

Study of China Variable Speed Air Conditioner: Energy Efficiency, Life-cycle Cost and Impacts of Subsidy Program

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Abstract:

Sales of variable speed room air conditioners (AC) in China reached 25 millions in 2011, expanding from 10% to 42% of all the ACs in only 5 years.

This development was supported by a series of national policies: a MEPS (Minimum Energy Performance Standard) for variable speed ACs was implemented in 2008, followed by an energy label in 2009, and the national energy efficient product subsidy program since June 2012.

This paper is based on retail market data gathered in the framework of the MACEEP study ("Market Analysis of China Energy Efficient Products" study led by Top10 China and CLASP (Collaborative Labeling & Appliance Standards Program). The data cover the ACs' energy related properties such as SEER (seasonal energy efficiency ratio), cooling and heating capacity and power, cooling season consumption and purchase price for end-consumers.

The cooling capacity is the crucial property, which influences also the heating capacity, the SEER, energy efficiency tier and retail price. The energy efficiency tier is the key element regarding the MEPS, label and subsidy. The market shares according to tiers show that revising MEPS and label is urgently needed to promote the market transformation.

Based on the retail price and electricity consumption, the life cycle cost and payback time of the high efficient products can be calculated. The results show that the subsidy program and other incentive policies should be improved to help the expansion of the high efficient conditioners.

1 Product background

1.1 Market status

The variable speed air conditioners were introduced to the Chinese market in the 1990s. The sales remained low with slow growth rate up to 2009. In 2010 and 2011, the sales doubled over each of the previous years and the market share rapidly expanded from 16% in 2009 to 35% in 2011. The growth rate of sales plateaued in 2012, but the market share of the variable speed air conditioner increased to 44%, which was resulted from the significant decline in the sales of the fixed speed air conditioner.

1.2 Energy efficiency standard and label

The first energy efficient standard for variable speed air conditioner - GB 21455-2008, was implemented in September 2008 and hence covered by China Energy Label Program in March 2009. The implementation of efficiency standard and energy label contributed to the rapid expansion of the market share of the variable speed air conditioners.

GB 21455 - 2008 adopts SEER as its main energy efficiency performance indicator. SEER is calculated according to the testing results under maximum and half load operating conditions and the cooling season operating time, which is 1,136 hours. The MEPS has 5 tiers and only sets the requirements for the cooling function (not for heating).

Table 1-1 Minimum efficiency requirements of tiers in GB 21455 – 2008 Unit: [W*h/(W*h)]

Cooling capacity range (W)	Tier 1 SEER requirement	Tier 2 SEER requirement	Tier 3 SEER requirement	Tier 4 SEER requirement	Tier 5 SEER requirement
CC≤4500	5.20	4.50	3.90	3.40	3.00
4500<CC ≤7100	4.70	4.10	3.60	3.20	2.90
7100<CC	4.20	3.70	3.30	3.00	2.80

1.3 Subsidy program

The variable speed air conditioner was included in the subsidy program from June 2012. Comparing to the same cooling capacity with the fixed speed air conditioners, the variable speed air conditioner receives more subsidy, which helps its market penetration.

Table 1-2 Subsidy for Variable Speed Air Conditioner Unit: RMB

	CC≤2800	2800<CC≤4500	4500<CC≤7100	CC>7100
Tier 1	300	300	350	400
Tier 2	240	240	280	330
Tier 3	0	0	0	0
Tier 4	0	0	0	0
Tier 5	0	0	0	0

1.4 Data information

The main performance and energy efficiency related properties analyzed in this paper are listed below. All the analysis will be performed based on the market data of those properties.

- Cooling capacity (CC)
- Energy efficiency tier (EET)
- Seasonal energy efficiency ratio (SEER)
- Price
- Heating capacity (HC)
- Co-efficiency of the performance (COP)

2 Product analysis

2.1 Product types and market distribution

Variable speed air conditioner has two types of products – wall mounted and free standing. The wall air conditioners have over 2/3 shares of the market. Besides the traditional cooling function, consumers have become accustomed to the heating function. About 97% of variable speed air conditioners on the market have the heating function.

It is discovered that many models have cooling capacity between 2400W and 2700W. The products are classified by their cooling capacities in 4 groups as shown in Table 2-1.

Table2-1 Variable speed air conditioner product groups

Product group NO.	Cooling capacity range (W)	Number of product models
1	$CC \leq 2800$	315
2	$2800 < CC \leq 4500$	379
3	$4500 < CC \leq 7100$	174
4	$7100 < CC$	136

4500W is the point of distinction in cooling capacities between the wall and standing conditioners. Very few wall air conditioners have cooling capacity of 5000W or higher.

The heating capacity has the similar distribution pattern with the cooling capacity. 3600W and 4300W are the most popular heating capacities among variable speed air conditioners. The cooling and heating capacities are closely correlated with a coefficient of correlation of 0.873. In general, heating capacity is slightly higher than cooling capacity.

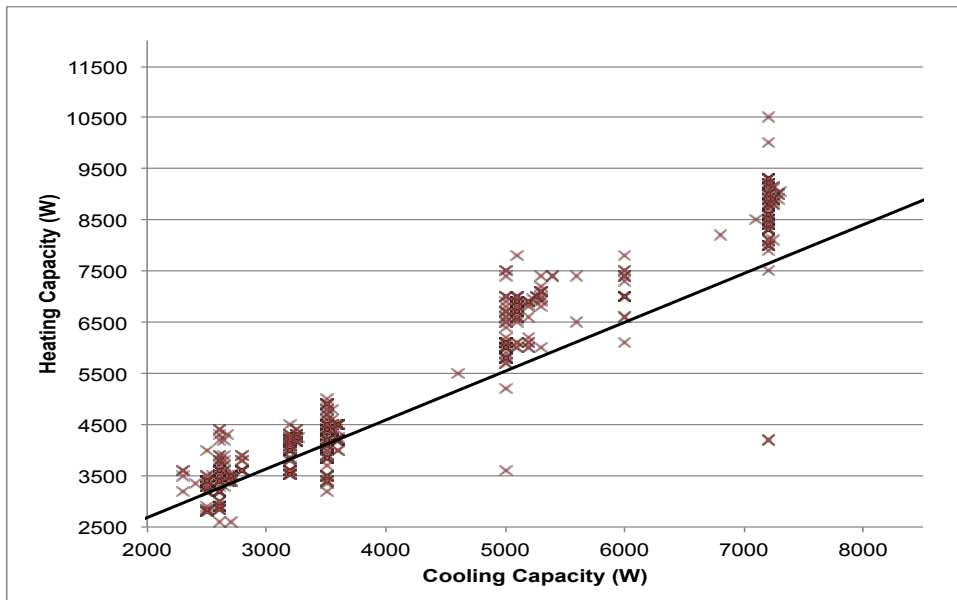


Figure 2-1 Correlation between the cooling and heating capacities

2.2 Energy efficiency

2.2.1 Energy efficiency tier distribution

The current energy efficiency tiers distribution is shown in Figure 2-2. The tier 5 products are almost eliminated from the market, while tier 1 products only occupy a small percentage of the market. Tier 3 dominates the market with over 50% market share. The total percentage of the energy efficient air conditioners (tier 1 + tier 2) is 31.3%, which is higher than normal percentage (20%~25%) of the energy efficient products among other appliances.

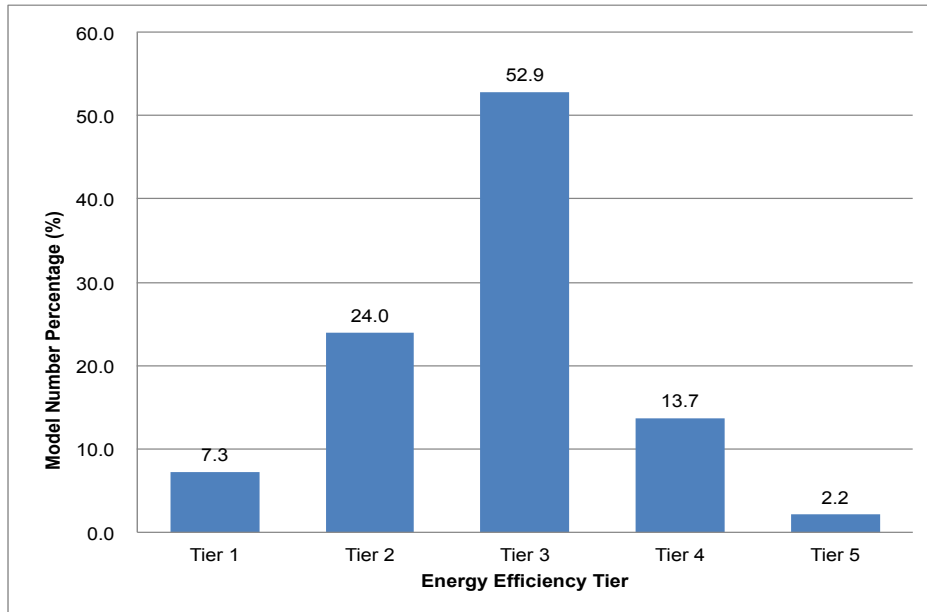


Figure 2-2 Variable speed air conditioner energy efficiency tiers distribution

2.2.2 Seasonal energy efficiency ratio (SEER)

GB 21455-2008 adopts seasonal energy efficiency ratio as the efficiency indicator. Most products have SEERs that are of the minimum requirements of tier 2 and 3. The best available variable speed air conditioner's SEER is higher than 7.

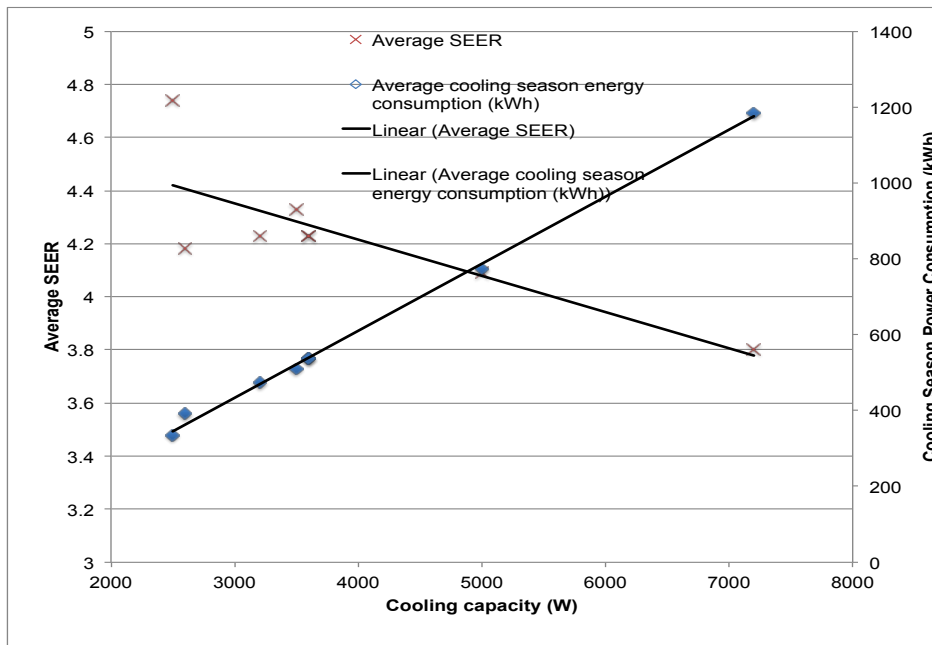


Figure 2-3 Average SEER and cooling season energy consumption

As shown in Figure 2-3, the SEER generally decreases with the increase in the cooling capacity, while the cooling season energy consumption increases proportionally with the cooling capacity in a near-linear relationship.

2.2.3 COP

In GB/T 7725 - 2004 "Room air conditioners", which sets the testing method and defines the performance indicators of the air conditioners, the heating seasonal performance factor

(HSPF) is introduced as the energy performance of the heating function. It is a voluntary indicator declared by the manufacturers. Due to the lack of data of HSPF, COP is calculated based on the rated heating capacity and heating power consumption. It can also indicate the heating energy efficiency of the variable speed air conditioners.

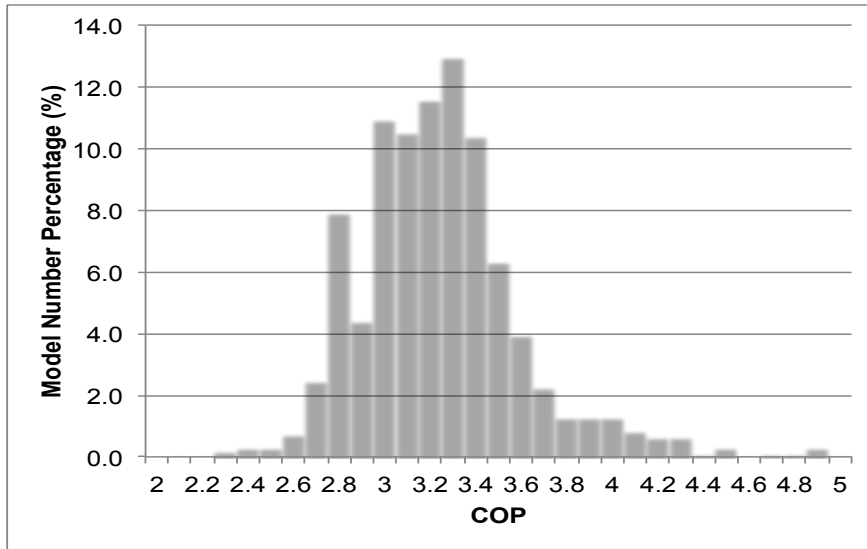


Figure 2-4 COPs distribution

The COPs follows a normal distribution ranging from 2 to 5. Most of the COPs lie within the intervals of 3 to 3.5.

2.2.4 Price

Figure 2-5 shows that the price increases with the increase in cooling capacity. However, the price of air conditioners with cooling capacity of 2500W is much higher than those with cooling capacities between 2600W and 3500W. It can be explained that the average SEER of the 2500W models is much higher than others. This is what the figure shows energy efficiency significantly affects the price of air conditioners with cooling capacities between 2500W and 3500W.

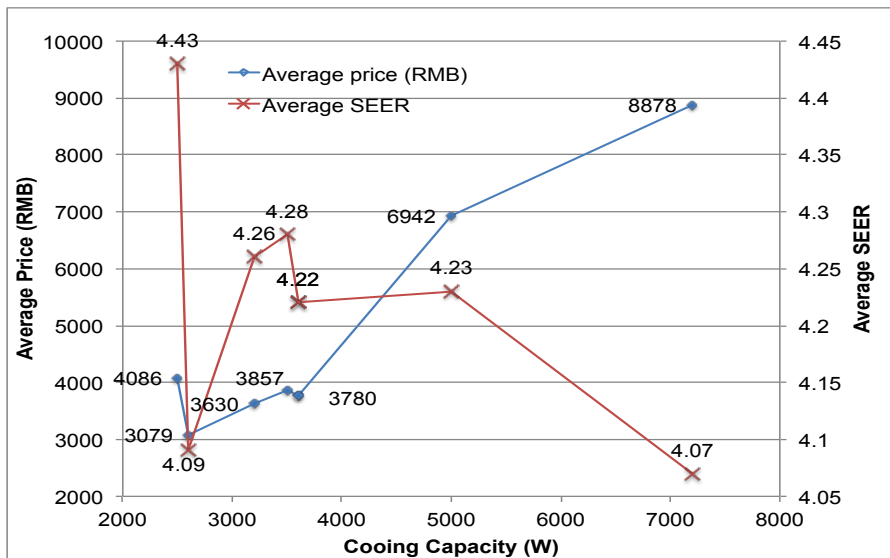


Figure 2-5 Correlation between cooling capacity and price

The subsidy is set based on the fact that the price of the high efficiency products is much higher than the normal or inefficient ones. Figure 2-6 shows the correlation between price and efficiency tiers.

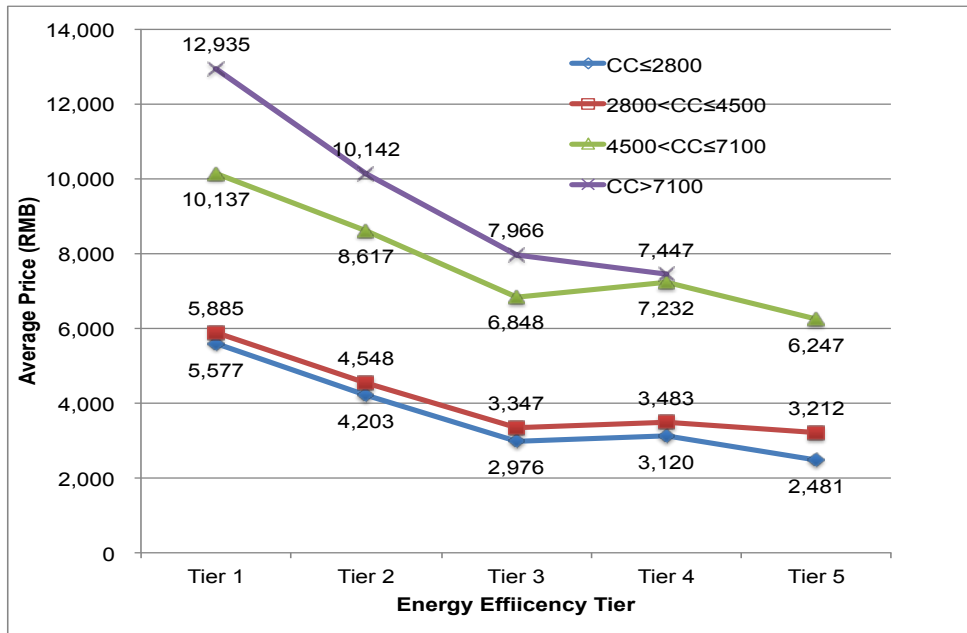


Figure 2-6 Average price of each efficiency tier in four groups

It is evident that the price increases with the cooling capacity. With each product group, from tier 3 to tier 1, the average price increases with the decrease in tiers with a constant rate, especially for the three groups below 7100W. The price differences among tier 3, 4 and 5 are not as big as tier 1 and 2. Products under tier 1~3 can be considered in the same price level, barring some cases where tier 4 and 5 air conditioners are more expensive than those under tier 3. Taking the subsidy into consideration, it cannot sufficiently close or reduce the price gap between tier 1, tier 2 and tier 3 products.

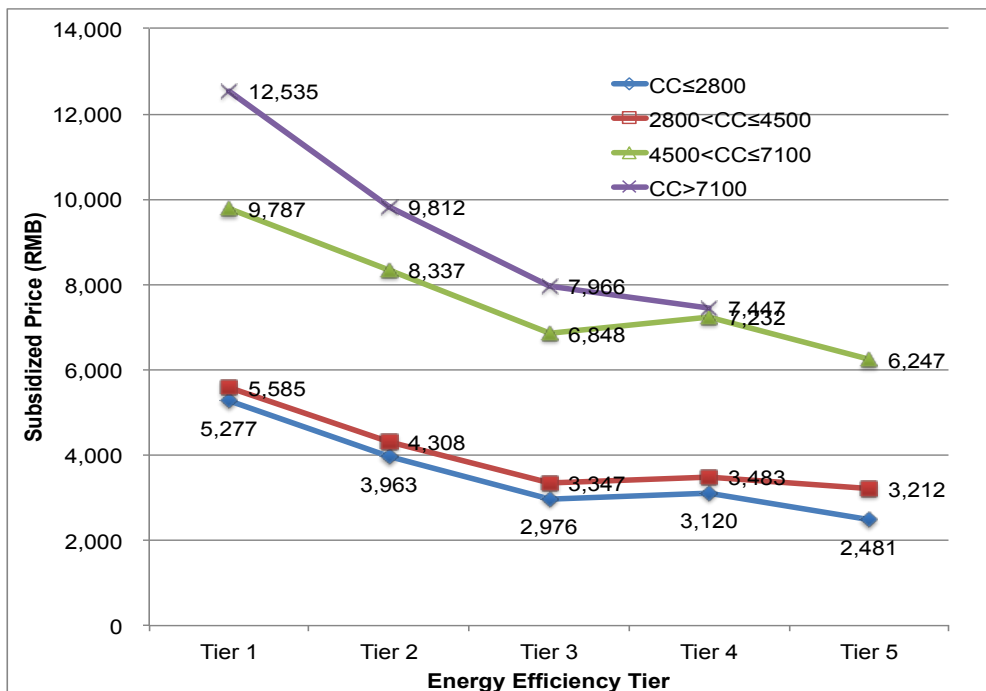


Figure 2-7 Subsidized average price of each efficiency tier in four groups

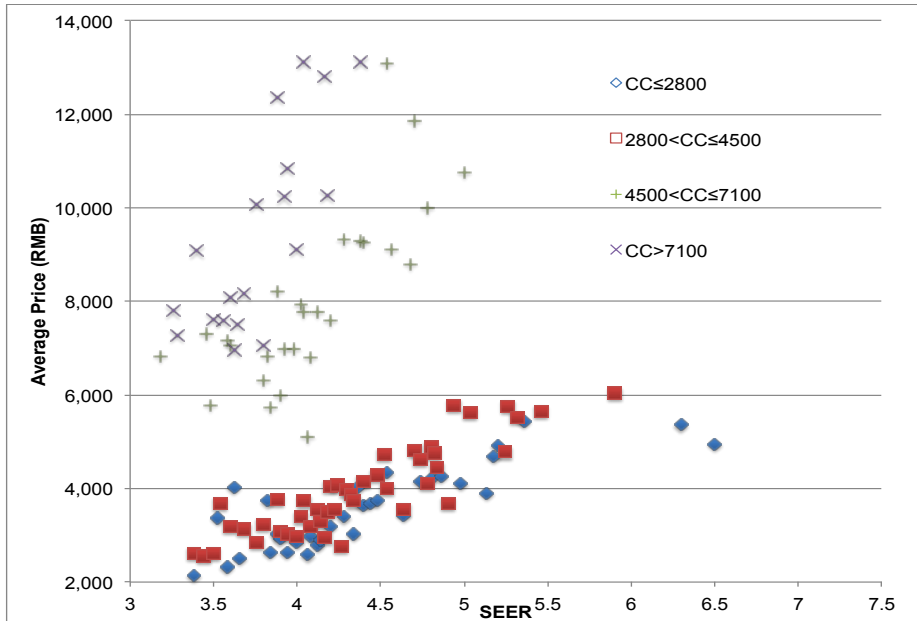


Figure 2-8 Correlation between SEER and average price

Each mark in Figure 2-8 represents the average price of the SEER whose value is calculated from at least 2 samples. In every product group, the similar trend shows that the price increases with the increasing of the SEER, which has the similar trends of the EET-Price.

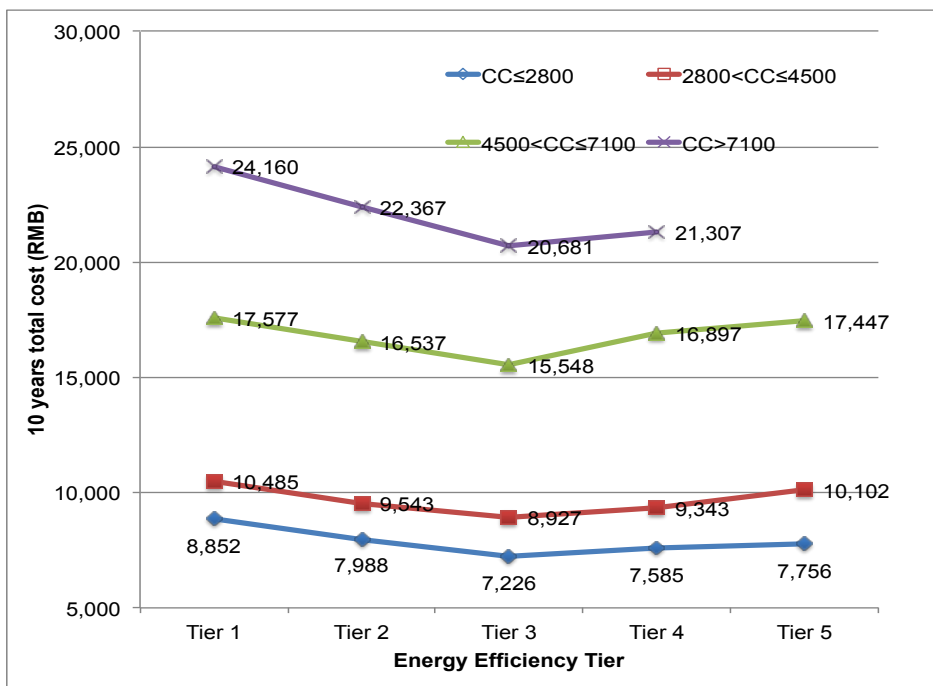


Figure 2-9 10 years total cost of different product groups

Figure 2-9 follows the similar trends with the purchasing price trends. Among all product groups, tier 3 products have the lowest total cost, since tier 3 products have much cheaper price than the tier 1 and tier 2 products. This also indicates that the energy cost savings of high efficiency products cannot offset the high purchasing prices in 10 years time.

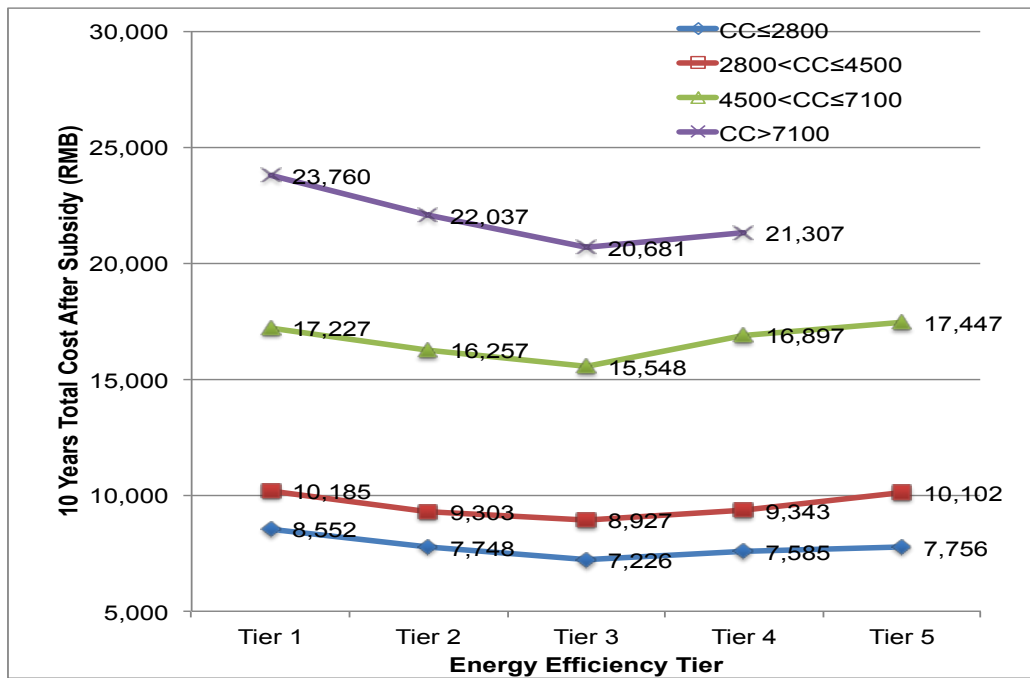


Figure 2-10 10 years total cost of different product groups

Figure 2-10 shows that the subsidy has little or limited impacts on the total cost.

2.3 Recommendations

1. Increase the requirements of the minimum energy performance and hyper energy performances: 1) It has been 4 years since the implementation of the current standard in 2008. It is the time to review and revise this standard. It has been proven that the standard played an essential role in helping the variable speed AC expand its market since 2008; 2) Tier 3 of current standard should be set as the MEPR (Minimum Energy Performance Requirement) in the new MEPS, since the market share of tier 4 and 5 products are already reduced to less than 20%. Based on the experience from the fixed speed air conditioner standard revision, the new MEPS can even use the tier 2 of current standard as its new MEPR, since the variable speed AC has already been included in the new subsidy program. It is well known that the subsidy program phase I played key role in upgrading the fixed speed air conditioner MEPR from tier 5 to tier 2; 3) The average SEER of top efficiency products on the market is much higher than the requirement of tier 1, which means that the manufacturers have the capability to produce products with energy efficiencies much higher than the current tier 1. The requirement of tier 1 should be increased to help these higher efficiency products to distinguish themselves from others.

2. Increase the subsidy and reduce the product models covered by the subsidy program: 1) more subsidy is needed for the high efficiency products in order for them to compete with the normal products in terms of life-cycle cost. The current subsidy is very low compared to the total cost of high efficiency products. In order to close the price gap between higher and lower efficiency products, the subsidy for higher efficiency products should be increased to a point where it is sufficient to affect the decision of the consumers'; 2) subsidy should only be available for top performance products. The existing subsidy program covers both tier 1 and tier 2 products with little distinction. The tier 2 products should be eliminated from the subsidy program and only the top products from tier 1 should be subsidized in order to maximize the impact.

3. Add heating performance requirement to the new MEPS: The COP distribution shows wide range of COPs of the conditioners. The classification scheme of the heating efficiency should be introduced to distinguish high efficiency products from low efficiency products. Users are becoming accustomed with the heating function of air conditioner, as indicated in the study that more than 97% conditioners on the market are with heating function. It was proposed to

include the heating function during the revision of the fixed speed air conditioners MEPS, but the proposal was denied. The latest European standard "Implementing Directive 2009/125/EC of the European Parliament and of the Council with regard to eco-design requirements for air conditioners and comfort fans" included both cooling and heating functions of air conditioner in the MEPS.

Reference

[1] GB 21455-2008, the minimum allowable values of the energy efficiency and energy efficiency grades for variable speed room air conditioners.

[2] GB/T 7725-2004, Room air conditioners (ISO5151: 1994, Non-ducted air conditioners and heat pumps testing and rating for performance. NEQ).

[3] <http://www.etao.com>

[4] <http://www.sdpc.gov.cn/>

[5] <http://www.energylabel.gov.cn/>