CHILLER HEAT RECOVERY APPLICATION GUIDE

This publication was prepared under ASHRAE Research Project 892 by Dorgan Associates, Inc., Madison, Wisconsin. It was sponsored by TC 9.4, Applied Heat Pump/Heat Recovery Systems.

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American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc.

ISBN 1-883413-74-5

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and Air-Conditioning Engineers, Inc.
1791 Tullie Circle N.E.
Atlanta, Georgia 30329
www.ashrae.org

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Printed in the United States of America

Cover illustration by Julie Stephan

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Acknowledgments

This guide was developed through a cooperative effort of Dorgan Associates, Inc., chiller manufacturers, building owners, and building O&M personnel. The input of the ASHRAE Project Monitoring Subcommittee, chaired by Frank Pucciano (Southern Company), with members Richard Niess (Gilbert & Assoc.), Ellen Trick (Trane Co.), Jerry Beihn, and Ron Brown, was instrumental in achieving a successful guide. Special thanks to John Murphy from Trane for providing detailed equipment performance, application, and cost information and to Jim Elleson for his detailed review and input.

Dorgan Associates' staff members who deserve recognition for their contributions include Joy Altwies, Zachary Obert, Nathaniel Blaz, Kathryn Reif, and Paul Reimer for their assistance throughout the project. Thanks also to Joan Dorgan for assisting in final proofreading of the guide and to Suzanne Bowen for her endless support in material preparation and word processing.

Chapter 1
Introduction

BACKGROUND

The American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE), Inc., commissioned this application guide in response to the need for a comprehensive reference manual on the options available relative to chiller heat recovery. It is intended that the information in this guide assist engineers, owners, and system operators to evaluate the potential of integrating chiller heat recovery into their cooling and heating systems. The primary focus is on new construction and applications where a chiller is being replaced due to inefficiency, high O&M costs, or elimination of CFC/HCFCs. While chiller systems for commercial buildings are primarily presented in this guide, the information and procedures also apply to industrial heat pumps. The objectives of the guide are to provide guidelines for the application of chiller heat recovery, including

1. Determination of system performance
2. Evaluation of economic feasibility
3. Design (including integration of heat exchangers)
4. Commissioning
5. Installation
6. Operation and maintenance

The use of recovered heat from chillers can be a very efficient and cost-effective means of providing heat for domestic hot water, space heating, tempering of outdoor air, process heating, preheating feed water for boilers, or other processes. The benefits include both reduced gas or other fuel source requirements to meet the heating loads, thus increasing the total system efficiency, and the condenser heat is not rejected to the environment.

The practice of chiller heat recovery has been integrated into heating and cooling systems since the 1950s. One of the first appli-

cations of chiller heat recovery was the preheating of boiler feed water and the recovery heating for space air[1]. These applications are still utilized today along with a number of new and improved applications.

This guide is organized to be used by a diverse audience, from building owners to design engineers. It is assumed that the reader has an understanding of basic heating and cooling requirements in commercial buildings and the current use of boilers and chillers to meet these requirements. This guide consists of ten chapters. The level of detail increases with each chapter, enabling those desiring only a brief overview to obtain it, while providing those requiring additional information the resources in the later chapters.

- Chapter 1 - *Introduction*, provides basic background information on chiller heat recovery and associated terminology.
- Chapter 2 - *Fundamentals*, presents information on the use of recovered heat and the typical heat recovery system configurations.
- Chapter 3 - *Equipment*, details the current types of chillers and heat pumps available for application in the heat recovery role.
- Chapter 4 - *Application Procedure*, introduces a stepwise procedure for determining the applicability of chiller heat recovery for a specific system.
- Chapter 5 - *Evaluation of Heating and Cooling Loads*, provides information on accurately determining a system's coincident heating and cooling load.
- Chapter 6 - *Equipment Selection*, presents a process to select the correct type of equipment for an application.
- Chapter 7 - *Economic Analysis*, details the various economic aspects of a chiller heat recovery project.
- Chapter 8 - *System Optimization*, focuses on areas to optimize the chiller heat recovery system.
- Chapter 9 - *Example*, presents an example using the procedure detailed in this guide.
- Chapter 10 - *Other Requirements*, reviews the commissioning, installation, and operation and maintenance aspects of a chiller heat recovery project.

BENEFITS OF CHILLER HEAT RECOVERY

In order to optimize a heating and cooling system it is important to understand the benefits a specific system has compared to

alternative systems. This comparison process is typically made using a common base system. The base system is often considered the *traditional* system. For this guide the traditional system is composed of

- chiller,
- boiler,
- primary/secondary piping systems,
- central air-handling units, and
- perimeter heating.

For each of the heating and cooling systems evaluated, the space loads will be relatively independent of system type. Any slight variances are typically due to the addition of fans or other loads to the space. However, when evaluating central system changes for simplicity, any equipment beyond the central plant is often considered fixed, resulting in a consistent load on the central plant for comparative purposes.

For chiller heat recovery to be viable there must be a simultaneous heating and cooling load. In a typical building, the central core of the building (any space without an exterior wall/roof) will require cooling year-round due to the lighting, computer, and occupant loads. However, the perimeter areas of the building will require cooling in the summer and heating in the winter due to the heat transmission through the building envelope. Figures 1 and 2 show the differentiation between interior and exterior zones.

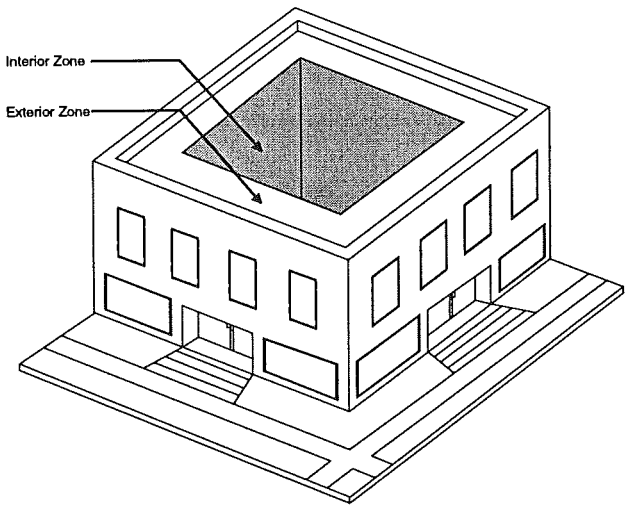


FIGURE 1 General zone distinctions.

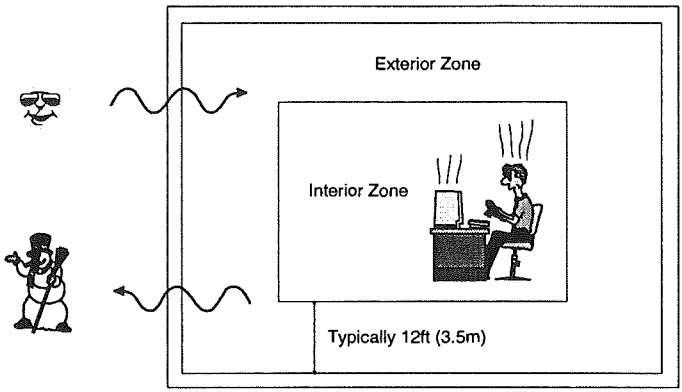


FIGURE 2 Interior/exterior zones.

During the transitional months (between summer and winter) in a typical building, cooling will be required for the central core and heating for the perimeter areas. The heating may be generated using a gas or electric boiler or met with perimeter electric heat. The cooling is provided by one of the following:

- Central chiller
- Cool outdoor air (outdoor air economizer)

A deficiency of traditional systems is that mechanical cooling is provided to the interior areas by rejecting heat to the outdoors (cooling tower) and, simultaneously, heat is provided to the perimeter area with a boiler using gas or electricity. Under these conditions there is an energy imbalance within the building, using up to twice the amount of energy that is necessary. There is also an energy imbalance when using the outdoor air economizer to cool the interior space. This is not as severe an energy penalty as the chiller system; however, the interior heat load is still being rejected to the outdoors (outdoor air). Further, if the same air-handling unit supplies the interior and exterior zones, the outdoor air for cooling is mechanically reheated for the exterior zones.

Chiller heat recovery is an effective means for balancing simultaneous heating and cooling needs of a building. The condenser heat from the chiller, which is providing cooling to the core areas, provides the majority of perimeter heating requirements with little or no additional heat required in well-designed and maintained systems. This works even better with cool thermal storage, where

morning warm-up and weekend heating can be managed. Figure 3 provides an example comparison of the energy use for traditional and chiller heat recovery systems relative to the outdoor air temperature. As can be seen in Figure 3, the decrease in energy usage for the chiller heat recovery system (A) is significant compared to the traditional system (B), which is composed of the chiller energy use (C) and the boiler energy use (D). The actual cost savings are dependent upon actual electricity and gas energy rates.

The primary benefits of a chiller heat recovery system include

- Reduced energy use;
- Reduced energy cost;
- Reduced heating equipment size (unless backup is desired or required);
- Increased utilization of equipment (when mechanical cooling is required year-round);
- Humidification equipment may not be required during cooler periods and winter (compared to outdoor economizer);
- Improved load balancing (when used in conjunction with cool thermal storage).

Due to differences in core to perimeter areas and relative loads, not all buildings have the proper characteristics for economical

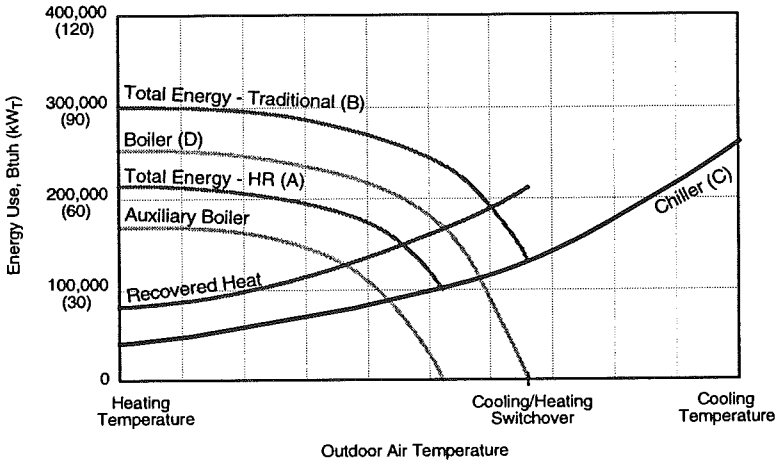


FIGURE 3 Energy use comparison.