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Building an Implementation Ecosystem for South Korea's Refrigerant Transition

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Solutions for Our Climate (SFOC) is an independent policy research and advocacy group that aims to make emissions trajectories across Asia compatible with the Paris Agreement 1.5°C warming target.

Published November 2026

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Executive Summary

South Korea has established a growing set of policies and targets on the phase-down of hydrofluorocarbons (HFCs) for climate action. Yet these measures remain fragmented across institutions, laws, and policy frameworks, while overlapping targets are not fully aligned into a clear transition pathway. As Korea moves from establishing policy foundations toward implementation, the key challenge is not simply to strengthen its compliance with the Kigali Amendment (KA), but to build a coherent national framework that can provide clear direction for refrigerant transition and translate existing policy ambition into sustained emissions reductions. This report examines this implementation challenge through experiences across Asia and identifies practical priorities for Korea.

Summary Table

Limited ■ ■ ■ Well-established

Component	China	India	Thailand	South Korea
National Strategy	■	■	■	■
Lead Institution	■	■	■	■
Multi-stakeholder coordination	■	■	■	■
External technical support	■	■	■	■
LRM	■	■	■	■
Demonstration projects	■	■	■	■
Financial incentives	■	■	■	■
Local implementation	■	■	■	■

1. A decade after the Kigali Amendment, Korea is firmly positioned within Asia's sustainable cooling transition.

A decade after the adoption of the KA, cooling demand is growing rapidly in Asia, stressing the importance of implementing phase-down commitments. Asia accounted for approximately 65% of global air conditioner demand in 2024. At the same time, South Korea remains an important manufacturing and technology hub for the cooling sector, with major Korean manufacturers operating production networks across Asia. This places Korea within a broader regional transition in which the choice of refrigerants, equipment technologies, servicing practices, and end-of-life management will increasingly shape both domestic and regional HFCs emissions.

2. Meeting refrigerant transition goals requires more than controlling HFCs consumption.

The continued increase in HFCs emissions across much of Asia, despite the expansion of national policies, demonstrates the gap between policy commitments and emissions outcomes. Refrigerant transition requires an implementation system that connects regulation with technical capacity, financing, industry participation, and lifecycle refrigerant management (LRM). Declining HFCs consumption does not necessarily result in declining emissions because large quantities of refrigerants remain contained in existing equipment and can be released over many years through leakage, servicing, and disposal. In Korea, the estimated quantity of refrigerants

contained in existing equipment is roughly twice its reported annual HFCs emissions. This highlights why consumption controls alone cannot deliver the full climate benefits of the KA and why recovery, reclamation, reuse, and end-of-life management must be integrated into the transition.

3. Korea has made policy progress, but fragmented governance and unreconciled goals are limiting implementation.

Korea has ratified the KA and developed several policy measures and planned legislation to strengthen refrigerant management. However, responsibilities for refrigerant recovery, treatment, reporting, and transition remain distributed across different ministries and laws, while existing regulations cover only specific equipment categories. At the same time, Korea's HFCs reduction targets under different policy frameworks are not yet presented within a single, coherent ambition framework. This creates uncertainty over how individual measures contribute to an overall transition pathway and makes it difficult to establish clear institutional responsibilities for delivering them. The challenge is particularly important because Korea's recent decline in HFCs consumption has not been accompanied by declining emissions, suggesting that current progress is not yet supported by a sufficiently durable implementation system.

4. Upcoming legislation and regional models offer South Korea a path to durable refrigerant governance.

China's binding national planning, India's distributed multi-stakeholder responsibility, and Thailand's reciprocal international partnerships each illustrate adaptable mechanism for closing implementation gaps. These provide concrete starting points suited to Korea's own institutional context. Two developments already underway offer a concrete opportunity to do this: the pending *Refrigerant Management Act*, which would give Korea's refrigerant measures legal force, and the upcoming *2nd National Basic Plan for Carbon Neutrality and Green Growth*, through which Korea's overlapping targets could be reconciled within a single, coherent ambition framework. Alongside these, strengthening inter-agency coordination, expanding financial and technical support for local governments to replicate and scale initiatives such as Chungnam's and pursuing reciprocal international engagement would help convert Korea's existing policy ambition into a durable implementation system. This is not just for Korea's own climate objectives, but for the broader success of refrigerant transition across Asia.

I. Introduction

Global cooling demand is rising rapidly as temperatures increase, urbanization accelerates, and living standards improve. Cooling technologies such as air conditioners and refrigeration are becoming essential for protecting human health, food security, and economic productivity.

Cooling systems rely heavily on hydrofluorocarbons (HFCs), potent greenhouse gases with global warming potential (GWP) ranging from 140 to 12,400 times that of CO_2. Unless effectively managed, the continued growth of cooling demand risks driving a significant increase in HFCs emissions.

The Kigali Amendment (KA) to the Montreal Protocol has been adopted in 2016 to phase down the production and consumption of HFCs. As of 2026, 173 countries have ratified, committing to HFCs phase-down schedules according to their respective classifications[1] (UNEP, 2026). Implementation of the KA is crucial as it can avoid up to 0.4°C of warming by 2100 (UNEP & IEA, 2020).

Asia is expected to play a decisive role in determining the success of the KA. The region accounts for a substantial share of global cooling demand, manufacturing capacity, and future market growth. Countries such as South Korea, China, India, Indonesia, and Thailand are expanding their cooling sectors while simultaneously developing policies to reduce HFCs emissions and transition toward alternative cooling technologies. As refrigerant demand continues to grow across the region, effective implementation of these policies will become increasingly important.

South Korea sits in a unique position within the KA due to its classification[2]. Although an Article 5 country, it does not receive financial assistance from the Multilateral Fund (MLF). As a result, Korea has largely developed its refrigerant transition policies without internationally supported implementation initiatives available to other Article 5 countries. These include technical assistance for National Cooling Action Plans (NCAPs), lifecycle refrigerant management (LRM), minimum energy performance standards (MEPS), and other implementation programs coordinated by international partners. While Korea has introduced several domestic policies and regulatory initiatives, questions remain regarding how these measures can be translated into an effective and coherent implementation framework.

This report examines how South Korea can strengthen implementation by drawing lessons from across Asia. Rather than a narrow focus on commitments, the report explores governance arrangements, implementation pathways, financing mechanisms, and local capacity-building efforts supporting refrigerant transition in other countries. Through comparative lessons, the report identifies practical considerations for building a more coordinated implementation framework for South Korea.

1 The Kigali Amendment distinguishes between non-Article 5 (developed) and Article 5 (developing) Parties under the Montreal Protocol. These groups are subject to different HFCs phase-down schedules, with Article 5 Parties generally benefiting from longer implementation timelines and eligibility for technical and financial assistance through the Multilateral Fund (MLF).

2 South Korea was initially classified as a non-Article 5 Party due to its reported per-capita ozone-depleting substances (ODS) consumption but was later reclassified as an Article 5 Party (Ozone Secretariat, 1993, 1994). While it received access to the Article 5 compliance schedule, it was encouraged not to seek MLF assistance and therefore does not receive MLF implementation funding (Ozone Secretariat, 1994).

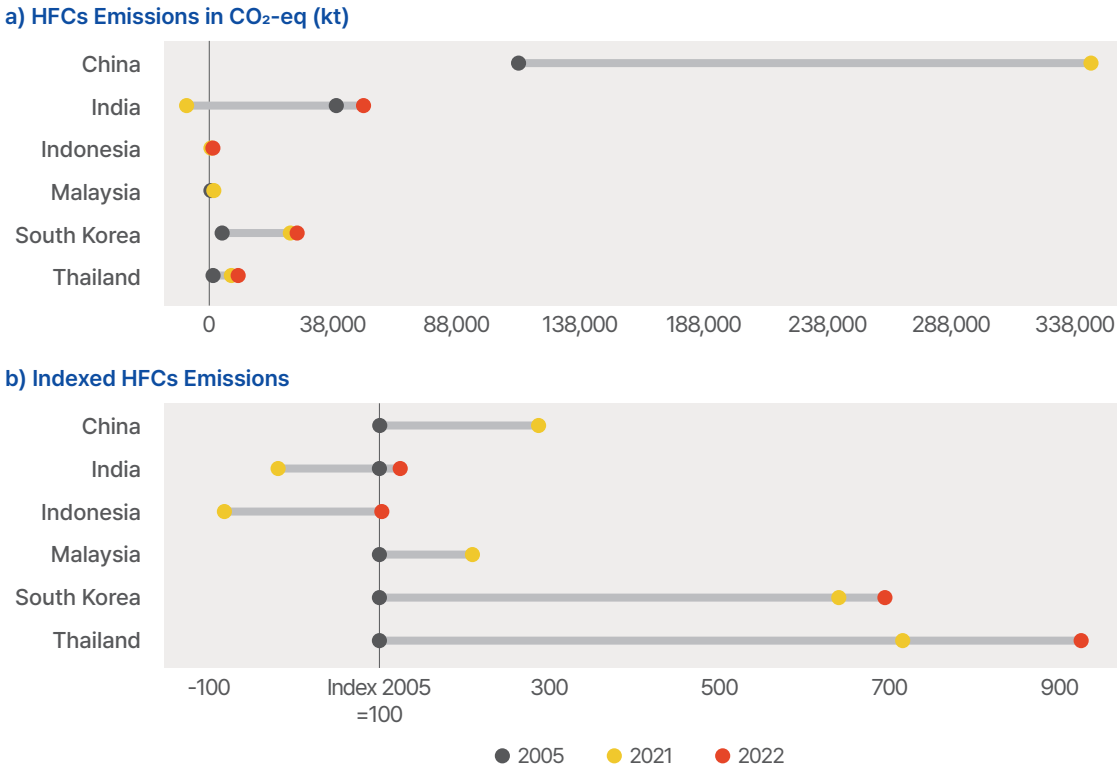
II. The Growing Implementation Challenge

The KA establishes a clear global pathway for reducing HFCs emissions, but achieving its climate benefits ultimately depends on implementation at the national level. As countries move from adopting international commitments to putting them into practice, they face a common challenge: translating phase-down targets into policies, institutions, financing, and market changes that reduce emissions in practice. This implementation challenge is particularly evident across Asia, where rapid growth in cooling demand is increasing refrigerant use even as HFCs phase-down policies begin to take effect. The following sections examine the scale of this challenge and why implementation capacity has become a central issue for refrigerant transition.

A. Rising HFCs Emissions in Asia

A decade after the adoption of the KA, many countries have established regulatory frameworks and national commitments to phase down HFCs. Yet reported emissions indicate a continued rising trend across much of Asia. This highlights an important gap between international commitments and emissions outcomes, suggesting that policy adoption alone is insufficient to deliver significant reductions.

[Figure 1] HFCs emissions trends in selected Article 5 countries (2005, 2021, 2022)[3]



Source: Compilation based on Common Reporting Tables (CRT) submitted to the UNFCCC by China, 2025; India, 2026; Indonesia, 2024; Malaysia, 2024; Republic of Korea, 2025; Thailand, 2025.

3 Indonesia's CRT data does not provide separate emissions for HFCs only, so an aggregate data of HFCs and perfluorocarbons (PFCs) has been used instead. Many CRTs had missing entries for HFCs emissions, so the years 2005, 2021, and 2022 were chosen since most countries reported emissions for those.

Official reports to the UNFCCC indicate that HFCs emissions have risen across most major Asian economies over the past two decades (Figure 1, a)). South Korea's emissions increased over sixfold between 2005 and 2022, while India and Thailand also saw substantial growth in recent years. While India's emissions are lower in 2021 compared to 2005, figures in 2022 have surpassed that of 2005. China reported over 330 $MtCO_2e$ of HFCs emissions in 2022, reflecting the scale of refrigerant use in the world's largest cooling equipment market. While China's actual emissions outweigh the rest in the region, South Korea and Thailand have seen a significant increase from 2005 (Figure 1, b)). Although the magnitude and trajectories differ across countries, the overall trend suggests that HFCs emissions have continued to grow despite the expansion of international commitments and national policy frameworks.

[Table 1] HFCs consumption trends relative to Kigali baseline in selected Article 5 Parties ($MtCO_2e$)

Country	Baseline	Measure	2020	2021	2022	2023	2024 (v. Baseline)
China	905	Consumption	530	581	666	769	572 (63%)
		y/y change	-	10%	15%	15%	-26%
India	NA[4]	Consumption	-	42	57	51	67
		y/y change	-	-	37%	-11%	31%
South Korea	89	Consumption	63	61	68	65	54 (60%)
		y/y change	-	-3%	11%	-5%	-17%
Thailand	59	Consumption	32	35	62	-	33 (55%)
		y/y change	-	6%	79%	-	-47% (v. 2022)

Source: (Ozone Secretariat, 2025b)

Comparing these emissions trends against HFCs consumption, the metric directly governed by KA reveals further gaps (Table 1). Between 2020 and 2024, consumption declined relative to baseline in China, South Korea, and Thailand, falling to 63%, 60%, and 55% of baseline levels respectively. Notably, even where consumption has declined, this has not been accompanied by a corresponding decline in emissions (Figure 1). This divergence reflects the substantial lag between refrigerant consumption and its eventual release into the atmosphere. Hence, consumption trends alone provide an incomplete, and potentially misleading picture of implementation progress.

B. Growing Cooling Demand and Economic Drivers

Rising HFCs emissions are closely linked to rapidly growing demand for cooling across Asia. Population growth, urbanization, rising incomes, and more frequent heatwaves are driving increased ownership of air conditioners and refrigeration equipment throughout the region. In 2024, approximately 65% of the world's total air conditioner demand came from Asia, and China alone accounted for 38% of the total (JRAIA, 2025).

This expanding cooling market creates a structural challenge for refrigerant transition. Without improvements in refrigerant technology, refrigerant recovery, and end-of-life management, growing equipment stocks are likely

4 Unlike the other countries in the table, India is an Article 5 Group 2 country that follows a delayed phase-down schedule. The baseline is calculated using HFCs data from 2024 to 2026, in addition to 65% of the historic HCFCs baseline, which is why the baseline is unavailable at the time of the report publication.

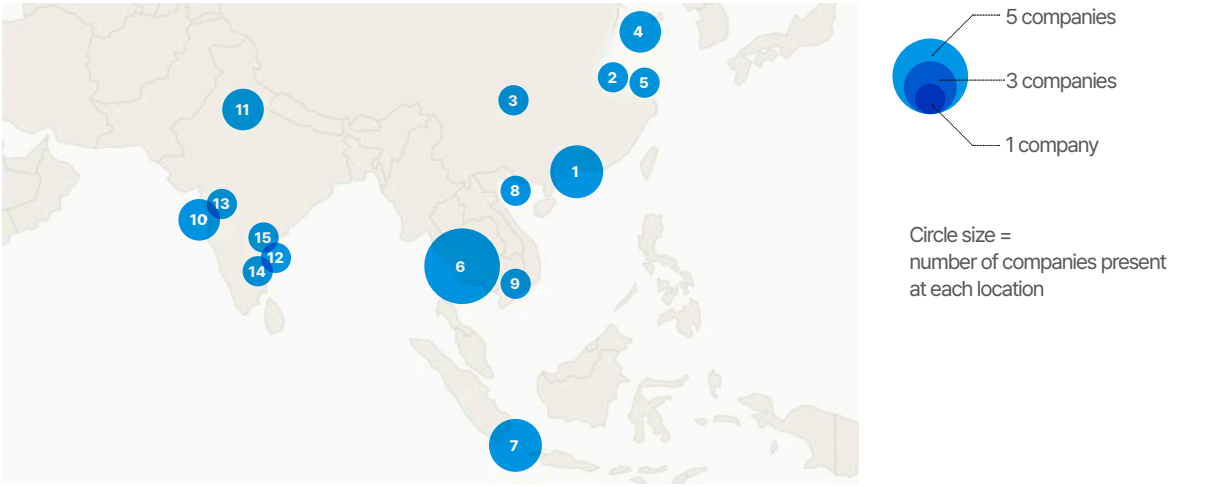
to increase HFCs demand and emissions. As cooling demand continues to accelerate across Asia, reducing emissions will therefore depend not only on adopting lower-GWP refrigerants but also on establishing effective policies and institutions that can support their deployment throughout the equipment lifecycle.

Figure 2 identifies major manufacturing facilities operated by leading HVAC manufacturers located within Asia. Facilities located in South Korea and Japan are excluded as many of them serve the domestic market or multiple regions that go beyond the Asian market. Nearby facilities are grouped into manufacturing hubs to reflect the concentrated, cluster-based nature of regional HVAC production. Selected facilities produce HVAC equipment and products, refrigerators, often with other home appliances and electronics.

HVAC manufacturing in Asia is concentrated on several industrial clusters. Thailand's Eastern Seaboard and China's Pearl River Delta emerge as particularly dense manufacturing hubs, incorporating facilities operated by multiple major companies. This reflects the growing cooling demand across Asia, and these central hubs allow supplying products both domestically and exporting within the region.

South Korean manufacturers, LG Electronics and Samsung, operate significant production facilities across Indonesia, India, Thailand, and Vietnam. Although Korea does not benefit from MLF programs domestically, it is heavily involved in the regional manufacturing networks that are subject to other countries' Kigali implementation frameworks. Hence, Korea is in a dual position as a key manufacturer within the regional supply chains, but a policy outlier in terms of implementation support. This unique position underscores why the country's engagement with regional implementation lessons, carries particular relevance, which will be discussed in the following sections.

[Figure 2] Location of major HVAC manufacturing facilities in selected Asian countries[5]



5 While detailed proprietary market-share data is not publicly accessible to make a verified market-share ranking, the selected companies commonly appear across multiple independent industry market reports, reflecting industry consensus on major manufacturers. The map is illustrative of the region's manufacturing significance rather than an exhaustive inventory of RAC manufacturers operating in Asia.

#	Country	City / Province	Companies
1	China	Pearl River Delta (Shunde, Guangzhou, Zhuhai)	Midea, Gree, Hisense
2	China	Hefei	Gree
3	China	Chongqing	Gree
4	China	Shandong (Qingdao, Jiaozhou)	Haier, Hisense
5	China	Suzhou	Daikin
6	Thailand	Eastern Seaboard (Chonburi, Rayong)	LG, Samsung, Midea, Mitsubishi, Haier
7	Indonesia	West Java (Bekasi, Cikarang, Karawang)	LG, Samsung, Midea
8	Vietnam	Haiphong	LG
9	Vietnam	Binh Duong	Midea
10	India	Pune	LG, Samsung
11	India	NCR (Noida, Greater Noida)	LG, Haier
12	India	Sri City	LG (TBD)
13	India	Supa / Ahmednagar	Midea
14	India	Tamil Nadu	Mitsubishi
15	India	Andhra Pradesh	Hisense

C. Building Implementation Capacity

The growing body of research on refrigerant transition suggests that effective implementation depends on far more than establishing regulatory targets or phase-down schedules. Translating the KA into sustained emissions reductions requires a broader implementation framework comprising institutional arrangements, technical capacity, financing mechanisms, and coordination across the cooling sector. Rather than relying on a single policy instrument, countries increasingly employ complementary measures that address different stages of the transition process.

Experience under the Montreal Protocol illustrates this broader understanding of implementation. In many Article 5 countries, HCFC[6] Phase-out Management Plans (HPMPs) and Kigali Implementation Plans (KIPs) include a range of servicing-sector interventions beyond production and consumption controls, such as technician training, certification systems, good servicing practices, refrigerant recovery and recycling programs, and the provision of recovery equipment. These measures recognize that emissions are influenced not only by refrigerant production and consumption but also by how cooling equipment is installed, maintained, serviced, and disposed of throughout its lifetime (UNEP et al., 2026).

Recognizing that refrigerant transition spans multiple sectors, international initiatives have increasingly promoted integrated implementation frameworks. The UNEP Cool Coalition, for example, identifies complementary policy areas, including National Cooling Action Plans (NCAPs), LRM, MEPS, sustainable cooling finance, and integrated cooling policies as key enablers for translating Kigali commitments into practice (Cool Coalition, 2025b). Rather

6 Hydrochlorofluorocarbons (HCFCs) are ozone-depleting refrigerants being phased down under the Montreal Protocol. For Article 5 Parties, the Kigali baseline includes HFCs production and consumption plus 65% of the HCFC baseline, reflecting the ongoing transition from HCFCs to low-GWP refrigerants.

than representing standalone initiatives, these measures reinforce one another by addressing different parts of the cooling value chain, linking refrigerant transition with energy efficiency, market transformation, and broader climate and development objectives (Cool Coalition, 2025b; UNEP et al., 2026).

Effective implementation also depends on coordination among multiple stakeholders. Refrigerant transition involves a diverse range of actors—including national and local governments, technical agencies, industry associations, manufacturers, servicing technicians, financial institutions, and international organizations—whose responsibilities extend across policy development, technical implementation, market transformation, and capacity building. Multi-stakeholder governance has therefore emerged as an increasingly important approach for coordinating these complementary roles and supporting implementation beyond government regulation alone. Studies of climate governance similarly identify knowledge-sharing and peer learning as important drivers of local implementation, particularly in technically complex fields where local institutions require specialized expertise (M. Kim & Yun, 2024).

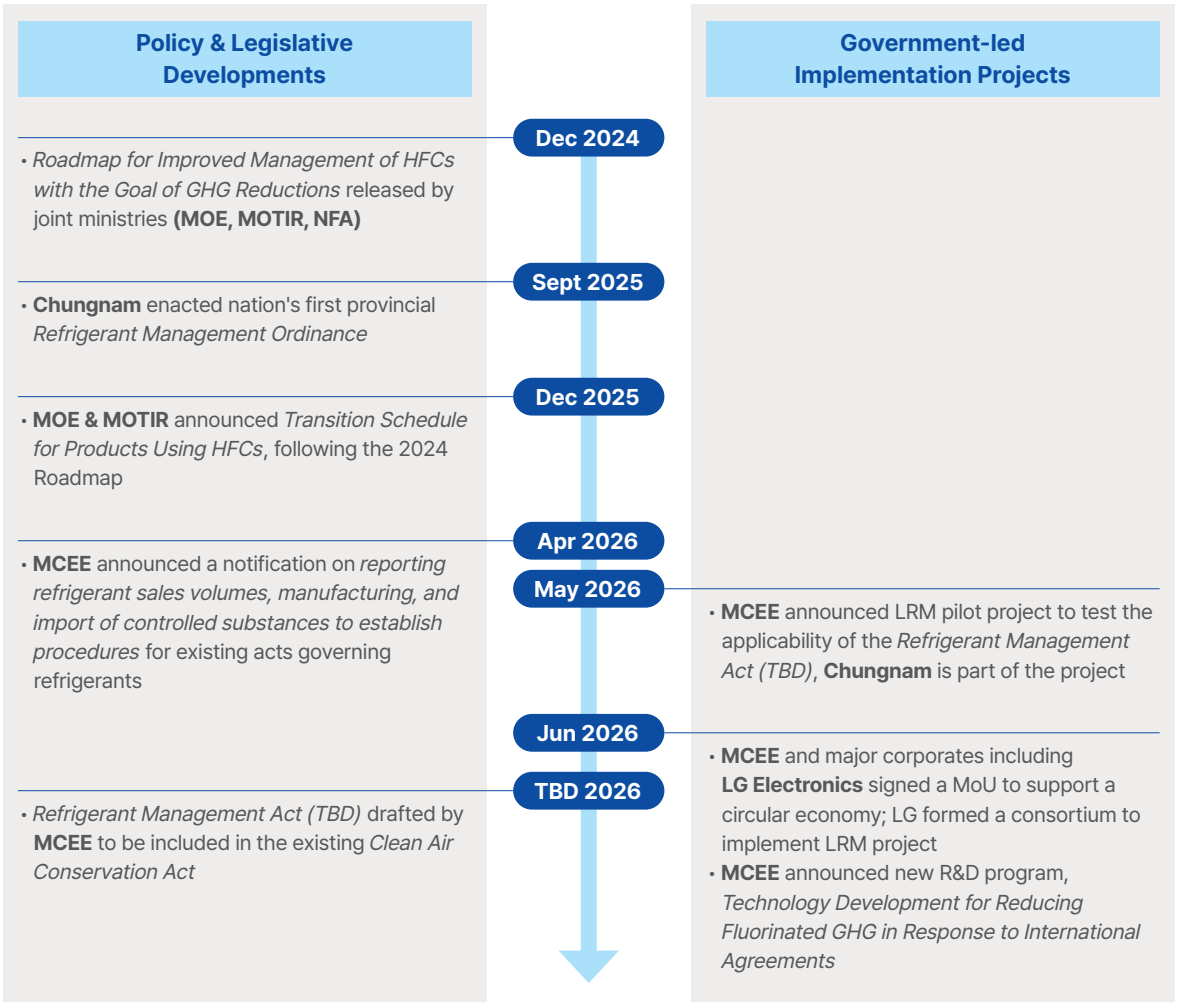
Implementation capacity is equally important at the local level. Research on South Korea's climate governance under the 2019 *Carbon Neutrality Act* reveals that despite a centralized legal framework, implementation varies considerably across local governments due to differences in administrative capacity, fiscal resources, political priorities, and local economic conditions (Y. Kim et al., 2025). These findings suggest that national legislation alone cannot guarantee effective implementation without sufficient institutional capacity at the local level.

Beyond domestic governance arrangements, implementation can be strengthened through external learning and knowledge-sharing mechanisms. Transnational municipal networks (TMNs), for example, support local governments through knowledge exchange, peer learning, and policy implementation support. One study found that participation in ICLEI, one of the largest climate-focused TMNs, was associated with average reductions in energy consumption of 4.5–11% (M. Kim & Yun, 2024). This suggests that implementation outcomes can be improved through capacity-building and policy learning.

III. South Korea: Ambition and the Gap in Between

Since ratifying the KA in 2023, South Korea has progressively strengthened its domestic policy framework for HFCs management. HFCs were designated as a "Type 2 Specific Substance" under the *Act on the Management of Specific Substances for the Protection of the Ozone Layer*, establishing the legal basis for implementing Korea's Kigali phase-down obligations. Since then, the government has introduced a series of policy initiatives aimed at strengthening refrigerant governance, including improvements to HFCs management, pilot projects for LRM, support for natural refrigerant technologies, and preparation of a *Refrigerant Management Act* (Figure 3). Together, these developments indicate that refrigerant transition is becoming an increasingly important component of Korea's climate policy.

[Figure 3] Timeline of South Korea's refrigerant transition policy developments (2024-2026)



Source: (Chungcheongnam-do, 2026; Chungcheongnam-do Council, 2025; LG Electronics, 2026; MCEE, 2026a, 2026b, 2026c; MOE, 2024; MOE & MOTIR, 2025)

Korea's quantified ambition for reducing refrigerant emissions is expressed across instruments tied to two different international regimes—the climate regime (NDC) and the ozone regime (Kigali Amendment)—alongside a domestic HFCs-specific target (Table 2). These targets differ in scope, baseline, and methodology, making direct comparison difficult without further government clarification on how they are formally reconciled with one another.

The 2035 Nationally Determined Contribution (NDC) sets a reduction target for the broader "refrigerant" sector, including HCFCs and HFCs. The 2035 NDC lays out a reduction target range based on two scenarios (53% and 61%) (Presidential Commission on Climate Crisis Response, 2026). Independent analysis has questioned whether the targets fully reflect the sector's reduction potential: a 2026 report by the climate group Plan 1.5, based on industry data submitted to the National Assembly, found that strengthening refrigerant leak management beyond the government plan could increase the 2035 reduction potential by 6.9 $MtCO_2e$ (Choi et al., 2026). On a separate note, the Ministry of Environment (MOE)[7] announced an HFCs-specific target in December 2024, measured against a projected BAU trajectory rather than a historical baseline, but for HFCs. In the meanwhile, Korea's KA obligations apply to HFCs consumption—not emissions—under a separate schedule.

[Table 2] Korea's overlapping refrigerant and HFCs targets for 2035

Regime	Target		Scope	Baseline	2035 Target
Climate	2035 NDC	53% scenario	Refrigerant emissions	2018 emissions: 23.1 $MtCO_2e$	27.4 $MtCO_2e$ (+18.6% vs. 2018)
Climate		61% scenario			25.5 $MtCO_2e$ (+10.4% vs. 2018)
Domestic (HFCs-specific)	Roadmap for Improved Management of HFCs		HFCs emissions	Projected 2035 BAU: 61.2 $MtCO_2e$[8]	41.2 $MtCO_2e$ (-20 $MtCO_2e$ from BAU)
Ozone	KA Article 5 Group 1		HFCs production & consumption	2020–22 average + 65% of HCFC baseline	-30% from baseline

Source: (MOE, 2024; Presidential Commission on Climate Crisis Response, 2026)

Recent policy developments also suggest a gradual shift beyond HFCs phase-down toward implementation measures. Alongside pilot projects for lifecycle refrigerant management, the Ministry of Climate, Energy and Environment (MCEE) is reportedly preparing financial support for replacing high-GWP refrigeration equipment with natural refrigerant systems, particularly in commercial cold storage facilities. Although still under development, the proposal reflects an emerging policy emphasis on accelerating equipment transition in addition to managing refrigerants already in use (Kang, 2026). The broader *Roadmap for Improved Management of HFCs* similarly outlines a staged transition schedule and supporting measures extending through 2032, though the transition is mostly in its early stages.

7 The Ministry of Environment (MOE) has been reorganized to the Ministry of Climate, Energy and Environment (MCEE) in 2025 (Government of the Republic of Korea, 2025). References to ministry documents retain the institutional name used at the time of publication.

8 The official *Roadmap for Improved Management of HFCs* document mentions the goal of reducing HFCs emissions by 20 $MtCO_2e$ without a baseline. However, an article quotes MOE from a meeting that the baseline is 61.2 $MtCO_2e$, a projection of HFCs emissions in 2035 (MOE, 2024; Yoon, 2024).

Nevertheless, existing legislation remains fragmented. Measures concerning refrigerant recovery, treatment, and reporting remain regulated separately under the *Clean Air Conservation Act and the Act on Resource Circulation of Electrical and Electronic Equipment and Vehicles.* These provisions apply only to specific categories of refrigeration and air-conditioning equipment, leaving significant portions of the refrigerant lifecycle outside comprehensive management (Park, 2025).

One consequence of this fragmented approach concerns refrigerant banks already contained within existing equipment. Unlike combustion-related greenhouse gases, a substantial share of future HFCs emissions originates from refrigerants that have already been produced and charged into air conditioners, refrigeration systems, and heat pumps. These refrigerants may remain in equipment for many years before being released gradually through leakage during operation, servicing, or end-of-life disposal.

South Korea's estimated potential emissions, the total quantity of refrigerants contained within existing equipment, are roughly twice as large as its reported annual HFCs emissions, indicating that substantial future emissions remain embedded in the current stock of cooling equipment (Park, 2025). This reflects the considerable time lag between refrigerant consumption and actual emissions, which can extend for more than a decade as refrigerants remain stored in equipment before being gradually released through leakage, servicing, or end-of-life disposal (GIZ, 2021). Recognizing this challenge, the MOE has noted that HFCs emissions are expected to continue to increase unless additional management measures are introduced, identifying refrigerant transition as an important component of achieving South Korea's national greenhouse gas reduction targets (MOE, 2024)

The problem where declining consumption does not necessarily translate into declining emissions is not unique to Korea. Section IV.E of this report examines this pattern alongside comparable HFCs consumption trends across other Article 5 Parties.

Taken together, these developments illustrate that South Korea's primary challenge is building an integrated implementation framework capable of managing refrigerants throughout their lifecycle. While recent policies indicate growing momentum, effective implementation will require stronger coordination across institutions, expansion of lifecycle management beyond currently regulated equipment, and mechanisms that support technology transition, recovery, reclamation, and local implementation. Addressing this challenge requires attention not only at the national level but also at the local level, where some jurisdictions have already begun to act—as well as stronger coordination and financing mechanisms to support implementation more broadly.

A. Local implementation capacity

One example of local refrigerant governance in South Korea is Chungcheongnam-do (Chungnam), which has been developing refrigerant management measures that extend beyond national requirements. Through its *Ordinance on Supporting Refrigerant Management for Climate Crisis Response*, the province has sought to address regulatory gaps, particularly for small refrigeration and air-conditioning equipment below 20 RT[9] that is not currently subject to national leak management requirements. Chungnam is also registered to the local refrigerant management system (FIMS), through which 121 public institutions and 7,456 pieces of equipment are registered and monitored to support leak prevention efforts (Chungcheongnam-do, 2026).

9 Refrigeration ton

In 2025, the province launched Korea's first pilot project for the collection of used refrigerant cylinders, collecting 1,858 cylinders and avoiding an estimated 1,890 tonnes of CO_2-equivalent emissions. The program is being expanded with targets to collect 10,000 cylinders and recover 1,000 kg of residual refrigerant, alongside refrigerant surveys, business training, and public awareness activities (J. Kim, 2026).

While these initiatives demonstrate the potential for local governments to play an active role in refrigerant management, they also highlight the need for a national framework that can support, coordinate, and scale successful local approaches across jurisdictions. Chungnam is an example that reveals local government action depends heavily on local political leadership and capacity.

B. Strengthening Coordination and Learning Mechanisms

Korea's experience with refrigerant technician training illustrates the practical limits of its current coordination and capacity-building infrastructure. Since 2017, technicians registered under the recovery business licensing system have been required to complete training administered by the MOE (now MCEE). In 2019, the Korea Refrigerants Recycling Engineers Center (KRRC) has been designated as an official education center to deliver the training (KRRC, 2019). In principle, this is an established technician training pathway that many Article 5 Parties are still working to build.

However, industry representatives have identified significant gaps between this training system, and the field conditions it is meant to address. KRRC noted that existing training remains oriented toward large-scale refrigeration equipment (20RT and above, which typically has a dedicated safety manager on-site), even as Korea's regulatory scope is set to expand to much smaller equipment (10RT for the general sector, 3RT for public institutions). Moreover, the shortage of technicians qualified to handle natural refrigerants is also a rising problem as HFCs alternatives become more widely used. Currently, recovered refrigerant volumes remain insufficient compared to imports, suggesting that certification requirements alone have not translated into effective recovery in practice (Sung, 2026).

Several structural bottlenecks compound to these training gaps. Korea lacks standardized recovery and charging cylinders, requiring recovery companies to maintain separate containers for different refrigerant types and pressures. This disproportionately raises costs for small operators. The absence of intermediate logistics hubs requires recovery companies to transport recovered refrigerant directly to recycling or disposal facilities themselves, even in small volumes, adding further cost and inefficiency. Reporting requirements also creates friction, as the current system requires equipment owners to report recovery activity before recovery companies can do so. This creates administrative burden and penalty exposure for recovery business despite their more direct role in the recovery process (Sung, 2026).

These gaps illustrate that Korea's challenges extend beyond establishing formal coordination structures on paper. Even where certification and training requirements already exist, field-level capacity, logistics, and reporting systems have not kept pace with the scope of activity they are meant to support. This suggests that strengthening coordination in Korea will require not only new institutional arrangements but also addressing operational gaps within existing mechanisms that have constrained their effectiveness to date.

C. Supporting Local Transition Through Resources and Incentives

Successful implementation also requires sustained technical and financial support. Across many Article 5 Parties, implementation extends beyond regulatory requirements through complementary mechanisms such as technician training, recovery infrastructure, demonstration projects, financial incentives, and public awareness programs. International initiatives, including the Multilateral Fund, the UNEP Cool Coalition, and bilateral cooperation programs, have often played an important role in supporting these activities. South Korea does not receive Multilateral Fund implementation assistance, making domestic policy instruments particularly important.

As refrigerant transition increasingly overlaps with industrial upgrading, cooling efficiency, and circular economy strategies, supporting implementation through coordinated investments may generate benefits beyond HFCs emissions reduction alone.

IV. Lessons from Asia: Building Effective Implementation Systems

A. Building Implementation Systems

Implementing the KA requires more than adopting legislation. It also requires institutional, technical, and financial systems that enable the transition to low-GWP alternatives across the cooling sector. Although implementation remains at different stages across Asia, experiences from countries such as China, India, and Thailand suggest several recurring components that support refrigerant transition efforts. Drawing on UNEP guidance, Multilateral Fund documentation, and the country experiences examined in this report, these components provide an analytical framework for comparing how countries have translated Kigali commitments into implementation (Table 3). They are not intended as a prescriptive model or indicators of success, but rather as common elements that have emerged across different national approaches.

[Table 3] Components of refrigerant transition implementation

Component	Purpose
Governance & coordination	Defines institutional responsibilities
Policy & regulation	Establishes transition pathway
Financial incentives	Reduces transition costs
Technical & implementation support	Builds capacity
Industry engagement	Enables market transition
LRM	Addresses emissions throughout equipment life

B. China: Coordination of National Priorities and Transition Pathways

1. Translating National Priorities into Local Implementation

China's implementation of the KA is characterized by a coordinated multi-level governance structure that translates national priorities into local implementation. Under the leadership of the State Council, provincial governments are responsible for implementing national policies while coordinating with municipal and local authorities (China Internet Information Center, 2002).

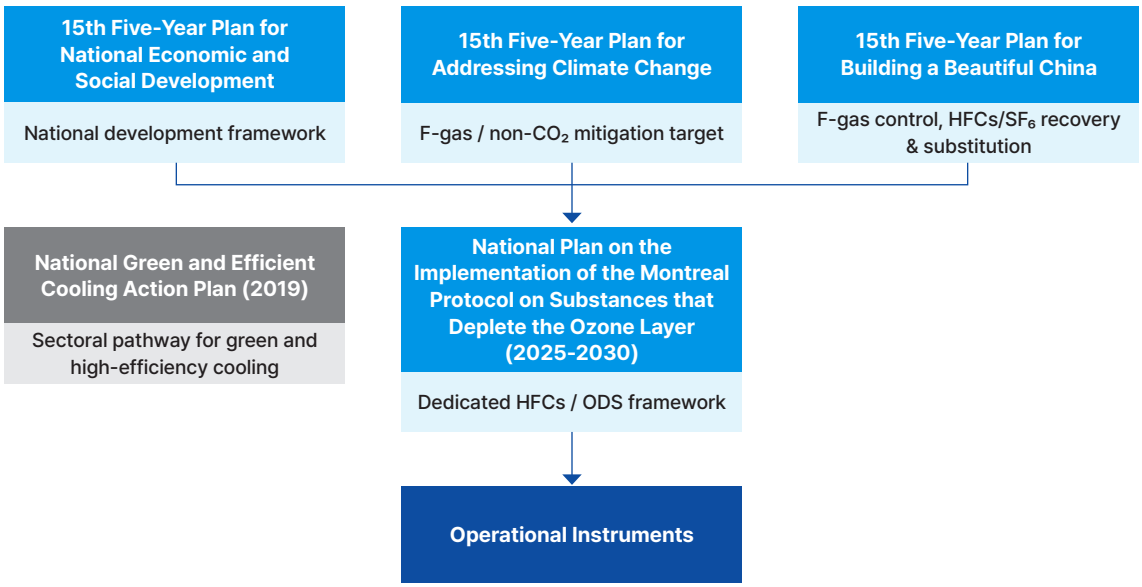
This governance model is reflected in the *National Plan on the Implementation of the Montreal Protocol on Substances that Deplete the Ozone Layer (2025–2030)* (hereafter the "Plan"), jointly issued by five central government agencies. Rather than focusing solely on HFCs reduction targets, the Plan assigns complementary responsibilities across central ministries, local governments, industry associations, and enterprises. Central agencies oversee policy development, standards, and enforcement, while local governments manage permitting, registration, supervision, and compliance. Industry associations promote technology exchange, and enterprises are responsible for reporting and meeting quota requirements (MEE, 2025a). Together, these arrangements establish a coordinated implementation framework spanning the refrigerant value chain.

This distribution of responsibilities illustrates how institutional coordination can facilitate implementation beyond setting national targets.

2. Establishing a Clear Transition Pathway for Industry

China's approach demonstrates the importance of providing a clear and predictable transition pathway for industry. Rather than treating refrigerant transition as a standalone environmental obligation, China has increasingly embedded HFCs mitigation within its broader industrial, economic, and climate development agenda. This direction is reflected in China's *15th Five-Year Plan for National Economic and Social Development (2026–2030)*, which identifies HFCs alongside methane and other super climate pollutants as priorities for climate mitigation, while linking emissions reductions with industrial modernization, energy efficiency, product carbon footprint standards, and green consumption (Xinhuanet, 2026). The *15th Five-Year Plan for Addressing Climate Change* and the *15th Five-Year Plan for Building a Beautiful China* both builds onto this and calls for strengthened targets and controls including HFCs and f-gases (MEE, 2026b; State Council of the People's Republic of China, 2026).

[Figure 4] Strategic policy framework for China's HFCs and cooling transition



Source: (Xinhuanet, 2026; MEE, 2026b; State Council of the People's Republic of China, 2026; MEE, 2025a; NDRC, 2019)

This strategic direction is operationalized through the Plan, which establishes a clear implementation pathway for key cooling sectors (Figure 4). Rather than relying solely on economy-wide phase-down targets, the Plan introduces clear implementation milestones, including GWP thresholds, technology transition timelines, and sector-specific restrictions. For example, household refrigerators and freezers using HFCs refrigerants will be prohibited from January 2026, while room air conditioners for the domestic market will be required to use refrigerants with a GWP below 750 from January 2029, subject to limited exceptions. Similar transition schedules are provided for commercial refrigeration, industrial cooling equipment, and vehicle air-conditioning systems (MEE, 2025a).

Importantly, the Plan extends beyond regulatory restrictions by introducing measures that support implementation. These include demonstration projects, the development of alternative technologies, updates to product and safety standards, technician training, and the establishment of a recommended catalogue of low-GWP alternatives (Table 4). These measures provide greater certainty for manufacturers while aligning refrigerant transition with wider industrial development objectives.

[Table 4] Key operational instruments supporting China's HFCs transition

Instrument	Year	Purpose	Significance
Amendment to the Regulation on the Administration of Ozone-Depleting Substances	2024	LRM	Recovery, recycling, and reuse requirements; prohibits direct refrigerant release.
Project Catalogue for Green Finance Support	2025	Financing	Facilitates financing for products and equipment with zero ODP and low GWP refrigerants.
Announcement on the Prohibition of Producing Household Refrigerators and Freezers Using HFCs as Refrigerants	2025	Sectoral transition	Prohibits production of household refrigerators and freezers using HFCs refrigerants. Local authorities responsible for compliance.
Notice on Further Strengthening the Management of Ozone-Depleting Substances and Hydrofluorocarbons	2026	Regulatory management	Full-chain management and enforcement.
Notice on Implementing the Initiative for Advancing Green Consumption	2026	Market transition	Encourages purchase of fluorine-free ACs and other green home appliances.

Source: (State Council of the People's Republic of China, 2024; People's Bank of China, 2025; MEE, 2026a, 2025b; MOFCOM, 2026)

[Table 5] HFCs production and consumption data in China ($MtCO_2e$)

	2020	2021	2022	2023	2024	Baseline
Production	1,212	1,427	1,581	1,472	1,261	1,853
Consumption	530	581	666	769	572	905
Net export	682	847	915	702	689	-

Source: (Ozone Secretariat, 2025a)

China's policy framework has also been accompanied by early implementation measures. Following ratification of the KA, China reportedly halted new production capacity for five of the eleven HFCs produced domestically, representing over 75% of its total HFCs production (McKenna, 2022). Moreover, official data indicate that HFCs production and consumption peaked in 2022 and 2023, respectively, and by 2024 had declined to approximately 68% and 63% of baseline levels, respectively (Table 5). While multiple factors are likely to have contributed to these trends, including earlier adoption of low-GWP alternatives in some sectors, they suggest that implementation measures are beginning to influence the market. Nevertheless, China remains one of the world's largest emitters of fluorinated greenhouse gases, and recent studies suggest that achieving its 2035 climate targets will require emissions reductions beyond those required under the KA (Hu, 2026).

3. Supporting Lifecycle Refrigerant Management

China has increasingly expanded implementation beyond production and consumption controls by strengthening lifecycle refrigerant management. Recognizing that emissions occur throughout the lifetime of cooling equipment, recent policies have introduced measures to improve refrigerant recovery, recycling, reuse, and environmentally sound disposal during servicing and end-of-life treatment.

A significant step was the 2024 amendment to the *Regulation on the Administration of Ozone-Depleting Substances*, which prohibits the direct release of refrigerants and requires their recovery, recycling, reuse, or environmentally sound disposal during servicing and equipment retirement. Complementary policies have sought to strengthen the supporting infrastructure needed to implement these requirements. In January 2024, the Ministry of Commerce and eight other ministries jointly issued guidance to improve recycling systems for used household appliances and furniture, including targets to increase appliance recycling rates, establish pilot recycling cities, and strengthen supporting regulations and standards. Additional financial support has also been proposed through dedicated funding mechanisms for waste electrical and electronic products (State Council of the People's Republic of China, 2024).

These measures indicate an increasing integration of refrigerant management with China's broader circular economy and resource efficiency policies. Together with appliance trade-in programs and investments in recycling infrastructure, they recognize that reducing emissions depends not only on transitioning to lower-GWP refrigerants but also on minimizing refrigerant losses during servicing and ensuring environmentally sound treatment at the end of equipment life.

C. India: Building implementation pathways

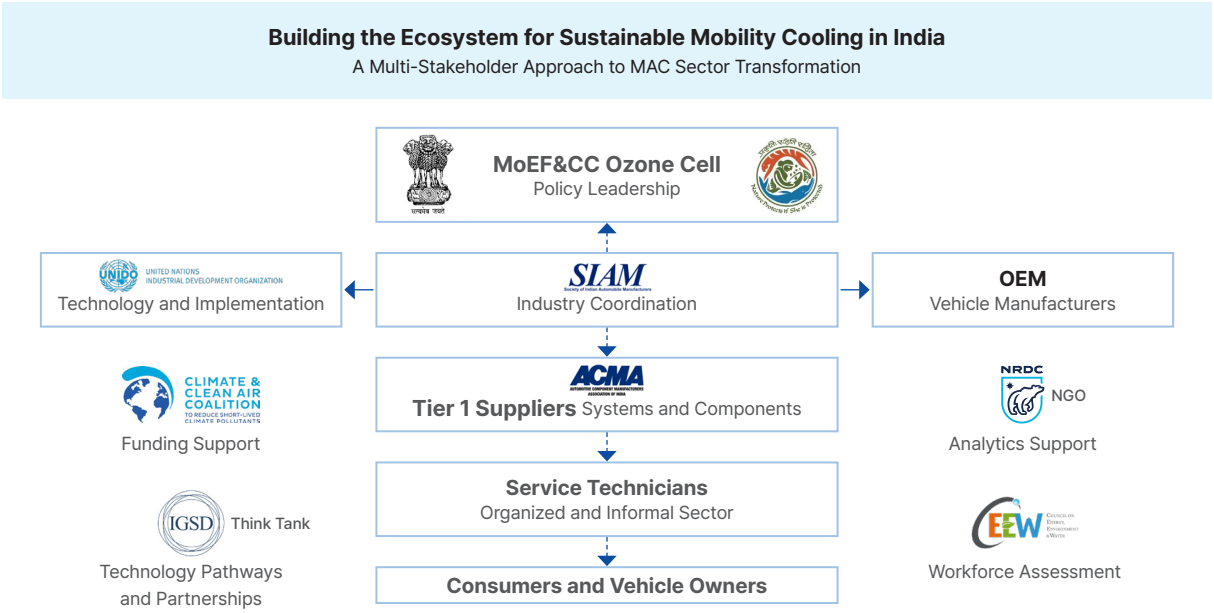
While China's refrigerant transition is characterized by strong central coordination and integration within national development planning, India's approach places greater emphasis on coordinating a diverse network of public institutions, industry, and international partners. Rather than relying primarily on hierarchical implementation, India has developed a collaborative governance model that combines national policy leadership with technical support, industry engagement, and international cooperation.

India established the India Cooling Action Plan (ICAP) in 2019, one of the world's first comprehensive national cooling strategies. ICAP integrates cooling access, energy efficiency, refrigerant management, and climate resilience within a single policy framework (Ministry of Environment, Forest, & Climate Change, 2019). Building on ICAP, the UNEP Cool Coalition and its partners have developed a long-term India Cooling Programme that supports implementation across multiple sectors, including passive cooling, sustainable cold chains, district cooling, and urban heat adaptation (Cool Coalition, 2025a).

A notable feature of India's implementation approach is its institutional coordination. Rather than assigning implementation solely to government agencies, responsibilities are distributed across multiple actors. For example, implementation of the mobile air-conditioning (MAC) sector is coordinated through a multi-stakeholder structure led by the Ministry of Environment, Forest and Climate Change (MoEFCC) Ozone Cell, with technical implementation supported by UNIDO, industry coordination led by the Society of Indian Automobile Manufacturers (SIAM), and vehicle manufacturers responsible for technology adoption and deployment

(Figure 5). This arrangement allows policy development, technical expertise, industry engagement, and market implementation to progress simultaneously.

[Figure 5] India's multi-stakeholder approach in the MAC sector



Source: (Kapoor, 2026)

Beyond sector-specific coordination, India benefits from extensive international implementation support available to Article 5 Parties. Through partnerships with organizations, implementation activities extend beyond regulatory compliance to include technician training, demonstration projects, standards development, capacity building, and policy advisory support. These initiatives strengthen institutional capacity while facilitating knowledge exchange between government, industry, academia, and international organizations.

India's experience illustrates that refrigerant transition depends not only on national policies but also on governance structures that enable coordination across multiple stakeholders. By combining government leadership with technical expertise, industry participation, and international collaboration, India has developed an implementation ecosystem capable of translating national cooling strategies into sector-specific action.

D. Thailand: Integrating refrigerant transition with industrial competitiveness and regional leadership

Thailand demonstrates how refrigerant transition can be integrated with industrial competitiveness, energy efficiency, and long-term financing. As one of the world's largest manufacturers and exporters of RAC equipment, Thailand has identified compliance with increasingly stringent international refrigerant, energy efficiency, and safety requirements as essential to maintaining export competitiveness. Accordingly, the country's HPMP Stage III and KIP Stage I combine refrigerant transition with broader industrial modernization measures, including strengthening MEPS, expanding technician training and certification, upgrading testing and certification infrastructure, and supporting manufacturers in adopting low-GWP, high-efficiency technologies (Hirunwatsiri, 2026).

Thailand also illustrates the importance of aligning financial mechanisms with refrigerant transition. In June 2026, the Executive Committee of the Multilateral Fund approved a US$21.9 million Energy Efficiency Revolving Fund project for Thailand, demonstrating a financing model intended to provide sustainable, long-term investment in energy-efficient cooling technologies while complementing the country's ongoing KA implementation (Multilateral Fund, 2026). In parallel, Thailand has piloted sector-specific financing mechanisms, including the Cooling Innovation Fund (CIF) of the Electricity Generating Authority of Thailand (EGAT), to support innovation and the scaling-up of green cooling technologies (GIZ Thailand, 2022).

Beyond domestic implementation, Thailand has positioned itself as a regional hub for green cooling knowledge exchange through the Green Cooling Initiative III (GCI III), a German funded project implemented by GIZ across seven countries (Thailand, Vietnam, Bangladesh, Kenya, Uganda, Colombia, and Honduras). Since its launch in 2021, GCI III's work in Thailand has centered on institutionalizing technician training capacity. GIZ partnered with Thailand's Department of Skill Development (DSD) to establish a formal cooperation framework covering upgraded training curricular, national skill standards and occupational licensing, and knowledge exchange. This collaboration produced a revised national curriculum incorporating safety training for flammable natural refrigerants, which DSD is using to train more than 1,400 technicians in the electrical and refrigeration sectors under a 2025 workforce development program (GIZ Thailand, 2022, 2024).

The training infrastructure has developed alongside CIF and EGAT as part of the exit strategy for an earlier, MLF-supported RAC sector project. Over its operation, CIF has supported the certification of industrial safety standards for R290 air-conditioning products, upgraded laboratory and testing infrastructure, a solar-powered refrigerator demonstration project, and the "Label No. 5" energy-efficiency certification for natural refrigerant appliances. Combined, these initiatives are projected to deliver an additional 40 $ktCO_2e$ in emission reductions, building on the 1.056 $MtCO_2e$ already achieved under the original project (Mitigation Action Facility, 2025). This continued, self-sustaining impact after the original project's formal completion depicts how internationally supported technical assistance can evolve into durable, nationally owned institutional capacity rather than remaining dependent on a single funding cycle.

This approach illustrates how countries with significant cooling manufacturing capacity can leverage refrigerant transition not only as a climate obligation but also as an opportunity to strengthen industrial competitiveness and regional leadership.

E. Common Implementation Gaps and Their Relevance for South Korea

Although China, India, and Thailand differ substantially in their institutional structures, economic circumstances, and access to international financial assistance, several common implementation patterns emerge. Rather than relying on a single policy instrument, each country has developed a broader implementation system that combines regulatory measures with institutional coordination, technical support, pilot projects, and stakeholder engagement (Figure 6). Read against these experiences, Korea's implementation framework shows five specific, addressable gaps.

[Figure 6] Comparison of implementation ecosystems across selected Asian countries

Limited ■ ■ ■ Well-established

Component	China	India	Thailand
National Strategy	National Plan (2025–2030)	ICAP (2019)	HPMP III / KIP I
Lead Institution	Central and provincial	Ozone Cell (MoEFCC)	GCI Network
Multi-stakeholder coordination	Ministries, local governments, industry	UNIDO, SIAM, manufacturers	DCCE, DSD, EGAT, universities, manufacturers
External technical support	Bilateral cooperation	MLF, UNIDO, Cool Coalition	GIZ (GCI III), MLF
LRM	2024 ODS Regulation amendment	Included in ICAP	Major focus in HPMP/KIP
Demonstration projects	CO_2 supermarkets, industrial pilots	MAC pilots	Refrigerant conversion pilots, R290 certification
Financial incentives	Targeted programs (e.g., trade-in, recycling infrastructure funding)	MLF + sector programs	MLF + EGAT Cooling Innovation Fund
Local implementation	Provincial	State	National/sectoral

1. Institutional coordination remains underdeveloped.

In all three countries, implementation is led by a designated government authority working alongside a broader network of ministries, technical agencies, industry associations, and international partners (Figure 6). India's multi-stakeholder model illustrates how responsibilities can be distributed across policy leadership, technical implementation, industry coordination, and equipment manufacturers, while China combines central government leadership with provincial authorities, technical agencies, and bilateral cooperation.

Korea's approach to stakeholder engagement differs in kind. For instance, ahead of the policy announcement in December 2024, the government held approximately 30 meetings with industry stakeholders between May and September 2024 (MOE, 2024). While this reflects meaningful consultation, it remains structured around industry input into a government-authored policy rather than an institutionalized implementation role comparable to India's, where UNIDO and SIAM hold defined, ongoing responsibilities that persist through delivery. Korea's process also does not appear to involve international technical partners or civil society organizations, unlike the structures observed in the three countries. Korea's regulatory responsibilities remain split across multiple ministries and laws without a clearly designated lead authority (Section III).

2. Technical capacity-building relies on partnerships Korea cannot fully replicate.

China, India, and Thailand each build technical implementation capacity through external partnerships: technician training, demonstration projects, and technical assistance delivered through MLF, UNIDO, GIZ, and bilateral cooperation (Figure 6). Since Korea does not receive MLF implementation financing, this pathway is not

directly available. Thailand's experience as a regional hub under the GCI, which has built a national technician certification pipeline, suggests that meaningful international engagement is possible through reciprocal, non-MLF channels. Korea has yet to develop an equivalent mechanism. Domestically, Korea's own technician training system illustrates that formal certification requirements alone do not guarantee this capacity. Industry representatives report that training remains oriented toward large-scale equipment, leaving a gap as regulatory coverage expands to smaller equipment without on-site safety personnel (Section III.B).

3. Local pilots lack a national mechanism for coordination and scale.

China and India both operationalize national strategy at the provincial or state level, embedding local implementation within a broader governance structure. Chungnam's pilot projects demonstrate that comparable local action is possible in Korea, but they have emerged without a coherent national framework to support, coordinate, or scale similar efforts elsewhere. This leaves Korea without the connective layer between local initiative and national strategy that the other countries provide (Section III.A).

4. Consumption progress has not been translated into a durable framework.

Between 2020 and 2024, Korea's HFCs consumption declined to approximately 60% of its Kigali baseline—a trajectory broadly comparable to China's (63%) and Thailand's (55%) over the same period (Table 1). Considered in isolation, this suggests Korea is not meaningfully behind its regional peers on this metric. However, unlike China, whose consumption and production achievement reflects a decade of documented, codified policy and industrial measures (Section IV.B.2), Korea's decline lacks a clear institutional driver, and consumption progress in Korea, China, and the region more broadly has not been accompanied by declining emissions (Figure 1)—a divergence consistent with the refrigerant bank dynamic discussed in Section III. This suggests that Korea's current position reflects favorable conditions rather than a secure trajectory, and that its overlapping, unreconciled targets (Table 2) are not yet backed by the institutional capacity needed to sustain progress as cooling demand continues to grow.

5. LRM remains underdeveloped.

China's 2024 ODS Regulation amendment mandates recovery, recycling, and reuse nationally; Thailand's HPMP/KIP treats LRM as a major focus area backed by MLF financing; India has incorporated LRM into ICAP. Korea's own LRM remains split across separate laws applying only to specific, narrowly defined equipment categories, and the operational bottlenecks identified by industry practitioners suggest that Korea's existing legal requirements are not yet functioning effectively in practice. While the *Refrigerant Management Act* is expected to be announced, it is difficult to expect current challenges to be entirely addressed while continuing with its fragmented governance.

V. Recommendations

South Korea has taken important steps to strengthen its refrigerant transition following ratification of the KA. However, these measures remain distributed across multiple ministries and laws, and Korea's various emissions and consumption targets have not been reconciled into a single ambition framework. Korea's recent decline in HFCs consumption, while broadly comparable to China's and Thailand's, is not backed by the sustained, codified policy record that underpins China's trajectory, leaving it more exposed to reversal as cooling demand continues to grow. The result is a gap not between ambition and intent, but between policy design and operational delivery. The following recommendations are suggested based on the experiences from other A5 countries.

1. Consolidate fragmented HFCs commitments into a single, enforceable national roadmap.

Move beyond individual policy measures by establishing a coordinated framework that aligns governance, lifecycle refrigerant management, financing, technical support, and industry participation. Two developments already underway offer an opportunity to do this: the pending *Refrigerant Management Act*, which would give Korea's currently non-binding refrigerant measures legal force, and the upcoming *2nd National Basic Plan for Carbon Neutrality and Green Growth*, the mandated national planning instrument through which sectoral targets are formally set and revised. The government should use these two vehicles together. In particular, Korea's current overlapping refrigerant and HFCs targets, spanning the 2035 NDC, HFCs-specific Roadmap, and Korea's Kigali obligations, should be reconciled within the 2nd Basic Plan.

2. Establish permanent interagency mechanisms to ensure consistent policy implementation.

Establish regular coordination mechanisms among relevant ministries, local governments, industry associations, equipment manufacturers, and technical organizations to improve implementation consistency. India's model—distributing responsibility across a lead ministry, technical implementation partners, industry coordination bodies, and manufacturers—illustrates how such coordination can function without concentrating all responsibility in a single regulatory authority. South Korea should continue and expand the current policy discussions to include local governments, international communities, and civil society with increased transparency. This will contribute to achieving more effective emissions reduction by regularly monitoring the implementation of policies.

3. Expand support for local implementation.

Local implementation support should be expanded through a combination of financial and technical assistance.

Financially, the central government could establish a matching-grant mechanism to help other local governments replicate pilot programs such as Chungnam's refrigerant cylinder collection initiative, rather than requiring each province to fund such efforts independently. Alongside this, the central government could introduce priority budget allocations for local governments that have already demonstrated implementation capacity, such as Chungnam, ensuring that early movers are rewarded for sustaining and expanding their initiatives rather than only supporting jurisdictions that have yet to begin. Together, matching grants for new adopters and priority funding for demonstrated leaders would create complementary incentives: lowering the barrier to entry for local governments starting out, while sustaining the momentum of those already ahead.

Technically, the national government could promote Chungnam's Ordinance on Supporting Refrigerant Management for Climate Crisis Response as a model that other localities could adapt and encourage broader registration and active use of the existing FIMS among local governments that have not yet done so, building on Chungnam's experience as a demonstrated model for implementation. Recurring technician training support, addressing the capacity gaps identified in Section III.B would further ensure that adequately trained personnel back local recovery and monitoring efforts.

Together, these measures would allow local initiatives to be scaled and replicated nationally, rather than depending on local political leadership and capacity alone.

4. Increase engagement in international implementation networks.

Although South Korea is not eligible for MLF, its existing technical capacity and policy experience suggest that a reciprocal model of regional engagement may be more appropriate than a one-direction, assistance-seeking approach. Thailand's experience under the GCI offers a concrete comparator: its DSD partnered with GIZ to build a national technician certification pipeline, positioning Thailand as a regional hub that both contributes expertise and continues to build its own capacity.

Korea could pursue a similar model—for example, by partnering with regional or international technical cooperation programs to formalize and export its own technician training and certification standards—rather than limiting engagement to seeking external assistance. Expanding participation in international technical cooperation, policy dialogue, and knowledge-sharing initiatives can strengthen domestic implementation capacity while facilitating the exchange of implementation experience with other countries in the region.

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Solutions for Our Climate

Solutions for Our Climate(SFOC) is an independent policy research and advocacy group that aims to make emissions trajectories across Asia compatible with the Paris Agreement 1.5°C warming target.