OMEGA
SOLUTIONS

INDEPENDENT REVIEW

Commissioned for:

MARSTAIR
REFRIGERATION AND SPECIALIST AIR CONDITIONING

REFRIGERATION IN CONVNEIENCE RETAIL EVALUATION REV B

A Comparison of Capital Cost, Operational Cost, Total Cost of Ownership, Emissions & Refrigerant Costs of Available Refrigeration Technologies in the Retail Convenience Sector

MARSTAIR
REFRIGERATION AND SPECIALIST AIR CONDITIONING

CONTENTS

VERSION CONTROL

Rev -	Draft issue for review
Rev A	Updated to reflect average retail kWh rate costs
Rev B	Updated for distribution

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.

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 (both synthetic and naturally occurring) have and continue to be placed on the market. The current industry-led trend in food retail is the adoption of naturally occurring refrigerants, with the most common applied being CO2, which has a GWP of one.

Alternatives to CO2 exist; newly developed A2L refrigerants are available, viable, and match a repeatable small plant footprint and space requirement that will meet the model construction design standard of convenience food retailers*

This report presents findings on the following metrics of CO2 and A2L refrigeration systems:

- CAPEX Cost
- OPEX Cost (with analysis provided on the pre-2022 energy cost increase (£0.153) and current kWh rate of electricity (£0.224)
- Total Cost of Ownership
- Emissions
- Refrigerant Volume

*Though CO2 is the main alternative to A2L refrigeration systems, based on information available to OMEGA Solutions, this report also assesses other available refrigeration technologies that are suitable for the convenience food retail sector:

- HFC's (including but not limited to R404A, R407A, R407F, R448A and R449A) - due to the F-gas regulations and Kigali agreement, they are considered obsolete but included for:
    - Information/emphasising that F-Gas compliant technologies will increase capital cost
    - The likely and significant cost increase of these refrigerants in the coming years
- Air Cooled Integrals
- Secondary Glycol

TABLE OF FIGURES

1. EXECUTIVE SUMMARY

The findings of this report are based on a convenience store containing the following connected linear meters of Chilled and Frozen Food (presenting a "typical" small convenience store):

- Chilled – 34.71m (display cases and one small coldroom)
- Frozen – 5.63m (display cases and one small coldroom)

The report identifies the following key findings:

- **Based on OMEGA Solutions calculations, the capital costs* by technology are:**
  - £143,892.78 – HFC (considered obsolete)
  - £158,455.52 – A2L
  - £183,708.36 – CO2
  - £129,491.40 – Air Cooled Integrals
  - £195,366.36 – Secondary Glycol

*Circa. 10% of the capital costs are apportioned to store heating (air conditioning heat pumps operating on R32)

- **Based on OMEGA Solutions calculations, the annual energy costs based on the previous energy tariffs by technology are:**
  - £20,663.67 – HFC (considered obsolete)
  - £19,909.44 – A2L
  - £27,553.00 – CO2
  - £35,907.48 – Air Cooled Integrals
  - £22,149.83 – Secondary Glycol

- **Based on OMEGA Solutions calculations, the annual energy costs based on current energy tariffs by technology are:**
  - £30,252.69 – HFC (considered obsolete)
  - £29,148.46 – A2L
  - £40,309.76 – CO2
  - £52,570.43 – Air Cooled Integrals
  - £32,428.51 – Secondary Glycol

- **Based on OMEGA Solutions calculations, the Total Cost of Ownership/TCO (14-years including a mid-life refit where plant is retained) determined on the previous energy tariffs are:**
  - £580,078.17 – HFC (considered obsolete)
  - £586,994.32 – A2L
  - £741,778.82 – CO2
  - £818,163.53 – Air Cooled Integrals
  - £672,738.05 – Secondary Glycol

- **Based on OMEGA Solutions calculations, the Total Cost of Ownership/TCO (14-years including a mid-life refit where plant is retained) determined on current energy tariffs are:**
    - £714,324.46 – HFC (considered obsolete)
    - £716,340.63 – A2L
    - £920,653.36 – CO2
    - £1,051,444.81 – Air Cooled Integrals
    - £816,639.54 – Secondary Glycol

- **Based on OMEGA Solutions calculations, the current annual emissions (based on a 5% leak rate and emissions factor of 0.21233) are:**
    - 38 TCO2 – HFC (considered obsolete)
    - 30 TCO2 – A2L
    - 38 TCO2 – CO2
    - 51 TCO2 – Air Cooled Integrals
    - 37 TCO2 – Secondary Glycol

- **Based on OMEGA Solutions calculations, future annual emissions (based on a 5% leak rate and emissions factor of zero) are:**
    - 10 TCO2 – HFC (considered obsolete)
    - 1 TCO2 – A2L
    - 0 TCO2 – CO2
    - 1 TCO2 – Air Cooled Integrals
    - 0 TCO2 – Secondary Glycol

- **Based on OMEGA Solutions calculations, the Refrigerant Charge Volumes of the Direct Expansion (DX) systems (the most common type of refrigeration system) are:**
    - 143 kg – HFC (considered obsolete)
    - 53 kg – A2L
    - 143 kg – CO2

In addition to these findings, it is critical that retail operators consider the cost of refrigerants and how they are expected to rise as a consequence of the F-gas regulations that will affect the available quantity placed on the market. Though the figures in this report are based on estimation, they consider the cost impact of refrigerant R404A that was experienced in 2017-2019. The method of mitigation during that time was to replace R404A (GWP of 3,922) with lower GWP HFC refrigerants such as R448A (GWP of 1,273), however the quota percentage reduction has reduced significantly in the preceding years meaning that all HFC refrigerants should be considered obsolete as chemical manufacturers will want to provide refrigerants with lower a GWP – e.g., A2L's to ensure that they can continue to place on market pre-F-gas regulations quantities of refrigerant. **Section 3 projects a possible impact of the rising cost of HFC's as their availability reduces in the coming years.**

It is estimated that the average GWP of a refrigerant will need to be <300 to maintain previous supply levels. Unlike the switch from R404A to R448A, the switch to A2L also requires wholescale refrigeration equipment replacement.

NB. A2L R454A with a GWP of 238 has been chosen for the purpose of this report.

Removing HFC technology (considered obsolete), the table below ranks the four alternative technologies by each criterion identified in the executive summary.

Metric	DX A2L	DX CO2	Air Cooled Integrals	Secondary Glycol
CAPEX	2	3	1	4
Energy – Old	1	3	4	2
Energy – New	1	3	4	2
Emissions – Current	1	3	4	2
Emissions – Net Zero	2	1	2	1
TCO – Old Energy Rate	1	3	4	2
TCO – New Energy Rate	1	3	4	2
Refrigerant Charge Volume	1	2	N/A	N/A

FIGURE 1 – TECHNOLOGY RANKING BY METRIC

With reference to the refrigerant charge volume metric, this report focusses on the most common application of refrigeration in retail – direct expansion (DX) systems.

2. GRAPHICAL RESULTS & CALCULATIONS

Figures 1 – 6 provide the results presented in the executive summary graphically (OPEX data includes energy and maintenance costs. The calculations are that form the data in these graphs are presented in figures 7, 8, 9 and 10.

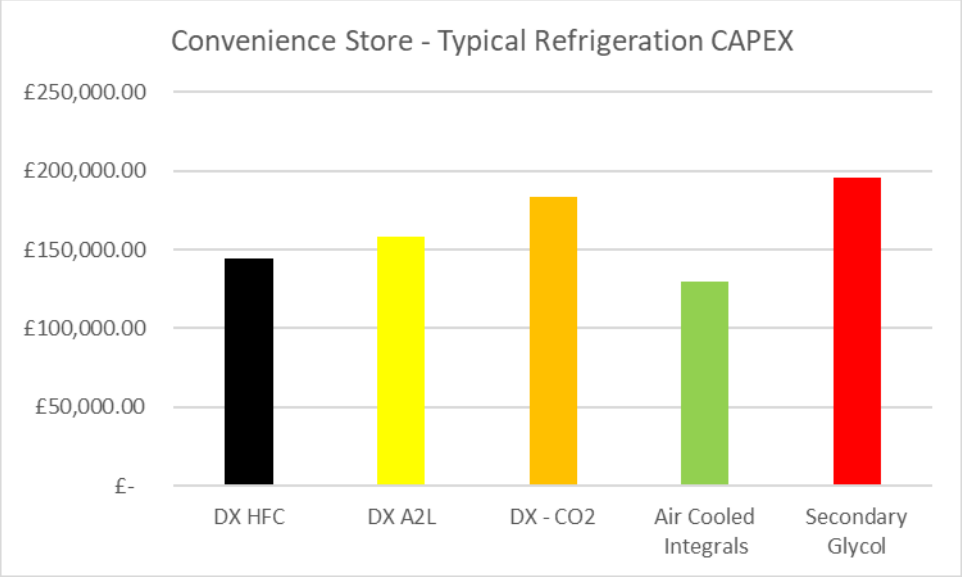

FIGURE 2 – CAPEX BY TECHNOLOGY

Though air-cooled integrals are the most cost-effective CAPEX solution, caution must be applied towards the energy cost of this technology.

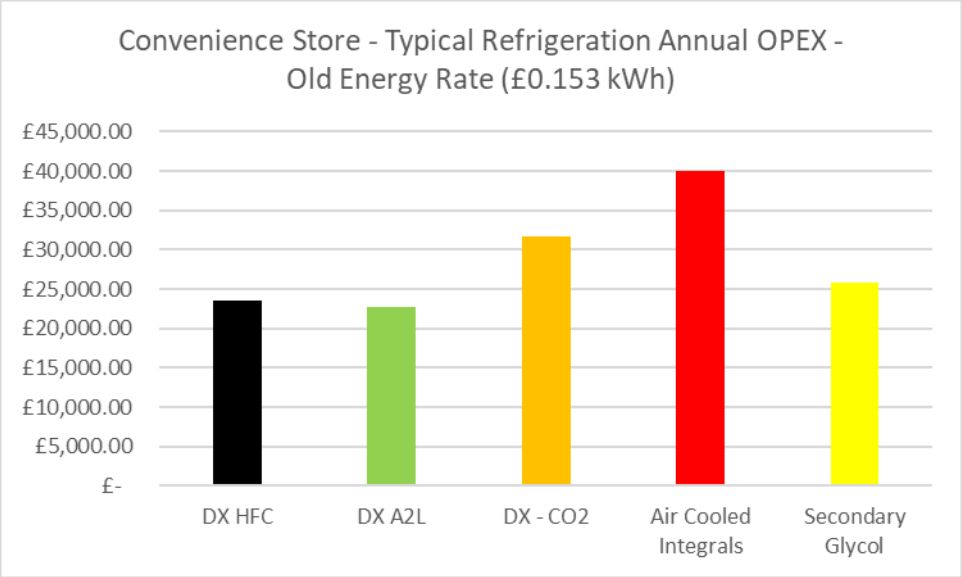

FIGURE 3a – OPEX BY TECHNOLOGY (PREVIOUS ENERGY RATE)

A2L technology attracts the lowest OPEX ranks highly from a CAPEX perspective.

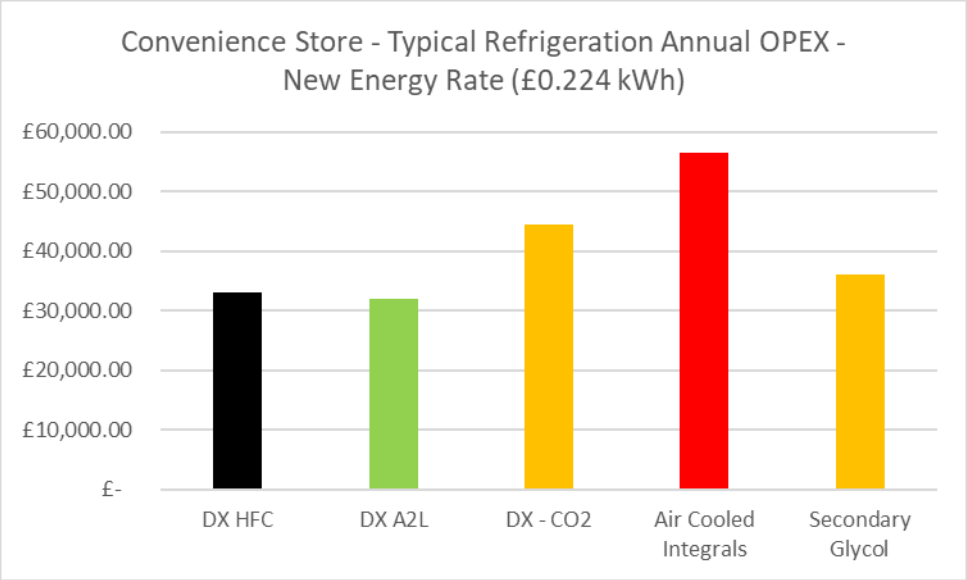

FIGURE 3b – OPEX BY TECHNOLOGY (CURRENT ENERGY RATE)

A2L technology maintains the lowest OPEX cost based on the current energy kWh rate.

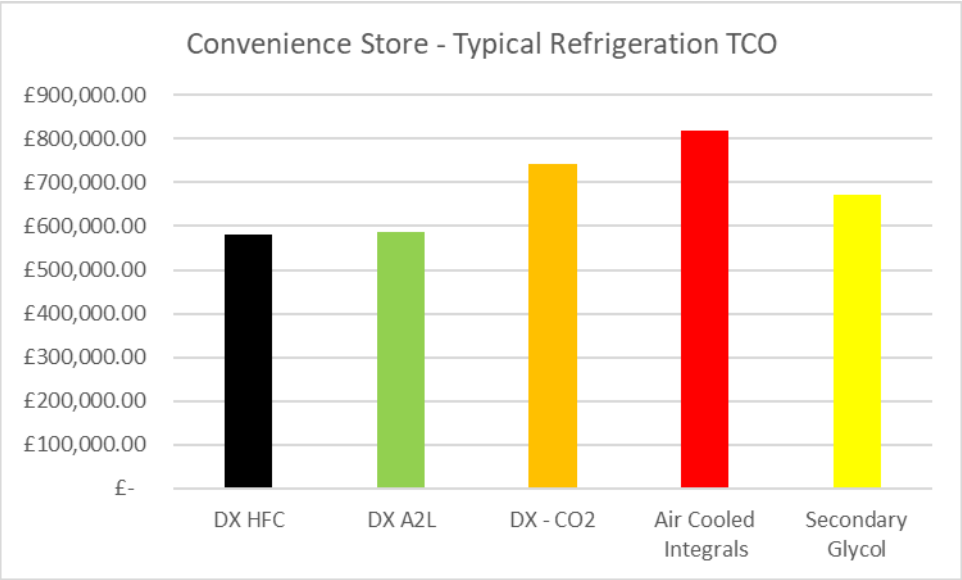

FIGURE 4a – TOTAL COST OF OWNERSHIP (PREVIOUS ENERGY RATE)

Combining CAPEX and OPEX over a 14-year life cycle identifies that A2L systems are the most cost effective of all F-gas/Kigali agreement solutions; at the previous and current kW energy rate (please also refer to Figure 4b below).

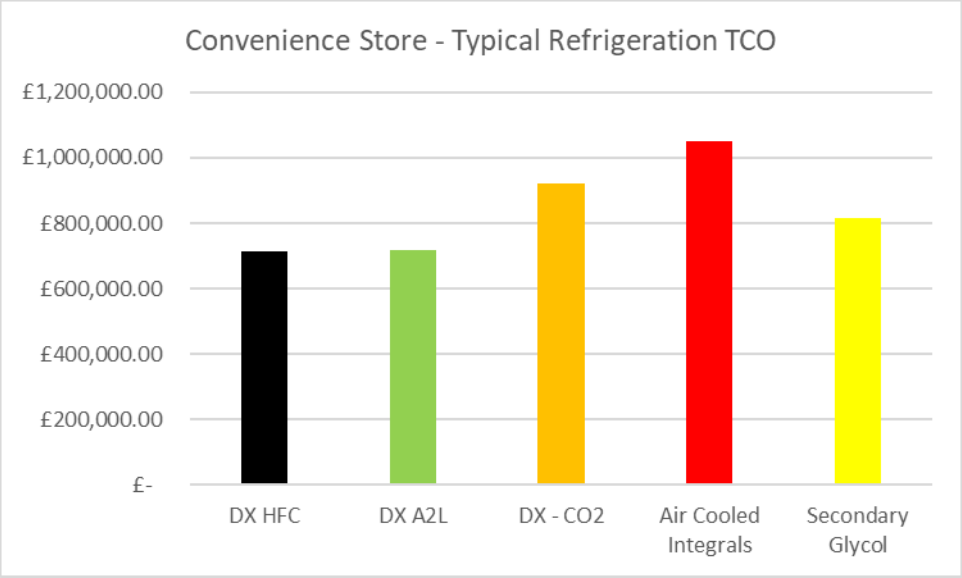

FIGURE 4b – TOTAL COST OF OWNERSHIP (CURRENT ENERGY RATE)

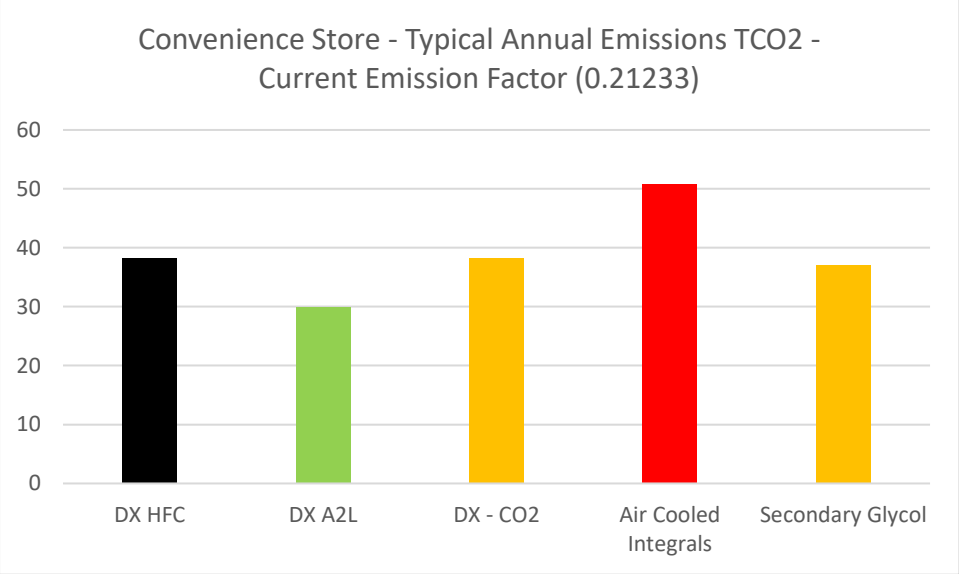

FIGURE 5a – ANNUAL EMISSIONS (CURRENT EMISSIONS FACTOR – 0.21233)

Based on the current emissions factor (a government released annual figure) that is calculated from combining the amount of fossil fuel and renewable energy used in the generation of electricity, A2L refrigerants possess the lowest environmental impact/Total CO2 emissions (based on direct 'refrigerant leakage @ 5%' and indirect 'electricity' usage).

For most operators it is likely that a refrigeration system leak rate of 10-20% is accurate. However, maintaining leakage below 5% is possible through best practice installation and maintenance.

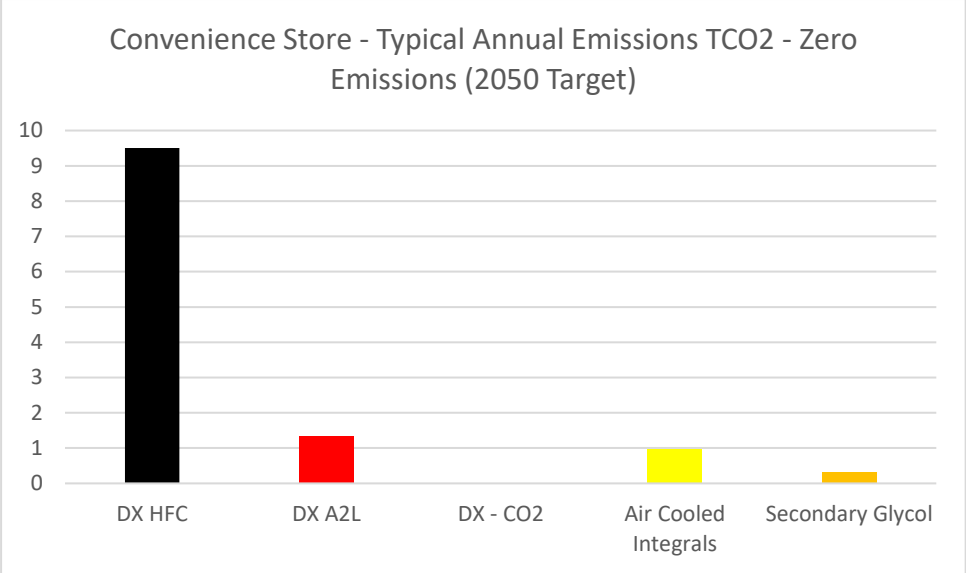

FIGURE 5b – ANNUAL EMISSIONS (NET ZERO/2050 EMISSIONS)

As the UK intensifies its efforts to achieve Net Zero by 2050, the national grid will continue to be decarbonised to a position where electricity is generated through renewable energy sources only. Owing to a refrigerant GWP and its interconnected direct emissions (considered as fugitive emissions), A2L refrigerants will not fully achieve Net Zero, however in considering their excellent energy performance, any possible off-setting of these emissions through taxation will still result in them being the most cost-effective solution based on current information available to OMEGA Solutions. However, if it is more important for a given retailer to achieve the lowest GWP value possible, then CO2 is the best fit, but this is at the detriment of CAPEX, OPEX and Total Cost of Ownership.

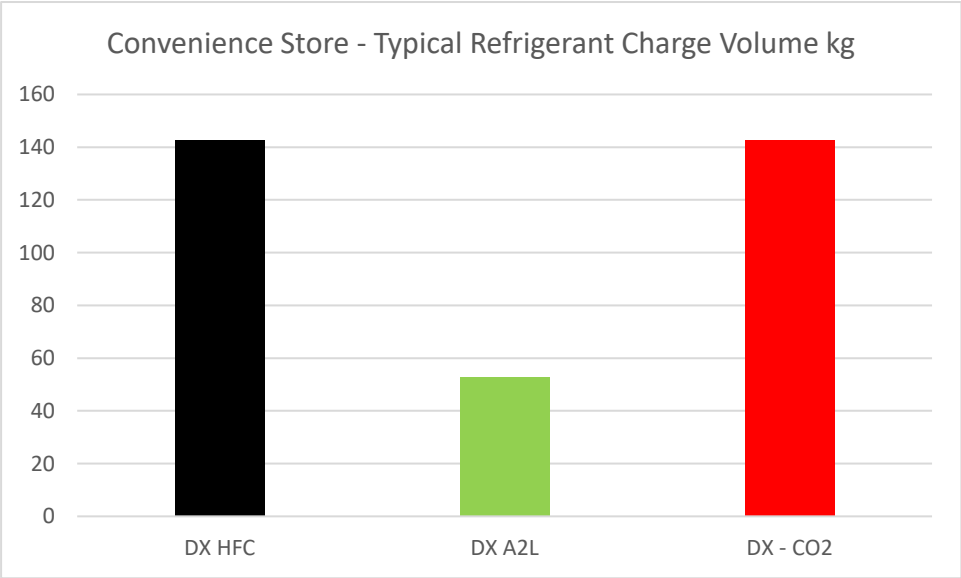

FIGURE 6 – REFRIGERANT CHARGE VOLUME – ANALYSIS OF DX SYSTEMS

Owing to advancements in innovation since the introduction of A2L refrigerants, Marstair have developed technology that reduces the amount of refrigeration required to a desired cooling effect.

34.71	**Chill (m)**	**Retail Refrigeration - CAPEX, OPEX & Emissions, Based on:**
5.63	**Frozen (m)**	Current Emissions Factor ß Kg CO2 / kWh of 0.21233
14	**Life (years)**	Previous Energy Cost of £0.12 kWh
		Annual Refrigerant Leak Rate of 5%

	DX HFC	DX A2L	DX - CO2	Air Cooled Integrals	Secondary Glycol
Refrigerant Global Warming Potential (GWP)	1273	**238**	**1**	3	3
Engineering - CAPEX - m	£ 1,157	£ 1,518	£ 2,144	£ 3,210	£ 2,433
Display Cases (inc Coldrooms) - CAPEX - m	£ 2,410	£ 2,410	£ 2,410		£ 2,410
MT Annual Energy kW-m	3326	3205	4792	5745	3347
LT Annual Energy kW-m	3483	3356	2423	6266	5080
MT Annual TEWI TCO2-m	0.95	0.74	1.02	1.24	0.86
LT Annual TEWI TCO2-m	0.94	0.78	0.51	1.38	1.29
MT Annual Energy £-m	£ 508.88	£ 490.30	£ 733.10	£ 879.00	£ 512.06
LT Annual Energy £-m	£ 532.96	£ 513.51	£ 370.69	£ 958.70	£ 777.29
Maintenance Annual £-m	£ 71.43	£ 71.43	£ 102.86	£ 100.00	£ 89.29
Charge Volume kg	143	53	143	53	53
ENGINEERING CAPEX	£ 46,673.38	£ 61,236.12	£ 86,488.96	£ 129,491.40	£ 98,147.22
DISPLAY CASES & COLDROOM CAPEX	£ 97,219.40	£ 97,219.40	£ 97,219.40	£ -	£ 97,219.40
TOTAL CAPEX	£ 143,892.78	£ 158,455.52	£ 183,708.36	£ 129,491.40	£ 195,366.62
ANNUAL ENERGY COST	£ 20,663.67	£ 19,909.44	£ 27,533.00	£ 35,907.48	£ 22,149.83
ANNUAL MAINTENANCE COST	£ 2,881.43	£ 2,881.43	£ 4,149.37	£ 4,034.00	£ 3,601.79
ANNUAL OPEX	£ 23,545.09	£ 22,790.87	£ 31,682.38	£ 39,941.48	£ 25,751.61
MID LIFE REFIT CAPEX	£ 106,554.08	£ 109,466.62	£ 114,517.19	£ 129,491.40	£ 116,848.84
TOTAL COST of OWNERSHIP	£ 580,078.17	£ 586,994.32	£ 741,778.82	£ 818,163.53	£ 672,738.05
ANNUAL EMISSIONS (TCO2)	38	30	38	51	37
LIFE CYCLE EMISSIONS (TCO2)	535	420	535	711	518

NOTES
1. Connected meters (green cells) can be adjusted to suit a store layout.
2. Direct emissions (refrigerant leakage) are based on an annual leak rate of 5%
3. Indirect emissions (electricity generation) are based on the current UK emissions factor ß Kg CO2 / k

FIGURE 7 – CAPITAL COST, TOTAL COST OF OWNERSHIP, CURRENT EMISSIONS AND PREVIOUS ENERGY COST CALCULATIONS

34.71	**Chill (m)**	**Retail Refrigeration - CAPEX, OPEX & Emissions, Based on:**
5.63	**Frozen (m)**	Current Emissions Factor ß Kg CO2 / kWh of 0.21233
14	**Life (years)**	Current Cost of £0.173 kWh
		Annual Refrigerant Leak Rate of 5%

	DX HFC	DX A2L	DX - CO2	Air Cooled Integrals	Secondary Glycol
Refrigerant Global Warming Potential (GWP)	1273	238	1	3	3
Engineering - CAPEX - m	£ 1,157	£ 1,518	£ 2,144	£ 3,210	£ 2,433
Display Cases (inc Coldrooms) - CAPEX - m	£ 2,410	£ 2,410	£ 2,410		£ 2,410
MT Annual Energy kW-m	3326	3205	4792	5745	3347
LT Annual Energy kW-m	3483	3356	2423	6266	5080
MT Annual TEWI TCO2-m	0.95	0.74	1.02	1.24	0.86
LT Annual TEWI TCO2-m	0.94	0.78	0.51	1.38	1.29
MT Annual Energy £-m	£ 745.02	£ 717.83	£ 1,073.30	£ 1,286.90	£ 749.69
LT Annual Energy £-m	£ 780.28	£ 751.80	£ 542.71	£ 1,403.59	£ 1,138.00
Maintenance Annual £-m	£ 71.43	£ 71.43	£ 102.86	£ 100.00	£ 89.29
Charge Volume kg	143	53	143	53	53
ENGINEERING CAPEX	£ 46,673.38	£ 61,236.12	£ 86,488.96	£ 129,491.40	£ 98,147.22
DISPLAY CASES & COLDROOM CAPEX	£ 97,219.40	£ 97,219.40	£ 97,219.40	£ -	£ 97,219.40
TOTAL CAPEX	£ 143,892.78	£ 158,455.52	£ 183,708.36	£ 129,491.40	£ 195,366.62
ANNUAL ENERGY COST	£ 30,252.69	£ 29,148.46	£ 40,309.76	£ 52,570.43	£ 32,428.51
ANNUAL MAINTENANCE COST	£ 2,881.43	£ 2,881.43	£ 4,149.37	£ 4,034.00	£ 3,601.79
ANNUAL OPEX	£ 33,134.11	£ 32,029.89	£ 44,459.13	£ 56,604.43	£ 36,030.29
MID LIFE REFIT CAPEX	£ 106,554.08	£ 109,466.62	£ 114,517.19	£ 129,491.40	£ 116,848.84
TOTAL COST of OWNERSHIP	£ 714,324.46	£ 716,340.63	£ 920,653.36	£ 1,051,444.81	£ 816,639.54
ANNUAL EMISSIONS (TCO2)	38	30	38	51	37
LIFE CYCLE EMISSIONS (TCO2)	535	420	535	711	518

NOTES
1. Connected meters (green cells) can be adjusted to suit a store layout.
2. Direct emissions (refrigerant leakage) are based on an annual leak rate of 5%
3. Indirect emissions (electricity generation) are based on the current UK emissions factor ß Kg CO2 / k

FIGURE 8 – CAPITAL COST, TOTAL COST OF OWNERSHIP, CURRENT EMISSIONS, AND CURRENT ENERGY COST CALCULATIONS

34.71	**Chill (m)**	**Retail Refrigeration - CAPEX, OPEX & Emissions, Based on:**
5.63	**Frozen (m)**	Emissions Factor ß Kg CO2 / kWh of 0 Previous Energy Cost of £0.12 kWh
14	**Life (years)**	Annual Refrigerant Leak Rate of 5%

	DX HFC	DX A2L	DX - CO2	Air Cooled Integrals	Secondary Glycol
Refrigerant Global Warming Potential (GWP)	1273	238	1	3	3
Engineering - CAPEX - m	£ 1,157	£ 1,518	£ 2,144	£ 3,210	£ 2,433
Display Cases (inc Coldrooms) - CAPEX - m	£ 2,410	£ 2,410	£ 2,410		£ 2,410
MT Annual Energy kW-m	3326	3205	4792	5745	3347
LT Annual Energy kW-m	3483	3356	2423	6266	5080
MT Annual TEWI TCO2-m	0.24	0.03	0.00	0.02	0.01
LT Annual TEWI TCO2-m	0.20	0.04	0.00	0.05	0.00
MT Annual Energy £-m	£ 508.88	£ 490.30	£ 733.10	£ 879.00	£ 512.06
LT Annual Energy £-m	£ 532.96	£ 513.51	£ 370.69	£ 958.70	£ 777.29
Maintenance Annual £-m	£ 71.43	£ 71.43	£ 102.86	£ 100.00	£ 89.29
Charge Volume kg	143	53	143	53	53
ENGINEERING CAPEX	£ 46,673.38	£ 61,236.12	£ 86,488.96	£ 129,491.40	£ 98,147.22
DISPLAY CASES & COLDROOM CAPEX	£ 97,219.40	£ 97,219.40	£ 97,219.40	£ -	£ 97,219.40
TOTAL CAPEX	£ 143,892.78	£ 158,455.52	£ 183,708.36	£ 129,491.40	£ 195,366.62
ANNUAL ENERGY COST	£ 20,663.67	£ 19,909.44	£ 27,533.00	£ 35,907.48	£ 22,149.83
ANNUAL MAINTENANCE COST	£ 2,881.43	£ 2,881.43	£ 4,149.37	£ 4,034.00	£ 3,601.79
ANNUAL OPEX	£ 23,545.09	£ 22,790.87	£ 31,682.38	£ 39,941.48	£ 25,751.61
MID LIFE REFIT CAPEX	£ 106,554.08	£ 109,466.62	£ 114,517.19	£ 129,491.40	£ 116,848.84
TOTAL COST of OWNERSHIP	£ 580,078.17	£ 586,994.32	£ 741,778.82	£ 818,163.53	£ 672,738.05
ANNUAL EMISSIONS (TCO2)	10	1	0	1	0
LIFE CYCLE EMISSIONS (TCO2)	133	19	0.12	13	4

NOTES
1. Connected meters (green cells) can be adjusted to suit a store layout.
2. Direct emissions (refrigerant leakage) are based on an annual leak rate of 5%
3. Indirect emissions (electricity generation) are based on a Net Zero emissions factor ß Kg CO2 / kWh

FIGURE 9 – CAPITAL COST, TOTAL COST OF OWNERSHIP, ZERO EMISSIONS, AND PREVIOUS ENERGY COST CALCULATIONS

OMEGA SOLUTIONS

34.71	**Chill (m)**
5.63	**Frozen (m)**
14	**Life (years)**

Retail Refrigeration - CAPEX, OPEX & Emissions, Based on:
Emissions Factor ß Kg CO2 / kWh of 0
Current Energy Cost of £0.173 kWh
Annual Refrigerant Leak Rate of 5%

	DX HFC	DX A2L	DX - CO2	Air Cooled Integrals	Secondary Glycol
Refrigerant Global Warming Potential (GWP)	1273	**238**	**1**	3	3
Engineering - CAPEX - m	£ 1,157	£ 1,518	£ 2,144	£ 3,210	£ 2,433
Display Cases (inc Coldrooms) - CAPEX - m	£ 2,410	£ 2,410	£ 2,410		£ 2,410
MT Annual Energy kW-m	3326	3205	4792	5745	3347
LT Annual Energy kW-m	3483	3356	2423	6266	5080
MT Annual TEWI TCO2-m	0.24	0.03	0.00	0.02	0.01
LT Annual TEWI TCO2-m	0.20	0.04	0.00	0.05	0.00
MT Annual Energy £-m	£ 745.02	£ 717.83	£ 1,073.30	£ 1,286.90	£ 749.69
LT Annual Energy £-m	£ 780.28	£ 751.80	£ 542.71	£ 1,403.59	£ 1,138.00
Maintenance Annual £-m	£ 71.43	£ 71.43	£ 102.86	£ 100.00	£ 89.29
Charge Volume kg	143	53	143	53	53
ENGINEERING CAPEX	£ 46,673.38	£ 61,236.12	£ 86,488.96	£ 129,491.40	£ 98,147.22
DISPLAY CASES & COLDROOM CAPEX	£ 97,219.40	£ 97,219.40	£ 97,219.40	£ -	£ 97,219.40
TOTAL CAPEX	£ 143,892.78	£ 158,455.52	£ 183,708.36	£ 129,491.40	£ 195,366.62
ANNUAL ENERGY COST	£ 30,252.69	£ 29,148.46	£ 40,309.76	£ 52,570.43	£ 32,428.51
ANNUAL MAINTENANCE COST	£ 2,881.43	£ 2,881.43	£ 4,149.37	£ 4,034.00	£ 3,601.79
ANNUAL OPEX	£ 33,134.11	£ 32,029.89	£ 44,459.13	£ 56,604.43	£ 36,030.29
MID LIFE REFIT CAPEX	£ 106,554.08	£ 109,466.62	£ 114,517.19	£ 129,491.40	£ 116,848.84
TOTAL COST of OWNERSHIP	£ 714,324.46	£ 716,340.63	£ 920,653.36	£ 1,051,444.81	£ 816,639.54
ANNUAL EMISSIONS (TCO2)	10	1	0	1	0
LIFE CYCLE EMISSIONS (TCO2)	133	19	0.12	13	4

NOTES
1. Connected meters (green cells) can be adjusted to suit a store layout.
2. Direct emissions (refrigerant leakage) are based on an annual leak rate of 5%
3. Indirect emissions (electricity generation) are based on a Net Zero emissions factor ß Kg CO2 / kWh

FIGURE 10 – CAPITAL COST, TOTAL COST OF OWNERSHIP, ZERO EMISSIONS, AND CURRENT ENERGY COST CALCULATIONS

MARSTAIR
REFRIGERATION AND SPECIALIST AIR CONDITIONING

3. COST OF REFRIGERANT

Figure 11 focuses on HFC, CO2 and A2L estimated refrigerant costs as highlighted in the executive summary. The costs are based on the experience of OMEGA Solutions and previous refrigerant cost increases (see appendix). This report has been based on an aspirational leak rate of 5% but figure 11 identifies the cost of leakage based on 5%, 10% and 20% refrigerant release per year.

Cost Per kg	2023	2024	2025	2026	2027	2028	2029	2030
HFC	£ 60.00	£ 78.00	£ 101.40	£ 131.82	£ 171.37	£ 222.78	£ 289.61	£ 376.49
CO2	£ 3.00	£ 3.08	£ 3.15	£ 3.23	£ 3.31	£ 3.39	£ 3.48	£ 3.57
A2L	£ 40.00	£ 41.00	£ 42.03	£ 43.08	£ 44.15	£ 45.26	£ 46.39	£ 47.55

5%	2023	2024	2025	2026	2027	2028	2029	2030
HFC	£ 429.00	£ 557.70	£ 725.01	£ 942.51	£ 1,225.27	£ 1,592.85	£ 2,070.70	£ 2,691.91
CO2	£ 21.45	£ 21.99	£ 22.54	£ 23.10	£ 23.68	£ 24.27	£ 24.88	£ 25.50
A2L	£ 106.00	£ 108.65	£ 111.37	£ 114.15	£ 117.00	£ 119.93	£ 122.93	£ 126.00

10%	2023	2024	2025	2026	2027	2028	2029	2030
HFC	£ 858.00	£ 1,115.40	£ 1,450.02	£ 1,885.03	£ 2,450.53	£ 3,185.69	£ 4,141.40	£ 5,383.82
CO2	£ 42.90	£ 43.97	£ 45.07	£ 46.20	£ 47.35	£ 48.54	£ 49.75	£ 50.99
A2L	£ 212.00	£ 217.30	£ 222.73	£ 228.30	£ 234.01	£ 239.86	£ 245.86	£ 252.00

20%	2023	2024	2025	2026	2027	2028	2029	2030
HFC	£ 1,716.00	£ 2,230.80	£ 2,900.04	£ 3,770.05	£ 4,901.07	£ 6,371.39	£ 8,282.80	£ 10,767.65
CO2	£ 85.80	£ 87.95	£ 90.14	£ 92.40	£ 94.71	£ 97.07	£ 99.50	£ 101.99
A2L	£ 424.00	£ 434.60	£ 445.47	£ 456.60	£ 468.02	£ 479.72	£ 491.71	£ 504.00

FIGURE 11 – HFC, CO2 AND A2L TABLE OF kg COSTS AND THE COST OF LEAKAGE AT VARIOUS LEAK RATES

Though the cost of CO2 per kg is significantly lower than either HFC or A2L refrigerants, it is recommended that all metrics as presented in Figure 1 are considered (all retailers will consider individual metrics with varying levels of strategic importance).

The most alarming finding is the potential cost of HFC refrigerants. Taking a low leak rate of 5% in 2030, it is possible that the cost of replacing the volume of this refrigerant would be >£2,600, compared with £126 for an A2L system or £25.50 for a CO2 system.

At a leak rate of 20% in 2030, it is possible that the cost of replacing the volume of an HFC would be >£10,000, compared with £504 for an A2L system or £102 for a CO2 system.

For this reason, it is imperative that refrigeration CAPEX decisions taken now consider the impact of HFC refrigerant cost increases. It is strongly recommended that a switch away from HFC refrigerants in new systems is immediate to prevent convenience retailers from being exposed to these costs.

Figures 12, 13, 14 and 15 present the information contained in Figure 11 graphically.

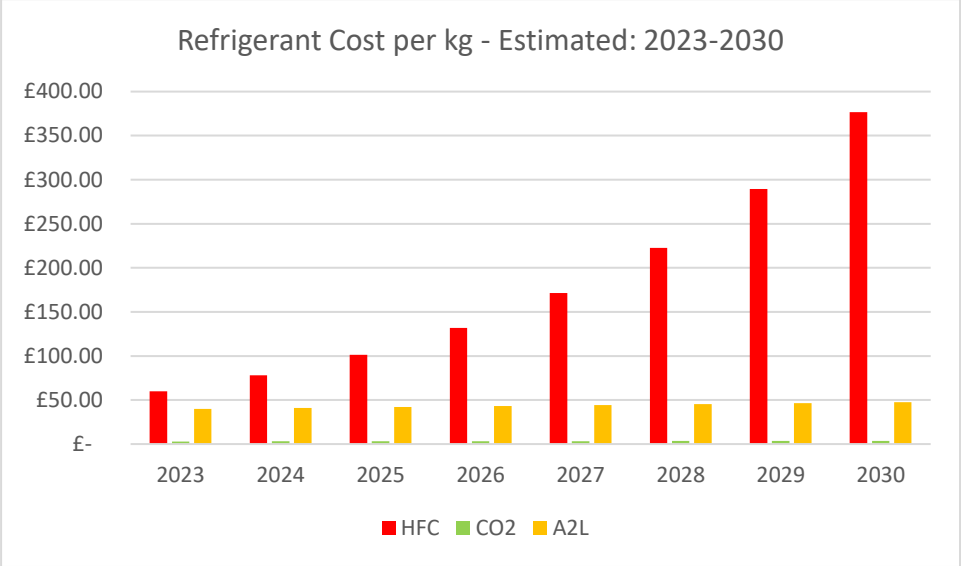

FIGURE 12 – REFRIGERANT COST PER kg – ESTIMATED: 2023-2030

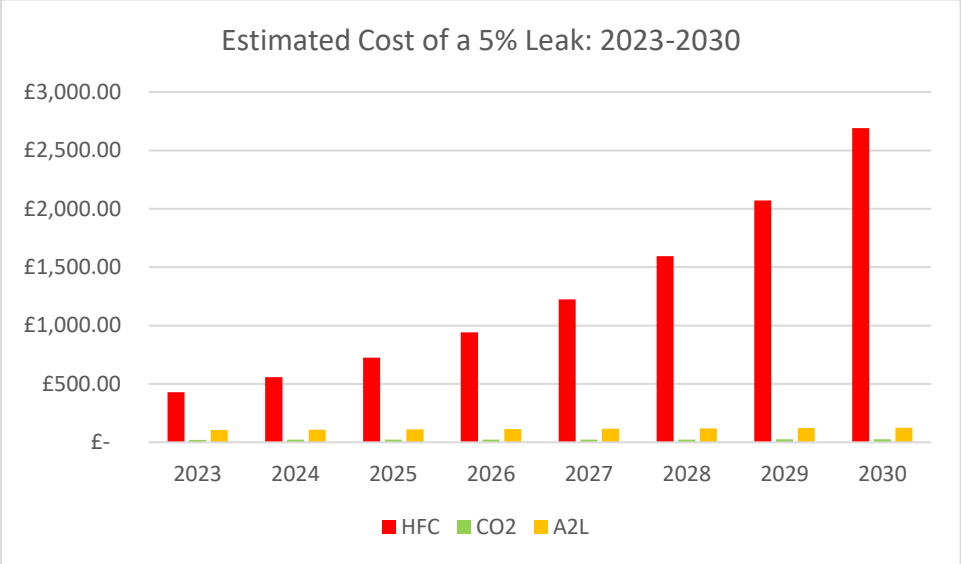

FIGURE 13 – ESTIMATED COST OF A 5% LEAK: 2023-2030

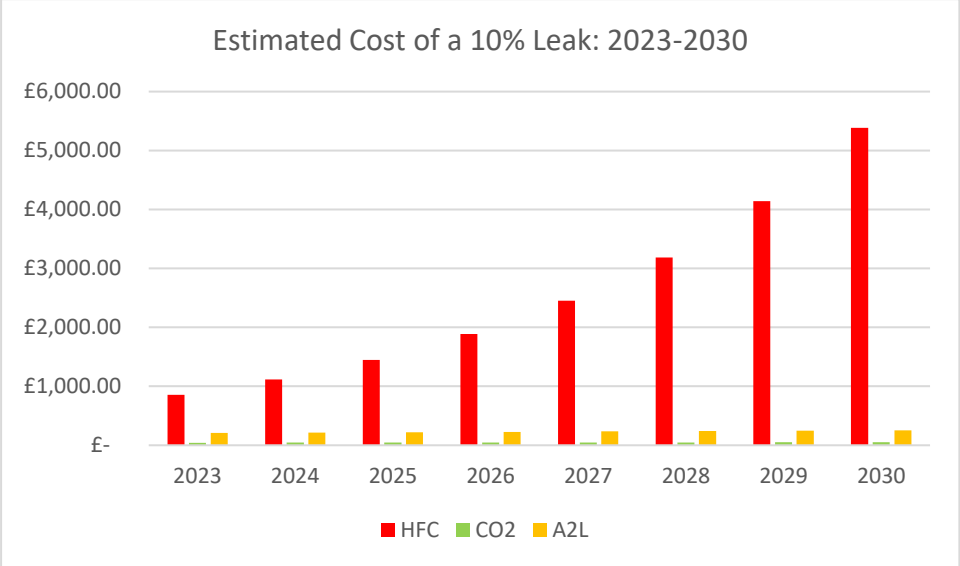

FIGURE 14 – ESTIMATED COST OF A 10% LEAK: 2023-2030

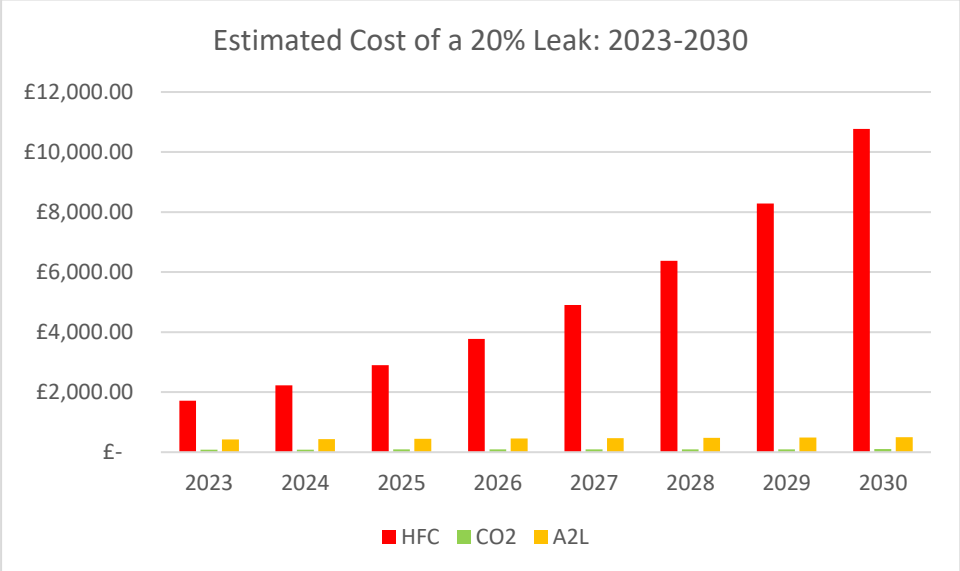

FIGURE 15 – ESTIMATED COST OF A 20% LEAK: 2023-2030

4. COST OF ENERGY

This report has used the following electricity energy rates:

- £0.153 (Pre-increase cost per kWh – 2021)
- £0.224 (Current cost per kWh – 2022)
- The electricity energy cost going forward (2023) is projected to be £0.272 per kWh

Based on this data, Figure 16 compares the energy costs by system type and year:

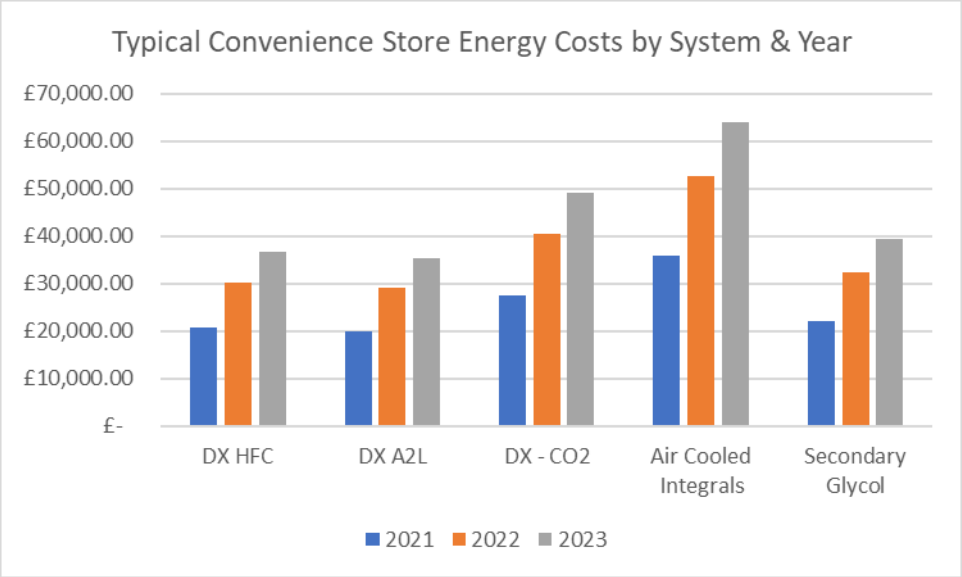

FIGURE 16 – TYPICAL CONVENIENCE STORE ENERGY COSTS BY SYSTEM & YEAR

Based on the same data, Figure 17 compares the 14-year Total Cost of Ownership (TCO) by system type:

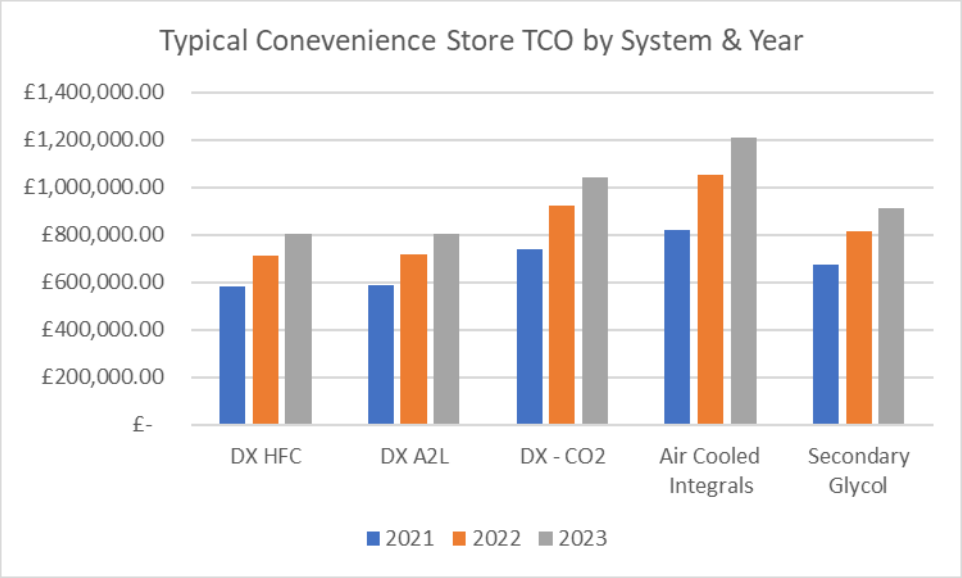

FIGURE 17 – TYPICAL CONVENIENCE STORE TCO BY SYSTEM & YEAR

There is no indication that energy costs will stabilise or decrease in the immediate future. It is therefore critical that convenience store operators carefully consider impact of decisions taken in respect of refrigeration technology. As an example, just one convenience store could cost an operator £237,797 over a 14-year life expectancy if selecting CO2 over an A2L system. This is a worse case scenario based on the likely future electricity kWh cost of £0.272 and this report basing operating costs on chilled food display cases being open fronted as opposed to display cases that use doors.

For the majority of convenience store operators, the cost to adopt CO2 refrigeration will be prohibitive even though several large UK food retailers are adopting this technology. Therefore, it is important to compare HFC and A2L systems:

- Both refrigerants are applied in the most common type of system – direct expansion (following the basic principles for the vapour compression cycle)

- A2L systems are more energy efficient than HFC systems

- A2L systems can present a >95% emissions reduction when compared to HFC systems (R404A)

- The capital and Total Cost of Ownership (TCO) of A2L systems is slightly higher than HFC systems (though the cost increase in HFC refrigerants will reverse this)

- 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
    - In plant areas (rooms or containers) ensure a forced ventilation system is installed where required that activates upon detection of a leak
    - 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

- A2L systems are almost identical in design and construction as HFC systems. Therefore, they are easy to understand by service and maintenance technicians

ASDA and Central England Co-op are two retailers who have successfully adopted A2L refrigeration systems. These two retailers selected A2L technology based on CAPEX & OPEX costs, emissions, system familiarity with HFCs and safety.

In respect of decisions taken in refrigeration equipment, convenience store operators would also be well placed to consider how they heat their stores and possible investment in solar panels and battery storage to generate their own electricity to mitigate rising energy costs.

APPENDIX

Figure 18 was released in July 2022 (source. The Cooling Post) and identifies the current and continuing rising cost of refrigerants. This graph is included to provide back-up to the data presented in section 3 of this report.

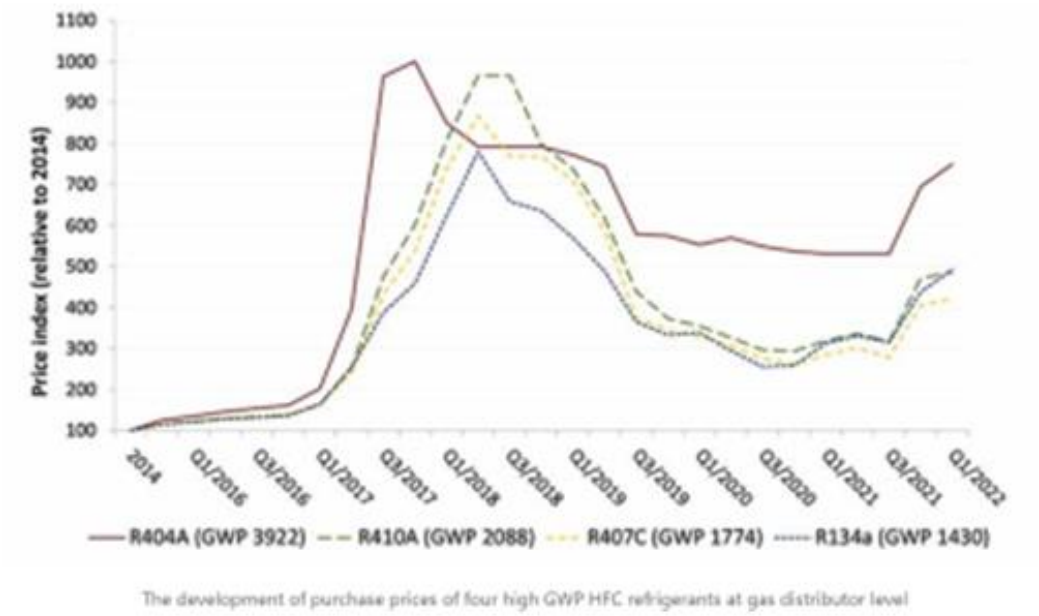

FIGURE 18 – REFRIGERANT COST INCREASE ANALYSIS