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Indoor Air Quality Impact on HVAC Costs

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Abstract
The cost of procuring HVAC equipment for a new building or maintaining existing units can be significantly high. Hence, choosing the best method that satisfies indoor air quality (IAQ) requirements while maintaining a low cost becomes imperative. The objective of this paper is to establish the relationship between additional cost of retrofitting existing commercial HVAC units by adding reheating coils and the cost of procuring new units. Actual cost data for various elementary school projects across the United States were obtained from a third party HVAC retrofitting shop. Modifications were done on the units in order to increase the air volume and heating temperature. This retrofitting includes adding a reheating coil, fan, damper and economizer. The result indicates that the cost of retrofitting these units to meet specific heat output were 50% lower than procuring new units, hence making the lifecycle cost of the building efficient. Furthermore, HVAC contractors will find this helpful, as this will aid in cost comparative analysis for bidding purposes. The dependent variable within this study is the cost of the manufactured unit while the independent variable is the additional costs of retrofitting units by adding reheating coils.

Keywords
HVAC Cost; HVAC contractors; IAQ; Procurement, Reheating Coils

1. Introduction

The objective of this study was to establish the relationship between cost of retrofitting existing commercial HVAC by adding reheating coils and the cost of procuring a brand new unit in order to maintain the required indoor air quality. Hence, this study will enable HVAC contractors to choose HVAC equipment which gives the best value for a given set of specifications. In addition, the procedure defined in this study can be used to compare the cost of replacing existing HVACs versus the cost of retrofitting current units. Samples collected were from a third party HVAC retrofitting shop comprising of 77 units, and were grouped based on the manufacturer's specification. Finally, the average cost of new units were obtained from the manufacturer and compared with the average cost of retrofitted HVAC units. The result showed that the average cost of retrofitting HVAC units to meet the standard required indoor air quality was 50% less than the cost of procuring a new unit.

2. Background

Angus (1968) states that the purpose of ventilation is the removal of vitiated air and replacing it with fresh air. More so, bio-pollutants such as mold can result if humidity is not controlled. In ASHRAE Standard 62-99, (1999) entitled "Ventilation for Acceptable Indoor Air Quality," specifies the amount of outside air needed to cover various levels of occupancy. Janis and Tao (2008), states that indoor air quality has been correlated with employee productivity. One study was performed to determine the effects of ventilation rate on absenteeism. Buildings were classified as moderate ventilation (25 CFM/occ) or high ventilation (50 CFM/occ). Absence rate was 35 percent lower in high-ventilation buildings. The moderate ventilation rate cited in the study is higher than rates prescribed by ASHRAE Standard 62, indicating potential for improvement in current design practices. The need to maintain the IAQ comes at a high price. Systems must provide sufficient amounts of clean air to keep oxygen at an acceptable level and to dilute contaminants generated within occupied spaces.

However, most buildings today are faced with increased occupancy rates; hence the need to constantly maintain the quality of air and space temperature becomes a daily challenge. Janis and Tao (2008), states that the air temperature has been documented to affect worker performance. Small differences in temperature have been reported to have 2 to 20 percent performance impact in tasks such as typing, learning performance, reading speed, multiplication speed, and word memory. Consequently, air should be reasonably free of dust, and spaces free of odors or other pollutants that may be hazardous or objectionable. These conditions are generally achieved through the use of filters and by the introduction of 100% outside air into the system. In providing outside air, the quality of air is improved, and the CO_2 level is reduced to accommodate the treated air.

Another alternative is to include reheating coils in order to transfer the excess heat given off by the condensing unit back to the downstream of the DX coil. This has proven to be a better cost effective method as more clients are seeing the benefit of using reheating coils. With increasing pressure to cut cost and the limited budget of most elementary schools, the search for alternative ways of saving energy without compromising the quality of the indoor space has become more important. This alternative is to retrofit HVAC units to meet air quality requirements at a low cost. Retrofitting HVAC units has shown to have a higher cost savings than procuring new units.

3. Research Methodology

Between the years 2004 and 2008, a total of 77 HVAC units were customized to meet the IAQ requirements. Reheating coils, dampers and economizers were added to existing HVAC units. During this period, the cost data for procuring new HVAC units was also collected from a major HVAC equipment manufacturer. Cost data of retrofitting similar HVAC units to meet (IAQ) requirements were collected from another company with 20 years experience in HVAC modification. All the HVAC units used in this study were grouped according to compressor size (tons) and manufactures' equipment model.

4. Data Analysis

Between 2004 and 2008, an average of $500 per ton was the HVAC cost. Subsequently, the average cost for each group of compressor size was calculated and was compared with the average cost of retrofitting the same units.

Table 1: Average Cost of New HVAC Units between 2004 and 2008		
Compressor Size (Ton)	Cost per Ton ($)	Average Cost of New Unit ($)
6-10	500	5000
11-25	500	8,500
26-35	500	15,500
36- 50	500	21,500

Table 2: Average Cost of Retrofitting HVAC Units between 2004 and 2008

Compressor Size (Tons)	Modification	Average Cost 2004	Average Cost 2005	Average Cost 2006	Average Cost 2007	Average Cost 2008
6-10	Reheat	$4434	-	$3200	$4233	$5132
11-25	Reheat	$3764	$5175	$5290	$4484	$8206
26-35	Reheat	$3917	$2000	-	-	$28,882
36-50	Reheat	-	-	-	-	$3344

Table 3: Number of HVAC Units between 2004 and 2008						
Compressor Size (Tons)	Modification	2004	2005	2006	2007	2008
6-10	Reheat	4	-	5	2	15
11-25	Reheat	4	4	4	10	17
26-35	Reheat	2	1	1	3	2
36-50	Reheat	-	-	-	1	2

5. Results

The result showed that the cost of retrofitting HVAC units between 2004 and 2008 was 50% lower than the cost of procuring new units. Below are graphs showing the average costs of retrofitting and replacing the units.

Figure 1: Average Cost of Procuring New HVAC Units between 2004 and 2008

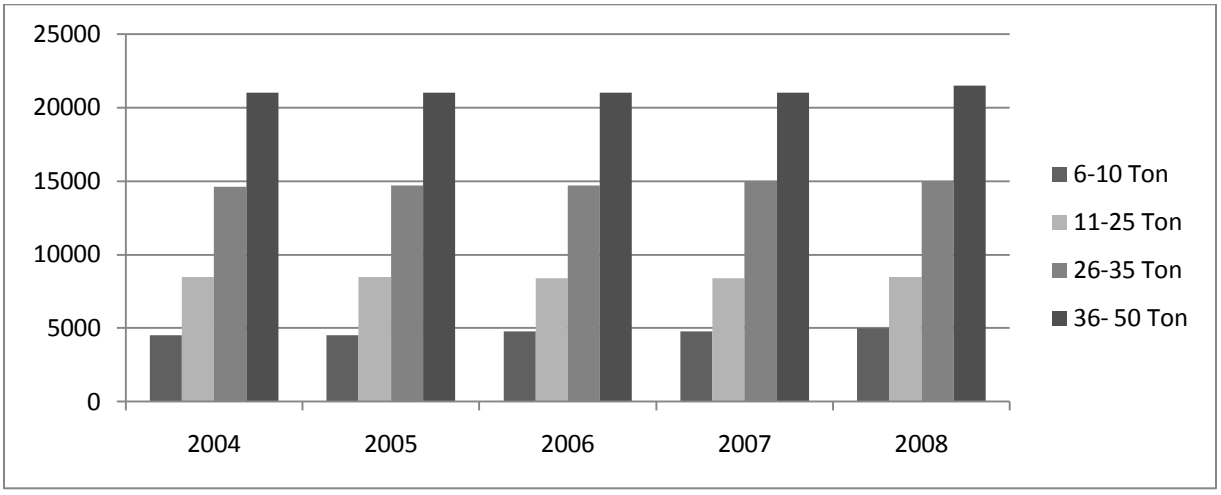

Figure 2: Average Cost of Retrofitting Existing HVAC Units between 2004 and 2008

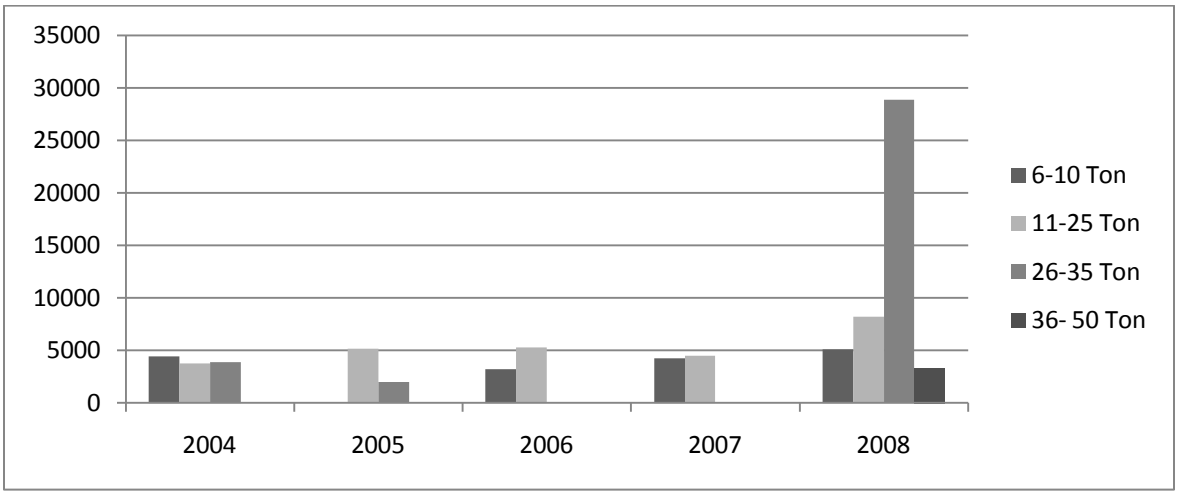

Table 4: Comparable Average Cost of Retrofitting vs. Replacing HVAC Units

Units	2004		2005		2006		2007		2008	
	Retro	**New**	**Retro**	**New**	**Retro**	**New**	**Retro**	**New**	**Retro**	**New**
6-10	4434	5000		5000	3200	5000	4233	5000	5132	5000
11-25	3764	8500	5175	8500	5290	8500	4484	8500	8206	8500
26-35	3917	15000	2000	15000		15000	-	15000	28882	15000
35-50	-	21500	-	21500	-	21500	-	21500	-	21500

6. Definition of Terms

Reheating Coil: Peci Reference guide states that the reheating process is employed when the discharge temperature required to dehumidify an air stream results in air that will overcool the area when delivered in the required volume (Sellers et. al., 2003). Therefore, reheating is required to maintain space temperature control. The reheating process allows for improved control of relative humidity levels. When the cooling medium is a refrigerant (e.g., Freon), the reheating coil is designed to allow the refrigerant to vaporize in the coil, thus absorbing heat from the air.

Damper: Carrier (1974) states the louver damper is used for three important functions in the air handling apparatus: (1) to control and mix outdoor and return air; (2) to bypass heat transfer equipment; and (3) to control air quantities by the fan.

Retrofitting: Refers to the addition of new components to older units in order to improve the efficiency. However, existing units can be retrofitted depending on the use of the client to meet design specifications without having to manufacture new units. Retrofitting in this research study is comprised of adding reheating coils to existing HVAC units whereby higher heat output (BTU) is gained by redirecting the expended heat from the condensing unit back to the airstream of the evaporative coil. Furthermore, other

components which can be retrofitted include the addition of economizers, outside air hoods, hot gases by pass valves, blowers and thermo-expansion valves (TXV).

7. Cost Implications of Retrofitting Existing Units

This research study has shown that it costs 50% less to retrofit existing units rather than procure new units. The independent variable chosen for this study was limited to the cost required to add reheating coils to existing units. However, other independent variables like the addition of economizers, outside air hoods, hot gases by pass valves, blowers and thermo-expansion valves (TXV) can add to the total cost of retrofitting existing HVAC units, if required. The additional cost of adding these components can be between 2% to 5% of the total cost of retrofitting existing units by adding reheating coils.

8. Conclusions

Numerous factors like the category and use of the building bear an influence on the decision to procure a new HVAC unit or retrofit an existing one. However, if cost is a vital issue, retrofitting existing HVAC units is the most cost efficient process of achieving maximum air quality.

9. References

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