Refrigerants of the Future:

A Sustainable Approach

This white paper explores the transformation of the HVAC industry toward low-Global Warming Potential (GWP) refrigerants, driven by environmental regulations and sustainability goals. It highlights new refrigerant types, global regulations, safety measures, and LG's strategic approach to compliance.

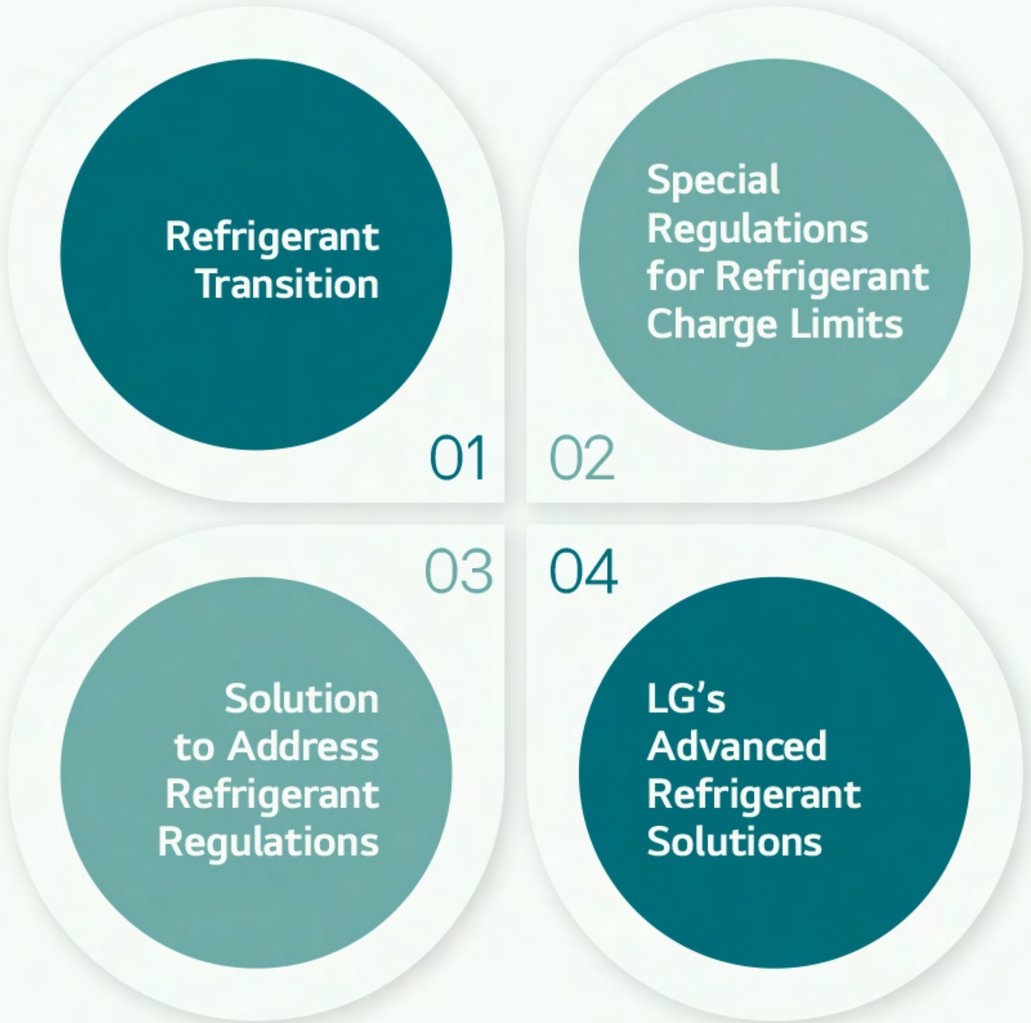
Refrigerant

White Paper Contents

01

01. Introduction

The HVAC industry is currently undergoing a significant transformation, primarily driven by the urgent need for environmental sustainability and the global shift toward more efficient refrigerants. This shift is largely motivated by efforts to reduce CO_2 emissions through the adoption of low-Global Warming Potential (GWP) refrigerants. At the same time, it is important to explain the restrictions on installation area based on refrigerant charge to ensure safety. Therefore, this white paper aims to explore various perspectives on the types of refrigerants we will face and the regulations regarding installation areas according to refrigerant charges.



02

02.
Global Regulation Emerging Refrigerant Types

On a global scale, the landscape of refrigerants is undergoing significant changes due to environmental regulations, notably the Kigali Amendment, which targets an 85% reduction in CO_2 emissions by 2045. In response to these stringent goals, the International Energy Agency (IEA) has been active, bringing together refrigerant companies and major HVAC manufacturers. This collaboration focuses on joint research and evaluation of alternative refrigerants to R410A. Additionally, revisions to international electrical safety standards have been made to adapt to these new requirements. In addition to these initiatives, regulations are being adopted regionally that are influencing the market.

02

a. Europe

The European Union has recently revised its F-Gas Regulation (F-GAS Regulation 2024/573), adopted on February 7, 2024, and enacted on March 11, 2024, to strengthen climate change regulations. The amendment aims to expand the use of refrigerants with low GWP.

In addition, enhanced reduction quotas to reduce the volume of high-GWP HFC refrigerants in the market. The goal of these reduction quotas is to achieve climate neutrality by 2050. The restrictions on the use of solutions with a GWP of 150 or higher vary depending on the type and capacity of the solution being used.

Furthermore, stricter regulations on the recovery of high-GWP refrigerants, such as R410A, ensure proper disposal and recycling processes. Implementation of regulations restricting the use of PFAS (Per-and Polyfluoroalkyl Substances)* in refrigerant applications, reflecting growing environmental and health concerns.

* Per- and polyfluoroalkyl substances (PFAS) are man-made chemicals used for their resistance to heat, water, and oil. Known as "forever chemicals," they persist in the environment and the human body and are linked to adverse health effects.

* Source: https://www.consilium.europa.eu/en/press/press-releases/2023/10/05/fluorinated-gases-and-ozone-depleting-substances-council-and-parliament-reach-agreement/

* Source: https://heatpumpingtechnologies.org/final-adoption-of-the-revised-european-f-gas-regulation/

Prohibitions of F-Gases with a GWP > 150

b. United States

Current guidelines and policies in the U.S. are shaping a significant shift in the HVAC industry by promoting the use of low-GWP refrigerants and mandating sustainable practices. These regulations include transitioning to approved refrigerants, banning high-GWP options such as R410A, and enforcing the use of reclaimed refrigerants to reduce environmental impact. To begin with, the U.S. has enacted regulations promoting the transition to A2L refrigerants as endorsed by the EPA and AHRI.

Types of A2L Refrigerants

- R-1234yf
- R-1234ze
- R-32
- R-452B
- R-454B
- R-454C
- R-455A

The majority of new low-GWP refrigerants are classified by ASHRAE as A2L. California has also banned the use of refrigerants with a GWP greater than 700. Starting January 1, 2026, new Variable Refrigerant Flow (VRF) systems cannot use refrigerants with a GWP over 700. Additionally, beginning January 1, 2025, stationary residential and light commercial air conditioning and heat pumps are also prohibited from using refrigerants with a GWP above 700.

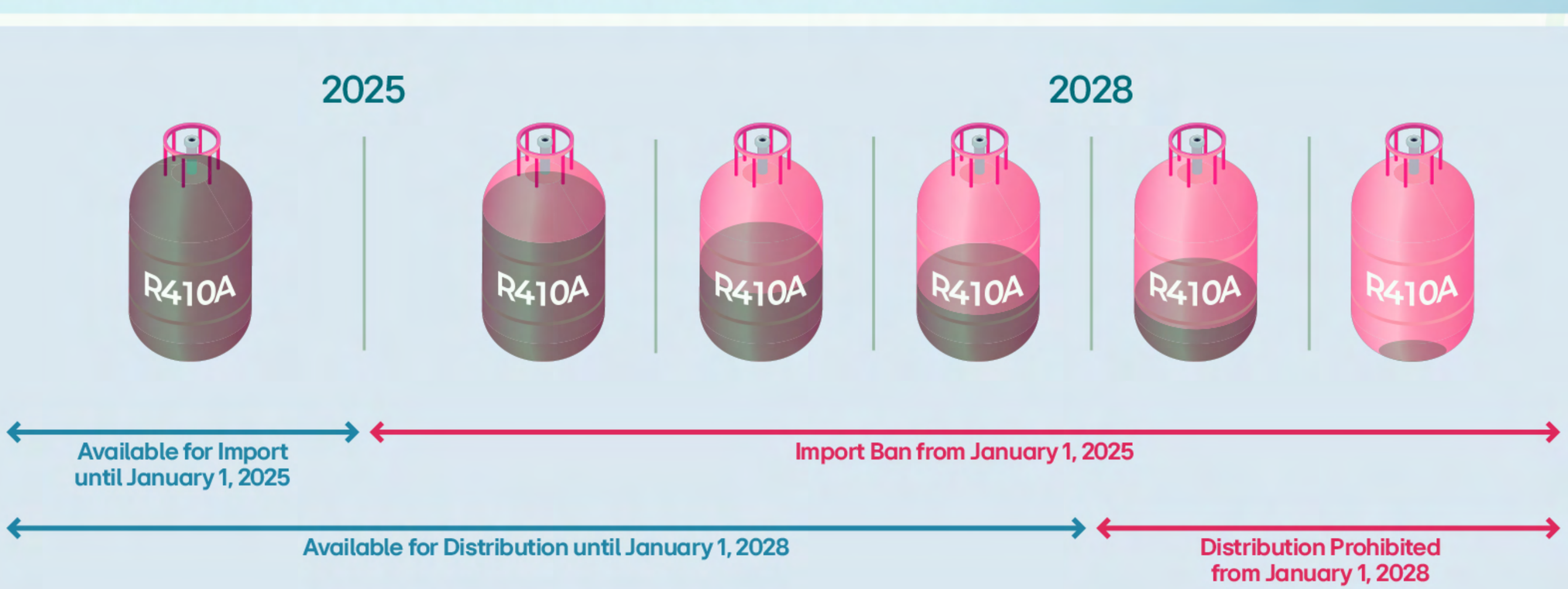
Subsector	System	Gtobal Warming Potential Limit or Prohibited Substances	Installation Compliance Date
Stationary residential and light commercial air conditioning and heat pumps	Residential and light commercial air conditioning and heat pump systems (e.g., mini-split, unitary systems)	700	January 1, 2025
Stationary air conditioning and heat pumps	Variable Refrigerant Flow systems (VRFs)	700	January 1, 2026

* Source: https://www.epa.gov/climate-hfcs-reduction/technology-transitions-hfc-restrictions-sector

02

The accelerated implementation of the AIM (American Innovation and Manufacturing) Act will prohibit the import of products that use R410A refrigerant starting January 1, 2025. Lower-GWP refrigerants will be required thereafter, but R410A products can be sold until January 1, 2028. Furthermore, 23 states have implemented mandates for the use of reclaimed refrigerants with a focus on sustainability and the reduction of refrigerant emissions.

The Import of Products Using R410A refrigerant is prohibited



* Source: https://www.epa.gov/climate-hfcs-reduction/frequent-questions-phasedown-hydrofluorocarbons
* Import prohibition date may vary depending on the product's capacity.

03

03.

Factors to Consider When Evaluating and Selecting Refrigerants

a. Environmental Impact

Consideration is being given to factors such as the GWP, Ozone Depletion Potential (ODP), Life Cycle Climate Performance (LCCP), and CO_2 emissions of refrigerants. These metrics help in assessing the environmental footprint of different refrigerants and their long-term sustainability in HVAC applications.

b. Efficiency

Evaluation of heating and cooling efficiency and the required refrigerant charge. Efficient refrigerants not only provide better performance but also contribute to energy conservation, which is critical in reducing overall operational costs.

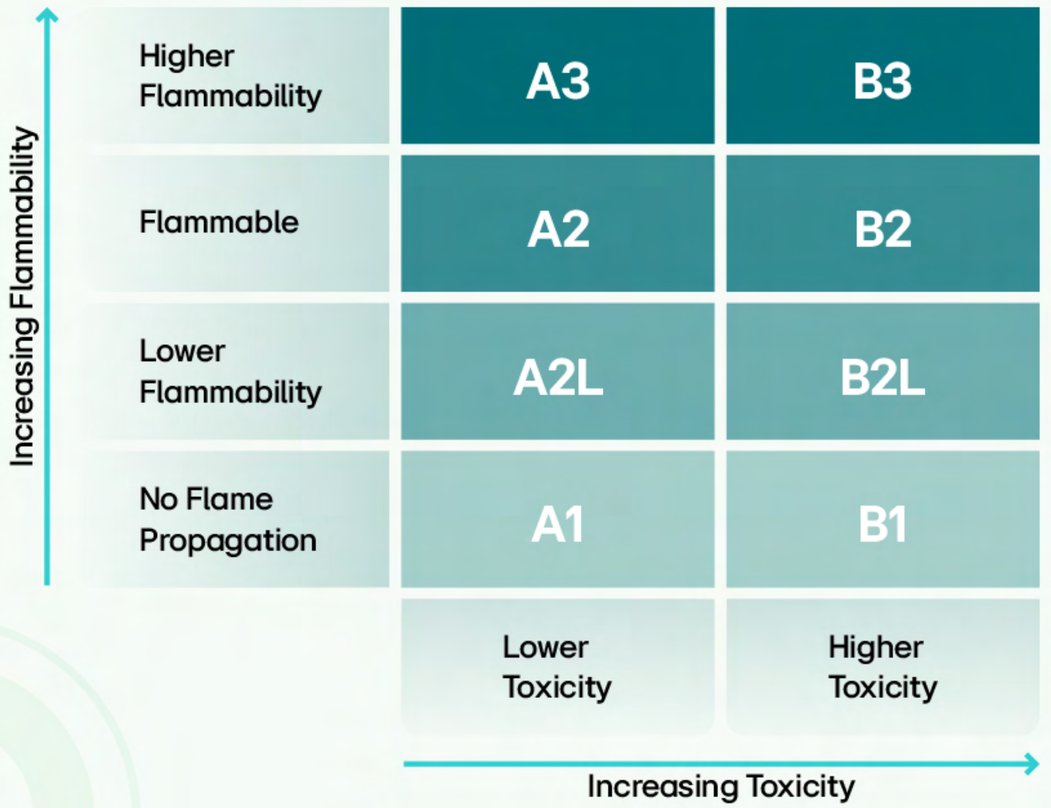
03

c. Cost-Effectiveness

It is necessary to analyze the costs associated with purchasing and using different refrigerants. It is crucial to balance initial refrigerant costs with long-term savings from reduced energy consumption and potential regulatory compliance costs.

d. Safety

Assessment is also done of refrigerant safety based on its classification in terms of toxicity and flammability. Choosing refrigerants with lower risks of toxicity and flammability enhances safety standards in HVAC systems, crucial for both residential and commercial settings.



03

e. Reliability

Examination is also done for the consistent performance of heating and cooling functions and the reliability of refrigerant operation under varied environmental conditions. Reliable refrigerants ensure stable HVAC operation, minimizing maintenance and downtime.

f. Sustainability

Consideration of how well a refrigerant aligns with future regulatory changes and its availability in the market also factors into selecting refrigerants. Selecting refrigerants that are likely to remain compliant with upcoming regulations and are readily available can safeguard investments and ensure compliance over the lifespan of HVAC systems.

These considerations are integral not only to optimizing the performance of HVAC systems but also to aligning with broader environmental objectives and regulatory frameworks.

04

04. Criteria for Assessment of Refrigerants in the Market

Assessing key characteristics such as GWP, chemical composition (including HFCs, HFOs), classification by ASHRAE, presence of PFAS, and regulatory compliance. This evaluation helps identify the advantages and disadvantages of each refrigerant, facilitating informed decisions based on performance, environmental impact, and safety.

04

Refrigerant Evaluation Criteria

Refrigerant	Designation	ASHRAE Safety Classification	ODP	GWP (AR4)	GWP (AR5)	Pressure	PFAS (OECD)
R22	HCFC	A1	0.055	1810	1760	High	No
R134a	HFC	A1	0	1430	1300	Medium	Yes
R404A	HFC	A1	0	3922	3943	Medium	Yes
R407C	HFC	A1	0	1774	1624	High	Yes
R407F	HFC	A1	0	1825	1824	High	Yes
R410A	HFC	A1	0	2088	1924	High	Yes
R507A	HFC	A1	0	3985	3985	High	Yes
R32	HFC	A2L	0	675	677	High	No
R448A	HFO Blend	A1	0	1387	1273	High	Yes
R449A	HFO Blend	A1	0	1397	1282	High	Yes
R454B	HFO Blend	A2L	0	466	467	High	Yes
R513A	HFO Blend	A1	0	631	573	Medium	Yes
R1233zd	HFO	A1	0	-	<1	Low	No
R1234ze	HFO	A2L	0	-	<1	Medium	-
R290	Natural	A3	0	3	-	High	No
R704	Natural	A1	0	0	0	Cryogenic	No
R717	Natural	B2L	0	0	0	High	No
R718	Natural	A1	0	0	0	Very Low	No
R744	Natural	A1	0	1	1	Very High	No
R1270	Natural	A3	0	2	-	High	No

* Source: https://ozone.unep.org/system/files/documents/OEWG45_ATMO_sidevent.pdf

Definition of Terms

ODP (Ozone Depletion Potential)

This is the potential for a single molecule of refrigerant to destroy the ozone layer, with R-11 being fixed as a reference at an ODP of 1.0.

GWP (Global Warming Potential)

This is a characteristic factor estimating the greenhouse effect of a gas being released into the atmosphere compared to the effect of CO2.

HC (Hydrocarbons)

Substance composed of hydrogen and carbon. They are natural, non toxic refrigerants that have no ozone depleting properties and minimal GWP.

HCFC (Hydrochlorofluorocarbon)

Substance which contains hydrogen, fluorine, carbon and chlorine. They are considered the "second generation" of refrigerants, substituting CFCs (Chlorofluorocarbons) such as R-12.

HFC (Hydrofluorocarbon)

Substance containing hydrogen, fluorine and carbon. They are considered the "third-generation" of refrigerants, with no ODP, but are greenhouse gases (high GWP).

HFO (Hydrofluoroolefin)

Substance composed of hydrogen, fluorine and carbon. They are considered the "fourth generation" of refrigerants, with a thousand times lower GWP than HFCs.

Natural Refrigerants

Chemicals which occur in nature's bio-chemical processes. They do not deplete the ozone layer and make a negligible or no contribution to global warming.

PFAS (Per- and polyfluoroalkyl substance)

Per- and polyfluoroalkyl substances (PFAS) are a large, complex group of synthetic chemicals that have been used in consumer products around the world since about the 1950s. They are ingredients in various everyday products.

05

05.

Spatial Regulations for Refrigerant Charge Limits

The IEC (International Electrotechnical Commission) is a global organization that develops and publishes international standards for all electrical, electronic, and related technologies, ensuring safety, reliability, and efficiency. Under the IEC, IEC 60335-2-40 outlines the safety requirements for electrical heat pumps, air-conditioners, and dehumidifiers, ensuring refrigerants are designed with enhanced safety features to prevent major refrigerant leaks.

IEC 60335-2-40 incorporates stricter safety measures, such as mandatory refrigerant leak detection systems with refrigerant leak alarm (integrated within the refrigerant leak detector) to notify users of refrigerant leaks, shut-off valve to stop refrigerant leaks, and natural ventilation or mechanical ventilation to disperse and dilute leaked refrigerant. Appliances must also be free of internal ignition sources to mitigate fire risks. Refrigerant charge limits are based on the minimum occupied room volume.

05

Refrigerant Leak Detection System

- Utilization of refrigerant leak alarm (integrated within the refrigerant leak detector)
- Incorporation of shut-off valve
- Natural ventilation or mechanical ventilation

Fire Risk Mitigation

- No internal ignition sources in appliances

Refrigerant Charge Limits

- Based on minimum occupied room volume

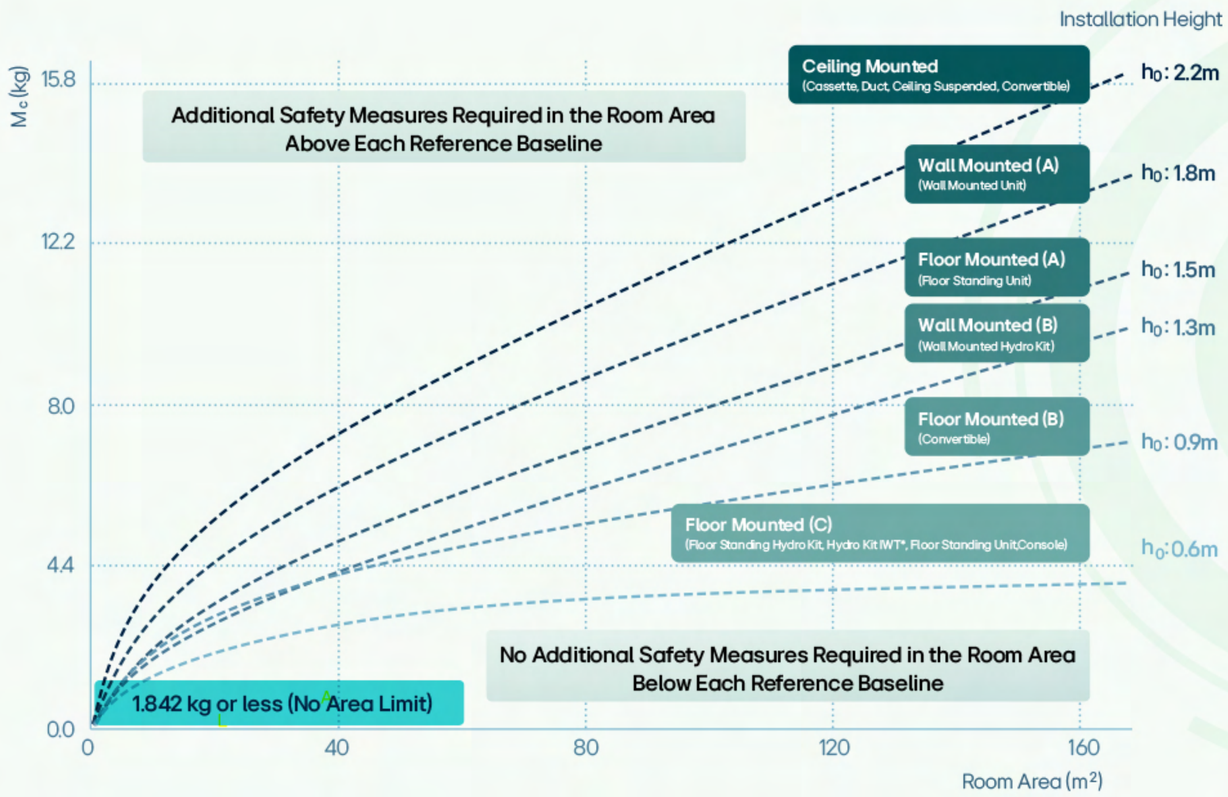
Now, let's examine how these regulations apply specifically to A2L refrigerants such as R32 regarding charge limits. The regulations go further to specify detailed guidelines for refrigerant charge limits.

Considering various environmental variables, our explanation here will focus on using unventilated spaces as an example. Please refer to the table below to help in further understanding these concepts.

05

This chart outlines the room area requirements for unventilated spaces based on the total refrigerant charge. For ceiling-mounted units installed at a certain height, no additional safety measures are needed if the refrigerant amount is within a certain range. If the refrigerant amount falls within a higher range, one or more safety devices are required.

Similar rules apply to wall-mounted units at different installation heights, with different thresholds for when additional safety devices are required based on the refrigerant charge. Of course, this data assumes that all Enhanced Tightness Refrigerating Systems (ETRS) measures have been applied properly.



* IWT: Integrated Water Tank

05

In addition to enhanced tightness, solutions such as refrigerant leak alarm (integrated within the refrigerant leak detector), shut-off valve, and natural ventilation or mechanical ventilation, in conjunction with refrigerant detection systems are available to comply with refrigerant regulations. However, since natural ventilation can be challenging to define and highly dependent on the installer's expertise, which increases the risk of errors, LG provides solutions that exclude the natural ventilation approach.

* Please be aware that while this qualifies as a Safety Device in Europe, it may not be recognized as such in the United States. It is essential to verify the specific regulatory requirements for each region.

This is just one example of the many cases for which IEC 60335-2-40 outlines safety regulations. For more detailed information, please contact a local LG representative.

This regulatory framework ensures that HVAC systems using modern refrigerants operate safely and efficiently across different regions by enforcing stringent requirements for leak detection, ignition prevention, and safety measures.

06

06. LG's Strategy to Address Refrigerant Regulations

Manufacturers are actively developing a range of strategies to comply with the evolving regulations surrounding refrigerants. LG is addressing these challenges by categorizing refrigerants based on regional and product-specific requirements, ensuring tailored solutions that meet diverse regulatory standards.

Furthermore, LG implements advanced safety devices to allow for increased refrigerant charge limits, enhancing both safety and efficiency. To support this, LG also provides comprehensive design support tools, enabling users to simulate and understand these complex regulations before actual implementation, thereby ensuring compliance and optimal performance.

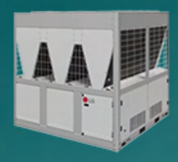
06

a. Refrigerant Lineup by Region

LG actively manages a broad spectrum of refrigerants, effectively adapting to regulatory changes. The company utilizes a variety of refrigerants, including R32, R454B, and R290, considering regional needs and product characteristics.

For instance, utilizing R290 refrigerant for single split and R32 refrigerant for large-capacity Variable Refrigerant Flow (VRF) systems in the European market, LG offers consumers a streamlined solution. With LG, there's no need to sift through various product lines to ensure compliance with regulations; everything you need is readily available in one place.

LG has also implemented a differentiated application strategy to comply with refrigerant regulations across various product types. Additionally, LG is exploring ways to enhance energy efficiency and durability using new refrigerants and is manufacturing key components of HVAC systems, such as the Inverter Scroll Compressor, incorporating LG's technology.

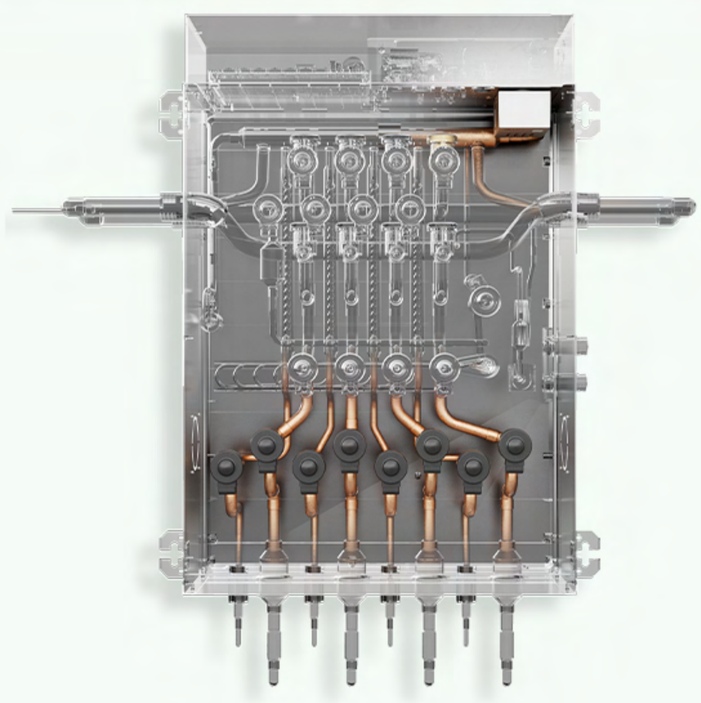
LG		
Single Split 	R22 ▶ R410A ▶ R32 ▶ R290	R410A ▶ R32 ▶ R454B
VRF 	R410A ▶ R32	R410A ▶ R32
Inverter Heat Pump Water Heater & Air-Source Heat Pump 	Inverter Heat Pump Water Heater: **R134a ▶ R290** Air-to-Water Heat Pump Monobloc: **R32 ▶ R290**	Inverter Heat Pump Water Heater: **R134a** Air-to-Water Heat Pump Monobloc: **R32**
Air-Cooled Inverter Scroll Chiller 	R410A ▶ R32	R410A ▶ R32

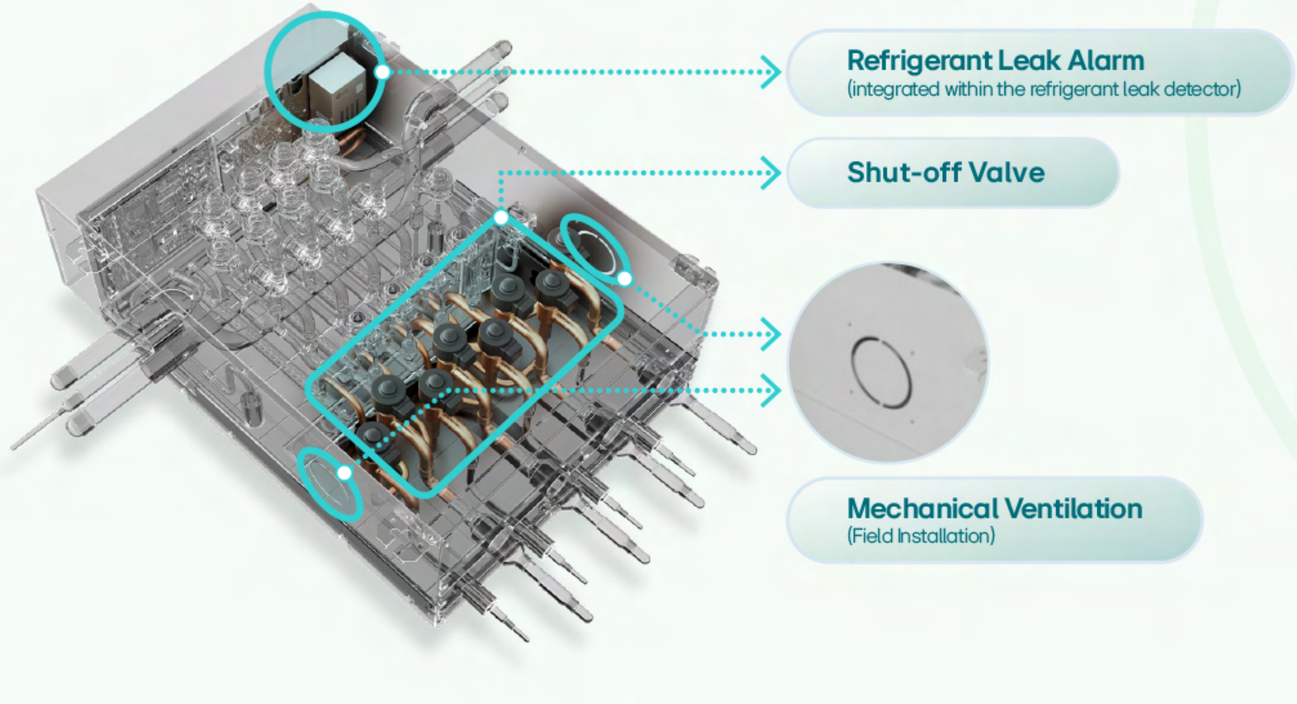
06

b. Safety Device Response Scenarios for Various Solutions

To ensure system safety and compliance with refrigerant regulations, LG offers advanced leak prevention solutions that include the design and installation of refrigerant leak alarm (integrated within the refrigerant leak detector), shut-off valve, and mechanical ventilation. For example, in the European market, LG's embedded leakage detection operation includes a built-in refrigerant leak alarm and shut-off valve inside the Heat Recovery (HR) Unit. When a refrigerant leak is detected, the leaking shut-off valve closes, allowing the remaining indoor units to continue operating normally. The mechanical ventilation to manage the leak effectively is activated, interlocking with the refrigerant leak detection system. This integrated safety feature allows for a reduction in the minimum required room area.

Heat Recovery (HR) Unit

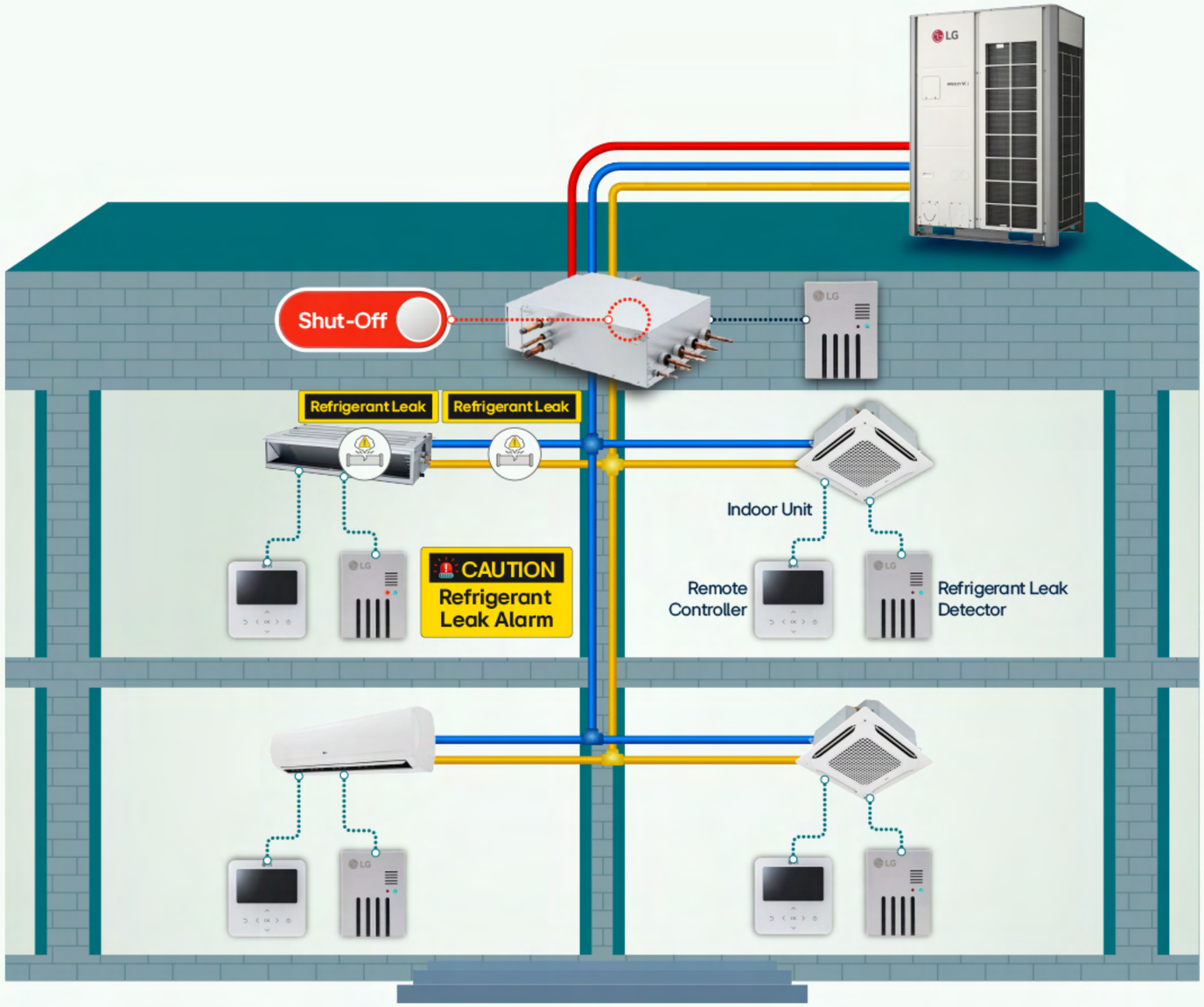




* This image above was created to illustrate the heat recovery unit and may appear different from the actual unit itself.

Next, let’s explore a scenario that illustrates how these safety devices operate in a real-world setting. This example involves an HR unit installation in a space that requires two safety devices. This information assumes that the foundational features of ETRS are already established for the use of A2L refrigerants.

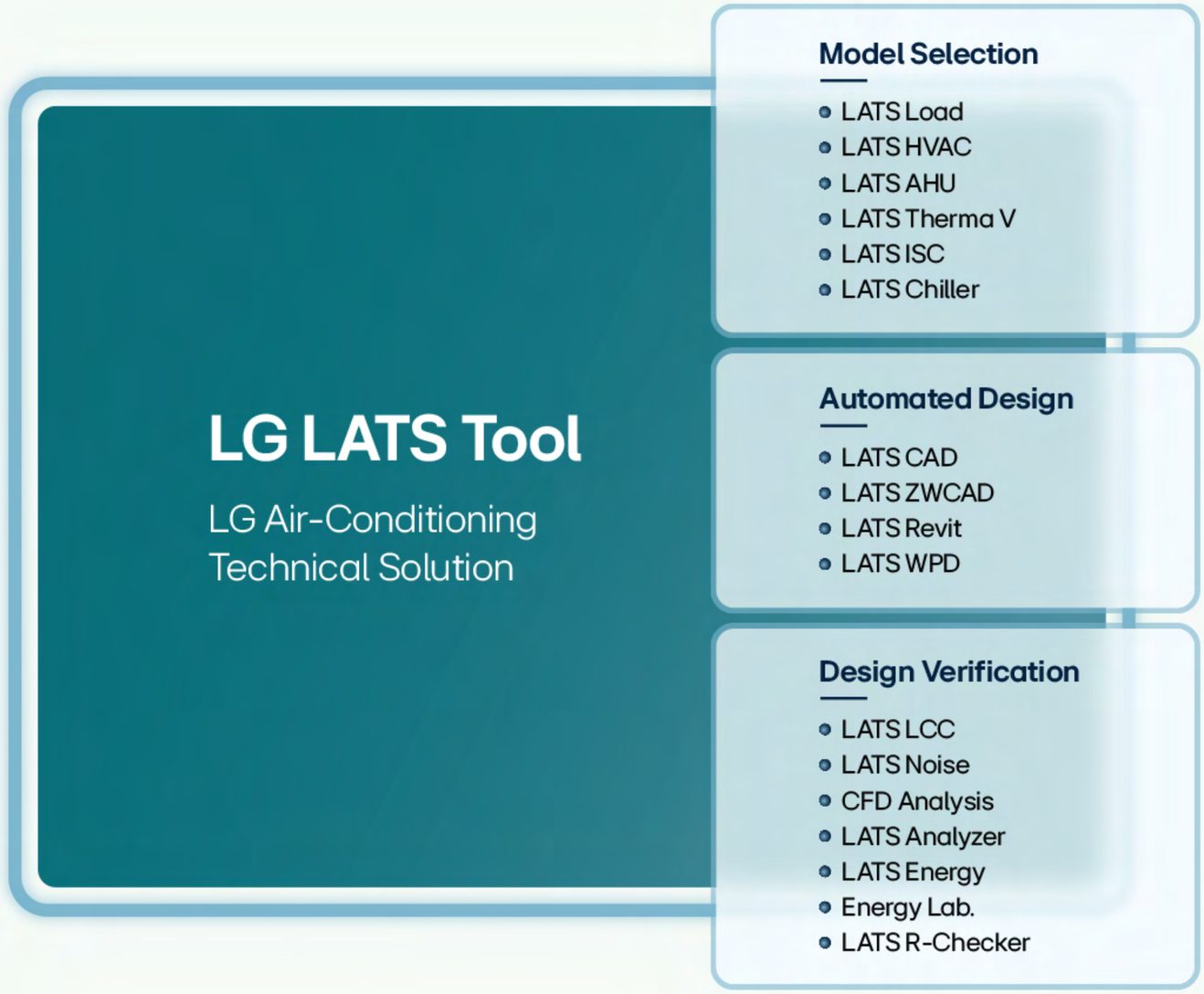
When a refrigerant leak occurs in the indoor unit or in the piping between the Heat Recovery (HR) Unit and the indoor unit, the system operates as follows: All indoor units will stop operating even if only one indoor unit has a leak. Alternatively, the shut-off valve of the leaking indoor unit will close, and the leaking unit will stop while other indoor units continue to operate. This integration is designed to enhance safety by quickly identifying leaks and preventing the spread of refrigerants to ensure compliance with refrigerant regulations.



06

c. Tools That Provide Support for System Designers

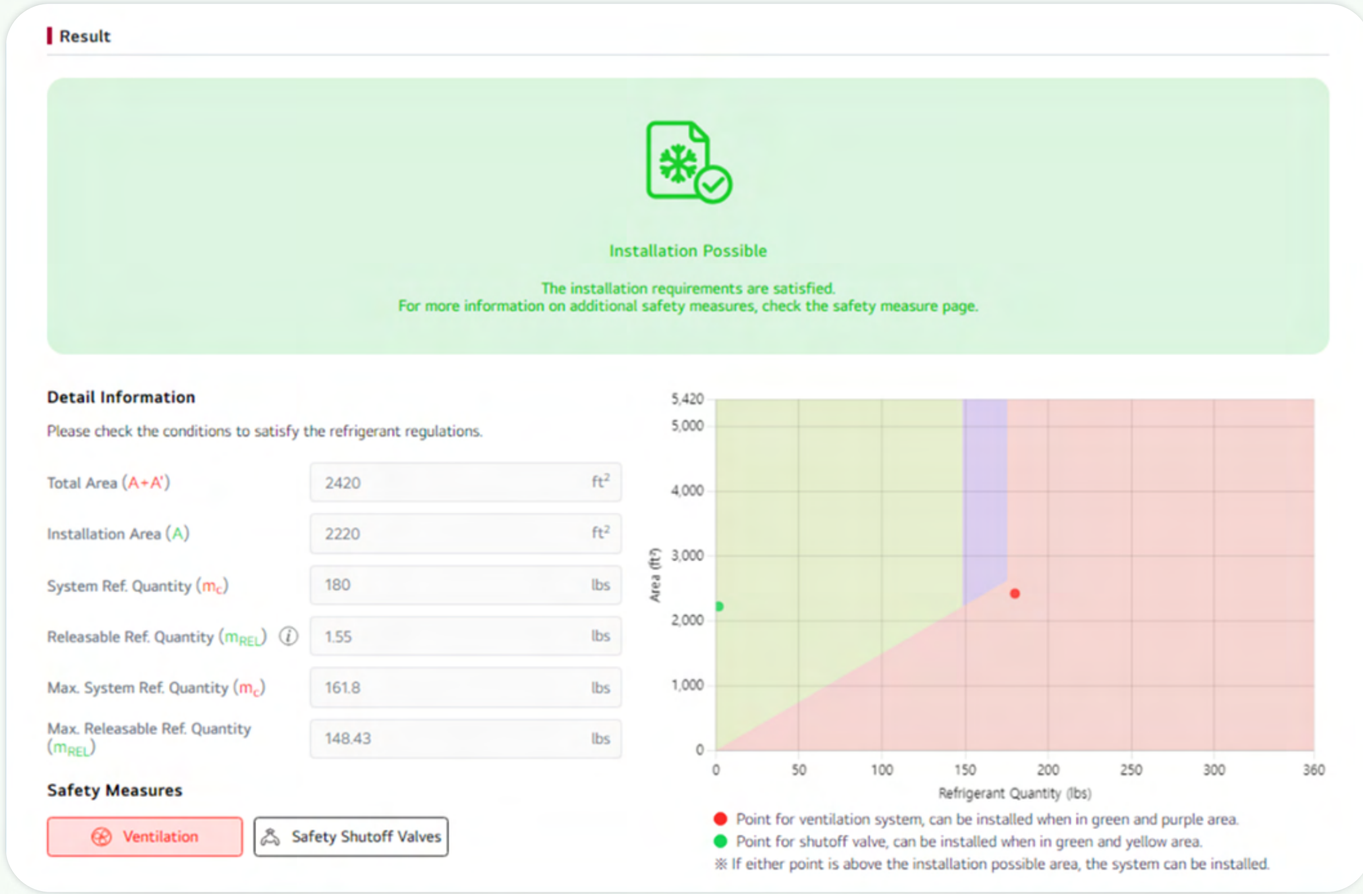
Meeting the complex spatial restrictions associated with refrigerant charge limits can lead to potential errors during the design phase. To mitigate this, LG provide advanced LG Air-Conditioning Technical Solution (LATS) Tools that offer precise calculations and simulations, helping professionals adhere to these stringent requirements.



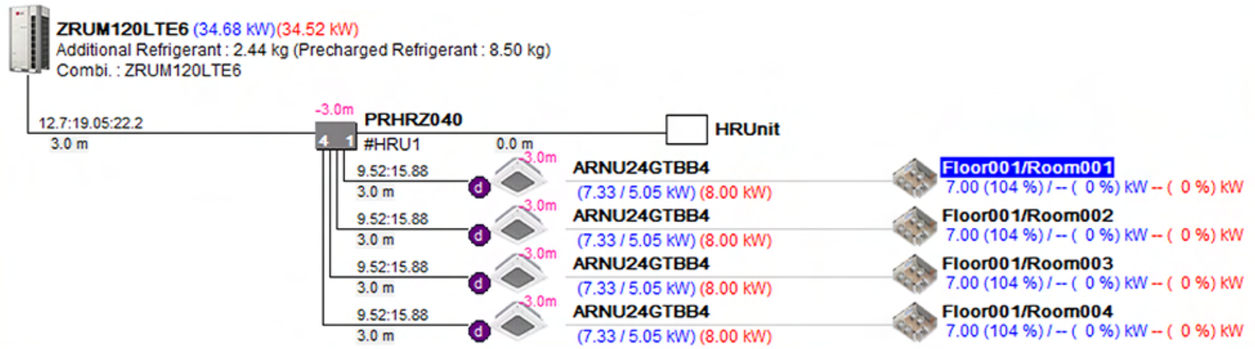
LG LATS R-Checker

These tools enhance accuracy and streamline the process, ensuring that HVAC systems meet safety standards while optimizing performance. By leveraging such technologies, the industry can better navigate the regulatory landscape and achieve greater operational efficiency.

LG offers two tools designed to help HVAC designers and installers easily navigate complex refrigerant regulations. The LATS R-Checker tool allows users to input system properties and information about spaces in a building at the start of a project, enabling them to identify the necessary safety measures with ease.

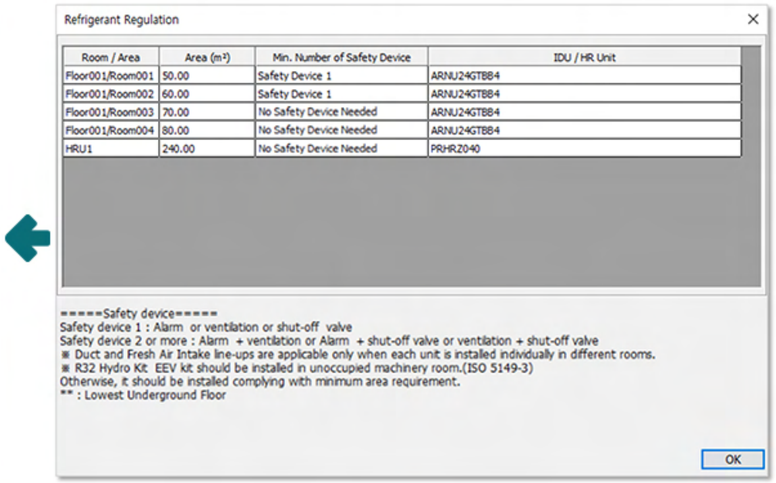


LG LATS HVAC



Confirmation of Compliance with Refrigerant Regulation

- Room / Area
- Min. Number of Safety Device
- IDU (Indoor Unit) / HR Unit (Heat Recovery Unit)
- Safety Device Guidance



On the other hand, the LATS HVAC tool calculates specific refrigerant regulations based on each space or product configuration during the project phase, helping to detect and prevent potential errors that may arise during design and installation.

07

07. Conclusion

LG's vision for refrigerant transition centers on sustainability and the implementation of environmentally responsible practices, reflecting its commitment to environmental and social principles. This vision includes ongoing efforts to respond to low GWP mandates and the continued development of more energy-efficient systems.

To facilitate an easy transition for its customers, LG is dedicated to providing robust support through the development of design tools such as the LATS tool, the establishment of a global academy environment, and comprehensive global engineering support. This comprehensive approach not only underscores LG's leadership in the HVAC industry but also reinforces its commitment to supporting its customers through every step of the transition towards more sustainable refrigerant solutions. Through these initiatives, LG aims to lead by example, driving the industry forward while ensuring that both the planet and the needs of its customers are well catered to.

The overview provided in this white paper doesn't cover all the details of each regulation regarding refrigerants or specific exceptions. As regulations are broad and constantly evolving, please contact your local LG consultant for more detailed information.

www.lg.com/global/business/hvac

facebook.com/lghvacglobal

linkedin.com/company/lghvacglobal