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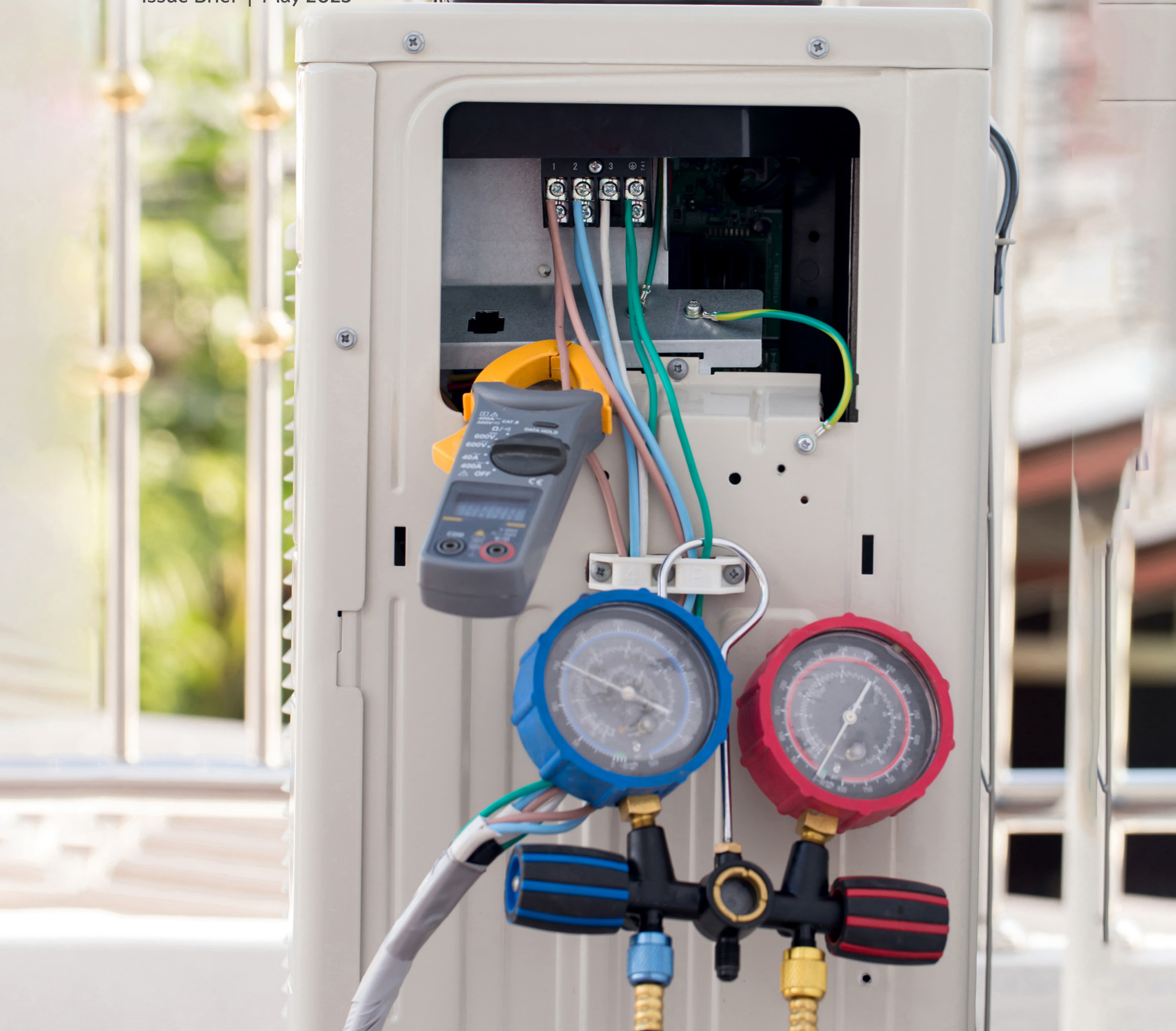
Activating Circular Economy for Sustainable Cooling

Current Status and Barriers to Lifecycle Refrigerant Management in India

Aditya Garg, Sonal Kumar, and Shikha Bhasin

Issue Brief | May 2023



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About the report: This issue brief on *Current status and Barriers to Lifecycle Refrigerant management in India* is part of a series of publications on on "Activating Circular Economy for Sustainable Cooling" through lifecycle refrigerant management in India under the INDEE+ project. The series offers a comprehensive analysis of refrigerant management practices in India and globally, including a case study of Norway's legislation, proposals for effective implementation in India, and innovative business models.

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Organisations: The **Council on Energy, Environment and Water (CEEW)** is one of Asia's leading not-for-profit policy research institutions. The Council uses data, integrated analysis, and strategic outreach to explain – and change – the use, reuse, and misuse of resources. It prides itself on the independence of its high-quality research, develops partnerships with public and private institutions, and engages with the wider public. In 2021, CEEW once again featured extensively across ten categories in the *2020 Global Go To Think Tank Index Report*, including being ranked as South Asia's top think tank (15th globally) in our category for the eighth year in a row. The Council has also been consistently ranked among the world's top climate change think tanks. Follow us on Twitter @CEEWIndia for the latest updates.

Future Refrigeration India (INDEE+) is an umbrella project, focused at enhancing the use of natural refrigerants, and lifecycle management of refrigerant gases having ozone depletion and high global warming potential. Overall, this project aims to achieve the goals of the ratified Kigali Amendment of the Montreal Protocol. Under this project, CEEW and NEA have collaborated to support the lifecycle management of highly potent refrigerants in an environmentally sound manner in India.

The **Norwegian Environment Agency (NEA)** is a government agency under the Ministry of Climate and Environment, Government of Norway. The NEA employs over 700 personnel across two offices stationed in Trondheim and Oslo and at the Norwegian Nature Inspectorate's (SNO) sixty local offices. NEA's primary tasks are to reduce greenhouse gas emissions, manage Norwegian nature, and prevent pollution.

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About CEEW

The Council on Energy, Environment and Water (CEEW) is one of Asia's leading not-for-profit policy research institutions and one of the world's leading climate think tanks. **The Council uses data, integrated analysis, and strategic outreach to explain — and change — the use, reuse, and misuse of resources.** The Council addresses pressing global challenges through an integrated and internationally focused approach. It prides itself on the independence of its high-quality research, develops partnerships with public and private institutions, and engages with the wider public.

The Council's illustrious Board comprises Mr Jamshyd Godrej (Chairperson), Mr Tarun Das, Dr Anil Kakodkar, Mr S. Ramadorai, Mr Montek Singh Ahluwalia, Dr Naushad Forbes, Ambassador Nengcha Lhouvum Mukhopadhaya, and Dr Janmejaya Sinha. The 140-plus executive team is led by Dr Arunabha Ghosh. CEEW was certified a **Great Place To Work® in 2020 and 2021.**

In 2021, CEEW once again featured extensively across ten categories in the *2020 Global Go To Think Tank Index Report*, including being ranked as **South Asia's top think tank (15th globally) in our category for the eighth year in a row**. CEEW has also been ranked as South Asia's top energy and resource policy think tank for the third year running. It has consistently featured among the world's best managed and independent think tanks, and twice among the world's 20 best climate think tanks.

In twelve years of operations, The Council has engaged in nearly 400 research projects, published 320+ peer-reviewed books, policy reports and papers, created 160+ databases or improved access to data, advised governments around the world 1100+ times, promoted bilateral and multilateral initiatives on 110+ occasions, and organised 460+ seminars and conferences. In July 2019, Minister Dharmendra Pradhan and Dr Fatih Birol (IEA) launched the CEEW Centre for Energy Finance. In August 2020, Powering Livelihoods — a CEEW and Villgro initiative for rural start-ups — was launched by Minister Mr Piyush Goyal, Dr Rajiv Kumar (NITI Aayog), and H.E. Ms Damilola Ogunbiyi (SEforAll).

The Council's major contributions include: The 584-page *National Water Resources Framework Study* for India's 12th Five Year Plan; *the first independent evaluation of the National Solar Mission*; India's first report on global governance, submitted to the National Security Adviser; irrigation reform for Bihar; the birth of the Clean Energy Access Network; work for the PMO on accelerated targets for renewables, power sector reforms, environmental clearances, *Swachh Bharat*; pathbreaking work for the Paris Agreement, the HFC deal, the aviation emissions agreement, and international climate technology cooperation; the concept and strategy for the International Solar Alliance (ISA); the Common Risk Mitigation Mechanism (CRMM); critical minerals for *Make in India*; modelling uncertainties across 200+ scenarios for India's low-carbon pathways; India's largest multidimensional energy access survey (ACCESS); climate geoengineering governance; circular economy of water and waste; and the flagship event, Energy Horizons. It recently published *Jobs, Growth and Sustainability: A New Social Contract for India's Recovery*.

The Council's current initiatives include: A go-to-market programme for decentralised renewable energy-powered livelihood appliances; examining country-wide residential energy consumption patterns; raising consumer engagement on power issues; piloting business models for solar rooftop adoption; developing a renewable energy project performance dashboard; green hydrogen for industry decarbonisation; state-level modelling for energy and climate policy; reallocating water for faster economic growth; creating a democratic demand for clean air; raising consumer awareness on sustainable cooling; and supporting India's electric vehicle and battery ambitions. It also analyses the energy transition in emerging economies, including Indonesia, South Africa, Sri Lanka and Vietnam.

The Council has a footprint in 22 Indian states, working extensively with state governments and grassroots NGOs. It is supporting power sector reforms in Uttar Pradesh and Rajasthan, scaling up solar-powered irrigation in Chhattisgarh, supporting climate action plans in Gujarat and Madhya Pradesh, evaluating community-based natural farming in Andhra Pradesh, examining crop residue burning in Punjab, promoting and deploying solar rooftops in Delhi, Bihar and Jharkhand.

Contents

Recovered refrigerant purified to virgin-like specifications through reclamation, offers a sustainable solution for servicing demands during the phase-down of high GWP refrigerants while promoting efficient use of resources.

Image: iStock

Summary

Due to increasing population, rapid urbanisation, improving per capita income, and, most critically, an increase in global temperatures due to climate change, cooling demand is expected to increase significantly both in India and globally. This will increase the demand and consumption of potent refrigerants like chlorofluorocarbons (CFCs), hydrochlorofluorocarbons (HCFCs) and hydrofluorocarbons (HFCs), which are currently being used as refrigerants in cooling devices, until natural refrigerant-based cooling devices become commercially viable.

In the cooling industry, India is one of the top producers and consumers of refrigerants in the world. In accordance with the Montreal Protocol, the Government of India has implemented significant measures to control the production and consumption of synthetic refrigerants like CFCs, HCFCs and HFCs. However, insufficient actions are taken till now to avoid the emissions from the operational stage and end-of-life (EOL) of the already installed devices containing refrigerants. If no significant measures are taken beside controlling the production and consumption, a significant amount of refrigerants will collect over the coming decades, which will most likely get emitted into the environment. Refrigerant management is one method of limiting emissions in the refrigerant's lifetime and promoting an orderly phase-out in developing nations. It involves refrigerant recovery, recycling, reclamation, reuse, and destruction. Hence, to control refrigerant emissions, it is crucial to adopt a refrigerant management approach and address the issue comprehensively throughout the lifecycle of the refrigerant.

This issue brief examines the current status of the refrigerant recovery, recycling, reuse, and destruction ecosystem in India with regards to regulations, laws, infrastructure and the various initiatives the Government of India has taken to curb the emission of these potent gases into the atmosphere. Additionally, the brief discusses the barriers coming in the way of the effective management of refrigerants in India.

Even though India has the least access to cooling, it is one of the biggest producers and consumers of synthetic refrigerants worldwide. In India, to a large extent, the unorganised sector caters to the servicing and EOL waste-handling needs. The study's results suggest that although India has taken several initiatives to limit refrigerant emissions, various barriers still remain unaddressed.

Limiting the refrigerant emissions from the cooling sector in India will require capacity building accompanied by a formalisation of the servicing sector, stringent regulations and reporting mechanisms, incentives to the end users and waste handlers, infrastructure, and coordinated industry efforts. These measures, directly or indirectly, will be critical actors in limiting refrigerant lifecycle emissions and help India achieve its ambitious net-zero targets by 2070.

1. Introduction

Ozone-depleting substances (ODS), mainly HCFCs, and non-ozone-depleting alternatives like HFCs are currently the most widely used compounds in refrigeration and air-conditioning applications. The Montreal Protocol on Substances that Deplete the Ozone Layer is the historic multi-nation environmental treaty that controls the production and consumption of ODS, like CFCs and HCFCs, and has eliminated 98 per cent of ODS as of today, compared to 1990 levels (UNEP n.d.). HFCs replaced CFCs and HCFCs and do not destroy the stratospheric ozone layer; however, some HFCs exhibit 12–14,000 times more global warming potential (GWP) than CO_2 (UNEP n.d.). HFCs are widely used in various products, including air conditioners, refrigerators, foams and aerosols. By 2050, yearly HFC emissions are expected to account for 7–19 per cent of all CO_2 emissions, expanding at a rate of 8 per cent annually (UNEP n.d.). Thus, controlling refrigerant emissions becomes essential to limiting the rise in global temperature to 2°C or less by the end of the century. To promote the phase-down and subsequent phase-out of these substances, the Kigali Amendment to the Montreal Protocol came into effect in 2016. The nations supported the phase-down of HFCs, agreed to add them to the list of restricted substances, and devised a schedule for their gradual reduction by 80–85 per cent by the late 2040s (UNTC 2016).

The Montreal Protocol does not directly regulate the emissions of ODS and HFCs from existing cooling devices, often known as 'refrigerant banks', which might be due to practical and techno-economic challenges. Nevertheless, only a small number of nations have mandatory or voluntary restrictions on the emissions of refrigerants once cooling equipment has reached the EOL.

> **In India, to a large extent, the unorganised sector caters to the servicing and end-of-life waste handling needs of the cooling devices.**

Due to a lack of legislation, education, and enforcement measures regarding the proper handling of the gases, these refrigerants are frequently vented out during the operational stage and during the decommissioning of the cooling equipment, which contributes to global warming and ozone layer damage.

Theoretically, refrigerant gases can be used indefinitely unless they become permanently contaminated (RTOC 2006). This makes it essential to create value by recovering and reusing them, until they get completely contaminated, and are eligible for destruction. The term 'refrigerant management' refers to the understanding and proper handling of refrigerants along the entire supply chain: from the storage and shipment of refrigerants to good service practices, recovery, recycling and reclamation, and proper disposal of these potent GHGs (UNEP n.d.). This report puts forward the data collected from the literature on the existing barriers and current status of recovery, recycling, reuse, and disposal of refrigerant gases from cooling appliances in India.

2. Encompassing the circular economy approach in the cooling sector

The world's economic and ecological systems are severely stressed due to the loss of finite natural resources (UNIDO 2018). This can be linked to the global system's linear economy, which does not reuse expensive resources by converting them into reusable secondary raw materials. The transition towards the waste-to-resource paradigm needs a circular economy model, which is restorative or regenerative by intention and design, in which resources are recycled back into raw materials, used as an energy source, reused, or, in the last instance, disposed of (WEF 2019). This model aims to eliminate waste through the advanced design of materials, products, systems, and value chains, replacing the EOL concept with restoration and shifting towards renewable energy. It also eradicates the use of hazardous chemicals, which might otherwise be reused and returned to the biosphere (WEF 2014). According to the Ellen MacArthur Foundation, the three principles of the circular economy, which is driven by design, are (Ellen MacArthur Foundation n.d.):

> To reduce additional burden on the environment, the circular system differs from the linear system in how value is created or preserved.

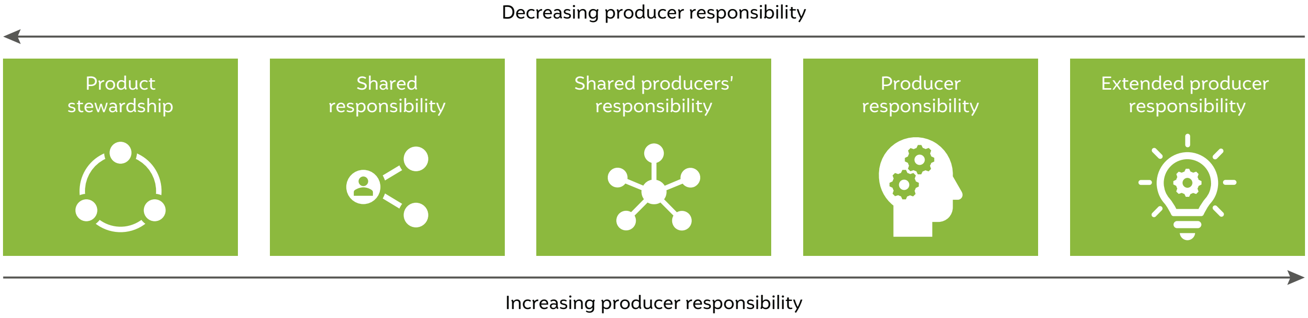
- Regenerate natural systems: The regeneration of natural systems is one of the critical fundamentals of the circular economy. It boosts natural capital and creates the conditions for natural system revitalisation. The basic principle underlying this fundamental is the regulation of finite stocks and the balance of renewable resource flow.
- Keep products and materials in use: A circular economy seeks to increase the useful life of products and resources by connecting the materials and products circulating through the economy, increasing resource yields by constantly cycling goods, parts, and resources at their highest utility.
- Design out waste and pollution: Enhance system efficacy by eliminating negative externalities. During manufacturing, by design, the system should be made such that the decommissioned equipment gets dismantled and its composite parts can be put back into the systems.

2.1 Economic & environmental benefits

For a sustainable future, change is required in several areas, including product design, resource use, production techniques and business strategies. As a result, it will open up an extensive array of employment options as well as economic, environmental, and social potentials that have not yet been explored due to several barriers like regulatory, statutory, infrastructure and market-readiness issues (UNIDO 2018).

The circular economy strategy strongly emphasises recovery, recycling, and reuse because they serve as transformative forces that help people recognise the full value of limited resources by transforming waste into valuable products. By 2030, the circular economy, which promotes resource conservation and waste reduction, has the potential to produce USD 4.5 trillion in economic benefits (WEF 2019). To reduce additional burden on the environment, the circular system differs from the linear system in how value is created or preserved. Our efforts to reduce the environmental impact are centred on eco-efficiency when addressing sustainability in a linear economy. In a circular economy, sustainability is sought by increasing the eco-effectiveness of the system. This demonstrates that the environmental impact is not just reduced but that the environmental, economic, and social impacts are all advantageous (Kjaer et al. 2019). This makes it clear that in a circular economy, sustainability is attempted by making the system more environmentally friendly.

Figure 1 Circular economy strategies



Source: Authors' analysis adapted from OECD, 1998

2.2 Approaches for circularity

In order to stop hazardous substances, such as refrigerants, from going into the environment and instead create value out of them, a comprehensive circular economy approach is required. Different ways and legislative measures are being utilised throughout the world to eliminate what we don't need and how we may recover, recycle, reclaim, and reuse the items we've discarded in order to reintroduce them into the system and reduce the strain on the natural ecosystem and the environment (Rizos, Behrens and Kafyeke 2015). Although difficult to set up, if successful, it can be a game changer in the worldwide transition to a more economically and environmentally sustainable future (Eijk 2015).

Various practices for waste management, with or without the producer's responsibility, are operational in some countries. Figure 1 gives the continuum of producer responsibility for different strategies. The Product Stewardship Program (PSP) and Extended Producer Responsibility (EPR) are the two most popular strategies utilised globally for waste management. Both have radically different results, as well as advantages and disadvantages.

Product stewardship

As part of an environmental management strategy known as product stewardship, everyone involved in a product's design, production, sale, or usage is accountable for reducing that product's environmental effect at every point in its lifespan. This multi-stakeholder method encourages participation from all stakeholders engaged in the supply chain. It includes the producer, manufacturer, importer, wholesaler, store owner, consumer, and waste handler (Nicol and Thompson 2007).

According to this strategy, the ideal division of labour is as follows: producers ensure that there is infrastructure for disposal and recycling, end users pay fees and deliver waste to a collection centre, retailers participate in collecting waste, and governments set standards and make sure that the system is safe from freeloaders (Thorpe, Kruszewska and McPherson 2004). This shared responsibility strategy falls short of internalising the expenses associated with environmental impact, giving producers little information about the costs associated with the lifetime management of their goods. Due to the numerous parties engaged in the products' supply chain, it frequently needs to be made clear who is principally managing EOL.

Extended Producer Responsibility

Producers have a significant financial and physical liability under EPR for managing or disposing of EOL waste (OECD 2001). In theory, assigning such accountability encourages waste prevention at the source, advances environmentally friendly product design, and aids in accomplishing societal recycling and materials management goals (OECD 2001). Physical accountability includes handling a product, whether direct or indirect, such as the producer's buyback scheme of a product for recycling or directly managing EOL devices (Nicol and Thompson 2007). The expense of recycling and disposal at the EOL of a product is the producer's obligation under the law (Nicol and Thompson 2007). With the most product-specific knowledge and control over the production and design processes, the producer has a better understanding to take on waste management responsibilities (OECD 2001). This relieves municipalities from paying for trash disposal while encouraging companies to use fewer raw materials and more recycled materials and enhance product design features to reduce waste.

EPR involves redesign, regulation, and product recycling as sustainable alternatives. A few examples of EPR policy measures include product fees, such as advance recycling fees (ARFs), product buyback requirements on retailers and manufacturers, tax on the use of raw material, fee for disposal, trash collection prices, and landfill bans (Sachs 2006). Programmes for educating customers that promote the recycling of products rather than throwing them away assist manufacturers in efficiently collecting their products from consumers (Ellen MacArthur Foundation 2021).

Shift towards Extended Producer Responsibility

While EPR and product stewardship programmes expand waste management accountability, their efficacy is very different. The funding scheme chosen for these methods is crucial in deciding whether a product management system may qualify for EPR or product stewardship. Since EPR satisfies the requirements of the circular economy and complements sustainable development goals, it is considered to be superior in attaining high recycling rates, lowering harmful emissions, enhancing product design, and for appropriate financing (Sachs 2006). On the other hand, product stewardship externalises EOL expenses, provides no incentive to prevent waste from being generated during the design process, and doesn't impose any regulations to reduce emissions or upsurge in recycling rates (Nicol and Thompson 2007). The benefits of regulatory EPR programmes that aim for specific rates of recovery and recycling include lower waste and the advancement of environmentally friendly design modifications to consumer goods. With EPR, a product's manufacturer covers the expense of product disposal. The items may be physically collected at the EOL or used in conjunction with a producer responsibility organisation (PRO). A PRO is a third-party business that collects and processes information. Producers do not physically take the product back when using a PRO; instead, they provide financial assistance for the procedure. Practices for EPR might be either voluntary or regulated. Departments and organisations from the public and commercial sectors attempt to promote voluntary practices of EPR in place of formal regulation, sometimes in collaboration with non-governmental institutes.

> **EPR programmes are recognised as a successful way to address inadequate waste management on a global scale.**

EPR programmes are becoming more widely recognised as a successful way to address inadequate waste management on a global scale. There is much experience with EPR programmes for various kinds of waste in Europe and other nations. Many low- and middle-income nations' governments have also begun to propose or develop regulations in this area. Additionally, some businesses and organisations have started efforts and voluntary pledges to promote EPR programmes and hasten the transition to sustainable waste management and the circular economy.

2.3 Relevance of circularity in the cooling sector and refrigerant management

Between 1981 and 1990, India experienced 413 heatwave days, but there were 600 such days between 2011 and 2020, according to the Indian Meteorological Department (Rajeevan and Nayak 2021). “Cooling is no longer something that should be considered a luxury; it's an issue of sustainability,” says Ben Hartley of Sustainable Energy for All (SEA 2021). In the coming decades, the need for cooling is anticipated to increase dramatically due to heatwaves that occur more frequently and are more intense, as well as increased urbanisation and economic growth. According to projections by the International Energy Agency (IEA), India will have over 1 billion stock of room air conditioners by 2050 compared to a mere 27 million units in 2016, a 40-fold increase (IEA 2018).

Thus, moving towards the circular economy becomes essential to prepare for the country's growing, cross-sector cooling infrastructure developments and their accompanying energy and emission implications. The US Environmental Investigation Agency estimates that proper management and reuse of the potent refrigerants found in cooling systems could prevent the emission of 100 billion gigatons of CO_2 equivalent globally between 2020 and 2050 (EIA 2019). Therefore, proper management of refrigerants is crucial. The largest source of unaddressed emissions, which accounts for approximately 90 per cent of refrigerant emissions, occurs at the EOL when the refrigerant is released into the air from the cooling appliance (Purohit and Höglund-Isaksson 2017). To the greatest extent possible, ODS and high-GWP refrigerants' EOL emissions can be reduced through the circular economy. Hence, recovering, reusing, and destroying refrigerants at the EOL of the cooling system, will minimise its negative environmental impact. Furthermore, the circular economy in the cooling space won't just reduce environmental impact but will also create a number of business and job opportunities, as mentioned in the *India Cooling Action Plan* (MoEFCC 2019).

2.4 Barriers to circular economy

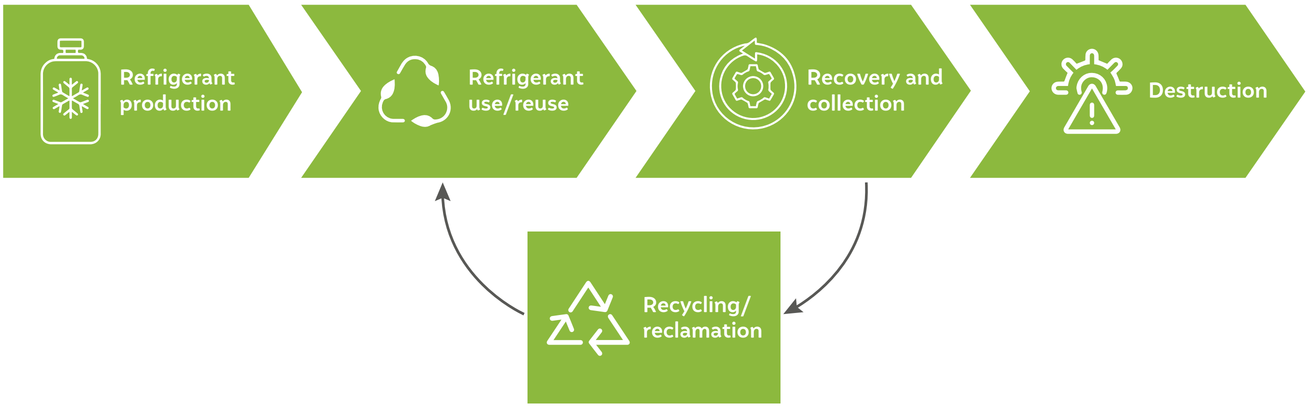
Transitioning to the circular economy model for economic sustainability will necessitate a significant transformation of the entire industry, including all stakeholders (Jaeger and Upadhyay 2020). The circular economy model will be unfavourable at the initial stages because of the existing system in place. For the circular economy method to be successful, the following obstacles must be removed:

- **Policies and regulations:** The crucial barrier among most developing countries is the absence of policies for waste management for different industries. Lack of infrastructure, legislation, and enforcement mechanisms in the areas relevant to recycling, such as training, labour and employment, environmental protection and enforcement, needs to be addressed (UNIDO 2018).
- **Lack of awareness, technical knowledge and skills:** It is difficult for small and medium-sized businesses to adopt the circular economy because of a lack of technological know-how. Furthermore, they are unaware of the advantages of utilising energy-saving and environmentally friendly technologies (Rizos, Behrens and Kafyeke 2015).
- **Recovery:** The composition of equipment and product design are increasingly becoming more complex. This makes dismantling and recovery more difficult for the untrained technician handling the waste at the last stage of a product (Eijk 2015). The recovery of such products with adequate purity levels in order to be recycled and reused is a major challenge.
- **Lack of knowledge regarding product production and design:** The end phase of the product is not considered while designing the products, and hence the removal of toxic materials from the components or the product is lacking (Eijk 2015). The products should be designed in such a manner that it doesn't come as a hurdle for the waste handler to dismantle and recycle them.
- **High infrastructure costs:** While the circular economy model would eventually result in sustainable advantages and higher growth, in the short term, it would require high start-up expenditures for infrastructure setup, waste channelisation, recycling, enhanced product design, etc. (Eijk 2015).
- **Complex supply chain:** Production and consumption are frequently in different countries due to globalisation, and supply chains might need to be reconfigured to enable recycling and reuse. Companies must be encouraged throughout the supply chain to actively consider durable materials, ease of maintenance, and reuse (Preston 2012).

3. Refrigerant course from manufacturing to disposal

The refrigerant goes through different lifecycle stages from its production until its EOL. After production, the refrigerant enters the market through appliance manufacturers, or through servicing enterprises. Ideally, during the commissioning and operational stage of the cooling appliances, overcharging and leakage must be avoided by the servicing personnel. During servicing or maintenance, the refrigerants can be reused in the same system after preliminary purification. Once the refrigerant cannot be reused, it must be stored in cylinders and transported to the designated refrigerant reclamation or destruction facility. The lifecycle of the refrigerant is described in the figure below:

Figure 2 Lifecycle of the refrigerant from its manufacturing to EOL of a cooling device



Source: Authors' analysis from the literature

Refrigerant manufacturing

The refrigerants are produced on a large scale by the refrigerant manufacturers. They are then either exported or sold to the equipment manufacturers for various application such as residential air conditioning (RAC), commercial air conditioning (CAC), mobile air conditioning (MAC), residential refrigeration (RR) and commercial refrigeration (CR).

Refrigerant usage

Refrigerant is a cooling chemical that absorbs heat and produces cool air after passing through a compressor and evaporator. It is used in almost all cooling devices. During the lifecycle of the cooling product, these refrigerants gradually leak into the atmosphere; hence, refilling is often required. A trained technician refills the refrigerant into the cooling device using the appropriate equipment.

Refrigerant recovery and collection

Recovery refers to the removal and short-term storage of refrigerant from a system being repaired or disposed.

Recycling

Recycling is the process of filtration purifying the recovered refrigerant so that it is ready to be used in the same equipment from which it was extracted. Its repackaging and sale to the refrigerant business is not recommended.

Reclamation

Reclamation, according to ICAP, is the process of restoring used refrigerant to new specifications in conformity with industry purity specifications (such as AHRI Standard 700) by extracting impurities like moisture, acid and non-condensable gases (MoEFCC 2019). Reclaimed refrigerants are suitable for resale, specifically for servicing and maintenance.

Transportation

It refers to the transportation of stored recovered refrigerants to the refrigerant reclamation or destruction facility. In some countries, which are lacking in refrigerant reclamation and destruction infrastructure, the refrigerants are consolidated and transported in suitable tanks to countries having the required disposal infrastructure.

> **The lifecycle management of refrigerants can reduce emissions and enable long-term climate change mitigation.**

Destruction

At last, the non-recyclable and non-reusable fully contaminated refrigerant is neutralised by destruction. The non-reusable refrigerant stored in the cylinders is destroyed in an environmentally sound manner in TEAP-approved refrigerant destruction technologies such as cement kilns and plasma arc incinerators (TEAP 2018).

4. Importance of refrigerant management during its lifecycle

Due to the increase in demand for refrigerants because of the rise in cooling demand, it is essential to address the harmful emissions of refrigerants throughout their lifecycle, be it from refrigerant manufacturing, cooling equipment operating stage, or the EOL of the cooling device. IEA's research estimates that the total global stock of ACs are expected to increase from 1.6 billion units in 2018 to 4.5 billion units by 2050, which nearly accounts to four-time increase (IEA 2018). Considering the ten-year lifespan of an AC, with this exponential growth, more than 45 million ACs will enter the waste stream annually, posing a severe environmental concern (GIZ 2014). If the additional concrete steps on refrigerant emissions are not taken, in particular, middle to downstream of the lifecycle, the total amount of refrigerant emissions is predicted to rise to 100 billion MT of global CO_2 eq emissions between 2020 and 2050, even with the ODS phase-out plan, HCFC phase-out management plan and the Kigali Amendment to the Montreal Protocol in place (EIA 2019).

The lifecycle management of refrigerants will result in a considerable reduction in emissions and long-term climate change mitigation through the introduction of comprehensive policies, technologies, and infrastructure. It will also promote innovation, improve resource efficiency, and support excellent jobs and long-term economic growth (CCAC UNEP 2020). Enforcing downstream actions, such as recovering the refrigerants at the EOL of cooling appliances, which are substantial sources of GHG emissions, is just as important as enforcing upstream measures, such as the development of new lower GWP refrigerants and replacing existing cooling equipment. Only a handful of countries have voluntarily initiated refrigerant management practices involving refrigerant recovery, recycling, reuse, and safe destruction (UNEP and IEA 2020). Additionally, refrigerant management will also support the HCFC phase-out and HFC phase-down, as the recovered gases can be returned to the market for reuse, leading to decreased production.

A lifecycle management approach to reducing fluorocarbon emissions will also advance the growth of new businesses, high-quality employment opportunities, and the circular economy. The increase in the lifecycle management of fluorocarbons while working with already existing activities and frameworks can be facilitated by practical actions, innovation, and the cooperation of governments, the private sector, and international institutions.

5. Current status of refrigerant management in India

This chapter highlights the current status of the management of refrigerants like high-GWP gases and ODS such as HFCs and HCFCs at the time of operation and EOL in India. The Government of India has adopted many measures to reduce the production and use of ODS and high-GWP gases. Experiences from other countries highlight that refrigerant management has been instrumental in reducing the cooling sector's GHG emissions and has played a key role in successfully phasing out synthetic refrigerants in a timely manner (Oberthur 1999). According to TEAP, refrigerant management practices consistently and significantly reduce both ozone depletion and climate change (TEAP 2007).

In India, this part of the value chain still needs to be developed and needs to acquire know-how. In the transition to climate-friendly refrigerants such as hydrocarbons, NH_3 and CO_2, there is a need to limit emissions from the operational stage of the cooling appliances and EOL emissions of the refrigerants. Given India's lack of policy, infrastructure, funding, and stakeholder awareness on this issue, it is necessary to recognise and understand the efforts India has taken and the barriers between implementing such efforts to minimise operational and EOL emissions of refrigerants.

> **Present cooling, which mostly relies on HCFCs and HFCs, is a threat to India's net-zero commitments and its growing population.**

5.1 Country background

Due to its low air-conditioning penetration rate, increasing per capita income, urban sprawl, and predominately hot and humid climate, India is a developing nation with a greater need for cooling. Despite this, India is one of the countries with the least access to cooling worldwide, as evidenced by its low per capita energy utilisation for space cooling, which is only 69 kWh compared to the average for all countries of 272 kWh (MoEFCC 2019). Without any interventions, the national cooling energy demand is projected to increase from the baseline level in 2018 to approximately 1,000 tonnages of refrigeration by 2038 (MoEFCC 2019). It amounts to 810 million tonnes of CO_2-eq emissions per year (direct and indirect) and around 7 per cent of the anticipated total yearly national emissions for 2037 (Nain and Bhasin 2022). Around 68 per cent of the demand will come from space cooling, which will be followed by refrigeration, transport, air conditioning, and cold chain (Cooling India 2020). India's imposing cooling needs will significantly influence its emissions intensity and global warming obligations. This rise in cooling demand will be catered through refrigerants; thus it is critical to choose the right refrigerant which ensures a balance between energy efficiency and minimum to no environmental impact.

India has successfully met phase-out targets of all the ODS as per the Montreal Protocol schedule. The increasingly urbanising population of India continues to seek sanctuary in an artificially cooled oasis. This cooling, which mostly relies on HCFCs and HFCs, is a threat to India's net-zero commitments and its growing population. In addition, the Kigali Amendment to the Montreal Protocol for the phase-down of HFCs has been ratified by the Indian cabinet.

5.2 The supporting legislation and policies in India

ODS (Regulation and Control) Rules of 2000

- These rules restrict the manufacturing and use of ODS and devices based on them (MoEFCC 2000).
- India has so for been successful in carrying out projects and activities related to the phase-out of ozone-depleting chemicals in accordance with the Montreal Protocol's phase-out timetable.
- No regulation restricts the venting of undesired ODS, but the regulations do encourage refrigerant recovery, recycling, and destruction.

Hydrochlorofluorocarbons Phase-Out Management Plan (HPMP)

- India has established methods to achieve its ambitious goal of phase-out of hydrochlorofluorocarbons (HCFCs) by 2030 (MoEFCC 2017).
- HPMP Stage I: To ensure compliance with the 2013 and 2015 control objectives for HCFC consumption, the plan combines interventions such as technological conversions, laws and regulations, technical support, training, awareness, coordination and monitoring in specified HCFC-consuming industries.
- HPMP Stage II: In this stage, India is willing to move towards adoption of comparatively low-GWP refrigerants like HFC-32 and low-GWP natural refrigerants such as HC-290.
- HPMP highlighted that following GSPs to avoid leaks, recovery, and recycling at the workshop level will supplement the timely phase-out of HCFCs.
- As part of HPMP, three training programmes were used to teach 77 ITIs' instructors. Additionally, a pilot programme to promote refrigerant recovery and reclamation was also initiated (MoEFCC 2021).

India Cooling Action Plan (ICAP)

- ICAP aims to create an integrated vision for cooling across sectors that includes, among other things, lowering cooling demand, switching to new refrigerants, increasing energy efficiency and improving technological alternatives. The ICAP offers short-, medium-, and long-term suggestions for a variety of industries and establishes connections with several government programmes designed to provide everyone with sustainable cooling and thermal comfort. To organise the execution of these recommendations, a framework for implementation is also presented (MoEFCC 2019).
- ICAP focuses on the importance of recovery, recycling, and reuse of refrigerants as these are the key processes for refrigerant management and puts a spotlight on the high cost of recovery and recycling machines and the affordability of the servicing technicians.

E-waste (Management) Rules 2016

- The rules implemented the EPR scheme to manage and create a system for collecting, storing, transporting, and recycling waste electrical and electronic equipment (WEEE) in an environmentally responsible manner.
- The guidelines for implementation of these rules specifies that the authorised WEEE collection centres and storage facilities must handle the refrigerators and air-conditioners with additional care so as to prevent the leakage of refrigerants from them while loading, transportation, and unloading.
- The implementation guidelines suggest that WEEE dismantlers and refurbishers must have the adequate facilities and systems to manage the leakage of refrigerants. Additionally, the authorised dismantlers are recommended to deploy the skilled manpower having required tools and personal protective equipment to manually separate the compressors from cooling systems. The dismantlers are further advised to recover and store all the hazardous waste and compressor oils from the cooling systems.
- The guidelines also highlight the importance of recovery of resources from the WEEE but don't explicitly mention the recovery of refrigerant gases.

Vehicle Scrappage Policy 2021

- The Vehicle Scrappage Policy aims to create an eco-system for the environmentally beneficial and safe phasing out of unsuitable and polluting cars that have finished their lives (15-20 years) (MoRTH 2021).
- This policy proposes constructing registered vehicle scrapping facilities (VSFs) and automated testing stations for scrapping vehicles across the nation (MoRTH 2021).
- This is a voluntary process but vehicle owners might receive incentives in the form of rebate on road tax, scrappage value, waiver of registration fee, and discount from OEMs on purchase of new vehicle, which will motivate customers to scrap their old vehicles (MoRTH 2021).
- The *ODS Rules, 2000* applies to vehicle scrappage policy, and VSFs under this act are bound to recover hazardous wastes, including refrigerants, using suitable tools to ensure zero leakage and then dismantle the vehicles.
- Further, it states that materials must be sold to duly authorised recyclers who have adequate capability and license, if the vehicle scrappage facility lacks sufficient capability for safe treatment of hazardous waste beyond its scope.

> **The ODS Rules, 2000, applies to *Vehicle Scrappage Policy*, and VSFs under this act are bound to recover hazardous wastes, including refrigerants.**

Table 1 Refrigerant production expected to increase in India in the coming decades

	2017–18	2022–23	2027–28	2037–38
Annual refrigerant production (MT)	24,300	40,500–45,500	68,500–75,500	1,66,000–1,81,000

Source: ICAP, 2019

5.3 Refrigerant market in India

India has a very low adoption rate of air conditioning (merely 8 per cent) and refrigeration, and has the world's highest unmet cooling demand which is projected to increase six-fold by 2038 (MoEFCC 2019). The two most common refrigerant types now in use, HCFCs and HFCs, are subject to worldwide phase-out and phase-down, respectively. India has adopted the accelerated HCFC phase-out schedule and will phase out most of the HCFCs by 2030 (MoEFCC 2017). Along with 130 countries, India has also ratified the Kigali Amendment and is now required to phase down the production and consumption of HFCs (UNEP Ozone Secretariat 2016). India, which signed the Kigali Amendment as an Article 5 country, is obliged to follow HFC phase-down schedule for Article 5 countries and has to freeze HFC production and consumption in 2028 and phase down in a graduated manner to 15 per cent of the baseline in 2047.

The production of HFCs in India has significantly increased at a CAGR of 14 per cent in the last 18 years (MoEFCC 2019). In FY18, India produced around 24,300 MT of refrigerants domestically. By 2037–2038, that amount is expected to rise to between 1,66,000 and 1,81,000 MT (MoEFCC 2019), but demand is expected to decrease by 25–30 per cent, thanks to the ICAP 2019 and accelerated HCFC phase-out management plan. A significant role in achieving India's economic independence in the development and manufacture of fluorocarbons has been taken by refrigerant manufacturers. Additionally, the sector exports refrigerants to several other nations and directly or indirectly employs a sizeable population (MoEFCC 2019).

5.4 Refrigerant management efforts taken by India

India is one of the largest producers and users of synthetic refrigerants in the cooling sector. Recovery, recycling, reuse, and destruction of refrigerants are the key pillars of refrigerant management. Various developed and developing countries have voluntarily formulated legislation and mechanisms to deal with refrigerant emissions since the Montreal Protocol came into effect. Due to practical and techno-economic issues, these efforts were not promising. The MAC sector played a crucial role in implementing refrigerant management practices since it is mostly dealt with by the formal servicing sector worldwide. However, refrigerant management practices are yet to make an impact in India, although they are practiced in the MAC sector to an extent. Through its accelerated HCFC phase-out plan and ratification of the Kigali Amendment to the Montreal Protocol, India can achieve the phase-out of synthetic refrigerants like HCFCs and HFCs, in which recovery, recycling, reclamation, and disposal can play a major role.

The Ozone Cell of the Ministry of Environment, Forest & Climate Change (MoEFCC) started a National Halon Reclamation and Banking Facility in 2004 as part of the CFC phase-out regime's National CFC Consumption Phasing-out Plan (NCCoPP) (ICF 2008). The institution created a comprehensive database of the halon that major consumers have in the banks. Additionally, this facility offered equipment for the recovery and purification of halon.

NCCoPP created training infrastructure in 15 Indian states, including training cells. It sought to promote good servicing practices across some RAC servicing enterprises, with a specific emphasis on those firms that used over 50 kg of CFCs per year. In four stages, 955 recovery and recycling units were distributed to businesses. Equipment support was also offered to 120 Industrial Training Institutes (ITIs). The training of RAC-servicing technicians was the emphasis of the NCCoPP strategy. The participants/technicians were trained on how to handle alternative refrigerants, excellent service methods, and the recovery, recycling, reclamation, and reuse of CFCs. CFC requirements were significantly reduced as a result of training in good service techniques. These training programmes aided in the creation of a market for recovered and reclaimed refrigerants, and the refilling need for maintenance was met by CFC reclamation and reuse. Under NCCoPP, two ODS reclamation facilities were first built in Bengaluru and Chandigarh in India. With the use of MLF funds, the NCCoPP planned to put up 29 additional transportable reclamation units around the nation by 2009, expanding its coverage (ICF 2008).

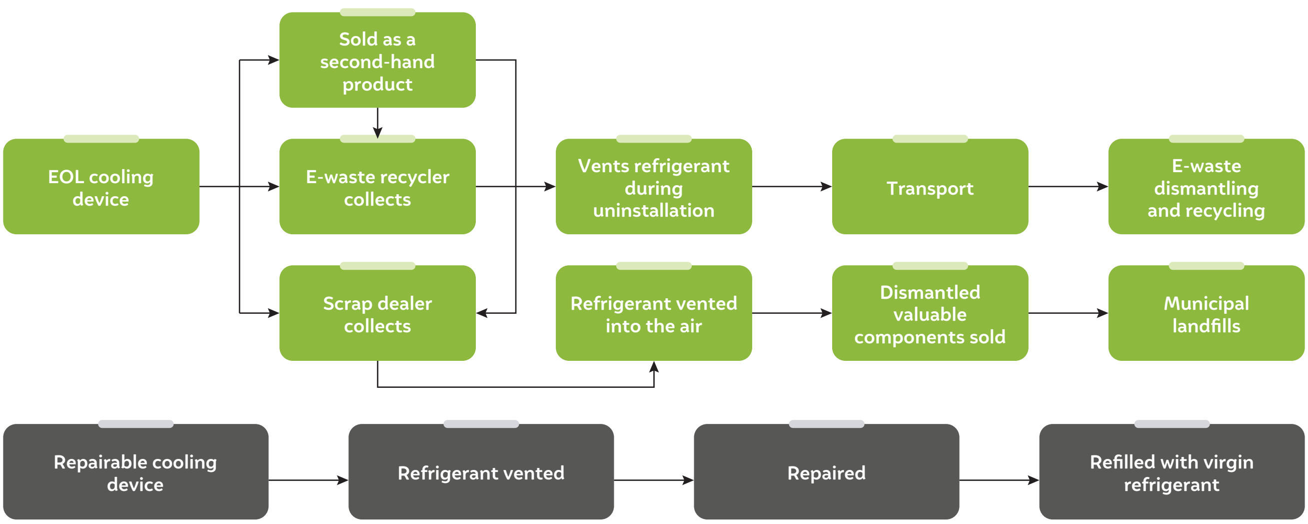
According to *ICAP 2019*, India opened 18 mini-reclamation centres, including 7 in the private sector (including Chandigarh, Gujarat, Maharashtra, Rajasthan, Uttar Pradesh and West Bengal) and 11 for institutional users (including the Indian Railways, Army, Air Force, and Navy). Mobile service units were started that collected CFCs and delivered them to facilities for reclamation (ICF 2008). The reclamation units were set up for 20 per cent of the total cost, with the MLF covering the remaining 80 per cent. While the cost of recovering and reclaiming CFCs was around USD 10.20/kg (INR 400/kg), the virgin refrigerant cost generally varied around USD 15.30/kg (INR 600/kg) (ICF 2008). Therefore, it was more cost effective to recover and reclaim CFCs than to use virgin CFCs for service. It is claimed that these small reclamation machines have the ability to treat a variety of refrigerants, including several HFC blends, HCFCs and CFCs (MoEFCC 2019). Additionally, through programmes financed by the MLF, India has taught GSPs to over 30,000 technicians, most of whom work in the unorganised sector. Through this initiative, some of the technicians were benefitted with recovery and recycling tools as well (MoEFCC 2019).

However, in practice, due to the lack of manufacturer initiative, incentive schemes, logistical difficulties, and the absence of directives or implementation mechanisms to promote a functional reverse-supply chain, these programmes were not very effective. Unless the recovery and recycling tools are subsidised, refrigerant management is neither affordable nor economically feasible for small workshops and servicing technicians. The lack of availability of qualified and trained technicians and their awareness about the impact of ODS and high-GWP gases on the ozone layer and atmosphere also plays an important factor for their readiness to recover and reuse the refrigerant. Godrej, one of the major equipment manufacturers, with the help of MLF and GIZ funding, voluntarily retrofitted the ODS-based cooling devices with the low-GWP refrigerants.

5.5 Refrigerant management in the residential cooling sector

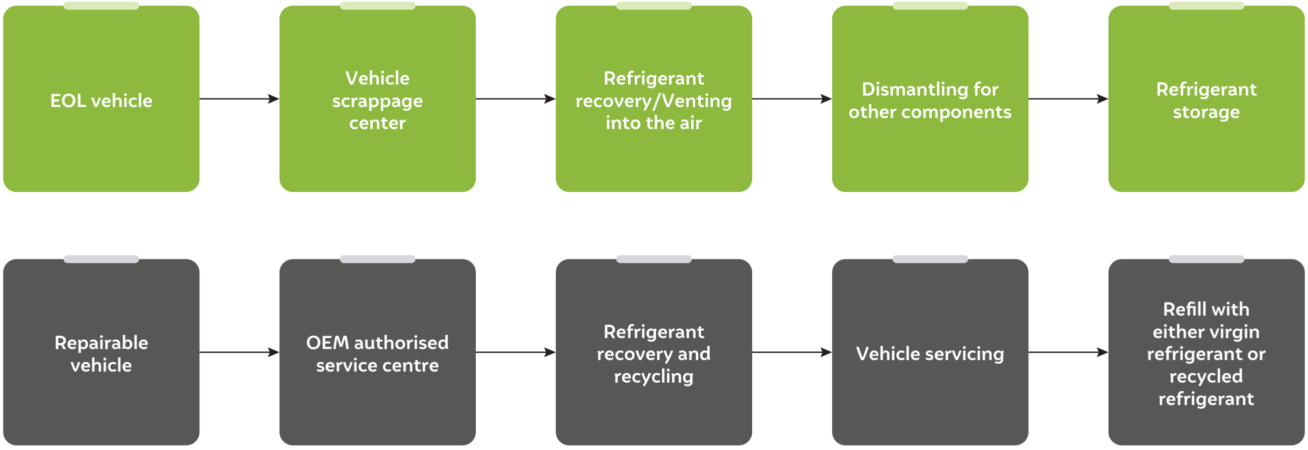
Only 22.7 per cent of the 10,14,961.21 tonnes of WEEE produced in India in 2019–20 was handled by the formal sector and treated in an environmentally sound manner (PIB 2022). In India, air conditioners and refrigerators are not often disposed of even after their economic lifecycle is over; they are still available on the market and resold as used appliances. Refrigerators used in homes and in commercial applications are thought to last for 10–15 years (Devotta, Asthana and Joshi 2004). Some percentage of ACs are collected from government and private institutions, but the refrigerant is vented out in the air by the unaware and unskilled technicians during the dismantling on-site, after which the ACs are taken to the formal WEEE facility for material recycling. Additionally, some decommissioned ACs and refrigerators are handled by unorganised WEEE handlers at municipal landfills. The usable and valuable parts, like the compressor, are removed by them and they are then either left in the landfills or handed to formal scrap recyclers in exchange for a little money. During this process, the refrigerants are vented out. Lack of awareness and high upfront cost of the recovery and recycling equipment leads to the venting of potent refrigerants during the time of servicing and the EOL. During servicing, after the system is repaired, it is charged using virgin refrigerant leading to the highest demand of refrigerants in the servicing sector in India.

Figure 3 Current landscape in India while treating EOL or operational cooling devices containing refrigerants



Source: Authors' analysis

Figure 4 Current landscape in India while treating EOL or operational motor vehicle containing refrigerants



Source: Authors' analysis

5.6 MAC sector and refrigerant management

The mobile air conditioner sector which is mostly handled by the organised sector has been successful in recovering the refrigerants during servicing and the EOL of the vehicle. Under the *Vehicle Scrappage Policy 2021*, the vehicle scrappage centres are mandated to recover the toxic gases such as refrigerants before dismantling the vehicle. Since most of the vehicles are serviced in authorised vehicle manufacturer serving premises, the cost of the recovery and recycling equipment is not a barrier for them and is being used to recycle the recovered refrigerants and reuse them. It is still unknown how much of the refrigerant is being recovered and reused by the sector though.

6. Barriers to sustainable refrigerant management in India

Although several programmes and facilities have been established in the past for the management of refrigerants, India still needs an appropriate ecosystem for the recovery, reclamation, or destruction of refrigerant gases. The recovery equipment, storage facility, and transportation costs nevertheless serve as a significant deterrent even in the presence of gas disposal facilities, necessitating the employment of incentives or regulatory requirements to ensure recovery (Bhasin et al. 2019). In order to address this substantial source of emissions, which is not controlled by the Montreal Protocol or mandated by any law in India, it is crucial to establish an efficient refrigerant bank management system. The proper management of refrigerants found in decommissioned devices in India is hampered by a number of obstacles, including those that are informational, financial, technical, logistical, and legal in nature.

6.1 Lack of strategy and infrastructure

It is necessary to have a strategy at the country level on how to deal with the emission of refrigerants during the operational stage and at their EOL for the various sectors where refrigerants are consumed, since it doesn't fall under the framework of the Montreal Protocol. A lack of infrastructure, business models and the absence of effective financing mechanisms comes as a disincentive to recover and subsequently, recycle, reclaim, or destruct the refrigerants at the EOL in India.

6.2 Lack of robust regulation with an enforcement mechanism

Even with the existing mandates in place for the management of WEEE, hazardous waste and decommissioned vehicles, a large chunk of decommissioned products are handled by the informal sector, due to which refrigerants are generally vented out into the atmosphere causing damage to the environment. The lack of legislation preventing refrigerant venting, monitoring and enforcement mechanism, and strict guidelines to handle the refrigerants from the decommissioned device by the WEEE and the EOL vehicle handlers is the restraint to support the refrigerant management.

> **The recovery equipment, storage facility, and transportation costs serve as a significant deterrent even in the presence of gas disposal facilities.**

6.3 Lack of information

Unawareness and lack of information dissemination among the consumers and servicing personnel about harmful environmental impacts stop the consumer from getting the periodical servicing of the cooling device done and safe handling of refrigerants by the servicing technician, respectively. The information asymmetry about the refrigerant recycling and reclamation facilities, and the associated incentives for them is lacking among the servicing technicians and servicing agencies. Information on the operations and whereabouts of the existing refrigerant reclamation facilities is very limited; and further there is lack of data on refrigerant collected, recycled, reclaimed, and disposed of.

6.4 High cost of refrigerant treatment infrastructure and destruction facility

The high cost of recovery and recycling machines, cost associated with the storage facility and the cost involved in the transportation of contaminated refrigerants to the reclamation or destruction facility are serious deterrents. This makes the procurement of recovery and recycling machines challenging for the low-earning servicing technicians which makes them vent out the refrigerant and use virgin refrigerant.

6.5 Enhanced training and certification of servicing technicians needed

The training and certification of personnel handling the equipment containing fluorocarbons during servicing and the EOL is a crucial dimension which needs consideration. The need for more training of servicing technicians for the recovery, recycling, and reclamation of refrigerants is one of the critical hurdles to ensure effective refrigerant management practices. Consumer and technician knowledge has to be increased so that they can properly dispose of the EOL devices and are aware of the effects venting refrigerants has on the environment.

> **Information on the operations and whereabouts of the existing refrigerant reclamation facilities is very limited.**

6.6 Lack of synergy in policies and their implementation

To comprehensively manage the refrigerants at their EOL and reduce emissions from across all the sectors, it is necessary to have synergies between policies for the sectors using refrigerants. Policies like *E-Waste (Management) Rules, Hazardous Waste Management Rules, Vehicle Scrappage Policy,* and *HPMP Stage I&II* lack linkages to deal with refrigerants in a holistic manner. The *MoEFCC* is the nodal agency for the implementation of the Montreal Protocol and its Kigali Amendment to phase out refrigerant gases with high GWP. The Central Pollution Control Board (CPCB) has notified the *E-Waste Rules* which are being implemented through the state authorities. E-waste also includes equipment used for refrigeration and air conditioning. The Ministry of Road Transport and Highways has notified the *Vehicle Scrappage Policy*, where refrigerants are also handled. There is also a guideline for training and certification of service technicians. For effective refrigerant management practices, there should be synergies in these policies and their implementation.

7. Conclusion

A developing country like India must look into refrigerant management in a comprehensive and innovative manner to formulate a national policy for refrigerant recovery, recycling, reclamation, reuse, and destruction considering the current international trends, including the successes and failures. In order for the refrigerant management ecosystem to succeed, the government and the private sector must move quickly to urge the industry to reduce emissions and maximise refrigerant reuse and its environmentally sound degradation. Participation of multiple stakeholders from upstream to downstream use of the refrigerant is required for the refrigerant management initiatives in India to be successful across the entire lifespan of the refrigerant. Initial attempts have already been made in India with regards to refrigerant management, but it needs to be looked into in a comprehensive manner to develop a pragmatic strategy across the different sectors to limit the emissions of highly potent refrigerants. The following measures are necessary for a developing country like India to address this issue:

7.1 Regulatory measures and enforcement mechanism

National law must be put in place that mandates the collection, reuse and safe destruction of refrigerant, bans refrigerant venting, and establishes appropriate processes for maintaining and recovering refrigerant at the EOL. It is crucial to implement complementary policy arrangements that address refrigerant collection from the servicing workshops and WEEE facilities when creating a policy framework to limit emissions from refrigerant banks. This law must be tailored as per the needs and challenges of each sector the refrigerants are being used in and must ensure the accountability of involved stakeholders.

An implementation agency must be in place to monitor and administer the use and management of refrigerants. The right training and certification of the relevant staff involved in monitoring and audit for the management of refrigerants is another crucial factor.

7.2 Fiscal measures

Innovative financial incentives and subsidies are critical for India since refrigerant management equipment is costly, especially given service dealers' modest refrigerant handling capacity. A financial structure for the administration of refrigerants, as well as destruction technologies, is required to ensure the long-term viability of reclamation and destruction activities.

End-user incentives are required, which can include consumer discounts, such as a GST reduction for purchasing new energy-efficient, low-GWP refrigerant equipment, or the option of obtaining a new unit in exchange for surrendering an old item. The purpose of these replacement programmes is to encourage energy-efficient and environmentally friendly technologies in order to reduce energy consumption and environmental effects from refrigerants and reducing strain on electric systems.

7.3 Capacity building

Certification and training is a potential step for ensuring that the service industry is appropriately qualified and that best containment practices are used throughout installation, maintenance, and repair. Integrating technician qualification into law is a crucial strategy to ensure proper refrigerant handling and emission reductions. Certification of servicing technicians must be connected to refrigerant purchases since it improves the service technician's credentials and thus increases refrigerant management; in other words, only those with certification may purchase refrigerants. In this context, it is critical to provide appropriate capacity-building and training facilities for service technicians, as well as low- or no-cost courses.

To sum up, various policy initiatives are necessary to build an effective lifecycle refrigerant management ecosystem in India. Regulations and enforcement, the establishment of technical standards and economic instruments to build a sustainable funding mechanism, such as EPR schemes, and capacity building and enhancing consumer awareness will support curbing refrigerant emissions from the refrigerant banks in India.

> **Integrating technician qualification into law is a crucial strategy to ensure proper refrigerant handling and emission reductions.**

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Acronyms

AC	air conditioning
AHRI	Air Conditioning, Heating, and Refrigeration Institute
ARF	advance recycling fees
BIS	Bureau of Indian Standards
CAC	commercial air conditioning
CFC	chlorofluorocarbon
CO_2	carbon dioxide
CO_2eq	carbon dioxide equivalent
CR	commercial refrigeration
EEE	electrical and electronic equipment
EOL	end-of-life
EPR	extended producer responsibility
EU	European Union
F-gas	fluorinated gas
GDP	gross domestic product
GHG	greenhouse gases
GIZ	Deutsche Gesellschaft fur Internationale Zusammenarbeit
GST	goods and service tax
GWP	global warming potential
HC	hydrocarbon
HCFC	hydrochlorofluorocarbon
HFC	hydrofluorocarbon
HPMP	Hydrochlorofluorocarbons Phase-out Management Plan
HVAC	heating, ventilation, and air conditioning
ICAP	India Cooling Action Plan
IEA	International Energy Agency
IPCC	Intergovernmental Panel on Climate Change
ITI	industrial training institutes
kWh	kilowatt hour
MAC	mobile air conditioning
MLF	multilateral fund
MT	metric tonnes
MoEFCC	Ministry of Environment, Forest and Climate Change
MoRTH	Ministry of Road Transport and Highways
NCCoPP	National Chlorofluorocarbon Consumption Phase-out Plan
OECD	Organisation for Economic Co-operation and Development
OEM	original equipment manufacturer
ODP	ozone-depletion potential
ODS	ozone-depleting substances
PIB	press information bureau
PRO	producer responsibility organisation
PSP	product stewardship program
R&D	research and development
RAC	residential air conditioning
RR	residential refrigeration
RTOC	Refrigeration, Air Conditioning and Heat Pumps Technical Options Committee
SEA	Sustainable Energy for All
TEAP	Technology and Energy Assessment Panel
TR	tonnes of refrigeration
UNDP Programme	United Nations Development
UNEP	United Nations Environment Programme
UNIDO	United Nations Industrial Development Organisation
UNTC	United Nations Treaty Collection
VSF	vehicle scrapping facilities
WEEE	waste from electrical or electronic equipment
WEF	World Economic Forum

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"Effective implementation of lifecycle refrigerant management requires a comprehensive approach. Our study emphasises the need for a collaborative and coordinated effort by policymakers, private industry, and consumers to ensure sustainable management of refrigerants throughout their lifecycle in India."

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Sonal is a Programme Lead in the Sustainable Cooling team at The Council. His work is focused around sustainable cooling wherein he supports implementation of the Kigali Amendment to the Montreal Protocol and ICAP.

"India has been successfully implementing its commitments under the Montreal Protocol and its subsequent amendments. Now it is the time to act beyond phasing out/down the use of refrigerant gases and undertake initiatives on lifecycle refrigerant management to minimise the environmental impact of these gases."

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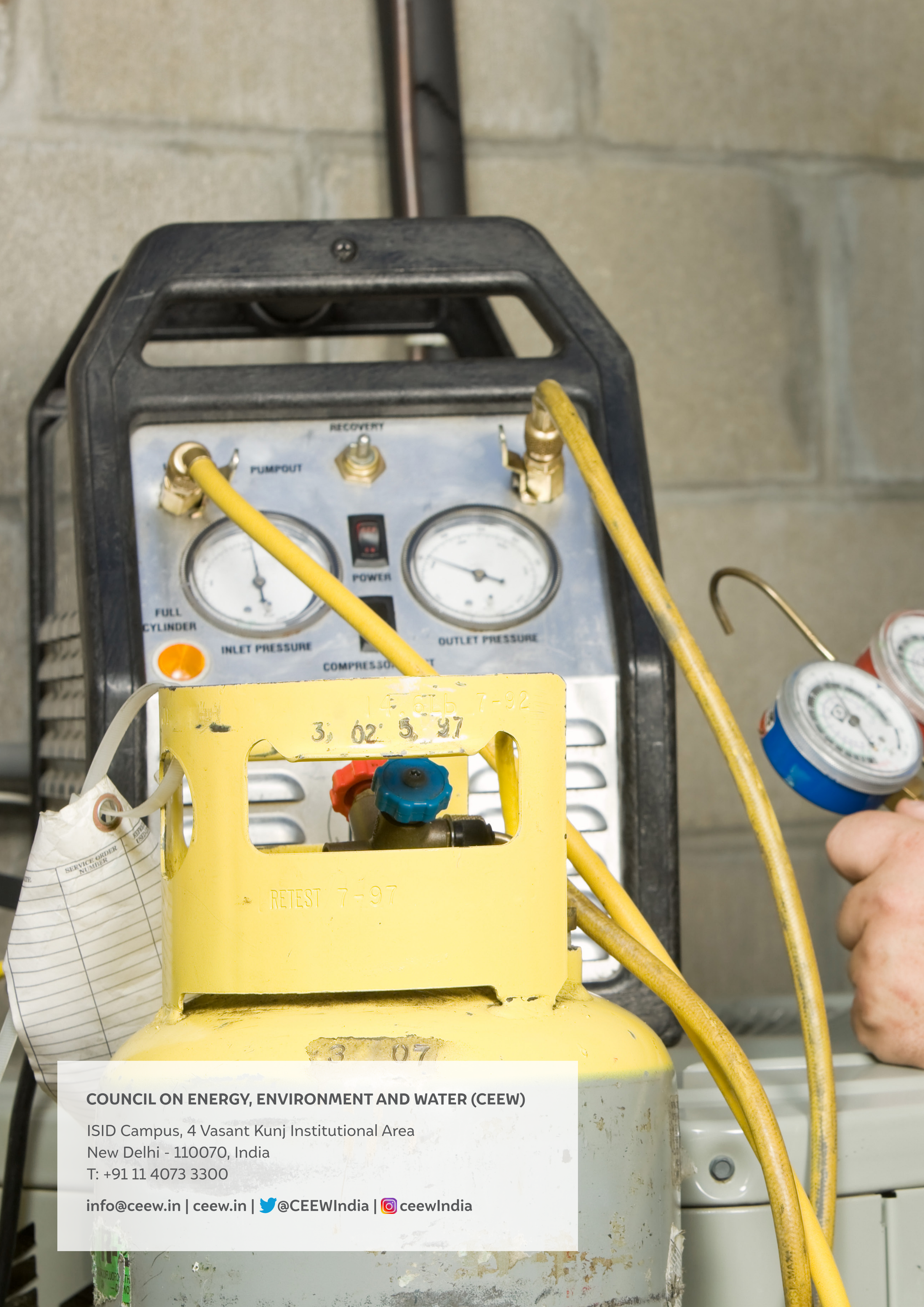
Shikha is a Researcher on climate change mitigation policies with a keen interest in innovation systems of low-carbon technologies. She is currently Adviser to the Sustainable Cooling team at The Council. She has previously worked on regulatory frameworks required to meet India's Kigali Amendment commitments, and the institutionalisation of an R&D platform for supporting the phase-out of HFCs in India. A co-author of ICAP, she continues to represent CEEW as a member of ICAP working groups to implement its R&D and servicing sector goals.

"Lifecycle refrigerant management is a critical tool in the fight against climate change, and India has a significant opportunity to lead the way. By implementing this, India can reduce its environmental footprint and promote a circular economy in the cooling sector. "



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