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Transitioning to New Refrigerants in Air Conditioning Systems

What are refrigerants?

Refrigerants are the fluids used by the air conditioning's refrigeration equipment as a heat transfer medium. Traditionally a huge range of substances have been used as refrigerants dating from the 19th century. To make referencing easier, they are each designated with an "R" number. Carbon dioxide, for example, is referred to as R744 when used as a refrigerant.

The case for heating

While traditionally used for cooling applications, refrigeration-based air conditioning systems started to be used as reverse cycle heating devices (heatpumps) from the 1930s. Heatpumps utilise the same refrigeration cycle used for cooling but in reverse, allowing the system to extract heat from the outside environment and transfer it indoors for heating purposes.

Heatpumps can therefore transfer heat from a low-temperature source, such as outdoor air, water, or the ground, to a higher-temperature space (indoors). Modern heatpumps can achieve COP (Coefficient of Performance) values greater than 4, so provide four times the heating output compared to the electrical energy consumed.

Extreme cold temperatures may reduce the efficiency of air-source heatpumps, while ground-source (geothermal) heatpumps can offer higher heating efficiencies due to the relatively stable ground temperature.

It is important to note that air conditioning systems primarily designed for cooling may not provide the same level of heating performance as dedicated heating systems. While refrigerants can provide heating during the reverse cycle operation of air conditioning systems, their primary purpose is cooling. For optimal heating performance, dedicated heatpumps designed specifically for heating are generally more efficient.

Early signs of an Environmental problem

For more than 40 years, the Air Conditioning and Refrigeration industry have been aware of the negative effects of refrigerants when they escape into the environment, triggered by the discovery of the growing ozone hole over Antarctica in the 1980's, due in part to the release of reactive chlorine in the upper atmosphere from CFC and HCFC refrigerants. As a result, from 1987 efforts were made to eliminate refrigerants with ozone-depleting properties from use. Refrigerants with *'Zero'* Ozone Depletion Potential (ODP) had fully replaced ozone-depleting refrigerants for new commercial refrigeration systems in New Zealand by 2010, and importing ozone depleting refrigerants was banned from 2015. Some stocks still remain of the ozone depleting refrigerants for servicing and maintenance purposes (most commonly R22), but they are becoming extremely scarce.

Common refrigerants phased out due to their high ODP properties are shown below.

Refrigerant	ASHRAE Number	Ozone Depletion Potential (ODP)
Chlorofluorocarbons (CFCs)	R-11, R-12, R-502, etc.	High
Hydrochlorofluorocarbons (HCFCs)	R-22, R-123, R-141b, etc.	Moderate

So why are we transitioning systems to new refrigerants again?

The new refrigerants that replaced the ozone-depleting substances are now themselves causing concern by contributing to climate change, because of their Greenhouse Effect properties when they escape to atmosphere. The greenhouse effect is the process by which certain gases in the Earth's atmosphere trap heat, causing warming of the planet's surface.

The severity of a refrigerant's effect on climate change is described by its Global Warming Potential, or GWP. Carbon dioxide is assigned a GWP of 1 and all other refrigerants are assigned a GWP based on the heat they absorb in the atmosphere, as a multiple of the heat that would be absorbed by the same mass of carbon dioxide.

The GWP may be zero, in the case of ammonia (R717), or up to a very high number like the commonly used R410a refrigerant with a GWP of more than 2,000.

The following table shows the Global Warming Potential (GWP) of common Zero Ozone Depleting Potential (Zero ODP) refrigerants.

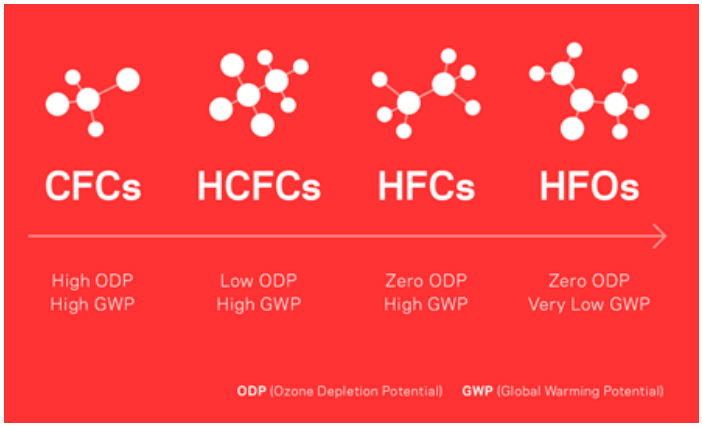
Refrigerant	ASHRAE Number	Global Warming Potential (GWP)
Hydrofluorocarbon (HFC)	R404A, R507A	High (Circa 4,000)
Hydrofluorocarbon (HFC)	R134a, R407A, R410A, R407C	Moderate (Circa 1,400 – 2,100)
Hydrofluorocarbon (HFC)	R32	Moderate (Circa 675 – 771)**
Hydrofluoroolefin (HFO)	R454B, R513A, R515B	Moderate (Circa 290 – 630)
Hydrofluoroolefin (HFO)	R515A, R1234yf, R1234ze	Low (Circa 1 – 7)
Carbon Dioxide (CO2)	R744	Very Low (1)
Hydrocarbon (HC)	R290 (Propane), R600a (Isobutane)	Very Low (3)
Ammonia (NH3)	R717	Very Low (0)

** GWP for R32 was increased from 675 to 771 in Aug 2021 according to the Intergovernmental Panel on Climate Change (IPCC) sixth assessment report "Climate Change 2021. This is greater than the Kigali Agreement's target of 750 for refrigerants from 2024, but at this time is still generally considered compliant with that target within the industry.

When will the transition happen?

It has already begun, following the Paris Agreement of 2015 and the Kigali Agreement of 2016.

Commitments were made to reduce the GWP of refrigerants, and manufacturers have redeveloped their refrigeration products to operate with new refrigerants since then. The targeted GWP for new systems was to reduce to less than 750 by 2024, and less than 150 by 2029.



What new-refrigerant systems are available now?

New refrigerants with Zero ODP and low or very low GWP are widely available for large-scale chillers, which are most applicable for air conditioning in large buildings of more than 3,000m^2.

Small air conditioning systems that typically serve retail spaces and small offices are widely available with GWP of approximately 750 now, with low-GWP systems under development.

The most problematic systems at the moment are for mid-size office buildings of between 500m^2 and 3,000m^2, that have been typically served by Variable Refrigerant Flow systems. These systems contain relatively large quantities of refrigerant that is reticulated throughout the building within in-ceiling pipework.

The increased flammability of the most suitable new refrigerant (R32) gives an increased risk to occupant safety in the event of a leak, making it a less than ideal option. Research has been conducted into refrigerants that are equivalent to R32 but with a low flammability (such as R466A), but prevailing technical issues mean this has not been adopted by any VRF manufacturer.

Only one VRF manufacturer currently offers a practical low-GWP solution (known as HVRF) where the majority of the reticulated refrigerant is replaced by water as the heat transfer medium, which reduces the flammability issue but at an increased cost.

What does this mean for commercial air conditioning systems?

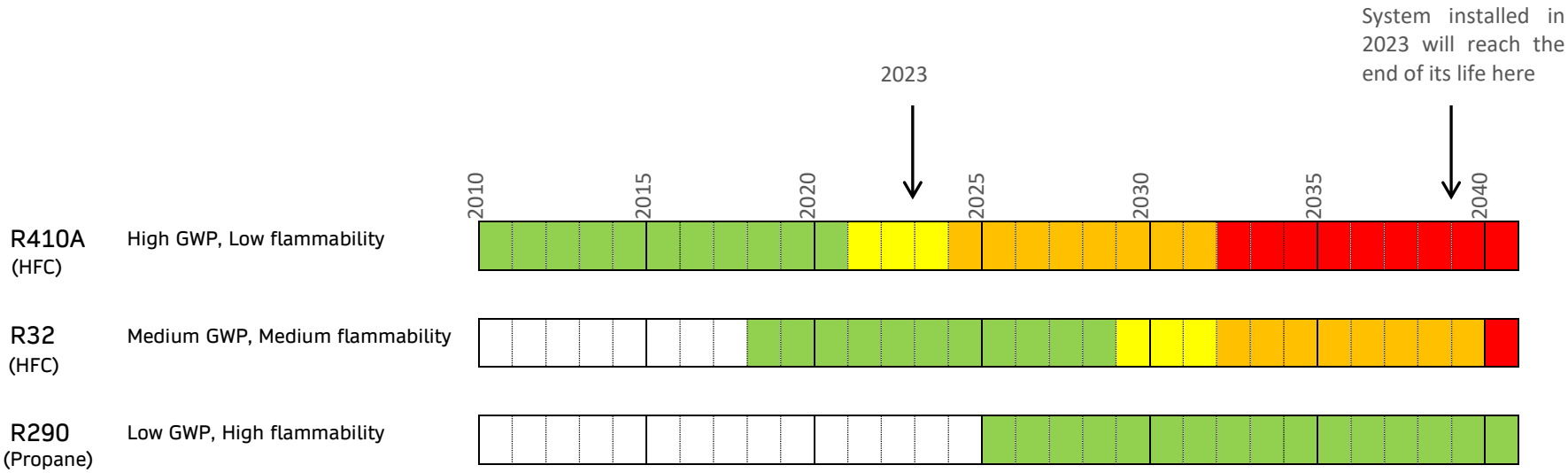
A new air cooled chiller may be expected to last 18 to 20 years if well designed, selected and maintained. This means that any new chiller installed in 2023 will likely still be operational in 2040.

VRF or small split-type systems have a typically shorter life, of 15 to 18 years. It is therefore recommended that the possible effects of obsolescence, increased costs and reduced availability for replacement refrigerant over the lifetime of the system are considered if a higher-GWP refrigerant system is used.

The timeline of these effects are shown below:

Split System AC Units (Small Buildings)

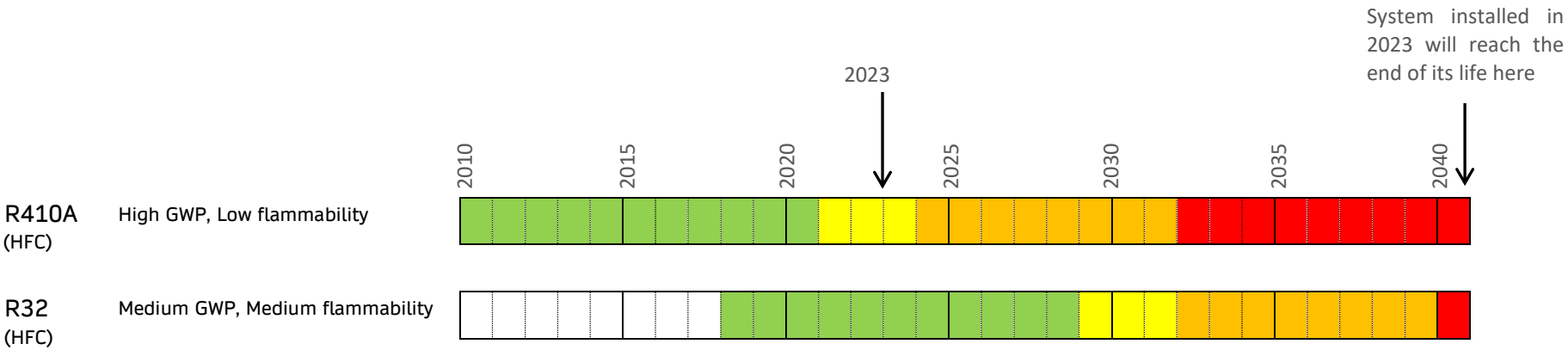
- New equipment readily available
- New equipment in transition to new refrigerant, replacement components widely available
- New equipment becoming scarce, replacement components widely available
- Replacement components becoming scarce, refrigerant cost becoming prohibitive for maintenance



Note: All of the above are Zero ODP

Variable Refrigerant Flow Systems – VRF (Mid-sized Buildings)

- New equipment readily available
- New equipment in transition to new refrigerant, replacement components widely available
- New equipment becoming scarce, replacement components widely available
- Replacement components becoming scarce, refrigerant cost becoming prohibitive for maintenance

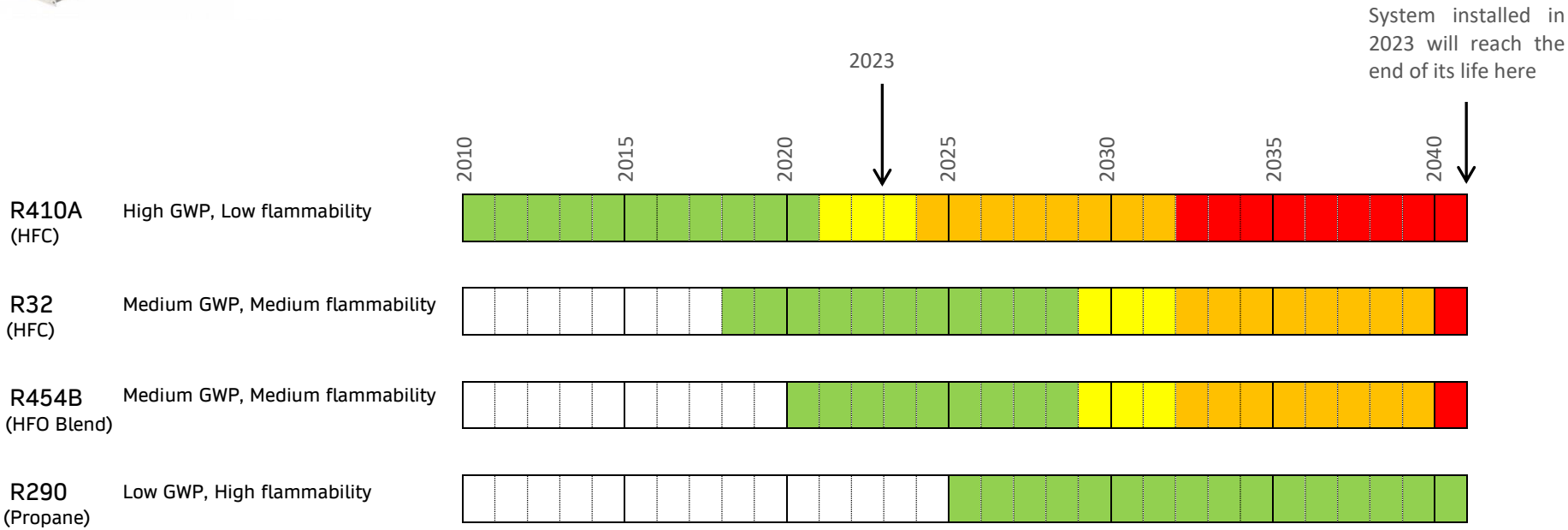


Note: All of the above are Zero ODP

Small Chillers/ Small Heatpump Chillers (Medium to Large Buildings)

Up to 600 kilowatts

- New equipment readily available
- New equipment in transition to new refrigerant, replacement components widely available
- New equipment becoming scarce, replacement components widely available
- Replacement components becoming scarce, refrigerant cost becoming prohibitive for maintenance

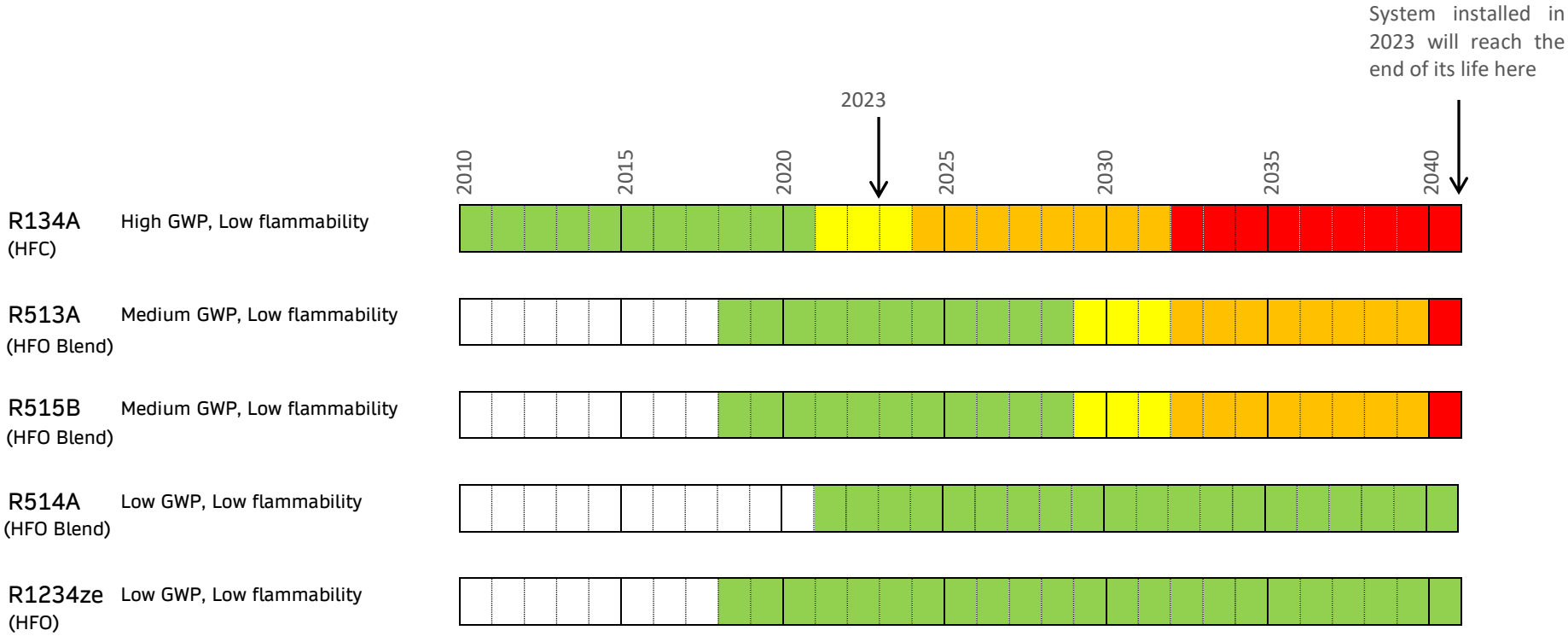


Note: All of the above are Zero ODP

Large Chillers (Large Buildings)

Greater than 600 kilowatts

- New equipment readily available
- New equipment in transition to new refrigerant, replacement components widely available
- New equipment becoming scarce, replacement components widely available
- Replacement components becoming scarce, refrigerant cost becoming prohibitive for maintenance



Note: All of the above are Zero ODP

Applications Advice

While each project must be assessed in its own right, the following general guidelines provide some basic guidance.

Small Office Buildings

For a small office building, an ideal choice of refrigerant would be one that has both zero Ozone Depletion Potential (ODP) and low Global Warming Potential (GWP) to minimize environmental impact. Two examples of current options that meet these criteria are:

R32 (Difluoromethane):

ODP: Zero (no ozone depletion potential)

GWP: Approximately 750 (relatively low compared to other HFC refrigerants)

Description: R32 is a single-component HFC refrigerant that has gained popularity in recent years due to its favourable thermodynamic properties and lower GWP compared to other HFCs. R32 offers good energy efficiency and is now commonly available in air conditioning and heatpump applications, particularly in split type air conditioning systems.

Medium sized Office Buildings

For a medium sized office building, the ideal choice of refrigerant would also be one that has zero Ozone Depletion Potential (ODP) coupled with low Global Warming Potential (GWP), to minimising environmental impact. Three current options that meet these criteria are:

R32 (Difluoromethane):

ODP: Zero (no ozone depletion potential)

GWP: Approximately 771 (relatively low compared to other HFC refrigerants)

Description: R32 is a single-component HFC refrigerant that has gained popularity in recent years due to its favourable thermodynamic properties and lower GWP compared to other HFCs. R32 offers good energy efficiency and is now commonly available in air conditioning and heatpump applications, particularly in split air conditioning systems.

R1234ze (Trans-1,3,3,3-Tetrafluoropropene):

ODP: Zero (no ozone depletion potential)

GWP: Approximately 6-7 (very low GWP)

Description: R1234ze is a hydrofluoroolefin (HFO) refrigerant that is a low-GWP alternative to HFC refrigerants. It is used in various applications, including chillers, air conditioning systems, and heatpumps, although its low specific heat capacity means that in heating applications, larger machine may be required. R1234ze offers reasonable energy efficiency and has a negligible environmental impact due to its extremely low GWP. Physical sizes of chillers are typically larger than machines they replace using older refrigerants.

R454B (a blend of R1234yf and R32):

ODP: Zero (no ozone depletion potential)

GWP: Approximately 467 (relatively low compared to other HFC refrigerants)

Description: R454B is a Blended hydrofluoroolefin (HFO) refrigerant that is a low-GWP alternative to HFC refrigerants. R454B offers similar energy efficiency and was primarily intended to replace R404A and R507A. It is now commonly available in air conditioning applications, medium sized chillers.

R32, R454B and R1234ze all provide zero ODP, which means they do not contribute to ozone depletion. R1234ze has a significantly lower GWP compared to R454B and even more so compared to R32, making it a preferable choice in terms of climate impact, although it is currently still more suitable to larger installations.

Large Office Buildings

For large-sized office buildings, where the scale of the HVAC systems is significant, it's advisable to consider refrigerants that not only have zero Ozone Depletion Potential (ODP) and low Global Warming Potential (GWP), but also provide efficient performance at a larger capacity. One option that fits these criteria is R1234ze (Trans-1,3,3,3-Tetrafluoropropene). Here's why it could be a suitable choice:

R1234ze (Hydrofluoroolefin HFO**):**

ODP: Zero (no ozone depletion potential)

GWP: Approximately 6-7 (very low GWP)

Description: R1234ze is a hydrofluoroolefin (HFO) refrigerant that offers a compelling combination of zero ODP and a very low GWP and is increasingly being used as an alternative to high-GWP HFC refrigerants. R1234ze provides efficient cooling performance and is suitable for larger-scale applications, such as in large-sized office buildings. It is commonly used in chillers, air conditioning systems, and heatpumps.

By opting for R1234ze, you can prioritise environmental responsibility while still achieving efficient and effective cooling for a large office building.

Systems that use other HFO refrigerants, including R513A and R515B are under development and of increasing usage.

Industrial Sites

Larger industrial sites typically have a range of process and environmental heating and cooling requirements, ranging from low temperature applications such as freezers and cool rooms, through to more traditional HVAC heating and cooling requirements. An integrated design approach is recommended to incorporate heat recovery strategies essential to maximise energy efficiency, as well as minimising the Global Warming outcomes from the site. Suitable refrigerants include:

R717 (Ammonia):

ODP: Zero (no ozone depletion potential)

GWP: 0

Description: Ammonia (NH3) has excellent thermodynamic properties that make it efficient and well-suited for refrigeration applications. However, Ammonia is a toxic substance, and exposure to high concentrations can be harmful to people. Proper safety measures, including appropriate system design, installation, and maintenance, must be followed to ensure safe handling and operation. It is commonly used in large scale industrial refrigeration systems, such as food processing plants, cold storage warehouses, and chemical manufacturing facilities.

R744 (Carbon Dioxide):

ODP: Zero (no ozone depletion potential)

GWP: 1

Description: Carbon Dioxide (CO_2) is a natural refrigerant commonly used in transcritical and subcritical CO_2 refrigeration systems. CO_2 has good heat transfer properties, making it suitable for a range of cooling applications, including freezers and cool rooms. However, its performance may be affected by high ambient temperatures.

R290 (Propane):

ODP: Zero (no ozone depletion potential)

GWP: 0.02

Description: Propane is a hydrocarbon refrigerant with zero ODP and very low GWP. It is used in commercial and industrial refrigeration systems, including freezers and cool rooms. It has good thermodynamic properties and high energy efficiency; however it is flammable and requires specific safety measures during design, installation, operation, and maintenance.

HFO Blends (e.g., R448A, R449A, R450A):

ODP: Zero (no ozone depletion potential)

GWP: Low

Description: HFO blends are hydrofluoroolefin-based refrigerants with zero ODP and low GWP's compared to traditional HFCs. They are designed as drop-in replacements for existing HFC refrigerants and can be used in a variety of industrial cooling applications, including freezers, cool rooms, and HVAC systems.

Note that drop-in replacement refrigerants can result in a small reduction in system capacity compared to the original equipment refrigerant the system was designed around. Blends can also result in significant Glide due to the mixture of constituents, which can lead to operational / reduced efficiency issues in some instances. Compatibility checks are required to make sure original system oils and seals are compatible with the new refrigerant.

Decarbonisation

In the context of buildings, decarbonisation is focussed on the reduction or replacement of fossil fuels such as gas, oil, coal or diesel in favour of lower GWP fuel sources, such as electricity or biomass boilers which utilise organic materials such as wood pellets for fuel.

Heatpumps offer a viable option for replacing fossil fuel use in building heating and air conditioning systems, offering advantages including energy efficiency, reduced greenhouse gas emissions, and the potential for renewable energy integration.

Key considerations include assessing different heatpump types, such as air-source, ground-source (geothermal), or water-source, together with considering spatial requirements, energy availability, integration into existing systems and costs.

While heatpumps can offer long-term cost savings through energy efficiency, the capital cost is likely to be significant with a corresponding long return on investment.

Decarbonisation goals coupled with natural end-of-life plant replacement programmes will stimulate conversion to Zero ODP and low GWP heatpump based heating systems.

A closer look at Carbon Dioxide as a refrigerant

Carbon dioxide (CO_2), also known as R744, can be a suitable refrigerant for use in certain applications, including the production of heating or domestic hot water. Here are some key considerations regarding the use of CO_2 as a refrigerant:

Advantages of CO_2 as a Refrigerant:

Environmentally Friendly: CO_2 has a Global Warming Potential (GWP) of 1, which means it has no direct contribution to global warming. It is a natural refrigerant and does not deplete the ozone layer, making it very environmentally friendly.

Abundant and Cost-Effective: CO_2 is readily available and cost-effective compared to some synthetic refrigerants. It can be easily obtained from various sources, including industrial processes and waste streams.

Energy Efficiency: CO_2 exhibits good thermodynamic properties, allowing for efficient heat transfer and energy performance. It has excellent heat transfer characteristics, particularly in transcritical cooling systems.

Higher Temperatures: CO_2 Heatpump systems can produce heating or domestic hot water up to 90°C

Considerations and Challenges:

High Operating Pressures: CO_2 operates at high pressures compared to traditional refrigerants, requiring the use of specialised equipment and components designed to withstand higher pressures. This can add complexity and cost to the system design and installation and may require specialist installation techniques and skills.

System Complexity: CO_2 systems typically require more complex components, including multiple heat exchangers and pressure regulation devices, to optimize performance. The system design and controls need to be carefully engineered to ensure efficient and reliable operation.

Cooling Capacity Limitations: CO_2 has a lower critical temperature compared to other refrigerants, which can limit its cooling capacity in high-temperature environments. It may not be suitable for regions with hot climates without additional cooling techniques or system designs.

System Safety: CO_2 is a non-toxic refrigerant, but it can be hazardous in high concentrations. Proper safety measures and ventilation systems must be in place to ensure safe operation and avoid potential risks.

The use of CO_2 as a refrigerant in commercial office air conditioning systems has been gaining attention. It is currently commonly employed in specialised applications such as supermarkets, cold storage, some industrial cooling systems and increasingly for smaller domestic hot water heating applications. These applications suit this refrigerant well as they have naturally higher temperature differences than comfort air conditioning applications.

However, implementing CO_2-based air conditioning systems in commercial office buildings requires careful consideration of system design, equipment selection, safety measures, and local regulations.

A closer look at Propane as a Refrigerant:

Propane (R290) is generally not considered for use in commercial office air conditioning systems. There are important considerations to keep in mind when considering the use of propane as a refrigerant in any application:

Advantages of Propane as a Refrigerant:

Environmental Friendliness: Propane is a natural refrigerant with zero ozone depletion potential (ODP) and a very low global warming potential (GWP). It has a GWP of 3, making it one of the lowest-GWP refrigerants available. Its use can help reduce the environmental impact of the cooling system.

Energy Efficiency: Propane has favourable thermodynamic properties, allowing for efficient heat transfer and energy performance. It can provide good cooling capacity and energy efficiency, which can be beneficial for commercial air conditioning applications.

Cost-Effectiveness: Propane is generally more affordable compared to some synthetic refrigerants. It is widely available and cost-effective, which can be advantageous in terms of overall system cost.

Considerations and Challenges:

Flammability: Propane is a highly flammable refrigerant. It falls under the A3 safety classification, indicating that it has a lower flammability limit. Therefore, safety considerations and precautions are of utmost importance. Specialised equipment, installation techniques, and safety measures must be implemented to ensure safe operation and prevent potential fire hazards.

Building Codes and Regulations: The use of flammable refrigerants like propane in commercial office air conditioning systems may be subject to specific building codes, regulations, and safety standards. Compliance with these requirements is essential and should be thoroughly evaluated before implementing propane as a refrigerant.

Equipment and System Design: Propane requires equipment and components designed specifically for its flammability characteristics. Special attention must be given to system design, including material selection, piping, valves, and leak detection systems, to ensure safety and reliability.

Training and Awareness: Proper training of personnel and awareness of safety protocols are crucial when working with flammable refrigerants like propane. Building occupants and maintenance staff should be educated on the specific safety measures and response procedures related to the refrigerant used in the system.

Given the flammability of propane, its use as a refrigerant in commercial office air conditioning systems will require a more stringent approach to safety and compliance. Consulting with HVAC professionals and refrigeration experts experienced in flammable refrigerants is highly recommended to assess the specific requirements, safety considerations, regulatory compliance, and overall feasibility, before considering propane as a refrigerant in a commercial office air conditioning system.

Breaking news on new HFO refrigerants

An increasing level of concern is emerging around secondary effects associated with the breakdown of HFO refrigerants when they are released and migrate to the upper atmosphere.

Commercially available HFO's (Hydrofluoroolefins) are essentially Zero ODP and low-GWP refrigerants in their pure form. These HFO's are based on alkenes like propene (e.g. HFO-1234yf or HFO-1234ze). Their chemical composition makes their molecules less stable, leading to fast decomposition in the atmosphere – within a few days, instead of years to decades for current HFC refrigerants.

When HFO's decompose in the atmosphere, they transition to other substances. These other substances may then break down again, or linger in the atmosphere. Recent research has focused on Per- or Poly- Alkyl Substances (PFAS's), which are potentially harmful and long lasting chemicals that break down very slowly. Of these Trifluoroacetic acid (TFA(A)) is of greatest concern for HFO's.

TFA(A) is formed at much higher rates than current HFC's, which remain in the atmosphere for several days. The trifluoroacetic acid then forms trifluoroacetate (TFA), a salt of trifluoroacetic acid, which is washed out of the air by rain, subsequently appearing in water and on the ground. R1234yf produces approximately 5 times the amount of TFA than the equivalent amount of R134a.

TFA is difficult to remove from drinking water and it is unlikely that the natural degradation rate will keep up with the increasing rates of TFA as the use of HFO refrigerants increases.

In addition, research is now suggesting that R1234ze may form HFC-23 as one of its secondary atmospheric breakdown products, which is a very potent greenhouse gas. Considering the amount of HFC-23 formed from HFO-1234ze, the equivalent GWP is estimated to be in the region of 1,400 +/- 700. If that is indeed found to be true, it would be massively greater than the previously accepted GWP of 7! It would effectively land us back where we started, before low-GWP refrigerant options were being actively explored.

A rear-view mirror summary of the environmental impacts resulting from the use of synthetic refrigerants does not present a compelling narrative:

- The introduction and use of CFC Refrigerants, aerosols and blowing agents over the last 60 years has resulted in damage to the Ozone layer, located some 10-30 km above the earth's surface in the lower stratosphere. The Ozone layer plays a critical role in absorbing the majority of the Sun's harmful ultraviolet (UV) radiation, providing protection to life on Earth.
- The use of Zero ODP, but high GWP HFC's over the last 30 years or so, has resulted in heating of the atmosphere below the ozone layer.
- Science is now questioning whether the use of HFO refrigerants will lead to damage to the lowest layer of the atmosphere and water located at the Earth's surface.

An analysis of the PubChem database (a listing of more than 60 million chemical compounds), has concluded that there are no fundamentally new classes of chemicals suitable for use in vapour compression refrigeration systems. McLinden and Huber (2020) conclude that HFO's are likely to be the last generation of synthetic refrigerants.

The potential environmental harm from HFO refrigerants due to the trifluoroacetic acid, which is formed as one of their atmospheric decay products, may well lead to HFO refrigerants being banned under a future European F-gas regulation.

With so much current uncertainty around HFO's, where does that leave us?

It is increasingly likely that natural refrigerants will become standard for new installations, perhaps almost exclusively. The development of indirect refrigeration systems is being explored as a mechanism to reduce the risk of flammability and toxicity of some natural refrigerants, especially for applications where access by the general public is required.

The future of vapour compression refrigeration technology may well revert to the domain of natural refrigerants that have already been used successfully for more than a hundred years.

i.e. Ammonia, Carbon Dioxide and Hydrocarbons.

(Ref: www.openaccessgovernment.org - Environmental impact of HFO refrigerants & alternatives for the future, published 11 June 2021)

Health & Safety Considerations with respect to Refrigerants

Understanding the following health and safety topics and implementing appropriate measures can help mitigate risks associated with handling refrigerants, protect workers' health, and ensure the safe operation of refrigeration systems. When dealing with refrigerants, including HFC's, HFO's, hydrocarbons, ammonia, and CO2, it is important to be cognisant of key health and safety requirements related to safe handling, storage, and operation. Considerations include the following, as well as any other site or project specific nuances or requirements.

Toxicity: This includes having and understanding of permissible exposure limits, occupational exposure limits, and recommended safety practices for handling, storage and working with each refrigerant.

Flammability: Hydrocarbons such as propane, are flammable. Understanding the flammability characteristics, such as the lower and upper flammability limits of all refrigerants is important to ensure safe handling, storage, and installation practices. Additional requirements include adequate ventilation, fire prevention, and the use of explosion-proof equipment where flammable refrigerant systems are utilised.

Asphyxiation Hazard: Refrigerants, including ammonia and CO_2, can displace oxygen in confined spaces, leading to a risk of asphyxiation. Many refrigerants are odourless and colourless, so their presence in high quantities may not be readily identifiable. Understanding the properties and behaviour of all refrigerants is essential. Mitigation measures such as ventilation, gas detection systems, and adherence to confined space protocols are necessary to ensure safety for everyone. This includes design level calculations to assess the risk of leaks into confined spaces.

Pressure Hazards: Refrigerants are typically stored and operated under high pressure. Understanding the pressure ratings, pressure relief mechanisms, and safe operating practices is crucial to prevent overpressure incidents, leaks, and other pressure-related hazards. Proper training on the safe handling of pressurized systems is essential.

Personal Protective Equipment (PPE): A basic requirement is the use of appropriate personal protective equipment when working with refrigerants. This may include safety glasses, gloves, respiratory protection, and protective clothing to minimize the risk of exposure, especially during handling, charging, and leak repair procedures.

Leak Detection and Repair: Regular leak detection is an essential practice to minimize refrigerant emissions with consequent damage to the environment and to maintain a safe working environment.

Training and Certification: Training and certification programs should be implemented to ensure that personnel handling refrigerants have the necessary knowledge and skills.

Regulatory Compliance: It is important to be aware of local and international regulations and standards regarding the handling, storage, and use of refrigerants. Compliance with the relevant regulations, including proper record-keeping, reporting, and disposal practices, is necessary to ensure environmental and worker safety.

Getting Advice and Compliance

It is important to consult with HVAC and other industry professionals as well as refrigeration specialists, to evaluate the specific requirements and compatibility of refrigerants for your project. Local regulations and codes should be considered when selecting and implementing refrigerants in any building.

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