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Can India's Air Conditioning Service Sector Turn Climate Friendly?

Evaluating the Skill Gap

by Lekha Sridhar and Vaibhav Chaturvedi

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A report on 'Can India's Air Conditioning Service Sector Turn Climate Friendly? : Evaluating the Skill Gap'.

Mr Jamshyd Godrej, who is the Chairman and Managing Director of Godrej & Boyce Manufacturing Co. Ltd., is also a member of the Board of Trustees at CEEW. It is clarified that Mr Godrej was not involved in any capacity in the preparation of this report.

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Contents

Acronyms and Abbreviations

AC&R	Air-conditioners and Refrigeration Systems
AHRI	Air-Conditioning, Heating and Refrigeration Institute
AMC	Annual Maintenance Contract
CAC	Commercial Air-conditioning
CFC	Chlorofluorocarbons
ECOFRIG	Ecological Refrigeration Project
FADA	Federation of Automobile Dealers Association
FGD	Focused Group Discussion
GWP	Global Warming Potential
HCFC	Hydrochlorofluorocarbons
HPMP	HCFC Phase-out Management Plan
HFO	Hydrofluoroolefin
HIDECOR	Human and Institutional Development in Ecological Refrigeration
ITI	Industrial Training Institute
MAC	Mobile Air-conditioning
MLF	Multilateral Fund
NCCoPP	National CFC Consumption Phase-out Plan
NOS	National Occupational Standards
NSSO	National Sample Survey Office
ODP	Ozone Depleting Potential
ODS	Ozone Depleting Substance
R&R	Recovery and Recycling
RAC	Residential Air-conditioning
RAMA	Refrigeration and Air-Conditioning Manufacturers Association
RASSS	Refrigeration and Air-Conditioning Service Sector Society
SAE	Society of Automotive Engineers
SDC	Skill Development Council
SIAM	Society of Indian Automobile Manufacturers
SOP	Standard Operating Procedure

Executive Summary

Hydrofluorocarbons (HFCs) are greenhouse gases commonly used as refrigerants in air-conditioning (AC) and refrigeration applications as well as in other applications like aerosols, foams, and solvents. The massive growth in air-conditioning in India in the coming years will not only increase electricity demand but will also contribute to the country's carbon footprint by as much as 6.8 Gt CO_2-eq between 2015 and 2050 in a business-as-usual scenario.

The air-conditioning service sector is important not only from the perspective of reducing HFC emissions during servicing, but also from the perspective of maintaining energy efficiency of the equipment and ensuring safe operation of the equipment. In India, the service sector is estimated to account for as much as 40 per cent of all refrigerant consumption in the country. Reducing demand from this sector by increasing adherence to good service practices (GSPs)—that is, servicing and installation practices that are vital for the safe, reliable, and climate-friendly operation of the system—is key to addressing the issue of cutting HFC emissions.

With the adoption of the Kigali Amendment to the Montreal Protocol on Substances that Deplete the Ozone Layer in October 2016, HFCs will have to be phased down from all sectors in India from 2028 onwards. A major challenge of the phase-down will be to find safe and cost-effective low-global warming potential (GWP) alternative refrigerants for all applications. Assessment of available alternative refrigerants shows that many of the replacement refrigerants are either flammable and toxic or operate at very high pressures. This means that service technicians will have to be trained specifically to address these safety concerns.

The purpose of this study was to understand the present state of the AC servicing sector, to assess the level of skill and knowledge of the technicians about GSPs to reduce refrigerant leakages, and to provide a foundation for future policy decisions. Given the lack of demographic information about technicians, including details about their numbers, education levels, access to training, and level of formality, it would be difficult to make policy interventions to improve service practices. Hence, the research questions of the study were:

1. What is the nature and extent of knowledge of servicing sector professionals of solutions and practices for minimising leakages?
2. What are the incentives and disincentives that influence servicing sector professionals to minimise leakages?
3. What policy interventions can the government adopt to minimise leakages of refrigerant through servicing?

A primary survey with a sample size of 642 technicians in the residential, mobile, and commercial air-conditioning sectors (known as the RAC, MAC and CAC sectors, respectively) in New Delhi, Jaipur, and Madurai was conducted. The questionnaire aimed to capture demographic information about the technicians, as well as their routine servicing practices (including practices like leak testing, recovery, and recycling), level of knowledge about GSPs, ownership of tools, and technicians' perspective of customers' knowledge about GSPs. The findings of the survey were validated through two focused group discussions (FGDs) held in New Delhi with technicians from all sectors and interviews with industry representatives to understand all perspectives.

The findings of the study should be situated within the continuum of research on the service sector already existing in India, especially research on the differences between the formal sector (authorised service centres and other registered enterprises) and the informal sector (own-account and unregistered enterprises). Several studies referred to in this report point to a trend of growing informalisation in the service sector, even within

formal enterprises. They also identify a growing skill gap, especially in the MAC servicing sector, where the number of trained technicians required is insufficient. In light of this, the following key findings from this study are important:

1. The survey respondents reported that the nature of servicing work is no longer seasonal. Over 90 per cent of the respondents reported that they were involved in AC-related work all year-round. Many respondents reported that since ACs are being used for longer durations, service needs have also increased.
2. Around 36 per cent of all respondents across all sectors reported having received AC-specific training. More than half the technicians in the formal sector in all three sectors had received AC training, while only about a quarter of the technicians in the informal sector had received AC training.
3. Around 10 per cent of RAC and 16 per cent of CAC technicians who have received servicing training are not adhering to GSPs.
4. Across all three sectors, more formal enterprises own recovery equipment than informal enterprises, with the most prominent disparity being observed in the MAC sector. It is noteworthy that the number of technicians who have reported that they recover refrigerant during servicing are considerably less than those who own recovery units, suggesting that the lack of equipment may not be the sole reason for not recovering refrigerants. Other factors like the time required or the relative effort required for recovery could also be acting as disincentives.
5. Additionally, technicians report that many customers only get the equipment serviced after it has broken down. By this time, the refrigerant has already leaked out, leaving no opportunity for recovery.
6. Respondents perceived customer awareness of GSPs to be low, in addition to customers displaying price sensitivity and demanding or requiring short turnaround time for servicing. Technicians reported that all of these factors could affect the choice of a service centre/technician by the customer and could dis-incentivise technicians from adhering to GSPs.
7. Knowledge about the environmental impacts of refrigerants, new alternative refrigerants, and practices like reclamation was low among the respondents across all sectors. That said, more than half the respondents were aware of the energy efficiency gains emanating from GSPs, flammability concerns associated with some refrigerants, and recycling of refrigerants.
8. In all three sectors, regression analysis showed that a technician with AC servicing training was more likely to have good knowledge about GSPs and related information. Other factors like customer knowledge and ownership of tools had limited impact.
9. Some GSPs like leak testing of ACs were universally followed whereas other practices like recovery were followed by less than half the respondents. While the formal sector showed greater adherence to some of the practices, the overall performance of the formal sector was not significantly ahead of the performance of the informal sector, despite greater access to training and equipment. Hence there is a need to further investigate other disincentives to GSPs.
10. The regression analysis showed that in the RAC and CAC sectors, a technician with AC servicing training was more likely to adhere to GSPs, while training had no impact on a technician's service practices in the MAC sector.
11. In the RAC and MAC sectors, technicians were more likely to adhere to GSPs if their customers had some knowledge about refrigerants. However, the impact of customer knowledge was limited. Ownership of recovery units had an impact on the likelihood of a service technician following GSPs.

Based on the analysis, the following are the key recommendations that have been made in the report:

1. Despite there being a plethora of training programmes conducted by the government (through institutes and sector skill councils) and other training providers like manufacturing companies and private institutes, there is no consistency in the programmes, and many of them may not have been updated to reflect changes in technology. While Industrial Training Institutes (ITIs) have recently updated their syllabi, the National Occupational Standards for the RAC and MAC sectors have not been updated.

Policy interventions to standardise training programmes and to ensure that AC training programmes across the country meet minimum criteria are necessary.

2. In addition to training programmes for technicians, awareness-raising campaigns about GSPs and proper servicing techniques are necessary for customers. Manufacturers could also raise awareness of proper installation and servicing practices when customers purchase ACs/cars and highlight the possibility of increased electricity/fuel consumption due to faulty installation/servicing. Customers could also be incentivised to use service centres that adhere to GSPs by including servicing costs in the price of the AC or by offering the same at discounted rates.
3. Formal sector service centres are better placed to improve GSPs as manufacturing companies are in the position of mandating that GSPs be followed by their authorised service centres. Such parameters could be included among key performance indicators to incentivise better adherence to GSPs. Manufacturing companies could also conduct regular training and re-training sessions for their employees to ensure that their skills remain up to date.

The above findings and insights should be taken as indicative, although we believe that the findings are as robust as one can derive in the absence of a sampling frame and the lack of baseline information. As better baseline information becomes available in the future, our research questions could be revisited. One of the areas that the survey was unable to satisfactorily test was the possible relation between poor service practices and low fees for servicing ACs. Given the growing informalisation of services in the country, including in the formal sector, the impacts of the loss of employment security on the servicing sector need to be better understood

While dedicated research on finding suitable low-GWP refrigerants is important, this study highlights the crucial role played by service technicians in minimising emissions. Without a well-trained service sector that is well incentivised to adhering to GSPs, many of the gains from such technological improvements may be lost. Furthermore, the emphasis placed by the Government of India (through the Ozone Cell) on increasing AC training programmes for technicians is supported by the results of this study, which shows that a technician with training is more likely to follow GSPs. The near-universal adoption of some GSPs like leak testing, as well as awareness of the relationship between GSPs and the energy efficiency of the equipment, point to the necessity of continuing such programmes.

However, without increasing customer awareness of GSPs and without incentivising customers to use service centres that adhere to GSPs, the impact of such training programmes may be limited because technicians' practices are, to an extent, driven by their customers' knowledge (or lack of knowledge) about GSPs and by their willingness to pay for better services.

1. Introduction

Hydrofluorocarbons (HFCs) are greenhouse gases that are widely used in applications like air-conditioning and refrigeration. HFCs replaced hydrochlorofluorocarbons (HCFCs) and chlorofluorocarbons (CFCs) in such applications after these ozone-depleting substances (ODS) were phased out under the Montreal Protocol on Substances that Deplete the Ozone Layer. While HFCs have minimal impact on the ozone layer, they have a significant impact on global warming due to their high GWP. Indeed, the cumulative global warming impact of HFC emissions on India's total carbon dioxide and HFC emissions between 2015 and 2050 is estimated to be 3.9 per cent in a business-as-usual scenario (Chaturvedi et al., 2015). Globally, phasing down HFCs could avoid as much as 0.5°C warming by the end of the century (Velders et al., 2009).

While much of the attention has been focused on finding suitable alternatives and replacement technologies for HFCs, focusing on the practices of AC technicians who install and repair air-conditioners and refrigeration systems (collectively known as AC&R) is necessary if countries want to successfully phase down these refrigerants. The servicing sector in India accounts for as much as 40 per cent of the total refrigerant consumption, much of which can be reduced by GSPs, use of proper tools, and regular servicing of AC equipment (Ozone Cell, 2017).

The AC and automobile markets in India have been witnessing high growth. It is crucial to address deficiencies in the servicing sector to reduce HFC consumption and to reduce the country's carbon footprint.

This report analyses the practices followed by AC servicing technicians in the residential, mobile, and commercial air-conditioning (referred to as RAC, MAC, and CAC, respectively) sectors to identify potential policy interventions to reduce HFC consumption. While the three sectors are different enough for each to require its own study, many of the techniques for minimising HFC emissions and for dealing with other challenges are similar across all sectors. Several findings from this study can be generalised across the three sectors. Wherever necessary, sector-specific findings have also been discussed.

The main research questions for the study were:

1. What is the nature and extent of knowledge of servicing sector professionals of solutions and practices for minimising leakages?
2. What are the incentives and disincentives that influence servicing sector professionals to minimise leakages?
3. What policy interventions can the government adopt to minimise leakage of refrigerants through servicing?

In addition, the study also gathered information on the technicians' knowledge about flammability of refrigerants, alternative refrigerants, and related topics. The analysis is based on primary data from surveys and interviews, and on secondary data from a literature review.

1.1 Control Mechanisms under the Montreal Protocol

The Montreal Protocol on Substances that Deplete the Ozone Layer (1989) is an international treaty to which 197 countries are now signatories. Originally created to phase out ozone- depleting substances like CFCs and HCFCs, the treaty has been termed as one of the most successful multilateral environmental treaties. Most developed countries have already phased out HCFCs (with a minor component remaining for servicing and essential uses) and developing countries are on track to fully phasing out HCFCs by 2030.

India is currently in the process of phasing out HCFCs and transitioning to HFCs in all sectors. The MAC sector has already shifted completely to HFC-134a. The RAC industry has begun the transition from HCFC-22 to HFCs, a process that has to be completed by 2025 (by which time no new HCFC-based ACs will be permitted to be manufactured). The sector is expected to largely shift to HFC-410A, which has extremely high GWP, and a few manufacturers are transitioning to HFC-32, which has one-third of the GWP of HFC-410A. The commercial air-conditioning sector has transitioned to HFC-134a, HFC-410A, and HFC-407C, all of which have extremely high GWP.[1]

However, HFCs, which replaced HCFCs, are also now subject to control measures following the adoption of the Kigali Amendment to the Montreal Protocol in October 2016. Since India is an Article 5–Group 2 country, it must freeze its HFC consumption in 2028 and reduce consumption thereon to phase down HFCs to 15 per cent of the baseline by 2047. Developed countries (or non-Article 5 countries) are required to phase down HFC consumption earlier.

Table 1: HFC Phase-down schedule for Article 5 parties to the Montreal Protocol

	Articles 5 Parties: Group 1		Articles 5 Parties: Group 2	
Baseline Year	2020, 2021 & 2022		2024, 2025 & 2028	
Baseline Calculation	Average production/consumption of HFCs in 2020, 2021 and 2022		Average production/consumption of HFCs in2024, 2025 and 2028	
	plus 65% of HFCs baseline production consumption		plus 65% of HFCs baseline production/consumption	
Reduction Steps Freeze	2024		2028	
Step 1	2029	10%	2032	10%
Step 2	2035	30%	2037	20%
Step 3	2040	60%	2042	30%
Step 4	2045	80%	2047	85%

Source: UNEP Factsheet

1.2 Alternatives to HFCs

In the RAC sector, a few alternatives to HFCs already exist in the market. HFC-32 as a refrigerant is considered to be a suitable alternative to high-GWP refrigerants like HFC-410A even though HFC-32 is also an HFC.[2] The use of HFC-32 offers some energy efficiency gains and also requires smaller refrigerant charge. Currently, Daikin is the only manufacturer of HFC-32-based ACs. Several major RAC manufacturers have also committed to converting their manufacturing facilities from HCFC-22 to HFC-32 in the coming years under the HCFC Phase-Out Management Plan Stage-II. While HFC-32 may be a suitable transition refrigerant, most manufacturers will eventually have to transition away from HFC-32 also due to the considerable growth anticipated in the RAC sector.

1 The GWP values (100 years) are 1430 (HFC-134a), 2088.5 (HFC-410A), and 1774 (HFC-407C).
2 It is considered a medium-GWP refrigerant with a GWP of 675. It is included among the controlled HFCs under the Montreal Protocol.

So far, only one company, Godrej Appliances, has introduced RACs containing a refrigerant (HC-290) that has no ODP or global warming impact. However, the share of HC-290 ACs constitutes an extremely small percentage of the total RACs sold in the country. Some industry representatives anticipate that R290-based RACs could become more widely available as companies begin exporting such ACs to India. HFO-HFC-32 blends may also become available in the future, especially for retrofitting existing RACs if required.
In the CAC sector, it is difficult to identify a single refrigerant alternative as many different types of chillers and technologies are available. Nevertheless, some alternative refrigerants proposed are Honeywell's HFO-1234ze and HFO-1234zd, and also HFO-based blends like R513A (GWP 600), R444 (GWP 300), and R452B (GWP 680). However, many of these blends are flammable.

In the MAC sector, an alternative refrigerant to HFC-134a that many automobile manufacturers intend to transition to is Honeywell's HFO-1234yf, which has negligible GWP. However, some manufacturers have expressed concerns about its flammability and patent-related costs, and are testing cars with R744 (carbon dioxide). However, R744 may not be a suitable alternative for high ambient temperature climatic zones like India, and most Indian manufacturers are expected to transition to HFO-1234yf. Tata Motors has been testing an alternative, HFC-152a (GWP: 124), in a secondary loop system.

2. An Overview of the AC Servicing Sector

2.1 Why is the servicing sector important for the HFC phase-down?

The AC servicing sector, that is, the MAC, RAC, and CAC servicing sectors, is an important consumer of refrigerants, accounting for up to 40 per cent of refrigerant consumption in India (Ozone Cell, Montreal Protocol Report, 2016). Refrigerant gases leak out of the AC system and must be refilled by service technicians for the system to perform optimally. Refrigerant gases are also used for flushing the system, leading to further usage of the gases during servicing. Finally, at the end of the life of an air-conditioner or a car, the residual HFC/HCFC in the system are typically not recovered before the system is salvaged for its parts.

However, with technological advances, techniques and equipment are now available to reduce HFC emissions during servicing. From low-tech methods like leak testing with soap solution to more advanced methods like recovery and recycling (R&R) machines, there is now great scope for reduction of HFC emissions. Control of HFC consumption from and by this sector has been, and will continue to be, paramount to achieving the phase-out targets specified under the Montreal Protocol's control measures.

2.2 History of servicing sector policies in India

Right from the inception of the ODS phase-out in India, the servicing sector has been the focus of several policies of the government. In 1991, the RAC sector was identified as one of the priority sectors for phase-out due to its large consumption of CFCs and HCFCs. Of the 1,990 MT of ODS phased out during the CFC phase-out regime by 2010, about two-thirds were estimated to be used in the servicing of equipment.

The first activities initiated for ODP phase-out were the Ecological Refrigeration Project (ECOFRIG), an Indo-Swiss-German initiative, and the Human and Institutional Development in Ecological Refrigeration (HIDECOR), an Indo-Swiss initiative, in 1998. ECOFRIG and HIDECOR jointly established a training programme with modules and qualified trainers across the country. The programme's activities were restricted to six states,[3] and small and medium informal enterprises were the target group.

In 2004, the Executive Committee of the Multilateral Fund (MLF) of the Montreal Protocol approved funding for the National CFC Consumption Phase-out Plan (NCCoPP) to phase out 1,502 Ozone Depleting Potential (ODP) tonnes of CFCs from the RAC sector. The NCCoPP took over from HIDECOR and expanded its programme to establish training infrastructure in 15 states and conducted awareness-raising workshops across the country. NCCoPP focused its efforts on enterprises consuming 50 kg or more of refrigerants per year. The programme also expanded training programmes to technicians in the MAC and commercial refrigeration sectors. The programme provided subsidised R&R units to enterprises and to ITIs (Ozone Cell, 2016).

While the ODS emission reduction from these efforts has not been quantified, more than 20,000 technicians have been trained under HIDECOR and NCCoPP.

3 Later expanded to 12 states: Karnataka, Tamil Nadu, Andhra Pradesh, Delhi, Maharashtra, Gujarat, West Bengal and later Punjab, Haryana, Uttar Pradesh, Rajasthan, and Kerala.

The phase-out of HCFCs was carried out through the HCFC Phase-Out Management Plan (HPMP). Preparation for Stage I was approved by the Executive Committee of the Multilateral Fund (MLF) for the Implementation of the Montreal Protocol in 2008; this called for developing the Plan to meet the 2013 freeze and for achieving 10 per cent reduction in 2015. The Roadmap document to the HPMP identified the RAC servicing sector as a major priority sector with a target of reducing this sector's HCFC consumption by 10 per cent. The three activities identified for Stage I were:

1. Continuing training programmes for servicing technicians on GSPs across the country
2. Focusing on the existing reclamation centres associated with institutional users as these could adopt suitable policies on the reclamation and reuse of refrigerants
3. Promoting recovery and reclamation in the private sector in cooperation with the existing reclamation centres.

Among the reclamation centres that were set up, many are no longer functional. The Jaipur reclamation centre was operational for four or five years after its commencement, but has not been in use in the last one or two years due to a lack of customers. During the time of its operation, both small- and medium-scale enterprises reclaimed refrigerants at the centre.[4]

Stage II of the HPMP for India was approved in November and was launched in March 2017. Plans for the servicing sector include specific interventions for the provision of technical assistance and capacity building. The planned reduction of HCFC-22 consumption is 1,250 MT (or 68.75 ODP tonnes) by 2023, with an investment of USD 5.1 million. The specific planned activities include:
Increasing the number of training programmes to reach more technicians and using new training partners to reach the technicians;

a. Institutional-strengthening activities like revising the syllabus at ITIs, increasing the number of trainers at such institutes, and establishing state-of-the-art institutes;
b. Awareness-raising activities like organising workshops, especially for spare parts dealers, to disseminate information, and producing more printed material, especially on new refrigerants, servicing methods, etc.;
c. Certification programmes for technicians.

2.3 The Servicing Sector in India: What does it look like?

The service sector consists of many types of enterprises. For the purpose of this study, enterprises were divided into two categories: formal and informal sector enterprises. This distinction between formal and informal enterprises is commonly used in social science research, especially in developing countries where a large part of a country's economic activities take place in the 'informal' sector. The 'informal' (sometimes referred to as 'unorganised') sector is defined in many ways both in India and internationally, based on parameters like avoidance of government regulations and taxes, lack of employment benefits, and self-employment (Justine George, 2014). For the purpose of this study, the following definitions were used:

- Self-employed individuals and own-account or unregistered enterprises, together known as the '**informal' or unorganised sector**;
- Service centres authorised by the manufacturers (who provide services for goods under warranty or have access to official spare parts) and multi-brand service centres which are registered enterprises (which are not authorised by the manufacturers), together known as the '**formal' or organised sector**.

4 Amounts ranging anywhere between 1–2 kg to 10 kg of refrigerant at the rate of INR 100 per kg were reclaimed by customers. Based on interview with the proprietor of the Jaipur reclamation centre.

The servicing sector in India—both RAC and MAC—relies heavily on the informal/unorganised sector to bridge the servicing gap. While all major manufacturers offer free or reduced charges on services for one to four years on their products, many customers do not return to 'authorised' dealerships or service centres for servicing needs once the equipment is no longer new. For cars, it is estimated that only 50 per cent of customers return to official service centres[5] once the cars no longer qualify for free servicing. As a result, a majority of older equipment relies on services from the unorganised sector, many of whose personnel or technicians have no formal training in the repair and servicing of equipment. For RACs, it is estimated that far fewer people return to authorised service centres for servicing after the warranty period has expired, with customers relying on existing informal networks. For commercial air-conditioners, it is estimated that many customers enter into annual maintenance contracts (AMCs) with enterprises to cover their routine servicing requirements.[6]

In the formal sector, most manufacturers no longer run authorised service centres, but instead have authorised dealerships that provide services for goods that are under warranty and have access to official spare parts. Service centres today are largely operated by dealerships and franchisees because the expenses associated with operating own service centres tend to be significant. In the automobile sector, Tata Motors is one of the few manufacturers that operates its own service centres, through its subsidiary. The level of adherence to standard operating procedures (SOP) varies with manufacturers. Some have detailed prerequisites, including mandatory equipment, training for technicians, and other servicing practices that are part of their global corporate practices, while others have fewer requirements. Furthermore, each company has its own audit system and therefore it is not possible to ascertain the level of adherence to such procedures by the authorised dealerships.[7]

2.4 How many service technicians are employed?

It is difficult to estimate the number of service technicians in India (across all three of the study sectors) as no nationwide census of the sector has been conducted. Based on industry and government sources, some estimates are available:

- In the RAC sector, the industry estimate is 200,000 technicians, which is based on existing AC stocks in the country (Ozone Cell, 2017).
- In the automobile industry, persons employed in the passenger cars and commercial vehicles servicing industry were estimated to be around 585,000 technicians in 2010, of whom about 63 per cent were estimated to be mechanics (CII–KPMG, 2010). A 65 per cent increase by 2015 (950,000 persons) was projected, of which a 68 per cent increase in the formal sector was anticipated (CII–KPMG, 2010). It should be noted that that the number of AC technicians would be a smaller percentage of this. According to the Federation of Automobile Dealers Association (FADA), approximately 50 per cent of servicing enterprises are informal. In the formal sector, about 75 per cent are authorised service centres while the rest are multi-brand service centres. FADA also estimates that car dealerships tend to employ around 40–50 technicians at each centre on average.
- There is some overlap between the CAC sector and the RAC sector. The former is estimated to be largely formal, although there are no estimates available on the number of persons employed.

5 Estimate from representatives of the Federation of Automobile Dealers Associations and the Society of Indian Automobile Manufacturers (2016).
6 Based on interviews with industry representatives.
7 Based on interviews with industry representatives.

2.5 Training available for AC technicians

One of the primary goals of the HPMP (both Stages I and II) has been to train technicians in proper service practices as many continue to learn AC servicing through apprenticeship or by trial and error. Apart from the workshops and training programmes conducted by the government through the Ozone Cell, there are a few other avenues of training available to technicians:

- The Ministry of Skill Development and Entrepreneurship manages ITIs which provide training and diplomas in electronics, refrigeration, and automobile management among other subjects. There are nearly 12,000 ITIs in the country, either run by private companies or by the government, and hence there can be significant variation in the quality of training and practical skill development. That said, it may be more accessible than university education for many, especially in rural areas.
- The National Skill Development Council and its Sector Skill Councils (Electronic and Automobile Skill Development Councils) run short training programmes for technicians. National Occupational Standards have been specified for both RAC and MAC servicing skills by the SDCs.[8] However, technicians are not mandated by law to meet these skill standards in order to be employed.
- Most companies also impart training to their technicians (either conducted in-house or outsourced to training institutes). The duration of these trainings ranges from a few days to a few weeks. Many companies also organise re-trainings, especially for newer technologies.

2.6 Organisation and representation

Even though the AC, automobile, and refrigerant industries are well represented through their respective industry associations, until recently AC technicians lacked representation through an industry body. In 2014, with the support of the Ozone Cell, a registered society for representing technicians was set up as the Refrigeration and Air-Conditioning Service Sector Society (RASSS). RASSS currently has branches in Punjab, Maharashtra, Uttarakhand, Haryana, and Uttar Pradesh, and a membership of over 500 people and organisations.

2.7 A brief overview of the informal sector in India

This report and survey should be viewed within the continuum of research on the informal sector in India. Many studies on the informal sector explore the definition of 'informal' as used in the context of labour and the sector's interactions with the formal sector. More than 90 per cent of the workforce and about 50 per cent of the country's GDP are accounted for by the informal economy. In the last two decades, the high levels of growth of the Indian economy have been accompanied by increasing informalisation. The growth of informal labour has not been limited to informal and unorganised sector enterprises alone, but also extends to formal and organised sector enterprises (National Statistics Commission, 2012).

The National Sample Survey 2010–2011 (67th Round) surveyed non-agricultural enterprises (excluding construction), which include manufacturing, trade and other services. Out of the estimated 57.7 million enterprises, two-thirds were involved in non-manufacturing activities (trade and other services, which include repair of automobiles and household goods). Of the 28.8 million enterprises engaged in trading activities, about 4 per cent work in the 'trade and repair of automobiles' sector, which consists of around 1.15 million enterprises (NSSO, 2013).

8 ASC/Q1416 and ELE/Q3102.

Between the three survey areas selected for the present report, NSSO data show that Rajasthan has the biggest disparity between formal and informal enterprises in urban areas with four own-account enterprises for every established enterprise, with Tamil Nadu having three own-account enterprises for every established enterprise, and Delhi having nearly equal numbers of own-account and established enterprises.

2.7.1 Interactions with formal sector

An analysis of the informal labour market based on NSSO data found a growing trend of informalisation in the labour market even in the organised sector:

The composition of employment in the organised vs unorganised sector shows an increase in organised sector employment from 13% in 2004–05 to 17% in 2011–12. But this increase in organised sector employment was informal in nature (48% in 2004–05 increased to 55% in 2011–12) while the share of organised formal employment decreased (52% in 2004–05 decreased to 45% in 2011–12). On the whole[,] the number of formally employed increased from 33.41 million in 2004–05 to 38.56 million in 2011–12, while [the number of] informally employed increased from 426.20 million to 435.66 million during this period.

(Shrija and Shirke, 2014)

Furthermore, the broad sectoral distribution of formal and informal sector employment shows that the addition of workers to the services sector has been modest, with the biggest additions in the informal sector.

Table 2: Broad Sectoral Distribution of Formal-Informal Employment (in percentage share)

2004-05	Organised Sector		Unorganised Sector		Total
	Formal	Informal	Formal	Informal	
Agriculture	0.76	0.99	0.00	56.75	58.50
Manufacturing	1.21	2.10	0.10	8.33	11.73
Non Manufacturing	053	1.45	0.00	4.42	6.41
Services	4.48	1.89	0.19	16.80	23.36
Total	**6.98**	**6.43**	**0.29**	**86.30**	**100.00**
2011-12	**Organised Sector**		**Unorganised Sector**		**Total**
	Formal	**Informal**	**Formal**	**Informal**	
Agriculture	0.06	016	0.00	48.69	48.90
Manufacturing	1.48	2.76	0.06	8.28	12.60
Non Manufacturing	0.69	3.77	0.01	7.18	11.65
Services	5.62	2.72	0.22	18.29	26.84
Total	**7.84**	**9.43**	**0.29**	**8243**	**100.00**

Source: Shrija and Shirke, 2014

The analysis concludes that the reasons for the growing informalisation of the sector are not linked to labour market rigidities, but rather to poor skill levels and increasing competition from imports.

In the sectors under study in this report, there is a strong relation between the organised and unorganised sectors. Formal education systems like ITIs and polytechnic institutes feed trained people into the formal and informal sectors, while many formal sector technicians who work at authorised service centres receive training in new technologies and go on to start their own enterprises. Many technicians working at authorised service centres also take on servicing jobs during their free time or on weekends to earn extra income. Meanwhile, the formal sector simply does not have sufficient coverage across the country and therefore relies on the informal network, especially for older models of air-conditioners and automobiles.

3. Study Methodology

The study methodology adopted for analysing the level of skill and knowledge of GSPs consisted of the following major strategies:

1. Literature review of existing surveys and studies of the servicing sector;
2. Primary survey of 642 technicians in the RAC, MAC and CAC sectors;
3. Two focused group discussions (FGDs) with technicians to validate and investigate the findings of the survey;
4. Interviews and discussions with personnel from industry associations, representatives, and other experts.

3.1 Literature review

The report extensively reviewed all available information on the informal/unorganised sector in India, previous surveys of AC technicians, as well as studies of the servicing sector internationally. The findings of the review were used to develop the questionnaire and the recommendations.

In the automobile sector, a 2010 study by CII and KPMG of the entire automobile servicing sector (not limited only to MAC servicing) notes that the need for skilled manpower in this sector will outstrip the supply of trained technicians. The report states:

Based on institutes offering auto/ auto engineering/ auto repair courses, we estimate that about 530,000 people graduate from these institutes every year. This is the number catering to the auto, auto components and auto service sectors. Yet it is lower than the auto service sector manpower requirement of over 780,000. Currently, much of the gap is being bridged by OEM training programs and small private institutes offering unorganized training. (CII–KPMG, 2010)

The CII–KPMG report also stressed the need for specialised skills rather than general car servicing skills.

Few studies have been conducted on the AC servicing sector in India. Of these, the most prominent are a study of recovery and recycling in the refrigeration and air-conditioning sector (Devotta et al., 2004) and a survey of MAC sector technicians by the National Chemical Laboratory (Devotta and Asthana, 2000).

The latter, even though it was a small survey, is relevant to the present study as it largely focused on servicing practices like recovery and recycling and provides a useful comparison to CEEW's study. Some important observations that emerged from the National Chemical Laboratory study were:

a. GSPs like charging by weight and recovery were restricted to the organised sector (authorised service centres). The unorganised sector did not observe these practices, even though the technicians were well aware of them, because of the time taken, cost restrictions (of the equipment), and the relatively small quantities of refrigerants used by them.
b. The survey also found that trained technicians were largely employed by the organised sector, while technicians in the unorganised sector tended to be apprenticed or self-trained, with only the proprietor possessing some sort of training, which was then passed on to his mechanics. In the organised sector, however, training is conducted from time to time for all mechanics.
c. Traditional methods of refrigerant charging such as by pressure and feel were found to be common in the unorganised sector. 'Topping-up' was a common practice in the servicing of MACs. However, the survey

found that many major car manufacturers' servicing centres had already started practising R&R, based on global corporate practices.

d. The differences between practices in the organised and unorganised sectors were also reflected in the servicing fees as well as the use of imported equipment.

e. Interestingly, most respondents stated that MACs require recharging once a year on an average. The most commonly found reasons for the failures of MAC systems were leakages due to vibrations on bad roads and hot climatic conditions.

Devotta et al. (2004) mainly focused on the cost-effectiveness of purchasing R&R units for small servicing enterprises, given their high cost and the relatively small volumes of refrigerant used by such enterprises. The study also referred to a nationwide perception-based study of the domestic refrigeration sector organised by the Government of India in 2002, which revealed that most of the small and medium enterprises involved in servicing activities in India have an annual turnover of less than INR 0.5 million at the time of the study. However, the latter study was not publicly available.

Internationally, the two studies that were reviewed focused on the availability of trained personnel in Europe for the safe handling of natural refrigerants; these were by the European Commission (2016) and by Shecco (2017).

The European Commission report—on availability of training for service personnel in Europe on the safe handling of climate-friendly technologies aimed at replacing or reducing the use of fluorinated greenhouse gases—analysed the availability and uptake of training on natural refrigerant among member states. The report found that the level of preparedness for the upcoming phase-down of HFCs in 2019 was insufficient, with only 0–2.3 per cent of technicians trained in the use of alternative refrigerants. The only exception was ammonia, since it has been used for many years now. The report noted that while good training material was available, wider reach of the material had become limited due to the lack of translated versions and the absence of practical training facilities.

The second report, produced by Shecco, bolstered the above-mentioned findings with the results of an industry survey of natural refrigerant training in the European Union. It found that the key reasons for the relatively low numbers of technicians trained in natural refrigerant handling among European countries were the investment costs associated with the training and the lack of appropriate facilities. These findings match the findings of the first report. However, European industry stakeholder respondents in the survey stated that lack of good training material was a key reason for the low numbers of trained technicians. The respondents also stated that there was no need for formal training and that on-the-job training was sufficient. The responses of the industry stakeholders seem to differ from the findings of the European Commission report with regard to the availability of suitable training material and may require further investigation.

The above reports provide some useful insights into the Indian servicing sector in that availability of good training material, especially in vernacular languages, and practical training facilities can be crucial in ensuring better uptake of natural refrigerant training.

Recovery and recycling has not been successful throughout the world because the consumer usually approaches the service centre only when the AC system has broken down, in which case there is no refrigerant left in the system or a very small quantity is left which is not very economical to recover. Even developed countries like the USA, Australia, Canada, and the EU member nations are unable to sufficiently optimise supply chains to increase recovery rates. A 2016 paper by Navigant Consulting Inc. prepared for the Air-Conditioning, Heating and Refrigeration Institute (AHRI) compared the recovery rates in Australia, Canada, the EU, UK, Japan, USA and California (Navigant Consulting Inc., 2016). While the report largely focused on end-of-life recovery as opposed to recovery during servicing, some important issues emerged:

1. Recovery rates range between 30 and 80 per cent; of this, the lowest recovery rates are from domestic equipment.
2. End-of-life recovery rates improve when manufacturers are mandated to recover refrigerant and when the costs of recovery and destruction are included at the time of purchase of the equipment.
3. While venting of refrigerants is illegal in many of the jurisdictions under study in the current report, only a few have recovery and destruction programmes for HFCs.
4. Anecdotal evidence from many of the jurisdictions suggests that compliance with recovery requirements are low among domestic consumers.
5. Most of the jurisdictions require compulsory certification for service technicians, and some of the countries also mandatorily require consumers to have their equipment/vehicle regularly tested for leaks.

The report concluded with some recommendations that may also be applicable to India:

1. HFCs must be included in the national regulation mandating recovery and destruction, so as to level the playing field between the synthetic refrigerants in use.
2. Portraying refrigerant management as a cost saver to end-users and consumers can greatly improve participation and performance.
3. Overambitious regulations like phase-out targets, service bans, or other licensing requirements can drive undesirable behaviour like venting or the use of unlicensed technicians.
4. Mandatory record-keeping of refrigerant recovery and recharge by the service technician and the end-user of commercial equipment can be useful in gathering data about recovery rates.

3.2 Survey Methodology

Target Population

Formally employed and informally employed servicing technicians in the residential, commercial, and mobile air-conditioning sectors in three locations in India (New Delhi, Jaipur, and Madurai).

Sample Size

A sample size of 642 respondents was surveyed for the study, split across cities and sectors as under:

Table 3: Distribution of survey respondents across sectors and cities

	Delhi	Jaipur	Madurai	Formal	Informal	Total
RAC	96	79	57	97	135	232
MAC	98	78	57	67	166	233
CAC	74	58	45	102	75	177
Total	268	215	159	266	376	642

Sampling Frame

Since no previous survey or census has been taken of this sector, there was no sampling frame on which the survey could be based. Some of the publicly available directories of service technicians like 'Just Dial' and 'Sulekha' could not be used for random sampling due to self-selection bias which would also exclude more persons from the informal sector than the formal sector. As a result, non-probability-based sampling techniques were deemed appropriate for this study.

Sampling Methods

As mentioned before, due to the lack of a comprehensive sampling frame, probability-based sampling methods could not be used to conduct the survey, and therefore **convenience sampling** has been used. Furthermore, since the target population has significant differences between the sub-populations (that is, self-employed persons working in the unorganised sector, those employed in authorised service centres, etc.), quotas were allotted to the formal and informal sectors to ensure that there were sufficient representative samples from the sub-populations. The sub-populations covered were:

Table 4: Distribution of survey respondents between the formal and informal sectors

	RAC	MAC	CAC
Informal/Unorganised sector enterprises	60%	50%	No quota
Formal sector: Authorised service centres	20%	25%	50%
Formal sector: Unauthorised service centres	20%	25%	50%

Source: CEEW Analysis (2017)

Within each category, the **snowballing method** was used to identify respondents. The initial respondents were contacted via 'Just Dial' and also by visiting some areas where a number of service enterprises are located. While it was recognised that within each category, there are further sub-populations (that is, both self-employed persons and unregistered enterprises fall within the unorganised sector and also each company with its network of service centres forms a sub-population), no quotas were assigned to these. Enumerators were also instructed to ensure representation from the service centres of different companies and also from various locations. Enumerators were also instructed to ensure some representation of service technicians from Godrej's service centre network because Godrej is the only manufacturer in India that uses R290, a flammable low-GWP refrigerant, in its ACs.

Location Selection

The three survey locations were determined based on climate, geographic location, and population to ensure diversity in responses. All three cities are located in states with high AC stocks. One of the cities, Jaipur, was selected because it has a reclamation centre to determine whether the presence of a reclamation centre has any impact on servicing recovery practices.

Table 5: Comparison of location characteristics of survey locations

	Delhi	Jaipur	Madurai
Location	Northern India	Western India	Southern India
Climatic zone	Composite	Hot and dry	Warm and humid
Average temperatures (April to September)	33°C – 41°C	31°C - 40°C	33°C – 41°C
Wet bulb temp	16.8 – 29.1 °C	15.7 – 32.7 °C	22.9 – 23.6 °C
Population	16,787,941	3,046,163	1,017,865
Per capita income current price (state-wise, 2013–14)	219,979	65,974	112,664
% of households with access to electricity (2011)	99%	97%	97%
Car ownership per 1,000 (state-wise, 2011–12)	387	130	257
AC stocks (state-wise, 2015) [million units]	0.26	0.98	2.08
Refrigerant reclamation centre	No	Yes	No

Source: CEEW Analysis (2017)

The sample size was divided based on the population of the three cities—with the highest number of respondents in Delhi and the smallest number in Madurai. With regard to the three sectors, the CAC sector has fewer respondents as it is more homogeneous than the other two, with fewer informal enterprises.

3.2.1 Questionnaire Design

The survey questionnaire[9] was designed based on the extensive literature review and consultations with industry experts. The questionnaire was designed to include quantitative and qualitative aspects, with the aim of capturing essential information on the following:

1. Background information on the technician, including training, education, years of experience;
2. Routine servicing practices, including information on leak detection and refrigerant recharge;
3. Knowledge of the technician about GSPs and important concepts necessary for minimising venting of refrigerants;
4. Recovery, recycling, and reclamation;
5. Ownership of tools and equipment;
6. Customer awareness of refrigerants and GSPs.

3.2.2 Ethical Concerns

All respondents, during the survey and the FGDs, were informed about the purpose of the study, that is, to study and understand practices followed by AC technicians during servicing. All respondents were surveyed only after their informed consent had been obtained.

3.2.3 Limitations of the Study

Due to the lack of a sampling frame and the absence of any baseline data, the approaches used in the study had certain limitations. In terms of sampling methodology, a probability-based sampling method could not be used. Due to this and the limited sample size and the small number of survey locations, caution should be exercised when generalising the results of the study to the entire population under study.

9 See Annexure 1 for the full questionnaire

Other limitations of the study include possible biases, listed below:

Selection Bias

Since the sampling method was non-random, there is a possibility of the investigators' bias in the selection of respondents. Furthermore, since respondents were surveyed during their usual working hours, many respondents who were approached refused to participate in the survey, and hence it is possible for selection bias to have affected the sample.

Attempts to address this issue were made by using quota sampling so that responses from technicians from a wide variety of backgrounds could be captured. Some respondents were interviewed over the span of two or more days, during the time that they were available for this exercise.

Response Bias

The questions were designed to test the professional knowledge of respondents, so there was a likelihood that some respondents reported 'positive' answers rather than reporting their actual practices.

To tackle this issue, survey enumerators were instructed not to prompt the respondents to give any answers. Answers to some questions were re-confirmed over the phone a few days after the survey was taken. Additionally, test questions and confirmation questions were included in the questionnaire.

3.3 Focused Group Discussions

Two FGDs were conducted in New Delhi after the primary survey was completed to understand and explore some of the responses from the survey.

The first FGD involved RAC and CAC technicians from the informal and formal sectors. Respondents were selected to ensure diversity in type of employment, educational background, years of experience, and training received. A total of nine technicians attended the discussion.

The second FGD was attended by four MAC sector technicians, with two from the formal sector and two from the informal sector.

The following topics were explored during both discussions:

a. Impact and usefulness of servicing training for technicians in adhering to GSPs
b. Differences between formal and informal sector enterprises
c. Source of knowledge about new technologies
d. Routine servicing practices and those that are the most important
e. Customers' knowledge about servicing and the impact of this on the servicing practices of technicians
f. Access to servicing tools and equipment
g. Knowledge about the environmental impact of refrigerants
h. Knowledge about recovery, recycling, and reclamation
i. Policies that the government could adopt to support technicians.

3.4 Interviews

In addition to the survey, views of the service sector were also sought from the following:

a. Representatives of industry associations, namely the Society of Indian Automobile Manufacturers (SIAM), Refrigeration and Air-Conditioning Manufacturers Association (RAMA), Federation of Automobile Dealers Associations (FADA), and Refrigeration and Air-Conditioning Servicing Sector Society (RASSS);
b. Three technician trainers in the three survey locations;
c. Owner of the reclamation centre in Jaipur (one of the survey locations) and industry representatives from two manufacturing companies.

3.5 Survey Analysis Methodology

Regression analysis was undertaken to evaluate the impact of various factors on knowledge of GSPs and adoption of GSPs by service technicians. Five GSPs were considered for the analysis: leak testing, calibrated charging, brazing/flaring of parts, flushing without refrigerant, and recovery of refrigerant. Since the five practices vary in terms of effort, equipment, and level of adherence, each practice was weighted as per the relative rarity of the practice within the sample. Since recovery is done by only a small percentage of the respondents, this practice has a higher weight.

Table 6: Proportion of respondents following GSPs

Parameters	RAC	CAC	MAC
Base	232	177	233
Leak testing	93	89	92
Charge measurement	52	67	58
Brazing/flaring of tubes	72	68	67
Flushing without refrigerant	33	38	41
Recovery of refrigerant	44	25	9

Source: CEEW Analysis (2017)

Table 7: Weights for GSPs converted to a 10-point scale

GSPs	RAC	CAC	MAC
Leak testing	0.3	0.5	0.3
Charge measurement	2.3	1.5	1.8
Brazing/flaring of tubes	1.4	1.5	1.4
Flushing without refrigerant	3.2	2.9	2.5
Recovery of refrigerant	2.7	3.5	3.9
Total	10.0	10.0	10.0

Knowledge about GSPs	RAC	CAC	MAC
Awareness about undercharging refrigerant	1	1	1
Awareness about overcharging refrigerant	1	-	1
Awareness about natural refrigerants	1	1	1
Awareness about energy efficiency maintenance through GSPs	1	1	1
Awareness about flammability of refrigerants	1	1	1
Awareness about environmental impacts of refrigerants	1	1	1
Awareness about refrigerant recycling	1	1	1
Awareness about refrigerant reclamation	1	1	1
Total	**8**	**7**	**8**

Source: CEEW Analysis (2017)

Based on the above weights and the responses from the survey, each service technician was given a 'servicing score' and a 'knowledge score' and thereafter divided into three categories based on the score:

Table 8: Service practice and Knowledge categories

Service practice	Category	Score
Poor servicing practices	1	0 – 2.99
Moderate servicing practices	2	3 – 5.99
Good servicing practices	3	6 – 10

Knowledge	Category	Score
Poor knowledge	1	0 – 2
Moderate knowledge	2	3 – 5
Good knowledge	3	6 – 8

Source: CEEW Analysis (2017)

The purpose of grouping technicians into categories was twofold: first, irrespective of the survey analysis, this would give an indication of how many technicians fall in which category as per the above understanding of 'good' servicing; and second, this information was essential for the regression analysis to identify the factors that influence the GSP/knowledge of technicians.

Generalised ordered logistic regression was used for the analysis of the survey results:

$$Pr[Y \geq jX] = 1/(1+\exp[-(\alpha j + X\beta)])$$

where j=1, 2 ……. k is the general equation for the generalised ordered logistic regression model.

In this case, Y is the service practice/knowledge score of the technician; j refers to three threshold values (0, 2.99, and 5.99 for service practices; and 0, 3, and 5 for knowledge);
X stands for the AC training, years of experience, ownership of recovery unit, and customer knowledge about refrigerants.

AC training (actrain) = 1 when the technician has received AC training
= 0 when the technician has not received AC training

Years of experience (exp) is a discrete variable starting from 1.

Tools (tools) = 1 when the technician owns or has access to recovery unit
= 0 when the technician does not own or does not have access to recovery unit

Customer knowledge (custknow) = 1 when the technician believes that customers have some knowledge about refrigerants
= 0 when the technician believes that customers have no knowledge about refrigerants

This regression model was selected because ordinal logistic models are suitable in cases where the dependent variables (service practice category/knowledge category in the present instance) are ordinal and categorical (Harrell, Jr., 2015). However, the ordinal logistic regression model does not report coefficients/odds ratios for each of the categories. This is because it assumes that there is no significant difference between the categories (above the lowest one). This assumption is known as the proportional odds assumption (or, parallel regression assumption).

In this case, since the data violates the proportional odds/parallel regression assumption (which means that a significant difference is assumed between category 2 and category 3), the generalised ordered logistic regression model was selected, since it would account for the above assumptions, and report different coefficients/odds ratios for each of the different categories.

Originally, it was planned to also include location (city), level of education, and employment type (formal/informal sector) of the technician in the regression model since these variables were likely to influence service practices/knowledge. However, due to the high degree of the pair-wise correlation existing between level of education and AC training, between city and employment type, and between employment type and AC training, location, level of education, and employment type were omitted from the regression equation to avoid multicollinearity.

The results from the regression analysis are discussed in the chapter on key findings.

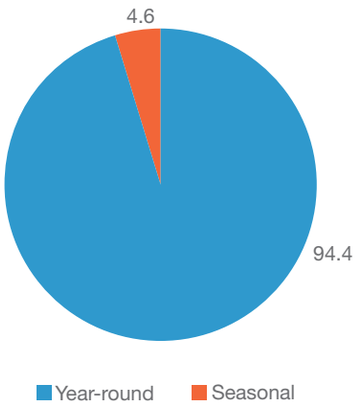
4. Key Results from the Survey

4.1 Most technicians are employed in AC-related work year-round[10]

An assumption about the air-conditioning servicing sector, particularly the RAC sector, is that technicians do not work year-round in the sector. However, in the survey, over 90 per cent of technicians, across sectors and across formal and informal enterprises, work year-round in AC servicing.

During the FGD sessions, informal sector technicians reported that servicing ACs in offices and commercial enterprises (where room ACs are installed) went on from February till October every year (roughly nine months). In the residential sector, servicing of ACs went on for around six or seven months. In the remaining months, the technicians reported that AC installation and repair work was available. Others reported that other refrigeration-related work like repair of chillers, refrigerators, and other electronic equipment was available year-round.

Figure 1: AC technicians working year-round or working seasonally

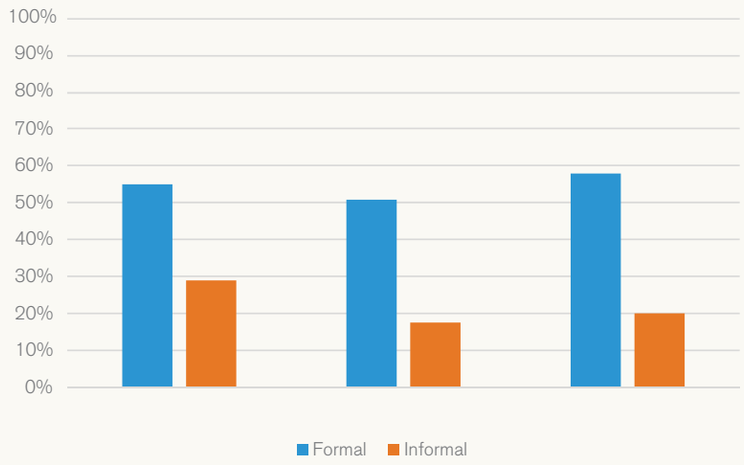


Source: CEEW Analysis (2017)

While this result needs verification at other locations in India, this finding may point to a positive trend towards increasing professionalisation of the service sector. When technicians are no longer seasonal workers, they may be more willing to invest in equipment and training, and therefore policies directed towards them may have greater gains.

4.2 AC training is not common among service technicians

Figure 2: Percentage of trained technicians in the formal and informal sectors



Source: CEEW Analysis (2017)

10 The definitions used in the survey are given in Annexure 2.

Overall, 36 per cent of service technicians from the sample have received AC servicing training, a majority of which has been through ITIs. For the purpose of the survey, any AC training—ranging from that provided by polytechnics to that provided by manufacturers to their employees—was considered to be 'AC training'.

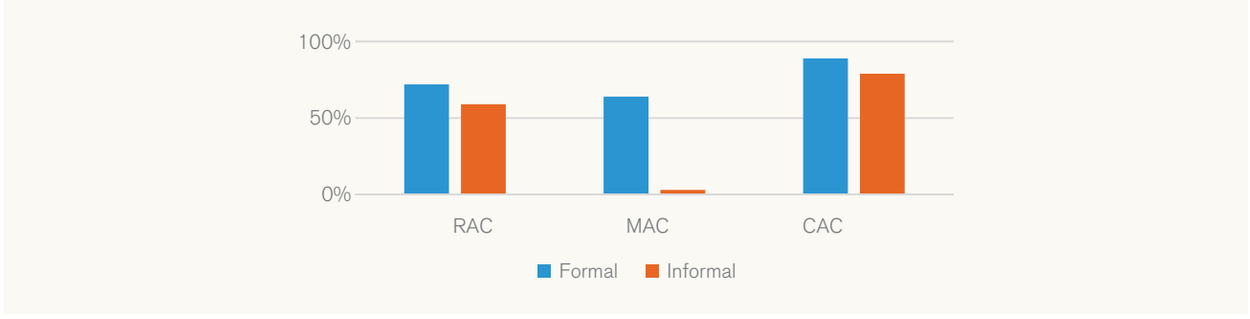
Within each sector, more than half of the formal sector technicians were trained, while approximately only a quarter of the informal sector technicians were trained. While the immediate assumption made in this regard is that skill training programmes have not benefitted the informal sector, it is possible that persons in the informal sector who have received such training have moved to the formal sector. Other reasons for this disparity between the formal and informal sectors were explored during the FGDs.

During the FGD session with the RAC and CAC technicians, many technicians stated that having an ITI or polytechnic diploma is considered a prerequisite for joining authorised service centres. Furthermore, most manufacturers offer training to their employees, especially for new technologies.

Many technicians reported dissatisfaction with this low barrier to entry to the field of AC servicing. They expressed the belief that many non-trained technicians start servicing even though they have no training and therefore do not adhere to GSPs. Due to the influx of many technicians, it was reported that fees for servicing visits were being driven low. Technicians also reported some difficulty in picking up servicing practices for new technologies, especially in the MAC sector, due to the increasing level of computerisation involved. Many now rely on electricians or other specialists for carrying out repairs related to those components as they lack the expertise.

4.3 Ownership of tools and equipment does not result in greater adherence to GSPs

Figure 3: Ownership of recovery units across all sectors



Source: CEEW Analysis (2017)

Ownership of recovery units (and other tools) was surveyed across all three sectors. In the RAC sector, 59 per cent and 72 per cent of the informal and formal sectors, respectively; in the MAC sector, 3 per cent and 64 per cent of the informal and formal sectors, respectively; and in the CAC sector, 79 per cent and 89 per cent of the informal and formal sectors respectively have recovery units. The biggest disparity can be seen in the MAC sector, possibly due to the fact that the recovery units required for automobiles are much more expensive.

Ownership of recovery & recycling units was extremely low across all sectors, with only 4 per cent of the surveyed respondents being owners, while the ownership of vacuum pumps was higher across all sectors.[11]

Even though over 50 per cent of the technicians own recovery units in the RAC and CAC sectors (and in the MAC formal sector), the number of technicians recovering refrigerant during servicing is considerably lower (see Figures 8 to 11). This suggests that the lack of equipment may not be the primary reason for the non-

11 See Annexure 2 for definitions of R&R units.

recovery of refrigerant. Some industry experts report that some of the locally manufactured servicing tools like recovery units are of extremely poor quality and may therefore not function as required. This may be an impediment to the greater uptake of recovery during servicing. Furthermore, during the FGD, technicians reported that customers only get their ACs serviced when they do not cool properly. In such instances, the refrigerant may have already leaked out, leaving no opportunity for the technicians to recover it.

4.4 Fees for servicing is low, especially for informal sector technicians

The survey results on the fees charged per servicing visit were excluded from the survey analysis, as the survey was unable to capture information on the fees charged for the same services. Since technicians were asked to report the fees charged for routine services, it is unclear as to what service practices were included by the technicians when reporting the figures. That said, the results are still useful in understanding the extent and nature of the fees charged by technicians.

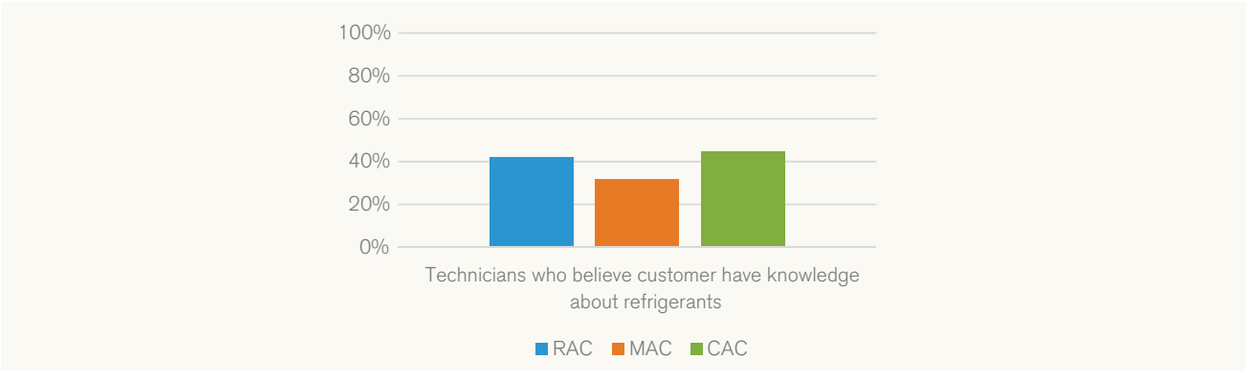
In the RAC sector, 98 per cent of informal technicians earn less than INR 600 per AC for servicing, while a fifth of the technicians earn less than INR 300 per AC. In the formal sector, less than 80 per cent earn less than INR 600 per AC while a tenth earn over INR 600 per AC.[12]

In all, 87 per cent of technicians in the informal sector in CAC earn less than INR 600 per unit while only 52 per cent of technicians in the formal sector earn less than this. In the formal sector, remuneration was as high as INR 1,500 per unit. The reason for this may be that informal sector technicians tend to service only packaged ACs in the CAC sector and not large-scale chillers, which require greater manpower and expertise. Hence, the comparison between the two groups may not be appropriate.

The MAC sector showed the greatest disparities in fees for servicing between the informal and formal sectors. In all, 66 per cent of technicians in the informal sector earned less than INR 500 per car AC, while 81 per cent of the group earned less than INR 2,000 per car. On the other hand, only 57 per cent of technicians in the formal sector earned less than INR 2,000 per car, while several respondents reported fees as high as INR 4,000 and more per car. This may be because many of the enterprises that can charge such high fees tend to cater to high-end automobile models and also because such enterprises have greater overheads from rent, electricity, equipment, etc.

4.5 Perceptions of service technicians about customers' knowledge is an important factor

Figure 4: Percentage of technicians who believe their customers have knowledge about refrigerants



Source: CEEW Analysis (2017)

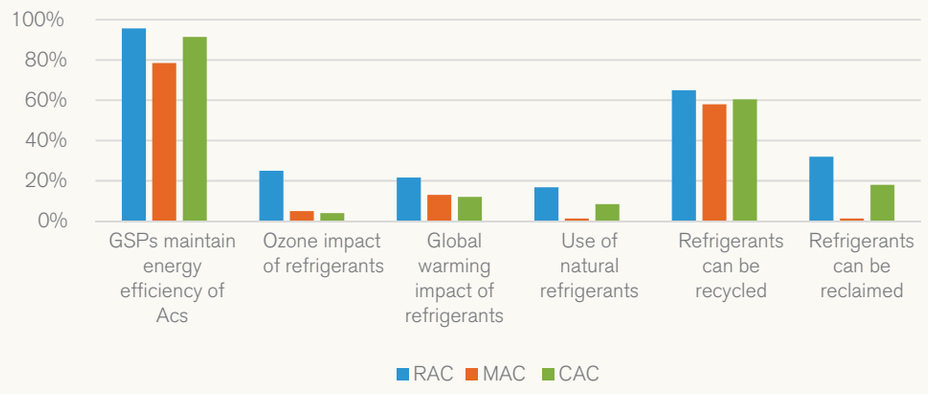
12 Fees exclude the cost of spare parts, refrigerants, etc.

For a service industry, perceptions about what customers want or the extent to which they demand adherence to GSPs could be crucial to the adoption of better servicing practices. During the FGDs, customers' knowledge or awareness of GSPs was acknowledged by many of the participants to be the most important factor in influencing the kinds of processes followed by them.

During the FGDs, technicians from all sectors reported that there is some reluctance on the part of customers to pay very high fees for servicing and that the customers would prefer to use a non-authorised service centre or an informal enterprise for servicing if the fees charged were sufficiently low. Some technicians also reported that many customers are suspicious of what seem to them to be complicated or unnecessary servicing procedures.

4.6 Knowledge about refrigerants, environmental impacts, and the benefits of recycling and reclamation is low

Figure 5: Knowledge of service technicians about issues related to GSPs



Source: CEEW Analysis (2017)

While most of the respondents were aware that proper servicing practices would maintain energy efficiency of the equipment, many were unaware of other issues like natural refrigerant alternatives to commonly used refrigerants, environmental impacts of refrigerants, and reclamation of refrigerants. Even though Jaipur had a functional reclamation centre till recently, only a small percentage of the respondents from the city were aware of the practice.

While many technicians, especially in the RAC and CAC sectors, were aware of the recycling of refrigerants, during the FGD the opinion was that this practice is only useful for large enterprises with high usage of refrigerants. Portable R&R units were not seen as feasible for RAC technicians due to the process being cumbersome and time-consuming. With regard to natural refrigerants, RAC technicians were more likely to be aware of hydrocarbons due to their now-ubiquitous use in domestic refrigerators. A key reason for the lack of awareness of natural refrigerants is the relatively low uptake of such refrigerants in most sectors: One manufacturer has introduced R-290-based ACs in the RAC sector while the MAC and CAC sectors have seen no change since the shift to HFCs. Manufacturers may not be clear about what information to provide to service technicians, given that such refrigerants have little or no market penetration today.

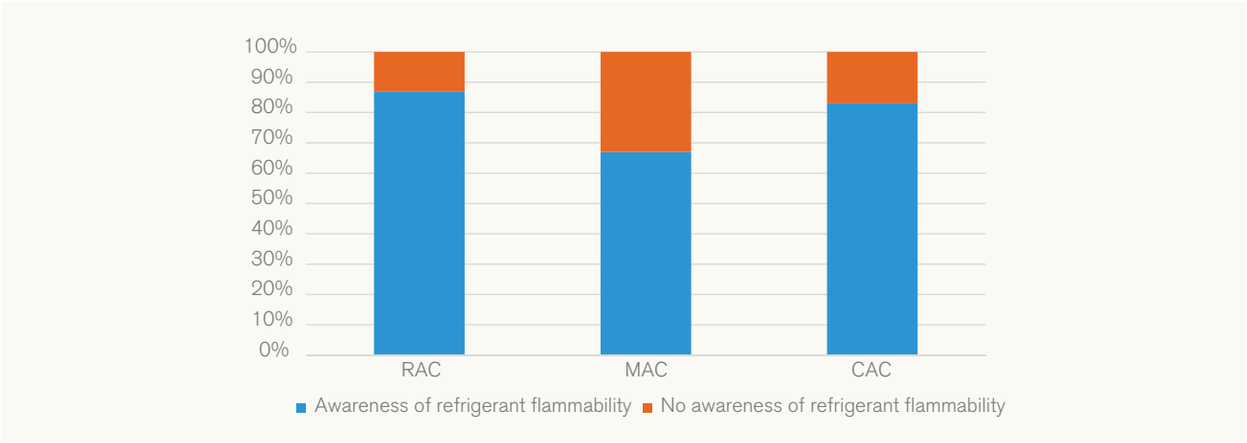
During the FGDs, several technicians stated that they had become aware of environmental impacts of refrigerants (although many also said that they did not know what exactly the impacts were) because of the previous phase-out of CFCs and HCFCs. However, many were also of the opinion that HFCs, which

replaced the older refrigerants, had no environmental impacts since they were the alternatives. There was no awareness of the Kigali Amendment nor of the upcoming phase-out of HFCs in the next decade.

For technicians, the main sources of information are the proprietors of their respective organisations and, in the case of self-employed technicians, the main sources of information are spare parts dealers and other colleagues. Spare parts dealers were also stated to be the source of information on servicing new technology.

4.7 More than half the surveyed population was aware of the flammability of refrigerants

Figure 6: Awareness of refrigerant flammability



Source: CEEW Analysis (2017)

Given that all sectors in the future will require the use of flammable or toxic refrigerants, and that more than half the respondents (with greater percentages in the RAC and CAC sectors) are aware that some refrigerants are flammable, it is important to note that many technicians have no knowledge about the flammability aspects of some refrigerants. This is especially true in the MAC sector, where at least one of the proposed alternative low-GWP refrigerants, HFC-1234yf, is flammable.

During the FGD with the RAC and CAC technicians, many reported having experience with the use and service of hydrocarbon-based refrigerants (which are flammable), given their widespread use in domestic refrigerators. However, even though HFC-32 is a flammable refrigerant, none of the technicians claimed to be aware of this fact during the FGD. Furthermore, CAC technicians did not report having knowledge of other natural refrigerants like ammonia or carbon dioxide.

Increasing awareness about flammability, toxicity, and necessary safety procedures will be crucial to effective and safe servicing in the coming years. Given the increasingly widespread use of HFC-32 in the RAC sector, as well as the use of HC-290 and HFO-1234yf and other blends, this is an important concern for policymakers.

4.8 What factors impact knowledge about refrigerants and GSPs?

The respondents' responses to eight questions were considered for the regression analysis (see Table 7). Based on their scores, respondents were placed in three categories: poor knowledge, moderate knowledge, and good knowledge.[13] Regression analysis of the scores was done using the variables: AC training, access to recovery unit, years of experience, and customers' knowledge about refrigerants. From the significance of the coefficients (p-value), the impacts of the variables could be observed for all three sectors.

In the RAC sector, AC training and years of experience were observed to be significant predictors of good knowledge. With AC training, a technician is 47 per cent more probable to not have poor knowledge about GSPs and refrigerants, while every year of work experience makes a technician 1 per cent less probable to have poor knowledge (see Table 9, Annexure 3).

In the MAC sector also, AC training was observed to be a significant predictor of good knowledge. A technician with AC servicing training is 12 per cent more probable to not have poor knowledge about GSPs (see Table 10, Annexure 3).

In the CAC sector also, AC training was a significant predictor; having AC training would make a technician 14 per cent more probable to have good knowledge. Ownership of recovery units was also a significant predictor; technicians who own recovery units were 7 per cent more probable to have good knowledge (see Table 11, Annexure 3).

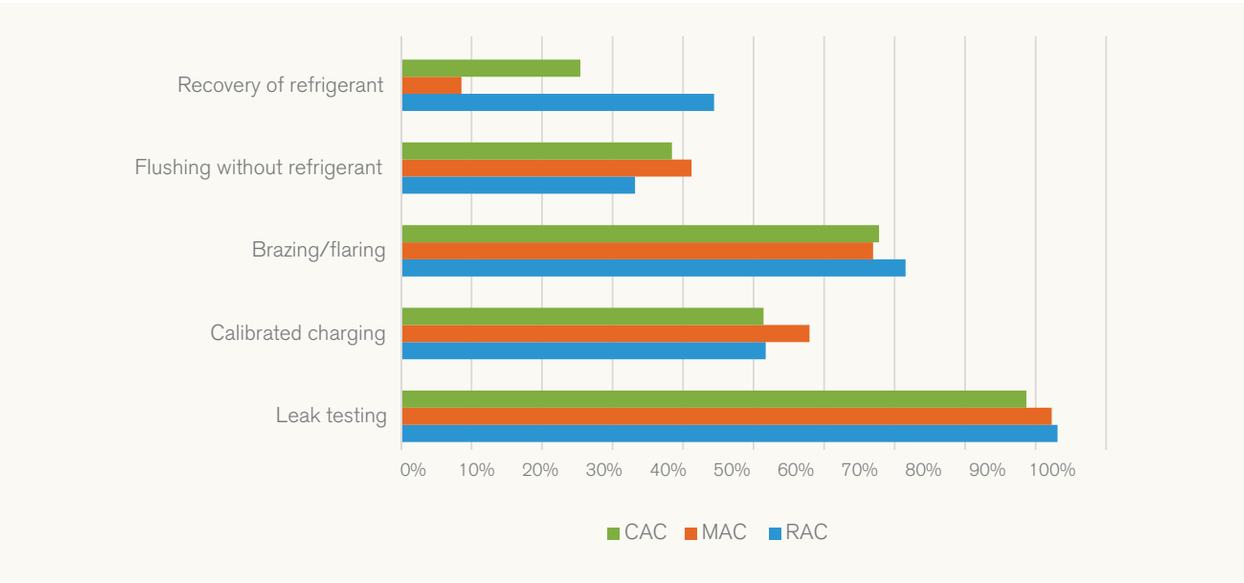
From the above analysis, we can draw a few conclusions:

1. AC training has the clearest effect on technicians having good knowledge of GSPs and associated information, with technicians from all three sectors who have completed AC training being more probable to have 'moderate' to 'good' knowledge about GSPs.
2. While the link between AC servicing training and the level of knowledge about GSPs and refrigerants is obvious, it is less clear why years of experience has minimal to no impact on the level of knowledge of technicians. It is possible that technicians with many years of experience are less able, or are less willing, to learn about new technologies and new developments.
3. Ownership of recovery units is a significant predictor of a technician having good knowledge in the CAC sector. Since there may be a bi-directional relationship between ownership of recovery units and good knowledge, technicians who own recovery units would require good knowledge about GSPs to use such tools.
4. Further analysis of the factors that impact good knowledge is difficult since the number of technicians falling in the 'good knowledge' category was too few in the MAC and CAC sectors and hence did not provide any meaningful insights.

13 See the section on methodology for more details.

4.9 Nearly all technicians follow some GSPs

Figure 7: Percentage of technicians who follow GSPs in each sector



Source: CEEW Analysis (2017)

The survey focused on five major GSPs: leak testing before refrigerant recharge, calibrated charging (by the appropriate method for the sector), brazing of tubes/flaring of parts, flushing without refrigerant, and recovery of refrigerant during servicing.

Nearly all respondents reported conducting leak testing before recharge. Leak testing in RAC and MAC requires no tools and can be done with soap-bubble solution. Similarly, a high percentage of respondents reported charging by weight and brazing/flaring, where the necessary equipment is easily available and relatively inexpensive.

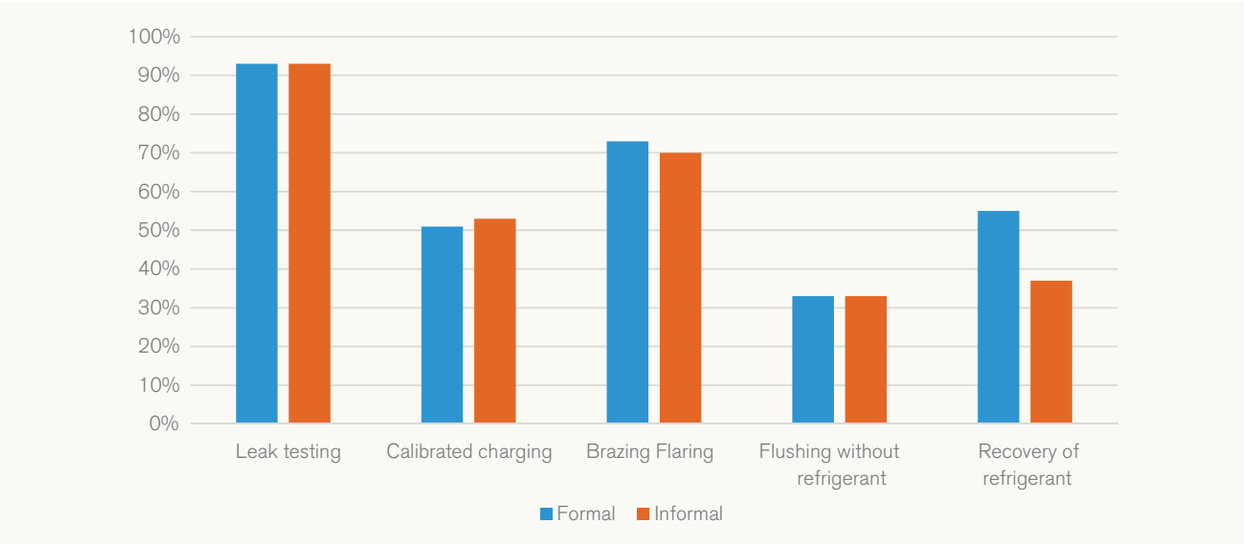
However, flushing without refrigerant and recovery of refrigerant are done by less than half of the respondents. Flushing of the AC system is done to remove impurities and contamination. GSPs require flushing to be done with nitrogen. Previously flushing used to be done with virgin refrigerant and this practice has continued. During the FGD sessions, participants reported that this practice has declined considerably in the MAC sector due to the rise in the cost of refrigerant and that the cost of nitrogen is less than that of R134a. However, from the survey results, it is clear that the practice continues in all sectors, possibly due to non-availability of nitrogen or lack of awareness among technicians.

Recovery of refrigerant is not well understood nor is it followed in the servicing sector. In the RAC sector, many reported that recovery is only done when there is still a significant quantity of refrigerant remaining in the system. If there is only a small quantity, it is vented out. This is done primarily as a cost-saving measure. During the FGD, technicians reported that recovery is only done by larger enterprises and rarely by individual technicians or by smaller enterprises.

4.10 There is more adherence to some GSPs in the formal sector than the informal sector; however, even adherence in the formal sector is low

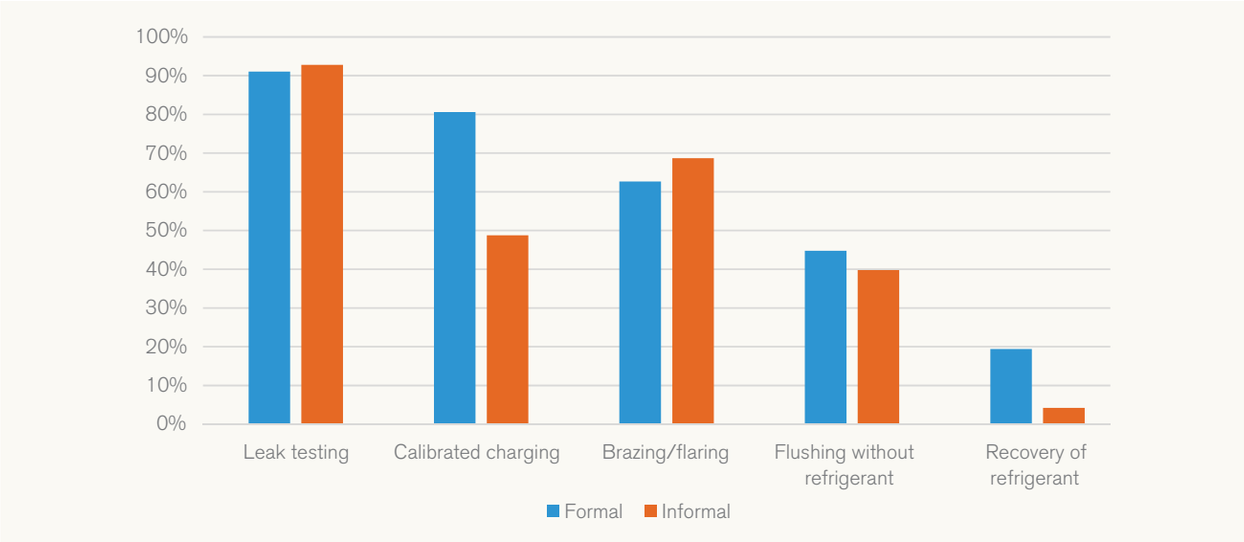
Among the respondents, a greater percentage of formal sector respondents adhere to GSPs than those in the informal sector, across MAC, RAC, and CAC sectors. In all three sectors, recovery was far more prevalent among formal sector enterprises than informal sector enterprises. For other practices like leak testing and brazing/flaring, the difference between formal and informal enterprises was minimal.

Figure 8: GSP adherence in the formal and informal RAC sectors



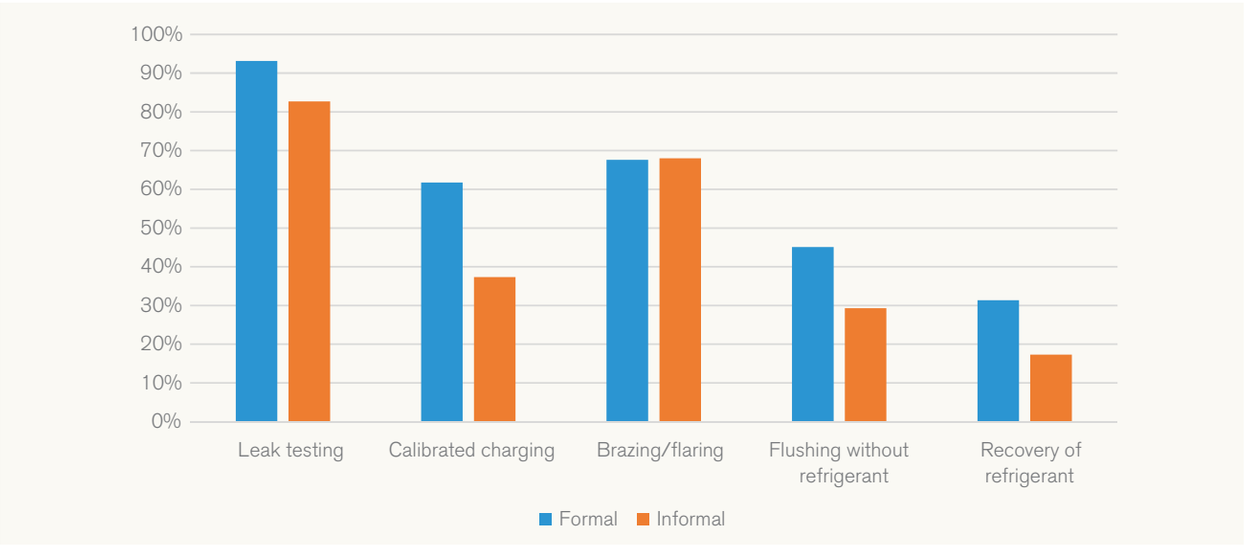
Source: CEEW Analysis (2017)

Figure 9: GSP adherence in the formal and informal MAC sectors



Source: CEEW Analysis (2017)

Figure 10: GSP adherence in the formal and informal CAC sectors



Source: CEEW Analysis (2017)

The reasons for this may be better access to equipment, increased training, and SOPs mandated by manufacturers even though there may be no profit from such practices. In addition, some manufacturers require service centre operators to mandatorily install and operate certain equipment (like recovery units in MAC service centres), which may explain the better service practices.

However, when considering the overall performance of the formal sector, adherence to many practices is below 50 per cent or is comparable with the performance of the informal sector, showing that increasing formalisation in the sector alone may not be sufficient to improve GSPs.

4.11 What factors impact adherence to GSPs?

Similar to the regression analysis of the 'knowledge scores' of the surveyed technicians, the service practices of the technicians were also scored. Each practice was given a different weight, based on the relative rarity of the practice (see Tables 7 and 8). After each technician's practices were scored, the technicians were divided into three categories: poor service practices, moderate service practices, and good service practices, and were then accordingly analysed using AC training, ownership of recovery units, customer knowledge, and years of experience as the independent variables.

In the RAC sector, AC training was observed to be a significant predictor in determining adherence to service practices. With AC training, a technician is three times more likely to not follow poor service practices and a technician who follows 'moderate' service practices is three times more likely to follow 'good' service practices (see Table 12, Annexure 3).

It was also observed that if customers have knowledge about refrigerants, then service technicians are more than twice as likely to not follow poor practices. However, customer knowledge was not a significant predictor of GSP adherence in the 'moderate' service practices category (see Table 12, Annexure 3). This may suggest that beyond a point, customers' knowledge cannot positively influence service practices, possibly because customers do not have deep knowledge about servicing techniques.
The effect of ownership of recovery units was only observed when the technician was already following 'moderate' service practices. Having tools would make a moderate service technician three times more likely to follow best service practices (see Table 13, Annexure 3).

In the MAC sector, ownership of recovery unit was the only variable to have an effect on service practice scores in both categories. A technician with a recovery unit is seven times likely to not follow poor service practices, and a technician who follows 'moderate' service practices is seven times more likely to follow 'good' service practices if he owns a recovery unit (see Table 13, Annexure 3).

Similar to the RAC sector, customer knowledge was observed to be a significant predictor of GSPs in the MAC sector. Technicians whose customers had some knowledge of refrigerants were two times more likely to not follow poor service practices. However, customer knowledge is not a significant predictor of GSPs in the 'moderate' service practices category (see Table 13, Annexure 3).

From this analysis, it is difficult to explain why AC training has no effect at all on service practices in the MAC sector. It is possible that the type of training received by technicians is more general in nature and does not focus too much on MAC servicing alone. As a result, technicians may have only been trained in the basics and not in GSPs.

In the CAC sector, both AC training and ownership of tools are significant predictors of adherence to GSPs. A technician who has AC training is more than twice as likely to not follow poor service practices. A technician with AC training who is following 'moderate' service practices is more than eight times as likely to follow 'good' service practices. Therefore, it is clear that AC training has a substantial impact on CAC servicing. With access to recovery units, a technician is seven times more likely to not follow poor service practices; for a technician following 'moderate' service practices, access to recovery units would make the technician seven times more likely to follow 'good' service practices (see Table 14, Annexure 3).

From the above analysis, we can draw a few important conclusions:

1. The impact of AC servicing training is significant across all categories in the RAC and CAC sectors. While the present study could not capture the differences, if any, between the different types of trainings (that is, those provided by manufacturing companies, ITIs, sector skill councils, and other organisations), the importance of AC training in improving GSPs cannot be overstated. However, given that 10 per cent of RAC technicians and 16 per cent of CAC technicians who have received training fall in the 'poor service practices' category, this may point to inadequate or incomplete training programmes or a lack of incentives to follow GSPs.
2. The lack of impact of training on MAC servicing should be further studied. The adequacy of automobile servicing training programmes with respect to GSPs should be examined.
3. The link between access to recovery units and GSPs is obvious since recovery of refrigerant cannot be done without recovery units. It should be noted that those who have recovery units are more likely to be in the highest category of service practices, which means that they are practising three or more GSPs. However, as it is clear from Figures 3 and 8, not all owners of recovery units are, in fact, recovering refrigerants. This suggests that while not all technicians who own recovery units practise recovery (due to the lack of incentives to do this or because of the relatively complicated process involved), they may be following the other GSPs due to factors that have not been captured in this study.
4. Another important conclusion is the effect of customer knowledge on GSPs. In the RAC and MAC sectors, customers having knowledge about refrigerants made a technician less likely to follow poor service practices. However, as the results of the analysis show, customer knowledge does not make technicians who follow 'moderate' service practices more likely to follow 'good' service practices. This may be because customers who have some knowledge about refrigerants and GSPs may not be experts on the subject, thus limiting their effect.
5. It is possible that other factors like fees per servicing visit may have an effect on service practices. The survey questionnaire did not differentiate between the different service practices and the fees charged for them. Nevertheless, this is an important area of enquiry, especially given the difference in fees charged between formal and informal enterprises.

5. Key Insights and Recommendations

The purpose of this survey is to understand the level of knowledge of, and adherence to, GSPs in the servicing sector and to lay the groundwork for further research. The survey also provides some useful insights to guide policy development for the service sector.

5.1 Standardisation of training programmes is necessary

Expansion of training and skill development programmes is extremely important, given the significant effect of training on adherence to GSPs (see Section 4.11 of the Report). AC servicing training increased the likelihood of both good knowledge and GSP outcomes in every category and in every sector (except MAC). As a result, given that only 36 per cent of the survey respondents have received any training, the importance of, and the need for, training programmes to reach more technicians cannot be overstated.

However, in addition to the overall level of GSP adherence being low (See figure 7), 10 per cent of RAC technicians and 16 per cent of CAC technicians who have received servicing training do not follow GSPs. One of the aspects that the survey was unable to satisfactorily compare was the quality of the different types of training programmes available. Therefore, it is difficult to say whether the poor adherence to GSPs by technicians (especially those with training) is due to the poor quality of training programmes or to other disincentives.

That said, the quality of training programmes provided by different institutes and organisations needs further assessment. Even though various government bodies like skill development councils and ITIs are training hundreds of people, the quality of the training provided is not consistent, and many of them do not keep up with new technologies.

Training programmes at ITIs were recently updated to include the latest information, including details about flammability and natural refrigerants. However, trainings conducted by sector skill development councils and other agencies must also update their syllabi to conform to similar standards that include safety training, GSPs, and use of new refrigerants.

Recommendations

- Lack of consistency in training may be due to the absence of updated servicing standards for training in the entire country. The National Occupational Standards, which are merely voluntary, are neither sufficiently in-depth nor up-to-date with the latest technology. They also do not cover aspects related to reducing the environmental impact of refrigerants through minimisation of leaks. Policy interventions like notifying servicing training standards through the Bureau of Indian Standards (BIS) and updating the NOS for all sectors are necessary to establish norms for training standards across the country.
- Low awareness of service technicians on topics like environmental impacts, safety issues, and flammability and toxicity of refrigerants are issues of concern. While the technical specifications of training standards would be different for the three sectors, these topics would be common to all, and therefore should be included in the training standards.

- Unlike the RAC and CAC sectors, servicing training for MAC technicians does not make it more likely for them to follow GSPs. This may be due to the fact that training programmes may not be focused on MAC servicing alone, but rather on automobile servicing as a whole. Targeted training for the MAC sector may improve adherence to GSPs.

5.2 Price sensitivity and lack of customer awareness are barriers to GSP adherence

Technicians report that low customer awareness of GSPs, price sensitivity, and the need for short turnaround time for servicing affect customer choice of the service centre. During the FGDs, technicians stated that their servicing practices hinge on how happy the customer is and that a large part of customer satisfaction has to do with low-priced services.

The importance of customer awareness of GSPs was also confirmed by the regression analysis, where the results showed that when customers have awareness of GSPs, service technicians in the RAC and MAC sectors are more likely to follow GSPs.

Another issue is that many customers (especially in the RAC and MAC sectors) are unlikely to get the AC serviced regularly unless it is not working properly. In such cases, the refrigerant has probably already leaked out and there would be no possibility of recovery.

Recommendations

- In addition to training programmes for technicians, awareness-raising campaigns about GSPs and proper servicing techniques are necessary for customers.
- Manufacturers could also raise awareness of the importance of proper installation and servicing practices when customers purchase ACs/cars and highlight the possibility of increased electricity consumption due to faulty installation/servicing. They could also include simplified ‘checklists’ with the AC/car so that customers understand what services are required or recommended to be regularly carried out.
- To encourage early detection of problems through regular servicing of equipment, manufacturers could include servicing costs (for longer than one year) within the retail price of the AC/car or offer servicing at discounted rates. This would incentivise customers to get their equipment regularly serviced and since the cost of servicing is already included, technicians would not be dis-incentivised from adhering to GSPs.

5.3 There is greater scope for GSP improvement in the formal sector

While the formal sector exhibits higher adherence to some GSPs, this is not much better than the informal sector. As seen in the survey, despite better access to servicing equipment and training programmes, the formal sector has not shown a comparatively better performance of GSPs than the informal sector (see Figures 2 and 3 along with Figures 8, 9, and 10). A possible reason for this could be the lack of inclusion of GSPs in manufacturing companies’ SOPs for their servicing franchisees. These companies are better placed to improve GSPs as they are in the position of mandating GSPs to be followed by their authorised service centres. Furthermore, any increased costs associated with servicing could be more easily absorbed by the formal sector through appropriate fee hikes.

Recommendations

- Manufacturing companies could regularly conduct training and re-training programmes for all their servicing employees, as servicing training has been shown to increase the likelihood of adherence to GSPs. This is especially necessary in the MAC sector, where training should include specific modules on GSPs.
- Manufacturers could also include GSP-specific key performance indicators their authorised servicing franchisees to incentivise them.
- Since the survey analysis shows that technicians (from all sectors) who have access to recovery units are more likely to follow GSPs, manufacturers could mandate the installation/purchase of GSP-related equipment like recovery units or R&R units. However, it should be noted that many manufacturers in the MAC sector already require their franchisees to own tools like recovery units. However, as the survey results show, many more technicians own recovery units than those who practise recovery. Therefore, additional audit mechanisms should be put in place to ensure that the tools are actually used.

5.4 Compulsory certification schemes will require more infrastructure before implementation

Compulsory certification for service technicians is a much-cited recommendation for improving GSPs. Many technicians even expressed support for such a scheme during the FGDs. While technicians decry the influx of non-trained technicians and may support a compulsory certification scheme in theory, there may be a lot of opposition in practice because this means that even highly experienced technicians would have to re-learn many skills.

Furthermore, it is doubtful whether the training infrastructure required to provide such training and testing around the country is adequate. If the quality of the certification programme is low and its coverage is limited, then it would become another unnecessary barrier to entry that has no impact on reducing refrigerant emissions. However, if the government were to opt for voluntary certification instead, some incentives will have to be offered to technicians to obtain this certification.

Technicians report having a difficult time charging premium fees due to customers being price sensitive. If the certification scheme is not given sufficient publicity and credibility among customers, customers may continue to rely on informal networks for servicing.

Recommendations

- Before the implementation of a compulsory certification scheme, the nationwide implementation of servicing standards and training standards is necessary.
- A robust training centre network across the country, of consistent quality and incorporating practical training methods, must be in place before the implementation of such a scheme.
- Compulsory certification should be given due publicity and should be strictly enforced to ensure that customers do not continue to rely on unlicensed technicians for servicing.
- Before certification is made mandatory, service technicians should, as a first step, be required to mandatorily complete training sessions on safety procedures during servicing.

5.5 Further research is required to understand the impacts of fees and informalisation on GSPs

Other disincentives like the time factor involved in the completion of GSPs, aggressive competition driving down fees for servicing, and the lack of awareness of the negative impacts of poor servicing practices may all be reasons for the lack of adherence to GSPs, as evidenced by the FGDs.

Increasing informalisation in the country, including in the formal sector, is an issue of concern as these low-paid workers would then have greater incentive to cut corners (keeping servicing to a minimum, rather than doing all that is necessary). This is certainly a concern for the informal sector where technicians are forced to keep their servicing fees as low as possible. However, due to the limitations of the survey, these issues could not be fully examined and need further investigation.

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Annexure 1

Sample Questionnaire (used in the RAC Sector)

Sl. No.	Question
SECTION A: BASIC DETAILS OF THE RESPONDENTS	
A.1	What is your name?
A.2	What is your age?
A.3	Gender of the respondent
A.4	Do you service or repair ACs?
A.5	What is your employment type?
5.1	What is the name of the place where you are currently employed?
5.2	What is your position in your current company?
5.3	What is your mode of payment?
5.4	What is the total number of employees at your place of employment?
5.5	What was the annual turnover of your company in 2016?
A.6	What is your highest educational qualification?
A.7	Have you completed any AC servicing training course?
Q7.1	Please specify which training course you have completed.
Q7.2	How did you learn about servicing of ACs if you have not attended any training course or certification programme?
Q7.3	Why did you not attend any training programme or course?
A.8	Are you employed in the AC servicing work the entire year?
8.1	For how many months in the year are you employed in AC servicing?
8.2	During which months of the year are you employed in AC servicing?
8.3	Do you work in the industry full time or part time?
8.4	What is your alternative/secondary employment/job?
8.5	What is your yearly income from your secondary/alternative job?
8.6	What is your total yearly income from AC servicing?
8.7	How many years of experience do you have in AC servicing?
SECTION B: WORK ROUTINE DURING SERVICING	
B.1	What are the various types of AC units you service?
B.2	What is the average number of AC units you service in a month?
B.4.1	How many times do regular customers get their AC units serviced every year?
B.4.2	What are all the activities that are done during routine AC servicing?
B.4.3	What is the most common problem in the case of AC malfunctioning?
B.5	What is the payment for servicing per visit excluding the cost of new parts, refrigerants, etc.?
B.6	Does your enterprise offer AMC for customers?
B.6.1	What are the services provided to AMC customers?
B.7	How much is the payment made for AMC?
SECTION C: REFRIGERANT RECHARGE AND LEAK DETECTION	
C.1	Which method is used to determine refrigerant leakage?
C.2	What are the most common causes or reasons for refrigerant leakage from an AC?
C.3	What are the steps followed in recharging refrigerant in case a refrigerant recharge is required?
C.4	Is leak testing and pressure testing done before refrigerant is recharged?
C.5	When charging the AC with refrigerant, how is the refrigerant charge measured?

Sl. No.	Question
C.6	Is brazing of parts or flaring of tubes done before charging?
C.7	Do you flush the system with refrigerant?
C.8	How often are refrigerant leaks detected per 100 ACs (on average across all servicing locations)?
C.9	How many times would an AC have refrigerant leakages in its lifetime (10 years) (on average across all locations)?
C.10	From where do you/your company purchase refrigerant?
C.11	What is the cost at which refrigerant is purchased?
C.12	How much refrigerant is purchased per year by the enterprise?
C.13	How much refrigerant is used per year by the enterprise?
C.14	Do you minimise venting of refrigerants into the atmosphere during servicing?
C.15	Is it important to minimise venting of refrigerants into the atmosphere during servicing?
C.16	If yes, why it is important to minimise venting of refrigerants into the atmosphere during servicing?
C.17	Which methods do you use to minimise venting of refrigerants into the atmosphere?
C.18	Are you aware of different refrigerants?
C.19	If yes, which refrigerants are you familiar with?
C.20	Which refrigerants do you use during AC servicing?
SECTION D: KNOWLEDGE OF GOOD SERVICE PRACTICES AND DIFFERENT REFRIGERANTS	
D.1	Is it possible to overcharge the refrigerant in an AC?
D.2	What are the problems caused by the overcharging of ACs?
D.3	How can overcharging the refrigerant be avoided?
D.4	Are there any problems with undercharged ACs?
D.5	What are the problems associated with undercharged ACs?
D.6	What safety precautions are undertaken while servicing ACs?
D.7	Are you aware of the environmental impacts of refrigerants?
D.8	What are the environment impacts you are aware of?
D.9	Are you aware that good servicing practices (GSPs) will maintain the energy efficiency of ACs?
D.10	Are you aware of the use of natural refrigerants in ACs?
D.11	What are the different types of natural refrigerants used in ACs that you are aware of?
D.12	Have you received any training in servicing applications (AC) that use natural refrigerants?
D.13	Is there any difference in servicing practices between natural refrigerants and other refrigerants?
D.14	Are you aware that some refrigerants are flammable?
D.15	Are you aware that refrigerants can be recycled?
D.16	Are you aware that refrigerants can be reclaimed?
D.17	How can you make use of recovered refrigerant?
D.18	Are you aware of any industry associations for service technicians?
D.19	Which are the industry associations you are aware of?
D.20	Are you a member of any body/union representing the industry?
D.21	Which is the industry body/union with which you are associated?
SECTION E: TOOLS AND EQUIPMENT FOR RECOVERY AND RECHARGE	
E.1	Do you own any AC servicing equipment (owned either by the enterprise or by the technician)?
E.2	What are the various kinds of equipment owned by the individual/ enterprise?
E.3	What are the reasons for not owning the equipment?
E.4	Is any equipment rented, leased, or borrowed?
E.5	What are the various kinds of equipment that are rented, leased, or borrowed?
E.6	How much refrigerant is recycled every week?
E.7	What was the cost of the R&R equipment at the time of purchase?

Sl. No.	Question
E.8	How was the purchase of the R&R equipment financed?
SECTION F: REFRIGERATION RECOLLECTION	
F.1	Do you recover refrigerant from the system during servicing?
F.2	Why do you recover refrigerant during servicing?
F.2.1	Do you reuse the entire amount of refrigerant recovered at your enterprise?
F.2.2	If no, what is done with the unused recovered refrigerant?
F.3	Why do you not recover refrigerant during servicing?
F.4	Are you aware of any refrigerant reclamation centre?
F.5	Which refrigerant reclamation centre are you aware of?
F.6	Have you ever reclaimed refrigerant at a refrigerant reclamation centre or at any other private enterprise?
F.7	Have you continued the practice of reclaiming refrigerant?
F.8	Why have you not continued the practice of reclaiming refrigerant?
SECTION G: CUSTOMER AWARENESS OF REFRIGERANT GOOD SERVICING PRACTICES	
G.1	Do any customers request the technician to minimise the venting of refrigerant or to recover refrigerant?
G.2	Out of 100, how many customers ask the technician to minimise the venting of refrigerant or to recover refrigerant?
G.3	Do customers display any knowledge about refrigerants?
G.4	Out of 100, how many customers display any knowledge about refrigerants?
G.5	What knowledge do customers have about refrigerants?
SECTION H: POLICY RECOMMENDATIONS	
H.1	How can service technicians be encouraged to recover and recycle refrigerant?
H.2	How can service technicians be encouraged to minimise the venting of refrigerant into the atmosphere?
H.3	Would any government policies or rules encourage service technicians?
H.4	Would any other incentives encourage service technicians?

Annexure 2

Definitions Used in the Survey

AC servicing training course

This refers to any training course on AC servicing provided under a vocational, occupational, or polytechnic programme, of any duration. This could also be a training course conducted by the enterprise or by the AC company.

Alternative/secondary employment

This refers to all occupations pursued by the respondent in addition to AC servicing. Servicing of other electronic goods is to be recorded as a separate occupation from AC servicing. Please note that in the case of the MAC sector, the primary employment will be 'car servicing' as a whole, and not 'car AC servicing'. In case the respondent reports that s/he has a separate, informal business of AC servicing, this is to be recorded by the investigator.

Authorised dealership/service centre

A service centre operated by an organisation that is permitted to provide services on products that are covered by warranties held by the manufacturing company. Also includes service centres/branches operated by the manufacturing company or its subsidy.

Brazing

Brazing is a process of joining metals together by melting them at high temperature through a burner. Brazing of joints give the tubes used in air-conditioners increased strength and resistance against shocks, vibrations, and tension.

Casual/daily wage

A person casually engaged in enterprises (both household and non-household) and getting in return a wage according to the terms of the daily or periodic work contract is a casual wage labour.

Contractor

Persons who receive a percentage on every piece of work done by them.

Employee

Persons working in enterprises (both household and non-household) owned by others and getting in return a salary or wage on a regular basis (and not on the basis of the daily or periodic renewal of the work contract) are regular wage/salaried employees. This category includes persons getting time wage, persons receiving piece wage or salary, and paid apprentices, both full time and part time.

Employment year-round

Being employed in the industry/enterprise (either full time or part time) for nine months or more in the year.

Fluorinated refrigerants

Also known as F-gases, these are man-made gases that can stay in the atmosphere for centuries and contribute to a global greenhouse effect. They are largely used in refrigeration and air-conditioning. Some gases, like hydrochlorofluorocarbons (HCFCs) and chlorofluorocarbons (CFCs), also have a major impact on the ozone layer, e.g., R22, R12, R13, R123, R124.

Currently, HCFCs and CFCs are being phased out of use in most applications as mandated by government regulations and are being replaced with hydrofluorocarbons (HFCs). HFCs do not have an impact on the ozone layer, but they have very high GWP, e.g., R134a, R410A, R404A, R407C.

Flushing

Flushing is done to remove contaminants like oil and dirt by passing pressurised gas through the system. The recommended gas for flushing is Oxygen-Free Dry Nitrogen.

Full-time and part-time employment

Persons working for less than or equal to half of the normal working hours of the enterprise on a fairly regular basis are considered as part-time workers. Full-time workers are those who work for more than half of the period of normal working hours of the enterprise on a fairly regular basis.

Good servicing practices (GSPs)

These are servicing and installation practices that are vital for the safe and reliable operation of the system. They also reduce the environmental impact of servicing (from venting of refrigerants) and ensure reliable, trouble-free, and efficient operation of an AC system. While there are different GSPs for different types of AC systems, for this study, five GSPs were selected for analysis: leak testing, calibrated charging, flushing without refrigerant, brazing/flaring, and recovery of refrigerant.

In many countries, there are laws that punish technicians who do not follow specified GSPs. In India, there is no legal requirement to follow GSPs. However, the government has published a manual on GSP for servicing of MAC, and GIZ-India (in collaboration with the government) has published a manual on GSPs for RAC (GIZ, 2013).

Natural refrigerants

Natural refrigerants are chemicals that occur in or through biochemical processes in nature. They do not deplete the ozone layer and make a negligible contribution to global warming. They are derived from hydrocarbons, ammonia, and carbon dioxide. However, many have to be handled carefully due to high pressure or flammability issues, and are currently not as widely used as F-gases in the RAC and MAC sectors. R600a is widely used in domestic refrigeration and ammonia is used in commercial refrigeration. Examples of natural refrigerants are R290, R32, R600a, R744, R717.

Recovery

To remove refrigerant, in any condition, from a system and store it in an external container. Portable recovery units are used by service technicians to carry out recovery.

Reclamation

To reprocess used refrigerant, typically through distillation, to specifications close to the virgin refrigerant. Reclamation removes contaminants such as water, chloride, hydrogen fluoride reaction products, other acids, high boiling residue, particulates/solids, non-condensable gases, and impurities including other refrigerants. Chemical analysis of the refrigerant is required to determine that appropriate specifications. The identification

of contaminants and chemical analysis are specified under national or international standards for new product specifications. Reclamation is typically carried out at a reprocessing or chemical manufacturing facility.

Reclamation unit

This is generally the most expensive option as it is able to fully decontaminate refrigerant and the resultant product is comparable with refrigerant obtained from the manufacturer. Given its prohibitive cost, the Government of India has set up refrigerant reclamation centres in many cities in the country where refrigerants can be decontaminated for a fee.

Recovery and recycling unit (RR unit)

A recovery unit with cylinder is the simplest and cheapest type of unit. It removes refrigerant from the AC system which is then passed through a filter to remove a few contaminants. It is suitable for cases where the refrigerant is pumped back into the same AC. Some recovery units are slightly more elaborate in that they can remove more contaminants like moisture.

An RR unit recovers gas from the AC system and passes it through more sophisticated purification mechanisms compared to a simple recovery unit. Some RR units meet Society of Automotive Engineers (SAE) standards. The purified refrigerants can be used in other ACs. RR units are far more expensive than recovery units.

Recycling

To extract refrigerant from an appliance and clean it using oil separation and single or multiple passes through filter driers. These devices reduce moisture, acidity, and particulate matter. Recycling normally takes place in the field or at the site of the job.

Self-employed

Working for oneself, as one who operates their enterprises on their own account or with one or a few partners and who during the reference period, by and large, runs their enterprise without hiring any labour. They may, however, have unpaid helpers to assist them with the activity of the enterprise.

Unorganised/informal sector

This is defined as consisting of all unincorporated private enterprises owned by individuals or households engaged in the sale or production of goods and services operated on a proprietary or partnership basis. An informal enterprise is characterised by the absence of legal organisation, separate complete accounts, and workers who are not employed on a continuous basis.

Unregistered enterprise

All unincorporated private enterprises owned by individuals or households engaged in the sale or production of goods and services operated on a proprietary or partnership basis and with fewer than ten total workers.

Annexure 3

Regression Analysis Tables: Marginal effects and odds ratio

Regression analysis of 'good knowledge' scores:

Table 9: RAC Sector – Marginal Effects

Model gologit2_mfx (*Marginal effects after gologit2*)

knowscore	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
1						
actrain	-.4685443	.0598738	-7.83	0.000	-.5858948	-.3511937
exp	-.0097444	.0045903	-2.12	0.034	-.0187413	-.0007476
tools	-.0212901	.065754	-0.32	0.746	-.1501656	.1075854
custknow	-.1246278	.066354	-1.88	0.060	-.2546793	.0054237
2						
actrain	.4685443	.0598738	7.83	0.000	.3511937	.5858948
exp	.0097444	.0045903	2.12	0.034	.0007476	.0187413
tools	.0212901	.065754	0.32	0.746	-.1075854	.1501656
custknow	.1246278	.066354	1.88	0.060	-.0054237	.2546793

Source: CEEW Analysis (2017)

Table 10: MAC Sector - Marginal Effects

Model gologit2_mfx (*Marginal effects after gologit2*)

knowscore	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
1						
actrain	-.1229825	.0580444	-2.12	0.034	-.2367475	-.0092176
exp	1.95e-09	2.82e-06	0.00	0.999	-5.53e-06	5.53e-06
tools	7.07e-08	.0001019	0.00	0.999	-.0001997	.0001999
custknow	-6.66e-07	.0009593	-0.00	0.999	-.0018809	.0018795
2						
actrain	.1229825	.0580444	2.12	0.034	.0092176	.2367475
exp	-1.91e-09	2.75e-06	-0.00	0.999	-5.40e-06	5.39e-06
tools	-7.07e-08	.0001019	-0.00	0.999	-.0001999	.0001997
custknow	6.66e-07	.0009593	0.00	0.999	-.0018795	.0018809

Source: CEEW Anaylsis (2017)

Table 11: CAC Sector – Marginal Effects

Model gologit2_mfx (*Marginal effects after gologit2*)

knowscore	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
1						
actrain	-.1182775	.0369738	-3.20	0.001	-.1907449	-.0458101
exp	-.0145832	.003615	-4.03	0.000	-.0216685	-.0074979
tools	-.0862149	.0351563	-2.45	0.014	-.15512	-.0173098
custknow	.0013134	.0008287	1.58	0.113	-.0003109	.0029377
2						
actrain	-.0253484	.0445474	-0.57	0.569	-.1126596	.0619628
exp	.0165993	.0043365	3.83	0.000	.0080999	.0250987
tools	.0136099	.0287756	0.47	0.636	-.0427893	.070009
custknow	-.0000806	.0004551	-0.18	0.859	-.0009726	.0008114
3						
actrain	.1436259	.0412887	3.48	0.001	.0627016	.2245503
exp	-.0020161	.0026884	-0.75	0.453	-.0072853	.0032531
tools	.0726051	.0270115	2.69	0.007	.0196634	.1255467
custknow	-.0012328	.0008149	-1.51	0.130	-.00283	.0003644

Source: CEEW Analysis (2017)

Regression analysis of 'good service practices' scores:

Table 12: RAC Sector Service Practices – Odds Ratio

Generalized Ordered Logit Estimates — Number of obs = 232; LR chi2(6) = 39.00; Prob > chi2 = 0.0000; Log likelihood = -227.68282; Pseudo R2 = 0.0789

(1) [1]exp - [2]exp = 0
(2) [1]actrain - [2]actrain = 0

servscore	Odds Ratio	Std. Err.	z	P>|z|	[95% Conf.	Interval]
1						
actrain	3.00788	.8065841	4.11	0.000	1.778299	5.087638
exp	1.011655	.0187982	0.62	0.533	.9754743	1.049178
tools	.9706809	.3306522	-0.09	0.930	.4978788	1.892471
custknow	2.27659	.8064686	2.32	0.020	1.136977	4.558458
_cons	1.657613	.6127541	1.37	0.172	.8032068	3.420887
2						
actrain	3.00788	.8065841	4.11	0.000	1.778299	5.087638
exp	1.011655	.0187982	0.62	0.533	.9754743	1.049178
tools	2.910599	.9456972	3.29	0.001	1.539623	5.502379
custknow	1.055999	.3095968	0.19	0.853	.5944412	1.875936
_cons	.1486413	.0580618	-4.88	0.000	.0691266	.3196196

Source: CEEW Analysis (2017)

Table 13: MAC Sector Service Practices – Odds Ratio

Generalized Ordered Logit Estimates — Number of obs = 233; LR chi2(5) = 51.48; Prob > chi2 = 0.0000; Log likelihood = -186.26962; Pseudo R2 = 0.1214

(1) [1]exp - [2]exp = 0
(2) [1]actrain - [2]actrain = 0
(3) [1]tools - [2]tools = 0

servscore	Odds Ratio	Std. Err.	z	P>|z|	[95% Conf.	Interval]
1						
actrain	1.484277	.4797228	1.22	0.222	.7877782	2.796571
exp	.9678333	.0217952	-1.45	0.147	.9260446	1.011508
tools	7.262838	2.936648	4.90	0.000	3.288005	16.0428
custknow	2.137799	.671638	2.42	0.016	1.154895	3.957229
_cons	1.004662	.3257023	0.01	0.989	.5321919	1.896583
2						
actrain	1.484277	.4797228	1.22	0.222	.7877782	2.796571
exp	.9678333	.0217952	-1.45	0.147	.9260446	1.011508
tools	7.262838	2.936648	4.90	0.000	3.288005	16.0428
custknow	.3922651	.263156	-1.39	0.163	.1053271	1.460895
_cons	.061127	.0263775	-6.48	0.000	.0262375	.142411

Source: CEEW Analysis (2017)

Table 14: CAC Sector Service Practices – Odds Ratio

Generalized Ordered Logit Estimates — Number of obs = 177; LR chi2(5) = 41.70; Prob > chi2 = 0.0000; Log likelihood = -162.73971; Pseudo R2 = 0.1136

(1) [1]exp - [2]exp = 0
(2) [1]custknow - [2]custknow = 0
(3) [1]tools - [2]tools = 0

servscore	Odds Ratio	Std. Err.	z	P>|z|	[95% Conf.	Interval]
1						
actrain	2.422714	.9347934	2.29	0.022	1.137286	5.161007
exp	1.042893	.0249326	1.76	0.079	.9951536	1.092923
tools	2.22182	.6745472	2.63	0.009	1.225415	4.02842
custknow	.9925207	.0105826	-0.70	0.481	.9719944	1.013481
_cons	.9994884	.3348545	-0.00	0.999	.5183262	1.927313
2						
actrain	8.361994	3.564298	4.98	0.000	3.626481	19.28121
exp	1.042893	.0249326	1.76	0.079	.9951536	1.092923
tools	2.22182	.6745472	2.63	0.009	1.225415	4.02842
custknow	.9925207	.0105826	-0.70	0.481	.9719944	1.013481
_cons	.0416808	.0195643	-6.77	0.000	.016611	.1045869

Source: CEEW Analysis (2017)

Annexure 4

Updated information on alternatives in the refrigeration and air conditioning sectors from the Technology and Economic Assessment Panel: Decision XXVII/4 Task Force Report Further Information on Alternatives to Ozone-Depleting Substances (Volume 1) (September 2016)

Pure substances proposed under various test programs and in ASHRAE 34

Refrigerant Designation	Proposed to replace (from AREP phase I)	Safety Class	Participation in AREP program		High ambient programmes for HCFC-22 and R-410A alternatives			Chemical Formula	Chemical Name	Molecular Weight	Boiling Point (°C)	ATEL/ODL (kg/m3)	LFL (kg/m3)	GWP 100 Year (IPCC5)	GWP 100 Year (RTOC)
			Phase 1	Phase 2	PRAHA	EGYPRA	US DoE								
HFC-32	R-404A, R-410A	A2L	X	X	X	X	X	CH2F2	Difluoro-methane (methylene fluoride)	52,0	–52	0,30	0,307	677	704
HC-290	HCFC-22, R-404A, R-407C	A3	X		X	X	X	CH3CH2 CH3	propane	44,1	–42	0,09	0,038		5
HC-600a	HFC-134a	A3	X					CH(CH3)2-CH3	2-methyl-propane (isobutane)	58,1	–12	0,059	0,043		~20
R-717	HCFC-22, R-407C	B2L	X					NH3	ammonia	17,0	–33	0,000 22	0,116		
R-744	R-404A, R-410A	A1	X					CO2	carbon dioxide	44,0	–78	0,072	NF	1	1
HCFO-1233zd(E)	HCFC-123	A1		X				CF3CH= CHCl	trans-1-chloro-3,3,3-trifluoro-1-propene	130,5	18,1	0	NF	1	1
HFO-1234yf	HFC-134a	A2L	X	X				CF3CF= CH2	2,3,3,3-tetrafluoro-1-propene	114,0	–29,4	0,47	0,289	<1	<1
HFO-1234ze(E)	HFC-134a	A2L	X	X				CF3CH= CHF	trans-1,3,3,3-tetrafluoro-1-propene	114,0	–19,0	0,28	0,303	<1	<1
HC-1270	HCFC-22, R-407C	A3	X					CH3CH= CH2	propene (propylene)	42,1	–48	0,001 7	0,046		1,8
HFO-1336mzz (Z)	HCFC-123	A1						CF3CH= CH- CF3	cis-1,1,1,4,4,4-hexafluoro-2-butene	164,1	33,4	0	NF	2	2
HCC-1130(E)**	HCFC-123	B2						CHCl= CHCl	trans-dichloro-ethene	96,9	47,7			<1	<1

** Indicates refrigerants pending official ASHRAE 34 approval, submitted June 2015.*

*** Indicates refrigerants pending official ASHRAE 34 approval, submitted January 2016.*

Blend refrigerants proposed under various test programs or in ASHRAE 34

Refrigerant Designation	Refrigerant development name	Proposed to replace (from AREP phase I)	Safety Class	Participation in AREP program		High ambient programmes for HCFC-22 and R-410A alternatives			Composition	Molecular Weight	Bubble point/ dew or Normal boiling point (°C)	GWP 100 Year (IPCC5)	GWP 100 Year (RTOC)
				Phase 1	Phase 2	PRAHA	EGYPRA	US DoE					
R-514A**	XP30	HCFC-123	B1						R-1336mzz(Z)/ 1130 (E) (74,7/25,3)	139,6		1,7	1,7
—	ARM-41a	HFC-134a	A1	X					R-134a/ 1234yf/32 (63/31/6)	99,5		860	900
R-513A	XP10	HFC-134a	A1	X	X				R-1234yf/ 134a (56/44)	108,4	–29,2	570	600
—	N-13a	HFC-134a	A1	X					R-134a/ 1234ze(E)/ 1234yf (42/40/18)	108,7		550	570
R-450A	N-13b	HFC-134a	A1	X	X				R-1234ze(E)/ 134a (58/42)	108,7	–23,4/		
–22,8	550	570											
R-515A**	HDR-115	HFC-134a	A1						R-1234ze(E)/ 227ea (88/12)	118,7	-19,2	400	380
R-513B*		HFC-134a	A1						R-1234yf/ 134a (58,5/41,5)	108,7	–29,9	540	560
—	D-4Y	HFC-134a	A1	X	X				R-1234yf/ 134a (60/40)	108,9		520	540
—	AC5X	HFC-134a	A1	X	X				R-1234ze(E)/ 134a/32 (53/40/7)	100,9		570	590
—	ARM-42a	HFC-134a	A2L	X	X				R-1234yf/ 152a/134a (82/11/7)	104,8		110	110
R-444A	AC5	HFC-134a	A2L	X	X				R-1234ze(E)/ 32/152a (83/12/5)	96,7	–34,3/		
–24,3	89	93											
R-445A	AC6	HFC-											
134a	A2L						R-744/ 134a/ 1234ze(E) (6/9/85)	103,1	–50,3/				
–23,5	120	120											
—	R290/R600a	HFC-134a	A3	X					R-600a/290 (60/40)	51,6			14
R-456A**		HFC-134a	A1						R-32/ 134a/ 1234ze(E) (6/45/49)	101,4	-31,1/ -25,7	630	650
R-407G		HFC-134a	A1						R-32/125/ 134a (2,5/2,5/95,0)	100,0	-29,1/ -27,2	1 300	1 400
—	LTR4X	HCFC-22,											
R-407C	A1	X	X				R-1234ze (E)/32/125/ 134a (31/28/ 25/16)	85,1		1 200	1 300		

Refrigerant Designation	Refrigerant development name	Proposed to replace (from AREP phase I)	Safety Class	Participation in AREP program		High ambient programmes for HCFC-22 and R-410A alternatives			Composition	Molecular Weight	Bubble point/ dew or Normal boiling point (°C)	GWP 100 Year (IPCC5)	GWP 100 Year (RTOC)
				Phase 1	Phase 2	PRAHA	EGYPRA	US DoE					
—	N-20	HCFC-22,											
R-407C	A1	X	X				R-134a/ 1234ze(E)/ 1234yf/						
32/125 (31,5/ 30/13, 5/12, 5/12,5)	96,7		890	950									
—	D52Y	HCFC-22,											
R-407C	A2L	X	X				R-1234yf/ 125/32 (60/25/15)	97,8		890	970		
—	L-20	HCFC-22,											
R-407C	A2L	X					R-32/1234ze(E)/152a (45/35/20)	67,8		330	350		
—	LTR6A	HCFC-22,											
R-407C	A2L	X	X				R-1234ze(E)/32/744 (63/30/7)	77,6		200	210		
R-444B	L-20a	HCFC-22,											
R-407C	A2L		X	X	X	X	R-32/1234ze(E)/152a (41,5/48,5/10)	72,8	–44,6/				
–34,9	300	310											
—	ARM-32a	HCFC-22,											
R-404A, R-407C	A1	X					R-125/32/134a/1234yf (30/25/25/20)	86,9		1 400	1 600		
R-442A		HCFC-22,											
R-404A, R-407C	A1		X				R-32/125/134a/152a/227ea (31,0/31,0/30,0/3,0/5,0)	81,8	–46,5/				
–39,9	1 800	1 900											
R-449B		HCFC-22,											
R-404A, R-407C	A1						R-32/125/1234yf/134a (25,2/24,3/23,2/27,3)	86,4	–46,1/				
–40,2	1 300	1 400											
R-449C*	DR-93	HCFC-22,											
R-407C	A1					X	R-32/125/1234yf/134a (20/20/31/29)	90,3	–45,5/–38,5				
1 100	1 200												
R-453A	RS-70	HCFC-22,											

Refrigerant Designation	Refrigerant development name	Proposed to replace (from AREP phase I)	Safety Class	Participation in AREP program		High ambient programmes for HCFC-22 and R-410A alternatives			Composition	Molecular Weight	Bubble point/ dew or Normal boiling point (°C)	GWP 100 Year (IPCC5)	GWP 100 Year (RTOC)
				Phase 1	Phase 2	PRAHA	EGYPRA	US DoE					
R-407C	A1						R-32/125/134a/227ea/600/						
601a (20,0/20,0/ 53, 8/5,0/0,6/0,6)	88,8	-42,2/ -35,0	1 600	1 700									
R-407H*		HCFC-22, R-407C	A1						R-32/125/134a (32,5/15,0/52,5)	79,1	-44,6/ -37,6	1 400	1 500
R-449A	DR-33 (XP40)	R-404A	A1	X	X				R-32/125/1234yf/134a (24,3/24,7/25,3/25,7)	87,2	–46,0/		
–39,9	1 300	1 400											
—	N-40a	R-404A	A1	X					R-32/125/134a/1234ze(E)/				
1234yf (25/25/21/20/9)	87		1 200	1 300									
—	N-40b	R-404A	A1	X					R-1234yf/32/125/134a (30/25/25/20)	87,1		1 200	1 300
R-452A	DR-34 (XP44)	R-404A	A1		X				R-1234yf/32/125 (30/11/59)	103,5	–47,0/		
–43,2	1 900	2 100											
R-452C**	ARM-35	R-404A	A1						R-32/125/1234yf (12,5/61,0/26,5)	101,9	-47,8/ -44,4	2 000	2 200
R-448A	N-40c	R-404A	A1		X				R-32/125/1234yf/134a/				
1234ze(E) (26,0/26, 0/20,0/21,0/7,0)	86,3	–45,9/											
–39,8	1 300	1 400											
—	R32/R134a	R-404A	A2L	X					R-32/134a (50/50)	68,9		990	1 000
—	ARM-31a	R-404A	A2L	X					R-1234yf/32/134a (51/28/21)	83,9		460	480
—	L-40	R-404A	A2L	X	X				R-32/1234ze(E)/1234yf/				
152a (40/30/20/10)	73,6		290	300									
R-454A	DR-7◊	R-404A	A2L	X	X				R-1234yf/32 (65/35)	80,5	–48,4/		
–41,6	240	250											
R-454C*	DR-3	R-404A	A2L		X	X	X	X	R-1234yf/32 (78,5/21,5)	90,8	–45,8/		
–38,0	150	150											
R-454A	D2Y-65	R-404A	A2L	X	X				R-1234yf/32 (65/35)	80,5	–48,4/		
–41,6	240	250											

Refrigerant Designation	Refrigerant development name	Proposed to replace (from AREP phase I)	Safety Class	Participation in AREP program		High ambient programmes for HCFC-22 and R-410A alternatives			Composition	Molecular Weight	Bubble point/ dew or Normal boiling point (°C)	GWP 100 Year (IPCC5)	GWP 100 Year (RTOC)
				Phase 1	Phase 2	PRAHA	EGYPRA	US DoE					
R-457A**	ARM-20a	R-404A	A2L						R-32/1234yf/152a (18/70/12)	87,6		140	150
—	ARM-30a	R-404A	A2L	X					R-1234yf/32 (71/29)	84,7		200	200
R-455A	HDR-110	R-404A	A2L		X				R-32/1234yf/744 (21,5/75,5/3)	87,5	-51,6/ -39,1	150	150
—	R32/R134a	R-410A	A2L	X					R-32/134a (95/5)	53,3		710	740
—	R32/R152a	R-410A	A2L	X					R-32/152a (95/5)	52,6		650	680
—	DR-5	R-410A	A2L	X					R-32/1234yf (72,5/27,5)	61,2		490	510
—	L-41a	R-410A	A2L	X					R-32/1234yf/1234ze(E) (73/15/12)	61		490	510
—	L-41b	R-410A	A2L	X					R-32/1234ze(E) (73/27)	61		490	510
—	ARM-70a	R-410A	A2L	X					R-32/1234yf/134a (50/40/10)	70,9		470	490
—	HPR1D	R-410A	A2L	X	X				R-32/1234ze(E)/744 (60/34/6)	63		410	420
—	D2Y-60	R-410A	A2L	X	X				R-1234yf/32 (60/40)	77,2		270	280
R-454B	DR-5A	R-410A	A2L		X	X	X	X	R-32/1234yf (68,9/31,1)	62,6	–50,9/		
–50,0	470	490											
R-452B**	DR-55												
(XL55)	R-410A	A2L					X	R-32/1234yf/ 125 (67/26/7)	63,5	-50,9/-50,0	680	710	
R-446A	L-41-1	R-410A	A2L		X				R-32/1234ze(E)/600 (68,0/29,0/3,0)	62	–49,4/		
–44,0	460	480											
R-447A	L-41-2	R-410A	A2L		X	X	X	X	R-32/125/1234ze(E) (68,0/3,5/28,5)	63	–49,3/		
–44,2	570	600											
R-447B**	L-41z	R-410A	A2L						R-32/125/1234ze(E) (68,0/8,0/24,0)	63,1	–50,3/		
–46,2	710	750											

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