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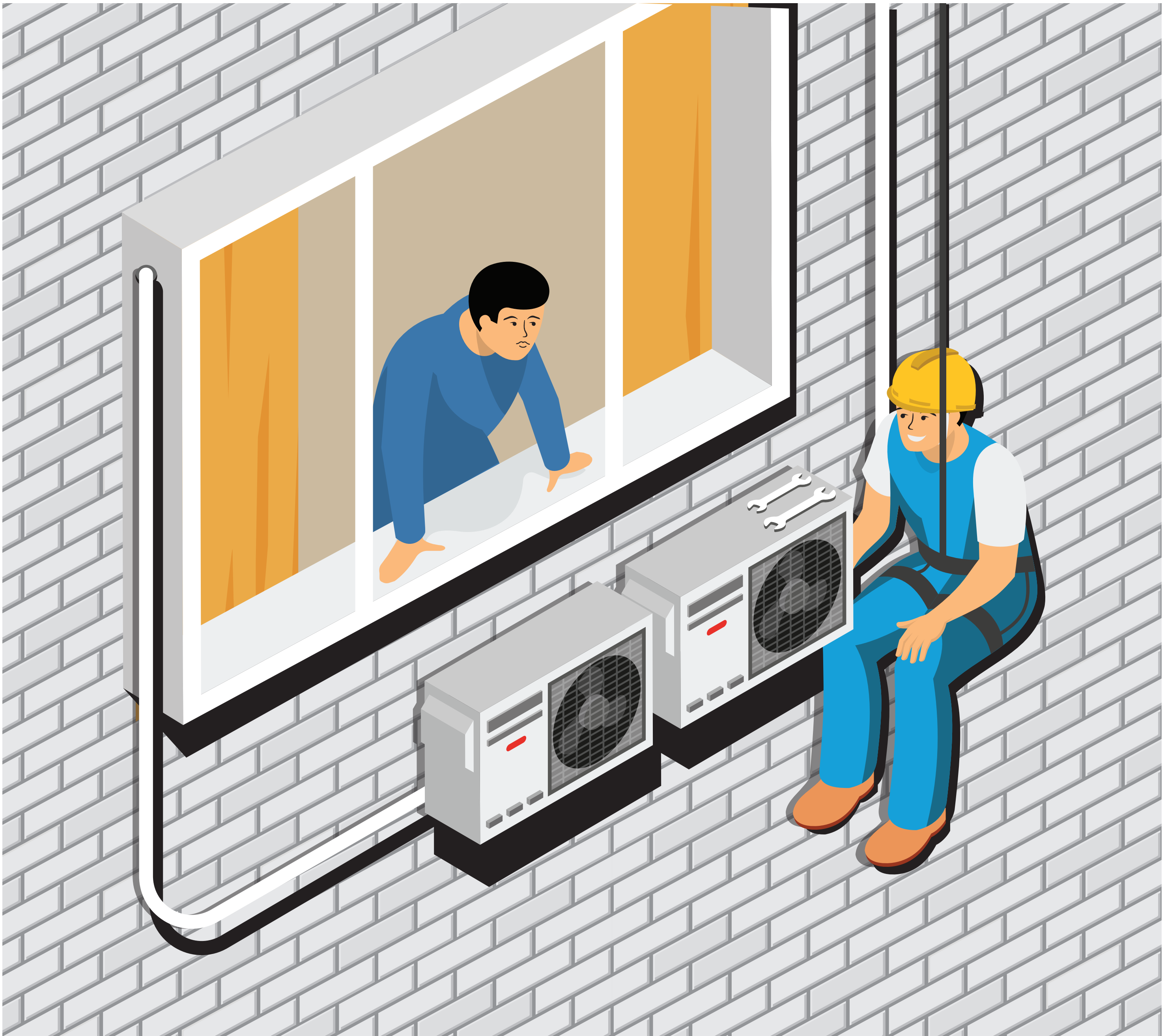
Ozone Cell
Ministry of Environment, Forest and Climate Change
Government of India



GOOD SERVICING PRACTICES FOR ENERGY EFFICIENT OPERATION OF ROOM AIR CONDITIONERS

A book
on

GOOD SERVICING PRACTICES FOR ENERGY EFFICIENT OPERATION OF ROOM AIR CONDITIONERS

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Developed by

Energy Efficiency Services Limited (EESL)

for

Ozone Cell
Ministry of Environment, Forest and Climate Change (MoEFCC)

Government of India

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और
श्रम एवं रोज़गार
भारत सरकार

स्वच्छ भारत
एक कदम स्वच्छता की ओर

सत्यमेव जयते

भूपेन्द्र यादव
BHUPENDER YADAV

MINISTER
ENVIRONMENT, FOREST AND CLIMATE CHANGE
AND
LABOUR AND EMPLOYMENT
GOVERNMENT OF INDIA

MESSAGE

Room Air-Conditioners (ACs) contributes significantly a large percentage of electricity consumption in the households and the use of room ACs in India are growing very rapidly due to rapid urbanization, electrification, fast-growing economy per capita income, changing working conditions, rising temperatures etc. Room ACs constitute the dominant share of the sector's cooling energy consumption in the country. Refrigerants currently used in these appliances are mostly either Hydrochlorofluorocarbons (HCFCs) which are ozone depleting substances (ODSs) or Hydrofluorocarbons (HFCs). Both HCFCs and HFCs have high global warming potential (GWP). ACs contribute to both direct and indirect greenhouse gas (GHG) emissions to the environment. The indirect GHG emissions are through the electricity consumption while operating the air-conditioner and the direct emissions of refrigerant leakage are mainly due to poor servicing and at the end of life of the AC.

Installation, preventive maintenance, good service practices (GSPs) and awareness among AC users and service technicians would play a vital role in the efficient operation of these units during their working life resulting in reducing refrigerant consumption, saving of electricity and the environment.

Servicing sector is an important and integral part of the refrigeration and air-conditioning industry and consumes a large proportion of refrigerants used in the industry. Good service practices (GSPs) reduce the refrigerant leakages to the environment and also maintain the designed energy efficiency of room ACs and thus reduces greenhouse gas emissions to the environment.

The servicing sector plays a significant role in the HCFC phase-out and HFCs phase-down process. Servicing sector is increasingly recognized as the key for reducing refrigerant consumption and emissions of refrigerants to the environment as well as for ensuring the efficient operation of ACs during their working life. Since the implementation of the Montreal Protocol in the country, due attention has been given to the servicing in the Air-conditioning sector. The servicing practices need to be improved for minimizing emissions and to cater to the needs for coming up with alternative technologies. The quality of servicing room AC depends on the knowledge and skill levels of technicians and the use of appropriate tools & equipment during servicing.

I am glad to note that the Ministry of Environment Forest and Climate Change, in association with the UN Environment and Energy Efficiency Services Limited have come out with this handbook on good servicing practices for energy efficient operations of room air conditioners. I am sure, this publication will serve as an effective reference document for service end users, service technicians and HCFC phase-out plan in India.

With best wishes.

Date: 14.09.2021

(Bhupender Yadav)

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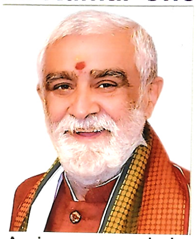

सत्यमेव जयते

आहारशुद्धौ सत्त्वशुद्धिः

एक कदम स्वच्छता की ओर

राज्य मंत्री
पर्यावरण, वन एवं जलवायु परिवर्तन
उपभोक्ता मामले, खाद्य और सार्वजनिक वितरण
भारत सरकार
MINISTER OF STATE
ENVIRONMENT, FOREST AND CLIMATE CHANGE
CONSUMER AFFAIRS, FOOD & PUBLIC DISTRIBUTION
GOVERNMENT OF INDIA

MESSAGE

As is commonly known, the efficiency of Refrigeration and Air-conditioning (RAC) equipment decreases over the period of operation due to ageing wear and tear, defects and poor service practices. Good Service Practices (GSPs) are becoming essential not only to maintain the designed energy efficiency of the Air conditioners (ACs), but also to prolong working life and reduce refrigerant and greenhouse gas emissions to the environment.

Environment protection and sustainable development are the twin goals globally. Under the realm of the Montreal Protocol, in the ongoing Hydrochlorofluorocarbon (HCFC) Phase out Management Plan (HPMP), the large RAC enterprises in the country are also moving to low Global warming Potential (GWP) options. The reduction of refrigerant emissions should be the focus for which an integrated approach encompassing good installation practices, preventive maintenance, good service practices, and responsive use of AC by the customers are of utmost importance for the efficient operation of room ACs during their working life.

The increased use of low- GWP refrigerants have challenges relating to flammability, toxicity or both. Some of the low refrigerants have very high operating pressures as well. Hence there is a need for the RAC servicing sector, a focused attention and interventions to upgrade the skills of the RAC servicing technicians and new technicians entering in this sector to keep them in business. The servicing sector in the country is mainly catered by the unorganized and informal sector. The RAC technicians in country may not have had opportunity for the formal education/vocational education and most of them have learnt by doing (on job training). There is a need to enhance the skills of the servicing personnel through training especially on GSPs and on alternatives to currently used refrigerants and practices for handling and servicing of air conditioning equipment/appliances using flammable refrigerants.

The present publication on good servicing practices has been brought out at a very appropriate time and this important resource material should be disseminated widely amongst all concerned stakeholders for promoting GSPs.

(Ashwini Kumar Choubey)

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सत्यमेव जयते

MESSAGE

With majority of the regions in India having hot and humid climates, the use of room Air-conditioners (ACs) in India is growing very rapidly as space cooling is becoming key to a healthy living and working environment. This not only results in high electricity consumption but also contributes to greenhouse gas emissions.

The Hydrochlorofluorocarbon (HCFC)-22 is one of the main refrigerants currently used in room ACs. Although HCFC-22 refrigerant is being phased out under the HCFC Phase-out Management Plan (HPMP) of the Montreal Protocol, a significant percentage of installed stock of ACs currently are charged with this refrigerant. HCFC-22 refrigerant is not only one of the Ozone Depleting Substances (ODS), but it also has a high global warming potential (GWP). Moreover, most of the commercially available alternate refrigerants such as Hydrofluorocarbon (HFC)-32, R-410A, except hydrocarbons (R-290), are having high global warming potential and emissions from these refrigerants are harmful to the environment.

The efficient performance of in-use air conditioning equipment and the prevention of emissions of refrigerants used in the room ACs depends on good service practices of service technicians which includes proper installation, preventive maintenance and servicing of the equipment. Good service practices optimize energy consumption by maintaining the energy efficiency of the equipment as designed and thus minimizes the indirect GHG emissions from room ACs associated with power consumption.

A large number of technicians in India are working in the informal sector having limited knowledge and skill manpower because the servicing is seasonal and cost-sensitive and the lack of consumer awareness towards the importance of quality service, the servicing jobs are being done by the informal sector. Recognizing the importance of servicing sector for efficient operation of the equipment, the Government of India has emphasized human and institutional development in this sector, including training, skilling and certification of Refrigeration and Air Conditioning (RAC) service technicians programs. Besides the training of RAC technicians under the ongoing HPMP, the Ministry has also initiated a project along with Ministry of Skills Development and Entrepreneurship to train and certify one lakh RAC service technicians under the National Skill Qualification Framework under the Pradhan Mantri Kaushal Vikas Yojana.

The publication which deals with the good servicing practices for energy efficient operation of room ACs will serve as the reference to service technicians gaining knowledge and skill to improve their service practices of room ACs.

[R P Gupta]

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EXECUTIVE SUMMARY

Context

Room ACs are widely used for space cooling in residential and small commercial establishments and contribute a large percentage of energy consumption in a household as the climate of most of the regions in the country are hot & humid. ACs contribute to the direct emission of refrigerants and indirect GHG emissions to the environment.

The cooling demand for households has led to the increasing use of ACs. The exponential increase in room ACs is associated with the current low penetration, rapid urbanization, electrification, fast-growing economy per capita income, changing working conditions, rising temperatures etc. Servicing sector is an important and integral part of the Refrigeration and Air-conditioning (RAC) industry and consumes a large proportion of refrigerants used in the industry.

The servicing sector plays a significant role in the HCFC phase-out and HFCs phase-down process as servicing sector accounts for more than 40% of the refrigerants used annually in the country. Servicing sector is increasingly recognized as the key for reducing refrigerant consumption and emissions of refrigerants to the environment as well as for ensuring the efficient operation of ACs during their working life. The servicing practices need to be improved for minimizing emissions and to cater to the needs for coming up with alternative technologies. The quality of servicing room AC depends on the knowledge & skill levels of technicians and the use of appropriate tools & equipment during servicing. This sector also faces challenges with the introduction of new alternative refrigerants as those are either flammable or operate at higher pressure or both.

Training and certification of RAC service technicians are becoming a necessity in the country to improve their understanding and skills enabling them for safe handling of a variety of refrigerants and technologies introduced in the market. Training and certification would also significantly increase employment opportunities as well as better livelihood for the technicians.

It is well understood that the efficiency of RAC equipment decreases over the period of operation due to ageing wear & tear, defects, and poor service practices even though the equipment is designed at a higher Seasonal Energy Efficiency Ratio (SEER). GSPs are becoming essential not only to maintain the designed energy efficiency of the ACs but also to prolong working life and reduce refrigerant & GHG emissions to the environment. This book has systematically presented the measures that would reduce the deterioration in energy efficiency, frequent failures of ACs and refrigerant and GHG emissions to the environment.

Pillars of Energy Efficiency in the Service Sector

The book describes an integrated approach encompassing four pillars to be taken care of in servicing sector, viz. good installation practices, preventive maintenance, good service practices, and responsive use of AC by the customers which are of utmost importance for the energy efficient operation of room ACs during their working life. These are presented in Figure A.

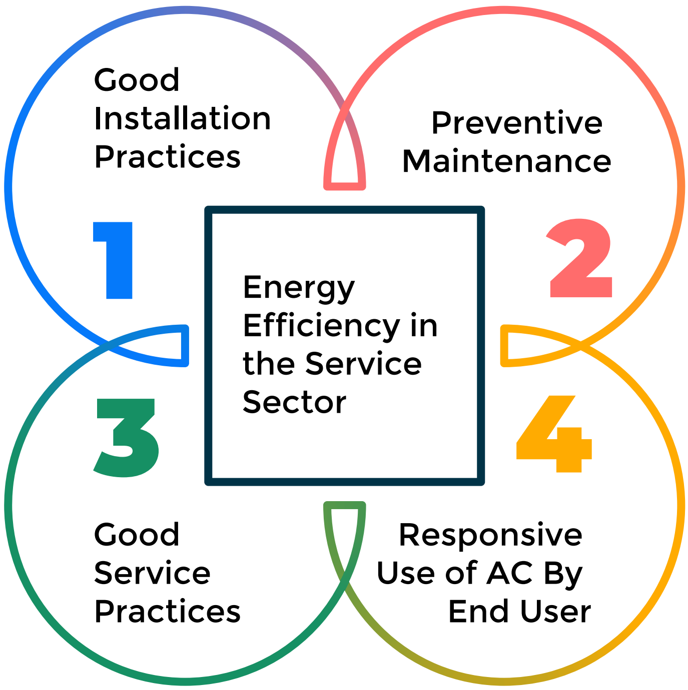


Figure A: Pillars of Energy Efficiency in the Service Sector

CONTENTS

ACRONYMS & ABBREVIATIONS

AC	Air-conditioner
BEE	Bureau of Energy Efficiency
CFC	Chlorofluorocarbon
CO2	Carbon Dioxide
CO2-eq	Carbon Dioxide Equivalent
COP	Coefficient of Performance
CTC	Carbon tetrachloride
ECBC	Energy Conservation Building Code
GHG	Greenhouse Gas
GIZ	Deutsche Gesellschaft fur Internationale Zusam menarbeit
GSP	Good service practices
GWP	Global Warming Potential
HCFC	Hydrochlorofluorocarbon
HFC	Hydrofluorocarbon
HFO	Hydrofluoroolefin
HIDECOR	Human and Institutional Development for Ecological Refrigeration
HPMP	HCFC Phase-out Management Plan
IDU	Indoor Unit
ISEER	Indian Seasonal Energy Efficiency ratio
ITI	Industrial Training Institutes
ITOT	Instructor Training of Trainers
LED	Light Emitting Diode
MEPS	Minimum Energy Performance Standards
MLF	Multilateral Fund
MoEF&CC	Ministry of Environment, Forests and Climate Change
NCCoPP	National CFC Consumption Phase-out Plan
NSTIs	National Skill Training Institutes
O&M	Operation and Maintenance
ODP	Ozone Depletion Potential
ODS	Ozone Depleting Substance

ODU	Outdoor Unit
OFDN	Oxygen Free Dry Nitrogen
PMKVY	Pradhan Mantri Kaushal Vikas Yojana
RAC	Refrigeration and Air Conditioning
RRR	Recovery, Recycling & Reclamation
TEAP	Technology and Economic Assessment Panel
TOC	Technical Options Committee
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
UNFCCC	United Nations Framework Convention on Climate Change
UV	Ultraviolet

LIST OF FIGURES

Overview of Chapters

The chapters are organized to cover each of the important aspects related to energy efficiency in the serving sector.

Chapter-1: INTRODUCTION presents the find out of emissions of chlorofluorocarbons (CFCs) refrigerants to the environment, emitted refrigerants reach to the stratosphere and deplete the Stratospheric Ozone. The chapter presents the global warming impact of ACs due to electricity consumption and emission of refrigerants like HCFCs, HFCs which are potent greenhouse gases. This chapter discusses the Montreal Protocol, a successful treaty to phase-out the production and consumption of Ozone Depleting Substances (ODSs), and the Kigali Amendment of the protocol to phase down the HFCs. The chapter outlined the role of servicing sector in the efficient operation of room AC equipment and how good service practices can help in mitigating global warming and climate change issues.

Chapter-2: SERVICING SECTOR AND ENERGY EFFICIENCY OF REFRIGERATION AND AIR CONDITIONING EQUIPMENT covers the current trend of servicing and the expected growth in this sector and reviews the available servicing sector training programs and training networks. The importance of energy efficiency in the RAC servicing sector in the country to meet the sustainable growth of cooling demand is discussed. An integrated approach with four pillars for energy efficiency in the service sectoris presented. This chapter also presents how current servicing practices in India influence energy consumption & the environment. Sources of emissions from room ACs are discussed and sustainable use of appliances consuming high energy room ACs are reviewed.

Chapter-3: GOOD INSTALLATION PRACTICES FOR EFFICIENT OPERATION OF EQUIPMENT describes the practices that technicians must follow for AC installation. The performance of room AC at designed energy efficiency by themanufacturer can be achieved only if the installation of room AC is carried out by following good installation practices. The right selection of space and placement of outdoor and indoor units, refrigerant tube processing and connecting the tubes to the system, leak testing & then flushing, good evacuation practice of indoor units, post-installation checking, and educating customers on how to operate to save energy are important steps of good installation practice for energy efficiency.

Chapter-4: PREVENTIVE MAINTENANCE FOR EFFICIENT OPERATION OF EQUIPMENT focuses on the preventive maintenance to be carried out by the trained service technicians as well as by AC user for energy efficient operation of the room AC.

Chater-5: GOOD SERVICE PRACTICES FOR SERVICING THE REFRIGERATION SYSTEM OF AC describes important practices viz. recovery of refrigerant, proper copper tube processing to minimize the leakage, leak and pressure testing using Oxygen-Free Dry Nitrogen (OFDN), proper evacuation of the system before charging, use quality refrigerants and charging the refrigerant with the right procedure, use recommended and cleaned lubrication, energy efficiency consideration on electricalcomponents, and maintenance of service tools and equipment.

Chapter-6: CHALLENGES AND OPPORTUNITIES IN SERVICING SECTOR FOR ENERGY EFFICIENCY presents the challenges mainly arising due to exponential growing cooling demand and introduction of alternative refrigerants and technologies. This chapter also addresses how we can overcome some of the challenges faced by the sector. It is challenging for the servicing technicians to handle and service all ACs using different types of refrigerants those are having different properties and characteristics. The other challenging part in the sector is refrigerant management viz. recovery, recycling & reclamation (RRR), and safe handling of alternative refrigerants. The challenges with the availability of tools and equipment especially in the informal sector are discussed in detail.

The chapter also discusses the opportunities in the servicing sector especially with respect to energy efficiency and reduced GHG emissions such as capacity building for safe handling, good service practices for alternative refrigerants through training programs, certification of technicians, and the potential for employment generation within the country as well in the global market in the room AC service sector. The customer and stakeholder awareness, development of the nation's service standard, planning & policy formulation, and employment opportunity are presented in this chapter.

CHAPTER 1: INTRODUCTION

CHAPTER 1: INTRODUCTION

Room AC is one of the high energy consuming appliances in Indian households. As most of the regionsin the country have hot & humid climate, ACs run for a longer time with a high condensing temperature. This not only results in high electricity consumption but also contributes to direct and indirect GHG emissions to the environment. The indirect GHG emissions are through the electricity consumption while operating the air-conditioner and the direct emissions are owing to refrigerant emissions during servicing and at the end of life of the AC.

Although HCFC-22 refrigerant is being phased out under the HPMP of the Montreal Protocol, a significant percentage of installed stock of ACs currently are charged with this refrigerant. HCFC-22 refrigerant is not only one of the ODSs, but it also has a high global warming potential (GWP). The most used alternative refrigerants to HCFC-22 are HFCs like HFC-32 and R-410A (a blend of HFC-32 and HFC-125) in room AC. The HFC refrigerants are non-ODSs but are high global warming substances. Most of the commercially available refrigerants except hydrocarbons (R-290) are either contribute to ozone depletion or global warming or both. R-290 being highly flammable as of now it is not being widely adopted by the industry.

1.1 Linkage between Fluorocarbons Emissions and Stratospheric Ozone Depletion

As early as the beginning of the 1970s, the world community, especially in the southern hemisphere was experiencing a significant increase in skin cancer and eye cataract cases. The scientific community was trying to understand the causes of this unnatural development. Thanks to the scientific community, in a very short time they could conclude and provided an explanation that this is due to the increase in-coming Ultra Violet (UV)-B radiations on the earth's surface. Soon after, it was scientifically established that the increased UV-B radiations are because of depletion of the Stratospheric Ozone. The Stratospheric Ozone which acts as sealed to protect the Earth's surface from harmful UV-B radiation is being depleted. The scientific observations suggest that the Earth's ozone layer was formed some 400 million years ago and remained practically undisturbed. It was taken for granted that it would virtually remain undisturbed for all the time despite human activities on the Earth's surface.

In the mid-1970s, two chemists from the University of California at Irvine based on their pioneer research findings alerted the world community with deep concern that the ozone layer might be threatened by the continuing emissions of CFCs, a widely used set of industrial chemicals. A research paper published in Nature in 1974 by F. Sherwood Rowland

and Mario Molina [1]theorized that the very stable CFCs reached the stratosphere, their exposure to UV radiation from the Sun led to their decomposition. The chlorine atoms freed from the CFC molecule initiate a chain reaction process that destroys a significant quantity of stratospheric ozone. The consequence of this drop in stratospheric ozone increases the UV-B radiation reachingthe Earth's surface resulting in increased skin cancers, genetic mutations, crop damage, and possibly other drastic changes. Extensive research continued during 1975 and 1976. The research work of Professor Paul J.Crutzen of the Max Planck Institute, Germany that explained the process of ozone depletion by CFCsfurther strengthened the hypothesis on ozone depletion. Prof F. Sherwood Rowland, Prof Mario Molina and Prof Paul J. Crutzen shared the 1995 Nobel Prize for Chemistry.

1.2 Linkage between GreenhouseGas Emissions and Use of Fluorocarbon Refrigerant & Energy Use

It is well known that ODSs are also high global warming gases that contribute to the radiative forcing of the climate. The phase-out of production and consumption of ODSs by the implementation of the Montreal Protocol has also helped in the mitigation of climate change. HCFCs were introduced as a low-ODP transitional substances to substitute some of the high-ODP CFCs. The developed countries have already phased out the production and consumption of HCFCs as of 1st January 2020. Developing countries are now phasing out HCFCs from various sectors, in accordance with the accelerated phase-out schedule of the Montreal Protocol. HFCs are the next-generation alternatives to HCFCs, developed as zero-ODP substances. However, under the United Nations Framework Convention on Climate Change (UNFCCC) and its Kyoto Protocol, the emissions of HFCs are controlled along with other Kyoto basket of potent greenhouse gases. These are responsible for direct and/or indirect greenhouse gas emissions that contribute to the radiative forcing of the climate. Yet, the consumption of HFCs continues to increase because of increased industrial activities, particularly cooling requirements across the globe. By proper management of use of alternatives like HFCs and/or adopting low-GWP options would result in significant climate benefits.

1.3 Montreal Protocol

The chemical compounds containing chlorine and bromine like CFCs, halons, carbon tetrachloride (CTC), HCFCs, etc.; CFCs and HCFCs used as refrigerant in room ACs, responsible for the depletion of the Ozone Layer in the earth's atmosphere. These chemicals also have high global warming potential.

The “Montreal Protocol on Substances that Deplete the Ozone Layer” is an international treaty designed to protect the ozone layer by phasing out the production and consumption of a number of substances that cause stratospheric ozone depletion. The treaty was opened for signature on September 16, 1987, and entered into force on January 1, 1989. Since then, it has undergone several amendments based on scientific and technical developments.

The Montreal Protocol has been universally ratified by all the countries and it is the most successful international treaty so far. The production and consumption of high ODP ODSs like CFCs, CTC, and halons havealready been phased out globally, including in India. The next family of ODSs, the HCFCsare being phased out globally.

The Montreal Protocol on substances that deplete the Ozone layer was ratified by India in June 1992. India is one of the parties operating under Paragraph-1, Article-5 of the Montreal Protocol, and qualified for technical and financial assistance, including the transfer of technology, through the financial mechanism of the Montreal Protocol. The MoEF&CC has been designated as the nodal ministry for the implementation of the Montreal Protocol and stablished Ozone Cell, for facilitating the implementation of the Montreal Protocol in the country.

Recognizing the environmental benefits of early phase-out of production and consumption of HCFCs, the Meeting of the Parties to the Montreal Protocol held in Montreal in September 2007, accelerated the phase-out schedule for HCFCs by ten years [2].The accelerated HCFC phase-out schedule for Article-5 countries is thefreeze in 2013 at the baseline level (an average of 2009 and 2010) for production and consumption respectively and subsequently, 10% reductionof the baseline in 2015, 35% reduction in 2020, 67.5% in 2025 and complete phase-out in 2030 while allowing for servicing an annual averageof 2.5% during the period 2030-2040.Figure 1.1 shows the phase-out schedule of HCFCs in Article 5 countries.

Room AC servicing sector under HPMP is being implemented by the Government of Germany represented by Deutsche Gesellschaft fur Internationale Zusammenarbeit (GIZ) GmbH and UNEP under the guidance of Ozone Cell, MoEF&CC. India has achieved all the compliance targets set by the Montreal Protocol for the phase-out of HCFCs.

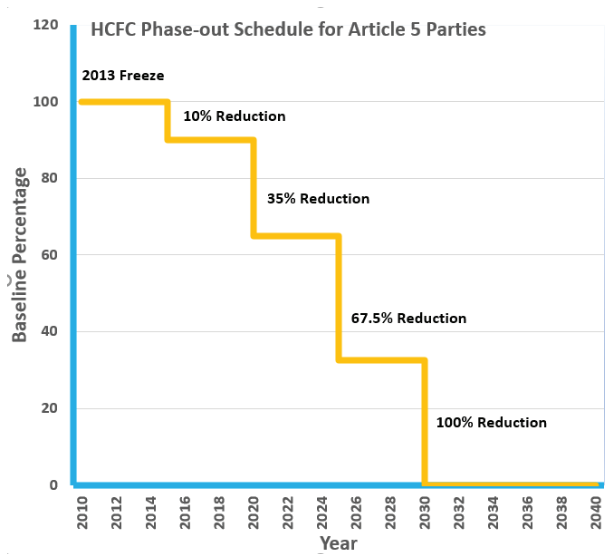


Figure 1.1: HCFC Phase-out Schedule for Article-5 Countries

1.4 Kigali Amendment - Energy Efficiency of RAC Equipment and Climate Change

HFCs have been phased in as alternatives to CFCs, HCFCs, etc. while phasing out ODSs. HFCs being potent greenhouse gases are part of the basket of GHGs under the UNFCCC. The phase-out of ODSs is addressing the objective of protection of the ozone layer and upto certain extent climatic, however, the introduction of high GWP HFCs as alternatives to ODSs and their exponential increased production and consumption has raised global concerns about global warming/climate change. Hence, the growing use of HFCs as alternatives to HCFCs has been recognized as a major climatic concern.

HFC emissions are projected in a business as a usual scenario to rise to about 3.5 to 8.8 GtCO2-eq in 2050 which is comparable to the reduction of 11.6 GtCO2-eq achieved due to phasing out of ODS between 1988 and 2010[3]. This means that without intervention, HFC emissions are projected to offset the climate benefits achieved by the Montreal Protocol through phasing out ODS. Globally, there are many ongoing efforts and discussions to address this issue of the HFC phase-down as part of the Montreal Protocol.

The Meeting of Parties to the Montreal Protocol at its 28th Meeting held in Kigali, Rwanda in October 2016 reached a historical agreement for phase-down of HFCs under the ambit of the Montreal Protocol.The Kigali agreement [4]is the latest amendment to the Montreal Protocol. As per the agreement, countries are expected to reduce the manufacture and use of HFCs by 80-85% from their respective baselines, till 2045.The phase-down of HFCs is expected to arrest the global average temperature rise from 0.30C to 0.5o C by the end of the century as shown in figure 1.2 [5].

The Kigali amendment is unique, that brings non-ODS chemicals under the ambit of the Montreal Protocol. For the purpose of phase-down of production and consumption of HFCs, countries have been categorized into four groups having a different schedule for HFC phase-down. These phase-down schedules as decided give the flexibility to the countries to implement the phase-down of HFCs as per the national circumstances.

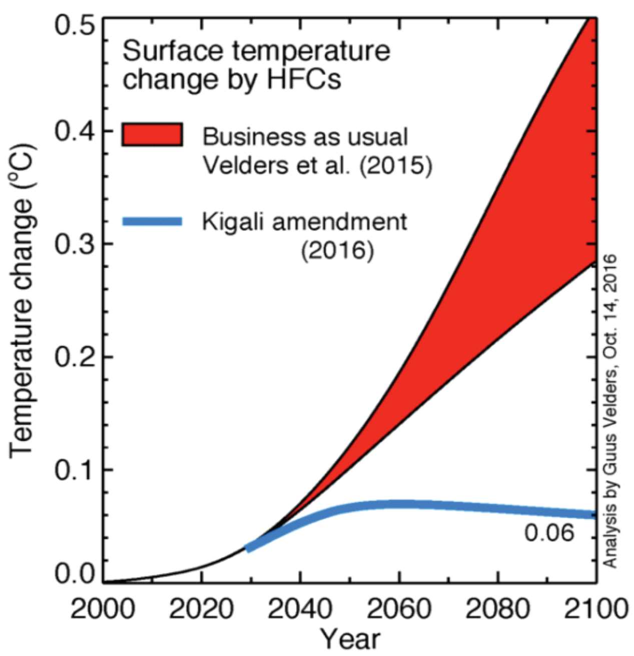


Figure 1.2: Surface Temperature Change by HFCs

The phase-down schedule of HFCs for Article 5 and Non-Article 5 countries as per the Kigali amendment to the Montreal Protocol is given in figure 1.3. There are four groups, two for non-Article 5 countries and two for Article 5 countries.

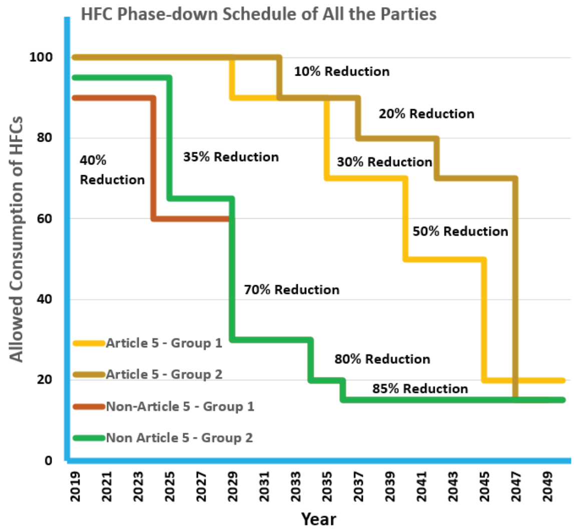


Figure 1.3: HFCs Phase-down Schedule

- **Article-5 Group 1** consists of several developing countries including China & other Asia Pacific countries, Latin American countries, African countries, etc. that will start phase-down of production and consumption of HFCs in 2024 and reduce it to 20% of the baseline levels by 2045.

- **Article-5 Group 2** consists of developing economies and some of the high ambient temperature countries like India, Bahrain, Kuwait, Pakistan, Iran, Saudi Arabia, etc., that will start phasing down of production and consumption of HFCs with a freeze at the baseline in 2028 and reduce it to 15% of the baseline levels by 2047.

India opted for the Group 2 of the Article 5 countries, recognizing that current penetration of cooling is very low in the country but growing rapidly and non-availability of alternatives for all the applications, especially the high-pressure applications which are needed in the country. The baseline for Group 2 Article 5 countries is the average production and consumption of HFCs for the years 2024, 2025 and 2026 plus 65% of HCFCs baseline, respectively.

The Kigali amendment is unique, in which control measures of non-ODS substances have been included under the ambit of the Montreal Protocol. Secondly, the agreement calls for “phase-down” instead of “phase-out” since the low-GWP alternatives are not yet widely available for all the applications where HFCs are currently used. The technical and financial assistance to meet the obligations of phase-down of HFCs in Article 5 countries will be met by the Multilateral Fund for the implementation of the Montreal Protocol. It is important to note that phase-down will be quantified in terms of CO_2 equivalent emissions since HFCs have no ozone-depleting potential.

1.5 Role of Servicing Sector in the Efficient Operation of Room AC Equipment

The cooling demand for households, and thus room AC has been increasing rapidly as it becomes integral to the economic growth and necessity to the health, well-being, and productivity of people, rapid urbanization and population growth, therefore, the use of room ACs will grow many folds from the current level. The servicing and service technician's requirement is also expected to grow in a similar proportion. The room AC sector consumes a large proportion of refrigerants majority of which is HCFCs, which are phasing-out.

RAC servicing sector contributes to the emissions in two ways; one is direct emissions due to release/leakage of refrigerants and the second is the degradation of performance of in-use air conditioning equipment. The efficiency of RAC equipment decreases over the period of operation due to age, defects and poor service practices even though the equipment is designed with quite a higher Indian Seasonal Energy Efficiency ratio (ISEER). GSPs are becoming essential not only to reduce the electricity bill by maintaining the design energy efficiency of the air-conditioners but also for a better environment. The quality of servicing room AC depends on knowledge & skill levels of technicians and using appropriate tools &equipment.Proper maintenance and servicing can curtail up to a 50% reduction in performance and maintain rated performance over the lifetime [6].

Kigali amendment was signed to phasedown HFCs by adopting low GWP alternatives. The servicing sector has a significant role in the phase-down process and the role is challenging as the new alternative refrigerants are either flammable or operate at higher pressure. The servicing practices must be improved for minimizing emissions and to cater to the needs for coming up with alternative technologies. Good installation and servicing practices are discussed further in the book.

CHAPTER 2: SERVICING SECTOR AND ENERGY EFFICIENCY OF REFRIGERATION AND AIR CONDITIONING EQUIPMENT

CHAPTER 2: SERVICING SECTOR AND ENERGY EFFICIENCY OF REFRIGERATION AND AIR CONDITIONING EQUIPMENT

2.1 Servicing Sector in India – Current and Growth

Room ACs are widely used for space cooling in residential and small commercial establishments. Currently, there is hardly 7-9% penetration of air conditioners in the country but it is expected that it would rise to 21% and 40% by 2027-28 and 2037-38 respectively; it has also been estimated that the current Room ACs stock of 40 million would rise to 400 million by 2037-38 [7]. This exponential increase has been associated with the current low penetration, rapid urbanization, and electrification, fast-growing economy and per capita income, changing working conditions, rising temperatures, etc.

Servicing sector is an important and integral part of the RAC industry. In recent years its importance is further increasing with the realization that most of the emissions of refrigerants to the environment are especially during servicing of RAC equipment and end-of-life disposal. Servicing sector consumes a large proportion of refrigerants used in the industry, accounts for more than 40% of refrigerants consumed annually in the country[8]. As the stock of room AC is increasing, the service requirement in this sector is also growing rapidly.

The AC servicing sector in India is made up of a diverse range of establishments that provide maintenance services for all types of RAC systems. Manufacturers operate their own sales and service networks in the larger cities. In order to attend to customers in smaller cities and towns as well, manufacturers contract service workshops all over the country (so-called 'authorised' or 'franchised' service workshops). Besides, there is a considerably large informal service sector with no tie-up to manufacturers. These workshops are present from larger cities down to small towns and thus closest to the customers. It is estimated that there are around 200,000 technicians in the stationary air conditioning service sector[8]. A majority of the technicians engaged in this sector are those who have not gone through formal technical education and/ or training and these technicians have learnt while working in the field over several years. The number of technicians deployed in this sector would grow rapidly as the penetration of ACs will increase as estimated in ICAP-2019. Training programs for RAC service technicians have been a continuous activity as part of the ODS phase-out programs being implemented in the country under the Montreal Protocol framework. Separately, there have been training for service technicians being organized by industry associations and air conditioning equipment manufacturers.

2.2 India's Current RAC Servicing Sector Training Landscape

Training and certification of RAC service technicians have the potential to provide significant environmental and livelihood benefits. These could be achieved through appropriate skill development of service technicians for following good servicing practices to maintain the energy efficient operation of serviced air conditioners along with creating a market demand for skilled technicians, which shall be a key driver.

Continuous training of service technicians is becoming very important to cater to the needs of servicing of upcoming technologies and for the safe handling of alternative refrigerants as the new alternative refrigerants are either mildly flammable or highly flammable. Well-structured training will help in gradually transforming the service technicians working in the informal sector to the formal sector and also enhance the livelihood opportunities in this sector.

India has a very good technical education network, including vocational training programmes. The country has two National Skill Training Institutes (NSTIs) and one Instructor Training of Trainers (ITOT) conducting long-term training for the trainers/instructors in the RAC field as well as conducting short-term refresher programs for the trained teachers in RAC. Currently, these institutes are imparting training to about 250 trainers per year. These institutes are not yet well equipped both in terms of faculty and tools & equipment for providing training to the trainers on upcoming changing technologies.

India also has a very good network of Industrial Training Institutes (ITIs) across the country. There are more than 1000 institutes in the country imparting training in RAC trade. These institutes are producing about 15,000 formally trained technicians annually who take up a variety of jobs from manufacturing, installation, and operation to service.

During the CFC phase-out regime, Human and Institutional Development for Ecological Refrigeration (HIDECOR), a bilateral project of Government of India and Switzerland and National CFC Consumption Phase-out Plan (NCCoPP) under the Montreal Protocol ODS phase-out project were implemented and about 20,000 service technicians were trained on GSP working in the refrigeration servicing sector. Recognizing the importance of servicing sector, training programs on good servicing practices have been conducted through MLF funded projects, the HPMPs. HPMP Stage I involved training of more than 11,000 technicians, and Stage II of the Plan will train around 17,000 technicians. Despite these efforts, only a small number of technicians, especially in the informal sector have received any form of training and there is a need to assess the status of skill development in the country.

Recently, the MoEF&CC and the Ministry of Skill Development and Entrepreneurship, Government of India, signed a Memorandum of Understanding to train 100,000 RAC service technicians in good servicing practices and the new alternative refrigerants under the Pradhan Mantri Kaushal Vikas Yojana (PMKVY) – Skill India Mission.

Most of the room AC manufacturers in India have established training facilities for servicing personnel to meet the challenges in the introduction of new products and technologies. Equipment manufacturers have developed their own service network to train the service providers on their products. The network includes company owned service centers, authorized dealers, franchisees retailers/distributors, service associates, and freelance technicians. The industry network caters to the servicing needs of their products mainly during the warranty period of the product. During the peak sales season, the industry also largely utilizes freelancer technicians who are similar to informal sector technicians. It is challenging how to motivate the industry to include GSPs in general rather than only training on their products and extend its training network to informal sector technicians.

2.3 Room Air-conditioner Energy Efficiency Standards and Labelling in India

Recognizing the growth in space cooling, the Bureau of Energy Efficiency (BEE) instituted the Standards and Labelling program (S&L) in 2006 to set minimum energy performance standards (MEPS) for room ACs, along with other consumer appliances. The objective of the Standards and Labelling program is to lower energy consumption by adopting high energy star labeled appliances and efficient operation. BEE started mandatory energy efficiency Star rating from 2010 for room ACs up to a rated cooling capacity of 10.465 kW. The BEE label to the room AC is a maximum of 5 stars with an interval of 1 star, and the room air conditioner is rated from star 1 to star 5 based on their relative energy efficiencies.

2009-2011	2012-2013	2014-2015	2016-2017	2018-2020	2021-2023	EER/ISEER
Star-1						(EER - 2.3 to 2.49)
Star-2	Star-1					(EER - 2.5 to 2.69)
Star-3	Star-2	Star-1	Star-1			(EER - 2.7 to 2.89)
Star-4	Star-3	Star-2	Star-2			(EER - 2.9 to 3.09)
Star-5	Star-4	Star-3	Star-3	Star-1		(EER/ISEER - 3.1 to 3.29)
	Star-5	Star-4	Star-4	Star-2	Star-1	(EER/ISEER - 3.3 to 3.49)
		Star-5	Star-5	Star-3	Star-2	(ISEER - 3.5 to 3.79) (EER/ISEER - 3.5 to 3.99)
				Star-4	Star-3	(ISEER - 3.8 to 4.39) (ISEER - 4.0 to 4.49)
				Star-5	Star-4	(ISEER - 4.4 to 4.99 (ISEER - 4.5 & above)
					Star-5	(ISEER - 5.0 and above)

Figure 2.1: BEE Star Labelling of Split ACs

BEE labels the system based on the ISEER, which means the ratio of the total annual amount of heat that the equipment may remove from the space when operated for cooling in active mode to the total annualamount of energy consumed by the equipment during the same period.The labeling program is a dynamic system; every two years BEE revises and enhances energy efficiency values. Figure 2.1 presents the EER/ISEER up-gradation of the BEE STAR Label[9].

2.4 Importance of Energy Efficiency in the RAC Servicing Sector

The consumption and prevention of emissions of refrigerants used in the room ACs and efficient performance of in-use air conditioning equipment directly depends on proper installation and servicing of the equipment. The use of good servicing practices by service technicians reduces refrigerant leakage and optimizes energy consumption and thus minimizes the indirect emissions of air conditioning equipment related to power generation by maintaining the energy efficiency designed for the equipment.

The Technology and Economic Assessment Panel (TEAP)report, 2018 [6] observes that some energy efficiency degradation over the lifetime of equipment is inevitable; however, there are ways to limit the degradation through improved servicing which includes both installation and maintenance. The impact of proper installation, maintenance and servicing on the energy efficiency of equipment is considerable over the working lifetime of the equipment while the impact on additional cost is minimal. Proper maintenance and servicing can curtail up to a 50% reduction in performance and maintain rated performance over the lifetime.

The residential sector is likely to be the driver for the growth of air-conditioning equipment in India in the next twenty years due to the low existing penetration of ACs, increasing purchasing power, urbanisation trends etc. The space cooling sector presents unique opportunities for optimization of cooling demand, including through energy efficiency, since a large portion of the cooling demand is yet to come. As Per ICAP, 2019, the intervention scenario projects that around a 30% reduction in cooling energy can be achieved through improvements in cooling equipment efficiency, and better servicing and operation and maintenance (O&M) practices. Further significant energy savings could be accrued over and above the projected 30% reduction by optimizing, and in effect, reducing the cooling load of built spaces: a reduction potential of around 20% in cooling load could be achieved by 2037-38, through climate-appropriate building envelopes driven by higher adoption of ECBC in the upcoming commercial buildings, and through the adoption of adaptive thermal comfort practices (pre-setting of lower setpoint temperature in air conditioning equipment).

2.5 Integrated Approach for Energy Efficiency in the Service Sector

An integrated approach encompassing four pillars that are important for the energy efficient operation of room AC during working life. Conceptualization of the integrated approach is depicted in Figure 2.2. It comprises four pillars: good installation practices, preventive maintenance, good service practices, and responsive use of AC by the customers. These are discussed in detail further in the book.

Good installation is the first and most important step to make sure the room AC operates efficiently. Location of indoor and outdoor units, copper tube installation, electric connections, drain pipes connection are few critical elements for proper installation for ensuring energy efficient operation.

Preventive maintenance conducted as per manufacturer recommendations minimizes emissions of refrigerant, prevents chances of parts failure, and thus helps in maintaining designed energy efficiency over a period. Preventive maintenance should be carried out by expert technicians, however, few maintenances can be carried out by the AC users such as filter cleaning.

Air-conditioners are designed for operation for long hours and years under different weather and working conditions; there is a deterioration of AC performance, system failure and leakage of refrigerant due to wear and tear of parts, tube joint, etc.

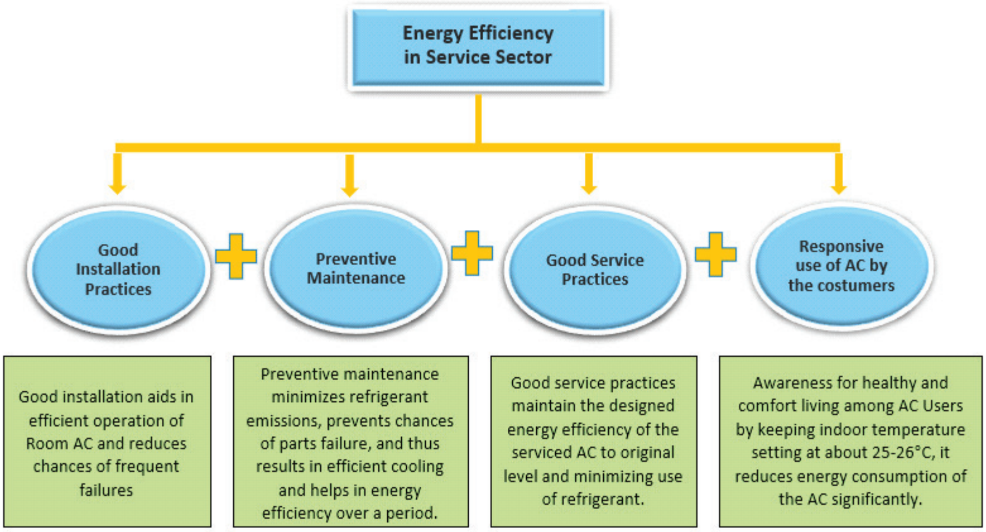


Figure 2.2: Integrated Approach for Energy Efficiency in the Service Sector

The use of good service practices not only minimizes refrigerant use and its emissions to the environment but also brings back the energy efficiency of serviced AC to its original designed value. There is a need to generate awareness about good service practices among technicians as well as in customers.

The fourth and last pillar is the responsive use of AC for healthy and comfortable living/working by keeping indoor temperature settings at 25-26˚C instead of at 18-22˚C. This would not only result in a significant reduction in electricity bills without sacrificing any comfort but it would also provide health benefits.

2.6 Sources of Emissions and Energy Efficiency Consideration of Components of a RAC System

There are direct emissions of refrigerant from ACs due to leakages during installation & servicing and disposal of ACs at the end of life [10]. As HCFCs and HFCs are having high global warming potential (e.g. GWP of HCFC-22 is 1810, R-410A is 2080), such emissions to the environment contribute towards global warming. Indirect emissions contribute to global warming due to electricity consumption during the working lifetime of the ACs. The generation of electricity in the power plants results in GHGs*emissions to the environment.

The contributions in global warming of indirect emissions are significantly higher than that of refrigerant emissions. Figure 2.3 outlines the sources of direct and indirect emissions.

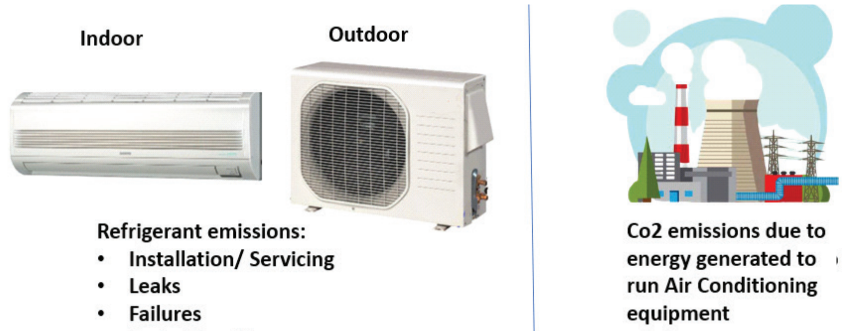


Figure 2.3: Room AC: Sources of Emissions

2.7 Impact of Sustainable Use of ACs on Energy Consumption

ANSI/ASHRAE Standard 55 (Thermal Environmental Conditions for Human Occupancy) is a standard that provides minimum requirements for acceptable thermal indoor environments [11].

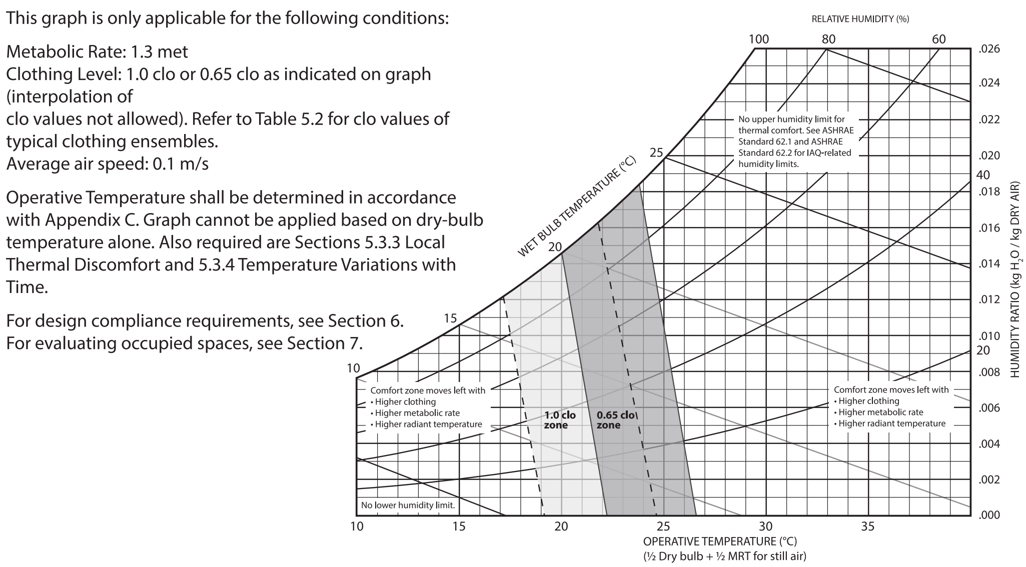


Figure 2.4: ASHRAE Thermal Comfort Chart

It establishes the ranges of indoor environmental conditions that are acceptable to achieve thermal comfort for occupants. The chart (Figure 2.4) shows a thermal comfort zone; comfort zone refers to the combinations of air temperature, and humidity that are predicted to be an acceptable thermal environment at values of air speed, metabolic rate, and clothing insulation. It can be seen that thermal comfort is achievable for a wide range of operative (indoor) temperature which varies from 21 to 27˚C.

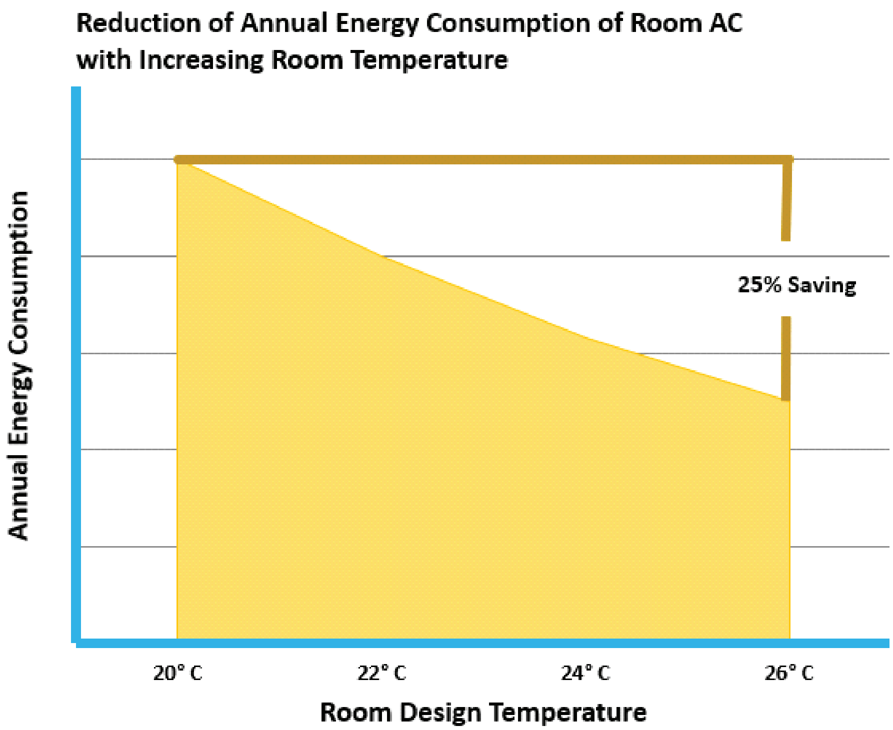


Figure 2.5: Impact of Indoor Temperature Settings on Energy Consumption

There is a need to create consumer awareness in the country on the sustainable use of ACs. Technicians role in customer awareness is addressed in the next chapter of the book. The thermostat temperature setting plays a critical role in the cooling capacity requirement of the space to be air-conditioned, the lower the set point temperature; the more is the cooling requirement and more energy consumption for space. Making the room temperature set to 26˚C the energy savings can be around 25% than the room temperature set of 20˚C as shown in Figure 2.5.

2.8 Current Servicing Practices and Their Influence on Energy Consumption & the Environment

As per ICAP 2019, the GSPs for the reduction of refrigerant consumption and emissions are largely not followed by the service technicians. Most of the technicians, both in formal and informal sectors do leak testing which is being done by soap solution. Many technicians follow the right process of brazing & flaring, calibrated charging and flushing. Charging by weight in servicing is not followed by informal sector technicians, they usually do "top-up" of refrigerant, based on suction pressure, which is not a good practice. Very few technicians do flushing with OFDN, as the cost of the process and equipment are high and there are challenges in the transportation of OFDN as most technicians travel on 2-wheelers. The recovery of refrigerants is very rare due to the high cost of the recovery equipment and lack of reclamation facilities in the country.

Therefore, in general, the GSPs are currently not very much in practice and the service practices that are followed currently by most of the technicians lead to inefficient operation of the appliance and significant wastage of refrigerants and emissions of HCFCs and HFCs to the environment like flushing with refrigerants, leak testing using compressed air or refrigerant; inadequate evacuation; poor brazing; inaccurate charging; lack of or inadequate recovery & recycling of refrigerant.

CHAPTER 3: GOOD INSTALLATION PRACTICES FOR EFFICIENT OPERATION OF EQUIPMENT

CHAPTER 3: GOOD INSTALLATION PRACTICES FOR EFFICIENT OPERATION OF EQUIPMENT

3.1 Introduction

The performance of room AC depends on proper installation of air-conditioners; following all the steps of installation practices properly results in the optimum energy performance of air-conditioners. If the equipment is not correctly installed, increased chances of refrigerant leakage, operate at lower efficiency than designed efficiency, results in poor air circulation thus lesser comfort, may require more maintenance and will not have the expected working life. Some of the good installation practices to be considered for efficient operation are discussed in this chapter.

3.2 Placement/Installation of Outdoor and Indoor Units

The installation of the outdoor unit (ODU) and the indoor unit (IDU) should be such that there should not be any obstruction to the circulation of air; restriction on airflow will reduce the performance of the AC. If there is a shade above the ODU, it will improve the cooling performance. An air conditioner installed in the shade will run more efficiently than an A/C unit mounted in direct sunlight; avoid locating the ODU wherever possible where it would not be exposed to the sunlight. The units should be placed away from any flammable materials, strictly follow in case of flammable refrigerant. The minimum space around the ODU and IDU must be as shown in Figure 3.1. The tubing should have minimum bends and elbows, seal the gap around the tubes using putty. All these are important considerations during installation for optimum energy performance.

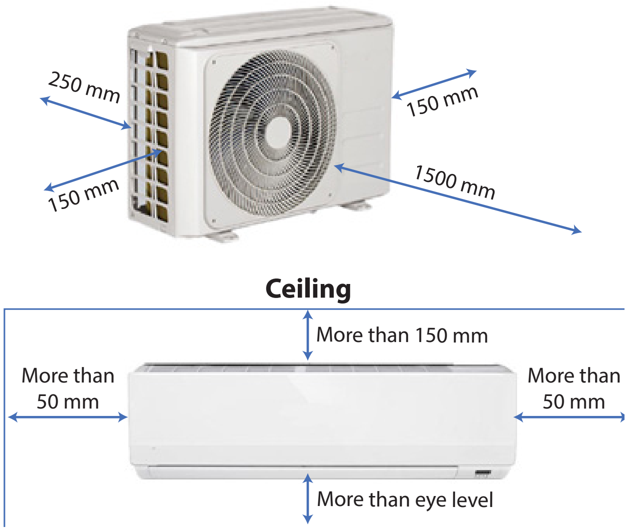


Figure 3.1: Proper Distancing Around Indoor and Outdoor Units

3.3 Refrigerant Tube Processing and Connecting the Tubes

For connecting IDU & ODU, copper tubing is to be done properly. Technicians must follow the correct steps followed for the installation of refrigerant tubes as specified in the installation manual for the efficient operation of the equipment. The following are some important consideration, if not followed then it will lead to inefficient energy performance:

- Insulate IDU – ODU connecting tubingto minimize heat gain resulting better performance.

- Remove burrs from the cut edges of the tubes.

- Apply torque that is just right for flare nuts, over-tightening shears the tubes, ultimately resulting in the leak. The torque required for tightening different tube sizes varies according to the diameter of the tube.

- If a flare joint leaks even after tightening to the required torque, the reason for leakage may be due to bad flare, burrs on the tube and wrong size flare. Then cut the tube and make the new flare.

- Insulate the drain hose laid indoors. The drain hose should be inclined downward. In the case of the drain pipe placed like a siphon, the condensate will not flow. Remove filters and pour water into the drain pan to confirm the smooth flow of water.

3.4 Leak Testing

Leak testing is very important for the efficient operation of AC and for minimizing the emission of the refrigerant to the environment. During leak testing system should not be purged with refrigerant. Only OFDN must be used to check for leakage. The test pressure of OFDN should be higher than the operating pressure of the AC (depending on refrigerant). The procedure for leak testing is the same for all refrigerants e. g. HCFCs, HFCs and HCs. First, flush the indoor unit with OFDN and fill the IDU with OFDN and keep the system under pressure for 15 minutes and observe any drop in pressure [12]. If there is any drop in pressure identify the leak and rectify it. Apply soap solution on each joint with the help of a brush and look for leakage, if any.

3.5 Good Evacuation Practice of Indoor Units

The system should be free from air, moisture, and non-condensable gases to ensure the proper and efficient operation of the air conditioner. Therefore, it is important to evacuate the IDU during the installation of the air-conditioner before connecting it to the ODU through refrigerant tubes, the process is shown in figure 3.2. For deep vacuum, a suitable 2-stage rotary vane vacuum pump should be deployed. Use a micron gauge to measure evacuation pressure. The evacuation must reach 500 or lower microns level.

3.6 Post-installation Checking

The following checks to be made after the completion of the installation process. The post-installation check is very important for the efficient operation of the installed equipment.

- Check the air-conditioner is installed securely and there is enough space provided around the IDU and ODU for better performance.
- Check that circulation of air is not obstructed.
- Check the gaps around the unit are filled with thermal insulation.
- Observe that there won't be receiving any potential complaints from neighbors about vibration and dripping of water.

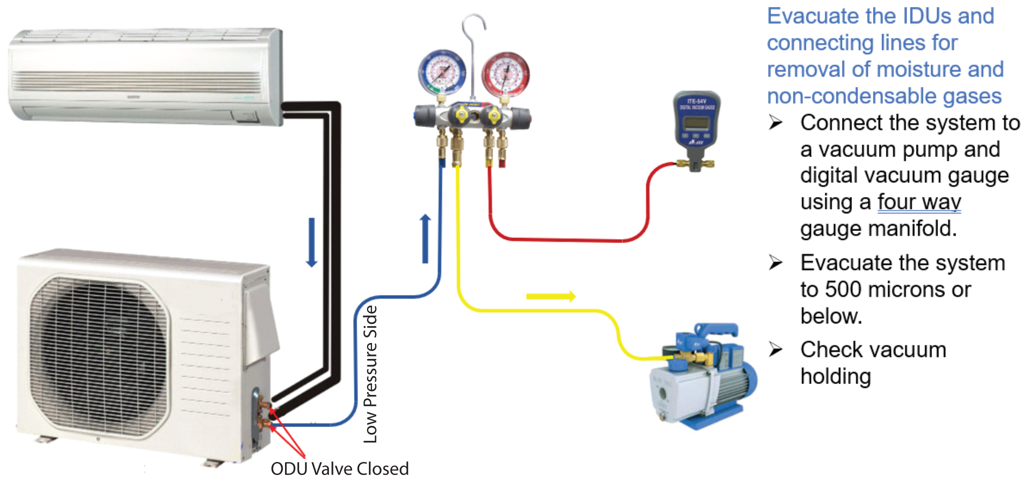


Figure 3.2: Good Installation Practice: Evacuation of IDU and Connecting Lines

- Ensure that the electric wires used as per the requirements and earthing wire connected properly to the units.
- Check line voltage and supply of current areas specified and operations of the electronic and electrical control panel.
- Ensure no leakage of refrigerant and condensate flows out smoothly.

- Measure the temperature of supply and return air, the difference to be 10-12˚C.

- Educate customers how energy use can be saved by regular maintenance, e.g. cleaning filters, front grille panel, etc.

3.7 Education to Customer on Energy Efficient Operations

Educating customerson how to properly operate the room AC is important forthe efficient operation of the equipment. Few advices the technicians should give to the customer after installation are as below.

- Purchase a higher BEE star rating system, 5-star BEE rated room AC consumes about 20 to 25% lower energy than 1 star AC.

- Running AC at higher indoor temperature consume 15 to 25% less energy, set the temperature of the AC in a range of 24-27˚C.

- Certified technicians should only be allowed to service AC who knows the good service practices to improve energy efficiency and also for the safety considerations.

- While operating the room AC, the doors and windows of the room should be closed so that there will be no outside hot air entering the space as well as cold air leaking from the room.

- The temperature set point can be increased, running ceiling fan at low speed that helps the circulation of the air inside the room properly, by which the overall energy consumption of room AC will be lowered.

- LED light may be used that reduces the cooling load in the space and would result in saving electricity consumption for lighting as well as operating air-conditioning.

- Cooling energy consumption can be lowered using curtains, drapes, and blinds by reducing the heat transfer through windows and walls.

- The air filters accumulate dirt which restricts air circulation. Clean the air filter periodically at least once a month and AC should be serviced at least twice a year.

CHAPTER 4: PREVENTIVE MAINTENANCE FOR EFFICIENT OPERATION OF EQUIPMENT

CHAPTER 4: PREVENTIVE MAINTENANCE FOR EFFICIENT OPERATION OF EQUIPMENT

4.1 Introduction

Regular preventive maintenance of room AC is very important to maintain the original energy efficiency of the system and minimizing leakage of refrigerant to the environment. It also improves the working life, performance, reliability and safety of the system. To prevent the chance of sudden failure of the system, it is must to have a periodic inspection, cleaning and replacing the defective parts. It is good to replace poor performing parts before it will actually fail to work, otherwise, it will leadto higher energy consumption or leakage of refrigerants. The technicians are advised to follow the preventive maintenance as the schedule specified by the manufacturer.

One of the most important preventive maintenance is the cleaning of the indoor and outdoor units of the AC.The effectiveness of the heat transfer rate of evaporator coils is very important as the cold air is supplied by the indoor unit and the cooling performance depends on it. It also helps to maintain the humidity of comfort level of the room. As air blows across the indoor unit's coils usually contain dust, since the coils are usually damp from the dehumidification process, it is very easy for dust to stick to the surfaces which reduce airflow and poor heat transfer in condenser and evaporator resulting in less cooling and reduction in overall performance and efficiency of AC. The excessive accumulation of dirt on the evaporator may have ice formation on the coil surface.

Dust can be sucked into the fins of a condensing unit coil as air is drawn through them by the fan. These obstructions will lower the effectiveness of the coil, elevate condensing temperature, and reduce the cooling efficiency. A visual inspection is generally adequate to determine whether the coil needs to clean or not.

Figure 4.1 depicts the cleaning process of the cooling coil and condenser coil.The evaporator and condenser coil should be cleaned at least twice a year.

Figure 4.1: Cleaning of Condenser & Evaporator Coil

Maintenance of AC must be carried out by well-trained technical personnel periodically. AC users may also take care of some preventive maintenance. Some of these are listed below.

4.2 Preventive Maintenance by AC Users

- Carefully clean the primary filter periodically, steps as shown in Figure 4.2.

- Remove dust particles from the indoor evaporator coil and wipe away built-updirt, heavier, stubborn dirt deposits or mould accumulation if not possible to clean, leave it for cleaning by a professional technician.

- Check and clean the condensate drain pan and drain hose and verify that the drain is open. Ifthere's evidence of mould or other bacterial growth, leave it for the technicianto clean it.

- Cut weeds or other encroaching vegetation from around the outdoor condenser to allow free space on all sides for air flow.

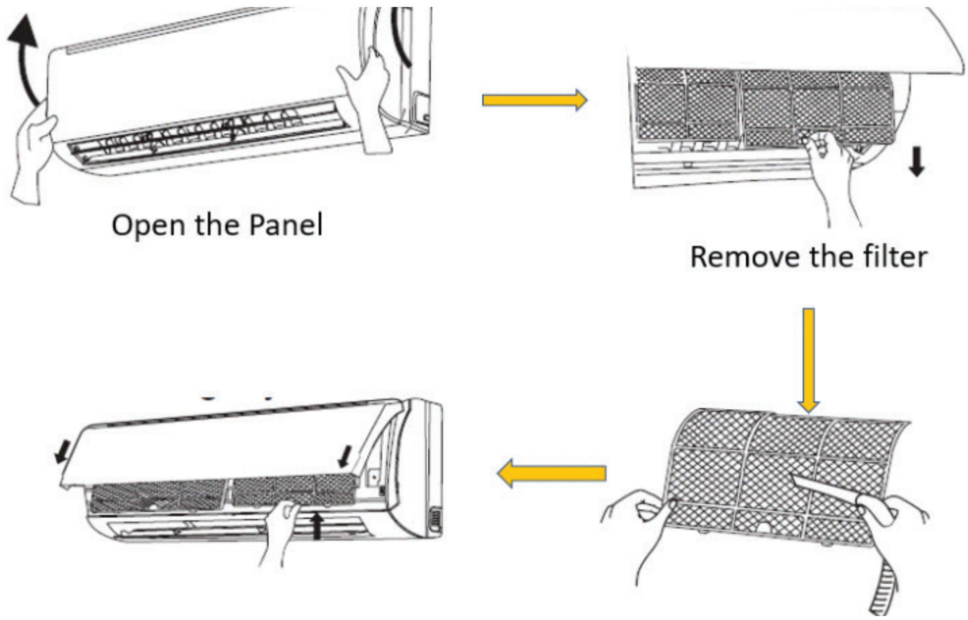


Figure 4.2: Preventive Maintenance by AC users: Cleaning of AC filters

4.3 Preventive Maintenance by Technician

- Check and examine the fan is running smoothly.
- Check voltage, current and earthing.
- Inspect for refrigerant/lubricant/oil leaks and proper levels.
- Confirm that the condenser coil is free from debris.
- Straighten any bent heat exchanger fins on the condenser coil.
- Examine suction pipe insulation and replace, if needed.
- If the AC is of the old design, lubricate the fan motors/bearings.
- Check fan/blower blades/fins for damage and cleanliness.
- Ensure proper condition of 2- and 3-way service valves, with caps.
- Check all wiring, electrical connections, if free of damage and screws are tight.
- Test controls/thermostat/PCB for proper functioning.
- Assess air filters for proper size and cleanliness.
- Confirm that the evaporator coil is free from dust.
- Check condensate pan and drain for cleanliness.
- Ensure there are no leakages of refrigerant from the unit.
- Verify the supply air and temperatures maintained as desired.
- Record all the work done during preventive maintenance. Refer to the sample overleaf.

Table 4.1: Preventive Maintenance Checklist for Energy Efficient Operation of Room AC

Parts	Cleaned	Repaired	Replaced	Remarks
Surface of Evaporator				
Evaporator fins				
Condensate pan and drain hose				
Air filter				
Fan, motor and smooth operation				
Indoor air temperature °C – Inlet (return air)				
Indoor air temperature °C –Oulet (supply air)				
Surface of Condenser				
Condenser fins heat exchanger				
Outdoor Fan, motor and smooth operation				
Outdoor Housing				
Outdoor air temperature °C- Inlet				
Outdoor air temperature °C - Outlet				
Compressor fixing and dampers				
Operational noise				
Drawn current				
Refrigerant discharge temperature °C				
Ref. suction gas temperature °C				
Suction pressure (bar)				
Leak tightness				
Vibrations of pipes				
Friction of pipes				
Remote control				
Cables and wiring/fixing, friction				
Wiring – screws tightness				
Temperature sensors				
Relays or other electrical components				
Labelling of the system				
Availability of documentation				
Any clients complain				

CHAPTER 5: GOOD SERVICE PRACTICES FOR SERVICING THE REFRIGERATION SYSTEM OF AC

CHAPTER 5: GOOD SERVICE PRACTICES FOR SERVICING THE REFRIGERATION SYSTEM OF AC

5.1 Introduction

It is important to understand and follow stepwise GSPs when servicing refrigeration systems (System is opened for servicing due to leakage of refrigerant, lower cooling, etc.). Following good service practices would not only be avoiding frequent failures of the unit but it would result in lower refrigerant consumption during servicing and less electricity consumption. The energy efficient operations of serviced AC will give service satisfaction to the customer and will help the technician in getting enhanced and repeated business.

The good service practices that should be followed for energy efficient operation of room air-conditioners are given explained in the following sections.

5.2 Recovery of Refrigerant from Sealed Refrigeration System

The refrigerant such as HCFCs and HFCs in the system should not be vented out as these are ozone depleting andglobal warming gasses. Such refrigerant should be recovered while opening the system for servicing. This would not only reduce the consumption of refrigerants but also protect the environment. Recovery of refrigerant could be carried out using either passive or active recovery processes, these are described in detail [12]. The top-up of refrigerant in the system does not ensure the accurate required charge quantity of refrigerant as recommended by the manufacturer that results in performance degradation of the system.

Figure 5.1 shows the decrease in energy efficiency due to top-up in the system. It is recommended to recover the refrigerant before servicing and do the fresh refrigerant charging in the system post servicing.

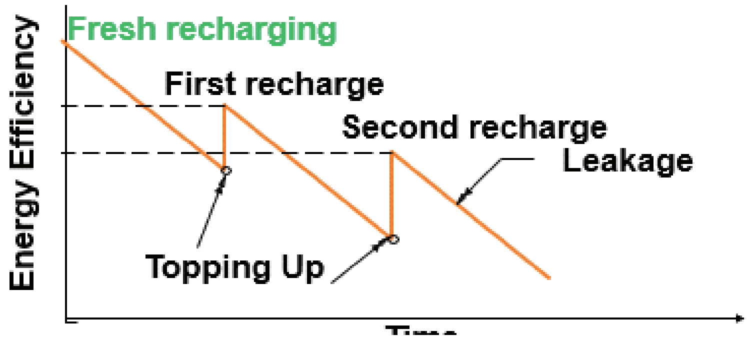


Figure 5.1: Refrigerant Top Up and Energy Efficiency

5.3 Cleaning and Flushing

While servicing, after dismantling the system for servicing, all the parts of the system must be cleaned properly so that no contaminants remain in the system enter into the refrigerant line, which causes degradation of the performance of AC. The system and connecting refrigerant lines must be flushed using OFDN, at a pressure of about 150 psi. Residue or sludge formed inside the tube affect the heat transfer rate, causing poor performance of the system; refrigerants and lubricants are very sensitive to contaminants and moisture, if solvent cleaning is required for removing any sludge formation, solvents like Per Chloroethylene (PCE), Hexane or Methylene Dichloride (MDC) or any other branded chemical solvent should be used.

5.4 Aim for Zero Refrigerant Emission –Copper Tube Processing

It is important to follow the correct method and GSPs for copper tube operation to ensure no leakage is there from copper tubing joints. Leakage of refrigerant is not only harmful to the environment by direct emission but the reduction of refrigerant charge in the system due to leakage results in a decrease in system performance and efficiency. The incorrect size and more number of bends result in pressure drop in the refrigeration circuit which increases the energy consumption of the AC. This changes the performance characteristics, so maintain the right size of tubes and try minimum bends. It is very important to select the right tools and proper use of copper tubing tools, the standard steps needed for copper tubing, like bending, flared connections, brazed joints should be followed.

The quality of copper tube operations is very important in air-conditioning, some of the critical points that should be taken care of for copper tube processing are as follows considering optimum energy performance:

- All tubing in air-conditioning is carefully processed to be sure that it is clean and dry inside. The copper tube coils are filled with low-pressure nitrogen gas and sealed with a cap at each end to keep the tubing safe from contamination by oxygen, dust, and moisture in the air. Oxygen reacts with copper and creates a layer of copperoxide inside the tube. The air causes contamination in the system so always close the remaining parts of the copper tubes with caps after cutting as well as those in the system, if it is opened for servicing.

- Measure and cut the required length tube, do not cut out an excessive or less length of the copper tube, as those will not result in optimum energy performance.

- Remove both external and internal burrs using a deburring tool or reamer and remove the surfaces dirt, debris and foreign substances from the tube end by using emery cloths.

- To perform swage, the flaring block, hammer, and proper size swaging tools are required, never use a nose-plier for swaging.
- Do not over-tighten a flare joint and never use Teflon tapes.
- Flush with OFDN, never flushwith air.

Brazing is an important process for fixing leaking refrigeration system. Swaging of one of the ends of tube is to be done for enlarging the diameter while joining the same diameter tube, so the end of another length can be slipped into it. The length of the overlap of the two copper tubes to be swaged should be equal to at least the outer diameter of the tubing. While brazing, slowly pass OFDN through the tube, adjust the torch for a slightly reduced flame, apply heat uniformly to both, tube and fitting, by moving the torch around to ensure even heating before adding the filler rod; as the heated area gradually changes colour to cherry red, apply filler rod by lightly brushing the tip of the stick into the shoulder. Do not overheat. Protect service valves with wet rags or heat sink material while doing brazing. Use only recommended fillers for various joints. The steps of the brazing process of the copper tube are depicted in Figure 5.2 [13].

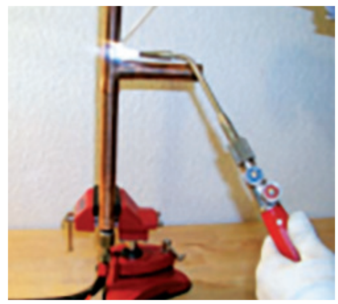
Cutting tube: Use only a wheel cutter.

Removing internal burrs: A de-burring or reamer to be used to remove internal burrs.

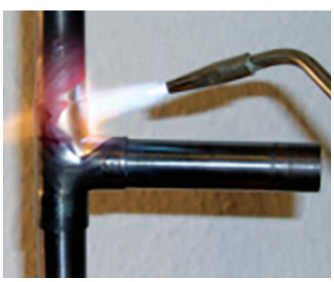
Cleaning the surfaces: For surface cleaning use abrasive plastic scouring pad.

Cleaning the fitting: Use a properly sized fitting brush for interior fitting cleaning.

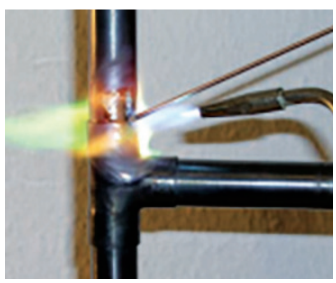
Assembly: Put the pipe and swaged pipes together maintaining the right joint depth.



Apply Nitrogen flow: Slowly pass Nitrogen through the tube, end to be open to the atmosphere, without build-ing up pressure.



Apply heat: Adjust the torch for a slightly reduced flame and apply heat uniformly to both, tube and fitting, by moving the torch around to ensure even heating before adding the filler material.



Apply filler: As the heat-ed area gradually changes colour to red (a cherry red), apply filler material (rod) by lightly brushing the tip of the stick into the shoulder of the fitting. Care should be taken not to over-heatthe tube

Complete joint and Remove Heat: An even build-up of solder will be visible around the shoulder of the fitting. Remove the heat until the molten brazing alloy solidifies to a tan black colour.

Figure 5.2: Brazing Process

5.5 Leak and Pressure Testing - Use Oxygen-Free Dry Nitrogen

Air-conditioners are designed to operate with a fixed amount of refrigerant charge. If there is leakage in the system, the efficiency of the system drops and power consumption increases. The leak test is important for efficient operation, reliability and environmental protection. Apply soap solution to joints, connections and fittings while the system is running or under a standing pressure of OFDN to identify leak points through the appearance of bubbles. An electronic leak detector can also be used for leak detection. The most common locations of leakages are joints and at flare connections/nuts, service valve: O-rings, access fitting, mounting, cracked brazed joints in the tubing, deteriorated evaporator and/or condenser end bends, tubes rubbing with each other or with other materials.

After repairing and joining processes the system must be pressure tested. This is to be done by pressurizing the system with OFDN to a pressure higher than the operating pressure and check the system for pressure holding for at least fifteen minutes to ensure there is no leak in the system. The leak and pressure testing with OFDN is shown in Figure 5.3. Keep noticing the pressure gauge for the pressure drop, if any. The system should not be pressurized with pressures that are above the system's test pressures (1.1 x operating pressure). For leakages, the system must be checked by leaving it under pressure for 15 minutes (pressure holding).

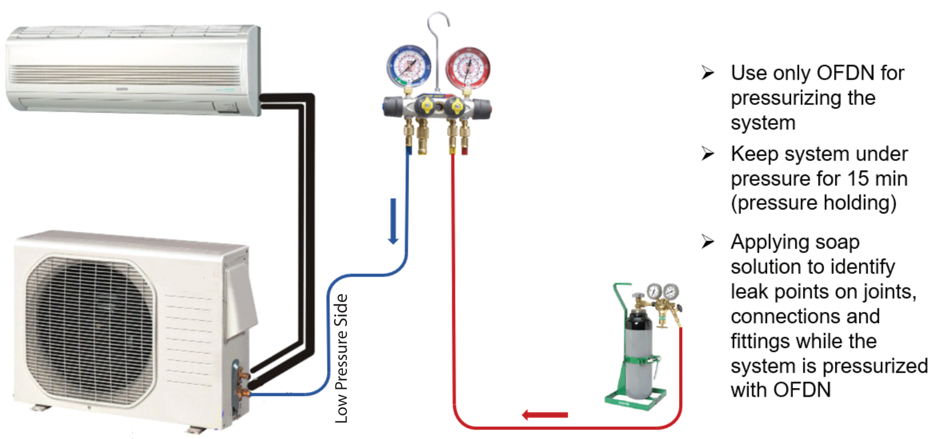


Figure 5.3: Leak and Pressure Testing with OFDN

5.6 Proper evacuation of the system

For better performance of air-conditioner, the system should be free from air, moisture, and non-condensable gases. The presence of moisture leads to choking of the capillary, strainers, and filter/drier. The non-condensable gases increase system pressure, higher condenser and discharge temperature result in a decrease in the energy efficiency of the system. This also results in a lower cooling capacity of the system. Evacuation is a process by which pressure in the sealed system is reduced, causing moisture to evaporate tovapour, it removes air, moisture and other non-condensable gases from the system. Therefore, the proper vacuum of the system is important before charging the refrigerant. The evacuation must be carried out to 500 or lower microns level. Evacuate the system at least for 30 minutes to ensure adequate vacuum, if a micron gauge is not available.

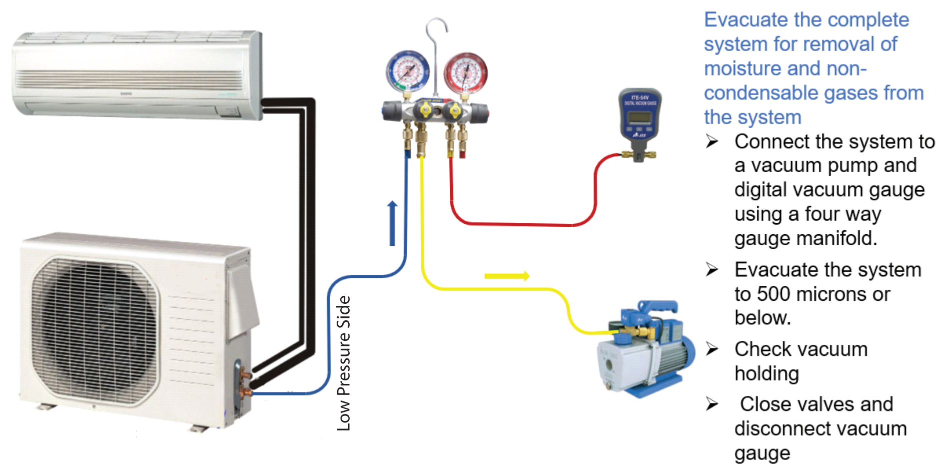


Figure 5.4: Good Service Practices: Evacuation of the System

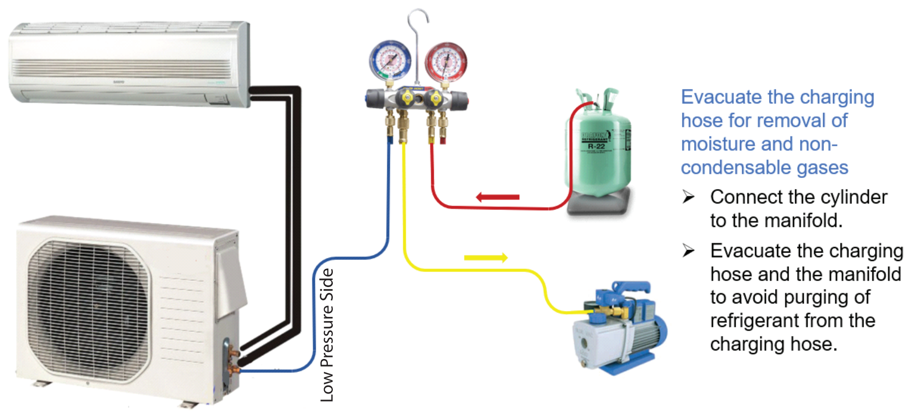


Figure 5.5: Good Service Practices: Evacuation of the Charging Hose

The figure 5.4 and 5.5 represents the evacuation process for good service practices, once the system is evacuated to remove non-condensable gases and ready for charging, the charging line should be evacuated to avoid refrigerant purging [12].

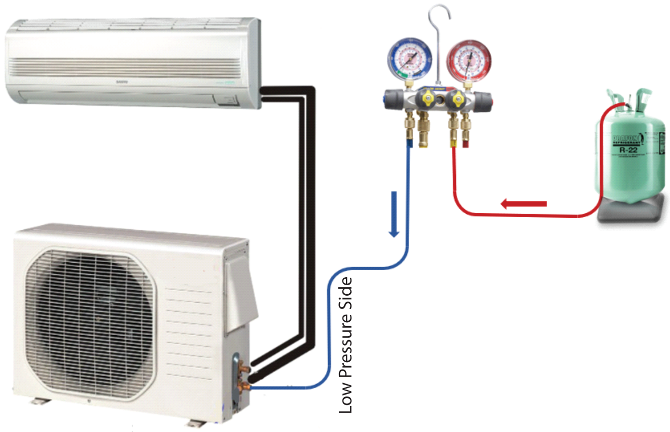
5.7 Use Quality Refrigerants

Ensure that refrigerants of proper quality and purity are used. Contaminated refrigerant may contain non-condensable gases and moisture; these will result in sludge formation and creates chocking of capillary and sludge formation in the system. Cross-contamination of refrigerants should be avoided; it may result in reduced performance and even failure of the system.

5.8 Refrigerant Charging Practices

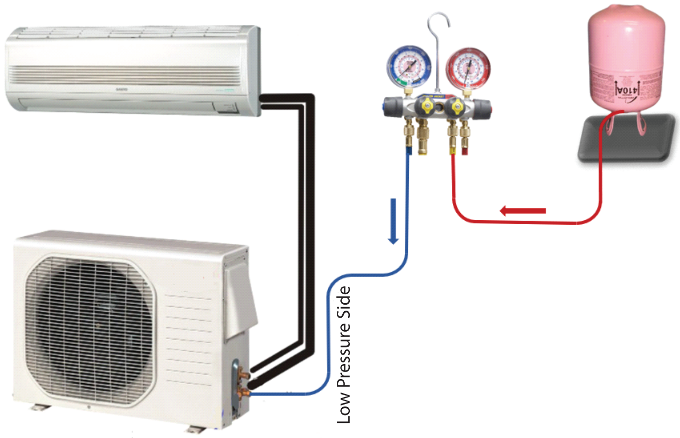
The energy efficiency of the room AC decreases with higher and lower charge quantities. Charge the quantity of refrigerant as per the manufacturer's recommendation (specified on the outdoor unit).

ACs capillary as expansion device isvery sensitive to charge quantity. ACs should be charged with the specified amount of refrigerant, it is recommended that refrigerant charging is done by weight, the charging process is depicted in Figure 5.6. One of the reasons for the increase in compressor power consumption is due to overcharging of refrigerant into the system. High operating pressures/temperatures indicate that the system is overcharged and chances of leakage from the system will be high. Undercharged will causea lower cooling effect thus system will run relatively longer period resulting in a decrease in the system efficiency. Both overcharging and undercharging result in a decrease inthe efficiency of the system. Monitoring of charge level frequently will lead to early detection of refrigerant leakage and avoidance of under or overcharging.



- Charging refrigerant by weight using a weighing balance is the most accurate method
- Charging should be done using a cylinder connected to the system via manifold/hoses.
- Single component refrigerants should be charged in form of vapor.
- Refrigerant blends should be charged in liquid form only.

Figure 5.6: Charging of Refrigerant by Weight



- Charging refrigerant by weight using a weighing balance is the most accurate method
- Charging should be done using a cylinder connected to the system via manifold/hoses.
- Single component refrigerants should be charged in form of vapor.
- Refrigerant blends should be charged in liquid form only.

Figure 5.7: Charging of Zeotropic Refrigerant Blends

Zeotropic refrigerant blends such as R-410A, R-407C should be charged as a liquid as shown in Figure 5.7, where the refrigerant cylinder is placed upside downwards. If it is charged as vapour, the refrigerant with the highest vapour pressure will be charged at a higher proportion than the other component(s) and will result in less energy performance of the system.

5.9 Use Clean and Recommended Lubrication

Lubrication of moving parts is very important in the room air-conditioning system. Always use good quality recommended lubricating oil. The change in oil may result in improper miscibility of refrigerant and lubricant. This would result in the separation of oil in the cooling coil. Replace strainer/filter so that there will be a minimum possibility of moisture and other contaminants in the system while servicing the system.

5.10 Energy Efficiency Consideration on Electrical components

During servicing, technicians sometimes need to replace the parts including electrical parts like relay or capacitor, controls, the parts should be replaced only with parts recommended by the manufacturer. A wrong size capacitor could cause the compressor/fan motor to overheat, decrease the efficiency and shorten its life. There will be energy loss due to loose connections of wires and also chances of overheating and sparking which is a heavy danger in the case of flammable refrigerant. Ensure all wires/cables are properly connected; any loose connections should be avoided completely.

5.11 Maintenance of service tools and equipment

It is necessary to maintain the tool or equipment in a serviceable condition or restoring it to a serviceable condition. This includes servicing, repair, modification, overhaul, inspection and condition verification. Maintenance such as lubricating, overhauling of equipment and tools and changing oils/lubricants increase the availability of tools and equipment and keeps the same in working order.

The basic goal of maintenance is to prevent the failure of tools and equipment before it actually occurs. Maintenance is designed to preserve and enhance the reliability of tools and equipment by replacing worn components before they actually fail.It helps reliability, safety and productivity as also avoids waste, disruption, accidents and inconvenience.

Considering GSPs for energy efficient operation; vacuum pump, micron gauge and manifolds are very critical. These should be maintained properly. Vacuum pump oil must be carefully maintained and changed at proper intervals or after the pump is used for about 100 hours. If the oil looks milky or rusty, it should be replaced immediately. Use the type of oil recommended by the manufacturer of the pump.

The micron gauge must be maintained at its best as it is very crucial in evacuation or system repairs. Always keep the connections clean. Check the sensor regularly, keep it safe and clean it only with Isopropyl alcohol.

The manifold gauge set has to be kept clean for better and safer performance and maintain regularly. The manifolds are generally made of precision machined aluminum with a Teflon valve. These are designed for light touch operation, hence should not be over-tightened. If there is any leak in the valves, the O rings on the valve piston require to be replaced. The manifold should not be exposed to rain or used in damp or wet environments.

CHAPTER 6: CHALLENGES AND OPPORTUNITIES IN SERVICING SECTOR FOR ENERGY EFFICIENCY

CHAPTER 6: CHALLENGES AND OPPORTUNITIES IN SERVICING SECTOR FOR ENERGY EFFICIENCY

6.1 Introduction

It has been well recognized that the servicing sector comprises formal and informal sectors.There are a large number of technicians working in the informal sector because the servicing is seasonal and cost-sensitive. Due to the lack of consumer awareness towards the importance of quality service, most of the servicing jobs are being done by the informal sector. As per the industry estimates, more than 75% of service technicians are from the informal sector[14]. The service technicians who are in the formal sector are also not very well equipped to take up the challenges which are faced due to changing technologies.

6.2 Challenges in Service Sector

The challenges faced by the service sector industry for adopting GSPs for the improvement of energy efficiency of servicing existing technologies and for safe handling and servicing with flammable and high-pressure alternative refrigerants are discussed in this section.

6.2.1 Alternative Refrigerants and Technologies

HCFCs are being phased out and it is challenging for servicing sector to adopt low-GWP refrigerants due to safety issues because most of the alternatives are either flammable or high pressure or both. There are a number of room air-conditioning appliances with different technologies, service technicians should have knowledge and skill to service equipment charged with different refrigerants with all the technologies available in the market because each of the technologies has its own requirements. Each refrigerant has different operating pressures, required charge quantities, lubricating oil miscibility, safety requirements etc.

RAC industry, including the service industry, has been so far using mainly single component refrigerants such as HCFC-22, etc. or azeotropic/ and some zeotropic blends with a very small temperature glide. It is becoming quite challenging for the industry to cater to the need for growing RAC requirements.

There are limited single component lower-GWP refrigerants, both in the natural and fluorocarbon family of refrigerants, especially for high-pressure applications. The currently available single-component refrigerants are either highly (A3) or mildly (A2L) flammable. There are safety concerns within the industry and users.

Owing tocommercially available non-ODS, low/lower GWP alternative refrigerants are flammable and/or have higher pressure; the servicing sector possesses several challenges.The service technicians have very limited knowledge of handling of these gases, therefore training on GSPs including hand-on practices needs to be provided on a large scale. The lack of financial resources with the technicians to purchase tools and equipment for practicing GSPs is a big challenge, especially for the informal sector. The customer awareness programmes for seeking quality servicing at some premium through certified technicians is one of the important elements for the adoption of GSPs and to reduce repeated servicing of equipment, refrigerant consumption/emissions as well as maintaining the energy efficiency of serviced RAC equipment.

There are various training channels that offer courses for RAC technicians training, but these institutes are not yet equipped both in terms of faculty and tools and equipment for providing training to the trainers on upcoming changing technologies. It is challenging, but essential for the skill development of the new entrants/nextgeneration technicians.

6.2.2 Refrigerant Management - Recovery, Recycling, and Reclamation

It is important to minimize leaks and emissions from old room air conditioning appliances containing HCFCs and HFCs as these refrigerants are ODSs and/or having high global warming potential. The Montreal Protocol has been phasing out the production and consumption of HCFCs and will be phaseddown the production and consumption of HFCs. However, these substances are still present in existing appliances that are either still in use or abandoned or in storage cylinders after collection. If no measures are taken, these refrigerants will be emitted into the atmosphere.

The servicing sector is the key tothe conservation of refrigerants through seizing mitigation potential. Recovery, recycling, and reuse of refrigerants are the key processes for refrigerant conservation.The recovery is a process to remove the remaining refrigerant in the RAC equipment and store it in a cylinder before service to be done or for disposal. The recovery of the refrigerants during servicing or decommissioning is the crucial first step for refrigerant management. The collection of used refrigerants enables either their destruction in case of unwanted and contaminated substances or their reuse, the reuse reduces the need for new refrigerants.

In order to make the refrigerant suitable for reuse,the recycling process is carried out by passing the recovered refrigerant through filters. Reclamation is a process that removes impurities including non-condensable, moisture, and acids, reprocessing of used refrigerant back to virgin specifications to meet the purity of the refrigerant.

For the recycling process, to reuse the recovered refrigerant without reclamation the service technicians should have specific knowledge and skills for correct cleaning of the recovered fluids to ensure the proper functioning of the equipment. Reclaimed refrigerants can be placed into the refrigerant market especially for servicing but the recycling process is not intended to be placed back the used refrigerant into the market. The refrigerant management efforts should be placed on refrigerant recovery at the point of installation and continue throughout service and ultimate equipment end-of-life.

One of the challenges for refrigerant management in the country is to train the processes and informed the importance of these processes to service personnel. Develop policies and infrastructure for effective collection, recovery, recycling and reclamation of refrigerants including incentive schemes is also needed. This will not only reduce unintended emissions of these high GWP gases to the environment but also reduce the demand forvirgin refrigerants in the country; resulting in the protection of stratospheric ozone and climate system along with economic gains, thus it would prove to be a Win-Winsituation. A very limited number of functioning recycling and destruction infrastructure currently exists in the country.

6.2.3 Safe Handling of Alternative Refrigerants

HCFC-22 is the most widely used refrigerant in the room AC as it has very good thermo dynamic and thermo physical properties, but, it is an ozone-depleting substance and also has high global warming potential, thus the production and consumption of this refrigerant are being phased out under the Montreal Protocol. The alternative refrigerants commercially available that are suitable for air-conditioners are natural refrigerants or fluorocarbon-based refrigerants.

Attempts are also made to introduce propane or R-290 as an alternative natural refrigerant to HCFC-22 for Room AC. It has zero ODP and zero or negligible GWP. R-290 charged room ACs have better energy efficiency, an excellent alternative to HCFC-22 in the current situation. But it is highly flammable;the safety issue needs tobe addressed, prior to the adoption of such refrigerants.

HFCs are not having ozone-depleting potential, but they are having global warming potential. HFC-32, the fluorocarbon refrigerant used in room AC is a high-pressure refrigerant, higher than that of HCFC-22. HFC-32 is a relatively high pressure like R-410A and mildly flammable refrigerant, miscible with POE lubricants thatare highly hygroscopic.

HFC-32 is now emerging as the most preferred choice of refrigerant for this sector. It must be recommended that technicians handling R-290 and HFC-32 refrigerant are well trained.

There are several challenges for service technicians in handling and servicing room AC charged with flammable and/or high-pressure refrigerant. The training for the service technicians is very crucial for handling equipment charged with these refrigerants. The training centres to be created and/or the existing training centres to be upgraded as per the facilities required for the alternative refrigerants. Equipment support to the training centres and the development of a pool of trained trainers and training materials are very crucial.

6.2.4 Availability of Tools and Equipment

Tools and equipment are essential for practicing good service practices. Most of the technicians being from the informal sector don't have the financial resources to purchase tools and equipment for practicing GSPs and handling flammable refrigerants. Some mechanisms need to be developed or linked with existing schemes for financial support and/or to facilitate the technicians for purchasing tools and equipment.

6.2.5 Market Scenario – Demand and Customer Behaviour

For good servicing practices, both installation and servicing, the training and certification of service technicians are now essential to ensure that the performance of services and equipment meet the national standards of servicing and to protect the environmental impacts. The government would facilitate the transition through policies, regulations, incentive schemes etc., while the industry would play an important role in increasing access to social security, training and certification for technicians. Service technicians and customers are responsible for the field-level implementation of regular and appropriate servicing and maintenance practices. Feedback from service technicians and customers would be central to creating policy actions. Civil society plays an important role in advisory and research capacities.

The means for consumer awareness are by-product labeling systems that indicate environmental performance or goodness. Awareness building must also be included in larger training programmes for retail suppliers and sales teams.

The demand for trained and certified technicians can be increased by establishing consumer awareness. The trained service technicians have to compete with untrained technicians due to the cost factor. Due to a lack of awareness in consumers, the technicians do not follow good service practices; therefore, training and certification alone may not offer an apparent advantage for technicians. Consumer awareness will create a demand for qualified and certified service technicians.

Monetary gains offered by well-serviced RAC units should be highlighted. This could be in terms of the money saved in electricity bills or in terms of refrigerant gas by preventing leaks and venting.

Online media is the least used source of information by households to employ service technicians for their ACs. The majority of the AC users prefer recommendations from friends/ family and retailers to find technicians for servicing their ACs. Additionally, Print media and television advertisements could be employed to create awareness on certification. Further, retailers could be used as a medium to recommend certified technicians to consumers.

6.3 Opportunities

Recognition of the importance of servicing sector in reducing refrigerant emissions and maintaining the designed energy efficiency of serviced ACs has laid the emphasis on human and institutional development in this sector. Training and certification are the keys to the successful adoption of non-ODS low/lower- GWP refrigerants. Skilling and certification of RAC service technicians will benefit them in livelihood enhancement. In addition to the training and certification, there are opportunities for implementing policies & regulations, developing service standards, creating awareness in industry and market for promoting good service practices.

6.3.1 Capacity Building for Safe Handling and Practices for Alternative Refrigerants

The servicing sector is required to service equipment with several technologies; each of the technologies has its own requirements as all these technologies have different operating pressures, charge quantities, lubricating oil, safety requirements, etc. Most of the new technologies being flammability and/or high pressure, therefore, there are safety concerns within the service industry, including during refrigerant handling, equipment installation and servicing. Currently, the servicing sector is to handle a number of technologies like HCFC-22, R-410A, HFC-32, R-290, etc., therefore, it is becoming increasingly challenging for the service sector to cope up with the safety aspect while handling multiple technologies. Experiences from previous servicing sector projects funded by the Multilateral Fund (MLF) for the implementation of the Montreal Protocol in India have shown significant improvement in servicing practices for the technicians who had undergone training. It is very important to create a training infrastructure focused on safety, especially considering that more than 75% of service technicians are from the informal sector.

For preparedness of both the new technicians in the field of servicing and existing technicians for safe handling and servicing with flammable and high-pressure alternative refrigerants; there is a need forcapacity building of training infrastructure for accessibility of training on good service practices and safety of service personnel and end-users in using new alternative refrigerants and availability of minimum requisite training tools and equipment. Given the context, training cannot be only theoretical training, the hands ontraining is a critical aspect of the training process; Industry participation is essential in the training infrastructure capacity building, participation in training delivery and commitment to employ a fixed number of trained &certified candidates. To overcome the barrier of the multiplicity of languages, it is important to make available training material in different languages to cater to different sub-target groups.

6.3.2 Certification of Technicians

India has introduced a technician certification program in the room AC sub-sector on a voluntary basis. It is essential to develop a competency-based certification for these technicians. This would not only provide an opportunity to end users' satisfactory services from a certified technician but also enhance the employability of these technicians within the country and overseas. The current certification system, including a robust evaluation mechanism, needs to be developed.

The certification process in the country is in its development stage, currently, it requires two days of training on theoretical as well as practical aspects and on the third day, there will be an assessment for each of the candidates. However, the technicians who possess technical knowledge and hands-on experience of servicing can undergo for certification directly. There is a lack of awareness about certified technicians in the market, especially in the informal sectormarket. Another challenge is the periodic recertification of already certified technicians as the servicing practices are evolving with changing technologies with respect to refrigerants, including flammable refrigerants. Therefore, regardless technicians have formal technical training and field experience but the refresher training and recertification are becoming a necessity.

There is a need for a mass awareness program about the certification program. Currently, the consumers are largely not aware of the certificated technician and benefits (such as energy efficiency and safety aspects, especially for alternative refrigerants) of getting servicing done by a certified technician. The certification should be valid only for a limited period say 5 years and it could be renewed after the successfully clearing reevaluation test.

The certification process would require the development of infrastructure for testing individual candidates. There is a need to develop evaluation centres across the country. It would enhance the capacity by taking on board the RAC industry and industry associations. However, the overall certification system may be operated under the Government.

6.3.3 Tools and Equipment Availability for Good Servicing Practices

Technicians mainly in the informal sector don't have financial resources to purchase tools and equipment which are must for a practicing GSPs. Recognizing tools & equipment is the key to the adoption of GSPs and bring down the consumption and emissions of refrigerants. It is becoming increasingly important for upcoming technologies. There is a need for developing an equipment support scheme or link with some existing scheme in consultation with industry and the stakeholders for providing minimum tool kit & equipment to the technicians.

6.3.4 Customer and Stakeholder Awareness

Mass customer awareness is necessary to educate them on the importance of quality and regular servicing and its impact on the energy performance of the AC system. The customer appreciation and demand for quality service need to be enhanced. This will bring a change in customer behavior to look for certified technicians and due payment for their services. It would also motivate the technicians for learning and practicing GSPs, and this would create a Win-WIN situation in this sector.

6.3.5 Development of the Nation's Service Standard

The servicing of the RAC equipment with stringent environmental requirements and technological changes is a continuous process. Most of the manufacturers develop operation and service manuals, it may be a little challenging but useful to develop a common standard/manual for servicing for Indian conditions to be followed by the service to ensure a certain product quality, safety consideration in working and equipment/ system performances. The standards should cover GSPs for all the technologies currently in the market and possibly with provision periodic updates. The standard/ manual should be developed in consultation with the industry.

6.3.6 Planning and Policy Formulation

For planning and policy formulation for the servicing sector, it is imperative to understand the current number of servicing sector technicians, as well as their potential future growth. It is estimated that around 200,000 technicians in the stationary air conditioning service sector as per existing AC stock are present in the country [6].

Planning and policy formulation for the servicing sector viz. social security system, occupational safety, health insurance and retirement benefits can be an important incentive for servicing technicians to invest in their education and training in proper tools and equipment's.

The informal nature of the service sector and lack of certified technicians in the current market could be addressed by providing incentives to the service technicians as part of a voluntary scheme to initiate a successful universal certification system within India. As an example, the RPL scheme in the country offers a cash award of INR 500 per technician for obtaining the certificate (NSDC, 2016). A further step can be taken by integrating schemes like Pradhan Mantri Jan Arogya Yojna with certification thereby providing, health and accident insurance to service technicians and their family members. Given that, Ayushman Bharat already recognises 'repair workers/ mechanics/ electricians' eligibility (FP staff 2019), certification could be added as an additional criterion for securing accidental insurance under the scheme. The use of incentives would create the necessary 'push' required to encourage more technicians to acquire certification.

6.3.7 Employment Opportunity

The air-conditioning sector is one of the major sectors for employment and the service sector has a significant proportion of this employment. There is huge potential for employment generation in this sector, as there is high growth expected in coming years in the sector. Refrigerant-based equipment stock is likely to increase by around 10 times in the next 20 years; room ACs will continue to dominate at 80-90% share and room AC sales will grow at a CAGR of 11%-15% in the next 10 years and 8%-12% in the following 10 years [7].

The training on GSPs are very important for the professional competency of service technicians to enhance employability within the country as well as abroad. Training and certification processes of RAC technicians will enhance the employability of the Indian workforce in the global market.

Appendix A- List of tools and equipment

1. Two stage rotary vane high vacuum pump
2. Propane/LPG Gas detector/alarm
3. Four-way gauge manifold with hosepipes
4. Two-way Gauge manifold
4. Weighing scale
5. Refrigerant Recycling Unit
6. Mini hand held refrigerant identifier for HCFC / R-22
7. Core Removal Tool
8. Refrigerant Transfer Hose Brass Adapter
9. Capillary Tube Cutter
10. Tube Cutter
11. Reamer
12. Burr Remover
13. Tube Bender (lever-mechanical type)
14. 45° Flaring and Swaging Tool
15. Torque Wrench
16. Hose pipes with crocodile clips for N_2 and O_2 gas and LPG
17. Vent hose
18. Digital Clamp Meter
19. Digital Thermometer
20. Line Tester (500 V, 150-200mm long)
21. dB Meter or Noise Tester
22. Piercing pliers/wrench/valves
23. Pinch Off Pliers / Self Locking Pliers up to 3/8" OD
24. Screw driver set
25. Adjustable spanner set (150mm)
26. Insulated combination pliers (200 mm)
27. Insulated nose pliers (200 mm)
28. Monkey pliers (100 mm open jaw)
29. Allen key Set

30. Ratchet wrench / Service valve wrench with Sockets ¼,", 3/16", 5/16"
31. Flat Rough File (25 mm width, 200 mm long)
32. Round File (150 mm long)
33. Hacksaw kit with wing nut (frame size 300 mm)
34. Hammer (400/500 g) with wooden handle
35. Chisels (20mm)
36. Circular Mirror - (50 mm ϕ)
37. Tongs
38. Gas lighter
39. Spirit Level / Inclinometer
40. Measuring Tape (5 meter long 13 mm wide with steel, winding type)
41. Fins Comb / Fin tool Fitting all sizes
42. Light Weight Hand Electrical Air Blower
43. Hand Drill Machine
44. Scrubber / Brass Wire Brush
45. Asbestos lined Heat Deflector
46. LED Torch
47. Protective goggles
48. Protective Gloves
49. Wire stripping Tool
50. Wire Connector
51. Paint Brush
52. Double Stage Pressure Regulator - Oxygen-ESAB
53. Double Stage Pressure Regulator -Nitrogen-ESAB
54. Digital Vacuum Gauge

Appendix B- Alternative Refrigerants and their Properties[4]

Property	HCFC-22	HFC-32	HC-290	R-410A
Chemical formula	CHClF2	CH2F2	C3H8	CH2F2/ C2HF5 (50% HFC-32+ 50% HFC-125)
Cooling capacity relative to HCFC-22	100	160	94	140
Boiling Point	-41˚C	-52˚C	-42˚C	-51.5˚C
Ozone Depleting Potential (ODP)	0.055	0	0	0
Global Warming Potential (GWP)	1810	675	3	2100
Flammability*	Non-flammable (A1)	Mild-flammable (A2L)	Flammable (A3)	Non-flammable (A1)
Toxicity	Low	Low	Low	Low

Appendix C- Does and Don'ts

Does	Install ODU in a shaded area
	Seal the gap around the tubes using putty. Insulate the drain hose laid indoors.
	Use OFDN to check for leakage in the piping system
	Flush with OFDN and evacuate the IDU before connecting it to the ODU
	Clean the primary filter periodically
	Clean both the evaporator and condenser coil at least twice a year
	Recover refrigerant before repairing done
	Flush refrigerant line using OFDN
	While brazing, slowly pass OFDN through the tube
	After repairing pressure test the system with OFDN to a pressure higher than the operating pressure
	Before charging the system evacuate to 500 or lower microns level
	Evacuate the charging hose for removal of moisture and non-condensable gases
	Use refrigerants of proper quality and purity
	Charge refrigerant by weight as per manufacturer-recommended quantity
	Always use good quality recommended lubricating oil
	Maintain the service tool or equipment, e.g., vacuum pump, micron gauge and manifolds
	Run room AC setting temperature above 24˚C
Dont's	Don't use air for pressure and leak testing
	Never top-up with refrigerant by referring to suction pressure value
	Refrigerant should not be overcharged nor undercharged
	Do not over-tighten a flare joint and never use Teflon tapes
	Never use air for flushing and leak testing the refrigerant lines

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