Is it time to stop using R404A?

R404A is one of the most popular refrigerants in use today, but switching away from it will boost operators' environmental credentials and profit, contends **Ray Gluckman** of SKM Enviros

During the past 10 to 15 years, R404A has become one of the most widely used refrigerants in the industry. It was introduced in the mid-1990s as a replacement for ozone- depleting refrigerants including CFCs (such as R12 and R502) and, more recently, as a replacement for HCFCs (such as R22).

In the supermarket sector it has become the dominant refrigerant across Europe for both chilled and frozen food refrigeration. It is also used widely in other commercial systems, for industrial refrigeration and cold storage.

I have often wondered why R404A became so successful – because it is not a particularly good refrigerant! The fluid filled an urgent gap during the 1990s and it was well marketed. End-users and refrigeration contractors became familiar with it and have continued using it as the "refrigerant of choice" in many applications.

It is still used in many new systems, even though there are other better refrigerants now available. So it is time to stop being complacent about refrigerant choice and to use better alternatives.

Switching away from R404A has the potential to quickly and cost effectively help the environment and reduce running costs. A cost-effective alternative is available for all new refrigeration systems and for most existing ones.

What is wrong with R404A?
The two key problems with R404A are that it does not achieve the best energy efficiency in many applications and it has a particularly high global warming potential (GWP).

The relatively poor energy efficiency leads to extra running costs and additional CO_2 emissions from the power stations that generate the electricity being used. Alternative refrigerants can give electricity savings of between 7 and 12 per cent in many applications.

The GWP of R404A at 3922 is the highest of all the commonly used refrigerants. R134A is only 1430 and R407F (Performax LT) is 1850. So leakage of 1 kg of R404A is two to three times worse in terms of global warming impact than some other HFC refrigerants.

It is worth noting that, historically, supermarkets used two different refrigerants in-store: R12 was used for chill systems and R502 for freezer systems. Each refrigerant could be well optimised to its operating temperature.

When these ozone-depleting systems were phased out, most supermarkets decided to rationalise their refrigerant use – the chill and freezer systems in most UK supermarkets now use R404A. That may have been convenient but it creates some degree of compromise in the plant design and leads to an overall loss of efficiency.

A strategy for new refrigeration plants
A very simple strategy can be applied immediately: do not use R404A in any new systems. This is a practical and cost-effective policy because there are refrigerants now available that suit all R404A applications, and can deliver improved efficiency and a significantly lower GWP.

When buying a new refrigeration plant, three crucial design factors should be considered:

■ How can maximum energy efficiency be achieved?

This is the most important issue, both in terms of running costs and energy-related CO_2 emissions. The choice of refrigerant has an effct on energy efficiency and R404A is a poor choice.

For a chill system, R134a should give 10 per cent better efficiency, although it would need a slightly larger compressor. Alternatively, refrigerants such as R407A or the recently announced R407F also give good efficiency with GWPs that are less than 50 per cent of the GWP of R404A.

It is vital to remember that other design parameters have an even bigger impact on efficiency than the refrigerant. When buying a new system that could run for the next 20 years, it is essential to make every effort to maximise the efficiency.

■ What type of refrigerant should be used?

For a new plant you have many options that can help you avoid R404A. These fall into three main groups:
1) Medium GWP HFCs such as R134A, R407A, R407F and R410A. These can offer better energy efficiency and much lower GWP than R404A. Medium GWP options represent a good short- to medium-term alternative.
2) Newly developed very low GWP hydro-fluoro-olefins (HFOs). HFO1234yf has a GWP of just 4 and properties similar to R134A. It is going to be used by car manufacturers to address the R134A ban that applies to mobile air-conditioning in new vehicle types from 2011.

HFO1234yf is slightly flammable, requiring a relatively high-energy ignition source, and is classified as an A2 refrigerant, requiring appropriate design measures to ensure its safety in use.

Refrigerant manufacturers are also looking at various blends that combine HFOs with HFCs, which can remove the flammability issue while giving good performance, with GWPs in the range of 500 to 1,000.

Unfortunately, HFOs will not become commercially available for use in stationary refrigeration applications for another two or three years. So while these fluids can be considered, they cannot be used immediately on new systems.
3) Refrigerants such as ammonia, CO_2 and hydrocarbons (HCs), often called "natural" refrigerants. These all have very low GWP (between 0 and 5) and can provide efficient performance in many applications if they are carefully designed.

They all have practical issues that make them more expensive to use than HFCs.

Ammonia is highly toxic; it is well-suited to large industrial systems, but less cost effective at small and medium sizes. HCs are highly flammable; they are excellent refrigerants for small hermetically sealed systems

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but safety is an issue for medium and large sizes.

CO_2 has emerged as a strong contender for supermarket refrigeration and other applications during the past few years. There are many design issues to be addressed as CO_2 operates at much higher pressures than other types of refrigerant, but it can be a good alternative to R404A; however investment costs can be high.

■ How can the new design minimise leakage?

There is no better time to reduce leakage than on the drawing board. Low leakage is vital whichever refrigerant option is chosen.

For HFCs we are trying to avoid emission of high GWP gases; for "natural" refrigerants, leakage could cause safety problems. HFOs will probably be much more expensive than HFCs, so leakage will cost money Spending a little extra on valves, joints, pipework and so on can produce a new system with much less risk of leakage.

It is vital to ensure good installation quality for site-built pipework – many leaks on large systems come from poor installation.

A strategy for existing refrigeration plants
What about all that R404A that is already in use? Are we stuck with low efficiency and emissions of a high GWP gas for the life of these plants? The good news is that there is a cost-effective strategy that can be implemented on many plants to make a significant reduction to running costs and greenhouse gas emissions.

Most supermarket chill systems can be retrofitted with a medium GWP refrigerant such as R407A or R407F. In a carefully planned retrofit programme, a switch to one of these refrigerants can offer four benefits:
1) The energy efficiency can be improved by 7-12 per cent because the new refrigerants have superior efficiency characteristics to R404A. A few minor design changes may be required, such as changes to expansion valves, but the cost of such changes are small.
2) The new refrigerant will have a GWP less than half of R404A, so there is an immediate step change reduction in the greenhouse gas emissions of any leaked refrigerant.
3) During a "best practice" retrofit programme, some components in the old system can be upgraded to reduce the risk of leakage. Some small investments in valves, joints and seals will in many cases reduce the historic rate of refrigerant leakage substantially – a 50 per cent cut in leak rate is a realistic target.
4) The retrofit programme

should also include a thorough check of all components and plant re-commissioning. There are many examples where this process has uncovered previous problems and led to overall energy savings well above the 7-12 per cent target.

Combining these benefits can reduce the direct global warming impact of the old R404A system by as much as 75 per cent and reduce indirect electricity-related CO_2 emissions by a further 10-15 per cent. The reduction in electricity use provides very useful cost savings.

The payback period for a retrofit of a typical super-market system will be in the range of three to five years. But the major UK supermarket chains participate in the Carbon Reduction Commit-ment Energy Efficiency Scheme, which means they have to buy carbon allowances priced at £12 for each tonne of CO_2 from electricity used, making the payback period shorter.

Given the enormous pressure to reduce CO_2 emissions throughout Europe, it is good to find an opportunity that will deliver significant greenhouse gas reductions and add extra profit to the bottom line.

An opportunity being missed

Some end-users are missing this excellent opportunity for short-term greenhouse gas reductions. They are concentrating on a strategy for their new equipment, for example using CO_2 on new systems. This is an effective long-term approach, but will only take effect slowly, as old plants are replaced.

Most supermarket refriger-ation systems have a life of 15 to 20 years. It is important to have an investment programme that combines the best refrigeration strategies for new and existing plants. This is demonstrated in the graph above, which shows three strategies that could be used by a supermarket that owns many stores:

■ Strategy 1: the company retains R404A equipment in all new and existing systems (this is the "base case" for comparison).

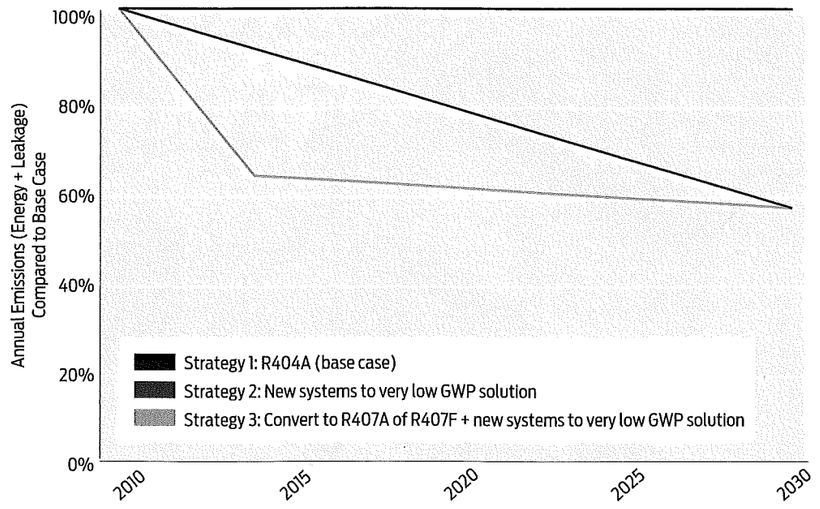
■ Strategy 2: the company slowly eliminates its R404A equipment over a 20-year period; as each old R404A plant reaches the end of its life, it is replaced with new plant based on very low GWP technology.

■ Strategy 3: the company combines a short- and long-term strategy. Existing R404A equipment is converted to R407A or R407F over a four-year period. All old plant reaching end of life is replaced with a very low GWP system.

The graph clearly shows that emission reduction in the early years is much greater with Strategy 3 than with Strategy 2. The overall savings achieved over 20 years is equivalent to the area under each curve – which is also much larger for Strategy 3.

The significantly improved savings are summarised in the table. During the first 10 years, Strategy 3 achieves twice as much emission reduction as Strategy 2. Because the energy efficiency is improved when R404A chill systems are converted to R407A or R407F, these extra emission reductions are achieved at lower overall cost.

The benefits of switching from R404A



	Emission reduction compared with Strategy 1 (R404A in all systems)	
	2011 to 2020	2011 to 2030
Strategy 2: New systems use very low GWP solution	12%	32%
Strategy 3: Existing systems converted to R407A or R407F over 4 years and new systems use low GWP solution	23%	37%

Conclusion

We are in an era of increasing concern over climate change. Across Europe, tough policies to reduce greenhouse gas emissions are being introduced.

Refrigeration plants have two types of GHG emission: from the energy they consume and from refrigerants that leak. R404A has proved to be a convenient "interim" refrigerant, to help us replace ozone-depleting refrigerants. But it has a very high global warming potential and is not particularly efficient – so the time has come to stop using R404A in applications where better alternatives exist.

For new plants, a number of approaches can be considered to improve efficiency and reduce leakage-related emissions. Big step change improvements can be achieved, especially if energy efficiency is maximised.

New plants will often be running for more than 20 years, so it is vital that every opportunity is taken to make cost effective improvements. R404A should be avoided on all new plants. For existing plants running on R404A there are some good retrofit opportunities to use a medium GWP refrigerant. These have less than half the GWP of R404A and can often deliver a 10-15 per cent improvement in efficiency in a well managed retrofit programme.

In many situations, this efficiency improvement will provide sufficient energy savings to give a good payback period on the investment required to convert to a new refrigerant – and the GHG emissions can be reduced at the same time.