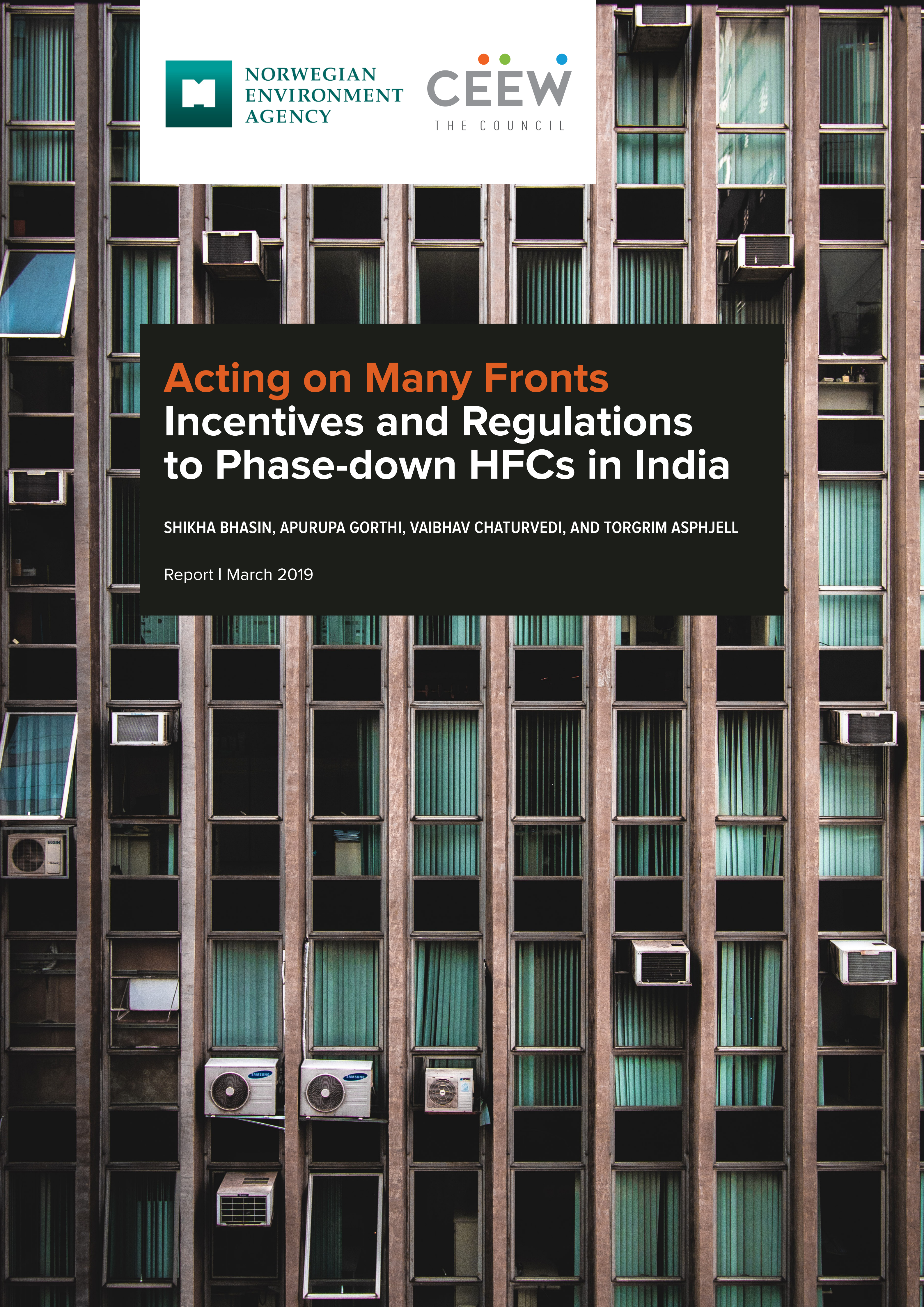

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Acting on Many Fronts
Incentives and Regulations to Phase-down HFCs in India

SHIKHA BHASIN, APURUPA GORTHI, VAIBHAV CHATURVEDI, AND TORGRIM ASPHJELL

Report I March 2019

Refrigerant-based cold chains are still largely underdeveloped in India. They have the potential to reduce post-harvest food losses and support India's goal of doubling farmer incomes.

Image: Jaun Rizvi

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Organisations:

Council on Energy, Environment and Water

The Council on Energy, Environment and Water is one of South 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 2019, CEEW has once again been featured across nine categories in the '2018 Global Go To Think Tank Index Report'. It has also been consistently ranked among the world's top climate change think tanks. Follow us on Twitter @CEEWIndia for the latest updates.

Norwegian Environment Agency

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. The NEA is professionally independent.

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About CEEW

The Council on Energy, Environment and Water (CEEW) is one of South 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. 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.

In 2019, CEEW once again featured extensively across nine categories in the '2018 Global Go To Think Tank Index Report', including being ranked as South Asia's top think tank (15th globally) with an annual operating budget of less than USD 5 million for the sixth year in a row. CEEW has also been ranked as South Asia's top energy and resource policy think tank in the latest rankings. In 2016, CEEW was ranked 2nd in India, 4th outside Europe and North America, and 20th globally out of 240 think tanks as per the ICCG Climate Think Tank's standardised rankings.

In over eight years of operations, The Council has engaged in over 210 research projects, published nearly 150 peer-reviewed books, policy reports and papers, advised governments around the world nearly 500 times, engaged with industry to encourage investments in clean technologies and improve efficiency in resource use, promoted bilateral and multilateral initiatives between governments on more than 60 occasions, helped state governments with water and irrigation reforms, and organised over 260 seminars and conferences.

The Council's major projects on energy policy include India's largest multidimensional energy access survey (ACCESS); the first independent assessment of India's solar mission; the Clean Energy Access Network (CLEAN) of hundreds of decentralised clean energy firms; India's green industrial policy; the USD 125 million India-U.S. Joint Clean Energy R&D Centers; developing the strategy for and supporting activities related to the International Solar Alliance; designing the Common Risk Mitigation Mechanism (CRMM); modelling long-term energy scenarios; energy subsidies reform; energy storage technologies; India's 2030 Renewable Energy Roadmap; energy efficiency measures for MSMEs; clean energy subsidies (for the Rio+20 Summit); clean energy innovations for rural economies; community energy; scaling up rooftop solar; and renewable energy jobs, finance and skills.

The Council's major projects on climate, environment and resource security include advising and contributing to climate negotiations (COP-24) in Katowice, especially on the formulating guidelines of the Paris Agreement rule-book; pathways for achieving INDCs and mid-century strategies for decarbonisation; assessing global climate risks; heat-health action plans for Indian cities; assessing India's adaptation gap; low-carbon rural development; environmental clearances; modelling HFC emissions; the business case for phasing down HFCs; assessing India's critical minerals; geoengineering governance; climate finance; nuclear power and low-carbon pathways; electric rail transport; monitoring air quality; the business case for energy efficiency and emissions reductions; India's first report on global governance, submitted to the National Security Adviser; foreign policy implications for resource security; India's power sector reforms; zero budget natural farming; resource nexus, and strategic industries and technologies; and the Maharashtra-Guangdong partnership on sustainability.

The Council's major projects on water governance and security include the 584-page National Water Resources Framework Study for India's 12th Five Year Plan; irrigation reform for Bihar; Swachh Bharat; supporting India's National Water Mission; collective action for water security; mapping India's traditional water bodies; modelling water-energy nexus; circular economy of water; participatory irrigation management in South Asia; domestic water conflicts; modelling decision making at the basin-level; rainwater harvesting; and multi-stakeholder initiatives for urban water management.

About NEA

The Norwegian Environment Agency (NEA) is a government agency under the Ministry of Climate and Environment, Government of Norway. The Norwegian Ministry of Climate and Environment has the main responsibility for ensuring integrated governmental climate and environmental policies. The NEA is dedicated to working for a clean and diverse environment. Through a merger between the Norwegian Directorate for Nature Management and the Norwegian Climate and Pollution Agency, the NEA was created in July, 2013.

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. The SNO preserves national environmental values and prevents environmental crime by means of inspections, monitoring, information, guidance, and operative management in important natural and cultural heritage areas.

NEA's primary tasks are to reduce greenhouse gas emissions, manage Norwegian nature, and prevent pollution. They implement and give advice on the development of climate and environmental policy. The NEA is professionally independent. This means that they act independently in the individual cases that they decide and when they communicate knowledge and information or give advice.

NEA's principal functions include collating and communicating environmental information, exercising regulatory authority, supervising and guiding regional and local government level, giving professional and technical advice, and participating in international environmental activities. The NEA exercises authority pursuant to the Pollution Control Act, Product Control Act and Nature Diversity Act under the Ministry of Climate and Environment.

Acknowledgments

The authors of this report would like to thank the Norwegian Ministry of Foreign Affairs and the Royal Norwegian Embassy in New Delhi for their financial support for this project. We are particularly grateful to Erlend Draget and Vivek Kumar from the Embassy for their continued support.

This research project was undertaken in partnership with the Norwegian Environment Agency (NEA), and we are extremely grateful to NEA, and in particular to Hilde Knapstad and Tor Skudal for their reviews, feedback, and research inputs. We are especially thankful to NEA for organising the study trip to Norway and Sweden, which exposed us to best-case practices for hydrofluorocarbon (HFC) phase-down. Our sincere thanks also go to the Swedish Environmental Protection Agency (SEPA) for hosting our study trip in Sweden. We are particularly grateful to all the experts and stakeholders who made time to speak with us and teach us about different aspects of the regulations in their countries; as well as to Satish Kumar, Kapil Singhal, and Lekha Sridhar for being a part of this study trip and contributing to our study report with their notes and feedback.

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We would also like to thank our reviewers for their comments and feedback that helped improve this report: Karan Mangotra (The Energy and Resources Institute) and Saikiran Kasamsetty (Alliance for an Energy Efficient Economy). We are indebted to the entire CEEW team for their constant support and feedback - particularly Dr Arunabha Ghosh for his guidance through the course of this research study; Kanika Chawla for her review of, and inputs to, the draft report; Adil Jamal (a former intern) and Deepa Janakiraman for helping with the Sankey diagram used in this report; and the Outreach team for their support in communicating and showcasing our research findings.

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Shikha Bhasin is a researcher on climate change mitigation policies who has a keen interest in innovation systems for low-carbon technologies. She is currently leading The Council's research on regulatory incentives and approaches required for phasing down HFCs and enabling cooling in India. She has previously worked on the institutionalisation of an R&D platform to support the phase-down of HFCs in India, and has served as a member of the National Cooling Action Plan's R&D Working Group.

"Over a hundred stakeholder meetings to understand technologies, challenges, and policies that will enable India's contributions to potentially avoid 0.5 degrees of warming - this was an exhilarating research opportunity! India is home to so many development aspirations, and if we can crack our cooling and HFC challenge, we can contribute to jobs, industrial growth, productivity, health, and sustainability."

APURUPA GORTHI
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Apurupa Gorthi is a Research Analyst at CEEW on the Technology, Finance, and Trade team. Her research interests broadly concern climate change mitigation policies and the food-water-energy nexus. Prior to joining the Council, Apurupa served as a research intern and project lead for the Food and Water Security team in the Think Tanks and Civil Societies Program at the University of Pennsylvania.

"Interacting with industry stakeholders on a daily basis for this project taught me about the ground realities of this industry and the many opportunities for growth here. This study is especially important as it addresses India's international commitments through the voices of the industry stakeholders. What is encouraging is that they care about the environment just as much as I do."

VAIBHAV CHATURVEDI
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Vaibhav Chaturvedi is a Research Fellow at CEEW, and leads The Council's research on Low-carbon Pathways. His research focuses on Indian and global energy and climate change mitigation policy issues within the integrated assessment modelling framework of the Global Change Assessment Model (GCAM). Vaibhav has been part of Government of India committees for advising on issues related to energy and climate policy. He actively publishes in, and reviews articles for, leading international energy and climate policy journals.

"The Kigali deal has been done, and India has demonstrated its leadership in structuring the deal. Active domestic engagements and progress is required now to ensure that India aligns the objectives of the Kigali deal with its developmental goals as well as with the multiple objectives of its national cooling action plan. Without thinking strategically about regulations and incentive policies, India might miss achieving this strategic alignment."

TORGRIM ASPHJELL
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Torgrim Asphjell is a Senior Adviser at the Department of Climate in the Norwegian Environment Agency. His key fields of work include fluorinated greenhouse gases, climate gas inventories, and development assistance. With over 10 years of work experience on fluorinated greenhouse gases, Torgrim has been instrumental in the implementation of the regulations for these gases in Norway. He has worked at the Norwegian Public Administration on climate change, air pollution and other environmental issues since 1992. While he is currently working with the NEA and the Pollution Control Authority in Norway, in the past, Torgrim has worked for the Ministry of Environment in Norway and also the Norwegian Agency for Development Cooperation. He has a Master of Science in Mechanical Engineering from the Technical University of Norway (NTH).

"India is set to be one of the biggest AC and cooling markets in the world and it is crucial to make this transition as sustainable as possible. Norway is pleased to give inputs to the very professional team at CEEW and we hope that the Norwegian experience can contribute to finding the right path for HFC phase-down in India."

Author contributions

Shikha Bhasin
Led the design and execution of this research project. She led the development of the methodological framework, data collection, analysis of the results and the project's outreach strategy. She was responsible for initiating and maintaining working relationships with the interviewees and experts in India and internationally, as well as for coordinating all outreach activities relating to this research.

Apurupa Gorthi
Provided research assistance and support for the entire research project through desk-based studies, database management, data collection, data analysis, stakeholder meetings, and research writing.

Vaibhav Chaturvedi
Conceptualised the project and was one of the original contributors to the proposal for this research project. He was responsible for high-level engagement with project funders, and overall project management. He oversaw the execution of the entire project, providing management and strategic guidance at every stage.

Torgrim Asphjell
Was an original contributor to the proposal for this research projecton behalf of NEA. He supported the development of the research strategy for this project, providing guidance and feedback. Torgrim also organised the study trip to learn and gather information on Norway's and the European Union's strategies for enabling an HFC phase-down.

Abbreviations

AC	air conditioning
AHRI	Air Conditioning, Heating and Refrigeration Institute
AHU	air handling unit
B2B	business-to-business
BEE	Bureau of Energy Efficiency
BIS	Bureau of Indian Standards
CAC	commercial air conditioning
CARB	California Air Resources Board
CFC	chlorofluorocarbons
CGT	Classical Grounded Theory
CO_2e	carbon dioxide equivalents
CR	commercial refrigeration
CSO	civil society organisations
EMAS	Eco-Management and Audit Scheme
EOL	end-of-life
EU	European Union
F-gas	fluorinated gas
FTE	full-time employment
GDP	gross domestic product
GHG	greenhouse gases
GIZ	Deutsche Gesellschaft fur Internationale Zusammenarbeit
Gt CO_2e /year	Gigatons of CO_2 equivalent per year
GWP	global warming potential
HC	hydrocarbons
HCFC	hydrochlorofluorocarbon
HFC	hydrofluorocarbon
HVAC	heating, ventilation, and air conditioning
HVAC&R	heating, ventilation, air conditioning, and refrigeration
IEA	International Energy Agency
IIT	Indian Institute of Technology
INR	Indian Rupee
IPCC	Intergovernmental Panel on Climate Change
ISHRAE	Indian Society for Heating, Refrigerating and Air Conditioning Engineers
IPUA	India Polyurethane Association
MAC	mobile air conditioning
MEA	Ministry of External Affairs
MLF	multilateral fund
MoEFCC	Ministry of Environment, Forest and Climate Change
MoU	memorandum of understanding
MRV	Measurement, Review, and Verification
MSME	micro, small, and medium enterprises
NCAP	National Cooling Action Plan
NEA	Norwegian Environment Agency
NGO	non-governmental organisation
NOK	Norwegian Krone
ODS	ozone-depleting substances
OEM	original equipment manufacturers
OPSGGM	ozone protection and synthetic greenhouse gas management
R&D	research and development
RAC	residential air conditioning
RAMA	Refrigeration and Air Conditioning Manufacturers Association
RASSS	Refrigeration and Air Conditioning Service Sector Society
R&R	recovery and recycling
SINTEF	Norwegian Foundation for Scientific and Industrial Research
SLCP	short-lived climate pollutants
SNAP	Significant Alternatives Policy Program
SRG	ReturGass Foundation (Norwegian HFC/CFC waste collection company)
TEAP	Technology and Energy Assessment Panel
TPES	total primary energy supply
TR	tonnes of refrigeration
TWh	terawatt hours
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
UNIDO	United Nations Industrial Development Organisation
USD	United States Dollar
VKE	Norwegian HVAC & refrigeration association

Image: iStock

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HFCs, commonly used as refrigerants, have a very high global warming potential. The Kigali Amendment to the Montreal Protocol established a global timeline to phase-down emissions resulting from their use.

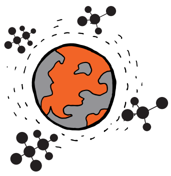
Image:Satish Kumar

Executive Summary

Limiting global warming upto a two-degree celsius temperature increase requires significant ambition and action. At the current rate, even if all global pledges made under the Paris Agreement are met, the world is set to warm by at least 2.7°C by the end of the century.[i] In this warming world, remaining safe, healthy, and productive has become even more challenging. Our rapidly urbanising population continues to find refuge in artificially cooled oases. This cooling, largely based on hydrofluorocarbons (HFCs), is an Achilles heel.

HFCs are far more potent than carbon dioxide as greenhouse gases. A transition away from these high-global warming potential (GWP) fluorinated gases holds the key to 0.5°C of global warming.[ii] In October 2016, 197 countries committed to the Montreal Protocol's Kigali Amendment, agreeing to lower consumption and production of HFCs with high global warming potential (GWP), in recognition of the role of HFCs in contributing to global warming.[iii]

The Government of India agreed to a timeline of curtailing national HFC emissions by 85 per cent by 2047, as part of the Kigali Amendment. India negotiated for an extended phase-down period, allowing it a window of opportunity to learn from global best practices, and to recalibrate domestic strategies and plans to successfully meet its international commitments while ensuring that gains on other domestic frontlines, such as industrial productivity, jobs and skilling, manufacturing capacity, technology improvements and R&D, energy efficiency, and others, are optimised.



In October 2016, 197 countries committed to the Montreal Protocol's Kigali Amendment, agreeing to lower consumption and production of HFCs with high global warming potential (GWP), in recognition of the role of HFCs in contributing to global warming

[i] Climate Action Tracker (2017) "Improvement in Warming Outlook as India and China Move Ahead, but Paris Agreement Gap Still Looms Large," Climate Action Tracker, November, available at https://climateactiontracker.org/publications/improvement-warming-outlook-india-and-china-move-ahead-paris-agreement-gap-still-looms-large/. accessed 12 January 2019.

[ii] Velders, Guus, David Fahey, John Daniel, Stephen Andersen, and Mack McFarland. (2017) "Climate Impacts of Montreal Protocol and Kigali Amendment," paper presented at the IO3C 30th anniversary MP Symposium, Paris, 28 March, available at http://www.montreal30.io3c.org/sites/montreal30.io3c.org/files/pictures/20%20matin/Velders_30MP_Symposium_Paris_Sept2017.pdf; accessed 12 January 2019.

[iii] India committed to reducing 85 per cent of its average production/consumption of HFCs compared to its baseline years (2024–2026). See Chapter 1 for more details.

The sectors that will lie at the heart of this refrigerant transition - residential air conditioning (RAC), mobile air conditioning (MAC), commercial air conditioning (CAC), and commercial refrigeration (CR) - are poised for significant growth that will add to India's GDP and job creation potential.[iv,v] Moreover, these sectors will also be central to India's development imperatives, including providing thermal comfort against heat stress to ensure well-being and productivity, minimising food losses through cold chain development, and enhancing energy savings as a result of efficient appliances and equipment.

In response to this international environmental and national development imperative, in 2018, the Government of India released a consultative draft of its National Cooling Action Plan (NCAP), the first country to do so.[vi] It also created and signed a memorandum of understanding (MoU) to enhance servicing technicians' training,[vii] as well as initiated efforts to update standards for some refrigerants that can be used as alternatives to HFCs.[viii,ix,x] The government has also recently announced a 'Global Cooling Prize' to encourage innovation for climate-friendly cooling.[xi] A snapshot of international and domestic policy drivers that are increasing the momentum towards climate-friendly cooling in India have been captured in the following page.

Continuing its efforts to research pathways to phase-down HFCs and transition to alternative refrigerants, CEEW signed an agreement with the Government of Norway in November 2017 to study incentives and regulatory approaches to enable the HFC phase-down in India.[xii] This research project, funded by the Government of Norway, has been undertaken in collaboration with the Norwegian Environment Agency (NEA). It intends to inform policymakers on the expected challenges and the role of regulations and policies in phasing down HFCs in sectors where these refrigerants are already in use, and where they could come into use in the near future.

Continuing its efforts to research pathways to phase-down HFCs and transition to alternative refrigerants, CEEW signed an agreement with the Government of Norway in November 2017 to study incentives and regulatory approaches to enable the HFC phase-down in India

It is widely accepted that the air conditioning and refrigeration sectors, as a whole, need to be overhauled to successfully transition away from HFCs. This will encompass changes and challenges for all parts of the supply chain, including: refrigerant and component manufacturers and suppliers; commercial users of these refrigerants and equipment; original equipment manufacturers (OEMs); research and testing labs; technology providers; standards authorities; educational and training institutions; operating, maintenance, and sales personnel.

[iv] Bhasin, Shikha, Lekha Sridhar, and Vaibhav Chaturvedi (2017) "Developing an Ecosystem to Phaseout HFCs in India: Establishing a Research and Development Platform," CEEW, September, available at https://www.ceew.in/publications/developing-ecosystem-phase-out-hfcs-india; accessed 12 January 2019.

[v] Chaturvedi, Vaibhav, Mohit Sharma, Shourjomoy Chattopadhyay, and Pallav Purohit (2015) "India's Long Term Hydrofluorcarbon Emissions," CEEW-IIASA Report, May, New Delhi.

[vi] Press Information Bureau (2018) "World Ozone Day 2018," Press Release, MoEFCC, Government of India, 17 September, available at http://pib.nic.in/newsite/PrintRelease.aspx?relid=183506; accessed 12 January 2019.

[vii] UNI (2018) "MSDE Inks MoU with Environment Ministry for Upskilling in AC Sector," United News of India, 2 August, available at http://www.uniindia.com/msde-inks-mou-with-environment-ministry-for-upskilling-in-ac-sector/business-economy/news/1307899.html; accessed 12 January 2019.

[viii] According to industry experts, BIS has created a panel to consider amendments to refrigerant standards for wider use of HC 290, a low-GWP, flammable refrigerant.

[ix] CSE (2016) "Safety Issues and Standards for HC-290 in Room Air Conditioners," Shakti Foundation, available at http://shaktifoundation.in/wp-content/uploads/2017/06/CSE-2016-Safety-issues-and-standards-for-HC-209-in-RAC.pdf; accessed 12 January 2019.

[x] According to industry experts, BIS has created a panel to consider amendments to refrigerant standards for wider use of HC 290, a low-GWP, flammable refrigerant.

[xi] For more information, please see https://globalcoolingprize.org/

[xii] Royal Norwegian Embassy. 2017. "Cool Alternatives." The Royal Norwegian Embassy in New Delhi, News and Events, December 4, 2017. available at https://www.norway.no/en/india/norway-india/news-and-events/new-delhi/news/cool-alternatives/; accessed 12 January 2019.

Increasing Momentum for Climate-friendly Cooling in India

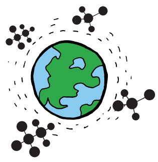
DETAILS INSIDE

1985

Vienna Convention. Established mechanisms for international cooperation **to address the Earth's ozone hole** caused by Ozone Depleting Substances (ODS).

1987

Montreal Protocol. Milestone global agreement to **tackle substances that deplete the ozone layer.**



1990

London Amendment. Montreal Protocol changed to mandate **complete phase out of CFCs and other ODSs** by 2000 in developed countries and by 2010 in developing countries.

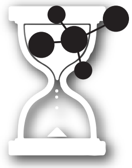
2002

Indian CFC manufacturers pledge to **phase out CFC production by 2010.**

2003

India ratifies Copenhagen Amendment (1992), Montreal Amendment (1997) and Beijing Amendment (1999).

CFC phase out initiated.



2004

National CFC Consumption Phase out Plan for **service technicians** launched.

2005

India achieves 50% reduction in CFC production and consumption.

2006

India's Country Programme to phase out ODSs updated.

Bureau of Energy Efficiency (BEE) launches the first voluntary star labelling programme for home appliances.

2007

Montreal Protocol. Accelerated phase out of HCFCs adopted for all countries.

BEE launches the Energy Conservation Building Code (ECBC).

2016

Kigali Amendment. Hydrofluorocarbons (HFCs) to be phased down globally.

R&D programme to develop alternatives to HFC refrigerants proposed by the Government of India.

Foam sector enterprises in India receive government support to transition from HCFCs to low GWP HFC cyclopentane.

BEE introduced an India-specific energy efficiency measure (Indian Seasonal Energy Efficiency Ratio (ISEER)).

2017

India's HPMP Phase II launched.

Energy Conservation Building Code updated to reduce building energy consumption.

2018

Draft National Cooling Action Plan released for public comments.

An MoU signed with Ministry of Skill Development and Entrepreneurship for **Recognition of Prior Learning scheme for service technicians.**

Global Cooling Prize launched to encourage climate-friendly cooling innovation.

Doubling of Farmers' Income by 2022 becomes a national agenda, encourages cold chain expansion.

Ministry of Power issues advisory to air conditioner manufacturing companies to limit minimum temperature of the units to 24°C for promoting energy efficiency.

2020-22

Baseline years for Article 5 (Group 1) Parties under the Kigali Amendment.

HCFC phase out complete in developed countries (2020).

Bharat Stage VI norms for vehicle to come into effect (2020).

2024-26

Baseline years for India (Group 2) under Kigali Amendment.

India to achieve 67.5% reduction in HCFC consumption and production (2025).

International treaties | Domestic policy drivers | Indirect domestic policy drivers

1991

Multilateral Fund (MLF). Established to **financially assist** Article 5 countries for ODS phase out.

India joins the Vienna Convention for the **Protection of the Ozone Layer.**

1992

Copenhagen Amendment. **Hydrochlorofluorocarbons (HCFC) included as ODS** to be phased out in 2030.

India signs the Montreal Protocol and ratifies the London Amendment.

India-Swiss-German collaboration (ECOFRIG) launched to **transfer ODS-free technologies** to refrigeration equipment manufacturers in India.

1993

India's Country Programme to phase out ODSs developed.

1997

Montreal Amendment. **Established HCFC phase out** in developing countries.

Kyoto Protocol. Adopted under the United Nations Framework Convention on Climate Change, to **control greenhouse gas emissions.**

1998

Indo-Swiss Human and Institutional Development in Ecological Refrigeration (HIDECOR) commences, aimed at encouraging **good servicing practices** for CFCs.

1999

Beijing Amendment. **Increased controls** on production and trade of HCFCs.

CFC freeze established for production and consumption under the Montreal Protocol.

2000

Ozone depleting substances (regulation and control) Rules 2000, enforced to **regulate production, consumption, export, import and trade.**

2008

ODS global consumption reduced by 98%.

India launches its Hydrochlorofluorocarbons Phaseout Management Plan (HPMP).

Ministry of Food Processing Industries initiates the **Scheme of Cold Chain, Value Addition and Preservation Infrastructure.**

2009-10

Universal Ratification. Montreal Protocol ratified by 196 countries (2009).

CFCs and Halons global production ends (2010).

India's baseline years for HCFC phase out.

BEE mandates star labelling for room air conditioners and frost-free refrigerators (2010).

2011-13

Baseline years for non-Article 5 Parties under the Kigali Amendment.

CFCs completely phased out (2012).

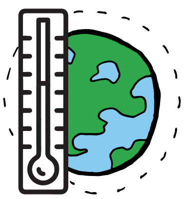
HCFC consumption and production frozen, as per the Montreal Protocol (2013).

2014

Make in India initiative launched to promote manufacturing.

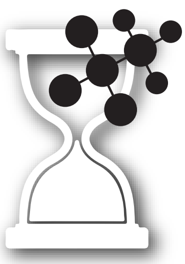
2015

Paris Agreement. Limiting global warming to 'well under 2°C' target accepted.



2028

Freeze HFC production and consumption in India.



Increasing Momentum for Climate-friendly Cooling in India

Source: CEEW compilation, 2019

Image: iStock

Accomplishing this transition, as a result, will depend on the collaboration and cooperation of many actors. It will require calibrated and coordinated efforts all along the supply chain. Multiple governing agencies will also need to be actively involved, including ministries responsible for industry and commerce, human resource development, agriculture, health, buildings, automobiles, heavy industry, power, consumers, as well as the Ozone Cell of the Ministry of Environment, Forest and Climate Change.

Each of these actors has their own rationale, and their own barriers preventing them from moving forward. This research study is based on an effort to understand their challenges, and prioritise actions to address the rationales of different stakeholder groups.

For this study, the authors focused on stakeholder groups within industry, the main protagonist in the execution of India's Kigali commitments. The research methodology included desk research, study trips to countries with policies to phase-down HFCs, and a series of interviews with private-sector stakeholders across the RAC, MAC, CAC, and CR supply chains, supplemented by consultations with experts from academia and government.

The information gathered from these studies and discussions has been used to understand policy preferences, the challenges in undertaking an HFC phase-down, and the larger elements of the entire ecosystem that must be made ready for India's successful transition away from HFCs. Moreover, this study addresses India's transition imperatives in achieving HFC phase-down commitments internationally, while enhancing its industrial and economic value to meet its growing aspirations for adequate cooling and a better quality of life.

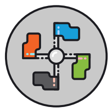
In an effort to bridge the research gap impeding India's policy discourse on phasing down HFCs, this report presents specific responses to the following research questions.

1. What policies and regulations do other countries use to phase-down emissions from HFC consumption and production?

2. Who are the different stakeholders in India (for example, HFC producers, equipment manufacturers, commercial building managers, service sector and waste collection personnel, etc.)?

3. What are the challenges for stakeholders, and what actions will they need to undertake, in order to move towards low-GWP refrigerant alternatives, and to reduce the operational and end-of-life emissions of high-GWP HFCs?

4. What policy incentives and regulatory approaches can propel the actions of different stakeholders towards an accelerated transition away from high-GWP HFCs?



Research findings arising from an attempt to answer these questions have been highlighted below. To this end, this report is an attempt at introducing policy choices that can support India's transition away from HFC gases. Key findings, on challenges and policy prescriptions, have been tabulated in the following spreadsheet ahead.

A. Learning from global regulations

Although the Kigali Amendment to the Montreal Protocol was formalised only in 2016, many countries have already established regulations, policies, and incentive structures to phase-down the use of high-GWP refrigerant gases. The authors undertook an extensive literature review to map out global regulations and policies affecting HFC consumption and resultant emissions. They supplemented this with a study trip to understand the regulatory framework of Norway and the European Union (EU), including policies and mandates spanning the supply chain, servicing standards and trainings, refrigerant technology references, leakage and operational management of equipment, as well as end-of-life disposal. Key lessons for India from global policies are listed below.

Lessons from global regulations and previous transitions:

- A successful transition will depend on policy coherence across a range of government agencies and multiple stakeholders.
- Industry is the key protagonist in undertaking the transition away from HFCs.

The critical role of industry and markets

- Firms remain the most significant stakeholders in implementing commitments made internationally to phase-down HFCs, and regulations should attempt to incentivise such actions.[xiii,xiv]
- Voluntary industry actions dissipate the need for imposing strong regulatory measures on industry.[xv, xvi, xvii]
- The purpose of regulations in this sector is to direct market behaviour, as evidenced in several studies.[xviii]

[xiii] Bergeson, Lynn L. (2017) "The Montreal Protocol Is Amended and Strengthened," Environmental Quality Management 26(3): 137–41.

[xiv] DeSombre, Elizabeth R. (2000) "The Experience of the Montreal Protocol: Particularly Remarkable, and Remarkably Particular," UCLA Journal of Environmental Law and Policy 19(1): 49–81.

[xv] Consumer Goods Forum (2018) "Refrigeration," available at https://www.theconsumergoodsforum.com/initiatives/environmental-sustainability/key-projects/refrigeration/; accessed 12 January 2019.

[xvi] Samuelson, Shiela (2010) "Voluntary Reporting of Carbon Emissions: How and Where?" Triple Pundit, available at https://www.triplepundit.com/2010/05/voluntary-reporting-carbon-emissions/; accessed 12 January 2019

[xvii] Schwarz, Winfried, Barbara Gschrey, Andre Leisewitz, Herold Anke, Sabine Gores, Irene Papst, Jurgen Usinger, et al. (2011) "Preparatory Study for a Review of Regulation," (EC) No 842/2006 on Certain Fluorinated Greenhouse Gases, European Environment Agency, available at https://www.eea.europa.eu/data-and-maps/indicators/emissions-and-consumption-of-fluorinated-2/preparatory-study-for-a-review; accessed 12 January 2019.

[xviii] Molina, Mario, Durwood Zaelkeb, K. Madhava Sarmac, Stephen O. Andersend, Veerabhadran Ramanathane, Donald Kaniaruf (2009) "Reducing Abrupt Climate Change Risk Using the Montreal Protocol and Other Regulatory Actions to Complement Cuts in CO2 Emissions," Proceedings of the Natural Academy of Science 106(49): 20616-20621.

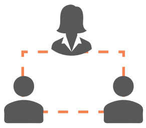
- Some of the key qualifiers for the success of the Montreal Protocol include: (1) having a broad international agreement mandating global markets to move in a particular direction, thereby opening up a large market for companies offering non-CFC refrigerant-based products; (2) domestic regulations imposed on ozone-depleting substances (ODSs), to incentivise the use of alternative refrigerants; and (3) ensuring the representation of companies and industry in policy and technical discussions, encouraging them to find alternative technological solutions.[xix, xx, xxi]

HFC phase-down is a multi-institutional regulatory challenge

- A successful transition requires tackling the HFC phase-down through a regulatory framework that is based on systematic stakeholder engagement.[xxii]

- Different regulations have been employed for phasing down HFCs across the world, addressing HFC refrigerant use in terms of the supply side, demand side, service sector, and/or end-of-life disposal.[xxiii, xxiv]

- For a smooth transition to alternative refrigerants, it is imperative to establish regulations for safety and technology standards, national phase-down targets, operational emissions, and end-of-life disposal policies.[xxv]



A successful HFC phase-down in India will need in-depth and broad-based stakeholder interactions between the government, scientific community, and industry

- The success of the Montreal Protocol is largely attributed to regulations working in tandem with the private sector.[xxvi] Drawing on this, a successful HFC phase-down in India will need in-depth and broad-based stakeholder interactions between the government, scientific community, and industry.

B. Key stakeholders for India's HFC phase-down

As highlighted above, the HFC phase-down in India will require the participation of various stakeholders, both within and outside the government.

Based on literature, existing networks, consultations with experts, and the snowballing method, an estimation was made of the broad base of institutions, sectors, and supply chains impacted by, or influencing, India's Kigali Amendment commitments. Specific to this study, we identified key stakeholder groups in India, as detailed in the table on the following page.

[xix] Oye, K. A, and Maxwell, J H. (1995) "Self-Interest And Environmental Management", in Local Commons and Global Interdependence: Heterogeneity and Cooperation in Two Domains 191,198 (Robert O. Keohane & Elinor Ostrom, eds., 1995)

[xx] Greene, Owen (1998) The System For Implementation Review In The Ozone Regime, In the Implementation and Effectiveness of International Environmental Theory and Practice 89, 97-8 (David G. Victor et. al., eds. 1998)

[xxi] Hoerner, J. A, (2000) "Taxing Pollution, In Ozone Protection in the United States, 39-54.

[xxii] UNEP. 2016. "OzonAction Factsheet: The Kigali Amendment to the Montreal Protocol: HFC Phase-Down." UNEP. http://wedocs.unep.org/bitstream/handle/20.500.11822/26589/HFC_Phase-down_EN.pdf?sequence=1&isAllowed=y; accessed 12 January 2019.

[xxiii] see for example Zaelke, Durwood, Nathan Borgford-Parnell, and Stephen O Andersen (2018) "Primer on HFCs," Institute for Governance and Sustainable Development, available at http://www.igsd.org/wp-content/uploads/2018/01/HFC-Primer-v11Jan18.pdf; accessed 12 January 2019.

[xxiv] Brack, Duncan (2017) "National Legislation on Hydrofluorocarbons," Institute for Governance & Sustainable Development, available at http://igsd.org/documents/NationalLegislationonHydrofluorocarbons_9.11.15.pdf; accessed 12 January 2019.

[xxv] Based on learnings from study trip and literature review. Refer to Annex I and Annex II of the main report for details.

[xxvi] DeSombre, Elizabeth R. (2000) "The Experience of the Montreal Protocol: Particularly Remarkable, and Remarkably Particular," UCLA Journal of Environmental Law and Policy 19(1): 49–81.

Stakeholders to enable India's HFC phase-down

Stakeholder group	Key stakeholder
Government	» Ministry of Environment, Forest and Climate Change » Ministry of Power » Ministry of Consumer Affairs, Food and Public Distribution » Ministry of Commerce and Industry » Ministry of Skill Development and Entrepreneurship » Department of Science and Technology » Ministry of Finance » Ministry of External Affairs
International Stakeholders	» Governing bodies of the Montreal Protocol, the Paris Agreement, and other international treaties » Development agencies » Subsidiary bodies of the Montreal Protocol » Multilateral funds and banks » Other countries' governments
Research and Educational Institutions	» Think tanks and research organisations » Universities and research labs » Technical and other expert consultants
Industry	» Associations » Manufacturers and suppliers of refrigerant gases » Manufacturers and suppliers of components » Consultants and service providers » Primary users of refrigerants » Commercial users of end products

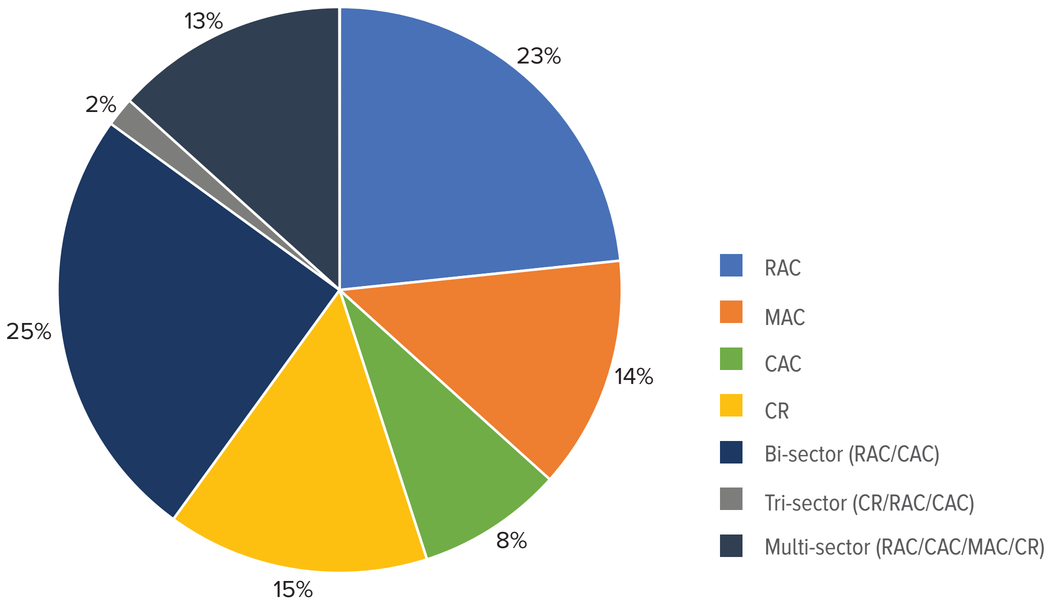
Source: CEEW compilation, 2019

C. Industry challenges and policy responses to propelling the phase-down of HFCs

Using the above mapping, industry stakeholders were identified across supply chain roles, and 60 mid- to senior-level respondents were interviewed for this study. These interviews were based on semi-structured questionnaires aimed at developing an understanding of industry's policy needs and regulatory preferences with regard to taking forward the challenge of transitioning away from HFCs in India.

The interviewees belonged to the RAC (23 per cent), MAC (14 per cent), CAC (8 per cent), and CR (15 per cent) sectors. Close to 40 per cent of the stakeholders were involved in two or more of these major sectors. In terms of supply chain roles, primary refrigerant consumers constituted the largest percentage of stakeholders, followed by component manufacturers/ suppliers, consultants and service providers, refrigerant manufacturers and suppliers, and commercial users of products. The authors also interviewed four industry associations representatives from the RAC, CAC, and CR sectors. The study also covers stakeholders from small, medium, and large enterprises, which are classified according to their annual turnover, representing 20 per cent, 27 per cent, and 46 per cent of the stakeholderbase, respectively. Associations were not classified in terms of enterprise size.

Sectoral mix of industry stakeholders interviewed



Source: CEEW compilation, 2019

Barriers to transition: policy uncertainty

In order to empirically understand and record the challenges and opportunities anticipated by stakeholders in enabling or undertaking HFC reductions, and the ways in which regulations or policy incentives could respond to them, we used qualitative data from interviews to construct a 'grounded theory'. Based on this qualitative analysis, we found that the largest drawback that unanimously came through in all interviews was the policy uncertainty, preventing companies from making adequate changes in preparation for phasing down HFCs in India.

The key reasons why this lack of policy certainty emerges so consistently as an impediment can be understood from the perspective of both supply chain readiness, as well as the investments that HFC phase-down would require.

Supply chain readiness

Alternative refrigerants' applicability

Stakeholders spoke of the need to know definitively which alternatives to high-GWP HFCs would be viable and available, before investing accordingly. While several natural and synthetic refrigerants have been identified and are being deployed globally as alternatives to HFCs, their application is contingent on several factors, including standards, charge limits, levels of energy consumption, safety aspects, as well as performance. For smaller players,[xxvii] these factors constrain future strategy and planning, especially given the lack of policy certainty around the phase-down in general, and the alternatives' standards and applicability in India. The lack of government-initiated pilot programmes to measure and test alternatives also contribute to this information gap.

[xxvii] Bergeson, Lynn L. (2017) "The Montreal Protocol Is Amended and Strengthened," Environmental Quality Management 26(3): 137–41.

Alternative refrigerants' affordability and availability

Sourcing affordable and adequately available alternative refrigerants is a huge anticipated challenge for industry. In India's previous refrigerant transition, the prices of refrigerants rose dramatically, and in smaller cities and towns there was a recorded shortage as well as price hike. This, in turn, led to the creation of an unorganised black market that sold the refrigerants, many of them uncertified blends, at an even higher price. The policy framework for any phase-down must include checks and balances, such that refrigerants are readily available in the market, and illegal market capture through imports and shortage-induced price manipulations are kept in check. Policy measures to consider while creating a regulatory framework to phase-down HFCs in India may include measures to monitor refrigerant availability by reporting national production; transparent and diligent testing of imports; minimising leakage during operations and at the end-of-life of the refrigerant; as well as indicating a 'maximum retail price' of various refrigerants.

Alternative refrigerants' standards and benchmarks

Several industry stakeholders have been working closely with the Bureau of Indian Standards (BIS) on reforming and updating standards for various low-GWP refrigerants; however, progress has been slow on multiple fronts in this regard. The lack of government-authenticated performance and safety benchmarks for alternatives discourages their uptake, and lowers investments towards R&D to optimise these refrigerants' applications in India. A fast-track window to develop or update different refrigerants' standards may be a way to indicate intent towards a low-GWP transition. More significantly, it may facilitate a fairer competition between various refrigerants in the market, rather than inadvertently picking winners based on a few established standards. India would also benefit by undertaking a life-cycle assessment of all alternatives coming into the market, given that several alternatives in use globally are being found to have negative environmental impacts.

The lack of government-authenticated performance and safety benchmarks for alternatives discourages their uptake and investments towards R&D to optimise these refrigerants' applications in India

Component availability and readiness

Some degree of change is required in components and system design for integrating any alternative refrigerant, even in the case of retrofitting replacement gases. In order to invest in such changes in systems and components, a clear timeline of how a phase-down will affect each sector (and thereby each company) is required, so that component manufacturers and suppliers can ready themselves. If this is not planned adequately as an opportunity for Indian industries to upgrade their supply chains, factories and companies will be forced to rely on imports and international suppliers, rather than encouraging innovation and investments among Indian component suppliers.

Service sector readiness

If the quality and safety of servicing practices are to remain intact, a minimum threshold for trainings has to be established by way of updated curricula, and more significantly, certifications for service technicians. Many countries prohibit non-licensed or non-certified service technicians from installing, servicing, or repairing air conditioners, or handling refrigerants. With such certifications, social welfare and

If the quality and safety of servicing practices are to remain intact, a minimum threshold for trainings has to be established security can also be enabled through targeted insurance and repeated trainings. Investments and a blueprint for undertaking such a formalisation of the service sector will be necessary to create an ecosystem in which several refrigerant gases can exist in the Indian market. Moreover, training and the fomalisation of the service sector need to be accompanied by a policy instrument that mandates leak tests (in large and mobile applications especially) and establishes standardised professional servicing practices. Good policy-directed practices that have already been brought out in India, such as the banning of disposable cylinders, also need to be implemented effectively.

End-of-life disposal

In India, there is no mandate to recover, reclaim, or destroy refrigerant gases effectively. Even where facilities exist for the disposal of gases, the recovery and transportation costs act as a huge disincentive, so there is often a need for incentives or regulations to ensure recovery. This part of the value chain in India remains severely constrained and inadequately understood. Convenient and functional infrastructure, accompanied by policy mandates, is crucial to ensure safe and effective end-of-life management of gases. For India to meet its HFC phase-down targets, end-of-life disposal of refrigerants is important, as is reducing emissions during the operational life cycle. Given the lack of infrastructure, policy, and business action in India on this front, there is a need to identify and understand different business cases for effective policy implementation to minimize operational and end-of-life emissions.

Investment decisions

Any policy to phase-down HFCs will affect significant parts of the value chain; the transition will require investments in, and upgrading of, industrial supply chains in the heating, ventilation, and air conditioning (HVAC) sectors. For any change that the manufacturing or adoption of an alternative refrigerant will require, a company will need to pay for associated costs. Investments will be directed towards safety on factory floors, infrastructure modulations, technology training, the cost of new manufacturing facilities, updating systems to adapt to the new refrigerant, and other verticals, in addition to the new cost of manufacturing or procuring the refrigerant itself. As highlighted above, even gases that can be substituted for HFCs through retrofitting will still require some degree of component change. There is a need for clear policy directives to guide the timing of such an investment, especially given the cost-competitive market that India already is. Moreover, a strategic policy framework can propel investments towards R&D and increased manufacturing in these sectors, and provide a fillip to key policy initiatives of the Government of India, such as Make in India and Doubling of Farmers' Income.

> Investments will be directed towards safety on factory floors, infrastructure modulations, technology training, the cost of new manufacturing facilities, updating systems to adapt to the new refrigerant, and other verticals, in addition to the new cost of manufacturing or procuring the refrigerant itself

Policy coordination and effective implementation

Given that refrigerant change will not occur in isolation, stakeholders across government agencies must cooperate to ease the transition, rather than imposing multiple mandates on industry. This will require policy cohesiveness between the Ozone Cell and other government agencies. A coordinated effort to meet India's HFC phase-down commitments can also benefit strategic industrial growth in cold chain development, enhanced energy efficient appliances, etc. Similarly, development and implementation of building norms, accompanied by the roll out of alternatives to HFCs for cooling needs, must be considered. Furthermore, misuse or non-compliance with guidelines and norms set by the government, sale of spurious or substandard components and gases, and the use of equipment that is in direct violation of regulations must be checked. Ineffectiveness in policy implementation is a huge challenge for India, and is not limited to this sector.[xxviii]

Consumer awareness

For the supply side to deliver effectively, demand must also be created and assured for this transition. To aide policy in this direction, it is important to identify the role of information and awareness on consumer behaviour. Suggestions from industry with regard to policy interventions on this front include labelling systems for products which indicate environmental performance or 'goodness'. This awareness must also be reflected in larger training interventions for retail suppliers and sales teams.

Given the challenges faced by industry in phasing down HFCs, their expressed policy preferences, and their proven potential for leadership in this endeavour, there is a clear need for a robust regulatory framework supporting industry in the transition away from HFCs. The next section of this study, therefore, highlights the stakeholders' perceived preferences for specific HFC phase-down regulations and policies and their expected impact, as applicable in the Indian context.

D. Regulatory options for phasing down HFCs in India

Five policy options employed to lower HFC consumption in different parts of the world were handpicked in consultation with senior India experts from civil society, industry, and the Government of India's Ozone Cell. These were then assessed based on stakeholders' responses to them during the interviews. Interviewees were requested to rank these policies, as well as to indicate their preferences and the anticipated impact across two Likert scales, ranging from least to most desirable, and least to most impactful, respectively.

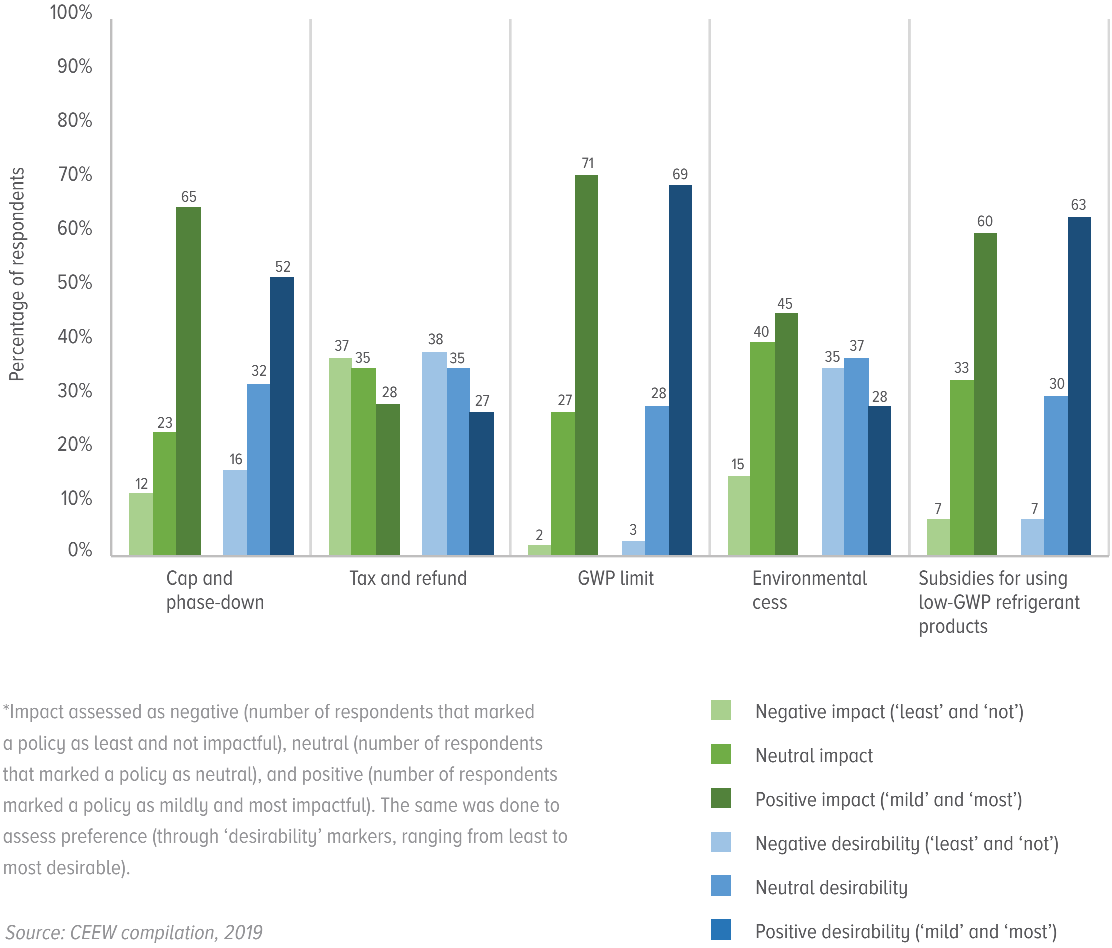
Responses on policy choices were evaluated at a macro-scale, following which data was reassessed to examine any trends emerging in policy choices based on sector (RAC, CAC, MAC, and CR) and enterprise size (small, medium, and large).

At the macro-level, a subsidy-based policy instrument emerged as the top policy choice, followed closely by the GWP limit policy instrument. This was based on a policy receiving the highest number of 'most impactful' and 'most desirable' ratings from stakeholders. The subsidy-based policy would be directed at users of refrigerants, so as to encourage demand creation for low-GWP alternatives to high-GWP HFCs; and the GWP limit policy suggested mandating medium-term targets on the maximum GWP value applicable on refrigerants in specific applications, based on current commercial viability.

On aggregating Likert scale values into negative ('not' and 'least') and positive ('mildly' and 'most') responses for policy preference and impact, we observed a slightly different trend. The GWP limit policy instrument emerged as the top choice in terms of preference and impact, followed by the subsidies-based policy instrument. Further, the GWP limit was ranked fifth (the lowest preference) by 18 per cent of the stakeholders, while 25 per cent of the stakeholders ranked the subsidies-based policy instrument, fifth. The third-highest ranked policy choice was cap and phase-down.

[xxviii] This is beyond the scope of the study at hand; hence, no policy recommendations are being indicated here.

Comparison between preference* and impact* of the policy options based on Likert scale evaluation



*Impact assessed as negative (number of respondents that marked a policy as least and not impactful), neutral (number of respondents that marked a policy as neutral), and positive (number of respondents marked a policy as mildly and most impactful). The same was done to assess preference (through 'desirability' markers, ranging from least to most desirable).

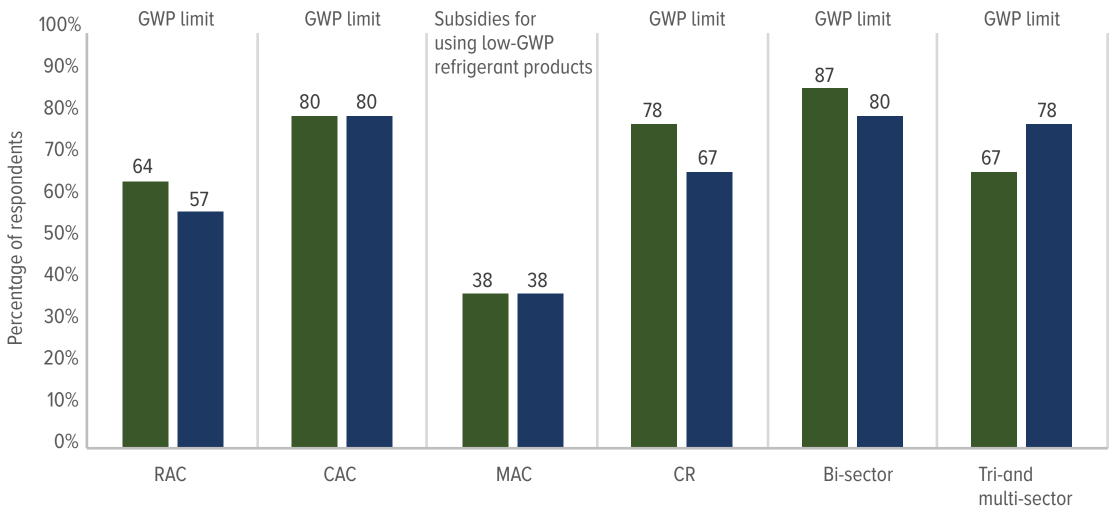
Source: CEEW compilation, 2019

Trends in policy choices based on sector and enterprise size

The top three policy choices at the macro-level, based on a sector-based classification (RAC, CAC, MAC, and CR) and on enterprise size (small, medium, and large) were: the GWP limit, subsidising low-GWP-based products, and the cap and phase-down approach.

In terms of positive impact and desirability, GWP limit was the top policy choice for all sectors, except MAC. 38 per cent of MAC sector stakeholders indicated subsidies for using low-GWP refrigerant products as their top policy choice, still, 25 per cent of MAC sector stakeholders also chose GWP limit.

Sectoral trends: **Top policy choices based on impact* and preference***

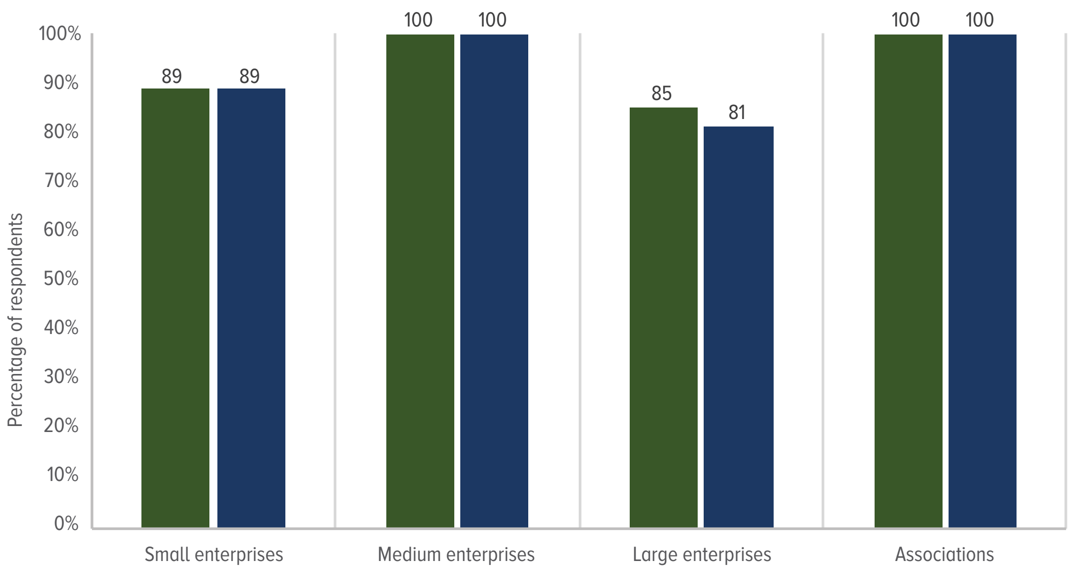


*Impact indicates the number of respondents which marked policies as'mildly impactful' and 'most impactful'; desirability indicates the number of respondents which marked policies as 'mildly desirable' and 'most desirable'.

Source: CEEW compilation, 2019

Medium-sized enterprises and associations unanimously selected GWP limit as the top policy choice in terms of preference and impact. Among large enterprises as well, the GWP limit emerged as the top policy choice in terms of impact and desirability. In terms of positive preference and impact, about 89% of small enterprises placed the GWP limit at the top.

GWP limit was the top policy choice across enterprises of different sizes based on impact* and preference*



*Impact indicates the number of respondents which marked policies as'mildly impactful' and 'most impactful'; desirability indicates the number of respondents which marked policies as 'mildly desirable' and 'most desirable'.

Source: CEEW compilation, 2019

Thus, based on the 60 stakeholder interviews, we find that the most popular and feasible policies according to industry were: (i) placing of GWP limits, (ii) subsidising low-GWP-based products, and (iii) the cap and phase-down approach. Among these, the GWP limit - based policy instrument emerged as the most popular, with a few deviations observed under specific conditions. At the macro-level, the aggregate positive responses for preference and impact were noticeably higher for the GWP limit option than for the subsidies-based policy instrument. Given that this policy choice was also validated as a key outcome of a closed-door industry roundtable that the research team hosted to share initial research results, the authors are able to conclude that a policy placing a medium-term GWP limit on refrigerant-based applications, based on current commercial viability, is the most preferred industry option for establishing India's HFC phase-down strategy.

E. Conclusion

India has a lot at stake in how industry in the RAC, MAC, CAC and CR sectors moves forward, from a domestic development perspective as well as from a global good, or environmental preservation, perspective. Despite the data that asserts the criticality of a timely and adequate transition to low-GWP refrigerants, research has yet to put forward the various policy elements that a regulatory framework in India must incorporate to achieve this end. This report is an attempt at bridging this research gap.

This report presents policy prescriptions based on the responses gathered from key stakeholders in Indian industry. The study empirically establishes that policy certainty is key to achieving India's international commitments to phasing down HFCs. This factor is most relevant for industry to initiate this transition, as it is crucial to enabling supply chain readiness and justifying the necessary investments.

Among the policies discussed with stakeholders to enable a refrigerant transition in India, the most preferred policy involved putting a medium-term limit on the GWP value of HFC refrigerant gases for each application, based on current commercial viability. A supplementary incentive for the end-user to promote low-GWP products would be an ideal policy package directed at discouraging high-GWP HFCs. Furthermore, checks and balances to implement these policies are critical to their success in India.

In addition to the above, ancillary policies to facilitate other refrigerant-management strategies should form an important part of India's phase-down strategy. These management practices could address servicing standards and the certification of service sector professionals as a way to limit operational leakages, as well as regulate the end-of-life recovery and disposal of refrigerants. There is an industry inclination towards the impending HFC transition, but the 'ecosystem' of the supply chain, policy directives towards end-of-life disposal, as well as service sector training and certifications, must be readied adequately for it to have an impact. This would also include institutionalising measurement, review, and verification (MRV) systems and agencies, in order to control stockpiling and the emergence of a second-tier black market, regulate the availability and pricing of refrigerants to avoid market manipulation, and bring out clear standards and safety mandates for all refrigerants to be able to compete in the Indian market.

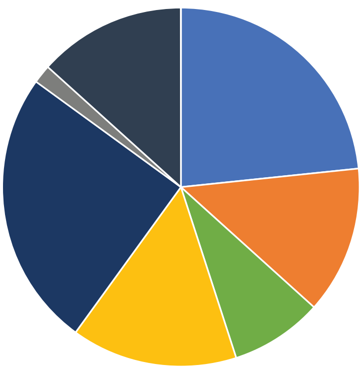
Finally, access to information regarding the refrigerant transition has to be systematically organised and widely diffused. This is important for consumers (to change purchasing behaviour and demand), for industry (to prepare itself for the impending refrigerant transition), and for service sector technicians (to ensure safety and maintenance).

Challenges and policy recommendations: Enabling India's transition to low-GWP refrigerants

Industry-group classification of survey respondents

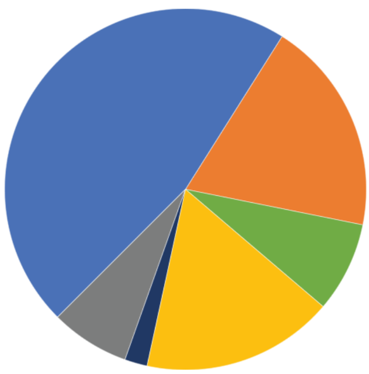
By sector

23%	RAC
14%	MAC
8%	CAC
15%	CR
25%	Bi-sector (RAC/CAC)
2%	Tri-sector (CR/RAC/CAC)
13%	Multi-sector (RAC/CAC/MAC/CR)



By supply chain role

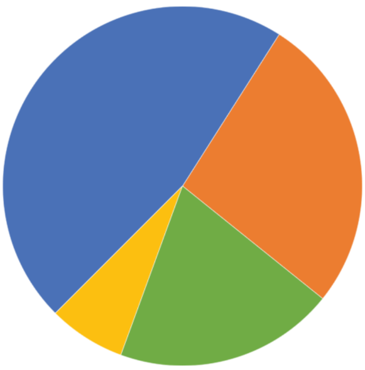
47%	Primary refrigerant consumers
19%	Component manufacturers/suppliers
8%	Refrigerant manufacturers/suppliers
17%	Consultants and service providers
2%	Commercial users of product
7%	Associations



Source: CEEW compilation, 2019

By size of enterprise

46% Large
27% Medium
20% Small
7% Associations



Policy recommendations
next page

Industry group	Challenge to transition
All	Investment justification and supply chain readiness
Small enterprises (across supply chain roles)	Alternative refrigerants' applicability
Refrigerant suppliers; primary users of refrigerants; commercial users of refrigerants	Alternative refrigerants' availability and affordability
All	Alternative refrigerants' standards and benchmarks
Component manufacturers and suppliers; commercial users of refrigerants; primary users of refrigerants; industry associations	Component availability and readiness
All	Service sector readiness
Primary and commercial users of refrigerants; service sector associations; other industry associations	End-of-life disposal
Medium enterprises (particularly: component manufacturers and suppliers; and primary users of refrigerants)	Investment in R&D
Refrigerant manufacturers; primary and commercial users of refrigerants	Investment in manufacturing
Large and medium enterprises (across supply chain)	Policy coordination
Primary users of refrigerants; service sector associations; refrigerant manufacturers and suppliers	Consumer awareness

Source: CEEW compilation, 2019

Policy recommendation	Key policy stakeholders
Medium-to long-term policy certainty to signal upcoming market reform to industry and regulators. **Imposing medium-term limits** on the permissible GWP value as per India's phase-down timeline, based on current commercial viability for refrigerants specific to every application.	Ozone Cell, MoEFCC
Publish government authenticated list of refrigerant alternatives and their application benchmarks specifically for India. **Increase pilot programme** to test and adjudge alternative refrigerants' applicability and usability in India. **Increase public procurement** of equipment using alternative refrigerants, especially those with energy efficiency gains.	Ozone Cell, MoEFCC; Department of Science and Technology; Ministry of Commerce and Industry; Ministry of Power
Indicate a medium-to long-term policy for refrigerant manufacturers and suppliers to ensure availability. **Create checks and balances** in the refrigerant market to ensure availability and affordability: • Institutionalise production and consumption reporting. • Establish a maximum pricing cap on refrigerants. • Effectively check stockpiling and illegal imports through stricter reporting and custom controls. • Ensure the quality of refrigerants through increased testing facilities.	Ministry of Finance; Ozone Cell, MoEFCC; Ministry of Commerce and Industry
Develop a fast-track window to update and develop standards for alternatives to high-GWP refrigerants. **Create government authorised benchmarks** for referencing these technologies usage.	Ministry of Consumer Affairs, Food & Public Distribution; Ozone Cell, MoEFCC; Department of Science and Technology
Indicate a medium-to long-term policy for component manufacturers and suppliers to ensure availability of components. **Public procurement programmes** can support development of know-how within component manufacturers and suppliers on reforms in value chain for low-GWP end-products.	Ozone Cell, MoEFCC; Ministry of Commerce and Industry
Large-scale trainings and certification schemes for service sector technicians. **Mandate good-servicing practices** to be employed across sectors. **Update curricula for trainings, and trainings of trainers,** to include low-GWP alternative refrigerants. **Create a labelling system** to help easily recognise the type of refrigerant in an equipment/ product.	Ozone Cell, MoEFCC; Electronics Sector Skill Council of India, Ministry of Skill Development and Entrepreneurship; Ministry of Commerce and Industry; Ministry of Human Resource Development
Establish infrastructure and a mandate to enable safe disposal of refrigerants.	Ministry of Power; Ozone Cell, MoEFCC
Institutionalise the collaborative R&D programme announced by Government in September 2016 to encourage innovations to support this transition. **Medium- to long-term policy certainty** on HFC phase-down plan for India.	Ozone Cell, MoEFCC; Department of Science and Technology; Prime Minister's Office
Recognise cooling sectors as strategic within industry-focussed programmes such as Make in India. **Assess the potential of import tariffs** on refrigerants and components that are being/have potential to be manufactured in India. **Establish mandates for certified quality and standards** on components to discourage their imports.	Ministry of Commerce and Industry; Ministry of Finance; Ozone Cell, MoEFCC; Ministry of Consumer Affairs, Food & Public Distribution
Minimise competing policy mandates on the sectors in a systematic manner. This would include issuing technological guidelines or mandates to ensure: • Energy efficiency enhancements are aligned with the impending refrigerant transition. • Building norms reflect the need for climate-friendly cooling or space comfort. • Cold chain development takes into account the impending refrigerant transition.	Ministry of Power; Ministry of Consumer Affairs, Food and Public Distribution; Ministry of Commerce and Industry; Ministry of Housing and Urban Affairs; Ministry of Food Processing Industry; Ozone Cell, MoEFCC
Demand-creating consumer awareness programmes for low-GWP products. **Labelling programme to suggest environment-friendliness** of appliances in addition to energy efficiency.	Ministry of Consumer Affairs, Food and Public Distribution; Ozone Cell, MoEFCC

With increasing incomes and heat-stress, India’s cooling needs are expected to rise over eight fold.

Image: iStock

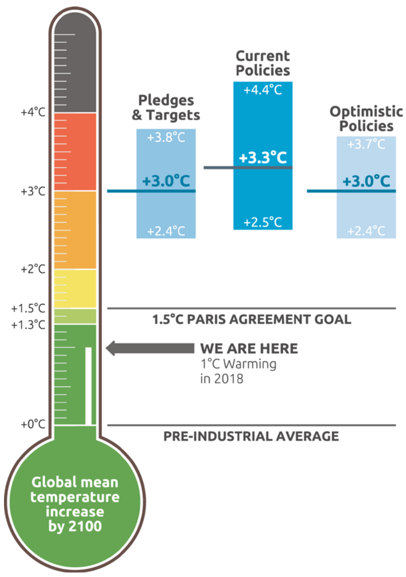
1. Cooling in a Warming World

In 2018, the Intergovernmental Panel on Climate Change (IPCC) published a seminal study substantiating the urgency, and the limited time span of 12 years within which greenhouse gas (GHG) emissions must be lowered, if global warming is to be limited to 1.5°C.[1] As we continue to identify and grapple with the threats of global warming, the reality of realising commitments and increasing ambitions continues to be reiterated in diplomatic circles reflective of non-governmental actions and sentiment. India, one of the largest and fastest growing economies globally, has committed to meet goals enshrined in the Paris Agreement to limit global warming to up to two degrees. However, achieving this limit will require significant action, from India and the world. At the current rate, even if all global pledges made under the Paris Agreement are met, the world is set to warm by at least 2.4°C by the end of the century.[2]

In this increasingly warming world, the challenge of keeping global populations safe, healthy, and productive has become even more pronounced. Our rapidly urbanising population continues to find refuge in artificially cooled and heated oasis. According to the International Energy Agency (IEA), the global air conditioning market will grow by 244 per cent (in number of AC units) and will be valued at USD 400 billion by 2050.[3] This cooling, largely based on refrigerants called hydrofluorocarbons (HFCs), is an Achilles heel.

HFCs provide relief from climate change effects, yet themselves have a high global warming potential (GWP). HFCs are far more potent than carbon dioxide as greenhouse gases, and a transition away from these high-GWP gases holds the key to 0.5°C of global warming.[4] Technological solutions that can replace these refrigerants are a plenty, but decisions to curb their growth and phase-down their consumption remain rife with commercial risks for industry and investors, especially where policy remains uncertain.

Figure 1: Expected Global Warming Based on Current Pledges and Policies



Source: Climate Action Tracker, 2018

[1] IPCC (2018)
[2] Climate Action Tracker (2017)
[3] IEA (2018)
[4] Velders et al. (2017)

1.1 India's transition imperative

The Government of India, in recognition of HFCs' role in amplifying global warming, agreed to curtail HFC emissions, as part of the Kigali Amendment to the Montreal Protocol.[5] India invoked its global leadership and negotiated for a longer timeline for itself, as part of a distinct track of countries, to phase-down emissions arising from HFC production and consumption (see Table 1 below). This timeline was markedly different from that of other country groupings, keeping in mind the technological and financial burden that such a transition would place on its development agenda.

This extended phase-down period allows India to recalibrate strategies and plans to successfully meet its international commitments, while ensuring that gains on other domestic frontlines, such as industrial productivity, jobs and skilling, manufacturing capacity, technology improvements and R&D, and energy efficiency, are optimised.

Decisions to replace or phase-down HFCs remain rife with commercial risks, especially where policy remains uncertain

Table 1: Phase-down commitments under the Kigali Amendment to the Montreal Protocol

	Non-Article 5 Parties*: (Main Group)	**Non-Article 5 Parties:** Belarus, the Russian Federation, Kazakhstan, Tajikistan, and Uzbekistan	**Article 5 Parties*:** Group 1	**Article 5 Parties:** Group 2 (India, Bahrain, Iran, Iraq, Kuwait, Oman, Pakistan, Qatar, Saudi Arabia, and the United Arab Emirates)
Baseline years	» 2011, 2012, 2013	» 2011, 2012, 2013	» 2020, 2021, 2022	» 2024, 2025, 2026
Baseline Calculation	Average production/ consumption of HFCs in baseline years, plus 15% of hydrochlorofluorocarbon (HCFC) baseline production/consumption	Average production/ consumption of HFCs in baseline years, plus 25% of HCFC baseline production/consumption	Average production/ consumption of HFCs in baseline years, plus 65% of HCFC baseline production/consumption	Average production/ consumption of HFCs in baseline years, plus 65% of HCFC baseline production/consumption
Reduction Step 1	2019: 10%	2020: 5%	Freeze: 2024	Freeze: 2028
Reduction Step 2	2024: 40%	2025: 35%	2029: 10%	2032: 10%
Reduction Step 3	2029: 70%	2029: 70%	2035: 30%	2037: 20%
Reduction Step 4	2034: 80%	2034: 80%	2040: 50%	2042: 30%
Reduction Step 5	2036: 85%	2036: 85%	2045: 80%	2047: 85%

Source: Based on OzonAction (2016) . 'Article 5 Parties' under the Montreal Protocol are comprised largely of developing and least-developed countries, while 'Non–Article 5 Parties' include developed and early industrialised countries.*

[5] This is calculated as 85 per cent of the average production/consumption of HFCs in baseline years, plus 25 per cent of HCFC baseline production/consumption (average for the years 2024–2026). See Table 1.

That the sectors most likely to be affected by HFC phase-down strategies - heating, ventilation, and air conditioning (HVAC) will also be critical to India's development story at large, makes them even more strategic.

- **Sector valuation, and growth in the service sector:** As of 2016, India's air conditioning market (including residential, mobile, and commercial air conditioning applications) was estimated at USD 3 billion.[6] Room air conditioners (RAC) alone constitute 56 per cent of this, despite a current penetration rate of seven to nine per cent.[7] By 2038, India's cooling needs - the demand for refrigeration and air conditioning in residential, mobile, and commercial settings - are projected to increase approximately eight-fold, relative to a current demand of 125 million tonnes of refrigeration (TR).[8] Further, by 2038, the combined demand for air conditioning in residential and commercial applications is expected to see the most growth, at 11 times its current demand.[9] In the mobile air conditioning (MAC) sector, cars in India are expected to increase from 10 million units in 2010 to approximately 80 million units by 2030.[10] The stock of buses, estimated at a little over 50 million units in 2015, is expected to increase by two and a half times by 2050.[11] The refrigerant allocation for this projected demand is proportionately large, and will require a corresponding increase in the number of air conditioning service technicians as well. The current number of jobs in the airconditioning service sector is estimated to be 200,000, and is expected to increase to 2,000,000 by 2030.[12]

- **Economic and productivity losses:** Globally, heat stress is expected to cause losses in productivity equivalent to 72 million full-time jobs by 2030.[13] Heat stress-related economic losses will also affect the global economy, with Kjellstrom et al. (2016) estimating a two per cent decline in gross domestic product (GDP) by 2050, and Mensbrugghe and Roson (2010) estimating more than six per cent decrease in GDP by 2100. By 2030, India is also expected to experience a productivity loss equivalent to 30.8 million full-time jobs as a direct consequence of heat stress.[14] An earlier study estimated that this extent of productivity loss would occur by 2055.[15] As of today, ACs and refrigeration technologies will continue to provide thermal comfort and relief from heat stress.

The ILO estimates that India is expected to experience a productivity loss equivalent to 30.8 million full-time jobs as a direct consequence of heat stress by 2030

- **Health impacts:** Kjellstrom et al. (2016) state that India is among the countries most vulnerable to losses due to climate change.[16] A study on 12 urban areas across various countries, including India, found a 3.94 per cent rise in mortality risk for every degree of temperature increase above 29°C.[17] Hajat et al. (2005) further found that, in Delhi, children up to 14 years of age were at greater risk than adults and the elderly. They also found that heat stress-induced deaths occurred amongst the general population, not amongst individuals who were already near death. Moreover, a recent study states that while cooling

[6] ISHRAE (2015)
[7] Ibid.
[8] Draft NCAP, Ozone Cell (2018)
[9] Ibid.
[10] Chaturvedi et al. (2015)
[11] Ibid.
[12] As per the draft NCAP, Ozone Cell (2018), these will be seasonal jobs and should not be equated with full-time employment (FTE).
[13] ILO (2018)
[14] Ibid.
[15] Kjellstrom et al. (2016)
[16] Ibid.
[17] McMichael et al. (2008)

requirements will rise due to a projected increase in heat waves, there will be a trade-off if the cooling equipment is powered by fossil fuels.[18] The consequences of the resultant increase in pollution will lead to increased premature deaths.[19]

- **Energy demand for cooling:** The global energy usage for cooling in 2018 was estimated at 3,900 terawatt hours (TWh). With an aggressive energy-mitigation strategy, this is expected to increase by 90 percent by 2050 (to 7500 TWh), and without aggressive energy efficiency improvements, it is projected to increase by over 250 percent (to 9,500 TWh).[20] India alone will play a critical part in such energy utilisation. The IEA estimates that for India, the energy required for space cooling (comprised of air conditioning applications for residential and commercial buildings), as a share of peak electricity load, will increase from its current 10 percent to 45 percent by 2050.[21] According to recent government estimates for India, the total primary energy supply (TPES) for cooling is expected to grow to 4.5 times its current value by 2038.[22,23] As reported in previous CEEW studies[24], already 40 to 60 per cent of Delhi's peak load electricity demand stems from the use of air conditioners.[25]

1.2 Policy and research requisites

In response to this international environmental and national development imperative, in 2018, the Government of India released a draft of its National Cooling Action Plan (NCAP) for consultation, making it the first country to do so.[26] It also signed a memorandum of understanding (MoU) to enhance service technicians' training,[27] as well as updated standards for some refrigerants that can be used as alternatives to HFCs.[28,29,30] The government has also recently announced a 'Global Cooling Prize' to encourage innovation for climate-friendly cooling.[31] A snapshot of international and domestic policy drivers that are increasing the momentum towards climate-friendly cooling in India is presented in the following page.

[18] Abel et al. (2018)

[19] Ibid.

[20] Peters (n.d.)

[21] IEA (2018)

[22] Draft NCAP, Ozone Cell (2018)

[23] TPES is an aggregate of primary energy sources like coal, oil, gas, nuclear, hydro, solar, wind, and other renewables. Currently India's TPES is estimated at approximately 60 million tonnes of oil equivalent.

[24] Bhasin, Sridhar, and Chaturvedi (2017)

[25] Lawrence Berkeley National Laboratory (2015)

[26] Press Information Bureau (2018)

[27] UNI (2018)

[28] According to industry experts, standards for ammonia refrigeration have been authored by the Association for Ammonia Refrigeration (AAR) and submitted to the Bureau for Indian Standards (BIS) for final approval.

[29] CSE (2016)

[30] According to industry experts, the BIS has created a panel to consider amendments to refrigerant standards for wider use of HC 290, a low global warming potential (GWP) flammable refrigerant.

[31] For more information, please see https://globalcoolingprize.org/

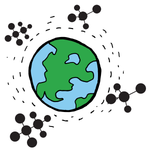
Figure 2: Increasing Momentum for Climate-friendly Cooling in India

Turn over for details

Image: iStock

1985
Vienna Convention. Established mechanisms for international cooperation **to address the Earth's ozone hole** caused by Ozone Depleting Substances (ODS).

1987
Montreal Protocol. Milestone global agreement to **tackle substances that deplete the ozone layer.**



1990
London Amendment. Montreal Protocol changed to mandate **complete phase out of CFCs and other ODSs** by 2000 in developed countries and by 2010 in developing countries.

2002
Indian CFC manufacturers pledge to **phase out CFC production by 2010.**

2003
India ratifies Copenhagen Amendment (1992), Montreal Amendment (1997) and Beijing Amendment (1999).
CFC phase out initiated.

2004
National CFC Consumption Phase out Plan for **service technicians** launched.

2005
India achieves 50% reduction in CFC production and consumption.

2006
India's Country Programme to phase out ODSs updated.
Bureau of Energy Efficiency (BEE) launches the first voluntary star labelling programme for home appliances.

2007
Montreal Protocol. Accelerated phase out of HCFCs adopted for all countries.
BEE launches the Energy Conservation Building Code (ECBC).

2016
Kigali Amendment. Hydrofluorocarbons (HFCs) to be phased down globally.
R&D programme to develop alternatives to HFC refrigerants proposed by the Government of India.
Foam sector enterprises in India receive government support to transition from HCFCs to low GWP HFC cyclopentane.
BEE introduced an India-specific energy efficiency measure (Indian Seasonal Energy Efficiency Ratio (ISEER)).

2017
India's HPMP Phase II launched.
Energy Conservation Building Code updated to reduce building energy consumption.

2018
Draft National Cooling Action Plan released for public comments.
An MoU signed with Ministry of Skill Development and Entrepreneurship for **Recognition of Prior Learning scheme for service technicians.**
Global Cooling Prize launched to encourage climate-friendly cooling innovation.
Doubling of Farmers' Income by 2022 becomes a national agenda, encourages cold chain expansion.
Ministry of Power issues advisory to air conditioner manufacturing companies to limit minimum temperature of the units to 24°C for promoting energy efficiency.

2020-22
Baseline years for Article 5 (Group 1) Parties under the Kigali Amendment.
HCFC phase out complete in developed countries (2020).
Bharat Stage VI norms for vehicle to come into effect (2020).

2024-26
Baseline years for India (Group 2) under Kigali Amendment.
India to achieve 67.5% reduction in HCFC consumption and production (2025).

International treaties | Domestic policy drivers | Indirect domestic policy drivers

1991
Multilateral Fund (MLF). Established to **financially assist** Article 5 countries for ODS phase out.
India joins the Vienna Convention for the **Protection of the Ozone Layer.**

1992
Copenhagen Amendment. **Hydrochlorofluorocarbons (HCFC) included as ODS** to be phased out in 2030.
India signs the Montreal Protocol and ratifies the London Amendment.
India-Swiss-German collaboration (ECOFRIG) launched to **transfer ODS-free technologies** to refrigeration equipment manufacturers in India.

1993
India's Country Programme to phase out ODSs developed.

1997
Montreal Amendment. **Established HCFC phase out** in developing countries.
Kyoto Protocol. Adopted under the United Nations Framework Convention on Climate Change, to **control greenhouse gas emissions.**

1998
Indo-Swiss Human and Institutional Development in Ecological Refrigeration (HIDECOR) commences, aimed at encouraging **good servicing practices** for CFCs.

1999
Beijing Amendment. **Increased controls** on production and trade of HCFCs.
CFC freeze established for production and consumption under the Montreal Protocol.

2000
Ozone depleting substances (regulation and control) Rules 2000, enforced to **regulate production, consumption, export, import and trade.**

2008
ODS global consumption reduced by 98%.
India launches its Hydrochlorofluorocarbons Phaseout Management Plan (HPMP).
Ministry of Food Processing Industries initiates the **Scheme of Cold Chain, Value Addition and Preservation Infrastructure.**

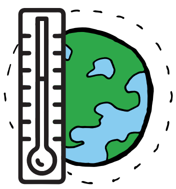
2009-10
Universal Ratification. Montreal Protocol ratified by 196 countries (2009).
CFCs and Halons global production ends (2010).
India's baseline years for HCFC phase out.
BEE mandates star labelling for room air conditioners and frost-free refrigerators (2010).

2011-13
Baseline years for non-Article 5 Parties under the Kigali Amendment.
CFCs completely phased out (2012).
HCFC consumption and production frozen, as per the Montreal Protocol (2013).

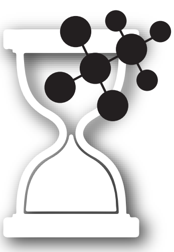
2014
Make in India initiative launched to promote manufacturing.

MAKE IN INDIA

2015
Paris Agreement. Limiting global warming to 'well under 2°C' target accepted.



2028
Freeze HFC production and consumption in India.



Increasing Momentum for Climate-friendly Cooling in India

Source: CEEW compilation, 2019

Image: iStock

It is widely accepted that the air conditioning and refrigeration sectors, as a whole, need an overhaul in order to successfully transition away from HFCs. This will encompass changes and challenges for all parts of the supply chain, including: refrigerant and component manufacturers; primary and commercial users of these refrigerants and equipment; original equipment manufacturers (OEM); research and testing labs; technology providers; standards authorities; educational and training institutions; operating, maintenance, and sales personnel; and others.

However, the key ingredient to limiting and phasing down these gases is still missing - a policy mandate to lower HFC consumption and emissions domestically, in keeping with the nation's international commitments. The draft NCAP signals to the Indian industry and service sector the government's intent to move towards low-GWP HFCs or natural refrigerants. However, there is no national policy consideration yet on the Kigali Amendment's impact on different sectors and stakeholders in India. As there has been no formal communication on India's HFC phase-down plans, there may also be a lack of certainty for industry across the supply chain to initiate this transition. This may also have a direct bearing on the speed of the transition as well as on how soon the planning for such processes can begin.

The air conditioning and refrigeration sectors need an overhaul in order to successfully transition away from HFCs. This will encompass changes and challenges for all parts of the supply chain

Policies or regulations, and their timelines, are essential for developing a roadmap for the HFC phase-down. The role of various stakeholders in developing and implementing these policies cannot be emphasised enough. The NCAP, through its development, emphasised significantly on stakeholder engagement and participation in its authorship. However, the development of NCAP focused on India's cooling needs as a whole, and is not a roadmap for meeting India's global commitments to phase-down HFCs. A similar multi-stakeholder, multipronged engagement strategy will be key to realising India's ambitions for HFC phase-down.

As in the previous transition process of phasing out ozone-depleting substances (ODS), the government should strive to provide policy direction, with inputs from civil society members, industry experts, and research and educational institutions. Further, the ultimate responsibility for executing the phase-down strategy rests on various industry stakeholders, making them critical to this process. This research report, therefore, approaches the need for a comprehensive policy for India's HFC phase-down through the lens of industry stakeholders and other experts.

Image: Jaun Rizvi

1.3 Addressing research gaps

One of the reasons for the lack of a coherent policy framework in India is the significant research gap that remains in India-focused studies. In particular, there has been little emphasis on examining the types of policies and their impact in India, and the undocumented challenges that industry has or could face, especially smaller industry players. Typically, current research focuses on the market mechanisms or incentive structures that are necessary for incorporating energy efficiency into the refrigerant transition in India.[32,33] Some have examined available technologies that can be used for such a transition.[34,35] So far, however, no study has assessed the appropriate regulatory instrument(s) that would be necessary to implement such a transition in India specifically. As we attempt to embark on developing a phase-down strategy, it is also imperative to probe industry's experiences of previous transitions to identify the types of challenges that may be anticipated and averted in the upcoming phase-down.

It is clear that India has a lot at stake in how industry moves forward to achieve this transition - from a domestic development perspective as well as from a global environment-preservation perspective. Despite the data that asserts the criticality of a timely and adequate transition to low-GWP refrigerants, away from high-GWP HFCs, research has yet to put forward the various policy elements that a regulatory framework in India must incorporate to accomplish this. Moreover, the challenges in successfully transitioning to low-GWP refrigerants remain largely undocumented in emerging economies like India. Such research gaps make it even harder to develop and posit policies such that international commitments are met and domestic industrial competitiveness, jobs, and safety remain intact, while access to cooling and resilience to heat stress increases. Furthermore, there is little understanding of how such a transition would impact smaller firms and entrepreneurs in India along the supply chain, once it comes into effect.

Research gaps make it harder to develop policies such that international commitments are met; domestic industrial competitiveness, jobs, and safety remain intact; and access to cooling and resilience to heat stress increases

This report proposes policy instruments that will support such a transition, and which will also help meet India's international commitments without compromising on its industrial and economic value; as well as its growing aspirations for adequate cooling and a better quality of life. Specifically, it attempts to systematically respond to the following research questions to bridge the research gap impeding India's policy discourse on phasing down HFCs:

1. What policies and regulations do other countries have to phase-down HFC consumption and emissions?

2. Who are the different stakeholders in India (for example, HFC producers, equipment manufacturers, commercial building managers, service sector businesses, waste management agencies, etc.)?

3. What are the challenges, and what actions will stakeholders need to undertake, to move towards low-GWP refrigerant alternatives, and to reduce operational and end-of-life disposal emissions of high-GWP HFCs?

4. What policy incentives and regulatory approaches can propel the actions of different stakeholders towards an accelerated transition away from high-GWP HFCs?

[32] CSE (2018)
[33] Shah et al. (2016)
[34] NRDC et al. (2013)
[35] TERI et al. (2018)

This report lays out policy prescriptions based on responses gathered from key stakeholders in Indian industry, government and civil society. Chapter 2 describes the methods undertaken to arrive at responses to the above questions. Chapter 3 presents key findings from HFC-targeting regulations around the world. Chapter 4 highlights the broad range of stakeholders who are relevant for India's HFC phase-down strategy, and a subsection therein highlights the subset of industry stakeholders with whom the authors conducted interviews. Chapter 5 constructs a grounded theory based on the challenges and (planned) actions reported by industry stakeholders, and lays out policy options that industry is looking for in order to undertake HFC phase-down readiness. Finally, Chapter 6 concludes with key findings, policy recommendations, and questions for further research.

Enterprises in the HVAC sectors will be the key protagonists in executing India's Kiagli commitments domestically.

Image: CEEW

2. Methodology

This research study focuses on understanding the role and kinds of policies and regulations that may enable the phase-down of HFCs in India, from stakeholders' perspectives. This chapter highlights the methodologies used to answer the research questions targeted in this study to understand:

1. Lessons from global policies and regulations that India can benefit from to enable its phase-down strategy.
2. Key stakeholders in India that would enable and implement India's Kigali Commitments nationally.
3. Stakeholders' challenges and action-plans to phase-down HFCs.
4. Policy preferences and regulatory requirements to enable HFCs phase-down in India

2.1 Understanding global policies for India's HFC transition

A literature review was undertaken to map and understand global regulations and policies affecting HFC consumption and the resultant emissions. This was supplemented by a study trip to Norway and Sweden to understand the entire regulatory framework in Norway and the European Union (EU). The topics covered included policies and mandates spanning the supply chain - servicing standards and training programmes, refrigerant technology references, refrigerants life-cycle and environmental assessments, leakage and operational management of equipment, and EOL disposal.

Consultations and bilateral meetings with Indian and international policymakers aided in developing an understanding of existing policies and literature, and helped clarify which of these would be useful for India to explore. Based on the long list of regulations that were studied and mapped[36], periodic consultations with government and civil society experts were employed to identify policy instruments most relevant to India. Furthermore, authors engaged with international and national stakeholders at workshops, training programmes, events, and international conferences to learn from their insights on global policies that enable HFC phase-down. The research team also hosted an event and discussion on the role of policies in phasing down HFCs at the 40th Meeting of the Open-ended Working Group of the Parties to the Montreal Protocol.[37] While the entire literature review and study report are presented in Annexes I and II respectively, key findings from the literature and analysis of global policies - particularly those with relevance to India's impending phase-down - are highlighted in Chapter 3.

2.2 Understanding the stakeholders in India's HFC transition

A stakeholder mapping exercise based on literature, existing networks, consultations with experts, and a snowballing method[38] helped to broadly identify the institutions, sectors, and supply chains impacted by, or influencing, India's Kigali Amendment commitments. The results of this stakeholder mapping are discussed in Chapter 4.

2.3 Understanding stakeholder challenges and actions in the transition away from HFCs

The authors conducted in-depth interviews with key stakeholders to record qualitative data on the key challenges of the impending HFC phase-down, and the actions that they foresee as being imperative to that process.

Given the projected growth in the air conditioning and refrigeration sectors[39,40] and the lack of documentation on the opportunities and challenges that industries anticipate during the HFC transition, the primary stakeholders that were targeted for interviews were companies and industry associations in residential air conditioning (RAC), mobile air conditioning (MAC), commercial refrigeration (CR), and commercial air conditioning (CAC), in Tier I, II, and III cities in India.[41]

The authors used qualitative data from interviews to construct a 'grounded theory', as an analytical methodology, to empirically understand the challenges and opportunities anticipated

[36] Listed and tabled in Chapter 3

[37] Held in Vienna, in July 2018

[38] Listed In a snowballing method,stakeholders provide information and references about other relevant stakeholders.

[39] Bhasin, Sridhar, and Chaturvedi (2017)

[40] Chaturvediet al. (2015)

[41] Cities in India are classified as Tier I, II, or III based on their population ranges. As per the Reserve Bank of India (RBI 2011), centres with a population of 1,00,000 and above are Tier I, cities of 50,000-99,999 are Tier II, those with populations of 20,000-49,999 are Tier III, cities of 10,000-19,999 are Tier IV, those with 5,000-9,999 are Tier V, and towns of less than 5,000 are Tier VI.

by stakeholders in the course of reducing HFCs, and to generate a framework for action from policymakers and industry.

The section below sheds light on the interview base, questionnaire, and grounded theory.

2.3.1 Interviewees

Based on the stakeholder mapping undertaken for this study, the authors created a target interview list of industry players in the RAC, MAC, CAC, and CR sectors. Close to 100 industry stakeholders - based on their sector, market share, role in the supply chain, and annual turnover - were identified and contacted for interviews. The aim of the interviews was to understand policy preferences and anticipated challenges in phasing down HFCs in India. Ultimately, within the project's tight timeline, a total of 60 interviews were conducted, having fulfilled the requirements for data collection to construct a grounded theory.[42] Interviews were conducted between August and October 2018, with stakeholders spanning the RAC, MAC, CAC and CR supply chains across India. An in-depth description of the interviewees - sector, size, role in supply chain, etc. - is presented in Chapter 3.

While most interviews were face-to-face, five were conducted over telephone. Hindi was used in certain instances, but English was the primary language of communication. All the interviews were transcribed based on notes taken during interviews.[43]

2.3.2 Questionnaire

The interviews were designed to facilitate in-depth conversations on participants' policy preferences, perceived impacts, challenges, levels of awareness, and opinions on the impending phase-down of HFCs within their firm and in India. The interviews also addressed topics such as the scope and capacity required for manufacturing, R&D, end-of-life disposal of refrigerants, energy efficiency, and job generation. Furthermore, the questionnaire had several open-ended questions on current and anticipated challenges for the transition; interviewees' past experiences with phasing out chlorofluorocarbons (CFCs) and hydrochlorofluorocarbons (HCFCs); the level of expected or required financing and support; anticipated jobs, required skills and gaps therein; and larger sector-level challenges on technology viability, standards, and safety norms. The questionnaire is included in Annex III.


Image: CEEW, 2019

CEEW's Shikha Bhasin (R) interviewing Mr K. K. Sharma, Executive Member of All India Air Conditioning and Refrigeration Association (AIACRA).

2.3.3 Grounded theory

In order to analyse data gathered, the research team adopted grounded theory as the methodology. This choice seemed apt as it limits researcher bias, which is often introduced even in defining hypotheses or guiding questions for research study.[44] It is essential to avoid

[42] Some industry stakeholders were non-responsive to multiple requests for an interview.

[43] Most stakeholders requested to not be recorded, and many offices did not allow electronic devices.

[44] Glaser and Holton (2004)

such bias, particularly in studies that could influence future policies or those that make recommendations for regulatory recommendations. The grounded theory approach is inductive; that is, theory emerges from the data rather than being deduced.[45] Both governmental and non-governmental stakeholders are often involved in making policy choices, so it is important for the approach to objectively capture the opinions and concerns of all parties. Further, as the emergent theory will be the product of a robust methodology based on explicit guidelines, it will have a systematic and scientific basis.[46]

CEEW interviewing officials from Honeywell India on the impending HFC phase-down.
R to L: Shikha Bhasin, Madhuri Boob, Nitin Karwa, Dr Sudipto Chakraborty, Ashwini Channan, Arun Jyoti.

Additionally, grounded theory output is more than just a collation of the most popular choices or a consensus-building exercise; in addition to the 'what' and 'how', grounded theory provides the tools to addressing the 'why' question.[47] Thus, from a policy study perspective, in addition to the policies chosen by stakeholders, the qualitative data from the interviews can provide insight into why a given policy option was picked and how it would respond to the challenges associated with phasing down HFCs. For the current study, a semi-structured questionnaire with continually evolving concepts was used for data collection. While overarching concepts were used to guide the interviews, the type of enterprise and the respondent's area of expertise determined the trajectory of each interview.

Given that this study aims to propose policy recommendations for India's HFC phase-down, a rigorous analytical method was required. Iterative data collection and analysis are imperative to grounded theory research. Egan (2002) describes grounded theory research as involving the following steps: initiating research, data selection, initiation of data collection, data analysis, and concluding research. The data analysis itself is a series of steps beginning with coding the first set of data, and then applying these codes to identify emerging categories. Thorough and repeated analysis of the interrelations among these categories, along with continued data collection and analysis, aids in identifying the emerging theory.[48] Furthermore, simultaneous and repeated coding, and analysis form the backbone of grounded theory research (called 'constant comparative analysis'). Glaser and Strauss (1967) recommend stopping the interview process when adding more participants does not result in additional themes - commonly defined as the 'saturation effect'. Therefore, the quintessential characteristics of grounded theory are theoretical sampling, comparative analysis, and substantive or emerging (as opposed to formal) theory.[49]

[45] Glaser and Strauss (1967)
[46] Charmaz (2006)
[47] Charmaz (2012)
[48] Glaser and Strauss (1967)
[49] Kenny and Fourie (2015)

The following steps were applied to the data from interviews, in order to construct the grounded theory:

1. **Data collection.** The interviews were transcribed and recorded in as much detail as possible. The questionnaire covered a range of subjects, and respondents elaborated on wider challenges and actions during interviews.
2. **Categorisation of qualitative data based on stakeholder groups.** The initial categorisation was done based on sector, role in the supply chain, and the size of the organisation that the respondent represented.
3. **Initial coding.** This was a long list of issues or concerns that were raised over the course of the interviews.
4. **Memo writing and analysis.** An explanation of all the 'codes' that were identified were defined to understand the relationships and patterns between them.
5. **Axial coding.** Based on the initial codes, the data were reorganised and subcategorised into themes. At this stage, all related categories were placed around the 'axes' of more abstract themes.[50]
6. **Advanced coding and theoretical integration.** Having identified the relations among codes and their frequency, the authors assessed the hierarchy of challenges. Using this hierarchy, the data were recoded to streamline issue areas, and to estimate why certain policy recommendations occurred more often than others.
7. **Generating theory.** Key conclusions were arrived at from the recorded data and analysis thereof.

The authors used the computer-aided software NVIVO to support the categorisation, coding, memo writing, recoding, and establishment of hierarchies. The software helped organise the recorded data into various categories, enlisted all codes and the proportion of responses recorded under each, and helped discern any patterns in coding structures according to stakeholder categorisation. The steps used and results from this analysis are discussed in Chapter 5.

CEEW and NEA hosted a closed-door industry roundtable in October 2018 to share their initial research findings.

[50] Ramezani et al. (2017)

What is Grounded Theory?

Grounded theory research is a rigorous qualitative methodology wherein data direct the discovery of a new theory. It was first discovered for use in sociology and was later employed in nursing health and organisational studies.[51] It is increasingly being used in a range of subjects, including social policy.[52] The main purpose of this method is to 'discover' or 'uncover' a new theory by identifying recurring themes and their interrelations from qualitative data. Hypotheses are not generated ahead of data collection. Additionally, data collection and analysis are done simultaneously and iteratively - the analysis informs the direction of data collection.

Since it was first applied, a number of versions of grounded theory have been used and described in the literature - Classical Grounded Theory (CGT),[53] Straussian Grounded Theory,[54] and Constructivist Grounded Theory.[55] Amongst these, CGT and Straussian Grounded Theory are considered the two main branches of the original grounded theory. The key disagreement between the two is methodology, in that, the original grounded theory is not meant to be prescriptive.[56] Strauss and Corbin (1990) developed rules for coding practices to guide novice researchers in applying grounded theory. This, according to many patrons of CGT, is problematic, as grounded theory was never meant to be rigid or prescriptive (see, for example, Keddy et al. 1996). The third branch of grounded theory - Constructivist Grounded Theory, which has been used in this report - 'constructs' a formal theory from the data.[57] Interestingly, the constructivist branch was developed by a student of Glaser and Strauss, and is strongly criticized in Glaser (2002). It derives, yet deviates from, both of the aforementioned models of grounded theory, in that (a) coding is meant to 'construct' a theory through open and refocused coding, and (b) the use of literature is encouraged, with an additional need to compile a literature review.[58,59]

2.4 Policies to propel action for India's HFC phase-down

Based on consultations with experts and findings from the literature review, five policy options employed to lower HFC consumption in different parts of the world were hand picked by experts from civil society, industry, and the Government of India's Ozone Cell. These options were then assessed based on stakeholders' perceived impact and preferences, noted as part of interviews conducted with 60 industry stakeholders across the MAC, RAC, CAC, and CR supply chains.

These policy options and their descriptions were included in the interview questionnaire (see Annex III). The five policy options were explained verbally to respondents, who were also encouraged to read through the descriptors before responding. Respondents were asked to evaluate each policy on two five-point Likert scales, based on their perceived impact of the policies and on their individual- or firm-level preferences. Scales ranged from 'least impactful' to 'most impactful', and 'least desirable' to 'most desirable'. Individuals recorded their responses on physical documents featuring policy explanations and Likert scales, which were provided to respondents during the interview. The two scales were used to determine the potential impact of a policy on a sector-wide transition away from HFCs, as well as the personal or firm-level preference for these same policy options. Respondents were also asked to rank the five policies by preference.

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[51] Goulding (2005)
[52] Charmaz (2012)
[53] Glaser and Strauss (1967)
[54] Strauss and Corbin (1990)
[55] Charmaz (1996)
[56] Glaser and Holton (2004)
[57] Charmaz (2008)
[58] Kenny and Fourie (2015)
[59] Charmaz (2008)

Table 2: Likert scale presented to interviewees to indicate policy impact and desirability

Least impactful	Not impactful	Neutral	Mildly impactful	Most impactful
Least desirable	**Not desirable**	**Neutral**	**Mildly desirable**	**Most desirable**

Source: CEEW compilation, 2019

Multiple categories of answers were provided for the same policy choices to make explicit to the interviewee that what may be the most impactful approach, across sectors, in lowering HFC usage may not necessarily be the interviewee's (or their firm's) preferred option. The authors also wanted to avoid a situation where the interviewees failed to differentiate between the national agenda and a personal one. Moreover, while interviewees were given the option of indicating their perceived preference and the national impact across the five policy options, rankings of these policies were also requested in order to gauge the most preferred policies.

The Likert scale responses for each policy were tabulated and tallied on Microsoft Excel. While 60 industry stakeholders were interviewed, some of them explicitly chose not to rank some of the five policies on the Likert scale while ranking others. In our analysis, we have interpreted this as giving the lowest rank on the Likert scale for the policy in question, i.e. rank 5. Please note that a respondent was allowed to give the same rank to more than one policy, so two policies could be assigned the lowest rank on the Likert scale simultaneously. Wherever respondents chose not to respond to questions related to the impact and desirability of policy options, we interpreted their response as 'neutral' for our analysis.

Based on this interview data, the following analysis was carried out using Microsoft Excel:

1. Macro assessment of all responses on perceived impact and preferences.

2. Top policy choices for stakeholders from different sectors, supply chain roles, and enterprise sizes.

The authors and project partners hosted a closed-door roundtable meeting with industry stakeholders to present the initial results from the first 30 recorded interviews. The findings and proceedings from this session can be found in Annex V. The results from this meeting and an analysis of the responses of all 60 interviewees are discussed in Chapter 5.

Since India's HFC phase-down will begin at a later stage as compared to many other countries, it has the benefit of learning from their best practices.

Image: CEEW

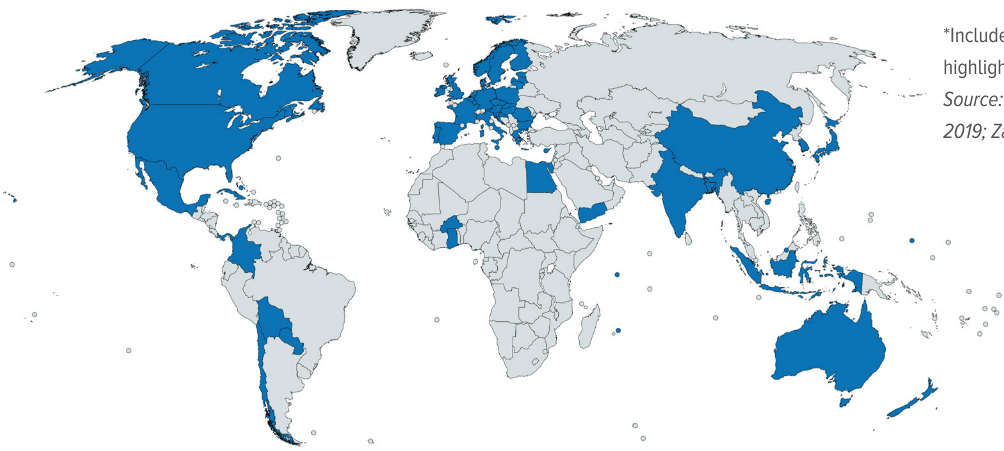
3. Mapping Global Regulations

Although the Kigali Amendment to the Montreal Protocol was agreed to globally in 2016, many countries had already established regulations, policies, and incentive structures to phase-down the use of high-GWP refrigerant gases. This section provides an overview of such regulations and policy instruments in place globally, across sectors. This information was gathered through an extensive literature review, study trips and workshops, and stakeholder consultations with national and international experts. A summary of country-wise policies or regulations for HFC phase-downs is listed in Table 2. (The entire literature review can be found in Annex I.)

3.1 Existing policies and regulations aiming at phasing down HFC consumption and emissions in other countries

Broadly, the policies implemented for HFC phase-down in developed countries can be classified into two types - regulatory limits based on the GWP of the refrigerant, and incentive structures for the uptake of low-GWP refrigerants. Most developing countries focus on import licensing as a part of their HFC phase-down process; so far, few have adopted phase-down targets domestically. This section highlights: policies or regulations that control or regulate HFC usage; policies effecting HFCs end-of-life disposal and operational management; the institutional implementation of such policies; as well as voluntary industry initiatives on minimizing HFC consumption.

Figure 3: Countries that regulate HFC use or have control mechanisms*



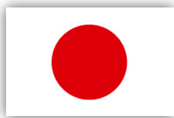
*Includes countries as highlighted in Tables 3 and 4

Source: CEEW compilation, 2019; Zaelke et al., 2018

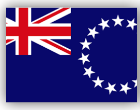
Table 3: Regulations and policy actions targeting HFCs in various countries

Countries	Regulation/areas covered
 European Union (EU)	EU's F-gas Regulations (No. 842/2006 and No. 517/2014)[60] impact. • Reduction in the quantity of HFCs placed on the market (phase-down). • Emission reduction and containment (leakage checks). • Reporting. • Mandatory recovery and recycling. • Education and certification schemes. • Labelling of HFC-containing products. • Restrictions on certain applications. • Restrictions on placing HFCs on the market.[61]
 Norway	EU Regulations (No. 842/2006 and No 517/2014 from 14 December 2018); currently, No. 842/2006 and No 517/2014 are in preparation Tax-and-refund scheme for HFCs.[62] Promotion of low-GWP refrigerants. Mandatory recovery.
 USA	Significant New Alternatives Policy Program (SNAP).[63,64] SNAP, established in 1994 to evaluate and regulate substitutes for ozone-depleting substances (ODS), identifies and approves climate-friendly alternatives while prohibiting certain uses of the most harmful chemical alternatives. It encourages reduced use of virgin refrigerants (through better refrigerant management and recovery), and requires contractors to keep records of the amounts of HFCs added or removed during routine maintenance, service, repair, and disposal of government equipment, appliances, and supplies. Three SNAP rules (20, 21, and 22) were withdrawn in 2018, based on a ruling by the federal court. These affect the replacement of high-GWP HFCs in common applications and reapply charge size restriction on flammable refrigerants (for example, HC 290 and HC 600).[65,66] The refrigerant management regulations (Section 608, Clean Air Act) were changed in September 2018 to exclude substitutes to ODS refrigerants – that is, HFCs. Requirements for leak management, refrigerant reclamation and disposal, and technician certification have been rescinded.[67]
 California	In 2014, California passed a law that required the California Air Resources Board (CARB) to develop a comprehensive strategy to reduce emissions of HFCs and other short-lived climate pollutants (SLCPs) by 1 January 2016. CARB released its draft SLCP Reduction Strategy for public comment in September 2015, which called for more than 40 per cent reduction in HFC emissions by 2030. Beginning in 2018, HFCs will also be regulated according to a state-wide cap-and-trade system.[68] CARB has been updated to prohibit the use of high-GWP HFCs in new equipment and materials in California. Additionally, manufacturers are responsible for providing a disclosure statement that certifies the use of acceptable refrigerants and foam expansion agents in their products.

[60] "F" stands for "fluorinated".
[61] Krajnik (2017)
[62] Norwegian Environment Agency (2018)
[63] The SNAP programme's HFC phase-down status is currently unclear due to a federal court ruling vacating the 2015 EPA rule to replace HFCs with low-GWP alternatives. This ruling is currently being appealed.
[64] US EPA (2018)
[65] Armstrong (2018)
[66] US EPA (2014)
[67] US EPA (2016, 60)
[68] Zaelke et al. (2018)

Countries	Regulation/areas covered
	Notably, in 2018, three other states in the US - New York,[69] Maryland,[70] and Connecticut[71] - announced plans to reduce HFC emissions.
 **Australia**	Under the Ozone Protection and Synthetic Greenhouse Gas Management (OPSGGM) Act, a statutory phase-down of HFC imports has been imposed, as of January 2018[72]; HFC emissions will reduce by 85 per cent by 2036.
 **New Zealand**	New Zealand's HFC phase-down plan (in effect from 1 January 2019) includes:[73] HFC import licensing system. A permit system for HFC exports and imports of recycled HFCs. Support programmes for alternative refrigerants (open for consultation). Target of reducing HFC consumption by more than 80 per cent, and HFC imports from around 1,340 Kilotons CO_2 to less than 260 Kilotons CO_2, by 2036.
 **Japan**	GWP targets for every application (each coming into force in different years between 2018-2025). A subsidy programme is in place; the current focus of the programme is industrial refrigeration.
 **Canada**	Canada is implementing the HFC phase-down until 2030. It has specified GWP limits, by application.
 **Bangladesh, Cuba, El Salvador, Panama, Bahamas**	Roadmap of legal and policy frameworks for the ratification and implementation of the Kigali Amendment.[74] Proposal to extend the licensing system on the import/export of HFCs and HFC-based equipment.[75] New data reporting system on HFCs has been established.[76] National action plan on phasing down HFCs has been published.[77] Awareness-raising and training workshops to commence in 2019.[78]
 **Bolivia**	Early ratification of the Kigali Amendment and related legal measures are being facilitated.[79] Capacity building and training for low and zero-GWP alternatives are ongoing.[80] Regulatory package for an import/export licensing system for HFCs and HFC alternatives is ready. The Ministry of Environment and Water is empowered for implementation once the Kigali Amendment is ratified.[81]

[69] Garry (2018)
[70] Apperson (2018)
[71] Garry (2018)
[72] Department of the Environment and Energy (n.d.)
[73] Chasserot (2017)
[74] UNEP (2018a)
[75] Ibid.
[76] Ibid.
[77] Ibid.
[78] Ibid.
[79] UNEP (2018b)
[80] UNEP (2018b)
[81] Ibid.

Countries	Regulation/areas covered
	The RAC service sector is trained in the safe handling of flammable refrigerants. End-users are proactively trained to adopt alternatives to HFCs.[82] Revising the national labour competency standards for professionals in the RAC sector will prepare them to handle flammable refrigerants.[83]
 Mauritius	Preparing for ratification of the Kigali Amendment: existing legislations have been revised and amendments drafted; consultative meetings held during legislation drafting are complete; awareness materials on the HFC phase-down have been produced; and legal texts to domesticate the Kigali Amendment are in place.[84] A quota system has been established for the import of HFCs.[85] Training schemes and targeted communication with stakeholders have been introduced in order to leapfrog to natural refrigerants.[86]
 Timor-Leste	Activities to enable the implementation of the Kigali Amendment have been proposed to the Multilateral Fund (of the Montreal Protocol).[87] Enabling discussions on policy and technical requirements to facilitate the ratification of the Kigali Amendment.[88] Capacity building and training on low-GWP alternatives.[89] Facilitating the establishment of a licensing/quota system for HFCs.[90] Communication and awareness building among the general public on ODS-free, low-GWP refrigerant gases and more energy efficient products.[91]
 Ghana	Activities to enable the implementation of the Kigali Amendment have been proposed to the Multilateral Fund (of the Montreal Protocol).[92] An HFC survey was completed with help from the Climate and Clean Air Coalition and the United Nations Development Programme (UNDP).
 Brunei Darussalam	Activities to enable the implementation of the Kigali Amendment have been proposed to the Multilateral Fund (of the Montreal Protocol).[93] Currently, a voluntary agreement exists between the Department of Environment, Parks and Recreation and importers of HFCs, for record keeping for future reference. The proposal for enabling activities includes: facilitating the ratification of the Kigali Amendment; capacity building of stakeholders in the safe adoption of low-GWP (flammable) alternatives; import/export licensing and reporting; and communication and awareness building.
  Cook Island, Cape Verde	Activities to enable the implementation of the Kigali Amendment have been proposed to the Multilateral Fund (of the Montreal Protocol).[94] Consultation workshops for the implementation of the Kigali Amendment. Import/export licensing and reporting. Communication and awareness building. Capacity building for the safe adoption of low-GWP alternatives.

[82] UNEP (2018b)
[83] UNEP (2018b)
[84] Ibid.
[85] Ibid.
[86] Ibid.
[87] Ibid.
[88] Ibid.
[89] Ibid.
[90] Ibid.
[91] Ibid.
[92] Ibid.
[93] UNEP (2018b)
[94] Ibid.

Countries	Regulation/areas covered
 Burkina Faso, Colombia, Egypt	Import licenses, and prior approval before import required.[95]
 China	Has an updated list of recommended substitutes for HCFC-22 in refrigeration systems, which includes low-GWP alternatives[96] (propane, isobutane, CO_2, NH_3, and difluoromethane).
 Mexico	Climate Change General Law 2012.[97] Target of 30 per cent reduction in greenhouse gas (GHG) emissions by 2020, and 50 per cent by 2050, with the year 2000 as a baseline. National Emission Registry (2014): the GHGs subject to reporting are CO_2, methane, nitrogen oxide, black carbon, CFC, HCFC, HFC, perfluorocarbons, sulphur hexafluoride, and those GHGs and compounds that the IPCC determines.
 Paraguay	Subsidies for retrofitting existing air conditioners with hydrocarbons (HCs).[98] Provision to impose import restrictions on HFCs. Funding grant for enabling activities; specifics unknown.
 Seychelles	A 100 per cent import duty on high-GWP refrigerants.[99]
 India	Consultative draft on India's Cooling Action Plan released.[100] • Multi-stakeholder (including contributions from civil society organisations and industry associations) integrated approach to address India's cooling needs over 20 years (2017/18 to 2037/38); the report aims to facilitate regulatory action. • Sectors covered are: residential cooling, cold chain, transport air cooling and refrigeration, refrigerant demand and indigenous production, and research and development. • Provides short-, medium-, and long-term recommendations as guidelines for how cooling can be incorporated in various sectors.

Note: This list is not exhaustive; it was last updated in October 2018.
Source: CEEW compilation, 2019; Zaelke et al., 2018; UNEP,2018a;UNEP, 2018b

In addition to these overall policies and programmes that are intended to estimate and regulate the use of HFCs, there are also policies dedicated to minimising HFC emissions due to leakages during the lifetime of refrigerants, and at their end-of-life disposal. In the following subsection, policies directed at the service sector and at managing end-of-life of refrigerants have been highlighted as global best practices.

[95] Brack (2017)
[96] Brack (2017)
[97] Ibid.
[98] Ibid.
[99] Ibid.
[100] Draft NCAP,Ozone Cell (2018)

3.1.1 Policies directed at refrigerant servicing and end-of-life recovery

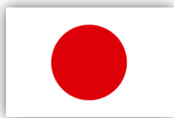
Addressing the end-of-life (EOL) disposal of refrigerants is crucial for reducing HFC emissions. Often, there is no incentive for manufacturers to recover refrigerants from discarded equipment; therefore, incentives or regulations to ensure recovery are often necessary. Among countries that do regulate the safe disposal of refrigerants (including HFCs), there is a reliance either on voluntary programmes (with incentives) or on robust regulations with enforcement mechanisms. The Air-Conditioning, Heating, & Refrigeration Institute's (AHRI) 2016 study[101] on the efficacy of different types of refrigerant recovery programmes provides a useful comparison of systems.

Often, there is no incentive for manufacturers to recover refrigerants from discarded equipment; therefore, incentives or regulations to ensure recovery are often necessary

Table 4: Servicing and end-of-life recovery policies

Originating country	Best practice advantages
 Australia	A comprehensive product stewardship scheme built on existing distribution channels minimises the cost burden on industry and reduces friction among contractors. Including all synthetic refrigerants (CFCs, HCFCs, and HFCs) in the phase-down and in regulatory requirements has created consistent market incentives for better refrigerant management. Banning disposable cylinders was pivotal in improving refrigerant management. Returning cylinders for refills supports the ethos that refrigerants are not a commodity but a specialised good; this encouraged refrigerant return for proper destruction.
 California	Robust maintenance and servicing requirements for large refrigerant charges serve as an educational tool for industries and promote best practices. Utility energy efficiency programmes capture large volumes of appliances, enabling easy refrigerant/resource management. Moving away from disposable small refrigerant cans to reusable canisters has set a precedent, despite the limited volumes of recoverable refrigerants in small cans.
 European Union	Collaborative training and the development of best practices have been proved to reduce leak rates. The European Commission is committed to developing easy-to-use, robust, and thorough documentation for industry. From 1 January 2020, the use of fluorinated greenhouse gases with a GWP of 2,500 or more, to service or maintain refrigeration equipment with a charge size of 40 tonnes of CO_2 equivalent (CO_2e) or more, shall be prohibited. Some countries within the EU have introduced legislations that are stricter than the EU F-gas Regulation. These were highlighted in a report commissioned by the European Commission:[102] o **Lower minimum charges:** Equipment containing lower minimum charges of F-gases than set out by the F-gas Regulation are subject to containment rules in Denmark (minimum charge of 2.5 kg) and France (minimum charge of 2 kg). o **Mandatory leakage checks for mobile equipment:** Leakage checks of certain types of mobile equipment are mandatory in Germany (refrigerated trucks containing charges of more than 3 kg of F-gases), Sweden (refrigeration and

[101] Navigant Consulting Inc. (2016)
[102] Schwarz et al. (2011)

Countries	Regulation/areas covered
	air conditioning systems installed on ships containing charges of more than 10 kg of F-gases), and the Netherlands (mobile refrigeration and air conditioning equipment, including on ships, according to the schedule set out by the F-gas Regulation). o **Maximum annual leakage rates:** Leakage rates for stationary equipment have been established in Germany (refrigeration and air conditioning equipment, depending on the charge and date of manufacture), Belgium (new equipment: five per cent), and Luxembourg (five per cent). o **Monitoring equipment:** Several countries require registration of equipment in a database for monitoring and enforcement purposes, such as Hungary (cooling circuits), Slovenia (charges of more than 3 kg of ODS or F-gases), and Estonia (charges of more than 3 kg of F-gases). o **Producer responsibility:** Such schemes are in place, which require producers and suppliers of F-gases to take back recovered bulk F-gases for further recycling, reclamation, and destruction, in Sweden (legally binding for fluorinated greenhouse gases since 2007, for ODS since 1989) and Germany (legally binding since 2008). Recovery of CFCs, HCFCs, and HFCs has been mandated in France since 1992. Denmark (KMO system), Sweden (SWEDAC), and the Netherlands (STEK system) have also been training companies and personnel since 1992.
 Japan	Industry-specific refrigerant management programmes built on current product EOL infrastructure, with opportunities for innovation and competition among product stewardship schemes. Fees for motor vehicle EOL management (including refrigerants) are charged at the time of purchase, which greatly encourages compliance.
 United Kingdom	There is no explicit cost to consumers for appliance disposal – instead, manufacturers incur costs as part of operations and build those costs into retail prices.

Source: CEEW compilation, 2019; Navigant Consulting Inc., 2016; Schwarz et al., 2011

Many countries, especially developed nations, prohibit unlicensed or uncertified service technicians from installing, servicing, or repairing air conditioners or handling refrigerants. For example, Canadian regulations define a certified person as ‘a service technician who holds a certificate recognised by three or more provinces or by the province in which the work is being done, indicating successful completion of an environmental awareness course in recycling, recovery, and handling procedures for halocarbon refrigerants, as outlined in the Refrigerant Code of Practice.’[103] Non-certified technicians are prohibited from installing, servicing, leak testing, charging, or completing other work that may result in the release of a halocarbon from a refrigeration or air conditioning system. Even certified technicians are prohibited from releasing/venting halocarbons, charging systems without leak testing, and using wrong containers to store/transport halocarbons, among other activities. Regulations also require all systems (other than small refrigeration and air conditioning units) to be leak tested every 12 months. Similarly, the EU F-gas Regulation seeks to improve the prevention of leaks from equipment containing F-gases by:

- Containing gases and employing proper equipment recovery
- Training and certifying personnel and companies handling these gases
- Labelling equipment containing F-gases[104]

[103] Environment Canada (2013), p 3

[104] European Commission (2018)

3.1.2 Implementing policies through multipronged regulatory structures

In order to understand the functions of the multiple regulatory agencies involved in the development and successful implementation of policies such as those listed above, the authors undertook a policy study trip to Norway and Sweden. The tour included several meetings and discussions with different stakeholders responsible for various aspects of the regulatory value chain.[105] Norway's tax-and-refund scheme aims to tax all HFCs either produced in, or imported into, Norway. The tax is based on the GWP of the HFCs or the blends used. This encourages the use of low-GWP HFCs and natural refrigerants in new installations. The relatively high taxation level (approximately USD 62 per GWP-tonne) is also believed to contribute to better housekeeping of gas and less leakage. Finally, when the HFC is destroyed at an approved facility, the tax amount is refunded to the party that delivered the waste.[106] A few organisations central to the implementation of the Norwegian tax-and-refund policy, as well as their roles, have been highlighted in Table 5 below.

Table 5: Key learnings from meetings with regulatory stakeholders in Norway

Stakeholder	Function	Key discussion points
Norwegian Environment Agency (NEA), Section for Product Control	Control of F-gases through regular inspection activities for resellers, installers, maintenance companies, and equipment owners. The various inspections undertaken were: » Use of prohibited refrigerants HCFC (R-22) and prohibitions on F-gases for some applications placed on-the-market. » Regular leakage checks according to regulations. » Documented maintenance (log book). » Certification of personnel and service companies.	The NEA reported that supervision through inspections had a positive effect on compliance with EU regulations. Based on their analysis, compliance was observed for non-use of HCFCs; meticulous documentation for maintenance; and certification of operating personnel and companies.
Norwegian Directorate for Civil Protection	Responsible for the regulation of flammable and toxic refrigerants.	All legal instruments that regulate flammable refrigerants were presented. The discussion focused largely on the need to revise standards for low-GWP refrigerants that are flammable.
SRG (StiftelsenReturGass, Isovator AS) (Hazardous waste company)	Collects used HFCs and organises safe destruction. Processes refunds to service companies, etc. Certifies personnel and companies.	The implementation of the tax-and-refund scheme The implementation and enforcement of service technician certification schemes under the new F-gas Regulation
Foreningen for Ventilasjon, Kulde og Energi (VKE) Industry Association	Industry association for companies in the cooling sector. The main focus of the association is legislation and education.	The discussion focused on the responsibilities and challenges that companies face in complying with the new F-gas Regulations.

[105] For a full listing of meetings and interviews, please see the study tour report in Annex II.

[106] Norwegian Tax Administration (2017)

Stakeholder	Function	Key discussion points
Norwegian Foundation for Scientific and Industrial Research (SINTEF)	In the area of cooling, they are working on: » Expanding the use of natural refrigerants. » Refrigerant destruction technology.	Based on a demonstration project in IIT Madras (India), they found that leapfrogging from HCFC 22 to CO2 refrigeration is possible for India. They further stated that CO2 refrigeration systems are energy efficient. They also assessed the use of cement kilns to destroy halons and CFCs. They found that cement kilns are more efficient and cheaper than incinerators.

Source: CEEW and NEA compilation, 2019

3.1.3 Voluntary industry initiatives

Several voluntary industry programmes exist globally, which aid in self-regulation. The Refrigeration Resolution by the 'Consumer Goods Forum' is one such example.[107] This scheme focuses on the installation of new refrigeration equipment in markets where viable, engaging with key stakeholders to overcome barriers in markets where installation is not currently viable, reducing the environmental impact of existing refrigeration systems and developing individual targets and action plans to measure the first three points.[108]

Another initiative, Refrigerants, Naturally!, of the United Nations Environment Program (UNEP) and Greenpeace, encourages the private sector to phase out HFC-based equipment.[109] Finally, individual efforts by companies like Chemours, Daikin, Honeywell, and many others to eliminate by-production and process-related emissions of HFC-23 are noteworthy.[110]

Even on the emissions-reporting front, programmes by The Climate Registry, EPA Climate Leaders, and the Climate Disclosure Project are examples of institutional mechanisms and voluntary registries established for companies' disclosure of GHG emissions.[111] Another programme by the European Commission - the Eco-Management and Audit Scheme (EMAS) - was instituted for 'companies and other organisations to evaluate, report, and improve their environmental performance.'[112] These include reporting on issues central to HFC management - GHG emissions, waste generation, energy efficiency and consumption, and material efficiency.[113]

Industry-led voluntary initiatives for servicing and EOL disposal have been documented by Schwarz et al. (2011), and are included in the literature review (Annexure I).

[107] Consumer Goods Forum (2018)
[108] Ibid.
[109] Refrigerants, Naturally! (2018)
[110] Bergeson (2017)
[111] Samuelson (2010)
[112] Schwarz et al. (2011) p 49
[113] Schwarz et al. (2011)

3.2 Key takeaways for India

Based on an extensive literature review and a study trip undertaken to understand (i) the kinds of policies in place globally to encourage a transition away from HFCs, and (ii) experiences and successes within the Montreal Protocol so far, the following can be summarised as key learnings for India as it initiates its policy engagement to phase-down HFCs.

Lessons from global regulations and previous transitions:

- A successful transition will depend on policy coherence across a range of government agencies and multiple stakeholders.
- Industry is the key protagonist in undertaking the transition away from HFCs.

3.2.1 The critical role of industries and markets

- Voluntary actions dissipate the need for strong regulatory measures and instruments to be imposed on industries. Firms remain the most significant stakeholders in implementing commitments made internationally to phase-down HFCs, and regulations should attempt to incentivise such actions.

- Industries have, so far, played a key role in the success of the Montreal Protocol, which is considered among the world's most successful environmental agreements, having reduced the consumption of ODS by up to 97 per cent.[114] As DeSombre (2000) notes, 'market forces have played a valuable role in the successes of the Montreal Protocol, some of them as a direct result of the way the Protocol process is structured, and others because of serendipity in the way industry has made or used ozone depleting substances. Due to what is in part a happy coincidence, and in part well-developed regulatory incentives, some of the main ODS-producing industries were the main innovators of the substitutes used to replace them.'[115]

- Some key qualifiers for the success of the Montreal Protocol are: (1) a broad international agreement mandating global markets to move in a particular direction, thereby opening up a large market for companies offering non-CFC refrigerant-based products; (2) domestic regulations, by way of taxes imposed on ODS, incentivising the use of alternative refrigerants; and (3) increasing companies' and industry's representation in the Technology and Energy Assessment Panel (TEAP) encouraged them to find alternative technological solutions.[116]

- The very nature of regulations in this sector is to direct market behaviour, which is evidenced in several studies. With regard specifically to HFCs, Molina et al. (2009) note

[114] Bergeson 2017
[115] DeSombre (2000: 57)
[116] For example, see Oye and Maxwell (1995);Greene (1998) and Hoerner, J. Andrew (1996).

that ‘six low-GWP substitutes were announced by chemical companies just weeks after the European F-gas Directive set the schedule for phasing out HFC-134a refrigerants in automobile air-conditioning.’[117]

3.2.2. HFC phase-down is a multi-institutional regulatory challenge

- Different regulations have been employed for phasing down HFCs across the world. Broadly, these can be classified according to whether they address HFC refrigerant use on the supply side, demand side, or service side and/or end-of-life disposal.

- For a smooth transition to low-GWP alternatives, it is imperative to set safety and technology standards, national phase-down targets, regulations for operational emissions, and end-of-life disposal policies.

- The success of the Montreal Protocol is largely attributed to regulations working in tandem with the private sector. Drawing on this, a successful HFC phase-down in India will need in-depth and broad-based stakeholder interactions between the government, scientific community, and industries.

- Finally, studies have shown a correlation between scientific findings and environmental policies.[118] Therefore, tackling the HFC phase-down with a regulatory framework based on systematic stakeholder engagement that includes the scientific community, civil society and public policy researchers, industry, regulators, and policy makers, is imperative for a successful transition.

The following chapter highlights the broad stakeholder base, with a particular emphasis on industries that will affect and be affected by India’s impending HFC phase-down.

As part of the study trip undertaken to understand EU and Norwegian F-gas regulations, the authors visited a food processing cold chain facility in Norway.

[117] Molina et al. (2009), p 3

[118] See, for example, Andresen et al. (2018)

The impending refrigerant transition can mobilise jobs, manufacturing growth, and increased R&D investments in India's HVAC industry.

Image: iStock

4. Stakeholder Analysis and Mapping

The purpose of any policy or reform is to bring about a positive change for individuals or groups of people. Therefore, policymakers need to stay cognizant of the various actors that are likely to be impacted, either positively or negatively. This chapter puts forward a stakeholder mapping for enabling a transition away from HFCs in India.

4.1 Stakeholder mapping for the HFC phase-down strategy

The importance of stakeholders in any policy reform is evidenced in the concept of innovation systems for technology deployment, as discussed in a previous CEEW study.[119] The authors emphasise that beyond technical innovation, 'all sorts of market and innovation ecosystems factors influence commercial experience and success'.[120] For climate-friendly technologies, policy interventions are essential to ensure that the market will be receptive. This entails creating a network of local suppliers, users, and research institutions to sustain an innovation ecosystem.[121] Notably, the aforementioned CEEW study was aimed at facilitating innovation and adoption of low-GWP technologies for India's HFC phase-down and, therefore, set the stage for the stakeholder analysis undertaken in the current research.[122] HFCs' phase-down in India demands the participation of various stakeholders, both governmental and non-governmental. As per OzonAction, a division of the United Nations Environment Programme (UNEP), the stakeholders most relevant to enabling an HFC phase-down can be classified into the following groups:[123]

i. National Ozone Unit (NOU)

ii. Other government ministries or officials

iii. International agencies and experts from other countries

iv. Civil society organisations (CSO), and educational and research institutions

v. Industry and private sector experts and associations

For climate-friendly technologies, policy interventions are essential to ensure that the market will be receptive

[119] IPCC Bhasin, Sridhar, and Chaturvedi (2017) p 4
[120] Ibid.
[121] Bhasin, Sridhar, and Chaturvedi (2017)
[122] Ibid.
[123] OzonAction (n.d.)b

We identified key stakeholder groups relevant to this study (see Table 5). The implementation of the Montreal Protocol has already started building momentum among these stakeholder groups, as it defines specific roles and responsibilities. The following section discusses the roles of these stakeholder groups and their specific contributions to HFC phase-down in India.

i. National Ozone Unit

India's NOU, the Ozone Cell, is instituted in the Ministry of Environment, Forest and Climate Change (MoEFCC) of the Government of India. It is the nodal agency in charge of meeting all commitments made within the Montreal Protocol, including the Kigali Amendment. The Ozone Cell engages with other government ministries and agencies, CSOs, research organisations, private sector associations, experts, and international agencies to enact various activities and implementation plans related to the Montreal Protocol. It is the primary body leading the development and institutionalisation of any strategy aimed at lowering HFC consumption in India.[124]

ii. Government ministries

Specific ministries responsible for various legislative and administrative actions associated with the phase-down of HFCs are listed below:[125]

- The Ministry of External Affairs (MEA) will provide support for the ratification process.
- The Ministry of Commerce and Industry is responsible for HFC licensing, quota allocation, and monitoring the production, imports, and exports of HFCs.
- The Ministry of Environment, Forest and Climate Change will oversee the need to modify existing legislation to enable the Montreal Protocol's Kigali Amendment. Awareness drives and implementation activities will also be organised by the MoEFCC.
- The Central Board of Indirect Taxes and Customs under the Ministry of Finance will provide support in monitoring HFC imports.
- The Ministry of Consumer Affairs, Food and Public Distribution's Bureau of Indian Standards (BIS) will provide support in activities related to safety codes and standards necessary for adopting low-GWP alternatives.
- The Ministry of Skill Development and Entrepreneurship will oversee technician training and national-level workshops during the transition.
- The Bureau of Energy Efficiency (BEE) under the Ministry of Power will be instrumental in facilitating policies to encourage energy efficiency in equipment that runs on refrigerant gases.

iii. International agencies

Since India has a longer timeline than developed and some developing countries for phasing out HFCs, engagement with experts from other countries and international organisations could be beneficial to identify best practices and programme strategies.

[124] MoEFCC (n.d.)
[125] OzonAction (n.d.)b

The four Multilateral Fund (MLF) implementing agencies (UNEP OzonAction, UNDP [United Nations Development Programme], UNIDO [United Nations Industrial Development Organization], and the World Bank) provide useful resources for implementing a HFC phase-down (e.g.,OzonAction Kigali Factsheets).[126] The websites of these agencies also provide information on technology trends related to low-GWP alternatives available internationally. Furthermore, these implementing agencies are instrumental in facilitating funding for less developed Article 5 countries under the MLF.

iv. Civil society organisations, and educational and research institutions

Non-governmental organisations (NGOs) and research institutions will play a pivotal role in providing research support to the government, through expertise on refrigerant gases (i.e., low-GWP alternatives) from technical and policy perspectives. These organisations could be mobilised as consultation forums to help draft the national HFC phase-down strategy. Additionally, CSOs could be instrumental in raising awareness among wider stakeholders (consumers and private sector agencies) and in assessing the further support required.

Policy interventions are essential to ensure that the market will be receptive to climate-friendly technologies. This entails creating a network of local suppliers, users, research institutions, and others, to sustain an innovation ecosystem

v. The private sector and industry stakeholders

By 2020, India's air conditioning market - comprising the room air conditioning (RAC), mobile air conditioning (MAC), and commercial air conditioning (CAC) sectors - is expected to be valued at USD 6.3 billion.[127] The resultant growth rate of this market in 2018 is estimated at around nine per cent; it has expanded at this rate for the last few years now.[128,129] Given that air conditioning use is expected to triple by 2030 relative to today,[130] industry stakeholders stand to play a significant role in implementing India's HFC phase-down. During India's ODS phase out, industry associations like the Refrigeration and Air Conditioning Manufacturers' Association (RAMA) and Indian Polyurethane Association (IPUA) were instrumental in administering sector-level surveys, organising outreach activities, and designing sector strategies to achieve phase out targets.[131] Outreach and awareness programmes can help less informed stakeholders understand new products and technologies - these initiatives could include training workshops or assistance with setting up new infrastructure for low-GWP alternatives. In addition to bridging information asymmetry, Industry stakeholders would be the key executors of any strategy related to low-GWP alternatives or phasing down HFCs, through the market diffusion of new technologies and products.

Given the volume of expected demand in the future, the participation of industry stakeholders in the development and execution of the refrigerant phase-down is vital. Key industry stakeholders can be classified according to their role in the supply chain in the relevant sector (see Table 6); as their contribution or support towards India's HFC phase-down strategy would vary.

[126] OzonAction (n.d.) a
[127] ASHRAE (2018)
[128] ASHRAE (2018)
[129] ASHRAE (2018)
[130] ASHRAE (2018)
[131] Ozone Cell (2017)

Table 6: Stakeholders to enable India's HFC phase-down

Stakeholder group	Key stakeholder
Government	» Ministry of Environment, Forest and Climate Change » Ministry of Power » Ministry of Consumer Affairs, Food and Public Distribution » Ministry of Commerce and Industry » Ministry of Skill Development and Entrepreneurship » Department of Science and Technology » Ministry of Finance » Ministry of External Affairs
International Stakeholders	» Governing bodies of the Montreal Protocol, the Paris Agreement, and other international treaties » Development agencies » Subsidiary bodies of the Montreal Protocol » Multilateral funds and banks » Other countries' governments
Research and Educational Institutions	» Think tanks and research organisations » Universities and research labs » Technical and other expert consultants
Industry	» Associations » Manufacturers and suppliers of refrigerant gases » Manufacturers and suppliers of components » Consultants and service providers » Primary users of refrigerants » Commercial users of end products

Source: CEEW compilation, 2019

Owing to the critical role of industry stakeholders in executing HFC phase-down in India, the following subsection offers an analysis of the types of industry stakeholders represented in this study.

4.2 Key industry stakeholders: interviewees

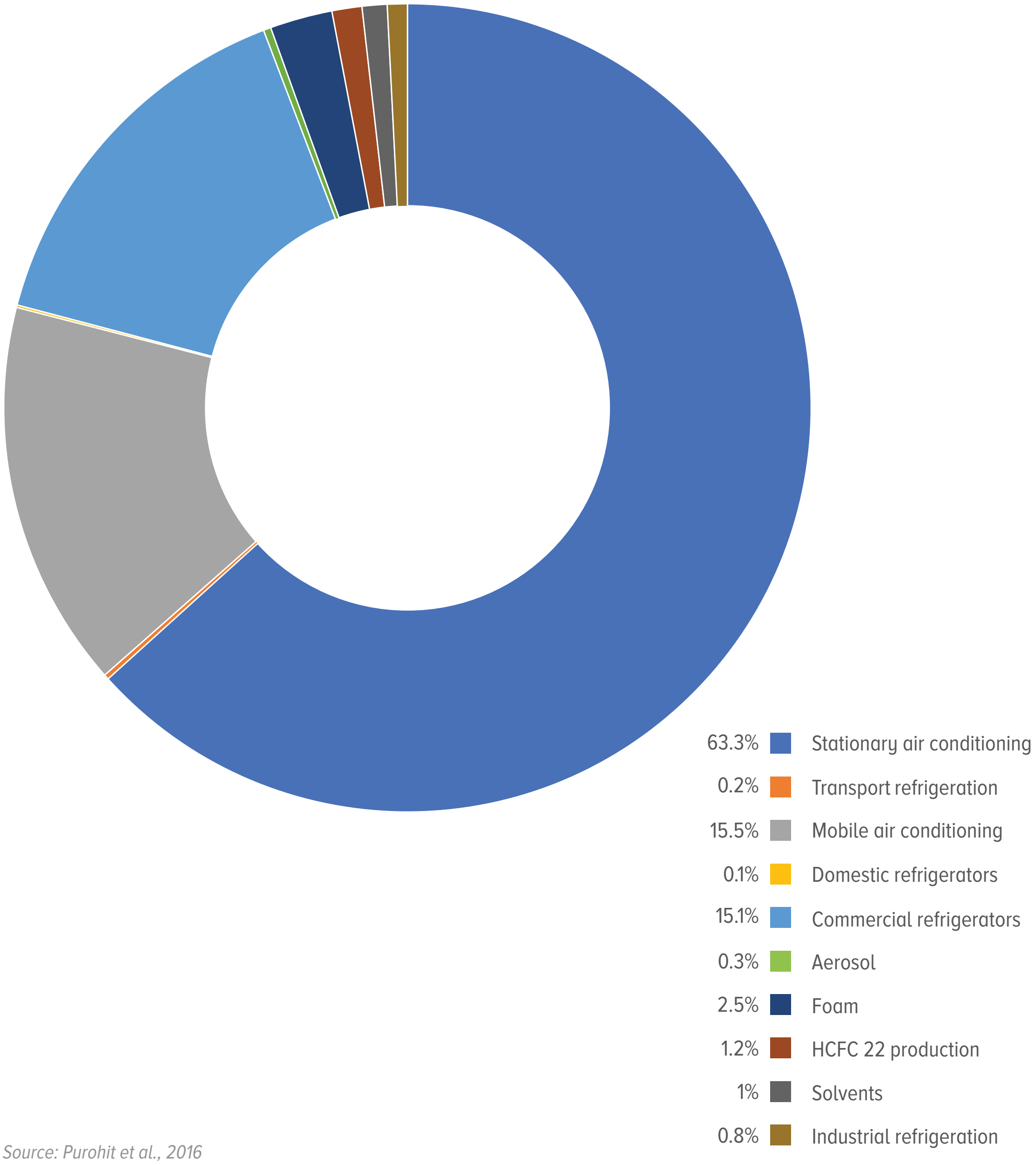
For this study, 60 stakeholders from the RAC, MAC, CAC, and commercial refrigeration (CR) sectors were interviewed to understand industry preferences for regulatory mechanisms and the challenges that can be expected in the upcoming transition to low-GWP refrigerants. This section provides an analysis of the key industry stakeholders based on the sectors they represent, their role in the supply chain, and company size.[132,133,134] Various other classifiers such as market share, country of origin, manufacturing, and research and development (R&D) capacity in India offer further insight.

[132] The classification of companies by size was done based on turnover data. As per a recent government definition reported by Prasad (2018), businesses with annual turnovers of INR 5–75 crore (approximately USD 0.7 million – USD 10.7 million) are small and those with INR 75–250 crore (approximately USD 10.7 million – USD 35.7 million) turnovers are medium-sized enterprises. For our study, we have considered businesses with annual turnovers of more than INR 250 crore (greater than USD 35.7 million) as large companies.

[133] Exchange calculated based on currency values as on 30 December 2018.

[134] Prasad (2018)

Figure 4: Projected HFC emissions in 2050 by sector



Source: Purohit et al., 2016

As highlighted in the chart above, among the variety of industries that use HFCs,[135] the air conditioning and refrigeration sectors have emerged as most critical due to their high HFC emission potential and prolific growth rates. Therefore, RAC, CAC, MAC, and CR constitute the four big sectors in India's refrigerant story and were chosen as a focus area in this study for their rapid growth and significant share in HFC emissions. Chaturvedi et al. (2015) used the following sectoral classification, which has been applied in this study as well:

- RAC - residential window/split air conditioning units
- MAC - air conditioning for passenger transport (cars, buses, and trains), freight transport (light and heavy-duty trucks)
- CAC - air handling units (AHU) and air conditioning for commercial buildings[136]
- CR - commercial refrigeration units

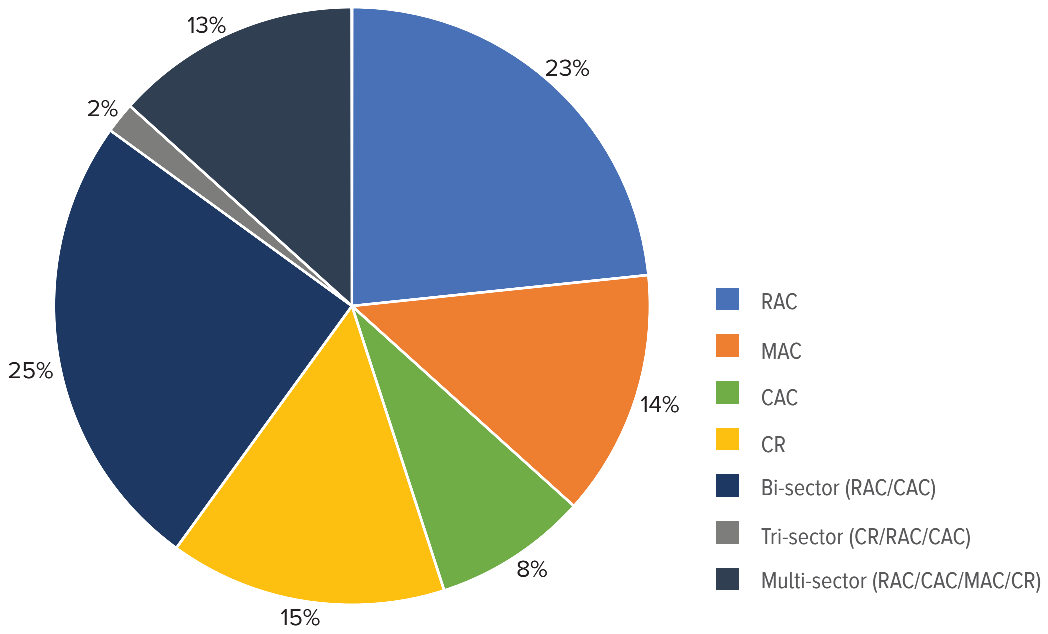
[135] For instance, in foams, aerosols (medical and non-medical), solvents, refrigeration, and air conditioning.

[136] Chaturvedi et al. (2015) include HVAC (heating, ventilation, and air conditioning) units in this segment.

As per the draft India Cooling Action Plan, the demand for cooling in India is expected to grow to eight times its current size by 2038.[137] An industry estimate further states that air conditioner use (including RAC, CAC, and MAC) is expected to triple by 2030.[138] Given the rising need for commercial refrigeration in India (e.g., agricultural cold chain),[139] this sector is expected to quadruple by 2038 relative to its 2018 capacity.[140] In terms of HFC emissions, an India-specific modelling study by Chaturvedi et al. (2015) showed that by 2050, of the 5.4 per cent attributed to HFCs in India's total GHG emissions , five per cent would be from the RAC, MAC, CAC, and CR sectors alone.[141,142] These four sectors will, therefore, be significant in India's HFC phase-down strategy and implementation.

From a sectoral perspective, the largest percentage of industry stakeholders interviewed were from the RAC (23 per cent) sector, followed by CR (15 per cent), MAC (14 per cent), and CAC (eight per cent). As detailed in Figure 5 below, 40 per cent of the stakeholders were involved in more than one sector (dual, tri- and multi-sector stakeholders).

Figure 5: Sectoral mix of industry stakeholders interviewed



Source: CEEW compilation, 2019

The supply chain roles covered in this study were: manufacturers/suppliers of refrigerants; manufacturers/suppliers of components; primary consumers of refrigerants;[143] consultants and service providers; commercial users of products[144]; and industry associations. Primary refrigerant consumers constituted the largest percentage of stakeholders (47 per cent) interviewed - 61 per cent of these were OEMs. Ten of the primary refrigerant consumers across sectors offered business-to-business (B2B) solutions. Enterprises manufacturing and

[137] Draft NCAP, Ozone Cell (2018)

[138] ASHRAE (2018)

[139] Sharma (2017)

[140] Draft NCAP, Ozone Cell (2018)

[141] The overall HFC emission percentages in India of the RAC, CAC, MAC, and CR sectors were 35 per cent, 28 per cent, 15 per cent, and 14 per cent, respectively.

[142] Chaturvedi et al. (2015)

[143] Primary consumers of refrigerant gas include OEMs, business-to-business solutions, and manufacturers of whole equipment.

[144] For example, real estate companies.

supplying components were the next largest group at 19 per cent followed by consultants and service providers at 17 per cent. Finally, refrigerant manufacturers and suppliers, industry associations,and commercial users of products constituted eight per cent, seven per cent and two per cent of the stakeholders respectively.[145]

A total of four industry associations were interviewed for this study, which represented the RAC, CAC, and CR sectors. All four associations are actively involved in providing training and/or certification programmes; for example, the Indian Society for Heating, Refrigerating and Air Conditioning Engineers (ISHRAE) offers a professional certification programme for heating, ventilation, air conditioning, and refrigeration (HVAC&R) professionals in servicing, drafting, and design.[146] Refrigeration and Air Conditioning Service Sector Society (RASSS) focuses on training servicing sector professionals exclusively. The Association of Ammonia Refrigeration (AAR) is actively involved in the use of ammonia in commercial and industrial refrigeration.

The market shares of stakeholders varied wildly.[147] Specifically, among the RAC sector primary refrigerant consumers, companies typically had market shares ranging from seven per cent (Panasonic India) to 21 per cent (Tata Voltas).[148] In the MAC sector primary refrigerant consumers interviewed represented market shares ranging from six per cent of car sales (Tata Motors)[149], 35 per cent (Ashok Leyland) in freight transport,[150] and up to 50 per cent of automobile component manufacturers (Subros).[151] The refrigerant manufacturers and suppliers interviewed for this study are major international players with a significant presence in India; however, their market shares in India were not disclosed. None of the Indian refrigerant manufacturers responded to any of the authors' multiple interview requests.

In terms of enterprise size, approximately 20 and 27 per cent of interviewees represented small and medium enterprises, respectively. Large enterprises constituted 46 per cent of the total. Among large enterprises, 29 per cent were companies with Indian origins, founded and registered in India. The rest were either multinationals or Indian subsidiaries of foreign companies. As industry associations were not assigned a size, they constituted the remaining 7 per cent.

Fifteen per cent of stakeholders mentioned having an R&D facility in India. Of these, 78 per cent were primary consumers of refrigerants and 22 per cent were manufacturers/suppliers of components or refrigerants. Half of the 20 multinationals we interviewed reported having established manufacturing facilities in India. Several manufacturing facilities were used for equipment assembly, with imported components and/or refrigerants.[152]

Among large and medium enterprises, companies that operated in multiple sectors (RAC/CAC, CR/RAC/CAC and RAC/CAC/MAC/CR) formed the majority (see Figure 6). 67 per cent of the small enterprises were interviewed were from the CR sector. About 25 per cent of the small enterprises were from the RAC sector, and there were no small enterprises from the MAC and CAC sectors. All four industry associations' interviews represented the RAC, CAC, and CR sectors.

[145] Many of the equipment dealerships we contacted were non-responsive or turned down interview requests, citing a busy season.

[146] ISHRAE Certified Professional (ICP) is offered by the ISHRAE Institute of Excellence (IIE). Many senior ISHRAE members teach these courses. For more information, see http://icp.ishrae.in/.

[147] Analysis based on market share data available for 11 companies; data sources mentioned in text.

[148] Sharma and Shah (2017)

[149] Shah (2018)

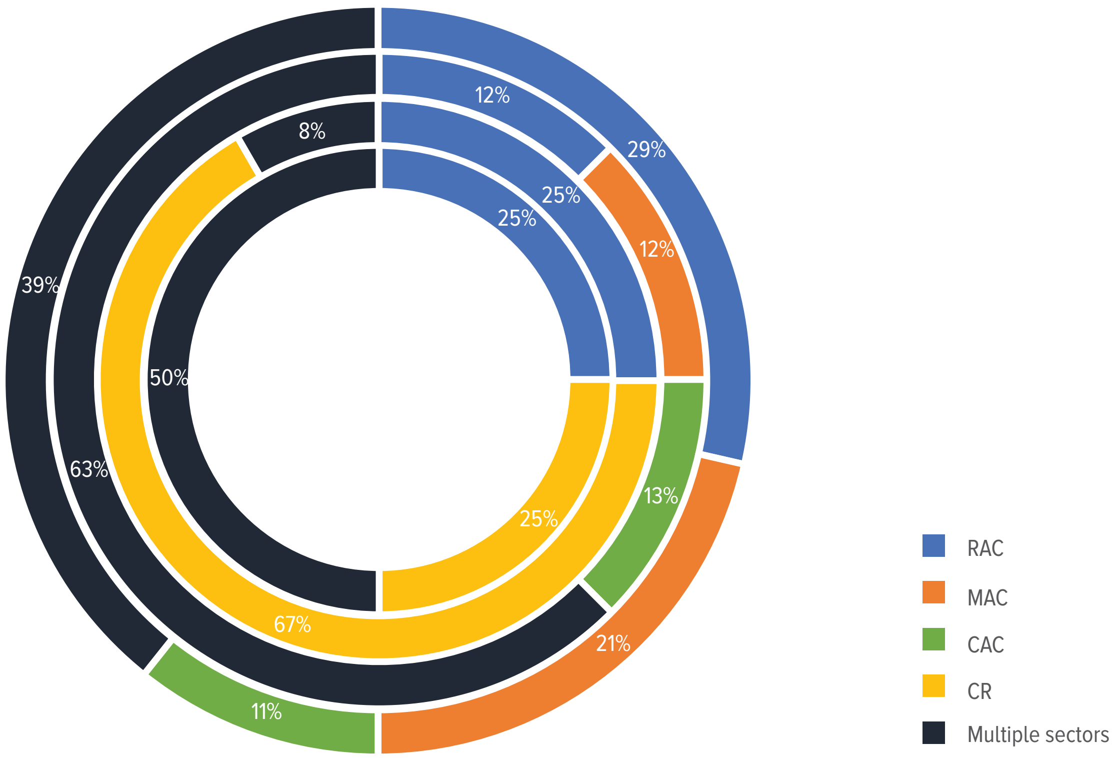
[150] Narasimhan and Babu (2017)

[151] Autocar Professional (2006)

[152] Many components and refrigerant gases are imported from China because bulk production is cheaper there. Information is from stakeholder interviews.

The stakeholders interviewed for this study represent various sectors, supply chain roles, and enterprise sizes. While there were fewer stakeholders from the MAC sector, these were large enterprises with an annual turnover ranging between INR 100-50,000 crores (approximately USD 14 million-7 billion).[153] In contrast, while there were more stakeholders in the CAC and CR sectors, these were typically small or medium enterprises with annual turnover ranges between INR 1 crore and 100 crores (USD 1.4-114 million).[154]

Figure 6: Enterprise size and sectoral mix of interviewees



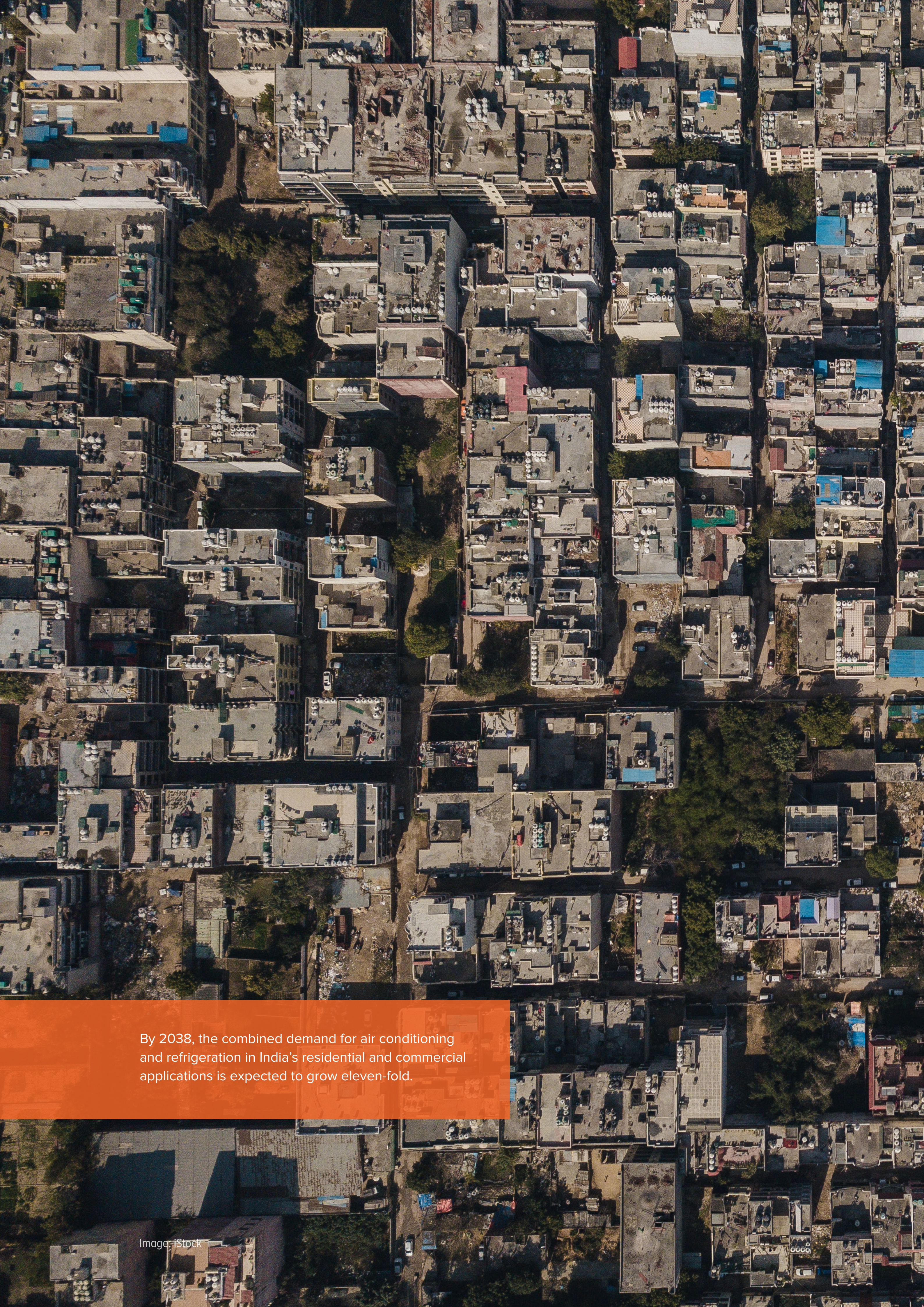
Note: Large enterprises are represented in the outer-most circle; medium-sized enterprises in the second largest circle; and small-sized enterprises are in the third largest circle. Industry Associations are represented in the inner-most circle.

Source:CEEW analysis, 2019

[153] Exchange calculated based on currency values as on 30 December 2018.

[154] Exchange calculated based on currency values as on 30 December 2018.

Image: iStock



By 2038, the combined demand for air conditioning and refrigeration in India's residential and commercial applications is expected to grow eleven-fold.

Image: iStock

5. Industry Challenges and Policy Responses to Propel Action to Phase-down HFCs

The intended phase-down for India only needs to begin after a decade, in 2028. As such, the transition and technology adoption will be contingent on firms' uptake and the technological diffusion in the market. This chapter highlights key challenges that various industry players foresee for India. Furthermore, this chapter seeks to develop an understanding of industry's policy needs and regulatory preferences to take on the challenge of transitioning away from HFCs in India.

This information is based on data collected through intensive interviews with 60 industry stakeholders (see Chapter 4 for more information) and analysed through the lens of grounded theory.

5.1 Constructing grounded theory: Barriers to transition

In order to analyse recorded data, the following steps were undertaken:

First, all interview transcripts were coded by lines or sections using interviewees' words, or to convey what the interviewee had meant by his/her statement. There were over 40 codes - a word cloud illustrates them (see Figure 7).

India's refrigerant transition and alternative technologies' adoption will be contingent on firms' uptake and the technological diffusion in the market

Figure 7: Word cloud: Coded interview data

Source: CEEW analysis,2019. Analysis was conducted on NVIVO

Second, all data were reorganised according to codes to identify emerging themes. At the end of this process, key themes and codes, as reflected in the data, emerged. Figure 8 highlights the main themes that emerged through this process of ‘axial coding’.

Figure 8: Axial codes used to construct grounded theory

Source: CEEW analysis, 2019. Analysis was conducted on NVIVO

Finally, the authors assessed the hierarchy of themes and challenges, as described in the data and the previous ‘coding’ steps - analysing themes, relationships, and the frequency of codes. Using these hierarchies, the data were re-coded to streamline the number of issue areas, and to understand any relationships between the stated challenges and policy requirements. The results of this analysis are presented below.

Barriers to transition

The main concern that all stakeholders shared was the lack of certainty surrounding policy.

'There is a need for policy. But when will it come and what will it affect?'[155]

'Will India commit to early action, or increase consumption and production to ease its phase-down?'[156]

'Government intervention in the form of policies is essential to market non-HFC refrigerants.'[157]

'If there is an established policy, clients will start demanding better products.'[158]

Government intervention in the form of policies is essential to market non-HFC refrigerants

'Industries can undertake the transition without a problem, but the government should give the go-ahead.'[159]

'We cannot simply leapfrog without the necessary market signals.'[160]

The largest drawback that unanimously came through in all interviews and interactions was that policy uncertainty prevents companies from making adequate changes to prepare to phase-down HFCs in India. Policy uncertainty was the most commonly cited challenge; and it was rationalised by industry stakeholders in what can be understood to be the need to ensure supply chain readiness and a valid justification for investments. These have been elaborated on below.

(I) Supply chain readiness

Within supply chain readiness are a range of issues that stakeholders raised as being critical barriers to a successful transition in India, preventing industry action:

Alternatives to high-GWP refrigerants

Applicability of alternatives

'If the Government tell us about existing systems and the gases required for them, it will be useful. Nobody will throw away their equipment - so, systems will persist, but what are the alternatives to HFCs?'[161]

'Currently, there is not enough technological know-how among entrepreneurs.'[162]

Stakeholders all spoke of the need for policy certainty to identify and invest in a low-GWP alternative to the in-use high-GWP refrigerants. While several advocated for natural refrigerants - ammonia and carbon dioxide, in particular - others debated the critical challenges associated with natural refrigerants, such as flammability, toxicity, and overall safety concerns. The authors, in an effort to remain technologically agnostic and to maintain confidentiality regarding companies' future strategies, refrained from elaborate conversations on this issue. However, a key takeaway from these interventions, especially from interviews with smaller

We cannot simply leapfrog without the necessary market signals

[155] Excerpt from an interview conducted by the authors.
[156] Excerpt from an interview conducted by the authors.
[157] Excerpt from an interview conducted by the authors.
[158] Excerpt from an interview conducted by the authors.
[159] Excerpt from an interview conducted by the authors.
[160] Excerpt from an interview conducted by the authors.
[161] Excerpt from an interview conducted by the authors.
[162] Excerpt from an interview conducted by the authors.

industry players, is that the lack of information on alternatives and their applications - including synthetic chemicals - is a major barrier to planning any transition strategy. Moreover, there is no government-issued publicly available evaluation that establishes the working references, and the applications of the available refrigerants and their performance in India. While several natural and synthetic refrigerants have been identified and are being deployed globally as alternatives to HFCs, their application is contingent on several factors - standards, charge limits, energy consumption levels, safety aspects, and performance indicators and references. Among smaller industry players,[163] these factors constrain future strategy and planning, especially in the face of policy uncertainty surrounding the phase-down in general, and alternatives' standards and applicability in India, in particular. A lack of public pilot programmes to test alternatives in India also contributes to the information barrier.

Availability of alternatives

'Planning for this policy must be done in accordance with the availability of alternative refrigerants.'[164]

'The costs shot up for CFCs to HFCs mainly due to HFC non-availability.'[165]

'The transition also depends on the prices of alternative refrigerants. If the prices are relatively low, the transition is likely to happen more quickly. Otherwise, industries will wait until the last possible moment to make the transition.'[166]

Industry players anticipate challenges associated with the availability and affordability of alternative refrigerants in the face of an HFC phase-down. This fear stems from a previous refrigerant transition in India that caused a dramatic rise in prices and an accompanying shortage in refrigerants in smaller cities and towns. This, in turn, led to the creation of an unorganised black market that sold the refrigerants, many of them uncertified blends, at an even higher price. The policy framework for any phase-down must include checks and balances, so that quality refrigerants are available in plenty in the market, and market capture through imports and shortage-induced price manipulations are kept in check. Regulating refrigerant availability through national production reports and a transparent analysis of imports, as well as indicating a maximum retail price for various refrigerants, may be policy measures to consider while creating a regulatory framework to phase-down HFCs in India.

Standards for alternatives

'The main problem is the lack of standards in India.'[167]

'The government needs to develop standards that should be very strictly implemented.'[168]

Although various alternative refrigerants exist for HFC-based applications in India, their uptake is contingent on charge size, safety standards, permissible ambient applications, etc. Several industry stakeholders have been working closely with the Bureau of Indian Standards (BIS) to reform and update standards for various low-GWP refrigerants; however, progress in this regard has been slow. Moreover, the lack of government authenticated performance and safety benchmarks for these alternatives also discourages their uptake; it also lowers stakeholders' willingness to invest in R&D to optimise the applications of these refrigerants in India. There have been

The main problem is the lack of standards in India

[163] In this report, "small" industry players are those with annual turnovers of under INR 5 crore (approximately USD 0.7 million).

[164] Excerpt from an interview conducted by the authors.

[165] Excerpt from an interview conducted by the authors.

[166] Excerpt from an interview conducted by the authors.

[167] Excerpt from an interview conducted by the authors.

[168] Excerpt from an interview conducted by the authors.

[169] Excerpt from an interview conducted by the authors.

discussions among industry agencies to begin a research and testing initiative to establish standards for alternatives in India.[169] However, government authorisation to establish technology references and standards remains paramount for the diffusion of alternative refrigerants. A fast-track window to develop or update different refrigerants' standards may indicate intentions towards a low-GWP transition. More significantly, it may facilitate fairer competition among various refrigerants in the market, rather than winners emerging inadvertently based on already-established standards.

It would also be useful to publish life-cycle assessments of alternative refrigerants before industry starts to transition to these, keeping in mind that several synthetic HFOs are being found to have negative environmental impacts and may be subject to global controls in the future.

Component availability and readiness

'So many technical changes need to happen in the meantime, particularly to compressors, system design, and other components.'[170]

'We should encourage micro and small and medium enterprises to build components to make our sector more independent.'[171]

Encouraging micro, small, and medium enterprises to build components can make India's HVAC sectors more independent

Certain degree of change is required in components and system design to allow for an alternative refrigerant. This is the case even with retrofit replacement gases, according to industry players who are using these. In order to invest in such changes to systems and components, a clear timeline of how a phase-down will affect each sector (and consequently, company) is required, so that component manufacturers and suppliers can prepare themselves. If this is not planned effectively as an opportunity for industries to upgrade their supply chains within India, factories and companies will be forced to rely on imports and international suppliers, instead of encouraging innovation and investments within Indian.

Service sector readiness

'In the future, several more gases – with different properties – will be used as refrigerants. If mechanics have no idea what gas is being used, results would be disastrous.'[172]

'Service technicians need to know about the different gases and how to handle them.'[173]

Several industry stakeholders (i) elaborated on the training programmes offered by their companies; (ii) commended peers for using low-GWP refrigerants, and for training technicians extensively and preparing the sector significantly for those specific gases; and (iii) volunteered resources and commitments to support government efforts to train more service technicians.

To maintain the quality and safety of servicing practices, a minimum standard for training programmes has to be established through updated curricula; and more significantly, this learning among service technicians needs to be certified. Many countries prohibit non-licensed or non-certified service technicians from installing, servicing, or repairing air conditioners or handling refrigerants. With certifications, social welfare and security can also be facilitated through targeted insurances and repeated training programmes for the technicians. Such a formalisation of this service sector will be necessary to create an ecosystem where multiple

[170] Excerpt from an interview conducted by the authors.
[171] Excerpt from an interview conducted by the authors.
[172] Excerpt from an interview conducted by the authors.
[173] Excerpt from an interview conducted by the authors.

refrigerant gases can co-exist in the Indian market; it will impact up to two million jobs in the industry.[174]

The government has indicated its intention to train and certify technicians as part of the National Cooling Action Plan draft.[175] Additionally, as part of its next leg of research, CEEW will focus on investigating training curricula and institutional requirements for updating training programmes and formalising this sector. Given the current informal nature of the industry,[176] several industry stakeholders spoke of the need for an updated labelling programme for equipment, perhaps using different colours, to identify refrigerants. Training programmes for the service sector would have to incorporate this information on labelling to ensure that personnel are able to quickly identify the colour-coded refrigerant and its properties for safe servicing practices. Moreover, the training programmes and the formalisation of the servicing sector should be accompanied by mandatory leak tests (in large and mobile applications especially), as well as standardised servicing practices. Good policy-directed practices that have already been introduced in India, such as the banning of disposable cylinders, must be implemented effectively.

End-of-life disposal

'There is a lack of infrastructure for recovery.'[177]

'Recycling and destruction is not financially feasible in India.'[178]

Recycling and destruction is not financially feasible in India

In India, there is no government mandate to effectively recover, reclaim, or destroy refrigerant gases. Even where facilities exist for the disposal of gases, the steep recovery and transportation costs act as disincentives. As such, incentives and regulations are necessary to ensure recovery. Countries that regulate the safe disposal of refrigerants (including HFCs) either rely on voluntary programmes (with incentives) or on robust regulations with enforcement mechanisms. Refrigerant recovery and recycling (R&R) was first introduced under the Montreal Protocol as a strategy to manage banned refrigerant banks.[179] To facilitate this, the Indian Government and Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) established eight facilities to reclaim contaminated refrigerant gases across India.[180] Further, portable R&R machines were provided to service technicians at subsidised rates to encourage on-site recovery.[181] Despite these efforts, refrigerant management through recovery, recycling, and reclamation has not taken off on a large scale in India.[182]

This part of the value chain in India remains severely constrained and misunderstood - the right infrastructure and incentives for recovering gases are lacking. For India to meet its targets of phasing down HFCs, end-of-life emissions must be reduced, as well as those created during-the operational life cycle of the refrigerant. Creating convenient and functional infrastructure, in parallel with establishing policy mandates, is crucial to ensuring safe and effective end-of-life management of gases. Given the lack of infrastructure, favourable policies, and business action in India on this front, it is necessary to identify and understand different business cases for effective policy implementation to this end.

[174] Excerpt Draft NCAP, Ozone Cell (2018)
[175] Draft NCAP, Ozone Cell (2018)
[176] Sridhar and Chaturvedi (2017)
[177] Excerpt from an interview conducted by the authors.
[178] Excerpt from an interview conducted by the authors.
[179] UNEP (1999)
[180] Ozone Cell (n.d.)
[181] Personal communication with an industry expert, who runs a reclamation facility in India.
[182] Devotta, Asthana, and Joshi (2004)

(II) Investment decisions

'We have a world-class R&D facility where we've tested non-HFC-based machines. But we are not selling these yet because they require huge investments.'[183]

'A lot of policies place the onus of change on industries, which entails a great financial burden.' [184]

'A new refrigerant often requires that the manufacturing line be updated, which necessitates more investment.'[185]

'Costs are forcing imports from China; even a 10 per cent increase is difficult for companies to absorb.'[186]

Costs are forcing imports from China; even a 10 per cent increase is difficult for companies to absorb

Any policy to phase-down HFCs will affect significant parts of the value chain; the transition will require investments and the upgradation of industrial supply chains in the HVAC sectors. For any change related to the manufacturing or adoption of an alternative refrigerant, there will be associated costs for companies. Investments will finance - in addition to the new refrigerant itself - safety measures on factory floors, infrastructure modifications, technology training programmes, new manufacturing facilities, system updates to adapt to new refrigerants, and other verticals. As highlighted earlier, even applications using gases that are meant to be drop-in retrofit alternatives to HFCs require some degree of component change. A policy directive would justify such an investment, especially given the cost-competitive nature of the Indian market.

Investment in R&D

'Currently, technological set up and R&D capacity are missing in India.'[187]

A regulatory framework that indicates a timeline for the phase-down of HFCs would also support timely investments in R&D and innovations. The R&D platform announced by the Government for developing low-GWP alternatives must be brought to life to pool investments, solutions, and technical fixes for the benefit of stakeholders in India.[188]

Investments in manufacturing

'Policy should immediately focus on increasing the price of imports to encourage manufacturing in India.'[189]

'There are three main challenges - supply chain, costs, and manufacturing.'[190]

There are three main challenges – supply chain, costs, and manufacturing

On the one hand, there is limited manufacturing of synthetic and natural low-GWP alternatives in India; on the other, as discussed in Chapter 1, air conditioning sectors are expected to grow very rapidly in the near future. A timely policy signal to move to low-GWP refrigerants would prompt refrigerant manufacturers to make investments to cater to this new need in the Indian subcontinent. This policy, in conjunction with the Make in India programme, could create a strategic opportunity for investments in this sector. The Government could also aim to raise tariffs on imported gases. A similar discourse applies to manufacturing components and products based on low-GWP refrigerants. Import

[183] Excerpt from an interview conducted by the authors.
[184] Excerpt from an interview conducted by the authors.
[185] Excerpt from an interview conducted by the authors.
[186] Excerpt from an interview conducted by the authors.
[187] Excerpt from an interview conducted by the authors.
[188] See Bhasin, Sridhar, and Chaturvedi (2017)
[189] Excerpt from an interview conducted by the authors.
[190] Excerpt from an interview conducted by the authors.

tariffs and quality mandates are also critical factors to consider when designing corresponding policies.

In addition to supply chain and investment concerns, there are other factors, as noted by several stakeholders across sectors and supply chain roles, that pose barriers to the phase-down of HFCs in India. These broadly relate to (1) policy coordination and effective policy implementation, and (2) consumer awareness.

Policy coordination and effective implementation

'Nobody wants to work in two phases – one, transition to a new refrigerant, and two, improve energy efficiency.'[191]

Given that refrigerant change will not occur in isolation, stakeholders across government agencies must cooperate to ease the transition, rather than imposing multiple mandates on industry. This will require policy cohesiveness between the Ozone Cell and other government agencies. A coordinated effort to meet India's HFC phase-down commitments can also benefit strategic industrial growth in cold chain development, enhanced energy efficient appliances, etc. Similarly, development and implementation of building norms, accompanied by the roll out of alternatives to HFCs for cooling needs, must be considered. In addition to coordinating policies to adopt new technologies, public procurement will play a key role in mobilizing demand and comfort with new technologies, and must be scaled up significantly and strategically.

Furthermore, the misuse or lack of compliance with government guidelines and norms, the sale of spurious or substandard components and gases, and the use of equipment in direct violation of regulations must all be checked. Ineffective policy implementation is a huge challenge in India - it is not limited to this sector. Adequate emphasis and energy must be devoted to understanding the barriers to effective implementation, and targeted solutions to these should be considered. Coordinated policy implementation is a large issue, much beyond the scope of the study at hand; thus no recommendations have been offered to this end.

Consumer awareness

'Public awareness is key to a smooth transition.'[192]

'The major hurdle is not the technology, but the willingness among consumers to change.'[193]

'Consumers do not always remember how 'green' a product is at the point of sale.'[194]

A central part of the value chain that requires transformation for the success of the impending HFC phase-down is related to consumer awareness and information dissemination. Data on the sales of star-labelled air conditioners (with high rankings and the promise of savings) indicate that most units being sold are not the most energy efficient.[195] Given the direct cost-savings benefit to end-users, how consumers can be encouraged to opt for low-GWP gases? Several stakeholders suggested that for the transition to be effective, intensive consumer awareness is needed to increase demand. To aid policy in this direction, CEEW will be conducting research to examine the role of awareness on consumer behaviour. Stakeholders suggested products labelling systems that indicate environmental performance or 'goodness'. Awareness building must also be included in larger training programmes for retail suppliers and sales teams.

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[191] Excerpt from an interview conducted by the authors.

[192] Excerpt from an interview conducted by the authors.

[193] Excerpt from an interview conducted by the authors.

[194] Excerpt from an interview conducted by the authors.

[195] Sharma and Shah (2017: 8)

As is evidenced by the challenges detailed above by industry stakeholders, there is a need for a policy framework to enable HFCs phase-down in India. The next section highlights industry's perceived desirability and impacts of regulations to this end, solely directed at phasing down HFCs.

5.2 Regulatory options for phasing down HFCs in India

This section presents an analysis of regulatory options based on stakeholders' responses and evaluations. The following policy preferences were presented to each interviewee. This list of policy options was based on the authors' mapping of global regulations - it was distilled to five options following consultations with experts from the Ozone Cell, civil society, and academia.

1. Quotas/cap and phase-down

Cap and phase-down, or a quota system, allows for a decrease in HFCs by placing limits on the maximum quantity of HFCs (in tonnes of CO_2 equivalent) permissible in the market. In practice, the total supply of HFCs will be limited, which will affect the quantity of HFCs produced and imported, including those contained in equipment. Capping the availability of HFCs can lead to shortages and a spike in gas prices. Therefore, effective implementation should include regulating recovery and operational containment (leakage avoidance) of the refrigerant to ensure most optimal use of available gas.

2. Tax-and-refund

This scheme imposes a tax based on the GWP value of the refrigerant, which is to be refunded when the refrigerant is recovered and destroyed. It is imposed during production, gas imports, or on equipment containing HFCs. The scheme is set up to implement a carbon equivalent tax on HFC emissions. This scheme also incentivises recovery of refrigerant as the tax amount would be fully refunded once the refrigerant is recovered and destroyed. The tax is applicable on products as well as on gases at production facilities for refrigerants. In keeping with international trade law, taxation will also be applied on imports of refrigerants (as bulk gas or in appliances).

3. Limits on GWPs and incentives for low-GWP products (hereafter GWP limit)

This scheme would entail establishing a GWP limit on refrigerants to signal markets towards an HFC-free transition. This limit would be imposed for each application, based on the two or three lowest GWPs that exist in the market for each specific application or equipment. It could be implemented such that the status quo of refrigerant usage is allowed to continue until the year(s) of implementation by when the GWP limit would come into order. The limits may also be supported by a financial incentive to the end-user who will receive a rebate on the final sales prices of low-GWP products, making them competitive with the lower-cost high-GWP products already on the market.

4. Environmental cess

The Indian Government may impose an 'environmental cess' or 'HFC levy' based on the GWP value of the refrigerant in use. Refrigerant manufacturers would pay the tax, and it would trickle down the supply chain to consumers purchasing equipment or refrigerants.[196] The increased prices of refrigerants would translate into improvements in maintenance, leakage control, charge size, and the use of low-GWP alternatives. Equipment costs may increase or decrease depending on charge size, type of refrigerant, and leakage rates. Moreover, this additional revenue from the 'cess' or 'levy' may be used towards adequate disposal of the refrigerants to minimise end-of-life emissions.

[196] The same cess would be applicable on the volume of the gas being imported (in bulk or in equipment).

5. Subsidies for using low-GWP refrigerants and products

The phase-down of HFCs is expected to cause market shock, including gas shortages, price hikes, resentment among stakeholders, etc. Incentives, such as subsidies on low-GWP alternatives, can provide stakeholders the motivation to make the shift. The Indian Government could introduce subsidies for refrigerant users to encourage a market transition to low-GWP, natural and/or royalty-free refrigerants. Moreover, such programmes and schemes would be likely to increase overall awareness and willingness in the industry to adopt low-GWP refrigerants.

Respondents were requested to indicate the desirability and perceived impact of the above policies on two Likert scales (depicted earlier in Table 2). The evaluation form provided to stakeholders during interviews is part of a larger questionnaire provided in Annexure III of this report. Data from these indicators have been presented below. The following subsections also include insights from interviews with stakeholders - why a policy was favoured and their anticipated challenges towards its implementation.

Identifying policy impact and desirability

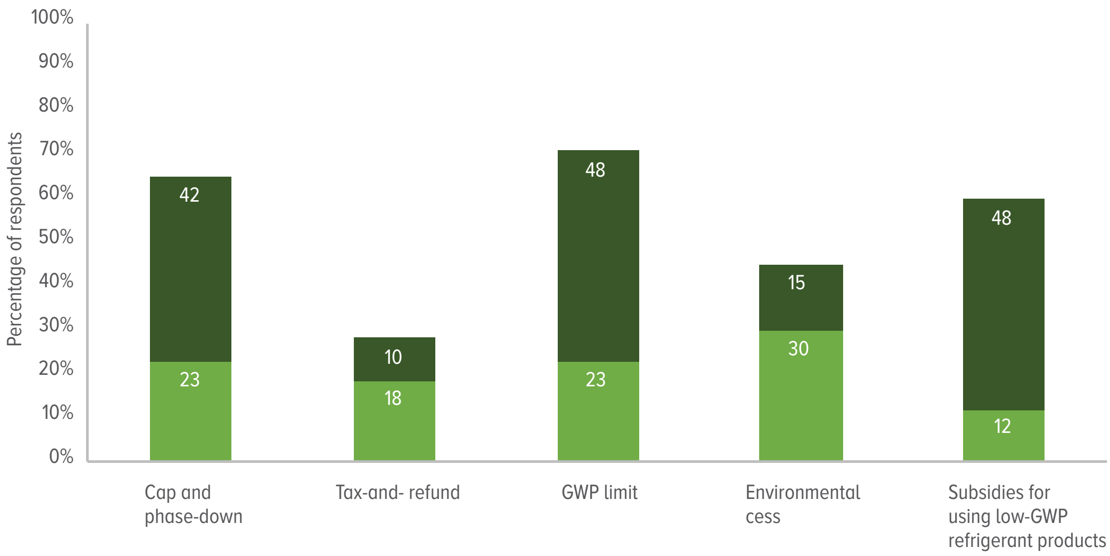
Subsidies and the GWP limit were the top choices

i. Impact

The subsidies and GWP limit policy options were considered the top two 'most impactful' interventions, as indicated by an equal number of respondents. Cap and phase-down was rated by 42 per cent of respondents as 'most impactful' (see Figure 9).

Most respondents indicated that the tax-and-refund policy would have little or no impact in India due to the lack of recovery, recycling, and destruction infrastructure. However, a combined total of 28 per cent stakeholders rated tax-and-refund either as 'mildly impactful' or 'most impactful'. With regard to the environmental cess policy, 45 per cent of the stakeholders indicated that it would have positive impact (aggregated responses for 'mildly impactful' and 'most impactful') (see Figure 9).

Figure 9: Respondents' perceived positive impact on policy choices



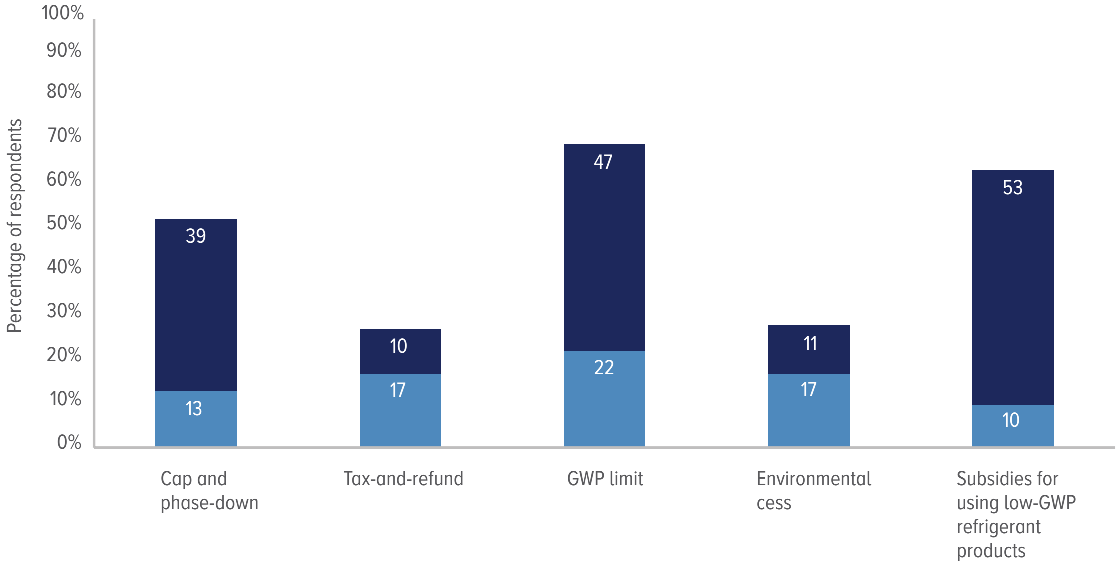
Note: Positive impact includes respondents' marking a policy as 'mildly impactful' and 'most impactful'.

Source: CEEW analysis, 2019

ii. Desirability

The subsidy-based policy instrument was marked as 'most desirable' by 53 per cent of the respondents. This policy instrument incentivises industry to lower the sale prices of products or to invest in the use of low-GWP refrigerants. The second 'most desirable' policy, which had the support of 47 per cent of respondents, was the one that would place hard limits on the GWP of HFCs, according to the application. This essentially places a medium- to long-term minimum standard or benchmark on the GWP value of refrigerants based on existing commercial technology offerings in the market (see Figure 10).

Figure 10: Respondents' perceived positive desirability on policy choices



Note: Positive desirability includes respondents' marking a policy as mildly impactful and most impactful.

Source: CEEW Analysis, 2019

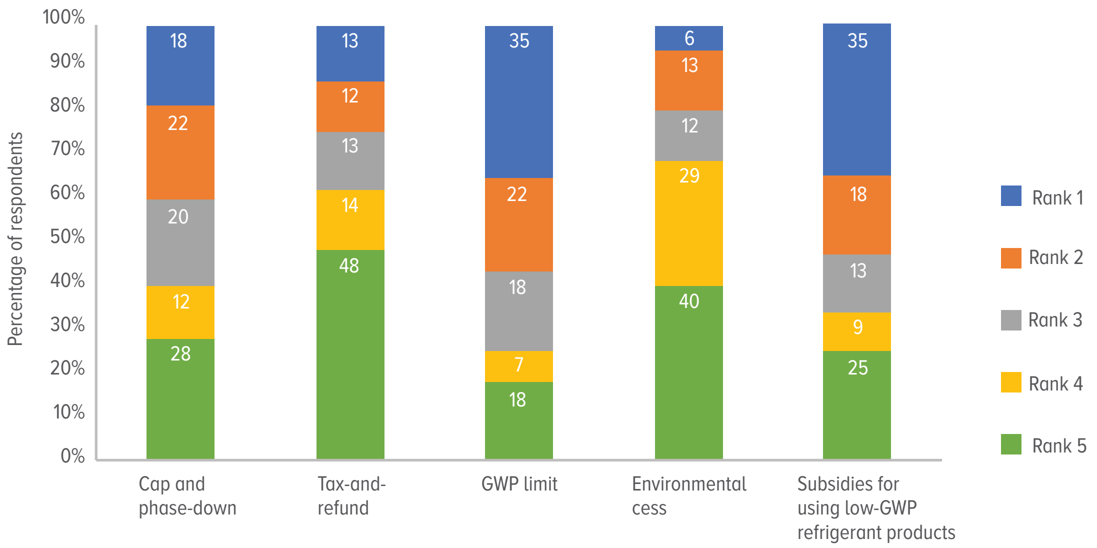
It is noteworthy that none of the interviewees indicated 'least desirable' for subsidies or GWP limit-based policy instruments. The tax-based policy instruments - the tax-and-refund and environmental cess policy options - were the least popular, with less than 30 per cent of respondents rating them as positively desirable (aggregated responses marked as 'mildly desirable' and 'most desirable') (see Figure 10). Cap and phase-down, the regulatory approach applied in India during previous refrigerant transitions,[197] was the 'most desirable' policy option according to 39 per cent of respondents.

iii. Ranking

Based on impact and desirability, the top policy choices according to most respondents were the subsidy-based and GWP limit policy instruments (see Figure 12). Between the two, GWP limit was ranked '5' (which is the lowest rank awarded) by 18 per cent of the interviewees, whereas 25 per cent of the interviewees ranked the subsidies based policy thus (Figure 11). This could be indicative of stakeholders' low confidence in subsidies due to the potential for misuse. Cap and phase-down emerged as the third choice. The tax-based policies (tax-and-refund and environmental cess) received the highest share of negative responses (ranks '5' and '4').

[197] MoEFCC (2014)

Figure 11: Policies rankings by respondents



Source: CEEW analysis, 2019

As a part of this study, the authors organised an industry roundtable to present the preliminary findings from 30 stakeholder interviews. The initial assessment yielded the same results as noted for the final 60 interviews; that is, the GWP limit and subsidy-based policy instruments emerged as the top choices. All stakeholders[198] who participated in the roundtable agreed unanimously with these initial findings. Many also indicated that a combination of subsidies and a GWP limit would facilitate a quicker transition away from high-GWP HFCs.

Overall, considering the desirability, perceived impact, and the rankings of policies as reported by stakeholders, subsidies for using low-GWP refrigerant products emerged as the most favoured option, with the GWP limit in a close second. When positive impact and desirability were considered GWP limit emerged as the top policy. Due to the high investment costs associated with transitioning to low-GWP alternatives, especially for primary refrigerant consumers, stakeholders favoured a policy that provides financial support. The availability of low-GWP technologies, both for refrigerants and the associated components, especially for the RAC and MAC sectors, may have resulted in the GWP limit being deemed the next best policy. Many regarded a quota-based policy as appropriate for India because of their familiarity with the cap and phase-down model used in previous such transitions.

We explore these outcomes further by closely evaluating if the different classifications of stakeholders exhibited different policy choices.

Few respondents provided conflicting evaluations in terms of their preference for, and the perceived impact of, a policy choice

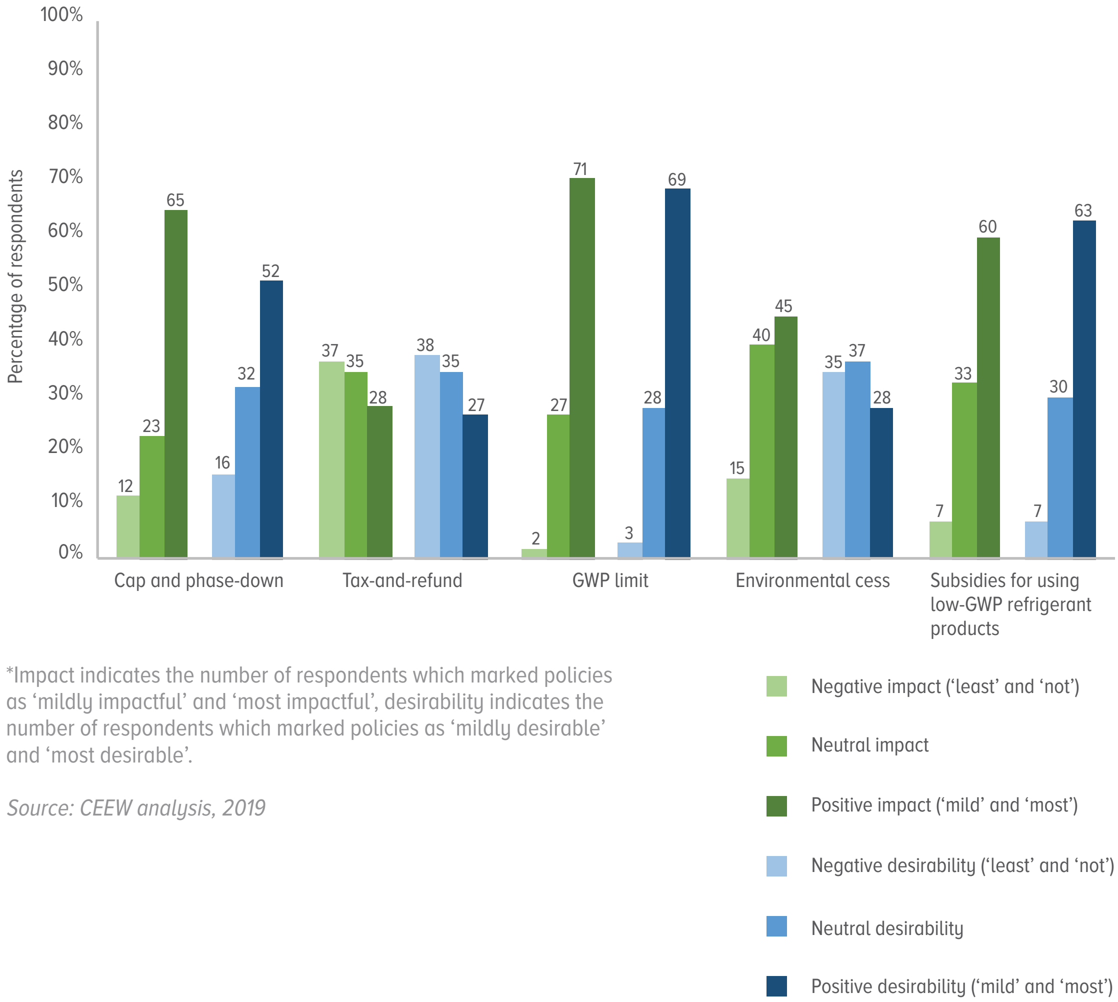
A pattern observed during interviews was that many stakeholders rated the perceived impact and their preference for policies on the same level in the Likert-scale. While designing the questionnaire, it was hypothesised that respondents would evaluate policies such that there may be a difference between the perceived sector-wide impact and company/personal preferences. Overall, less than 40 per cent of respondents made such a distinction with at least one policy. The policy with the greatest percentage of dissonant ratings was the cap and phase-down intervention. Most respondents indicated that this quota-based policy was 'most desirable' or 'mildly desirable', citing ease and familiarity with its implementation; however,

[198] The stakeholders that participated in the industry roundtable were chosen at random from our database of key industry players. Furthermore, as we had completed more than 30 interviews by that point, it was not necessary to represent the stakeholders at the roundtable in the preliminary results.

based on prior experience with the HCFC phase out, stakeholders indicated that it may not be impactful. Shortage of refrigerant gas was one of the biggest anticipated challenges associated with this policy.

For the tax-based policies, a little over 50 per cent of the stakeholders provided different ratings for desirability and impact (more so for environmental cess than tax-and-refund). For the top two policy choices (i.e. subsidies and GWP limit) such differences in ratings of desirability, impact, and ranking were not apparent as less than 10 per cent respondents made such a distinction.

Figure 12: Comparison between impact* and desirability* of the policy options



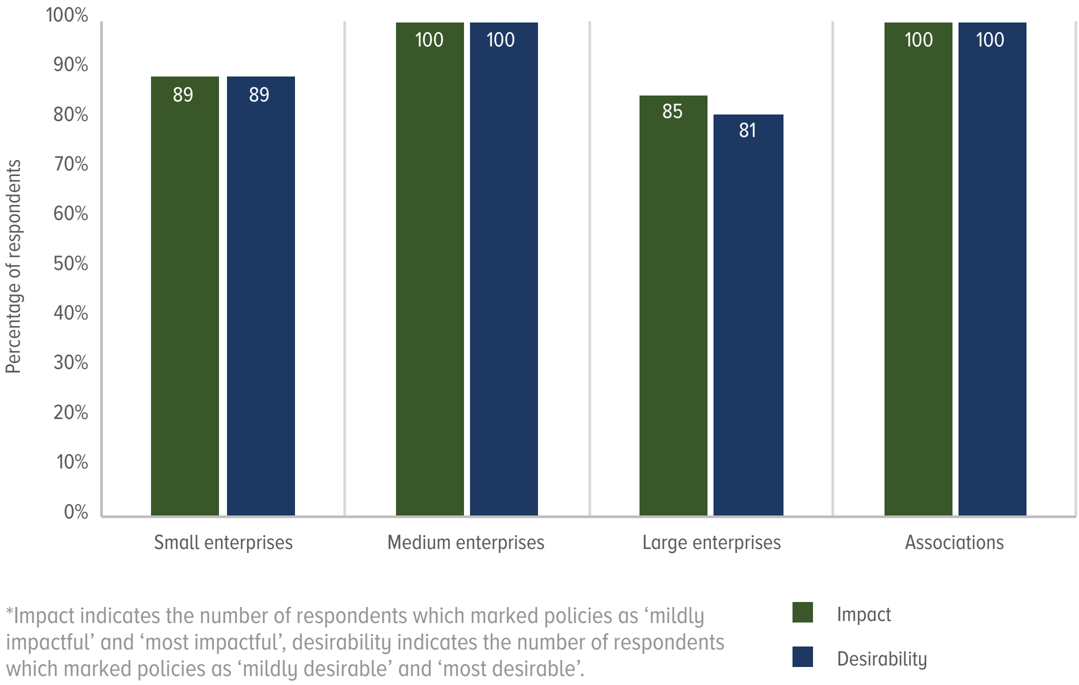
*Impact indicates the number of respondents which marked policies as 'mildly impactful' and 'most impactful', desirability indicates the number of respondents which marked policies as 'mildly desirable' and 'most desirable'.

Source: CEEW analysis, 2019

Policy preferences, based on respondents' enterprise sizes

Stakeholder companies were classified as small, medium, or large enterprises. Associations were treated as a separate category.

Figure 13: 'GWP limit' was the top policy choice across companies of different sizes based on impact* and desirability*



*Impact indicates the number of respondents which marked policies as 'mildly impactful' and 'most impactful', desirability indicates the number of respondents which marked policies as 'mildly desirable' and 'most desirable'.

Source: CEEW analysis, 2019

The top three policy choices for stakeholders, grouped according to their enterprise sizes, were the same as in the macro-level analysis - cap and phase-down, the GWP limit, and subsidies on low-GWP products. However, the responses for the top policy varied in terms of desirability and perceived impact (see Table 7). Among large companies, the GWP limit-based policy was the most popular. Interestingly, the subsidy-based policy was a close second, both in terms of desirability and impact. Among medium-sized enterprises, again, the GWP limit was a popular policy choice when considering impact. However, 92 per cent of stakeholders in this category marked the subsidy-based policy choice as 'most desirable'. Small enterprises deviated from the above trend; 78 per cent believed that cap and phase-down would be 'most impactful'. However, the subsidy-based policy was considered 'most desirable' by this group. Among industry associations, 100 per cent of respondents deemed the subsidy-based policy as 'most impactful' and 'most desirable'.

In terms of positive preference and impact (aggregate sum of responses for 'mildly' and 'most'), more than 80 per cent of the small, medium and large enterprises, including a 100 percent of associations, placed GWP limit on the top (see Figure 13). Remarkably, the subsidy-based policy instrument emerged as close second as denoted in table 7. Cap and phase-down emerged as a top choice only once in this evaluation - 89 per cent of small enterprises indicated positive desirability for this policy.

Table 7: Impact and desirability of policies according to enterprise size

Type	Most impactful	Most desirable	Positive impact (sum of 'most' and 'mildly')	Positive desirability (sum of 'most' and 'mildly')
Small	Cap and phase-down (78%)	Subsidies on low-GWP products (78%)	GWP limit (89%)	Cap and phase-down and GWP limit (89% each)
Medium	GWP limit and subsidies on low-GWP products (64% each)	Subsidies on low-GWP products (92%)	GWP limit (100%)	GWP limit and subsidies on low-GWP products (both 100%)
Large	GWP limit (60%); subsidies on low-GWP products (58%)	GWP limit (57%); subsidies on low-GWP products (55%)	GWP limit (85%); Subsidies on low-GWP products (84%); cap and phase-down (82%)	GWP limit (81%); subsidies on low-GWP products (80%)
Associations	Subsidies on low-GWP products (100%)	Subsidies on low-GWP products (100%)	Subsidies on low-GWP products and GWP limit (both 100%)	Subsidies on low-GWP products and GWP limit (both 100%)

Numbers in the parenthesis indicate the percentage of stakeholders belonging to a given company type that picked the given policy. The top three policy choices were: GWP limit, cap and phase-down, and subsidies for low-GWP products (in no particular order).

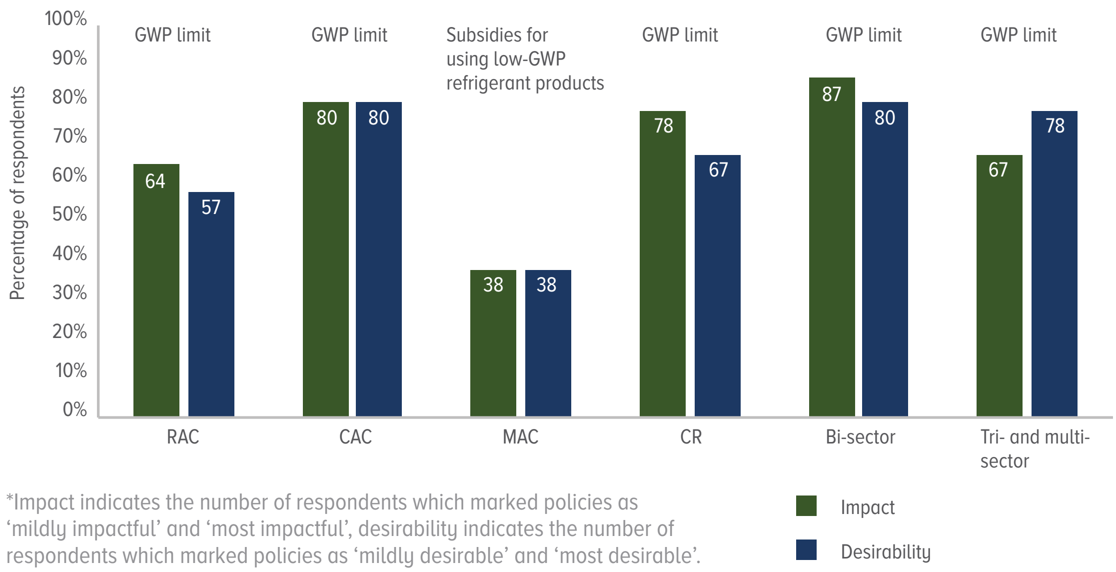
Source: CEEW analysis, 2019

Sectoral trends

We next examined stakeholder responses on a sectoral basis to see if there was any marked deviation from the macro-level analysis. As highlighted in Chapter 4, the stakeholders interviewed for this study belonged to the RAC, CAC, MAC, and CR sectors. Additionally, stakeholders that operated in more than one sector were considered under caveats of bi-sector (RAC/CAC), tri-sector (RAC/CAC/CR) and multi-sector (RAC/CAC/MAC/CR). In this section, stakeholders operating under multiple sectors such as bi-, tri and multi-sectors are considered as a separate sectoral classification, as seen in Figure 14. Annex VI provides sector-specific results for RAC, CAC, MAC and CR sectors after including respondents representing multiple sectors in each of the sectors that they represent. For example, if a company operates in both RAC and CAC space, its response in these graphs has been included in both RAC and CAC sectors. The results from these graphs in Annex VI should be read as the collective opinion of all the interviewed experts working in a given sector, irrespective of whether they operate only in this sector or across multiple sectors.

None of the sectors showed an obvious deviation from the main finding - the top three policy choices were cap and phase-down, the GWP limit, and subsidies for low-GWP products. However, among these top three policy choices, sector-wise differences were observed. For example, the CAC , bi-, tri- and multi-sectors indicated the GWP limit to be 'most' desirable and impactful. In contrast, the RAC, MAC and CR sectors considered the subsidy-based policy as ‘most’ desirable and impactful. For RAC, MAC and CR, every stakeholder that indicated ‘most desirable’ also chose ‘most impactful’ for their chosen policy option. Interestingly, cap and phase-down was more likely to be perceived ‘most impactful’ than ‘most desirable’ by stakeholders in the RAC, MAC and CR sector stakeholders. The opposite was found to be the case for the remaining sectors.

Figure 14: Top policy choices based on impact* and desirability*



*Impact indicates the number of respondents which marked policies as ‘mildly impactful’ and ‘most impactful’, desirability indicates the number of respondents which marked policies as ‘mildly desirable’ and ‘most desirable’.

Source: CEEW analysis, 2019

The two tax-based policies were the least popular in all four sectors. Between the two, tax-and-refund was rated lower by a greater number of stakeholders from each sector. The CAC sector had the highest number of respondents indicating least desirability, for the tax-and-refund policy, followed by tri-and multi-sector stakeholders. Notably, across all sectors, the GWP limit had the lowest number of negative desirability ratings.

As indicated in figure 14, in terms of positive impact and desirability, GWP limit was the top policy choice for all sectors, except MAC. MAC sector stakeholders indicated the subsidies-based policy as their top policy choice (38 per cent), followed by GWP limit (25 per cent).

For cap and phase-down, a greater proportion of stakeholders, from across the sectors, indicated a positive impact relative to those that indicated a positive preference. For example, while 71 per cent of RAC stakeholders indicated that cap and phase-down would have a positive impact, only half of these preferred this policy. For the subsidies-based policy, on the other hand, the proportion of respondents indicating positive preference or impact was generally lower than that observed for the GWP limit policy. Therefore, cap and phase-down and the subsidies-based policies were a close second after GWP limit. Furthermore, the tax-based policies (tax-and-refund and environmental cess) were the least popular policy options across the sectors.

There were no significant deviations from the overall trend among stakeholders belonging to different sections of the supply chain. For each supply chain role, subsidies and the GWP limit (in this order) emerged as the top policies, with cap and phase-down as a close third.

Thus, based on the 60 stakeholder interviews, the most popular and feasible policies are (i) subsidising the use of low-GWP products, (ii) placing a limit on the GWP of refrigerants, and (iii) the cap and phase-down approach. While cap and phase-down finished in a close third, the subsidy-based and GWP limit-based policy instruments emerged as the two most popular, based on ranking, impact, and desirability. Between these, the GWP limit-based policy instrument was most popular, despite the deviations observed under specific conditions. At the macro-level, the aggregate positive responses for preference and impact were noticeably higher for the GWP limit option than for the subsidies-based policy instrument. Given that this policy choice was also validated as a key outcome of a closed-door industry roundtable that the research team hosted to share initial research results, the authors are able to conclude that a policy placing a medium-term GWP limit on refrigerant-based applications, based on current commercial viability, is the most preferred industry option for establishing India's HFC phase-down.

In addition to the above, ancillary policies to facilitate other refrigerant management strategies will perform a crucial role in the nation's phase-down strategy. These alternate management practices could help improve servicing standards, and introduce a certification system for service sector professionals in limiting leakages and end-of-life recovery of refrigerant gases. As highlighted in the section on grounded theory, there is an industry-wide inclination towards the impending HFC transition. However, the supply chain, policy directives towards better management of the refrigerant during its operations through service sector training programmes and certifications, and end-of-life disposal must be adequately readied for the regulatory framework controlling HFC emissions to be impactful.

A regulatory framework to phase-down HFCs, if developed with multiple government agencies and stakeholders, can yield several development gains for India in its quest to cool.

Image: Pexels

6. Conclusion

This research study investigated the role of regulations in facilitating a transition away from HFCs. As the key protagonist in undertaking this transition will be industry, the research highlights their anticipated challenges and perceived policy barriers in phasing down HFCs. This research effort has been based on an extensive literature review and study trips by the authors, frequent consultations with government officials and experts from academia and civil society, in-depth interviews with 60 industry stakeholders, and a thorough qualitative analysis of the data collected.

Chapter 3 highlights the policy instruments and regulatory approaches that have been used by other countries to meet phase-down targets, which may be instructive for India. Chapters 3 and 4 also outline the layers of stakeholders that need to be engaged in creating a cohesive regulatory framework, and highlights that industry lies at the centre of all successful transitions that have so far been mapped in the Montreal Protocol. In Chapter 5, a grounded theory was constructed based on interviewee responses regarding challenges impeding action towards phasing down HFCs in India. This analysis reflected a unanimous need for policy certainty in order to support a national transition away from high-GWP HFCs and towards low-GWP refrigerants. The need for policy certainty is tied to challenges associated with supply-chain readiness and the significant investments that industry will need to make. Moreover, different policy approaches were presented to industry representatives, and the most desirable and impactful policies for India were identified.

Some of the key conclusions that have emerged as a result, and some further areas that require research attention, are highlighted below. In addition, the main challenges for the impending transition to low-GWP refrigerants in India, and policy actions and actors that may respond to these, have been put forth in Figure 14.

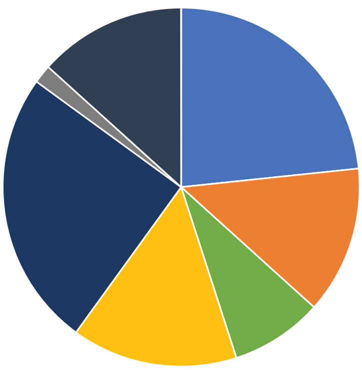
This research effort has been based on an extensive literature review and study trips by the authors, frequent consultations with government officials and experts from academia and civil society, in-depth interviews with 60 industry stakeholders, and a thorough qualitative analysis of the data collected

Figure 15: Challenges and policy recommendations; enabling India's transition to low-GWP refrigerants

Industry group classification of survey respondents

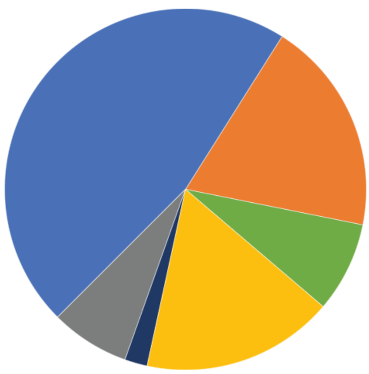
By sector

23%	RAC
14%	MAC
8%	CAC
15%	CR
25%	Bi-sector (RAC/CAC)
2%	Tri-sector (CR/RAC/CAC)
13%	Multi-sector (RAC/CAC/MAC/CR)



By supply chain role

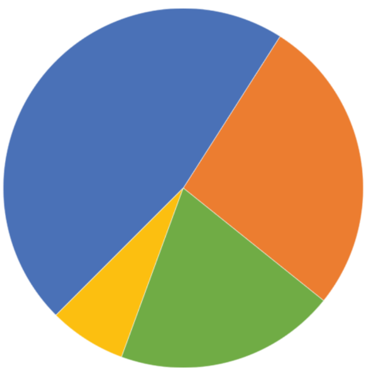
47%	Primary refrigerant consumers
19%	Component manufacturers/suppliers
8%	Refrigerant manufacturers/suppliers
17%	Consultants and service providers
2%	Commercial users of product
7%	Associations



Source: CEEW compilation, 2019

By size of enterprise

46% Large
27% Medium
20% Small
7% Associations



Policy recommendations
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Industry group	Challenge to transition
All	Investment justification and supply chain readiness
Small enterprises (across supply chain roles)	Alternative refrigerants' applicability
Refrigerant suppliers; primary users of refrigerants; commercial users of refrigerants	Alternative refrigerants' availability and affordability
All	Alternative refrigerants' standards and benchmarks
Component manufacturers and suppliers; commercial users of refrigerants; primary users of refrigerants; industry associations	Component availability and readiness
All	Service sector readiness
Primary and commercial users of refrigerants; service sector associations; other industry associations	End-of-life disposal
Medium enterprises (particularly: component manufacturers and suppliers; and primary users of refrigerants)	Investment in R&D
Refrigerant manufacturers; primary and commercial users of refrigerants	Investment in manufacturing
Large and medium enterprises (across supply chain)	Policy coordination
Primary users of refrigerants; service sector associations; refrigerant manufacturers and suppliers	Consumer awareness

Source: CEEW compilation, 2019

Policy recommendation	Key policy stakeholders
Medium-to long-term policy certainty to signal upcoming market reform to industry and regulators. **Imposing medium-term limits** on the permissible GWP value as per India's phase-down timeline, based on current commercial viability for refrigerants specific to every application.	Ozone Cell, MoEFCC
Publish government authenticated list of refrigerant alternatives and their application benchmarks specifically for India. **Increase pilot programme** to test and adjudge alternative refrigerants' applicability and usability in India. **Increase public procurement** of equipment using alternative refrigerants, especially those with energy efficiency gains.	Ozone Cell, MoEFCC; Department of Science and Technology; Ministry of Commerce and Industry; Ministry of Power
Indicate a medium-to long-term policy for refrigerant manufacturers and suppliers to ensure availability. **Create checks and balances** in the refrigerant market to ensure availability and affordability: • Institutionalise production and consumption reporting. • Establish a maximum pricing cap on refrigerants. • Effectively check stockpiling and illegal imports through stricter reporting and custom controls. • Ensure the quality of refrigerants through increased testing facilities.	Ministry of Finance; Ozone Cell, MoEFCC; Ministry of Commerce and Industry
Develop a fast-track window to update and develop standards for alternatives to high-GWP refrigerants. **Create government authorised benchmarks** for referencing these technologies usage.	Ministry of Consumer Affairs, Food & Public Distribution; Ozone Cell, MoEFCC; Department of Science and Technology
Indicate a medium-to long-term policy for component manufacturers and suppliers to ensure availability of components. **Public procurement programmes** can support development of know-how within component manufacturers and suppliers on reforms in value chain for low-GWP end-products.	Ozone Cell, MoEFCC; Ministry of Commerce and Industry
Large-scale trainings and certification schemes for service sector technicians. **Mandate good-servicing practices** to be employed across sectors. **Update curricula for trainings, and trainings of trainers,** to include low-GWP alternative refrigerants. **Create a labelling system** to help easily recognise the type of refrigerant in an equipment/ product.	Ozone Cell, MoEFCC; Electronics Sector Skill Council of India, Ministry of Skill Development and Entrepreneurship; Ministry of Commerce and Industry; Ministry of Human Resource Development
Establish infrastructure and a mandate to enable safe disposal of refrigerants.	Ministry of Power; Ozone Cell, MoEFCC
Institutionalise the collaborative R&D programme announced by Government in September 2016 to encourage innovations to support this transition. **Medium- to long-term policy certainty** on HFC phase-down plan for India.	Ozone Cell, MoEFCC; Department of Science and Technology; Prime Minister's Office
Recognise cooling sectors as strategic within industry-focussed programmes such as Make in India. **Assess the potential of import tariffs** on refrigerants and components that are being/have potential to be manufactured in India. **Establish mandates for certified quality and standards** on components to discourage their imports.	Ministry of Commerce and Industry; Ministry of Finance; Ozone Cell, MoEFCC; Ministry of Consumer Affairs, Food & Public Distribution
Minimise competing policy mandates on the sectors in a systematic manner. This would include issuing technological guidelines or mandates to ensure: • Energy efficiency enhancements are aligned with the impending refrigerant transition. • Building norms reflect the need for climate-friendly cooling or space comfort. • Cold chain development takes into account the impending refrigerant transition.	Ministry of Power; Ministry of Consumer Affairs, Food and Public Distribution; Ministry of Commerce and Industry; Ministry of Housing and Urban Affairs; Ministry of Food Processing Industry; Ozone Cell, MoEFCC
Demand-creating consumer awareness programmes for low-GWP products. **Labelling programme to suggest environment-friendliness** of appliances in addition to energy efficiency.	Ministry of Consumer Affairs, Food and Public Distribution; Ozone Cell, MoEFCC

Key results

- Policy certainty is key to realising India's international commitments to phasing down HFCs. This is most relevant for industry, as a policy signal will help create supply-chain readiness and justify the extensive investments that are necessary to this end.
- Putting a medium-term limit on the global warming potential (GWP) of HFC refrigerant gases for each specific application based on current commercial viability would be a welcome and unique approach to ensuring a refrigerant transition in India. In addition, incentives for end-user to opt for low-GWP based products would be an ideal policy package to phase-down high-GWP HFCs.
- Checks and balances in the implementation of a refrigerant-focused policy are critical to its success in India. This includes institutionalising measurement, review, and verification (MRV) systems and agencies; controlling stockpiling and the emergence of a second-tier 'black' market; regulating the availability and pricing of refrigerants to avoid market manipulation; and bringing out clear standards and safety mandates for all refrigerants to be able to compete in the Indian market.
- Information on the refrigerant transition must be widely disseminated. This is important for consumers (to change purchasing behaviour and demand), industry (to prepare itself for the impending refrigerant transition), and service sector technicians (to ensure safety and proper maintenance).
- Ancillary policies that support domestic competitiveness in manufacturing and in research and development, and which will subsequently limit reliance on non-certified imported components and products, would support India's HFC phase-down strategy and would also enable development and economic gains for the country.

Areas for further research

- Achieving universal certification for all service technicians, formalising the service sector, developing standards and technology references, achieving refrigerant transition with energy efficiency - these are all areas that require further focus and analysis. Both government and industry are aware of these challenges, and there are discussion and efforts underway to address these challenges. However, India focussed research on setting such targets and ways of achieving them is missing.
- An part of the refrigerant value chain that is being critically ignored in India and which urgently requires research, is managing EOL emissions from refrigerants. Policy mandates, business cases, infrastructure, and incentives are all lacking, and must be understood and organised in order to target action to address this important gap.
- A structured analysis of barriers and behaviours to enable the effective implementation of policies is another research area that needs to be addressed, although it goes much beyond the study of HFC transitions, per se.

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Annex I.

Literature Review

The reader should please note: Chapter 1 includes information taken from this literature review, and may be repeated below. This literature review was finalised in October 2018, and does not include policies that have come into effect since.

I. Introduction

The Council on Energy, Environment and Water (CEEW) has published pioneering research on several HFC-related issues in India. It has made a business case for phasing down HFCs, modelled India's long-term HFC emissions, calculated the mitigation potential and cost to the economy of a HFC phase-down, evaluated the skill gap in the air conditioning service sector, and developed an R&D platform to facilitate a systems-level cross-sector transition to low-GWP refrigerants. Continuing its efforts to explore ways of phasing down HFCs and sourcing alternative refrigerants, CEEW signed an agreement with the Government of Norway on 29 November 2017 to collaborate on researching the phasing down of HFCs in India through incentives and regulatory approaches (HIIRA).

One of the key research questions that the HIIRA research programme aims to answer relates to the existing policies and regulations in other countries that are enabling the phase-down of HFC consumption and emissions.

Understanding the suite of policies that have facilitated a HFC phase-down in other countries is crucial to being able to learn and assimilate their best practices, before assessing their applicability and feasibility in India. This report aims to provide a succinct overview of existing literature on international HFC phase-down policies and regulations, as well as the role of the private sector in the success of the Montreal Protocol thus far. As part of the HIIRA research programme, CEEW's HFC research team travelled to Norway and Sweden in December 2017 to meet key technical and policy experts. Those meetings helped draw out lessons, incentive schemes, and regulatory measures that may be relevant for India's transition away from HFCs. The key takeaways from this study trip have been put forward in Annex II.

Alternatives to HFCs

India has committed to limiting future use of HFCs domestically, as per the Kigali Amendment to the Montreal Protocol.[199] According to the Agreement, India will have to freeze its HFC usage and peak by 2028, and reduce this amount by 15 per cent (2025 levels) by 2047.

Internationally, both natural and synthetic refrigerants are being used as HFC alternatives. Some refrigerants that are relevant for India are listed below, along with information on patents, identified as one of the key barriers to a successful HFC phase-down. On other challenges facing refrigerant transition, Polonara et al. (2017) succinctly note that the uptake of HFC-free alternatives is restricted by standards. Enabling a transition to low-GWP refrigerants will be contingent on a revision of standards, the alternatives' energy consumption and efficiency, flammability and safety, costs and national regulations.

[199] TAs Bergeson (2017) explains, "most Article 2 parties reducing HFCs by 10% by 2019, and by 85% by 2036 relative to production and consumption levels in 2011–2013. The majority of Article 5 Parties -- including China and Latin American, African, and island nations – will follow on a similar trajectory, with a freeze by 2024 and then a reduction of 80 percent by 2045 relative to production and consumption levels in 2020–2022. Parties agreed to flexibilities to meet the demands of a global HFC phase-down with respect to a small number of countries. This small group of countries will freeze their consumption by 2028". India is a part of the latter.

According to Velders et al. (2009), flammability, access to patented technology, health and safety, and other concerns are at the forefront of a transition away from HFCs in India. Translating scientific and theoretical findings into a positive narrative around low-GWP refrigerants would require cohesive policy and firm-level actions, consumer awareness programmes, and technical training and education.

CEEW's seminal research on HFC emissions in India pointed out that there are significant opportunities to reduce HFC consumption and emissions in India if the technical and financial challenges (e.g. flammability and safety, patents, performance in high ambient conditions) to the adoption of alternatives available for various sectors are overcome... ***Therefore, adequate domestic policy measures are required to increase incentives and to adopt regulations for more energy-efficient appliances in the phase out of HCFCs and the phase-down of HFC."***[200]

In order to understand what these domestic policies may capture, this report looks to existing literature to highlight (1) existing international policies and programmes that are tackling HFC phase-down, and (2) the role of industry in meeting the Montreal Protocol commitments so far.

Table 1: Plausible HFC-alternatives for India*

Sector	Baseline Refrigerant in Use	Low-GWP Alternative	GWP	Patent Status/Information
Commercial Air Conditioners	HFC-134a	R-32 + HFO blend	92–1577	R-32 generic
		R-134a + HFO blend	>547	R-134a's patent expired in 2015
		R-1234yf	<1	Patent will expire by 2025
		R-1234ze	6	MexichemAmanco Holding S.A. de C.V (filing date 16 April 2010) (application suspended)
	HCFC-22	R-32 + HFO blend	675	R-32 generic
		R-290	3	MexichemAmanco Holding S.A. de C.V (filing date 24 June 2011)
		R-1270	2	MexichemAmanco Holding S.A. de C.V (filing date 16 April 2010)
	HFC-22	N20 (R-32 + HFO blend)	675	Honeywell
		Water		Generic
		R-290	3	MexichemAmanco Holding S.A. de C.V (filing date 24 June 2011)

[200] Purohit et al. (2016)

Sector	Baseline Refrigerant in Use	Low-GWP Alternative	GWP	Patent Status/Information
Commercial Refrigeration	HFC-22	R-717 (ammonia)	1	Generic
		R-600a	3	-
		R-744 (carbon dioxide)	1	MexichemAmanco Holding S.A. de C.V (application suspended) Dürr Somac GmbH (filling date 16 April 2010)
		R-32 + HFO blend	675	R-32 generic
	HFC-134a	(XP 10/ R513A) R-134a + R-1234yf blend	631	Dupont/Chemours
Residential Air Conditioners	R-410A	R-290	3	MexichemAmanco Holding S.A. de C.V (filing date 24 June 2011) (Application suspended)
		R-32	675	Open access (Daikin)
		DR-5 (R32 + R1234yf)	490	DuPont/Chemours
		R-744 (carbon dioxide)	1	
		R-32 + HFO blend	675	R-32 Open access
		R-32 + HFO blend	675	R-32 Open access
	HCFC-22	R-32 + HFO blend	675	R-32 Generic
		R-290	3	MexichemAmanco Holding S.A. de C.V (filing date 24 June 2011) (application suspended)
		R-32	675	Open access (Daikin)
Mobile Air Conditioners	R-134a	R-32	675	Open access (Daikin)
		R-744 (carbon dioxide)		MexichemAmanco Holding S.A. de C.V (application suspended) Dürr Somac GmbH (filing date 16 April 2010)
		R-1234yf	4	Honeywell
		R-152a	124	Dupont de Nemours (filing date 3 September 2010)
		R-32 + HFO blend	675	R-32 open access (Daikin)

Sector	Baseline Refrigerant in Use	Low-GWP Alternative	GWP	Patent Status/Information
Household Refrigeration	R-600a		<20	Generic
	R-134a	R-1234yf	<20	Dürr Somac GmbH (filing date 30 July 2015)
		R-290 and R-600 blend	<20	MexichemAmanco Holding S.A. de C.V (filing date 24 June 2011) (application suspended)
Foam Sector	HCFC-141b	R-290	3	MexichemAmanco Holding S.A. de C.V (filing date 24 June 2011) (application suspended)
		R-152A	124	Dupont de Nemours (filing date 3 September 2010)
		R-1234ze	6	MexichemAmanco Holding S.A. de C.V (application suspended)
		Metaforma		
		Isopentane	20	
		Water		
		Cyclopentane (C_5H_{10})		
		R-1234ze	675	MexichemAmanco Holding S.A. de C.V. (filing date 16 April 2010) (application suspended)
		R-290	3	MexichemAmanco Holding S.A. de C.V (filing date 24 June 2011) (application suspended)
		R-32	675	Open access (Daikin)

*This is not an exhaustive list.

Source: CEEW Compilation (2019) based on Bhasin, Sridhar, and Chaturvedi (2017)

II. Countries' policies directed at phasing down HFCs

Even though the impetus to phase-down HFCs at the domestic level - the Kigali Amendment to the Montreal Protocol on Substances that Deplete the Ozone Layer - was only agreed to globally in October 2016, many countries have already set up legal instruments, policies, and incentive structures to promote low-GWP refrigerants and reduce HFC emissions. This chapter is a cross-sector overview of different countries' approaches to the HFC phase-down, in order to recommend possible regulatory structures for India in the course of the HIIRA project.

Broadly speaking, most developed countries have two types of policies: first, regulatory limits on the GWP of refrigerants, depending on their application, and, second, subsidies and other incentives for the uptake of low-GWP refrigerants. Among developing countries, HFC regulation is largely focused on import licensing. Few developing countries have so far adopted any domestic phase-down targets.

Other refrigerant-management strategies - such as mandating servicing standards, or compulsory certification of personnel to limit leakages, or programmes for EOL recovery - exist for all refrigerants, not for HFCs alone. Finally, emissions trading, carbon taxes, and other such climate mitigation tools are applicable to HFCs in many countries, but have not been discussed in this brief as its purpose is to analyse HFC/refrigerant-specific regulations only.

Table 2: Types of HFC regulations in developed and developing countries

Country	Regulation	Areas covered
Developed countries		
European Union	EU's F-gas Regulations (842/2006, 517/2014)	Reduction of the quantity of HFCs placed on the market (phase-down). Emission reduction and containment (leakage checks). Reporting. Mandatory recovery and recycling. Education and certification schemes. Labelling of HFC-containing products. Use restrictions in certain applications. Restrictions for placing HFCs on the market.[201]
Norway[202]	EU Regulation	EU Regulation (No. 842/2006, No. 517/2014, from 14 December 2018). Tax-and-refund scheme for HFCs. Promotion of low-GWP refrigerants. Incentive for recycling and recovering HFCs.
USA	Significant New Alternatives Policy Programme[203,204]	The SNAP Programme, established in 1994 to evaluate and regulate substitutes for ozone-depleting substances (ODSs), identifies and approves climate-friendly alternatives while prohibiting certain uses of the most

[201] Krajnik (2017)

[202] Norwegian Environment Agency (2018)

[203] The SNAP programme's HFC phase-down status is currently unclear due to a federal court ruling vacating the 2015 EPA rule to replace HFCs with low-GWP alternatives. This ruling is currently being appealed.

[204] US EPA (2018)

Country	Regulation	Areas Covered
Developed countries		
		harmful chemical alternatives. It encourages the reduced use of virgin refrigerants (through better refrigerant management and recovery). It requires contractors to maintain records of the amounts of HFCs added or removed during routine maintenance, service, repair, and disposal of all government equipment, appliances, and supplies. Three SNAP rules (namely 20, 21, 22) have been withdrawn in 2018 based on a ruling by the federal court. These affect the replacement of high-GWP HFCs in common applications and re-apply charge size restriction on A3 refrigerants (e.g. HC 290, HC 600).[205,206] The refrigerant-management regulations (Section 608, Clean Air Act) were changed in September 2018 to exclude substitutes for ODS refrigerants (i.e., HFCs). Requirements for leak management, refrigerant reclamation and disposal, and technician certification have been rescinded.[207]
California	EU's F-gas Regulations (842/2006, 517/2014)	In 2014, California passed a law that required the California Air Resources Board (CARB) to develop a comprehensive strategy to reduce emissions of HFCs and other SLCPs by 1 January 2016. CARB released its draft SLCP Reduction Strategy for public comment in September 2015, calling for a more than 40 per cent reduction in HFC emissions by 2030. Beginning in 2018, HFCs will also be regulated according to a state-wide cap-and-trade system.[208] CARB has been updated to prohibit high-GWP HFCs in new equipment and materials in California. Additionally, manufacturers are responsible for a disclosure statement to certify the use of acceptable refrigerants and foam expansion agents in their products.
Australia	Ozone Protection and Synthetic Greenhouse Gas Management (OPSGGM) Act	A statutory phase-down of HFC imports will be implemented, commencing January 2018, and will reduce HFC emissions by 85 per cent by 2036.
New Zealand	Comes into effect on 1 January 2019	New Zealand HFC phase-down plan includes:[209] HFC import licensing system. Permit system for the export of HFCs and import of recycled HFCs. Support programmes for alternative refrigerants (open for consultation). Targets: reduce HFC consumption by more than 80 per cent, and HFC imports from around 1,340 Kilotons CO_2 to less than 260 Kilotons CO_2 by 2036.

205 Armstrong (2018)
206 US EPA (2014)
207 US EPA (2016: 60)
208 Zaelke et al. (2018)
209 Chasserot (2017)

Country	Regulation	Areas covered
Developed countries		
Japan		GWP targets for every application (each coming into force in different years between 2018 and 2025). Subsidy programme in place; current focus of the programme is on industrial refrigeration.
Canada		Canada implementing HFC phase-down until 2030, including reporting obligations. Has specified GWP limits, by application.
Developing countries		
Bangladesh, Cuba, El Salvador, Panama,[210] Bahamas[211]	Enabling activities for implementing Kigali Amendment (proposed)	Roadmap for a legal and policy framework for the ratification and implementation of the Kigali Amendment. Proposal to extend the licensing system on HFC and HFC-based equipment import/export. New data-reporting system for HFCs established. National action plan for phasing down HFCs published. Awareness raising and training workshops to commence in 2019.
Bolivia[212]	Enabling activities for implementing the Kigali Amendment (proposed)	Early ratification of the Kigali Amendment and related legal measures facilitated. Capacity building and training for low- and zero-GWP alternatives. Regulatory package for a import/export licensing system for HFCs and HFC alternatives is ready. The Ministry of Environment and Water is empowered for implementation once the Kigali Amendment is ratified. RAC service sector trained in safe handling of flammable refrigerants; end-users proactively engaged through training in the adoption of alternatives to HFCs. Revision of the national labour competency standards for professionals in the RAC sector, to prepare them for handling flammable refrigerants.
Mauritius[213]	Enabling activities for implementing the Kigali Amendment (proposed)	Facilitation of ratification of the Kigali Amendment: Existing legislation revised and amendments drafted; consultative meetings conducted during legislation drafting; awareness materials on HFC phase-down produced; legal texts to domesticate KA in place. Quota system established for import of HFCs. Training schemes and targeted communication with stakeholders introduced to leapfrog to natural refrigerants.
Timor-Leste	Enabling activities for implementing the Kigali Amendment (proposed)	Discussions on policy and technical requirements held to facilitate the ratification of the Kigali Amendment.

210 UNEP (2018a)
211 UNEP (2018b)
212 UNEP (2018b)
213 UNEP (2018b)

Country	Regulation	Areas Covered
Developing countries		
		Capacity building and training on low-GWP alternatives. Establishment of licensing/quota system for HFCs. Communication and awareness building among the general public on ODS-free low-GWP refrigerant gases and higher energy efficiency products.
Ghana[214]	Enabling activities for implementing the Kigali Amendment (proposed)	Completed an HFC survey with help from Climate and Clean Air Coalition and UNDP.
Brunei Darussalam[215]	Enabling activities for implementing the Kigali Amendment (proposed)	Currently, a voluntary agreement exists between the Department of Environment, Parks, and Recreation and importers of HFCs, for record keeping for future reference. Proposal for enabling activities includes: facilitate ratification of the Kigali Amendment, capacity building of stakeholders on the safe adoption of low-GWP (flammable) alternatives, import/export licensing and reporting, communication and awareness building.
Cook Islands, Cape Verde[216]	Enabling activities for implementing the Kigali Amendment (proposed)	Consultation workshops for implementing the Kigali Amendment. Import/export licensing and reporting. Communication and awareness building. Capacity building for the safe adoption of low-GWP alternatives.
Burkina Faso, Colombia, Egypt[217]		Import licenses and prior approval before import required.
China[218]		Has updated list of recommended substitutes for R22 in refrigeration systems to include low-GWP alternatives: propane, isobutane, CO_2, NH_3, difluoromethane.
Mexico[219]	Climate Change General Law 2012	A 30 per cent reduction of GHG emissions in 2020 and 50 per cent in 2050, taking the year 2000 as the base line. National Emission Registry (2014): the GHGs subject to reporting are: CO_2, methane, nitrogen oxide, black carbon, CFCs, HCFCs, HFCs, perfluorocarbons, sulphur hexafluoride, and those GHGs and compounds that the IPCC determines.

[213] UNEP (2018b)
[214] UNEP (2018a)
[215] UNEP (2018b)
[216] UNEP (2018b)
[217] Brack (2017)
[218] Brack (2017)
[219] Brack (2017)

Country	Regulation	Areas covered
Developing countries		
Paraguay[220]		Subsidies for retrofitting existing air conditioners with hydrocarbons (HCs). Provision to impose import restrictions on HFCs. Enabling activities funding granted, specifics unknown.
Seychelles[221]		100 per cent import duty on high-GWP refrigerants.
India[222]	India Cooling Action Plan (Draft)	Multi-stakeholder (contributions from civil society organisations and industry associations), integrated approach to address India's cooling needs over a 20-year time frame (2017/18 to 2037/38); report is aimed at facilitating regulatory action. Sectors covered are: residential cooling, cold chain, transport air cooling and refrigeration, refrigerant demand and indigenous production, research and development. Provides short-, medium-, and long-term recommendations/guidelines for how cooling can be incorporated into various sectors.

Source: Various studies; primarily Zaelke et al. (2018); UNEP (2018a); UNEP (2018b)

Examples of different types of regulatory mechanisms

Supply-side regulation

EU's F-Gas Regulation: Starting on 1 January 2015, the cap and phase-down policy limited the total supply of HFCs across the EU, based on total tonnes CO_2 equivalent (CO_2e). As of 2018, the supply of bulk HFCs has already been reduced to 63 per cent of the 2009-2012 average. By 2030, the supply will have been reduced further, to 21 per cent of the 2009-2012 baseline. Additionally, from 2017, it also included the supply of equipment containing HFCs. This sector was not included in the original 2009-2012 'baseline' calculation, and as such effectively reduces supply by a further 10 per cent. The cap and phase-down does not ban the sale of any particular HFC; instead, starting in 2015, it limits the total supply of all HFCs across the EU based on the total tonnes CO_2 equivalent (CO_2e), essentially forcing users and producers to switch to low-GWP equivalents.[223]

According to Schwarz et al. (2011), the cost of the F-Gas Regulation occurs from

application and enforcement in the Member States. One-off costs, which are related to implementation and application of the F-gas regulation, are estimated in the range of €617 million. Almost 90% thereof result from costs for certification of the personnel and companies. 66% of the certification costs relate to the servicing in RAC sector. Recurring annual costs of provisions set out by the F-gas Regulation are estimated at €702 million for EU-27 in 2010, at €1,061 million in 2015 and at €1,551 million in 2030. Containment measures account for high shares of these costs (leakage checks, records) and occur mostly in the stationary refrigeration, air conditioning and heat pump sector. The share of recovery costs increases significantly over time.[224]

[220] UNEP (2018b)
[221] UNEP (2018a)
[222] Draft NCAP, Ozone Cell (2018)
[223] Linde Group (2015)
[224] Schwarz et al. (2011: IX)

Many countries also have stringent record-keeping requirements to assess actual HFC consumption and emissions, and to support UNFCCC reporting requirements. While the EU F-Gas Regulation mandates reporting, several countries have placed reporting obligations over and above:

> Mandatory reporting of records of equipment containing charges of >10 kg of F-gases to local authorities is required in Sweden (charge, F-gas quantities refilled and recovered, dates and results of mandatory leakage checks, contact details of servicing company, discarded equipment); mandatory reporting of equipment records by operators and service companies (charges >3 kg) is planned or in place in some Member States (e.g. Hungary, Poland) and intends to build a link to national F-gas emission inventories according to Article 6(4) of the F-gas Regulation. Mandatory storage of equipment records is required in Czech Republic (5 years), France (5 years), the Netherlands (5 years) and Germany (5 years). Electronic recording is mandatory in Hungary and Slovakia.[225]

Norway: The tax-and-refund scheme aims to impose a tax on all HFCs either produced in, or imported into, Norway. The tax is based on the GWPs of the HFCs or blends used. This encourages the use of low-GWP HFCs and natural refrigerants in new installations. The relatively high taxation level (approximately USD 62 per GWP tonne) is also believed to contribute to better housekeeping of gas and less leakage. Finally, when the HFC is destroyed at an approved facility, the tax amount is refunded to the party which delivered the waste.[226]

Denmark: Denmark is an importer of F-gases, and levies a carbon tax creating a disincentive for the use of high-GWP refrigerants over low-GWP refrigerants. According to a preparatory study undertaken for the European Commission,

> taxes are generally imposed on imports of bulk F-gases and F-gases contained in products but several exemptions apply for F-gas quantities contained in equipment. The tax is also applicable to servicing quantities. Quantities contained in pre-charged refrigeration and air conditioning equipment, switchgear (<36 kV), XPS foam, mobile air conditioning equipment in cars, buses and trucks, are exempted from this tax.[227]

It's important to note that reclaimed gases are not taxed, thus creating an incentive for reclamation.

Demand-side regulation

Australia: Since 1 July 2012, as part of the Clean Energy Future Plan, synthetic greenhouse gas (SGG) refrigerants attract an 'equivalent carbon price' based on their global warming potential. SGG refrigerants will become more expensive to replace. SGGs imported before 1 July 2012 do not attract the HFC levy.[228]

The equivalent carbon price is implemented through the Ozone Protection and Synthetic Greenhouse Gas Management Act, 1989. It is paid quarterly as an import levy by refrigerant importers who pass associated costs down the supply chain. Ultimately, it is the end-user who will pay the levy when they purchase new or replacement refrigerant. The cost impact on 'low charge' consumer goods such as refrigerators and car air conditioning will be low. The cost impact on residential, commercial, and industrial refrigeration and air conditioning systems can be high depending on the type of refrigerant, the mass of refrigerant employed, and any leakage. Moving to low-GWP alternatives for new and replacement systems and minimising leaks in existing systems are the main ways that system owners can insulate themselves from this cost increase.

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[225] Schwarz et al. (2011)

[226] Norwegian Tax Administration (2017)

[227] Schwarz et al. (2011: 53)

[228] Australian Institute of Refrigeration, Air Conditioning and Heating (2012).

Japan: The Act on Rational Use and Proper Management of Fluorocarbons (2015) covers the entire lifecycle of refrigerant management. The HFC phase-down targets equipment manufacturers and importers of equipment:[229]

- Target index of weighted GWP per equipment application segment
- The phase-down is a bottom-up result of applying the target indexes, containment and competence measures, and EOL recovery
- No top-down reduction steps were calculated from historic baselines

In addition to phasing down HFCs, low-GWP refrigerants are promoted through targeted subsidies. In 2017, the Japanese government made subsidies available for low-GWP cold-chain systems, which some industry representatives credit with increasing awareness and adoption of HFC-free technology.[230] There is also a focus on leak prevention and recovery of refrigerants.

Service sector and end-of-life disposal of refrigerants

Many countries, especially developed nations, prohibit non-licensed or non-certified service technicians from installing, servicing, or repairing air conditioners, or handling refrigerants. End-of-life disposal of refrigerants is crucial to reducing HFC emissions. Often, there is no incentive for manufacturers to recover refrigerants from discarded equipment; therefore, there is often a need for incentives or regulation to ensure recovery. Among the countries that regulate the safe disposal of refrigerants (including HFCs), there is reliance on either voluntary programmes (with incentives) or robust regulations with enforcement mechanisms.

Canada: The Canadian regulations define a certified person as

> a service technician who holds a certificate recognized by three or more provinces or by the province in which the work is being done, indicating successful completion of an environmental awareness course in recycling, recovery and handling procedures for halocarbon refrigerants as outlined in the Refrigerant Code of Practice.

Non-certified persons are prohibited from installing, servicing, leak testing, charging, or undertaking other work that may result in the release of a halocarbon from a refrigeration or air conditioning system. Even certified technicians are prohibited from such activities as releasing/venting halocarbons; charging a system without leak testing; and using wrong containers to store/transport halocarbons. Regulations also require all systems (other than small refrigeration and air conditioning units) to be leak tested every 12 months.

EU: From 1 January 2020, the use of fluorinated greenhouse gases with a GWP of 2,500 or more, to service or maintain refrigeration equipment with a charge size of 40 tonnes of CO_2 equivalent (CO_2e) or more, shall be prohibited. The Regulation also seeks to improve the prevention of leaks from equipment containing F-gases through

- Containment of gases and proper recovery of equipment
- Training and certification of personnel and of companies handling these gases
- Labelling of equipment containing F-gases[231]

Denmark: For refrigerants' end-of-life disposal, a 'deposit-refund' scheme was institutionalised in 1992 by the Danish Refrigeration Installers' Environment Scheme (KMO system), mandating

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[229] Sato (2015)
[230] Yoshimoto (2018)
[231] European Commission (2017))

that only member companies can purchase new refrigerants from those importing synthetic refrigerants. Consumers pay a fee for the refrigerant, which is shared between the service company and the KMO. The former receives a refund from the KMO on returning refrigerants, depending on their purity level. The KMO Secretariat manages the reclamation and destruction, and reclaimed gases can be sold back to companies.

The Air-Conditioning, Heating & Refrigeration Institute's (AHRI) 2016 study[232] on the efficacy of different types of recovery programmes of refrigerants provides a useful comparison of systems.

Table 3: End-of-life recovery policies

Originating country	Best-practice advantages
Australia	• Comprehensive product stewardship scheme that is built on existing distribution channels minimises the cost burden on industry; reduces friction for contractors. • Inclusion of all synthetic refrigerants (CFCs, HCFCs, HFCs) in phase-down, and regulatory requirements have created consistent market incentives for better refrigerant management. • Banning disposable cylinders was pivotal in improving refrigerant management; returning cylinders for refills supports the ethos that refrigerants are not a commodity but a specialised good, and encourages the return of refrigerants for destruction.
California	• Robust maintenance and servicing requirements for major refrigerant charges have served as an educational tool for industry and have promoted best practices. • Utility energy efficiency programmes successfully capture large volumes of appliances; this enables easy refrigerant/resource management. • Moving away from disposable small refrigerant cans to reusable canisters sets a precedent (despite the limited volumes of recoverable refrigerant in small cans).
EU	• Collaborative training and best-practice development is proven to reduce leak rates (REAL Skills, Zero, etc.); the European Commission is committed to developing easy-to-use, robust, and thorough documentation for industry. • Some countries within the EU have brought out national legislation that is stricter than the EU F-Gas Regulation; these have been highlighted in a report commissioned by the European Commission:[233] » **Lower minimum charges:** Equipment containing lower minimum charges of F-gases than set out by the F-Gas Regulation are subject to containment rules in Denmark (minimum charge of 2.5 kg) and France (minimum charge of 2 kg). » **Mandatory leakage checks for mobile equipment:** Leakage checks of certain types of mobile equipment are mandatory in Germany (refrigerated trucks containing charges of more than 3 kg of F-gases), Sweden (refrigeration and air conditioning systems installed on ships containing charges of more than 10 kg of F-gases), and the Netherlands (mobile refrigeration and air conditioning equipment including ships, according to a schedule set out by the F-gas Regulation). » **Maximum annual leakage rates** for stationary equipment have been established in Germany (refrigeration and air conditioning equipment, depending on charge and date of manufacture), Belgium (new equipment: five per cent), and Luxembourg (five per cent).

[232] Navigant Consulting Inc. (2016)
[233] Schwarz et al (2011)

Originating country	Best-practice advantages
	» **Registration of equipment** in a database for monitoring and enforcement purposes in Hungary (cooling circuits), Slovenia (charges of more than 3 kg of ODSs or F-gases), Estonia (charges of more than 3 kg of F-gases). » **Producer-responsibility schemes** requiring producers and suppliers of F-gases to take back recovered bulk F-gases for further recycling, reclamation, and destruction are in place in Sweden (legally binding for fluorinated greenhouse gases since 2007, for ODS since 1989) and Germany (legally binding since 2008). Recovery of CFCs, HCFCs and HFCs has been mandated in France since 1992. Denmark (KMO system), Sweden (SWEDAC), and the Netherlands (STEK system) have also been working on the training of companies and personnel since 1992.
Japan	• Industry-specific refrigerant-management programmes built on current product EOL infrastructure, with opportunities for innovation, and competition between product-stewardship schemes. • Fees for motor vehicle EOL management (including refrigerants) charged at time of purchase; this greatly encourages compliance.
United Kingdom	• No explicit cost to consumers for appliance disposal; instead, manufacturers incur the cost as part of operations, and build costs into retail prices.

Source: CEEW compilation (2019), Navigant Consulting Inc. (2016); Schwarz et al (2011)

III. Voluntary industry initiatives

Supply side

There are also several forms of voluntary programmes that aim for the industry to 'self-regulate', rather than having legislations imposed. The Consumer Goods Forum (2018) brought together the refrigeration sector's consumer goods retailers and manufacturers, and, in October 2016, announced a Refrigeration Resolution to focus on:

the installation of new refrigeration equipment in markets where viable, the engagement with key stakeholders to overcome barriers in markets where installation is not currently viable, the reduction of the environmental impact of existing refrigeration systems and the development of individual targets and action plans to measure the first three points.[234]

Similarly, there are global platforms created by multilateral as well as non-governmental agencies to encourage and support companies coming together ad committing to actions in aid of international environmental concerns. For example, the United Nations Environment Programme and Greenpeace instituted 'Refrigerants, Naturally!' which has convinced companies such as Coca-Cola, Unilever, and McDonalds to 'working towards a phase out of HFCs in their point-of-sale cooling equipment'.[235] The individual ambitions of companies such as Chemours, Daikin, and Honeywell to eliminate by-production and process-related emissions of HFC-23 are also worth noting.[236]

There are several programmes for companies to voluntarily report their emissions and actions, which have been instituted both by governmental and non-governmental agencies. The Eco-

[234] Consumer Goods Forum (2018)
[235] Refrigerants Naturally! (2018)
[236] Bergeson (2017)

Management and Audit Scheme (EMAS) has been instituted by the European Commission for 'companies and other organisations to evaluate, report, and improve their environmental performance'. These include reporting on issues central to HFCs' management - GHG emissions, waste generation, energy efficiency and consumption, and material efficiency.[237] The table below, prepared by Samuelson (2010), captures the institutional mechanisms and scope of several voluntary registries focusing on companies' disclosure of GHG emissions.[238]

Table 4: Voluntary greenhouse gas emissions reporting options

	The Climate Registry	EPA Climate Leaders	Climate Disclosure Project
Website	www.theclimateregistry.org	www.epa.gov/climateleadership	www.cdproject.net/en
Year launched	2007	2002	2000
Legal structure	Non-profit 501(c)3 organisation	Programme of the US EPA, a federal agency	The Carbon Disclosure Project (CDP) is a UK Registered Charity No. 1122330, and a company limited by guarantee, registered in England No. 05013650. In the US, the CDP is a special project of the Rockefeller Philanthropy Advisors, with United States IRS 501(c)(3) charitable status.
Geographic scope	North America	United States	Global
Membership	Submit a statement of intent; tiered annual fee structure. Annual fees range from USD 450 to USD 10,000.	Large companies become partners, while small companies join the Small Business Network. (A company is considered a small business if it purchases less than 15 million kWh of electricity, one million gallons of transportation fuel, and two million therms of natural gas annually.)	• Reporting members: Reporting to CDP is free for all reporting organisations, with the option of additional support with a USD 12,000 membership • Signatory members: There are three levels of signatory membership ranging from free to USD 8,000 annually.
Scope of member commitment	• Identify all sources of GHG emissions. • Calculate emissions according to The Climate Registry Protocols. • Verify emissions with an American National Standards Institute (ANSI)-accredited Registry-recognised Verification Body.	• Develop a corporate-wide GHG inventory. • Set an aggressive corporate-wide GHG-emissions-reduction goal to be achieved over 5 to 10 years. • Partners report inventory data annually and document progress towards emissions-	The responses of reporting members include corporate emissions reduction targets and energy use; information on the risks and opportunities companies face from climate change; and management discussion and analysis on strategies to address climate change, including emissions trading.

[237] Schwarz et al (2011: 49)

[238] Samuelson (2010)

	The Climate Registry	EPA Climate Leaders	Climate Disclosure Project
	• Report the verified, entity-wide emissions data to the public via The Climate Registry website.	reduction goals. (Small Business Network members report progress after reaching their goal.) • Achieve the long-term GHG-reduction goal. • Publicise achievements through Climate Leaders.	
Reporting protocol used	General Reporting Protocol (GRP) v. 1.1. This protocol is based on the WRI/WBCSD GHG Protocol* and ISO 14064-1 standard.	Climate Leaders Greenhouse Gas Inventory Guidance, based on the GHG Protocol*	No
Reduction goal required?	No	Yes; absolute emission reduction (not normalised to growth)	No
Third-party verification required?	The Registry requires results to be verified by third-party verifiers that have been accredited as qualified to undertake the verification process.	Optional	No
Assistance provided?	• Guidance on building a high quality, cost-effective GHG inventory. • Step-by-step assistance with measurement, reporting, and verification. • The Registry's online calculation and reporting tools. • Training and technical support. • Policy updates from Governmental Board members. • A community of leaders from industry and government.	Technical assistance encompasses all aspects of creating a credible GHG inventory, including implementing GHG accounting methods, measuring, tracking, and reporting GHG emissions. EPA also provides an inventory-review process to offer feedback on improving the accuracy, efficiency, and relevance of partners' GHG inventory data and management systems. The level of assistance will vary with the needs of the partner and agency resources.	CDP provides a series of recorded webinars, workshops, and in-depth training courses to support companies in the reporting process. Reporting members receive additional analytical tools, climate disclosure best practices, networking opportunities, and dedicated support.
Data publicly available?	Yes, through the Climate Registry Information System (CRIS)	No	Data is made available to a wide audience including institutional investors, corporations, policymakers and their advisors, public sector organisations, government bodies, academics, and the general public.

*Greenhouse Gas Protocol by the World Resources Institute and World Business Council for Sustainable Development (WRI/WBCSD)

Source: Samuelson (2010)

Service and end-of-life disposal

The following list has been compiled in a report prepared for the European Commission[239], highlighting some of the significant voluntary industry initiatives:

Producers of refrigeration, air conditioning, and heat pump equipment: Voluntary take-back schemes established by industry for end-of-life equipment such as commercial and industrial air conditioning systems (Greece, UK, Belgium) and heat pumps (Belgium).

Producers of fluorinated gases: Voluntary take-back schemes established by industry for recovered bulk F-gases have been established in the Netherlands (following a mandatory take-back scheme for ODS, which has been in place since the early 1990s), and in France (a deposit/refund scheme covering ODS and HFCs which has been in place since 1993).

Fire protection industry: Prior to the EU F-Gas Regulation, voluntary agreements on monitoring HFC and perfluorocarbons emissions, and on leak detection and containment processes, were in place in the Netherlands (since 1999) and the UK (since 1994, renewed in 1997). These agreements were replaced by the F-Gas Regulation. A 2006 voluntary agreement by industry in Germany on the phase out of the use of HFC-23 as a fire extinguishing agent has been withdrawn by industry, due to pressure from one manufacturer of HFC-23 equipment.

Semiconductor industry: Global and European agreement to reduce emissions of HFC-23, perfluorocarbons, sulphur hexafluoride, and nitrogen trifluoride (1995-2010), which has been integrated into national targets for all member states where production is located.

Switchgear industry: Voluntary agreements addressing the use and emissions of sulphur hexafluoride exist in France (2005-2010; renewed agreement expected for the period 2011-2016), Germany (since 1996/renewed in 2005), Spain (2008-2012), and Norway (2002-2010). Voluntary commitments preceded the provisions of the F-Gas Regulation and were established through industry standards. Further emission reductions through the F-Gas Regulation are not expected as these industry standards have already established the same measures as the regulation.

Aluminium industry: A voluntary commitment by the only French producer of primary aluminium entered into force in May 1996, and aimed at reductions of absolute tetrafluoromethane emissions(in tonnes) by 63 per cent, and specific tetrafluoromethane emissions (in kilo gram per tonnes) by 73 per cent until 2000 (baseline 1990). A voluntary commitment had been made by the German primary aluminium industry in 1997, aiming at reducing absolute and specific perfluorocarbons emissions (tetrafluoromethane, hexafluoroethane) by 50 per cent by 2005 (baseline 1990). In 2001, the emissions were already 85 per cent below the baseline. In Norway, there was a voluntary agreement in effect from 1997 to 2005, with the aim of reducing emissions by 55 per cent from 1990 levels. The result was a 62 per cent reduction.

Incentivising business actions

Actions such as those highlighted above dissipate the need for strong regulatory measures and instruments to be imposed on industry. Firms remain the most significant stakeholders in implementing commitments made internationally to phase-down HFCs, and regulations should attempt to incentivise such actions. Industry has played a key role in the success of the Montreal Protocol so far, considered among the world's most successful environmental agreements

[239] Schwarz et al (2011)

[240] Bergeson (2017)

having reduced the consumption of ODSs by up to 97 per cent.[240]

The Montreal Protocol has allowed industry and markets to innovate and meet the targets set out by the parties, through its phased timelines, exemptions for the 'critical use' of substances when better options are not available, additions over time to the list of substances being controlled, as well as its consensus decision-making.[241] In a similar vein, the Kigali Amendment is an opportunity for the development of new markets and opportunities, while ensuring a better environment:

With the phase out of any class of chemicals comes in its wake new chemical innovations that address the deficiencies of the incumbent products and, of course, take on the challenges confronting any new product development. The Amendment paves the way for the innovation of new chemistries and products to replace HFCs. Businesses will need to rise to the challenge to innovate new products to fill the void created by the phase out, conform their operations to align with the phase out, and begin now to find alternatives in anticipation of the phase out.[242]

As DeSombre notes,

market forces have played a valuable role in the successes of the Montreal Protocol, some of them as a direct result of the way the Protocol process is structured, and others because of serendipity in the way industry has made or used ozone depleting substances. ***Due to what is in part a happy coincidence, and in part well-developed regulatory incentives, some of the main ODS-producing industries were the main innovators of the substitutes used to replace them.***[243]

Some of these incentives included (1) a broad international agreement mandating global markets to move in a particular direction, thereby opening up a large market for companies offering non-CFC refrigerant-based products; (2) domestic regulations, by way of taxes imposed on ODSs, which incentivise the use of alternative refrigerants; and (3) company and industry representation on the Technology and Economic Assessment Panel has encouraged them to find alternative technological solutions.[244]

The very nature of regulations in this sector is to direct market behaviour, which is evidenced in several studies.[245]

The key aim of the HIIRA project is to understand what these regulations and incentives may look like in India. The key learning from literature and from the project's next steps have been highlighted in the concluding chapter below.

[241] Molina et al (2009)

[242] Bergeson (2017)

[243] DeSombre (2000: 57)

[244] For example, see Oye and Maxwell (1995); Greene (1998); Hoerner (1996) in DeSombre (2000).

[245] See, for example, Molina et al. (2009)

IV. Key Learnings

Business and policy interactions

- The success of the Montreal Protocol has been contingent on its regulatory approach as well as the involvement of the private sector. A successful transition away from HFCs in India will depend on deep and broad stakeholder interactions between the government, the scientific community, and industry.
- The uptake of low-GWP alternatives is contingent on various regulations, ranging from safety and technology standards to national phase-down targets, as well as end-of-life disposal policies.
- The very nature of regulations is to direct market behaviour, as is evidenced in several studies. Specifically, with regard to HFCs, Molina et al. (2009) note that 'six low-GWP substitutes were announced by chemical companies just weeks after the European F-Gas Directive set the schedule for phasing out HFC-134a refrigerants in automobile air-conditioning'. [246]
- The necessity of a coalition of knowledge brokers is useful. While there is no conclusive empirical evidence that scientific evidence can explain policy, studies have shown a correlation between scientific studies and environmental policy.[247]

Types of policies in place globally

1. Supply side

- Cap and phase-down
- Tax-and-refund
- Reporting
- Import quotas

2. Demand side

- Equivalent carbon price
- Subsidies for using low-GWP refrigerant products

3. Service sector

- Prohibit non-licensed or non-certified service technicians from installing, servicing, or repairing air conditioners, or handling refrigerants
- Prohibit the service or maintenance of equipment above a particular charge size

4. End-of-life refrigerant disposal

- Voluntary programmes with incentives
- Robust regulations with enforcement mechanisms
- Banning certain products
- Including disposal costs in product prices

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[246] Molina et al. (2009)

[247] See, for example, Andresen et al. (2018)

Annex II:
HIIRA Study Trip Report

Norway and Sweden, December 2017

As part of the HIIRA research programme, the HFC research team from the Council on Energy, Environment and Water (CEEW), New Delhi, consisting of Dr Vaibhav Chaturvedi, Shikha Bhasin, and Lekha Sridhar (now a consultant at the Ozone Cell, Ministry of Environment, Forest and Climate Change, Government of India), along with two experts, Kapil Singhal (BP Refcool) and Satish Kumar (Alliance for an Energy Efficient Economy), visited Norway and Sweden in December 2017. The aim of this study tour was to better understand the regulations and incentives for phasing down hydrofluorocarbons (HFCs). The study group met with key technical and policy experts to draw out lessons, incentive schemes, and regulatory measures that may be relevant to India's transition away from HFCs.

Images: CEEW

The following table highlights the key agenda and learnings covered on the study trip.

Table 1: Key agenda and learnings

	4 December 2017
1.	Norwegian national regulations on refrigerants About Norway • Population: 5.3 million (Oslo: one million); three to four big cities in the southern and central region; area about 1/10th of India's • Culturally and climatically similar to Sweden • Not an EU member, but part of a cooperation agreement (European Economic Area or EEA) • Hydropower generates 98 per cent of the country's electricity - a few hundred MWs to one GW - from big dams in the mountains and some smaller hydropower stations • The oil and gas industry is about 50 per cent of the economy; Norway produces more raw materials than Sweden, which has more consumer- and product-oriented industries; it makes large fishing exports to China and Japan • Wind power is being introduced as an alternative means of power generation • Climate change impact: heavy rain in the summer and winter; reduced snow cover Norwegian regulation on refrigerants Background • No production of F-gases • Some production/assembly of large refrigeration equipment • Small, hermetically sealed equipment; all imported (heat pumps, car ACs) • GWP-based tax on import of HFCs • CFC licensing system introduced in 1991, finally phased out in 1996, and officially non-existent as an industry in present-day Norway • HCFCs licensing system introduced in 1996, HCFCs finally phased out in 2010 General approach of the regulation • Long-term goal: natural refrigerants and HFOs • Measures: refrigerants with the lowest possible climate effect (low-GWP), low leakage rates and reclamation of used gas Norway's tax-and-refund scheme, which began in 2003–2004, was set up as a way to implement a carbon equivalent tax on HFC emissions. The use of HFCs can be minimised and their leakage reduced through good servicing practices. Therefore, the Norwegian Government set up the tax so that once the end-users dispose of the equipment, the taxed amount is refunded when the refrigerant is recovered and returned to destruction facilities. This was also seen as a way to encourage end-users to recover refrigerants during end-of-life disposal, and minimise emissions from leakage while using the equipment. This tax is implemented on imported and locally manufactured refrigerants. Since Norway does not produce refrigerants domestically, all taxation is implemented at the import stage. Because of the tax, bulk gas imports have stabilised and are much lower than expected. The import of gas in appliances and products has not been significantly affected by the tax. Basic tenets of the tax Scope » Any import and domestic production of HFCs and perfluorocarbons, including recycled HFCs and perfluorocarbons » All mixtures of HFCs and perfluorocarbons, both as compounds and mixtures with other substances, as well as HFCs and perfluorocarbons that are included as ingredients of products or equipment Rate » Norwegian Krone (NOK) 0.487 per kg multiplied by the GWP value that each individual taxable HFC and perfluorocarbons gas represents

	» Mixtures: the net weight of each individual type of taxable compound in the mixture » HFCs and perfluorocarbons used as ingredients in other products; the calculation is based on the proportion of HFCs and perfluorocarbons in the product. » If the type of HFC or perfluorocarbons cannot be documented, apply the highest possible GWP value for the HFC/perfluorocarbons product type that cannot be ruled out. » If the mixing proportions of HFCs and/or perfluorocarbons cannot be documented, apply the GWP value of the product type with the highest rate for the entire mixture. Consideration will be given to documentation that might exclude any individual mixture proportions. » Duty must be paid as specified in the list below for the following products if the quantity of HFCs and perfluorocarbons as ingredients in other products cannot be documented. • Household refrigerators and freezers: 250 g per cooling unit • Compact liquid coolers (for air conditioning units in buildings): 0.25 kg per kW of cooling capacity • Air coolers (for air conditioners in buildings), heat pumps, and dehumidifiers: 0.5 kg per kW of cooling capacity • Milking systems, indirect: 1 kg per kW of cooling capacity • Milking systems, direct: 2 kg per kW of cooling capacity • Industrial refrigeration and freezer compartments: 1.5 kg per kW of cooling capacity • Commercial refrigeration and freezer units, including cooling rooms not for public use: 2.5 kg per kW of cooling capacity • Spray cans: 0.5 kg per unit, except for asthma inhalers, which use 10 g per unit • Air conditioners for motor vehicles such as passenger cars, goods transport vehicles, combination vehicles and motor caravans, tractors, and forklifts: 1 kg per unit • Air conditioners for lorries, vehicles for construction work, combine harvesters, and specialised cars: 2.5 kg per unit • Air conditioners in buses: 5 kg per unit • Expanding foam insulation: 0.5 kg per kg • Insulated doors and entry gates: 0.25 kg per m^2 • Extruded polystyrene for insulation: 2.5 kg per m^3 • Panels for industrial refrigeration and freezer compartments: 6 kg per m^3 Exemption HFCs and perfluorocarbons are exempt from this duty in the following cases: » Those meant for export to foreign countries » Those stored in customs warehouses when the products are designated for export » Those imported as personal effects, for use in transportation for commercial activities, that are of little or no economic value, or for temporary use » Those delivered to or introduced by diplomats, NATO, and military forces » Those returned to the registered company's warehousing facilities » Recycled goods
2.	Norwegian work with the Montreal Protocol and the Kigali Amendment The NEA is the nodal agency that manages and represents Norway at the Montreal Protocol. After a quick discussion on the tenets of the Kigali Amendment, the specifics undertaken nationally in Norway were put forth: • Proposition to Parliament consenting to the ratification was sent in April 2017 • The Parliament gave its consent in June • The agreement was ratified in September 2017 • Norway is developing new regulations and cost/benefit assessment of regulations • A public consultation was held in mid-2018 • They expect licensing to be in place by 1 January 2019[248]

[248] As planned, this has since been implemented.

	Norway and Switzerland have also worked on a mechanism under the Montreal Protocol to inform parties to the protocol about new and emerging HFCs with similar GWPs as those listed under Annex F of the protocol. All three panels under the protocol will be engaged to provide this information (refer to Decision XXIX/12).
3.	Short overview of ongoing NEA study on HFOs ● HFO substances used as refrigerants; understanding emissions, degradation products, and their atmospheric dispersion ● Environmental and health effects of HFOs and their degradation products ● Risk assessment of how the future use of HFOs and their subsequent emissions would affect the environment globally By-products of HFO (degradation) ● Rapid degradation of HFOs in the atmosphere ● Final degradation products » Carbon dioxide (CO_2) » Hydrofluoric acid, hydrochloric acid, formic acid » Trifluoroacetic acid (TFA) ● TFA » Highly persistent pollutant » Both natural and anthropogenic sources » Present in rain, rivers, lakes, springs, wetlands, and both coastal and deep-ocean sea water; accumulates in oceans, salt lakes, and play as Preliminary conclusions ● Emissions of HFOs are expected to increase ● Many knowledge gaps identified » Health effects of HFOs » Toxicity of TFA and salts to terrestrial plants » Limited information on the effects on organisms found in salt lakes and play as » TFA, highly persistent pollutant, is subject to the precautionary principle (This is a case of local versus global impact of technology and refrigerant selection affected by the Montreal Protocol.)
4.	Meeting with Section for Product Control Control authorities in Norway include the NEA, county governors, and the Norwegian Nature Inspectorate The NEA's control strategy is based on ● Risk-based control ● Strong reactions when risk to the environment is high ● Dialogue with business organisations ● Analysis/focus on the effect of supervision It will control F-gases through ● Many actors (installers, maintenance companies, and owners of equipment) affected by the regulation, who will be subject to inspection. ● Actions based on spot checks in 2013, 2014, and 2015 directed at installers and owners ● Inspections initiated by written complaints The NEA shared the results of various inspections, a large majority of these showed compliance as compared to non-compliance of the regulation. Overall, the team from the NEA concluded that the supervision had a positive effect, and that a good deal of work had been undertaken.

5.	Presentation of general methodology of Norwegian work on cost–benefit analysis: This method was presented as a general approach to assessing emission reduction measures. Key elements of a cost-effectiveness analysis include 1. Establishment of emission inventories and projections - business as usual (BaU) 2. Identification of possible measures (different technologies and actions) - direct actions that lead to emission reductions; for example, switching from fossil fuel vehicles to electrical vehicles, avoiding the use of HFCs in firefighting, etc. 3. Estimation of additional costs compared to BaU over the analysis period 4. Estimation of emission reductions compared to BaU 5. Estimations and (if possible) monetisation of other effects 6. Estimation of the net present value of cash flow divided by accumulated emission reductions, which yields costs/tonnes reduced 7. Description of non-monetised effects and their importance **The CEA is an important decision-making tool through which decision makers will also consider** 1. Non-monetised effects 2. Distribution effects 3. Employment benefits
6.	Visit to the Ministry of Climate and Environment This meeting aimed at discussing the HIIRA project, its deliverables, and plan of action. Moreover, it also highlighted the working of the Climate and Environment Ministry and its priorities and functions. The team from India also had the opportunity to learn about implementation challenges and discuss stakeholder engagement methods used in Norway.
	5 December 2017
7.	Visit to The Norwegian Directorate for Civil Protection (DSB), Tønsberg, responsible for the regulation of flammable refrigerants. After a brief review of the scope of the organisation and its work, the discussion focused largely on the need for revised standards for flammable, low-GWP refrigerants. Currently, refrigerants are regulated under the following legalese: ● Fire and Explosion Protection Act ● Regulations on the handling of hazardous substances ● Thematic guidance on refrigeration systems that expand the requirements of the regulation ● Pressure equipment directive (14/68 EU) ● Standards NS-EN 378: 2016 refrigerating systems and heat pumps safety and environmental requirements; and NS-EN 13313:2010 competence of personnel (under revision)
8.	Visit to SRG, Hokksund, a company that collects used HFCs and certifies personnel and companies The team also visited the refrigerant collection company, Returgass, in Hokksund. Returgass receives recovered refrigerants from end-users and processes the refund. Returgass is responsible for collecting the refrigerant; analysing its contents to determine the contaminants, type of refrigerant, etc.; and determining the quantum of refund. The unit also provides its own reusable cylinders, available at collection points all over the country, to its end-users. A hazardous waste facility in France handles the final destruction of the collected refrigerant. Returgass' subsidiary, Isovator, is a national body that certifies service technicians. No service technician is permitted to service refrigerant-charged equipment above specified sizes without certification. The Indian team was interested in learning how the industry, service technicians, and enforcement authorities coped with the regulations. This is of particular interest to India since a large section of its service technicians are untrained and belong to the informal sector.

6 December 2017

9.

Meeting with Ventilation, Kulde (refrigeration), and Energy (VKE), the industry association for companies in the cooling sector

The VKE focuses on members and acts as a link between companies and authorities. It concentrates on legislation and education. VKE is a technologically neutral association, so all legal refrigerants are equated. Our discussion centred on the responsibilities and challenges that companies face when complying with regulations.

- HFCs in refrigeration plants are the owner's responsibility:

Mandatory leak checking

All RACHP systems containing over 5 tonnes of CO_2 equivalent are subject to mandatory leak checks.

The frequency of checks depends on the CO_2 footprint of the refrigerant filling and on the installation of a fixed leak detection system. Detected leaks must be repaired as soon as possible.

EU mandatory energy assessment

This assessment applies to refrigeration systems with cooling output rates above 12 kW. Practical energy assessment should reveal leaks and a lack of maintenance, and lead to lower energy consumption after repair.

HFCs are hazardous waste

After recovery, used HFCs must be handled in accordance with hazardous waste regulations and returned for disposal or reclaim.

- Today, all new household refrigerators and freezers come with environmentally friendly refrigerants; the transition of domestic heat pumps from HFCs with high-GWPs to those with lower GWPs or HCs has begun.
- Propane is the most commonly used refrigerant in plug-in coolers, but CO_2 models are also being developed.
- Industrial refrigeration: HFCs are only used in cooling and freezing installations in companies with limited production capacity or facilities. Larger companies have mainly used ammonia (NH_3). Lately, however, CO_2 has been considered a better alternative since its leakage will not poison food.
- Buildings are a challenge. Each building is estimated to have a minimum of two refrigeration plants for air conditioning and ventilation; one computer equipment room air conditioning; canteens with cold rooms, cabinets, and counters, and often, heat pump installations. An average of four units per building multiplied by 140 buildings gives 560 refrigeration units. However, not as many units of refrigerants are being returned. In 2014 and 2015, the emissions of HFC gases amounted to approximately two per cent of GHG emissions in Norway, and a great part came from refrigeration systems in buildings. Norway has imported more than nine metric tonnes of HFCs over the last two decades, but annually, we only get 30 tonnes in return as hazardous waste (in 2016). This seems very low even when considering a time delay. One indicator is that these 30 tonnes came from 234 of a total of 800 F-gas certified companies.
- Other key challenges

» Reaching the consultants and plant owners with information about new legislation and technical solutions

» Increasing competence in environmentally friendly refrigerants in Norway's own businesses - training in ecologically friendly alternatives is neither mandatory nor easy accessible. Personal safety is a pressing issue, especially in the context of natural refrigerants, non-saturated HFOs, and blends containing these fluids.

» Legislation must be adjusted to today's realities to ensure a common understanding of regulations, directives, decisions, and recommendations and best practices.

10. Meeting with the Norwegian Foundation for Scientific and Industrial Research (SINTEF)

A presentation by Petter Neksa showcased the following experiences with transcritical CO_2:

1. A Kigali side-event held on 16 December 2016 projected that Indo-Norwegian leadership would leapfrog to long-term sustainable alternatives, based on natural refrigerants

2. REMA1000, one of Norway's most energy efficient supermarkets, uses transcritical CO_2 refrigeration.

- During the first field test, there were 199 commercial centralised refrigeration systems, now there are more than 8,000 supermarkets in Europe with transcritical CO_2.
- These systems vary in size: 10 kW to 1 MW
- Several systems have been installed outside Europe

3. INDEE, a demonstration project in India, to study if leapfrogging from HCFC-22 towards CO_2 refrigeration is possible.

Research partners

» SINTEF, Norway's largest applied research institute with 2,000 employees

» Norwegian University of Science and Technology (NTNU)

» IIT Madras/Chennai

Industry partners

» Danfoss India

» Danfoss Denmark

» Component contributions from several industry partners

» Associated partner: CEEW

Project period: 2016–2018

Rigs

» Factory testing of INDEE rig in Treviso, Italy

» Test rig installed at IIT Madras

» Compressors manufactured by Doris and controls from Danfoss

» Power input ratio, the efficiency metric, was found to be 2.58

» Efficiency metrics for R22 and R404 are 5.5; CO_2 seems to outperform existing technology in efficiency

The next step will be to widen the applications and monitor performance. Many countries can leapfrog from halocarbons to long-term solutions, including natural working fluids. CO_2 systems can work well in high ambient temperatures, and the idea is to initiate a second project (INDEE phase II). High pressure exceeding 100 bars would make the system more energy efficient, but system components will determine how much pressure is feasible.

Cost analysis was not part of the project. In Europe, a CO_2-based system was 10-20 per cent more expensive, yet it is fairly standard and is also considered more energy efficient.

11. Destruction of HFCs and ozone-depleting substances in cement kilns: a SINTEF case study in India

In association with the Asian Institute of Technology, Bangkok, SINTEF showcased its experiences of destructing ozone-depleting substances in cement kilns.

The cement industry in India

» 200 million tonnes in 2016 (China produced 1.2 billion tonnes)

» Consumes close to 50 MT of coal and 450 MT of raw materials (limestone, sandstone, alumina, and coal) annually

» Is responsible for seven per cent of India's CO_2 emissions

» Has an anticipated production range of 600-800 MT.

Co-processing waste in resource extraction-intensive industries can be useful. There are significant benefits for large cement plants that are doing thermal substitution. For example, ACC and Ultratech have less than one per cent thermal substitution, whereas in the USA it is 25 percent, Switzerland 47 per cent, and Norway 45 per cent.

Cement kilns can destroy halons and CFCs much more efficiently and cheaply than incinerators - their temperature is 2,000^0 C and resident time is seven seconds, as opposed to USEPA norms, which require 1,100^0 C for incineration and a resident time of two seconds.

The ACC plant at Katni is used for destroying CFCs - ODS feeding system at cement kiln:

Feed rate is 30-40 kg/hour - about 10 times the rate that was tried in Japanese plants in the 1990s.

When destroyed, CFCs can produce dioxins; hence emissions tests are required. These are very expensive, as the test equipment costs about INR three crores or more.

Regulatory frameworks for co-processing are favourable:

The Hazardous and Other Wastes (Management and Transboundary Movement) Rules, 2016 preferred co-processing to disposal options (SOPs prescribed; permits are based on emissions norms rather than trials).

Solid Waste Management Rules, 2016: non-recyclable waste with >1,500 kcal/kg to be converted to RDF and sent to cement plants or used to create energy from waste.

In 2017, the Central Pollution Control Board published guidelines for co-processing plastic waste in cement kilns.

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12. The Swedish and EU legislation on F-gases and experiences

The team at the Swedish EPA introduced F-gas regulations in Sweden, with a brief introduction to the F-gas market, consumption, and manufacturing statistics. There was also a discussion about the analysis that led to the EU F-gas regulations; it addressed the methodologies that agencies employ to assess the various policy options. The group also discussed the relative merits and demerits of the Norwegian tax-and-refund scheme and the reasons a similar scheme was not implemented in Sweden. A deeper description of the regulations and their implementation are presented below.

EU 2050 climate targets is to reduce GHG emissions by 80-95 per cent (1990-level).

- EU Low Carbon Roadmap 2050: non-agricultural non-CO_2 emissions must decline by 72-73 per cent by 2030, and by 70-79 per cent by 2050 (1990-level)
- EU F-gas emissions increased by 60 per cent (1990-level)
- International HFC phase-down proposals under the Montreal Protocol

The presentation made by the Swedish Environmental Protection Agency (SEPA) focused on breaking down the F-gas law, and what that means in terms of implementing targets and institutional and legal responsibilities. As per the presentation, the following tenets are key aspects of the F-gas law:

- Operator is responsible for equipment
- Work with F-gas equipment demands certification
- Leakage tests need to be performed at regular intervals depending on size
- Annual reports must be made to the regulatory authority
- The purchase of F-gas requires a certificate

These commission-level targets, implemented through acts and decisions, have broadly been translated into the following ambitions in Sweden:

1. Prevention of leakage and emissions

- Emission prevention and leakage checks
- Control of by-production
- End-of-life treatment of products and equipment
- Training and qualification
- Information for users (labelling and product details)

	2. Avoiding the use of F-gases • Training and qualification • Ban on new applications • Ban on uses • Phase-down HFC supply 3. Containment measures • Operators must prevent leakage • Conduct leakage checks; frequency depends on charge size • Install detection systems for larger charges • Label products and equipment, extended to foams • Ensure proper recovery and recycling, reclamation, or destruction • Train and certify service personnel, including information on alternatives At the domestic operational level in Sweden, these translate to the implementation of F-gas regulations, supervision regulation, and regulation for prosecution, penalties, and environmental sanction charges through the central, regional (21), and community-level (291) regulatory authorities. In addition to meeting the larger goals of decreasing the usage of high-GWP gases and minimising leakages, institutional responsibilities include making operators aware of environmental risks and their responsibilities, as well as giving local authorities tools for supervision. According to SEPA, the 'demand for leakage test has shown to lower leakage'[249] . End-of-life reclamation and destruction • Taking care of gas from waste equipment demands a simplified certificate • It is important that gas is taken care of for reuse, regeneration, or destruction • Destruction of gas is costly • Strict rules for handling waste • Producers are responsible for electrical products • Household waste must be collected close to households; recycled and hazardous waste is collected at central sites at the community level to ensure proper handling • Waste to energy plants; also use some hazardous, combustible waste • Exports and imports of waste have strict regulations
13.	ClimaCheck: how to help customers increase and sustain the efficiency, reliability, and lifetime of refrigeration, air conditioner, and heat pump systems through optimisation of performance. (presentation by KlasBerglöf, ClimaCheck) ClimaCheck is a private Swedish company offering online monitoring systems and on-site measurement tools for air conditioning, refrigeration, and heat pump systems. Key points from the presentation relevant to HIIRA are listed below. Capacity building is necessary • Capacity building is required to change BaU • Incentives are wrong • Equipment owners lack technical competence • The focus is on low initial price • The industry makes money on failures, not efficiency • Political pressure on reduced energy consumption is increasing • Energy audits are still in infancy for air conditioning and refrigeration - they do not open the black box • ClimaCheck is a part of the India Sweden Innovations' Accelerator Commonly identified problems • Refrigerant shortage or over-charge • Compressor damage or wear

[249] As told to the authors by SEPA staff members.

	• Controls are not well commissioned - adapted for the 'site' • Flow too high or low on secondary media (air/water/brine) • Fan/pump - high power consumption - under performance • Insufficient capacity control requires VFDs, which have better capacity control • Components are changed or upgraded without review systems or controls
14.	This section is based on a presentation made by Peter Rohlin after a visit to the Installations Certifieringi Stockholm AB (INCERT), an independent, accredited certification body for companies and personnel in the RACHP and switchgear sectors. INCERT does not provide education or training, but evaluation or examination and certification. Certification is a way to ensure that a product, person, or company meets the requirements given by a common specification. • The word certification is not protected. • Certification may be mandatory or optional. Mandatory certifications usually take place in a typically Swedish method of accreditation. An accredited certification body complies with an international standard. The accreditation body in Sweden is SWEDAC. (SS-ISO/IEC 17024:2012 indicates general requirements for bodies that issue certification of persons.) Certification requirements for refrigerant handling in Sweden: • Four categories of certification • The certification body has to be accredited according to ISO/IEC 17024:2012 (implies extra requirements compared to EC 517/2014 and EC 2015/2067) • There are requirements for approved theoretical and practical examinations in the case of first-time certification • No professional experience necessary for first-time certification • There are requirements for professional activity after certification, including annual reports • There are requirements for theoretical examination and professional activities in the case of recertification (every fifth year) Certification requirements for high-voltage switch gears handling in Sweden: • Only one category of such certification • The certification of sulphur hexafluoride (EC 2015/2066) is not accredited, but the certification body has to be accredited according to ISO/IEC 17024:2012 for another f-gas area (such as refrigerants) • There are requirements for approved theoretical and practical examinations in the case of first-time certification • Professional experience is not necessary for first-time certification • Professional activity with annual report is not necessary • There are requirements for theoretical examination and professional activities in the case of recertification (every fifth year) Experiences of certification in Sweden: • Positive long-term cooperation among authorities and industries • The refrigeration industry has supported certification by accredited certification bodies in Sweden. • Certification of persons and accreditation/certification of companies has made it difficult for 'gold-diggers' to enter the sector. • Sweden's overall leakage levels have fallen drastically; higher personal skills have provided better systems. • Customers can demand contractors for better systems. • The total cost of a new certification, voluntary courses not included, is around EUR 1,000 for five years. • Recertification costs approximately EUR 600 for five additional years; a company certificate costs EUR 550 for five years. • Legal requirements for certification provide healthier competition (if supervision is effective).

15.

The Montreal Protocol and its Kigali Amendment, and energy and climate strategies by Husamuddin Ahmadzai, SEPA

This presentation and discussion highlighted the role of the Montreal Protocol as a global driver of change.

- The current key narratives include moving towards low-GWP refrigerants, and linkages to energy efficiency. Together, these offer a global opportunity to lower temperature increase by 1^{0}C.
- The total environmental benefit (globally, A2 and A5 countries) from the HFC phase-down, including HFC-23 mitigation, is estimated at about 74-84 G-tonnes CO_2 equivalent, by 2050.
- Leapfrogging energy efficiency (EE) globally, 30 per cent can contribute additionally (LBNL/US), by 2050.
- Improving appliance energy efficiency in parallel with an HFC phase-down could avoid 80-100 G-tonnes CO_2 equivalent (CCAC 2016).
- An HFC phase-down estimated in avoided temperature change of up to ca 0.5^{0}C.
- Specific energy efficiency targets captured in the Kigali Amendment:

  i) § 16_Dec XXVIII/2: 'To request the Executive Committee to increase, in relation to the service sector, the funding available under Executive Committee Decision 74/50 above the amounts listed in that decision for parties with total HCFC baseline consumption up to 360 metric tonnes when needed for the introduction of alternatives to HCFC with low-GWP and zero-GWP alternatives to HFC *and maintaining energy efficiency also in the service/end-user sector.*[250]'

  ii) §22_Dec XXVIII/2: 'To request the Executive Committee to develop *cost guidance associated with maintaining and/or enhancing the energy efficiency of low-GWP or zero-GWP replacement technologies and equipment when phasing down HFC, while taking note of the roles of other institutions addressing energy efficiency, when appropriate.*[251]'
- District cooling is a key not-in-kind alternative used to meet Sweden's energy efficiency and heating and cooling requirements. (More on this below.)

16.

District cooling and heating in Sweden and Nordic countries, Par Dalin, Devcco

Basics of district energy:

- District energy is based on the central production of cold and warm water that is distributed to customers in a closed-loop pipe network. Production can be based on various sources and technologies.
- Common natural sources are seas, lakes, rivers, groundwater, sewage water, and waste heat. Where excess heat from industrial or energy production is available, heat pumps and absorption chillers can be used to produce cooling and heating.
- Day and night storage of cold and warm water can help increase efficiency and lower cost.
- At the customer end of the system, the cooling and heating is transferred to buildings via energy transfer stations (ETS).
- The reuse of sewage water is optional.

District heating (DH) in the EU:

- Serves 62 million EU citizens (approximately 13 per cent)
- Sales total approximately 1,500 pJ or 420 TWh
- Total trench length of DH pipeline system is over 140,000 km
- DH has an installed capacity of approximately 250 GWth
- District cooling (DC) in the EU:
- Today, the EU has a capacity of 3 TWh DC
- Approximately one to two per cent of the market share for DC is in the EU
- The market share in Sweden is greater than 25 per cent (1 TWh)

[250] Ozone Secretariat (2016), p2

[251] Ozone Secretariat (2016), p5

DC is recognised by the UN as playing a key role in meeting both targets (climate and cooling/heating) as the solution for up to 25 per cent of the global cooling demand.

Best practices in Sweden

Västerås (elaborated below)

Linköping

- The first cooling delivery was made in 1997 as a collaboration between the TekniskaVerken (the city energy utility) and Linköping University, and triggered by the Swedish early phase out of R12 and R22 (CFC and HCFC) to make use of the summertime surplus heat.
- In 2016, the network provided cooling solutions to 140 customers with a total demand of 55 MW (16 RT) and a total output of 100 GWh/year.
- Its total investment is about EUR 30 million.

Gothenburg

- The first decentralised cooling delivery was made in the mid-1990s , triggered by the Swedish early phase out of CFC and HCFC. In 2007, these systems were integrated into a large-scale network across the centre of Gothenburg to improve efficiency and be able to serve more customers.
- In 2016, the network provided cooling solutions to 57 customers and 147 buildings with a total demand of 88 MW and a total output of 90 GWh/year.
- Its total investment is about EUR 80 million.

Further development trends:

- New policy package to be put in place that will support DHC
- Energy performance of building directive (DHC)
- Energy efficiency directive (DHC)
- Renewable energy directive (DH)
- F-gas directive (DC)
- Security of supply, i.e. less EU dependency of imported fuel
- Governmental push for DH in the UK
- French utility companies expanding in Europe and elsewhere
- Goal of 50% DH market share and 25% DC market share
- Fast development of DC in the Nordic countries can reach the Swedish market share (more than 25 per cent) within the next 5-10 years
- Absorption cooling in Swedish DC systems
- DH suppliers in Sweden reaching beyond their physical grids offering geo-energy and/or energy services

17.

Waste to energy

Waste incineration and generation of district heating/cooling and electricity

- Around 35 waste incineration plants (except industries)
- Approximately 7.6 million tonnes of waste incinerated where energy was recovered
- Covers around 20 per cent of the total DH in Sweden
- Advanced and secure flue gas treatment
- Emissions of dioxins and heavy metals reduced by 95-99 per cent

Policy instruments for waste management

- Municipal waste planning was made compulsory in 1991
- Producer's responsibility was introduced in 1994
- Landfill tax was introduced in 2000
- Ban on landfill of combustible waste in 2002
- Ban on landfill of organic waste in 2005

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18.

Visit to Mälarenergi, Västerås: Waste incineration plant and DC plant

The team also visited a WtE plant in Västerås, Sweden. The plant, run by the energy company Mälerenergi, had a waste sorting facility, electricity generation plant, and DH and cooling plants located on-site. The DC facility takes advantage of free cooling from the lake as well as absorption chillers. The group learned about the fuel mix at the facility, types of technologies used, the problems associated with scaling up, and the future outlook for the facility. DC may have great potential in India since the country has huge cooling requirements. Since only six per cent of Indians have access to air conditioners, and several commercial buildings are being built, DC could reduce the need for HFCs and reduce the electricity demand for cooling.

About Västerås

- First cooling delivery done in 1992 - used cold wastewater, a by-product of DH from treated sewage. By 2016, the network provided cooling solutions to 72 customers with a total demand of 20 MW and an output of 28 GW/year.
- It led to an HFC phase-down of over 70 per cent and delivered an energy efficiency SSEER of 6.5.

19.

State financing of innovative DH, Vikor Andreen, the Swedish EPA

This presentation described a funding scheme for urban innovations, and some of the projects that have received money from it already.

- Policy instrument for a new generation of environmental technology in the urban environment
- EUR 6.8 million in total during 2016-2019
- Support for increasing the use of cutting-edge technologies and advanced system solutions; high degree of innovation and transformative effects on sustainability
- All aspects of the sustainable city
- Planning grants, not actual investments
- Assessment criteria:
  » Degree of innovation
  » Potential to contribute to significant effects on urban environmental, economic, and social sustainability
  » Capacity and willingness to carry out the planning project as well as the measures and concrete investments that follow
- Project examples:
  » Fourth-generation district heating (4GDH) or pre-study of 4GDH in the city of Varberg and Västerås (two projects):
    - Lower supply and return temperatures
    - Increased use of residual heat
    - Lower energy losses
    - Enables other construction materials
    - Integration with cooling systems
    - Expected results: bridging the implementation gap; creating a decision basis for the actual construction; acting as a test bed for innovation
  » Energy storage in phase change materials (PCM): demo-project for cool thermal energy storage within buildings in the city of Gothenburg through PCM
    - Expected to reduce added peak cooling power by 25 per cent
    - Expected results: bridging the implementation gap; creating a decision basis for the actual construction; acting as a test bed for innovation upscaling.

20.

Meeting with Ambassador Lars Ronnas, Ambassador for Climate Change, Ministry of Environment, Sweden

H. E. Lars Ronnås in Stockholm. The ambassador discussed Sweden's priorities for climate mitigation, its relationship with India, and took stock of all the HFC-related projects and research happening in India.

Annex III:

Questionnaire for Semi-structured Interviews with Stakeholders

The aim is to explain the rationale and motivation for the HIIRA project, its funding channels, methodology and anticipated outcomes, and attempt to gather answers to as many of the following questions.

General information

1. Stakeholder details (company or individual) (information provided before interview)

2. Product/output details (information provided before interview) (to be filled out before interview)

3. Refrigerant usage in India and internationally (information provided before interview)

4. Employee details – numbers, skill level (information provided before interview)

5. Turnover and type of organisation (SME, large, non-profit, academic, etc.) (information provided before interview)

6. Domestic or export market-oriented (information provided before interview)

7. Stakeholder goals

8. Stakeholder interests (imports/export-oriented/domestic market-oriented/skilled workforce/ environmental footprint/sales/others)

9. Stakeholder challenges

Views on HFC phase-down

10. Information on the recent HFC agreement – What do you know? What do you think?

11. What are the main challenges you anticipate in meeting India's Kigali commitments?

Transition

12. How will a low-GWP transition disrupt or benefit your sector?

13. If relevant, how does/will it affect your supply chain?

14. Share your plan of action to enable such a transition, if any.

15. What are the challenges associated with such a transition for (i) your company, (ii) sector, and (iii) nation?

16. What would you have to do to enable a low-GWP supply chain?

Voluntary initiatives

17. Are you part of a voluntary industry initiative?

a. Provide the details.

b. What is its membership base?

c. Are HFCs a part of the discussion?

d. Does this group tackle any sector-wide issues?

18. Would a voluntary commitment to phasing down HFCs be feasible, pan-industry?

Regulatory framework

In achieving the HFC phase-down goals, which of the following regulations would you prefer?

a. **Indicate (positive) environmental impact**
b. **Indicate preference**

19.1 Cap and phase-down, or a quota system, allows a gradual decrease of HFCs by placing limits on the maximum quantity of HFCs (in tonnes of CO_2 equivalents) available in the market. In practice, the total supply of HFCs will be limited affecting HFC produced and imported, including HFCs contained in equipment. A limit on available HFCs can cause shortages and a consequent spike in gas prices. Effective implementation of cap and phase-down in conjunction with regulations on containment and recovery has the potential to cushion such shocks.

Least impactful	Not impactful	Neutral	Mildly impactful	Most impactful
Least desirable	Not desirable	Neutral	Mildly desirable	Most desirable

19.2 Cap and phase-down, or a quota system, allows a gradual decrease of HFCs by placing limits on the maximum quantity of HFCs (in tonnes of CO_2 equivalents) available in the market. In practice, the total supply of HFCs will be limited affecting HFC produced and imported, including HFCs contained in equipment. A limit on available HFCs can cause shortages and a consequent spike in gas prices. Effective implementation of cap and phase-down in conjunction with regulations on containment and recovery has the potential to cushion such shocks.

Least impactful	Not impactful	Neutral	Mildly impactful	Most impactful
Least desirable	Not desirable	Neutral	Mildly desirable	Most desirable

19.3 This scheme would entail lowering of GWP limits on refrigerants to signal markets towards a HFC-free transition. It could be initiated at a limit that allows for the status quo to continue until the year(s) of implementation by when the GWP limits would come into order, taking in to account the two or three most ambitious of the GWPs that exist in the market. This may also be complemented by a financial incentive to the end-user who will be given a rebate on the final sale price of the low-GWP based product to match the competitive pricing offered by the high-GWP products placed on the market already.

Least impactful	Not impactful	Neutral	Mildly impactful	Most impactful
Least desirable	Not desirable	Neutral	Mildly desirable	Most desirable

19.4 India may impose an 'environmental cess' or 'HFC levy' based on the GWP of the HFC in use. This would be paid by refrigerant manufacturers, and passed down the supply chain to equipment owners during the purchase of new equipment or refrigerant. The price of refrigerants would bolster improvements in maintenance, leakage control, charge size and use of low-GWP alternatives. Costs can increase or decrease depending on charge size, type of refrigerant and if there are leaks. Moreover, this additional cost may cover the 'disposal' costs of the refrigerants to minimise EOL emissions.

Least impactful	Not impactful	Neutral	Mildly impactful	Most impactful
Least desirable	Not desirable	Neutral	Mildly desirable	Most desirable

19.5 Phase-down of HFC is expected to cause market shock in terms of gas shortages, price hikes, resentment among stakeholders etc. Incentive schemes through subsidies on low-GWP alternatives can provide motivation for the shift. This subsidy could be given to those procuring low-GWP refrigerants, to incentive its use and diffusion in the Indian market. The Indian government could introduce subsidies for refrigerant users in order to encourage market transition to low-GWP natural refrigerants. Moreover, such programmes and schemes are likely to increase awareness and willingness to adopt low-GWP refrigerants.

Least impactful	Not impactful	Neutral	Mildly impactful	Most impactful
Least desirable	Not desirable	Neutral	Mildly desirable	Most desirable

c. **Rank the options in order of preference**

1	
2	
3	
4	
5	

Follow-up questions:

20. Why did you choose this policy option?
21. Why not others?
22. What are the challenges associated with streamlining such regulations into your workflow, products, or supply chains?
23. Share your views on a regulatory approach that places a GWP limit and simultaneously incentivises low-GWP products.
24. Most countries have a quota on the amount of HFCs placed in the market, and/or a licensing system for those imported into the country. Would such an approach be successful in the Indian context?
25. Share your views on reporting; this is a prerequisite for most regulations to follow through on the supply side.
26. To implement these regulations successfully, do you think it is necessary to support policies with other developmental/economic gains? (Nudge for views on policies related to R&D, domestic manufacturing, jobs, energy efficiency, and formalising the service sector.)

Annex IV:
Industry Interviewee List

1. All India Air Conditioning Refrigeration Association (AIACRA)
2. AIHP
3. Amber Enterprises
4. Ashok Leyland
5. Association of Ammonia Refrigeration (AAR)
6. Baani Group
7. Benson Refrigeration
8. Bharat Refrigeration Co.
9. Birla Aircon International
10. Bluestar
11. BP Refcool
12. Carrefrost/Conzerve Solar Energy
13. Carrier Midea
14. Carrier Transicold
15. Cbalance
16. The Chemours Company
17. Daikin
18. Daimler
19. Danfoss Power Solutions India Pvt. Ltd.
20. Desiccant Rotors
21. Ecologyc
22. Emerson
23. Framework Interiors Pvt. Ltd.
24. Godrej
25. Honeywell
26. Ingersoll Rand (Trane)
27. Intertek
28. Indian Society of Heating, Refrigeration and Air conditioning Engineers (ISHRAE)
29. Johnson Controls
30. K-Flex
31. Kirloskar Chillers
32. Kirti Freeze
33. Mahindra and Mahindra
34. Manik Engineers
35. M Chill/Euro Air/Micro Coils
36. Mexichem
37. Mongia and Co. Chandigarh
38. Overdrive Engineering
39. Panasonic
40. Pankaj Dharkar & Associates
41. Refrigeration and Air conditioning Service Sector Society (RASSS)
42. Rockwell
43. Safe Refrigeration (P) Ltd.
44. Sarthak Refrigeration
45. Sidwal Refrigeration Industries Ltd.
46. Smart Joules
47. Spirotech Heat Exchangers Pvt. Ltd.
48. SS Gas Lab Asia
49. Subros
50. Swegon
51. Tata Motors
52. Tecumseh Products (India) Ltd.
53. Thermax Ltd.
54. Toro Watt
55. Trans ACNR
56. Univac Environment Systems Pvt. Ltd.
57. Value Refrigerants
58. Vertiv
59. Voltas
60. Zamil Air Conditioners

Annex V:
Industry Roundtable Discussion on Initial Findings

On 11 October 2018 - at the India Habitat Centre, New Delhi - CEEW, in partnership with the Norwegian Environment Agency (NEA), organised and hosted a closed-door roundtable discussion on the upcoming challenges and roles of various policies in phasing down HFCs in India.

This event brought together key industry stakeholders to discuss in depth the initial findings from our ongoing research on regulatory approaches and incentives that can support India's eventual HFC phase-down, in keeping with its commitments to the Kigali Amendment. The session began with CEEW's Dr Vaibhav Chaturvedi and NEA's Torgrim Asphjell contextualising the narrative and perspectives around refrigerant regulations in India and Norway.

CEEW's Shikha Bhasin presented the first set of results based on policy preferences and perceived impacts that industry stakeholders were asked to rank in 30 bilateral interviews. The roundtable discussed these findings in detail, and the audience validated them unanimously. They addressed several challenges and precursors to develop an ecosystem in which such policies could succeed.

Erlend Draget of the Norwegian Embassy delivered closing remarks and a formal vote of thanks, highlighting the enthusiasm of industry representatives.

Some of the key themes that emerged are highlighted below:

- Putting a limit on the GWP of HFC refrigerant gases, based on application and current commercial viability, would be a welcome and unique approach to ensure a refrigerant transition in India.
- Checks and balances to implement refrigerant-focused policy are critical to its success in India. This includes institutionalising MRV systems and agencies, controlling stockpiling, and the emergence of a second-tier black market, regulating the availability and pricing of refrigerants to avoid market manipulation, and establishing clear standards and safety mandates for all refrigerants to be able to compete in the Indian market.
- Access to information about refrigerant transition must be organised and widely disseminated. This is important for consumers to change purchasing behaviour and demand; for the industry to prepare itself for the impeding refrigerant transition; and for service sector technicians to ensure safety and maintenance.

Annex VI:
Sector-level policy choices

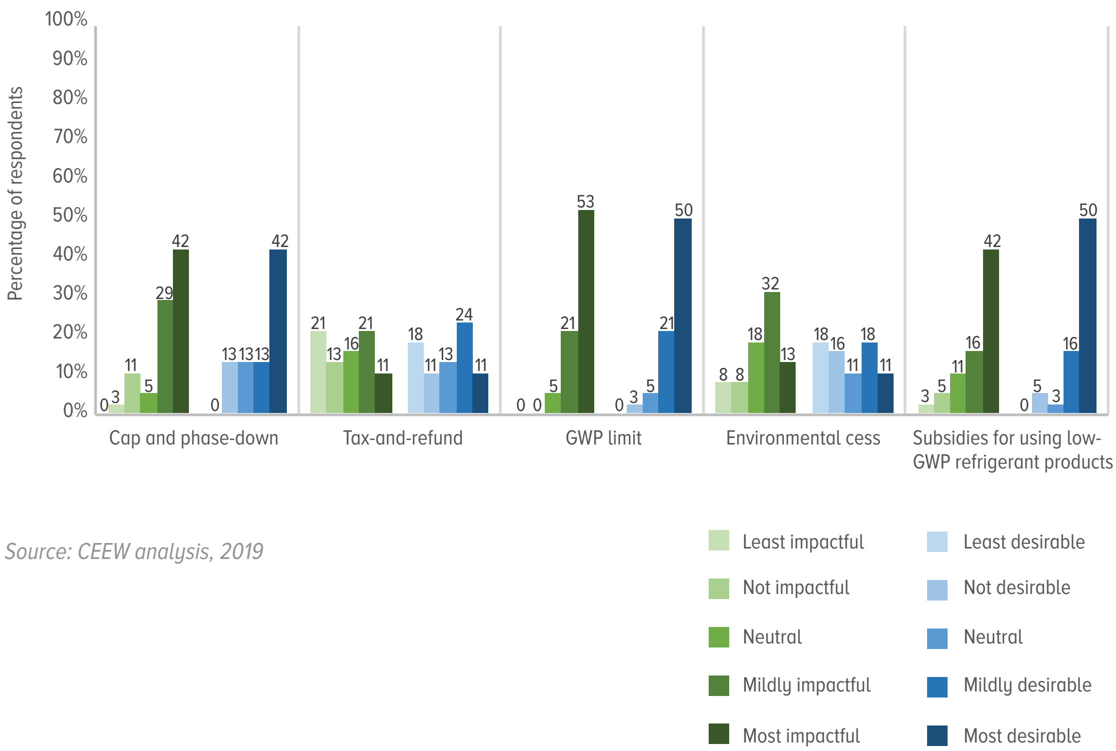
For sectoral analysis of policy choices, Likert scale responses of the stakeholders interviewed for this study were classified under their respective sectors, namely: Residential Air Conditioning (RAC); Commercial Air Conditioning (CAC); Mobile Air Conditioning (MAC); and Commercial Refrigeration (CR). However, around 40 per cent of the stakeholders operated in more than one sector. These multiple sector stakeholders were classified as three distinct sectors of bi-sector (RAC/CAC), tri-sector (CR/RAC/CAC) and multi-sector (RAC/CAC/MAC/CR) depending on their operations in these sectors.

We further analysed sectoral policy evaluation presented in Chapter 5, by considering multiple sector stakeholders under each of the sectors they may operate under. The outcome of this analysis was similar to the overall trends observed in the study. The top three policy choices for the four sectors, in no particular order, were: (i) cap and phase-down; (ii) GWP limit; and (iii) subsidies for using low-GWP refrigerant products. Tax-based policies were the least popular across the sectors.

The following section provides sector-specific trends observed with the inclusion of multiple sector stakeholders being included in each:

1. RAC

Figure I: Policy evaluation based on impact and desirability of RAC sector representatives



Source: CEEW analysis, 2019

GWP limit was the top policy choice among RAC sector stakeholders both in terms of 'most' impact and desirability. 53 per cent RAC sector respondents perceived GWP limit to be 'most impactful', as compared to 50 per cent positing it as 'most desirable'. Further, none of the RAC sector stakeholders indicated that GWP limit was 'least impactful' or 'least desirable'. The subsidies-based policy instrument, on the other hand was marked as 'most desirable' by 50 per cent and 'most impactful' by 42 per cent of the RAC sector stakeholders. Cap and phase-down was perceived to be 'most' impactful and desirable by less than 50 per cent of the RAC stakeholders.

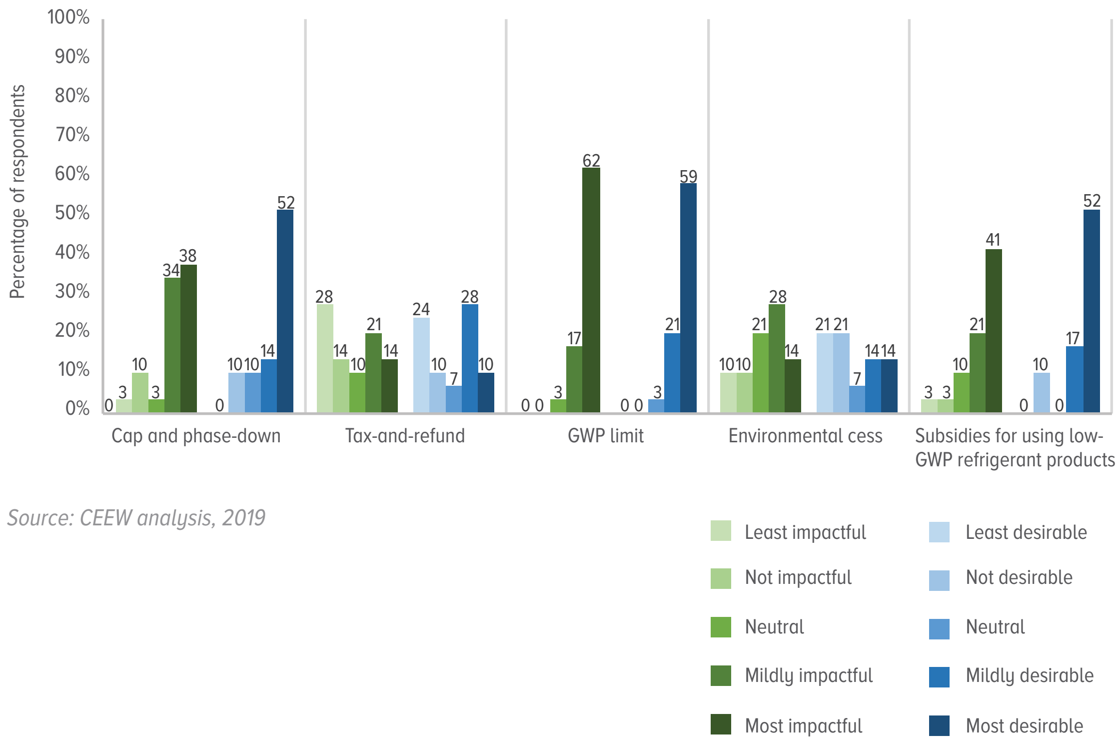
In terms of positive impact and desirability (sum of 'mild' and 'most' indicators in the Likert scales), GWP limit was the top choice. More than 70 per cent of the RAC sector stakeholders indicated a positive preference for and impact of GWP limit as a policy for India's HFC phase-down. A lower proportion of RAC representative favoured the subsidies-based policy. Further, this policy was indicated to be more desirable than impactful. Cap and phase-down, on the other hand, was indicated to be more impactful than desirable as a policy choice.

The two tax-based policies (tax-and-refund and environmental cess), received the highest percent of 'least' and 'not' Likert scale evaluation for impact and desirability. Further, these policies received a distinctly greater proportion of responses indicating 'mild' desirability or impact than 'most' desirability or impact.

2. CAC

Among CAC sector stakeholders GWP limit was the clear policy winner, in terms of the number of respondents marking it as 'most impactful' and 'most desirable'. Subsidies-based policy was the next most rated regulatory approach, followed by cap and phase-down. GWP limit was perceived to be more impactful than desirable by a small margin of 3 per cent of the CAC stakeholders. Subsidies for low-GWP refrigerant products and cap and phase-down were indicated to be more desirable than impactful by a margin of more than ten per cent stakeholders. In terms of positive impact and desirability, close to 80 per cent of the stakeholders chose GWP limit.

Figure II: Policy evaluation based on impact and desirability of CAC sector representatives

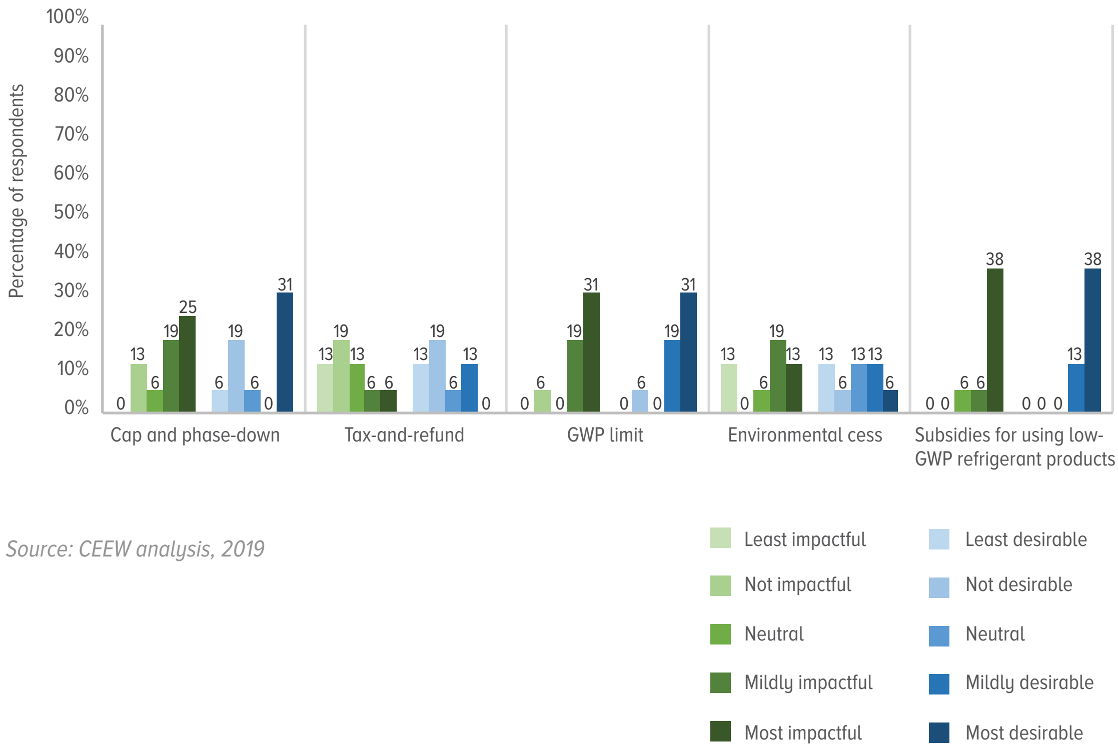


Source: CEEW analysis, 2019

3. MAC

The subsidies-based policy was the top choice among MAC sector stakeholders who marked it as 'most impactful' and 'most desirable', followed by GWP limit and cap and phase-down. Interestingly, in terms of positive impact, 6 per cent more MAC stakeholders indicated that GWP limit would be impactful than the subsidies-based policy. For both these policies, positive desirability was indicated almost equally across MAC stakeholders. Cap and phase-down trailed behind both GWP limit and subsidies-based policies in terms of positive desirability and/or impact. None of the MAC representative indicated least impact or desirability for the subsidies-based policy. The two tax-based policies were not popular among the MAC representative.

Figure III: Policy evaluation based on impact and desirability of MAC sector representatives

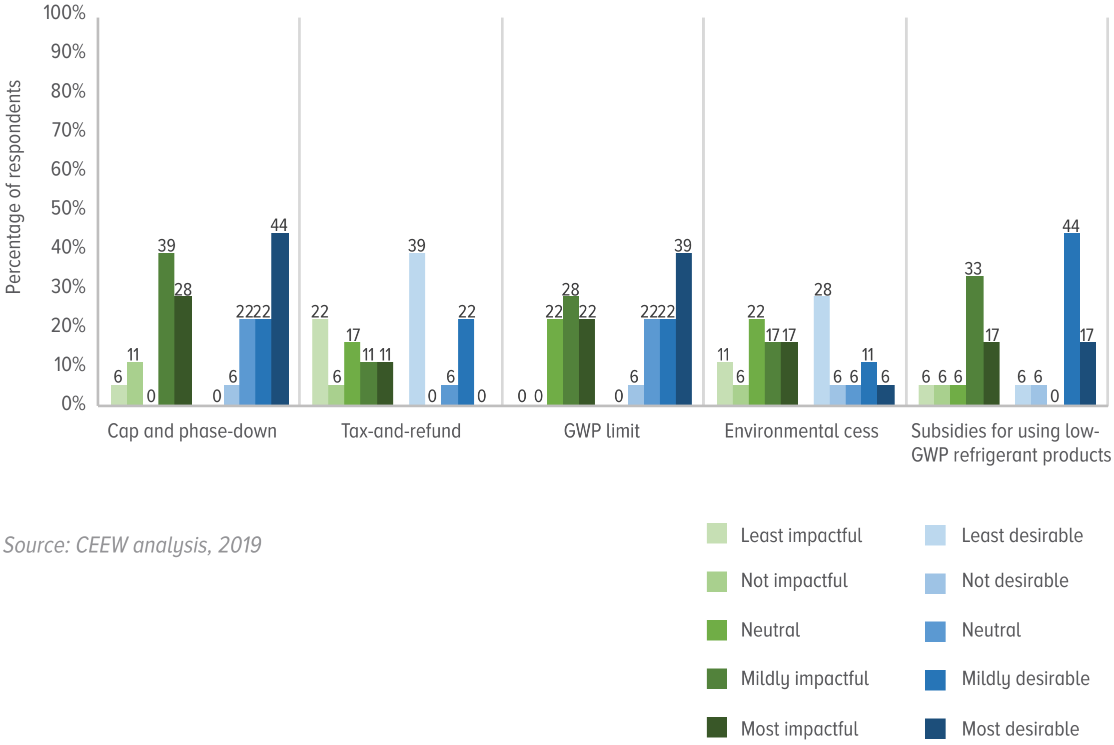


Source: CEEW analysis, 2019

4. CR

In terms of 'most impactful' and 'most desirable' policies, cap and phase-down was the top choice, followed by GWP-limit and the subsidies-based policy instrument among CR sector stakeholders. This was the only sector where the top three policies received a higher per cent of 'mild impact' than 'most impact'. . For example, 44 per cent of CR respondents indicated that subsidies-based policy was 'mildly desirable' relative to 17 per cent stakeholders that rated this policy as 'most desirable' (see Figure 4). Similar to other sectors, tax-and-refund and environmental cess were the lowest ranked policies. Close to 40 per cent of CR respondents rated tax-and-refund as 'least desirable'.

Figure IV: Policy evaluation based on impact and desirability of CR sector representatives



Source: CEEW analysis, 2019

Even in terms of positive impact and desirability, cap and phase-down was favoured by a majority of the stakeholders, while GWP limit and subsidies were the two policies tied in the second place.

Based on this sectoral evaluation, GWP-limit emerged as the top policy choice for the RAC and CAC sectors in terms of 'most impactful' and 'most desirable'. When positive desirability and impact were considered, GWP-limit was the popular choice among the three sectors, namely: RAC; CAC; and MAC. The cap and phase-down policy was favoured by the CR sector both in terms of 'most' and positive desirability and impact. However, in this case, GWP limit and the subsidies-based policies were the next most favoured options with a little over half the CR representatives indicating both positive desirability and impact. The two tax-based policies were the least popular policy choices across all sectors.

The HVAC industry is poised for significant growth in India. Policy must nudge it to move forward in environmentally conscious ways.


Image: iStock

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