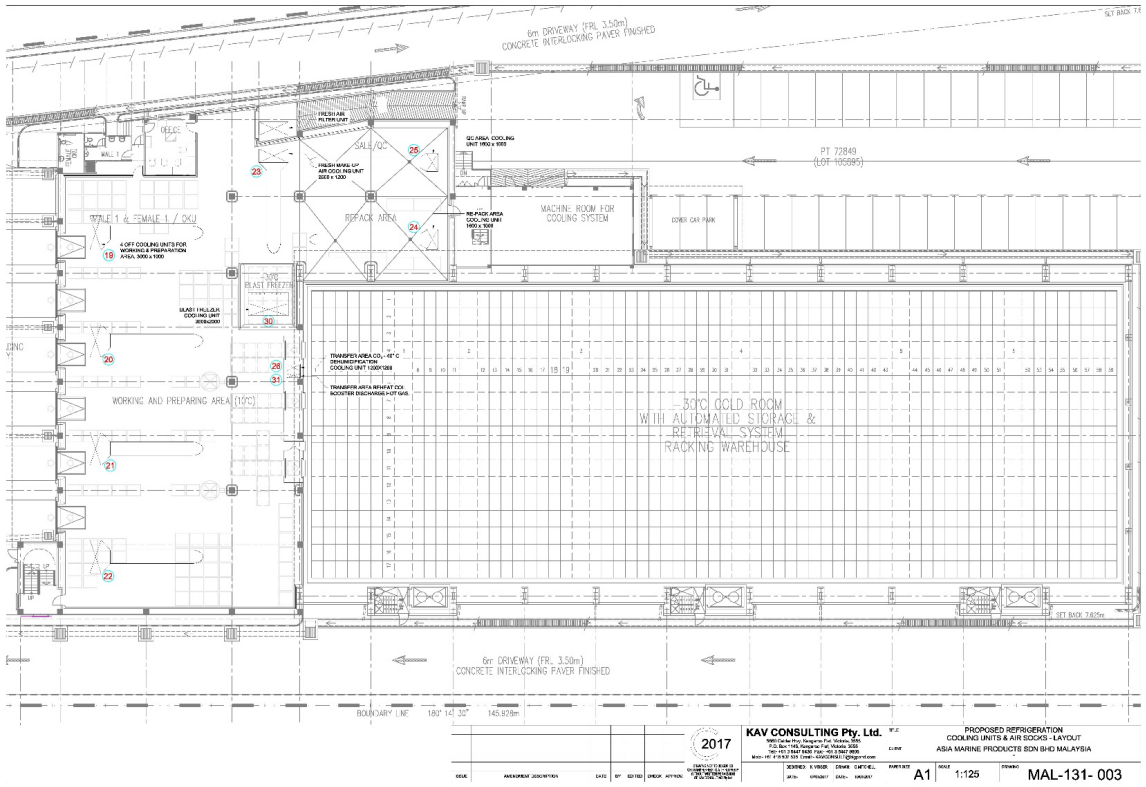

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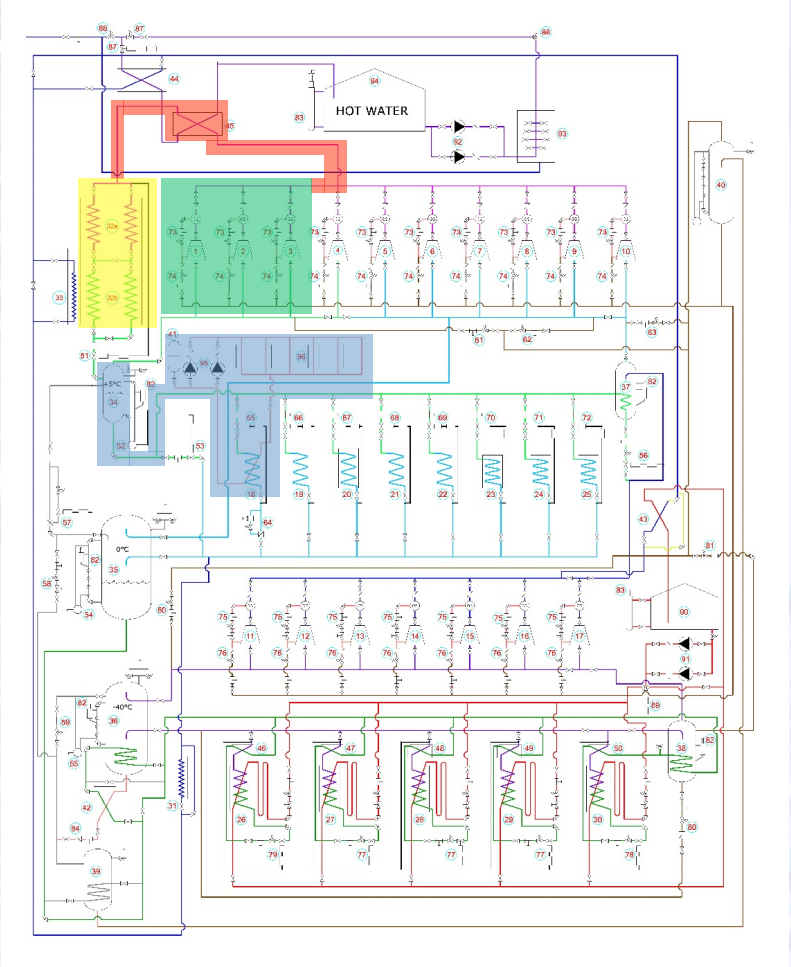

Figure 13: Asia Marine Products SDN BHD Malaysia. CO_2 System Schematic.

- Transcritical CO_2 Compressors
- CO_2 Water Heating
- CO_2 Cooling/Condensing
- CO_2 AC Chilled Water

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Conclusions

1. Significant reduction in energy consumption, both electrical and fuel energy.
2. Significant reduction in cooling water consumption if used with Hybrid Evaporative Condensers.
3. Significant reduction in carbon emissions due to both reduced energy consumption and no chemical refrigerants.
4. Significant reduction in costs for energy, water, water treatment and disposal to sewer.
5. Low cost refrigerant.
6. Retrofitting and new systems future proof systems with respect to the HFC Phase Down in accordance with the Kigali Amendment to the Montreal Protocol.

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Thank you for your Attention

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Questions?

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