Examining Patents for Alternatives to Hydrofluorocarbons in India

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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 find a solution to the patent debate. Rather, it examines developing country experiences in dealing with patents during earlier transitions under Montreal Protocol as well as highlights the key issues faced by Indian industry and policy makers, making the following key findings:

First, in the context of the phaseout 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.

Introduction

India is one of the fastest growing major economies in the world. Given the rising middle class, increased urbanization and electrification, and increasing temperatures in an already long, hot and humid climate, the vehicle, commercial and residential sectors are expanding the use of air conditioning. This expansion stresses energy supply and increases air and water pollution levels. Improving air conditioning to be less polluting and more efficient is a significant opportunity to strengthen the power sector and tackle climate change. In particular, shifting away from hydrofluorocarbons (HFCs), potent heat trapping gases used as refrigerants in air conditioning, to more energy efficient, lower global warming potential (GWP) alternatives is an immediate opportunity to achieve the Indian Government's goals to build a low carbon economy. Many countries around the world are moving away from HFCs and support a global phase down of HFCs under the Montreal Protocol. Resolving the costs of patents and intellectually property involving HFC alternatives in the market is a key issue in the discussions on achieving a global phase down.

BOX: ENERGY EFFICIENCY CO-BENEFITS OF PHASING DOWN HFCs

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 transition to environmentally superior alternatives for end use sectors. A 2014 analysis by 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% energy savings over a business-as-usual scenario, contributing to reductions of 31-38% in the global warming foot- print of the residential AC sector in India. For use in room ACs, R-290, R-32, and other low- and medium-GWP HFC/HFO blends are being demonstrated to provide superior energy efficiency performance. For use in automobile ACs, both HFO-1234yf and HFC-152a have demonstrated increase 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 Framework Convention on Climate Change (FCCC) and its Kyoto Protocol and Paris Accords with GWP up to thousands of times that of carbon dioxide. Over 108 Parties, including 54 African Parties, support phasing down 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 regulations. Global markets are equally active in phasing down HFCs.

India's long-term HFC emissions are expected to contribute to 5.4% of the entire economy's total global warming impact in 2050 – and a large contribution of this would result from HFC use in room and vehicle air conditioning. For major emitting sectors such as mobile air conditioning, residential cooling and commercial refrigeration, direct HFC emissions constitute a majority of total global warming impact of the respective sectors, reaching up to 50% in case of commercial refrigeration. In order to arrest runaway growth is use of high GWP HFCs, the Indian government submitted an amendment proposal to the Montreal Protocol, demonstrating its support for a global HFCs phase down.

In discussing an amendment, some in Indian industry have raised concerns that cost of licensing and acquiring patents and intellectual property barriers may prove to be an impediment and slow the pace of transition to lower GWP HFCs, placing Indian companies at a competitive disadvantage. The patent issue has become one of the important criteria along with other policy and technical challenges like baseline, safety, and energy efficiency. Patents are a complex issue, and this paper attempts to understand and highlight the key concerns for the Indian industry and policy makers. We do not attempt to find a solution to the patent debate. Rather, we examine developing country experiences in dealing with patents during earlier transitions under Montreal Protocol, as well as highlight the key issues that various stakeholders are facing in the impending transition.

Background on Patents and Intellectual Property

Patents are a form of intellectual property 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 publically disclose innovative technical knowledge at the time the patent is published, however, that others can use the information only after the patent has expired.[i]

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

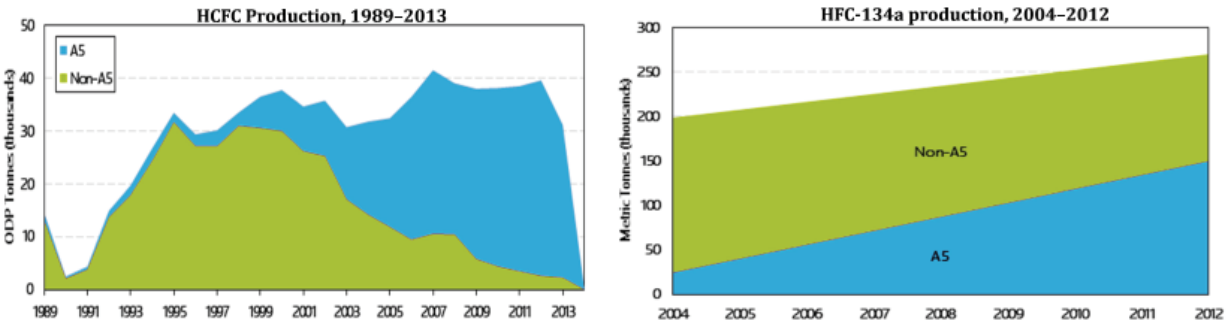
In India, patents are granted on basis of three key criteria: 1) The invention must be new, and the product or process must be original and such an invention must not have been used before; 2) The invention must involve an inventive step, and not be obvious to a person of normal skill in the particular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

In the context of refrigerants, patents can be broadly classified into three categories: (i) *process or production patents* for manufacture of chemicals, (ii) patents for compositions which includes blends of two or more chemicals in a specific ratio, and (iii) *application patents* for 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 on end use components like compressors or valves used in end use equipment.

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 as 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 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 India producers come up with their production processes they won't be able to sell their products because of application patents held by transnational companies. A review of earlier transitions under the Montreal Protocol shows that historic shifts

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



to patented alternatives did not result in reduced production in developing countries, nor did it result in increased imports or costs of these products in developing countries. Furthermore, only a small portion of the technology that replaced ODSs was patented. It should be highlighted that in the past, application patents were not the concern, however in the current transition, application patents have emerged as a big concern for Indian stakeholders.

Figure 1: Historical HCFC and HFC-134a production in A5 and non-A5 Parties shows how production of HCFC and HFC-134a has evolved historically. Until 1995, when 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 had shifted from non-A5 to A5 Party countries.

Similarly, for HFC-134a, widely used to replace 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 involved. By 2012 however, more than 50% of HFC-134a production was in Article 5 Parties, the increase largely happened as patent on this refrigerant expired by 2005.

The CFC transition also demonstrates the interplay between policy decisions to limit chemical use, patents, and 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 the year 1988 by technical experts that commercialization of alternatives would take a minimum of five years. A number of additional producers had opened commercial-scale production facilities over the next four years and volume had increased to 50,000 metric tonnes and was doubled again three years later.[iii] The rapid increase in the demand was met by expanding production, as the regulatory restrictions on CFCs took effect in many developed countries and lead to voluntarily shift to alternatives by many companies in advance of regulatory controls. The global 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 cased in almost every country, including India.

Similarly, the number of producers and percentage of production of HFC-134a in Article 5 Parties, particularly in 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 shows that production patents have not impeded refrigerant production in Article 5 Parties.

Opportunities and challenges for Indian chemical manufacturers

About Indian chemical manufacturers

The Indian chemical manufacturing sector has grown 13-14% in the last 5 years while petrochemicals have registered a growth of 8-9% 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 account over half of 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% 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 in Rajasthan. SRF has also announced its plan 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 the year 2007 at Dahej, Gujarat. GFL primarily used to manufacture CFCs & HCFCs, and now manufactures HCFC as feedstock for Polytetrafluoroethylene (PTFE), an engineered plastic best known as Teflonâ by Chemours (previously DuPont), it will continue manufacture of HCFC.

Navin Fluorine International Ltd. (NFIL): NFIL manufactures HCFC-22 in fluorochemical complexes in Surat and Dahej, Gujarat. 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.

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 manufacture of HFC-32 after necessary modifications.

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

Freely available and soon to be expired patents for refrigerants

Over the past three decades, many Indian companies have manufactured chemicals for which patents are expired or are freely available. In particular, the 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 GWP refrigerants that have been commercialised in India's residential air-conditioning sector.

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	1999
HFO (hydrofluoroolefin) -1234yf	Production Process	17 patents published, 4 patents granted	Honeywell International Inc	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 International (5 patents); Daikin (1 patent)	2010-2015
HFC-134a - HFO Blends	Blends	Refrigerants containing HFC 134a and HFO 1234yf, HFO 1234zf or other HFCs	Honeywell (3 patents); DuPont / Chemours (2 patents); Daikin (1 patent); Mexichem Industries (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/

New and emerging refrigerants and their patent ownership

There are many new and emerging refrigerants in the market. The table below gives a list of new and alternative refrigerants 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 Mc Quay	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, HFC134a	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	1577
	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
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	DuPont / Chemours	1410
	N40a	R-32/R-125/R-134a/R-1234yf/R-1234ze(E	Honeywell	1346
	N40b	R-32/R-125/R-134a/R-1234yf	Honeywell	1331
	R744	R-744	Generic	1
	ARM-30a	R-32/R-1234yf	Arkema	199

Baseline	Refrigerant	Composition	Company	GWP_{100}
	ARM-31a	R-32/R-134a/R-1234yf	Arkema	491
	D2Y65	R-32/R-1234yf	Du Pont / 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	1053
	R290	R-290	Generic	<20
	R452A	R-32/R-125/R-1234yf	Dupont / Chemours	2141
	R449A	R-32/R-125/ R-1234yf/ R-134a	Dupont / Chemours	1397
	N40/ R448A	R-32/ R-125/ R-134a/ R-1234ze/ R-1234yf	Honeywell	1273
HCFC-22	LTR4X	R-32/R-125/R-134a/R1234ze(E)	Mexichem	1295
	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 the direct and indirect emissions, and hence is a superior metric compared to GWP for measuring the climate impact of any refrigerant. However from the perspective 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 Indian amendment proposal – 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 lower GWP alternatives and particularly higher energy efficiency. Consider also that new technology that reduced 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. A near-zero emission also makes safer the use of toxic and flammable refrigerants safer.

Regardless of which alternatives emerge as substitute to high GWP HFCs, it is also worthwhile noting that leading innovators and patent holders

are foreign companies. 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.

Options Indian chemical manufacturers to move ahead

Based on the experience with earlier transitions, Indian chemical companies that seek to produce low GWP HFC, HFOs and their blends have four options. They can: (i) wait the remaining portion of the years covered by a patent before they can utilize 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 companies have developed their own patents for making HFC-134a. Within India, the process patent for HFC-134a was developed by an Indian institution and the license was bought by SRF. This happened mainly at a time when production patents for HFC-134a held by international companies were expiring. Production and use of HFC-134a increased in India as during this transition there was no concern related to application patents.

Within 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 manufacturing pharma grade HFC 134a, as well as ownership of DuPont's Dymel brand. This transaction provides SRF immediate access to DuPont technology, and highlights another possible option available for Indian manufacturers to enter low-GWP HFC alternative production through merger and acquisition. 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.

Irrespective of the production patents, a growing concern is that even if Indian producers could patent their own production processes that they wouldn't be able to sell the HFOs in India because of the broad application patent by foreign companies.

Opportunities and challenges for Indian end user companies

End use sectors and chemical applications in India

Indian end use sectors are slowly moving towards HFCs as use of HCFCs is phased out, the challenge is to devise a HCFC phasedown plan that begins with 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. Negotiators from Article 5 parties however will have to deal with the ambiguity on 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 commercialized ACs with R-32 and R-290. Domestic refrigeration, unlike in some parts of the developed world, has already seen a large transition and around 50% of refrigerators sold in the Indian market today utilise hydrocarbons or hydrocarbon blends. The commercial heating, ventilation and air conditioning (HVAC) and refrigeration still relies on traditional alternatives like HFC-134a

1 SRF Limited began producing HFC-134a in 2006 and recently expanded its production capacity of HFC-134a from 4500 tons per year to 17,000 tons per year. Transcript of SRF's Fourth Quarter Investor Conference Call.

and HFC-410a while use of HCFC-22 is still predominant in those sectors. At least one manufacturer has HFO based product available in the market for commercial sector.

The automobile air-conditioning sector in India already utilises HFC-134a. As per information from car manufacturers, the earlier transition towards 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 transition. If the refrigerant was not domestically manufactured, the Indian auto industry might not have been an early mover; (ii) Price of the refrigerant was not an issue, and (iii) There was no application patent or any related ambiguity over the use of domestically manufactured R-134a in Indian cars.

The alternative that is being most discussed currently is R-1234yf which is expected to be manufactured by end of 2016, however, the longer time price of this refrigerant is expected to be very high (7-8 times) compared to R-134a, and there is significant ambiguity around the issue of application patents. Current price of R-1234yf in the Indian market is almost 20 times the current price of R-134a.

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 costly. In foam applications, low-GWP hydrocarbon alternatives offer superior efficiency, and constitute 50% of the blowing agent market. The remaining 50% utilise HCFCs, and these applications could move to HFC-152a, HFC-134a, HFC-245fa or HFO-1234ze.

Options for 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 research and development of refrigerants. Another driver for innovations is that equipment manufacturers need to invest in design changes to maximize the effectiveness and efficiency of new refrigerants in their equipment.

Currently, there is a single low-GWP alternative that is freely available and commercialized: HC-290 (propane). Godrej, the company that has commercialised this refrigerant in room ACs, also has redesigned the equipment. There is no application patent required for adopting this refrigerant, although there are a considerable number of patents on the components using HC-290 and other natural refrigerants. 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. However, research and innovation on alternatives is rapidly occurring in developed markets.

Mobile air conditioning is the first sector shifting to HFOs in European, Japanese, and North American markets, due to the regulations in the European Union requiring refrigerants with GWP<150, regulations in Japan requiring HFC phase down, and incentives in the United States rewarding a shift to low-GWP refrigerants and prohibiting HFC-134a in new vehicles after 2021. It has been a significant end use sector for HFC-134a. There has been a huge shift in these countries, with all companies moving toward 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 EU and the US are being fought in courts.

Currently, the main option for Indian equipment manufacturers is to proactively engage with manufacturers of potential alternatives and start testing the alternatives in lab or in field. Maruti Suzuki, and TATA have already built and tested vehicles with HFO-1234yf and Subros and other Indian auto ancillary equipment providers – are

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

conducting tests with HFO-1234yf. TATA Motors Limited (TML) 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 a project's costs and so far, the projects with application patents have not been a significant hindrance under the MLF. However, with increasing use of application patents, the issue may hold importance deciding future actions under the MLF.[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, 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.

Innovation, patents, and learning for policy makers

Indian policy makers have emphasized the need for Indian industries 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 main issue in discussing phasing down 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.

Since most of the Indian refrigerant manufacturing companies also manufacture other chemicals, these companies have R&D facilities. The R&D teams across these companies have developed and implemented various process upgrade methods and other technologies in laboratory as well as plants.

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 increased role being played by application patents could create new difficulties for Article 5 companies and for the MLF.

However, there has been no success in development of any major refrigerant. 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. The MLF provides financial support for lost profits for companies that need to phaseout the production and consumption of ODSs. The MLF also envisions the potential for paying for patents and incremental costs of royalties, as well as, for research in adopting technology to local conditions. The MLF guidelines under certain circumstances allow funding for research and development (i.e. where it can be shown to be incremental[vi]) although the question remains, whether the MLF would require any intellectual property that results from such research to 1) be public property and available to all without licensing fees, 2) be MLF property free to companies in A5 Parties, but licensed to companies in non-A5 Parties, or 3) the property of the organization granted the patent regardless of who sponsored the work. .

Common R&D pool: Some Indian policy makers have suggested a common R&D pool dedicated to 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 withholding the approach of funding the creation of a publically held patent pool - allowing the right to use a patent across projects it funds within a single and across all the 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 utilized in order to assess its commercial viability and cost effectiveness to the MLF. Under such a global effort, the incentive for private companies with the technical knowhow to participate would be the fees paid by the MLF for any intellectual property rights. Generally speaking, it is the government R&D institutions and labs across countries that have col-

laborated in such efforts undertaken in other sectors. The structure of such an R&D pool, and how its fruits are distributed would 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.

(Endnotes)

i WIPO, World Intellectual Property Organisation. Frequently Asked Questions. http://www.wipo.int/patents/en/faq_patents.html *Last accessed online on 12 January, 2016.*

ii WIPO, World Intellectual Property Organisation. PCT – The International Patent System. http://www.wipo.int/pct/en/ *Last accessed online on 12 January, 2016.*

iii AFEAS 2007. Production and Sales Data, Alternative Fluorocarbons Environmental Acceptability Study (AFEAS). http://www.afeas.org/data.php *Last accessed online on 12 January, 2016.*

iv UNEP Ozone Secretariat. Background Material for HFC-Intercessional Informal Consultations: Funding Issues on the Feasibility of Managing HFCs. Inter-sessional informal meeting, 12-13 June 2015.

v Federation of Indian Chambers of Commerce and Industry http://ficci.com/sector/7/Project_docs/Chemical-Petrochemical-sector.pdf *Last accessed online on 12 January, 2016.*

vi United Nations Framework Convention on Climate Change, http://unfccc.int/files/essential_background/background_publications_htmlpdf/application/pdf/conveng.pdf. *Last accessed online on 12 January, 2016.*

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