ATMO sphere AUSTRALIA business case natural refrigerants

16 May 2016 — Melbourne

"Comparison of Integrated CO_2 Refrigerating Systems with Traditional HFC, and CO_2/HFC Hybrid and Cascade Systems in Australian Supermarkets"

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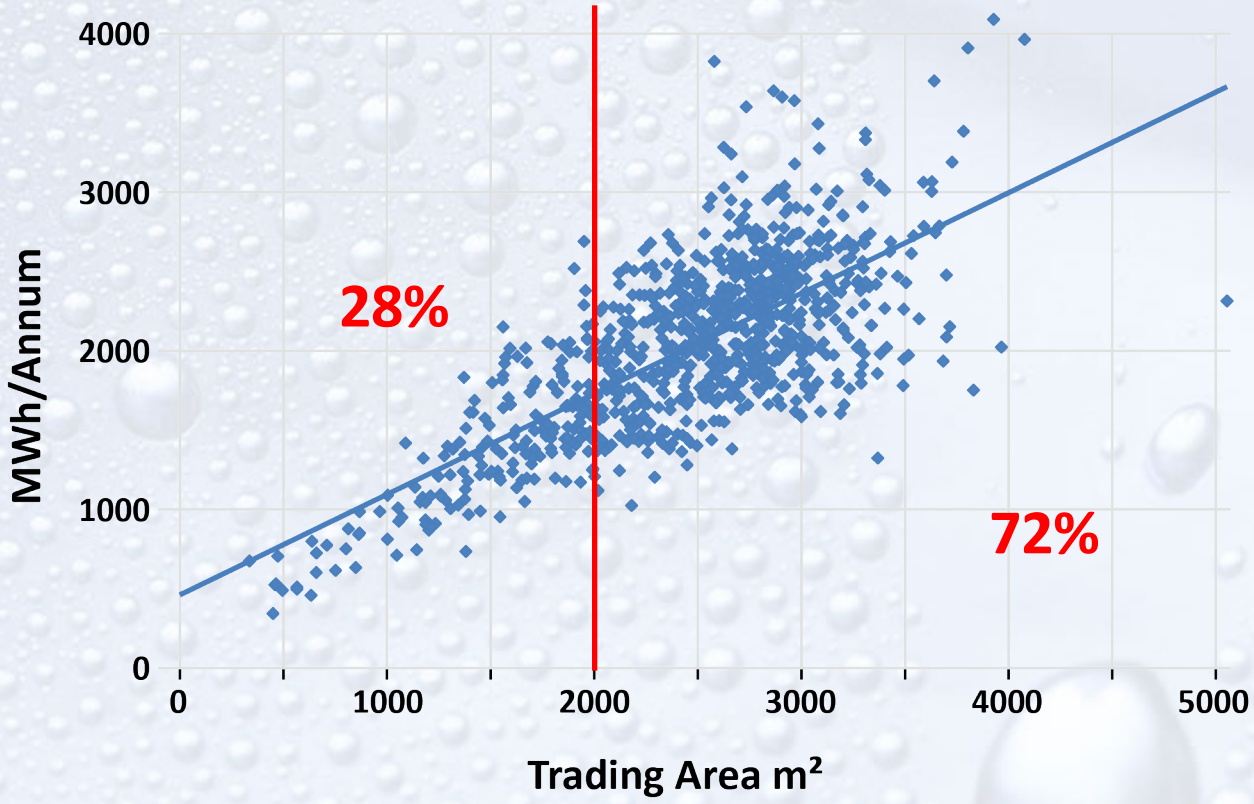
Advisers to the Refrigerated Food Industries

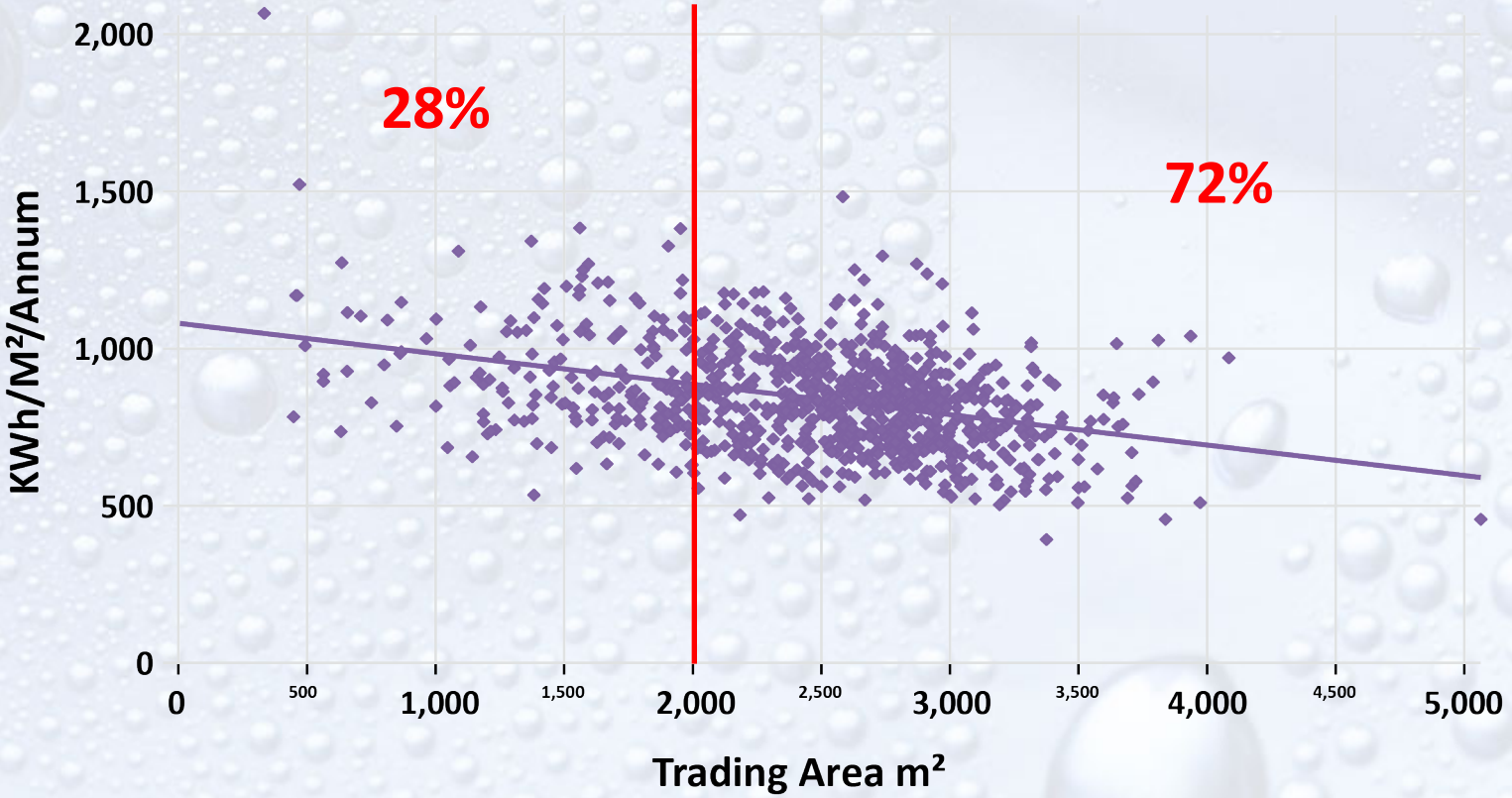
Introduction

- Analysis of Specific Electrical Energy Consumption (SEEC) in supermarkets by trade area and refrigerating plant type.
- Evaluation of energy savings with all water cooled CO_2 plants for AC, MT, LT refrigeration with parallel compression at;
  - 28% existing hybrid CO_2/HFC systems.
  - 30% existing HFC systems.
- Annual savings of $21 to $44 per m^2 trade area depending on location and local energy cost and electrical reheat cost when appropriate.
- Sharp reduction in indirect Global Warming Emissions (GWE).
- Virtual elimination of direct GWE from refrigerant fugitive gasses.
- All heat required for reheat, space heating and tap water recoverable from the CO_2 plant on demand.
- Reduced refrigerant top up replacement at much lower cost.

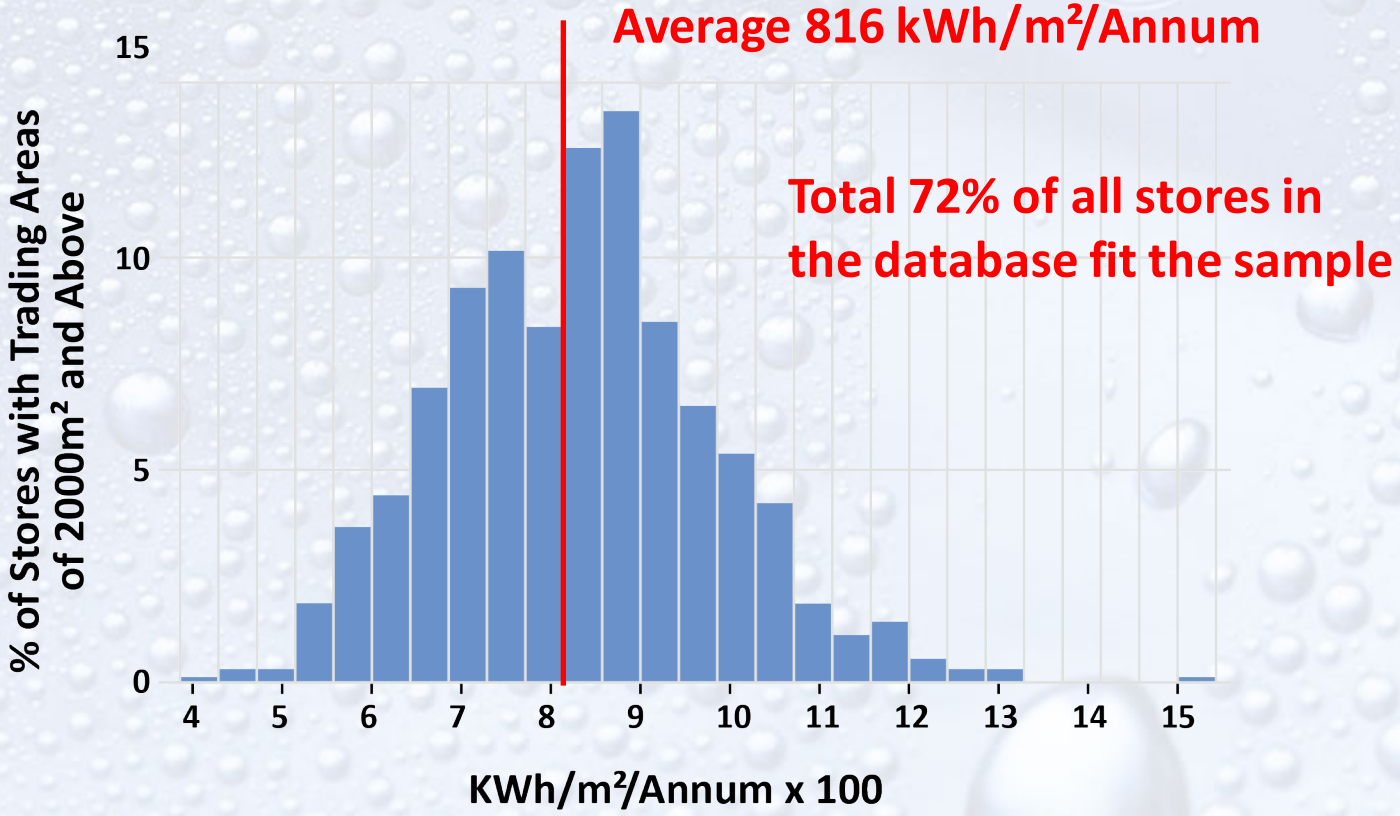
Total MWh/Annum vs Trading Area [m²] - All Stores



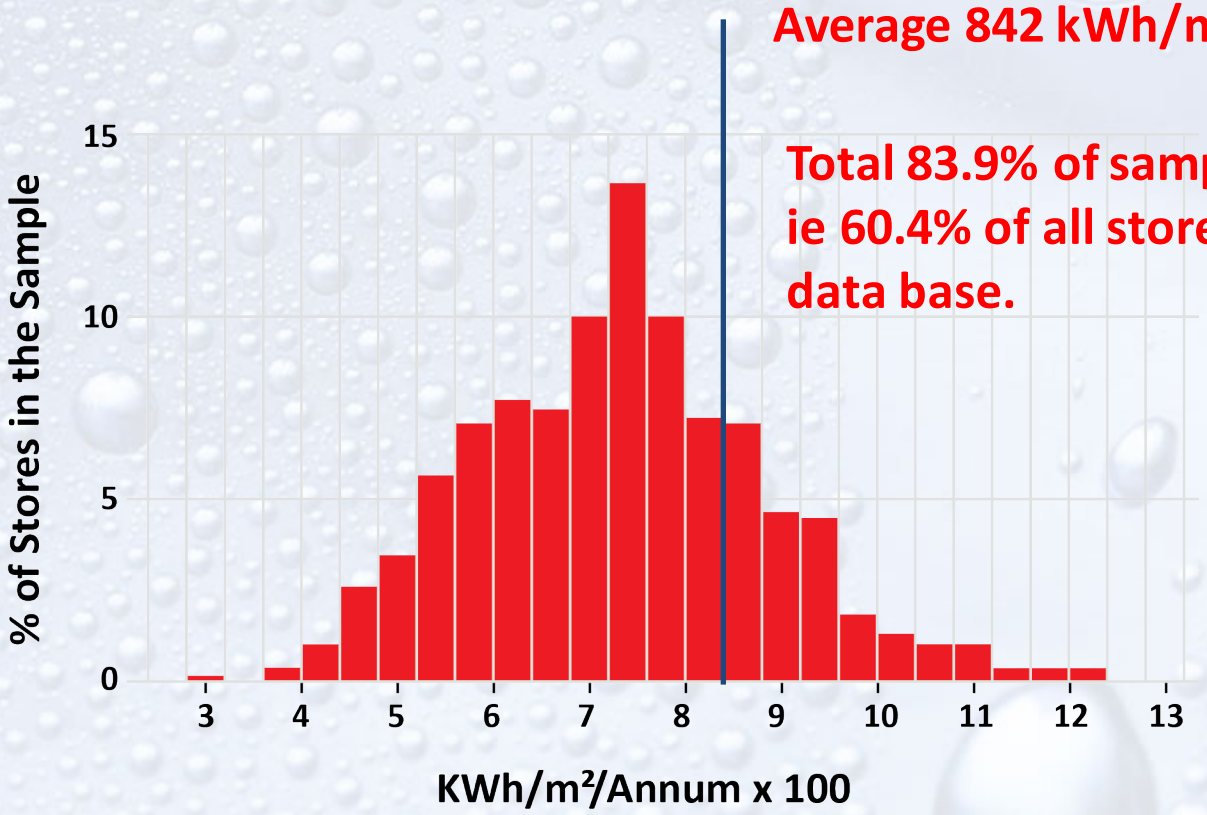
KWh/m²/Annum vs Trading Area [m²]



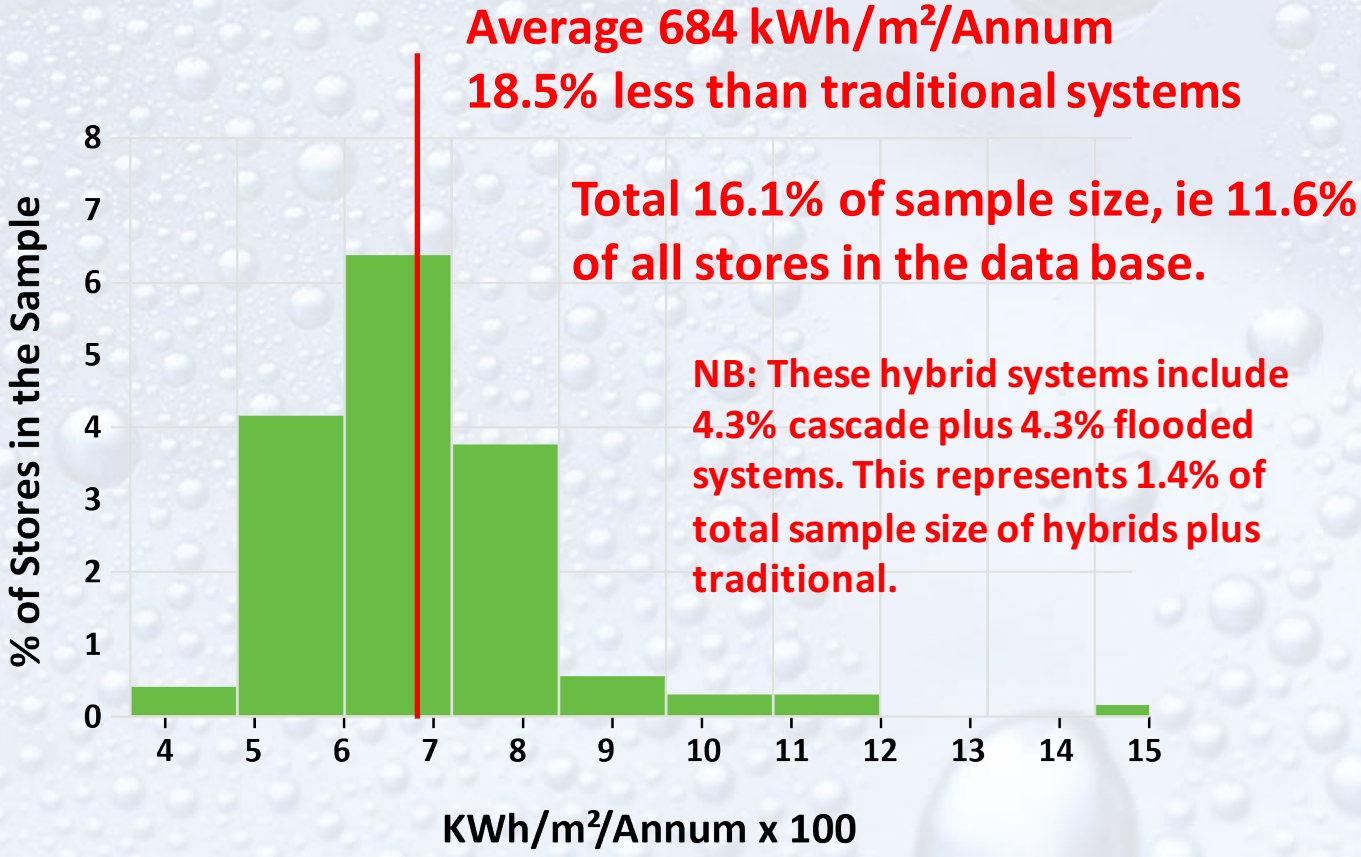
Histogram of KWh/m²/Annum – All Systems in Stores with Trading Areas of 2,000m² and Above



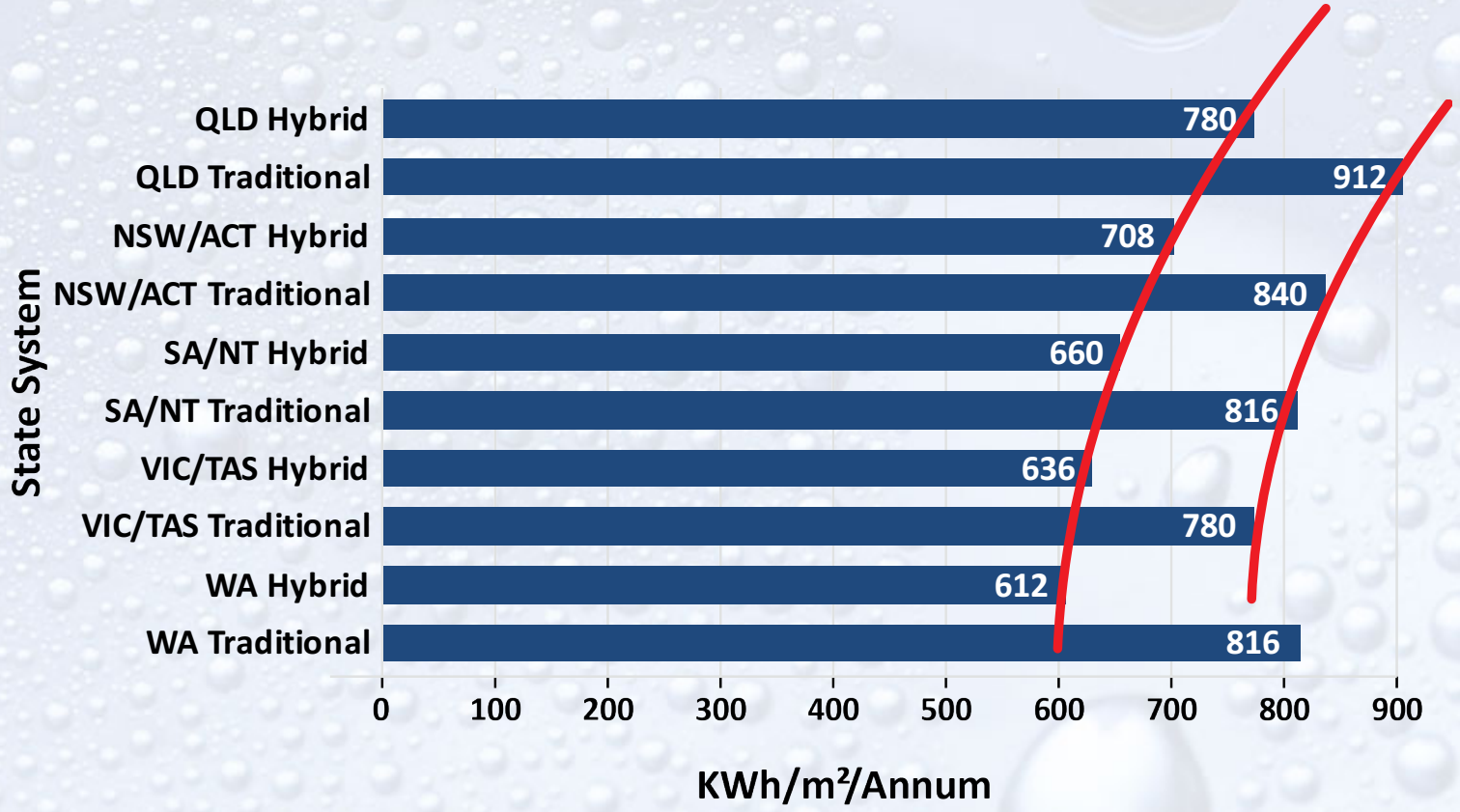
Histogram of KWh/m²/Annum – Traditional Systems in Stores with Trading Areas of 2,000m² and Above



Histogram of KWh/m²/Annum – Hybrid Systems in Stores with Trading Areas of 2,000m² and Above



KWh/m²/Annum – In Various Australian States in Stores with Trading Areas of 2,000m² and Above



Comparison of Integrated CO_2 Refrigerating Systems with Traditional HFC and CO_2/HFC Hybrid and Cascade Systems in Australian Supermarkets

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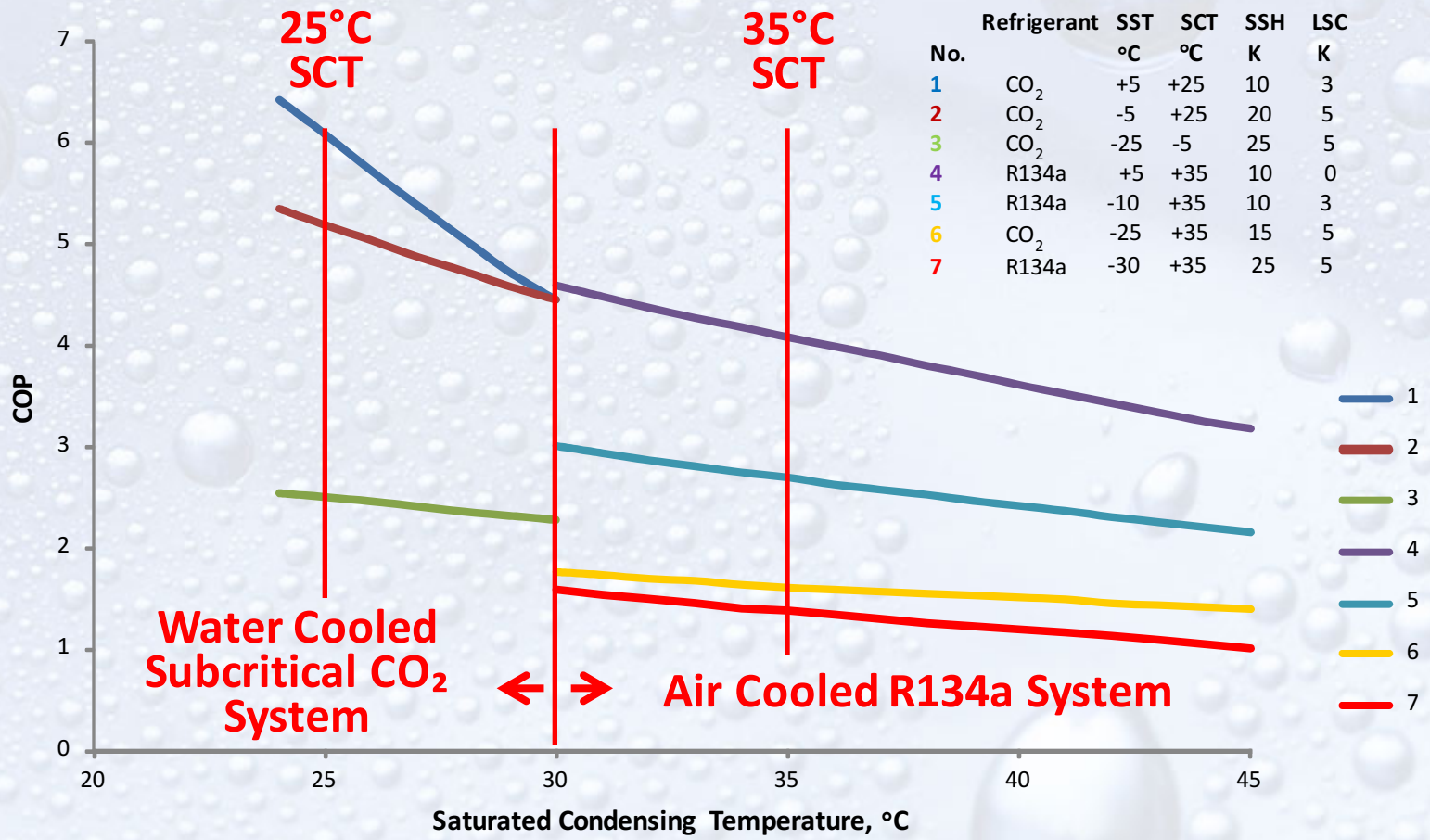
Coefficients of Performance (COP) of Water Cooled Subcritical CO_2 and Air Cooled R134a Refrigerating Systems



No.	Refrigerant	SST °C	SCT °C	SSH K	LSC K
1	CO_2	+5	+25	10	3
2	CO_2	-5	+25	20	5
3	CO_2	-25	-5	25	5
4	R134a	+5	+35	10	0
5	R134a	-10	+35	10	3
6	CO_2	-25	+35	15	5
7	R134a	-30	+35	25	5

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Comparison of Energy Consumption of Conventional Single Stage R134a Systems at 35°C Saturated Condensing Temperature with Two Stage Transcritical CO^2 System with Parallel Compression (2STCCO$_2$SPC) at 25°C Saturated Condensing Temperature

Energy Consumer		COPs at Sat. Suction				2STCCO$_2$SPC Saturated Suction Temperature, °C			Energy Saving, %[3]			
		R134a	R134a	CO_2	R134a							
Function	%	+5	-10	-25	-30	+5	-5	-25	% Saving in Function	Function % of Total	Function Saving Share of Total	
											CO_2	R134a
AC[1]	40	4.08	-	-	-	6.1	-	-	33	40	13.2	13.2
MT[2]	30	-	2.69	-	-	-	5.18	-	48	30	14.4	14.4
LT CO_2	15	-	-	1.61	-	-	-	2.5	36	15	5.4	-
LT R134a	15	-	-	-	1.38	-	-	2.5	45	15	-	6.8
% Total reduction in electrical energy consumption											33.0	34.4
Subtract parallel compression 25% of AC energy saving											3.3	3.3
Nett Energy Saving, %											29.7	31.1
Say %											29.0	30.0

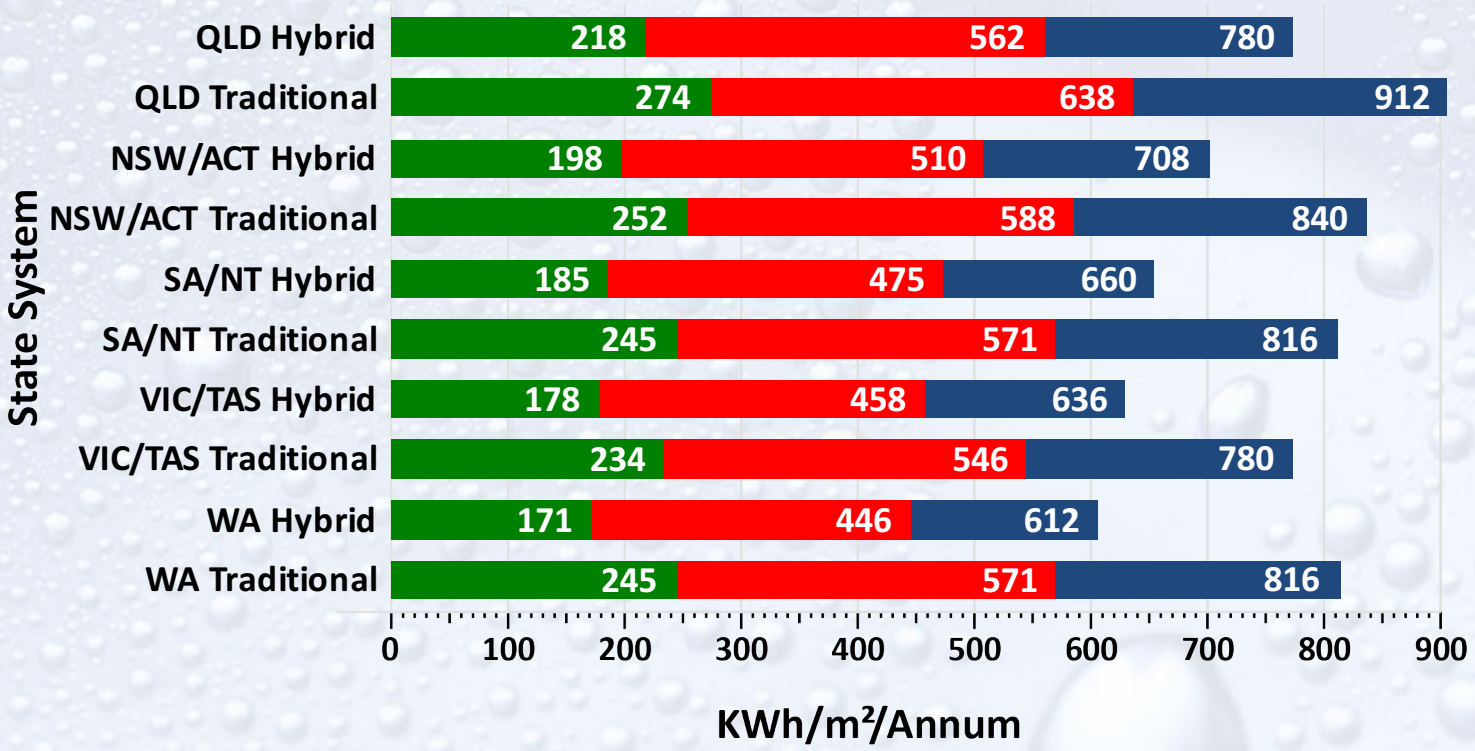
Average Capital City Temperatures, °C – Australia

Darwin	28°C	Brisbane	21°C	Sydney	18°C	Perth	18°C
Canberra	13°C	Adelaide	16°C	Melbourne	15°C	Hobart	13°C

Notes (1) Electric reheat and space heating also saved (2) Includes HT refrigeration

(3) % Energy saving contribution from function = $100\left(1-\frac{(\text{COP R134a})}{(\text{COP } CO_2)}\right)$

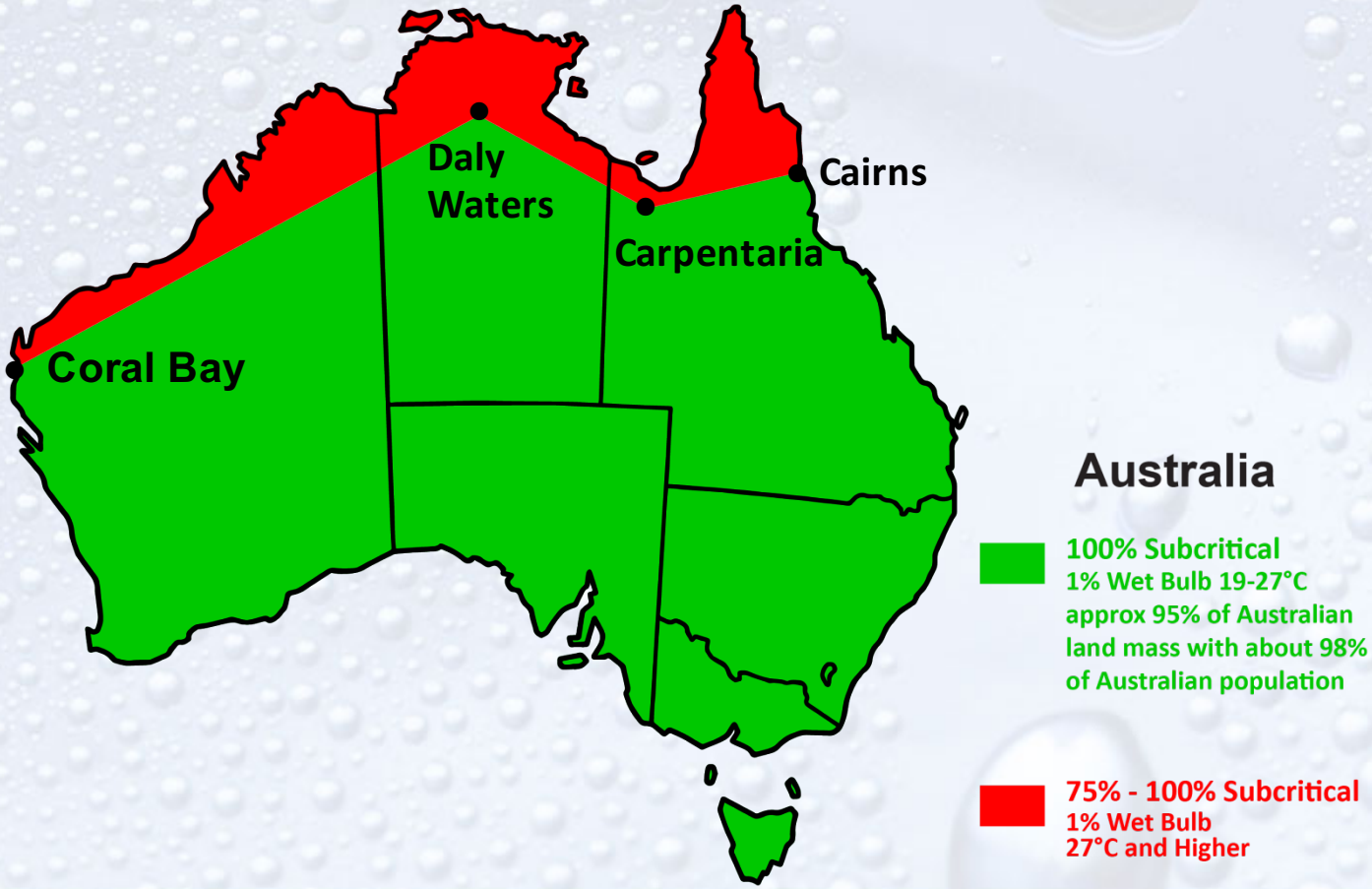
KWh/m²/Annum – In Various Australian States in Stores with Trading Areas of 2000m² and Above



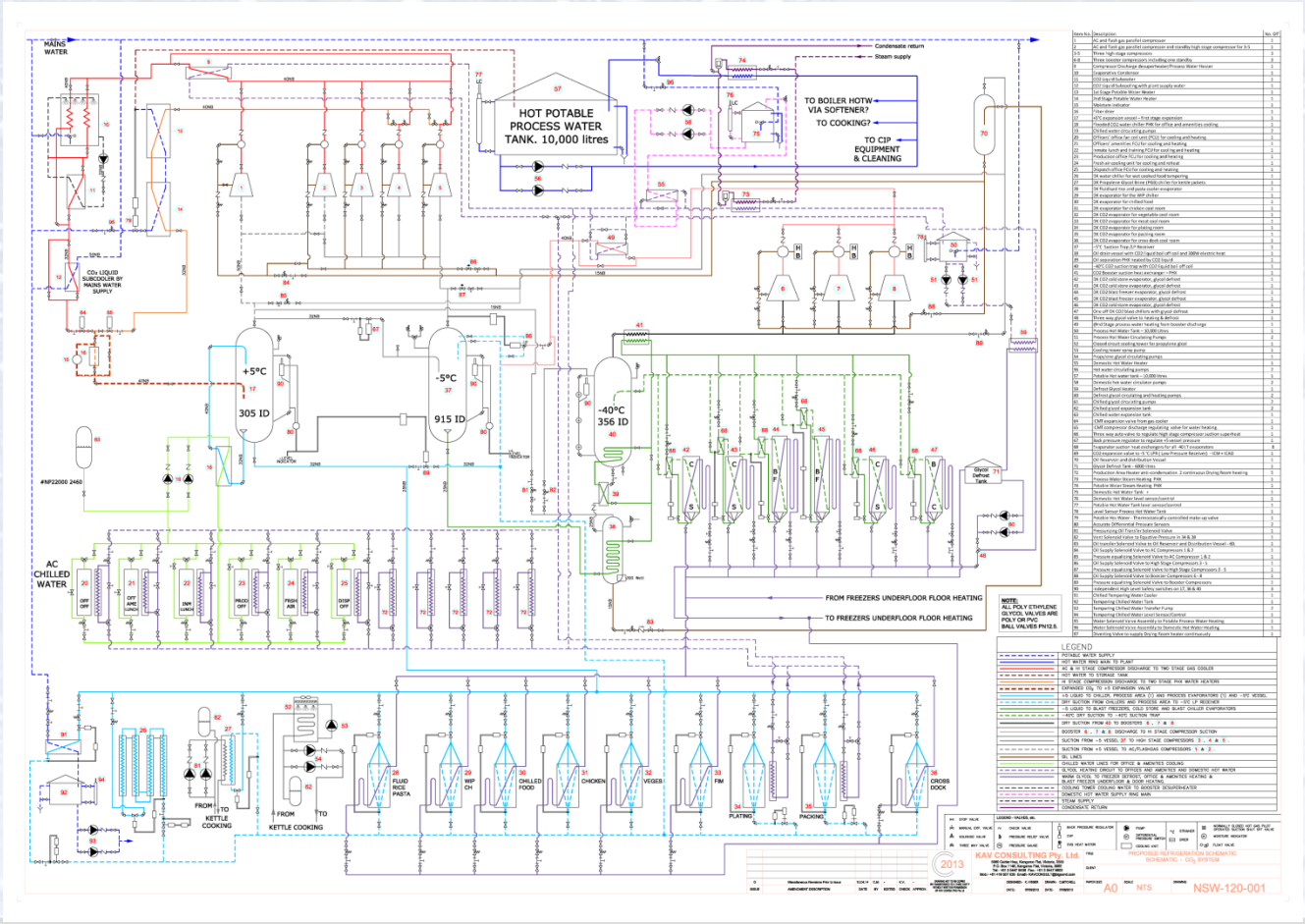
Energy Savings With Integrated 2 Stage Transcritical CO_2 Systems With Parallel Compression

State/ Territory	Reduction in Energy Consumption, kWh/m²/Annum		Energy Cost $/kWh	Energy Cost Reduction $/m²/Annum of Trading Area	
	Hybrid	Traditional		Hybrid	Traditional
QLD	218	274	0.13	$28.34	$35.62
NSW/ACT	198	252	0.12	$23.76	$30.24
SA/NT	185	245	0.16	$29.60	$39.20
VIC/TAS	178	234	0.12	$21.36	$28.08
WA	171	245	0.18	$30.78	$44.10

Australia Climate Zones with Approximate Percentage Incidence of Subcritical CO_2 Condensing Annually



Schematic of a Fully Integrated Multifunction Two-Stage Sub & Transcritical CO_2 System with Parallel Compression on AC Stage. Recently Tendered; Ready for Construction in a 24°C Wet Bulb Area Near Sydney.
7 Refrigeration Functions Plus 9 Heating Functions.



Conclusions

Two Stage Multifunction Transcritical CO_2 Refrigerating Systems have the following major benefits when applied to supermarket refrigeration requirements

- Supermarket energy cost reductions of $21 to $44 per m^2 trade area depending on system type, location and local energy costs, and assume chilled water for AC.
- All heat energy required such as reheat, space heating and tap water is free from the CO_2 system giving additional energy cost reductions.
- Operating cost reductions as HFC losses are entirely eliminated.
- Additional energy savings with all direct CO_2 refrigeration for AC, MT and LT.

Conclusions Cont…

- Hybrid Evaporative Condensers and Gas Coolers (HECGCs) for CO_2 completely obviate any need for expanders and ejectors. Development of these devices is akin to the search for the Golden Fleece as cooling CO_2 with a critical point of 31.1°C with air at a temperature higher than the critical point is thermodynamic nonsense.
- CO_2/ammonia and CO_2/HC systems are inherently more energy efficient than CO_2/HFC cascade systems.
- CO_2/HFC cascade and hybrid systems have limited energy efficiency scope because most of the required refrigeration – AC, MT and CO_2 LT heat rejection – is affected by inherently low COP HFC refrigerants. The cascade affects the LT refrigeration, i.e. only a small portion of the refrigeration required, at a higher efficiency.

Conclusions Cont…

- Reduced Global Warming Emissions (GWE) from reduced HFC leakage – direct GWE – and reduced energy consumption – indirect GWE.
- Future proofing of plants with the G20 agreed HFC phase down by about 80% by 2030.
- No fear of legionella with CO_2 hybrid condensers and they reduce water consumption compared to Cooling Towers and full service evaporative condensers.
- In new supermarkets reduced infrastructure costs for electrical supply and a heating gas supply if no gas cooking on site.

The *Gun* Gun Salesman

"No! – I can't be bothered to see any crazy salesman –
we've got a battle to fight!"

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Thank you for your attention.

Any Questions?

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