Cooling India with Less Warming: Examining Patents for Alternatives to Hydrofluorocarbons

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Executive Summary

Patents and other intellectual property such as know-how are a complex issue for policy makers and civil society experts, especially considering the large number of patents involved and the sensitivity and confidentiality around licensing agreements. This paper does not attempt to offer a solution to the patent debate. Rather, it examines the experiences of developing countries of dealing with patents during earlier transitions under the Montreal Protocol, highlights the key issues faced by Indian industry and policy makers, and presents the following key findings:

First, in the context of the phase-out of ozone-depleting substances (ODSs) under the Montreal Protocol and its implementation in India and in other developing economies, patents have historically not proven to be an obstacle to the expanded production of chemicals in developing countries. It has been observed that under the Montreal Protocol's grace period, where developed countries transition first and developing countries transition later, patents often expire and the previously patented technology is widely available globally at the time when developing countries begin their transition.

Second, several options exist for Indian refrigerant-manufacturing and end-use sector companies to address the patent issue through establishing joint marketing ventures, acquiring licenses for domestic production, entering into mergers and acquisitions, and using licence agreements without charge, as in the case of Daikin's action on HFC-32 for room air conditioners (ACs).

Third, application patents are increasingly becoming a cause for concern for Indian equipment manufacturers, and it is important to have clarity on the issue for Indian industry.

Fourth, based on an examination of earlier transitions, we see that the Montreal Protocol's Multilateral Fund (MLF), to some extent, has compensated for the cost of licences and access to patented technologies. Further evaluation is needed to assess if a licensing arrangement supported by the MLF can be used as a way to address the application patent barrier.

Fifth, investment in research and development (R&D) for fostering innovation is an important way for Indian companies to get ahead in the long run, and Indian companies need to seriously consider becoming global leaders in developing new processes and technologies irrespective of government support.

Sixth, the Indian government can support the establishment of a global alliance for a common R&D pool for the creation of climate-friendly technologies and solutions, along with supporting innovations, since the development of low-GWP (global warming potential) refrigerants that satisfy key technical criteria is an important near-term objective of the global community.

1. Introduction

India is one of the fastest growing major economies in the world. Given the country's burgeoning middle class, increasing rate of urbanisation and electrification, rising temperatures, and the hot and humid climate, the vehicle, commercial, and residential sectors are expanding the use of air conditioning. This huge expansion in demand strains energy supply and increases air and water pollution levels. Improving air conditioning so as to make it less polluting and more efficient offers a significant opportunity to strengthen the power sector and to tackle problems related to climate change. In particular, shifting away from hydrofluorocarbons (HFCs), potent heat-trapping gases used as refrigerants in air conditioning, to more energy-efficient, lower-GWP alternatives is an immediate opportunity to achieve the Indian government's goal of building a low-carbon economy. Many countries are moving away from HFCs and support a global phase-down of HFCs under the Montreal Protocol on Substances that Deplete the Ozone Layer, which came into effect on 1 January 1989. High cost of patents and intellectual property involving HFC alternatives in the market is a key issue that needs to be resolved in the discussions on achieving a global phase-down.

BOX: ENERGY EFFICIENCY CO-BENEFITS OF PHASING DOWN HFCS

The phasing down of high-GWP refrigerants presents a key opportunity for increasing the energy efficiency of air conditioning units and mobile air conditioners. By focusing on efficiency, life-cycle climate performance, and high ambient-temperature performance of refrigerants as key selection criteria, companies can ensure the transition to environmentally superior alternatives for end-use sectors. A 2014 study by the Council on Energy, Environment and Water (CEEW) found that a switch to lower-global warming potential (GWP) room ACs with energy-efficiency improvements could offer 15 per cent energy savings over a business-as-usual scenario, contributing to reductions of 31–38 per cent in the global warming footprint of the residential AC sector in India. For use in room ACs, R-290 and R-32 provide superior energy-efficiency performance, in addition to low- and medium-GWP respectively. For use in automobile ACs, both HFO-1234yf and HFC-152a have demonstrated increased energy efficiency of up to 30 per cent when compared with standard HFC-134a- based MAC systems.

Countries around the world are shifting away from HFCs – one of the six categories of greenhouse gases controlled under the United Nations Framework Convention on Climate Change (UNFCCC) and its Kyoto Protocol and Paris Accords, with a GWP up to thousands of times that of carbon dioxide. More than 108 Parties, including 54 African Parties, support the phasing down of HFCs through an amendment to the Montreal Protocol. Parties, including the European Union, Japan, China, and the United States, the world's largest economies, are already implementing domestic regulations to phase down HFCs. Global markets are equally active in phasing down HFCs.

India's long-term HFC emissions are expected to account for 5.4 per cent of the entire economy's total global warming impact in 2050, and a large part of this would result from HFC use in room and vehicle air conditioning. Major emitting sectors such as mobile air conditioning, residential cooling, and commercial refrigeration, direct HFC emissions are responsible for most of the total global warming impact, reaching up to 50 per cent in the case of commercial refrigeration. In order to arrest runaway growth in the use of high-GWP HFCs, the Indian government submitted an amendment proposal to the Montreal Protocol in March 2015, demonstrating its support for a global HFC phase-down.

In discussing the amendment, some in Indian industry have raised concerns that the cost of licensing and acquiring patents, and of overcoming intellectual property rights barriers, may prove to be an impediment and may slow the pace of the transition to lower-GWP HFCs, thereby placing Indian companies at a competitive disadvantage. The patent issue has become one of the important issues, along with other policy and technical challenges like selection of baseline, freeze year, safety, energy efficiency and capacity building in the service sector. The issue of patents is complex, and this paper highlights the key concerns articulated by Indian industry leaders and policy makers. We do not attempt to find a solution to the patent issue. Rather, we examine the experiences of developing countries in dealing with patents during earlier transitions under the Montreal Protocol, and highlight the key issues faced by various stakeholders in the impending transition.

2. Background on Patents and Intellectual Property

Patents are a form of intellectual property rights granted by governments to companies for creating new technical solutions or innovative methods to resolve or define problems for an exclusive and limited time. The patent applicant must publicly disclose innovative technical knowledge at the time the patent is published. However, others can use the information only after the patent has expired.[i]

Patents are limited in duration and are applicable only in the jurisdiction(s) in which they have been filed. For example, the patent rules and regulations for the sale and manufacture of a patented product in India apply to that product's sale and manufacture only in this country. In order to restrict the product's manufacture and use in other countries, separate patent filings are required. The cost of filing patents in a country often ranges in the thousands of dollars, and any company that develops a new technology is typically selective while filing patents in other countries. Companies balance the costs of filing patents against the potential market size and the requirements of the legal system operating in the country to defend their rights. The Patent Cooperation Treaty (PCT) of 1970 allowed for greater patent filing across multiple jurisdictions. From the date of the initial filing in the national patent office, there is a period of 12 months during which patents have to be filed under the PCT, and until the 30th month from the date of the earliest filing for the patent to be filed in a national patent office.[ii]

In India, patents are granted on the basis of three key criteria: (1) The invention must be new, the product or process must be original, and such an invention should not have been used before; (2) The invention must involve an inventive step, and should not be obvious to a person of normal skill in that particular field; and (3) The invention must be capable of industrial application and should be useful.

In the context of refrigerants, patents can be broadly classified into three categories: (i) *process or production patents* for the manufacture of chemicals; (ii) *patents for blends* of two or more chemicals in a specific ratio resulting in a superior application; and (iii) *application patents* for the use of specific chemicals or blends in equipment for a particular application or a group of related applications. Apart from these three broad categories, there could also be patents for end-use components like compressors or valves used in end-use equipment.

3. Earlier Transitions Under the Montreal Protocol and the Impact of Patents on Chemical Production in Developing Countries

Some representatives of the Indian chemical industry have expressed concerns about patents posing a potential challenge to the successful transition to low-GWP alternatives in achieving an HFC phase-down. The assertion is that a transition may lower domestic production in India and result in increased imports. Alternatively, the claim is that fluorochemical producers in India may be required to pay significant licensing costs to foreign companies that own production patents. Another key concern is that even if Indian producers come up with their own production processes, they will not be able to see their products because the application patents are held by transnational companies. A review of the earlier transitions under the Montreal Protocol shows that historic shifts to patented alternatives did not result in reduced production in developing countries, nor did they result in increased imports or enhanced costs of these products in developing countries. This was, to a large extent, because the patent had already expired by the time developing countries started using these refrigerants, and their cost was low as well. Furthermore, only a small portion of the technology that replaced ODSs was patented. It should be noted that in the past, application patents were not the main concern. However, in the current transition, application patents have emerged as a major issue for Indian stakeholders.

Figure 1: HCFC and HFC-134a production in A5 and non-A5 Parties

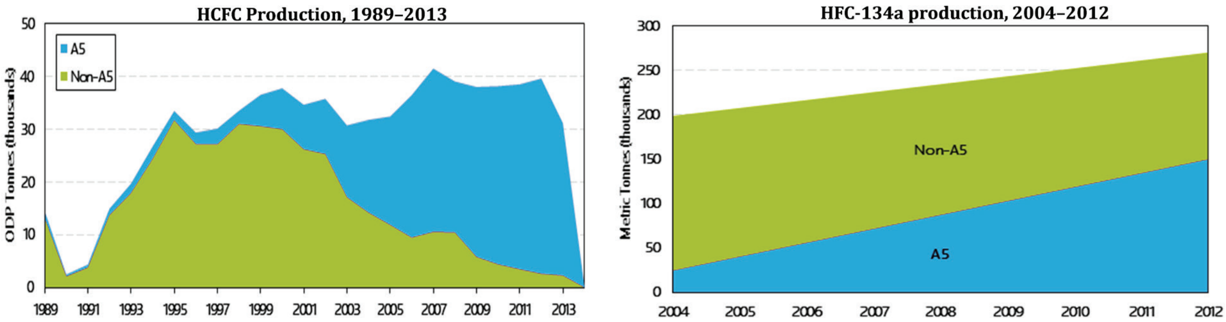

Figure 1 shows the evolution of the production of (Hydrochlorofluorocarbon) HCFC and HFC-134a. Until 1995, when the HCFC phase-out began in developed countries, almost all of the global production of HCFCs was concentrated in developed countries. Between 1996, when HCFC consumption was frozen in developed countries, and 2013, when HCFC production was frozen in developing countries, nearly the entire global HCFC production base shifted from non-A5 to A5 Party countries.

Similarly, HFC-134a is widely used to replace Chlorofluorocarbon-12 (CFC-12) in refrigeration and other applications. In 2004, when Article 5 Parties started this transition, most of the production was concentrated in non-Article 5 Parties, with patents being involved. By 2012, however, more than 50 per cent of HFC-134a production was in Article 5 Parties; the increase happened largely because the patent on this refrigerant had expired by 2005.

The CFC transition also demonstrates the interplay between policy decisions to limit chemical use, the ways in which patents are awarded, and the focus of R&D. HFC-134a was considered a primary alternative to CFC-12, and its commercial production started only in 1990. At the start of the Montreal Protocol negotiations in 1987, HFC-134a was only produced in laboratories in limited quantities. The first commercial-scale HFC-134a production plants were opened by ICI and DuPont in 1990 despite conclusions in 1988 by technical experts that the commercialisation of alternatives would take a minimum of five years. A number of other producers opened commercial-scale production facilities over the next four years and volume increased to 50,000 metric tonnes and doubled again three years later.[iii] The rapid increase in demand was met by expanding production, as the regulatory restrictions on CFCs took effect in many developed countries and led to the voluntary shifting to alternatives by many companies in advance of the imposition of regulatory controls. The motor vehicle sector in developed countries shifted completely from CFC-12 to HFC-134a by the 1995 model year, and the last developing country shifted by 2010. Meanwhile, hydrocarbons replaced CFCs in domestic refrigerators and stand-alone commercial refrigerated cases in almost every country, including India.

Similarly, the number of producers and the percentage of production of HFC-134a in Article 5 Parties, particularly China, increased dramatically, even though the first factories were built in the developed nations with strong demand due to the early regulatory controls and under patents. Information supplied by both the Alternative Fluorocarbon Environmental Acceptability Study (AFEAS) and the Montreal Protocol Technology and Economic Assessment Panel (TEAP) on global HFC production clearly indicates this dramatic shift. With China leading with the largest production, India, too, is producing HFCs, and, according to the current estimates, half of HFC-134a production now occurs in Article 5 Parties.[iv]

The earlier shifts under the Montreal Protocol, and historical data and trends, show that production patents have not impeded the production of refrigerants in Article 5 Parties.

4. Opportunities and challenges for Indian chemical manufacturers

4.1 About Indian chemical manufacturers

The Indian chemical manufacturing sector has grown 13–14 per cent in the last five years while petrochemicals have registered a growth of 8–9 per cent over the same period.[v] There are five producers of HCFCs in India. All of these have transitioned from being CFC producers to HCFC producers. HCFCs will be phased out in applications other than process agents and feedstocks, which are not controlled under the Montreal Protocol and which account for over half of the current HCFC production. The following is a brief snapshot of the main fluorochemical-producing companies in India.

SRF Limited: SRF is currently the only HFC producer in India, with installed capacity to manufacture 17,500 metric tonnes of HFC-134a. The company recently announced plans to convert 5,000 metric tonnes of HFC-134a capacity to HFC-32 production, which is used as a pure refrigerant and also as a 50 per cent ingredient in HFC-410A, a high-GWP refrigerant blend. SRF was established in 1970 and started fluorochemical manufacturing in 1989, with CFC and HCFC production in Bhiwadi, Rajasthan. SRF has also announced its plans to set up a pilot plant for new generation HFO -1234yf.

Gujarat Fluorocarbons Limited (GFL): GFL is a part of $2 billion INOX Group of Companies. The chemical complex of GFL commenced operations in 2007 at Dahej, Gujarat. GFL primarily used to manufacture CFCs and HCFCs, and now manufactures HCFC as feedstock for polytetrafluoroethylene (PTFE), an engineered plastic best known as Teflon®, produced by Chemours (previously DuPont). GFK will continue the manufacture of HCFC.

Navin Fluorine International Ltd. (NFIL): NFIL manufactures HCFC-22 in fluorochemical complexes in Surat and Dahej, Gujarat. In the refrigerant segment, the company has not invested in a new generation gas due to uncertainty over the successor of the refrigerant HCFC-22. Recently, NFIL has become the first chemical manufacturer in India to announce a technology licensing and supply agreement with Honeywell for production of HFO-1234yf in India, and is expected to begin domestic production in early 2017.

Hindustan Fluorocarbons Limited (HFL) – HFL manufactures HCFC-22 for use as feedstock for PTFE. HFL is also planning to convert one of its existing plants for the manufacture of HFC-32 after necessary modifications.

Chemplast Sanmar Limited – Chemplast produces HCFCs and markets them under the brand name Mettron. Chemplast is a part of Sanmar Group, a manufacturer of polyvinylchloride (PVC) resins, caustic soda, chlorochemicals, and refrigerant and industrial salt. The company is headquartered in Chennai, Tamil Nadu.

4.2 Freely available and soon-to-expire patents for refrigerants

Over the past three decades, many Indian companies have manufactured chemicals for which patents have expired or are freely available. In particular, HCFC-22 production is expected to be phased out soon. Table 1 shows the ownership of some alternatives under consideration as replacement refrigerants in the Indian market. HC-290 and HFC-32 are the only low- or mid-GWP refrigerants that have been commercialised in India's residential air-conditioning sector respectively.

Table 1: Selected Current and Emerging Alternative Refrigerants and Ownership of Patents

Refrigerant	Patent Type	Patents Description	Owner(s) / Applicant (s)	Filing Date
HFC-32	Production process	Improvement upon production process	Council of Scientific and Industrial Research (CSIR)	1999
HFO (hydrofluoroolefin)-1234yf	Production process	17 patents published, 4 patents granted	Honeywell	2008–2015
HC-290	-	-	Independent patent holders	2007–2014

HFC-32 – HFO Blend	Blends	Refrigerants containing HFC-32 and HFO-1234yf or 1234ze and other refrigerants	Honeywell (5 patents); Daikin (1 patent)	2010–2015
HFC-134a – HFO Blends	Blends	Refrigerants containing HFC-134a and HFO-1234yf, HFO-1234ze or other HFCs	Honeywell (3 patents); DuPont / Chemours (2 patents); Daikin (1 patent); Mexichem (7 patents)	2011–2015
Patents for refrigerants currently being manufactured by Indian companies				
HCFC-22	Application and Patented Blends	Refrigerant Blends, equipment design for low-temperature refrigeration, and equipment design	Independent patent holders (3 patents)	2005–2012
HFC-134A	Application and Patented Blends	Refrigerant Blends, equipment, and process patents	Arkema (3 patents); CSIR (2 patents); Daikin (1 patent); DuPont / Chemours (5 patents); Mexichem (6 patents); etc.	1999–2015

Source: Information compiled from http://ipindiaservices.gov.in/publicsearch/

4.3 New and emerging refrigerants and their patent ownership

Many new and emerging refrigerants are available in the market. Table 2 lists the new and alternative refrigerants available across sectors as well as the companies testing these chemicals.

Table 2: Sector wise new and emerging refrigerants

Baseline	Refrigerant	Composition	Company	GWP_{100}
Refrigerants used in the Commercial Sector for Air-Conditioning				
HFC-134a	AC5X	R-32/R-134a/R-1234ze(E)	Mexichem	622
	ARM-41a	R-32/R-134a/R-1234yf	Arkema	943
	D-4Y	R-134a/R-1234yf	Daikin McQuay	574
	N13a	R-134a/R-1234yf/R-1234ze(E)	Honeywell	604
	N13b	R-134a/R-1234ze(E)	Honeywell	604
	AC5	R-32/R-152a/R-1234ze(E)	Mexichem	92
	ARM 42a	R-134a/R-152a/R-1234yf	Arkema	117
	R1234yf	R1234yf	Various production patents; Honeywell application patent	<1
	R1234ze	R1234ze	Various	6
	R450A/ N13	R-134a/ R-1234ze	Honeywell	547
HCFC-123, HFC-134a	R1233ze	R1233ze	Honeywell	1
R410A (50% HFC-32/50% HFC-125	R-744 (carbon dioxide)	R-744	Generic	1 (reference chemical)
	ARM-70a	R-32/R-134a/R-1234yf	Arkema	482
	D2Y60	R-32/R-1234yf	Chemours	272
	HPR1D	R-32/R-744/R-1234ze(E)	Mexichem	407
	L41a	R-32/R-1234yf/R-1234ze(E)	Honeywell	494
	L41b	R-32/R-1234ze(E)	Honeywell	494
	R32/R134a	R-32/R-134a	patent expired	713
	R32/R152a	R-32/R-152a	patent expired	647
HCFC-22	ARM-32a	R-32/R-125/R-134a/R-1234yf	Arkema	1,577
	LTR4X	R-32/R-125/R-134a/R-1234ze€	Mexichem	1295
	D52Y	R-32/R-125/R-1234yf	DuPont/ Chemours	979
	L20	R-32/R-152a/R-1234ze(E)	Honeywell	331
	LTR6A	R-32/R-744/R-1234ze(E)	Mexichem	206
	R290	R290	Generic	<20
	R1270	R1270	Generic	<20

Baseline	Refrigerant	Composition	Company	GWP_{100}
Refrigerants used in the commercial sector for refrigeration				
HFC-134a	XP-10/ R513A	R-134a/R-1234yf	DuPont / Chemours	631
R404A	ARM-32a	R-32/R-125/R-134a/R-1234yf	Arkema	1577
	DR-33	R-32/R-125/R-134a/R-1234yf	Arkema	1,577
	N40a	R-32/R-125/R-134a/R-1234yf/R-1234ze(E	Honeywell	1,346
	N40b	R-32/R-125/R-134a/R-1234yf	Honeywell	1,331
	R744	R-744	Generic	1
	ARM-30a	R-32/R-1234yf	Arkema	199
	ARM-31a	R-32/R-134a/R-1234yf	Arkema	491
	D2Y65	R-32/R-1234yf	DuPont / Chemours	239
	DR-7	R-32/R-1234yf	DuPont / Chemours	246
	L40	R-32/R-152a/R-1234yf/R-1234ze(E)	Honeywell	285
	R-32	R-32	Daikin	675
	R-32/R-134a	R-32/R-134a	Out of patent	1,053
	R290	R-290	Generic	<20
	R452A	R-32/R-125/R-1234yf	DuPont / Chemours	2,141
	R449A	R-32/R-125/ R-1234yf/ R-134a	DuPont / Chemours	1,397
	N40/R448A	R-32/ R-125/ R-134a/ R-1234ze/ R-1234yf	Honeywell	1,273
HCFC-22	LTR4X	R-32/R-125/R-134a/R1234ze(E)	Mexichem	1,295
	N20	R-32/R-125/R-134a/R-1234yf/R-1234ze(E)	Honeywell	975
	R717	R717	Generic	<1
Refrigerants used in the domestic/residential sector for air conditioning				
R410A	DR-5	R-32/R-1234yf	DuPont / Chemours	490
	R32	R32	Daikin	675
	R-744	R-744	Generic	1
	ARM-70a	R-32/R-134a/R-1234yf	Arkema	482
	D2Y60	R-32/R-1234yf	DuPont / Chemours	272
	HPR1D	R-32/R-744/R-1234ze(E)	Mexichem	407
	L41a	R-32/R-1234yf/R-1234ze(E)	Honeywell	494
	L41b	R-32/R-1234ze(E)	Honeywell	494
	R32/R134a	R-32/R-134a	Out of patent	713
	R32/R152a	R-32/R-152a	Out of patent	647
	DR-55	HFO/HFC blend	Chemours	676
Refrigerants used in the domestic/residential sector for refrigeration				
R-134a	R-600a	R-600a	Generic	<20
	HC290/600a	R-290/R600a	Generic	<20

Source: Kapil Singhal (July 2015), ISHRAE Member and Independent Expert and manufacturers' websites

It is important to note that out of this list of alternatives being tested for various applications across sectors, there are relatively few alternatives (only 7 as per the list in Table 2) that are lower than GWP 100. Life Cycle Climate Performance (LCCP) is an important metric that accounts for both direct and indirect emissions, and hence is a superior metric compared to GWP for measuring the climate impact of any refrigerant. However, in terms of the various amendment proposals on the table, it is only GWP that will determine if an alternative is a long-term alternative or not. Most amendment proposals currently under consideration, including the amendment proposal moved by India, seek to transition towards low-GWP refrigerants in the long run. As a result, several alternative refrigerants under consideration may end up being medium-term solutions, requiring further innovation in the future towards finding lower-GWP alternatives and particularly towards achieving higher energy efficiency. Consider also that new technology that reduces life-cycle refrigerant emissions to near-zero would make GWP irrelevant to climate protection, as it would make ozone-depletion potential (ODP) irrelevant to ozone-layer protection.

Regardless of which alternatives emerge as substitutes to high-GWP HFCs, it is also worth noting that leading innovators and patent holders are foreign companies, none of the emerging alternative chemicals are being developed by any Indian company. Even the application of HC-290 to room ACs by Godrej is for a patent-free alternative, suggesting a lack so far of innovation by Indian chemical manufacturers, as discussed in more detail below. There is no public information indicating that the emerging alternative chemicals are being developed by Indian companies other than the partnership between NFIL and Honeywell, and SRF's recently announced plans for manufacture of HFO-1234yf through their in- house developed process.

4.4 Options available for Indian chemical manufacturers to move ahead

Based on the experience with earlier transitions, Indian chemical companies that seek to produce low- GWP HFCs, HFOs and their blends have four options. They can: (i) wait out the remaining years covered by a patent before they can use the information contained in it; (ii) move ahead with investing in research in developing their own unique process for producing the substance; (iii) acquire licenses to the technology from a company holding a patent; or (iv) participate in joint ventures.

Once the initial set of production patents began to expire, HFC-134a production expanded in Article 5 Parties, with a single producer in India and multiple producers in China.[1] Much of this production was not part of joint ventures, but was—and remains—locally owned. Some of these Article 5 Parties companies have developed their own patents for making HFC-134a. In India, the process patent for HFC-134a was developed by an Indian institution and the licence was bought by SRF. This happened mainly at a time when production patents for HFC-134a held by international companies were expiring. The production and use of HFC-134a increased in India, as during this transition there were no concerns related to application patents.

In India, SRF signed a binding agreement with DuPont in December 2014 to purchase its global 134a regulated medical pharmaceutical propellant business. Under the transaction, SRF received technology and know-how for setting up its own facility for the manufacturing of pharma-grade HFC-134a, as well as ownership of DuPont's Dymel brand. This transaction provides SRF immediate access to DuPont technology. It highlights another possible option available for Indian manufacturers to enter the production of low-GWP HFC alternatives through mergers and acquisitions (M&A). SRF also recently announced plans to setup up a pilot plant to manufacture HFO-1234yf using its own in-house developed chemical process. Another manufacturer, NFIL chose another route and recently announced plans to license proprietary process technologies for producing HFO-1234yf from Honeywell. NFIL will be manufacturing HFO-1234yf in India exclusively for Honeywell, and expects to begin limited production in early 2017.

Irrespective of the production patents, a growing concern is that even if Indian producers could patent their own production processes, they would not be able to sell the HFOs in India and abroad because of the broad-application patents held by foreign companies in respective geogrpahies.

1 SRF Limited began producing HFC-134a in 2006, and recently expanded its production capacity of HFC-134a from 4,500 metric tonnes per year to 17,000 metric tonnes per year. Transcript of SRF's Fourth Quarter Investor Conference Call.

5 Opportunities and challenges for Indian end-user companies

5.1 End use sectors and chemical applications in India

Indian end-use sectors are slowly moving towards HFCs as the use of HCFCs is phased out. The challenge is to devise a HCFC phase-down plan that begins with a HCFC phase-out in sectors where non-HFC options exist now (like foam) and over time to shift out of other sectors as low-HFC options develop and become more readily available. Negotiators from Article 5 Parties, however, will have to deal with the ambiguity related to the intellectual property rights issue for sectors where alternatives are not clear as of now.

The room AC sector has started shifting towards R-410A, with two manufacturers having commercialised ACs with R-32 and R-290.

Domestic refrigeration, unlike in some parts of the developed world, has already seen a major transition, and around 50 per cent of refrigerators sold in the Indian market today utilise hydrocarbons or hydrocarbon blends. Commercial heating, ventilation and air conditioning (HVAC) and refrigeration still rely on traditional alternatives like HFC-134a and HFC-410a, and the use of HCFC-22 is still predominant in these sectors. Several manufacturers active in India have HFO-based products available in international markets for the commercial sector.

The automobile air-conditioning sector in India already utilises HFC-134a, as do some other sectors like domestic refrigeration and chillers.

As per information from car manufacturers, the earlier transition towards HFC-134a was not challenging due to the following reasons: (i) Supply of R-134a was not an issue as there was enough domestic manufacturing of this refrigerant at the time of the transition. Had the refrigerant not been manufactured domestically, the Indian auto industry might not have been an early mover; (ii) The price of the refrigerant was not an issue; and (iii) There was no application patent in place or was there any related ambiguity over the use of domestically manufactured R-134a in Indian cars.

The alternative that is being discussed most widely at present is R-1234yf, which is not manufactured domestically as of now. The long-term price of this refrigerant is expected to be very high (7–8 times) compared to R-134a, and there is also significant ambiguity around the issue of application patents. The current price of R-1234yf in the Indian market is almost 20 times the current price of R-134a.[vi] However, it should be noted that currently, Indian companies produce a very small number of R-1234yf based vehicles, mainly for export markets.

A small number of manufacturers in India have begun experimenting with HFC-152a, CO_2, and HFO-1234yf as alternatives to HFC-134a, but these solutions are not yet available commercially and are also costly.

In foam applications, low-GWP hydrocarbon alternatives offer superior efficiency, and constitute 50 per cent of the blowing-agent market. The remaining 50 per cent utilise HCFCs, and these applications could move to HFC-152a, HFC-134a, or HFO-1234ze.

5.2 Options Indian companies have to move ahead

Traditionally, equipment manufacturers in India have waited for chemical manufacturers to invest in, and find, the "appropriate" chemical for a given sector and application. Recently, however, some large equipment manufacturers have also started investing in the R&D of refrigerants. Another driver for innovation is that equipment manufacturers need to invest in design changes to maximise the effectiveness and efficiency of new refrigerants in their equipment.

Currently, there is a single low-GWP alternative that is freely available and commercialised: HC-290 (propane). Godrej, the company that has commercialised this refrigerant in room ACs, also has redesigned the equipment. No application patent is required for adopting this refrigerant, although there are many patents on the components using HC-290 and other natural refrigerants. There are, however, concerns related to the flammability of this refrigerant, as per a section of industry stakeholders and representatives. These concerns need to be independently evaluated. Apart from this chemical, the other option for Indian companies is HFC-32.

HFC-32 is, however, not a long-term solution given its medium GWP (675), unless it achieves sufficiently higher energy efficiency than lower-GWP alternatives to offset any refrigerant emissions. Nevertheless, research and innovation on alternatives are taking place rapidly in the developed-country markets.

In European, Japanese, and North American markets, mobile air conditioning is the first sector that is shifting to HFOs due to the regulations in the European Union requiring refrigerants with GWP<150, regulations in Japan requiring HFC phase-down, and incentives in the USA rewarding a shift to low-GWP refrigerants and prohibiting HFC-134a in new vehicles after 2021. Mobile air conditioning has been a significant end-use sector for HFC-134a. There has been a huge shift in these countries, with all companies moving towards the use of HFO-1234yf. However, as highlighted above, a challenge for Indian manufacturers is the Honeywell application patent for certain uses of HFO-1234yf, including mobile air conditioning. [2] Other current and potential producers have challenged this application patent. While the EU has withdrawn its approval of the application patent, lawsuits filed in the EU and the USA are being fought in the courts.

Currently, the main option for Indian equipment manufacturers is to proactively engage with the manufacturers of potential alternatives and start testing the alternatives in the laboratory or in the field. Maruti-Suzuki and Tata have already built and tested vehicles with HFO-1234yf, and Subros and other Indian auto ancillary equipment providers are conducting tests with HFO-1234yf. Tata Motors has built and tested secondary-loop vehicle ACs and will soon demonstrate this technology with both HFO-1234yf and HFC-152a. The costs of patented technologies and licensing have been included in the costs of purchasing technology as part of the costs of a project. However, with the increasing use of application patents, the issue is important for deciding future actions under the MLF. There is also growing concern that overlapping patents (known as patent thickets) on aspects of production and use could slow down or impede the transition away from HFCs. While these have not proven to be a significant obstacle in past transitions, due largely to confidential licensing agreements between companies, the increased role being played by application patents could create new difficulties for Article 5 companies and for the MLF, unless similar licensing agreements are created.[3]

6 Innovation, patents, and learning for policy makers

Indian policy makers have emphasised the need for Indian industry to invest in research, development, and innovation. Because most of the alternatives to high-GWP HFCs are being developed by foreign companies with corresponding patents, the issue of patents and patent costs becomes a major point in discussions on the phasing down of HFCs in India. However, the transition to low-GWP HFCs offers Indian industry an opportunity to ramp up innovation and catch up with their industry peers in developed and emerging economies. To ramp up domestic efforts on alternatives, the Indian government recently announced a new R&D program in September 2016, which would help develop next generation refrigerant technologies.[vii]

Since most Indian refrigerant-manufacturing companies also manufacture other chemicals, these companies have their own R&D facilities. The R&D teams across these companies have developed and implemented various process-upgrade methods and other technologies in laboratories as well as plants. However, there has been no success in the development of any major refrigerant alternatives

2 US 8033120 and US 8065882 were filed by Honeywell in 2009 and published in 2011. They cover a wide range of uses of HFOs, including refrigeration, air conditioning, foams, and aerosols.

3 There is also growing concern that overlapping patents (known as patent thickets) on aspects of production and use could slow down or impede the transition away from HFCs. While these have not proven to be a significant obstacle in past transitions, the increasingly important role being played by application patents could create new difficulties for Article 5 companies and for the MLF.

to HFCs by any Indian company yet. The processes for refrigerants that historically and currently are being consumed and traded in the largest quantities globally have been patented by companies from the developed world.

Indian policy makers need to think about two important issues related to innovation and patents:

Covering patent cost through MLF: The MLF offers financial support for the transition of chemicals in Article 5 Parties in a few key ways. It provides financial support for lost profits for companies that need to phase out the production and consumption of ODSs. It also envisions the potential for paying for patents and incremental costs of royalties, as well as for research in adapting technology to local conditions. The MLF guidelines under certain circumstances allow funding for R&D (i.e., where it can be shown to be incremental),[viii] although the question remains whether the MLF would require any intellectual property that results from such research to (1) be public property and be available to all without licensing fees; (2) be MLF property that is made available free to companies in A5 Parties, but licensed to companies in non-A5 Parties; or (3) the property of the organisation that is granted the patent regardless of who sponsored the work.[ix]

Common R&D pool: Some Indian policy makers have suggested setting up a common R&D pool dedicated to the accelerated development of climate-friendly technologies. For the HFC phase-down, there could be a global common R&D pool, which could be funded through the MLF.

The MLF funding the establishment of a publicly held patent pool, thereby allowing the right to use a patent across the projects that it funds within a single Article 5 Party and across all Article 5 Parties, would be a powerful approach. This approach, however, needs to be evaluated, as it falls under the existing guidelines of the MLF, but has not yet been used to assess its commercial viability and cost-effectiveness to the MLF. Under such a global effort, the incentive for private companies with the requisite technical know-how to participate would be the fees paid by the MLF for any intellectual property rights. Generally, it is the government R&D institutions and laboratories across countries that have collaborated in such efforts undertaken in other sectors. Defining the structure of such an R&D pool, and determining how the fruits of its labour would be distributed, would necessarily be a fine balancing act, and in the end will determine the form, functionality, and potential success of such an effort.

Conclusion

Patents are complex and challenging to understand for both policy makers and civil society experts. This paper highlights challenges in the Indian context and makes key findings available as a means to engage industry, government and civil society stakeholders in discussion. Over the course of the year, the authors will garner feedback from a wide range of stakeholders and fine tune recommendations to arrive at actionable next steps.

First, in the context of the phase-down of ozone-depleting substances (ODSs) under the Montreal Protocol and its implementation in India and other developing economies, patents have historically not proven to be an obstacle to expanded production of chemicals in developing countries. Moreover, with the Montreal Protocol's grace period, where developed countries transition first before developing countries, patents are often expired and the previously patented technology has been widely available globally at the time when developing countries begin their transition.

Second, several options exist for Indian refrigerant manufacturing and end-use sector companies to address the patent through joint marketing ventures, acquiring licenses for domestic production, mergers and acquisitions as well as using license agreements without charge as in the case of Daikin's action on HFC-32 for room ACs.

Third, application patents are increasingly becoming a cause for concern for Indian equipment manufacturers, and it is important to have clarity on the issue for the Indian industry.

Fourth, based on examination of earlier transitions, to some extent the Montreal Protocol's Multilateral Fund (MLF) has compensated for the cost of licenses and access to patented technologies. Further evaluation is needed to assess if a licensing arrangement supported by MLF can be used as a way to address the application patent barrier.

Fifth, investment in research and development (R&D) for fostering innovation is a central way for Indian companies to be ahead in the long run and Indian companies need to seriously consider becoming global leaders in developing new processes and technologies irrespective of government support.

Sixth, the Indian government can support developing a global alliance for a common R&D pool for climate friendly technology and solutions, along with supporting innovations since developing low GWP refrigerants that satisfy key technical criteria is an important near term objective of global community.

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