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Ministry of Environment,
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Government of India
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सत्यमेव जयते

EFFICIENT AND SUSTAINABLE COOLING

ENERGY EFFICIENCY AND REFRIGERATION AND AIR-CONDITIONING (RAC) SERVICING SECTOR

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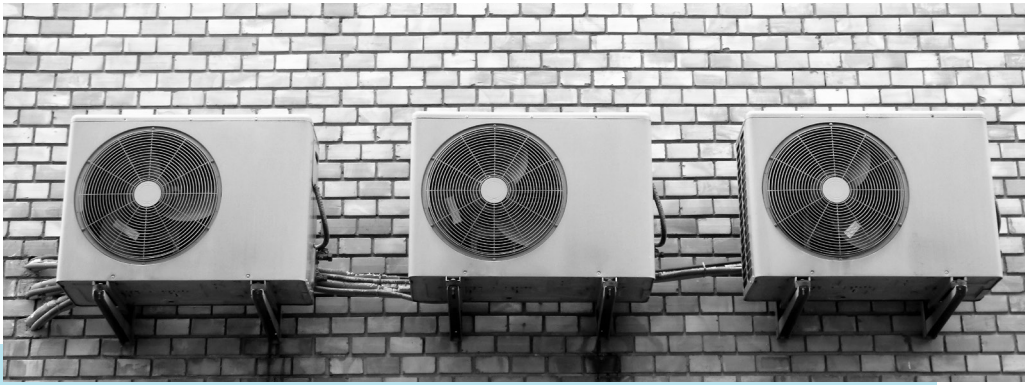
WHY EFFICIENT COOLING?



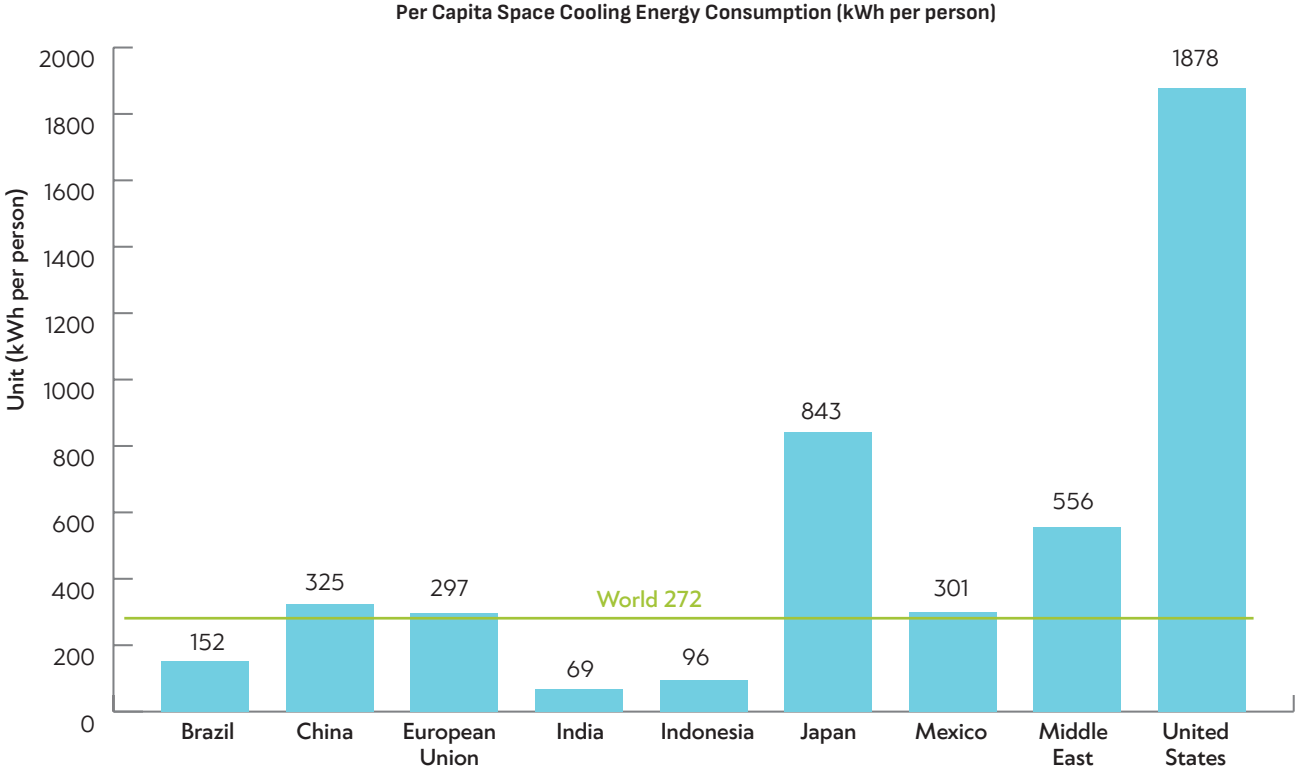
Cooling has been increasingly recognized as the key for the food preservation, health and well-being of people and is linked with many Sustainable Development Goals.

Requirements of cooling are growing worldwide. It is imperative that cooling requirements will grow relatively with higher growth rate in emerging economies like India where current level of penetration of cooling is very low (about 7%) and are located in tropical climate.

The growing demand of cooling would not only increase the demand of refrigerants and energy but also result in significant increase in CO_2 emissions. According to the International Energy Agency (IEA), refrigeration and air conditioning (RAC) causes 10% of the global CO_2 emissions.

India currently has one of the lowest accesses to cooling across the world at 69 kWh per capita as against 272 global averages. Figure 1 shows the accesses to cooling in various countries.

Figure 1: Per Capita Space Cooling Energy Consumption (IEA, 2018)

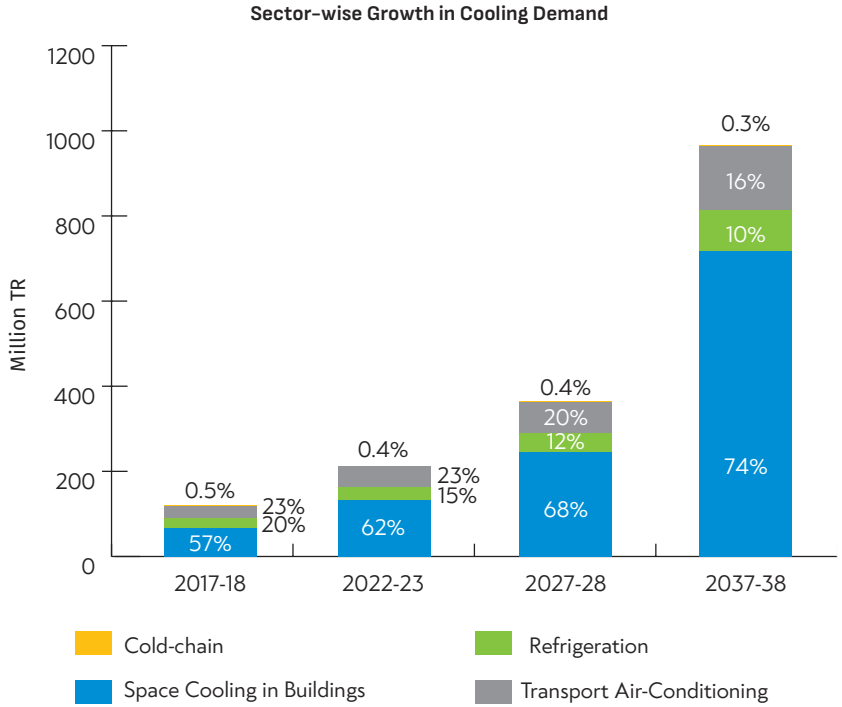


India Cooling Action Plan (ICAP) published in March, 2019 by the Ministry of Environment, Forest and Climate Change (MoEF&CC) Government of India (GoI) has estimated the aggregated cooling requirement will grow 8 times by 2037-38 and sector-wise would grow by 11, 4 and 5 times in space cooling, cold chain and transport sectors respectively over the 2017-18 baseline, Figure 2 shows sector-wise cooling demand in country over the short term, medium term and long term.

ICAP has estimated the Total Primary Energy Supply (TPES) required for cooling across all demand as aggregated primary energy (coal, oil, gas, nuclear, hydro, solar, wind, and other renewables) both electricity and oil products demand. It has been projected the total primary energy requirement for cooling will grow to nearly 4.5 times by 2037-38.

It is a challenging to meet the rapidly growing demand of cooling and primary energy required for cooling. It is imperative that it could only be accomplished through innovative solutions and integrated and holistic approach.

Figure 2: Sector-wise Growth in Cooling Demand in million Tonnes of Refrigeration (TR)

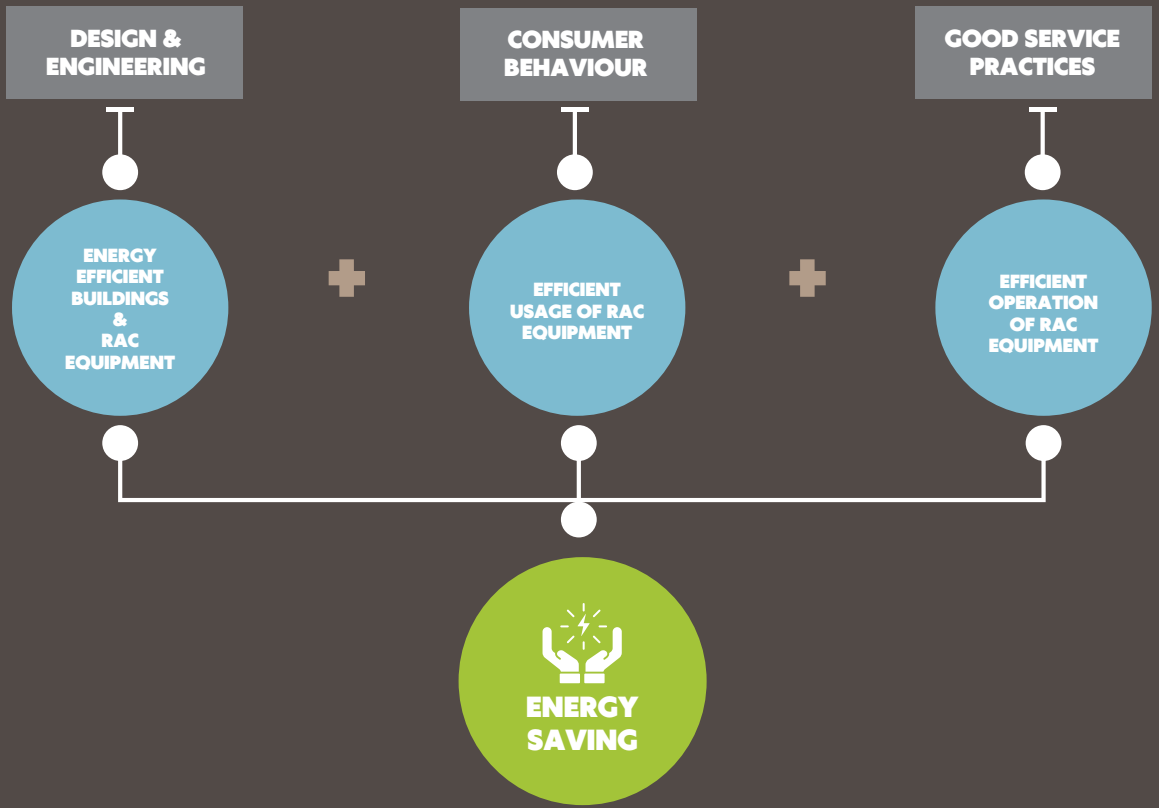


INTEGRATED APPROACH FOR EFFICIENT & SUSTAINABLE COOLING

An integrated approach encompassing cooling load reduction and change in use pattern along with energy efficiency are necessary for sustainable cooling.

Conceptualization of integrated approach is depicted in Figure 3. It comprises of three broad elements, efficient buildings and RAC Equipment, efficient usage of cooling equipment and Good service practices of RAC equipment.

Figure 3: Integrated approach for reduction in energy use in cooling



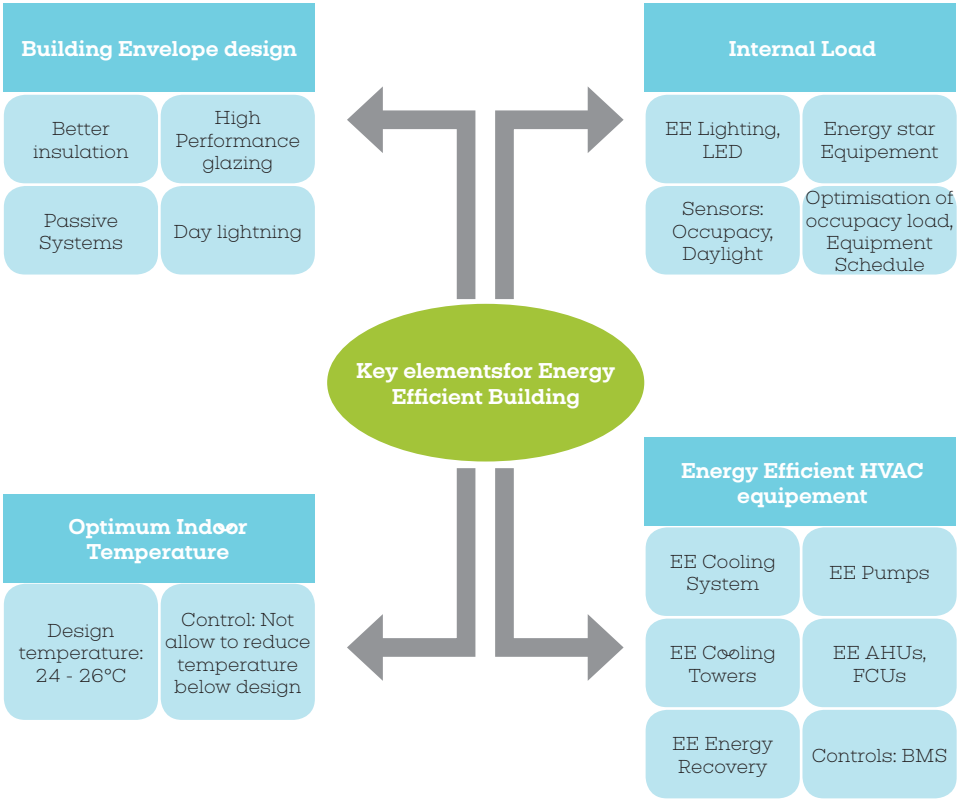
1. EFFICIENT BUILDINGS AND RAC EQUIPMENT

- Thermal building design must incorporate: living patterns vs. W/m^2, maintain healthy comfortable Indoor conditions in buildings etc. can result in significantly higher reduction in cooling, refrigerant requirement and total primary energy supply than the energy efficient RAC equipment alone.
- The contribution of RAC equipment efficiency (even doubling the Coefficient of Performance (COP) or Indian Seasonal Energy Efficiency Ratio (ISEER)) will still be much lower than the other interventions mentioned above in reduction of supply of total primary energy. It is similar to responsive electricity use vs efficient electricity generation.

A. ENERGY EFFICIENT BUILDINGS

- Bureau of Energy Efficiency (BEE), Ministry of Power developed and notified Energy Conservation Building Code (ECBC) 2017 for commercial buildings in 2017. ECBC 2017 is a comprehensive Code for efficient thermal designs for commercial buildings. The ECBC 2017 Implementation could result in significant reduction in cooling requirements in coming decades and total primary energy supply for cooling.
- Eco Niwas Samhita, Part-1 building envelope – Energy Conservation Building Code for residential sector is developed and launched in December, 2018.
- All commercial buildings to be built must be ECBC 2017 compliant. This includes, but not limited to having the right orientation, reduced window-wall ratio, appropriate shading devices, envelop material with code compliant U-values, efficient lightings and other passive cooling strategies. This approach will result in substantial reduction in cooling requirement.
- The efficient building designs will lead to considerable reduction of cooling capacity required for the same floor area without compromising comfort of occupants and hence the reduction in use of refrigerants.
- Elements which are key to reduce the cooling requirement in a building and leading to reduced refrigerant and total primary energy supply have been depicted in Figure 4.

Figure 4: Key Elements for Energy Efficient Building



B. ENERGY EFFICIENT RAC EQUIPMENT

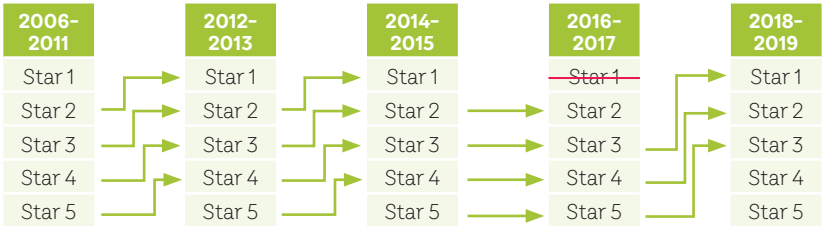
- A large part of the country's cooling requirements across sectors is met using active refrigeration and air conditioning technologies, which are based on the use of either synthetic refrigerants or natural refrigerants. Most of the refrigerants currently used are either Ozone Depleting Potential (ODP) or high Global Warming Potential (GWP) or both. These refrigerants are regulated for phase out/ phase-down as per the agreed schedule under the Montreal Protocol on Substances that Deplete the Ozone Layer.
- The Montreal Protocol has been the driver for the adoption of environmentally friendly technologies by the industry. The Montreal Protocol has recognized first time the climate benefits of energy efficiency under the last Amendment of the Montreal Protocol for phase-down of Hydrofluorocarbons (HFCs) in Kigali, Rwanda.
- Most of the technical options currently available to HFCs are energy inefficiency and highly/mildly flammable. There are challenges ahead for the industry especially while phase-down of HFCs.
- The requirement for space cooling is about 57% of the total cooling requirement and about 81% is catered by room air conditioners. This segment is also growing with a rapid rate. It has been estimated that total installed stock will grow from 39 million in 2017-18 to 350-400 million units by 2037-38.
- The ratcheting energy efficiency of RAC equipment is paramount important for reduction of direct emissions of refrigerant with the reduced refrigerant charge per unit as well as total primary energy supply and reduction in indirect emissions during the working life of the RAC equipment.
- Indian industry is dedicated and actively perusing the development of energy efficient RAC equipment guided by the energy Efficiency labeling programme of Bureau of Energy Efficiency (BEE). The BEE in close cooperation with the industry introduced the energy efficiency labeling programme for room ACs in way back in 2006 as voluntary and since 2011 mandatory.
- BEE energy efficiency labeling programme is dynamic system, improve elimination and assigning the enhanced energy efficiency of room ACs on a periodic basis in consultation with the industry. Table 1 illustrates the star labeling system for split ACs

- Chillers are commonly used for air conditioning of commercial buildings. These chillers are either with Air cooled or water cooled condensers and accordingly these are named as air cooled or water cooled chillers.
- Recently BEE has also introduced minimum Energy Programme for chillers used in commercial buildings. As per Energy Conservation Building Code (ECBC) 2017 Coefficient of Performance (COP) for air cooled and water cooled chillers are given in Table 2.

Table 2 : Minimum COP for Air Cooled and Water Cooled Chillers (for 100% load)

Cooling Capacity kW	Air Cooled Chillers COP	Water Cooled Chillers COP
<260	2.8	4.7
>=260	3.0	—
>=260 &<530		4.9
>= 530 &<1050		5.4
>=1050 &<1580		5.8
>=1580		6.3

Table 1 : Star label for Split Air Conditioner (2006-11 to 2018-19)



2016 - 17

Star Level	Min EER	Max EER
Star 1	2.70	2.89
Star 2	2.90	2.99
Star 3	3.10	3.29
Star 4	3.30	3.49
Star 5	3.50	-

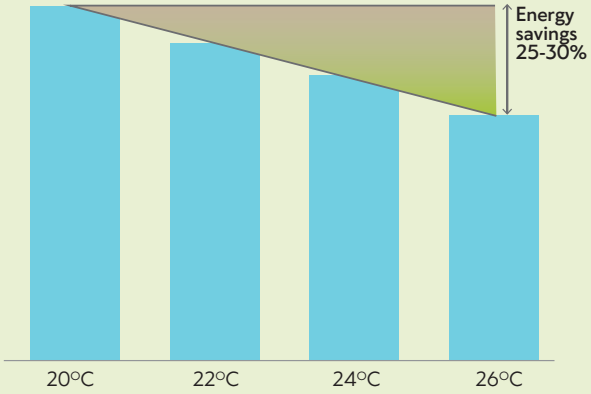
2018 - 19

Star Level	Min ISEER	Max ISEER
Star 1	3.10	3.29
Star 2	3.30	3.49
Star 3	3.50	3.99
Star 4	4.00	4.49
Star 5	4.50	-


TEMP
25°C

- Such air conditioning systems/units designs mostly result in overdesign and have significantly higher installed cooling capacity than needed. Probability to occur simultaneously the maximum load and worst outdoor temperature is extremely low. Over and above commercial air conditioning systems installed also have stand by cooling capacity to meet the system breakdowns.
- Mostly, the spaces are overcooled in the absence of appropriate controls or setting of controls. It not only increases energy consumption significantly and related emissions but also creates uncomfortable/ unhealthy indoor conditions for the occupants (shivering).
- Conditions of overcooling have been commonly experienced in convention halls, hotels, restaurants office buildings, railways and residential buildings including residential buildings using Split ACs.
- The Figure 5 shows the saving of energy for cooling with increased thermostat set temperatures without compromising the comfort. It could be seen that about 25 to 30% energy could be saved by increasing thermostat temperature from 20°C to 26° C.

Figure 5: Energy Saving in Space Cooling with increase in Indoor Temperature



3. GOOD SERVICE PRACTICES FOR EFFICIENT OPERATION OF RAC EQUIPMENT

- An important implication of the rapid increase of ownership of residential and commercial air-conditioners, as well as cars, is that the market for servicing these technologies has also increased rapidly.
- RAC servicing sector is important as it is directly related to consumption of refrigerants and optimum and efficient performance of in-use air conditioning equipment. Interventions in RAC servicing sector provide for twin benefits of environmental protection and livelihood enhancements.
- 40% to 45% of the total refrigerants consumption in the servicing sector; Servicing sector offers huge opportunity for securing environmental benefits both from direct and indirect emissions.
- Quality installation and use of good servicing practices during servicing of faulty units results in reduction in refrigerant leakage and maintain energy efficiency
- Installation is important as it is directly related to consumption of refrigerants and efficient performance of in-use air conditioning equipment. Systematic installation of AC is the key to ensure trouble free and the energy efficient operation during its working life. If an AC is installed improperly, irrespective of the star rating it will never work the way it was designed and result in poor cooling and higher electricity consumption.

- In general, the importance of installation of ACs has not been recognized in the country. There is a need to improve the core competencies of installers to ensure proper installation of ACs including in the peak season period. It would not only benefit the industry by reducing failure rate during warranty period but more importantly it would ensure refrigerant containment and reduces electricity bill to the users.
- Studies have proven that ACs that are installed improperly results in reduction in its cooling capacity and efficiency upto twenty percent.
- Adoption of good service practices (GSP) by service technicians during servicing reduce refrigerant leakage and minimize the indirect emissions from power generation by fossil fuel for air conditioning equipment by maintaining the rated energy efficiency of in-use equipment.
- The steps to be followed by the service technicians as GSP for ensuring energy efficient operation of ACs are listed in Figure 6.

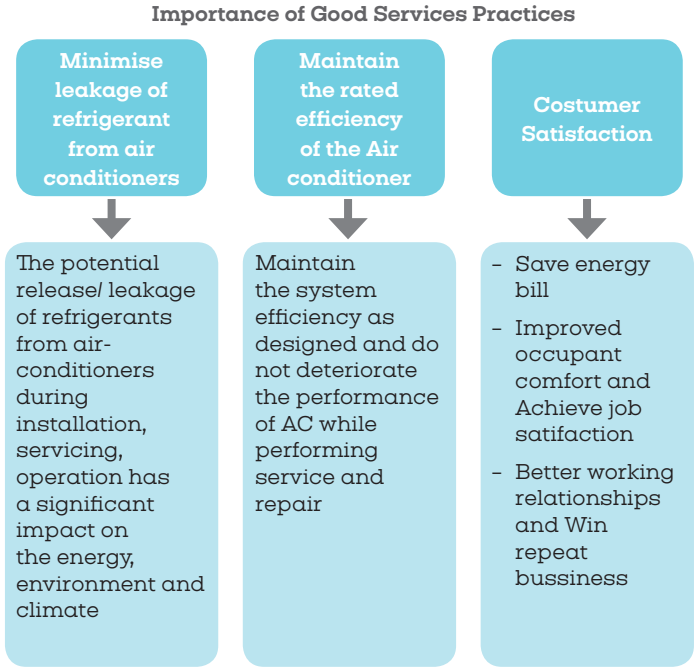
Figure 6: Steps for Good Service Practices of ACs

1. Recover refrigerant from system/Safe venting in case of R-290 refrigerant
2. Repair/replace inoperative parts parts/spares
3. Cleaning and flushing
4. Careful brazing &/or flaring
5. Leak/Pressure testing
6. Evacuation and Vacuum holding
7. Refrigerant Charging
8. Sealing process tube/Closing valves
9. Routine check of proper Operation
10. Record details of work done

BENEFITS OF USING GOOD SERVICING PRACTICES

- The benefits of using GSP are summarized in Figure 7.

Figure 7: Summary of Benefits of GSP



- The number of RAC service technicians in the country will rise with increase in the equipment stock. As per estimates at present, there are 200,000 service technicians in the country, most of whom are in the informal sector. Training programmes for RAC service technicians, have been a continuous activity as part of the ODS phase-out programmes being implemented in the country under the Montreal Protocol framework. Separately, there have been trainings for service technicians being organized by industry associations and air conditioning equipment manufacturers.

- The Ministry of Skill Development and Entrepreneurship (MSDE), GoI is mandated with development of skill ecosystem in the country and oversees and administers skilling and vocational training. The National Skill Qualification Framework (NSQF) under MSDE provides for certification of skills through National Skill Development Corporation, which implements the certification programme through Thematic Sector Skill Councils. The Electronic Sector Skill Council caters the RAC servicing sector trade. This could be further strengthened in terms of infrastructure and technical content. This system could be developed as a single certification system that has to be obtained by all technicians.

- MoEF&CC and MSDE, GoI entered into an MoU to skill and certify 100,000 service technicians under the Pradhan Mantri Kaushal Vikas Yojana – Skill India Mission.

IMPACT OF ENERGY SAVING INTERVENTIONS ON REFRIGERANT AND TOTAL PRIMARY ENERGY SUPPLY FOR COOLING

- The demand for cooling will continue to grow in coming decades. Following an holistic and sustainable approach by taking measures as stated above a substantial reduction in increase in refrigerant and total primary energy supply has been projected (ICAP -2019).
- The intervention scenario presented in here (ICAP 2019) incorporate improvements in equipment efficiency and operational practices only; however, as delineated earlier, further energy savings can be accrued due to reduced cooling load: a TR reduction potential of around 13% and around 23% could be achieved by 2027-28 and 2037-38, respectively, through climate-appropriate building envelopes driven by a higher adoption of ECBC in the upcoming commercial buildings.
- Figures 8 and 9 depicts the sector-wise reduction of refrigerant and total primary energy supply for cooling during short, medium and long terms respectively. It has been estimated for reference as well as for intervention (by deploying the measures discussed above) scenarios (ICAP 2019).
- The timely implementation of ECBC 2017 across country will further result in significant reduction in cooling requirements leading to further reduction in refrigerant and total primary energy supply for cooling.

Figure 8: India's Refrigerant Demand for Space Cooling and Servicing

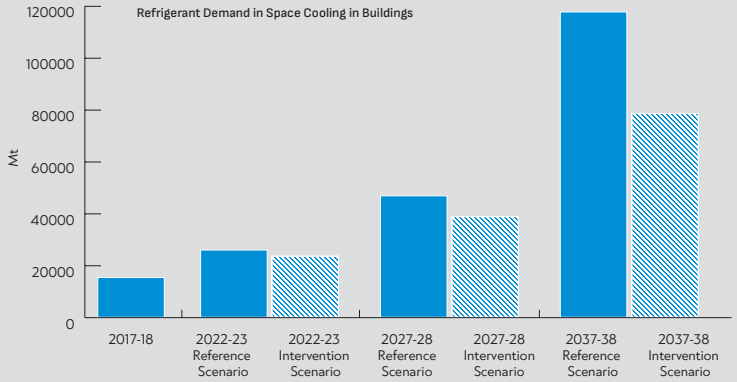
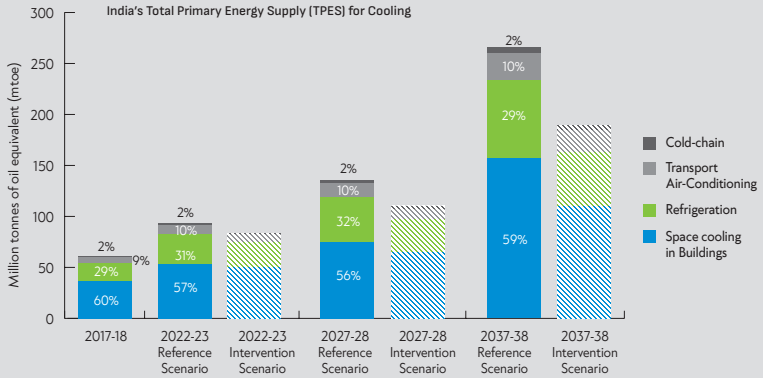
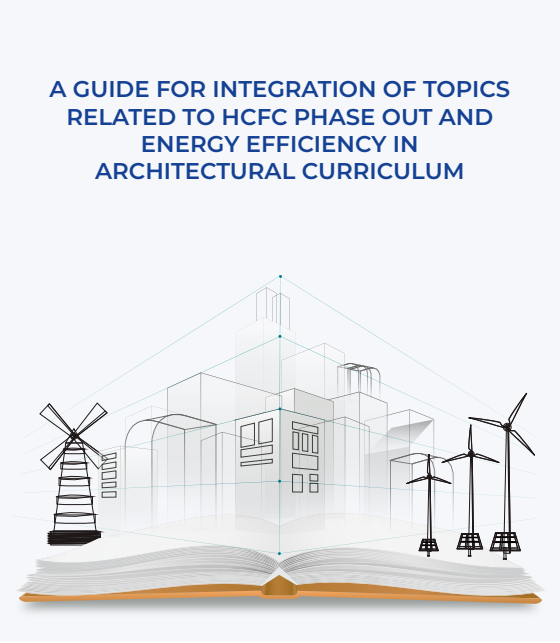
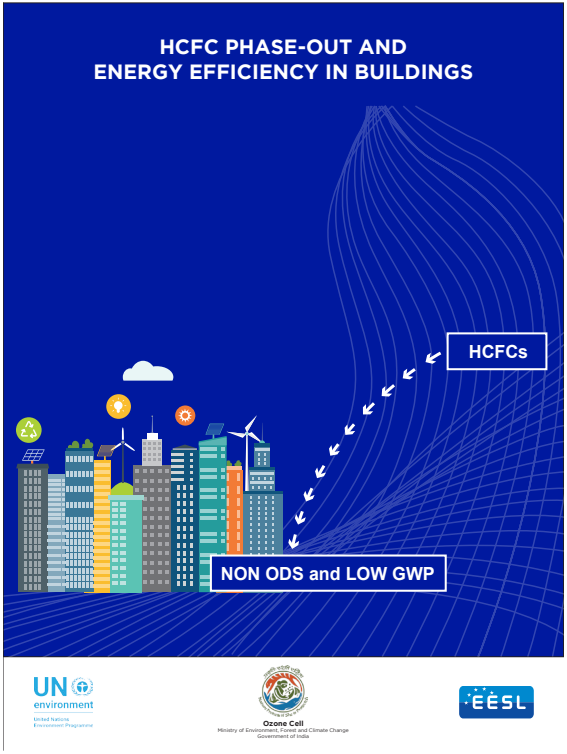


Figure 9: India's Total Primary Energy Supply (TPES) for Cooling



PUBLICATIONS RELEVANT TO ENERGY EFFICIENCY AND HCFC PHASE OUT IN BUILDING SECTOR





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