A PRACTICAL GUIDE TO COMMERCIAL AIR CONDITIONING REBATES FOR MUNICIPAL UTILITIES

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Table of Contents

INTRODUCTION 1
WHY COMMERCIAL COOLING REBATES? 1
ASSESS THE BENEFITS OF HIGH EFFICIENCY COOLING TECHNOLOGIES TO CUSTOMERS AND THE UTILITY 3
Become Familiar with Commercial Cooling Technologies 3
Establish Preliminary Qualifying Criteria for Incentives 8
Assess the Economics of Qualifying Equipment to Customers 14
Assess the Economics of Cooling Incentives to the Utility 17
OBTAIN DIRECTION FROM THE MUNICIPAL PUBLIC UTILITIES COMMISSION OR CITY COUNCIL 21
DESIGN THE PROGRAM 21
Determine the Project Budget 21
Define the Technical Aspects of the Program 22
Develop a Marketing Plan 31
Develop Program Processes and Staffing 34
Develop a Tracking and Evaluation Plan and Identify Data Requirements 35
Gather Information on Other Utilities' Experience 36
APPENDIX A. COMMERCIAL AIR CONDITIONING EQUIPMENT MARKET A-1
APPENDIX B. EFFICIENCY OF COMMERCIAL COOLING EQUIPMENT B-1
APPENDIX C. THE ECONOMICS OF HIGH EFFICIENCY COMMERCIAL COOLING EQUIPMENT C-1
APPENDIX D. THE COMMERCIAL COOLING EQUIPMENT PURCHASE PROCESS D-1
APPENDIX E. .....MARKET BARRIERS IDENTIFIED AND MARKET STRATEGIES RECOMMENDED BY MANUFACTURERS' REPRESENTATIVES E-1
APPENDIX F. CONTACT INFORMATION FOR MINNESOTA MANUFACTURERS' REPRESENTATIVES F-1
APPENDIX G. GLOSSARY G-1
SOURCES OF INFORMATION FOR THIS GUIDE R-1
REFERENCES R-2

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A PRACTICAL GUIDE TO COMMERCIAL AIR CONDITIONING EQUIPMENT REBATES FOR MUNICIPAL UTILITIES

INTRODUCTION

This purpose of this guide is to provide municipal utilities in Minnesota with basic, practical information on how to implement commercial air conditioning equipment rebates. The guide explains the potential benefits of cooling rebates to the utility, and explains in detail how to assess the benefits for a particular utility, and how to design a program. It also identifies resources that can provide more detailed information and assistance.

WHY COMMERCIAL COOLING REBATES?

Municipal utilities may consider offering commercial cooling rebates for three main reasons:

1. Incentives and assistance offered to key commercial customers can strengthen relations with them, which may help to retain them after deregulation.
2. Reducing demand and energy use through cooling incentives often costs a utility less than providing the energy. In some cases, it can also have a beneficial impact on rates. This depends on a utility's rate structure and costs to purchase or generate power.
3. Reducing energy use and power plant construction provides environmental benefits, and is consistent with a public sector utility's responsibility for environmental stewardship.

As electric utilities are deregulated, competition for commercial customers will be intense. Utilities that have developed a strong relationship with their customers will be more likely to keep them. Utilities often report that their energy efficiency programs are among their most popular and appreciated services. Incentive programs allow a utility to demonstrate that it has the capability and desire to help customers make the most of their energy dollars, and to begin to develop a one-on-one relationship with them.

Cooling accounts for about 21% of commercial electricity use in the U.S., second only to lighting at 38% (Figure 1). It is the largest component of summer system peak load, accounting for about 54% of summer peak load from commercial buildings nationwide (E-Source 1995). In Minnesota, NSP has estimated that cooling accounts for about 12% of its commercial electric use, second only to lighting at 34%. It is the largest component of the commercial sector's contribution to NSP's summer peak load, as well, at 37%. Cooling is therefore a significant contributor to commercial customers' electric bills. If a utility seeks to strengthen its relationships with commercial customers by providing assistance in managing energy costs, cooling costs must be a key focus.

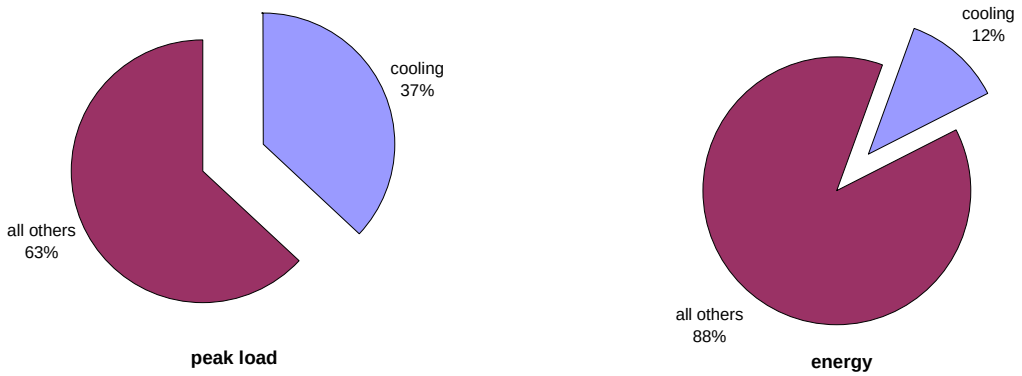

Figure 1. Contribution of Cooling to Peak Load and Energy Use in the Commercial Sector (NSP)

On average, of course, a utility's revenues must exceed its costs, or it will not be able to continue to function. However, it isn't always true that each kW and kWh you sell brings in more than it cost to produce it. Rates are often developed by dividing total costs for a given item (e.g., commercial customer demand) by total units sold, which results in rates set at the average cost. Some municipal utilities in Minnesota have some low cost power (e.g., an allocation from Western Area Power Administration), and then purchase their supplemental power from a more expensive supplier. Supplemental power actually costs some such utilities more than they collect for it through rates. For these utilities, encouraging energy efficiency can actually lower average costs and rates.

Commercial cooling has a load factor of only about 17% (i.e., the amount of energy consumed per year is only about 17% of what would be consumed if the equipment operated year round at the demand it requires at the time of the system peak). Cooling load therefore requires utilities to provide considerable capacity without generating commensurate annual electricity sales. If a utility is using capacity that has a high capital cost and low operating cost, loads with low load factors will be expensive to serve. Helping commercial customers control their cooling energy use can limit the growth of peak loads and improve load shape.

By slowing the growth of these peaks, a cooling efficiency program can help to reduce the need for unpopular new power plants and transmission lines. It can also substantially reduce commercial sector energy use with its attendant impacts on the environment.

This guide can help you first to assess the benefits of cooling incentives to your customers and the direct economic benefits or costs to the utility. The benefits in terms of strengthened customer relations are more difficult to quantify, but should be evaluated subjectively. If the program looks promising and the local utility commission or city council agrees, the later sections of the guide can help you design the program.

ASSESS THE BENEFITS OF HIGH EFFICIENCY COOLING TECHNOLOGIES TO CUSTOMERS AND THE UTILITY

Become Familiar with Commercial Cooling Technologies

To assess and design a cooling incentive program, you will need to become familiar with commercial cooling technologies.

Types of Cooling Equipment

There are three major types of commercial cooling technologies.

Unitary air conditioners (Figures 2 and 3) are factory-assembled and are installed in one or two self-contained units. The most common in commercial applications is the single package, typically mounted on the roof and often referred to as a "rooftop unit." Another type is a "split system," similar to residential units, with a condenser located outside the building (often on a pad beside the building) and an evaporator located inside in the building ductwork. Unitary equipment includes units designed for cooling only, units with a refrigeration system for cooling and a different system (gas or electric resistance) for heating (called "year-round air conditioners" in the industry), and units with a reversing refrigeration system used for both cooling and heating (heat pumps). It is sold in sizes from a few tons of cooling capacity (1 ton = 12,000 Btu/h) to 50 tons or more, but most units sold are in the smaller sizes. Unitary air conditioners use the refrigerant directly to cool the indoor air.[1] Nearly all the units sold in Minnesota reject the heat to the outdoor air through a dry heat exchanger, and are therefore "air-cooled."

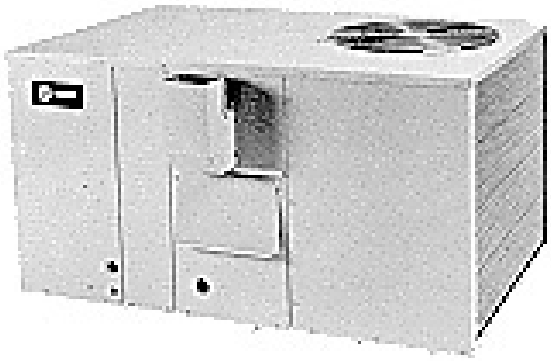

Figure 2. Small Single Package Year-Round Air Conditioner (Trane)

[1] Hence the term, "direct expansion."

Figure 3. Condenser for Split System (York)

Chillers (Figures 3 and 4) are large central systems, which use the primary refrigerant to chill water. The chilled water is then circulated through the building and serves as a "secondary refrigerant" to cool the building air. Some chiller systems have "air cooled" condensers, but many have water-cooled condensers coupled with a cooling tower to cool the condenser water. Chillers are sold in sizes from about 12 tons to hundreds of tons, but, in contrast to unitary equipment, few units are sold in the small sizes.

Figure 4. Reciprocating Chiller (York)

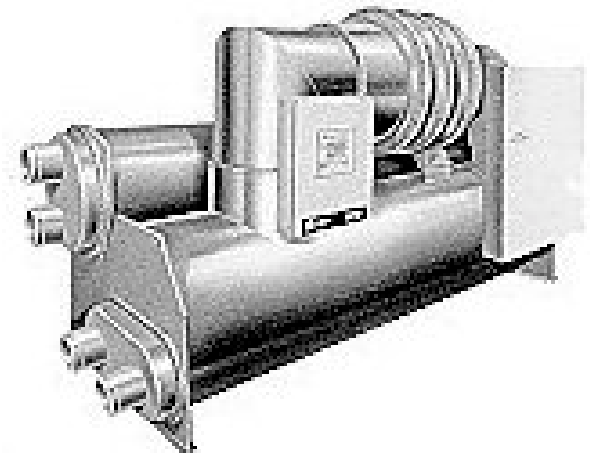

Figure 5. Centrifugal Chiller (Trane)

Packaged terminal equipment (Figure 6) includes packaged terminal air conditioners (PTACs) and packaged terminal heat pumps (PTHPs). These are self-contained units consisting of a wall sleeve and a separate unencased cooling and/or heating assembly. The systems typically installed below the window to heat and cool motel rooms are good examples of packaged terminal equipment.

Figure 6. Packaged Terminal Air Conditioner (Amana)

Other types of commercial cooling equipment are water source heat pumps, ground source heat pumps, and groundwater source heat pumps. Water source heat pumps are often used in commercial buildings with a central water loop. The heat pumps draw heat from or reject heat to the central water loop to maintain the desired air temperature in each space, and the temperature of the water loop is maintained in the desired range using a boiler and cooling tower. Ground source and groundwater source heat pumps are fairly uncommon, but are increasing in use. Because the costs are much greater, the installation issues more complex, and the trade allies more diverse, ground source and groundwater source heat pumps are typically addressed through a separate incentive program, and will not be discussed further here.

More information about the types, sizes and sales of commercial cooling equipment is provided in Appendix A.

Typical Applications of Cooling Equipment

The type of cooling equipment used varies by building size.

Small commercial buildings of 25,000 sq. ft. or less account for 89% of cooled commercial buildings and 39% of cooled commercial floor space. In buildings of this size, commercial- and residential-sized unitary equipment, PTACs, PTHPs and other through-the-wall units predominate.

Mid-sized commercial buildings of 25,001 to 100,000 sq. ft. account for only 9% of cooled commercial buildings but 28% of cooled floor space. Within this category, too, unitary equipment and individual air conditioners dominate, but chillers do provide part or all of the cooling for about 20% of the floor space.

Large commercial buildings of 100,001 sq.ft. or more account for only 2% of cooled commercial buildings, but fully 33% of cooled commercial floor space. Within this building category, chillers provide part or all of the cooling for 48% of floor space, and district chilled water systems cool another 10%, but unitary equipment still plays a significant role, providing part or all of the cooling for 57% of floor space, and individual air conditioners are also common.

More information on the distribution of cooling equipment types by building size is given in Appendix A.

Major Manufacturers

Commercial air-conditioning markets are fairly concentrated from a manufacturing perspective. Eight manufacturers account for nearly all the output of unitary cooling equipment, seven for essentially all the output of PTACs/PTHPs, and five for essentially all the output of chillers (Tables 1 through 3). The number of unitary equipment manufacturers, in particular, seems larger that it actually is because many manufacturers sell units under several brand names.

Information on regional market shares obtained through interviews with manufacturers' representatives is given in Appendix A.

Table 1. Major Manufacturers of Unitary Cooling Equipment

Manufacturer Selected Brand Names
Carrier Corporation Bryant, Carrier, Day & Night, Payne
Goodman Manufacturing Goodman, Mobiletemp
Rheem Manufacturing Rheem, Ruud, Weatherking
The Trane Company American Standard, Trane,
York International Airpro, Coleman Evcon, Fraser and Johnston, Guardian, Luxaire, Moncrief, York
International Comfort Products Corporation Airquest, Arcoaire, Comfortmaker, Heil, ICP, Maratherm, Tempstar
Lennox Industries Armstrong, Lennox
Nordyne Intertherm, Miller, Nordyne

Table 2. PTAC and PTHP Manufacturers

Manufacturer Brand Names
Amana Refrigeration, Inc. Amana
Carrier Corporation Carrier
Climate Master, Inc. (a subsidiary of LSB Industries) Climate Master
Friedrich Air Conditioning Friedrich
McQuay International AAF, Incremental, Incremental Remington, McQuay
The Trane Company Trane
General Electric Company Zoneline

Table 3. Chiller Manufacturers

Manufacturer
Carrier Corporation
Dunham Bush Incorporated
McQuay International
The Trane Company
York International Corporation

Resources

- *Appendix A. Commercial Air Conditioning Equipment Market*. More information on equipment types, applications, manufacturers and survey data on regional market shares by manufacturer.
- E-Source 1995. *Commercial Space Cooling and Air Handling. Technology Atlas Series, Volume II*. Boulder, CO: E-Source, Inc. Comprehensive summary of cooling technologies and energy efficiency opportunities. Useful for all phases of program planning and design, though the reference is not repeated in every section.

Establish Preliminary Qualifying Criteria for Incentives

To assess the economics of cooling rebates to customers and to the utility, it is necessary to estimate the incremental costs of high efficiency cooling equipment and the associated demand and energy savings. In order to do this, it is necessary to establish preliminary criteria for the efficiency of units with will qualify for an incentive. These criteria, as refined, will also be needed later in developing the program rules.

A number of factors must be considered in establishing qualifying criteria, as described below:

1. Legal minimum efficiencies: Most commercial cooling equipment is subject to minimum efficiency standards set by federal or state government. Obviously, incentives must be offered only for equipment that exceeds the legal minimum efficiencies.
2. Availability of equipment more efficient than the standards: Historically, very little high efficiency unitary equipment was available. The unitary market is generally driven by first-costs, and while there was a niche that was interested in efficiency, most manufacturers did not consider it large enough to justify the cost of producing a second product line. As of 1992, only one large manufacturer and one small manufacturer offered a high efficiency commercial unitary product line. A limited number of vendors can be a problem for utility rebate programs, since it gives the qualifying vendors a strong competitive advantage that generates animosity against the utility among other vendors. Fortunately, the Consortium for Energy Efficiency started to address this problem in 1993 by establishing a uniform set of higher efficiency levels, and encouraging utilities around the country to develop rebate programs to provide incentives for products at these efficiency levels. The Consortium currently has “Tier 1” and “Tier 2” efficiency levels for unitary equipment. The Tier 1 levels average roughly 13% above the current federal and ASHRAE standards, and the Tier 2 levels average about 10% above the Tier 1 levels. As a result of this initiative, the majority of major manufacturers now make qualifying unitary equipment. PTACs, PTHPs and chillers with efficiencies higher than the minimums are also available.
3. Market share of the high efficiency equipment. If the high efficiency equipment already has a major share of the market, then it will not be worthwhile to provide incentives, since there will be many free-riders (customers who would have installed the high efficiency equipment anyway, and who incur program costs without resulting in any net demand or energy savings). This may be the case with the PTAC/PTHP market, where the market share of high efficiency equipment appears to be about 75 to 80% of total sales. Most

PTAC/PTHP vendors only make one efficiency in any given size. It appears that, because the proposed increases in the efficiency standards for PTACs and PTHPs have been known for some time, many manufacturers have already modified their single product lines to meet these standards. If the high efficiency equipment has only a tiny share of the market, on the other hand, then contractors and customers may not be very familiar with it or comfortable with it, and few vendors may offer it, so it may be difficult to achieve much market penetration initially.

Tables 4 through 8 summarize current efficiency standards and recommended qualifying criteria for commercial cooling equipment. Because the market is diverse and system sizes vary widely, separate qualifying criteria must be specified for many sizes and types of equipment, as the tables show.

While the qualifying criteria (or in the case of the unitary equipment, the Tier 1 qualifying criteria) indicate the lowest efficiency that should receive an incentive, there is a definite advantage to providing an additional, incremental incentive for higher efficiencies. This helps to offset the higher equipment costs for these higher efficiencies, and encourages customers to buy the most efficient equipment.

Appendix B provides more details on current standards and results of interviews with manufacturers' reps regarding regional market shares of high efficiency equipment of various types and sizes.

Resources

- *Appendix B. Commercial Cooling Equipment Efficiencies.* More information on current federal and state efficiency standards and forthcoming federal standards, recommended levels for incentives, number and percent of certified models on the market meeting qualifying criteria, and survey data on market share of high efficiency equipment.
- ARI *Electronic Directory of Certified Applied Air-Conditioning Products.* Arlington, VA: Air Conditioning & Refrigeration Institute. Provides capacity and efficiency data for every model of certified applied equipment (large unitary equipment, large condensing units, PTACs, PTHPs).
- ARI *Electronic Directory of Certified Unitary Equipment.* Arlington, VA: Air Conditioning & Refrigeration Institute. Provides capacity and efficiency data for every model of certified unitary equipment under 135,000 Btu/h cooling capacity.
- Air Conditioning and Refrigeration Institute web site, www.ari.org. Provides a "PrimeNet" directory that does not currently offer as much functionality as the electronic directories on CD-ROM, but its functionality should improve, and it will be the most current directory at any given time.
- Rob Scott-Hovland, Minnesota Municipal Utilities Association. 612/551-1230 ext. 206. rhovland@mmua.org. Rob can provide up to date information on federal and state efficiency standards and recommended qualifying criteria, either directly or through MMUA's contractor, the Center for Energy and Environment. Rob can also put you in touch with other MMUA members who have developed commercial cooling programs.

- Consortium for Energy Efficiency web site. www.ceeformt.org. Provides information on the Consortium's market transformation initiatives, including their high efficiency commercial air conditioning initiative.
- Bruce Nelson, Minnesota Department of Public Service. Mr. Nelson developed the Minnesota Energy Code.

Table 4. Current Minimum Efficiency Requirements and Efficiency Levels Recommended for Incentives for Unitary Air Conditioners

Equipment Type	Size Category*	Sub-Category	Current Minimum Efficiency Requirements	Recommended for Incentives: Consortium for Energy Efficiency	
				Tier 1 Efficiency	Tier 2 Efficiency
Air Cooled Air Conditioners	<65,000 Btu/h	Split System	10.0 SEER (1)	12.0 SEER	13.0 SEER
		Single Package	9.7 SEER (1)	11.0 SEER	13.0 SEER
	≥65,000 Btu/h and < 135,000 Btu/h	Split System & Single Package	8.9 EER (2) 8.3 IPLV (3)	10.3 EER 10.6 IPLV	11.0 EER 11.4 IPLV
	≥135,000 Btu/h and < 240,000 Btu/h	Split System & Single Package	8.5 EER (2) 7.5 IPLV (3)	9.7 EER 9.9 IPLV	10.8 EER 11.2 IPLV
	≥240,000 Btu/h and ≤ 760,000 Btu/h	Split System & Single Package	8.5 EER (3) 7.5 IPLV (3)	9.5 EER 9.7 IPLV	10.0 EER 10.4 IPLV
	> 760,000 Btu/h	Split System & Single Package	8.2 EER (3) 7.5 IPLV (3)	9.5 EER 9.7 IPLV	10.0 EER 10.4 IPLV
Evaporatively Cooled Air Conditioners	<65,000 Btu/h	Split System & Single Package	9.3 EER (2) 8.5 IPLV	12.1 EER 11.2 IPLV	14.0 EER
	≥65,000 Btu/h and < 135,000 Btu/h	Split System & Single Package	10.5 EER (2) 9.7 IPLV (3)	11.5 EER 10.6 IPLV	14.0 EER
	≥135,000 Btu/h and <240,000 Btu/h	Split System & Single Package	9.6 EER (2) 9.0 IPLV (3)	11.0 EER 10.3 IPLV	14.0 EER
	≥240,000 Btu/h	Split System & Single Package	9.6 EER (3) 9.0 IPLV (3)	11.0 EER 10.3 IPLV	14.0 EER
Water Cooled Air Conditioners	<65,000 Btu/h	Split System & Single Package	9.3 EER (2) 8.3 IPLV (3)	12.1 EER 11.2 IPLV	14.0 EER
	≥65,000 Btu/h and < 135,000 Btu/h	Split System & Single Package	10.5 EER (2)	11.5 EER 10.6 IPLV	14.0 EER
	≥135,000 Btu/h and < 240,000 Btu/h	Split System & Single Package	9.6 EER (2) 9.0 IPLV (3)	11.0 EER 10.3 IPLV	14.0 EER
	≥ 240,000 Btu/h	Split System & Single Package	9.6 EER (3) 9.0 IPLV (3)	11.0 EER 10.3 IPLV	14.0 EER

(1) For single phase equipment, National Appliance Energy Conservation Act of 1987, as amended. 42 U.S.C. Ch. 77 Subch. 3, Sec. 6295 (d), and Minnesota Rules 7670.0660. For three phase equipment, Energy Policy Act of 1992. PL 102-486, Subtitle C, Section 122 (d). 42 U.S.C. Ch 77 Subch 3, Sec. 6313.

(2) Energy Policy Act of 1992, as above, and ASHRAE/IES 90.1-1989 and Minnesota Rules 7670.0660.

(3) ASHRAE/IES 90.1-1989 (requirements labelled "January 1, 1992") and Minnesota Rules 7670.0660. Note that, for equipment over 135,000 Btu/h, ASHRAE/IES 90.1-1989 specifies that minimum EERs and IPLVs shall be reduced by 0.2 if there is a heating section. This deduction was not carried over into the Minnesota Energy Code.

Table 5. Current Minimum Efficiency Requirements and Efficiency Levels Recommended for Incentives for Heat Pumps

Equipment Type	Size Category*	Sub-Category	Current Minimum Efficiency Requirements	Recommended for Incentives: Consortium for Energy Efficiency	
				Tier 1 Efficiency	Tier 2 Efficiency
Air Cooled (Cooling Mode)	<65,000 Btu/h	Split System	10.0 SEER (1)	12.0 SEER	13.0 SEER
		Single Package	9.7 SEER (1)	11.0 SEER	13.0 SEER
	≥65,000 Btu/h and < 135,000 Btu/h	Split System & Single Package	8.9 EER (2) 8.3 IPLV (3)	10.1 EER 10.4 IPLV	11.0 EER 11.4 IPLV
	≥135,000 Btu/h and < 240,000 Btu/h	Split System & Single Package	8.5 EER (2) 7.5 IPLV (3)	9.3 EER 9.5 IPLV	10.8 EER 11.2 IPLV
	≥240,000 Btu/h and ≤ 760,000 Btu/h	Split System & Single Package	8.5 EER (3) 7.5 IPLV (3)	9.0 EER 9.2 IPLV	10.0 EER 10.4 IPLV
	> 760,000 Btu/h	Split System & Single Package	8.7 EER (3) 7.5 IPLV (3)	9.0 EER 9.2 IPLV	10.0 EER 10.4 IPLV
Air Cooled (Heating Mode))	<65,000 Btu/h	Split System	6.8 HSPF (1)	7.0 HSPF	8.0 HSPF
		Single Package	6.6 HSPF (1)	6.8 HSPF	7.5 HSPF
	≥65,000 Btu/h and < 135,000 Btu/h	outdoor air at 47°Fdb/43°Fwb	3.0 COP (2)	3.2 COP	3.4 COP
		outdoor air at 17°Fdb/15°Fwb	2.0 COP (3)	2.2 COP	2.4 COP
	≥135,000 Btu/h	outdoor air at 47°Fdb/43°Fwb	2.9 COP (2)	3.1 COP	3.3 COP
		outdoor air at 17°Fdb/15°Fwb	2.0 COP (3)	2.0 COP	2.2 COP
Water Source (Cooling Mode)[2]	<65,000 Btu/h	85°F entering water	9.3 EER (2)	12.0 EER	14.0 EER
		75°F entering water	10.2 EER (3)	--	--
	≥65,000 Btu/h and < 135,000 Btu/h	85°F entering water	10.5 EER (2)	12.0 EER	14.0 EER
Water Source (Heating Mode)	<135,000 Btu/h	70°F entering water	3.8 COP (2)	4.1 COP	4.6 COP

(1) For single phase equipment, National Appliance Energy Conservation Act of 1987, as amended. 42 U.S.C. Ch. 77 Subch. 3, Sec. 6295 (d) and Minnesota Rules 7670.0660. For three phase equipment, Energy Policy Act of 1992. PL 102-486, Subtitle C, Section 122 (d). 42 U.S.C. Ch 77 Subch 3, Sec. 6313.

(2) Energy Policy Act of 1992 as above. Note that the EPACT standards for water and evaporatively cooled air conditioners also apply to water and evaporatively cooled heat pumps, although such products are uncommon.

(3) ASHRAE/IES 90.1-1989 (requirements labelled "January 1, 1992") and Minnesota Rules 7670.0660. Note that, for equipment over 135,000 Btu/h, ASHRAE/IES 90.1-1989 specifies that minimum EERs and IPLVs shall be reduced by 0.2 if there is a heating section. This deduction was not carried over into the Minnesota Energy Code.

[2] Over half the water source heat pump models meet the Consortium's Tier 1 criteria, whereas only 12% meet the Tier 2 criteria. While market share data are not available, it may be that the market share of Tier 1 equipment is too high to warrant a rebate. This requires further investigation of market share.

Table 6. Current Minimum Efficiency Requirements and Efficiency Levels Recommended for Incentives for Large Condensing Units

Equipment Type	Size Category*	Sub-Category	Current Minimum Efficiency Requirements	Recommended for Incentives
Air Cooled Condensing Units	≥135,000 Btu/h	NA	9.9 EER (1) 11.0 IPLV (1)	10.1 EER (2) 11.2 IPLV (2)
Water or Evaporatively Cooled Condensing Units	≥135,000 Btu/h	NA	12.9 EER (1) 12.9 IPLV (1)	13.1 EER (2) 13.1 IPLV (2)

(1) ASHRAE/IES 90.1-1989 (requirements labelled "January 1, 1992") and Minnesota Rules 7670.0660.
(2) ASHRAE 90.1 as approved for publication by ASHRAE board of directors June 1999. Requirements labelled "efficiency as of 9/1/2001."

Table 7. Current Minimum Efficiency Requirements and Efficiency Levels Recommended for Incentives for Packaged Terminal Air Conditioners and Packaged Terminal Heat Pumps*[3]

Equipment Type	Current Minimum Efficiency Requirements	NSP rebate criteria (not recommended)	new ASHRAE 90.1 for 9/1/2001 (possibly recommended)(4)
PTAC, PTHP in cooling mode	EER= 10.0 – 0.16C at 95°F (1)	9.2	PTAC 12.5 - 0.213C (3) PTHP 12.3 – 0.213C (3)
	EER = 12.2 – 0.20 C at 82°F (2)	NA	NA
PTHP in heating mode	COP = 1.3+0.16 EER (1)	NA	3.2-0.026C

(1) Energy Policy Act of 1992. PL 102-486, Subtitle C, Section 122 (d). 42 U.S.C. Ch 77 Subch 3, Sec. 6313. Minnesota Rules 7670.0660 is the same for cooling mode and equivalent for heating mode but does not contain the special exceptions for < 7000 Btu/h or > 15,000 Btu/h units in either case. For EER, C is the capacity in 1000s of Btu/h at 95 F db outdoor temperature. If capacity < 7000 Btu/h, C = 7. If capacity > 15,000 Btu/h, C = 15. The COP is at 47 F db. EER is computed from the formula above.
(2) ASHRAE/IES 90.1 and Minnesota Rules 7670.0660.
(3) The efficiency stated is for new construction. ASHRAE has a much lower proposed rating for replacements, due to the need to fit into existing openings, but 95% of units on the market pass it.
(4) Equipment with these efficiencies already has 75 to 80% of the market. (Virtually all equipment meets the NSP criteria).

[3] High Efficiency PTACs and PTHPs may have too high a market share to warrant rebates. See Appendix B for details.

Table 8. Current Minimum Efficiency Requirements and Efficiency Levels Recommended for Incentives for Chillers

Equipment Type	Category	Current Minimum Efficiency: ASHRAE/IES 90.1-1989		Current Minimum Efficiency: Mn Rules 7670.0660, kW/ton (COP)		Recommended for incentives: NSP rebate criteria, kW/ton (COP) (b)		new ASHRAE/IES 90.1 for 9/1/2001	
		COP	IPLV	CFC	non-CFC	COP	IPLV	COP	IPLV
water cooled	≥ 300 tons centrifugal	5.2 (a)	5.3 (a)	0.63 (5.58)	0.73 (4.82)	0.60 (5.86)	0.56 (6.28)	6.10	6.10
	≥ 300 tons screw	5.2 (a)	5.3 (a)	0.75 (4.69)	0.80 (4.39)	0.60 (5.86)	0.56 (6.28)	5.50	5.60
	≥ 300 tons scroll	5.2 (a)	5.3 (a)	0.93 (3.78)		0.60 (5.86)	0.56 (6.28)	5.50	5.60
	≥ 300 tons recip	5.2 (a)	5.3 (a)	0.93 (3.78)		0.60 (5.86)	0.56 (6.28)	4.20	4.65
	≥ 150 and < 300 tons centrifugal	4.2	4.5	0.63 (5.58)	0.73 (4.82)	0.60 (5.86)	0.56 (6.28)	5.55	5.55
	≥ 150 and < 300 tons screw	4.2	4.5	0.75 (4.69)	0.80 (4.39)	0.60 (5.86)	0.56 (6.28)	4.90	4.95
	≥ 150 and < 300 tons scroll	4.2	4.5	0.93 (3.78)		0.60 (5.86)	0.56 (6.28)	4.90	4.95
	≥ 150 and < 300 tons recip	4.2	4.5	0.93 (3.78)		0.60 (5.86)	0.56 (6.28)	4.20	4.65
	< 150 tons centrifugal	3.8	3.9	0.63 (5.58)	0.73 (4.82)	0.65 (5.41)	0.65 (5.41)	5.00	5.00
	< 150 tons screw	3.8	3.9	0.75 (4.69)	0.80 (4.39)	0.65 (5.41)	0.65 (5.41)	4.45	4.50
	< 150 tons scroll	3.8	3.9	0.93 (3.78)		0.65 (5.41)	0.65 (5.41)	4.45	4.50
	< 150 tons recip	3.8	3.9	0.93 (3.78)		0.65 (5.41)	0.65 (5.41)	4.20	4.65
air cooled with condenser	>=150 tons	2.5	2.5	1.41 (2.49)		0.60 (5.86)	0.56 (6.28)	2.8	2.8
	<150 tons	2.7	2.8	1.30 (2.70)		0.65 (5.41)	0.65 (5.41)	2.8	2.8
air cooled without condenser	all capacities	3.1	3.2					3.1	3.1

(a) Where R 22 or CFC refrigerants with ODP <= that for R22 is used, these requirements are reduced to 4.7 COP and 4.8 IPLV
(b) An NSP letter to trade allies of 10/1/98 indicated that their chiller program now covers only screw and centrifugal chillers.

Assess the Economics of Qualifying Equipment to Customers

To determine whether high efficiency cooling equipment will be cost-effective to customers, you must determine the energy and demand savings, incremental costs, and payback. The payback without incentives, combined with an understanding of the paybacks commercial customers normally find attractive, can be used to determine the size of incentive likely needed to move the

market. Typical customer economics can be estimated fairly readily for unitary equipment, and this equipment is amenable to standardized rebates. For chillers and PTACs/PTHPs, estimation of savings is more difficult, and a custom rebate based on site-specific analysis is preferable.

Demand and Energy Savings

Table 9 shows estimates of energy and demand savings for unitary equipment from 5 to 20 tons in size. The development of these estimates is described in Appendix C.

Table 9. Estimated Energy and Demand Savings for High Efficiency Unitary Equipment with Minneapolis Weather (Tier 1 Efficiency vs. Minimum Efficiency)

tons	Estimated kWh svgs	Peak kW Savings	Total kW Apr-Oct	Total kW May-Sep	Estimated kWh svgs	Peak kW Savings	Total kW Apr-Oct	Total kW May-Sep
5.0	496	not est.	not est.	not est.	not est.	not est.	not est.	not est.
7.5	1062	1.2	7.7	5.7	1584	1.7	12.5	9.2
10	1410	1.6	10.3	7.6	2106	2.2	16.6	12.2
15	1892	2.3	14.7	10.9	3609	3.9	29.1	21.4
20	2100	2.6	16.6	12.4	3141	3.7	27.3	20.1

The energy and demand savings for chillers are best estimated using software provided by the chiller manufacturers. The design engineer, contractor or manufacturers' representative should be able to produce output from this software for standard and qualifying high efficiency equipment. A small municipal utility is not likely to encounter a large number of opportunities for chiller replacements, due to the fairly small number of large buildings in their service territories, combined with the long life-expectancy of chiller equipment. These can best be analyzed on a site-specific, "custom rebate" basis, with the utility providing an incentive per kW saved and/or per kWh saved based on the output from the analysis software.

It can also be difficult to accurately estimate the energy and demand savings from high efficiency PTACs and PTHPs. These units are often used in applications like motels, where the demand and energy use can be greatly affected by occupancy. A site-specific, custom rebate approach for these units makes sense, too.

Incremental Costs

The incremental cost to the contractor for unitary equipment ranges from roughly $400 to $3,800 for 5 to 20 ton equipment respectively, based on interviews with manufacturers' representatives. (Table 10). This amounts to roughly a 10% premium in most cases, and about 15% for the largest size shown. Note that the incremental cost to the contractor varies considerably with size. Since both costs and savings vary with size, it is important to scale the incentives for equipment size ($/ton) or savings ($/kW or per kWh).

The incremental cost charged to the customer may be rather variable since the contractor mark-up is influenced by "what the market will bear" from job to job. The Consortium for Energy

Efficiency (1998) reported that the incremental cost to the end user averages around 15% in areas where utilities have developed programs based on their criteria.

Table 10. Incremental Contractor Costs for Commercial Unitary Equipment [1]

Size Category	Average	Sales-Weighted Average [2]	Sales-Weighted Average/Ton
5 ton split systems	$403	$397	$79
5 ton packaged systems	$431	$415	$83
7.5 ton split/packaged systems	$520	$549	$73
10 ton split/packaged systems	$650	$676	$68
15 ton split/packaged systems	$902	$970	$65
20 ton split/packaged systems	$1,260	$1,392	$70
30 ton split/packaged systems	$3,800	$3,800	$127

Source: Survey of manufacturers' representatives
[1] Incremental costs for equipment that meets CEE proposed standards versus equipment that does not.
[2] Weighting is based on representatives estimates of local sales for only those manufacturers who make units of each particular size.

The incremental cost for high efficiency PTACs and PTHPs is somewhat more difficult to estimate, for reasons explained in Appendix C, but is on the order of $100 to $200 per unit, roughly a 10% premium. The incremental cost for chillers is best estimated on a project-specific basis, based on bid information provided by the contractor.

Customer Paybacks

Using the information provided here and the utility's own rate structure, a utility can easily calculate the economics to the customer of a high efficiency air conditioner. Using typical summer rates and assuming a 10% mark-up of the contractor cost to the customer results in the customer economics shown in Table 11. Note that for most equipment the payback to the customer is on the order of 5 to 6 years. Most business customers are reluctant to consider an investment that has a payback of more than 1 to 2 years, or 3 years at the outside. Therefore, a utility that hopes to be successful in increasing the market share of high efficiency equipment will probably need to contribute 50% or more of the incremental cost in the form of a rebate.

Table 11. Sample Customer Economics for Unitary Equipment

tons	energy cost/kWh	demand cost/kW	energy cost savings	demand cost savings	total savings	incremental cost	payback
5	$0.07	na	$ 34.72	na	$ 34.72	$443	12.8
7.5	$0.03	$9.00	$ 31.85	$ 69.27	$ 101.11	$572	5.7
10	$0.03	$9.00	$ 42.29	$ 92.36	$ 134.64	$715	5.3
15	$0.03	$9.00	$ 56.75	$ 132.02	$ 188.77	$992	5.3
20	$0.03	$9.00	$ 62.99	$ 149.78	$ 212.77	$1,386	6.5

Resources

- *Appendix C. The Economics of High Efficiency Commercial Cooling Equipment*. Detailed information on how to estimate the energy and demand savings from high efficiency commercial cooling equipment.
- Rob Scott-Hovland, Minnesota Municipal Utilities Association. 612/551-1230 ext. 206. rhovland@mmua.org. Rob can provide assistance in estimating the customer economics for a broader range of situations, either directly or through MMUA's contractor, the Center for Energy and Environment.

Assess the Economics of Cooling Incentives to the Utility

Determining the net cost or benefit of a commercial cooling rebate program to the utility, and the impact on rates, involves the use of standard benefit-cost tests. Different tests reflect different perspectives. For example, the cost-effectiveness to the participant is clearly different from the cost-effectiveness to the utility, since the costs they pay and the benefits they obtain are different. The indirect effects of rebates on non-participant ratepayers, in the form of rate impacts, reflect still another perspective. The overall cost-effectiveness to all ratepayers, including participants and non-participants, is reflected in the total resource cost test. The cost-effectiveness to society, including the environmental benefits of decreased power consumption, is reflected in the societal test. In order to determine whether a cooling incentive program makes sense for your utility, you need to examine the cost-effectiveness from all these perspectives. The Minnesota Department of Public Service has a spreadsheet tool, called ELECBEN, that can greatly facilitate the determination of benefit-cost ratios for incentive programs.

The basic concept of each test is to add up the benefits that apply to that particular perspective, add up the costs, and then compare the benefits to the costs. This is made a bit more complicated by the fact that some of the benefits and costs occur over time. For example, the benefits that accrue to the non-participant ratepayers as a group, in terms of reduced needs for purchased power ("avoided costs"), occur over the life of the cooling equipment. By the same token, the costs that accrue to them, in the form of lost revenue from reduced sales, occur over the same lifetime. To total these yearly costs and benefits up and determine a net present value, it is necessary to apply a discount rate to the savings and costs in future years, to account for the fact that a dollar saved (or spent) a year from now is worth less than a dollar saved (or spent) today.

The most difficult aspect of benefit-cost analysis for municipal utilities at the present time will be uncertainty about the future cost of purchased power and about associated changes in future rates charged to customers. These costs and rates were easier to predict when utilities had long term power contracts and rates were set on a cost-of-service basis, but under retail competition, many municipal utilities may buy their last increment of power on the open market and may reconfigure their rates to be more competitive. The relevant purchased power cost is the cost for the last kW and kWh purchased, since that is the power that will be displaced by the efficiency measure. Many utilities will want to obtain assistance in making these estimates.

Table 12 shows sample results of a benefit-cost analysis of commercial cooling incentives for a municipal utility. Although the analysis is hypothetical, it uses estimates of avoided costs (purchased power costs) and lost revenue from decreased sales from an actual analysis of these factors done by MMUA and its consultants for a particular municipal utility. Based on the data in Tables 9 and 10 and other data, the analysis assumed an incremental cost for the cooling equipment of $400 per kW of peak demand reduction at the customer, energy savings of 850 kWh per kW of demand reduction, and 6.4 kW of total summer demand reduction per kW of peak demand reduction. A coincidence-loss factor of 93% was assumed.

The revenue requirements test (utility test) determines whether it is cheaper for the utility to purchase power or to achieve conservation through the cooling rebates. Every year, the utility will avoid the purchase of 850 kWh of energy and of 6.5 kW of demand. Over the 15 year life of the cooling equipment, the net present value of the purchased power that the utility will not have to buy because of the cooling incentive is $1,120 (all costs are per customer peak kW saved). It was assumed that the utility would pay half the incremental cost of the high efficiency equipment, or $200/kW, and that the administrative costs would be 10% of the incentive costs. There is a net benefit to the utility of $900/kW, or a benefit-cost ratio of 5.1. It is clearly much cheaper for the utility to buy conservation than to buy power. Use of the revenue requirements test to analyze efficiency programs is similar to the approach utilities use to compare different types of generating plants.

The rate impact test measures the effect of the program on non-participant ratepayers. Even though a program passes the revenue requirements test, it can have a negative effect on ratepayers. The reason is that, though the utility's total costs have decreased, the revenues have also decreased. In this case, the utility avoids purchasing $1,120 of power, but it loses $1,223 in revenue. The net loss of money from decreased sales, after subtracting the cost of the purchased power, is only $103. In addition, the utility pays the $200 incentive plus $20 administration cost, for a net loss of $324. While this loss is significant, it is much less than a utility might at first think in considering the revenue reduction alone. This utility buys a fixed block of low cost power and then buys supplemental power at a higher cost. Their rates are set based on a blended price. In this particular case, the lost revenues would have actually been *lower* than the avoided costs except that their supplemental power provider uses a five year rolling average to determine demand charges, so that the beneficial effect of the reduction in demand is not immediately realized.

It is important to note that the actual magnitude of the rate increase from such a program is trivial. Suppose this utility has about 800 commercial customers, and that, with a 15 year equipment life, about 50 customers per year replace their cooling equipment. If the average system size is 15 tons, for example, then the average peak demand reduction is 2.3 kW. If the utility were able to get all 50 customers to install high efficiency equipment, the total reduction would be 50*2.3 or 115 kW, and the total net present value of the rate impact over the entire life of the cooling equipment would be 115*$324 or $37,260. This includes the initial first year program cost of 115*220 or $25,300, so most of the cost is incurred in the first year. If the utility sells a total of 400,000,000 kWh per year, then the total rate impact of this program would be $37,260/400,000,000 or $0.00009315/kWh. This is the impact with the entire cost loaded onto the kWh sales in the first year, and is clearly not very large. In this situation, the utility

needs to weigh whether it is worth it to increase rates *very* slightly, to operate a program that can generate goodwill and possibly customer retention among its key customers.

The total resource test shows the cost-effectiveness to all ratepayers on average, including both program participants and non-participants. In this case, the cooling rebate has a net present value to all ratepayers of $700/kW, or a benefit/cost ratio of 2.7.

The societal test is similar to the total resource cost test but includes the environmental benefits of reduced energy generation. In this case, using the approved Minnesota values of environmental externalities, the net benefit to society is $801/kW or a benefit/cost ratio of 2.9.

The total resource cost and societal tests are particularly appropriate for municipal utilities to consider since they are owned by the public as a whole.

Table 12. Sample Results of a Benefit-Cost Analysis of Commercial Cooling Rebates*

	Participant Test $/kW	Revenue Requirements (Utility) Test $/kW	Rate Impact Test $/kW	Total Resource Test, $/kW	Societal Test, $/kW
Avoided Utility Costs	NA	$1,120	$1,120	$1,120	$1,120
Avoided Environmental Externalities	NA	NA	NA	NA	$101
Incentive Plus Admin	NA	$220	$220	$220	$220
Revenue Reduction	$1,223	NA	$1,223	NA	NA
Net Participant Cost	$200	NA	NA	$200	$200
Total Benefits	$1,223	$1,120	$1,120	$1,120	$1,221
Total Costs	$200	$220	$1,443	$420	$420
Net Present Benefit	$1,023	$900	($324)	$700	$801
Benefit/Cost Ratio	6.1	5.1	0.8	2.7	2.9

*All results are expressed per kW of demand reduction during the summer peak at the customer.

In summary, in this example, the cooling rebate program is cost-effective to the participant, the utility, all ratepayers as a whole, and society as a whole. It imposes a very small net cost on non-participating ratepayers (Figure 7), reflected in a miniscule increase in the rates that would need to be charged to cover the utility's total costs. The utility must determine whether this cost is worthwhile in the interests of helping to build relationships with key customers. In the long run, the retention or loss of key customers will affect rates for everyone. On the other hand, even a tiny rate increase can be perceived negatively by customers when it shows up as a $25,000 line item on the utility's annual budget. These are trade-offs that each utility must consider in determining the suitability of a cooling rebate program for them.

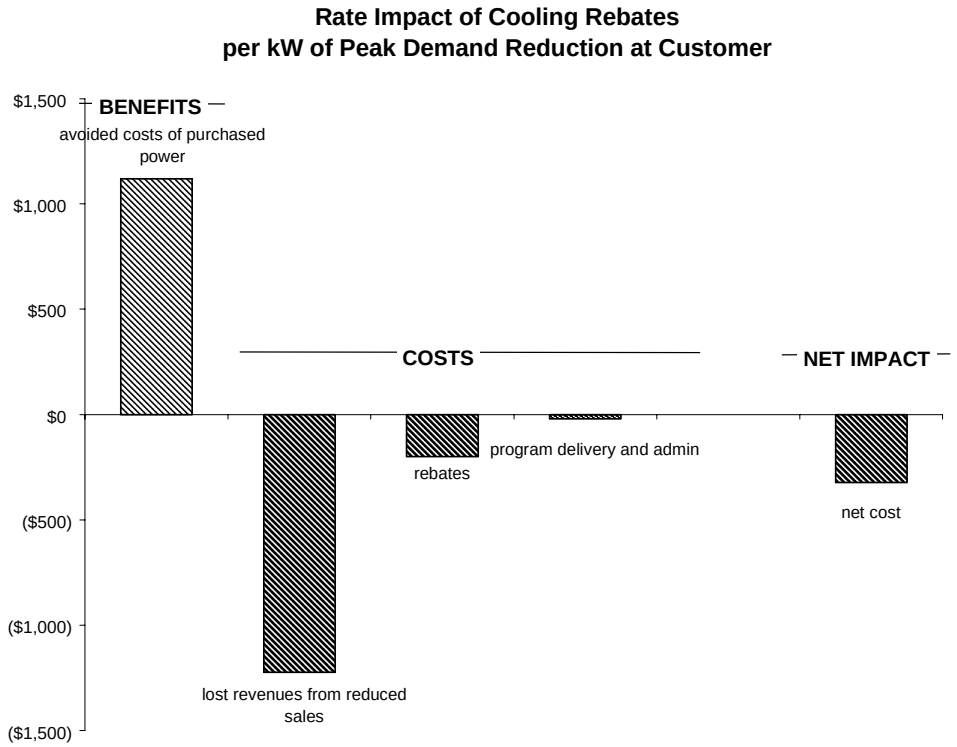

Figure 7. Benefits and Costs Entering Into Rate Impact Test of Cooling Rebates

Resources

- *Appendix C. The Economics of High Efficiency Commercial Cooling Equipment*. Detailed descriptions of cost-effectiveness tests for participants, non-participating ratepayers, all ratepayers, the utility, and society.
- Rob Scott-Hovland, Minnesota Municipal Utilities Association. 612/551-1230 ext. 206. rhovland@mmua.org. Rob can provide and help you use the ELECBEN spreadsheet for benefit/cost analysis, and can help work with you to estimate your future energy costs and rates, either directly or through MMUA's contractor, the Center for Energy and Environment. Rob can also put you in touch with other MMUA members who have developed commercial cooling programs.
- Christopher Davis, Minnesota Department of Public Service. 651/296-7130 . cdavis@dpsv.state.mn.us. Chris can also provide and help you use the ELECBEN spreadsheet for benefit/cost analysis.

OBTAIN DIRECTION FROM THE MUNICIPAL PUBLIC UTILITIES COMMISSION OR CITY COUNCIL

At various stages in the process, you will want to obtain direction from your local Public Utilities Commission or City Council. Appropriate points in the process might be:

1. To advise the PUC or Council that you believe a cooling incentive program may be worthwhile and are beginning to assess its cost-effectiveness.
2. To present your analysis of the cost-effectiveness, potential benefits of the program and a proposed budget, and obtain authorization to design and implement a program.
3. To present your program design prior to program launch.

Resources

- Rob Scott-Hovland, Minnesota Municipal Utilities Association. 612/551-1230 ext. 206. rhovland@mmua.org. Rob can help you prepare materials to present to your commission or council, and can help you present these materials. Rob can also put you in touch with other MMUA members who have developed commercial cooling programs.

DESIGN THE PROGRAM

Determine the Project Budget

To determine a program budget, you need to estimate how many participants you will have, how large the incentive will be for each participant, and the administrative costs you will incur for development of program materials, marketing, processing and tracking applications, and other administrative tasks.

The estimated service life of commercial cooling equipment ranges from 10 to 30 years, with a typical lifetime of 15 years (see Appendix C for further details). If you divide the total number of commercial accounts by 15, you will have a rough idea of how many customers are likely to be replacing cooling equipment in any given year. If you had 600 commercial customers, for example, you might expect about 40 to be replacing their cooling equipment in a given year. If you know how much your commercial customer base is growing due to construction, you can then add the number of commercial customers installing equipment for the first time. If this were about 10 customers per year, for example, you might expect a total of 50 cooling equipment installations to be done in your service territory.

The next question is the market penetration you might be able to achieve. Municipal utilities have some advantages in this regard because of their closer relationships with customers. Even so, you'd probably be doing extremely well to get a 20% participation rate, or, in our example, 10 customers.

As a rough rule of thumb, a commercial building requires about 1 ton of cooling capacity for every 450 sq.ft. Based on data from the U.S. Energy Information Administration, the average commercial building is 14,000 sq.ft. (total sq.ft. divided by total number of buildings), but the median commercial building has less than 5,000 sq.ft. This suggests that the average commercial customer replacing all of his cooling equipment or installing equipment in a new building would be installing roughly 10 to 30 tons of equipment, so you might estimate an average of 15 tons. From Table 9, you can estimate that you will obtain about 0.16 kW of demand savings for each ton of high efficiency equipment installed (assuming it just meets the minimum qualifying criteria). So you might estimate an average of 15*0.16 = 2.4 kW per participant.

Combining information from Tables 9 and 10, the average incremental cost per kW of demand savings ranges from about $390 to $485. The utility will need to pay at least half of this to get the payback for the high efficiency equipment down to a range that customers will find attractive. Thus, the rebate amount should be at least $200/kW or $0.20/W. With an average of 2.4 kW per participant, this would amount to about $480 per participant. With the 10 customers estimated above, that would be about $4,800 for incentives. Keep in mind, however, that if you had one or two large participants, they could quickly exhaust your incentive budget.

Typically, utilities figure about 10 to 20% of incentive costs for administrative costs, including materials and labor for development of program materials, marketing, processing and tracking applications, and other administrative tasks. Given the small number of participants over which the program development costs must be averaged, municipal utilities may find the administrative costs somewhat higher. On the other hand, the information in this guide can give you a significant jump start and reduce the development costs substantially. With further help from MMUA, the staff time required to develop the program can be kept to a minimum.

Resources

- Rob Scott-Hovland, Minnesota Municipal Utilities Association. 612/551-1230 ext. 206. rhovland@mmua.org. Rob can help you develop a budget, either directly or through MMUA's contractor, the Center for Energy and Environment. Rob can also put you in touch with other MMUA members who have developed commercial cooling programs.

Define the Technical Aspects of the Program

Before the program is launched, you will need to define all of its technical aspects.

Technologies Included, Qualifying Criteria

You will need to decide what technologies to include and what efficiencies will qualify. We recommend that you include unitary equipment as a standard item and chillers and PTACs/PTHPs as custom items. We recommend that you use the qualifying criteria listed

earlier. Figure 8 shows the qualifying criteria developed by Marshall Municipal Utilities with the assistance of MMUA and its consultants.[4]

Other Aspects of Efficient Cooling

A number of factors besides the efficiency of the equipment affect the overall amount of energy and demand required to cool a commercial building, especially oversizing, duct leakage, and building cooling loads.

Oversizing can have a significant impact on the peak demand of cooling equipment. Oversized units also diminish comfort relative to a properly sized unit. Air conditioners need to run continuously for a while to get the cooling coil cold enough to condense moisture out of the air, and an oversized unit will satisfy the thermostat so quickly that it does not condense enough moisture to lower the humidity to a comfortable level. Ideally, a utility should require A&E firms or contractors to perform a complete and accurate cooling load calculation and to install a system that does not exceed the calculated capacity. At the least, it should require that units rebated in existing buildings be no larger than the units being replaced.

The ductwork in commercial buildings frequently runs through spaces above dropped ceilings. These spaces can be substantially warmer than the air in the occupied zone, due to transmission through the roof and to heat from light fixtures. Poorly sealed and insulated ductwork can dramatically reduce the overall efficiency of the cooling system in delivering cooling to the occupied space. A recent study of packaged roof-top systems in light commercial buildings found an average supply-side air leakage rate of 26% and an average efficiency of the duct systems, combining conduction losses and leakage, of only 65%. Ideally, utilities should require higher than minimum levels of duct sealing and insulation, especially in new construction.

Relatively little of the cooling load in commercial buildings comes from conduction through the building envelope. In this respect, cooling and heating loads are rather different. The largest contributors to cooling load are ventilation air, solar gain by radiation through windows, and internal gains from lighting, plug loads, etc. Occupant loads can be major contributors in densely occupied buildings like schools and theatres. Therefore, to reduce cooling loads, utilities should encourage customers to install high efficiency lighting first. Outside air flow should be measured by one-time tests, rather than assumed based on the position of outside air dampers. Cooling loads can also be reduced by installing windows or window treatments that exclude a substantial proportion of solar radiation, yet let in enough visible light that lighting loads are not increased.

[4]When the Marshall program was developed, PTACs and PTHPs were included as a standard item based on the low percentage of qualifying, high efficiency, models in the ARI directory, and the assumption that the market share was even lower than the proportion of models, as is most commonly the case. Information gathered later in the survey of manufacturers' representatives, however, indicated that the market share of high efficiency PTACs and PTHPs in this area is already around 75%. It does not appear worthwhile to provide standardized rebates for these units based on this information, although customized rebates could be warranted if an engineering study documents that the PTACs/PTHPs will be substantially more efficient than some other type of system being considered.

Table 13. Key Strategies to Reduce Cooling Energy Use and Demand

Cooling Equipment
Do not oversize. Require sizing no greater than ACCA Manual J sizing.
Ductwork
Seal and insulate ductwork to reduce energy loss to unconditioned or semi-conditioned ceiling spaces.
Ventilation
Actually measure minimum outside air to assure that it is not too high
Lighting
Replace T12 fluorescent lamps/electromagnetic ballasts with T8 lamps/electronic ballasts
Replace incandescent lamps with compact fluorescent lamps
Glazing
Install windows or window treatments (films, solar screens) with shading coefficients of 0.45 or less or solar heat gain coefficient of roughly 0.39 to 0.41 or less but a visible light transmissivity of over 15% (to minimize the need for additional lighting).

Incentive Amounts, Form of Incentive, and Recipients

You will need to decide how large the incentive will be, what form it will take, and even to whom it will be given.

As described earlier, the average incremental cost of high-efficiency cooling equipment is about $400 per kW of peak demand savings, and, with typical rates, this results in about a 5 or 6 year payback for the customer. Since most business customers are interested primarily in 1 and 2 year investment opportunities, the utility will have to provide a rebate of at least $200/kW to bring the payback down to a range businesses will consider.

The importance of the rebate amount cannot be overstated. Appendix E describes the barriers to increased market penetration of high efficiency equipment identified by manufacturers' representatives, and the market strategies they recommended to overcome these. For some high efficiency technologies, reliability, serviceability or other factors are the key barriers. Not for high efficiency cooling equipment! First cost was identified by 83% of manufacturers' reps as the *most important* barrier to increased market penetration. When asked what advice they had for municipal utilities that are developing incentive programs for high efficiency cooling equipment, a number of representatives stressed that the incentives need to be large enough to counter the incremental cost, since this market is mainly a first-cost driven market. Token incentives will not be large enough to motivate trade allies to promote or end-users to purchase high-efficiency options.

As a rule, customers are much more interested in rebates than they are in financing, even when the financing is at a below market interest rate that offers the same net present benefit as the rebate. In addition, financing can require more administrative time on the part of staff to originate loans and process and track payments. If you plan to use one or the other alone, rebates are definitely better. However, offering financing *in addition* to rebates can be very attractive. Marshall Municipal Utilities offered financing along with rebates to its demand-metered customers for its direct-installation lighting program, and this package was extremely

well received. By limiting the financing to demand-metered customers (>75 kW in Marshall's case), they were able to restrict it to a group of financially stable (and important) customers and therefore eliminate the need to qualify businesses for loans. A number of manufacturers' reps mentioned financing as a helpful add-on to rebates.

You should seriously consider offering a rebate to the installing contractor as well. Many manufacturers' reps pointed out that the contractor is in the best position to influence what the end-user purchases, by either promoting or discrediting particular equipment. In addition, contractors often end up filling out the paperwork to apply for rebates, since they have the necessary information on model numbers, etc., and an incentive helps to cover their real costs of doing this. In the same vein, NSP has found that the lack of hands-on participation by the owner in the decision-making process is a significant barrier to installation of high efficiency equipment, and that rebates to the specifying contractor encourage distributors to stock high efficiency equipment.

Program Rules

You will need to develop program rules. Figure 8 shows the "General Terms and Conditions" developed by Marshall Municipal Utilities with MMUA and its consultants.

Application Form

You will need to develop an application form that will allow you to gather the information you need to decide whether an installation qualifies and to track the impact of the program. Figure 8 shows the rebate application form developed by Marshall Municipal Utilities with the assistance of MMUA and its contractors.

Resources

- *Appendix B. Commercial Cooling Equipment Efficiencies.* More information on current federal and state efficiency standards and forthcoming federal standards, recommended levels for incentives, number and percent of certified models on the market meeting qualifying criteria, and survey data on market share of high efficiency equipment.
- *Appendix E. Market Barriers Identified and Market Strategies Recommended by Manufacturers' Representatives*. Provides input on incentive amounts, form and recipients from Minnesota representatives for all major manufacturers of unitary and PTAC/PTHP equipment.
- Consortium for Energy Efficiency. The Consortium formed a quality installation roundtable in 1998 to explore ways to increase proper installation of cooling equipment. As of summer 1999, the Consortium was in the process of developing an RFP for a contractor to develop an HVAC installation specification. The New York State Energy Research and Development Authority, the NEES Companies and PG&E had provided funding as of that time. Development of a residential specification was already underway. Up-to-date information may be available on their web site or by contacting them at One State Street, Suite 1400, Boston, Massachusetts 02109-3507 USA (617) 589-3949

- E-Source 1995. *Commercial Space Cooling and Air Handling. Technology Atlas Series, Volume II*. Boulder, CO: E-Source, Inc. Provides information on building and system design features that affect overall cooling efficiency.
- Rob Scott-Hovland, Minnesota Municipal Utilities Association. 612/551-1230 ext. 206. rhovland@mmua.org. Rob can assist you with program design, either directly or through MMUA's contractor, the Center for Energy and Environment. Rob can also put you in touch with other MMUA members who have developed commercial cooling programs.

Figure 8

Business High Efficiency Air Conditioning

Rebate Application

Business Information

Business Name:_____

Mailing Address:_____ City: _____ State: _____ Zip:_____

Installation Address: _____ City: _____ State: _____ Zip:_____

Contact Person: _____ Phone: _____

SSN/Tax ID: _____ MMU Account No: _____

I certify that the information provided in this application is accurate and that all rules of the MMU program have been followed. I have read and agree to the general terms and conditions included with this application. I understand that if any equipment in conjunction with this application is ordered, purchased or installed before approval from MMU is received, the proposed project will not qualify for a rebate. I acknowledge that nothing in this application shall impose any liability on MMU for the work performed by the vendor.

Customer signature: _____ Date: _____

New Equipment Information

	A Code	B # of Units	C Manufacturer	D Model Number	E Size in Tons	F SEER or EER
1						
2						
3						
4						

Rebate Calculation

	G Minimum SEER or EER (see tables)	H Base Rebate $/ton (see tables)	I Base Rebate $ Col B*E*H	J Incremental Efficiency Points Over Minimum 10*(Col F-G)	K Additional Rebate per point (see tables)	L Incremental Rebate Col B*J*K	M Total Rebate Col I+L
1							
2							
3							
4							

MMU reserves the right to correct incentive calculations if necessary. **Grand Total Rows 1-4** _____

Vendor Information

Vendor Name:_____

Mailing Address:_____ City: _____ State: _____ Zip:_____

Contact Person: _____ Phone: _____

A copy of the invoice must be attached. See "General Terms and Conditions" for details.

Facility Information

Facility Type

- ❑ office
- ❑ non-food retail
- ❑ food store
- ❑ restaurant/bar
- ❑ warehouse
- ❑ school
- ❑ health care
- ❑ lodging
- ❑ personal services
- ❑ assembly (church, theater, etc.)
- ❑ industrial
- ❑ other

Type of Application:

- ❑ replacing existing units l
- ❑ adding new units

Operating Hours

Primary Schedule

Months J F M A M J J A S O N D		
	Open	Close
Mon		
Tues		
Wed		
Thurs		
Fri		
Sat		
Sun		

Off-Season Schedule, if any

Months J F M A M J J A S O N D		
	Open	Close
Mon		
Tues		
Wed		
Thurs		
Fri		
Sat		
Sun		

Area

Facility area _____ sq. ft.

Proportion of facility cooled by equipment being installed:

- ❑ less than 25%
- ❑ more than 25% but less than 50%
- ❑ more than 50% but less than 75%
- ❑ more than 75%

For Office use only. Do not write in this box.			
Date Received	Date Approved	Date Verified	Date Paid
Received by	Approved by	Verified by	Paid by
Rebate $'s	Rebate $'s	Rebate $'s	Rebate $'s

Business High Efficiency Air Conditioning

Rebate Qualifying Criteria

EQUIPMENT QUALIFYING CRITERIA AND REBATE AMOUNTS

Air Cooled Unitary Equipment (e.g., Rooftop Units, Split Systems)

Code	Size category, Btu/h	Size category, tons[1]	Minimum Qualifying Criteria		Base Rebate $/ton	Additional Rebate, $/ton per 0.1 EER above minimum
			EER	IPLV[2]		
U-1ss	<65,000 (split system)	<5.4	12.0 (SEER)	NA	$35.00	$1.50
U-1sp	< 65,000 (single pkg)	<5.4	11.0 (SEER)	NA	$35.00	$1.50
U-2	≥65,000 but < 135,000	≥ 5.4 but < 11.3	10.3	10.6	$35.00	$2.00
U-3	≥135,000 but < 240,000	≥ 11.3 but < 20	9.7	9.9	$35.00	$2.00
U-4	≥240,000	≥ 20	9.5	9.7	$30.00	$2.50
U-5	condensing units ≥135,000	≥ 11.3	10.1	11.2	$5	$2.00

[1]1 ton = 12,000 Btu/h
[2]IPLV requirement applies to units having capacity reduction steps

Packaged Terminal Air Conditioners

Minimum qualifying criterion: EER = 12.5-0.213 * Capacity in 1000s of Btu/h. Examples are given below.

Code	Size category, Btu/h	Size category, tons	Minimum Qualifying EER	Base Rebate $/ton	Additional Rebate, $/ton per 0.1 EER above minimum
PTAC	7,000 or less	0.58 or less	11.0	$35	$2.00
PTAC	8,000	0.67	10.8	$35	$2.00
PTAC	9,000	0.75	10.6	$35	$2.00
PTAC	10,000	0.83	10.4	$35	$2.00
PTAC	11,000	0.92	10.2	$35	$2.00
PTAC	12,000	1.00	9.9	$35	$2.00
PTAC	13,000	1.08	9.7	$35	$2.00
PTAC	14,000	1.17	9.5	$35	$2.00
PTAC	15,000 or more	1.25 or more	9.3	$35	$2.00

For chillers, water and evaporatively cooled unitary equipment, and other equipment, contact MMU staff.

General Terms and Conditions

1. Rebates are available to non-residential customers of MMU. All products must be in use in facilities in the MMU service territory. The applicant shall be an end user (i.e., not an air conditioning wholesaler, distributor, or installer) of either commercial or industrial air conditioners.
2. The application period is January 1 through December 31 of the current calendar year. Due to limited funding, this rebate offer can be withdrawn at any time without notice, and is available on a first-come, first-served basis. Applications for work done prior to this period will not accepted.
3. MMU reserves the right to inspect the customer's facility prior to installation and to inspect after installation to verify a rebatable installation.
4. Qualifying energy-efficient cooling equipment installed and operational within six months of the date of purchase is eligible for rebate under the rebate schedule. Additional time may be granted subject to MMU's prior approval. In no case shall the rebate paid exceed the purchase price of the equipment. The minimum rebate application is $35. The maximum rebate amount is $2,000 per business location, not to exceed $5,000 per customer per year.
5. When the purchase has been completed, **the customer must notify MMU and submit original invoices specifying the manufacturer, model number, size in tons, quantity and price of all materials purchased, the date ordered, installation costs and applicable taxes**. After satisfactory review of the invoices and on-site verification, a rebate will be credited to the customer's MMU electric bill. Please allow 30 days from the date of on-site inspection for processing of rebate.
6. Unitary equipment under 135,000 Btu/h must be certified per ARI Standard 210/240-94, and equipment of 135,000 Btu/h or more but less than 250,000 Btu/h must be certified per ARI Standard 340/360-93. Condensing units of 135,000 Btu/h or more must be certified per ARI Standard 365-87. Equipment 250,000 Btu/h or more must be tested using ARI test procedures, and must be listed as a standard combination in the manufacturer's literature. Packaged terminal air conditioners must be certified per ARI Standards 310/380-93. Equipment must have the SEER or EER rating stamped on its nameplate. **A copy of the manufacturer's technical literature rating the unit must accompany the application.**
7. MMU will not be responsible for any tax liability imposed as a result of the rebate. Customers are advised to consult their tax advisors for detail. Customers must submit the appropriate Tax ID on the application form.
8. MMU does not guarantee that the implementation of energy efficiency measures or use of the equipment purchased or installed pursuant to this program will result in energy or cost savings. MMU makes no warranties, expressed or implied with respect to any equipment purchased or installed, but not limited to, any warrant of merchantability or fitness for purpose. In no event shall MMU be liable for any incidental or consequential damages. Customers are solely responsible for the proper disposal of existing equipment. Consult the Minnesota Pollution Control Agency (MPCA) office for details, (651) 297-8363 or (651) 297-8331.
9. MMU does not endorse any particular vendor, manufacturer, product, or system in promoting this rebate program. Listing a vendor or product does not constitute an endorsement, nor does it imply that unlisted vendors or products are deficient or defective in any way.

Mail Application to:

Marshall Municipal Utilities
113 4th Street S.
Marshall, MN 56258-1223
Attn: Joni Livingston

Develop a Marketing Plan

The commercial cooling equipment market is one in which working with trade allies is absolutely essential to success, for several reasons. (1) Trade allies are themselves the key decision-makers for the majority of commercial cooling equipment purchases. (2) Even when the owner is the key decision-maker, he often relies on the contractor for input and advice. (3) Cooling equipment is a very infrequent purchase, since equipment lives are typically on the order of 15 years. Broad-based marketing to all commercial customers will seldom reach a customer at the time of purchase. Trade allies, in contrast, will always be present at the time of purchase, and are therefore in a unique position to promote high efficiency equipment at that time. (4) Whether distributors stock high efficiency equipment will have an impact on the success of the program.

Develop Strategies for Working with Trade Allies

For unitary cooling equipment, manufacturers' representatives reported that the architecture and engineering (A&E) firm is the key decision-maker for about a third of sales, the contractor for about a third, and the building owner for only about a third. For the plan and specification segment, which is mostly new construction, the A&E firm is almost always the key decision-maker. For the design-build market (i.e. cases in which the end-user has asked a contractor to design and build/install a job for a new or retrofit project), the building owner is the key decision-maker about half of the time and the contractor the other half. For packaged terminal equipment the building owner is the decision-maker for less than half of sales, the contractor for over a third of sales, and the A&E firm for about 1/5 of sales. Thus for a utility interested in promoting high efficiency cooling equipment it is as important or more important to market to contractors and A&E firms as to owners.

Providing some incentive to these trade allies themselves, as mentioned earlier, is particularly helpful, since it offsets the costs of their involvement and gives them a direct benefit for promoting the equipment.

You will need to develop plans for making contractors and A&E firms aware of the program, and for educating them about the benefits of high efficiency equipment to themselves and their customers. Much of the initial familiarization and promotion can be accomplished through a trade-ally meeting as the program is launched. Additional one-on-one contact is highly desirable, to answer individual questions, to further persuade the contractors of the benefits of the program to them and their customers, and to help them with at least the first few applications.

A third of unitary manufacturers' representatives mentioned that lack of familiarity with high efficiency equipment on the part of contractors is a barrier to increased market penetration. They stressed that the contractor will install whatever equipment he/she feels comfortable with regardless of the efficiency, and that the building owner will put his/her trust in the contractor. In addition contractors must warranty the products, so they must be convinced that high efficiency models are worthwhile and trouble-free. The features used to increase efficiency in commercial unitary and PTAC/PTHP equipment are the same ones that have been used to

increase the efficiency of residential equipment for a number of years, and are quite reliable. Only one rep felt that service problems were a barrier to increased use of high efficiency cooling equipment. The utility is on firm ground in making the case that high efficiency commercial cooling equipment is reliable and does not increase service calls. You should consider who can best present a persuasive message to this effect to contractors. Experienced contractors who have installed the equipment would probably be most persuasive.

Manufacturers' reps indicated that energy efficiency is most often a secondary factor in the selection of unitary and PTAC/PTHP equipment for A&E firms and contractors. Contractors who have a long term relationship with an owner and are installing equipment on a non-competitive (non-bid) basis are more likely to put in better equipment and to be concerned about efficiency, because doing a good job for the owner is what keeps the owner coming back. Contractors responding to requests for bids are competing almost entirely on price, and would be very unlikely to submit a bid including higher efficiency equipment (except in the unlikely event that this were included in the spec).

Manufacturers' reps stressed that the program must be convenient to use, especially for the contractors and A&E firms who are expected to promote the qualifying equipment. In particular, since the contractor usually ends up completing the paperwork, it is vital that the contractor understands how to complete the paperwork and that it doesn't take a lot of time. According to these representatives, the dealer base is not very sophisticated, and a lot of contractors simply won't bother unless the program is well-explained, the incentive is large enough and the process of getting the incentive is simple enough.

You will need to make sure that contractors in the area have marketing pieces and application forms that they can use to promote the program to owners and to help them apply for the incentives.

Another issue to consider in working with trade allies is the role of distribution. Commercial cooling equipment is represented by and distributed by a number of different types of organizations, so the players a utility needs to work with differ somewhat for different manufacturers. Appendix D provides a breakdown of the type of rep and distributor for each of the major manufacturers, and Appendix F provides contact information for the manufacturers' representatives covering Minnesota.

For unitary equipment, the smallest sizes (5.4 ton or smaller) are generally sold from local inventory, while the larger sizes are usually ordered from manufacturers' stock. Most packaged terminal equipment is sold from manufacturers' inventory.

Thus, for the small unitary equipment, whether local distributors choose to stock high efficiency equipment, and how quickly they can get it if they don't stock it, can have a major impact on the success of a utility incentive program. Fortunately, all of the companies contacted indicated that the rep/distributor does stock small split systems that meet the proposed qualifying criteria. On the other hand, few of the reps/distributors stock small high efficiency single package equipment, and none stock high efficiency equipment in sizes above 5.4 tons.

Clearly, the major distributors in your area should be informed about the program before it starts. The manufacturers' reps listed in Appendix F and the local contractors in your area can help you identify the major distributors. The reps stressed that the program should be timed so that distributors have the lead time they need to stock the equipment, and changes to the program should be timed so that they come out between seasons rather than in the middle of a season. Distributors place somewhat more orders for inventory of commercial cooling equipment in spring than in other parts of the year, so utilities should contact them well ahead of that time to make them aware of program plans.

Finally, the reps noted that it is important to keep the program long enough to actually effect a permanent change in the market.

Develop Strategies for Working with Customers

Manufacturers' reps indicated that energy efficiency is most often not a factor for owners in the selection of unitary equipment, and is a secondary factor for owners in the selection of PTACs/PTHPs. The overwhelming majority felt that the most important barrier to increased use of high-efficiency equipment was first cost. Many also mentioned lack of familiarity of owners with high-efficiency equipment as another barrier. Fortunately, both first cost and familiarity are barriers that can be directly and easily addressed by utility incentive programs. Marketing messages should focus on overcoming these two barriers to increased acceptance.

Given the fact that cooling equipment is purchased infrequently by commercial customers, it is difficult to get the message directly into their hands at the point of decision. For that reason, as mentioned earlier, it is very important to secure the assistance of trade allies in promoting the program at the point of purchase. Direct mail or inclusion of program information in bill stuffers or media can primarily achieve awareness of the program and its economic benefits and comfort with the technology, so that at the point of purchase, the contractor or A&E firm is not starting "cold" with the customer.

Resources

- *Appendix D. The Commercial Cooling Equipment Purchase Process*. Provides information on distribution channels, inventory practices, promotion and other factors relating to the commercial cooling equipment purchase process.
- *Appendix E. Market Barriers Identified and Market Strategies Recommended by Manufacturers' Representatives*. Provides information on market barriers and market strategies from Minnesota representatives for all major manufacturers of unitary and PTAC/PTHP equipment.
- *Appendix F. Contact Information for Minnesota Manufacturers' Representatives.* Provides names, addresses and phone numbers of representatives for all major unitary and PTAC/PTHP equipment sold in Minnesota.
- Rob Scott-Hovland, Minnesota Municipal Utilities Association. 612/551-1230 ext. 206. rhovland@mmua.org. Rob can help you develop marketing plans, either directly or through MMUA's contractor, the Center for Energy and Environment. Rob can also put you in touch with other MMUA members who have developed commercial cooling programs.

Develop Program Processes and Staffing

You will need to consider the specific activities that must be accomplished in operating the program, and how you will staff these activities. This will be critical in estimating the staffing requirements and assuring that all materials and procedures are in place and functioning at the start of the program. The development of the technical aspects of the program, the marketing plan, the strategies for working with trade allies and the tracking and evaluation are described elsewhere, but you need to consider how much time will be required to do these things and who will do it. During the actual operation of the program, you will need processes and staff for the following:

- delivering the marketing messages to customers (direct mailings, one-on-one contact, interviews with media)
- working with trade allies
  - meeting with trade allies to explain the program benefits and application procedures
  - maintaining contact with trade allies
  - handling trade ally questions and problems
  - dealing with unsatisfactory service providers
- processing applications
  - conducting pre-inspections, if you require them
  - reviewing and approving applications received, including checking model numbers against the ARI directories (Figure 9) to assure that they are qualified and have the claimed SEER/EER/IPLV
  - conducting post-inspections
  - issuing incentive payments
  - setting up loans on the utility bill, if you offer them
  - handling customer and trade ally questions and problems
- entering data into the tracking system
- conducting periodic analysis of program results and reporting to management
- conducting analysis of program processes and refining them

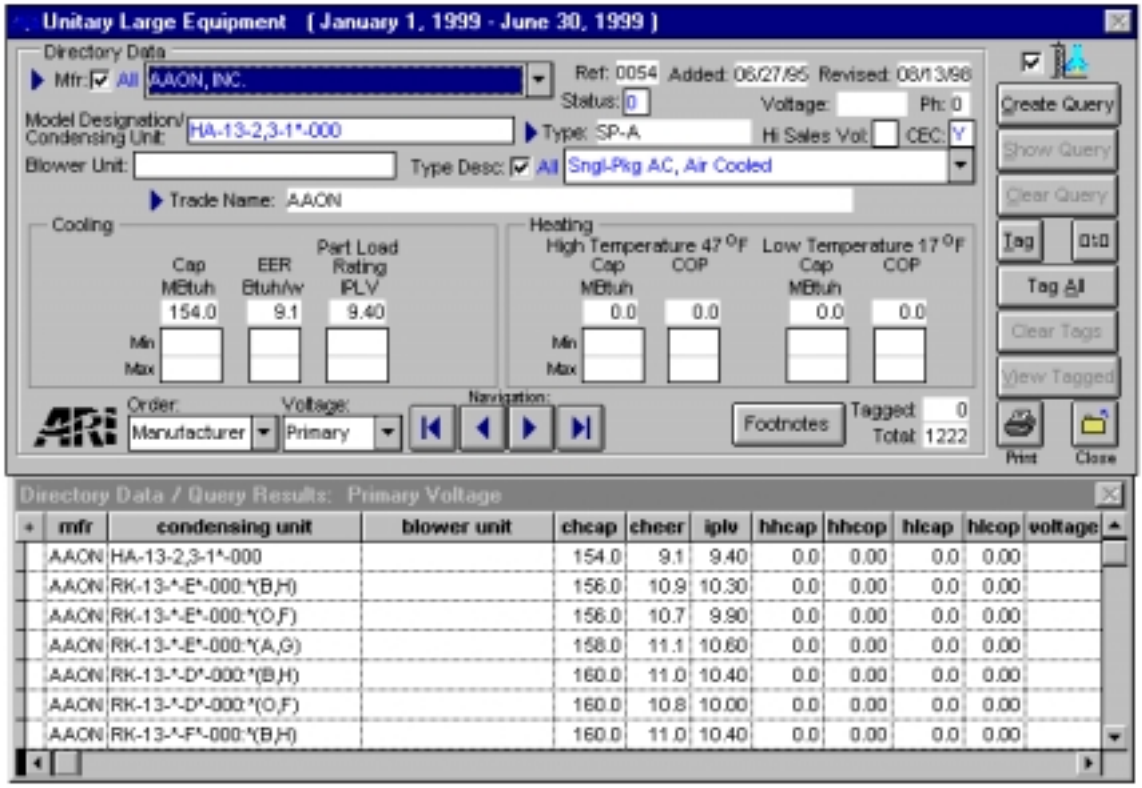

Figure 9. Example of Screen from ARI Electronic Directory for Unitary Large Equipment

Develop a Tracking and Evaluation Plan and Identify Data Requirements

You will need a systematic way to track the program, to assist you in tracking progress against goals (for number of participants, energy and demand savings, etc.), monitoring the balance of incentive dollars, estimating program impacts, and planning future budgets, marketing and work with trade allies. We recommend that you enter the following information in a spreadsheet or database, at a minimum. You may need more than one line per application if the application is for more than one size or EER of equipment.

Table 15. Information to Track

Item	Purpose
account number	general
business name and contact person	general, possible use of their name and/or remarks in promotional materials or press releases
type of unit and size category	to determine legal minimum efficiency baseline relative to which energy and demand savings are calculated
number of units	to estimate impact on power requirements
tons and/or Btu/h of cooling capacity	to estimate impact on power requirements
Actual EER or SEER	to estimate impact on power requirements
equipment and labor cost	
facility area and proportion of facility cooled by the equipment being installed	to estimate impact on power requirements
operating hours	to estimate impact on power requirements
rebate amount	to track budget and project future budget requirements
facility type	help promote program to similar facilities
contractor name	possible work with them to promote the rebate to additional customers
dates application received, data of approval, date of installation, date of post-installation inspection, date rebate issued	track timeliness of internal processes

Develop a plan for when and how you will evaluate the program. The best way to assure that everything you need is in your tracking database is to outline your evaluation report to the PUC or Council, and think about exactly how you will generate the information you'll need to write it.

Gather Information on Other Utilities' Experience

Obtaining information from other utilities can help you plan the technical aspects of the program, program marketing, and program processes. Among others, Marshall Municipal Utilities and Rochester Public Utilities have implemented commercial cooling incentive programs.

Resources

- Rob Scott-Hovland, Minnesota Municipal Utilities Association. 612/551-1230 ext. 206. rhovland@mmua.org. Rob can put you in touch with other MMUA members who have developed commercial cooling programs.

APPENDIX A. COMMERCIAL AIR CONDITIONING EQUIPMENT MARKET

Types of Commercial Cooling Equipment

A variety of types of equipment are used to cool commercial buildings. Data from the Census Bureau's Current Industrial Reports (Table A-1) gives a rough breakdown of shipments of commercial cooling equipment by U.S. manufacturers for 1997. Commercial equipment is generally considered to include equipment with 65,000 Btu/h or more of cooling capacity (5.4 "tons" of refrigeration[5]), and the shipments shown in Table A-1 for single package air conditioners, year round air conditioners, split systems, and air-source heat pumps include only equipment of this size or larger. These four product types, commonly known as "unitary equipment," account for about half of commercial units shipped and about half of the value of units shipped.[6]

Table A-1 also includes shipments of packaged terminal air conditioners (PTACs) and packaged terminal heat pumps (PTHPs). The table includes all PTACs and PTHPs regardless of size, even though the units on the market only range from about 6,000 to 15,000 Btu/h cooling capacity (0.5 to 1.25 tons)(ARI 1997), because these products are used primarily in commercial applications (e.g., hotel, motel, nursing home, office park). PTACs and PTHPs account for roughly 46% of units shipped, but only about 6% of the value of commercial equipment shipped, reflecting the fact that their size is small on average and they are relatively simple, low-cost units.

Chillers start at about 150,000 Btu/h capacity (12.6 tons), but most are considerably larger. Chillers account for only about 6% of units shipped but about 44% of value, reflecting their larger average size and greater complexity.

Water source heat pumps are typically applied in water loop heat pump systems. Each heat pump serves a different area within the building, and draws heat from and rejects heat to a water loop that typically includes a boiler and cooling tower to keep the water loop temperature within prescribed bounds. Ground and groundwater source heat pumps draw heat from and reject heat to the ground or groundwater. These systems are less common than other types of commercial cooling equipment and are not covered extensively here.

[5] one ton = 12,000 Btu/h
[6] Definitions of the terms used are given in Appendix G.

Table A-1. Approximate Quantity and Value of Shipments of Commercial Air-Conditioning Equipment, 1997*

Product description	Estimated Comm Quantity	Est Comm Value, $1000s	Avg Value/ Comm Unit	Pct of Comm Units	Pct of Comm Value
Single package air-conditioners	57,386	327,963	$ 5,715	9%	12%
Year-round air-conditioners	155,696	804,256	$ 5,166	24%	29%
Split system air-conditioning condensing units**	66,188	179,296	$ 2,709	10%	7%
Air source heat pumps	26,615	74,610	$ 2,803	4%	3%
Water source heat pumps	(D)	(D)	(D)	?	?
Ground and ground water source heat pumps	(D)	(D)	(D)	?	?
Packaged terminal air-conditioners	167,761	93,396	$ 557	26%	3%
Package terminal heat pumps	130,736	70,143	$ 537	20%	3%
Reciprocating, screw and scroll chillers	24,173	454,982	$ 18,822	4%	17%
Centrifugal chillers	9,579	737,252	$ 76,965	2%	27%
Available Total	**638,134**	**2,741,898**		**100%**	**100%**

*For single pkg, year-round, split system, and air source heat pumps, only units of 65,000 Btu/h or more were included
**Value is artificially low since the value of associated evaporator coils and fans is excluded.
(D) = withheld to avoid disclosing data for individual companies.
Source of raw shipment data: U.S. Census Bureau Current Industrial Reports, MA35M.

A study of commercial cooling equipment market shares by equipment type conducted by GRI in 1986, limited to equipment of 5 tons or more (and therefore ignoring PTACs and PTHPs), is useful because it provided a breakdown by tonnage as well as by number of units. For the equipment it included, it showed that unitary equipment accounted for about 92% of units sold, but only about 51% of capacity (Table B-2), while chillers accounted for only 8% of units sold but 49% of capacity. Although GRI has not updated this study, the overall market patterns have stayed more or less the same.

Table A-2. Commercial Cooling Equipment Market Shares by Type of Equipment, 1984 (GRI 1986)

	Over 5 tons		5 to 50 tons		Over 50 tons	
Product	**Units**	**Tons**	**Units**	**Tons**	**Units**	**Tons**
single package AC	14.4%	9.3%	15.2%	17.9%	0%	0%
year round AC	37.7%	21.1%	39.3%	37.6%	11.4%	3.4%
split system AC	28.4%	16.0%	29.8%	28.6%	8.3%	2.5%
heat pumps	11.4%	4.7%	12.1%	9.1%	0%	0%
unitary subtotal	**91.9%**	**51.1%**	**96.4%**	**93.2%**	**19.7%**	**5.9%**
reciprocating chillers	6.0%	13.5%	3.6%	7.0%	43.8%	20.6%
centrifugal chillers	2.0%	33.9%	0%	0%	34.6%	70.4%
absorption chillers	0.1%	1.5%	0%	0%	1.9%	3.1%
chiller subtotal	**8.1%**	**48.9%**	**3.6%**	**7.0%**	**80.3%**	**94.1%**

Unitary equipment under 65,000 Btu/h is not generally considered to be "commercial" equipment, because the great majority of equipment of this size is sold for residential applications. However, the amount used in the commercial sector is not trivial. In 1992, *ACH&R News* obtained estimates from manufacturers suggesting that the number of units under 5.4 tons sold for commercial applications is roughly twice the number of units over 5.4 tons. Thus, while the bulk of units under 5.4 tons are sold for residential applications, there are still enough sold for commercial applications to warrant their inclusion in a commercial cooling program.

Typical Applications of Cooling Equipment

The type of cooling equipment used varies by building size. Commercial buildings of 25,000 sq. ft. or less account for 89% of cooled commercial buildings, although they only account for 39% of cooled commercial floor space (CBECS 1995). In buildings of this size, various types of unitary equipment, along with individual air conditioners, dominate (Figure A-1 – note that the equipment categories used by this source are different from those used by the Census Bureau for the data given in Table A-1). Commercial buildings of 25,001 to 100,000 sq. ft. account for only 9% of cooled commercial buildings but 28% of cooled floor space. Within this category, too, unitary equipment and individual air conditioners (PTACs, PTHPs, window and wall units) dominate, but chillers do cool part or all of about 20% of the floor space. Buildings of 100,001 sq.ft. or more account for only 2% of cooled commercial buildings, but fully 33% of cooled commercial floor space. Within this building category, chillers cool part or all of 48% of floor space, and district chilled water systems cool another 10%, but unitary equipment still plays a significant role, providing part or all of the cooling for 57% of floor space.

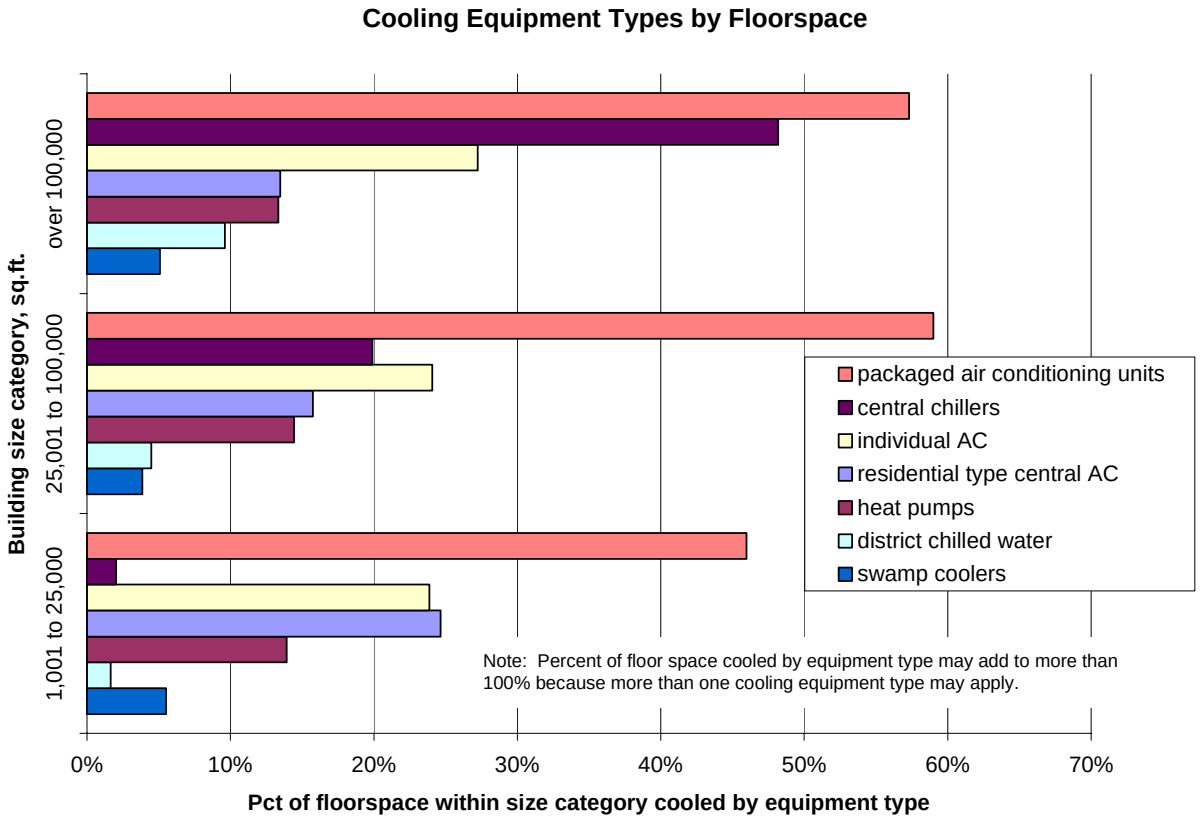

Figure A-1. Cooling Equipment Types by Floorspace (CBECS 1995). See Appendix G for definitions of these equipment types, which are somewhat different from the definitions used in the industry.

Key Players: Major Manufacturers and Market Shares

Eight major manufacturers account for nearly all the output of unitary cooling equipment nationally, as shown in Table A-3. Since most of the unitary equipment sold is in residential sizes, this market data gives only a rough indication of the relative importance of these manufacturers in the commercial market. Better information on the commercial market was obtained through interviews with manufacturers' representatives, by asking them to estimate their own market share of equipment in various sizes within the geographic areas they serve. Based on this information, Carrier/Payne, Lennox and Trane are the three dominant brands in the regional market for commercial-sized equipment (65,000 Btu/h or more)(Table A-4).

Table A-3. National Unitary Cooling Equipment Market Shares (Residential plus Commercial)

Manufacturer Selected Brand Names*	**Approximate Market Share****
Carrier Corporation Bryant, Carrier, Day & Night, Payne	22%
Goodman Manufacturing Goodman, Mobiletemp	17%
Rheem Manufacturing Rheem, Ruud, Weatherking	13%
The Trane Company American Standard, Trane,	11 to 12%
York International Airpro, Coleman Evcon, Fraser and Johnston, Guardian, Luxaire, Moncrief, York	11 to 12%
International Comfort Products Corporation Airquest, Arcoaire, Comfortmaker, Heil, ICP, Maratherm, Tempstar	10 to 11%
Lennox Industries Armstrong, Lennox	10 to 11%
Nordyne Intertherm, Miller, Nordyne	4%
Total	100%

*Brand name information from ARI 1998 and http://www.ari.org/members_alpha/e.html
***Air Conditioning, Heating & Refrigeration News*, April 13, 1998.

Table A-4. Unitary Cooling Equipment Regional Market Shares[1]

	Market Share by Equipment Size			
Brand Name	**65,000 Btu/h or less**	**65,000 to 135,000 Btu/h**	**135,000 to 240,000 Btu/h**	**240,000 Btu/h or more**
Carrier/Payne	Large	Large	Large	Large
Lennox	Medium	Large	Large	Large
Trane	Large	Large	Large	Large
Bryant	Medium	Small	Small	Medium
Goodman	Large	Medium	Small	NA
Weatherking	Medium	Small	Small	NA
York	Small	Medium	Medium	Medium
Armstrong	Small	Small	NA	NA
ICP[3]	Small	Medium	Medium	NA
Norydyne	Small	NA	NA	NA
Rheem	Small	NA	NA	NA
Ruud	Small	Small	Small	NA
Aaon [2]	Unknown	Unknown	Unknown	Unknown

Source: Survey of manufacturers' representatives
[1] Suppliers were categorized as "large," "medium," or "small" based on representatives' estimates of regional market shares (normalized to 100%) as follows: large supplier typically has at least 15% of regional market share, medium 6-14%, and small 5% or less. Within each category of market share (i.e. Large, Medium, and Small), manufacturers are listed alphabetically. Note that brands made by the same manufacturer sometimes have different representatives (for example, Carrier, Payne and Bryant are all made by Carrier, but Bryant has a different rep than Carrier/Payne).
[2] The survey with the Aaon representative could not be completed. Based on the report of several other unitary representatives, Aaon's regional market share is very small.
[3]Carrier has signed an agreement to purchase ICP.

The manufacturers and brand names for packaged terminal air conditioners (PTACs) and packaged terminal heat pumps (PTHPs) are shown in Table A-5. National market share data are not available, but based on self-reported market shares from manufacturers' reps, Amana and Zoneline are the two large suppliers of commercial PTACs and PTHPs in the area (Table A-6). Other companies which are large suppliers of one or the other equipment type are Carrier, Friedrich and McQuay. Trane appears to be a medium player in both markets.

Table A-5. PTAC and PTHP Manufacturers (ARI 1997)

Manufacturer and Brand Names
Amana Refrigeration, Inc. Amana
Carrier Corporation Carrier
Climate Master, Inc. (a subsidiary of LSB Industries) Climate Master
Friedrich Air Conditioning Friedrich
McQuay International AAF, Incremental, Incremental Remington, McQuay
The Trane Company Trane
General Electric Company Zoneline

Table A-6. Packaged Terminal Cooling Equipment Regional Market Ranks [1]

Brand Name	Rank by Equipment Type PTAC	PTHP
Amana	Large	Large
Zoneline	Large	Large
Carrier	Large	Small
Friedrich	Medium	Large
McQuay	Small	Large
Trane	Medium	Medium
Climatemaster [2]	Unknown	Unknown

Source: Survey of manufacturers' representatives
Note: Within each size category (i.e. Large, Medium, and Small), manufactures are listed alphabetically.
[1] Suppliers were categorized as "large," "medium," or "small" based on representatives estimates of regional market shares (normalized to 100%) as follows: large supplier typically has at least 15% of regional market share, medium 6-14%, and small 5% or less.
[2] The survey with the Climatemaster representative could not be completed. Climatemaster's market share is believed to be very small based on the reports of other PTAC/PTHP representatives.

Chiller manufacturers are listed in Table A-7. No data on national or regional market shares are available.

Table A-7. Chiller Manufacturers (ARI 1997)

Manufacturer
Carrier Corporation
Dunham Bush Incorporated
McQuay International
The Trane Company
York International Corporation

APPENDIX B. EFFICIENCY OF COMMERCIAL COOLING EQUIPMENT

Current Minimum Efficiency Requirements and Efficiency Levels Recommended for Incentives

The minimum efficiency levels of commercial cooling equipment are governed by both federal and state regulations.

The federal National Appliance Energy Conservation Act (NAECA) of 1987 and its amendments set standards for single-phase central air conditioners and heat pumps of the sizes commonly used in residences (capacities of less than 65,000 Btu/h), and for room air conditioners (which are not discussed further here). The standards for residential central air conditioners and heat pumps took effect on January 1, 1992 for split systems and on January 1, 1993 for single package systems.[7] They are show in Tables B-1 and B-2.

The federal Energy Policy Act of 1992 (EPACT)[8] set minimum efficiencies (Tables B-1, B-2 and B-3) for:

- three-phase central air conditioners and heat pumps under 65,000 Btu/h manufactured on or after January 1, 1994,
- unitary equipment from 65,000 Btu/h to 135,000 Btu/h manufactured on or after January 1, 1994,
- large unitary equipment from 135,000 Btu/h to 240,000 Btu/h manufactured on or after January 1, 1995, and
- packaged terminal air conditioners and heat pumps manufactured on or after January 1, 1994.

ASHRAE/IES Standard 90.1-1989, *Energy Efficient Design of New Buildings Except New Low-Rise Residential Buildings*, a national voluntary consensus standard, had incorporated the NAECA standards for single phase equipment under 65,000 Btu/h cooling capacity, and had established standards for larger equipment which formed the basis for the requirements in the Energy Policy Act.[9] However, the ASHRAE/IES requirements had generally been even more comprehensive that those in EPACT in several ways:

[7] The U.S. Department of Energy has initiated a workshop process to set new standards for residential central air conditioners and heat pumps. Their proposed schedule calls for an advance notice of proposed rulemaking in July of 1999, a notice of proposed rulemaking in March of 2000, and a final rule in November of 2000 (information presented to May 5, 1998 meeting of DOE Appliance Standards Advisory Committee). Standards typically take effect three or four years after the final rule is adopted.

[8] Codified in 42 U.S.C. 6313. The relevant portions of EPACT can be downloaded from www4.law.cornell.edu/uscode/42/6313.text.html.

[9] The ASHRAE/IES 90.1-1989 standards for 3 phase equipment under 65,000 Btu/h were actually lower than those later established by EPACT.

(1) They set no upper limit on the size of unitary equipment covered.[10]
(2) For equipment over 65,000 Btu/h, they set requirements not only for the steady state energy efficiency ratio (EER), but also for the integrated part load value (IPLV) for equipment capable of capacity reduction, intended to reflect performance at part load (see Tables B-1 and B-2).
(3) For PTACs and PTHPs, they set a second efficiency requirement for a lower outdoor air temperature, also intended to reflect performance at part load conditions (see Table B-3).
(4) They set standards for chillers.

The Energy Policy Act preempted state standards for products it covered, but with an important exception (42 U.S.C. Section 6316 b(2)):

> (A)A standard prescribed or established under section 6313(a) of this title shall, beginning on the effective date of such standard, supersede any State or local regulation concerning the energy efficiency or energy use of a product for which a standard is prescribed or established pursuant to such section.
> (B) Notwithstanding subparagraph (A), a standard prescribed or established under section 6313(a) of this title shall not supersede a standard for such a product contained in a State or local building code for new construction if -
>
> > (i) the standard in the building code does not require that the energy efficiency of such product exceed the applicable minimum energy efficiency requirement in amended ASHRAE/IES Standard 90.1; and
> > (ii) the standard in the building code does not take effect prior to the effective date of the applicable minimum energy efficiency requirement in amended ASHRAE/IES Standard 90.1.

The State of Minnesota has adopted most of the efficiency requirements in ASHRAE/IES 90.1-1989 as part of the State Building Code, as shown in Tables B-1, B-2 and B-3.[11] Thus the Minnesota Energy Code brings into force in Minnesota, for new construction, the requirements established by ASHRAE for unitary equipment over 240,000 Btu/h (since this is a type of equipment for which EPACT prescribed no standard and therefore did not preempt state action). The Minnesota Energy Code also sets standards for chillers, another type of equipment not covered by EPACT, which are in some cases stricter and in some cases more lenient than the ASHRAE/IES 90.1-1989 standards. Finally, it brings into force the additional ASHRAE/IES 90.1-1989 requirements for IPLV of equipment from 65,000 Btu/h to 240,000 Btu/h and for a lower outdoor air temperature rating for PTACs and PTHPs.

The market for commercial air conditioning equipment is primarily a first-cost driven market. In 1992, most of the major manufacturers of commercial unitary air conditioning equipment made only a single product line with one efficiency level for the commercial market. They found that, while there was a small market niche for more efficient equipment, the niche was simply not

[10] EPACT set requirements only up to 240,000 Btu/h (20 tons), reportedly due to the lack of an industry certification program for larger units and the limited number of testing facilities capable of testing them (actually the ARI certification program does go slightly higher, up to 250,000 Btu/h). However, vendors publish self-ratings for their larger equipment, and ASHRAE/IES 90.1-1989 states that "data furnished by the equipment manufacturer shall be acceptable to satisfy these requirements."
[11] Relevant chapters of the Minnesota Rules can be downloaded at www.revisor.leg.state.mn.us/getrulechap.html.

large enough to justify the cost of producing a second product line (Hewett and Sachi 1993).[12] The Consortium for Energy Efficiency started to address this problem in 1993 by establishing a uniform set of higher efficiency levels, and encouraging utilities around the country to develop rebate programs to provide incentives for products at these efficiency levels. The Consortium currently has "Tier 1" and "Tier 2" efficiency levels (see Tables B-1 and B-2). The Tier 1 levels average roughly 13% above the current federal and ASHRAE standards, and were based on the proposed efficiency levels in one of the early public review drafts of proposed revisions to ASHRAE/IES 90.1-1989 (some of the efficiency levels in early proposed revisions to 90.1 were reduced in later drafts). The Tier 2 levels average about 10% above the Tier 1 levels. The Consortium reports that only about 14% of models on the market met their Tier 1 efficiency levels in 1993 when the program started, but now 34% of models do. They further report that, in the areas served by participating utilities, products meeting their Tier 1 efficiency levels account for about 15% of equipment sales (CEE 1998). The Consortium's Tier 1 and Tier 2 efficiency levels form the best basis for a utility rebate program because all major manufacturers are aware of them, and many of the major manufacturers make products to meet them.[13]

An important aspect of the Energy Policy Act is that it requires that if ASHRAE/IES 90.1 is amended with respect to the product types and sizes covered by EPACT, the Secretary of Energy shall amend the national standard for that product, unless the Secretary determines that adoption of an even more stringent standard is warranted (42 U.S.C. 6313 (a)(6)). For unitary equipment under 135,000 Btu/h, as well as for PTACs and PTHPs, EPACT specifies that national standard shall take effect two years after the effective date specified in ASHRAE/IES 90.1, and for unitary equipment from 135,000 to 240,000 Btu/h, EPACT specifies that it shall take effect three years after the date specified.

ASHRAE and IES have been working on a revised version of 90.1 for some time. The version approved for publication by the ASHRAE board of directors in June 1999 included higher efficiency levels for many products and size categories, with a nominal effective date of September 1, 2001.[14] Based on the timelines specified in EPACT, it therefore appears that adoption of higher standards into federal regulations is probably 4 to 5 years away. For unitary equipment, most of the "9/1/2001" efficiency levels in this new version of ASHRAE 90.1 matched the Consortium for Energy Efficiency Tier 1 requirements, although for most equipment under 65,000 Btu/h, the new ASHRAE 90.1 efficiency levels are substantially below the CEE Tier 1 levels (they're also somewhat lower for air cooled equipment over 760,000 Btu/h).

[12] The exception among major manufacturers was Carrier, which made a high efficiency commercial product line even then, which they reported accounted for about 5% of their sales in Minnesota at that time. A smaller manufacturer, Aaon, also made high efficiency equipment.

[13] Three-quarters of the unitary manufacturers' reps, however, were not aware of the Consortium's efficiency levels, so utilities should expect to have to inform the reps of these criteria.

[14] Based on publication notes in the draft and discussions with ASHRAE staff, this date is expected to be adjusted to be two years after the date of the *final* board of directors' approval after consideration of appeals, likely to be February 2000, making the nominal effective date February 2002, and the date these standards take effect in federal law February 2004 or 2005.

Table B-1a. Current Minimum Efficiency Requirements and Efficiency Levels Recommended for Incentives for Unitary Air Conditioners

Equipment Type	Size Category*	Sub-Category	Current Minimum Efficiency Requirements	Recommended for Incentives: Consortium for Energy Efficiency	
				Tier 1 Efficiency	Tier 2 Efficiency
Air Cooled Air Conditioners	<65,000 Btu/h	Split System	10.0 SEER (1)	12.0 SEER	13.0 SEER
		Single Package	9.7 SEER (1)	11.0 SEER	13.0 SEER
	≥65,000 Btu/h and < 135,000 Btu/h	Split System & Single Package	8.9 EER (2) 8.3 IPLV (3)	10.3 EER 10.6 IPLV	11.0 EER 11.4 IPLV
	≥135,000 Btu/h and < 240,000 Btu/h	Split System & Single Package	8.5 EER (2) 7.5 IPLV (3)	9.7 EER 9.9 IPLV	10.8 EER 11.2 IPLV
	≥240,000 Btu/h and ≤ 760,000 Btu/h	Split System & Single Package	8.5 EER (3) 7.5 IPLV (3)	9.5 EER 9.7 IPLV	10.0 EER 10.4 IPLV
	> 760,000 Btu/h	Split System & Single Package	8.2 EER (3) 7.5 IPLV (3)	9.5 EER 9.7 IPLV	10.0 EER 10.4 IPLV
Evaporatively Cooled Air Conditioners	<65,000 Btu/h	Split System & Single Package	9.3 EER (2) 8.5 IPLV	12.1 EER 11.2 IPLV	14.0 EER
	≥65,000 Btu/h and < 135,000 Btu/h	Split System & Single Package	10.5 EER (2) 9.7 IPLV (3)	11.5 EER 10.6 IPLV	14.0 EER
	≥135,000 Btu/h and <240,000 Btu/h	Split System & Single Package	9.6 EER (2) 9.0 IPLV (3)	11.0 EER 10.3 IPLV	14.0 EER
	≥240,000 Btu/h	Split System & Single Package	9.6 EER (3) 9.0 IPLV (3)	11.0 EER 10.3 IPLV	14.0 EER
Water Cooled Air Conditioners	<65,000 Btu/h	Split System & Single Package	9.3 EER (2) 8.3 IPLV (3)	12.1 EER 11.2 IPLV	14.0 EER
	≥65,000 Btu/h and < 135,000 Btu/h	Split System & Single Package	10.5 EER (2)	11.5 EER 10.6 IPLV	14.0 EER
	≥135,000 Btu/h and < 240,000 Btu/h	Split System & Single Package	9.6 EER (2) 9.0 IPLV (3)	11.0 EER 10.3 IPLV	14.0 EER
	≥ 240,000 Btu/h	Split System & Single Package	9.6 EER (3) 9.0 IPLV (3)	11.0 EER 10.3 IPLV	14.0 EER

(1) For single phase equipment, National Appliance Energy Conservation Act of 1987, as amended. 42 U.S.C. Ch. 77 Subch. 3, Sec. 6295 (d), and Minnesota Rules 7670.0660. For three phase equipment, Energy Policy Act of 1992. PL 102-486, Subtitle C, Section 122 (d). 42 U.S.C. Ch 77 Subch 3, Sec. 6313.

(2) Energy Policy Act of 1992, as above, and ASHRAE/IES 90.1-1989 and Minnesota Rules 7670.0660.

(3) ASHRAE/IES 90.1-1989 (requirements labelled "January 1, 1992") and Minnesota Rules 7670.0660. Note that, for equipment over 135,000 Btu/h, ASHRAE/IES 90.1-1989 specifies that minimum EERs and IPLVs shall be reduced by 0.2 if there is a heating section. This deduction was not carried over into the Minnesota Energy Code.

Table B-1b. Current Minimum Efficiency Requirements and Efficiency Levels Recommended for Incentives for Large Condensing Units

Equipment Type	Size Category*	Sub-Category	Current Minimum Efficiency Requirements	Recommended for Incentives
Air Cooled Condensing Units	≥135,000 Btu/h	NA	9.9 EER (1) 11.0 IPLV (1)	10.1 EER (2) 11.2 IPLV (2)
Water or Evaporatively Cooled Condensing Units	≥135,000 Btu/h	NA	12.9 EER (1) 12.9 IPLV (1)	13.1 EER (2) 13.1 IPLV (2)

(1) ASHRAE/IES 90.1-1989 (requirements labelled "January 1, 1992") and Minnesota Rules 7670.0660.
(2) ASHRAE 90.1 as approved for publication by ASHRAE board of directors June 1999. Requirements labelled "efficiency as of 9/1/2001."

Table B-2. Current Minimum Efficiency Requirements and Efficiency Levels Recommended for Incentives for Heat Pumps

Equipment Type	Size Category*	Sub-Category	Current Minimum Efficiency Requirements	Recommended for Incentives: Consortium for Energy Efficiency	
				Tier 1 Efficiency	Tier 2 Efficiency
Air Cooled (Cooling Mode)	<65,000 Btu/h	Split System	10.0 SEER (1)	12.0 SEER	13.0 SEER
		Single Package	9.7 SEER (1)	11.0 SEER	13.0 SEER
	≥65,000 Btu/h and < 135,000 Btu/h	Split System & Single Package	8.9 EER (2) 8.3 IPLV (3)	10.1 EER 10.4 IPLV	11.0 EER 11.4 IPLV
	≥135,000 Btu/h and < 240,000 Btu/h	Split System & Single Package	8.5 EER (2) 7.5 IPLV (3)	9.3 EER 9.5 IPLV	10.8 EER 11.2 IPLV
	≥240,000 Btu/h and ≤ 760,000 Btu/h	Split System & Single Package	8.5 EER (3) 7.5 IPLV (3)	9.0 EER 9.2 IPLV	10.0 EER 10.4 IPLV
	> 760,000 Btu/h	Split System & Single Package	8.7 EER (3) 7.5 IPLV (3)	9.0 EER 9.2 IPLV	10.0 EER 10.4 IPLV
Air Cooled (Heating Mode))	<65,000 Btu/h	Split System	6.8 HSPF (1)	7.0 HSPF	8.0 HSPF
		Single Package	6.6 HSPF (1)	6.8 HSPF	7.5 HSPF
	≥65,000 Btu/h and < 135,000 Btu/h	outdoor air at 47°Fdb/43°Fwb	3.0 COP (2)	3.2 COP	3.4 COP
		outdoor air at 17°Fdb/15°Fwb	2.0 COP (3)	2.2 COP	2.4 COP
	≥135,000 Btu/h	outdoor air at 47°Fdb/43°Fwb	2.9 COP (2)	3.1 COP	3.3 COP
		outdoor air at 17°Fdb/15°Fwb	2.0 COP (3)	2.0 COP	2.2 COP
Water Source (Cooling Mode)	<65,000 Btu/h	85°F entering water	9.3 EER (2)	12.0 EER	14.0 EER
		75°F entering water	10.2 EER (3)	--	--
	≥65,000 Btu/h and < 135,000 Btu/h	85°F entering water	10.5 EER (2)	12.0 EER	14.0 EER
Water Source (Heating Mode)	<135,000 Btu/h	70°F entering water	3.8 COP (2)	4.1 COP	4.6 COP

(1) For single phase equipment, National Appliance Energy Conservation Act of 1987, as amended. 42 U.S.C. Ch. 77 Subch. 3, Sec. 6295 (d) and Minnesota Rules 7670.0660. For three phase equipment, Energy Policy Act of 1992. PL 102-486, Subtitle C, Section 122 (d). 42 U.S.C. Ch 77 Subch 3, Sec. 6313.

(2) Energy Policy Act of 1992 as above. Note that the EPACT standards for water and evaporatively cooled air conditioners also apply to water and evaporatively cooled heat pumps, although such products are uncommon.

(3) ASHRAE/IES 90.1-1989 (requirements labelled "January 1, 1992") and Minnesota Rules 7670.0660. Note that, for equipment over 135,000 Btu/h, ASHRAE/IES 90.1-1989 specifies that minimum EERs and IPLVs shall be reduced by 0.2 if there is a heating section. This deduction was not carried over into the Minnesota Energy Code.

The Consortium for Energy Efficiency has not established qualifying criteria for PTACs and PTHPs, but two other relevant sources could be considered in setting criteria (Table B-3). The new version of ASHRAE/IES 90.1 approved for publication in June 1999 lists proposed PTAC and PTHP efficiency criteria for September 1, 2001. These criteria would be targeted for adoption into federal regulations in roughly September 2003 or February 2004. These criteria

appear to be a logical target for a rebate program, since manufacturers would likely be moving their production capability toward units meeting them over the long term. NSP has also set a qualifying criterion for PTACs and PTHPs, which is simpler but less flexible, in that it is not dependent on capacity. The NSP criterion is not recommended, however, since nearly all units already meet it (see next section).

Table B-3. Current Minimum Efficiency Requirements and Efficiency Levels Recommended for Incentives for Packaged Terminal Air Conditioners and Packaged Terminal Heat Pumps

Equipment Type	Current Minimum Efficiency Requirements	NSP rebate criteria (not recommended)	new ASHRAE 90.1 for 9/1/2001 (possibly recommended)
PTAC, PTHP in cooling mode	EER= 10.0 – 0.16C at 95°F (1)	9.2	PTAC 12.5 - 0.213C (3) PTHP 12.3 – 0.213C (3)
	EER = 12.2 – 0.20 C at 82°F (2)	NA	NA
PTHP in heating mode	COP = 1.3+0.16 EER (1)	NA	3.2-0.026C

(1) Energy Policy Act of 1992. PL 102-486, Subtitle C, Section 122 (d). 42 U.S.C. Ch 77 Subch 3, Sec. 6313. Minnesota Rules 7670.0660 is the same for cooling mode and equivalent for heating mode but does not contain the special exceptions for < 7000 Btu/h or > 15,000 Btu/h units in either case. For EER, C is the capacity in 1000s of Btu/h at 95 F db outdoor temperature. If capacity < 7000 Btu/h, C = 7. If capacity > 15,000 Btu/h, C = 15. The COP is at 47 F db. EER is computed from the formula above.
(2) ASHRAE/IES 90.1 and Minnesota Rules 7670.0660.
(3) The efficiency stated is for new construction. ASHRAE has a much lower proposed rating for replacements, due to the need to fit into existing openings, but 95% of units on the market pass it.
(4) Equipment with these efficiencies already has 75 to 80% of the market. (Virtually all equipment meets the NSP criteria).

EPACT does not set minimum standards for chillers, but standards are set by Minnesota Rules. The Consortium for Energy Efficiency has not established uniform qualifying criteria for incentives for chillers, but two other relevant sources could be considered in setting criteria (Table B-4). The efficiencies proposed in the new version of ASHRAE/IES 90.1 are different for different types of chillers, reflecting the differences in realistically achievable efficiencies with different machine designs. The NSP criteria take a different tack, and set the same qualifying criterion for all types of equipment in the same size range. Since most municipal utilities in Minnesota will not have many commercial customers with facilities large enough to require chillers, the pros and cons of these approaches were not investigated in detail. However, the NSP criteria will produce greater energy and demand savings and were developed based on NSP's thorough knowledge of the Minnesota chiller market, so they are probably preferable.

Table B-4. Current Minimum Efficiency Requirements and Efficiency Levels Recommended for Incentives for Chillers

Equipment Type	Category	Current Minimum Efficiency: ASHRAE/IES 90.1-1989 COP	ASHRAE/IES 90.1-1989 IPLV	Mn Rules 7670.0660, kW/ton (COP) CFC	Mn Rules 7670.0660, kW/ton (COP) non-CFC	Recommended for incentives: NSP rebate criteria, kW/ton (COP) (b) COP	Recommended for incentives: NSP rebate criteria, kW/ton (COP) (b) IPLV	new ASHRAE/IES 90.1 for 9/1/2001 COP	new ASHRAE/IES 90.1 for 9/1/2001 IPLV
water cooled	≥ 300 tons centrifugal	5.2 (a)	5.3 (a)	0.63 (5.58)	0.73 (4.82)	0.60 (5.86)	0.56 (6.28)	6.10	6.10
	≥ 300 tons screw	5.2 (a)	5.3 (a)	0.75 (4.69)	0.80 (4.39)	0.60 (5.86)	0.56 (6.28)	5.50	5.60
	≥ 300 tons scroll	5.2 (a)	5.3 (a)	0.93 (3.78)		0.60 (5.86)	0.56 (6.28)	5.50	5.60
	≥ 300 tons recip	5.2 (a)	5.3 (a)	0.93 (3.78)		0.60 (5.86)	0.56 (6.28)	4.20	4.65
	≥ 150 and < 300 tons centrifugal	4.2	4.5	0.63 (5.58)	0.73 (4.82)	0.60 (5.86)	0.56 (6.28)	5.55	5.55
	≥ 150 and < 300 tons screw	4.2	4.5	0.75 (4.69)	0.80 (4.39)	0.60 (5.86)	0.56 (6.28)	4.90	4.95
	≥ 150 and < 300 tons scroll	4.2	4.5	0.93 (3.78)		0.60 (5.86)	0.56 (6.28)	4.90	4.95
	≥ 150 and < 300 tons recip	4.2	4.5	0.93 (3.78)		0.60 (5.86)	0.56 (6.28)	4.20	4.65
	< 150 tons centrifugal	3.8	3.9	0.63 (5.58)	0.73 (4.82)	0.65 (5.41)	0.65 (5.41)	5.00	5.00
	< 150 tons screw	3.8	3.9	0.75 (4.69)	0.80 (4.39)	0.65 (5.41)	0.65 (5.41)	4.45	4.50
	< 150 tons scroll	3.8	3.9	0.93 (3.78)		0.65 (5.41)	0.65 (5.41)	4.45	4.50
	< 150 tons recip	3.8	3.9	0.93 (3.78)		0.65 (5.41)	0.65 (5.41)	4.20	4.65
air cooled with condenser	>=150 tons	2.5	2.5	1.41 (2.49)		0.60 (5.86)	0.56 (6.28)	2.8	2.8
	<150 tons	2.7	2.8	1.30 (2.70)		0.65 (5.41)	0.65 (5.41)	2.8	2.8
air cooled without condenser	all capacities	3.1	3.2					3.1	3.1

(a) Where R 22 or CFC refrigerants with ODP <= that for R22 is used, these requirements are reduced to 4.7 COP and 4.8 IPLV
(b) An NSP letter to trade allies of 10/1/98 indicated that their chiller program now covers only screw and centrifugal chillers.

When specifying the qualifying criteria for cooling equipment, utilities should specify the relevant test procedures, to assure that equipment receiving rebates has been tested to consistent standards. The test procedures for air conditioning equipment are developed by the Air Conditioning and Refrigeration Institute, and are listed in the references.

Availability and Estimated Market Penetration of High Efficiency Equipment

It is relatively easy to identify models of unitary equipment, PTACs and PTHPs that meet any given efficiency requirement. The great majority of units on the market are certified through Air Conditioning and Refrigeration Institute (ARI) certification programs.[15] ARI publishes both print and electronic directories that are made available free of charge to companies in air conditioning and allied industries. The *Directory of Certified Unitary Equipment* covers unitary air conditioners and unitary air-source heat pumps under 135,000 Btu/h in cooling capacity. The *Directory of Certified Applied Air Conditioning Products* covers unitary air conditioners and heat pumps of at least 135,000 Btu/h but less than 250,000 Btu/h cooling capacity, PTACs, PTHPs, chillers and various other equipment. As of mid-1998, print and CD ROM versions were available from:

Air Conditioning and Refrigeration Institute
4301 N. Fairfax Dr., Suite 425
Arlington, VA 22203
voice: 703/524-8800 fax: 703-528-3816 www.ARI.org

The electronic directories were built on Foxpro databases and have fairly flexible query capabilities. Models can be extracted based on combinations of manufacturer, type of unit, capacity, EER, SEER, IPLV, etc. Extracted models can be exported to various spreadsheet applications for further analysis.

Table B-5, compiled from the electronic *ARI Directory of Certified Unitary Equipment* (version effective 2/1/98-7/31/98), shows the number and percentage of certified unitary models under 135,000 Btu/h meeting the Consortium for Energy Efficiency's Tier 1 and Tier 2 criteria.[16] For equipment under 65,000 Btu/h, Table B-5 shows that somewhat over one third of the models in the "systems" section of the directory meet the Consortium's Tier 1 criteria, while almost half of the models in the "indoor coils" section of the directory do. Only about 10% of each meet the Tier 2 criteria. Equipment under 65,000 Btu/h meeting Tier 1 criteria is made by all of the major manufacturers listed in Table 1 and many smaller companies as well.

For equipment from 65,000 Btu/h to 135, 000 Btu/h, less than 20% of models meet the Tier 1 criteria, and less than 10% meet the Tier 2 criteria. Yet qualifying equipment is broadly produced: equipment between 65,000 and 135,000 Btu/h meeting Tier 1 efficiency levels is manufactured by Aaon, Carrier (under Carrier, Bryant and Day&Night brands), Heat Controller (under Century and Heat Controller), Lennox, McQuay, Rheem (under Rheem, Ruud and

[15] In the hard copy of their August 1, 1998 – January 31, 1999 *Directory of Certified Unitary Equipment*, for example, ARI reports that over 90% of the total U.S. output of these types of equipment are certified and listed.
[16] The electronic directory has both "systems" sections and "indoor coils" sections. Air conditioning equipment manufacturers certify their systems and have them listed in the "systems" section. Manufacturers of indoor evaporator coils can match their coils with condensing units made by other manufacturers, and certify these combinations of equipment, which are listed in the "indoor coils" section.

Weatherking), Trane (under American Standard and Trane) and York (under Fraser & Johnston, Luxaire and York).[17]

Table B-6 shows the same information for units from 135,000 Btu/h to 240,000 Btu/h, taken from the *ARI Electronic Applied Directory* (version effective 6/1/98 – 11/30/98). Figures B-1 through B-3 show the information graphically for the most common types of equipment. One quarter of models meet the Consortium's Tier 1 criteria, and about 15% meet the Tier 2 criteria.[18] Tier 1 equipment is manufactured by Aaon, Carrier (under Bryant, Carrier, Day & Night and Payne), Lennox, Trane (under American Standard and Trane) and York (under Fraser & Johnston, Luxaire and York).

[17] The manufacturers' rep for Goodman indicated that Goodman makes high efficiency equipment in this size range, although there was no qualifying equipment listed in the ARI directory covering 2/1/98 through 7/31/98. They may have started to make this equipment after the directory was published but before the interviews, or the rep may have been mistaken.

[18] The table gives separate figures for equipment passing the EER criterion only and equipment passing the EER and IPLV criteria, because only equipment that has capacity steps has IPLV ratings.

Table B-5. Number and Percent of Models Passing Consortium for Energy Efficiency Tier 1 and Tier 2 Criteria, Unitary Equipment < 135,000 Btu/h.[19]

		number of models					percent of models			
			CEE Tier 1 or better		CEE Tier 2 or better		CEE Tier 1 or better		CEE Tier 2 or better	
ARI type code	**description**	**total**	**EER or SEER**	**EER & IPLV**	**EER or SEER**	**EER & IPLV**	**EER or SEER**	**EER & IPLV**	**EER or SEER**	**EER & IPLV**
UNITARY SMALL EQUIPMENT <65,000 Btu/h (Systems section)										
SP-A	single package air conditioner, air cooled	1418	511	NA	77	NA	36%	NA	5%	NA
SP-W	single package air conditioner, water cooled	9	1	0	0	0	11%	0%	0%	0%
RC-A	air-conditioner with remote air-cooled condenser	4	0	NA	0	NA	0%	NA	0%	NA
SPY-A	year-round single package air conditioner, air-cooled	2384	911	NA	42	NA	38%	NA	2%	NA
RCU-A-CB	split system: air-cooled condensing unit, coil with blower	23,304	10,274	NA	4,438	NA	44%	NA	19%	NA
RCU-A-C	split system: air-cooled condensing unit, coil alone	27,872	8,263	NA	1731	NA	30%	NA	6%	NA
RCUY-A-CB	year-round air conditioner, remote air-cooled condensing unit	941	485	NA	294	NA	52%	NA	31%	NA
RCU-A-CB-O	split system: air-cooled condensing unit, coil w/blower, free delivery	227	72	NA	0	NA	32%	NA	0%	NA
HSP-A	single-package heat pump, air source	1,643	707	NA	13	NA	43%	NA	1%	NA
HRCU-A-C	heat pump with remote outdoor unit, no indoor fan, air source	13,711	4,082	NA	605	NA	30%	NA	4%	NA
HRCU-A-CB	split system: heat pump with remote outdoor unit, air source	13,469	5,190	NA	1,732	NA	39%	NA	13%	NA
HRCU-A-CB-O	split system: heat pump with remote outdoor unit, air source, free delivery	112	0	NA	0	NA	0%	NA	0%	NA
Subtotal		**85,094**	**30,496**		**8,932**		**36%**		**10%**	
UNITARY SMALL EQUIPMENT <65,000 Btu/h (Indoor coils section)										
SP-A-O	single package air conditioner, air cooled, no field installed duct system	2	2	NA	1	NA	100%	NA	50%	NA
RCU-A-CB	split system: air-cooled condensing unit, coil with blower	2,097	1,045	NA	699	NA	50%	NA	33%	NA
RCU-A-C	split system: air-cooled condensing unit, coil alone	31,036	14,650	NA	4,522	NA	47%	NA	15%	NA
RCU-A-C	same but listed under heat pump section of directory	1,659	467	NA	5	NA	28%	NA	0%	NA
HRCU-A-C	heat pump with remote outdoor unit, no indoor fan, air source	5,823	1,905	NA	124	NA	33%	NA	2%	NA
HRCU-A-CB	split system: heat pump with remote outdoor unit, air source	765	185	NA	32	NA	24%	NA	4%	NA
Subtotal		**41,382**	**18,254**		**5,383**		**44%**		**13%**	
UNITARY SMALL EQUIPMENT >=65,000 Btu/h and <135,000 Btu/h (Systems section)										
SP-A	single package air conditioner, air cooled	461	126	39	80	26	27%	8%	17%	6%
SP-W	single package air conditioner, water cooled	15	3	2	0	NA	20%	13%	0%	NA
RC-A	air-conditioner with remote air-cooled condenser	7	0	0	0	0	0%	0%	0%	0%
SPY-A	year-round single package air conditioner, air-cooled	689	136	65	83	42	20%	9%	12%	6%
RCU-A-CB	split system: air-cooled condensing unit, coil with blower	467	62	0	17	0	13%	0%	4%	0%
RCU-A-C	split system: air-cooled condensing unit, coil alone	162	5	0	0	0	3%	0%	0%	0%
RCUY-A-CB	year-round air conditioner, remote air-cooled condensing unit	13	0	0	0	0	0%	0%	0%	0%
HSP-A	single-package heat pump, air source	158	0	0	0	0	0%	0%	0%	0%
HRCU-A-CB	split system: heat pump with remote outdoor unit, air source	173	31	not listed	2	not listed	18%	NA	1%	NA
HRCU-A-C	split system: heat pump with remote outdoor coil, no indoor fan, air source	24	0	0	0	0	0%	0%	0%	0%
Subtotal		**2,169**	**363**		**182**		**17%**		**8%**	
UNITARY SMALL EQUIPMENT >=65,000 Btu/h and <135,000 Btu/h (Coils section)										
RCU-A-C	split system: air-cooled condensing unit, coil alone	1	0	0	0	0	0%	0%	0%	0%

[19] For the products in this table only, the ARI electronic directory does not permit searches to screen out deleted models, so the analysis includes all models in the directory.

Table B-6. Number and Percent of Models Passing Consortium for Energy Efficiency Tier 1 and Tier 2 Criteria, Unitary Large Equipment >= 135,000 Btu/h

		number of models					percent of models			
			CEE Tier 1 or better		CEE Tier 2 or better		CEE Tier 1 or better		CEE Tier 2 or better	
ARI type code	**description**	**total**	**EER**	**EER&IPLV**	**EER**	**EER&IPLV**	**EER**	**EER&IPLV**	**EER**	**EER&IPLV**
SP-A	single package air conditioner, air cooled	231	72	70	50	34	31%	30%	22%	15%
SP-W	single package air conditioner, water cooled	6	2	0	0	0	33%	0%	0%	0%
RC-A	air-conditioner with remote air-cooled condenser	2	0	0	0	0	0%	0%	0%	0%
SPY-A	year-round single package air conditioner, air-cooled	377	97	87	61	54	26%	23%	16%	14%
RCU-A-CB	split system: air-cooled condensing unit, coil with blower	98	6	4	0	0	6%	4%	0%	0%
HSP-A	single-package heat pump, air source	36	8	8	0	0	22%	22%	0%	0%
HRCU-A-CB	split system: heat pump with remote outdoor unit, air source	10	4	4	0	0	40%	40%	0%	0%
RCU-A-C	split system: air-cooled condensing unit, coil only	2	2	2	0	0	100%	100%	0%	0%
RCU-A	condensing unit - air cooled	21	?	?	?	?	?	?	?	?
Total		**787**	**195**	**179**	**115**	**92**	**25%**	**23%**	**15%**	**12%**

Table B-7. Number and Percent of Models Passing Consortium for Energy Efficiency Tier 1 and Tier 2 Criteria, Water Source Heat Pumps

		number of models					percent of models			
			CEE Tier 1 or better		CEE Tier 2 or better		CEE Tier 1 or better		CEE Tier 2 or better	
ARI type code	**description**	**total**	**EER**	**EER&IPLV**	**EER**	**EER&IPLV**	**EER**	**EER&IPLV**	**EER**	**EER&IPLV**
WATER SOURCE HEAT PUMPS <65,000										
HSP-W	single-package heat pump water source (ducted)	802	487	NA	116	NA	61%	NA	14%	NA
HSP-W-O	single-package heat pump water source (free delivery)	123	40	NA	18	NA	33%	NA	15%	NA
HRCU-W	split system: heat pump with remote chiller-condensing unit - water source (ducted)	105	80	NA	0	NA	76%	NA	0%	NA
WATER SOURCE HEAT PUMPS ≥65,000 and <135,000										
HSP-W	single-package heat pump water source (ducted)	153	85	NA	10	NA	56%	NA	7%	NA
Total		**1183**	**692**		**144**		**58%**		**12%**	

Table B-8. Number and Percent of Models Passing Possible Rebate Criteria, PTACs and PTHPs

		number of models			percent of models	
		total	**NSP or better**	**proposed ASHRAE 90.1 for 2001 or better***	**NSP or better**	**proposed ASHRAE 90.1 for 2001 or better***
PTAC	packaged terminal air conditioner	778	616	228	79%	29%
PTHP	packaged terminal heat pump, cooling mode	475	383	203	81%	43%
PTHP	packaged terminal heat pump, heating mode	475	NA	236	NA	50%
PTHP	packaged terminal heat pump, both modes	475	NA	189	NA	40%

The number of models was determined based on the number that pass the ASHRAE efficiency criterion for new construction at 95F. ASHRAE also specifies a rating at 82F, but these data are not available in the ARI directory.

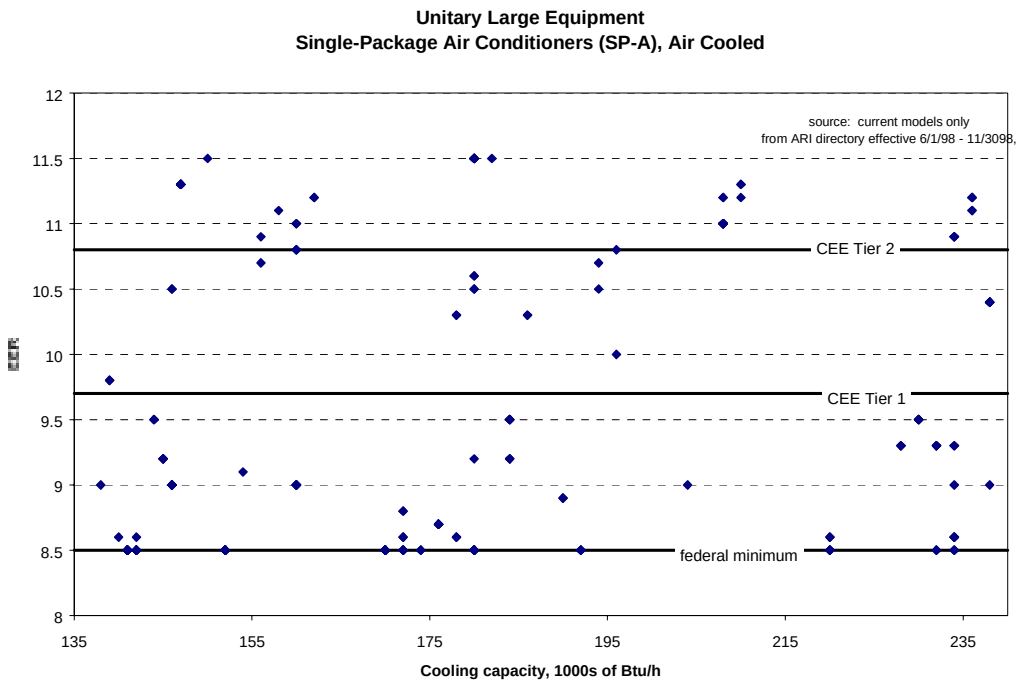

Figure B-1. Models meeting or exceeding the Consortium's Tier 1 and Tier 2 criteria, Type SP-A, ≥135,000 Btu/h and <240,000 Btu/h

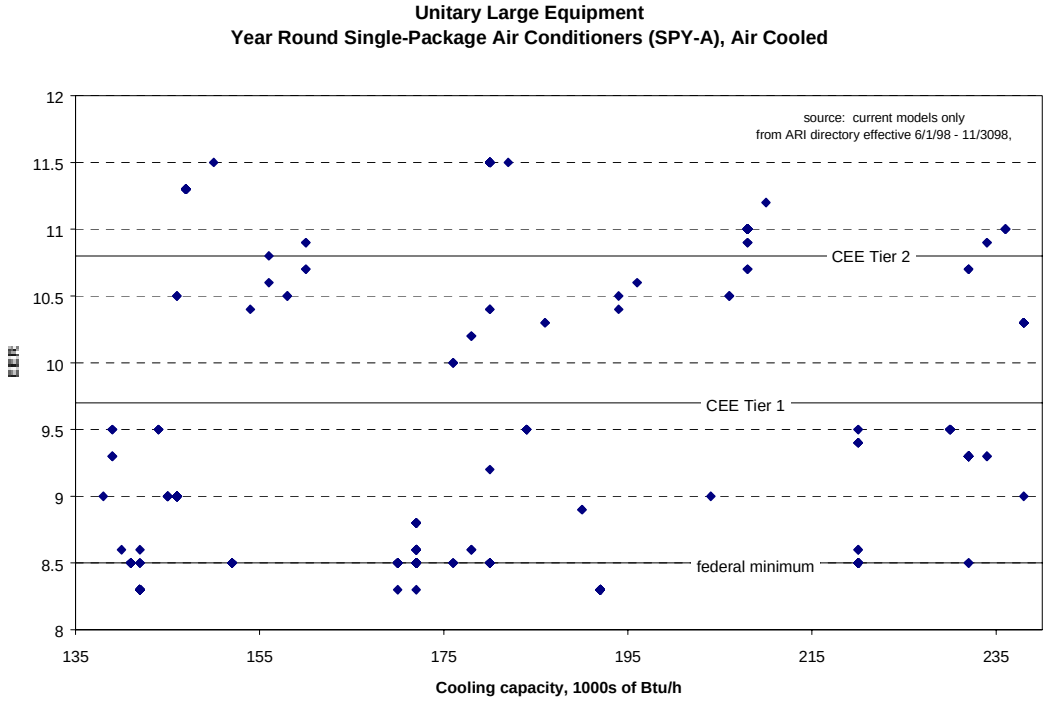

Figure B-2. Models meeting or exceeding the Consortium's Tier 1 and Tier 2 criteria, Type SPY-A, ≥135,000 Btu/h and <240,000 Btu/h

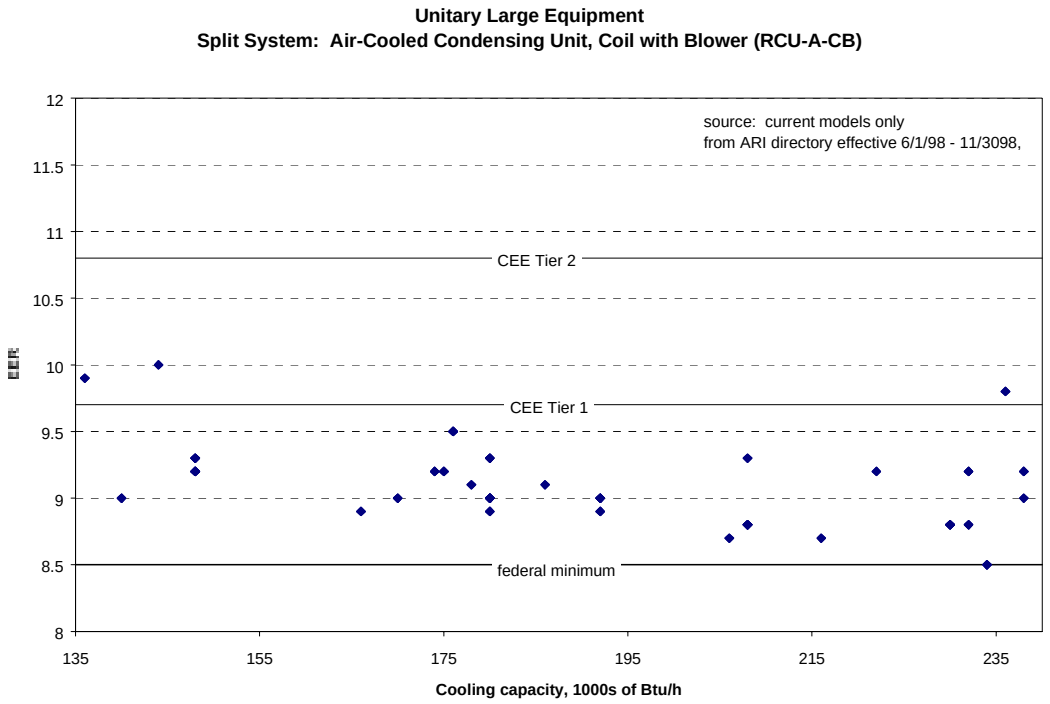

Figure B-3. Models meeting or exceeding the Consortium's Tier 1 and Tier 2 criteria, Type RCU-A-CB, ≥135,000 Btu/h and <240,000 Btu/h

ARI does not conduct a certified rating program for larger unitary equipment. Manufacturers do generate their own self-ratings, but these are not considered by the industry to be as reliable as the certified ratings. If these self-ratings are published in technical literature, where they are subject to scrutiny by competitors, they are generally considered more likely to be accurate than ratings that are only provided through verbal or customer-specific written communications. In interviews, all six of the representatives for the manufacturers who make unitary equipment over 240,000 Btu/h reported that they publish self-ratings. The same five who make qualifying equipment from 135,000 to 240,000 Btu/h (see above) indicated that they also made qualifying equipment for the larger sizes.

Based on representatives' self-reports of market share, the manufacturers who make qualifying unitary equipment account for 83 to 100% of the regional market in the various size categories (see Table B-9). Thus, these qualifying criteria will not impose substantial limitations on customers' choice of brands.

Table B-9. Proportion of Manufacturers Offering Qualifying Unitary Equipment

	Does Manufacturer Make Equipment that Meets the Proposed Qualifying Criteria (Tier 1)?			Pct Making High Efficiency Equipment, of Those Making Equipment in Size Range	Sales-Weighted Pct Making High Efficiency Equipment [1]
Size Category	**YES**	**NO**	**NA[2]**		
65,000 Btu/h split (5.4 ton) or less	12	0	0	100%	100%
65,000 Btu/h packaged (5.4 ton) or less	11	1	0	92%	100%
65,000 – 135,000 Btu/h (5.4-11.3 ton)	7	5	0	58%	86%
135,000 - 240,000 Btu/h (11.3-20 ton)	5	7	0	42%	83%
240,000 Btu/h (20 ton) or more	5	1	6	83%	100%

Source: Survey of manufacturers' representatives
[1] Weighting is based on representatives' estimates of regional market shares for equipment in each category. Thus, for example, in the case of 65,000 to 135,000 Btu/h equipment, manufacturers representing 86% of the regional market offer high efficiency equipment.
[2]Do not make equipment in this size range.

According to the manufacturers' representatives interviewed, unitary equipment meeting the Consortium for Energy Efficiency's Tier 1 criteria accounts for 14 to 46% of regional sales in the various size categories (Table B-10). Clearly, the high efficiency equipment is not rare, and so does not represent a risky decision for the purchaser, but it is also far from being the dominant choice, and there is substantial room for incentives to improve market penetration. Penetration appears to be highest for the larger sizes of unitary equipment (inputs of 240,000 Btu/h or more). It may be that a larger cooling load generates more concern for energy efficiency as well as better paybacks for the purchase of high efficiency equipment. Alternatively, this could reflect the lower qualifying criteria for large equipment or even the lack of a certification program for large equipment.

Table B-10. Market Penetration of Air-Cooled Unitary Equipment Meeting the Consortium for Energy Efficiency's Tier 1 Criteria

Size Category	Pct	Sales-Weighted Avg Pct[1]
65,000 Btu/h (5.4 tons) or less – split	15%	16%
65,000 Btu/h (5.4 tons) or less – packaged	9%	14%
65,000 – 135,000 Btu/h (5.4-11.3 tons)	12%	18%
135,000 - 240,000 Btu/h (11.3-20 tons)	16%	24%
240,000 Btu/h (20 tons) or more	32%	46%

Source: Survey of manufacturers' representatives
[1] Weighting is based on representatives estimates of their regional market shares for equipment in each category

Table B-7 shows that over half of water source heat pump models meet the Consortium's Tier 1 criteria, and 12% meet the Tier 2 criteria. Tier 1 equipment is made by Addison, Carrier, Climate Master, Command-Aire, FHP Manufacturing, Koldwave, Mammoth, McQuay, Trane

and Water Furnace in sizes under 65,000 Btu/h, and by all of these except Addison for equipment from 65,000 to 135,000 Btu/h.

Table B-8 and figures B-4 and B-5 show that the new proposed ASHRAE 90.1 9/1/2001 levels for PTACs and PTHPs appear to be reasonable criteria for incentives, with 29% of PTACs passing and 40% of PTHPs passing, while the NSP rebate criterion is too lenient, with 80% of models passing it. PTACs meeting the new ASHRAE 90.1 9/1/2001 criteria are manufactured by Amana, Carrier, Friedrich, General Electric, McQuay and Trane, and PTHPs meeting both ASHRAE's cooling and heating criteria are manufactured by all of these except Carrier.

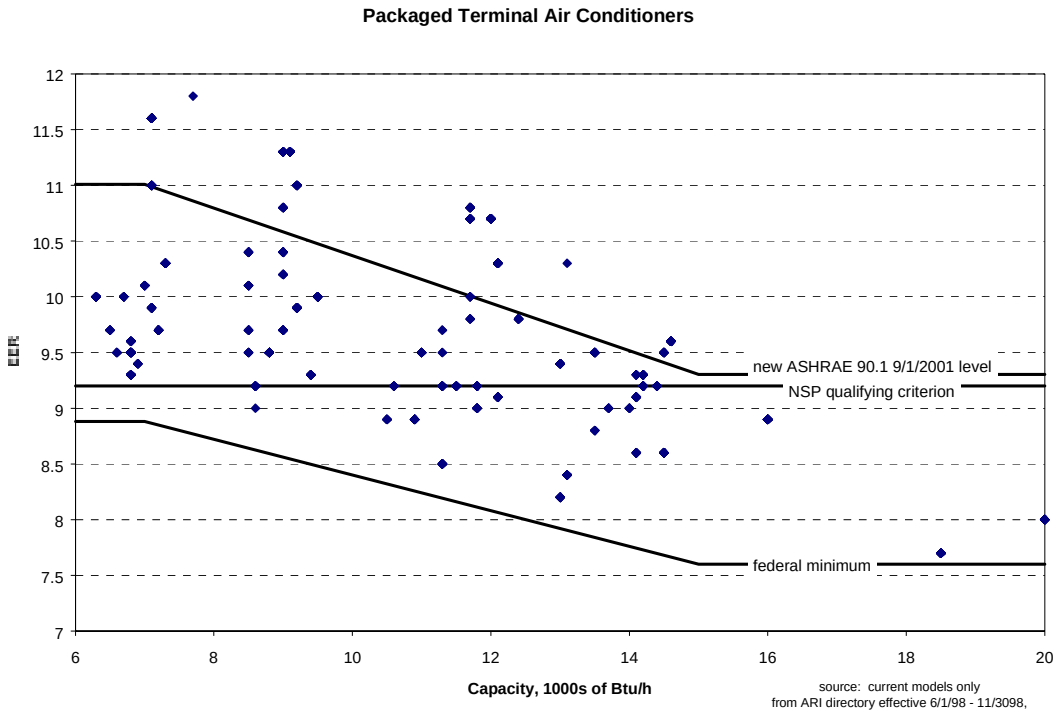

Figure B-4. PTACs meeting or exceeding the NSP and ASHRAE 90.1 9/1/2001 criteria

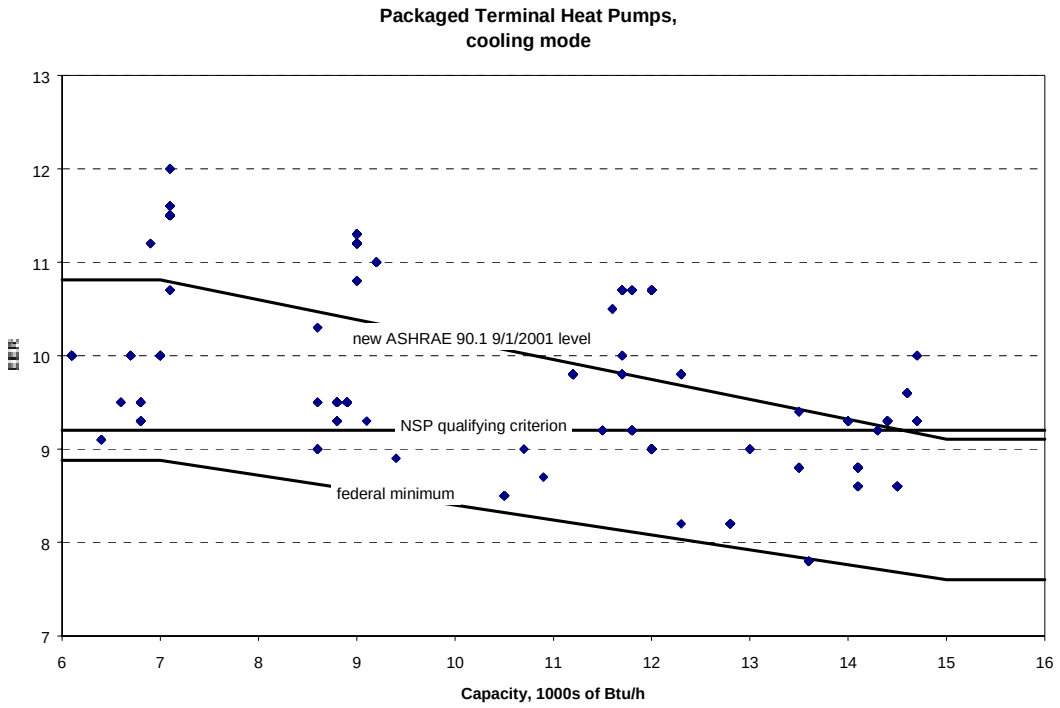

Figure B-5. PTHPs meeting or exceeding the NSP and ASHRAE 90.1 9/1/2001 criteria, cooling mode

Table B-11 shows the availability of high efficiency packaged terminal equipment that meets ASHRAE 90.1 9/1/2001 efficiencies, as reported by the manufacturers' reps. Five out of the six manufacturers' representatives interviewed said the companies they represent make at least some equipment that meets these criteria, though not in all sizes (The one rep who said his company did not was actually in error).

Table B-11. Availability of Packaged Terminal Equipment that Meets Potential Rebate Critieria*

Does Manufacturer Make Equipment that Meets the Criteria?									
	Number			% Average			% Weighted Avg [1]		
Size Category	YES	NO	NA	YES	NO	NA	YES	NO	NA
PTAC Any Size	5	1	0	83%	17%	0%	96%	4%	0%
PTAC 7,000 Btu/h	4	2	0	67%	33%	0%	86%	14%	0%
PTAC 9,000 Btu/h	4	2	0	67%	33%	0%	79%	21%	0%
PTAC 12,000 Btu/h	4	2	0	67%	33%	0%	86%	14%	0%
PTAC 15,000 Btu/h	1	4	1	17%	66%	17%	18%	43%	39%
PTAC Overall Average:				55%	41%	4%	67%	23%	10%
PTHP Any Size**	5	1	0	83%	17%	0%	82%	18%	0%
PTHP 7,000 Btu/h	3	3	0	50%	50%	0%	68%	32%	0%
PTHP 9,000 Btu/h	5	1	0	83%	17%	0%	83%	17%	0%
PTHP 12,000 Btu/h	5	1	0	83%	17%	0%	83%	17%	0%
PTHP 15,000 Btu/h	2	3	1	33%	50%	17%	22%	39%	39%
PTHP Overall Average:				62%	34%	4%	64%	26%	10%

*One rep who reported in the interviews that the manufacturer did not make qualifying PTACs of any size was definitely in error based on published certifications.
**Due to an error, the cooling efficiencies asked about for PTHPs was the same as for PTACs, and therefore 0.2 percentage points higher than they should have been.

Most of the PTAC/PTHP manufacturers make equipment of only efficiency at any given cooling output. For example, the ARI directory has 14 entries for Amana PTACs with cooling capacity of 12,000 Btu/h, but all of these have EERs of 10.7. They appear to be the same basic cooling unit with different types (hot water, steam, electric) and sizes of heating provided.

According to the manufacturers' reps interviewed, the market share of qualifying PTACs and PTHPs in this area is already about 75 to 80% of sales. It may not be worthwhile to offer rebates for efficiency levels that already have market shares this high, because there will be many free riders (customers who would have installed the high efficiency equipment without the rebate, so that the rebate dollars spent for those customers do not have any net effect on the market). Raising the qualifying criteria might not be a good solution for this particular product group, because in a given size range, the EERs of products by different manufacturers cluster near each other. A somewhat higher criterion thus might still include the majority of units sold, or if raised slightly more, might arbitrarily rebate some units and not others with very similar EERs, or if raised higher still might exclude nearly all units.

There might be other reasons to rebate PTACs or PTHPs for a particular application. For example, if a motel or hotel were converting from a central chiller to PTACs or PTHPs there might be considerable savings, because PTACs and PTHPs can be turned off whenever a room is unoccupied, whereas some of the base load energy use of the chiller system is incurred even when only a fraction of the building requires cooling. The energy and demand savings from this type of installation would have to be analyzed through simulations done by an energy consultant hired by the utility.

Other Aspects of Efficient Cooling

A number of factors besides the efficiency of the equipment affect the overall amount of energy and demand required to cool a commercial building, especially oversizng, duct leakage, and building cooling loads.

Oversizing can have a significant impact on the peak demand of cooling equipment (Geiola et al. 1985, Neal and O'Neal, 1992, Proctor et al. 1995, Reddy and Claridge 1993, James et al. 1997). Oversized units also diminish comfort relative to a correctly sized unit. Air conditioners need to run continuously for a while to get the cooling coil cold enough to condense moisture out of the air, and an oversized unit may satisfy the thermostat so quickly that it does not condense enough moisture to lower the humidity to a comfortable level.

Ideally, utilities should require A&E firms or contractors to perform a complete and accurate cooling load calculation[20] or at least, for existing buildings, to install a unit no larger than the unit being replaced.

The ductwork in commercial buildings frequently runs through spaces above dropped ceilings. These spaces can be substantially warmer than the air in the occupied zone, due to transmission through the roof and to heat from light fixtures. Poorly sealed ductwork, which is common in low pressure unitary cooling systems, will allow hot air from the ceiling cavity to be sucked into the return ducts and cool air from the unit to be discharged to the ceiling cavity. Poorly insulated ductwork can gain heat by conduction from the ceiling cavity. The impact of duct leakage on energy use and peak demand has been extensively studied in residential buildings, but only to a limited extent in commercial buildings. The duct systems in light commercial buildings of the kind that normally use unitary cooling equipment are similar in materials and construction to residential duct systems. A recent study (Delp et al. 1998) of 25 packaged roof-top systems in commercial buildings in northern California found that in 30%, the cavity above the ceiling and below the roof deck was functionally outside both the building's air barrier and its thermal barrier. The effective leakage area of the ducts was almost three times that for California residential buildings, with an average supply-side leakage rate of 26% of the system flow rate. The average efficiency of the duct systems, combining conduction losses and leakage, averaged only 65%. Similar results were found in Florida (Cummings et al. 1996). Clearly, the levels of duct sealing and insulation required by mechanical codes are sufficiently lax that a significant fraction of the cooling paid for is not delivered to the conditioned space. Ducts should never be sealed with duct tape. Fiberglass mesh tape applied with mastic, butyl-backed aluminum tape, silicone caulk, neoprene gaskets (for removable panels and doors) and similar materials are durable, but so-called duct tape is not.

Relatively little of the cooling load in commercial buildings comes from conduction through the building envelope. In this respect, cooling and heating loads are rather different. The largest contributors to cooling load are ventilation air (which must be brought in for occupant health and cooled for comfort), solar gain by radiation through windows, and internal gains from lighting,

[20] Using an approved method such as that in the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) *Handbook of Fundamentals* or the Air Conditioning Contractors Association (ACCA) *Manual J*.

plug loads, etc (E-Source 1995 p. 3.1). Occupant loads can be major contributors in densely occupied buildings like schools and theatres. Therefore, to reduce cooling loads, utilities should encourage customers to install high efficiency lighting first. The most important measures in this regard are the use of T8 fluorescent lamps and electronic ballasts instead of T12 lamps with electromagnetic ballasts, and the use of compact fluorescent lamps instead of incandescent lamps. The cooling energy saved from high efficiency lighting is about 10% of the lighting savings themselves. See the *Practical Guide to Direct Installation Lighting Retrofit Programs for Municipal Utilities* for a recommended approach to improving the lighting efficiency of commercial customers. Minimum outside air flow should be measured and set by one-time tests (such as can be conducted by a test-and-balance firm), rather than assumed based on the position of outside air dampers. Cooling loads can also be reduced by installing windows or window treatments that exclude a substantial proportion of solar radiation, yet let in enough visible light that lighting loads are not increased.[21]

Table 12. Key Strategies to Reduce Cooling Energy Use and Demand

Cooling Equipment
Do not oversize. Require sizing no greater than ACCA Manual J sizing.
Ductwork
Seal and insulate ductwork to reduce energy loss to unconditioned or semi-conditioned ceiling spaces.
Lighting
Replace T12 fluorescent lamps/electromagnetic ballasts with T8 lamps/electronic ballasts
Replace incandescent lamps with compact fluorescent lamps
Ventilation
Actually measure minimum outside air to assure that it is not too high
Glazing
Install windows or window treatments (films, solar screens) with shading coefficients of 0.45 or less or solar heat gain coefficient of roughly 0.39 to 0.41 or less but a visible light transmissivity of over 15% (to minimize the need for additional lighting)

A Note on Refrigerants

Essentially all unitary equipment, PTACs and PTHPs on the market today use a hydroclorofluorocarbon (HCFC) refrigerant called HCFC-22 (or R-22). At this time, international agreements specify that virgin HCFC-22 can be used in new equipment through 2010 and can be manufactured for use in existing equipment through 2020. Recycled refrigerant will be available beyond that time, so the availability of HCFC-22 should exceed the life-expectancy of unitary equipment, PTACs and PTHPs being sold today. Historically, chillers have used chorofluorocarbons (CFCs) (especially CFC-11, CFC-12), for which production stopped in 1995. New chillers are being designed for use with hydroclorofluorocarbons, such as HCFC-22, HCFC-123, HFC-134a, and hydrofluorocarbons (HFCs), such as R-410a (a mixture of two HFCs).

[21] If films or screens are used, these should be permanently attached, have a manufacturers' warranty of at least five years, and be installed by a contractor recognized by the manufacturer (see NSP CIP filing 1993).

APPENDIX C. THE ECONOMICS OF HIGH EFFICIENCY COMMERCIAL COOLING EQUIPMENT

Simplified Methods of Estimating Demand and Energy Savings

Unitary SEER-Rated Units

Equipment under 65,000 Btu/h cooling capacity is rated with a seasonal energy efficiency ratio (SEER).

Demand Savings

Most commercial customers using cooling equipment of under 65,000 Btu/h will not be demand-billed customers, so the demand savings will not need to be calculated from the customer's perspective. However, all equipment that has a certified SEER rating does also have an EER rating in the *ARI Directory of Certified Unitary Equipment*, so if demand savings are needed, they can be calculated for this equipment using the method described below under Unitary EER-Rated Units.

Energy Savings

For equipment that has a SEER rating, estimating annual energy use is straightforward. The savings for high efficiency equipment can then be determined as the difference in energy use between the standard and high efficiency equipment.

The *ARI Directory of Certified Unitary Equipment* gives a cooling cost for each certified model. This cost is based on a national average electricity price (currently $0.0842/kWh), a national average number of cooling load hours (1000), and no oversizing. The ARI directory also contains an "EnergyGuide" section that explains how to calculate the operating cost for another location based on Federal Trade Commission rules. The calculations below are equivalent to those in the ARI EnergyGuide.

The national average energy use for a given unit with zero oversizing is:

Nat'l Avg Energy Use (no oversizing) = ARI "Cooling Cost"/Nat'l Avg Energy Price

= ARI "Cooling Cost"/$0.0842

Using the map in the ARI directory, and taking Marshall as an example, Mashall has only about 600 cooling load hours per year, compared to the national average of 1000 cooling load hours (The range for Minnesota as a whole is from about 700 to less than 400 cooling load hours). Therefore, the average energy use for an air conditioner with zero oversizing in Marshall is:

Marshall Avg Energy Use (no oversizing) = Nat'l Avg Energy Use * (600/1000)

If a unit is installed in an application where it is oversized, it will not run as many hours as it would in an application with no oversizing. To correct for this, the EnergyGuide procedure is to multiply by the ratio of the building design heat gain (i.e., the design cooling load) to the unit's capacity. This is equivalent to dividing by the oversizing ratio:

Marshall Avg Energy Use (with oversizing) = Nat'l Avg Energy Use * (600/1000) * (design heat gain/unit capacity)

=Nat'l Avg Energy Use * (600/1000) * (1/oversizing ratio)

Generally, the utility will not have access to a good estimate of the design heat gain. In this situation, it is reasonable to estimate the oversizing ratio as 1.21. This is the maximum amount of oversizing allowed by Minnesota Rules 7670.0610 Building Mechanical Systems, part of the Minnesota Energy Code, taking into account both a 10% safety factor and 10% for pick-up loads.[22]

Putting all of these relationships together, the estimate of average energy use for a unit in Marshall can be calculated from:

Marshall Avg Energy Use (with oversizing) = (ARI "Cooling Cost"/$0.0842/kWh)* (600/1000) * (1/1.21)

If the national average energy cost used in the ARI Cooling Cost calculation changes, then the $0.0842 figure in the above equation will need to be changed. If a utility other than Marshall Municipal Utilities uses this equation, they need to substitute the number of cooling load hours in their location, from the map in the ARI directory, for the 600 in the above equation.

The savings from installation of a high efficiency air conditioner can be determined by calculating the energy use of the efficient unit in Marshall, and subtracting it from the energy use of a unit with the same oversizing but with the minimum SEER given in Table B-1. If you can find a unit in the ARI directory with the same capacity and a SEER exactly equal to the minimum, you can use the cooling cost for it and the equation above to calculate the annual energy use. Otherwise, the energy use of a unit with a known SEER and oversizing in Marshall can be calculated from

Marshall Avg Energy Use (with oversizing, in kWh) = total annual cooling (Btu)/(SEER*1000 Wh/kWh)

= (unit capacity, Btu/h * 600 cooling load hours/oversizing ratio)/(SEER*1000 Wh/kWh)

This calculation compares the high efficiency air conditioner to the lowest efficiency equipment on the market today. This is the appropriate comparison for new construction or for replacement of existing equipment due to equipment failure. If the cooling equipment were being replaced for energy savings only, the relevant comparison would be to the SEER of the existing unit, but such replacements are rarely cost-effective and virtually never made.

[22] The design conditions relative to which this oversizing is determined are specified in Mn Rules 7670.0400, subpart 3. For Marshall the value would be about 88F outdoor dry bulb temperature and about 72F outdoor wet bulb temperature. This is probably lower than the outdoor temperature during which utility system peaks occur, so the oversizing at the time of the system peak would be less.

Example:

A 5 ton (60,000 Btu/h) split system air conditioner meeting the Consortium's Tier 1 criteria (SEER of 12.0) is listed in the ARI directory as having an annual cooling cost of $421. The Marshall average energy use assuming 21% oversizing is:

Marshall Avg Energy Use (with oversizing) = (ARI "Cooling Cost"/$0.0842/kWh)* (600/1000) * (1/1.21).

= ($421/$0.0842/kWh)*(600/1000)*(1/1.21) = 2,479 kWh/y

The utility wants to compare this to the energy use of a unit with the standard efficiency (SEER = 10.0). Rather than try to find such a unit in the directory, they calculate the energy use as follows:

Marshall Avg Energy Use (with oversizing) = (unit capacity, Btu/h * 600 cooling load hours/oversizing ratio)/(SEER*1000 Wh/kWh)

= (60,000 * 600/1.21)/(10.0*1000) = 2,975 kWh

The savings from the high efficiency unit is 2,975 – 2,479 or 496 kWh.

This estimate may be conservative for business customers, since they may run their air conditioning equipment more than a residence would.

The ARI unitary directory gives calculation procedures for the annual energy use of small heat pumps similar to those for small air conditioners.

Unitary EER-Rated Units

Demand Savings

The peak demand savings achieved by installing a high efficiency air conditioner rather than a standard unit can be estimated from the energy efficiency ratio (EER). The EER is defined as the ratio of the cooling capacity at the rating conditions, in Btu/h, to the power input in Watts at the rating condition. Therefore, from the capacity (Btu/h) and EER in the ARI directory, the power input at the rating conditions can be calculated from:

power input (watts) = [capacity (Btu/h)]/[EER (Btu/h/watt)]

A rough estimate of the demand savings from installing a high efficiency unitary air conditioner rather than a minimum efficiency air conditioner can be made by computing the power input for both units at ARI rating conditions and subtracting the high efficiency power input from the minimum efficiency power input.

To get a more accurate estimate, the two power inputs must first be adjusted for several factors:

- the difference between the rating condition and the conditions occurring at the time of the peak (customer peak, if calculating the customer's monthly demand reduction, or system peak, if calculating the annual or monthly system peak reduction),

- the oversizing of the equipment, and therefore the extent to which it is cycling rather than running continuously at the time of the (customer's or system) peak,
- the coincidence-loss factor (for system peak), to account for the fact that the peaks for individual air conditioners are not necessarily coincident with the utility's peak, and to account for the fact that the power required at the plant is larger than the power required at the customer due to line losses.

The ARI rating conditions are 95F outdoor dry bulb temperature and 67F indoor ("return air") wet bulb temperature. The steady state power required at other conditions reasonably close to these rating conditions can be estimated using adjustment factors taken from the DOE-2 reference manual (LBL 1980) for packaged single-zone systems:

$$P_{adj} = \frac{C_{ARI} * (0.418943 + 0.017421 T_{RAWB} - 0.00617 T_{OADB})}{EER_{ARI} / (0.282094 - 0.005832 T_{RAWB} + 0.01167 T_{OADB})}$$

where:

P_{adj} = the adjusted power input at some desired condition other than the ARI rating condition
C_{ARI} = the unit capacity at ARI rating conditions
EER_{ARI} = the unit EER at ARI rating conditions
T_{RAWB} = the return air (indoor) wet bulb temperature at the desired condition
T_{OADB} = the outside air dry bulb temperature at the desired condition

When a utility is interested in calculating the system demand for a given air conditioner for any given month, they may know what outside air dry bulb temperature they consider to be the normal peak temperature for the month, in which case they can substitute this value for T_{OADB}. If not, a reasonable estimate can be obtained from a nearby weather station included in the *International Station Meteorological Climate Summary* CD-ROM available from the National Climatic Data Center. Use the average values of the "extreme daily maximum temperature" for each month (from Table 30 for each ISMCS station). The ISMCS data for weather stations in or near Minnesota is given in Table C-1.

Table C-1. Average Extreme Daily Maximum Temperatures (F) for April through October from ISMCS for Locations in or Near Minnesota

Location	April	May	June	July	Aug	Sep	Oct
Duluth	70.8	81.8	85.9	88.8	87.6	81.3	73.2
Fargo, ND	78.3	88.1	92.0	95.3	95.7	89.5	79.5
International Falls	72.9	84.5	88.1	90.5	89.4	82.6	74.4
LaCrosse, WI	80.0	87.7	93.1	95.0	94.0	89.0	79.8
Minneapolis	78.9	87.5	93.2	94.8	93.7	88.6	79.9
Rochester	77.9	85.7	91.2	92.8	91.1	86.3	78.3
St. Cloud	77.5	86.9	92.0	93.4	92.6	87.1	78.3
Sioux Falls, SD	82.3	88.6	95.0	99.0	97.0	90.7	81.9

The return air (indoor) wet bulb temperature is more difficult to estimate. For unitary cooling equipment, which is generally only operated during the summer months, the indoor wet bulb temperatures during times when the cooling equipment is operating are typically in the range of 56 to 70F. As a first approximation, it is probably reasonable to set T_{RAWB} in the low 60s for peak conditions in the milder months of April, May, September and October and near the ARI condition of 67F for peak periods in June, July and August in Minnesota. Figure C-1 below shows correction factors calculated from the equation above. To estimate the steady state power at other-than-ARI conditions, calculate the power requirement at ARI conditions:

P_{ARI} (Watts) = C_{ARI}/EER_{ARI}

and then calculate the adjusted power:

$P_{adj} = P_{ARI} *$ correction factor from Figure C-1.

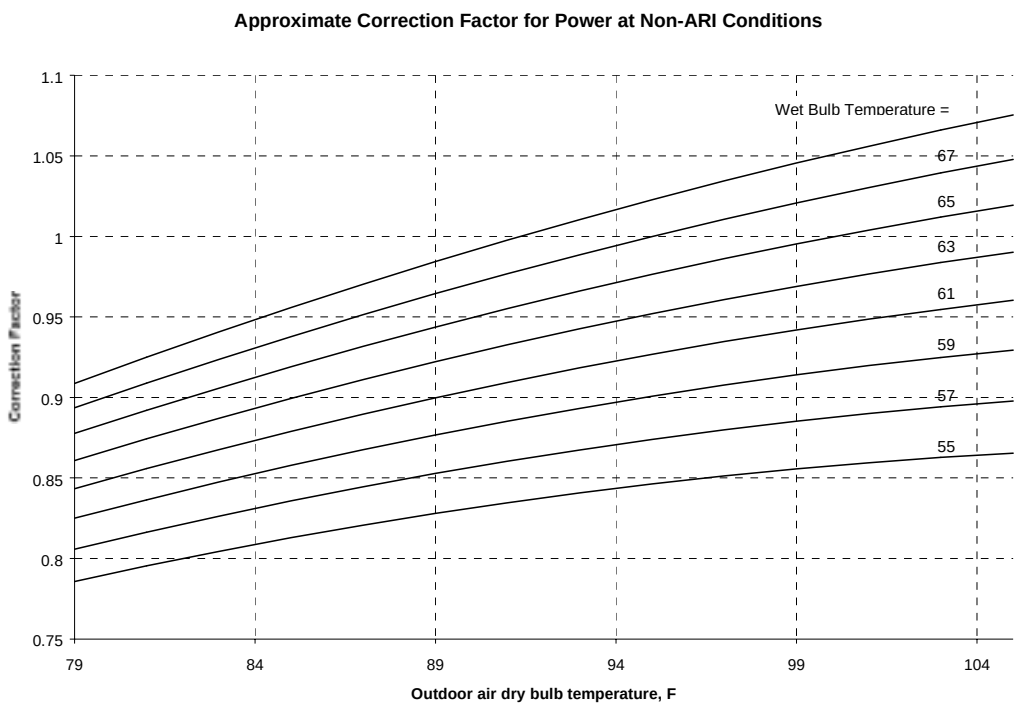

Figure C-1. Approximate Correction Factor for Power at Non-ARI Conditions

Most air conditioners are oversized relative to design conditions, and may be even more oversized relative to individual monthly peak periods. Therefore, the power determined from the above equation should be corrected for oversizing. For design conditions (roughly 90 F for most of the southern half of Minnesota), it is reasonable to estimate the oversizing ratio as roughly 1.21. This is the maximum amount of oversizing allowed by Minnesota Rules 7670.0610 Building Mechanical Systems, part of the Minnesota Energy Code, taking into account both a 10% safety factor and 10% for pick-up loads.

Oversizing is, by definition, the ratio of the unit capacity to the building load. The oversizing ratio changes at off-design conditions for two reasons: the building load changes with changing conditions, and the unit capacity changes with changing conditions. Capacity varies as a function of outdoor dry bulb temperature and indoor wet bulb temperature (as shown in the numerator of the first equation for P_{adj} above). Assuming that the unit that has an oversizing ratio of 1.21 at 90F outdoor air dry bulb temperature and 67F indoor air wet bulb temperature, the oversizing ratio relative to the same building load at other conditions can be estimated from Figure C-2. The building load is somewhat higher during June, July and August peaks than it is at Minnesota design conditions, and can be substantially lower during peaks in April, May, September and October. The changes in building load with changing conditions are more difficult to estimate in a simplified fashion, though, since they depend on the relative proportion of the building load that is a function of weather conditions (ventilation loads, solar gain, conduction), vs. that which is not a function of weather conditions (internal gains from lights, plug loads and occupants).

Ignoring the effects of different building loads, the peak demand at the customer for each month can be roughly estimated for monthly peak conditions as:

$D_{customer,adj} = P_{adj}$/oversizing ratio at that month's peak conditions from Figure C-2.

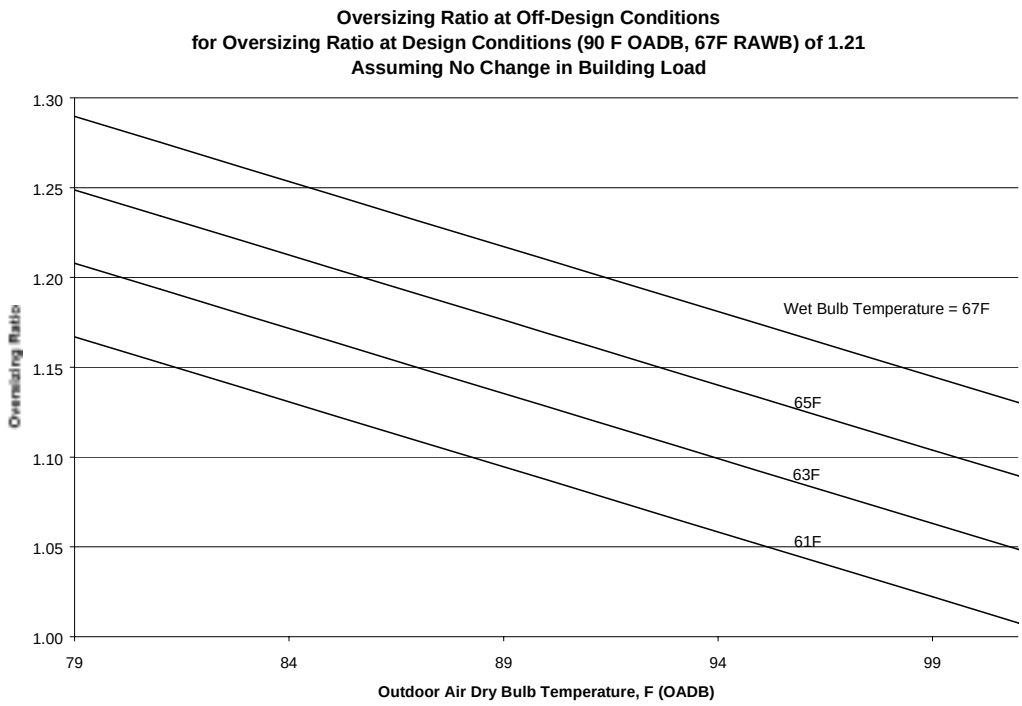

Figure C-2. Oversizing Ratio at Off-Design Conditions for Oversizing Ratio at Design Conditions of 1.21 Assuming No Change in Building Load

In determining the system peak demand, the utility must take into account the facts that customers' peaks do not necessarily coincide with the system peak (which causes the diversified system peak demand to be less than the sum of the customer peak demands) and that there are losses from the generator to the customer (which causes the system peak demand to be greater than the demand at the customer). As of 1993, the last year for which NSP filed detailed CIP plans by end use, NSP estimated the combined coincidence/loss factor for unitary air conditioning equipment relative to their summer system peak at 93%. Using this figure would reduce the system demand to 93% of the amount computed from the formula above.

Once the appropriate adjustments have been made for both the minimum efficiency unit and the high efficiency unit, the adjusted demand for the latter can be subtracted from the adjusted demand for the former to estimate customer or system demand savings.

If all of the customer's existing cooling equipment is to be replaced, the customer's utility bills can be examined as a check on the reasonableness of the demand estimate for the minimum efficiency units. For customers without other seasonal loads, the difference between their summer peak demand and their demand in non-cooling, non-heating months is an estimate of their current summer demand for cooling. Since the units currently in place are probably substantially less efficient than even the minimum efficiency units available today, the peak demands estimated for the minimum efficiency units should be lower than the customer's current summer demand for cooling.

Some units that are not officially SEER-rated do have SEERs listed in the *ARI Directory of Certified Unitary Equipment.* For these units, annual energy savings can be calculated by using the method described in the section on Unitary SEER-Rated Units.

For other units, a rough estimate of the energy savings can be obtained from Figure C-3. This figure summarizes the results of 123 detailed hourly simulations of office, school and retail buildings in Minnesota. The diamonds show the results of individual simulations, and the line shows the regression through all data points. The savings are quite variable. They are higher for buildings with higher lighting power densities, and for air conditioning systems without economizers. They are lower for schools that are unoccupied in the summer. As an overall average for purposes of program planning, the regression results can be used. This gives:

kWh saved/ton = 17.4 + 885 x fractional improvement in efficiency

For example, if on average the high efficiency air conditioners are expected to be 10% more efficient than the minimum efficiency units, the fractional improvement in efficiency is 0.1 and the kWh saved/ton is 106 kWh. If the average system size is 10 tons, the average savings per customer is 1060 kWh/year.

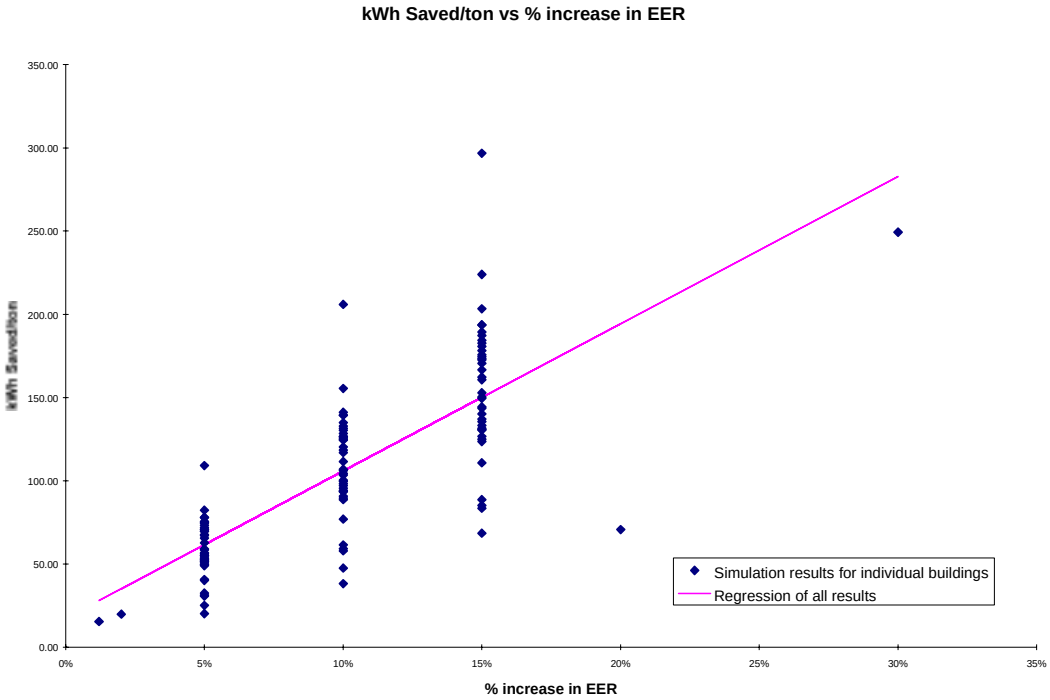

Figure C-3. Estimated kWh Saved per Ton of Cooling Capacity Installed, Based on Simulations with DOE-2 Model for Office, School and Retail Buildings in Minnesota.

In NSP's 1993 CIP filing, the last one in which they provided detailed data for individual retrofits, they estimated the kWh savings for unitary air conditioner replacements per kW of demand reduction at the customer at 1443 kWh/kW. The source of this estimate is unknown, but it is about 60 to 75% higher than the simulation results in Figure C-3, so these are perhaps conservative.

Estimating the demand and energy savings for EER – rated units using the methods outlined above produced the following results shown in Table C-2.

Table C-2. Estimated Energy and Demand Savings for High Efficiency Unitary Equipment in Minneapolis (Tier 1 Efficiency vs. Minimum Efficiency)

tons	Estimated kWh svgs	Peak kW Savings	Total kW Apr-Oct	Total kW May-Sep	Estimated kWh svgs	Peak kW Savings	Total kW Apr-Oct	Total kW May-Sep
7.5	1062	1.2	7.7	5.7	1584	1.7	12.5	9.2
10	1410	1.6	10.3	7.6	2106	2.2	16.6	12.2
15	1892	2.3	14.7	10.9	3609	3.9	29.1	21.4
20	2100	2.6	16.6	12.4	3141	3.7	27.3	20.1

PTACs and PTHPs

PTACs and PTHPs are rated for EER at the same rating conditions as unitary equipment, so demand savings from PTACs and PTHPs can be estimated using the same procedures. Some of the types of buildings that use PTACs and PTHPs (e.g. motels) may not be fully occupied at the time of monthly system peaks, and they also may peak at different times from the utility system peak. For buildings of these types, the coincidence-loss factor is probably lower than for unitary equipment. Energy savings from high efficiency PTACs and PTHPs are difficult to estimate accurately for these same building types because of the wide variation in occupancy rates.

Chillers

All chiller manufacturers have software programs that they use to estimate the energy use of their chillers in various applications. Utilities offering incentives for chillers should require the project engineer or contractor to analyze the high efficiency and minimum efficiency chillers to generate energy and demand savings estimates. Incentives can then be calculated on a custom basis for each installation.

Design Life of Commercial Cooling Equipment

The economics of high efficiency cooling equipment for both customers and the utility are affected by the equipment lifetime. Table C-3 shows estimates of equipment life from two different sources for common types of commercial cooling equipment.

Table C-3. Lifetimes of Commercial Cooling Equipment (years)

	BOMA 1996 "avg useful life"*	ASHRAE 1995 "median service life"**
window AC	10	10
commercial through the wall (PTAC, PTHP)	10	15
rooftop air conditioner	15	15
commercial air to air heat pump	15	15
commercial water to air heat pump	18	19
chiller, reciprocating or screw	20	20
chiller, centrifugal	28	23

* with regular preventive maintenance at prescribed frequencies. Designed for use in planning equipment replacement budgets
** service life is defined as "the period during which a particular system or component remains in its original service application. Replacement may be for any reason, including, but not limited to, failure, general obsolescence, reduced reliability, excessive maintenance cost, and changed system requirements due to such influences as building characteristics or energy prices."

Incremental Cost of High Efficiency Equipment and Customer Economics

The incremental cost to the contractor for high efficiency unitary equipment ranges from roughly $400 to $3,800 for 5 to 20 ton equipment respectively (Table C-4). This amounts to roughly a 10% premium in most cases, and about 15% for the largest size shown.[23] The incremental cost

[23] Based on bare (no profit) costs for materials for single zone units with gas heat (R.S. Means 1997).

charged to the customer may be rather variable. The Consortium for Energy Efficiency (1998) reported that the incremental cost to the end user averages around 15% in areas where utilities have developed programs based on their criteria.

Table C-4. Incremental Contractor Costs for Commercial Unitary Equipment [1]

Size Category	Average	Sales-Weighted Average [2]	Sales-Weighted Average/Ton
5 ton split systems	$403	$397	$79
5 ton packaged systems	$431	$415	$83
7.5 ton split/packaged systems	$520	$549	$73
10 ton split/packaged systems	$650	$676	$68
15 ton split/packaged systems	$902	$970	$65
20 ton split/packaged systems	$1,260	$1,392	$70
30 ton split/packaged systems	$3,800	$3,800	$127

Source: Survey of manufacturers' representatives
[1] Incremental costs for equipment that meets CEE proposed standards versus equipment that does not.
[2] Weighting is based on representatives estimates of local sales for only those manufacturers who make units of each particular size.

Incremental contractor costs for PTACs/PTHPs were harder to estimate since all the companies but one (McQuay) only make one unit in each size, and it was not possible to compare units from the same manufacturer with different efficiencies. A comparison of costs between manufacturers indicates that the incremental contractor cost of high efficiency units ranges from roughly $50 to $300, with $100 to $200 being typical. This is roughly a 10% premium.

Using the information provided here and the utility's own rate structure, a utility can easily calculate the economics to the customer of a high efficiency air conditioner. Using typical summer rates, and assuming a 10% mark-up of the contractor cost to the customer, results in the customer economics shown in Table C-5. Note that for most equipment the payback to the customer is on the order of 5 to 6 years. Most business customers are reluctant to consider an investment that has a payback of more than 1 to 2 years, or 3 years at the outside. This is particularly true of businesses that lease their space, since the majority of such leases are for periods of 2 years or less (even though many businesses end up staying in these spaces much longer). Although these businesses are often responsible for replacement of equipment like air conditioners, they are loathe to invest more than necessary in property they don't own. For both owners and renters, a utility that hopes to be successful in increasing the market share of high efficiency equipment will probably need to contribute 50% or more of the incremental cost in the form of a rebate.

Table C-5. Sample Customer Economics for High Efficiency Unitary Equipment

tons	energy cost/kWh	demand cost/kW	energy cost savings	demand cost savings	total savings	incremental cost	payback
5	$0.07	na	$ 34.72	na	$ 34.72	$443	12.8
7.5	$0.03	$9.00	$ 31.85	$ 69.27	$ 101.11	$572	5.7
10	$0.03	$9.00	$ 42.29	$ 92.36	$ 134.64	$715	5.3
15	$0.03	$9.00	$ 56.75	$ 132.02	$ 188.77	$992	5.3
20	$0.03	$9.00	$ 62.99	$ 149.78	$ 212.77	$1,386	6.5

The Economics of Cooling Equipment Incentives to the Utility

Determining the net cost or benefit of a commercial cooling rebate program to the utility, and the impact on rates, involves the use of standard benefit-cost tests. Different tests reflect different perspectives. For example, the cost-effectiveness to the participant is clearly different from the cost-effectiveness to the utility, since the costs they pay and the benefits they obtain are different. The indirect effects of rebates on non-participant ratepayers, in the form of rate impacts, reflect still another perspective. The overall cost-effectiveness to all ratepayers, including participants and non-participants, is reflected in the total resource cost test. The cost-effectiveness to society, including the environmental benefits of decreased power consumption, is reflected in the societal test. Figures C-4 through C-8 describe these tests in detail.

The Minnesota Department of Public Service has a spreadsheet tool, called ELECBEN, that can greatly facilitate the determination of benefit-cost ratios for incentive programs. The basic concept of each test is to add up the benefits that apply to that particular perspective, add up the costs, and then compare the benefits to the costs. This is made a bit more complicated by the fact that some of the benefits and costs occur over time. For example, the benefits that accrue to non-participant ratepayers as a group in the form of reduced needs for purchased power ("avoided costs"), occur over the life of the cooling equipment. By the same token, the costs that occur, in the form of lost revenue from reduced sales, occur over the same lifetime. To total these yearly costs and benefits up and determine a net present value, it is necessary to apply a discount rate to the savings and costs in future years, to account for the fact that a dollar saved (or spent) a year from now is worth less than a dollar saved (or spent) today.

The most difficult aspect of benefit-cost analysis for municipal utilities at the present time will be uncertainty about the future cost of purchased power and about associated changes in future rates charged to customers. These costs and rates were easier to predict when utilities had long term power contracts and rates were set on a cost-of-service basis, but under retail competition, many municipal utilities may buy their last increment of power on the open market and may reconfigure their rates to be more competitive. The relevant purchased power cost is the cost for the last kW and kWh purchased, since that is the power that will be displaced by the efficiency measure. Many utilities will want to obtain assistance in making these estimates.

Figure C-4. Participant Test

Perspective:	Customers participating in the program.
Use:	Tests likelihood of successfully marketing the program.
Benefits:	Reduction in electric bill [tax credits, if any]. (A few versions of this test include the participant share of the utility's avoided costs).
Costs:	Participant's net costs (equipment, operation and maintenance, etc) after rebate. (A few versions of this test include the participant share of the utility program costs).
Discount rate:	Participant's. Usually taken as the interest rate the participant could earn by putting the same money into another investment. Sometimes a high rate is used to capture participants' aversion to the risk that the measure may not give the claimed savings.
Form:	Commonly expressed as net present value or as benefit to cost ratio, even though participants themselves normally look at programs in terms of payback or return on investment.
Strengths:	Gives a first indication of potential participation. Can help in program design, if it is used to evaluate the incentive level needed to get the NPV, return on investment, or payback to the threshold level at which the desired fraction of customers will participate.
Weaknesses:	Does not capture the complexities of customer decision-making processes. Many customers don't base decisions entirely on quantifiable variables.

- **Perspective: Program participants.**
- **Use: Tests likelihood of successfully marketing program.**
- **Discount rate: Customer's.**

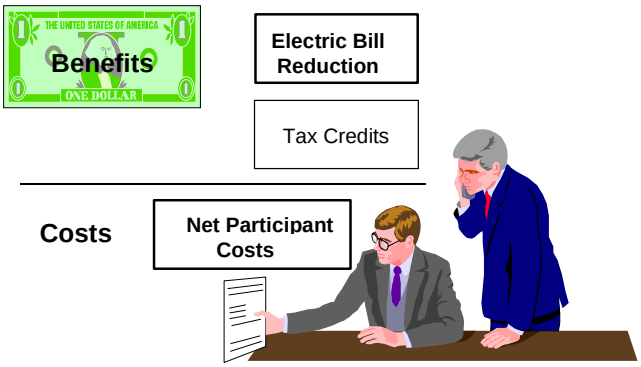

Figure C-5. Revenue Requirements (RR) Test (Utility Test)

Perspective:	Utility
Use:	Tests whether achieving conservation or load reduction through the proposed program is cheaper for the utility than providing the equivalent amount of power, and therefore should be passed by any proposed program. Can be used to rank those program options that pass the test.
Benefits:	Avoided costs of generation, transmission and distribution of energy, avoided capital costs of increasing system capacity.
Costs:	Utility program costs (marketing, administration, delivery, evaluation, etc), incentives given to participants, [increased costs of generation, transmission, distribution, system capacity, if any]
Discount rate:	Utility's. Generally taken as the utility's rate of return or cost of capital (as established by regulators for regulated utilities, or through bond issues for municipal utilities).
Form:	Commonly expressed as net present value or as benefit to cost ratio.
Strengths:	Costs include only the utility's costs, not participant costs, so in this way costs are defined analogously to supply-side projects. Takes into account who pays costs (utility or customer), which the total resource cost test does not.
Weaknesses:	Does not capture rate impacts Cannot be used to evaluate load-building projects because the benefit is zero.
Comments:	Measures efficiency in terms of total costs to the utility (i.e., the lowest cost way for the utility to acquire a given amount of resources). If a program passes this test, the energy bill of the average customer will drop. But unless rates decrease, only customers who can take advantage of the program will actually experience the drop in their bills. It is not generally difficult to pass this test.

- **Perspective: Utility**
- **Use: Compare costs to utility of various options for acquiring DSM resources.**
- **Discount rate: Utility's cost of capital**

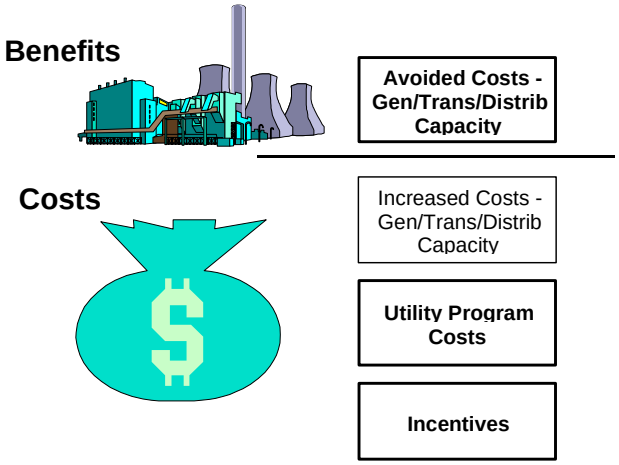

Figure C-6. Rate Impact Measure (RIM) Test

Perspective: Non-participant ratepayers.

Use: Tests whether offering the program will result in an increase in rates.

Benefits: Avoided costs of generation, transmission and distribution of energy, avoided capital costs of increasing system capacity, [revenue gain, if any].

Costs: Utility program costs (marketing, administration, delivery, evaluation, etc.), incentives given to participants, net lost revenues due to decreased energy sales (net after taxes or transfer fees), [increased costs of generation, transmission, distribution, system capacity, if any]

Discount rate: Utility's. Generally taken as the utility's rate of return or cost of capital.

Form: Most commonly expressed in terms of the impact on rates per kWh over the life of the measure. Sometimes expressed as net present value, lifecycle revenue impact (impact on energy costs) per customer, annual revenue impact, benefit/cost ratio.

Strengths: Only test that considers the impact of lost revenues on other ratepayers.
Can be used to help establish rebate levels, by looking at how much incentive can be provided while still passing the RIM test.

Weaknesses: Sensitive to differences between projections of long term marginal costs and long term rates.
In isolation, would justify indiscriminate load-building activity for a utility for which revenues generated from new sales exceed marginal costs to provide the energy.
Not comparable to the way supply options are analyzed.

Comments: For many utilities, only load management programs pass the RIM test, because for conservation programs, lost revenues exceed avoided costs. Typically the rate impacts are small, even when a program does not pass the RIM test, but this may still be significant for very large customers.
New supply often will not pass the RIM test either, if the new plant increases the average cost per kWh, but this is not usually considered when new supply is analyzed. Increased costs are simply passed on to customers. The rationales for this include the obligation to serve, the idea that growth is inherently good, and the fact that shareholders make more money when the capital assets of an investor-owned utility are increased.

- **Perspective: Non-participant rate-payers.**
- **Use: Test impact on non-participants.**
- **Discount rate: Utility's cost of capital.**

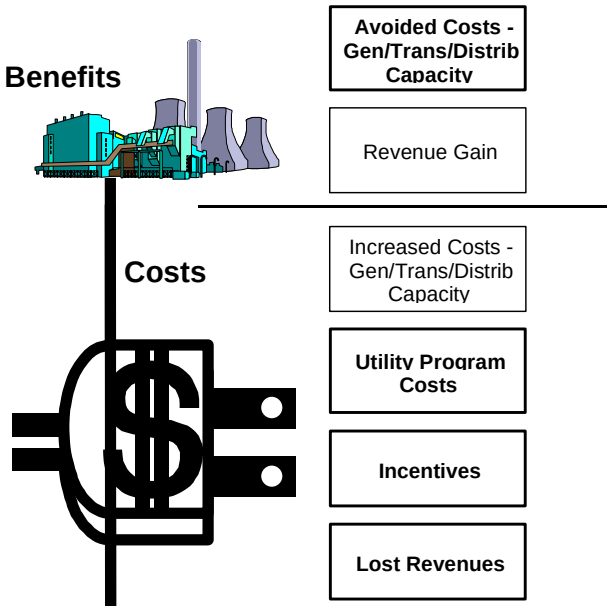

Figure C-7. Total Resource Cost (TRC) Test

Perspective:	All ratepayers (on average).
Benefits:	Avoided costs of generation, transmission and distribution of energy, avoided capital costs of increasing system capacity.
Costs:	Utility program costs (marketing, administration, delivery, evaluation, etc, but not incentives), gross participant costs (total cost before receiving incentives), [increased costs of generation, transmission, distribution, system capacity, if any]
Discount rate:	Generally taken as the utility's rate of return.
Form:	Commonly expressed as net present value or as benefit to cost ratio, but can also be given as a levelized cost per unit of energy or demand.
Strengths:	Has a broad scope that considers total costs and benefits. Particularly appropriate for a municipal utility since "all ratepayers" = citizenry. Similar to supply side in the sense of including total costs to acquire a resource. Insensitive to uncertainties about rate projections.
Weaknesses:	Ignores rate impacts. Doesn't differentiate based on whose money is spent (the utility's or the participants', the participants' or the non-participants'). Cannot be used to evaluate load-building projects because the benefit is zero. Different from supply side in the sense of including non-utility costs.
Comments:	Measures efficiency in terms of the total resources expended to meet an energy demand. If a program passes this test, the total costs (energy bills plus conservation investments) of the average ratepayer to meet their energy needs will drop. But unless rates decrease, only customers who can take advantage of the program will actually experience the decrease in costs. Anything that passes the TRC test will pass the RR test, since they are the same except that the TRC test includes gross participant costs and the RR test includes incentives only.

- **Perspective: all ratepayers (on average)**
- **Use: Measures total economic efficiency**
- **Discount rate: Utility's cost of capital**

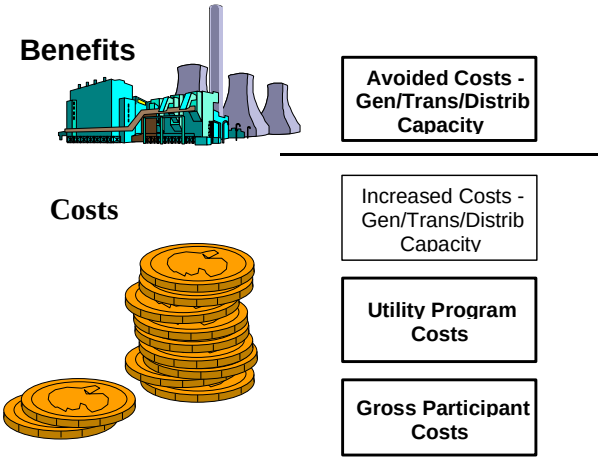

Figure C-8. Societal Test

Perspective:	Society as a whole.
Benefits:	Avoided costs of generation, transmission and distribution of energy, avoided capital costs of increasing system capacity, avoided externalities (e.g., environmental damage costs).
Costs:	Utility program costs (marketing, administration, delivery, evaluation, etc, but not incentives), gross participant costs (total cost before receiving incentives), [increased costs of generation, transmission, distribution, system capacity, if any]
Discount rate:	Generally a low societal rate is used, reflecting society's longer term perspective and interest in the future. (At the time of this project, the State of Minnesota was using an unusual combination of rates, including a societal discount rate for externalities and the utility discount rate for all other factors).
Form:	Commonly expressed as net present value or as benefit to cost ratio but can also be given as a levelized cost per unit of energy or demand.
Strengths:	Has a broad scope that considers total costs and benefits. Includes environmental and other factors left out of conventional economic analysis. Does not discount future benefits as sharply as do individuals and corporations.
Weaknesses:	Ignores rate impacts. Doesn't differentiate based on whose money is spent (the utility's or the participants', the participants' or the non-participants'). Cannot be used to evaluate load-building projects because the benefit is zero.
Comments:	Measures efficiency in terms of the total resources expended to meet an energy demand, including the hidden costs of environmental damage.

- **Perspective: Society as a whole.**
- **Use: Used by government to measure net resources expended more broadly.**
- **Discount rate: Societal/utility.**

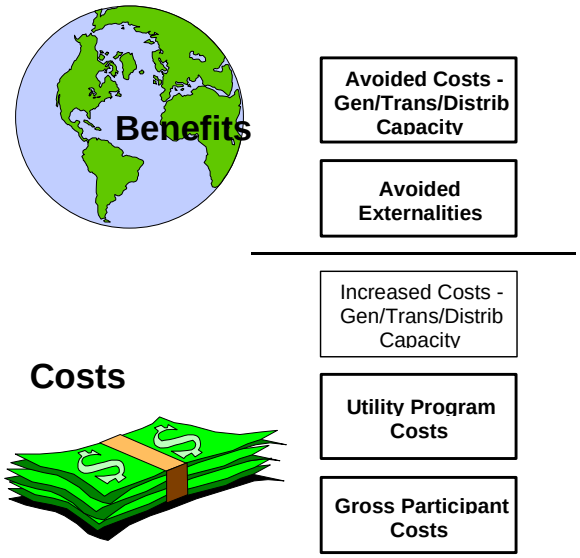

Table C-6 shows sample results of a benefit-cost analysis of commercial cooling incentives for a municipal utility. Although the analysis is hypothetical, it uses estimates of avoided costs (purchased power costs) and lost revenue from decreased sales from an actual analysis of these factors done by MMUA and its consultants for a particular municipal utility. Based on the data in Tables C-2 and C-4, the analysis assumed an incremental cost for the cooling equipment of $400 per kW of peak demand reduction at the customer, energy savings of 850 kWh per kW of demand reduction, and 6.4 kW of total summer demand reduction per kW of peak demand reduction. A coincidence-loss factor of 93% was assumed.

The revenue requirements test determines whether it is cheaper for the utility to purchase power or to achieve conservation through the cooling rebates. It is essentially the same as the test that would be used to compare two sources of supply. Every year, the utility will avoid the purchase of 850 kWh and of 6.5 kW of demand (per kW of customer peak demand reduction). Over the 15 year life of the cooling equipment, the net present value of the purchased power that the utility will not have to buy because of the cooling incentive is $1,120. It was assumed that the utility would pay half the incremental cost of the high efficiency equipment, or $200/kW, and that the administrative costs would be 10% of the incentive costs. There is a net benefit to the utility of $900/kW, or a benefit-cost ratio of 5.1. It is cheaper for the utility to buy conservation than to buy power.

The rate impact test measures the effect of the program on non-participant ratepayers. Even though a program passes the revenue requirements test, it can have a negative effect on ratepayers. The reason is that, though the utility's total costs have decreased, the revenues have also decreased. In this case, the utility avoids purchasing $1,120 of power, but it loses $1,223 in revenue. But the net loss of money from decreased sales, after subtracting the cost of the purchased power, is only $103. In addition, the utility pays the $200 incentive plus $20 administration cost, for a net loss of $324. While this loss is significant, it is much less than a utility might at first think in considering the revenue reduction alone. This utility buys a fixed block of low cost power and a then buys supplemental power at a higher cost. Their rates are set based on a blended price. In this particular case, the lost revenues would actually have been *lower* than the avoided costs except that their supplemental power provider uses a five year rolling average to determine demand charges, so that the beneficial effect of the reduction in demand is not immediately realized.

It is important to note that the actual magnitude of the rate increase from such a program is trivial. Suppose this utility has about 800 commercial customers, and that, with a 15 year life, about 50 customers per year replace their cooling equipment. If the average system size is 15 tons, for example, then the average peak demand reduction is 2.3 kW at the customer. If the utility were able to get all 50 customers to install high efficiency equipment, the total reduction would be 50*2.3 or 115 kW, and the total net present value of the rate impact over the entire life of the cooling equipment would be 115*$324 or $37,260. This includes the initial first year program cost of 115*220 or $25,300, so most of the cost is incurred in the first year. If the utility sells a total of 400,000,000 kWh per year, then the total rate impact of this program would be $37,260/400,000,000 or $0.00009315/kWh. This is the impact with the entire cost loaded onto the kWh sales in the first year, and is clearly not very large. In this situation, the utility

needs to weigh whether it is worth it to increase rates very slightly, to operate a program that can generate goodwill and possibly customer retention among its key customers.

The total resource test shows the cost-effectiveness to all ratepayers on average, including both program participants and non-participants. In this case, the cooling rebate has a net present value to all ratepayers of $700/kW, or a benefit/cost ratio of 2.7.

The societal test is similar to the total resource cost test but includes the environmental benefits of reduced energy generation. In this case, using the approved Minnesota values of environmental externalities, the net benefit to society is $801/kW or a benefit/cost ratio of 2.9.

The total resource cost and societal tests are particularly appropriate for municipal utilities to consider since they are owned by the public as a whole.

Table C-6. Sample Results of a Benefit-Cost Analysis of Commercial Cooling Rebates*

	Participant Test $/kW	Revenue Requirements (Utility) Test $/kW	Rate Impact Test $/kW	Total Resource Test, $/kW	Societal Test, $/kW
Avoided Utility Costs	NA	$1,120	$1,120	$1,120	$1,120
Avoided Environmental Externalities	NA	NA	NA	NA	$101
Incentive Plus Admin	NA	$220	$220	$220	$220
Revenue Reduction	$1,223	NA	$1,223	NA	NA
Net Participant Cost	$200	NA	NA	$200	$200
Total Benefits	$1,223	$1,120	$1,120	$1,120	$1,221
Total Costs	$200	$220	$1,443	$420	$420
Net Present Benefit	$1,023	$900	($324)	$700	$801
Benefit/Cost Ratio	6.1	5.1	0.8	2.7	2.9

*All results are expressed per kW of demand reduction during the summer peak at the customer.

In summary, in this example, the cooling rebate program is cost-effective to the participant, the utility, all ratepayers as a whole, and society as a whole. It imposes a very small net cost on non-participating ratepayers, reflected in a miniscule increase in the rates that would need to be charged to cover the utility's total costs. The utility must determine whether this cost is worthwhile in the interests of helping to build relationships with key customers. In the long run, the retention or loss of key customers will affect rates for everyone. On the other hand, even a tiny rate increase can be perceived negatively by the public when it shows up as a $25,000 line item on the utility's annual budget. These are trade-offs that each utility must consider in determining the suitability of a cooling rebate program for them.

APPENDIX D. THE COMMERCIAL COOLING EQUIPMENT PURCHASE PROCESS

In order to develop a successful incentive program, a utility needs to understand how a product gets to market. The organizations in the distribution channel, the decisions they make about what to stock and what to promote, when they fill their inventory, and the extent to which various players influence purchase decisions must be carefully considered in designing an incentive program, since they will have a major impact on the success of utility efforts. The information in this appendix was developed through interviews with the major manufacturers' representatives for unitary cooling equipment and PTACs/PTHPs.

Manufacturers' Representatives and Distributors

There are four types of manufacturer's representatives for commercial unitary and packaged terminal air conditioning equipment (Table D-1). The most important types on a sales-weighted basis are independent or manufacturer-owned distributors who also serve as manufacturer's representatives. The second most important type is the representative who is an employee of the manufacturer, and the third is the independent manufacturer's representative.

Table D-1. Types of Manufacturer's Representatives for Unitary and Packaged Terminal Equipment

Representative Type	Unitary			Packaged Terminal		
	Number	Pct	Sales-Weighted Pct [1]	Number	Pct	Sales-Weighted Pct [1]
Independent Mfgr. Rep./Distrib.	3	25%	28%	2	33%	42%
Mfr.-Employed Rep./Distrib.	1	8%	16%	0	0%	0%
Mfr.-Employed Rep.	6	50%	30%	2	33%	36%
Independent Mfgr. Rep.	2	17%	26%	2	33%	22%

Source: Survey of manufacturers' representatives
[1] Based on representatives estimates of local market shares for equipment in each category

The combined representative/distributors generally have territories that include either just Minnesota, or Minnesota and parts of a border state or states, whereas the manufacturer-employed and independent representatives tend to have larger service territories including all of several states. Contact information for unitary and packaged terminal equipment reps is given in Appendix F.

According to the manufacturers' representatives, unitary equipment is distributed to customers through independent distributors, manufacturer-owned distribution centers and independent non-stocking representatives (Table D-2). Of these, most sales are through independent distributors. Packaged terminal equipment is distributed through even more varied channels, but the top three in terms of sales are direct to the customer, through an independent non-stocking representative and through an independent distributor (Table D-2).

Table D-2. Distribution Channels

	Unitary Equipment		Packaged Terminal Equipment	
Distribution Method	**Pct**	**Sales-Weighted Pct [1]**	**Pct**	**Sales-Weighted Pct [1]**
Independent Distributor	76%	50%	15%	27%
Mfg. Owned Distribution Center	16%	25%	20%	14%
Stocking Representative	0%	0%	3%	2%
Independent, Non-Stocking Rep	8%	25%	40%	27%
Direct to End-User	0%	0%	22%	31%
Total:	100%	100%	100%	100%

Source: Survey of manufacturers' representatives
[1] Weighting is based on representatives' estimates of local market shares for equipment in each category
[2] Not applicable refers to cases in which the equipment is available with only one efficiency level.

Thus the players a utility needs to work with differ somewhat for different manufacturers. Manufacturer-specific details are provided in Table D-3 and D-4.

Table D-3. Unitary Equipment Manufacturers' Representative Types and Distributor Types

	Type of Manufacturers' Rep	Means of Distribution
Armstrong	independent distrib serves as rep	independent distrib
Bryant	independent distrib serves as rep	independent distrib
Carrier/Payne	independent distrib serves as rep	independent and manuf-owned distrib
Goodman	mfr-employed rep	independent and manuf-owned distrib
ICP	mfr-employed rep	independent distrib
Lennox	mfr.-employed rep/distrib	manuf-owned distrib
Nordyne	independent rep	independent distrib
Rheem	mfr-employed rep	independent distrib
Ruud	mfr-employed rep	independent distrib
Trane	independent rep	independent distrib and non-stocking rep
Weatherking	mfr-employed rep	independent distrib
York	mfr-employed rep	independent and manuf-owned distrib

Table D-4. Packaged Terminal Equipment Manufacturers' Representative Types and Distributor Types

	Type of Manufacturers' Rep	Means of Distribution
Amana	independent distrib serves as rep	independent distrib and direct
Carrier	rep employed by manuf	all five channels
Friedrich	independent rep	non-stocking rep
McQuay	independent distrib serves as rep	non-stocking rep (do not stock PTACs)
Trane	independent rep	non-stocking rep in this area, manuf-owned distrib on other parts of the country
Zoneline	rep employed by manuf	all five channels

Inventory Practices

For unitary equipment, the smallest sizes (5.4 ton or smaller) are generally sold from local inventory, while the larger sizes are usually ordered from manufacturers' stock (Table D-5). Most packaged terminal equipment is sold from manufacturers' inventory (Table D-6).

Table D-5. Unitary Equipment Sold from Local Inventory Versus Manufacturers' Stock

Size Category	Pct		Sales-Weighted Pct [1]	
	Local Inventory	Manufacturers' Stock	Local Inventory	Manufacturers' Stock
65,000 Btu/h (5.4 ton) or less	78%	22%	74%	26%
65,000 to 135,000 Btu/h (5.4-11.3 ton)	33%	67%	31%	69%
135,000 to 240,000 Btu/h (11.3-20 ton)	9%	91%	16%	84%
240,000 Btu/h (20 ton) or more	0%	100%	0%	100%
Overall Average:	30%	70%	30%	70%

Source: Survey of manufacturers' representatives
[1] Weighting is based on representatives estimates of regional market shares for equipment in each category

Table D-6. Packaged Terminal Equipment Sold from Local Inventory versus Manufacturers' Stock

Equipment Type	Pct		Sales-Weighted Pct [1]	
	Local	Manufacturer	Local	Manufacturer
PTAC	13%	88%	17%	83%
PTHP	10%	90%	17%	83%

Source: Survey of manufacturers' representatives
[1] Weighting is based on representatives' estimates of regional market shares for equipment in each category

Thus, for the small unitary equipment, whether local distributors choose to stock high efficiency equipment, and how quickly they can get it if they don't stock it, can have a major impact on the success of a utility incentive program. For replacements, which are typically made when equipment fails, the equipment that is most readily available is much more likely to be installed.

Fortunately, all of the companies contacted indicated that the rep/distributor does stock small split systems that meet the proposed qualifying criteria (see Table D-7) (split systems are the most common type of small equipment). On the other hand, few of the reps/distributors stock small high efficiency single package equipment, and none stock high efficiency equipment in sizes above 5.4 tons. Thus, although some equipment in the 5.4 to 20 ton size range is sold from local inventory, with current inventory practices that equipment will not be high efficiency equipment.

Table D-7. Does Manufacturers' Representative / Distributor Stock Equipment that Meets the Proposed Qualifying Criteria?

	Number			Pct			Sales-Weighted Pct [1]		
Size Category	**YES**	**NO**	**NA**	**YES**	**NO**	**NA**	**YES**	**NO**	NA
65,000 Btu/h split (5.4 ton) or less	12	0	0	100%	0%	0%	100%	0%	0%
65,000 Btu/h packaged (5.4 ton) or less	3	8	1	25%	67%	8%	22%	75%	2%
65,000 – 135,000 Btu/h (5.4-11.3 ton)	0	7	5%	0%	58%	42%	0%	86%	14%
135,000 – 240,000 Btu/h (11.3-20 ton)	0	5	7	0%	42%	58%	0%	83%	17%
240,000 Btu/h (20 ton) or more	0	5	7	0%	42%	58%	0%	100%	0%

Source: Survey of manufacturers' representatives
[1]Weighting is based on representatives' estimates of regional market shares for equipment in each size category
[2]Do not make high efficiency equipment in this size range, or does not make any equipment in this size range.

Only two manufacturers' reps indicated that PTACs and PTHPs meeting the proposed qualifying criteria are stocked locally (Table D-8). However, these two manufacturers represent almost 60% of area sales.

Table D-8. Does Manufacturers' Representative / Distributor Stock Equipment that Meets the Proposed Qualifying Criteria?

	Number			Pct			Sales-Weighted Pct[1]		
Equipment Type	YES	NO	NA[2]	YES	NO	NA	YES	NO	NA
PTAC Any Size	2	3	1	33%	50%	17%	57%	32%	11%
PTHP Any Size	2	2	2	33%	33%	33%	57%	14%	29%

Source: Survey of manufacturers' representatives
[1] Weighting is based on representatives' estimates of regional market shares for equipment in each category
[2]Do not make high efficiency equipment.

Table D-9 shows the extra days required to deliver unitary and packaged terminal air conditioning equipment from the factory rather than from local inventory. For unitary equipment the average delay is 21 days (20 days sales weighted average), and for packaged terminal equipment the average delay is 18 days (12 days sales weighted average), although the maximum delay can be substantially longer. When equipment is needed immediately, time delays on this order will lead to use of whatever equipment is available locally.

Table D-9. Number of Days it Required to Deliver Equipment from Factory versus Local Inventory

Category	Unitary Equipment	Packaged Terminal Equipment
Minimum Days Reported	2 days	2 days
Maximum Days Reported	90 days	70 days
Average Days Reported	21 days	18 days
Sales-Weighted Average [1]	20 days	12 days

Source: Survey of Manufacturers' Representatives
[1] Weighting is based on representatives' estimates of local market shares for equipment in each category

For some products, distributors tend to concentrate their inventory orders in a few months of the year. A utility wanting to start an incentive program needs to be aware of these ordering patterns, so that it does not begin a program right after a distributor has stocked up with equipment that does not qualify. In the markets addressed here, few manufacturers' representatives were able to readily identify a few months in which most orders were placed, with most of the representatives indicating that demand for commercial equipment of this type, especially packaged terminal equipment, has become more year-round. In addition, those representatives who identified specific months didn't always agree on which months were the most active in terms of orders (Table D-10). Slightly more orders may be placed in April, May and June for unitary equipment, and in April, May and October for packaged terminal equipment but these patterns are not pronounced.

Table D-10. Months in Which Most Orders are Placed

	Responses			
	Unitary Equipment		Packaged Terminal Equipment	
Month	Number	% of Sample [1]	Number	% of Sample [1]
January	1	8%	0	0%
February	2	17%	0	0%
March	3	25%	1	17%
April	5	42%	2	33%
May	7	58%	3	50%
June	5	42%	1	17%
July	3	25%	1	17%
August	3	25%	1	17%
September	3	25%	1	17%
October	3	25%	2	33%
November	1	8%	1	17%
December	0	0%	0	0%

Source: Survey of manufacturers' representatives
[1] Percent of survey respondents giving this answer. Sample size for unitary equipment equals 12, for packaged equals 6.

Representatives were also asked what percent of total yearly orders were placed in each of the three key months they identified. A number of representatives were unable to give this information but those who did generally said that each key month accounted for 12% to 20% of all yearly orders. Thus, coordinating program kick-off with distributors' ordering patterns is not

as critical for commercial cooling equipment as for some other products, but neither should it be completely ignored.

Manufacturers' representatives degree of influence on what is stocked locally depends on the type of representative they are (Table D-11). For example, 33% of unitary representatives (accounting for 44% of sales) are both the representative and the distributor. In this case, the representative obviously has complete control over what is stocked. Among unitary manufacturers' representatives who work with distributors as a customer, 25% said they did not have much influence over what is stocked and 33% thought they had some influence. None thought they had a lot of influence over what distributors stocked. Finally, one unitary representative (8%) indicated that the manufacturer did not work through distributors for commercial equipment, so the question was not applicable. Thus, in seeking to influence what unitary equipment is stocked locally, utilities must focus on the rep/distributor when this role is combined, but probably should focus on the distributor in the more common case when this role is separate from the rep. Only a small proportion of packaged terminal equipment is sold from local inventory, so utilities probably do not need to be terribly concerned about the efficiency of equipment that is stocked.

Table D-11. Manufacturers' Representatives Influence on what is Stocked Locally

Unitary Equipment How Much Influence?	**Number**	**Pct**	**Sales-Weighted Pct [1]**
Not Much Influence	3	25%	21%
Some Influence	4	33%	10%
A lot of Influence	0	0%	0%
Complete Influence (rep is also distributor)	4	33%	44%
Not Applicable (manuf ??) does not work through distributors	1	8%	25%
Total:	12	100%	100%

Source: Survey of manufacturers' representatives
[1] Based on representatives estimates of local market shares for equipment in each category.

Profitability of Standard and High-Efficiency Products to Distributors

If a standard product is more profitable to distributors, whether because of a higher mark-up, faster turnover, lower amount of support required, or other reason, it can be difficult to get distributors to stock the higher-efficiency equipment. Fortunately, that does not appear to be the case in this market.

Representatives of unitary equipment split half-and-half in saying that high efficiency equipment is more profitable or as profitable as minimum efficiency equipment (Table D-12). For packaged terminal equipment, this question was only applicable for one of the representatives surveyed since only one manufacturer makes more than one efficiency level in the same size. That one representative thought the profit was the same for both. No representative in either market saw the high efficiency equipment as less profitable.

Table D-12. Profitability of Commercial AC Equipment by Efficiency Level

Unitary Equipment **Which is Most Profitable?**	**Number**	**% Average**	**% Sales [1]**
Minimum Efficient	0	0	0%
High Efficient	6	50%	43%
Profit is the Same	6	50%	57%
Not Applicable [3]	0	0%	0%
Total:	12	100%	100%
Packaged Terminal Equipment **Which is Most Profitable?**	**Number**	**% Average**	**% Sales [1]**
Minimum Efficient	0	0%	0%
High Efficient	0	0%	0%
Profit is the Same	1	17%	10%
Not Applicable [3]	5	83%	90%
Total:	6	100%	100%

Source: Survey of manufacturers' representatives
[1] Based on representatives estimates of local market shares for equipment in each category.
[2] Not applicable refers to cases in which the equipment is available with only one efficiency level.

Players in the Purchase Decision

For unitary equipment the architecture and engineering (A&E) firm is the key decision-maker for about a third of sales, the contractor for about a third, and the building owner for about a third (Table D-13). One representative noted that who the decision-maker is depends on the market segment. He indicated that for the plan and specification segment, which is mostly new construction, the A&E is almost always the key decision-maker. For the design-build market (i.e. cases in which the end-user has asked a contractor to design and build/install a job for a new or retrofit project), the building owner is the key decision-maker about half of the time and the contractor the other half.

For packaged terminal equipment the building owner is the decision-maker for nearly half of sales, the contractor for over a third of sales, and the A&E firm for about 1/5 of sales (Table D-13).

Thus a utility interested in promoting high efficiency cooling equipment needs to market to owners, contractors and A&E firms.

Table D-13. Key Decision-Maker for Unitary and Packaged Terminal Equipment

Decision Maker	Unitary		Packaged Terminal	
	Pct	Sales-Weighted Pct [1]	Pct	Sales-Weighted Pct [1]
A&E Firm	31%	34%	28%	18%
Contractor	45%	34%	20%	36%
Building Owner	24%	30%	53%	47%
Other	1%	2%	0%	0%
Total:	100%	100%	100%	100%

Source: Survey of manufacturers' representatives
[1] Based on representatives estimates of local market shares for equipment in each category

Manufacturers' representatives of unitary equipment reported that they helped the customer to select equipment in only about 26% of sales, while the representatives of packaged terminal equipment said they assisted in 51% of sales (Table D-14). One unitary representative commented that how much the representative gets involved depends on who the decision-maker is. In cases where the contractor is the key decision-maker the representative gets involved more often (perhaps as much as 40% of the time). Alternatively, when the decision-maker is the building owner the representative might only be involved 10% of the time, and when it is an A&E firm the rep is almost never involved.

Table D-14. Percent of Sales in which Manufacturers' Representative has Influence

Equipment Type	Average	% Sales [1]
Unitary Equipment	14%	26%
Packaged Terminal Equipment	52%	51%

Source: Survey of manufacturers' representatives
[1] Based on representatives estimates of local market shares for equipment in each category

Even when they do help select the equipment, many representatives for unitary equipment believe that they have no or not much influence on the efficiency of the unit purchased. However, the representatives who account for the largest proportion of sales (over 60%) believe they have some influence on the efficiency level chosen. Similarly, 50% of the representatives for packaged terminal equipment (accounting for 33% of the sales) believed they had no or not much influence, while the other 50% thought they had some or a lot of influence (accounting for close to 70% of sales) (Table D-15). Distributors were not interviewed, so their level of influence on purchase decisions could not be assessed.

Table D-15. Manufacturers' Representatives' Influence on Efficiency of Unit Purchased

Degree of Influence	Unitary			Packaged Terminal		
	Number	Pct	Sales-Weighted Pct [1]	Number	Pct	Sales-Weighted Pct [1]
No Influence	3	25%	19%	1	17%	10%
Not Much Influence	4	33%	17%	2	33%	23%
Some Influence	4	33%	62%	2	33%	27%
A lot of Influence	1	8%	1%	1	17%	41%

Source: Survey of manufacturers' representatives
[1] Based on representatives estimates of local market shares for equipment in each category

Importance of Energy Efficiency in the Purchase Decision

Manufacturers' reps indicated that energy efficiency is most often a secondary factor in the selection of unitary equipment for A&E firms and contractors, and not a factor for owners (Table D-16). For packaged terminal units, representatives indicated that energy efficiency is most often a secondary factor for all three decision-makers. One unitary representative went on to say that there are two types of contractors in this market: the design/build contractor and the design/build specification and build contractor. In his experience, the design/build contractor (about 25% of the market) is more likely to put in better equipment and to be concerned about efficiency, because he receives the plan from the owner (usually in a situation where there is little or no competition), and then designs the HVAC system for the building. In this situation, the owner and contractor have a long-standing relationship where there is a lot of trust and the owner simply installs whatever the contractor recommends. As a result, the design contractor is more likely to keep up on what is efficient and what is going to save the owner money in the long run. This contractor is most interested in doing a good job for the owner because that is what keeps the owner coming back. By contrast the specification and build contractor is simply responding to a request for bids, and price competition is the driving force in his recommendations.

Table D-16. Importance of Efficiency to Various Decision-Makers in Selecting Equipment

Unitary Equipment									
	Number			**Pct**			**Sales-Weighted Pct [1]**		
How Important?	A&E	Cont.	Own.	A&E	Cont.	Own.	A&E	Cont.	Own.
Not a Factor	3	1	4	25%	8%	33%	34%	2%	62%
Secondary Factor	8	5	4	67%	42%	33%	60%	61%	20%
Primary Factor	1	5	1	8%	42%	8%	6%	21%	6%
Not Applicable [2]	0	1	3	0%	8%	25%	0%	16%	12%
Total:	12	12	12	100%	100%	100%	100%	100%	100%
Packaged Terminal Equipment									
	Number			**Pct**			**Sales-Weighted Pct [1]**		
Equipment Type	A&E	Cont.	Own.	A&E	Cont.	Own.	A&E	Cont.	Own.
Not a Factor	1	0	2	17%	0%	33%	9%	0%	26%
Secondary Factor	3	1	3	50%	17%	50%	36%	41%	60%
Primary Factor	1	2	1	17%	33%	17%	13%	26%	13%
Not Applicable [2]	1	3	0	17%	50%	0%	41%	33%	0%
Total:	6	6	6	100%	100%	100%	100%	100%	100%

Source: Survey of manufacturers' representatives
[1] Weighting is based on representatives' estimates of local market shares for equipment in each category
[2] Not Applicable because some interviewees said one or another of these were never the key decision-maker.

Promotion of Standard and High Efficiency Equipment

For unitary equipment, only 17% of the representatives (representing 9% of sales) reported promoted high efficiency equipment more than minimum efficiency equipment in the preceding 12 months. Forty-two percent (representing 48% of sales) said they promoted minimum efficiency equipment more than high efficiency equipment, and another 42% (representing 43% of sales) said they promoted them equally. For packaged terminal equipment, this question was only applicable for the one manufacturer (McQuay) who makes both minimum and high efficiency options, and the representative for this company said that he promoted the two types of equipment equally (Table D-17).

Table D-17. Efficiency Level Promoted Most by Manufacturers' Representatives

Equipment	**Unitary**			**Packaged Terminal**		
Promoted Most	**Number**	**Percent**	**% Sales [1]**	**Number**	**Percent**	**% Sales [1]**
Minimum Efficiency	5	42%	48%	0	0%	0%
High Efficiency	2	17%	9%	0	0%	0%
Promoted Same	5	42%	43%	1	17%	10%
Not Applicable [2]	0	0%	0%	5	83%	90%

Source: Survey of manufacturers' representatives
[1] Based on representatives estimates of local market shares for equipment in each category
[2] Not applicable because manufacturer only makes one option.

APPENDIX E. MARKET BARRIERS IDENTIFIED AND MARKET STRATEGIES RECOMMENDED BY MANUFACTURERS' REPRESENTATIVES

Barriers to Increased Use of High Efficiency Equipment

Manufacturers' reps were asked an open-ended question regarding what barriers they see to increasing the use of high efficiency air conditioners relative to minimum efficiency equipment in the commercial market. First cost was the barrier most frequently mentioned by representatives of both types of equipment. Lack of familiarity with high efficiency options on the part of building owners and of contractors and A&E firms were two other barriers mentioned by both (Table E-1). Representatives were also asked which of the barriers they had mentioned was the most important. Most manufacturers' representatives identified first cost, with lack of familiarity also being mentioned by a few (Table E-2).

Fortunately, both first cost and familiarity are barriers that can be directly and easily addressed by utility incentive programs. Other types of barriers such as poor reliability, which has been a concern in the past for such high efficiency products as condensing furnaces and electronic ballasts, or availability of a high efficiency product from only one vendor, can be much more problematic for utility programs to overcome. Fortunately, barriers of this sort were not identified in these markets.

Table E-1. Barriers to Increased Use of High Efficiency Equipment

	Responses			
	Unitary Equipment		Packaged Terminal Equipment	
Month	**Number**	**% of Sample [1]**	**Number**	**% of Sample [1]**
First Cost	12	100%	5	83%
Lack of Familiarity of Owners with High Efficiency Equipment	6	50%	1	17%
Lack of Familiarity of A&E and Contractors with High Efficiency Equipment	4	33%	1	17%
Status Quo	2	17%	0	0%
Service Problems	1	8%	0	0%
Low Rebates	1	8%	0	0%
Long Paybacks	1	8%	0	0%
Limited Cooling Hours in MN	1	8%	0	0%
Lack of Good Applications in MN	1	8%	0	0%
Limited Equipment Options	0	0%	1	17%
Competitive Bidding Process	0	0%	1	17%
Noise Associated w/ Higher EER Units	0	0%	1	17%

Source: Survey of manufacturers' representatives

[1] Percent of survey respondents giving this answer. Sample size for unitary equipment equals 12, for packaged equals 6.

Table E-2. Most Important Barrier to Increased Use of High Efficiency Equipment

Month	Responses: Unitary Equipment Number	Unitary Equipment % of Sample [1]	Packaged Terminal Equipment Number	Packaged Terminal Equipment % of Sample [1]
First Cost	10	83%	4	67%
Unfamiliarity of A&E and Contractors	1	8%	1	17%
Unfamiliarity of Owners	1	8%	0	0%
Limited Equipment Options	0	0%	1	17%
Total:				

Source: Survey of manufacturers' representatives
[1] Percent of survey respondents giving this answer. Sample size for unitary equipment equals 12, for packaged equals 6.

Market Strategies Recommended by Manufacturers' Representatives

Manufacturers' representatives for unitary, PTAC and PTHP equipment were asked an open-ended question regarding any advice they might have for municipal utilities developing incentive programs for that type of equipment. Almost all of the representatives expressed positive attitudes about such programs and a number pointed out that utilities are in a good position to promote efficient equipment because of the long-term relationship they have with customers as opposed to the one-time relationship manufacturers and distributors have.

Representatives suggested that utilities take the actions listed below. The reps' suggestions should not be accepted without question, but many are indeed good recommendations.

- Provide **more and better education to end-users** regarding high efficiency equipment options and the benefits associated with such equipment.

  Representatives said that it was important to educate the building owners so that they understand the long-term benefits of high efficiency equipment, and can use that understanding to help overcome the obstacle of first cost. One specific suggestion was for the utility to offer a cost analysis program that contractors could use to show building owners/operators in concrete terms how much money they will save, allowing owners to equitably compare options.

  One PTAC/PTHP representative believed it would be beneficial to educate building owners regarding the benefits of replacing older, working PTACs with high efficiency PTHP units.

- Provide **more and better education to contractors** (and other trade allies) regarding high efficiency equipment options and the benefits associated with such equipment.

  While educating building owners is important, most of the representatives believe it is even more important to target contractors and other trade allies with educational efforts. Representatives stressed that the contractor will install whatever equipment he/she feels comfortable with regardless of the efficiency, and that the building owner will put his/her trust in the contractor. In addition contractors must warranty the products, so they must be

convinced that high efficiency models are worthwhile and trouble-free. In particular, a couple of PTAC/PTHP representatives noted that there is a lot of misinformation about air-source heat pumps (e.g. the fear that they blow cold air all the time) which will require education to counter.

- **Target contractors with rebates or incentives** to make it worth their while to promote high efficiency equipment to their customers.

  Contractors are in the best position to influence what the end-user purchases by either promoting or discrediting particular equipment. As a result, many representatives believed that directing rebates or incentives to this particular trade ally group is especially important.

  Contractors often end up filling out the paperwork to apply for rebates, since they have the necessary information on size, model numbers, etc., and an incentive helps to cover their real costs of doing this.

- Make the **incentive large enough** (monetary or otherwise).

  A number of representatives noted that some utility programs have offered only token incentives which were not large enough to motivate contractors to promote or end-users to purchase higher efficiency options. They stressed that this market is mainly first-cost driven and incentives need to be large enough to offset the incremental cost of more efficient equipment. A number of representatives also noted that this might become increasingly important in future years if deregulation drives energy prices down, giving end-users even less incentive to purchase high efficiency equipment (In actuality the effect of deregulation on the cost of cooling commercial buildings might depend on relative changes in the cost of energy and demand).

- Consider **other incentives** to customers (e.g. no-cost financing, better utility rates) in addition to or instead of rebates.

  A number of representatives mentioned this option. One representative gave a specific example of an Iowa utility that offered a financing package for high efficiency equipment in which the end-user did not have to pay any interest for 12 months. In his experience, this particular program drove the sales of high efficiency units more than anything else he had seen. (Experience with utility programs in general suggests that customers generally view rebates more positively than financing alone, but that financing can complement rebates).

- Keep the program **long enough to actually effect a permanent change** in the market.

  One representative gave an example of a rebate program in Iowa that was working so well that a larger number of high efficiency units were being sold in Iowa than in Kansas or Missouri, even though Iowa has fewer cooling hours. However, the program was short-term and as soon as the rebates were discontinued, sales of high efficiency units in Iowa began to slide back to what he considered a “normal” profile.

- **Promote equipment that is available** from more than one manufacturer.

  Representatives voiced concerns over a program that restricts trade or is unduly exclusive. Specifically, they did not want to see a program that required an EER and/or COP that was so high only one or two manufacturers could participate. At the same time, they also emphasized the need to set the level high enough that the low end of the market (in terms of efficiency) doesn't qualify.

  One suggestion was to set up incentives so that the customer receives a baseline amount for a certain minimum efficiency. Then, offer an additional dollar amount per unit increase in SEERs/EERs/COPs that the customer purchases above that minimum. That way, all equipment except that with the very lowest efficiencies can be included in the program, but customers would receive the biggest incentive for the most efficient equipment. Another suggestion was to require different minimum efficiency levels for different equipment sizes. That way incentives can be geared more specifically to the high efficiency options actually available in each size category, potentially allowing more manufacturers to participate. The representatives felt it was particularly important that equipment in popular sizes (e.g. PTAC/PTHP equipment with inputs of 9,000 Btu/h and 12,000 Btu/h) have some units that are eligible for incentives. Otherwise customers get frustrated when they hear about an incentive program but can't find an eligible unit in the size they need.

- Design a program that is **convenient to use**, especially for the trade allies who are expected to promote the qualifying equipment.

  Representatives expressed the importance of developing a program that is easy to understand and use by everyone involved. In particular, since the contractor is usually the one who is ends up completing the bulk of the paperwork on incentive programs, it is vital that the contractor understands how to complete the paperwork and that it doesn't take a lot of time.

  The representatives noted that even though it's an end-user program, a contractor can undermine a program like this in a hurry by not participating. According to these representatives, the dealer base is not that sophisticated and a lot of contractors simply won't bother unless the program is well-explained, the incentive large enough and the process of getting the incentive simple enough. One representative even went so far as to say that contractors often use utility incentive programs as the hook to get in the door with the customer, but once they are in the door, high efficiency equipment is not what typically gets sold. Ideally a program would not only be easy for contractors, but would also motivate them to promote high efficiency equipment (and contractor incentives can help here).

  It is important to consider other trade allies in setting up and delivering a program. The program should be timed so that the distributors have the lead-time they need to stock the equipment, and changes to the program should be timed so that they come out in between seasons rather than in the middle of a season.

- **Offer incentives on a per ton or per Btu basis** (i.e. so many dollars per ton or per Btu) as this would be fairly consistent with equipment costs.

  Representatives noted that programs that offer a simple flat incentive don't take into account the fact that incremental costs tend to go up as equipment costs increase as a result of increasing size.

- Consider offering **additional incentives for related components** a customer could purchase at the same time or else require these items when applicable in order to qualify for the incentive.

  Several representatives felt that the installation of equipment (particularly in new construction) was a one-time opportunity to make the air conditioning "system" as efficient as possible and that the opportunity should be fully exploited. Examples of items mentioned by one or more representative for possible additional incentives included economizers, setback thermostats, and heat recovery units. (These recommendations would require further examination, since the Minnesota Energy Code already requires economizers for units of 134,000 Btu/h or more or 5,000 cfm or more (Mn Rules 7670.0610 Subp. 13) and since the cost-effectiveness of heat recovery varies for different building types and sizes.)

- Make incentive **programs as consistent as possible statewide and nationally**.

  This recommendation was particularly important to those representatives who had larger service territories and/or sold directly to the end-user. (This is one of the advantages of using the Consortium for Energy Efficiency qualifying criteria and/or the new ASHRAE 90.1 criteria for 9/1/2001 where possible).

- Design a program that provides **incentives for both the new and replacement** markets.

- Offer a **larger rebate for PTHP than for PTACs** since it provides a larger efficiency gain (relative to a PTAC with electric heat).

- In a PTAC/PTHP program, consider offering **rebates for appropriate sizing of the electric resistance heater** that provides the main or back-up heat.

  One PTAC/PTHP representative said that owners who purchase PTACs/PTHPs for motel units (the most common application) often purchase one size electric resistance heater for all the units since it is less expensive if you don't have to switch amperage and circuit breaker size to accommodate a variety of sizes. However, different units in the building typically need larger or smaller heaters (due to orientation on the site, solar gain, internal gains, and other factors). When only one size is used, it most often results in larger heaters than are needed in many of the units. A rebate program which covered the extra costs of switching amperage and circuit breaker sizes could result in considerable energy savings. This representative sited an example of a Nebraska utility (around North Platte) which actually did this and was very pleased with the results. (The merits of this recommendation have not been evaluated).

Additional comments included one representative who believes incentive programs for commercial equipment are a waste of time in Minnesota and that utilities should just focus on residential programs, and another representative who didn't really care what utilities do since he doesn't feel his company benefits in any way from incentive programs of this type.

APPENDIX F. CONTACT INFORMATION FOR MINNESOTA MANUFACTURERS' REPRESENTATIVES

Unitary Equipment

Manufacturer	Representative	Territory
Aaon Inc. Tulsa OK 918-583-2266 **Aaon**	Swaab-Volhaber Lubratt St. Paul, MN Dean Carpenter 651-481-8000	not available
Carrier Indianapolis, IN 317-240-5673 (Denise)		
Carrier, Payne	Minnesota Air St. Louis Park Bruce Wilen 1-800-383-1981 or 612-884-1981	MN, E-SD, W-WI
Bryant	Auer Steel Brooklyn Park, MN 331-9412	MN, E-ND, W-WI
Day & Night	Brand discontinued	
Goodman Manufacturing Houston, TX 713-861-2500 Customer Service - Press 1		
Goodman, GMC (distributor)	JH Larson Electric St. Paul Phil Dockendorff 651-774-6581	not available
(distributor)	JH Larson Electric Fairmont, MN 507-235-5549	not available
Janitro (distributor)l	Environmental Distributors Roseville, MN Don Malloy, Manager 651-631-3662	not available
Goodman, GMC, Janitrol	Midwest Regional Sales Manager Ken Creech (Lenexa, KS) car: 816-560-2922 page: 785-887-9005 home: 913-599-1861	Middle US, incl MN
Mobiletemp	Brand only for Mfrd Housing	

Manufacturer	Representative	Territory
International Comfort Products Lavergne, TN 615-771-0200 – extension 4128 Sales & Marketing Div: 931-270-4128 – Joann Martin *Airquest, Arcoaire, Comfortmaker, Heil, ICP, Marathan, Tempstar*	ICP Sales Rep JT Holschlage 931-270-4118	Entire US
Lennox Industries Dallas, TX 972-497-5000 – Laura Moore *Lennox*	Lennox District Office Minneapolis, MN Steve Simms 612-456-5499, extension 232	Most of MN
Armstrong	Excelsior Mfgr. & Supply. Excelsior, MN Kevin Dauenbaugh 612-553-1722	MN
Nordyne St. Louis, MO 314-878-6200 *Intertherm, Miller, Nordyne*	Sales Engineers Eden Prairie, MN Mike Dugan 612-944-0773	MN, ND, SD, W-WI
Rheem Manufacturring Fort Smith, AZ 501-648-4755 *Rheem*	Internal Sales Representatives one for each brand name: Jeff Miller voice mail: 501-648-4181 #2142 office: 402-345-8540	MN, ND, SD, NE, IA, E-MO
Ruud	Mike Scharff voice mail: 501-648-4181 #2130	MN, ND, SD, IA
Weatherking	Joe Brandt voice mail: 501-648-4181 #2175 office: 314-467-5811	MN, ND, SD, IA, NE, KS, MO
Trane Company Tyler, TX 903-581-3523 (Tim Storm) *Trane*	Kramer-Trane Minneapolis, MN Craig Drugge 612-798-3099	MN, NW-WI
American Standard	Brand not sold in this area	

Manufacturer	Representative	Territory
York International York, PA 717-845-1447 717-771-7890 Unitary Products Group 1-877-874-7378, #2 Cust. Serv. *Coleman Evcon, Fraser & Johnston, Luxaire, York*	Dave Fegley Des Moines, Iowa 515-288-2284 office 515-288-2274 home	MN, ND, SD, WI, IA, NE, E-IL
Airpro, Guardian	Brand to be discontinued by 2000	
Moncrief	Brand discontinued	

PTACs and PTHPs

Manufacturer	Representative	Rep Type	Territory
Amana Refrigeration, Inc. Amana, IA 319-622-2702 *Amana*	Stevens Inc. Eagan, MN Shelly Megard 1-800-482-6262 651-452-0872	3	MN, ND, SD, IA, WI, IL
Carrier Indianapolis, IN 317-240-5673 (Denise) *Carrier* **Climate Master, Inc.** **(subsidiary of LSB)** Oklahoma City, OK 405-745-6000 **Climate Master**	Direct Sales Item 1-800-827-7435 Pam Strauss, Carol Ferrese RJ Falk Co Crystal, MN Tom Perry 612-537-4615	 ?	Entire US not available
Friedrich Air Conditioning San Antonio, TX 210-357-4400 *Friedrich*	SS Products Inc. Brooklyn Park, MN Greg Szalchtowski 612-537-8007	2	MN, ND, SD, W-WI
General Electric Company Fairfield, Conneticut GE Info Services: 203-254-5400 GE Corp. Headquarters: 1-203-373-2211 Major Appliances Louisville, KT 502-452-4311 – Bob Davney *Zoneline*	Contract Sales Minneapolis, MN Laura Fite MN Rep 612-449-5795 GE Appliance Midwest Regional Rep Tom Kunz 630-810-4214	2 1	Entire Midwest
McQuay International Minneapolis, MN 612-553-5009 *AAF, Incremental, Incremental Remington, McQuay*	Swabb-Vollhaber-Lubratt Inc St. Paul, MN Rick Benson 651-481-8000	3	MN, ND, W-WI
Trane	see unitary list		

APPENDIX G. GLOSSARY

General

Air cooled air conditioner: an air conditioner which rejects heat to air flowing over the condensing surfaces

Chiller or water-chilling package: a complete refrigeration system used to produce chilled water which is then used to cool spaces within buildings.

* Reciprocating chiller: a chiller using a reciprocating compressor to compress the refrigerant
* Screw chiller: a chiller using a rotary compressor consisting of two intermeshed helical rotors to compress the refrigerant.
* Scroll chiller: a chiller using a scroll compressor consisting of one orbiting and one stationary scroll to compress the refrigerant.
* Centrifugal chiller: a chiller using centrifugal force to compress the refrigerant

Condensing unit: a machine designed to condense refrigerant vapor to a liquid, and including one or more motor driven compressors, condensers and accessories.

EER: energy efficiency ratio. Btu/h output divided by Watts input.

Evaporatively cooled air conditioner: an air conditioner which rejects heat by evaporation of water from the exterior of the condensing surface and by transfer of sensible heat to the air.

Heat pump: A device that extracts heat from the environment or other medium-temperature source and delivers it to a space to be heated. A heat pump may provide heating only, or may be designed to reverse flow and provide heating and cooling.

* Air source: A heat pump which extracts heat from the outside air to warm a conditioned space.
* Water source: A heat pump which extracts heat from water to warm a conditioned space.
* Ground source or groundwater source: A heat pump which extracts heat from the ground or from groundwater.
*

IPLV: a figure of merit for the part-load efficiency of commercial cooling equipment. The equipment is rated at each step of capacity reduction, and these rating points are used to calculate a weighted average efficiency.

Packaged terminal air-conditioner (PTAC): self-contained air conditioning system for through-the-wall installation. A PTAC has a wall sleeve and a separate unencased cooling/heating assembly. Cooling is provided by a refrigeration system within the unit, and heating, if present, may be provided by a hot water or steam coil or by electric resistance heat.

Package terminal heat pump (PTHP): self-contained heat pump for through-the-wall installation. A PTHP has a wall sleeve and a separate unencased heating/cooling assembly. Heating is provided primarily by reverse-cycle refrigeration, with supplementary heat provided

by a hot water or steam coil or by electric resistance. Cooling, if provided, is provided by normal operation of the refrigeration system within the unit.

SEER: seasonal energy efficiency ratio. The total cooling of a central air-conditioner in Btu's during the cooling season, divided by the total electric energy input in watt-hours during the same period.

Single package air-conditioner: A unitary air conditioner with the compressor, condenser, evaporator, and evaporator fan in a single assembly or enclosure.

Split system air-conditioner: A unitary air conditioner with the compressor, condenser, evaporator, and evaporator fan housed in more than one assembly or enclosure (Usually the evaporator is on one assembly and the condenser in another. The compressor is more often with the condenser, and the unit as sold may or may not include an evaporator fan).

Ton: 12,000 Btu/h of cooling capacity.

Unitary air conditioner: one or more factory-made assemblies which normally include an evaporator (cooling coil), compressor and condenser to provide cooling, and may include means to provide heating.

Water cooled air conditioner: an air conditioner which rejects heat to water flowing over the condensing surfaces

Year-round air-conditioner: A unitary air conditioner similar to a single package air conditioner but also including heating.

Definitions Used in CBECS Survey (Source of Data in Figure A-1)

Central Chiller: A type of cooling equipment that is centrally located and that produces chilled water in order to cool air. The chilled water or cold air is then distributed throughout the building by use of pipes or air ducts, or both. These systems are also commonly known as "chillers," "centrifugal chillers," "reciprocating chillers" or "absorption chillers." Chillers are generally located in, or just outside, the building they serve. Chillers located at central plants are included under District Chilled Water.

District Chilled Water: Water chilled outside of the building in a central plant and piped into the building as an energy source for cooling. Chilled water may be purchased from a utility or provided by a central physical plant in a separate building that is part of the same multibuilding facility (for example, a hospital complex or university).

Heat Pump: A type of heating and/or cooling equipment that draws heat into a building from outside and, during the cooling season, ejects heat from the building to the outside. Heat pumps are vapor-compression refrigeration systems whose indoor-outdoor coils are used reversibly as condensers or evaporators, depending on the need for heating or cooling.

Individual Air Conditioner: A type of cooling equipment installed in either walls or windows (with heat-radiating condensers exposed to the outdoor air). These self-contained units are characterized by a lack of pipes or duct work for distributing the cool air; the units condition only air in the room or areas where they are located.

Packaged Unit: A type of heating and/or cooling equipment that is assembled at a factory and installed as a self-contained unit. Packaged units are in contrast to engineer-specified units built up from individual components for use in a given building. Some type of electric packaged units are also called "Direct Expansion," or DX, units.

Residential-Type Central Air Conditioner: A type of cooling equipment in which there are four basic parts: (1) a condensing unit, (2) a cooling coil, (3) ductwork, and (4) a control mechanism, such as a thermostat. There are two basic configurations of residential central systems: (1) a "split system," where the condensing unit is located outside and the other components are inside, and (2) a packaged-terminal air-conditioning (PTAC) unit that both heats and cools or cools only. This system contains all four components encased in one unit and is usually found in a "utility closet." If the residential type is a "PTAC," it is considered a "Packaged air-conditioning unit.

Swamp Cooler: A type of cooling equipment that turns air into moist, cool air by saturating the air with water vapor. It does not cool air by use of a refrigeration unit. This type of equipment is commonly used in warm, dry climates.

SOURCES OF INFORMATION FOR THIS GUIDE

Information was gathered from a variety of published sources, as indicated. In addition, information on the regional market was obtained from interviews with manufacturers' representatives. Thirteen representatives of manufacturers of commercial unitary air conditioning equipment were selected to be interviewed. Ten were chosen because they represent the brands made by all of the major manufacturers of equipment under 65,000 Btu/h (since this was the size range for which market share data were available), accounting for virtually 100% of the market in that size range. These representatives and the corresponding manufacturers were expected to account for the great majority of sales in the larger equipment as well. Representatives of the three other manufacturers who make ARI-certified high-efficiency equipment in sizes over 65,000 Btu/h were added, bringing the total sample to thirteen. Representatives of seven manufacturers of commercial packaged terminal air conditioning equipment were selected. These included all of the ARI-certified manufacturers of packaged terminal equipment. In all but one case, these reps served all of Minnesota (and usually part or all of several other states as well) The one exception served most of Minnesota. Twelve of the unitary representative interviews (92% of the sample) and six of the packaged terminal representative interviews (86% of the sample) were successfully completed. Finally, hourly simulation data were assembled to estimate the energy savings from various increases in efficiency.

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