REPORT

# Regional Centers of Excellence for Sustainable Cooling

## A Strategic Guide for Developing Countries

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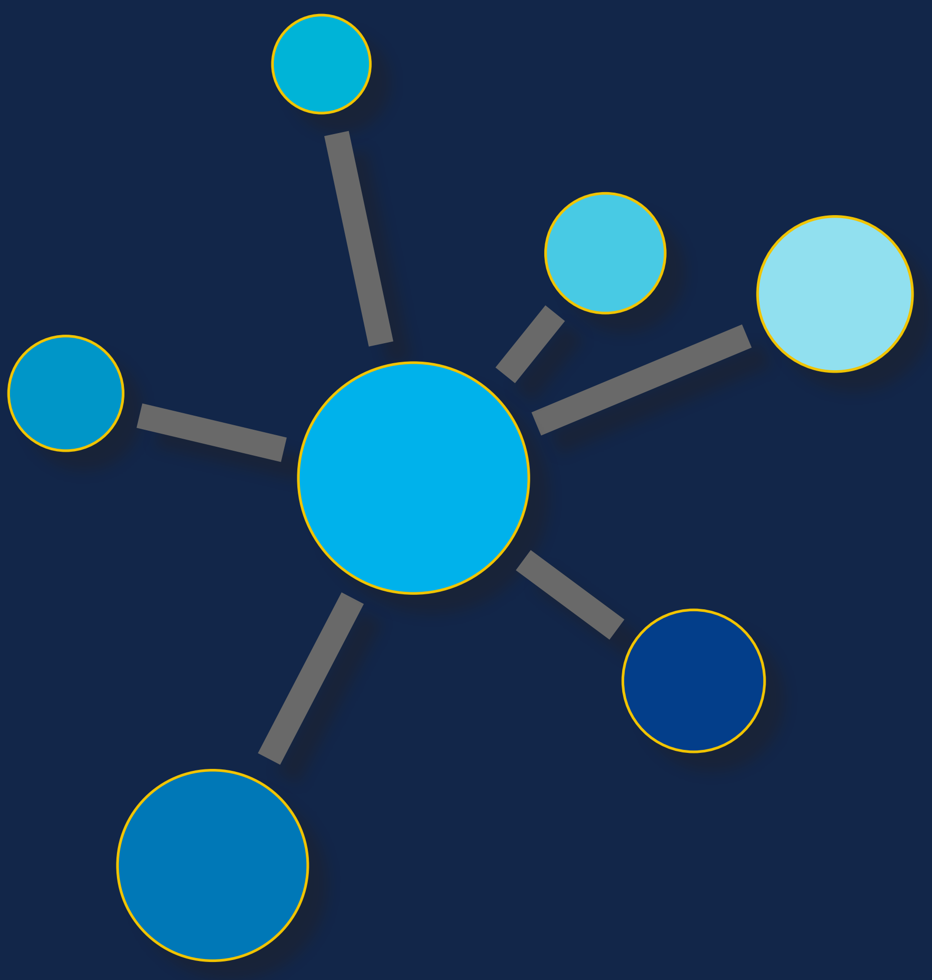

NRDC

Alliance for an Energy Efficient Economy™

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## ABOUT NRDC

NRDC (Natural Resources Defense Council) is an international nonprofit environmental organization with more than 3 million members and online activists. Established in 1970, NRDC uses science, policy, law, and people power to confront the climate crisis, protect public health, and safeguard nature. NRDC has offices in New York City, Washington, D.C., Los Angeles, San Francisco, Chicago, Bozeman, MT, Beijing and Delhi (an office of NRDC India Pvt. Ltd). Visit us at www.nrdc.org and follow us on Instagram @nrdc_org.

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# LIST OF ABBREVIATIONS

| | |
|---|---|
| **A5** | Article 5 |
| **ACE** | ASEAN Centre for Energy |
| **ACES** | Africa Centre of Excellence for Sustainable Cooling and Cold-chain |
| **ADB** | Asian Development Bank |
| **APAEC** | ASEAN Plan of Action for Energy Cooperation |
| **CEB** | Ceylon Electricity Board |
| **CoE** | Center of Excellence |
| **CSC** | Centre for Sustainable Cooling |
| **Defra** | UK Government's Department for Environment, Food & Rural Affairs |
| **EACREEE** | East African Centre of Excellence for Renewable Energy and Energy Efficiency |
| **ECREEE** | ECOWAS Centre for Renewable Energy and Energy Efficiency |
| **EM&V** | Evaluation, Measurement, & Verification |
| **GHG** | Greenhouse Gas |
| **GWP** | Global Warming Potential |
| **HFC** | Hydrofluorocarbon |
| **LRC** | Lighting Research Center |
| **MEPS** | Minimum Energy Performance Standards |
| **MLF** | Multilateral Fund for the Implementation of the Montreal Protocol |
| **$MTCO_2e$** | Million ton of carbon dioxide equivalent |
| **OEWG47** | 47th Meeting of the Open-ended Working Group of the Parties to the Montreal Protocol |
| **RAC** | Room air conditioner |
| **RCL** | Regional Centre for Lighting |
| **SACREE** | SADC Centre for Renewable Energy and Energy Efficiency |
| **SADC** | Southern African Development Community |
| **SLSEA** | Sri Lanka Sustainable Energy Authority |
| **SME** | Small and medium-sized enterprise |
| **TW** | Terawatt |
| **TWh** | Terawatt-hour |
| **U4E** | United for Efficiency |
| **UK** | United Kingdom |
| **UNEP** | United Nations Environment Programme |
| **UNIDO** | United Nations Industrial Development Organization |
| **USAID** | U.S. Agency for International Development |

# EXECUTIVE SUMMARY

Cooling for air conditioning, refrigeration, electronics, and industrial processes is even more critical in a world warming from climate change. The record-breaking heat waves and droughts continue to highlight the importance of and need for cooling. However, inefficient cooling technologies and obsolete refrigerants, like hydrofluorocarbons (HFCs), which have a high Global Warming Potential (GWP), worsen the climate crisis through both direct greenhouse gas (GHG) emissions, from refrigerants emitted from cooling equipment, and indirect GHG emissions generated by the power needed to operate this equipment. The Kigali Amendment to the Montreal Protocol on Substances that Deplete the Ozone Layer (Montreal Protocol) requires all nations to phasedown the production and consumption of HFCs while implementing energy efficiency improvements. Backed by the Multilateral Fund for the Implementation of the Montreal Protocol (MLF), developing countries (classified in the Montreal Protocol as Article 5 (A5) countries) are encouraged to merge energy efficiency into HFC reduction plans to maximize climate, economic, and health benefits. The 1997 Kyoto Protocol as replaced by the 2015 Paris Agreement requires all nations to reduce emissions of a basket of GHGs, including HFCs.

The MLF Executive Committee has been examining how regional Centers of Excellence (CoEs) can improve energy efficiency, alongside the HFC phasedown, in A5 Parties. A CoE is an institution that leads, shares best practices, builds capacity, fosters innovation, and encourages collaboration among government bodies, non-governmental organizations, industry, academia, environmental, and consumer protection enterprises. To earn the recognition of ‘excellence’, a CoE needs a clear vision, consistent growth, and dedication. Regional CoEs that support a group of countries instead of just one country provide unique advantages. These centers can promote strategic cooperation, achieve economies of scale, help harmonize policies, and facilitate knowledge sharing across countries. They can also boost funding opportunities by attracting support from donors, multilateral organizations, and private partners, which especially helps smaller or less-resourced nations.

According to the Global Cooling Emissions Model developed by Gluckman Consulting, cooling demand in A5 countries is expected to increase dramatically—over 240 percent (23.1 TW) by 2050—due to rising temperatures and economic growth. However, with targeted cooling policies and efficient technologies, it is possible to reduce indirect emissions by 27 percent (392 $MTCO_2e$) and direct emissions by 84 percent (503 $MTCO_2e$) by 2050 with respect to business-as-usual projections. Unfortunately, current regulatory gaps hinder this potential progress. Many countries do not have Minimum Energy Performance Standards for cooling appliances, particularly in Africa and Asia, which makes them vulnerable to offloading of inefficient, high-GWP imported appliances. This underscores the importance of regional CoEs to coordinate capacity building, technology transfer, policy alignment, and market transformation.

Understanding the successes and challenges of existing regional CoEs is vital for creating more effective future ones. Looking at their performances helps identify which strategies to replicate, which challenges to expect, and how to modify approaches to fit specific regional circumstances. Learning from their governance, funding, and core activities can help future regional CoEs maximize their impact, avoid common mistakes, and ensure they are tailored to local needs. For instance:

- Africa Centre of Excellence for Sustainable Cooling and Cold-chain shows the benefits of a hub-and-spoke model, where a central hub coordinates efforts while regional spokes adapt solutions to local situations;
- ASEAN Centre for Energy illustrates how a multi-stakeholder governance model—with a governing council that includes representatives from member states—supports inclusive decision-making and ensures that initiatives align with regional priorities;
- CoEs for renewable energy and energy efficiency in East Africa, Southern Africa, and the ECOWAS regions demonstrate how cooperative regional processes can speed up policy adoption and harmonization;
- Regional Centre for Lighting, Sri Lanka shows how independent testing to block substandard imports.

These case studies highlight several key success factors for regional CoEs: inclusive governance with diverse representation, strong partnerships across sectors, stable and varied funding sources, solid monitoring and evaluation systems, and early involvement of local institutions for relevance and ownership. Based on the transferable learnings from existing regional CoEs, stakeholder consultations, and the authors’ insights, we present the following recommendations for creating and managing regional CoEs in A5 countries. These aspects should be addressed together from the start, as their close connections require a unified approach.

1. Foundation and planning should begin with strong government leadership, spearheaded by dedicated nodal entities, in each participating country, that include both ozone and energy efficiency officers. These entities should conduct thorough country-level assessments to identify national needs, existing policies, market trends, and key stakeholders. Based on these findings, countries should collaboratively develop a Common Minimum Program to align regional priorities and reflect shared realities. Existing cooperation networks should be utilized to enhance efficiency and continuity, and the development of the regional CoE should adopt a phased approach that balances immediate needs with long-term sustainability.
2. Governance structures should draw on verified models of cooperation, leveraging established relationships to ensure continuity. A Governing Council, with fair representation from member states, international partners, and academic institutions, should provide transparency, accountability, and alignment with regional priorities. The governance framework must match the chosen structure, whether it's a single center, a hub-and-spoke model, country-level centers, or a hybrid approach, and function in a collaborative, consensus-driven way. Flexibility and adaptability are crucial for responding effectively to emerging challenges and opportunities.
3. A regional CoE should diversify its funding by drawing from MLF (with a multilateral decision on whether to establish a dedicated MLF window), non-MLF sources, and in-kind contributions. Strong host country commitment—including seed funding, land allocation, and setup support—is critical during the early stages. Over time, the CoE should build self-sustaining revenue streams through consulting, testing, training, and related services, complemented by time-bound MLF operational support. Membership fees or voluntary contributions can help share costs and foster ownership among participating countries. Robust financial risk management—through strong controls, regular audits, reserves, and independent decision-making—is essential for stability. Finally, the CoE must protect its independence by refusing funding that compromises neutrality and by maintaining full transparency on all funding sources.
4. Organizational structure and staffing should clarify roles for senior management and operational teams to ensure effective coordination and execution of activities. Hiring, training, and maintaining a skilled and motivated staff is vital for ensuring the CoE's credibility and reputation. Local partners and staff should oversee on-the-ground operations to foster trust within communities and ensure local relevance.
5. CoE activities must closely reflect its vision, mission, and strategic goals. Priority areas include linking energy efficiency improvements with HFC phasedown efforts, promoting capacity building, enhancing regional alignment, addressing technology gaps, developing indigenous technology, and engaging with the public at large. Structured prioritization tools should help identify high-impact, low-effort actions for quick wins, followed by a gradual expansion into more complex initiatives as resources grow.

Regional CoEs for cooling in A5 Parties can meet the rising demand for cooling and lower GHG emissions by connecting energy efficiency policies with strategies supporting the phase-out of high-GWP refrigerants. They can serve as hubs for standardizing best practices, building capacity, supporting small and medium enterprises, and enabling the adoption of low-GWP, energy-efficient technologies. Their success depends on inclusive stakeholder engagement, sustainable funding, regional cooperation, and adaptable operations. Political stability is critical for continuity, as shifts in leadership or policy direction can directly affect funding and priorities. Hosting the CoE in a politically neutral country can also help foster cooperation among nations with differing interests, ensuring that collaboration remains constructive and inclusive. By uniting energy efficiency and refrigerant transitions into a coherent strategy, these centers can make cooling in developing regions more sustainable, advancing both climate and development goals.

# 1. INTRODUCTION

## 1.1 Background

Access to cooling is no longer a luxury; it is a necessity in a rapidly warming world. 2024 was the hottest year ever recorded globally, beating the previous record of the average annual temperature set in 2023. It was the first year where the average annual temperature exceeded 1.5 degrees Celsius above the pre-industrial level.[1] Yet, how we use cooling to fulfil critical needs related to thermal comfort in buildings, agriculture and food supply chains, storage and transfer of medical products, transport, and industrial processes can either exacerbate or alleviate the climate crisis. As climate change accelerates[2], there is growing urgency around two key threats: indirect greenhouse gas (GHG) emissions from inefficient air-conditioning and refrigeration appliances powered by fossil fuel-based electricity; and direct GHG emissions from harmful refrigerants in these systems.

The Montreal Protocol on Substances that Deplete the Ozone Layer, adopted in 1987, originally intended to protect the stratospheric ozone layer, expanded its scope to GHG emissions in 2007 when the phaseout of refrigerant gases known as hydrochlorofluorocarbons was accelerated to protect the climate, and with the 2016 Kigali Amendment to address climate change pollution by targeting additional refrigerant gases called hydrofluorocarbons (HFCs). HFCs are highly potent GHGs, used for air-conditioning and refrigeration and for blowing thermal insulating foams, fire protection, metered dose inhalers for asthma and chronic obstructive pulmonary disease and miscellaneous uses.[3] This shift is rooted in the knowledge that HFCs could cause significant warming, potentially up to 0.52 degrees Celsius by 2100. It is estimated that the Kigali Amendment would limit the climate impact of HFCs to 0.06 degrees Celsius by 2100.[4] 165 parties have ratified the Kigali Amendment as of August 2025.[5] This amendment highlights the Protocol's focus on climate protection, creating an opportunity for synergizing the phasedown of HFCs and the deployment of energy-efficient cooling equipment, thereby enhancing the overall GHG reduction benefits.

Studies show that combining HFC phasedowns with energy efficiency improvements in cooling equipment significantly boosts GHG reductions and electricity savings.[6] Enhanced energy efficiency can contribute to about two-thirds of the GHG reductions by lowering electricity sector emissions, while low global warming potential (GWP) refrigerants account for the remaining one-third. This combined approach maximizes climate and health benefits[7] by reducing emissions and air pollution while also addressing the increasing demand for global cooling. There is a valuable opportunity to better integrate energy efficiency and refrigerant transitions within regulatory frameworks.

The 2016 Kigali Amendment encourages improved efficiency during the transition to low-GWP refrigerants. This goal is supported by the Multilateral Fund for the Implementation of the Montreal Protocol (MLF), along with coordinated assistance from other implementing agencies, to help Article 5 (A5) Parties[i], [8] enhance cooling equipment efficiency alongside the refrigerant transition. In 2022, the MLF approved a US$20 million fund for pilot projects integrating energy efficiency into HFC phasedown activities. Eligible projects could cover manufacturing, assembly, servicing, and technical assistance for small and medium-sized enterprises (SMEs). Access to funds required countries to have, or commit to developing, national or regional Minimum Energy Performance Standards (MEPS)[ii] and related monitoring systems.[9] In May 2024, the MLF approved a US$100 million fund to enhance energy efficiency in priority cooling equipment during HFC phasedown. This three-year program supports R&D, factory upgrades, testing facilities, and training, with incentives based on proven efficiency gains and calibrated against national MEPS.[10] Further, a US$40 million revolving fund was established to support end-user projects that replace existing cooling systems with energy-efficient, low-GWP models. This eight-year revolving mechanism targets equipment users, service providers, and cooling-as-a-service operators, prioritizing retrofits over new installations.[11]

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i Under the Montreal Protocol, developing countries, as defined by the United Nations, are classified as Article 5 (A5) Parties if consuming less than 0.5 kg of the Ozone Depleting Substances, controlled by the 1997 Montreal Protocol, and have later timelines for phasing out ozone-depleting GHGs and phasing down ozone-safe HFCs than non-Article 5 Parties, which are developed countries with earlier phaseout and phasedown schedules. A5 Parties are further split for the HFC phasedown into Group 1 (most developing countries) and Group 2 (a few very hot-climate countries that get extra time to transition).

ii A Minimum Energy Performance Standard is a regulation that sets the lowest level of energy efficiency that a product (such as an air conditioner or refrigerator) must meet to be sold in a country or region.

## 1.2 Evolving Discussions on Regional Centers of Excellence under the Montreal Protocol

A **Center of Excellence (CoE)** is a model institution that provides leadership, showcases best practices, builds capacity, serves as a knowledge hub, incubates technologies, fosters innovation, and promotes collaboration between industry and academia. However, the title "CoE" is not self-assigned—it must be earned. What begins as an aspiration evolves into recognition through a journey marked by clear vision, dedicated growth, and rigorous zeal.

Establishing **regional CoEs** that serve a group of countries (instead of just one country) offers distinct advantages. They foster political and strategic coordination by encouraging cooperation on shared priorities, enable economies of scale through shared infrastructure, and support the harmonization of policies and technical standards. Regional CoEs also facilitate knowledge exchange and capacity building across countries, helping bridge gaps—especially in smaller or less-resourced nations. Importantly, their regional character enhances funding appeal, drawing greater interest from donors, multilaterals, and private sector partners.

The Executive Committee of the MLF requested the MLF Secretariat to identify activities to maintain and/or enhance energy efficiency while phasing down HFCs, beyond manufacturing activities, servicing activities, and technical assistance for SMEs in the manufacturing and assembly/installation sectors. In response, at the 93rd meeting of the Executive Committee of the MLF, in August 2023, the MLF Secretariat identified regional centers of excellence as important *"for the adoption of energy-efficient technologies at SMEs that manufacture equipment, that undertake local installation and assembly, and through the training and capacity building of national stakeholders on maintaining and/or enhancing energy efficiency of equipment, developing energy efficiency regulations, and monitoring energy efficiency.[12] These regional centres will have an impact on the cost-effective delivery of capacity-building programmes and on the accelerated adoption of energy-efficient components and equipment."*

Further elaboration was provided at the 94th meeting in February 2024.[13] More recently, at the 95th meeting, held in December 2024, the Executive Committee requested the Secretariat *"to prepare, for consideration by the Executive Committee at its 97th meeting, an updated paper that would elaborate the specific functions for both centres of excellence for sustainable cooling and testing centres for energy efficiency; assess sustainable business models for regional centres; assess potential duplication with activities funded under HCFC phaseout management plans and/or Kigali HFC implementation plans, as well as with existing centres; identify potential opportunities to use existing centres and mechanisms already in place for testing the energy efficiency of equipment."*[14]

A '*Draft decision on national and regional initiatives to support implementation of the Kigali Amendment to the Montreal Protocol*' was introduced by Rwanda and the United Kingdom (UK) at the 47th meeting of the Open-ended Working Group of the Parties to the Montreal Protocol (OEWG47) in July 2025.[15] Several countries expressed strong support for the proposal during the plenary session, highlighting the potential role of regional CoEs in advancing the amendment's goals. However, some parties raised questions and concerns around the definition and functions of regional CoEs, the need to address country-specific challenges through national-level CoEs, and whether existing CoEs should be expanded rather than establishing new ones. The proposal was discussed in two contact groups and will be further considered at the upcoming Meeting of the Parties in November 2025. Further, Natural Resources Defense Council and Alliance for an Energy Efficient Economy held a side-event at OEWG47, to elicit feedback on the preliminary insights of this report and formulate next steps.

## 1.3 About the Report

This report provides an adaptable framework for establishing and managing regional CoEs for cooling in A5 Parties. It outlines key considerations while allowing for customization based on regional context, geopolitical factors, priorities, available resources, and timelines. The framework emphasizes the importance of avoiding duplication and aligning efforts with existing centers while acknowledging that a one-size-fits-all solution is not feasible. Given the complexity of establishing and sustaining these centers, the guidance encourages thoughtful exploration of various options, enabling relevant stakeholders to choose approaches that are most feasible, streamlined, and flexible. Alongside the authors' insights, the report incorporates perspectives from international experts and draws lessons from existing initiatives and efforts, including energy efficiency centers and regional cooperation models from developing countries. While these examples may not be solely focused on cooling, they offer valuable insights that can be adapted to the envisioned CoEs.

Section 2 elucidates the need for establishing regional CoEs in A5 Parties. Section 3 presents existing case studies, with a focus on transferable learnings. Sections 4 and 5 build on these lessons, along with insights from stakeholder consultations and offers a guiding framework for establishing and operating regional CoEs.

# 2. THE NEED FOR REGIONAL CENTERS OF EXCELLENCE IN A5 PARTIES

As the demand for cooling in A5 Parties accelerates rapidly due to climate change-induced rise in temperatures and population and economic growth, there is an urgent need for energy-efficient and climate-friendly cooling solutions. However, many of these countries face significant gaps in terms of policy, access to technology, and skilling that could hinder the effective implementation of the Kigali Amendment and the adoption of high-efficiency, low-GWP cooling technologies. In this context, regional CoEs can play a transformative role by supporting countries in closing these gaps through coordinated capacity building, technology transfer, policy alignment, and shared infrastructure to accelerate the shift to sustainable cooling. This section provides an overview of the cooling landscape in A5 Parties to highlight the need for establishing regional CoEs. Figure 1 demonstrates the need for regional CoEs.

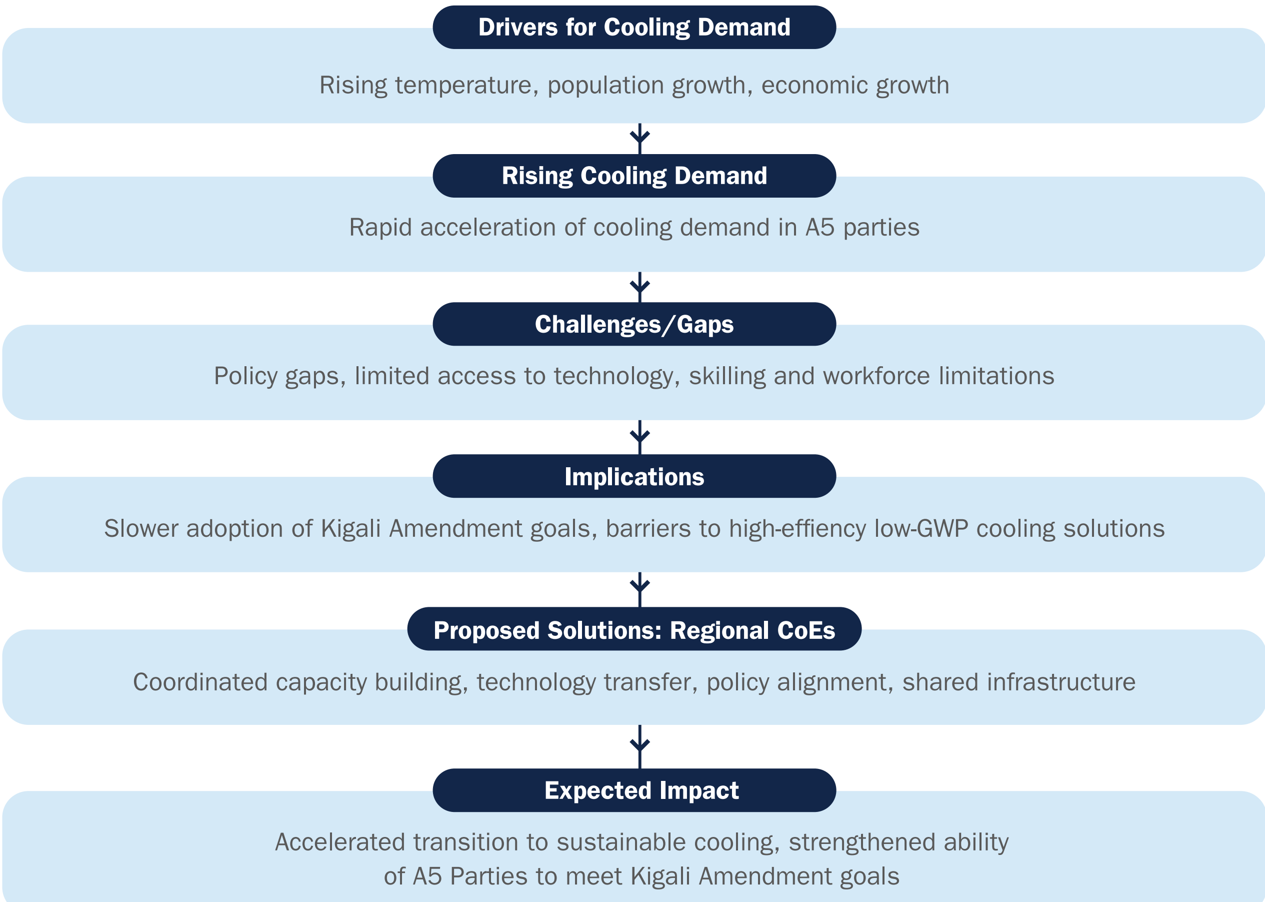
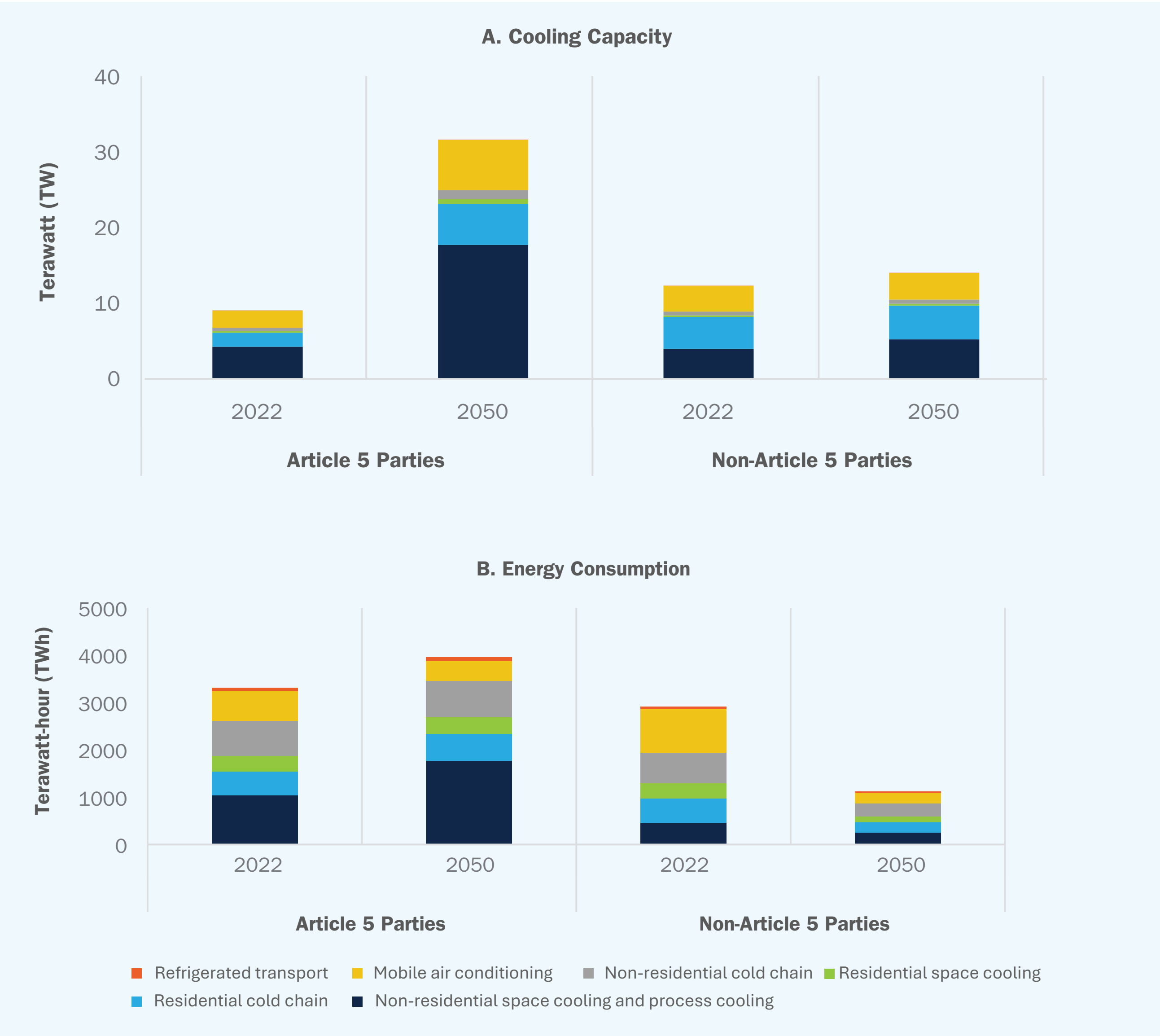



**Figure 1:** The Need for Regional CoEs in A5 Parties

## 2.1 Cooling Demand in A5 Parties

Figure 2 presents regional results from the Global Cooling Emissions Model by Gluckman Consulting, which provides estimates of both direct GHG emissions from refrigerants, emitted from cooling equipment, and indirect GHG emissions generated by the power needed to operate this equipment GHG emissions for 14 regions of the world. A short description of the model and more granular results from the model are included in the Appendix 1. According to the Global Cooling Emissions Model, cooling capacity in non-A5 Parties is expected to grow by only 14 percent (1.7 TW) between 2022 and 2050, compared to a staggering 242 percent (23.1 TW) growth projected in A5 Parties. Within A5 Parties, cooling capacity is anticipated to increase approximately 12 times in Africa and 11 times in South-Central Asia by 2050 relative to the 2022 baseline capacity. Residential space cooling and mobile air conditioning (in cars, buses, etc.) are consistently the dominant cooling sectors in A5 Parties, as well as non-A5 Parties; non-residential space cooling also plays a significant role in the non-A5 Parties and East Asia. Despite this significant rise in cooling demand, energy consumption and its associated environmental impact in A5 Parties can be mitigated through a combination of targeted cooling policies and energy-efficient products. The model estimates that, overall, this combination can achieve a 27 percent reduction in indirect emissions (392 $MTCO_2e$) and an 84 percent reduction in direct emissions (503 $MTCO_2e$) from cooling in the A5 Parties by 2050, compared to the 2022 baseline.



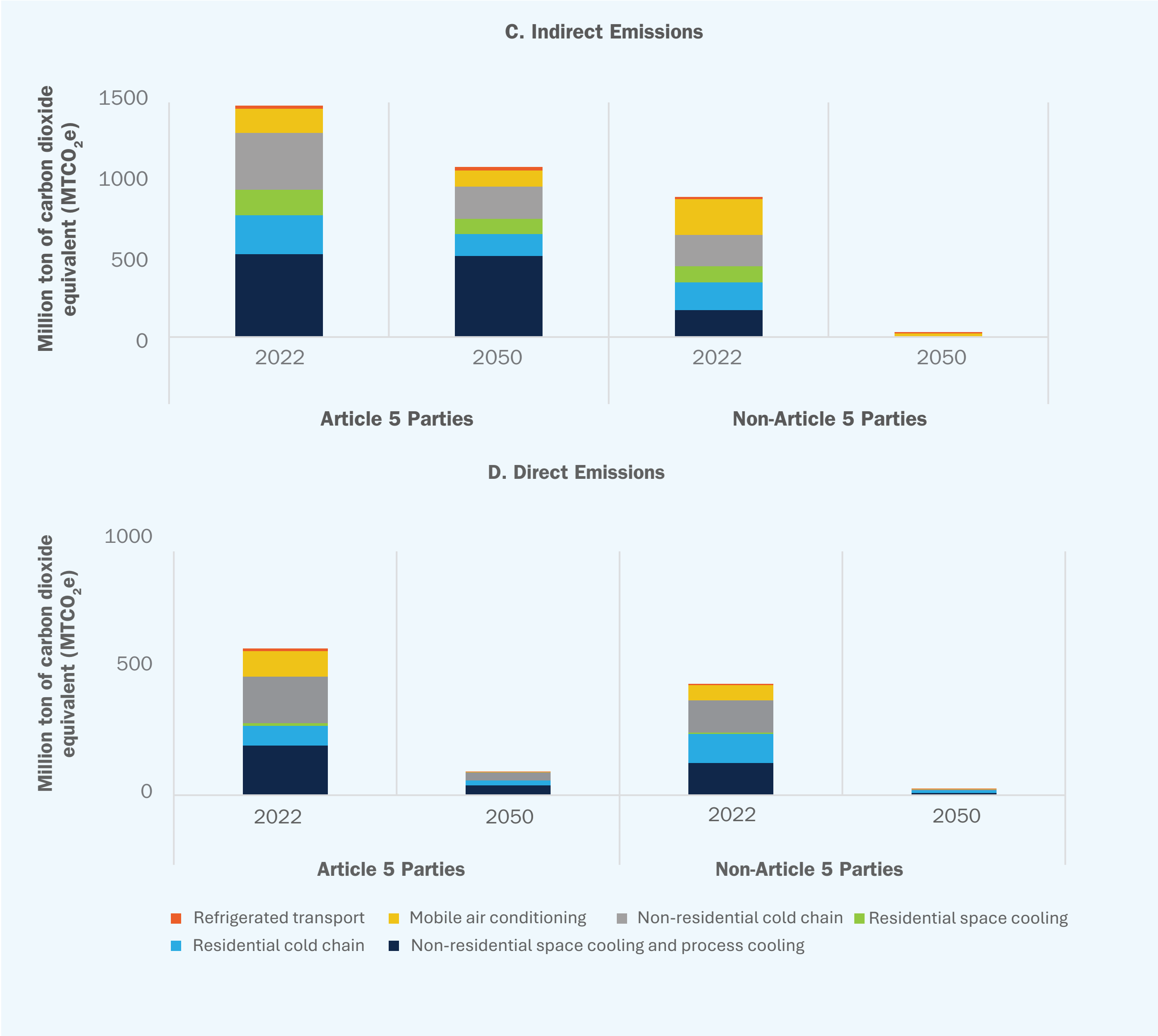



**Figure 2: A. Cooling Capacity, B. Energy Consumption, C. Indirect Emissions, and D. Direct Emissions Projections for Article 5 and Non-Article 5 Parties per the Global Cooling Emissions Model**

***Source: Global Cooling Emissions Model (2023)***

## 2.2 Regulatory Gaps in A5 Parties

Although 115 countries have established MEPS for space cooling and refrigeration, nearly 30 percent and 40 percent of countries do not have MEPS for space cooling and refrigeration appliances, respectively. The regulatory gap is more pronounced in Global South regions such as in Asia and Africa. For example, as of May 2023, 52 percent, 36 percent, and 15 percent of Africa, Asia, and Latin America & the Caribbean regions did not have MEPS for space cooling appliances, respectively; at the same time, 61 percent, 45 percent, and 24 percent of Africa, Asia, and Latin America & the Caribbean did not have MEPS for refrigeration appliances, respectively.[16]

This shortfall means inefficient cooling equipment using obsolete (ozone-depleting and global warming) refrigerants products, manufactured in both developed and developing countries, are sold in markets with fewer protections.[17] For example, Southeast Asia, Africa, Latin America, and the Caribbean regions are facing a surge in demand for room air conditioners (RACs) due to rising temperatures, but weak energy efficiency regulations have made these regions vulnerable to the dumping[iii] of inefficient and environmentally harmful units. In Southeast Asia, 74 percent of RACs sold in 2021 were low-efficiency models, especially in Indonesia and the Philippines, mostly produced by multinational companies or imported from China and Southeast Asia.

iii Dumping of inefficient, high-GWP appliances involves manufacturers or exporters send old, inefficient air conditioners or refrigerators—often phased out elsewhere—to countries without strong regulations, because they can still be sold there.

In Africa, the RAC market grew by 14 percent between 2005 and 2019, with 35 percent of sales being low-efficiency units and 47 percent using obsolete refrigerants like R-22. Local assembly in countries like Egypt and Nigeria accounts for 74 percent of low-efficiency units, while at least 50 percent are imported from China. This dumping drives up electricity bills, infrastructure costs, and GHG emissions due to inefficient energy use and high-GWP refrigerants.[18]

MEPS in most developing economies and many developed economies remain relatively lenient. Enacting more stringent MEPS would help these countries achieve greater energy savings by doubling efficiency in commercially available technologies. For example, RACs are available in most regions that exceed the highest efficiency levels recognized by labeling programs.[19] Moreover, few countries align their MEPS with regulations for phasing down high-GWP refrigerants, which is critical to achieving near-zero emissions from cooling equipment.[20] A regional landscape of cooling policies for four developing regions (South Asia, Southeast Asia, East Africa, and Southern Africa) reconstructed from the Global Cooling Policy Stocktake Survey and updated using secondary research is included in the Appendix 2.[21]

## 2.3 Technology and Infrastructure Gaps in A5 Parties

Alongside regulatory gaps, many A5 Parties face serious technology challenges that make it hard to move to efficient, low-GWP cooling. [22] In large parts of Africa, Asia, and Latin America, the equipment on sale is often two to three efficiency levels lower than the best available. In Southeast Asia, for example, more than 70 percent of air conditioners sold are low-efficiency fixed-speed models, even though higher-efficiency variable-speed units are available. While China has nearly 100 percent use of variable-speed compressors for its domestic AC market, exports are much lower at 42 percent. Adoption of high-efficiency cooling equipment in other A5 Parties varies – high in India, Thailand, and Vietnam; moderate in Brazil and South Africa; and very low across most of Africa, the Middle East, and Indonesia.

Many countries lack testing facilities for flammable refrigerants that require safety checks. In much of Africa and South Asia, there are fewer than five accredited labs, slowing approvals. Servicing of cooling equipment in many A5 Parties is carried out by a largely informal workforce, often without access to recovery or recycling equipment, and with limited application of safe handling practices for flammable refrigerants, such as leak testing and adequate ventilation.[23] Plasma destruction capacity favored by the wealthiest economies is available in only a few A5 Parties, such as India and Brazil, but cement kiln destruction is easily available in most A5 Parties.

Super-efficient cooling systems are rare in A5 Parties. One such system, $CO_2$ trans-critical refrigeration, is seen only in pilot supermarkets in Latin America and South Africa. Another such system, industrial heat pumps, are common in China and Europe but are almost absent elsewhere in A5 markets. Some key barriers include outdated safety codes, higher upfront costs (unless purchased by bulk procurement and buyers' clubs), and a lack of local assembly manufacturing. With a coordinated push to expand testing labs, modernize servicing, build robust lifecycle refrigerant management (LRM) systems, and update safety rules, A5 Parties can transition away from inefficient, high-GWP equipment and leap toward cleaner, more efficient cooling solutions.

# 3. CASE STUDIES

Understanding what works and what does not is key to designing effective regional CoEs. A review of the performance of existing CoEs offers critical insights into transferable successes, systemic barriers, and operational challenges. These learnings can guide the development of future regional CoEs, helping to replicate impact, avoid costly missteps, and ensure that new centers are fit-for-purpose and regionally grounded. This section presents an overview of key regional CoEs related to cooling and other consumption sectors (such as lighting), focusing on their governance and funding structures, core activities, and transferable learnings.[iv]

## 3.1 Africa Centre of Excellence for Sustainable Cooling and Cold-chain (ACES): Leveraging a Hub-and-Spoke Model for Knowledge Dissemination

ACES was established in 2020 through a collaborative effort involving Rwanda's Environment Management Authority and the United Kingdom government, the United Nations Environment Programme's (UNEP) United for Efficiency (U4E) initiative, the Centre for Sustainable Cooling (CSC) of the University of Birmingham, and the University of Rwanda. As part of the Rwanda Cooling Initiative, ACES aims to advance Rwanda's sustainable development goals and enhance regional collaboration on sustainable cooling solutions. ACES is hosted on the University of Rwanda's Rubirizi campus in Kigali.

ACES serves as a hub for innovation, research, and capacity building in sustainable cold-chain infrastructure. Its mission is to develop and promote integrated, inclusive, sustainable, and future-proof cooling and cold-chain infrastructure at scale in Africa's agriculture and health sectors, thereby empowering farmers, increasing export revenues, creating jobs, mitigating climate impacts, and fostering low-carbon development. ACES connects local and international experts, investors, private companies, farmers' organizations, and energy and logistics providers to achieve its mission.

ACES operates under a hub and spoke model, with its main campus in Rwanda and satellite centers, or Specialized Outreach and Knowledge Establishments (SPOKEs), being established in other African countries, the first of which has been developed in Kenya; a new SPOKE is being developed in Haryana, India, focused on reducing post-harvest crop losses.[24] Through its comprehensive programs and collaborative approach, ACES addresses critical challenges, such as food and vaccine loss, environmental impact, and the need for equitable access to cooling technologies.

**Funding and Governance.** ACES secures funding from various sources to cover its capital expenditure, operational costs, program implementation, R&D, and outreach and community engagement activities. The anchor funding is provided by the UK Government's Department for Environment, Food & Rural Affairs (Defra). Additional support through government grants, industry and private sector contributions, academic and research grants, and in-kind services have been provided by a variety of organizations.

UNEP, through the U4E Team, is the program manager receiving Defra funding directly and managing the distribution, working in partnership with the CSC, as the core design and delivery partner and lead academic partner.[25] Additionally, the newly established ACES Institute, an independent international non-governmental organization, manages the ACES campus, oversees program delivery, and has its own Board of Directors that ensure smooth operations. In-country partners, such as the University of Rwanda and the Integrated Polytechnic Regional College, Kigali, contribute to vocational training and technical support, with the Rwanda Biomedical Centre being a significant partner in health-related aspects. Local and regional teams, including UNEP program staff and technical advisors, provide hands-on support for local operations, procurement, and equipment specifications. Operational oversight and reporting are integral to the organizational structure. Program partners regularly report their progress and expenditures to UNEP, which subsequently submits quarterly reports to Defra, which then undertakesan annual independent review of the program.[26]

iv Disclaimer: These case studies were developed without the direct involvement of officials associated with them. They are based solely on publicly available information from websites and other documents. While every effort has been made to ensure accuracy, some details may be incomplete or outdated. The primary purpose of these case studies is to illustrate how regional CoEs have been established and managed, with an emphasis on transferable lessons to support the creation of effective future regional CoEs for sustainable cooling in A5 Parties.

ACES is extending its reach beyond Rwanda, establishing new centers and SPOKEs in other African countries and in India, creating a global network of centers of excellence for sustainable cooling and cold-chain. As part of this, ACES has created the reference and replicate model and supporting playbooks and materials on the Build, Own, Knowledge Transfer model to support the development of future Centers and SPOKEs. Moreover, they have launched an online knowledge and training hub, the Clean Cooling Network (CCN), a hub for sustainable cooling and cold-chain solutions program materials.[27]

**Activities.** ACES focuses on delivering specialized training and capacity building programs, developing innovative financial models, and advancing sustainable cooling technologies, while centering gender equality and social inclusion. Its efforts also extend to sophisticated system design and policy advocacy, fostering a comprehensive and equitable approach to cold-chain development.

**Training and Capacity Building:**

- ACES collaborates with academic and industry partners to design various vocational and technical training programs, including those tailored for early-career engineers, farmers, and informal sector practitioners.[28] These include a "Try Before You Buy" initiative and graduate education programs.[29] Through its SPOKE model, ACES intends to provide on-site training and knowledge transfer across Africa.[30]

**Finance and Business Models:**

- ACES is developing a return on investment model to identify, quantify, and monetize the impacts of sustainable and resilient cold-chains, emphasizing their role as critical national infrastructure.[31]
- ACES is also mapping practical financeable and innovative business models (e.g., "shared value" models) for community-based cold-chain projects, empowering agribusinesses in developing markets.[32]

**Testing and Demonstration:**

- ACES is developing a state-of-the-art Environment Test Chamber for independent equipment testing and certification, and Variable Testing Rooms for testing equipment in African climatic conditions.[33] ACES also collaborates with industry partners to procure and deploy novel cold-chain technologies, including those developed through the International Finance Corporation's TechEmerge program.[34]
- Looking ahead, ACES plans to explore new areas such as cold-chain needs for postharvest handling and road freight electrification.[35]

**System Design and Modelling:**

- ACES focused on designing a holistic, systems-level approach, integrating elements such as pre-cooling, storage, and transport logistics to sustainably meet community needs.[36] ACES is collaborating with Heriot-Watt University to use telemetrics and data collection to develop sophisticated virtual modelling tools for optimized cold-chain design.[37]
- ACES has also launched VaccMap, an innovative project to track vaccines through Rwanda's cold-chain in real time, aiming to identify failure points and deploy targeted interventions.[38]

**Policy:**

- ACES is advocating for the alignment of regional and international regulatory frameworks with sustainability, resilience, food, nutrition, health security, and broader developmental objectives.[39] ACES also emphasizes the importance of joined-up governance that bridges sectors and silos to co-develop cross-cutting policies, education, and innovation pipelines.[40]
- Looking ahead, ACES plans to expand its policy support initiatives by developing a Risk Radar and Cold-chain Security Index to assess the security and resilience of their cold-chain systems.[41]

**Transferrable Learnings.** (a) Implementing a hub-and-spoke model allows for efficient distribution of resources and knowledge, with a central hub coordinating activities and regional SPOKEs adapting to local contexts and showcasing practical, real-world applications for solutions; (b) Engaging local institutions and stakeholders, and securing local government support, is crucial for contextual understanding and creating an enabling environment; (c) Leveraging diverse funding sources and in-kind donations to ensure the center's financial sustainability.[42]

## 3.2 ASEAN Centre for Energy (ACE): Promoting Inclusive Decision-Making Through a Member-State Governing Council

ACE serves as a crucial intergovernmental organization dedicated to enhancing energy cooperation among ASEAN member states—Brunei, Darussalam, Cambodia, Indonesia, Laos, Malaysia, Myanmar, the Philippines, Singapore, Thailand, and Vietnam. Founded in 1999, ACE collaborates with energy authorities, Sub-sector Networks, and Specialized Energy Bodies to implement the ASEAN Plan of Action for Energy Cooperation (APAEC). It plays a central role as a catalyst, knowledge hub, and think tank, supporting sustainable regional development. It facilitates the sharing of best practices, policy advisory, and capacity building, thereby ensuring the integration of energy strategies across the region.

**Funding and Governance.** ACE operates under the guidance of the ASEAN Senior Officials on Energy, with governance provided by the Governing Council comprising representatives from the energy ministries of the 10 ASEAN member states. The funding for ACE primarily comes from the ASEAN Endowment Fund, managed by the ASEAN Secretariat. This funding supports ACE's initiatives, including policy advisory and capacity building, aimed at promoting energy cooperation across the region.

ACE is organized into several key departments and units, each focusing on different aspects of energy management and cooperation. Headed by the Executive Director, ACE departments comprise the APAEC Department, which focuses on the APAEC, Power, Fossil Fuel, Alternative Energy, and Storage Department, Sustainable Energy, Renewable Energy Department, Energy Modelling, Policy, and Planning Department, and Energy Efficiency and Conservation Department. Each department has senior officers, technical officers, and associate officers. The Governing Council and the ASEAN Secretariat manage the overall strategic direction and financial oversight.

**Activities Related to Cooling Appliances.** ACE works towards significantly enhancing the energy efficiency of cooling appliances through regional cooperation:

- **Development and Harmonization of MEPS of Cooling Appliances:** ACE has played a significant role in establishing MEPS for cooling appliances such as air-conditioners and refrigerators, including the endorsement of the Regional Policy Roadmap on Harmonization of MEPS. The UNEP-U4E ASEAN Cool Initiative supports the implementation of these goals.[43]
- **Regional Product Registration Database System:** ACE, in collaboration with partners like the Energy Conservation Center Japan, conducted extensive capacity building programs. The ASEAN Japan Energy Efficiency Partnership trained several energy manager trainers and focused on developing legal and regulatory frameworks for energy efficiency and conservation in member states like Cambodia and Laos. This initiative also provided training on the ASEAN Energy Management Accreditation Scheme, certifying roughly 1,000 energy managers by 2019.[44]
- **Training and Capacity Building:** ACE, in collaboration with partners like the Energy Conservation Center Japan, conducted extensive capacity building programs. The ASEAN Japan Energy Efficiency Partnership trained several energy manager trainers and focused on developing legal and regulatory frameworks for energy efficiency and conservation in member states like Cambodia and Laos. This initiative also provided training on the ASEAN Energy Management Accreditation Scheme, certifying roughly 1,000 energy managers by 2019.

**Transferrable Learnings.** (a) ACE's multi-stakeholder governance model, featuring a governing council with representatives from member states, promotes inclusive decision-making and ensures that initiatives align with regional priorities; (b) The central secretariat's role in managing funds and providing administrative support, funded through a centralized endowment, guarantees financial stability and operational efficiency; and (c) Collaborating with specialized bodies and integrating initiatives with broader regional and international goals enhances the coherence and impact of these centers.

## 3.3 Centers of Excellence for Renewable Energy and Energy Efficiency in Africa: Utilizing Regional Frameworks for Policy Adoption and Harmonization

Regional centers for renewable energy and energy efficiency have been instrumental in advancing sustainable energy transitions across Eastern, Southern, and Western African nations. By fostering regional cooperation, building technical capacity, and aligning policies, these institutions have created a strong foundation for harmonized energy efficiency standards, including for cooling appliances. Their experiences illustrate how coordinated, multi-country approaches can overcome fragmented markets and accelerate the adoption of efficient, climate-friendly technologies.

**East African Centre of Excellence for Renewable Energy and Energy Efficiency (EACREEE).** EACREEE focuses on promoting sustainable energy in the East African Community (EAC) region, which encompasses the Republic of Burundi, the Democratic Republic of the Congo, the Republic of Kenya, the Republic of Rwanda, the Federal Republic of Somalia, the Republic of South Sudan, the Republic of Uganda, and the United Republic of Tanzania. EACREE's headquarters is in Uganda's Makerere University. Primary objectives of EACREEE include increasing access to modern, affordable energy services, enhancing energy security, and reducing negative environmental impacts, while primary activities include developing regional policies, capacity building, and implementing renewable energy and energy efficiency projects. It also conducts workshops, training, and conferences to foster regional cooperation and knowledge sharing. EACREEE's institutional structure consists of an Executive Board, a Technical Committee, and a Secretariat. The Executive Board provides strategic guidance, approves plans, and monitors the EACREE's activities, and the Technical Committee offers technical reviews and recommendations. The Secretariat handles daily operations, including project development and implementation. Core partners like United Nations Industrial Development Organization (UNIDO) and the Austrian Development Agency support the Centre. EACREEE is established as an independent institution under the EAC's Energy Sectoral Council and operates within EAC's legal and administrative framework.[45]

**SADC Centre for Renewable Energy and Energy Efficiency (SACREE).** SACREE, established in 2015 and hosted by the Government of Namibia, promotes renewable energy and energy efficiency across Southern African Development Community (SADC) member states—Angola, Botswana, Comoros, Eswatini, Lesotho, Madagascar, Malawi, Mauritius, Mozambique, Namibia, Seychelles, South Africa, the Democratic Republic of the Congo, Tanzania, Zambia and Zimbabwe. Supported by UNIDO, the ADA, the EU Energy Initiative Partnership Dialogue Facility, and the SADC Secretariat, SACREEE focuses on increasing access to modern energy services and energy security.  Its mandate includes resource mobilization, policy harmonization, quality assurance, capacity building, knowledge dissemination, and investment promotion. SACREEE operates through a network of National Focal Institutions and is a subsidiary of SADC. It plays a pivotal role in the region's energy transition and economic development.[46]

**ECOWAS Centre for Renewable Energy and Energy Efficiency (ECREEE).** ECREEE was launched in 2010 in Praia, Cape Verde, following a 2008 regulation by the Economic Community of West African States (ECOWAS) Council.[47] Backed by UNIDO, Austria and Spain, it is a specialized ECOWAS agency tasked with creating market-ready conditions for renewable energy and energy efficiency across the region through regional frameworks, policies, and partnerships.[48] ECREEE is governed by an Executive Board and a Technical Committee, with a multilingual secretariat (English, French, Portuguese) based in Praia. It is funded through a combination of core contributions and project financing from partners such as UNIDO, Austrian Development Cooperation, Spanish AECID, and the Global Environment Facility, among others. It serves all 15 ECOWAS member countries: Benin, Burkina Faso, Cape Verde, Gambia, Ghana, Guinea, Guinea-Bissau, Côte d'Ivoire, Liberia, Mali, Niger, Nigeria, Senegal, Sierra Leone, and Togo. Two of these—Cape Verde and Guinea-Bissau—are classified as small island developing states.[49]

EACREEE, SACREEE, and ECREEE have played integral roles in facilitating the regional cooperation and technical work necessary to establish and implement harmonized MEPS, supporting the transition to more energy-efficient and climate-friendly cooling solutions in the EAC, SADC, and ECOWAS regions.

**Harmonization of MEPS for Room Air Conditioners and Residential Refrigerating Appliances in EAC, SADC, and ECOWAS Regions.** The rapid rise in cooling demand across East, Southern, and West Africa—driven by urbanization and economic growth—has underscored the need for energy-efficient and climate-friendly appliances. Yet, until recently, the lack of harmonized MEPS across the region posed challenges for both policy implementation and market transformation. Through coordinated efforts, supported by UNIDO and regional centers like EACREEE, SACREEE, and ECREEE a comprehensive process was undertaken to develop harmonized MEPS and energy labels for room air conditioners and residential refrigerators. This effort involved data collection, technical analysis, consultations with national governments, and consensus-building across member states. While institutional capacity varies and challenges remain, this coordinated approach has laid a strong foundation.

As a result, harmonized MEPS have now been formally adopted for national implementation across sixteen SADC countries. These new standards align with international best practices and reflect regional market realities, enabling countries to reduce trade barriers, lower compliance costs, and accelerate the shift to efficient cooling products. Several countries are already moving towards implementation, supported by regional centers through technical assistance, training, and policy advisory services.[50]

In West Africa, ECREEE has led similar efforts in the ECOWAS region, drafting a regional roadmap in 2018 to harmonize MEPS for key cooling appliances. Ghana spearheaded national action by introducing mandatory MEPS and labelling for air conditioners in 2005 and refrigerators in 2009, along with establishing local testing laboratories and import certification systems. Nigeria followed by adopting the ECOWAS MEPS into national law in 2017 and beginning enforcement in 2018 through its standards framework.[51]

**Transferrable Learnings.** (a) Collaborative regional processes can accelerate policy adoption and harmonization; (b) Strong partnerships and networks that encompass public and private sectors, academia, and civil society are essential for facilitating resource sharing, knowledge exchange, and coordinated action; and (c) A data-driven approach, involving comprehensive data collection and analysis, is crucial for informed decision-making and effective policy development.

## 3.4 Regional Centre for Lighting, Sri Lanka: Enabling Independent Testing to Block Substandard Imports

The Regional Centre for Lighting (RCL), headquartered in Colombo, Sri Lanka, was launched in April 2009 by the Sri Lanka Sustainable Energy Authority (SLSEA) with support from the U.S. Agency for International Development (USAID) under the South Asia Regional Initiative for Energy program.[52] The idea had its roots in a 2006 US–India energy efficiency conference, where an Indian delegate's question about demonstration hubs, coupled with lessons from the Bangalore Efficient Lighting Program, set the stage for a regional CoE. Sri Lanka's heavy dependence on imported oil, high evening peak demand from lighting, and the opportunity to reduce grid stress—backed by strong political will from the Ministry of Power and Energy and alignment with SLSEA's priorities—made it the natural host.[53] The Lighting Research Center (LRC) at Rensselaer Polytechnic Institute served as the technical knowledge partner.[54]

Serving Afghanistan, Bangladesh, Bhutan, India, Maldives, Nepal, Pakistan, and Sri Lanka, the RCL's mission was to promote efficient, reliable, and clean lighting, catalyze regional manufacturing, and train skilled personnel to support sustainable lighting markets.[55] Its state-of-the-art photometry laboratory, the first in Sri Lanka with a goniometer, enabled independent testing to block substandard imports.[56] Modelled partly on the U.S. LRC, RCL combined technical excellence with regional collaboration to deliver long-term benefits in energy, economics, and society.

**Funding and Governance.** Start-up funding was provided by USAID, with laboratory equipment support from the Asian Development Bank (ADB) and institutional backing from SLSEA. USAID contributed technical assistance, training, and early staffing, while SLSEA integrated the CoE into national policy. The LRC guided lab design, testing protocols, and training. ADB funded advanced photometry equipment and efficient street-lighting guidelines.

Initially governed under SLSEA, the RCL later came under the Ceylon Electricity Board (CEB) for operational management, driven by the Finance Ministry's preference to link operations with an entity directly benefiting from reduced peak demand.[57] Governance was overseen by a multi-stakeholder group, with roles distributed among SLSEA (initial host and policy liaison), USAID (strategic oversight and funding), LRC (technical knowledge partner), ADB (equipment and technical assistance), CEB (operations, staffing, revenue generation), and partner governments, industry, and academia (policy alignment, R&D, workforce training). This model highlighted independence from manufacturers to ensure unbiased testing.

**Activities.** The RCL undertook a range of initiatives spanning technical testing, market development, policy support, and regional collaboration, including:

- Operating South Asia's first accredited photometry lab with a goniometer and integrating spheres, testing CFLs and LEDs per national and international standards, and enforcing compliance labelling to prevent substandard imports.[58]
- Building local capacity through technical training for engineers, manufacturers, and policymakers, including initial intensive training at the U.S. LRC and ongoing workshops on lighting design, new technologies, and local performance.
- Conducting applied research in collaboration with the University of Moratuwa and other partners, carrying out pilot installations in public and commercial spaces to evaluate performance and demonstrate energy savings.

- Serving as a neutral platform for eight South Asian countries to share technical data, align standards, and coordinate market transformation strategies, hosting joint workshops and capacity-building events.
- Advising manufacturers on meeting quality requirements, encourages regional production, and provides independent testing to safeguard markets from low-quality products.
- Working with national and regional bodies to develop and implement policies such as minimum energy performance standards, labelling programs, and efficient street-lighting guidelines.

**Transferrable Learnings.** (a) Political stability is critical for continuity, as changes in leadership or policy direction can affect funding and priorities; (b) Establishing a clear mission and delivering early, visible results—such as publishing credible product test reports—helps secure trust among governments, industry, and consumers; (c) Independence from commercial funding preserves the integrity of testing; (d) Hosting the CoE in a politically neutral country encourages cooperation among nations with differing interests; (e) Diversifying income through fee-based testing, training, and research reduces reliance on donor support, creating a resilient and credible platform for regional market transformation.

**Key Transferable Learnings for Future Regional CoEs**

- Governance that includes like-minded representation from member states and regional actors ensures that decisions are participatory, context-sensitive, and focused on shared priorities.
- Strong partnerships across public, private, academic, and civil society sectors improve knowledge exchange, build capacity, and coordinate regional action.
- Securing diverse and sustained funding through a mix of donor contributions, in-kind support, and dedicated financing mechanisms strengthens operational stability and long-term impact.
- Embedding rigorous monitoring, evaluation, and learning systems allows for continuous improvement, accountability, and evidence-based scaling and replication of effective practices.
- Engaging local institutions and governments from the beginning fosters ownership, ensures relevance to local contexts, and creates a better environment for implementation.

# 4. A GUIDING FRAMEWORK FOR SETTING-UP REGIONAL CENTRES OF EXCELLENCE

Building on the case studies and transferable learnings discussed in Section 3, along with insights from NRDC-AEEE roundtable held at OEWG47 (the post-event meetings notes are included in the Appendix 3) and other stakeholder consultations, the following recommendations are proposed for establishing and operating regional CoEs in A5 Parties. Figure 3 presents a summary of the recommendations.

*These considerations must be addressed in parallel from the outset, as their deep interconnections require an integrated approach:*

| Foundation and Planning | Governance | Funding | Organizational Structure and Staffing | Activities |
|---|---|---|---|---|
| • Government leadership is essential, with designated nodal entities covering both ozone and energy efficiency officers.<br>• Country-level assessments must be conducted to map needs, policies, market trends, and stakeholders.<br>• A Common minimum program should be developed to align regional priorities and reflect shared realities.<br>• Existing networks of cooperations should be leveraged to enhance efficiency and continuity.<br>• The regional CoE's development should be phased to balance immediate needs with long-term sustainability. | • Government should build on proven cooperation models, leveraging established relationships for continuity.<br>• A Governing Council with fair representation from member states, international partners, and academic institutions should ensure transparency, accountability, and alignment with regional priorities.<br>• The governance framework should align with the chosen CoE configuration, whether a single center, hub and spoke, country-level centers, or a hybrid model.<br>• Governance should be collaborative, consensus-based, flexible, and adaptable to emerging challenges and opportunities. | • Diversify funding from MLF, non-MLF sources, and in-kind contributions; decide multilaterally on a dedicated MLF window.<br>• Ensure host country commitment with seed funding, land, and setup support.<br>• Build revenue streams (consulting, testing, training, etc.) with time-bound MLF operational support.<br>• Use membership or voluntary contributions to share costs and foster ownership.<br>• Manage financial risks with controls, audits, reserves, and independent decisions.<br>• Protect independence by refusing funding that compromises neutrality and disclosing all sources. | • Clear roles for senior managment and operational teams are essential for effective coordination and execution of initiatives.<br>• Recruiting, developing, and retaining skilled, motivated staff is critical to maintaining credibility and reputation as a CoE.<br>• Local partners and staff should lead on-the-ground operations to build community trust and ensure relevance. | • Activities should align closely with the CoE's vision, mission, and strategic objectives.<br>• Potential focus areas include energy efficiency aligned with HFC phasedown, capacity buildig, regional alignment, and bridging technology gaps.<br>• Identify and implement high-impact, low-effort actions first, then progressively expand to more complex initiatives as resources increase. |

**Figure 3: A Summary of the Guiding Framework for Setting-up Regional CoEs**

## 4.1 Foundation and Planning

- **Strong Government Leadership and Coordination:** Establishing a regional CoE requires a dedicated government nodal entity, i.e., a central coordinating body that acts as the main point of contact or authority, from each participating country to oversee its development, foster collaboration, and ensure active engagement. It is critical to have representation from both National Ozone Units[v] and energy efficiency departments in every participating country's nodal entity who must work in concert to achieve shared goals.

- **Country-level Assessment and Buy-in:** At the very outset, the nodal entity should:
  - Conduct a comprehensive assessment of the cooling landscape in the country, including evaluating socio-economic drivers, national and international commitments, relevant policies, and technological and market trends. Countries should leverage existing data-driven national cooling action plans as far as possible for drawing up this initial assessment.
  - Map and engage with relevant stakeholder such as government agencies, industry partners, academic institutions, NGOs, and local communities to secure broad support and trust.

- **Regional Alignment and Common Priorities:** Based on the context-mapping and stakeholder consultations mentioned above, the nodal entities should:
  - Develop a common minimum program, i.e., a jointly agreed action plan that sets out the minimum set of priorities and commitments that different participating countries agree to implement together to maximize regional impact. This common minimum program should account for factors such as the relative current and projected cooling demands of participating countries, the maturity and gaps in their regulatory frameworks, the status of the harmonization of standards, political will, interregional supply chains, refrigerant phasedown schedules, and the availability of financial and human resources. Additionally, it should consider the presence of existing CoEs, testing infrastructure, and their interoperability, as well as geopolitical sensitivities. This common minimum program should guide the CoE's vision, mission, and strategic objectives for the region.
  - Identify existing networks and frameworks for regional cooperation that can be leveraged to create a regional CoE; the Regional Networks of National Ozone Officers[59] is an excellent example of such networks, which is a highly-successful and cost-effective capacity building mechanism under the MLF that promotes the exchange of information, experience and know-how between countries on how to meet Montreal Protocol commitments, report data, set and enforce policies, adopt technologies and effectively manage their national programs.

- **Phased Development for Sustainable Growth:** The development of the regional CoE should follow a phased approach, balancing immediate needs with available resources. Existing CoEs for sustainable cooling in the region should be assessed and, where suitable, expanded to implement the mission, vision, and strategic objectives agreed upon by all country-level nodal entities.

## 4.2 Governance

- **Existing Cooperation Models:** The governance structure should build on proven models of cooperation as far as possible, leveraging established relationships for continuity while prioritizing long-term sustainability and expansion, and planning for smooth transitions when necessary.

- **Governing Council:** A Governing Council comprising nodal entities from member states, and international partners such as the Montreal Protocol implementing agencies (UNEP, UNDP, UNIDO, and the World Bank) active in the region, and academic institutes should be established to ensure transparency, accountability, and alignment with regional priorities. Representation on the Governing Council should be fair and equitable across all participating countries. The Governing Council may include an Apex Committee to provide high-level strategic direction, supported by thematic sub-committees focused on specific priority areas. Members of the Governing Council would typically possess high-level expertise in governance, strategic planning, finance, and international development.

- **Regional CoE Configuration:** The governance framework should be anchored in the chosen configuration of the regional CoE—whether a single center for the region, a hub-and-spoke model, one center per country working collaboratively, or a hybrid with national centers and subnational spokes—as illustrated in Figure 4.

v National Ozone Units are the government units in developing countries that are responsible for managing their national programs to comply with the Montreal Protocol on Substances that Deplete the Ozone Layer.

- **Governance Models:** Several models can be considered for regional CoEs, each offering distinct advantages depending on the context and stakeholder landscape. Typical governance structures include:
  - Industry Association–Led Model
    - Partnership between industry associations, local government, and multilateral funds/donors.
    - CoE staff drawn primarily from industry associations.
  - Utility–Led Model
    - Partnership between energy/power utilities, local government, and multilateral funds/donors.
    - CoE staff drawn from utilities and relevant government departments.
  - Academia–Led Model
    - Partnership between universities, multilateral funds/donors, industry, and local government.
    - CoE staff drawn from academia and industry.
  - Hybrid Model
    - Shared responsibilities across different actors.
    - Certain functions led by NGOs, while others are managed by academia and/or industry associations.
- **Consensus-based Governance:** Rather than relying on legal bindings that may cause delays, the governance should emphasize collaborative and consensus-based approaches. The governance structure should also be flexible and adaptable, allowing the center to respond effectively to emerging challenges and opportunities.

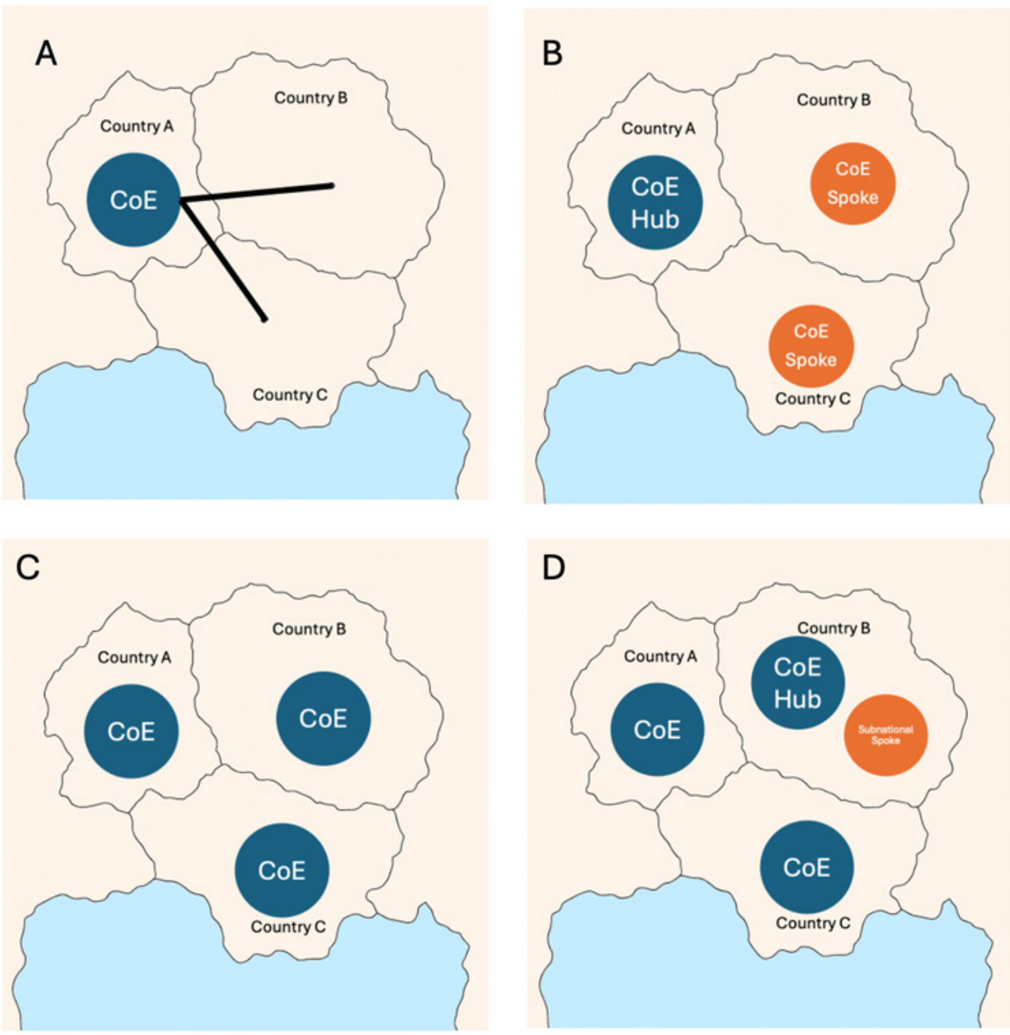



Figure 4: **Illustrative Configurations for Establishing Regional CoEs: A. One Single Center for the Region, B. Hub-and-Spoke Model, C. One Center per Country Working Collaboratively, or D. Hybrid Model with National Centers and Subnational Spokes**

*Note: This is a simple conceptual map of three fictitious countries generated using ChatGPT*

## 4.3 Funding

- **Diversified Funding Model:** To ensure the long-term sustainability of regional CoEs, it is recommended that they adopt a diversified, two-stage funding approach.
  - Initial Funding: Start-up financing may be drawn from one or two primary sources—such as the MLF, bilateral donors, governments, or philanthropic organizations—supplemented by in-kind contributions (e.g., land, equipment, or technical assistance). A decision may also be required at the multilateral level on whether to create a dedicated MLF funding window for CoEs.
  - Ongoing Funding: Over time, CoEs should transition to a broad and diversified funding base that reduces reliance on a single stream. Potential sources include MLF and non-MLF channels such as bilateral and multilateral funding agencies, regional and multilateral development banks, national development finance institutions, private banks, and public–private partnerships. Additional revenues can be generated through training, testing, and research services offered on a fee or grant basis, enabling the CoE to become self-sufficient. In-kind contributions—such as real estate or equipment from universities and research institutes—can also significantly lower capital expenditure needs.
- **Strong Host Country Commitment:** A committed host country can play a pivotal role in getting a regional CoE off the ground. This commitment should include providing an initial seed fund, allocating land for the CoE, and covering part of the setup costs. These contributions can be complemented by MLF support and additional funding from other governmental and non-governmental partners in the region. Contributions can be “in cash” or “in kind,” and may also include voluntary financial pledges from participating countries.
- **Sustainable Revenue Streams:** Beyond initial funding, the CoE should establish mechanisms to generate its own income to cover operational expenses. Potential revenue streams include offering consulting services, conducting technology testing and certification, delivering training and capacity-building programmes, showcasing technology demonstrations, and selling knowledge products. The MLF could consider covering a portion of the CoE’s operational costs for a defined number of years, with support gradually reduced as the CoE’s own revenue streams grow, until it reaches full financial self-sufficiency.
- **Membership and Voluntary Contributions:** Recurring costs for staff, maintenance, utilities, training, research, and stakeholder engagement can be offset through membership fees from participating countries. In cases where formal membership fees are not feasible, voluntary financial commitments can be pursued. These contributions ensure that all members countries have a stake in the CoE’s ongoing success.
- **Financial Risk Management:** Effective risk management is crucial for the sustainability of regional CoEs. This can be achieved by implementing strict financial controls, conducting regular audits, and establishing transparent reporting systems to ensure accountability and efficient use of funds. Setting aside reserves or emergency funds is essential to address unexpected financial shortfalls or operational disruptions. Maintaining open communication with funders and partners through regular updates on financial status and project progress will help build trust and sustain long-term support. Additionally, ensuring that financial management decisions are made independently will protect the center’s mission, allowing it to maintain focus and continuity despite potential challenges.
- **Institutional Independence and Credibility:** The CoE should establish and adhere to a strict funding policy that prohibits accepting financial or in-kind contributions from any source that could compromise its independence, neutrality, or credibility. All funding arrangements should be transparent, with clear terms that preserve the CoE’s ability to make impartial, evidence-based decisions in line with its mission and regional priorities. Regular disclosure of funding sources and governance oversight should be built into the CoE’s operational framework to maintain stakeholder trust.

## 4.4 Organizational Structure and Staffing

- **Organizational Design for Efficiency:** The organizational structure of a regional CoE should be designed to ensure operational efficiency. Figure 5 shows a sample organizational structure.
- **Leadership:** Effective leadership at all levels of decision-making is critical. Leaders who combine vision, ambition, and determination play a decisive role in ensuring the successful establishment and operation of CoEs.
- **Clear Roles and Skilled Workforce:** Defining clear roles for senior management and operational teams to coordinate and execute initiatives effectively is essential. Table 1 delineates the roles, responsibilities and skills required by key personnel.

It is critical to recruit, develop, and retain highly skilled, motivated staff whose dedication and expertise uphold the center's credibility and reputation as a true CoE.

- **Local Engagement and Inclusive Practices:** Local partners and staff should be actively engaged in managing on-the-ground operations, building community trust and maintaining relevance. Programs should be culturally sensitive and tailored to meet the specific needs of different communities. Actively involving local communities in decision-making and inclusive outreach initiatives will further ensure that the regional CoE remains relevant and equitable.

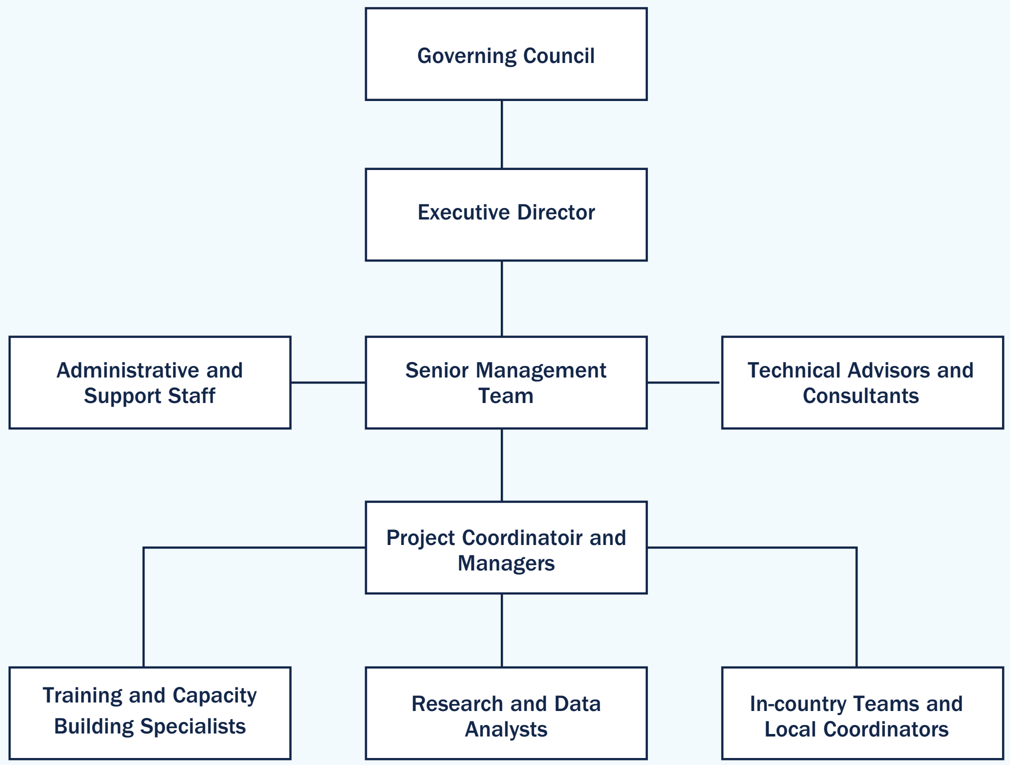



Figure 5: **Sample Organizational Structure**

**Table 1:** Illustrative Roles, Responsibilities and Skills of Key Personnel

| | Role and Responsibilities | Skills Required |
|---|---|---|
| **Governing Council** | The Governing Council provides strategic oversight and governance for the center. It supports the Senior Management Team, ensures alignment with center's mission, and oversees major decisions related to program direction, funding, and partnerships. | Members of the Governing Council typically possess high-level expertise in governance, strategic planning, finance, and international development. |
| **Executive Director** | The Executive Director (ED) leads the overall operation of the center, managing day-to-day activities and ensuring the successful implementation of the center's programs. The ED is also responsible for setting strategic goals, overseeing budget management, and representing the center in external engagements. | Strong leadership and management skills, experience in international development or a related field, excellent communication and networking abilities, and a deep sectoral understanding. |
| **Senior Management Team** | The Senior Management team includes key figures such as the Program Director, Finance Manager, Operations Manager, and Technical Lead. This team oversees specific areas of the center's operations, including program execution, financial management, operational logistics, and technical initiatives. | Specialized expertise in program management, financial oversight, operational planning, and cooling technology. Strong leadership, analytical skills, and the ability to manage cross-functional teams are essential. |
| **Technical Advisors and Consultants** | Technical advisors and consultants provide technical guidance and support across various aspects of the center's initiatives, including technology testing and demonstration, policy support, and capacity building. These experts work closely with in-country partners and local stakeholders to implement and optimize cooling solutions. | Technical expertise in refrigeration and cooling technologies, energy systems, and sustainable development. Consultants often bring experience in specific sectors. |
| **Project Coordinators and Managers** | Project coordinators and managers are responsible for coordinating specific projects within the center, these staff members manage timelines, budgets, and stakeholder communications. Managers ensure that project objectives are met and report on progress and outcomes. | Strong project management skills, including planning, coordination, and monitoring. Effective communication and problem-solving abilities are crucial for managing diverse projects and teams. |
| **Training and Capacity Building Specialists** | Training and capacity building specialists develop and deliver training programs for various stakeholders, including technicians and policymakers. These individuals design curricula, conduct workshops, and provide ongoing support to trainees. | Expertise in adult education and training methodologies, knowledge of cooling systems, and the ability to engage and inspire diverse audiences. |
| **Research and Data Analysts** | Research and data analysts conduct research on markets and policy frameworks. This team analyzes data, develops reports, and supports the center's knowledge-sharing initiatives. | Strong analytical and research skills, proficiency in data analysis tools, and experience in producing high-quality reports and publications. |
| **Administrative and Support Staff** | Administrative and support staff handle logistical aspects, including office management, scheduling, and communications. Staffers support the smooth operation of the center by managing documentation, coordinating events, and assisting with financial and HR tasks. | Organizational and administrative skills, attention to detail, proficiency in office software, and effective communication abilities. |
| **In-country Teams and Local Coordinators** | In-country teams and local coordinators provide on-the-ground support for projects and initiatives. These staff members work closely with local partners, manage field operations, and ensure that the center activities are adapted to local contexts. | Local knowledge and cultural awareness, strong interpersonal skills, and experience in community engagement and development. |

## 4.5 Activities

- **Adhering to the Vision, Mission, and Strategic Objectives:** The activities of regional CoEs should be closely tied to their vision, mission, and strategic objectives defined at the foundation and planning stage. Broadly, regional CoEs should be designed with the view of offering comprehensive infrastructure and technical support for adopting low-GWP refrigerant-based energy-efficient technologies, particularly benefiting small and informal enterprises. By providing locally accessible infrastructure and technical personnel, regional CoEs should deliver cost-effective training and technical support programs to technicians, ensuring a skilled workforce capable of handling new technologies. By networking with industry and service providers, they should enhance outreach on energy-efficient and safe equipment performance, while addressing national and regional market needs. Over time, regional CoEs should evolve into knowledge and innovation hubs, offering sustained support to local stakeholders on technical and policy issues, including product design and the local adaptation of technologies.
- **Potential Focus Areas:** Table 2 offers a menu of activities to choose from related to six potential focus areas:
  - Focus Area I: Core Actions for Aligning Energy Efficiency Improvements with the HFC Phasedown
  - Focus Area II: Promoting Capacity Building
  - Focus Area III: Supporting Regional Alignment
  - Focus Area IV: Bridging Technology Gaps
  - Focus Area V: Develop Indigenous Technology
  - Focus Area VI: Public Engagement
- **Prioritizing Activities for Maximum Impact:** Regional CoEs should adopt structured prioritization tools to systematically rank activities against criteria most relevant to the region.[60] This approach will enable regional CoEs to begin with high-impact, low-effort initiatives that deliver quick and visible results, before progressively expanding to more resource-intensive projects as financial and human capacities grow.

**Table 2: Menu of Activities**

| Recommended Activity | Recommended Sub-activities |
|---|---|
| ***Focus Area I: Core Actions for Aligning Energy Efficiency Improvements with the HFC Phasedown*** | |
| **Project Preparation Funding for Projects under the Operational Framework for Energy Efficiency** | • Provide guidance on project preparation and funding applications to source MLF funds dedicated to energy efficiency.<br>• Share insights and best practices from successful projects to guide new initiatives |
| **Data Collection & Modelling** | • Provide countries with guidelines and templates for robust refrigeration and air conditioning sector data collection and serve as the regional data repository.<br>• Host workshops and training sessions on best data practices and modelling tools.<br>• Develop region-specific methodologies for HFC use surveys.<br>• Conduct regional studies on how equipment design changes affect energy and refrigerant use, to inform policy and regulations. |
| **Evaluation, Measurement & Verification (EM&V)** | • Develop EM&V frameworks with clear metrics, methodologies, and data protocols.<br>• Train professionals in modern EM&V techniques and standards.<br>• Align EM&V efforts with regional climate and sustainability goals.<br>• Host workshops to share EM&V knowledge and best practices. |

| Recommended Activity | Recommended Sub-activities |
|---|---|
| ***Focus Area II: Promoting Capacity Building*** | |
| **Support for SMEs and Local Installers and Assemblers** | • Train SMEs, installers, and assemblers on energy-efficient, low-GWP technologies.<br>• Offer training-of-trainers programs and update materials with latest practices.<br>• Provide consultancy for design, installation, maintenance, and troubleshooting.<br>• Help access funding (grants, loans, subsidies) for sustainable technologies.<br>• Inform and prepare SMEs for upcoming regulatory changes.<br>• Enhance market access by boosting technological competitiveness.<br>• Organize study tours to showcase successful technology adoption.<br>• Foster partnerships and joint initiatives within the sector.<br>• Assist in sourcing components for SMEs and local service providers. |
| **Servicing Sector Support** | • Train technicians in designing, installing, and maintaining low-GWP, energy-efficient equipment.<br>• Foster collaboration between service enterprises and efficiency authorities.<br>• Support national certification systems to ensure high service quality and regulatory compliance. |
| **Lifecycle Refrigerant Management** | • Develop and run regional technician training and certification programmes on recovery, recycling, reclamation, and destruction, including safe handling and refrigerant blends.<br>• Operate shared recovery cylinder fleets, transport links, and mobile units to serve remote or low-volume consuming countries.<br>• Provide regional laboratories and facilities for refrigerant testing, purification, and reclamation.<br>• Support harmonised adoption of recovery and venting bans, rebates, buy-back schemes, and reclaimed content targets across member countries.<br>• Maintain regional refrigerant tracking systems, including electronic logbooks and a refrigerant bank inventory, to guide policy and monitor recovered gas flows.[61] |
| **Retrofitting Large Refrigeration and Air-conditioning Systems with Energy-efficient Alternatives** | • Conduct workshops on retrofitting technologies and best practices.<br>• Provide feasibility assessments for retrofit projects, including cost and efficiency analysis.<br>• Host sessions to share knowledge on standards, labeling, and new technologies. |
| **Capacity Building and Technical Assistance for National Funding Institutions on Energy Efficiency in the Context of HFC Phasedown** | • Train financial institutions on financing low-GWP, energy-efficient technologies.<br>• Guide the design of financing products tailored to the sector's needs.<br>• Support development of viable business models for district cooling projects. |
| ***Focus Area III: Supporting Regional Alignment*** | |
| **Regional Harmonization of Energy Efficiency Standards** | • Advise governments and organizations on aligning and localizing regional standards.<br>• Train technicians, engineers, and policymakers on energy efficiency technologies and standards.<br>• Share best practices to strengthen collaboration across countries and institutions.<br>• Coordinate cross-sectoral training programs for integrated planning on refrigerants and energy efficiency. |

| Recommended Activity | Recommended Sub-activities |
|---|---|
| **Testing Infrastructure** | • Conduct market assessments to confirm demand for lab operations.<br>• Provide technical support to set up advanced, standardized testing labs.<br>• Train technicians and engineers in test design and methodologies.<br>• Facilitate mutual recognition agreements and harmonize testing standards regionally.<br>• Support lab accreditation to international standards.<br>• Develop advanced protocols for evaluating energy efficiency across cooling equipment.<br>• Set up systems for continuous monitoring and quality assurance in testing labs. |
| ***Focus Area IV: Bridging Technology Gaps*** | |
| **Technology Transfer** | • Map and track emerging energy-efficient, low-GWP technologies and create a regional database to promote innovation.<br>• Organize regional technology fairs with industry associations and startup bodies, focused on efficient cooling solutions.<br>• Develop pilot projects to demonstrate technology feasibility and scalability in different countries.<br>• Support innovators with mentorship, business development, and strategic partnerships, boosting visibility for promising solutions.<br>• Establish regional innovation hubs for startups in the cooling sector.<br>• Provide training, guidance, and legal support on IP rights, patents, and licensing.<br>• Act as a regional matchmaking platform connecting investors, innovators, and adopters.<br>• Facilitate academia–startup–industry partnerships for scalable energy-efficient designs and localized component manufacturing. |
| **Creating Uninterrupted Supply Chains of Cooling Equipment Components** | • Map and build a database of the regional cooling equipment supply chain, covering suppliers, manufacturers, logistics, and distribution channels to identify vulnerabilities and bottlenecks.<br>• Create digital vendor directories and procurement platforms to streamline component sourcing and boost regional manufacturing opportunities.<br>• Develop a trade facilitation toolkit with guidance on regulations, tariffs, customs, and import/export procedures to ease cross-border movement of cooling components.<br>• Implement regional bulk procurement programs for energy-efficient, low-GWP technologies, prioritizing public sector projects in participating countries. |
| **Supporting Emerging Cooling Sectors** | • Assess feasibility and map emerging cooling sectors, such as data centers, along with suitable technologies and projected demand growth in the regional context.<br>• Develop guidelines for energy-efficient, low-GWP cooling solutions for data centers, covering operation and maintenance best practices.<br>• Support skill development and workforce training for specialized cooling technologies in new and emerging sectors. |
| ***Focus Area V: Develop Indigenous Technology*** | |
| **Alliance-Building & Partnerships** | • Forge alliances among academia, national labs, industry (public/private), financial institutions, and governments.<br>• Establish consortia to pool resources, share costs/risks, and accelerate commercialization of new technologies.<br>• Promote collaboration across key A5 countries to leverage indigenous innovation capacity. |
| **Technology Development & Research** | • Support indigenous technology development alongside international technology transfer.<br>• Commission contract research with academia and national labs on sustainable cooling technologies (basic and applied science).<br>• Facilitate joint projects bridging early-stage research and market-ready solutions. |

| Recommended Activity | Recommended Sub-activities |
|---|---|
| **Commercialization & Market Transformation** | • Develop cost-shared mechanisms for advancing embryonic cooling technologies from lab to market.<br>• Facilitate partnerships for scaling and marketing innovative cooling technologies. |
| **Outreach & Communication** | • Run targeted outreach and dissemination programs to engage potential consortium and research partners.<br>• Build visibility for indigenous technology development through regional platforms, events, and communications.<br>• Strengthen public and private sector awareness of sustainable cooling R&D opportunities. |
| ***Focus Area VI: Public Engagement*** | |
| **Public Education & Awareness** | • Educating the public on cooling technologies and efficient practices (thermostat control, insulation, natural ventilation, etc.)<br>• Raising awareness on protection from heat stress and methods of abatement<br>• Organizing conferences, seminars, and public meetings on energy efficiency and heat stress |
| **Community Engagement & Outreach** | • Developing designated programs for public involvement to build trust and increase visibility<br>• Engaging NGOs and community groups in sustainable cooling initiatives<br>• Leveraging media interest through public-facing activities |
| **Technical Services & Support** | • Establishing a service center to conduct cooling energy audits for households, businesses, and institutions<br>• Providing hardware lending (portable monitoring equipment, etc.) to support local assessments |

# 5. CONCLUSION

The establishment of regional CoEs for cooling in A5 Parties presents a significant opportunity to align energy efficiency best practices with the phasedown of high-GWP refrigerants, creating the dual benefit of reducing greenhouse gas emissions from cooling equipment while also meeting the growing demand for cooling. As cooling demand surges in developing regions, these centers can serve as critical hubs for harmonizing standards, building capacity, supporting SMEs, and facilitating the adoption of low-GWP and energy-efficient technologies.

The success of these centers will lie in their ability to engage like-minded stakeholders, from government agencies to local communities, while securing sustainable funding and fostering regional cooperation. The lessons learned from existing initiatives underscore the importance of a phased approach, leveraging existing infrastructure, and prioritizing outcomes and adaptability in operations. Political stability is critical for continuity, as shifts in leadership or policy direction can directly affect funding and priorities. Hosting the CoE in a politically neutral country can also help foster cooperation among nations with differing interests, ensuring that collaboration remains constructive and inclusive. In conclusion, regional CoEs hold the potential to transform the cooling sector by integrating energy efficiency and refrigerant transitions into a cohesive strategy that advances both environmental and developmental goals.

# APPENDIX 1

This section presents regional results from the Global Cooling Emissions Model. All scenarios assume significant growth in cooling equipment stock. The model covers equipment in four main markets for stationary cooling: residential space cooling, non-residential space and process cooling, residential cold-chain, and non-residential cold-chain. Additionally, two key sectors of transport cooling are included: mobile air conditioning and refrigerated transport. The model calculates both direct emissions from refrigerants, emitted from cooling equipment, and indirect emissions generated by the power needed to operate this equipment. The 2050 cooling capacity forecasts include adjustments for improved access to cooling appliances in economically disadvantaged regions and accounts for reductions in cooling demand due to passive load reduction measures. The 2050 energy consumption and emissions projections assume that enhanced cooling-related policy measures will:

- minimize cooling load growth through passive cooling strategies,
- maximize the energy efficiency of new cooling equipment,
- improve the operational efficiency of existing systems, and
- accelerate the reduction of HFC refrigerants beyond the requirements of the Kigali Amendment.

Additionally, the decarbonization pathway envisions developed countries achieving net-zero emissions by 2040, while developing countries reach net-zero by 2070. The direct emissions data in this analysis focuses exclusively on HFCs.

**The 14 Regions Modelled in the Global Cooling Emissions Model**

| Region | Kigali Amendment Group | Parties |
|---|---|---|
| **South America** | Article 5, Group 1 | Argentina, Plurinational State of Bolivia, Brazil, Chile, Colombia, Ecuador, Guyana, Paraguay, Peru, Suriname, Uruguay, Venezuela |
| **Central America and the Caribbean** | Article 5, Group 1 | Antigua and Barbuda, Bahamas, Barbados, Belize, Costa Rica, Cuba, Dominica, Dominican Republic, El Salvador, Grenada, Guatemala, Haiti, Honduras, Jamaica, Mexico, Nicaragua, Panama, Saint Kitts and Nevis, Saint Lucia, Saint Vincent and the Grenadines, Trinidad and Tobago |
| **North America** | Non-Article 5 | Canada, United States of America |
| **Africa** | Article 5, Group 1 | Algeria, Angola, Benin, Botswana, Burkina Faso, Burundi, Cameroon, Cabo Verde, Central African Republic, Chad, Comoros, Congo, Côte d'Ivoire, Democratic Republic of the Congo, Djibouti, Egypt, Equatorial Guinea, Eritrea, Eswatini, Ethiopia, Gabon, Gambia, Ghana, Guinea, Guinea Bissau, Kenya, Lesotho, Liberia, Libya, Madagascar, Malawi, Mali, Mauritania, Mauritius, Morocco, Mozambique, Namibia, Niger, Nigeria, Rwanda, São Tomé and Príncipe, Senegal, Seychelles, Sierra Leone, Somalia, South Africa, South Sudan, Sudan, United Republic of Tanzania, Togo, Tunisia, Uganda, Western Sahara, Zambia, Zimbabwe |
| **Europe 1** | Article 5, Group 1 | Albania, Armenia, Bosnia and Herzegovina, Georgia, Moldova, Montenegro, North Macedonia, Serbia, Türkiye |
| **Europe 2** | Non-Article 5 | Andorra, Austria, Belgium, Bulgaria, Croatia, Cyprus, Czechia, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Israel, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Palestinian National Authority, Poland, Portugal, Romania, San Marino, Slovakia, Slovenia, Spain, Sweden, Switzerland, United Kingdom of Great Britain and Northern Ireland |
| **Former Soviet Union** | Non-Article 5 | Azerbaijan, Belarus, Kazakhstan, Russian Federation, Tajikistan, Ukraine, Uzbekistan |
| **West Asia 1** | Article 5, Group 1 | Jordan, Lebanon, Syrian Arab Republic, Yemen |
| **West Asia 2** | Article 5, Group 2 | Bahrain, Kuwait, Oman, Qatar, Saudi Arabia, United Arab Emirates |
| **South-Central Asia 1** | Article 5, Group 1 | Afghanistan, Bangladesh, Bhutan, Kyrgyzstan, Maldives, Nepal, Sri Lanka, Turkmenistan |

| Region | Kigali Amendment Group | Parties |
|---|---|---|
| **South-Central Asia 2** | Article 5, Group 2 | India, Islamic Republic of Iran, Iraq, Pakistan |
| **East Asia** | Article 5, Group 1 | China, Mongolia, Democratic People's Republic of Korea |
| **Southeast Asia and Pacific Islands** | Article 5, Group 1 | Brunei Darussalam, Cambodia, Cook Islands, Federated States of Micronesia, Fiji, Indonesia, Kiribati, Lao People's Democratic Republic, Malaysia, Marshall Islands, Myanmar, Nauru, Niue, Palau, Papua New Guinea, The Philippines, Samoa, Singapore, Solomon Islands, Thailand, Timor-Leste, Tonga, Tuvalu, Vanuatu, Vietnam |
| **Asia Pacific** | Non-Article 5 | Australia, Japan, New Zealand, Republic of Korea |


Sector
- Residential space cooling
- Residential cold chain
- Refrigerated transport
- Non-residential space cooling and process cooling
- Non-residential cold chain
- Mobile air-conditioning

**A. Cooling Capacity, B. Energy Consumption, C. Indirect Emissions, and D. Direct Emissions Projections for the 14 Regions Modelled in the Global Cooling Emissions Model**

***Source: Global Cooling Emissions Model (2023)***

# APPENDIX 2

**An Illustrative Regional Landscape of Cooling Policies for Select A5 Regions**

| | South Asia | Southeast Asia | East Africa | Southern Africa |
|---|---|---|---|---|
| **Parties** | Afghanistan, Bangladesh, Bhutan, India, Iran, Maldives, Nepal, Pakistan, Sri Lanka | Brunei, Cambodia, East Timor, Indonesia, Laos, Malaysia, Myanmar, Singapore, The Philippines, Thailand, Vietnam | The Republic of Burundi, the Democratic Republic of Congo, the Republic of Kenya, the Republic of Rwanda, the Federal Republic of Somalia, the Republic of South Sudan, the Republic of Uganda, and the United Republic of Tanzania | Angola, Botswana, Comoros, Eswatini, Lesotho, Madagascar, Malawi, Mauritius, Mozambique, Namibia, Seychelles, South Africa, Zambia and Zimbabwe |
| **Montreal Protocol Refrigerant Phase-down Schedule** | India, Iran, and Pakistan: Article 5 Group 2<br>Rest: Article 5 Group 1 | Article 5 Group 1 | Article 5 Group 1 | Article 5 Group 1 |
| **MEPS** | Bangladesh, Maldives, India, Iran, Pakistan, and Sri Lanka have MEPS for cooling appliances, with only Bangladesh, India, and Iran regularly updating them. Nepal, Afghanistan, and Bhutan lack MEPS. Mandatory appliance labels are required only in Bangladesh, India, and Pakistan. | There is significant uptake of MEPs in the region. Thailand consistently updates these standards for cooling appliances, while Singapore, Indonesia, and Malaysia regularly update their MEPS for refrigeration equipment. Indonesia, Malaysia, the Philippines, Thailand, and Singapore require refrigeration appliances to meet strict efficiency standards and carry labels, promoting consumer awareness and energy-efficient product choices. Cambodia and Laos are currently working to develop MEPs for specific cooling appliances. | Only Kenya, Rwanda, and Uganda have implemented MEPS for appliances, but these are not regularly updated, potentially limiting energy efficiency gains. Kenya has mandatory labels for both cooling appliances and refrigeration equipment. | MEPS for space cooling appliances exist in South Africa, Mauritius, Zambia, Lesotho, and Angola but lack regular updates. MEPS for refrigeration equipment is in place in these 4 countries, excluding Angola. Regular updates occur only in Lesotho and Zambia. Zambia, Lesotho, and Mauritius have efficiency standards and labels for all refrigeration appliances, but only 20 percent of countries comply, resulting in higher emissions. |
| **Kigali Implementation Plan** | Sri Lanka is the only Party currently with an approved plan though other countries like India have ongoing projects aimed at HFC reduction. | Thailand, Singapore, The Philippines, Brunei Darussalam, Myanmar and Timor-Leste do not have KIPs, highlighting a gap in regional climate action. | Congo and Rwanda have KIPs; Burundi is developing its plan. | Eswatini, Lesotho, Malawi, Mauritius, Mozambique, Seychelles, and Zimbabwe have approved KIPs. |

| | South Asia | Southeast Asia | East Africa | Southern Africa |
|---|---|---|---|---|
| **Refrigerant Management** | Only Bangladesh, Maldives, and Sri Lanka have comprehensive regulations for refrigerant recovery and disposal, with Iran also having a policy for refrigerant disposal. These countries, along with Iran, have readily available low-GWP refrigerant-based equipment. There is a significant gap in refrigerant management policies across the region. | Only 4 countries have established programs to train technicians in handling new refrigerants, indicating a need for broader capacity building efforts. Indonesia, Malaysia, and Thailand have made progress in adopting low-GWP refrigerants, but availability remains limited in the region. Regulations for proper refrigerant disposal are in place only in Indonesia, Malaysia, the Philippines, and Singapore, underscoring a regional need for responsible environmental management. | Uganda is the only country with policies for refrigerant recovery and disposal. Low-GWP refrigerant equipment is not widely available in the region, limiting environmental benefits. Kenya and Uganda offer incentives and training for technicians, indicating a proactive approach to skill development. | South Africa, Namibia, Eswatini, Seychelles, and Botswana offer low-GWP refrigerant-based equipment, but Eswatini and Botswana lack regulations for refrigerant disposal and recovery. South Africa, Mauritius, Zambia, Angola, Eswatini, and Mozambique have incentives/ training programs for technicians. |
| **High-level Policies** | Bangladesh, India, and Sri Lanka have dedicated National Cooling Action Plans. Only Bangladesh and Sri Lanka include cooling targets in their NDCs or climate strategies, with Bangladesh also including cooling projections in electricity capacity planning. | Only Cambodia and the Philippines include cooling demand projections in their national electricity capacity planning, despite the significant impact of cooling on energy consumption in the region. Seven countries have cooling-related targets in their NDCs or climate strategies, but only five have developed National Cooling Action Plans. | Kenya and Rwanda have National Cooling Action Plans; Congo and Somalia include cooling targets in their NDCs. However, no country has integrated cooling projections into electricity capacity planning. | South Africa is the only country with a National Cooling Action Plan and cooling targets in its NDC/climate strategies. Namibia also includes cooling targets. No countries have included cooling projections in electricity capacity planning. |

# APPENDIX 3

Key takeaways from the roundtable discussion at OEWG47:

- Participants stressed the need for flexibility and local ownership in CoE design, drawing on past success stories where contextualized approaches led to better adoption and impact.
- Inclusive governance—engaging government, academia, service providers, and industry—was highlighted as vital to ensuring grounded and actionable strategies.
- While regional CoEs offer scale and harmonization benefits, some emphasized that national-level institutions may be more cost-effective, leveraging existing labs and universities.
- A phased or hybrid approach—starting locally or nationally and scaling regionally—was seen as more practical than launching region-wide institutions from the outset.
- Before building infrastructure or designing programs, it is essential to define the purpose ("why") of a CoE. Without a clear direction, structure alone won't deliver results.
- CoEs should be people- and process-focused, not merely physical buildings.
- There was openness to non-traditional models such as distributed networks, innovation hubs, or incubators that emphasize agility and collaboration over brick-and-mortar setups.
- Lessons from other sectors (e.g., cleantech, agriculture) show that startup support and flexible design can spur innovation in unexpected ways.
- Long-term, well-structured funding was considered essential. Ideas included revolving or performance-linked funds, and conditional support to ensure sustained impact.
- There was a call to avoid short-termism and donor-driven agendas and instead ensure CoEs align with national plans and Kigali implementation goals.
- Several participants supported piloting 1–2 CoEs first, with expansion based on demonstrated results.
- Clear performance metrics are needed to prevent CoEs from becoming ineffective. Monitoring, evaluation, and transparency were emphasized as critical components of CoE success.
- While strategic plans are easy to craft, implementation is complex. The group acknowledged that even some current models, even promising ones, still face scale and sustainability challenges.
- Simplicity and clarity—such as starting with a small, dedicated team—were seen as helpful for accountability and early success.

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