Natural Refrigerants in Indonesia : Challenge and Opportunity
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ABSTRACT

This paper presents the review of Indonesian country program after ratification of the Vienna Convention for the Ozone Layer and the Montreal Protocol on Substances that deplete the Ozone Layer in 1992 for refrigeration sector. Through this ratification Indonesia committed itself to phase out ODS by the end of the year 2010. The possibilities of using several natural refrigerants, e.g. Hydrocarbons and Carbon Dioxide are compared to be applied as alternative refrigerants for refrigeration applications in Indonesia. Non technical aspects are also presented as the important subjects for succeeding Indonesia country program.

Keywords: Natural refrigerants, ozone layer, hydrocarbons, carbon dioxide, refrigeration

1. Introduction

The impact of ozone depletion and global warming (more accurately, climate change) for refrigeration technology is very serious. Since the refrigerant play an important role for refrigeration system, its phase-out can influence and follow on consequences of trying to develop the new technology. Indonesia as a country with a big population and its nowadays economic situation, the phase out of the existing refrigerants and use of proper refrigerants will impact on country's future especially on economic and the environmental issues.

2. Ozone Depletion and Global Warming 'Myth'

After the publication of Molina and Rowland in Nature 1974 [1] which proposed that the emission of the chlorinated man-made chemicals to the atmospheric ozone could damage the stratospheric ozone layer. Subsequently, an extensive worldwide program of stratospheric ozone monitoring has confirmed that there is a pattern of depletion which is most pronounced over the Antarctic during springtime.

As a consequence, a series of intergovernmental agreement have been formulated started from 1985. One of them is the Montreal Protocol and its adjustments came measures to reduce the production and the use of the material with high ozone depletion potential (ODPs).

The ozone depletion process begins when ozone-depleting substances are released, usually near ground level. Winds efficiently mix the troposphere and evenly distribute the gases. The man-made refrigerants are extremely stable, and they do not dissolve in rain. After a period of several years, theses molecules reach the stratosphere, about 10 kilometers above the Earth's surface. In the stratosphere, strong ultraviolet (UV) light breaks apart the this molecule to yield very reactive chlorine atoms (radicals). It is these reactive chlorine atoms, and not the intact molecule of this refrigerant, that actually destroy ozone. It is estimated that one chlorine atom can destroy over 10,000 ozone molecules before finally being removed from the stratosphere. Ozone is constantly being produced and destroyed in a natural cycle. Large increases in stratospheric chlorine, however, have apparently upset that balance. In effect, chlorine atoms remove ozone faster than natural ozone creation reactions can keep up. Therefore, ozone levels fall. Because ozone filters out harmful UVB radiation, less ozone means higher UVB levels at the earth's surface. The more ozone depletion, the larger the increase in incoming UVB.

The second major environmental concern is climate change or global warming. This did not become a major area of attention until after responses to ozone depletion had been initiated. Concerns on this issue are now beginning to complicate our handling of ozone depletion.

Global warming arises because of the green house effect (Fig. 1). The frequency distribution of the radiation coming from the sun closely approximates that from a black body at a temperature of about 5800 K. The spectrum wavelengths range from less than 1 nm to hundreds of meters; the peak in the spectrum is in the visible region at about 500 nm. When solar radiation ($1360 Wm^{-2}$) arrives at the earth, about 30% is reflected back into space and most of the remainder passes through the atmosphere to the ground. This heats up the earth, which then behaves approximately as a black body, radiating energy with a spectral peak in the infra red. This infra red radiation cannot pass through the atmosphere because of absorption by water vapor, carbon dioxide and other infra red absorbers. As a consequence, heat energy is trapped and the temperature at the surface of the earth is higher than it would be without the insulating blanket of the atmosphere [2].

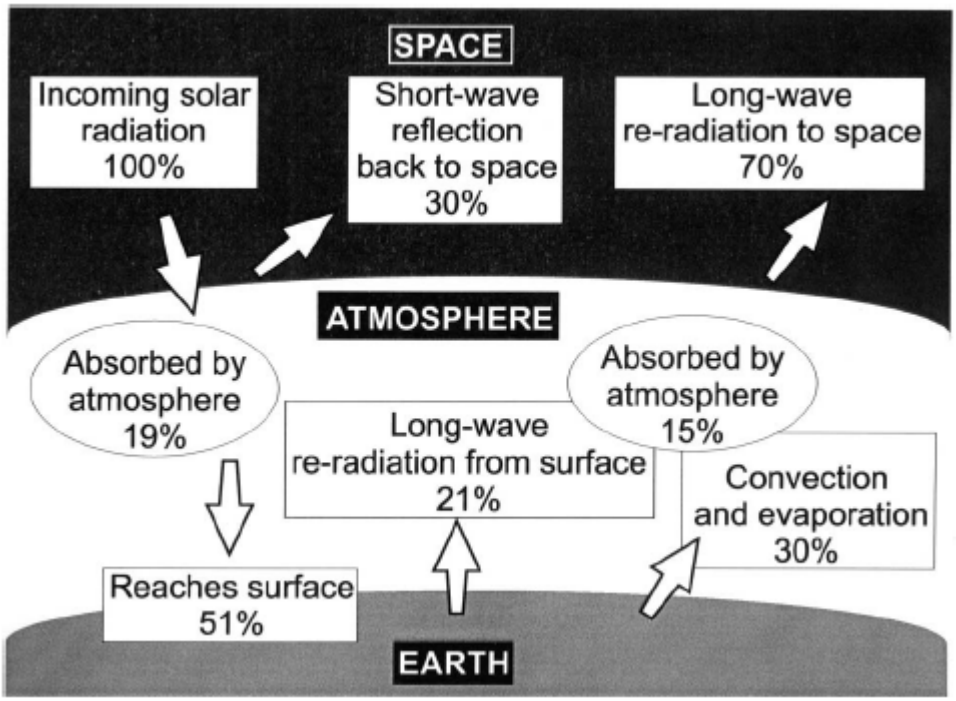

Fig. 1. The origin of global warming and the greenhouse effect

There is conflict between different ways of measuring global temperatures. Surface measurements indicate that global temperatures are rising, but satellite measurements made over the last 20 years show no such increase, even after correction for orbit variation (Fig. 2). The surface measurements are made at land based stations scattered over the globe and are supplemented by surface water temperature data to represent the oceans. There has been extensive criticism of the accuracy of this data for a variety of reasons such as heat island effects, the patchy and unrepresentative coverage of the measuring stations, the poor data record in some cases, and the fact that the ocean surface temperature measurements do not actually report air temperature, but are taken at water depths of 1-20 m depending on where ship intakes are located. The satellite measurements use microwave sounding units (MSUs) to record the microwave emissions from oxygen in the atmosphere and translate this into a vertical profile of atmospheric temperatures. As the satellites cross the entire surface of the earth over a period time, the global coverage is complete. Separate profiles are available for the troposphere and the stratosphere, and both show little change over the last 20 years. Balloonborne radiosonde measurements are consistent with the satellite data. The satellite measurements also show that the temperature structure of the atmosphere is much more complicated than is assumed in the model of computer simulation which used as basic for our today's global warming prediction.

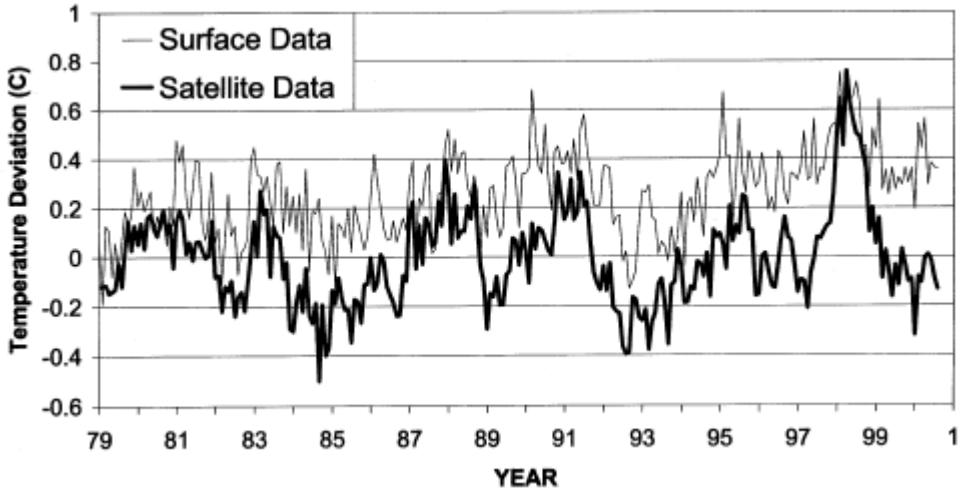

Fig. 2. Comparison of satellite (lower troposphere) and surface temperature measurements for January 1979-April 1999. [3]

Despite the unsatisfactory nature of the scientific debate, a public consensus has appeared which has driven large-scale government activity to reduce greenhouse gas emissions. So far, the emphasis has been on carbon dioxide from combustion, but the net is now being widened to include methane and refrigerants. The refrigeration industry is beginning to be influenced by these effects.

3. Implications for Refrigeration Sector in Indonesia

Based on the above explanations and from the "no regrets" policy, the use of non-man-made refrigerants or "natural" refrigerants as alternative is the option for the solutions. And also as consequence of our ratification of the Vienna convention and Montreal Protocol, Indonesia has to make country program to formulate and implement it.

Many alternative substances for ODS are proposed in the Indonesian country program for refrigeration sector. Hydrocarbon as an alternative has been introduced in the last few years to the market and to domestic and small commercial refrigeration applications in Indonesia. The possibility of another refrigerant is also an interesting alternative to be considered for Indonesia, namely Carbon dioxide (CO_2).

3.1 Hydrocarbon

The possible use hydrocarbons as a working fluid in systems for commercial refrigeration, chillers is well known, but it is not yet entirely common. Acceptance differs in different part of the world. Hydrocarbon fluids are generally as environmentally benign. The (only) problem is their flammability. Some data in relation to the their flammability show that the concentrations in atmospheric air for the most frequently used hydrocarbons (propane and iso-butane) require significantly lower ignition energy. They also have a much higher heat of combustion [4].

The safety issues must be taken seriously and limit the possibilities for a general wide use of hydrocarbons. There is always a fear of the unknown, while we can easily accept an "old well known risk". Indonesian already has national standard regarding this issues. The public attitude at all segments toward the use of the hydrocarbons as refrigerants is a matter of education, discipline and consistency. Have a better understanding of the safety aspects of Hydrocarbon refrigerants can support the achievement of its goal, i.e. environmental issue.

The economic situation nowadays in Indonesia could decrease the attentions of the safety aspects, because the first step to change the attitude is with educational training. People should not only think economical value of this national program but also parallel to safety and environmental portions. The need of international cooperation especially for funding this training is very essential, for example the International NGO Swisscontact. They have for many years participated in Indonesia to success the hydrocarbons campaign as alternative refrigerants.

The discomfort of using hydrocarbons as refrigerant must be handled in a proportional manners. Before using as refrigerant, we have already used hydrocarbons in our daily activities and in general applications such as the heating fuel in gas ovens, as aerosol fillers, as a blowing agent for insulation foam etc. For a domestic and small commercial application e.g. household refrigerator, automotive air conditioning, the use of hydrocarbon as refrigerant does have a huge risk if we follow their standard procedures. The overreaction of the safety in hydrocarbons can set back our national and international program. It does not mean that we do not care about the safety aspects especially for the system with medium and extensive refrigerant charge. Based on the author experience, the service sector as about 60% [5] of using ODS must be taken into account for our national program, the major part of this sector is not well-trained people in relation with safety in the refrigeration area and they need a better training concept and awareness in parallel with marketing the hydrocarbons.

Since the characteristics of the refrigeration system depends on its refrigerants and in order to have complete understanding of this refrigerant, the standardization of the product in Indonesia is very crucial. Hydrocarbons refrigerants sometimes does not consist of single fluid like CFC. Different product could have different compositions and it could have difficulties in technical service, engineering design and also to solve their problems.

From economic point of view, one interesting research has been conducted in University of New South Wales, Australia [6]. A methodology for predicting the economic and environmental impact of various CFC-replacement policies in eastern and southern Asia. Although the research only paying attention on car air-conditioning case (lack of accuracy of prediction has been found such as underestimation of Indonesian population around 179 million at 1990), it is trying to making correlation between per capita income, population growth, as well as vehicle ownership. It reveals that the use of hydrocarbons instead of HFC as CFC replacements in vehicle air condition can bring about significant savings in refrigerant cost, and a smaller but still significant reduction in greenhouse potential. Indonesia has huge resources of natural gas including hydrocarbons, with this capital we could not have a big problem with the availability and to penetrate the market with a lower price without importing from other countries like CFC, HCFC etc.

The study indicates that hydrocarbon automobile air-conditioners are almost 35% more efficient than HFC air conditioners and that if countries in Asia used hydrocarbons instead of HFCs in automobile air-conditioners there would be 3.7 billion tonnes less cumulative CO_2 emissions by the year 2020.

Since 1992, hydrocarbon refrigeration has increasingly penetrated the domestic markets in Western Europe. 100% of German industry has now converted to hydrocarbon technology. Outside of Europe, hydrocarbon refrigerators are now sold in Argentina, Australia, Brasil, China, Cuba, India, Indonesia and Japan. It is estimated that in China Green-freeze now represents over 50% of production for the total domestic market of 10-12 million units [7]. These developments will most likely have significant reverberations in the markets of South-East Asia and possibly even in North America. Japanese industry plays a dominant role in South East Asia, and Japanese style refrigerators are similar in size and features to North American products.

The government participation for this national program plays an significant role. Without any regulation and their supporting, it will be hopeless and unrealistic. The government must prevent the black market and associated illegal traffic of ODS refrigerants as well as exporting of the refrigeration equipment which use ODS from other countries.

3.2 Carbon dioxide

Another natural refrigerant is carbon dioxide. The utilization of using carbon dioxide in refrigeration of small commercial scale also emerged. Carbon dioxide can be used as refrigerant, which will deliver relatively small pressure ratio (ratio of discharge to suction pressure) while pressure difference (the value) is rather high [8]. As carbon dioxide has lower critical point (compare to the other common refrigerant), condenser will be replaced by gas cooler as the system releases heat in transcritical region.

Although until now this technology is not yet low-priced, but its application in the future is very promised. The massive introduction and training of carbon dioxide as alternative refrigerant should also start off as soon as possible. This technology sooner or later will arrive in our country for example through automotive or household industry or beverage companies which have their own refrigerators

using carbon dioxide as refrigerant. One of author's previous research deals about investigation of employing carbon dioxide for small-scale refrigeration system of one well known Danish refrigeration company. According to their plan, the display-type of this refrigeration system will be used in Olympic Games 2004, Athena, Greece, for serving a famous beverage product. It is clear that for great consumer brand, the image of 'green company' who cares about emission, ozone depletion potential and greenhouse effect issues is very important.

Indonesian government should have a priority for our national campaign for non-ODS and small GWP (Global Warming Potential) and small TEWI (Total Equivalent Warming Impact) refrigerants. Without this our goal will be confused and misled. They have to decide what is our priority regarding this actions with lack of economic and funding support. International community should not be only blamed on the progress of our country program, they should support with more fund and technical assistance and monitor it, in order to make sure their funds run on the right track. Based on the latest data from Ministry of Environment, Indonesia has phased-out 3 969.80 metric ton ODS in the time period 1994-2002. This project has been supported by UNDP and UNIDO and will be continued until 2007 [9].

4. Conclusions

As consequence of our ratification of the Vienna convention and Montreal Protocol, Indonesia has to make country program to formulate and implement it. Participation of nationwide components play an important role to success our national country program

Hydrocarbons nowadays and carbon dioxide for the future may be used as alternatives for ODS refrigerants Indonesia. From technical aspects, hydrocarbons and their mixtures are suitable for replacing the existing ODS Refrigerants. The awareness of safety issue for hydrocarbon refrigerants must be handled in a proportional manners.

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