REGIONAL REPORT – HEAT PUMPS IN ASIA & PACIFIC

Takamoto Saito,
Professor, Department of Mechanical Engineering,
Meisei University, Hino City, Tokyo 191-8506, Japan

Takeshi Yoshii,
Director, Heat Pump & Thermal Storage Technology
Center of Japan, Chuo-Ku, Tokyo 103-0014, Japan

ABSTRACT

As a regional report for Asia & Pacific, this paper focuses on the current market and technology situation in the region. One outstanding feature of the market in this region is that central need for heat pumping technology is for refrigeration and air conditioning. Specifically the market of air conditioners and heat pumps has experienced a remarkable growth during the last decade driven by the economic development in the region.

The expansion of air conditioning market, in some of the East Asian countries triggered increased demand for electric power, causing sharp increase in summer peak power demand and deterioration of power load factor. As a measure for power load leveling, thermal (cool) storage system and thermally driven cooling system have extensively been used for air conditioning, shaping a unique market structure in this region.

Considering the huge market potential for air conditioners and heat pumps in this region and the resulting future impact on global environment, through increased use of energy and refrigerant, technology development in energy efficiency and choice of environmentally friendly refrigerant are becoming extremely important.

INTRODUCTION

In this paper, the authors try to look into the market and technology situation in Asia & Pacific, and to give an overview of the region. However, quite different from North America and Europe, Asia & Pacific is not a unified quasi-single market, where there are so many countries with variety of socio-economic and climatic condition, geographically dispersed in both hemispheres stepping over the equator; it is beyond the authors' capability to cover all the countries in detail.

Therefore a more general and rather topical " bird's eye view " description on the current market and technology situation in Asia & Pacific will be covered, based on rather limited information available for us today.

GENERAL SITUATION - HEAT PUMPING TECHNOLOGY IN ASIA & PACIFIC

When we talk about the market for " heat pumping technologies " in Asia & Pacific with population of nearly one half of the gross world population, refrigeration and air conditioning for food preservation and space cooling, seems to be of dominating importance specifically in highly populated tropical and semi-tropical region, in broader meaning of " heat pumps " or as "heat pumping technologies ".

The market for air conditioners in East Asia has been rapidly growing during the last 10 to 15 years, driven by remarkable economic growth in the region. Fig.1 shows the estimated current market situation of unit-type air conditioners and heat pumps in Asia & Pacific, from which we can see that the total Asia & Pacific market of about 22 million units/year shares more than 50 % of the gross world market of about 42 million units/year.

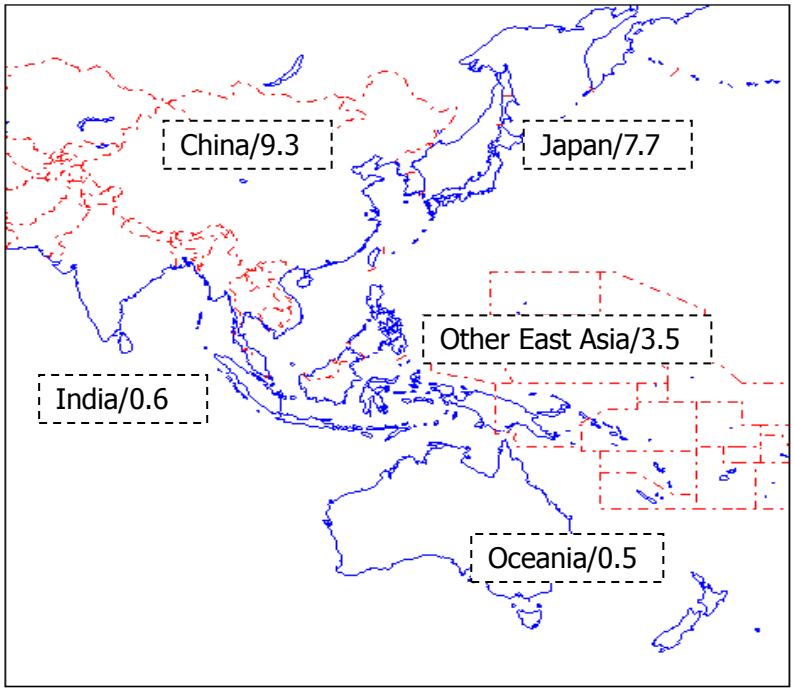


Figure 1. Market Situation of Unit-type AirConditioners and Heat Pumps (RACs + PACs) in Asia & Pacific
RAC : Room Air Conditioner (incl. reversible heat pump),
PAC : Packaged Air Conditioner (incl. reversible heat pump)

We can also find fairly significant market for space heating heat pump in regions with moderate climate, typically in China and Japan, mostly with air-to-air reversible heat pump for both heating in winter and cooling in summer. Of the total market size of over 20 million units/year for unit-type air conditioners and heat pumps in Asia & Pacific, nearly 60% is estimated to be reversible heat pumps, since Asia and Pacific market is predominated by the two big markets, in China and Japan, where reversible heat pumps have high market share of about 60% and 95% respectively.

Other notable market feature in Asia & Pacific is that the market for heating only heat pumps is rather limited, only for insignificant number of heat pump hot water heating and

industrial process heating. Also limited number of heat pump are also being used for drying lumber, fish and agricultural products, specifically in New Zealand, Singapore, China and Japan.

MARKET DEVELOPMENTS AND TRENDS

Table1 shows the estimated market situation of air conditioners, heat pumps and water chillers in countries of Asian & Pacific region, mostly based on the market survey by JARN (Japan Air Conditioning, Heating & Refrigeration News). Although market data in Table1 is not fully confirmed, it is clear that China and Japan currently are by far the leading markets for air conditioning equipment in Asia & Pacific. Some of the notable market features in Asia & Pacific are summarized as follows.

Table 1. Market Situation for Air Conditioners, Heat Pumps and Chillers in Asia & Pacific

	A/C and Heat Pumps			Water Chillers		
	RAC ×10³	PAC ×10³	GHP ×10³	Centrifugal	Recipro/Screw	Absorption
China	8,200	1,100	—	850	30,000	2,000
Korea	1,100		—	350	1,100	1,200
Japan	7,000	700	50	400	9,300	4,900[1)]
India	550	30	—	n.a.	150	300
Malaysia	300		—	1,200	3,000	n.a.
Singapore	190		—			n.a.
Indonesia	140		—			n.a.
Thailand	350		—			n.a.
Philipines	270		—			n.a.
Other East Asia	1,200		—		7,500	n.a.
Australia	500		—	n.a.	n.a.	n.a.
New Zealand			—	n.a.	n.a.	n.a.
A&P Total	21,630 ×10³		50 ×10³	2,450	51,250	8,400
World Total	41,500 ×10³		n.a.	8,000	n.a.	9,000
Share of A&P (%)	52		≒100	31	n.a.	93

RAC : Room Air Conditioner (incl. reversible heat pump and cooling only unit)
PAC : Packaged Air Conditioner (incl. reversible heat pump and cooling only unit)
GHP : Gas Engine Heat Pump (reversible heat pump)
Data Source : Estimation based on JARN data for the year 2000
1) Include units less than 40RT, exclude H2O/NH3 Chillers

(1) Air conditioners and heat pumps

According to the world market survey by JRAIA (The Japan Refrigeration and Air Conditioning Industry Association) on unit-type air conditioners and heat pumps which include RACs and PACs (RACs : room air conditioners- incl. reversible heat pumps, PACs : packaged air conditioners- incl. reversible heat pumps), as shown in Fig.2, during the last decade as a whole, the market in Asia & Pacific has experienced remarkable growth which began to proliferate in the late 1980s. The wave of market growth first started in 1970s in Japan, followed by other Asian countries in 1980s and in 1990s. Specifically in China the market has

grown at an exceptionally high speed to a world leading position at the turn of the millennium from an insignificant market size at the beginning of 1990s.

The main driving force for the market growth in Asia & Pacific has been decades of favorable economic growth during 1980s and 1990s, symbolically expressed as " New Emerging East ", although it slowed down after the financial crisis in 1997, which fit most of the East Asian countries. On the other hand the market in Japan flattened out during the last decade, due partly to saturation of the market with high penetration rate and partly also to staggering economy during 1990s.

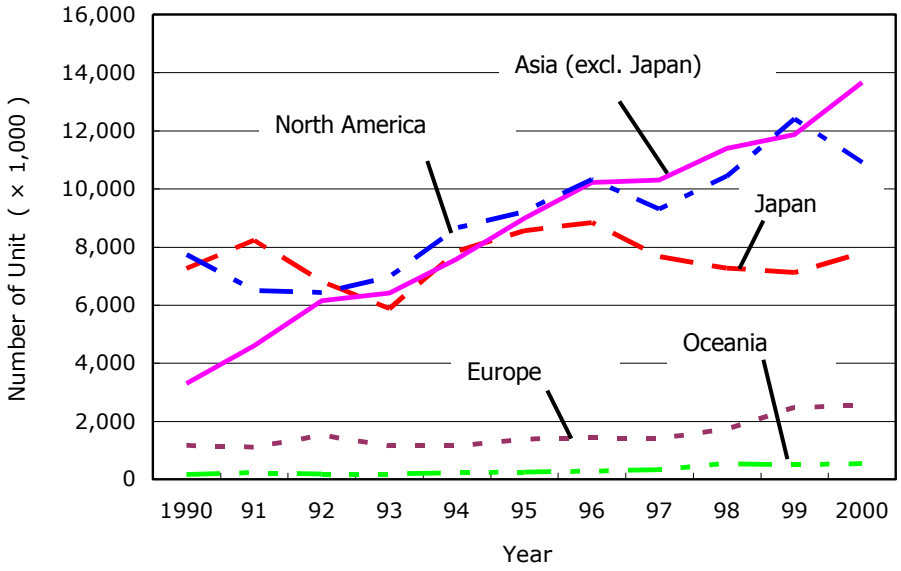


Figure 2. World Market Trend of Unit-Type Air Conditioners and Heat Pumps

In the residential sector, the penetration rate of room air conditioner in Japan reached nearly 85 %, on the other hand in some of the developing countries, it is estimated to be still below 10 %, which shows a very sharp contrast between countries in Asia. The resulting residential and commercial market of air conditioners and heat pumps in Asia & Pacific today is estimated to have grown to over 20 million units/year, occupying more than a half of the gross world market as cited above.

In the residential sector, electrically driven mini-split air conditioners and heat pumps are increasingly dominating the market in place of window-type room air conditioners for their flexibility of installation and other advantageous features. Also in the commercial sector, multi-split variable refrigerant flow (VRF) system is increasing its market share.

(2) Thermally driven chillers and heat pumps

Outstandingly Asia has the largest demand for thermally driven sorption machines for space air conditioning, with current total market volume of about 8,400 units/year, specifically in countries like China, Korea, India and Japan, sharing about 93% of the gross world market. They are mostly absorption chillers installed in office buildings and district cooling plants.

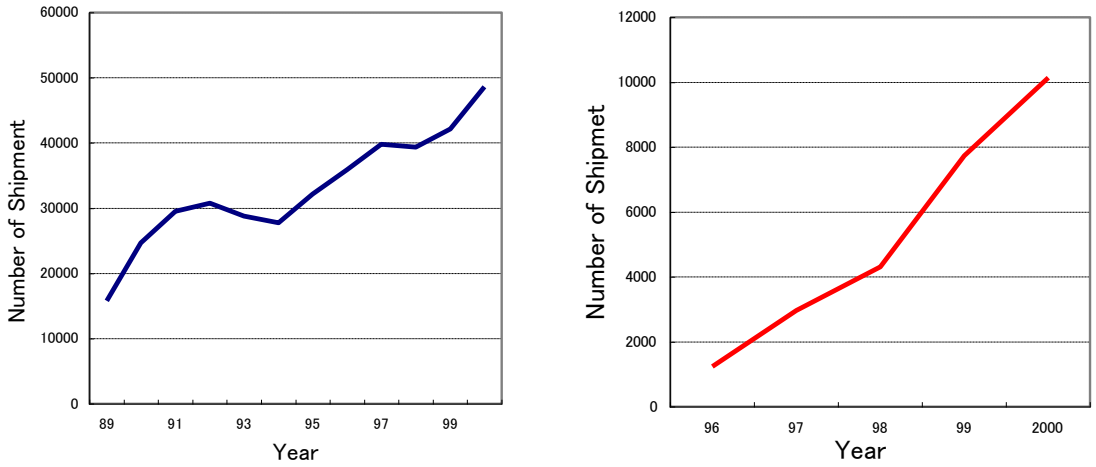
Market for gas engine driven heat pumps has successfully been developed in Japan during the last decade as shown in Fig.5 (a), expanding the market size to approximately 50 thousand units/year, most of them have been installed in light commercial and institutional buildings.

To a larger extent the demand for absorption machine and gas engine heat pump is driven by the need for power load leveling to cope with ever increasing peak power demand in summer. Other pull factor for absorption machine is the requirement for waste heat utilization in industrial processes and cogeneration systems.

(3) Thermal (cool) storage systems

The combined use of heat pump with ice or water thermal storage systems have increased in number of installation in countries like China, Korea and Japan, as a mean to shift on-peak power load to off-peak time. Japan seems to be leading in the number of installations of thermal storage system, surpassing thirteen thousands installations. In Japan market for split-type ice storage heat pump system, uniquely originated in Japan, has grown to over 10 thousands / year as shown in Fig.5 (b). Large ice or water thermal storage systems have rather extensively been used for district cooling in Malaysia and Japan.

Key motivation for the installation of thermal storage systems is the employment of time-of-use tariff structure favorable for peak shift, with low rate off-peak electricity down to one fifth of peak rate as seen in Japan, additionally backed up by incentives prepared by the government and electric utilities.



(a) Gas Engine Heat Pump (b) Ice Storage Heat Pump

Figure 5. Market Trend of Gas Engine Heat Pumps and Ice Storage Heat Pumps in Japan

MARKET FACTORS AND ISSUES

Outstanding market factors and issues for heat pumping technology in Asia and Pacific can be summarized as follows:

(a) Power load leveling

As the results of high market penetration rate of air conditioning, in countries like China, Korea, Thailand and Japan, it became more stringent to sustain stable and efficient electric power supply coping with power shortage and deteriorating power load factor, mainly caused by the rapid increase in power demand for air conditioning in summer. Fig.6 shows a typical example of historical trend of power load factor experienced in Japan, which clearly reflect the history of diffusion of air conditioning started in the early 1970s.

In order to cope with the deteriorating power load factor, typically in China, Korea and Japan, electric air conditioning systems with thermal storage or thermally driven absorption chillers or gas heat pump systems have actively been promoted by the government and gas utilities. Significant size of market has been or is being established in countries cited above for systems effective in power load leveling.

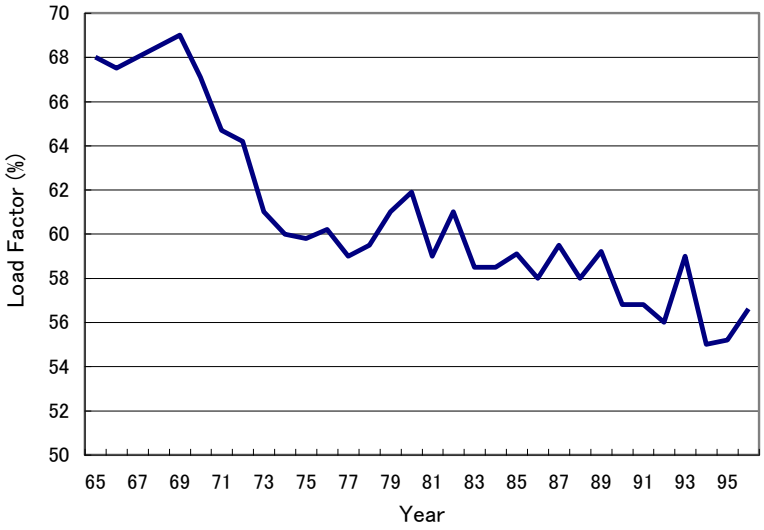


Figure 6. Historical Trend of Power Load Factor in Japan

(b) Environmental issue

Under the 1987 Montreal Protocol, most of the countries in Asia & Pacific are in the process of phasing-out ODS (Ozone Depleting Substances: CFCs and HCFCs) as refrigerant. And global warming issue under the 1997 Kyoto Protocol will be affecting heat pumps in two ways, firstly to restrict the use of alternative refrigerant HFCs and secondly to increase the demand for enhanced energy efficiency of air conditioning equipment and heat pumps.

(b-1) Phase-out of ODS

Situation for phasing out ODS is different from country to country. For countries like India, Malaysia, Indonesia, Thailand and China, defined as article 5 country in the Montreal Protocol, phasing-out of ODS, which are currently used as refrigerants for air conditioners and refrigerating machines, is a stringent issue to be tackled by the refrigeration and air conditioning industries. Other countries like Australia, New Zealand, Korea and Japan have already phased out CFCs and are in the process of phasing out HCFCs and shifting to HFCs or other natural working fluids. On the other hand in Australia, hydrocarbons are being used in significant volume as refrigerant for refrigerators and mobile air conditioners.

(b-2) Global warming

In order to comply with the Kyoto protocol, alternative working fluid HFCs will come to be under some restriction of their use, which might give more chance for natural working fluids as the next generation working fluids whether we want or not. Natural working fluids are being examined as potential future working fluids in countries like Korea, China, India and Japan.

Other important area for heat pumps to be considered, for mitigating the global warming, is the improvement of energy efficiency of air conditioners and heat pumps. Regulatory measures for improving energy efficiency of air conditioners and heat pumps are being put in place in Thailand and Japan. Specifically in Japan ambitious energy efficiency regulation have been put in place in the " top runner " program with a target COP higher than 5.0 for small air-to-air mini-split air conditioners and heat pumps, as part of revised so called " energy conservation law ". Some kind of energy efficiency regulation by labeling for room air conditioners is being implemented in Thailand.

TECHNOLOGY DEVELOPMENS

Today, the needs for heat pumping technologies in Asia & Pacific are fairly diversified in products and systems, depending on the climate, way of life and social needs. Some of the countries rely on import, and some other countries are exporting their products not only to neighboring countries in Asia & Pacific but also to Europe and North America.

Current research and development of heat pumping technologies are being focused on fields as follows:

(a) Advanced compression systems
- cold climate heat pump
- compression system with natural working fluids
- advanced system for ice (slurry) production and cool storage

(b) Advanced thermally driven systems
- advanced absorption system
- advanced adsorption system
- advanced desiccant system

(c) Industrial application of heat pumps
- drying of timber, agricultural and horticultural products

(d) Alternative heat source and heat sink
- ground source heat pump

- solar coupled heat pump

Some of the topical area of new developments in Asia & Pacific are summarized as follows :

(1) Development of cold climate heat pump has been an issue for heat pumps for a long time since the introduction of air-to-air heat pump. Air source heat pump which can be operated as low as minus 20℃ outdoor air temperature has been developed in Japan, and was put in the market in the northern part of Japan.

(2) Hot water heating heat pump with a natural working fluid CO_2 as refrigerant was recently developed and put into market in Japan and is expected to contribute to substantial energy savings and mitigating global warming.

(3) Development of systems for ice slurry production and their application to air conditioning is of international concern and Japan has been actively involved in this area.

(4) Active developments on gas driven residential absorption heat pump for space heating and cooling have been carried out in Korea and Japan. However still no commercial products are available today.

(5) Adsorption system for chilled water production, driven by low temperature waste heat, was developed as commercial product in Japan and is in further developments to be adapted to lower temperature heat sources.

(6) Desiccant cooling system is being accepted as an option for energy efficient cooling of supermarket or other applications such as waste heat utilization of micro-turbine generator.

(7) Humidity control is an important issue specifically in Southeast Asian countries with hot and humid climate, and varieties of option are in investigation.

(8) Application of heat pumps for drying timber, agricultural products and fish is finding their place in countries like New Zealand, China, Singapore and Japan.

(9) Concern about ground source heat pump is growing in countries like Australia, China and Japan. A ground source heat pump system largest in the south hemisphere, with 350 borehole heat exchangers, is in operation in Canberra, Australia.

(10) In Australia and New Zealand, solar boosted heat pump systems have a long history of development and still in active improvements of the technology.

FUTURE PROSPECTS

Since Asia & Pacific has population of nearly one half of the world total population,

concentrated in warm climate region, this region has the largest potential requirement for heat pumping technologies for refrigeration and air conditioning. Although during the last decade we have seen a surge of market development for air conditioners driven by rapid economic growth specifically in Southeast Asian countries until the 3rd quarter of 1990s when financial crisis broke out. This region still have a huge market potential for heat pumping technologies which will, in due course, bring about increase of energy and refrigerant consumption in the coming years.

Anticipated increase in energy consumption and refrigerant use in this region will bring about a fairly significant global issue in environmental protection. What we have to take into consideration at this moment is to find a solution in achieving harmonious balance in economic growth, energy security and environmental protection.

Development in heat pumping technology is expected to play an important role in creating sustainable development, by improving the energy efficiency and choosing environmentally friendly refrigerant. It is also expected that IEA heat pump program will contribute, as a tool for promoting international collaboration, to the development of heat pumping technology with more active involvement of countries from Asia & Pacific.

REFERENCES

1. JARN, Special Edition – Air Conditioner, May 25, 2001

2. JARN, Special Edition – Chillers and Large Air-Conditioning Equipment, November 25, 2000 and 2001

3. JSRAE International Symposium Proceedings: Refrigerating and Air-conditioning Systems in Harmony with Global Environment, Oct. 15, 1998, Osaka

4. JSRAE International Seminar, The Environment, Energy and Food in Asia, Dec. 11-12, 2000, Tokyo

5. ACRECONF 2001, Emerging Technologies in Airconditioning and Refrigeration, Sept. 26-28, 2001, New Delhi

6. Asia Pacific Conference on the Built Environment, Progress on Energy Efficiency and Indoor Air Quality, Nov. 14-17, 2001, Singapore