

## AN OVERVIEW OF RECENT HEAT PUMP TREND IN ASIA/OCEANIA REGION

*Takeshi Hikawa, Director, Heat Pump & Thermal Storage Technology Center of Japan,  
TOKYO, JAPAN*

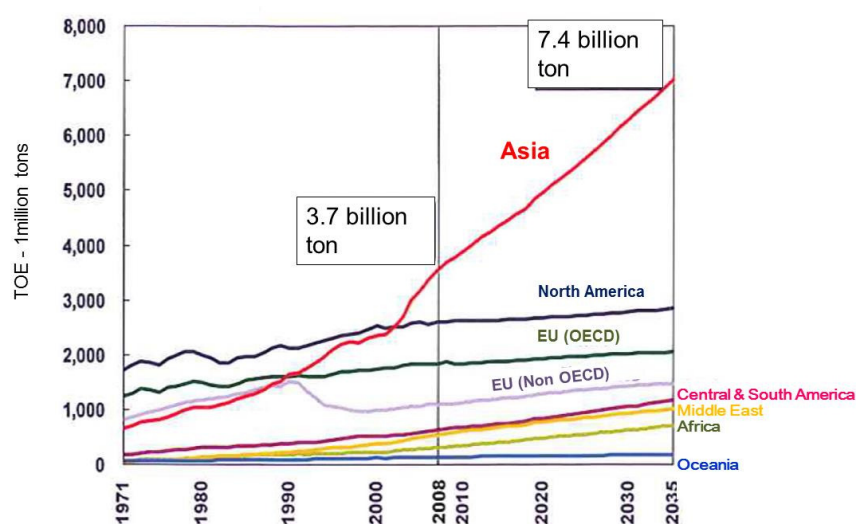
### Abstract:

This report introduces heat pump market trends in Asia and Oceania Region of which consists different levels of economies in a widespread area with variety of climates. It also picks out some installation cases of development or application of heat pumps, fitted in each policy or economy such as heat pump water heater, industrial heat pump application and so on. In addition, activity toward environmentally friendly society, such as introduction of standards for heat pump performance, development of heat pump unit designed to low GWP refrigerant, are also other features in this report.

**Key words:** *Asia and Pacific, Heat Pump technologies, energy saving,*

## 1 INTRODUCTION

Firstly we would like to focus on how large primary energy consumes during its continuous economic expansion in Asia. As Figure1, the estimation of IEEJ (The Institute of Energy Economics Japan) based on IEA WORLD ENERGY OUTLOOK 2008 indicates, Asia is a larger energy consumer than any other regions and its consumption is expected to be surging up outstandingly. The consumption level in 2030 is predicted to be double compared to the 2010 level.



**Figure1: Primary Energy Consumption by Region  
(IEEJ“ Asia/World Energy Outlook 2011”)**

Amid the increase in energy consumption, heat pump demand is on the upward trend. Consequently, Asia and Oceania Region confronts twin increase in energy consumption and greenhouse gas emission.

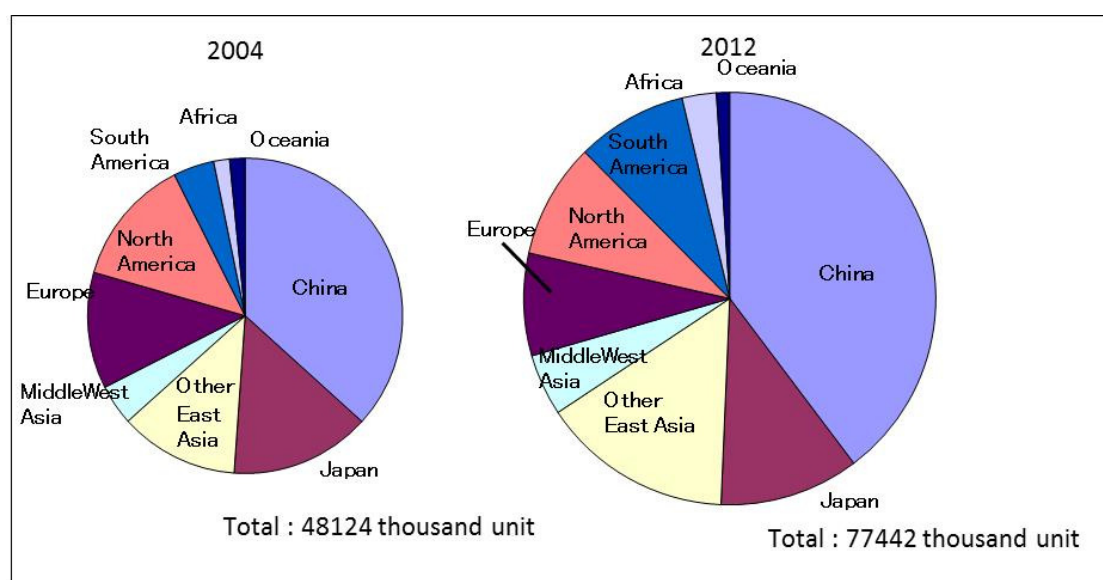
Developed economies such as the EU, North America and Japan have been implementing policies for reduction in energy consumption and greenhouse gas emission. For instance, the

EU has been implementing the EU's climate package, known as "20-20-20". The main objective of this package is to achieve, by 2020 a 20 % reduction in greenhouse gas emission, a 20 % improvement in energy efficiency and a 20 % share for renewables in the EU energy mix. North America has also been conducting various phase-out policies along with R&D support for energy efficient devices.

Now let's take a look at the situation in Asia and Oceania Region. The key is how to achieve economic development and decrease in energy consumption simultaneously in Asia which contains many developing countries. As for heat pumps, it would be critical to disseminate energy efficient and CO<sub>2</sub>-reduction-effective equipment immediately to meet increasing demand in developing countries. Followings are features of markets, energy conservation policies, R&Ds for developing energy efficient equipment and issues surrounding refrigeration in Asia and Oceania Region.

## 2 FEATURES OF MARKETS IN ASIA AND OCEANIA REGION

### 2.1 Space Conditioning (RACs & PACs)



**Figure 2: Room air-conditioner shipment (JRAIA 2013)**

Room air-conditioners in Figure2 are defined as package unit type air-conditioners used mainly in households both for cooling-only units and heat pump reversible units. Both Window air-conditioners and small size split air-conditioners are in this category. The total number was nearly 50 million units in 2004 and increased up to around 80 million in 2012.

Asia and Oceania Region accounts for near 70 % with more than 60 million units in 2012. Growth in demand in China is particularly remarkable by achieving 30 million in 2012 which accounts for 60 % in East Asia. Japan has kept steady demand around 8 million a year recently and 100 % of them deploy inverter technology. Shares are small but India achieved 3 million, Korea 2 million followed by Taiwan, Malaysia and Thailand which show sharp increase up to nearly 1 million.

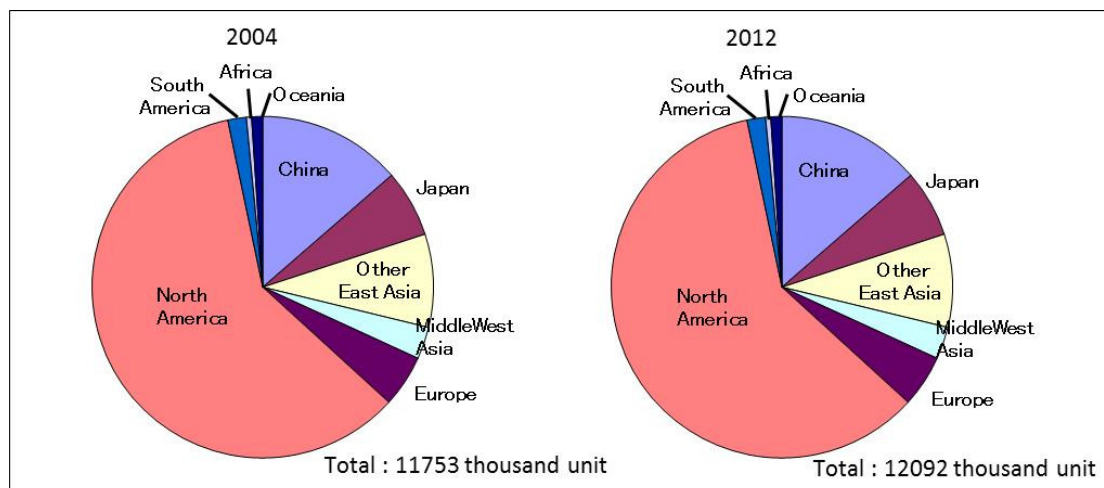


Figure 3: Package air-conditioner shipment (JRAIA 2013)

Other major category of air-conditioners, larger capacity than room air-conditioners consist of unitary type ones majorly used in the US and split type multi air conditioners for commercial use applied to medium size buildings. As Figure3 indicates unitary type in the US occupies a large share, while Asia accounts for 30 %. The demand in this region has been steady worldwide and it has also been stable around 4 million in entire Asia. A trend in Asia is that China and Japan occupy most of the demand.

## 2.2 Electric chillers and heat pumps

Electric chiller, classified into larger capacity category than package air-conditioners, is generally applied to central reversible air-conditioning system for large scale buildings and for industrial use as well. Compressor type is varied from reciprocating, scroll, screw to centrifugal depending on each capacity level.

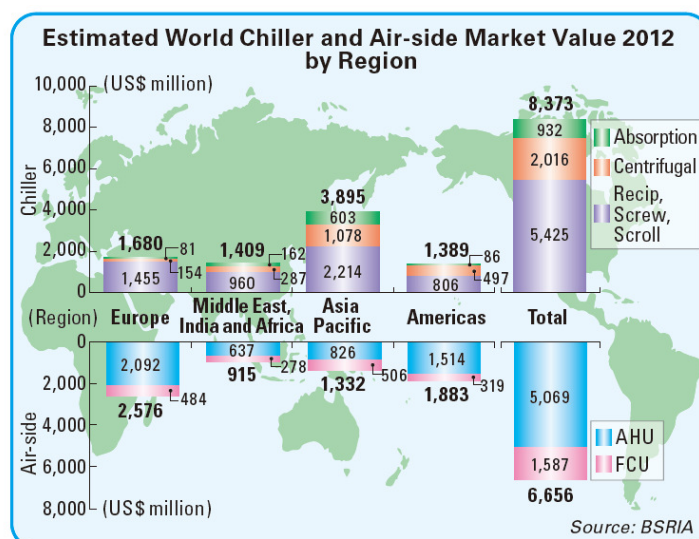


Figure 4: World Chiller Market by Region (JARN November edition 2013)

Their demand is heavily influenced by an economic situation. As Figure 4 shows, Asian market is the largest in the world, which accounts for nearly 50 %. An absorption chiller marks large growth thanks to lots of large-scale building development in China. Majority of demand in Japan, on the other hand is air-cooled electric chillers. Their trend is to be modularized for easy update, adjustability for system control and cost effectiveness. Besides, research and development for higher efficient technology has brought about innovation regarding heat exchangers and inverter technology for part load operation. Performance has been improved substantially, in fact some chillers in the market exceed IPLV value 11.

### 3. NEW TECHNOLOGY FEATURES IN ASIA

Some countries have made a unique development for energy saving, CO<sub>2</sub> reduction and introduction of renewables in accordance with its circumstance in Asia. This section picks out examples from Japan; CO<sub>2</sub> heat pump water heater and industrial heat pump application, China; Ground source heat pump and heat pump water heater and Korea: Smart city project.

#### 3.1 Heat pump water heater

Japanese government introduced a grant program from 2002 to disseminate energy efficient Eco Cute, a nickname of domestic water heater with CO<sub>2</sub> refrigerant, which can reduce energy consumption in water heating. In addition, manufactures have been making every effort to hike a COP value by improving compressor and heat exchanger performance, heat insulation performance, system control technology and so on. As a result, Eco Cute products achieved an Annual Performance Factor (APF) value, which will be described in detail in latter section, over 3.8, equivalent to primary COP 1.5. Not to mention, these are more environmentally-friendly and emit far less CO<sub>2</sub> than direct combustion type of water heating equipment. The cost reduction and improvement of performance have led Eco Cute to annual shipment of 0.5 million and achieve accumulated shipment number to be over 3 million units.

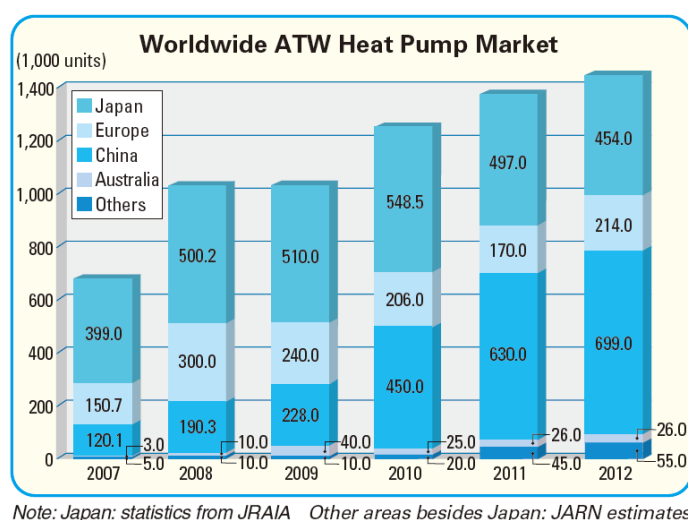


Figure 5: Worldwide ATW heat pump market trend (JARN August edition 2013)

Meanwhile an increase in deployment of heat pump water heaters in China is remarkable owing to its firm housing demand. Another reason for boosting Chinese demand can be found in the stable electricity rate, around 0.6 Yuan/kWh owing to majority in inexpensive coal fired power generation in China. As is shown in Figure 5, its shipment number has

shown significant growth as the years go on. The number was over 0.6 million in 2011 and is expected to be over 1 million near future. China has exceeded Japan regarding an annual shipment and become the world's largest market.

Feature of the heat pump water heater is applying R134a as refrigerant and its heat exchanger is designed to be laterally-contacted on a tank. They are less expensive but the hot water temperature in the tank is relatively low of about 50 °C.

### 3.2 Ground Source heat pumps in China

Ground source heat pump has been supported by the Chinese government as an eco-friendly technology because coal combustion type of heating equipment still dominates in China at present. The government support has spurred the expansion of ground source heat pump in China. Figure6 shows the market trend of ground source heat pump. It is predicted that the shipment number of ground source heat pump in China will become the largest in the world before too long. The feature of Chinese market is that there have been many introduction cases in large scale buildings such as commercial buildings, public facilities and multi dwellings.

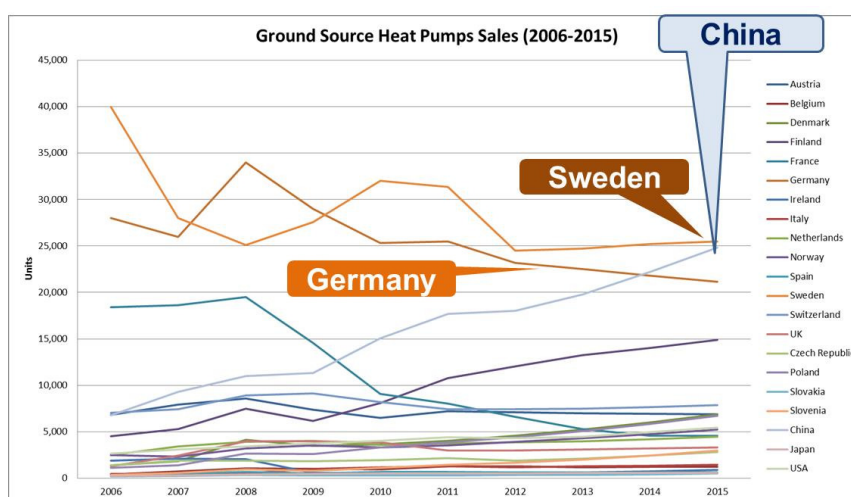


Figure 6: Ground Source Heat pump Sales Prediction (Oliver Peng 2013)

### 3.3 Heat pump Application for Industries

Boiler combustion has been used for various heating demand in industrial processes conventionally. Hence energy conservation utilizing alternative energy in industry sector has been considered seriously and consequently heat pump has been paid high attention. Actually, heat pump has been already used for cooling and heating in mild temperature range in industry process as well as for air-conditioning and refrigeration. However, for further energy conservation, waste heat can be used as a heat source for heat pump to produce higher temperature heat effectively.

On top of that, when both heating and cooling demand exist and utilized as heat source respectively at the same time, heat pump can save great deal of energy. These kinds of heat pump applications in industry, such as food processing factories and chemical processes for example, have been gradually increasing in Japan.

Figure 7 is an example of high temperature heat pump apparatus in practical use which can produce 80 °C to 120 °C heat and are in practical use in wide range of processes from drying



process of plastics to painting process of automobiles. Heat pump that can produce 160 °C heat has become available in the market and is expected to be used in variety of industrial applications.

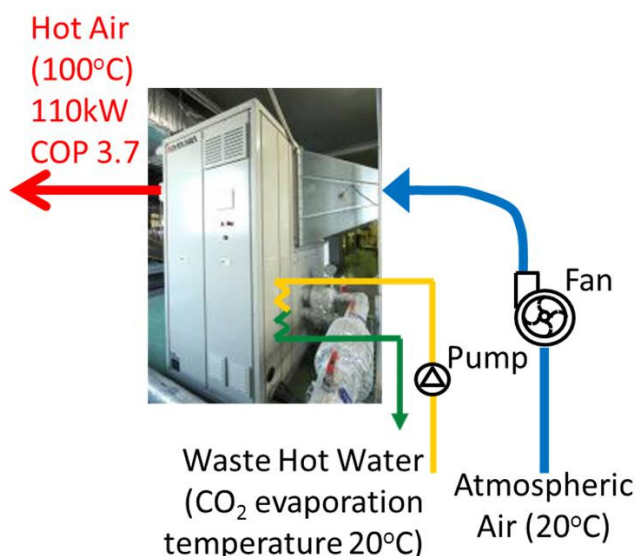


Figure 7: A case set up of Industrial heat pump (Watanabe 2012)

### 3.4 Korean Smart City Project

On expectation to realize a smart city in foreseeable future, the world's largest, cutting-edge smart grid test-bed was established on Jeju island, South Korea, in 2009. The test bed includes about 6,000 homes on the north-eastern part of the island. It is intended to lay the foundations for the early commercialization and creation of globally competitive export opportunities for smart grid technologies through demonstrations of smart grid technology as the key infrastructure element of green growth. (Park 2013)

## 4. POLICY & REGULATORY MEASURES

Asian nations have made an effort to conduct energy conservation policies by requiring manufacturers to meet minimum energy performance standards (MEPS) on the rated COP basis to remove low-performance appliances from the market or, by introducing a labeling system to motivate consumers to purchase higher efficient appliances.

Japan has conducted energy conservation policies since the 1970's after experiencing the 1<sup>st</sup> oil crisis. In addition, the Top Runner Program has enhanced the policies since its commencement in 1999. China, India and Taiwan have already introduced the labelling system and MEPS. Their MEPS value has improved up to the value used as a Japanese standard around 2000. Thailand has introduced the labelling system for air-conditioners since 1999 and MEPS since 2011. Vietnam has started the labelling system and MEPS will be introduced as early as 2014. Indonesia seems to be following these trends and we can say that energy conservation policies have been surely expanding throughout in East Asia.

**Table 1: Recent MEPS Status in Asia**

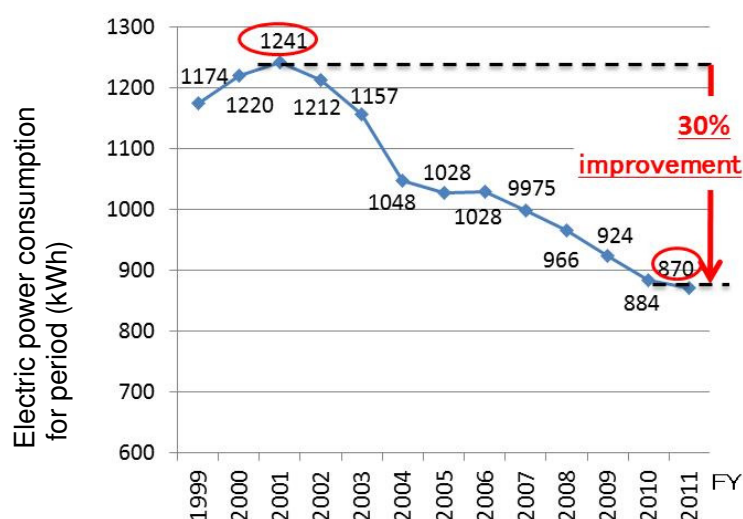
	COP	Period	Method	Remarks
Japan	<sup>**</sup> 3.0→5.0	1999~2004	Top Runner	
	<sup>**</sup> 4.9→5.7	2006~2010	Top Runner	APF
China	3.0	2010~	MEPS	Inverter(SEER)
	3.2	2010~	MEPS	Non Inverter
Taiwan	3.45	2011~	MEPS	
Thailand	2.82	2011~	MEPS	
India	2.7	2014~	MEPS	
	2.5	2012~14	MEPS	

<sup>\*\*</sup>Figures represent an average COP value in a starting year and one required to be achieved in a targeted year respectively.

Japan established the Annual Performance Factor (APF) standard in order to accurately evaluate the performance under the usual operating condition. APF evaluates the energy efficiency of air conditioners in accordance with the actual conditions by taking into consideration the load conditions of buildings, intended use of air conditioners, load hours during heating/cooling periods in relation to outdoor temperatures and changes of the efficiency along with the capacity changes. APF indexes are widely used in Japan, including labeling as well as the Top runner program implemented by the Japanese government to promote energy conservation efforts.

In addition, the Japanese government has implemented the Top Runner Program to increase the average performance levels of products in the market.

The Top Runner Program is one of the most stringent programs, which introduces mandatory fleet-average energy efficiency requirements set at the level of the most efficient product on the Japanese Market at the time the requirement was formulated. Consequently, the energy efficiencies of Japanese products were successfully able to rise remarkably as shown in Figure 8.

**Figure 8: Saving energy trend of wall mounted air conditioner in Japan (Fukuda 2013)**

(Note) Wall mounted cooling and heating units with cooling capacity of 2.8kW-class model; simple average values for a representative model of energy conserving-type products.

Furthermore, deployment of inverter technology has been accelerated in the Region because of its remarkable contribution to improve performance. As shown in Figure 9, 100 % of RAC in Japan deploy inverter technology thanks to the Top Runner program and the situation is similar in Oceania where nearly 100 % deployment has achieved. Labelling system and minimum energy efficiency standard requirement (MEPS) have boosted inverter dissemination in China also, achieving beyond 50 % share. The inverter trend can be observed in South East Asia with the shares of 17 % also. This rapid growth of inverter technology has been made within recent several years in Asia and Oceania Region and its effect of saving energy must be enormous.

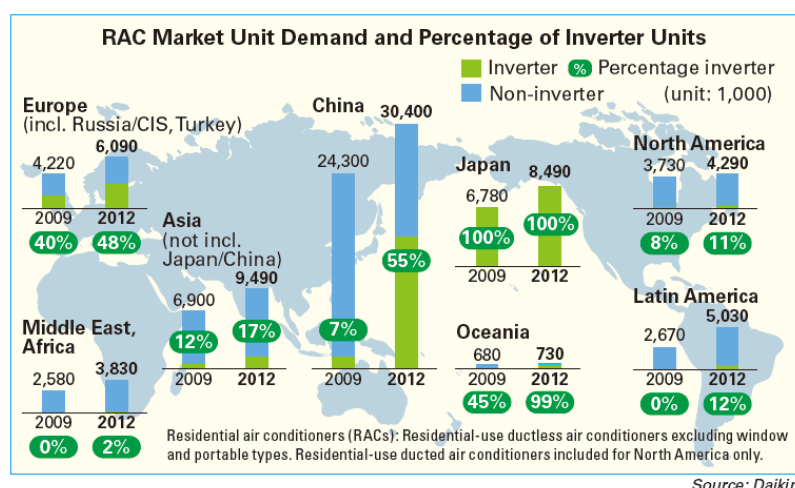


Figure 9: RAC market and Percentage of Inverter Units (JARN July edition 2013)

#### 4.1 Activities for heat pump performance validation

In order to make labelling systems and MEPS work effectively, it is important to have an independent third party which has capability to check an accuracy of declared performance values of products. When it comes to measuring heat pump performance, it is a must to equip precision measuring devices in a temperature-controlled testing room as well as to acquire its measuring know-how to get accurate data.

From this point of view, some of Asian nations have been working on establishing testing laboratories for accurate evaluation of air-conditioners' performance to promote energy efficient products. Japan has provided technological support for precise data acquisition method, or proper operation of testing facility.

Figure 10 shows technical exchanges between Japan Air Conditioning and Refrigeration Testing Laboratory (JATL) and Asia Oceania regions.

JATL which was established as a third-party institute for the purposes of offering appropriate information on air conditioning product performance has been networking with Korea Refrigeration and Air-conditioning Assessment Center (KRAAC) in Korea, Guangzhou Vkan Certification & Testing Institute (CVC) in China, Electrical and Electronics Institute (EEI) in Thailand, and so on. Furthermore Japan has provided some Asian countries with support of seasonal performance evaluation technology which requires accuracy through wide experiment range of capacity to evaluate real operation condition.





**Figure 10: Technical exchanges among Asian countries testing laboratory (JATL 2013)**

## 4.2 Japanese energy policy after the Great Eastern Japan Earthquake

Japanese energy policy has remarkably changed between pre- and post-great eastern Japan earthquake. All nuclear power stations in Japan have been stopped their operation and the ratio of thermal electric power generation has been increased after the incident. This has resulted in increase in CO<sub>2</sub> emission. In such a challenging situation, Japanese government has topped a great deal of incentives for promotion of renewable energy, energy conservation technology, unused energy usage or cogeneration technology in order to realize a low carbon society.

Energy Conservation Law has become effective since 1979 aiming at promotion of energy conservation policy in Japan. The present version after this earthquake focuses on supplying sides and promotes technology to level off the imbalance of electricity use in summer to meet severe supply demand tightness. Specifically, it encourages use of storage system of cold heat energy in the building, storage battery, building energy management system (BEMS), home energy management system (HEMS) or off-grid power system during peak hours of electricity consumption in a day.

## 5. REFRIGERANT DEPLOYMENT AS A MEASURE AGAINST GLOBAL WARMING

As refrigerant R22, R410A and R134a which currently used widely, have high GWP values of 1810, 2090 and 1430 respectively, heat pump designed for alternative refrigerants with relatively low GWP value, such as HFO, HFC(R32), HC and the mixture have been investigated dependent on application.

F-gas regulation has been under way in European and North American countries with targeting around 80% reduction. Meanwhile Japanese government has revised and tightened the Act regarding Fluorocarbons. Japanese Cabinet approved the Bill for the Act for Partial Revision of the Act on Recovery and Destruction of Fluorocarbons on June 2013, The revised Act is renamed to be the Act for Rationalized Use and Proper Management of Fluorocarbons, which concerns the complete life cycle of fluorocarbons. The following

entities should be paid particular attention to the new Act as additional or stricter obligations have been imposed accordingly:

1. Manufacturers; encouraged usage of non-fluorocarbons or low GWP refrigerants.
2. Gas suppliers; requested to phase down of fluorocarbons family practically by adopting their alternatives and introducing more renewables to carry out planned reduction of their import volume.
3. Users of commercial products containing fluorocarbons (e.g. distribution industry); required to conduct a periodic check of products and to submit and publicize an annual report on quantity of fluorocarbons leakage.

## 5.1 Development of heat pump unit designed to low GWP refrigerant

When it comes to major refrigerant in Asia and Oceania Region, HFC(R410A) occupies a large share in Japan and Australia etc while HCFC(R22) does in rest of Asia.

Amid this trend, alternative refrigerants have been examined for developing of appliances considered from the point of views of energy conservation and eco-friendliness in Japan. Consequently, R32 has been paid attention as the most promising candidate alternative of R410A because its GWP is one third of R410A and it shows somewhat better characteristics than R410A.

As Table 2 shows, R32 has lower flammability of A2L classification which was a crucial risk must to be considered when developing products.

**Table 2: Typical refrigerant's property (Matsuda 2011)**

Refrigerant		Refrigerant Property					
		GWP	Relative Efficiency	ODP	Flammability	Toxicity	Condensing Pressure(MPa)
HCFC	R22	1810	100	0.06	A1	low	1.73
HFC	R407C	1770	99	0	A1	low	1.86
	R410A	2090	92	0	A1	low	2.72
	R32	675	97	0	A2L	low	2.80
	R1234yf	4	90	0	A2L	low	1.16
Other	R717(NH3)	0	106	0	A2L	high	1.78
	R290(C3H8)	3>	98	0	A3	low	1.53
	R744(Co2)	1	41	0	A1	low	(10)

The evaluation of flammability carried out in Japan has proved that the fire risk of wall hanging room air-conditioners in practical use is less than  $10^{-10}$  incident of ignition / (year\*unit), which is within accepted values in household electronics appliances in Japan. Consequently, products with R32 have been launched in a market since autumn 2012 and the number of shipment has already achieved over one million units.

On the other hand, HCFC (R22) is still widely used in China or other Asian and Oceanian countries and regions. Chinese government has been aimed to introduce propane for household air-conditioners while R32 and R410A for commercial ones.

In some south east Asia countries, shift from R22 to R32 has been considered recently, since the movement of shift to R32 in Japan has started. Thailand and Indonesia are planning to shift R22 to R32. In Australia, the Carbon Tax and HFC Levy has been introduced since July 2012, imposing around \$40 per kilogram tax, which is another feature of measure regarding refrigerant. As aforementioned cases suggest, measures against

global warming are steadily making progress in Asia and Oceania region.

## 6. CONCLUSIONS

This Asia and Oceania regional report introduces energy saving policies and counter measure against global warming surrounding heat pump industry in the region where heat pumps are spreading rapidly.

Especially, environmental friendly activities such as the rapid spread of inverter technology which enable saving energy a lot, the active dissemination movement of air conditioning verification system which makes more effective labeling system and MEPS, and the spread of air conditioner which is applied low GWP refrigerant are focused.

These movements of heat pump technology allow economic development while considering environmental preservation, and have been conducted throughout the region.

Heat pump is the remarkable breakthrough technology to realize economic development concurrently with low carbon society and stop global warming.

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