



Business Case for
Natural Refrigerants

11-12/04/2018 – Beijing





Development of the R744 systems to meet Southern Chinese Ambient condition

Example - **Shenzhen**

Thursday 12 April

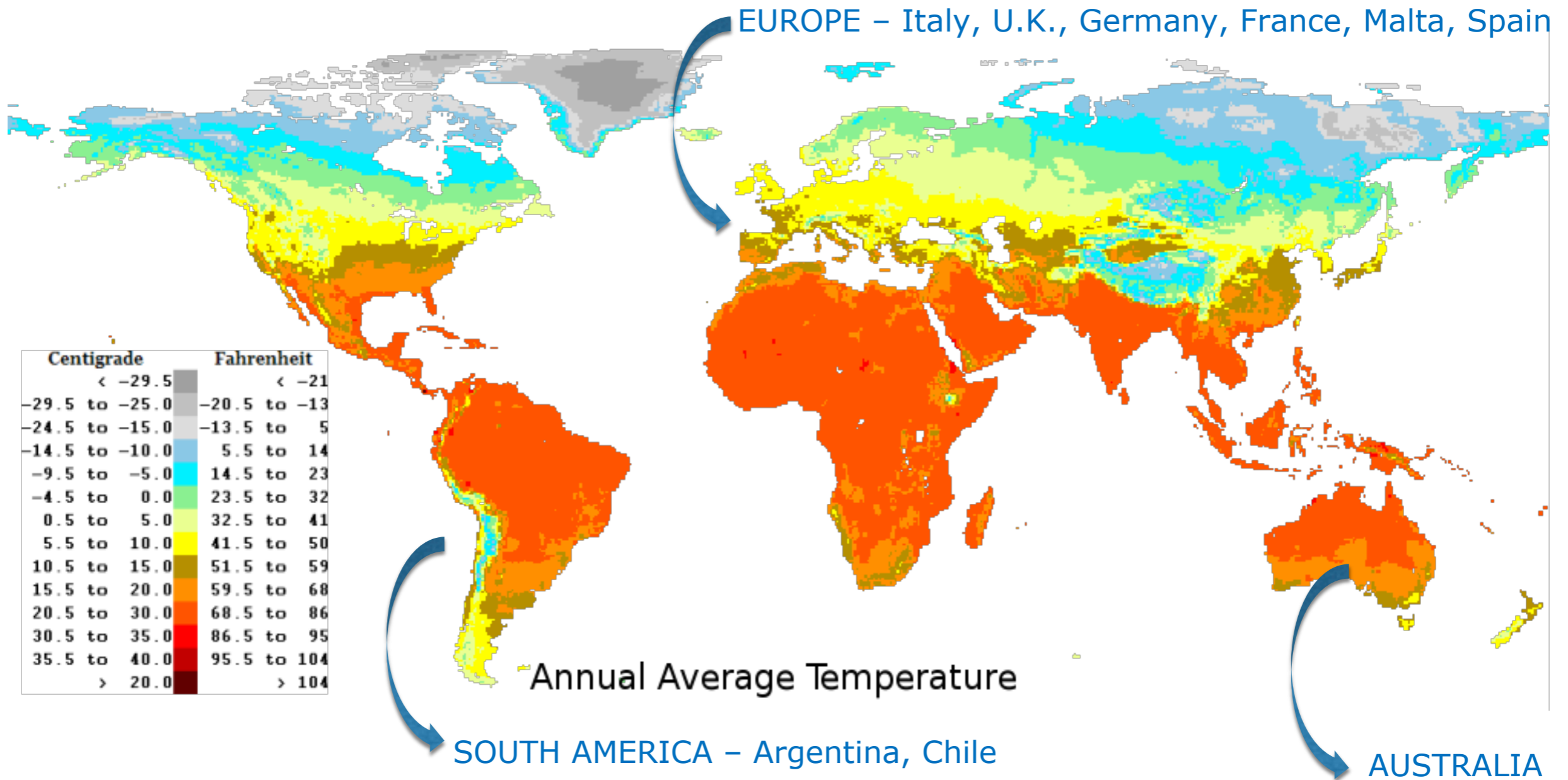
John Austin-Davies

Marketing Project Director



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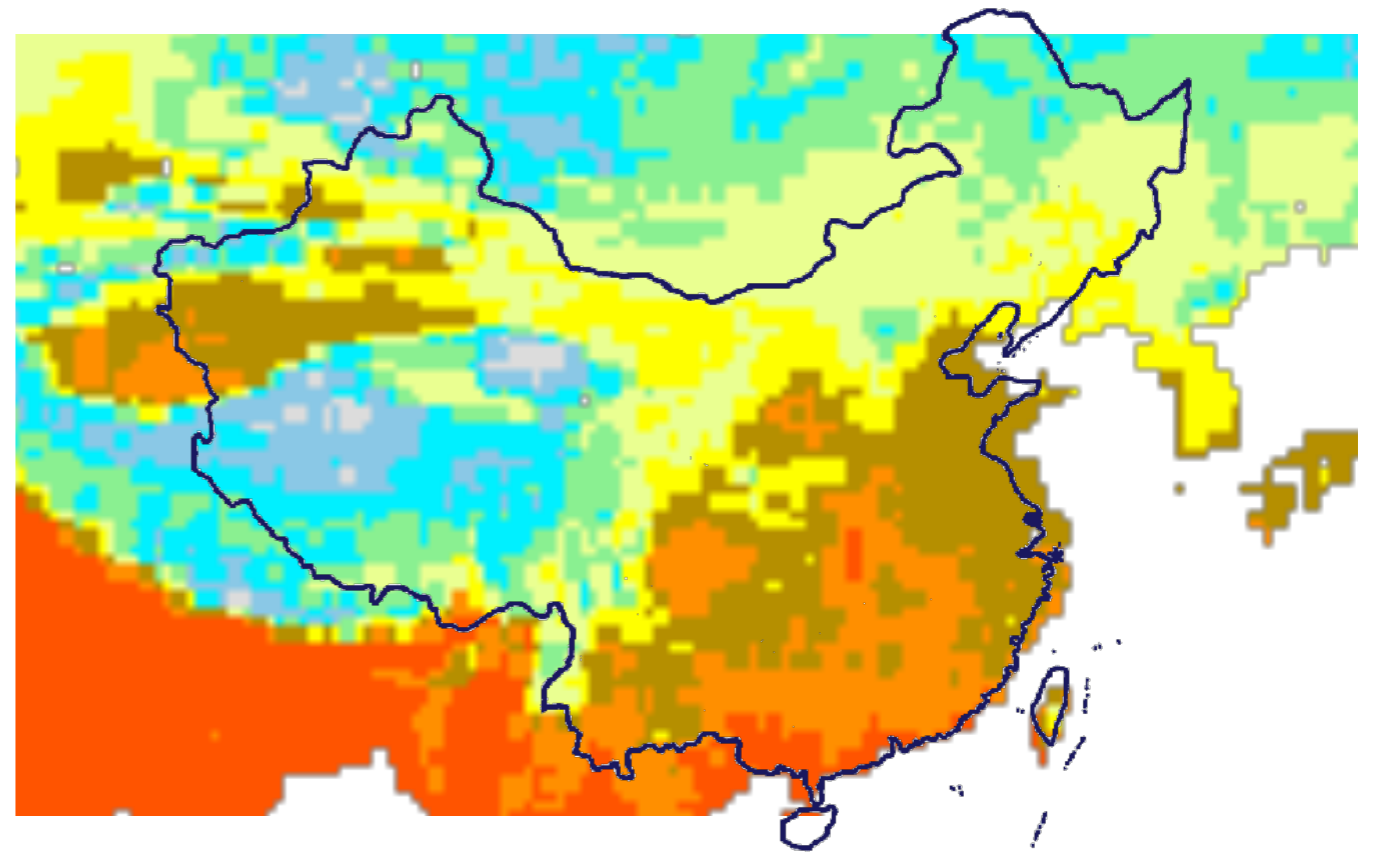
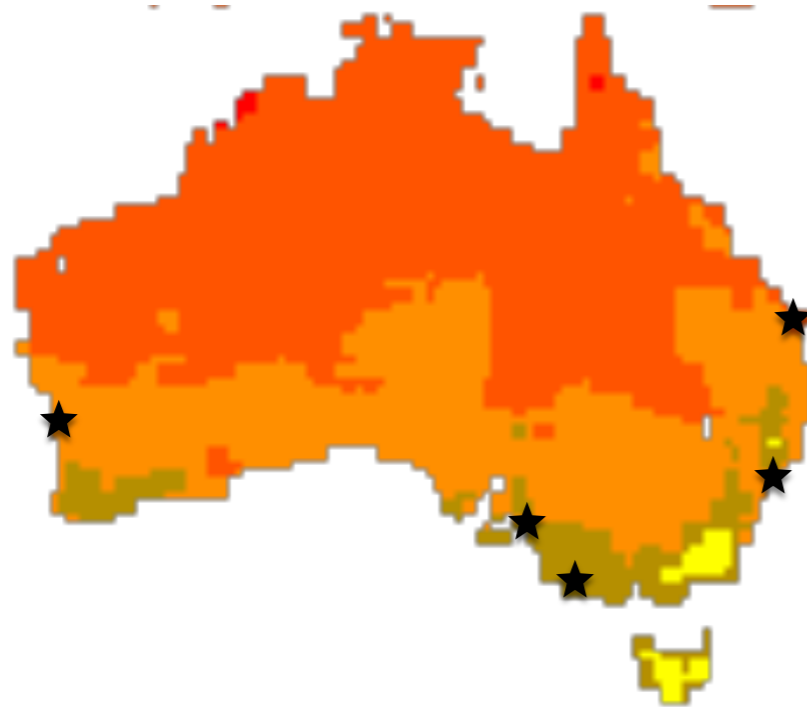
CO₂ Transcritical World for Epta





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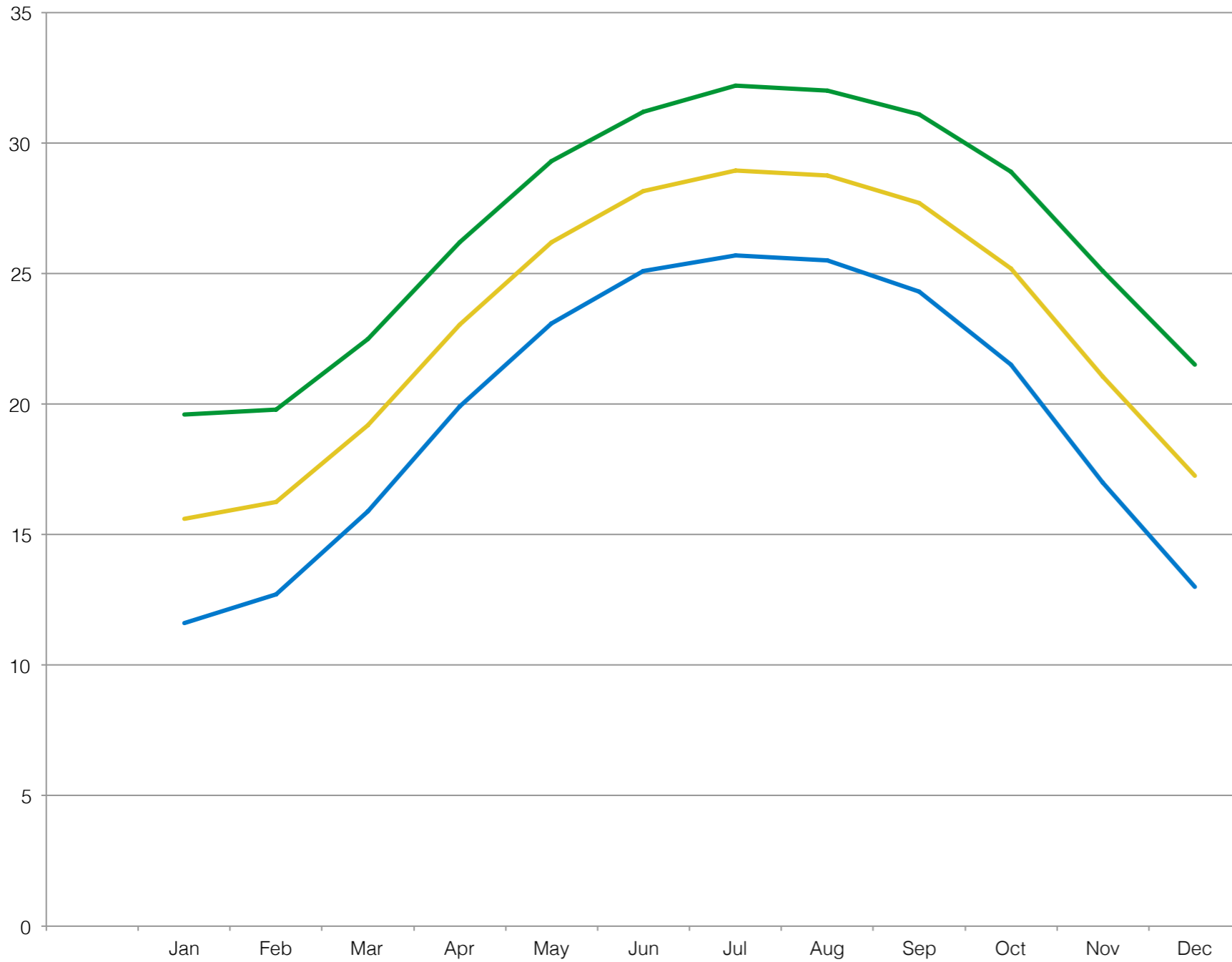
CO₂ Experience
Focus on Climate





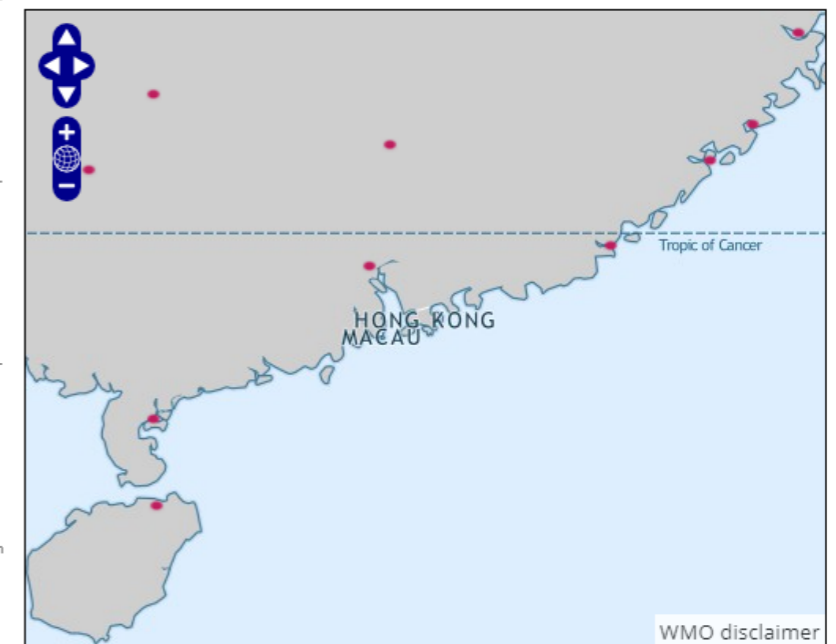
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Ambient Temperature Profile - Shenzhen



WORLD
METEOROLOGICAL
ORGANIZATION

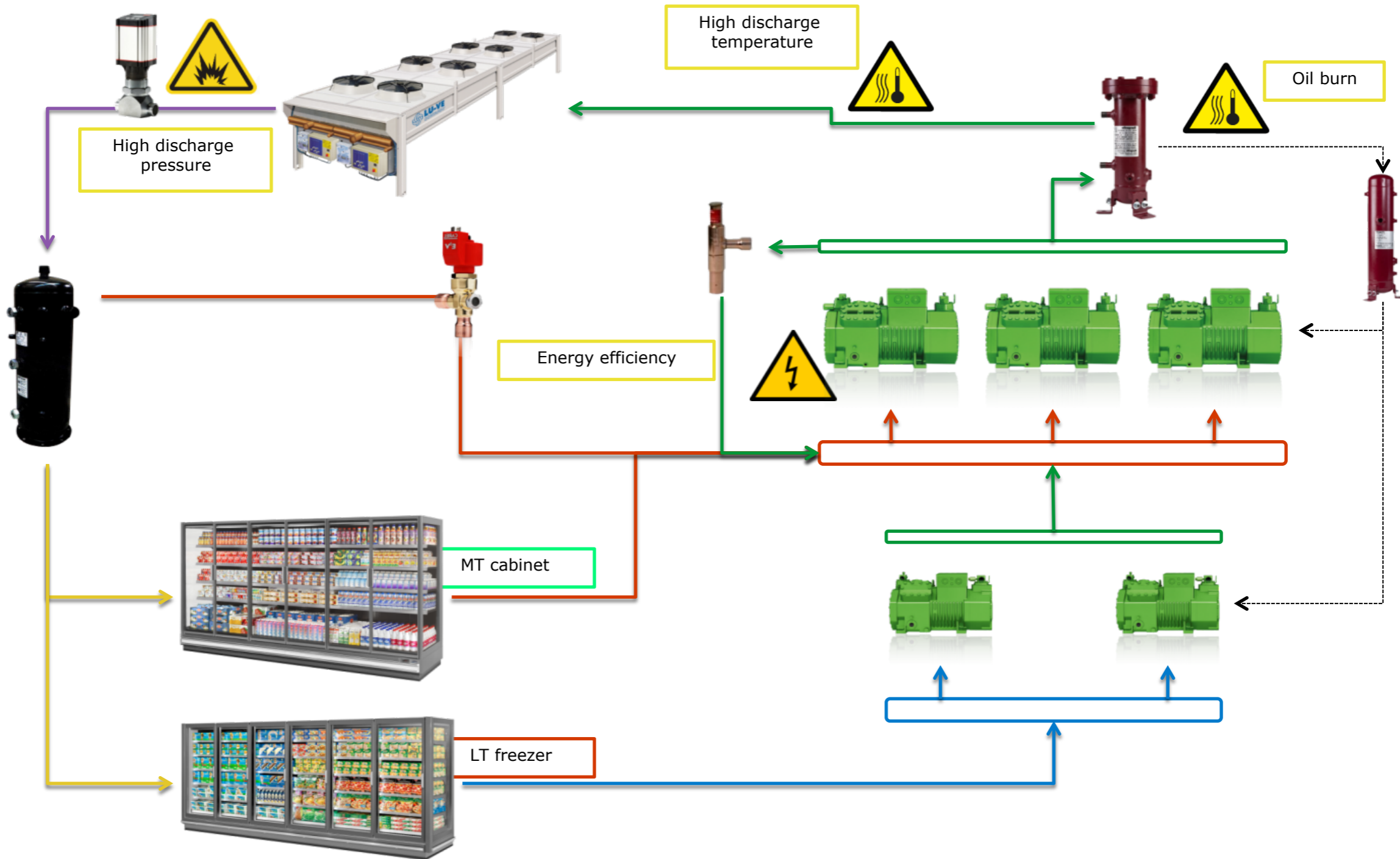
- Mean Daily Minimum Temperature (°C)
- Mean Daily Maximum Temperature (°C)
- AVE deg C





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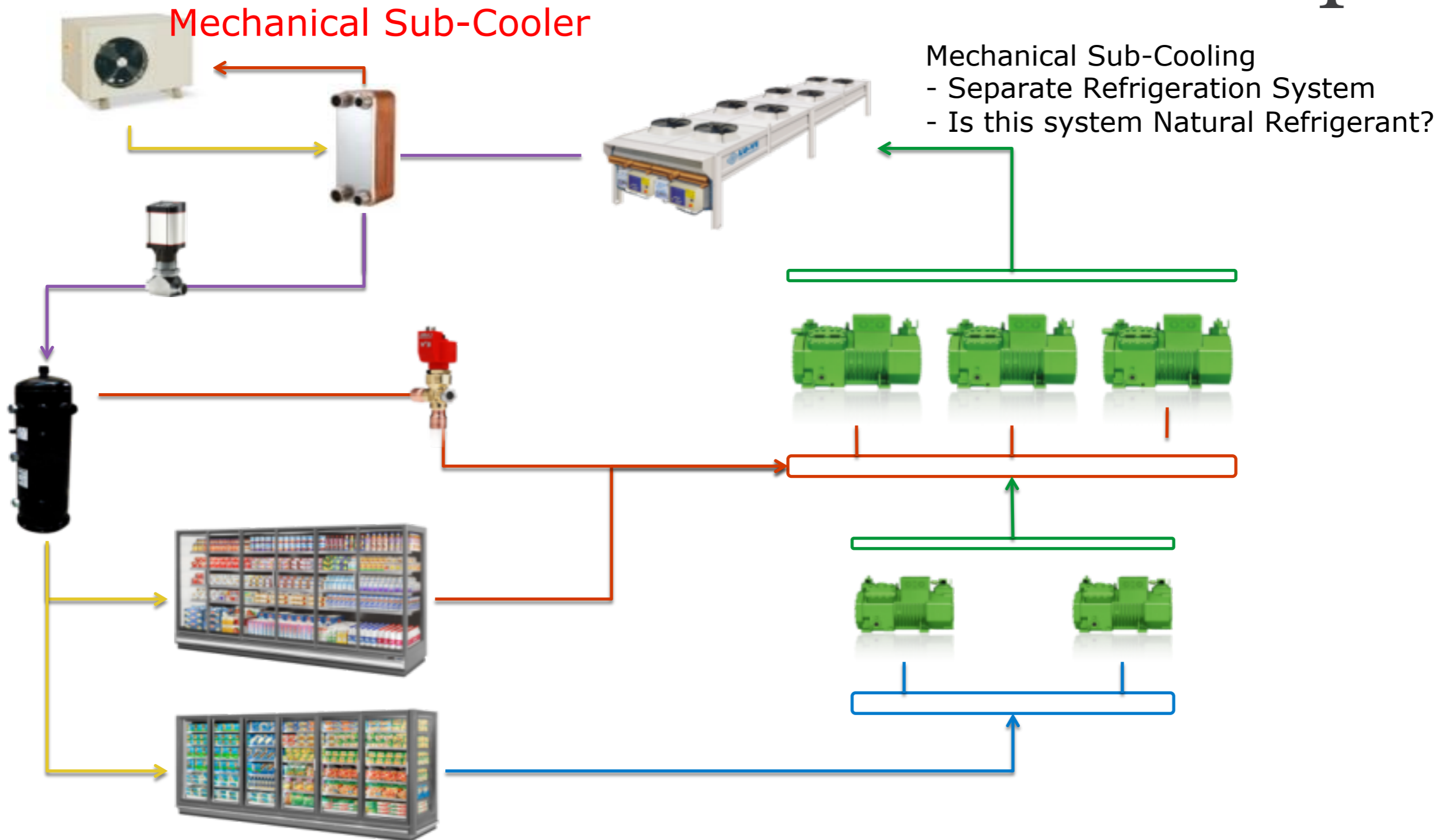
CO₂ Transcritical Limitations in Hot Climates





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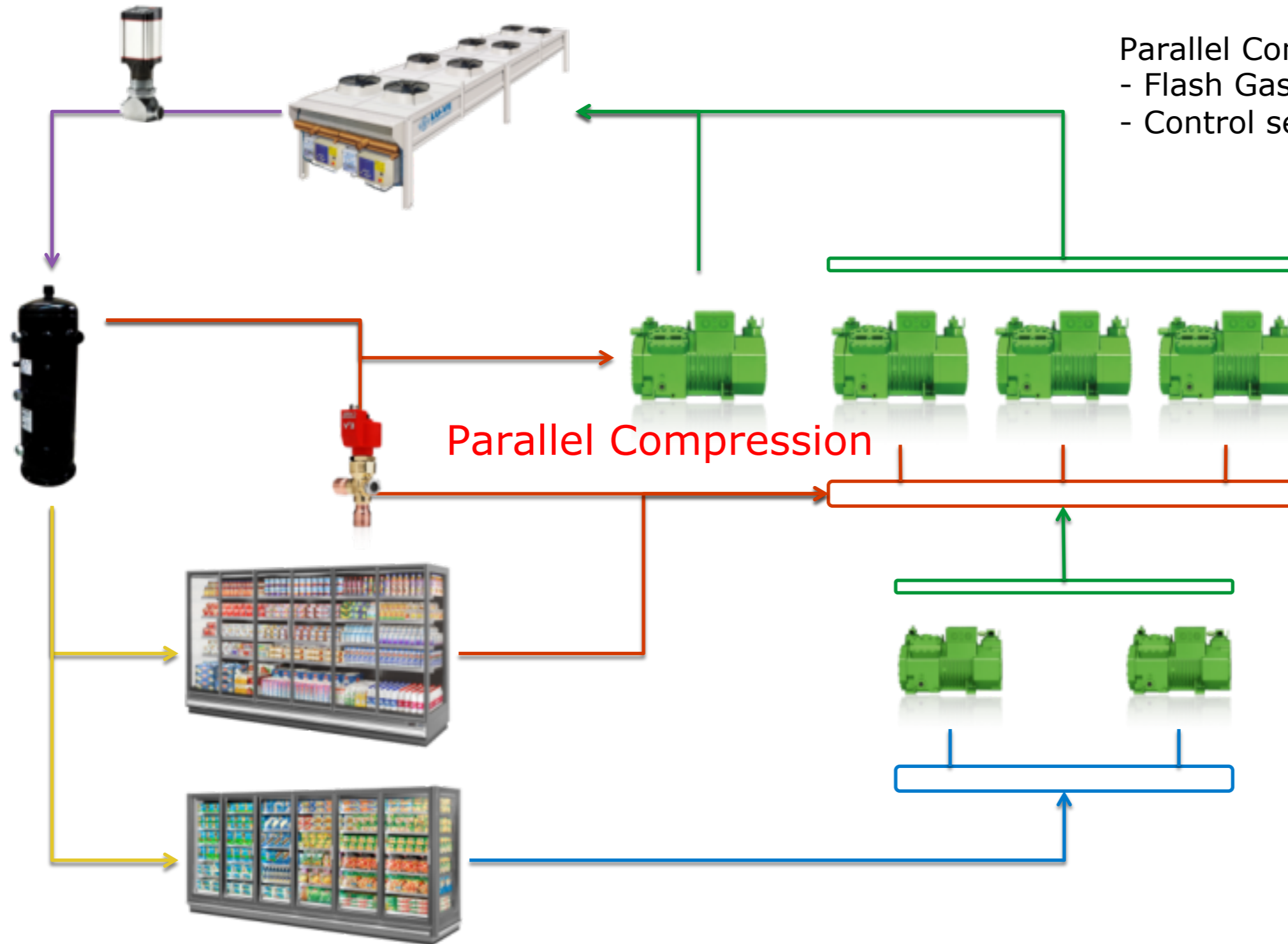
CO₂ System Enhancement (1)





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CO₂ System Enhancement (2)



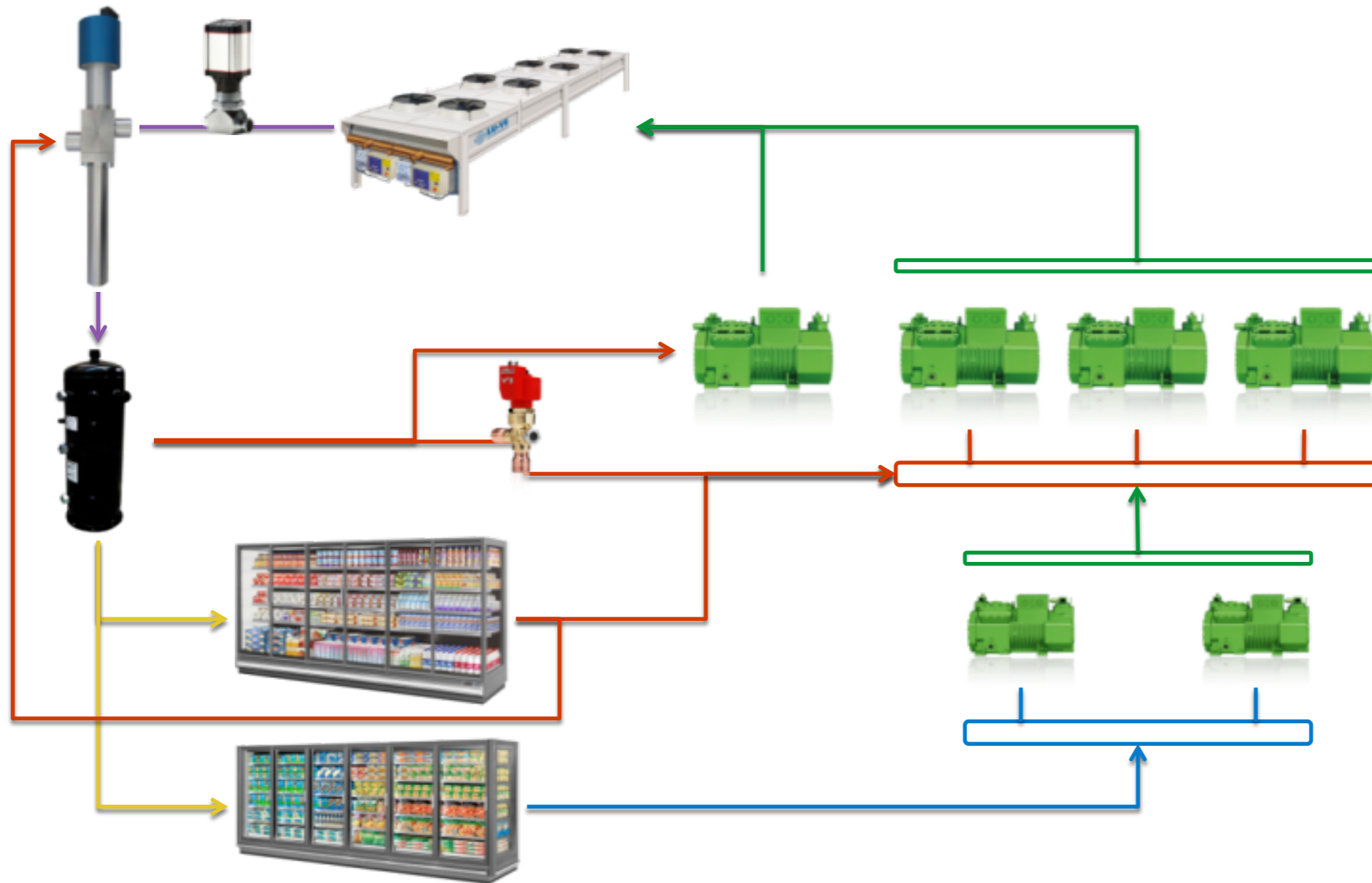
Parallel Compression
- Flash Gas Valve still required
- Control set-up critical

Parallel Compression

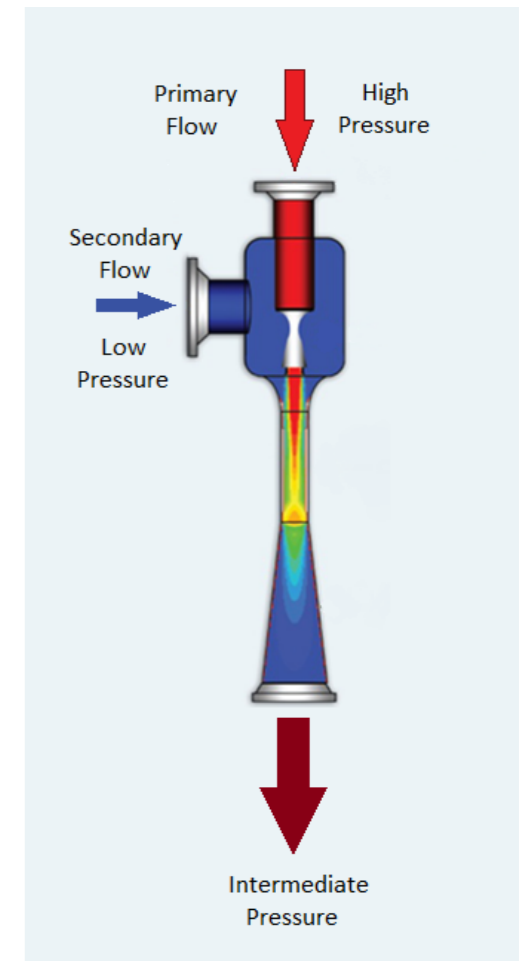


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CO₂ System Enhancement (3)



Gas Ejector System

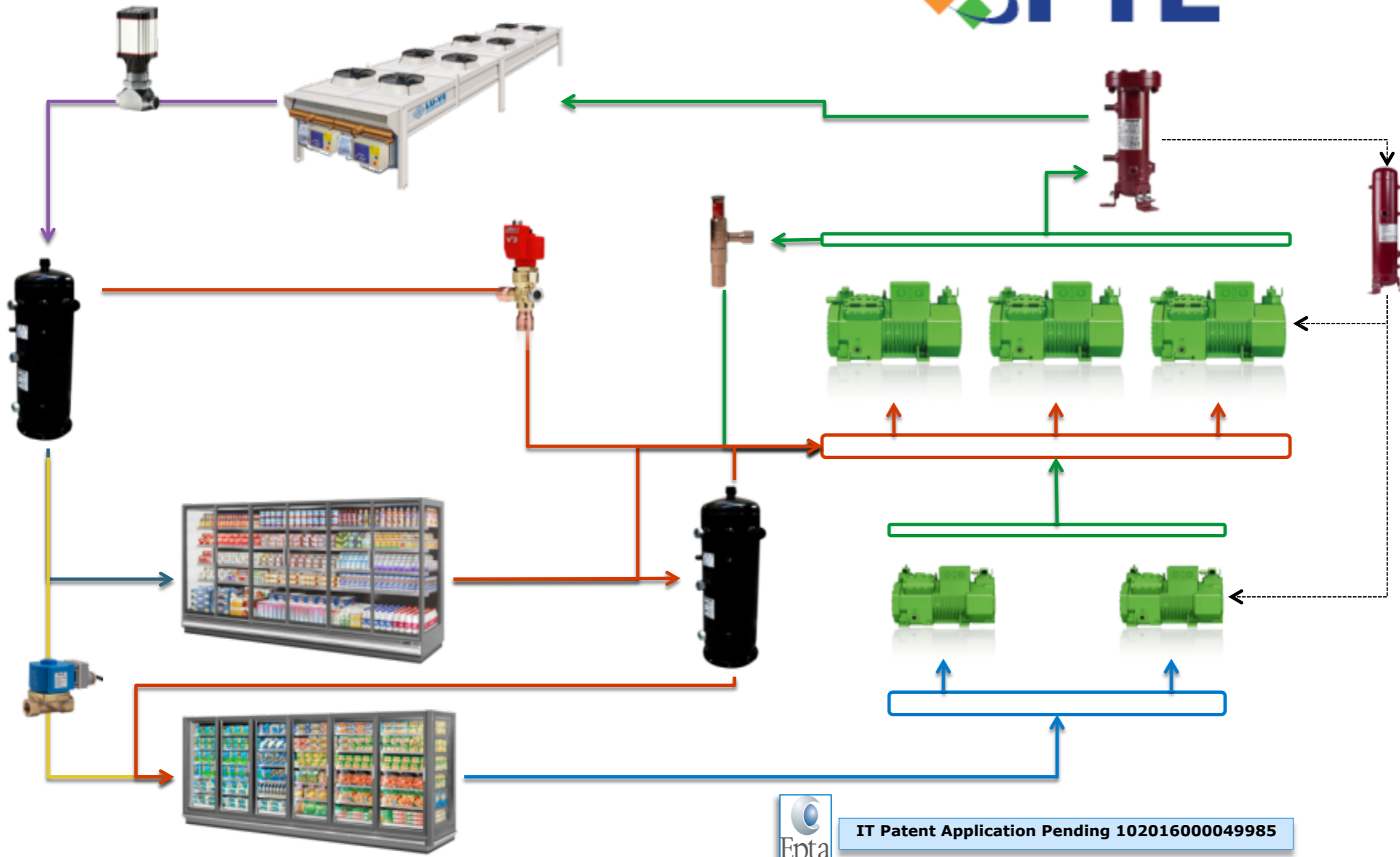


- Gas Ejector System
- Improves Efficiency in hot climate only
 - Control system critical



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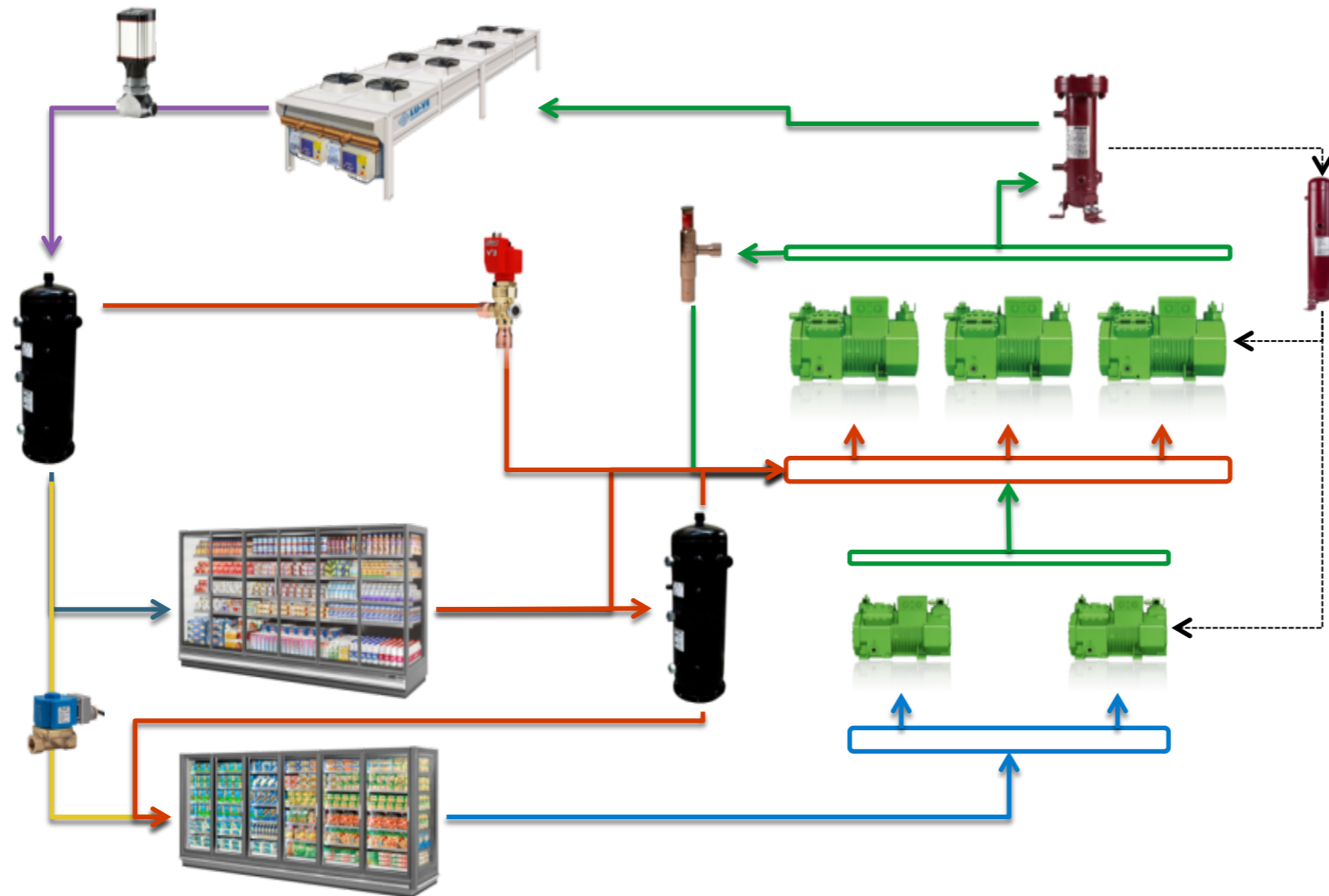
CO₂ System Enhancement





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CO₂ System Enhancement

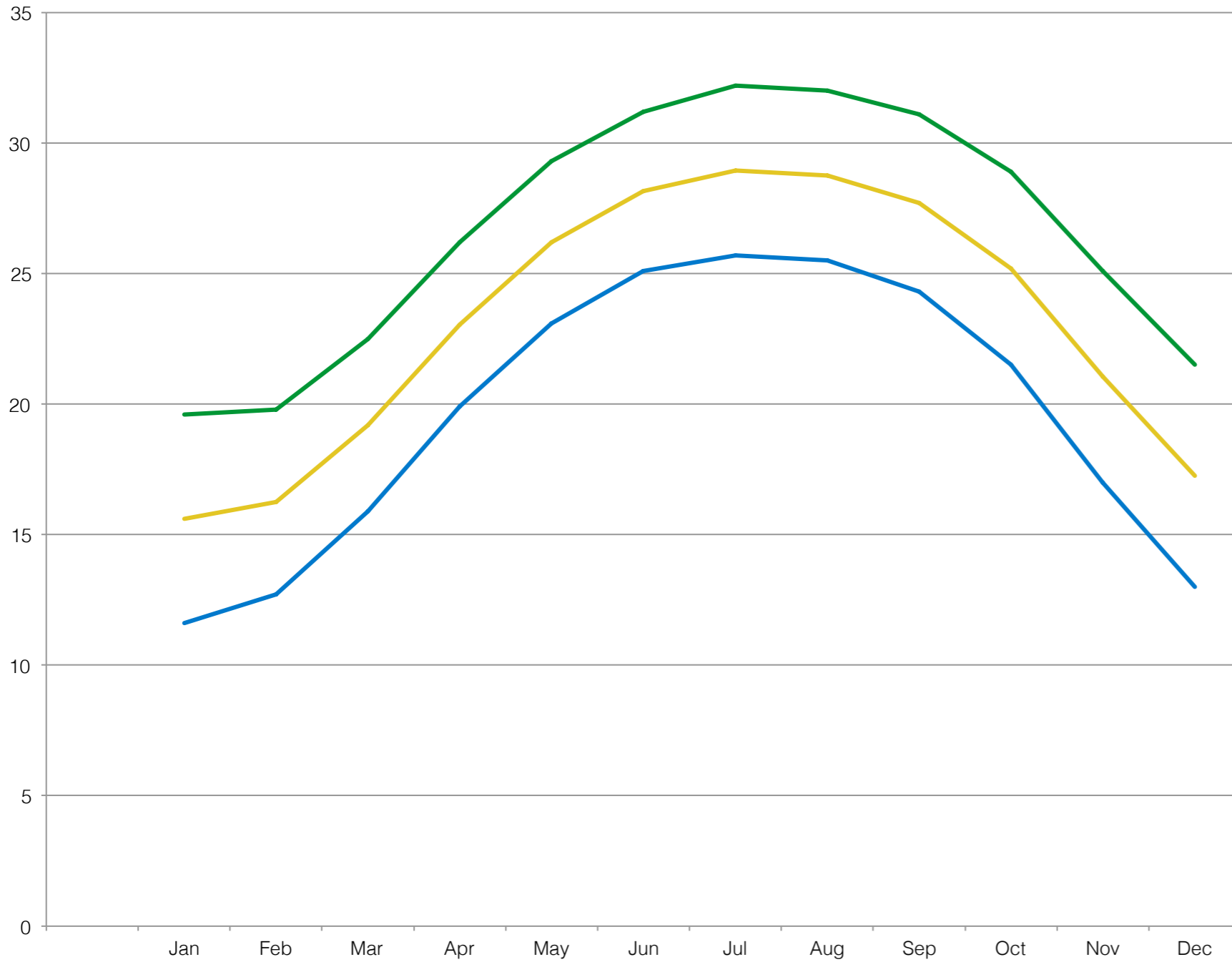


- A Simple mechanical solution, so reliable and easy to understand
- Designed to reduce MT suction temperature, hence reduce discharge temperature
- Approved by key compressor manufacturer (as this is good for oil temperature & condition)
- MT evaporators can be used flooded, no superheat necessary!
- Improved evaporator performance allows a higher MT evaporating temperature
- Thermodynamic system efficiency improved, pressure ratio reduced
- Improved efficiency during all climatic conditions



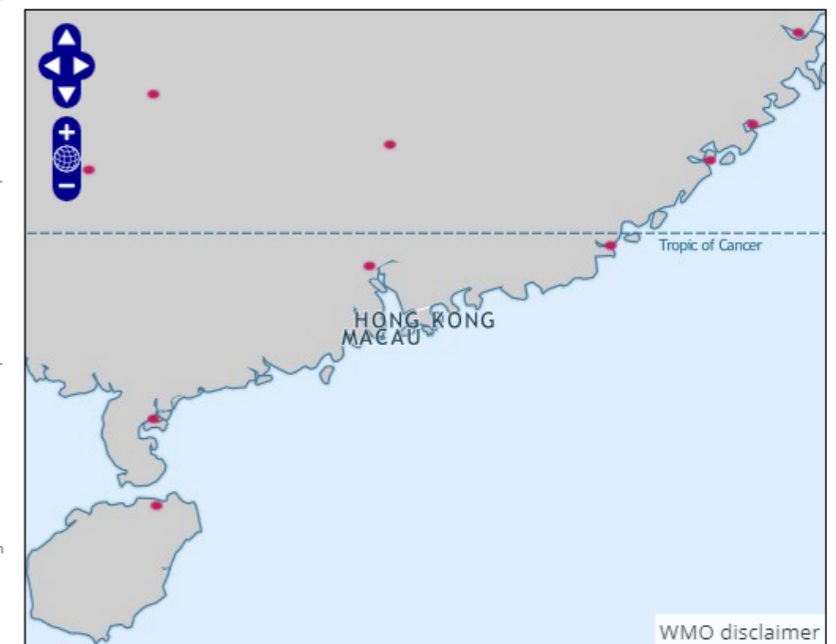
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Ambient Temperature Profile - Shenzhen



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METEOROLOGICAL
ORGANIZATION

- Mean Daily Minimum Temperature (°C)
- Mean Daily Maximum Temperature (°C)
- AVE deg C



System Comparison Methodology

(a "busy slide" explained by following slides ... **do not attempt to read it!**)

Temp	<2	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	
Days	4.80	2.5	3.4	4.3	4.8	7.3	6.5	9.7	12.2	16.6	12.6	17.2	14.5	20.0	17.4	17.8	17.3	20.4	16.4	18.7	14.8	15.6	13.5	13.8	11.2	12.6	7.4	7.5	5.6	4.8	3.9	3.4	2.2	1.7	1.1	0.9	0.1	0.0	0.0	0.0	
LT R404a	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.85	1.8	1.75	1.7	1.66	1.61	1.57	1.52	1.48	1.44	1.4	1.36	1.32	1.28	1.24	1.2	1.16	1.12	1.09	1.05	1.01	0.98	0.95	0.91	0.88	0.85	0.81	
Power Consumed	2183	1156	1535	1952	2160	3316	2956	4396	5533	7541	5741	7825	6613	9341	8360	8805	8767	10605	8810	10296	8432	9122	8100	8486	7121	8264	5006	5197	4050	3600	2989	2675	1817	1461	955	796	79	0	0	0	
LT CO2 Booster	6.02	6.02	6.02	6.02	6.02	6.02	6.02	6.02	6.02	6.02	6.02	6.02	6.02	6.02	6.02	6.02	6.02	6.02	6.02	6.02	6.02	6.02	6.02	6.02	6.02	6.02	6.02	6.02	6.02	6.02	6.02	6.02	6.02	6.02	6.02	6.02	6.02	6.02	6.02	6.02	
MT element COP	7.46	7.46	7.06	6.68	6.33	6	5.69	5.4	5.12	4.86	4.62	4.39	4.16	3.95	3.75	3.55	3.36	3.17	2.99	2.8	2.95	2.89	3.01	2.76	2.68	2.59	2.48	2.35	2.22	2.11	2	1.9	1.81	1.73	1.65	1.58	1.51	1.45	1.39	1.33	
LT Power	689	365	484	616	682	1047	933	1387	1746	2380	1812	2470	2087	2870	2500	2559	2476	2924	2356	2685	2129	2243	1938	1973	1609	1812	1064	1070	807	694	556	484	317	245	155	126	12	0	0	0	
MT Power	565	297	418	564	659	1077	1010	1600	2143	3124	2468	3596	3178	4689	4264	4618	4710	5959	5023	6160	4576	4933	4063	4517	3759	4402	2653	2816	2233	2013	1697	1553	1062	858	569	480	48	0	0	0	
Total Power Consumed	1254	662	902	1180	1341	2124	1943	2988	3889	5504	4280	6066	5265	7559	6763	7177	7186	8884	7379	8845	6705	7176	6000	6490	5367	6214	3717	3886	3041	2707	2253	2038	1379	1104	725	606	60	0	0	0	
MT R404a	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.16	4.03	3.91	3.79	3.67	3.56	3.45	3.35	3.25	3.15	3.06	2.97	2.88	2.79	2.71	2.62	2.54	2.47	2.39	2.32	2.24	2.17	2.1	2.04	1.97	1.9	1.84	
Power Consumed	1929	1021	1356	1725	1909	2930	2612	3885	4889	6664	5073	6915	5844	8308	7468	7881	7865	9593	7969	9370	7651	8308	7406	7765	6521	7575	4594	4756	3710	3288	2711	2440	1645	1318	863	720	71	0	0	0	
MT Transcritical COP	7.43	7.43	7.06	6.68	6.33	6	5.69	5.4	5.12	4.86	4.62	4.39	4.16	3.95	3.75	3.55	3.36	3.17	2.99	2.8	2.95	2.89	3.01	2.76	2.68	2.59	2.48	2.35	2.22	2.11	2	1.9	1.81	1.73	1.65	1.58	1.51	1.45	1.39	1.33	
Power Consumed	1116	591	826	1110	1297	2100	1974	3093	4106	5896	4722	6774	6040	8749	8026	8681	8871	11107	9488	11546	8689	9343	7750	8609	7227	8423	5168	5484	4378	3958	3348	3069	2108	1706	1135	957	95	0	0	0	
FTE 3C opt with																																									
MT Transcritical COP	7.43	7.43	7.43	7.43	7.01	6.63	6.27	5.94	5.62	5.33	5.05	4.79	4.53	4.3	4.07	3.85	3.64	3.43	3.23	3.23	3.17	3.11	3.04	2.96	2.88	2.78	2.67	2.52	2.38	2.25	2.14	2.03	1.94	1.84	1.76	1.68	1.61	1.54	1.47	1.41	
Power Consumed	1116	591	785	998	1171	1900	1791	2812	3741	5376	4320	6208	5547	8037	7395	8004	8189	10265	8783	10009	8086	8682	7674	8027	6725	7847	4800	5114	4084	3712	3129	2873	1967	1604	1064	900	89	0	0	0	
10% THR to R134a @60% diversity	7.43	7.43	7.06	6.68	6.33	6	5.69	5.4	5.12	4.86	4.62	4.39	4.16	3.95	3.75	3.55	3.36	3.17	2.99	2.80	2.95	2.89	3.01	2.76	2.68	2.59	2.48	2.35	2.22	2.11	2.03	1.93	1.83	1.75	1.64	1.56	1.49				
Power Consumed	1116	591	826	1110	1297	2100	1974	3093	4106	5896	4722	6774	6040	8749	8026	8681	8871	11107	9488	11546	8689	9343	7750	8609	7227	7428	4490	4817	3821	3450	2900	2668	1822	1473	983	824	82	0	0	0	
Parallel Only																																									
COP with Parallel compression @ OC	7.43	7.43	7.06	6.68	6.33	6	5.69	5.4	5.12	4.86	4.62	4.39	4.16	3.95	3.75	3.55	3.36	3.17	2.99	2.80	2.95	2.89	3.01	2.76	2.68	2.59	2.48	2.35	2.22	2.11	2.09	2.00	1.90	1.83	1.75	1.68	1.62	1.54			
Power Consumed	1116	591	826	1110	1297	2100	1974	3093	4106	5896	4722	6774	6040	8749	8026	8681	8871	11107	9488	11546	8689	9343	7750	8609	7227	7428	4490	4817	3821	3450	2900	2668	1822	1473	983	824	82	0	0	0	
Parallel + GCO cooling 10%																																									
COP with parallel compression @ OC	7.43	7.43	7.06	6.68	6.33	6	5.69	5.4	5.12	4.86	4.62	4.39	4.16	3.95	3.75	3.55	3.36	3.17	2.99	2.80	2.95	2.89	3.01	2.76	2.68	2.59	2.48	2.35	2.22	2.11	2.09	2.00	1.90	1.83	1.75	1.68	1.62	1.54			
Power Consumed	1116	591	826	1110	1297	2100	1974	3093	4106	5896	4722	6774	6040	8749	8026	8681	8871	11107	9488	11546	8689	9343	7750	8609	7227	7428	4490	4817	3821	3450	2900	2668	1822	1473	983	824	82	0	0	0	
Parallel + GCO cooling 10%+ FTE 3C opt																																									
COP with parallel compression @ OC	7.4	7.4	7.4	7.4	7.0	6.6	6.3	5.9	5.6	5.3	5.1	4.8	4.5	4.3	4.1	3.9	3.7	3.5	3.3	3.1	2.9	2.9	2.8	2.8	2.7	2.6	2.5	2.4	2.3	2.2	2.0	1.9	1.8								
Power Consumed	1116	591	785	998	1171	1900	1791	2812	3741	5376	4320	6208	5547	8037	7395	8004	8189	10265	8783	10009	8086	8682	7674	8027	6725	7847	4800	5114	4084	3712	3129	2873	1967	1604	1064	900	89	0	0	0	

Site MT Duty	120kW				Site LT Duty				40kW								
MT Utility	60%				LT Utility				90%								
Temp	< 2	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Days	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	59.00	31.00
LT R404a	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.85	1.8	1.75	1.7
Power Consumed	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	29129	15755
LT CO2 Booster	6.02	6.02	6.02	6.02	6.02	6.02	6.02	6.02	6.02	6.02	6.02	6.02	6.02	6.02	6.02	6.02	6.02
MT element COP	7.46	7.46	7.06	6.68	6.33	6	5.69	5.4	5.12	4.86	4.62	4.39	4.16	3.95	3.75	3.55	3.36
LT Power	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8468	4449
MT Power	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	17399	8858
Total Power Consumed	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	25867	13307



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System Comparison summary Shenzhen



LT R404a	
223004.57	Total Power per Year

MT R404a	
202973.95	Total Power per Year

MT Transcritical	
230422.22	Total Power per Year
+14%	R404a DX

MT Transcritical + FTE	
215215.03	Total Power per Year
+6%	R404a DX

MT Transcrit + 10% THR to R134a Chiller	
208582.17	Total Power per Year
+3%	R404a DX

MT Transcrit + Parallel Compression	
216465.00	Total Power per Year
+7%	R404a DX

MT Transcrit + Parallel Compression + 10% to chiller	
195170.30	Total Power per Year
-4%	R404a DX

MT Transcrit + Parallel Compression + 10% to chiller + FTE 3C	
182188.31	Total Power per Year
-10%	R404a DX

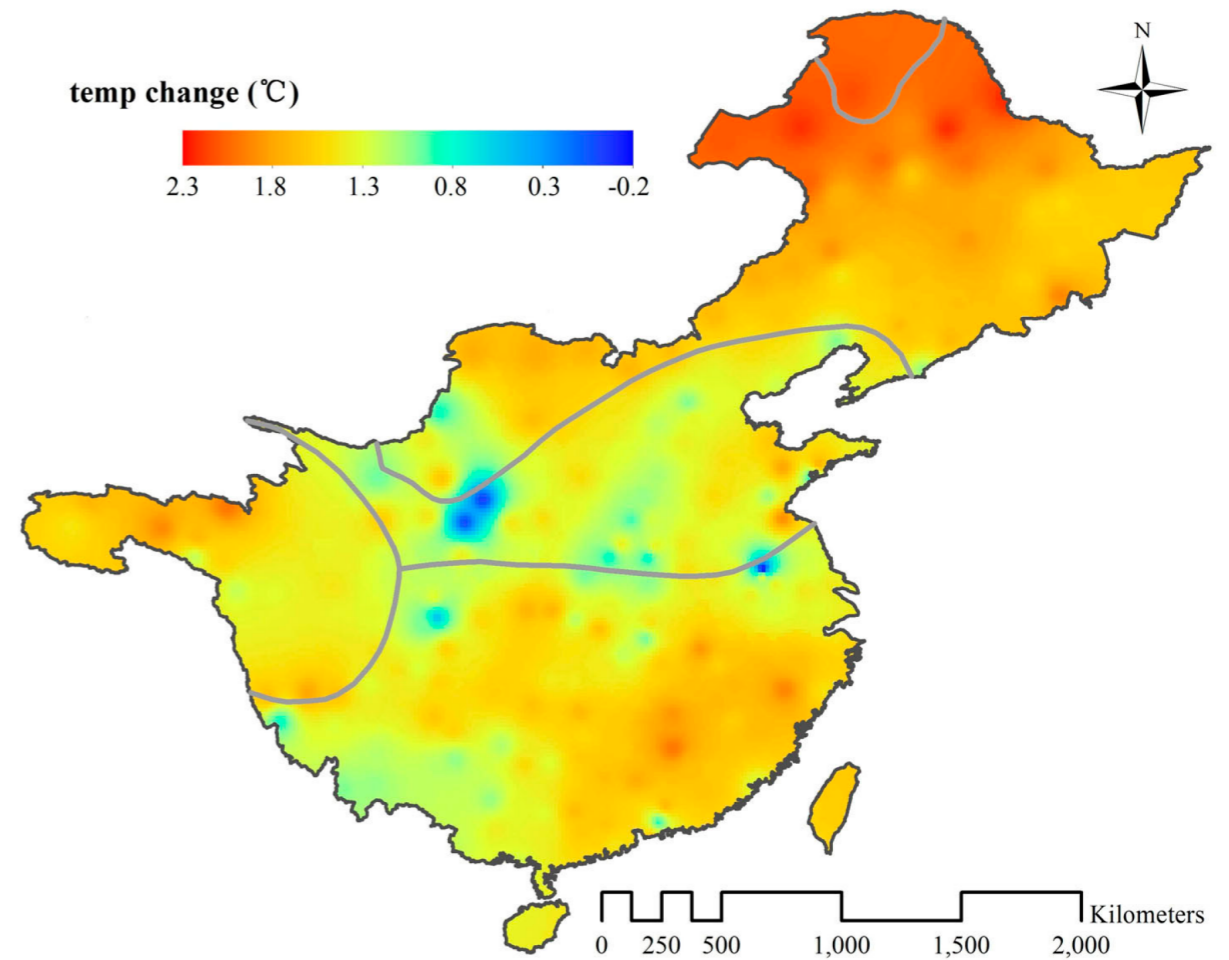
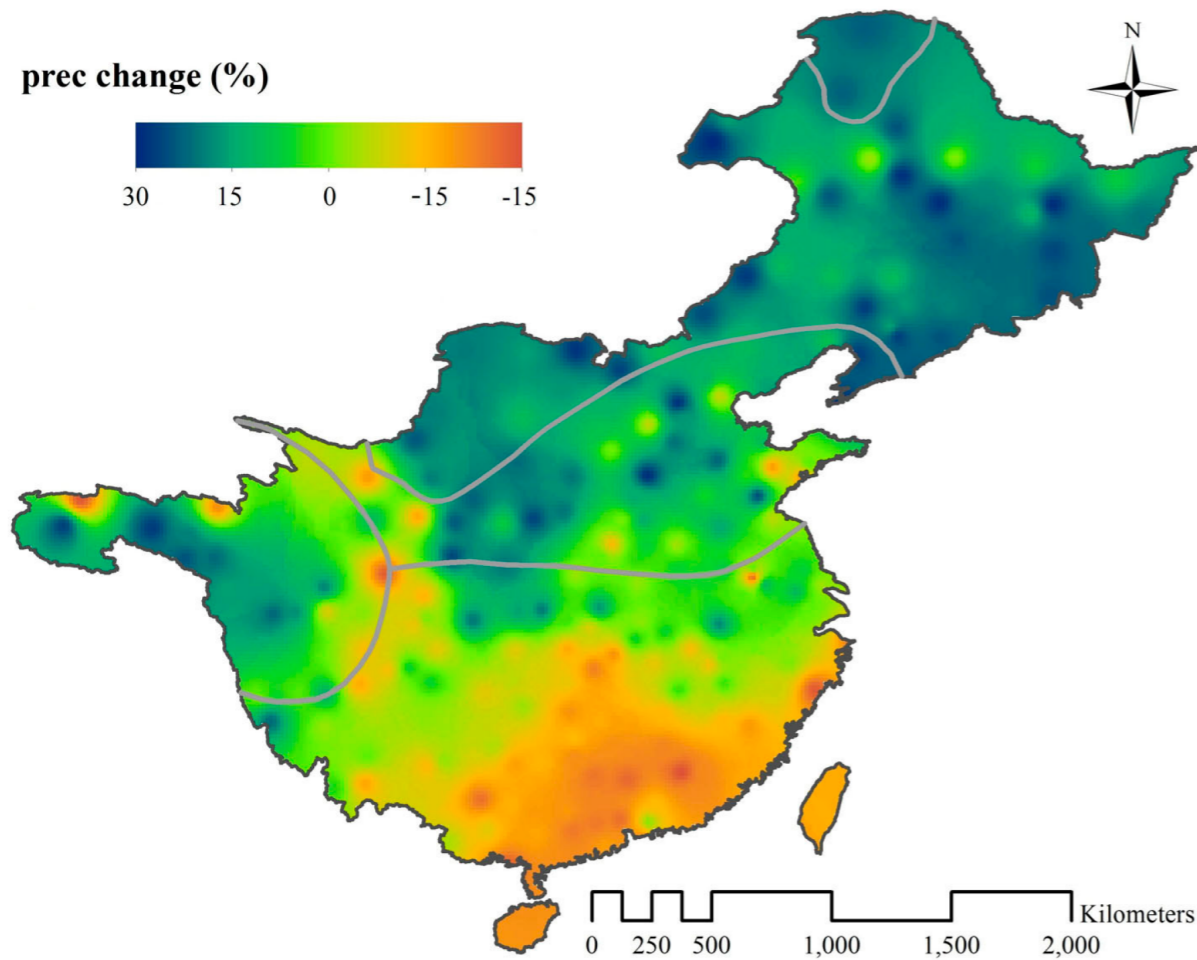
Site MT Duty	120kW	Site LT Duty	40kW
MT Utility	60%	LT Utility	90%

**...but we cannot continue
with R404A or R507!**

Projection of Climate Change Scenarios in Different Temperature Zones in the Eastern Monsoon Region, China

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Conclusions on a Study of Ambient Temperature Profile

Shenzhen



- A “Standard” CO₂ Transcritical system would be operating at limits, and be energy inefficient
- Enhancements using technology well-proven in 40+C conditions over a number of years, can provide a reliable solution with a improved energy efficiency
- The Roll-Out of such technology must take into account:
 - A step-by-step approach in each region
 - Build experience and confidence through training
 - Ensure a “joined-up” strategy
 - Consider the complete system, not at component level
 - Co-ordination of supply chain is essential



Business Case for
Natural Refrigerants

11-12/04/2018 – Beijing

Thank you very much!

