OMEGA
SOLUTIONS

INDEPENDENT REVIEW

Commissioned for:

MARSTAIR
REFRIGERATION AND SPECIALIST AIR CONDITIONING

BEER CELLAR COOLING ASSESSMENT REV B

A Comparison of Capital Cost, Operational Cost, Total Cost of Ownership (TCO), Emissions & Refrigerant Costs of Available Technologies for Beer Cellar Cooling

MARSTAIR
REFRIGERATION AND SPECIALIST AIR CONDITIONING

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VERSION CONTROL

Rev -	Draft issue for review
Rev A	Second draft for review
Rev B	Draft for issue

ABOUT OMEGA SOLUTIONS

OMEGA Solutions was established late 2021 by James Bailey to provide high quality and cost-effective consulting services in the Engineering, Energy & Environment, Training & Mentoring, and Management & Leadership sectors. James is a Chartered Engineer, Fellow of the Institute of Refrigeration, holder of a Business Management Master's Degree and Published Author.

Throughout his career James has gained extensive knowledge and experience in food retail refrigeration systems, covering all available applications including naturally occurring and next generation synthetic refrigerants. He is one of a small number of Chartered Engineers operating in the consulting sector, guaranteeing an unbiased data and fact driven approach in providing advice, guidance, and independent reporting. In 2020 he led his first company Wheatlands Aire Valley Engineering to the Number 1 ranking of all small Investors in People accredited companies in the UK, and on the 22nd of September 2022 at the RAC Cooling Industry Awards, James Bailey won the evening's most prestigious accolade – The Gold Award.

ABSTRACT

European wide legislation EU. 517/2014; commonly referred to as the F-gas regulations will phase down the use of HFC refrigerants by 79% in stages between 2017 and 2030. The purpose of this phase-down is to limit the direct emissions of refrigeration systems. A review to EU. 517/2014 is imminent and is expected to place further onus on the phase down targets.

The 79% reduction is based on the CO2 emission of a refrigerant, and this is calculated from its Global Warming Potential (GWP). To mitigate the impact of the phase-down, low GWP refrigerants known as A2L's have been introduced to the cellar cooling market. It is important that A2L refrigeration systems are adopted as the market availability of HFC will reduce in the coming years, and the cost of HFC refrigerants are projected to increase annually by 30%.

This report presents findings on the following metrics of 'previous generation' beer cellar coolers (operating on HFC refrigerants) that are currently sold in the UK and a recently developed Marstair A2L system:

- Capital Cost
- Energy Consumption
- Total Cost of Ownership
- Emissions
- Global Warming Potential
- System Charge Volume and Duty Comparison

TABLES AND FIGURES

1. EXECUTIVE SUMMARY

The findings of this report are based on five beer cellar coolers; three that are available from Marstair and two competing products. Table 1 identifies the capital costs (CAPEX) by system:

Model / Type / Refrigerant of System	CAPEX System Cost £
Marstair Trad R407C	£ 2,237
Marstair Pump Down R407C	£ 2,447
Competitor System R448A	£ 2,559
Competitor System R410A	£ 1,620
Marstair A2L - R454A	£ 4,521

TABLE 1 – CAPEX COST OF EACH SYSTEM

Though Marstair's A2L system has a higher capital cost, it is compliant to the F-Gas regulations and as such is future-proof. Additionally, it has the lowest energy consumption of the five systems assessed, and when layering the current and future cost of refrigerant, it also has the lowest Total Cost of Ownership (TCO) and emissions.

Based on OMEGA Solutions calculations, Table 2 identifies the annual energy and refrigerant operational (OPEX) cost of the systems per kW of cooling at the current energy rate of £0.25 kWh and at a projected increased rate of £0.40 kWh. As the cooling duty varies, Table 3 identifies the energy cost of each specific system:

Model / Type / Refrigerant of System	Annual OPEX Cost: Energy (£0.25 kWh) & Leakage	Annual OPEX Cost: Energy (£0.40 kWh) & Leakage
Marstair Trad R407C	£ 698	£ 986
Marstair Pump Down R407C	£ 735	£ 1,022
Competitor System R448A	£ 859	£ 1,125
Competitor System R410A	£ 709	£ 1,010
Marstair A2L - R454A	£ 430	£ 674

TABLE 2 – OPEX COST PER kW OF COOLING OF EACH SYSTEM

Annual Energy Cost of the System (£0.25 kWh)	Annual Energy Cost of the System (£0.40 kWh)
£ 2,395	£ 3,832
£ 2,395	£ 3,832
£ 1,995	£ 3,192
£ 2,145	£ 3,433
£ 1,789	£ 2,862

TABLE 3 – ENERGY COST OF EACH SYSTEM

Based on OMEGA Solutions calculations, Table 4 identifies the 10-year Life-Time Energy Cost at £0.25 kWh, OPEX TCO per kW, OPEX TCO per system, TCO (CAPEX & OPEX) per kW, and TCO (CAPEX & OPEX) per system:

	Based on Electricity Rate of £0.25 kWh				
Model / Type / Refrigerant of System	**Life Time Energy Cost £0.25 kWh of the System**	**OPEX TCO (Energy + Refrigerant) per kW**	**OPEX TCO (Energy + Refrigerant) of the System**	**Total per kW TCO based on £0.25 kWh: OPEX + CAPEX**	**Total System TCO based on £0.25 kWh: OPEX + CAPEX**
Marstair Trad R407C	£ 23,947	£ 6,983	£ 34,913	£ 7,430	£ 37,150
Marstair Pump Down R407C	£ 23,947	£ 7,346	£ 36,730	£ 7,835	£ 39,177
Competitor System R448A	£ 19,949	£ 8,586	£ 38,637	£ 9,155	£ 41,196
Competitor System R410A	£ 21,455	£ 7,088	£ 30,266	£ 7,467	£ 31,886
Marstair A2L - R454A	£ 17,891	£ 4,305	£ 18,941	£ 5,332	£ 23,462

TABLE 4 – ENERGY AND TCO – OPEX, OPEX & CAPEX BY kW AND BY SYSTEM (£0.25 kWh)

In Q4 2022, the cost of electricity will increase, and this assessment has projected a cost increase to £0.40 kWh. Table 5 identifies the 10-year Life-Time Energy Cost at £0.40 kWh, OPEX TCO per kW, OPEX TCO per system, TCO (CAPEX & OPEX) per kW, and TCO (CAPEX & OPEX) per system:

	Based on Electricity Rate of £0.40 kWh				
Model / Type / Refrigerant of System	**Life Time Energy Cost £0.40 kWh of the System**	**OPEX TCO (Energy + Refrigerant) per kW**	**OPEX TCO (Energy + Refrigerant) of the System**	**Total per kW TCO based on £0.40 kWh: OPEX + CAPEX**	**Total System TCO based on £0.40 kWh: OPEX + CAPEX**
Marstair Trad R407C	£ 38,315	£ 9,856	£ 49,281	£ 10,304	£ 51,518
Marstair Pump Down R407C	£ 38,315	£ 10,220	£ 51,098	£ 10,709	£ 53,545
Competitor System R448A	£ 31,919	£ 11,246	£ 50,607	£ 11,815	£ 53,166
Competitor System R410A	£ 34,328	£ 10,103	£ 43,139	£ 10,482	£ 44,759
Marstair A2L - R454A	£ 28,625	£ 6,744	£ 29,676	£ 7,772	£ 34,196

TABLE 5 – ENERGY AND TCO – OPEX, OPEX & CAPEX BY kW AND BY SYSTEM (£0.40 kWh)

Based on OMEGA Solutions calculations, Table 6 presents the life-time emissions of each system:

Model / Type / Refrigerant of System	Life Time TEWI TCO2
Marstair Trad R407C	35.55
Marstair Pump Down R407C	38.07
Competitor System R448A	39.47
Competitor System R410A	35.07
Marstair A2L - R454A	15.98

TABLE 6 – LIFE-TIME EMISSIONS OF EACH SYSTEM

Note:

- TCO is based on Capital Cost, Energy & 50% Refrigerant Charge Loss per Year and 2032 Projected Refrigerant Costs.
- TEWI – Total Environmental Warming Impact

Important considerations surrounding HFC refrigerants are availability and cost. Figure 1a below identifies the projected cost of refrigerants (HFCs and HFOs) from 2023 up until 2032.

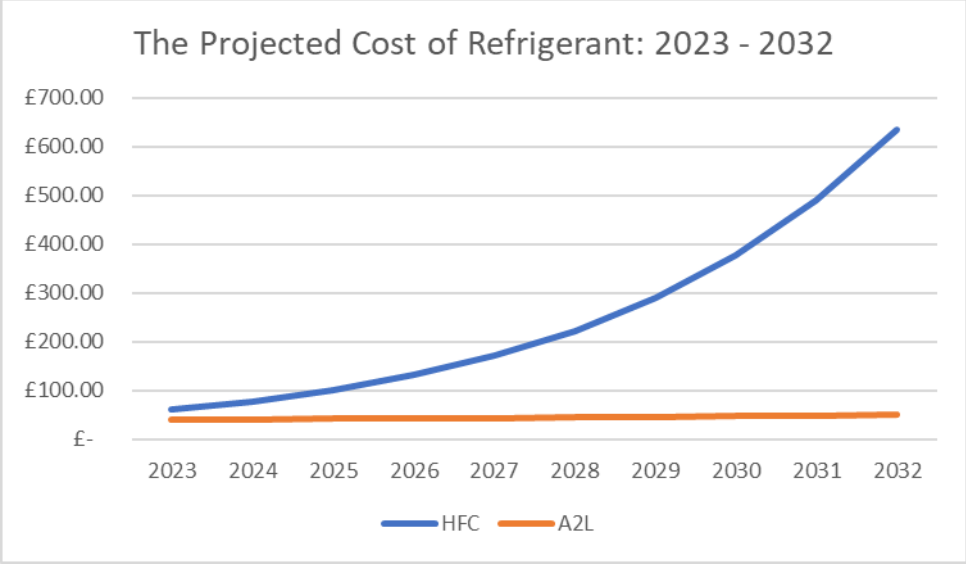

FIGURE 1a – THE PROJECTED COST OF REFRIGERANTS

Providing substantiation to the projected cost increase in refrigerants, in July 2022, The Cooling Post and identified the current and continuing rising cost of refrigerants. This graph is included to provide back-up to the data presented in this executive summary and section 3 of this report.

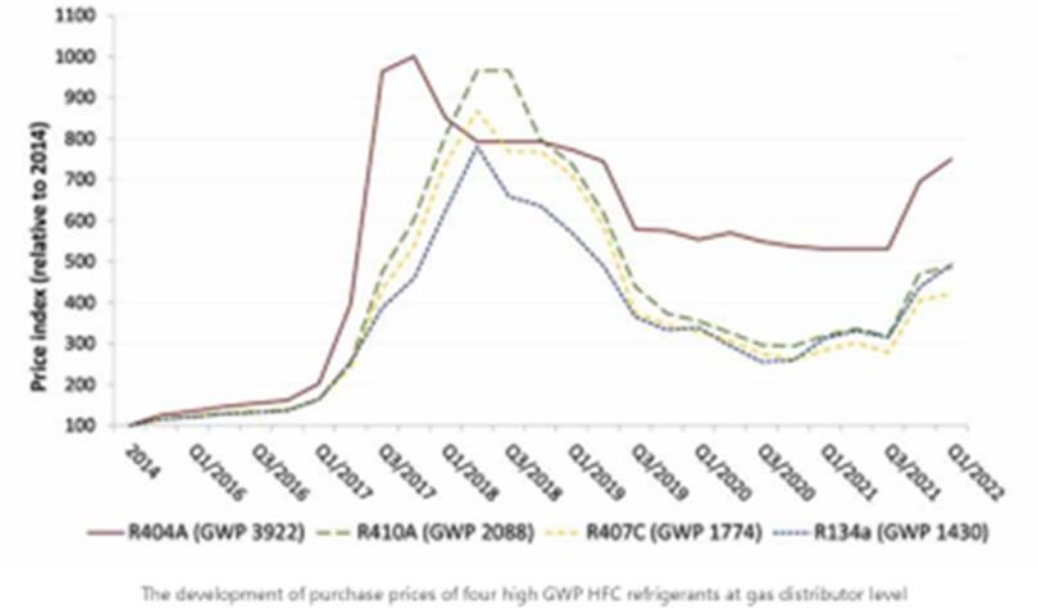

FIGURE 1b – THE PROJECTED COST OF REFRIGERANTS

Selecting a beer cellar cooling system based on capital cost is not viable or advisable, owing to reduced energy efficiency, higher TCO, lower environmental/emission benefits, and volatility/availability of HFC refrigerants, OMEGA Solutions would strongly recommend that A2L systems are selected for any new or upgraded cellar cooling requirements.

2. GRAPHICAL RESULTS AND CALCULATIONS

Figure 1 below presents the capital cost of the five-cellar cooling system assessed.

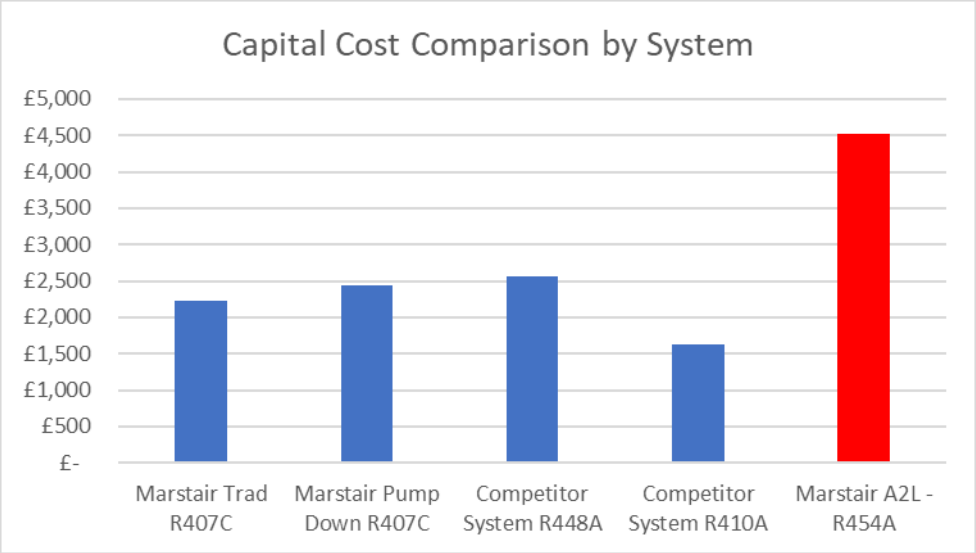

FIGURE 2 – CAPITAL COST

Though the capital cost of the A2L system is higher than HFC system equivalents, they are far superior in terms of every other metric. Figure 3 below presents the projected annual energy consumption of the five systems assessed.

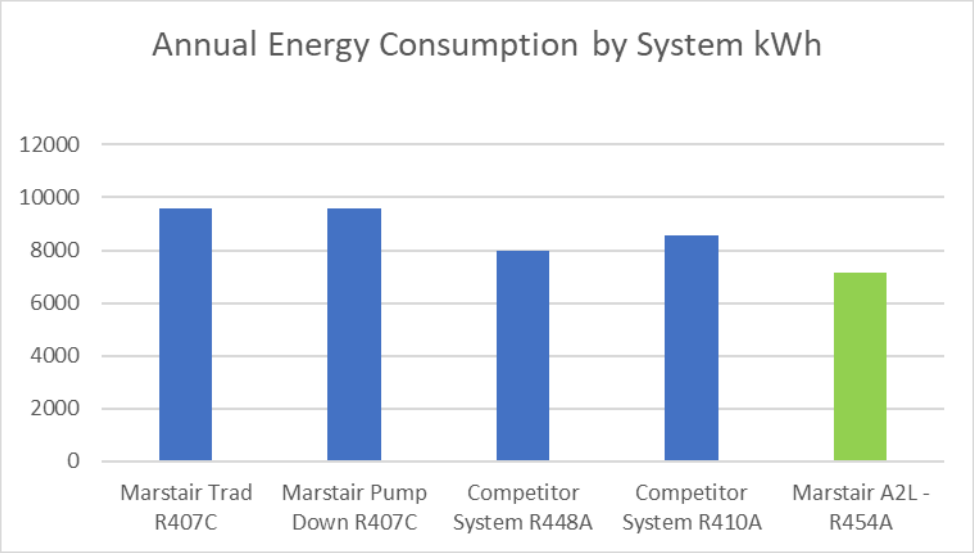

FIGURE 3 – ENERGY CONSUMPTION BY SYSTEM

The five systems assessed are of similar cooling duty, but they are different. Figure 4 presents the projected annual energy consumption of the five systems on a kW v kW basis.

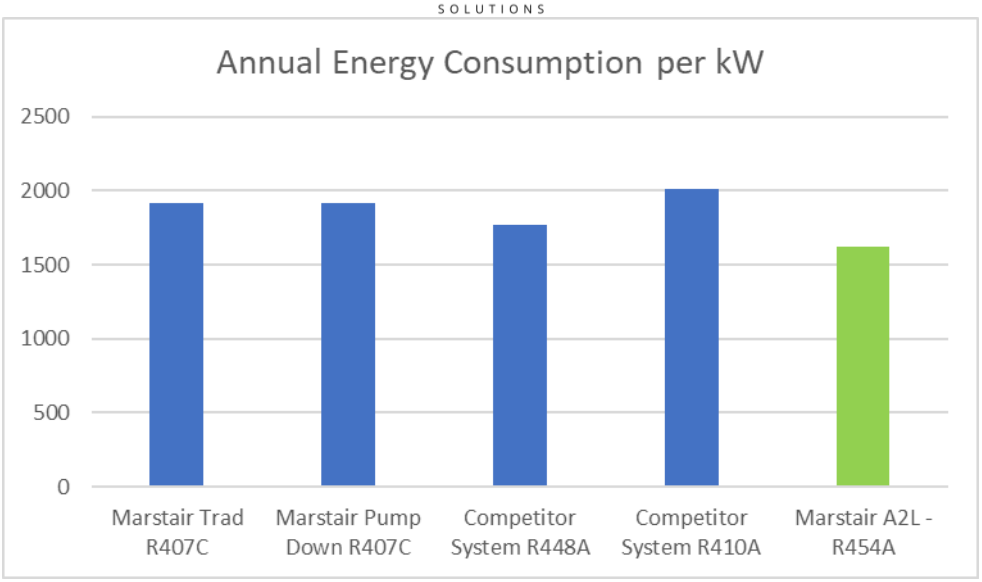

FIGURE 4 – ENERGY CONSUMPTION BY kW

Due to the energy performance of A2L refrigerants, this has a positive impact on a ten-year system lifetime. Figure 5 below presents the TCO of the five systems assessed based on a current cost of electricity £0.25 kWh, and a projected rate of £0.40 kWh.

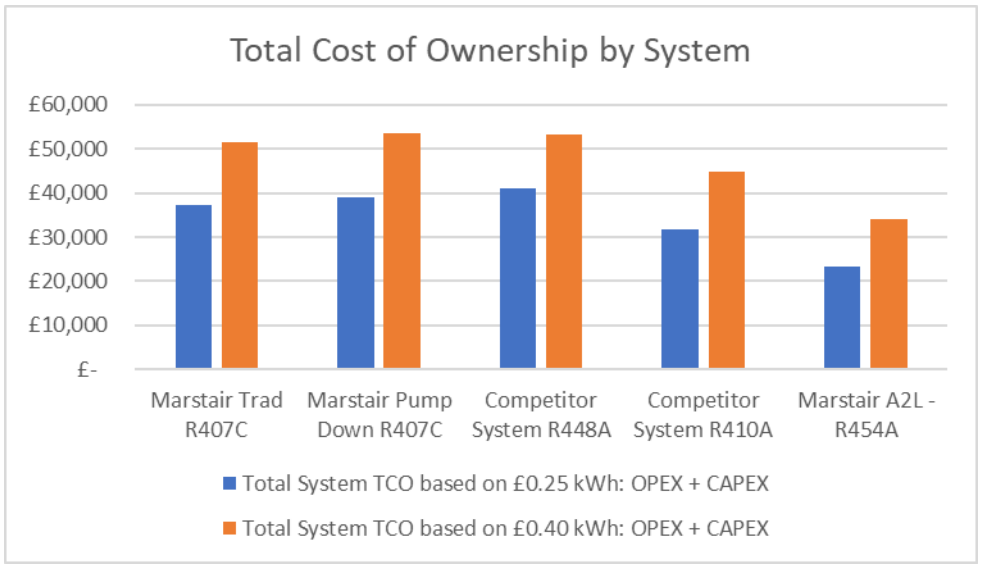

FIGURE 5 – TOTAL COST OF OWNERSHIP

Energy and refrigerant costs are the contributing factors in the A2L system having the lowest TCO, and there is a further significant benefit in that this system type has the lowest lifetime emissions. Figure 6 on the following page presents the emissions of the five systems assessed.

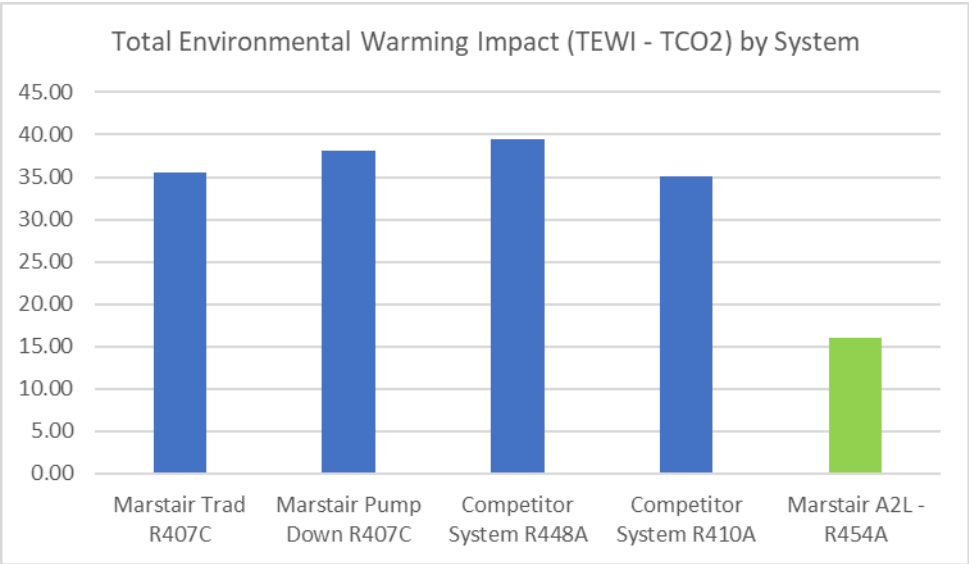

FIGURE 6 – EMISSIONS

System emissions are made up of direct (a consequence of refrigerant leakage) and indirect (energy consumption). From a direct emissions perspective, the driving factor is the Global Warming Potential of the systems refrigerant, Figure 7 below presents the Global Warming Potential of the four different refrigerants that this report assesses.

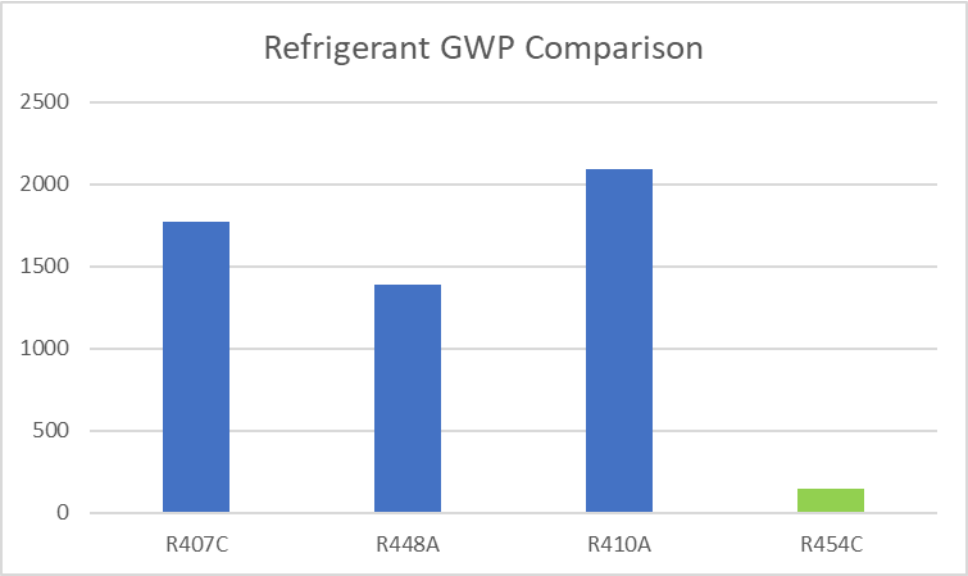

FIGURE 7 – GLOBAL WARMING POTENTIAL

It is clearly visible that from an environmental position that A2L refrigerants are more sustainable than previous generation refrigerants and will help support the transition to a Net Zero/Carbon Neutral future. Whilst refrigerants are a necessity, it is important to minimise their use. Marstair's A2L beer cellar cooling systems have incorporated novel technologies to reduce the amount of refrigerant that is required in their systems. Figure 8 on the following page compares refrigerant charge volume against the cooling duty required.

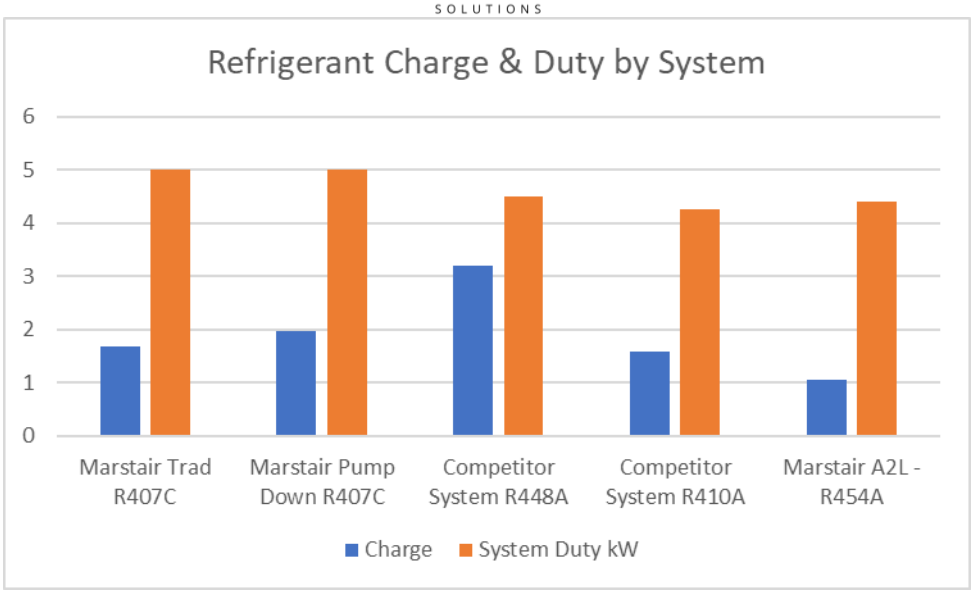

FIGURE 8 – REFRIGERANT CHARGE & COOLING DUTY

It is visible that Marstair's A2L system requires less refrigerant by system duty when compared to the other four systems assessed.

Figures 9, 10, 11, 12 and 13 presented on the following pages are OMEGA Solutions projected energy and emission calculations that this report is based on.

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Beer Cellar Cooling Analysis - Marstair CKC50

1	No. of Comps	Condensing Temperature (°C)											
£ 0.25	kW / H Cost	15		20		25		30		35		40	
		Power Input (kW)	Capacity (kW)	Power Input (kW)	Capacity (kW)	Power Input (kW)	Capacity (kW)	Power Input (kW)	Capacity (kW)	Power Input (kW)	Capacity (kW)	Power Input (kW)	Capacity (kW)
Compressor (ZR24)		1.00	6.52	1.21	6.21	1.27	5.92	1.34	5.63	1.41	5.37	1.48	5.11

Ambient Temperature (°C)	Annual Hours	Condensing Temperature (°C)	Ave duty / comp (kW)	No. of Comps	Applied load (kW)	No. of Comps Req	Ave PI / Comp (kW)	Total PI (kW/H)	THR (kW)	COP
32	13	43	5.11	1	5.00	0.98	1.48	18.83	6.45	3.45
27	145	38	5.37	1	5.00	0.93	1.406	189.98	6.31	3.82
22	692	33	5.63	1	5.00	0.89	1.3357	820.32	6.19	4.22
17	2152	23	5.92	1	5.00	0.85	1.268915	2,308.11	6.07	4.66
12	2863	18	6.21	1	5.00	0.80	1.20546925	2,778.24	5.97	5.15
7	2895	13	6.52	1	5.00	0.77	0.9975	2,213.93	5.76	6.54
										Ave COP
										4.64

Modelled SYSTEM Annual Energy Consumption (kW/H)		Total SYSTEM Annual Energy Consumption (kW)	Total Cost (£)
Compressors	8,329.41	9,579	£ 2,395
Fans	1,249.41		

Beer Cellar Cooling TEWI Analysis	
Application	DX
Refrigerant	R407C
Refrigerant Charge (Kg)	1.69
Annual Energy Consumption	
Compressors (kW/H)	8,329.41
Ancillaries (kW/H)	1,249.41
Sectorial Factors	
System Operational Life Time (years)	10
Refrigerant GWP	1774
Annual Leakage (%)	50
Automatic Purges (%)	0
Service Release (%)	0.25
Accidental Sudden Release (%)	0
Recovery Efficiency	0.95
CO^2 Emission Factor; ß (Kg CO^2 / kWh)	0.21233
TEWI Calculations	
a) Direct Effect	
Refrigerant Loss (Operational) (kg)	8.49
Refrigerant Loss (Retirement) (kg)	0.08
Total Lifetime Refrigerant Loss (kg)	8.58
CO^2 Equivalent (kg)	15215.15
b) Indirect Effect	
Indirect Effect (Kg CO^2)	20338.71
c) TEWI	
TEWI (kg CO^2)	35553.86
TEWI (Tonne CO^2)	35.55

FIGURE 9 – MARSTAIR R407C (NON-PUMP DOWN MODEL) PROJECTED ENERGY & EMISSIONS CALCULATION

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Beer Cellar Cooling Analysis - Marstair CKC50 PD

1	No. of Comps	Condensing Temperature (°C)											
£ 0.25	kW / H Cost	15		20		25		30		35		40	
		Power Input (kW)	Capacity (kW)	Power Input (kW)	Capacity (kW)	Power Input (kW)	Capacity (kW)	Power Input (kW)	Capacity (kW)	Power Input (kW)	Capacity (kW)	Power Input (kW)	Capacity (kW)
Compressor (ZR24)		1.00	6.52	1.21	6.21	1.27	5.92	1.34	5.63	1.41	5.37	1.48	5.11

Ambient Temperature (°C)	Annual Hours	Condensing Temperature (°C)	Ave duty / comp (kW)	No. of Comps	Applied load (kW)	No. of Comps Req	Ave PI / Comp (kW)	Total PI (kW/H)	THR (kW)	COP
32	13	43	5.11	1	5.00	0.98	1.48	18.83	6.45	3.45
27	145	38	5.37	1	5.00	0.93	1.406	189.98	6.31	3.82
22	692	33	5.63	1	5.00	0.89	1.3357	820.32	6.19	4.22
17	2152	23	5.92	1	5.00	0.85	1.268915	2,308.11	6.07	4.66
12	2863	18	6.21	1	5.00	0.80	1.20546925	2,778.24	5.97	5.15
7	2895	13	6.52	1	5.00	0.77	0.9975	2,213.93	5.76	6.54
										Ave COP
										4.64

Modelled SYSTEM Annual Energy Consumption (kW/H)		Total SYSTEM Annual Energy Consumption (kW)	Total Cost (£)
Compressors	8,329.41	9,579	£ 2,395
Fans	1,249.41		

Beer Cellar Cooling TEWI Analysis	
Application	DX
Refrigerant	R407C
Refrigerant Charge (Kg)	1.97
Annual Energy Consumption	
Compressors (kW/H)	8,329.41
Ancillaries (kW/H)	1,249.41
Sectorial Factors	
System Operational Life Time (years)	10
Refrigerant GWP	1774
Annual Leakage (%)	50
Automatic Purges (%)	0
Service Release (%)	0.25
Accidental Sudden Release (%)	0
Recovery Efficiency	0.95
CO^2 Emission Factor; ß (Kg CO^2 / kWh)	0.21233
TEWI Calculations	
a) Direct Effect	
Refrigerant Loss (Operational) (kg)	9.90
Refrigerant Loss (Retirement) (kg)	0.10
Total Lifetime Refrigerant Loss (kg)	10.00
CO^2 Equivalent (kg)	17736.01
b) Indirect Effect	
Indirect Effect (Kg CO^2)	20338.71
c) TEWI	
TEWI (kg CO^2)	38074.72
TEWI (Tonne CO^2)	38.07

FIGURE 10 – MARSTAIR R407C (PUMP DOWN MODEL) PROJECTED ENERGY & EMISSIONS CALCULATION

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Competitor R448A System

1	No. of Comps	Condensing Temperature (°C)											
£ 0.25	kW / H Cost	15		20		25		30		35		40	
		Power Input (kW)	Capacity (kW)	Power Input (kW)	Capacity (kW)	Power Input (kW)	Capacity (kW)	Power Input (kW)	Capacity (kW)	Power Input (kW)	Capacity (kW)	Power Input (kW)	Capacity (kW)
Compressor (ZS11)		0.92	5.51	0.86	5.28	0.94	5.02	1.03	4.78	1.14	4.54	1.26	4.31

Ambient Temperature (°C)	Annual Hours	Condensing Temperature (°C)	Ave duty / comp (kW)	No. of Comps	Applied load (kW)	No. of Comps Req	Ave PI / Comp (kW)	Total PI (kW/H)	THR (kW)	COP
32	13	43	4.31	1	4.50	1.04	1.26	17.10	5.82	3.42
27	145	38	4.54	1	4.50	0.99	1.14	163.84	5.63	3.98
22	692	33	4.78	1	4.50	0.94	1.03	671.01	5.47	4.64
17	2152	23	5.02	1	4.50	0.90	0.94	1,813.34	5.34	5.34
12	2863	18	5.28	1	4.50	0.85	0.86	2,098.45	5.23	6.14
7	2895	13	5.51	1	4.50	0.82	0.92	2,175.19	5.25	5.99
										Ave COP
										4.92

Modelled SYSTEM Annual Energy Consumption (kW/H)		Total SYSTEM Annual Energy Consumption (kW)	Total Cost (£)
Compressors	6,938.93	7,980	£ 1,995
Fans	1,040.84		

Beer Cellar Cooling TEWI Analysis	
Application	DX
Refrigerant	R448A
Refrigerant Charge (Kg)	3.2
Annual Energy Consumption	
Compressors (kW/H)	6,938.93
Ancillaries (kW/H)	1,040.84
Sectorial Factors	
System Operational Life Time (years)	10
Refrigerant GWP	1387
Annual Leakage (%)	50
Automatic Purges (%)	0
Service Release (%)	0.25
Accidental Sudden Release (%)	0
Recovery Efficiency	0.95
CO^2 Emission Factor; ß (Kg CO^2 / kWh)	0.21233
TEWI Calculations	
a) Direct Effect	
Refrigerant Loss (Operational) (kg)	16.08
Refrigerant Loss (Retirement) (kg)	0.16
Total Lifetime Refrigerant Loss (kg)	16.24
CO^2 Equivalent (kg)	22524.88
b) Indirect Effect	
Indirect Effect (Kg CO^2)	16943.45
c) TEWI	
TEWI (kg CO^2)	39468.33
TEWI (Tonne CO^2)	39.47

FIGURE 11 – COMPETITOR SYSTEM OPERATING ON R448A PROJECTED ENERGY & EMISSIONS CALCULATION

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Competitor R410A System

1	No. of Comps	Condensing Temperature (°C)											
£ 0.25	kW / H Cost	15		20		25		30		35		40	
		Power Input (kW)	Capacity (kW)	Power Input (kW)	Capacity (kW)	Power Input (kW)	Capacity (kW)	Power Input (kW)	Capacity (kW)	Power Input (kW)	Capacity (kW)	Power Input (kW)	Capacity (kW)
Compressor (ZS11)		0.97	5.50	1.03	5.24	1.08	4.99	1.14	4.75	1.20	4.53	1.26	4.31

Ambient Temperature (°C)	Annual Hours	Condensing Temperature (°C)	Ave duty / comp (kW)	No. of Comps	Applied load (kW)	No. of Comps Req	Ave PI / Comp (kW)	Total PI (kW/H)	THR (kW)	COP
32	13	43	4.31	1	4.27	0.99	1.26	16.23	5.52	3.42
27	145	38	4.53	1	4.27	0.94	1.20	163.77	5.40	3.78
22	692	33	4.75	1	4.27	0.90	1.14	707.12	5.29	4.18
17	2152	23	4.99	1	4.27	0.86	1.08	1,989.60	5.19	4.62
12	2863	18	5.24	1	4.27	0.82	1.03	2,394.86	5.11	5.10
7	2895	13	5.50	1	4.27	0.78	0.97	2,190.99	5.03	5.64
										Ave COP
										4.46

Modelled SYSTEM Annual Energy Consumption (kW/H)		Total SYSTEM Annual Energy Consumption (kW)	Total Cost (£)
Compressors	7,462.57	8,582	£ 2,145
Fans	1,119.39		

Beer Cellar Cooling TEWI Analysis	
Application	DX
Refrigerant	R410A
Refrigerant Charge (Kg)	1.59
Annual Energy Consumption	
Compressors (kW/H)	7,462.57
Ancillaries (kW/H)	1,119.39
Sectorial Factors	
System Operational Life Time (years)	10
Refrigerant GWP	2088
Annual Leakage (%)	50
Automatic Purges (%)	0
Service Release (%)	0.25
Accidental Sudden Release (%)	0
Recovery Efficiency	0.95
CO^2 Emission Factor; ß (Kg CO^2 / kWh)	0.21233
TEWI Calculations	
a) Direct Effect	
Refrigerant Loss (Operational) (kg)	7.99
Refrigerant Loss (Retirement) (kg)	0.08
Total Lifetime Refrigerant Loss (kg)	8.07
CO^2 Equivalent (kg)	16848.59
b) Indirect Effect	
Indirect Effect (Kg CO^2)	18222.07
c) TEWI	
TEWI (kg CO^2)	35070.67
TEWI (Tonne CO^2)	35.07

FIGURE 12 – COMPETITOR SYSTEM OPERATING ON R410A PROJECTED ENERGY & EMISSIONS CALCULATION

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OMEGA SOLUTIONS

Beer Cellar Cooling Analysis - Marstair SMC+45

1	No. of Comps	Condensing Temperature (°C)											
£ 0.25	kW / H Cost	15		20		25		30		35		40	
		Power Input (kW)	Capacity (kW)	Power Input (kW)	Capacity (kW)	Power Input (kW)	Capacity (kW)	Power Input (kW)	Capacity (kW)	Power Input (kW)	Capacity (kW)	Power Input (kW)	Capacity (kW)
Compressor (YB12)		1.02	5.83	0.93	5.57	1.02	5.31	1.12	5.05	1.22	4.78	1.29	4.40

Ambient Temperature (°C)	Annual Hours	Condensing Temperature (°C)	Ave duty / comp (kW)	No. of Comps	Applied load (kW)	No. of Comps Req	Ave PI / Comp (kW)	Total PI (kW/H)	THR (kW)	COP
32	13	43	4.40	1	4.40	1.00	1.29	16.73	5.69	3.42
27	145	38	4.78	1	4.40	0.92	1.22	162.84	5.52	3.92
22	692	33	5.05	1	4.40	0.87	1.12	675.28	5.38	4.51
17	2152	23	5.31	1	4.40	0.83	1.02	1,818.87	5.25	5.21
12	2863	18	5.57	1	4.40	0.79	0.93	2,103.30	5.13	5.99
7	2895	13	5.83	1	4.40	0.75	1.02	2,228.60	5.17	5.72
										Ave COP
										4.79

Modelled SYSTEM Annual Energy Consumption (kW/H)		Total SYSTEM Annual Energy Consumption (kW)	Total Cost (£)
Compressors	6,305.05	7,156	£ 1,789
Fans	851.18		

Beer Cellar Cooling TEWI Analysis	
Application	DX
Refrigerant	R454C
Refrigerant Charge (Kg)	1.05
Annual Energy Consumption	
Compressors (kW/H)	6,305.05
Ancillaries (kW/H)	851.18
Sectorial Factors	
System Operational Life Time (years)	10
Refrigerant GWP	148
Annual Leakage (%)	50
Automatic Purges (%)	0
Service Release (%)	0.25
Accidental Sudden Release (%)	0
Recovery Efficiency	0.95
CO^2 Emission Factor; ß (Kg CO^2 / kWh)	0.21233
TEWI Calculations	
a) Direct Effect	
Refrigerant Loss (Operational) (kg)	5.28
Refrigerant Loss (Retirement) (kg)	0.05
Total Lifetime Refrigerant Loss (kg)	5.33
CO^2 Equivalent (kg)	788.66
b) Indirect Effect	
Indirect Effect (Kg CO^2)	15194.84
c) TEWI	
TEWI (kg CO^2)	15983.49
TEWI (Tonne CO^2)	15.98

FIGURE 13 – MARSTAIR A2L SYSTEM PROJECTED ENERGY & EMISSIONS CALCULA

MARSTAIR
REFRIGERATION AND SPECIALIST AIR CONDITIONING

3. CONSIDERATIONS

A2L systems are classified as being mildly flammable. In considering an A2L it is necessary that the following factors are assessed and where appropriate consider the following:

- Flammability potential – consider suitable segregation, component choice (ATEX rated and DSEAR conforming) and eliminating ignition sources where appropriate
- Install a suitable leak detection system
- As with any refrigerant – handle with care in a ventilated area with tools and equipment specific for the refrigerant
- The projected capital cost uplift associated with A2L versus HFC systems are concerned with mitigation – compliance to ATEX/DSEAR/ventilation/leak detection

ASDA and Central England Co-op are two end users of refrigerants who have successfully adopted A2L refrigeration systems. These two retailers selected A2L technology based on TCO, emissions, system familiarity with HFCs and safety.