

## ST13 - Action Plan for the Phase-out of Ozone Depleting Substances at Hindalco

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### Abstract

Ozone Depleting Substances more commonly known as ODS are widely used as refrigerants in industrial and domestic appliances such as heating ventilation and air conditioning (HVAC), refrigerators, chillers, coolers, etc. These, when released into the atmosphere, react with the ozone layer, and deplete it resulting in the penetration of radioactive ultraviolet rays into the earth's atmosphere. Besides the depletion of the ozone layer, they disrupt the food chains, spread skin cancer, and cause other health hazards. With the enforcement of the Montreal Protocol accepted back in 1987, countries worldwide stopped the use of chlorofluorocarbons (CFCs) which were the most potent ozone-depleting substances used back then with an ozone-depleting potential (ODP) of 1. This protocol laid down the plan to phase out the rest of ODS in use by 2020 in developed nations and by 2030 in developing nations, such as India.

Hindalco has taken the initiative to achieve the target of phasing out ODS use from all its factories by 2026. Predominantly 5 types of ODS using equipment are used at Hindalco sites, i.e., HVAC systems, water coolers, refrigerators, chillers, dryers, and all the mentioned equipment uses R-22 as refrigerant. The action plan consists of factory-wise equipment inventory creation, year-wise phase out target and projecting the capex involved. The list of equipment to be replaced involved an exhaustive exercise at each factory as it involves many functions and departments. It also involves the process of declaring each equipment out from the "Asset Register" and completing all the related financial calculations.

This project includes a complete technical analysis of the alternate gases and their ODS potential, energy consumption, heat recovery, discharge temperature and Global Warming Potential (GWP). ODS have to be replaced by fiscal year 2026 (FY-26) in 4369 devices, at an estimated cost of 7.5 million USD. ODS substances are already reducing at Hindalco, and a complete phase out would not only make Hindalco environmentally friendly but also much more resource efficient.

**Keywords:** Ozone depleting substances (ODS), Refrigerants, ODS phase-out, Global warming potential, Inventory of ODS.

### 1. Introduction

Ozone depleting substances are man-made gases that destroy ozone once they reach the ozone layer. These are mostly used as refrigerants in commercial and residential air conditioners, refrigerators, coolers etc. foam blowing agents, components in electrical equipment and industrial solvents, cleaning solvents and aerosol spray propellants and fumigants.

#### 1.1 Types of Ozone Depleting Substances

- a) Chlorofluorocarbons (CFCs): R-11, R-12 etc.

- b) Hydrochlorofluorocarbons (HCFCs): R-22, R-141b etc
- c) Hydrobromofluorocarbons (HBFCs): HF2Br
- d) Halons- Halon-1211, Halon-1301 etc.
- e) Methyl bromide-  $\text{CH}_3\text{Br}$
- f) Carbon tetrachloride-  $\text{CCl}_4$
- g) Methyl chloroform –  $\text{CH}_3\text{CCl}_3$

## **1.2 Ban on the use of Ozone Depleting Substances is Essential Due to the Following Reasons**

### **a) Depletion of Ozone Layer**

ODS substances absorb the UV radiation of the sun and set up a chain reaction where a halogen atom attacks the Ozone Molecule ( $\text{O}_3$ ) to form monoxide and Oxygen ( $\text{O}_2$ ) which subsequently depletes the ozone layer.

### **b) Food Chain Disruptions**

Depletion of ozone has repercussions on the entire food chain of the planet wherein the plants get affected due to excessive UV Radiation. Life in the ocean also gets affected as Planktons and Fishes are sensitive to UV Radiations.

### **c) Spread of Skin Cancer**

Diseases like Melanoma- a type of skin cancer will be prevalent among humans due to abnormal exposure to UV Radiation.

## **2. British Antarctic Survey and its Role in Paving the Way to Montreal Protocol [1]**

The British Antarctic Survey (BAS) has been actively involved in researching the Earth's polar regions and has made significant contributions to the study of the ozone layer. One of the most notable findings made by the BAS was the identification of the Antarctic ozone hole during the 1980s. They discovered that the ozone layer over Antarctica was being depleted at a rapid pace due to the release of human-made chemicals, particularly chlorofluorocarbons (CFCs) that were commonly used in various industrial products such as refrigerants and aerosols. The ozone hole over Antarctica grew considerably during the 1980s and 1990s, which resulted in increased ultraviolet radiation reaching the Earth's surface. To identify the ozone hole, the BAS established research stations in Antarctica to monitor the atmospheric conditions and ozone levels. Moreover, the BAS played a pivotal role in providing scientific evidence that led to the establishment of the Montreal Protocol in 1987.

### **2.1 Montreal Protocol – 1987 [1]**

The Montreal Protocol, an international treaty established in 1987, has set specific targets to protect the Earth's ozone layer. Its primary objective is to phase out the production and consumption of ozone-depleting substances, such as chlorofluorocarbons (CFCs), by establishing timelines for their reduction. The first target set by the Protocol aimed to reduce CFC consumption and production by 50 % before 1999. This target was successfully achieved by most countries, leading to further targets for the complete phase-out of other ozone-depleting substances, including halons, carbon tetrachloride, and methyl chloroform. As of September -2021, 197 countries have signed up for the Montreal Protocol.

**Table 1. Target year of phasing out of listed refrigerants as per Montreal protocol.**

Ozone Depleting Substances	Target Year for Phasing Out	
	MDC*	LDC*
CFC's	1995	2010
Halons	1993	2010
Carbon tetrachloride	1995	2010
Methyl Chloroform	1995	2015
Methyl Bromide	2005	2015
HCFCs	2020	2030*

\*MDC- More Developed Countries \*LDC- Less Developed Countries

The Montreal Protocol currently calls for a complete phase-out of HCFCs by 2020 for developed countries and by 2030 for developing countries with a very small servicing tail up to 2040.

Additionally, as per UNEPA (United Nations Environment Protection Agency) Clean Air Act, ODS are classified under two classes:

- a) Class 1 ODS- CFCs, Halons, Carbon Tetrachloride, Methyl Chloroforms & Methyl Bromide Compounds
- b) Class 2 ODS- HCFCs

**Table 2. ODS classification as per UN EPA [3].**

S. No	Refrigerants	ODP Range
<b>Class-1</b>		
1	CFCs	0.6-1.0
2	Halons	3.0-10.0
3	Carbon Tetrachloride	1.1
4	Methyl Chloroform	0.02
5	Methyl Bromide	0.6
<b>Class-2</b>		
1	HCFCs	0.05-0.1

### 3. Hindalco's Ozone Depleting Substances Phase Out Plan

#### 3.1 Target for Phasing Out

Hindalco Industries Ltd aims to become ODS Free by March 2026

#### 3.2 Ozone Depleting Substances and its Usage in Various Systems at Hindalco Sites

We identified that, there are following five types of systems wherein ODS is used predominantly:

1. HVAC Systems
2. Water Coolers
3. Refrigerators
4. Chillers
5. Dryers

All the above-mentioned systems are using R-22/HCFC-22 as refrigerants.

### 3.3 Steps Taken to Phase Out Ozone Depleting Substances:

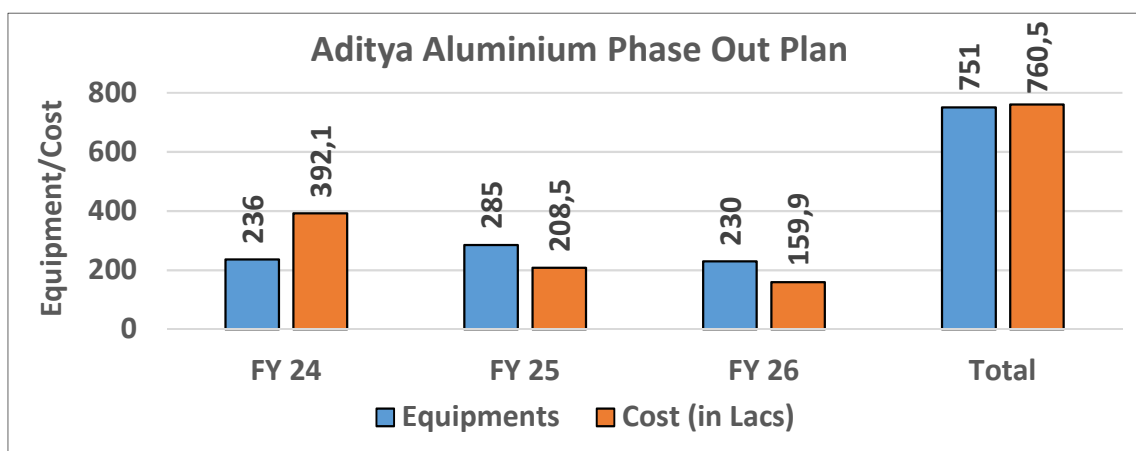
1. Sensitization and awareness among the relevant stakeholders and senior management about ODS and the business requirement of phasing it out.
2. Identification of ODS used in all the factories of Hindalco and their monthly consumption.
3. Identification of ODS free refrigerants that are used in the latest equipment /systems/ machinery, available in the market.
4. Creation of a factory-level inventory list of all ODS using equipment used in the factories and the phase out in consultation with original equipment suppliers
5. Planning the capital expenditure budget for the replacement of the same with the latest technology

**Table 3. Ozone depleting substances used at Hindalco and its possible replacement along with ozone depleting potential and global warming potential.**

ODS Used at Hindalco	ODP	GWP	Possible Replacement	ODP	GWP
R-22	0.05	1810	R-410	0	1890
			R-32	0	677
			R-407c	0	1774
			R-134a	0	1430
			<b>R-290</b>	<b>0</b>	<b>3</b>
			<b>R-600a</b>	<b>0</b>	<b>4</b>

- A. We identified that R-22/HCFC-22 (see the above table for reference) is the only ODS used in the factories of Hindalco; mostly used in Air Conditioners, Refrigerators, Industrial Dryers etc.
- B. Possible replacement for R-22 are R-410, R-32, R-407c, R134a, R-290 and R-600a. Among the possible replacements, R-290 and R-600a are preferred over others listed as they have low ODP (Ozone Depletion Potential) and GWP (Global Warming Potential)
- C. The replacement refrigerants cannot be retrofitted into the existing R-22 based equipment, hence the whole equipment/system needs to be replaced.

### 3.4 A Few Examples of Phase Out Plans Submitted by Factories.



**Figure 1. ODS phase out plan by Aditya Aluminium.**

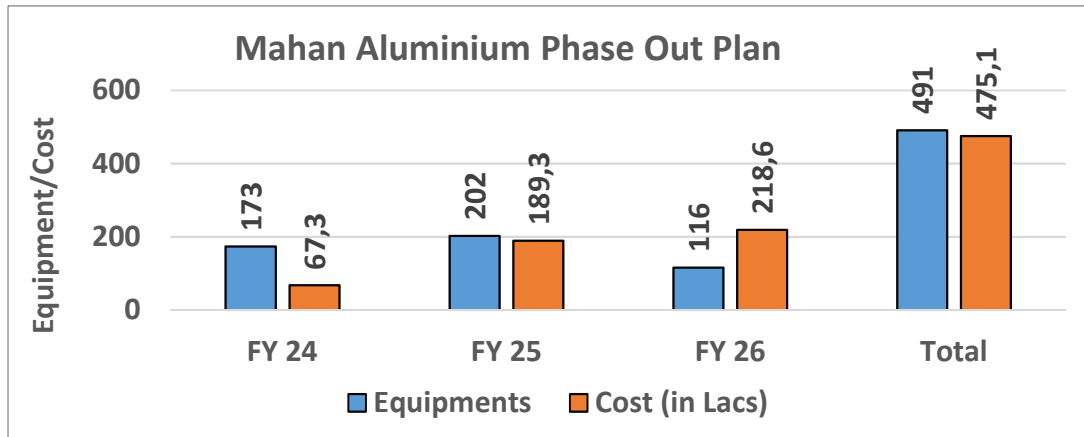


Figure 2. ODS phase out plan by Mahan Aluminium.

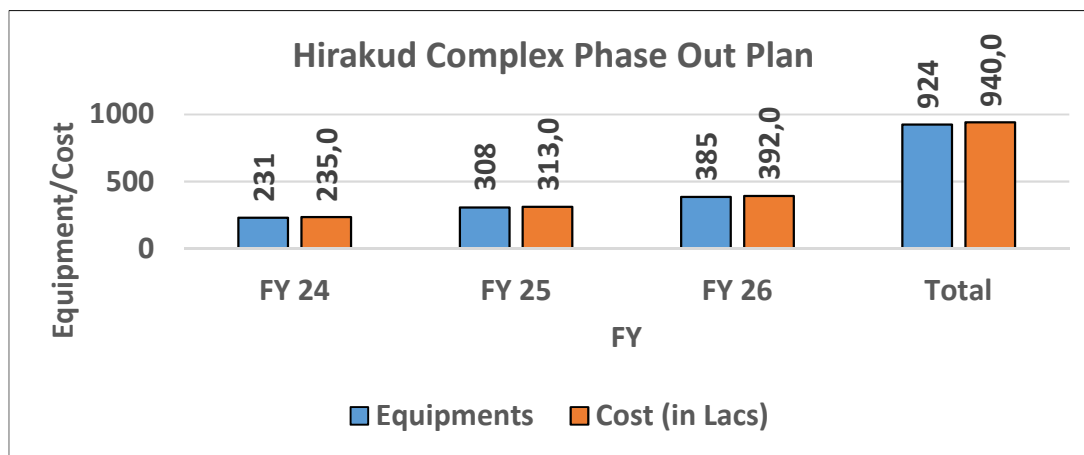


Figure 3. ODS phase out plan by Hirakud Complex.

Table 4. Detailed phase out plan of ODS from 13 factories with number of equipment to be replaced and capex provisions (crores, 10<sup>7</sup> INR) with details are mentioned below.

S. No	Factories	FY-23		FY-24		FY-25		FY-26	
		Equip-ment	Capex	Equip-ment	Capex	Equip-ment	Capex	Equip-ment	Capex
1	Renukoot	-	-	231	6.42	227	4.86	225	4.31
2	Renusagar	3	0.35	-	-	8	1.20	-	-
3	Mahan	-	-	173	0.67	202	1.89	116	2.18
4	Aditya			236	3.92	285	2.08	230	1.60
5	Hirakud			231	2.35	308	3.13	385	3.92
6	Utkal	2	1.7	164	3.88	154	3.45	155	3.86
7	Muri	-	-	198	1.18	13	1.98	-	-
8	Belagavi	6	0.05	5	0.15	-	-	-	-
9	Taloja	62	0.41	32	0.22	10	0.07	-	-
10	Dahej	-	-	145	1.11	145	1.45	144	1.44
11	Mouda			39	0.26	52	0.42	43	0.37
12	Alupuram			32	0.15	36	0.17	1	0.15
13	Belur FRP	-	-	24	0.29	23	0.40	24	0.13
	Total	73	2.51	1510	20.6	1463	21.1	1323	17.96

Total Equipment to be replaced by FY-26 = 4369,

Total Estimated Cost involved = 621 700 000 INR (7.5 million USD).

### 3.5 Case Study on Renukoot’s Phase Out Plan

Our oldest factory at Renukoot was the first to commit on the ODS phase out target and submit the plan. It was also the only factory which had begun phasing out since 2019 -before our public commitment. Taking a queue from its exhaustive work on the ground like conducting audits and assessments to vendor identification for replacements, other factories were mobilized to prepare a proper inventory and action plan.

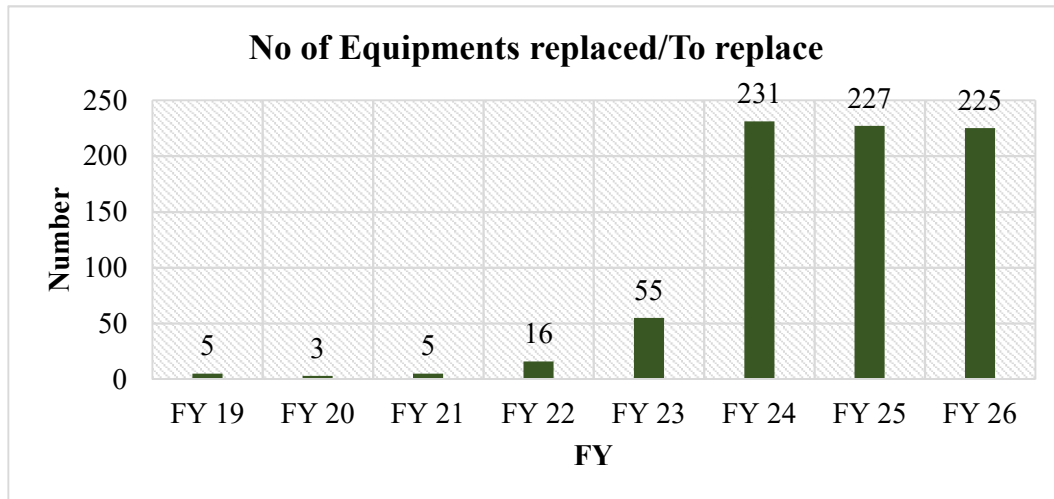


Figure 4. Equipment phase out plan by Renukoot complex.

Renukoot Complex also played a pivotal role in leading and hand holding other factories by conducting different on-site technical studies on refrigerants that can be used as replacements.

## 4. Technical Comparison of Refrigerants [4]

### 4.1 Case Study on R-22 vs R-410A

#### 4.1.1 Mass Flow Rates

The mass flow rate of R-410A can be up to 60 % higher than that of R-22 for the same cooling or heating load. This is because R-410A has a higher cooling capacity and a higher vapor pressure than R-22, which can result in a higher mass flow rate requirement to achieve the same level of cooling or heating.

#### 4.1.2 Energy Efficiency

According to the U.S. Environmental Protection Agency (EPA), the energy efficiency of an HVAC system that uses R-410A can be up to 50 % higher than that of a system using R-22. The higher energy efficiency of R-410A can translate into lower operating costs and reduced energy consumption.

#### 4.1.3 Discharge Temperature

R-410A has a lower discharge temperature compared to R-22 because it has a higher pressure and a higher specific heat capacity. This means that R-410A can absorb more heat without experiencing as much temperature increase as R-22. Lower discharge temperatures can result in improved system efficiency, reduced compressor wear and tear, and increased system reliability.

## 4.2 Case Study on R-290 vs R-407C

A comparison of mass flow rates, input powers and discharge temperatures when carried out between R407C and R290 in the same range of evaporating temperatures (-7 °C to +10 °C) and condensing temperatures (40 °C to 55 °C) gives the following results:

### 4.2.1 Mass Flow Rates

The R290 mass flow rate is 45.4 % lower than the R407C. This discrepancy acts unfavorably for the R290 scroll compressor because the heating or cooling capacities are proportional to the mass flow rate. Nevertheless, the ratio of latent heat recoverable by condensation at 50 °C of R407C over the one of R290 is in the same proportion as the inverse ratio of mass flow rates. So, the heating capacity is recoverable by implementing R290 instead of R407C.

### 4.2.2 Input Powers/Energy Efficiency

An average decrease of 12.4 % in the case of power consumption is observed when R290 is compared to R407c.

### 4.2.3 Discharge temperatures

The difference varies from 6.4 K to 12.0 K. It is a good result in terms of longevity of the compressor and prevention of oil deterioration. Besides, the de-superheating process will be decreased compared to an operation with the same discharge temperatures as the ones of R407C. However, the specific heat of R290 is twice the one of R407C in the vapor phase at these pressures. So, the heating capacity recoverable during the de-superheating process using R290 will be equivalent to or even higher than that of R407C.

Hence R-290 is superior to R407c in terms of Heat Recovery, Energy Consumption, Discharge Temperature, and Global Warming Potential.

*R-290 is a Class A3 Refrigerant by ASHRAE's (American Society for Heating, Refrigerating and Air Conditioning Engineers) which means it is highly flammable. Hence caution needs to be maintained before using R-290 based equipment, especially in an industrial setup.[6]*

## 5. Current Availability in Indian Markets

The Indian HVAC Industry market size is about US\$ 8000 million with many major players such as Carrier Midea India Pvt Ltd, Daikin Industries Ltd, Havells Industries Ltd, LG electronics Inc. etc. providing a range of solutions.

**Table 5. ODS Free Equipment Solutions by a few OEMs in India.**

S. No	OEMs	ODS Free Refrigerant Solutions
1	Carrier Midea	R-410a, R-32
2	Daikin Industries	R-32
3	LG Electronics	R-410a,R-32
4	Godrej	R-290, R-32
5	Blue Star	R-32

We can see that many of the OEMs in India have a range of ODS free solutions with R-32 and R-410a as the common offerings.

## 6. Overcoming major challenges

As Hindalco has numerous factories country-wide, it was a major challenge to collect the inventory and plan the phase out of ODS. The table below shows the challenges faced and steps taken to overcome .

**Table 6. Challenges faced and steps taken to overcome.**

S. No	Challenges	Steps taken
1	Aligning personnel at factories with the target of ODS phase out by FY 26	Multiple sessions and webinars with SPOCs from the factories and senior management to sensitize about the business requirement for phasing out ODS
2	Collection of inventory and data discrepancy	Conducted on-site audits to create an inventory of equipment along with refrigerant used. The collected data was verified with the procurement team at the site.
3	Strategic planning of YoY phase out along with budget requirement.	Consulted site team as well as senior management for year-wise allocation of budget for each factory according to the market price and inflation.

## 7. Conclusion

Taking a clue from international protocols for phasing out of ODS and commitment by Govt of India, Hindalco is taking proactive steps to phase out ODS from its Units by 2026 well before the Montreal Protocol deadline for India by 2030 and are committed to the cause. This involves substantial capital expenditure (Capex) provisioning therefore individual units of Hindalco have planned well in advance for phasing out ODS completely by 2026. Phasing out actions already started at many sites and each factory committed to meet the deadline.

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