Costs and benefits of improving the efficiency of Air Conditioners in China

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Overview

In October 2016, nearly 200 parties agreed to amend the Montreal Protocol to phase down consumption and production of hydrofluorocarbons (HFCs) by 2050. HFCs are currently the fastest-growing category of GHGs, increasing at the rate of 10–15 percent per year and are many thousands of times more powerful GHGs than CO_2. Air conditioning systems currently account for nearly 700 million metric tonnes of direct and indirect CO_2-equivalent emissions per year, with indirect emissions from electricity generation accounting for approximately 74 percent of this total. Direct emissions of HFC and hydrocluorofluorocarbon (HCFC) refrigerants account for the remaining 7 percent and 19 percent, respectively. Market potential for air conditioning and refrigeration, particularly in emerging economies such as China, India, and Indonesia is very high for a number of reasons, including hot climates, increasing incomes, falling prices, electrification, and urbanization. Currently, relatively small proportions of the large and growing populations in the emerging economies own air conditioners (ACs). Market penetration of room ACs was about 5 percent in India and 16 percent in Indonesia in 2013. The Japan Refrigeration and Air Conditioning Industry Association (JRAIA) estimated total residential AC demand worldwide at about 79 million units in 2015. China alone was responsible for 38 percent of total global residential AC demand. Penetration of room ACs in urban households in China increased rapidly from 5 percent in the mid-1990s to 126 percent in 2012, but rural ownership rates were still below 34 percent in 2014.

This study initially reviews the HCFC and HFC regulatory frameworks and energy-efficiency standards programs in 18 economies that account for roughly 65 percent of global demand for room air conditioners. Then, as an example, we estimate the economic benefits and costs of efficiency improvement for a room AC to determine feasible levels for AC energy-efficiency standards in China. We also evaluate the national impact of higher efficiency standards for room ACs in terms of electricity savings, emissions reductions, and peak load impacts.

Methods

Based on the estimates of reduction in AC electricity consumption due to improvement of efficiency of its key components, we analyze the performance of a room AC under several configurations of more efficient components (360 unique design combinations, for example of different compressor and heat exchanger designs). Benefit cost analysis is calculated by summing the costs and benefits of each design combination over the lifetime of the AC system and converted into a net present value (NPV) using a discount rate. The payback period for each combination is calculated using the annual electricity bill savings provided by that design combination relative to the baseline. We then estimate the lowest cost design configuration to reach a certain level of efficiency to develop a cost curve for efficiency improvement. The incremental cost estimates of more efficient components in China were developed in collaboration with the China National Institute of Standardization (CNIS) using market research and interviews with appliance and component manufacturers. We also evaluate the sensitivity of results to the rebound effect due to lower electricity consumption. In addition to this analysis at the per- standard level, we developed a model to estimate the nation-wide electricity demand, greenhouse gas emissions, and peak load impacts of deploying higher standards (see Table 1) for the 2020-2050 timeframe. Energy efficiency standards are based on annual performace factor (APF) metric.

Table 1. Energy-efficiency standard levels applied in each scenario by refrigerant category.

	Baseline	*Scenario 1*	*Scenario 2*	*Scenario 3*	*Scenario 4*	*Scenario 5*
0.75 RT	3.3	3.9	4.2	4.6	5.4	5.8
1.0 RT	3.3	3.8	4	4.4	4.9	5.3
1.5 RT	3.2	3.6	3.8	4.2	4.4	4.8
2.0 RT	3.1	3.4	3.5	3.9	4.4	4.8
>2.5	3.1	3.2				

Notes: RT represents refrigerant ton.

Results

Figure 1 shows a sensitivity analysis of the retail prices for 50% higher and lower costs per APF (annual performance factor). APF indicates cooling/heating capacity (W) per 1 W of power consumption. Markup between manufacturing and retail price represents all steps, including shipping and installation. Figure 2 displays the energy consumption and savings in each scenario.

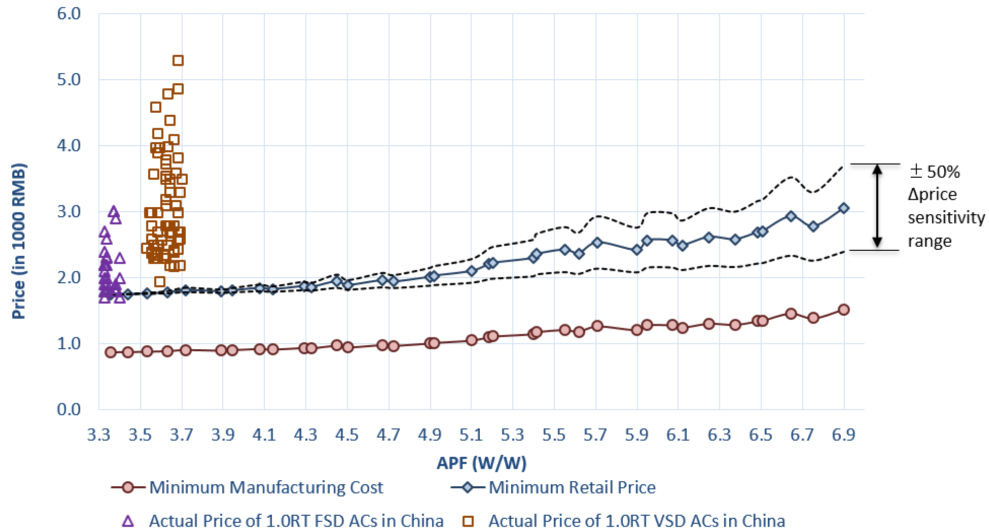

Figure 1. Minimum Manufacturing Cost and Retail Price for Room ACs in China.

Notes: Preliminary estimates for Chinese 1.0 RT (~3.52 kW) Room AC models. FSD and VSD represent fixed speed and variable speed models, respectively. Current MEPS is 3.2 EER (~3.33 APF) rating for FSD, and 3.5 APF rating for VSD.

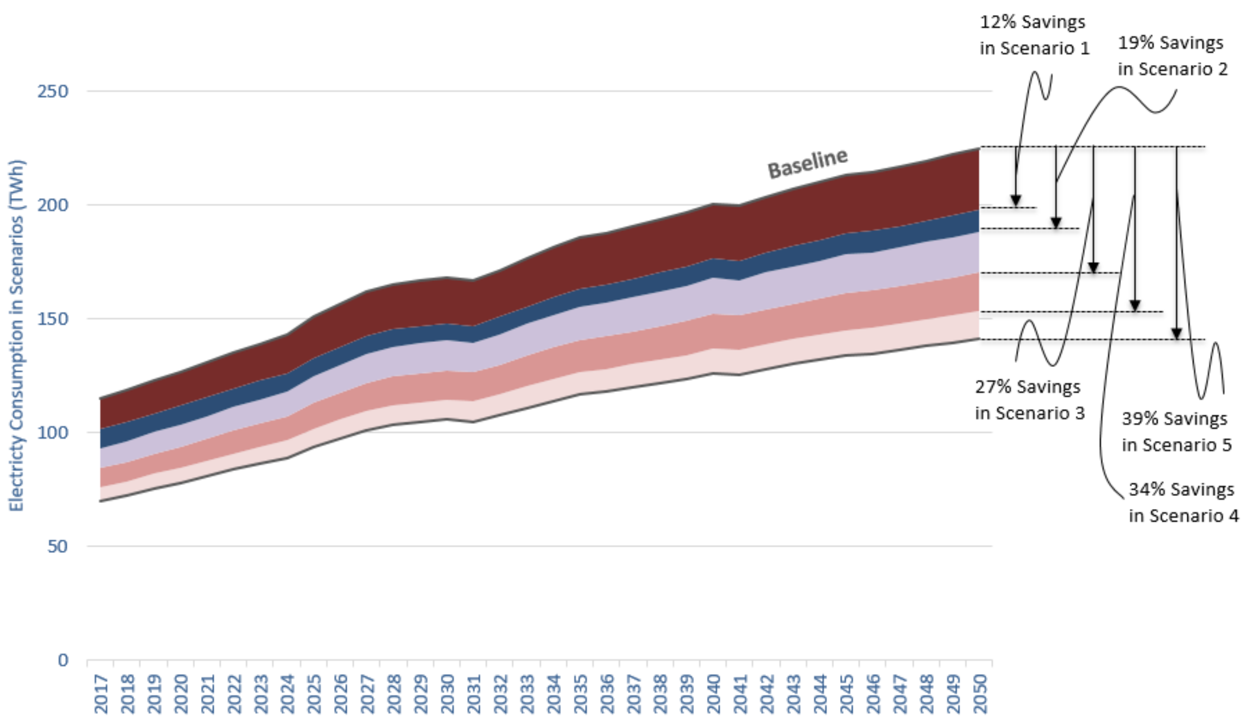

Figure 2. National Electricity Savings from Room AC Efficiency Improvement in China in Scenarios.

Conclusions

Our analysis finds that China has substantial opportunity to improve AC efficiency levels using cost-effective technologies that provide a return on the initial capital investment within 1 years. Results from our modelling also reveal that national electriciy consumption reductions between 12% and 39% are possible with higher efficiency technologies.