Market Characterization Study of Minnesota Multifamily New Construction Practices and Building Improvement Opportunities

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EXECUTIVE SUMMARY

Construction of multifamily residential housing in Minnesota has been growing at a large rate highlighting a growing opportunity to identify and implement building improvements in multifamily housing on a larger scale.

Recognizing the growing importance of the multifamily sector in Minnesota, CenterPoint Energy Minnegasco commissioned the Center for Energy and Environment (CEE) to conduct an effort to better understand this sector. The Minnesota Department of Commerce, State Energy Office, also interested in this effort, contributed funds that allowed the scope to extend beyond CenterPoint Energy Minnegasco's service territory and to address other multifamily housing types (i.e. townhomes) not covered under the original Minnegasco project.

The effort has two distinct parts. The first is to conduct a market survey and characterization study of multifamily housing in CenterPoint Energy Minnegasco's service territory. The goal of the study is to determine the impact of multi-family housing in the region, characterize multifamily new construction practices, and identify potential opportunities to encourage better building performance.

The study first identified the magnitude of the growing multifamily market in the state. Using data from the Metropolitan Council and the U.S. Census Bureau, CEE estimated the annual rates of multifamily new construction. CenterPoint Energy Minnegasco's territory is experiencing an addition of about 11,000 dwelling units per year, while the statewide total is at approximately 20,000 units per year. Common area (apartment/condo) buildings account for nearly two-thirds of this total, while townhomes represent just over one-third.

CEE gathered data on building characteristics and on the development process through 22 semi-structured interviews, ten plan reviews, and five on-site inspections. Those interviewed included developers, architects, engineers, general contractors, mechanical contractors and code officials who are active in the multifamily industry. The organizations represented deal with as many as 11,000 housing units per year throughout the state of Minnesota.

The findings of the survey and site-visits can be divided into nine main categories:

1.) Multifamily industry representatives expressed that their most serious concerns are about moisture and mold issues. Better specification of architectural details, better contractor execution of envelope details, better ventilation system design, and better contractor installation of ventilation systems provide the best pathways for realizing significant building performance improvements in this area. This might be effectively encouraged through educational promotion and better construction oversight

2.) Promotion of high efficiency furnaces provides the best opportunity to encourage better heating systems. Rebates and promotion of the venting flexibility of condensing furnaces should be effective for the single-family style furnaces installed in most new townhomes and a minority of apartment/condo buildings.

3.) A longer-term cooperative effort is probably needed to achieve heating system efficiency improvements in most apartment/condo style buildings because packaged heating/cooling units (known as PTACs [ie. packaged terminal air-conditioners]) that now dominate this market do not currently have a high efficiency heating option.

4.) Effectively achieving better energy efficiency in the minority of apartment style buildings using central space-heating boiler systems requires the use of both extensive education and verification to ensure proper specification, installation, and operation of boiler system improvements.

5.) Rebates or other promotions of more efficient residential water heaters and condensing commercial water heaters (>90%) are also expected to provide effective energy savings in townhomes and apartment/condo buildings, respectively. Venting flexibility has been a key factor in the moderate and growing use of condensing commercial water heaters.

6.) While lighting efficiency within multifamily units can theoretically be increased dramatically, the logistics of using compact fluorescent lamps within units—where tenants have historically been responsible for replacing light bulbs—present a challenge.

7.) The split incentives between the developer/manager who usually pays the up-front costs and the resident who pays the energy costs, make the use of energy efficient appliances rare in multifamily buildings. Flexible approaches, such as incentives paid to developers or laundry equipment service providers, offer the best opportunities to achieve significant movement of this market towards high efficiency equipment. However, in these cases the rebate might need to cover the entire incremental cost.

8.) The strong drive for lowest first cost combined with the lack of reliable, unbiased energy cost information have historically limited the consideration and ultimate implementation of building performance improvement options. The new construction design assistance service portion of this effort aims to provide this information so that developers and designers can conduct well-informed evaluations of design options and incorporate a number of improvements in current and/or future projects.

9.) Finally, there appears to be a need for commissioning services to provide review and quality control of the multifamily building design, construction, and start-up operation. Educational promotion to developers and design professionals, as well as funding for commissioning services, could significantly improve the ultimate energy efficiency of multifamily buildings.

The second part of the overall program effort is to work with specific multifamily projects in identifying and incorporating these types of recommendations. Many of the projects to date have illustrated a need by industry representatives to have additional information to assist in the design and construction of multifamily buildings.

INTRODUCTION

PURPOSE

CenterPoint Energy Minnegasco provided funding for this project's initial effort to develop a better understanding of current practices in the design and construction of new affordable multifamily buildings (defined as buildings with five or more units, excluding townhomes) within their service territory. The key goal was to identify any specific opportunities that exist for improving building performance.

PROJECT GOAL
Determine the impact of the multifamily sector in the region and identify opportunities for improving upon current practices in the design and construction of new multifamily buildings

CEE conducted a market survey of key players in the multifamily construction industry, such as developers, designers, and contractors. The survey characterized current practices in the construction of multifamily buildings. Current practice was compared with best practices to identify both technologies and design/construction procedures that could be changed to improve energy efficiency and building performance.

The market study design also included a limited number of construction document reviews to collect design information that is not easily communicated through interviews. Finally, on-site inspections provided indications of how well the construction process achieves the design intent and construction practices for detail items that may not be specified in the design documents. In particular, the effort strived to identify what differences may occur between multifamily buildings targeting the low and moderate-income sector and those in other sectors of the multifamily construction industry.

The Minnesota Department of Commerce, State Energy Office, also contributed funds allowing the scope of the study to be expanded beyond CenterPoint Energy Minnegasco's service territory and include other multifamily buildings (i.e. townhomes).

BACKGROUND

Recent trends in construction of residential housing in Minnesota show that is growing at a large rate. According to an April 4, 2002 Minneapolis Star-Tribune article, "for the first quarter, multifamily construction pushed the number of units planned to just one short of the two-decade high for the period, set in 2000, the [Builder's] association said."[1] This article and others like it, highlight a growing opportunity to identify and implement building improvements in multifamily housing on a larger scale.

In 2002, the number of planned multifamily units almost equaled the 20 year high – which was set in 2000.

Recognizing the importance of the multifamily sector, CenterPoint Energy Minnegasco commissioned the Center for Energy and Environment (CEE) to conduct such an effort in 2003 and 2004. The Minnesota Department of Commerce, State Energy Office, also interested in this effort, contributed funds that allowed the scope to extend beyond CenterPoint Energy Minnegasco's service territory and to address other multifamily housing types not covered under the original Minnegasco project.

The effort has two distinct parts. One part is to conduct a market survey and characterization study of multifamily housing in CenterPoint Energy Minnegasco's service territory. The goal of the study is to characterize multifamily new construction practices and to identify potential opportunities to encourage better building performance.

The second part is to work with specific multifamily projects in identifying and incorporating many of these recommendations. Many of the projects to date have illustrated a need by industry representatives to have additional information to assist in the design and construction of multifamily buildings. The ultimate goal of this effort is to have a positive effect on current practices and move the industry forward in developing more durable and energy efficient structures.

The first part of the study was to identify the magnitude of the growing multifamily market in the state. Using data from the Metropolitan Council and the U.S. Census Bureau, CEE estimated the annual rates of multifamily new construction. CenterPoint Energy Minnegasco's territory is experiencing an addition of about 11,000 units per year, while the statewide total is at approximately 20,000 units per year. Common area (apartment/condo) buildings account for nearly two-thirds of this total, while townhomes represent just over one-third.

CEE gathered building detail and development process information through 22 semi-structured interviews, ten blueprint reviews, and five on-site inspections. The interviews included developers, architects, engineers, general contractors, mechanical contractors and code officials that are active in the multifamily industry. The organizations represented deal with as many as 11,000 housing units per year throughout the state of Minnesota (although there is overlap of projects between organizations).

This report details these efforts. Recognizing that different people may only be interested in specific items, sections are

[1] "Twin Cities Builders Turn to Multiunit Housing" Minneapolis Star-Tribune, April 4, 2002.

written so they may be read independently. More specifically, one does not need to read the section on buildings with common areas if one is only interested in townhome design. At the end, a summary of differences among the multifamily industry is included as well as an overall summary of recommendations. Details on the survey tool and the participants are included in the Appendices.

Categorizations

The market survey primarily categorized multifamily housing into townhomes and common area buildings, and secondarily into rental vs. for-sale and low-rise vs. high-rise. Townhomes are defined as units having one to three stories, extending from the footings to the roof with an exposed exterior facade on two or three sides. The state fire-code distinction between high-rise and low-rise apartment building is based on whether or not the building rises 75 feet above fire department access. This fire-code definition usually means that high-rise apartment buildings are six stories or greater, while low-rise apartment building consists of one to five stories. The energy code definition of low-rise multifamily buildings only includes buildings of three stories or less.

Two Building Categories: Townhomes and Buildings with Common Areas.

Applicable Codes

Major changes are occurring in the State of Minnesota's codes applicable to multifamily building construction. The State of Minnesota is nearing the end of the process of converting the majority of its building codes from the more prescriptive-based Uniform Building Code series to the more performance-based International Building Code series. The International Building Code 2000 (IBC) volume went into effect March 31, 2003—along with Minnesota specific amendments found in Chapter 1305 of the state's code. The development of amendments to, and adoption of, the International Mechanical Code 2000 (IMC), has been slower, with it expected to go into effect in 2004. Such major code changes naturally create a degree of confusion in the construction industry. Moreover, the delayed adoption of the IMC has specifically led to a high degree of confusion about mechanical ventilation requirements because the previously used code series specified mechanical ventilation levels in the building code volume, while the newly adopted code series specifies mechanical ventilation levels in the mechanical code volume.

The energy code is also in the process of review and its history has also created a relatively complicated current status. Currently constructed multifamily buildings with no more than three stories above grade are only mandated to meet the (older) Chapter 7670 energy code requirements. However, Chapter 7674 Multi-family Residential Buildings, Three Stories or Less went into effect on April 15, 2000 as an alternative to—rather than a replacement for—Chapter 7670. Chapter 7674 generally provides an optionally higher energy efficiency standard level. This chapter also references Chapter 7678 Thermal Transmittance Calculations and Equipment Efficiencies for Residential and Multifamily Dwellings and Commercial Buildings, which became effective July 20, 1999. The current energy code for multifamily buildings more than three stories, Chapter 7676 Commercial Buildings, also became effective on July 20, 1999 and makes references to Chapter 7678. Chapter 7676 generally has much less restrictive envelope requirements (i.e. for insulation and window

performance) than the sections of the energy code for single-family and multifamily buildings with three stories or less.

Construction Starts

Housing Start Data

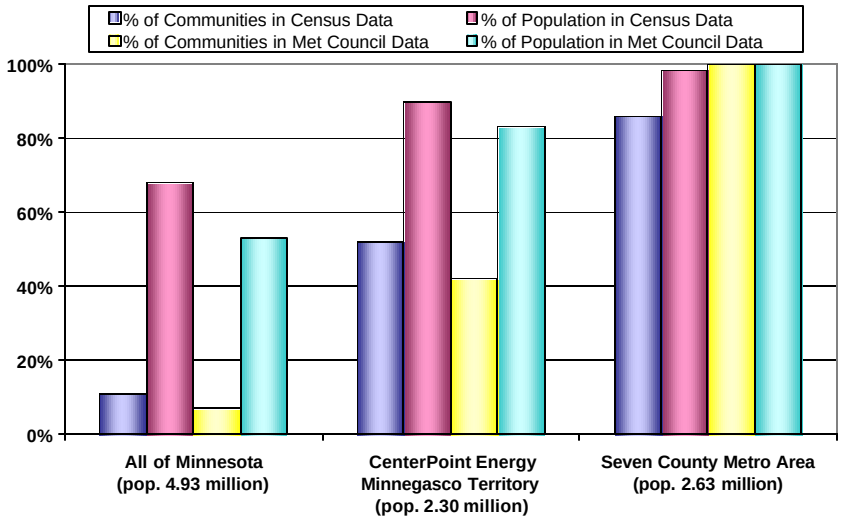
Data Sources

CEE obtained information on multifamily housing starts from two different data sources; the U. S. Census Bureau for 2001 and 2002, and a Metropolitan Council survey. Larger communities and those near population centers are much more heavily represented in these data. The Census Bureau data does not include townhomes, but does include 3-4 unit multifamily buildings. However these 3-4 unit buildings only represented roughly 10% of the total number of units in 3+ unit multifamily buildings.

The U.S. Census Bureau only collects housing start data from specific cities, townships and counties within the state of Minnesota. New housing construction data from the Census Bureau represents about 90% of the population of the communities served by CenterPoint Energy Minnegasco and about two-thirds of the state population (based on population data from the 2000 census).

The Metropolitan Council survey of all of the communities within the Twin Cities seven county metro area provided information on townhomes and 3+ multifamily units for 2001. The Metropolitan Council survey tended to capture more multifamily housing starts than the Census data for the same time period and communities (on average the Census Bureau data showed about 24% lower housing start rates, but this was very inconsistent). *Chart 1* shows how well different areas of interest are represented by the two data sources in terms of the percent of communities within each area and the percent of the population within each area.

Chart 1: Housing Starts Data Sampling Rate



Best estimates of new construction for various areas in 2001 were developed by summing the Metropolitan Council data for as much of the area as possible, and scaling the Census data for other parts of the state upward based on the apparent rate of undercounting in the Metro area. The state-wide estimate of new construction rates also took into account the typical new construction rates by community size (based on the available Census Bureau data for communities outside of the seven county metro area) in extrapolating data to communities that were not represented in either data source.

CenterPoint Energy Minnegasco Territory

Table 1 shows a best estimate of the total number of multifamily housing units built per year in 2001 and 2002 within CenterPoint Energy Minnegasco's service territory. CEE estimates that the townhomes represent about 700 buildings per year, based on an average of roughly 6 units per building found during surveys and plan reviews. Data from the Census Bureau indicates that about 441 multifamily buildings with common areas are built per year with an average of 15 units per building.

Table 1: CenterPoint Energy Minnegasco Territory Estimates of Multifamily New Construction Activity

Period	Townhomes	Other Multifamily	Total Multifamily
2001	3,269	5,521	8,790
2002	5,126	8,025	13,151
Annual Average	**4,198**	**6,773**	**10,971**

Chart 2 shows the communities served by CenterPoint Energy Minnegasco and shows that a large fraction of the multifamily construction is clustered in a few metro counties.

State-Wide

The project team's best estimate of the state-wide total number of multifamily housing units built per year in 2001 and 2002 is shown in *Table 2. Chart 3* shows the distribution of multifamily new construction by county as compared to the distribution of the state's population within the communities represented by the U.S. Census Bureau's housing starts data.

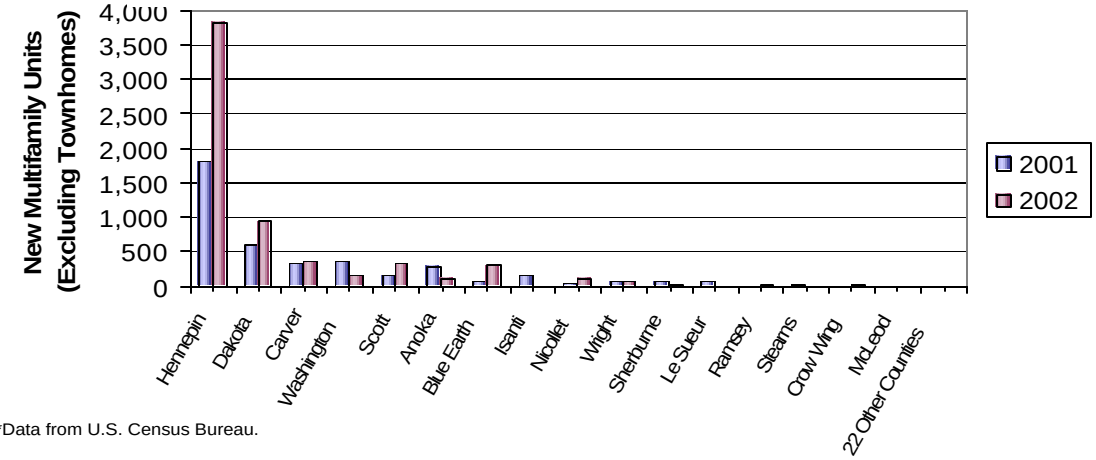
Analysis of the separate townhome and single-family data readily available for the seven county metro area yielded an understanding of how patterns in total residential construction are related to patterns in multifamily housing. *Chart 4* with 2001 data for the metro area shows that high volumes of single-family construction often occur in areas with relatively low volumes of multifamily construction.

Table 2: State-Wide Estimates of Multifamily New Construction Activity

Period	Townhomes	Other Multifamily	Total Multifamily
2001	5,706	10,394	16,100
2002	8,528	15,536	24,065
Annual Average	**7,117**	**12,965**	**20,082**

Chart 2: New Construction by County

Communities Served by CenterPoint Energy Minnegasco



*Data from U.S. Census Bureau.

Chart 3: Multifamily Construction Distribution Excluding Townhomes
Data from U.S. Census Bureau Represents 68% of State Population

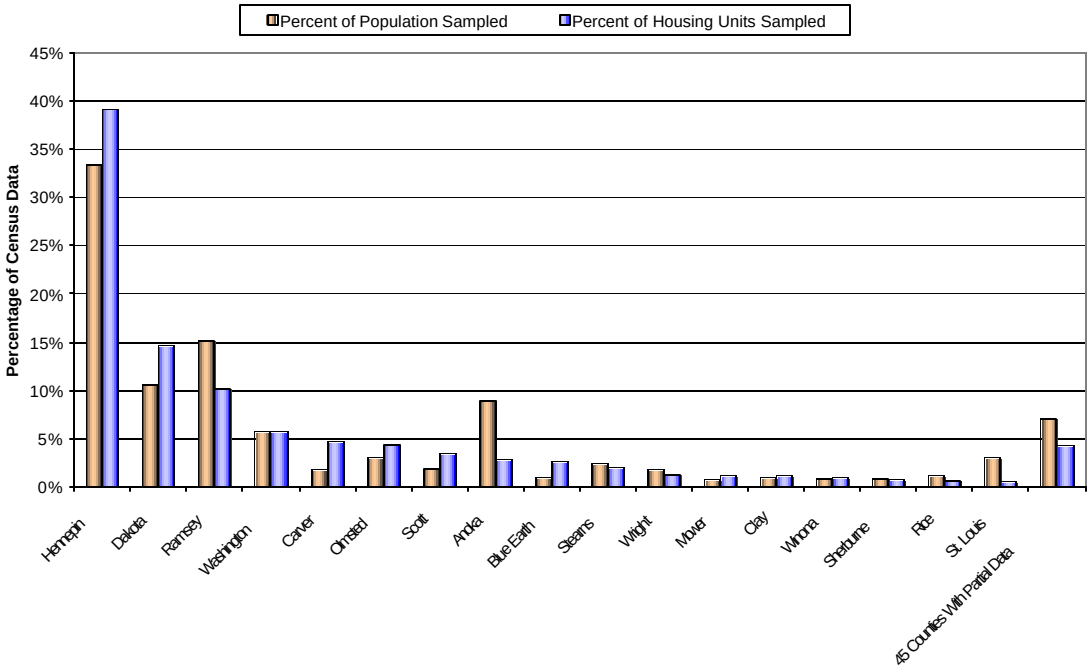
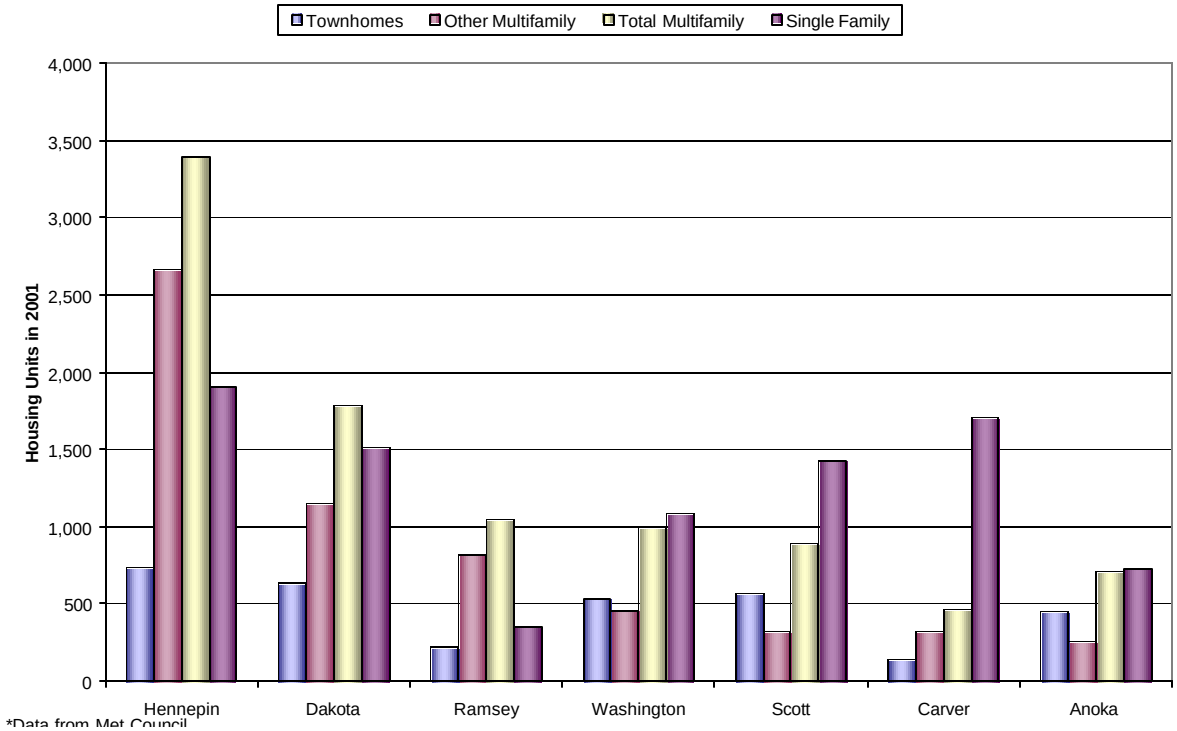
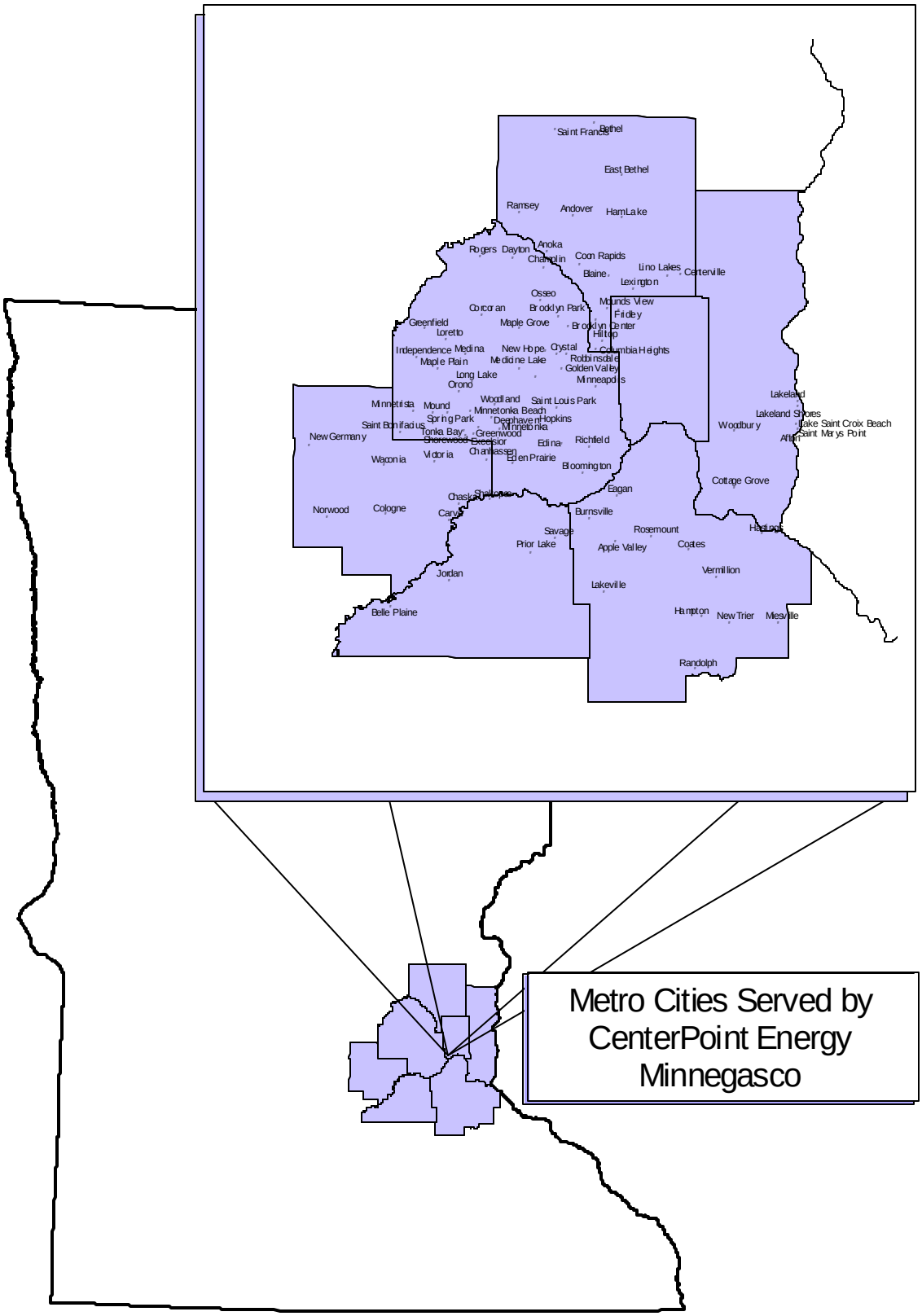


Chart 4: 2001 Housing New Construction in Seven-County Metro Area

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Ramsey
Andover
Ham Lake
Rogers
Dayton
Anoka
Champlin
Coon Rapids
Blaine
Lino Lakes
Centerville
Lexington
Osseo
Corcoran
Brooklyn Park
Mounds View
Fridley
Greenfield
Maple Grove
Brooklyn Center
Loretto
Hilltop
Independence
Medina
New Hope
Crystal
Columbia Heights
Maple Plain
Medicine Lake
Robbinsdale
Golden Valley
Long Lake
Minneapolis
Orono
Woodland
Saint Louis Park
Minnetrista
Mound
Minnetonka Beach
Lakeland
Lakeland Shores
Spring Park
Deephaven
Hopkins
Saint Bonifacius
Minnetonka
Woodbury
Lake Saint Croix Beach
Tonka Bay
Greenwood
Saint Marys Point
New Germany
Shorewood
Excelsior
Edina
Richfield
Afton
Victoria
Chanhassen
Eden Prairie
Waconia
Bloomington
Eagan
Cottage Grove
Chaska
Shakopee
Norwood
Cologne
Carver
Burnsville
Savage
Rosemount
Hastings
Prior Lake
Apple Valley
Coates
Jordan
Vermillion
Lakeville
Belle Plaine
Hampton
New Trier
Miesville
Randolph
Metro Cities Served by
CenterPoint Energy
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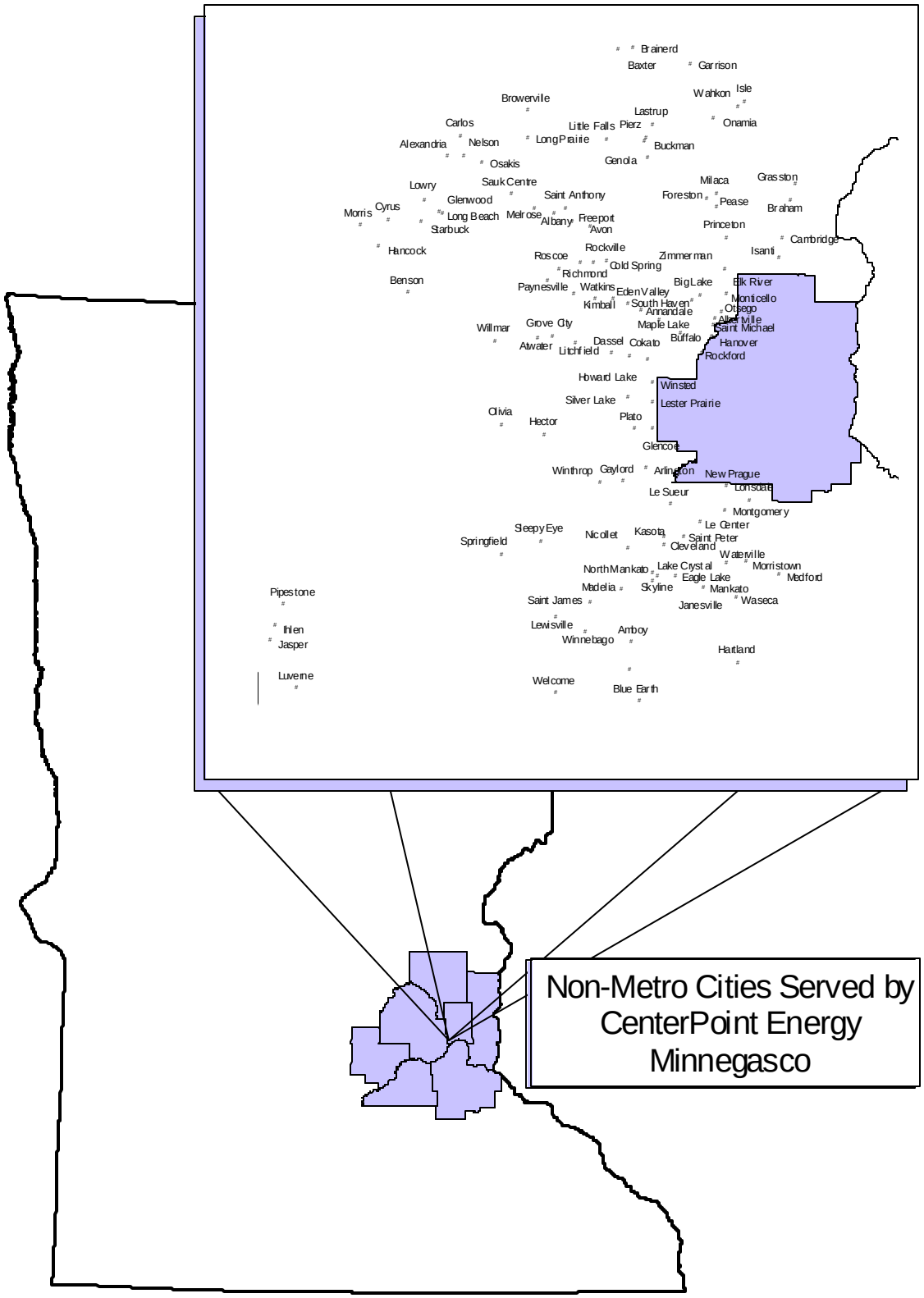
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Baxter
Garrison
Wahkon
Isle
Browerville
Lastrup
Carlos
Little Falls
Pierz
Onamia
Alexandria
Nelson
Long Prairie
Buckman
Osakis
Genola
Milaca
Grasston
Lowry
Sauk Centre
Foreston
Pease
Glenwood
Saint Anthony
Braham
Morris
Cyrus
Long Beach
Melrose
Albany
Freeport
Avon
Princeton
Starbuck
Cambridge
Hancock
Rockville
Roscoe
Zimmerman
Isanti
Richmond
Cold Spring
Benson
Paynesville
Watkins
Big Lake
Elk River
Eden Valley
Monticello
Kimball
South Haven
Otsego
Annandale
Albertville
Willmar
Grove City
Maple Lake
Saint Michael
Atwater
Litchfield
Dassel
Cokato
Buffalo
Hanover
Rockford
Howard Lake
Winsted
Silver Lake
Lester Prairie
Olivia
Hector
Plato
Glencoe
Winthrop
Gaylord
Arlington
New Prague
Lonsdale
Le Sueur
Montgomery
Le Center
Sleepy Eye
Nicollet
Kasota
Springfield
Saint Peter
Cleveland
Waterville
North Mankato
Lake Crystal
Morristown
Eagle Lake
Medford
Madelia
Skyline
Mankato
Pipestone
Saint James
Janesville
Waseca
Lewisville
Amboy
Winnebago
Jasper
Hartland
Luverne
Welcome
Blue Earth
Non-Metro Cities Served by
CenterPoint Energy
Minnegasco

Communities Served by CenterPoint Energy Minnegasco

Afton
Albertville
Amboy
Annandale
Apple Valley
Atwater
Baxter
Benson
Big Lake
Bloomington
Bongards
Brainerd
Brooklyn Park
Buckman
Burnsville
Carlos
Centerville
Chanhassen
Cleveland
Cokato
Cologne
Coon Rapids
Cottage Grove
Cyrus
Dayton
Eagan
East Bethel
Eden Valley
Elk River
Foreston
Fridley
Gaylord
Glencoe
Golden Valley
Grasston
Greenwood
Ham Lake
Hancock
Hartland
Hector
Hopkins
Ihlen
Isanti
Janesville
Jordan
Kimball
Lake St. Croix Beach
Lakeland Shores
Lastrup
Le Sueur
Lewisville
Lino Lakes
Little Falls
Albany
Alexandria
Andover
Anoka
Arlington
Avon
Belle Plaine
Bethel
Blaine
Blue Earth
Braham
Brooklyn Center
Browerville
Buffalo
Cambridge
Carver
Champlin
Chaska
Coates
Cold Spring
Columbia Heights
Corcoran
Crystal
Dassel
Deephaven
Eagle Lake
Eden Prairie
Edina
Excelsior
Freeport
Garrison
Genola
Glenwood
Grandy
Greenfield
Grove City
Hampton
Hanover
Hastings
Hilltop
Howard Lake
Independence
Isle
Jasper
Kasota
Lake Crystal
Lakeland
Lakeville
Le Center
Lester Prairie
Lexington
Litchfield
Long Beach
Long Lake
Lonsdale
Lowry
Madelia
Maple Grove
Maple Plain
Medford
Medina
Miesville
Minneapolis
Minnetonka Beach
Montgomery
Morris
Mound
Nelson
New Hope
New Trier
North Mankato
Oakdale
Olivia
Orono
Osseo
Paynesville
Pierz
Plato
Priam
Prior Lake
Randolph
Richmond
Rockford
Rogers
Rosemount
Saint Bonifacius
Saint James
Saint Mary's Point
Saint Peter
Savage
Shorewood
Skyline
South Haven
Spring Park
Starbuck
Vermillion
Victoria
Wahkon
Waterville
Wayzata
Winnebago
Winthrop
Woodland
Long Prairie
Loretto
Luverne
Mankato
Maple Lake
Mayer
Medicine Lake
Melrose
Milaca
Minnetonka
Minnetrista
Monticello
Morristown
Mounds View
New Germany
New Prague
Nicollet
Norwood
Oak Grove
Onamia
Osakis
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Pease
Pipestone
Plymouth
Princeton
Ramsey
Richfield
Robbinsdale
Rockville
Roscoe
Saint Anthony
Saint Francis
Saint Louis Park
Saint Michael
Sauk Centre
Shakopee
Silver Lake
Sleepy Eye
Spring Lake Park
Springfield
Tonka Bay
Veseli
Waconia
Waseca
Watkins
Willmar
Winsted
Woodbury
Zimmerman

INTERVIEW METHODOLOGY

CEE conducted interviews to identify current construction practices and problems in new multifamily buildings. Understanding gained through these interviews provided insight into opportunities for influencing the design and construction of future multifamily buildings to enhance their performance in the areas of energy efficiency, indoor air quality, and durability.

The interview procedure allowed in-depth discussion based on respondents answers and experience

The interviews primarily focused on affordable multifamily rental projects that will have a commercial heating gas account within CenterPoint Energy Minnegasco's service territory. However, the interviews included organizations that also deal with other projects (in other parts of Minnesota or for other sectors of the multifamily housing market), as well as questions about differences between these sectors. The market study aimed at interviewing individuals from the targeted types of organizations listed below:

- Developers
  - Private Firms
  - Non-Profit & Governmental Organizations
- Design Professionals
  - Architects
  - Engineers
- Contractors
  - General
  - Mechanical
- Building Code Inspectors
- Building/Facility Managers

Interviews consisted of roughly 60 minute in-person discussions or 20 minute telephone interviews with representatives from these organizations. A detailed interview tool provided a degree of consistency and direction for the interviews, but the interview procedure also allowed more in-depth discussion of particular issues based on the respondents' answers. A licensed mechanical engineer with extensive multifamily building performance experience conducted the interviews. This allowed for meaningful dialogue regarding the issues brought up by the interview tool and to show the targeted individuals that their time and input was highly valued. A licensed architect also took part in three of the interviews.

The flexible interview tool solicited different levels of detail in various subject areas depending on the respondent's role in the multifamily building industry, depth of knowledge, and time availability. For example, the interviewer asked developers more questions regarding economic evaluation of design alternatives and asked mechanical contractors more detail regarding specific types of equipment and control strategies.

Given the diversity in respondents, the interviews were not designed to obtain a rigorous statistical sampling of all respondents, but rather to get an indication of practices for a wide range of items and insight into the reasons for particular practices. Tables on the following pages provide more detail regarding the types of questions asked of each organization category, and the complete interview tool can be found in the appendices.

CEE first created a preliminary list of targeted organizations and individuals with input from the funding organizations. Interviews were initiated with individuals through established contacts, and then significant interview tool refinements were

made. Early interviews produced numerous referrals to additional key industry contacts, and CEE conducted a limited number of "cold calls" where necessary.

The goal of achieving a clear understanding of practices within a number of areas guided the total number and types of organizations included in the final sample. For example, CEE initially targeted electrical contractors (because of knowledge of lighting issues), but when representatives from other organization types provided a very consistent picture of lighting system practices, we dropped this group from the target list. On the other hand, initial interviews that provided inconsistent or unexpected trends in other areas led to more than the anticipated number of interviews for representatives of other types of organizations.

SURVEY GOAL
Gain a broad understanding of multifamily construction practices over a wide range of issues and insight into their basis.

CEE deemed this adaptive approach—combined with the flexible interview tool—more appropriate for gaining detailed insight into multifamily building practices than an attempt to perform rigorous, statistical sampling with an inflexible set of interview questions. A summary of the information collected based on the respondent's role is given in the graphics below.

Interview Tool Summary: Developers

Project Information:

- ☑ How many units, what type, and where do they typically plan to build?

Involvement:

- ☑ What do developers know about building details?
- ☑ How involved, if at all, is the developer in designing the building structure, mechanical and electrical systems, and the in-unit items?

Process:

- ☑ What factors influence their decision-making process on design issues?
- ☑ What recommendations, if any, would they make in order to improve the general design and construction process?

General Information:

- ☑ What type of problems with building construction, design, and performance have you seen occur with recent multifamily projects?
- ☑ What issues are they interested in learning more about?
- ☑ What information do they need to help them select more efficient technologies?

Interview Tool Summary: Design Professional (Architects, Engineers, etc.)

Project Information:

- ☑ How many units, what type, and where do they typically plan to build?

Involvement:

- ☑ How involved is the designer in the building structure and envelope, mechanical and electrical systems, and the in-unit items?
- ☑ How involved are the other parties in building design?

Process:

- ☑ What factors influence the designers' decision-making process on design issues?
- ☑ What current design practices are being incorporated into the preliminary design phase to improve energy efficiency, IAQ, and durability?
- ☑ What is the building owner's receptivity to these features? How much does cost influence the designer's decision to add these elements/features?
- ☑ What recommendations, if any, would designers make in order to improve the general design and construction process?

General Information:

- ☑ What recommendations, if any would they make in order to reduce project costs?
- ☑ What type of problems with building construction, design and performance have you seen occur with recent multi-family projects?
- ☑ What information do they need to help them select more efficient technologies?

Interview Tool Summary: General Contractors

Project Information:

- ☑ How many units, what type, and where do they typically plan to build?
- ☑ How involved is the contractor in the selection of the mechanical and electrical systems, and the in-unit items?
- ☑ How involved are the other parties in building design?

Process:

- ☑ What factors influence the contractor's decision-making process on incorporating construction techniques that enhance energy efficiency, IAQ, and durability?
- ☑ How much does cost influence the contractor's decision to add these elements/features?
- ☑ What current design practices are being incorporated during the building phase to improve energy efficiency, IAQ, and durability?
- ☑ What recommendations, if any, would contractors make in order to improve the general design and construction process?

Contractor Recommendations:

- ☑ What are the building components and systems that you typically use to enhance building performance (i.e. insulation, air sealing details, ventilation, etc...)?
- ☑ What is the building owner's receptivity to these features? How much do they influence the decision on adding or deleting these features?
- ☑ What type of problems with building construction, design, and performance have you seen occur with recent multifamily projects?

General Information:

- ☑ Where are contractors running into problems with the equipment that is specified?
- ☑ What recommendations, if any, would they make in order to reduce project costs?
- ☑ What information do they need to help select more energy efficient technologies?

Interview Tool Summary: Mechanical Contractors

Equipment Details:

- ☑ What types of HVAC systems are being used in multifamily buildings (i.e. boilers, gas-fired furnaces, etc...)?
- ☑ What are the features of these systems (i.e. gas-fired, electric, temperature settings, etc...)?
- ☑ How are these systems operated in the building? Who controls their operation?
- ☑ How are the heat-loss calculations performed?
- ☑ What type of ventilation is used?
- ☑ What are the features of the ventilation systems?

Equipment Selection:

- ☑ Who influences what type of HVAC system is installed in these buildings?
- ☑ What factors influence those decisions?

Process:

- ☑ What recommendations, if any, would mechanical contractors make in order to improve the general design and construction process?
- ☑ What recommendations, if any, would they make in order to reduce project costs?

General Information:

- ☑ What type of problems with building construction, design, and performance have you seen occur with recent multifamily projects?
- ☑ What information would help you in selecting more energy efficient technologies?

Interview Tool Summary: Building Code Officials

Project Information:

- ☑ How many multifamily buildings do you inspect in a month or year and in what areas?

Identification of Issues:

- ☑ What type of problems with building design and performance are you seeing occur with recent multifamily projects?
- ☑ What are the most common construction problems you encounter?
- ☑ What types of building product failures are you seeing? What types have you seen in the past?
- ☑ In what areas of the building process do you typically see potential problems (i.e. mechanical systems, electrical, wall assemblies, foundations, etc...)?

Differences in Building Types:

- ☑ Have you seen tendencies towards differences between affordable housing projects and other types?

Interview Tool Summary: Facilities Management Companies

Project Information:

- ☑ How many units, what type, and where do they manage properties?

Identification of Issues:

- ☑ What type of problems with building construction, design and performance have you seen occur with recent multifamily projects?
- ☑ What are the common building management issues you address in multifamily buildings?
- ☑ What re-occurring problems do you encounter?

Survey Respondents

Table 3 lists the type of organizations from which individuals were interviewed, along with their reported volume of multifamily new construction projects. These interviews are expected to yield a good representation of the multifamily market practices based on the high total number of housing units represented in the surveys (11,300) compared to the new multifamily construction rates of 11,000 units per year in CenterPoint Energy Minnegasco's territory and 20,000 units per year throughout the state (even after considering the expected multiple counting of a number of specific housing development projects).

Table 3: Summary of Represented Organizations

Organization Type	# Interviewed	Units/Year
Developers/Brokers	7	680
Architectural Firms	3	1,420
General Contractors	4	745
Mechanical Design Firms	3	5,175
Mechanical Contractors	3	2,200
City Building Inspections	2	1,050
Total	22	11,270*

Initially, interviews heavily targeted mechanical engineers and contractors because these groups tend to have a high unit volume as well as an intimate knowledge of mechanical equipment practices that the other groups may not have. However, early interviews also queried multiple individuals from each type of organization to get a more complete picture of other building features, as well as more insight into the factors affecting the design and construction process. Later interviews primarily targeted developers to gain more insight into their decision-making process during the design and construction.

The Twin Cities metro area is more heavily represented than the rest of the state

In the survey findings, the Twin Cities metro area is more heavily represented than the rest of the state since the contractors interviewed tend to work on projects over limited areas, while the engineers and architects tend to work on projects statewide. Interviews included a limited number of contractors serving portions of greater Minnesota (although each of these contractors contributes to a relatively low number of multifamily projects).

Plan Review & Inspections

Plan reviews for ten active (or recent) projects and on-site inspections of five of these projects provided further insight into construction practices. These projects included six traditional apartment building projects and four townhome projects (all of which, with the exception of one townhome, are affordable housing projects). This activity provided insight into practices that are hard to accurately characterize through interviews alone.

Five of the reviewed projects received design assistance services through the program associated with this market study. Design assistance services included a review of plans and analysis of the potential energy cost savings associated with numerous building envelope and equipment design options for each of these individual projects. Separate design assistance reports for each project provide more information about the projects reviewed and analysis results.

MARKET CHARACTERIZATIONS

COMMON AREA BUILDINGS

Summary

General Market Conditions

Multifamily buildings with common areas include both rental apartment buildings and condominium buildings that have common areas consisting of at least interior common hallways. The estimated annual new construction of multifamily buildings with common areas amounts to 6,800 housing units served by CenterPoint Energy Minnegasco and 13,000 housing units statewide. Survey respondents generally expect an overall modest reduction in the amount of multifamily new construction over the next two years, with a possible exception for senior housing. A weighted average of results from survey respondents that provided sound information about the balance between affordable and other multifamily projects indicated that just over half of the multifamily units they are involved with are affordable housing units.[2]

The jump from 16.1 units per building[3] in 2001 to 21.3 units per building in 2002 signifies a trend towards larger buildings. While the analysis of housing start data shows that there is some new multifamily construction in rapidly growing areas, the largest numbers of multifamily units are being built in or very near more established population centers.

Five common area buildings that had plan review averaged 1,100 square feet of building area per unit (i.e. including common space other than garages).[4] The mix between in-unit and common space varied between buildings, but averaged about 20 percent of the building area. Underground common garages added another 350 square feet per unit for the three buildings with this amenity.

Industry representatives reported problems related to mold and moisture issues more frequently than any other type of problem. Only a small number of design and construction teams reported making specific envelope design and/or ventilation system design changes to systematically address these issues. It appears that the majority of organizations continue to repeat practices that have not reliably prevented these problems.

Most often reported problems are related to mold and moisture issues.

The large and growing use of packaged terminal furnace and air-conditioners (referred to as PTACs) serving individual apartment units represents the most significant recent trend related to multifamily building mechanical systems. The use of packaged equipment limits options for high efficiency upgrades. This also typically leads to direct gas metering of each unit, thereby encouraging more responsible energy use by tenants taking away the developers' incentive to invest in energy efficient upgrades.

[2] This represents about 1,500 new affordable multifamily units per year for just the survey respondents. Extrapolating this ratio to all new common area multifamily buildings served by CenterPoint Energy Minnegasco would yield an estimated 3,600 new affordable housing units per year in common area buildings.

[3] The reported average numbers of units per building are for buildings with 5 or more units.

[4] One atypical building with a large amount of classroom space and was excluded from the average.

Related to this individual unit heating system trend is a growing trend toward very high efficiency central domestic water heating systems. These are related because the smaller vent piping of these water heaters—and potential for sidewall venting—typically allows high efficiency, sealed combustion water heaters to fit more easily within buildings that do not have a large central boiler chimney.

The most significant recent trend is in the use of individual packaged heating and cooling units (PTACs) for the dwelling units.

The split incentives associated with appliances in rental units have apparently played a role in minimizing the market penetration of high efficiency appliances. On the other hand, the selection of energy efficient items that provide energy cost savings for the building owner (and in some cases reduced maintenance costs) has become almost universal for common area lighting, exterior lighting controls, and low-flow plumbing fixtures.

Key Opportunities & Barriers

Moisture and Mold Issues. The market study identified the key opportunities for improving building durability as:

1) improving the design and construction of envelope details (e.g. window flashings, air barrier junction, and penetration sealing)
2) improving ventilation system design and installed performance to prevent moisture problems.

Possible steps that could be taken include:

- Promote existing research results and best-practices guides (such as those that have been specifically developed by the Canada Mortgage and Housing Corporation (CMHC)) to provide guidance in specifying envelope details.
- Promote improved ventilation system design to prevent the build-up of moisture in the apartment units.
- Fund or otherwise encourage increased oversight of the construction process (i.e. commissioning) to make sure that the design intent is successfully implemented—especially where more detailed or less common design specifications are used.

The program's continued delivery of design assistance services, of which this report is a part, provides a practical platform for the promotion of these improvements. Presentations to various trade groups provide another possible avenue

Individual Unit Heating and Cooling Systems. The large and growing dominance of PTACs serving individual apartments makes the current potential for the successful promotion of high efficiency space heating equipment in common area multifamily buildings lower than in the past. The currently available PTACs do not have any high efficiency heating options. In these circumstances significant impacts can only be made through long-term work with manufacturers to develop high efficiency units (such as multiple-utility cooperative efforts done through organizations like the Consortium for Energy Efficiency).

However, when specifics of the building design lead to the use of furnaces and split system air conditioners, high efficiency furnaces are often an attractive option—more so because of their venting flexibility than because of energy paybacks. Rebates

can also help improve paybacks and promotion of the venting flexibility of high efficiency furnaces to building design professionals may help improve market penetration.

Space-Heating Boiler Systems. There are good long-standing and newly emerging opportunities to improve the efficiency of new boiler plants for the decreasing minority of buildings that use central boiler systems. Long-standing boiler plant efficiency improvement opportunities that are not currently industry-wide standards include moderately higher efficiency boilers, high efficiency condensing boilers, modulating burners, outdoor cutout controls, and the effective isolation of idle boilers in multiple boiler installations. Promotion of high efficiency boilers and system options should be accompanied with extensive educational efforts since the optimal performance of boiler systems, especially condensing boiler systems, depends upon system design and/or control modifications that some local design engineers do not currently appreciate. Observed problems with boiler controls highlight the need for commissioning of boiler system controls to realize the potential savings of boiler controls and high efficiency condensing boilers.

One more recently available option is the selection of near-condensing boilers that not only have improved efficiencies which can also operate with much lower boiler system water temperatures than traditional boiler designs. The tolerance of lower water temperatures allows these boilers to reap more energy savings from outdoor reset controls which have now reportedly become standard practice.

A second recently available option is the use of propane-compressed air systems as a back-up fuel source. The use of propane-air systems can allow for much easier alternate fuel switchover and maintenance requirements than dual-fuel (natural gas and fuel oil) boiler burners, with the added benefit that all gas-fired appliances can be switched to the alternate fuel without any modifications to the individual appliances.

The industry awareness of these recently available options is low. Education efforts as well as rebates aimed at developers and design decision makers are tools that could be used to increase their market penetration.

Domestic Hot Water Systems. Commercial, high efficiency condensing water heaters introduced in the last few years by industry-leading manufacturers have made more inroads into the market than previously available, condensing water heater products. However, they still represent a minority of new installations. Better trade name recognition is one factor in their success, but their selection has reportedly been driven primarily by venting flexibility compared to traditional water heaters. Although high failure rates in early versions of the most prominent product line have been rumored, none of the respondents mentioned equipment problems with the installations in which they have been involved.

Continued demonstration of the energy benefits for specific projects is an effective way to promote this high efficiency technology. General educational promotion of the venting flexibility and energy savings are also recommended. Targeted equipment rebates could also very effectively supplement the education efforts.

Garage Ventilation and Heating Control. One key opportunity to improve common garage ventilation systems is to increase safety through low-level continuous exhaust ventilation as necessary to keep the garage

air pressure below the pressure of the adjacent building areas. This prevents long-term, low-level exposure in other parts of the building. Although improved air sealing between attached garages and adjacent building areas may be another method to improve indoor air quality within the building, further study is needed to determine the means and degree of improvement that might be achieved by addressing this area. More widespread use of optimal make-up air unit controls is the most significant energy savings opportunity in this arena.

Widespread use of optimal make-up air unit controls is the most significant energy savings opportunity for garages.

Continued delivery of design assistance services is an effective way to educate industry players about these opportunities. The complexities of these improvements make them more difficult to effectively promote through many traditional means. Code changes that provide more uniformity in the control requirements (which currently varies by jurisdiction or at least not uniformly interpreted) for garage ventilation systems may also make it easier for designers to more consistently apply optimal ventilation system control strategies.

Lighting. The use of compact fluorescents in high operating hour fixtures within units likely provides the largest untapped opportunity for energy efficiency improvements. The market barrier of central responsibility for replacement might be overcome through concerted efforts to encourage conveniently located retailers to maintain a reasonably priced stock of replacement plug-in type compact fluorescent bulbs.

Appliances. Split incentives have helped make the use of energy efficient appliances rare within apartment units. Flexible approaches, such as incentives paid to developers, provide the best opportunities to achieve significant movement of this market towards high efficiency equipment.

Likewise for coin operated laundry equipment, the split incentives and lease arrangements make it more challenging to effectively promote high efficiency equipment through traditional incentive programs. However, more flexible approaches, such as incentives that are at least partially paid to laundry equipment service companies, may be able to yield very significant energy cost savings.

Survey Respondents, Plan Reviews, and Inspections

The only survey respondent who reported no involvement with common area buildings is a general contractor who deals with only 40 units per year. Therefore the participants in the survey is a good representation of the organizations who deal with these types of buildings. Six common area building project plan reviews were conducted, three of which included design assistance services. On-site inspection of three of the reviewed projects provided additional information.

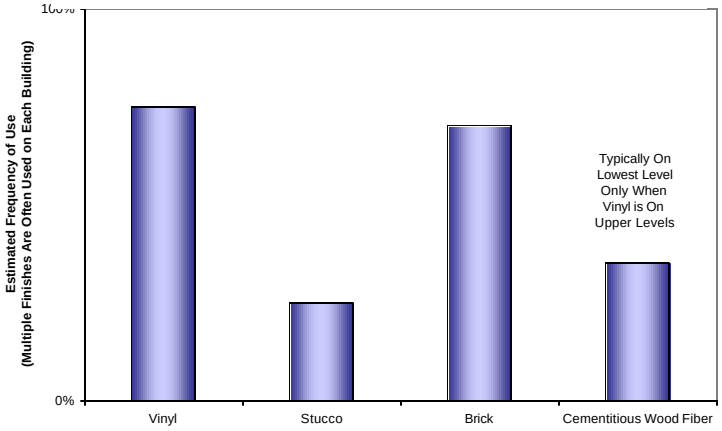
Building Features

Structure and Envelope

Wood frame construction dominates low-rise common area buildings, while concrete and steel construction dominates high-rise common area buildings. Other structural materials are common only for underground garages (typically masonry block exterior with pre-cast concrete floor/ceiling structure

above) and adjacent commercial spaces in mixed use buildings. *Chart 5* reports the estimated frequency of use of various types of building facades in multifamily buildings with common areas.

Chart 5: Exterior Finish Materials in Apartment/Condo Buildings



Insulation

We found significant differences in reported insulation levels specified by various designers, with some reportedly designing to the commercial building energy code level, some to the multifamily energy code level, and others on the more stringent residential energy code. Interviews uncovered apparent inconsistencies in the understanding of which code applies to specific variations of multifamily buildings among both designers and officials that are charged with enforcing the energy code. One code official also reported problems with permit applicants using old versions of the code compliance software tool.

Interviews identified apparent misunderstandings of which code applies to which variation of multifamily buildings.

Analyses of the economics of insulation for low-rise multifamily buildings often disappoint those who are accustomed to the more favorable economics in single-family homes. The reduction in exterior surface area due to long common walls in multifamily buildings makes the envelope insulation levels relatively less important. On the other hand, the relatively low code insulation level requirements for high-rise multifamily buildings may make the economics of increased insulation more favorable.

Interviews gave mixed results of how often the low-rise multifamily energy code requirement for exterior foundation insulation around underground garages is met. Plan reviews indicated more consistent exterior foundation insulation. Insulation is not commonly used between attached common garages and adjacent building areas.

Improper design or construction of details for items such as window flashings and wall-ceiling junction air or vapor barriers often lead to moisture intrusion and condensation problems.[5] Survey results and design review uncovered inadequate specification of these details in new multifamily buildings in Minnesota. This likely contributes significantly to the moisture-related problems reported by more than half of those interviewed. One architect stressed contractor performance as a key factor, stating that no matter how well these details are specified, construction crews will seldom deviate from their past construction methods without very close oversight.

The study also found some interest in the increased use of exterior finish insulation systems (EFIS) as a way to provide better control over sealing of the building shell. However, one general contractor reported

[5] See Canada Mortgage and Housing Corporation, 2001 Building Failures Study for more information.

avoiding EFIS installations at the insistence of his insurance company.

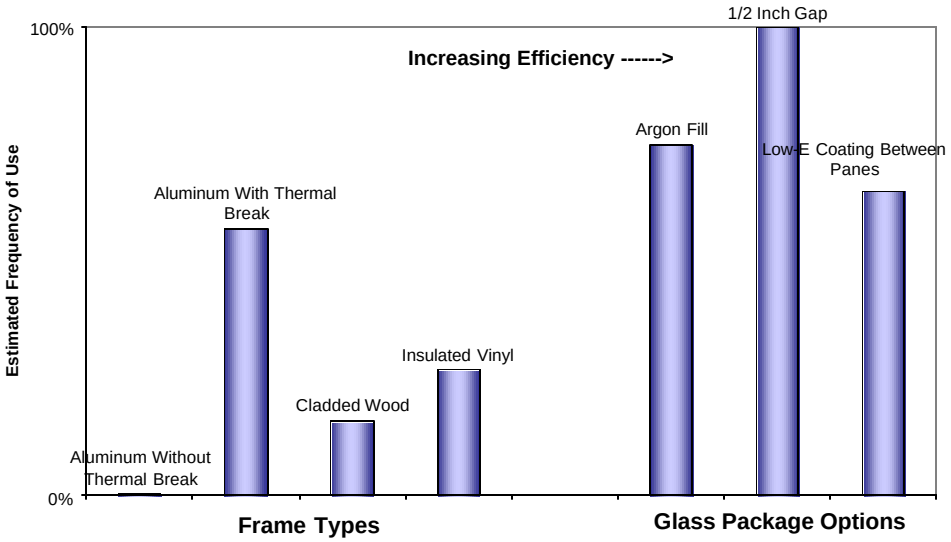
Windows

Minnesota Housing Finance Agency financing program requirements have strongly encouraged moderate market penetration of insulated, all-vinyl window frames. Unfortunately, respondents that reported the use of these windows often indicated regret over their use because of their reputation for poor durability and short product life. Others acknowledge previous problems with early vinyl windows and lower quality manufacturers, but have reported better success with recent projects. Because of some negative experiences, any efforts to promote window frame efficiency improvements should be undertaken with appreciation for the issue of long-term product durability.

Efficient glass package options have become very common, but promotion of energy efficient windows might still be useful. Representative data reported in the 2001 ASHRAE Handbook Fundamentals indicates that low-E coating is necessary to meet the optional 2000 energy code requirements for multifamily buildings in Chapter 7674, along with at least two of the following features: wood/vinyl framing, argon fill, and/or ½ inch spacing between the panes of glass. The stringent optional energy code requirements of Chapter 7674 for multifamily buildings suggest that there isn't dramatic potential for improvements beyond code (without going to much more expensive triple-pane windows).

Chart 6 summarizes the frequency of use of various window features. Note that while the frame types are mutually exclusive, the glass package options are potentially independent of each other.

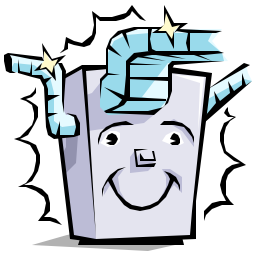
Chart 6: Window Package Features in Apartment/Condo Buildings



However, just getting buildings to meet the optionally higher energy code requirements may be a significant improvement. The survey results suggest that many buildings are not meeting the optional energy code. Many of the plans reviewed did not specify the window glass package or maximum U-value in enough detail to be able to assure that the installed windows would

meet code requirements. Common use of aluminum window frames in reviewed projects also suggests that the windows do not meet the optionally higher energy code levels. Moreover, one set of apartment building plans prepared in 2003 clearly specifies a maximum U-value of 0.47, well above the maximum of 0.37 called for by the optionally higher multifamily energy code. Therefore, multifamily building energy code education efforts geared towards architects, developers, and, code officials could be a fruitful approach to improving building energy efficiency. Providing public recognition of buildings meeting optional code levels may give developers a tool for marketing properties while encouraging more widespread use of energy efficient designs.

Mechanical Systems



Individual HVAC Systems

Although one high volume mechanical engineering firm disagreed, the vast majority of respondents and plan reviews indicated that individual unit heating and air conditioning systems have recently become more common than central boiler systems. Half of the plan-reviewed apartment/condo building projects use individual, packaged units. The availability of PTACs specifically designed for multi-unit buildings and the much lower installed cost of gas piping compared to central boiler systems have reportedly made individual heating systems a lower first-cost option.

In addition, heating costs can be billed directly to tenants and provides more effective cooling of the units. The billing of individual tenants is a significant factor both for the developer and for the project's energy efficiency, because it taps into the ability of the tenant to reduce energy costs through their own behavior.[6] However, developer interest in the tenant billing of energy costs for affordable units varies. Some developers don't individually meter because of specific low-income housing program guidelines or because they strive to make the overall housing costs as affordable as possible.

Drivers for the increasing use of PTACs include lower installed first-cost and the ability to do individual tenant billing easily.

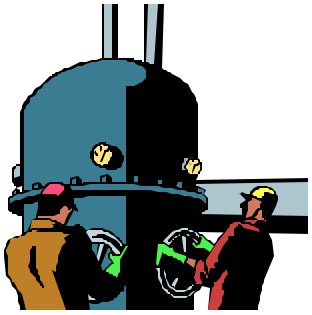
Traditional single-family style HVAC systems used in multifamily buildings have had a tendency towards high efficiencies (because the need for reliably venting has pushed designs towards power venting and lower vent temperatures), the packaged units, however, do not currently offer any heating efficiency options. One of the two major manufacturers has only very recently begun offering one level of increased air conditioner efficiency. It is still not as high as is available with some split system air conditioners.

The market penetration is currently limited by several factors. First, the capacities available are too large for some smaller dwelling units and too small for some larger, high-end condo units. An industry trend towards larger unit sizes still allows some room in the market for single-family type individual systems or central systems. Second, some locations and building designs

[6] "Heating Cost Allocation in Centrally Heated Rental Housing: Energy Conservation Potential and Standards Issues". (1986) by Hewett, Martha J., Helen J. Emslander, and Michael J. Koehler provides more information (available from CEE and in the ACEEE Proceedings of the 1986 Summer Study, pp. 2.141-2.161)

are not compatible with the large exterior grill openings needed for each packaged unit, but can incorporate more remotely located building penetrations for central systems or single-family style heating (and cooling) equipment. Besides the limited efficiency option, the author has concerns about the long-term maintenance and equipment replacement costs associated with individual unit heating systems.

Central Boiler Systems



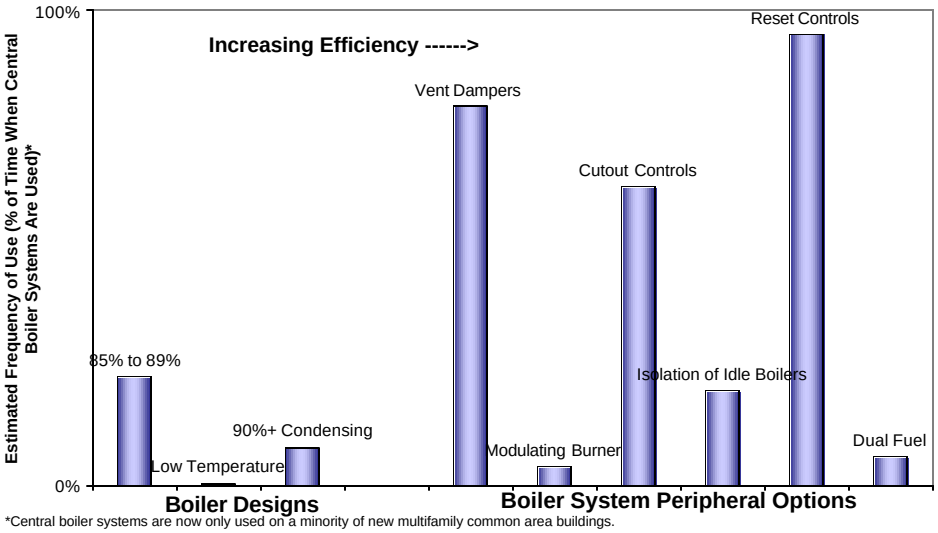
All respondents except one high-volume engineering firm indicated that, although central boiler heating systems had long been the standard method of heating apartment buildings, they are now used less often than individual unit systems. While some reported more frequent use of central boiler systems (and sometimes chiller systems) in high-rise buildings, the interviewees clearly seemed to indicate that packaged through the wall heating and cooling systems are also commonly installed in high-rise buildings. While half of the apartment/condo building projects reviewed use central boiler systems, the projects were self-selected to some degree to get a representation of current boiler system design and construction practices.

While respondents had some awareness of energy cost allocation (ECA) systems (which monitor the heating needs of individual apartments served by central heating systems for billing purposes), no respondents had been involved with a project. The net energy savings of this item was generally not considered as important as the potential to transfer energy cost responsibility to building tenants. When it had been considered for specific projects, the added first cost made the central systems even less competitive with individual unit packaged systems and the logistics of billing individual tenants were considered undesirable. Therefore, ECA systems are not having an effect on the number of central heating systems because of the significant market barriers of first cost and billing logistics.

Where central boiler systems are used, there is significant potential to improve energy efficiency. *Chart 7* summarizes the current market penetration of central boiler system efficiency options among buildings that have central boiler systems.

The first area of efficiency improvement is

Chart 7: Boiler System Options in Apartment/Condo Buildings



*Central boiler systems are now only used on a minority of new multifamily common area buildings.

simply increasing the efficiency of the boilers. Most of the respondents who deal with mechanical systems—especially those who do large number of multifamily projects—indicated that the use of condensing boilers (efficiency of 90% or more) is rare, while only one indicated that boilers in the 85 to 89% efficiency range are commonly used. One respondent wasn't even aware of the availability of large condensing boilers, which tend to be offered by different manufacturers than the market-leading manufacturers that offer high efficiency boiler options in smaller sizes.

Respondents appeared confused over the definition of "high efficiency" for boilers.

A number of respondents who are not as familiar with the mechanical details initially indicated that high efficiency condensing boilers (>90% efficiency) are usually used (when central boiler systems are used), but further inquiry suggested that lower efficiency boilers (~80%) are actually used and that these respondents were confused over the various definitions of "high efficiency" that have been applied to boilers.

A number of important lower-cost energy savings options for central boiler systems have achieved different degrees of market penetration. Respondents reported that the great majority of new boiler installations include outdoor reset controls (which save energy by adjusting the boiler temperature in proportion to the heating load). Unfortunately, serious problems with the outdoor reset controls were found in the two inspected boiler systems. One reset control had been bypassed and was reported by on-site staff to be inoperative, while the other building's control was found to have problematic placement of the outdoor temperature sensor (within an air intake duct that does not always have airflow) and very high settings that provided very little energy savings. Therefore, it appears that commissioning of boiler controls could greatly increase the energy savings that are actually realized.

A great majority of new boiler installations include outdoor reset controls. Unfortunately, serious problems in the installation and operation were found resulting in little or no energy savings.

Interviews indicated roughly 50% use of boiler cutout controls (which save energy by automatically shutting down the heating system in warm weather). While the three reviewed plans did not specify this feature, it was included in one of the two inspected boiler systems. Most respondents indicated little use of energy-saving isolation of idle boilers in multiple boiler systems. This finding was supported by the absence of automatic boiler isolation in plan reviews and inspections (including two systems designed by the one engineer who had reported common use of boiler isolation). Reviewed plans did not specify outdoor cutout controls and this was found to be true for all three reviewed projects with boilers. All respondents agreed that boiler vent dampers are used on the vast majority of new boiler installations, while neither of the inspected boiler installations incorporated them.

Modulating burners and dual-fuel burners—both of which CenterPoint Energy Minnegasco encourages with rebates or special rates—were reportedly rare and only considered applicable to very large buildings. Limited awareness of the commercial availability of packaged propane-air systems as a backup fuel source among many of the mechanical engineers and contractors apparently causes them to

think of fuel-oil as the only backup fuel option and one that only applies to large, power burner boilers. Two respondents mentioned variable speed control of distribution pumps (on very large buildings) as a design improvement that they are interested in pursuing.

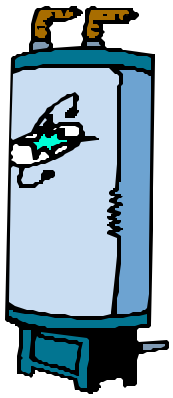
Space Temperature Controls

Setback thermostats are rarely used in apartment buildings for either the individual units or the hallways. Large common walls reduce the potential for significant energy savings relative to single-family homes, and difficulties with user friendliness and tenant education further reduce the practical potential. However, simple and effective setback thermostats can provide savings—especially where good tenant education is possible. Any promotional efforts for setback thermostats should focus on simple to use models.

Hallway heat control offers a lower potential for savings from setback controls, because the halls are reported to be kept only slightly warmer than the minimum temperature that must be maintained. The survey results also indicated that tenant access to hallway heat controls is already restricted in most cases (to prevent tenant adjustment from causing overheating).

Individual Domestic Hot Water Systems

The overwhelming majority of respondents indicated that water heaters are rarely, if ever, located in individual units. One respondent reported that the use of individual domestic hot water systems has not paralleled the growth in individual unit HVAC systems because insurance companies do not like the increased potential for water leaks. Another likely key factor is that typical unit layouts would require significantly more horizontal piping within each unit if individual water heaters were used. By contrast, one mechanical contractor who installs systems in portions of greater Minnesota indicated that most of his projects have an electric water heater in each unit.



Central Domestic Hot Water Systems

The majority of common area buildings use commercial tank-type water heaters with steady-state efficiencies of about 80 percent. While higher efficiency service water heating boilers (e.g. most copper fin-tube type) have long been available for use with separate storage tanks, there are some indications that higher efficiency condensing water heaters that have only recently been offered through leading water heater manufacturers are growing in popularity. The use of large numbers of lower efficiency, residential tank-type water heaters is reportedly very low.

In regards to control issues of central service hot water systems, the mechanical engineers and mechanical contractors provided conflicting reports about the use of aquastat controls to limit the operating time of service hot water recirculation pumps. While the engineers tended to indicate that this energy cost savings control is specified, other interviews indicate that it is often "value-engineered" out of many projects. Plan and on-site review results suggest frequent use of aquastat controls.

Controls that provide energy savings by automatically varying the service hot water temperature throughout the day are reportedly rarely used. It appears that most service hot water systems are designed to

provide service hot water temperatures within the appropriate range between high temperatures that increase scalding risks (and energy use), and low temperatures that allow Legionella bacteria to thrive. However, one designer reported use of an inappropriately low service hot water design temperature and on-site inspections found one inappropriately high service hot water temperature setting.

There was little or no reported use of or interest in the monitoring and allocation of service hot water usage to individual tenants (when central domestic water heating systems are used).

Building Ventilation and Garage Heating

Table 4 summarizes the typical ventilation system design practices for apartment/condo buildings. Many new designs fail to incorporate features that would address the respondents' own reported concerns with mold and moisture issues, despite long-standing recommendations in the ASHRAE Standard 62 for either low-level continuous or higher level intermittent exhaust ventilation of both kitchens and bathrooms (as well as low-level continuous ventilation for the balance of the living space).

While high volume mechanical designers and contractors tended to report nearly exclusive use of only re-circulating hoods in kitchens, a number of smaller volume developers and architects reported use of kitchen exhaust ventilation as typical for their projects. Design review and inspections found only re-circulating kitchen hoods. The study found only infrequent use of other means of increasing ventilation to reduce the potential for moisture problems (e.g. automatic or continuous operation of bath fans or a dedicated fresh air supply for each unit).

The use of central exhaust ventilation systems (e.g. a rooftop fan serving all of the in-unit bathrooms in a stack) is currently rare. The strong tendency to use sidewall venting for at least some of the levels of each building makes it more involved to convert to a central exhaust system. Interview results suggest that high-rises are the only types of projects that incorporate central exhaust systems and that they do so infrequently. This means that continuous exhaust ventilation systems would have to rely on continuously operating individual

Table 4: Typical Apartment/Condo Building Ventilation Design

Area	System Type	Fresh Air Source	Control
Kitchens in Units	Recirculating with Charcoal Filter	Natural Ventilation & Adjacent Hallway	Manual Switch & Opening Windows
Bathrooms in Units	Individual Exhaust Fans	Adjacent Area of Unit	Manual Switch[1]
Other In-Unit Areas	None[2]	Natural Ventilation & Adjacent Hallway	Opening Windows
Hallways	Recircualting with Fixed Fresh Air Opening	Makeup Air Opening	Continuous
Underground Garage	Balanced Fresh Air and Exhaust	Make-Up Air Heater	Carbon Monoxide Detectors, Timer (& Thermostat)

[1] Two respondents reported frequent use of automatic bath fan controls (comes on with light switch) or continuous (low-level) exhaust ventilation (with high-level exhaust activated by a manual switch).
[2] Four respondents reported very infrequent, but increasing use of fresh air supplies dedicated to each unit.

exhaust fans in most buildings.

Building code requirements for sub-ducts, fire/smoke dampers, and/or separation of ducting from different units were reported as key driving forces for the almost universal use of individual exhaust systems. It was also noted that different jurisdictions have different restrictions—or at least different interpretations of the same state restriction—regarding rooftop venting from multiple floors. This makes it more difficult for developers and designers to universally apply an optimal ventilation system design strategy.

CEE's field experiences with multifamily ventilation systems have found numerous problems with equipment selection and installation issues that go beyond the basic design issues of general ventilation system type and nominal air flow rating of ventilation equipment.

Common ventilation problems include:

1) Fans providing less than their rated airflow because of poor performance or incorrect estimations on the effect of the exhaust ductwork,

2) Low air flow because of excessive airflow restrictions in the ductwork—especially with flexible ductwork,

3) Tenant non-use of exhaust fans or covering of registers because of excessive noise or perceived odor transfer, and

4) Duct leakage reducing the effective ventilation at the registers. Some of these previous findings types of findings were echoed in the market study.

Findings include reports of equipment substitution by contractors and very limited detail in the specification of exhaust ducting and the use of the same rating condition for different locations within a building that are expected to have very different duct lengths.

Carbon monoxide (CO) sensing controls are almost universal (although Minneapolis reportedly prefers the use of timers). These controls minimize the energy impact of ventilation while protecting against CO concentrations that might be dangerous for short-term exposure.

Unfortunately, the typical control settings and cycling off of the ventilation system can allow infiltration of garage air into the building while it has concentrations of CO (or nitrogen oxides) that are dangerous for long-term exposure. Although some codes prevent this by requiring that the garage be continually kept at a lower pressure than the building, Minnesota's current building codes do not. It apparently relies on very good air sealing between the garage and the adjacent building. In cold weather, the stack effect within a multistory building and ventilation openings in the underground garage usually create a driving force for air flow from the garage into the building (unless the garage has some level of continuous exhaust ventilation).

Another concern with the universal use of CO sensors is that the periodic service requirements for calibration and/or sensor replacement must be steadfastly addressed

by building management to provide effective long-term control. These concerns are often being partially addressed through the use of timer controls that are used to force continuous operation of the ventilation system during high traffic morning and afternoon hours, or to operate the ventilation system for 15 minutes at a time throughout the day. This interview finding was confirmed by plan review and on-site inspections. It was also noteworthy that both engineers and contractors incorrectly quoted state building code requirements related to ventilation levels and/or control requirements. This may be due in part to different requirements imposed by local jurisdictions that are misunderstood to be applicable state-wide.

CEE's investigation was not able to quantify the potential impact of improving sealing between garages and adjacent building areas. CEE's previous field experience has provided anecdotal evidence that typical construction of pre-cast concrete ceilings above underground garages allows for significant air leakage to the building through the cracks between the pre-cast sections. However, gathering detailed, accurate information about this issue during interviews and project reviews was more difficult than with many other issues.

Underground garage heating and ventilation was found to be inseparably linked in most building designs. Interviews found that the only heating source for most new underground garages is a direct-fired make-up air heating unit that brings in 100% fresh air whenever it operates. The high efficiency (~89%) of this direct-fired heat source makes it very cost-effective for tempering make-up air when the ventilation system is purging vehicle exhaust gases from the garage. However, many new garages have a thermostat that operates the make-up air heater when the space temperature drops below 50°F. In some circumstances this design can greatly increase the energy use associated with heating the garage. This is because cold make-up air must be heated from a potentially very cold outdoor temperature. Conversely, a re-circulating furnace or unit heater installed in the garage would start with air that is already approximately 50°F. Since a majority of underground garages seldom need supplemental heat (beyond tempering of ventilation air and the heat gain from the building above), the energy use increase associated with this design approach is expected to be modest in many situations. However, it can be very substantial in situations where a garage has a relatively large amount of area that is exposed to the outdoors. One commonly available control option that greatly reduces energy use is the boosting of the make-up air heater's supply temperature when the thermostat in the garage calls for heat. This moderates the energy impact by reducing the time that the make-up air unit must operate—and thereby the amount of cold air brought into the garage. Interviews found that an alternate approach of using unit heaters that re-circulate air within the garage (rather than make-up air heaters that heat up cold outside air) is seldom used.

The degree to which garages are heated has a large impact on the amount of energy required to heat them. The 50°F that is maintained in most garages is higher than typically necessary to meet tenant needs; however, the reportedly universal location of wet sprinkler system piping and plumbing waste piping in the garages has been

reported as requiring (by code) a minimum temperature of 50°F to provide a safe cushion against possible freeze-up.

Although the high ventilation rates required for garages could make them good heat recovery candidates, the current market penetration of garage ventilation heat recovery systems was universally reported to be zero. The current practices of having little or no ductwork in the garages and generally locating the make-up air and exhaust equipment at opposite ends of the garages make the first costs relatively higher than roughly 20 years ago when heat recovery systems reportedly had some market penetration.

Current market penetration of garage ventilation heat recovery systems is reported to be zero.

Lighting

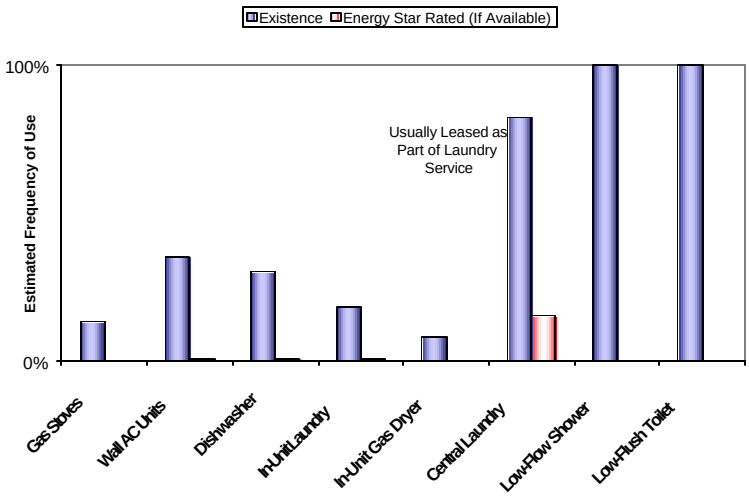
Although many respondents did not have detailed knowledge of the lighting systems, some general trends were fairly clear. Compact fluorescent lighting appears to dominate interior common area lighting with the use of incandescent lighting in these areas being limited primarily to specialty fixtures (e.g. accent lighting). However, there is very little use of anything other than incandescent lighting within each of the units and the use of incandescent exterior lighting (near entries) is still somewhat common.

Primary drivers preventing the use of other types of lighting within the units are that the tenants typically benefit from the energy cost savings or that developers reportedly don't feel that they can expect tenants to replace any type of light other than an incandescent screw-in bulb. In the latter case, developers don't want to have the building maintenance staff responsible for replacing bulbs within the units. Another factor limiting the use of compact fluorescent exterior lighting is a reputation for poor cold weather performance. It does appear that LED exit lights—which provide both energy savings and greatly extended bulb life—have come to dominate the new construction market.

In-Unit Equipment

Chart 8 shows the estimated market penetration of various in-unit appliances and options. Cooking equipment in apartment buildings is almost exclusively electric. In luxury condominiums, gas cooking equipment (typically only ranges or counter-top barbecues) is infrequently offered as an option. When it is used, exhaust ventilation is often provided. The near absence of gas-fired stoves reduces the perceived potential for indoor air quality risks.

Chart 8: Appliances and Fixtures in Apartment/Condo Buildings



The market penetration of high efficiency appliances has been very low to date. This is understandable in rental units because the electrical part of the energy saving benefits will be captured by the tenants rather than the building owner. But for some appliances there is a significant amount of savings due to lower hot water usage (ie. dishwashers and in-unit clothes washers) that may result in savings for the building owner. Developers of low-income housing may often be more interested in taking steps to minimize the expenses of their tenants and will therefore consider such options. In condominium applications, the tenant may be given the opportunity to select the appliances, but this is often done within a fixed appliance allowance that may not allow for high-efficiency upgrades.

The market penetration of high efficiency appliances has been very low to date

The surveys uncovered some other noteworthy trends in appliances and in-unit equipment. Although one developer chooses to purchase laundry equipment outright, it is much more common for a contracted laundry service to provide the laundry equipment. However, since the laundry service has no direct incentive to reduce the utility costs of the equipment, the lowest efficiency equipment is often used. There were mixed indications that in-unit laundry equipment and electric dryers may be more common throughout Greater Minnesota. A trend towards more in-unit appliances in higher rent apartments was also noted.

Many mistakenly reported that low-flow showers and faucets are required by code. This calls into question reports of high market penetration of low-flow fixtures

The market study wasn't able to definitively determine the market penetration of low-flow plumbing fixtures because of an apparent lack of detailed knowledge among those interviewed, and a lack of specific information in design documents. Respondents universally reported exclusive selection of low-flow plumbing fixtures (where the owner directly pays for the equipment and clearly realizes most of the savings benefits in rental units). Many also mistakenly reported that low-flow showers and faucets are required by code. Review of the plumbing code and an inquiry with the Minnesota Department of Health confirmed that minimum flow requirements apply to these fixtures, but that there are no mandated upper limits on the flow rates. The misunderstanding of code requirements calls into question reports of high market penetration for low-flow fixtures. The one apartment building plan review that included detailed plumbing fixture data evaluation confirmed the specification of low-flow fixtures that were at or just above the minimum flow requirements.

Finally, it appears that the potential for scalding injuries could be dramatically reduced through equipment improvements. Current plumbing code requirements for anti-scalding valves only guarantee protection against sudden shower temperature changes due to pressure fluctuations. It does not require protection against the common scalding injuries caused by the filling of a bathtub with water that is too hot. While temperature limiting valves are readily available, limited investigation into current practices suggests that designers allow contractors to decide whether to use either pressure variation protection valves or temperature limiting valves. Further investigation into this issue is recommended before undertaking any specific promotional action.

Variations within the Common Area Building Market

CenterPoint Energy Minnegasco's Service Territory and All of Minnesota

The survey results suggest that modest differences in building design occur in Greater Minnesota, such as slightly lower cost elements (e.g. vinyl siding throughout instead of the use of more durable, cementitious board siding on the lower level). A trend towards more appliances within the individual units, and the more widespread use of electric water heaters and dryers, was also suggested in the survey results. Perhaps the most critical difference is that new multifamily buildings in Greater Minnesota tend to have a lower level of oversight from design professionals dues to the typically long distance between the design offices and the construction site. This is likely to lead to more differences between the design intent and the actual finished building and may contribute to building performance problems.

Greater Minnesota tends to have a lower level of design and construction oversight

Affordable Housing and Luxury Housing

The survey found some of the expected trends in luxury housing, such as larger unit areas per bedroom, more appliances, and more setback thermostats. However, survey respondents generally reported little or no difference in the primary building equipment design and construction practices. One institutional difference is that the energy costs are borne by the developer in some of the low-income housing projects even when individual HVAC systems are used.

High Rise and Low-Rise

The structural use of masonry and/or reinforced concrete is the most striking difference between high-rise and low-rise apartment/condo buildings. High rise buildings also tend to have much lower envelope insulation levels. Significantly lower window performance and envelope insulation levels for these buildings are permitted as they fall under the commercial building section of the energy code. Similarly, aluminum frame windows are reportedly used more frequently in high-rise buildings than in low-rise buildings.

Centralized mechanical systems tend to be used more frequently in high-rise buildings and their larger size often makes the use of dual fuel systems potentially viable. Centralized mechanical systems that are seen more frequently in high-rise buildings include: boiler systems, chillers, and rooftop exhaust ventilation equipment serving the bathrooms or kitchens of multiple units (which are stacked and often arranged so that one shaft can serve back-to-back kitchens or bathrooms on a single floor).

Survey respondents generally reported little or no difference in the primary building equipment design and construction practices between affordable and luxury housing.

TOWNHOMES

Summary

General Market Conditions

Townhomes consist of multi-unit residential buildings with the vertical section of each unit extending from the footings through to the roof, with an exposed exterior facade on two or three sides of every unit.

The estimated annual new construction of townhomes amounts to 4,200 housing units served by CenterPoint Energy Minnegasco and 7,100 housing units statewide. Survey respondents generally expect an overall decrease in the amount of new construction over the next two years for townhomes, along with other types of multifamily buildings. A weighted average of results from survey respondents that provided sound information about the balance between affordable and other multifamily projects indicated that just over half of the multifamily units they are involved with are affordable housing units.[7]

Analysis of data from the Twin Cities metro area suggests that new townhome construction generally tends to outpace the construction of other types of multifamily units within the faster growing areas. The analysis also indicates the importance of townhome construction in established communities. The overall volume of townhome construction in the counties with more established populations outnumbered the volume of townhome construction in the counties that are experiencing much more rapid new construction per capita.

Building concerns most often reported are related to mold and moisture issues

Four townhome projects that had plans reviewed averaged 1,404 square feet of building area (excluding garages). When only the three affordable townhome projects are considered, the average drops to 1,172 square feet per unit.

Industry representatives reported problems related to mold and moisture issues more frequently than any other type of problem. Only a small number of design and construction teams reported making specific envelope design and/or ventilation system design changes to systematically address these issues. It appears that the majority of organizations continue to repeat practices that have not reliably prevented these problems.

During discussions of insulation levels used, various designers and contractors reported different information about which sections of the energy code apply to multifamily buildings. Discussions regarding this issue suggested that different code jurisdictions

[7] This represents about 1,500 new affordable multifamily units per year for just the survey respondents. Extrapolating this ratio to all new common area multifamily buildings served by CenterPoint Energy Minnegasco would yield an estimated 2,200 new affordable housing units per year in townhomes.

may categorize multifamily buildings differently in terms of the energy code. On the other hand, the plan reviews consistently showed insulation levels at, or slightly above, the low-rise multifamily building code levels. The payment of utility bills by the eventual townhome occupants gives developers little direct incentive to increase their investment in energy efficiency improvements (except for those improvements that provide some benefit besides energy cost savings).

Key Opportunities & Barriers

Moisture and Mold Issues. The market study identified the key opportunities for improving building durability as:

1) improving the design and construction of envelope details (e.g. window flashings, air barrier junction and penetration sealing)
2) improve the effectiveness of ventilation to prevent moisture problems.

Possible steps that could be taken include:

- Promote existing research results and best-practices guides (such as those that have been developed by the Canada Mortgage and Housing Corporation (CMHC)) to provide guidance in specifying envelope details.
- Promote improved ventilation system design to prevent the build-up of moisture in the apartment units.
- Fund or otherwise encourage increased oversight of the construction process (i.e. commissioning) to make sure that the design intent is successfully implemented—especially where more detailed or less common design specifications are used.

The program's continued delivery of design assistance services, of which this report is a part, provides a practical platform for the promotion of these improvements. Presentations to various trade groups provide another possible mode of promotion for these items.

Unit Heating and Cooling Systems. Townhomes almost exclusively use an individual heating and cooling system for each unit. Equipment types and designs are typically the same as those used in single-family homes. About one-third of the heating systems are high efficiency condensing furnaces. Venting flexibility leads to the selection of high efficiency furnaces more often than energy cost savings. However, some developers feel that the energy efficiency marketing advantage alone provides enough benefit to justify the added initial investment. Rebates and promotion of the venting flexibility of high efficiency furnaces to building designers both represent important opportunities to encourage the selection of high efficiency equipment.

Domestic Hot Water Systems. Separate, residential tank-type water heaters serve a majority of townhomes. These water heaters most often just meet the minimum efficiency requirements even though more efficient water heaters of similar type and size are available.

The few townhome projects that are served by central domestic hot water systems commonly use either high efficiency condensing type (>90%) water heaters (primarily due to venting flexibility) or standard efficiency models (~80%).

Effective promotional opportunities for high efficiency water heaters include:

1) continued demonstration of the energy cost saving benefits for specific projects;
2) general educational promotion of high efficiency condensing equipment's venting flexibility and energy savings; and
3) targeted equipment rebates for the higher efficiency levels within the different water heater types (residential for individual units or commercial for central systems).

Lighting. The use of compact fluorescents in high operating hour fixtures within units likely provides the largest untapped opportunity for energy efficiency improvement in townhomes. The market barrier of central responsibility for replacement might be overcome through concerted efforts to encourage conveniently located retailers to maintain a reasonably priced stock of replacement plug-in type compact fluorescent bulbs.

Interviews uncovered apparent inconsistencies in the understanding of which part of the energy code applies to specific variations of multifamily buildings.

Appliances. The split incentives make the use of energy efficient appliances in townhomes rare. Flexible approaches, such as incentives paid to developers, provide the best opportunities to achieve significant movement of this market towards high efficiency equipment.

Survey Respondents, Project Reviews and Inspections

Virtually all of the survey respondents deal with townhomes. Only one, a relatively low-volume design engineer that deals with ~375 units per year, reported no involvement with townhome buildings. Four townhome project plan reviews were conducted, two of which included design assistance services. In addition, On-site inspections were conducted on two of the reviewed projects.

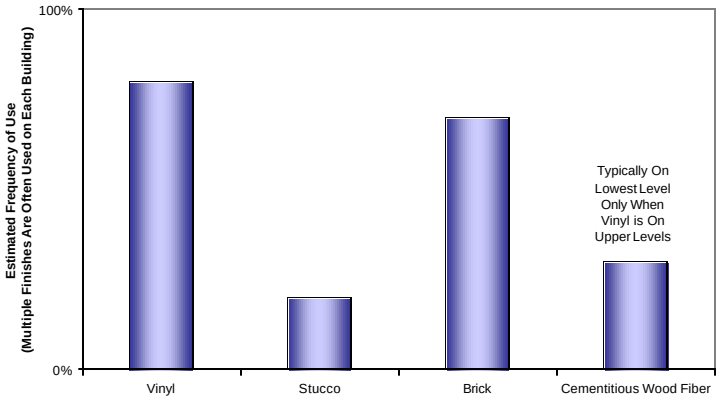
Building Features

Structure and Envelope

Wood-frame construction dominates this market. Other structural materials are common only in underground garages (typically masonry block exterior with pre-cast concrete floor/ceiling structure above) and adjacent commercial spaces in mixed use buildings. *Chart 9* shows the estimated frequency of use of various types of building exterior finishes.

The study found significant differences in reported insulation levels specified by various designers. Some reported designing to the commercial building energy code level, some to the multifamily energy code level, and others on the more stringent residential energy code. Interviews uncovered apparent inconsistencies in the understanding of which code applies to specific variations of multifamily buildings among both designers and code officials. One code official also reported problems

Chart 9: Exterior Finish Materials in Townhome Buildings



with permit applicants using old versions of the code compliance software tool.

Insulation

The survey found that insulation between the buildings and attached individual garages is typical and that there is seldom insulation around the exterior of these garages (which are generally unheated). Analyses of the economics of insulation upgrades often disappoint those who are accustomed to the more favorable economics in single-family homes. The reduction in exterior surface area due to long common walls in townhomes makes envelope insulation levels relatively less important.

Improper design or construction of details for items such as window flashings and air or vapor barriers often lead to moisture intrusion and condensation problems.[8] Survey results and design review showed that inadequate specification of these details is common for new multifamily buildings in Minnesota. As an example of this, one local code official reported directly observing problems with significant air infiltration through openings in the walls separating units. Inadequate detailing likely contributes significantly to the reports of moisture-related problems that were obtained from more than half of those interviewed. One architect stressed contractor performance as a key factor in this issue, stating that no matter how well these details are specified, construction crews will seldom deviate from their past construction methods without very close oversight.

Inadequate specification of construction details is of concern. However, without close oversight, construction crews will seldom deviate from historical practice.

[8] See Canada Mortgage and Housing Corporation, 2001 Building Failures Study for more information.

The study also found some interest in the increased use of exterior finish insulation systems (EFIS) as a way to provide better control over sealing of the building shell. On the other hand, one general contractor reported avoiding EFIS installations at the insistence of his insurance company.

Windows

Minnesota Housing Finance Agency financing program requirements have strongly encouraged moderate market penetration of insulated, all-vinyl window frames. Unfortunately, respondents who reported the use of these windows often indicated regret over their use because of their reputation for poor durability and short product life. Others acknowledge previous problems with early vinyl windows and lower quality manufacturers, but have reported better success with recent projects. Because of some negative experiences, any efforts to promote window frame efficiency improvements should be undertaken with appreciation for the issue of long-term product durability.

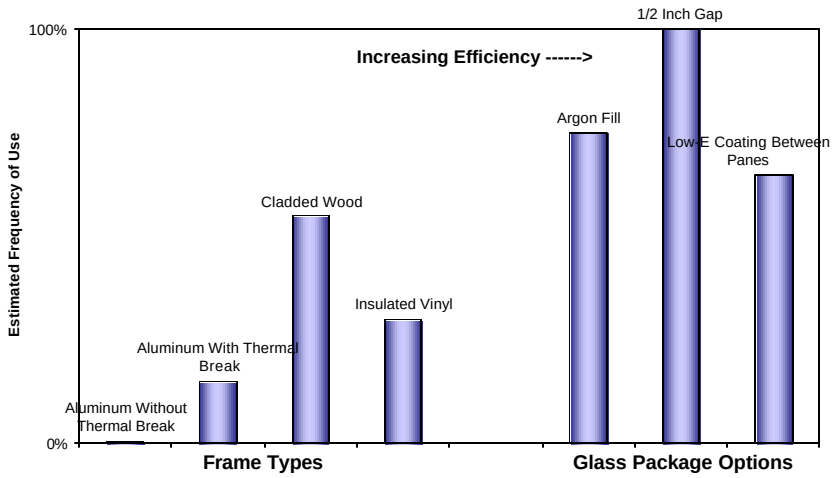
Efficient glass package options have become common, but promotion of energy efficient windows might still be useful. Representative data reported in the 2001 ASHRAE Handbook Fundamentals indicates that low-E coating is necessary to meet the optional 2000 energy code requirements for multifamily buildings in Chapter 7674, along with at least two of the following features: wood/vinyl framing, argon fill, and/or ½ inch spacing between the panes of glass. The stringent optional energy code requirements of Chapter 7674 for multifamily buildings suggest that there isn't dramatic potential for improvements

beyond code (without going to much more expensive triple-pane windows).

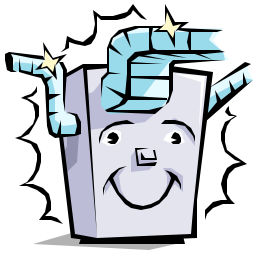
Chart 10 summarizes the estimated frequency of use of various window features in townhomes. Note that while the frame types are mutually exclusive, the glass package options are potentially independent of each other. However, manufacturers tend to offer standard combinations of glass package options.

However, just getting buildings to meet the optionally higher energy code requirements may be a significant improvement as survey results suggest that this is not occurring. Many plans reviewed did not specify the window glass package or maximum U-value in enough detail to be able to assure that the installed windows would meet code requirements and the common use of aluminum window frames in reviewed projects suggests that the windows do not meet the optionally higher energy code levels. Therefore, taking steps to require or encourage buildings to meet the higher, optional code level could be a fruitful approach to improving building energy efficiency. Providing public recognition of buildings meeting optional code levels may give developers a tool for marketing properties while encouraging more widespread use of energy efficient designs.

Chart 10: Window Package Features in Townhome



Mechanical Systems



Individual HVAC Systems

Single-family style furnace and air-conditioning systems dominate the townhome market. This allows for great flexibility in the selection of the efficiencies for the furnace, the indoor air conditioning coil, and the outdoor condensing unit.

Roughly one-third of new townhomes built in Minnesota install high efficiency condensing furnaces. The flexibility of being able to vent condensing furnaces through something other than a standard vertical chimney contributes significantly to their selection. Even though the developers do not directly receive savings from high efficiency furnaces, townhome buyers sometimes have input into this decision and some developers also view high efficiency furnaces as an important item for marketing of the townhomes.

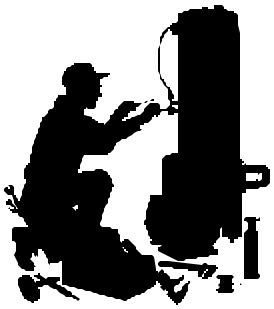
Getting buildings to meet the optionally higher energy code requirements may be a significant improvement.

Space Temperature Controls

Townhomes seldom include setback thermostats. The large common walls somewhat reduce the potential for significant energy savings relative to single-family homes and difficulties with user friendliness and tenant education further reduce the practical potential. However, simple and effective setback thermostats can provide savings—especially where good tenant education is possible. Any promotional efforts for setback thermostats should focus on simple to use models.

Individual Domestic Hot Water Systems

Individual, residential tank-type water heaters within each unit serve the majority of new townhomes. Within individual units, gas-fired water heaters that minimally meet code efficiency requirements overwhelmingly dominate the Twin Cities metro area. However, electric water heaters also see frequent use in at least portions of greater Minnesota.



Central Domestic Hot Water Systems

The central domestic hot water systems that serve only a minority of new townhomes usually use commercial, tank-type water heaters of higher efficiency than the residential water heaters used within individual units. While the water heater efficiencies are higher than the efficiencies of in-unit residential water heaters, the hot water distribution piping losses at least partially offsets the equipment efficiency difference.

Central water heating systems usually use either commercial tank-type water heaters with steady-state efficiencies of about 80% or high efficiency, condensing water heaters with steady-state efficiencies of over 90%. High efficiency, near condensing service water heating boilers (e.g. copper fin-tube type) with steady-state efficiencies of ~84% to 89% have long been available, but reportedly see only infrequent use in multifamily new construction. High efficiency, condensing water heaters enjoy higher market penetration because of their venting flexibility, which allows installation without a traditional large, vertical chimney.

Central service hot water control is also an important energy efficiency issues. The mechanical engineers and mechanical contractors provided conflicting reports about the use of aquastat controls to limit the operating time of service hot water recirculation pumps. While the engineers tended to report specification of this energy cost savings control, it appears that subsequent "value-engineering" takes this out of many projects. Interviews found only rare use of controls that provide energy savings by automatically varying the service hot water temperature throughout the day.

Most interviewees reported appropriate service hot water design temperatures, but one designer reportedly designs systems for hot water tap temperatures in the range where Legionella bacteria can thrive. Those questioned reported little or no interest in the monitoring and allocation of service hot water usage to individual units served by central domestic water heating systems.

Building Ventilation

Table 5 summarizes the typical ventilation system design practices for townhomes. Many new designs fail to incorporate features that would address the respondents'

Table 5: Typical Townhome Ventilation Design

Area	System Type	Fresh Air Source	Control
Kitchens in Units	Recirculating Hoods or Individual Exhaust Fans	Natural Ventilation	Manual Switch & Opening Windows
Bathrooms in Units	Individual Exhaust Fans	Adjacent Area of Unit	Manual Switch[1]
Other In-Unit Areas	None[2]	Natural Ventilation	Opening Windows

[1] Two respondents reported frequent use of automatic bath fan controls (comes on with light switch) or continuous (low-level) exhaust ventilation (with high-level exhaust activated by a manual switch).
[2] Four respondents reported very infrequent, but increasing use of fresh air supplies dedicated to each unit and one respondent reported reportedly uses a heat recovery ventilator in every townhome.

own reported concerns with mold and moisture issues despite the long-standing recommendations in ASHRAE Standard 62 for either low-level continuous or higher level intermittent exhaust ventilation of both kitchens and bathrooms (as well as low-level continuous ventilation for the balance of the living space).

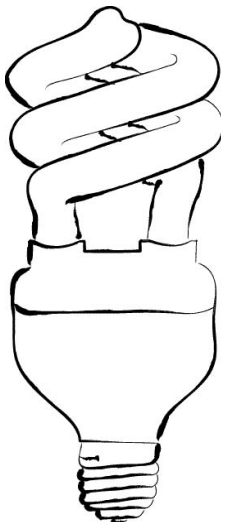
While high volume mechanical designers and contractors tended to report nearly exclusive use of re-circulating hoods in kitchens, a number of developers and architects reported the use of kitchen exhaust ventilation as typical for their projects. Design review and inspections found common use of both approaches. The study found only infrequent use of other means of increasing ventilation to reduce the potential for moisture problems (e.g. automatic or continuous operation of bath fans or a dedicated fresh air supply for each unit).

CEE's field experiences with multifamily ventilation systems have found numerous problems with equipment selection and installation issues that go beyond the basic design issues of general ventilation system type and nominal air flow rating of ventilation equipment. Common problems include:

1) Fans providing less than their rated airflow because of poor performance or incorrect estimations on the effect of the exhaust ductwork,
2) Low air flow because of excessive airflow restrictions in the ductwork—especially with flexible ductwork,
3) Tenant non-use of exhaust fans or covering of registers because of excessive noise or perceived odor transfer, and
4) Duct leakage reducing the effective ventilation at the registers.

Some of these previous findings types of findings were echoed in the market study. Findings include reports of equipment substitution by contractors and limited detail in the specification of exhaust ducting and the use of the same rating condition for different locations within a building that are expected to have varying duct lengths.

Lighting



Incandescent lighting dominates within each of the units (with the occasional exception of fluorescent fixtures in kitchens), and the use of incandescent exterior lighting (near entries) still generally pervades the more efficient, longer-lasting types of lighting.

A number of market factors work against the use of high efficiency

lighting in townhomes.

- Tenants would typically realize the energy cost savings for additional investment that must be made by the developer.

- Developers reported feeling that they can not expect tenants to replace any type of light other than an incandescent screw-in bulb. In this case, they don't want to have the building maintenance staff responsible for replacing bulbs within the units.

Some interviewees reported a history of very poor performance of compact fluorescent exterior lighting in cold weather, while one reported trouble-free cold weather performance in newer projects.

In-Unit Equipment

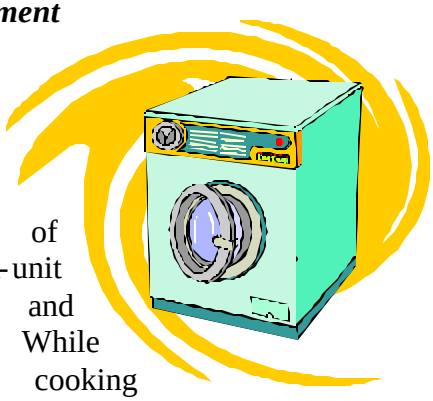


Chart 11 shows the estimated market penetration of various in-unit appliances and options. While electric cooking equipment dominates, a significant minority of townhomes incorporates gas ranges or counter-top barbecues, particularly in luxury townhomes. Kitchen exhaust ventilation usually accompanies gas cooking equipment. Mixed reports suggested more common use of electric dryers in Greater Minnesota.

We found very little market penetration of high efficiency appliances. The tenant's realization of the electrical part of the energy costs savings gives the developer little incentive to install more efficient appliances. Initial buyers may make appliance selection in owner-occupied townhomes, but often within a fixed appliance allowance that may not allow for the upgrade to efficient equipment. Many respondents also reported a pattern towards more in-unit appliances in higher end units.

In the rare townhome building with a central coin-operated laundry facility, the use of a contracted laundry service usually works against the selection of high-efficiency equipment. The laundry service companies that lease out most of the coin-operated equipment in multifamily buildings do not directly benefit from reduced energy and water costs.

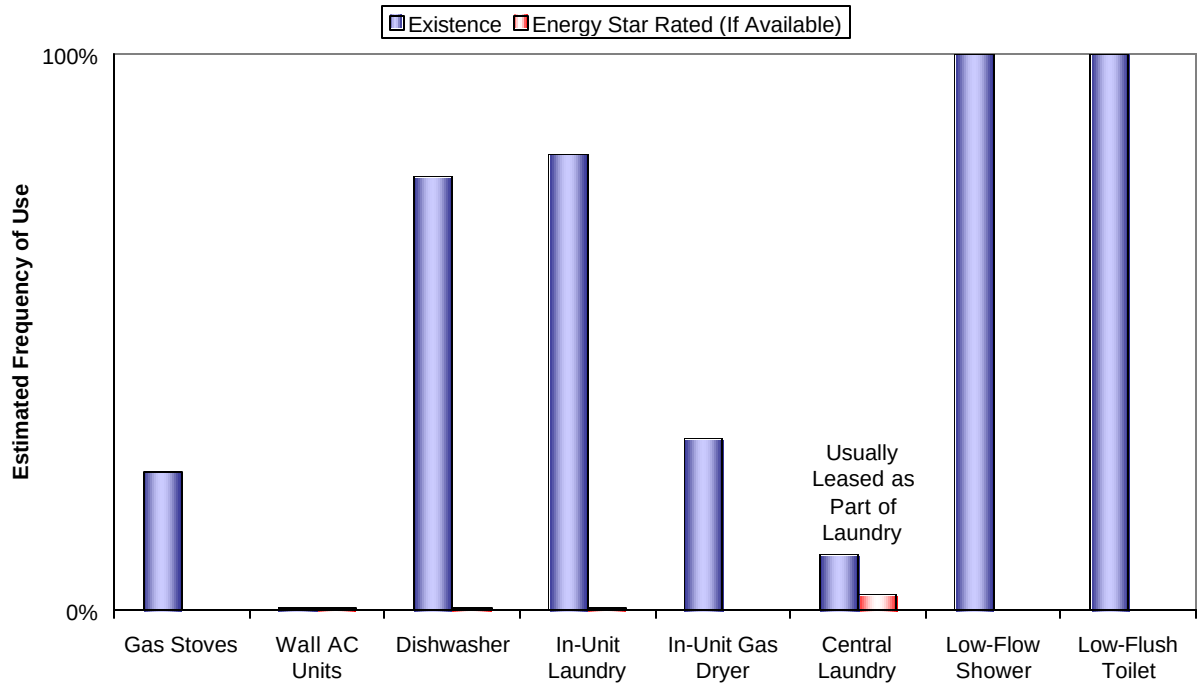
The survey found little market penetration of high efficiency appliances.

The market study wasn't able to definitively determine the market penetration of low-flow plumbing fixtures because of an apparent lack of detailed knowledge among those interviewed, and a lack of specific information in design documents. Respondents universally reported exclusive selection of low-flow plumbing fixtures (where the owner directly pays for the equipment and clearly realizes most of the savings benefits in rental units), but many also mistakenly reported that low-flow showers and faucets are required by code. Review of the plumbing code and an inquiry with the Minnesota Department of Health confirmed that minimum flow requirements apply to these fixtures, but that there are no mandated upper limits on the flow rates. The misunderstanding of code requirements calls into question the face-value reports of high market penetration for low-flow fixtures.

Finally, it appears that the potential for scalding injuries could be dramatically reduced through equipment improvements. Current plumbing code requirements for anti-scalding valves only guarantee protection against sudden shower temperature changes due to pressure fluctuations, and do not require protection against the very common scalding injuries caused by filling of a tub with water that is too hot. While temperature limiting valves are readily available, limited investigation into current practices suggests that designers also allow contractors to decide whether to use either pressure variation protection valves or temperature limiting valves. Further investigation into this issue is recommended before deciding to undertake any specific promotional action.

Many mistakenly reported that low-flow showers and faucets are required by code, which calls into question reports of high market penetration for low-flow fixtures

Chart 11: Appliances and Fixtures in Townhome Buildings



Variations within the Townhome Building Market

CenterPoint Energy Minnegasco's Service Territory and All of Minnesota

The survey results suggest that modest differences in building design occur in Greater Minnesota, such as slightly lower cost elements (e.g. vinyl siding throughout instead of the use of more durable, cementitious board siding on the lower level). The survey results also suggested a trend towards more appliances within the individual units, and the more widespread use of electric water heaters and dryers in Greater Minnesota.

Greater Minnesota tends to have a lower level of design and construction oversight

The study found that a lower level of construction oversight from design professionals in Greater Minnesota is probably the most critical difference in the design and construction process. The typically long distance between the design offices and the construction sites causes the lower level of oversight. This likely leads to more differences between the design intent and the actual finished building, which may lead to building performance problems.

Affordable Housing and Luxury Housing

The survey found some of the expected differences in luxury housing, such as larger unit areas per bedroom, more appliances, and more setback thermostats. However, the survey respondents generally reported little or no differences in the primary building equipment design and construction practices.

Survey respondents generally reported little or no difference in the primary building equipment design and construction practices between affordable and luxury housing

VARIATIONS WITHIN THE MULTIFAMILY HOUSING MARKET

TOWNHOMES VS COMMON AREA BUILDINGS

While the widespread use of individual unit heating/cooling systems in apartment/condo buildings has made these two building types more similar in terms of the institutional factors affecting energy efficient equipment selection and energy efficient operation (i.e. the developer has less direct incentive to reduce energy costs, while the tenant has a direct incentive for energy-efficient behavior) there are still some important differences in HVAC equipment. The use of single-family style equipment in townhomes currently offers greater opportunities for energy efficient improvements with simple equipment changes (i.e. the installation of high efficiency furnaces or air conditioners). On the other hand, the shortage of efficiency options for the PTACs that have become so common in apartment/condo buildings currently limits options for improving their heating system performance.

In contrast, the dominance of central service hot water systems in common area buildings provides significant energy cost-savings opportunities through the use of high efficiency, condensing water heaters.

CENTERPOINT ENERGY MINNEGASCO'S SERVICE TERRITORY VS ALL OF MINNESOTA

The survey results suggest that modest differences in building design occur in Greater Minnesota, such as slightly lower cost elements (e.g. vinyl siding throughout instead of the use of more durable, cementitious board siding on the lower level). A trend towards more appliances within the individual units, and the more widespread use of electric water heaters and dryers, was also suggested in the survey results. Perhaps the most critical difference is that multifamily buildings built in Greater Minnesota tend to have a lower level of oversight from design professionals—because of the typically long distance between the design professionals' offices and the construction site. This is likely to lead to more differences between the design intent and the actual finished building, which may lead to building performance problems.

AFFORDABLE HOUSING VS LUXURY HOUSING

The survey found some of the expected trends in luxury housing, such as larger unit areas per bedroom, more appliances, and more setback thermostats. However, the survey respondents generally reported little or no differences in the primary building equipment design and construction practices. One institutional difference is that some of the low-income housing projects have the energy costs borne by the developer—even when individual HVAC systems are used.

DESIGN AND CONSTRUCTION PROCESS

CONSIDERATION OF DESIGN ALTERNATIVES

The multifamily building project design process seldom incorporates a systematic evaluation of multiple design options that improve building performance. Developers have tended to give direction only for very specific items that tend to be highly visible (e.g. plumbing fixtures and building finish materials) or in a very general way (e.g. the use of packaged, through the wall furnace/air conditioning units in each apartment). Design professionals have, in turn, tended to replicate their previously used design approaches without bringing energy efficient design options to the attention of developers. Likewise, contractors have tended to present design alternatives that provide first cost savings rather than long-term building performance improvement. Prior to the implementation of the design assistance program, systematic evaluation of building performance options has generally taken place only when one of the following three events has occurred:

1) Building code changes were enacted,

2) First-hand building performance problems were experienced with previous similar projects, or

3) New products provided opportunities for either an overall reduction in project cost or better performance without a significant increase in cost.

When specific design options are evaluated, the overwhelming majority of individuals interviewed indicated that the first cost of design alternatives is far and away the most important consideration in most situations. Even though the vast majority of developers reportedly hold onto properties for more than three years, the long-term operating costs or life-cycle costs for design alternatives have generally not been evaluated in any consistent, systematic manner.

The multifamily building project design process seldom incorporates a systematic evaluation of multiple design options.

Since developers and designers generally have not had the resources available to make accurate assessments of energy costs for design alternatives, it is expected that the availability of design assistance services will be another event that causes at least some developers and designers to take a systematic look at various design options. Once they successfully incorporate specific building performance improvements into a project, it is expected that they will continue to those measures in a majority of similar future projects. While financing or other limitations may prevent the implementation of some improvements that are clearly demonstrated to provide a very attractive investment opportunity for long-term owners of a project, the information learned can often be incorporated into future, similar projects.

EFFECTS OF DESIGN PROCESS VARIATIONS

While it is clear that there is a mixture of projects that are either: a) contracted as design-build for the entire project (design-build) or b) designed by an architect prior to general contractor involvement (design-bid), the interviews provided conflicting information about the proportion of each. The responding developers, architects and general contractors tending to deal with

moderately low numbers of multifamily units indicated little or no involvement with design-build projects. Conversely, the responding mechanical engineers and subcontractors tending to deal with more projects all indicated that a majority of projects are complete design-build projects.

The mechanical and electrical system design processes also had inconsistencies reported in the balance between whether these specialties were handled as design-build or design-bid. These inconsistencies were spread across the various types of organizations represented and most of the individual respondents indicated a more moderate balance between the two processes. This is apparently related to differences in the project financing sources as multiple respondents reported that state and/or federal financing agencies have specific requirements that the mechanical design work is not contracted through the organizations contracted for mechanical construction. When these requirements do not apply, the tendency is for the specialty design work to be subcontracted through the mechanical and electrical subcontractors as part of design-build contracts. Organizations with slightly different market niches have different experiences in this regard.

Delegating design work to subcontractors tends to cause designs to focus on the lowest first cost design that meets minimal code requirements

The typically practiced delegation of specialty design work through subcontractors tends to cause design engineers to focus on the lowest first cost design that meets minimal code requirements and the basic mechanical system requirements as dictated by the architect and developer. The specifics of system requirement needs are typically very minimal beyond indicating the general type of system desired (e.g. PTACs vs. a central boiler system). In this situation the engineer often does not have a direct relationship with the developer (or even the architect) that might allow for meaningful dialogue concerning various design alternative benefits and limitations.

EQUIPMENT SIZING

While it was noted that mechanical engineers typically have the information necessary to optimally size equipment and piping (e.g. heating system capacity) various factors often cause this equipment to not be optimally sized. One factor is the widespread tendency to use general rules of thumb for sizing heating and cooling equipment (e.g. a set heating capacity per square foot of floor area) rather than to calculate loads based on detailed project-specific information (e.g. insulation levels, wall and roof exposures, window areas, and U-values, etc.).

Another factor is that the plumbing code has had very prescriptive pipe-sizing requirements that are effective at preventing under-sizing of piping under all circumstances. This does not allow for optimal downsizing of piping in conjunction with the use of low-flow fixtures or for optimal sizing of piping when there are different pipe branch lengths. While this code format has allowed individuals with less expertise to design piping systems with a minimum of performance problems, it has increased the construction costs in many situations where licensed engineers have been prevented from optimizing the system based on specific project details.

OVERSIGHT OF DESIGN AND CONSTRUCTION PROCESS

Interview results clearly indicated a shortage of systematic checks on the effectiveness of the design and construction process—especially in the area of mechanical and electrical systems. Ideally, building design and construction projects would use a commissioning agent to peer-review system designs for their expected ability to meet the building's needs. This would continue throughout the construction and start-up process to verify that the system designs are built and perform as expected.

Commissioning agents in multifamily construction are essentially non-existent

By all accounts, commissioning agents are not used in multifamily construction and construction review is often inadequate to provide quality building performance. Architects may be fairly involved in on-site review during the construction phase of some projects, but mechanical engineers typically do not confirm that the installation or operational performance of systems match their original design intent. The most that engineering firms might do is go through a punch list of what equipment has been installed (without verification of its operation). Even architects are often not consistently involved in the review of construction projects, especially for projects that are located in Greater Minnesota. Balance reports sometimes provided after construction are typically limited to verifying air flows through specific ducts or registers without systematically confirming the proper control sequence or heating/cooling performance of equipment.

Code official review and inspection by their nature are limited to specific items that provide a "least common denominator" check on building performance. Verifying the optimal coordination of the design, construction and operation of complex systems (such as a boiler heating system or garage HVAC system) is well beyond what can be accomplished through the enforcement of current codes.

DEGREE OF DESIGN DETAIL

Many opportunities for building performance improvement can be realized without changing design specifications. Rather providing more details in designs consistently and thereby providing better direction to contractors may have the largest effect. For example, design details for effective, continuous air and vapor barriers in areas such as party-exterior wall junctions and wall-ceiling/attic junctions are almost universally absent from current designs. Similarly, specific garage HVAC control details are commonly absent leaving the optimization of a primary system to chance. One engineer stressed that there has been a industry wide trend towards fewer design details being specified by the design engineer and more details being left up to the contractors. Unfortunately, contractors may or may not have the technical expertise needed to properly "fill in the gaps" left in the design.

On the other hand, a mechanical contractor noted multiple situations where engineers' use of "boiler-plate" specifications that were not tailored to the specific project (e.g. the use of hotel system equipment specifications for an apartment building) have caused confusion or significantly increased costs. This has also led to contractors ignoring the detailed specifications. Improvements must therefore be implemented by both the design engineers and the contractors.

SUMMARY OF RECOMMENDATIONS

GENERAL PROGRAM CONSIDERATIONS

Important general observations are as follows:

- Either mandatory enactment of the currently optional Chapter 7674 of the Energy Code or some incentive (financial and/or public recognition) could significantly reduce multifamily building energy use (primarily by improving the envelope performance).

- There is a need for commissioning services to provide review and quality control of the multifamily building design, construction, and operation. Educational promotion to developers and design professionals, as well as funding for commissioning services, could significantly improve the ultimate energy efficiency of multifamily buildings.

SPECIFIC BUILDING PERFORMANCE IMPROVEMENT ITEMS

Moisture and Mold Issues. The market study identified the key opportunities for improving building durability as:

1) Improving the design and construction of envelope details (e.g. window flashings, air barrier junction and penetration sealing)
2) Improving ventilation system design and installed performance to prevent moisture problems.

Possible steps that could be taken include:

- Promote improved ventilation system design to prevent the build-up of moisture in the apartment units.
- Fund or otherwise encourage increased oversight of the construction process (i.e. commissioning) to make sure that the design intent is successfully implemented—especially where more detailed or less common design specifications are used.

CenterPoint Energy Minnegasco's continued delivery of design assistance services provides a practical platform for the promotion of these improvements. Presentations to various trade groups provide another possible mode of promotion for these items.

Individual Unit Heating and Cooling Systems. Furnace and air conditioning types and designs used in townhomes and some apartment/condo buildings match those used in single-family homes and about one-third of these single-family style systems use high efficiency condensing furnaces. Venting flexibility leads to the selection of high efficiency furnaces more often than energy cost savings. However, some developers feel that the energy efficiency marketing advantage alone provides enough benefit to justify the added initial investment for units that will be sold. Rebates to improve energy cost savings paybacks and promotion of the venting flexibility of high efficiency furnaces to building designers are both important promotional strategies.

The PTACs now used in a majority of new apartment/condo buildings do not have any high efficiency heating options. Buildings where they are used can only be significantly impacted through long-term work with manufacturers to develop high efficiency units (through organizations such as the Consortium for Energy Efficiency).

Space-Heating Boiler Systems. There are good long-standing and newly emerging opportunities to improve the efficiency of new boiler plants for the decreasing minority of common area buildings that do use central boiler systems. Long-standing boiler plant efficiency improvement opportunities that are not currently industry-wide standards include moderately higher efficiency boilers, high efficiency condensing boilers, modulating burners, outdoor cutout controls, and the effective isolation of idle boilers in multiple boiler installations. Promotion of high efficiency boilers and system options should be accompanied with extensive educational efforts since the optimal performance of boiler systems, especially condensing boiler systems, depends upon system design and/or control modifications that some local design engineers do not currently appreciate. Observed problems with boiler controls highlight the need for commissioning to realize the potential savings of boiler controls and high efficiency condensing boilers.

Industry awareness of efficiency options is low. Education and rebates could increase market penetration.

One more recently available option is the selection of near-condensing boilers that not only have improved efficiencies, but which can also operate at much lower boiler system water temperatures than traditional boiler designs. The tolerance of lower water temperatures allows these boilers to reap more energy savings from outdoor reset controls which have now reportedly become standard practice.

A second recently available option is the use of propane-compressed air systems as a back-up fuel source. The use of propane-air systems can allow for much easier alternate fuel switchover and maintenance requirements than dual-fuel (natural gas and fuel oil) boiler burners, with the added benefit that all gas-fired appliances can be switched to the alternate fuel without any modifications to the individual appliances.

Industry awareness of these recently available options was low. Education efforts, as well as rebates, aimed at developers and design decision makers are tools that could be used to increase their market penetration.

Domestic Hot Water Systems. Separate, residential tank-type water heaters serve a majority of townhomes and a minority of common area buildings. These water heaters most often just meet the minimum efficiency requirements even though more efficient water heaters of similar type and size are available.

Apartment/condo buildings usually use central domestic hot water systems and these central systems now commonly use either high efficiency condensing type water heaters (>90%) or standard efficiency models (~80%). Commercial, high efficiency condensing water heaters introduced in the last few years by industry-leading manufacturers have made more inroads into the market than previously available condensing water heater products. They still, however, represent a minority of new installations. Better trade name recognition is one factor in their success, but selection has reportedly been driven primarily by their venting flexibility compared to atmospherically vented, tank-type water heaters. Although high failure rates in early versions of the most prominent product line have been rumored, none of the respondents mentioned equipment problems

with the installations that they have been involved in.

Effective promotional opportunities for high efficiency water heaters include:

1) continued demonstration of the energy cost saving benefits for specific projects;
2) general educational promotion of high efficiency condensing equipment's venting flexibility and energy savings; and
3) targeted equipment rebates for the higher efficiency levels within the different water heater types (residential for individual units or commercial for central systems).

Lighting. The use of compact fluorescents in high operating hour fixtures within units likely provides the largest untapped opportunity for energy efficiency improvement in townhomes. The market barrier of central responsibility for replacement might be overcome through concerted efforts to encourage conveniently located retailers to maintain a reasonably priced stock of replacement plug-in type compact fluorescent bulbs.

Appliances. The split incentives make the use of energy efficient appliances rare in multifamily buildings. Flexible approaches, such as incentives paid to developers, provide the best opportunities to achieve significant movement of this market towards high efficiency equipment.

Likewise for coin operated laundry equipment, the split incentives and lease arrangements makes it more challenging to effectively promote high efficiency equipment through traditional incentive programs. However, more flexible approaches, such as incentives that are at least partially paid to laundry equipment service companies, may be able to yield very significant energy cost savings.

Common Garage Ventilation and Heating Control. One key opportunity to improve common garage ventilation systems is to increase safety through low-level continuous exhaust ventilation to keep the garage air pressure below the pressure of the adjacent building areas (to prevent long-term, low-level exposure in other parts of the building). More widespread use of optimal make-up air unit controls is the most significant energy savings opportunity for this equipment.

Continued delivery of design assistance services is an effective way to educate industry players about these opportunities. The complexities of these improvements make them more difficult to effectively promote through many traditional means. Code changes that provide more uniformity in the control requirements (which currently vary by jurisdiction or are at least non-uniformly interpreted) for garage ventilation systems may also make it easier for designers to more consistently apply optimal ventilation system control strategies.

APPENDIX A: SURVEY TOOL

Multifamily New Construction Market Survey

Sample Opening Script

Hello _____, this is _____, I'm a mechanical engineer with CEE/LHB. I'm calling because CEE & LHB are interviewing individuals involved with multifamily new construction projects as part of a CenterPoint Energy Minnegasco funded pilot program to help enhance the performance of new affordable multifamily rental properties. *Who would you recommend we talk with in your organization to get the most insight into multifamily building development, design & construction issues?* _____

_____

These interviews are part of a market study that is the first step in the implementation of a pilot program. In addition to the market study that will identify ways in which building performance might be improved, the program will provide design assistance (in cooperation with The Weidt Group), assistance with identifying available utility rebates and financing, and verification of proper installation and performance of building enhancements. Supplemental funding from the State of Minnesota Department of Commerce, State Energy Office also allows us to expand the inquiries and services beyond the service territory of CenterPoint Energy Minnegasco and—on a limited basis—beyond affordable housing projects.

Could we get together for an interview (~1 hour) to get your insight and input into the development of the program? *If no, then--* How about 20 minutes for an over-the-phone interview?

Note: Only questions with an * and yellow shading will be asked during the shorter over-the-phone interview.

Participant Info

1) *Name _____

2) Title _____

3) *Organization Name_____

4) *Organization & Individual Services (circle all that apply & comment on % of work)

A) Development firm
B) Real estate holding company
C) Real estate holding and management
D) Architecture firm
E) Structural engineering design
F) Mechanical engineering design firm
G) Electrical engineering design firm
H) General contractor
I) Construction management
J) Mechanical contractor
K) Electrical contractor
L) TAB contractor
M) Other sub_____
N) Commissioning agent
O) Building code inspection
P) Plan review
Q) Other_____

5) How many units of each of the following types of buildings has your organization worked on in the last 2 years?

A) _____ Townhomes
B) _____ Low-rise w/common area
C) _____ High-rise
D) _____ High-rise
E) _____ Low-Income
F) _____ Other Affordable

G) _____ Luxury
H) _____ Senior
I) _____ Assisted Living
J) *If few projects, I'd like some basic information about each of the multifamily projects your organization has worked on in the last two years in Minnesota?

********** "Projects Table" FROM EXCEL **********

6) What percent change in units per year do you expect for 2003 & beyond?
A) _____ All types of multifamily units in all of Minnesota
B) _____ Affordable multifamily buildings served by CenterPoint Energy Minnegasco

Design/Construction Process

1) *How often does the design of multiple buildings (or mechanical systems/lighting systems) at a property involve more than minor variations between buildings? _____
{always, usually, often, seldom, never}

2) *How often does the design of a building (or mechanical systems/lighting systems) involve more than minor variations from a design that was previously used? _____
{always, usually, often, seldom, never}

3) How often were your projects with in the last two years? {always, usually, often, seldom, never}
   A) _____ design/build for entire building
   B) _____ pre-engineered for architectural & structural elements
   C) _____ design/build for mechanical & electrical
   D) _____ pre-engineered for mechanical & electrical

4) How often are the budgets decided in the various ways? {always, usually, often, seldom, never}
   A) _____ negotiated for general contractor
   B) _____ publicly bid for general contractor
   C) _____ negotiated for mechanical & electrical
   D) _____ publicly bid for mechanical & electrical

5) (*)Developer/Owner Input *(Skip if Organization Doesn't Drive Design Decisions)*
   A) *How often does the developer of a rental property plan to hold onto a completed property for 3+ years?_____
   B) *How often does the eventual buyer of the property provide substantial input into the design decision making process? *Rental*_____ *Sale*_____
   C) Which of the following criteria are typically evaluated when considering design alternatives, and how important of a factor is each item considered on a scale of 1 to 5 (5most)? *{"-" or #}*
      (1) *Rental*_____ *Sale*_____Life-cycle cost (over a period of 10 years or more)
      (2) *Rental*_____ *Sale*_____Rate of return (over a less than 5 year period)
      (3) *Rental*_____ *Sale*_____Rate of return (over a 5-10 year period)
      (4) *Rental*_____ *Sale*_____Rate of return (over a period of more than 10 years)
      (5) *Rental*_____ *Sale*_____First cost
      (6) *Rental*_____ *Sale*_____Impact on rental rates/resale value
      (7) *Rental*_____ *Sale*_____Risk of major tenant complaints or health risks (e.g. mold) <1 yr
      (8) *Rental*_____ *Sale*_____Risk of major tenant complaints/health risks (e.g. mold) 2+ yrs
      (9) *Rental*_____ *Sale*_____Risk of major building or equipment problems within one year
      (10) *Rental*_____ *Sale*_____Risk of major building/equipment problems after 2+ years
      (11) *Rental*_____ *Sale*_____Other_____
      (12) *Rental*_____ *Sale*_____Other_____

6) *How often is your organization the primary decision-maker regarding the following items? {always, usually, often, seldom, never}
   Project & Building Definition (skip for M&E focused firms)
      A) D/B_____ PreEng_____ Location/market (e.g. luxury condos vs affordable rental)
      B) D/B_____ PreEng_____ Budget limit—for entire project
      C) D/B_____ PreEng_____ Budget limit—for specific subcontractors
      D) D/B_____ PreEng_____ General building type (e.g. ~36 unit 3-story split-entry)
      E) D/B_____ PreEng_____ Specific unit plan &/or features to use (again)
   Envelope Details (skip for M&E focused firms)
      F) D/B_____ PreEng_____ Exterior finish type
      G) D/B_____ PreEng_____ Exterior wall insulation levels
      H) D/B_____ PreEng_____ Window types/sizes

I) D/B_____ PreEng_____ Exterior waterproofing details
J) D/B_____ PreEng_____ Exterior air and vapor sealing details (e.g. vapor barrier type and covering the tops of party walls where they reach the attic)
K) D/B_____ PreEng_____ Details for sealing partitions between units (e.g. sealing of penetrations of plumbing riser take-offs to units)
L) D/B_____ PreEng_____ Attic venting

Mechanical Systems--General

M) D/B_____ PreEng_____ General type of heating system (e.g. central boiler vs individual furnaces)
N) D/B_____ PreEng_____ Heating equipment efficiency requirement
O) D/B_____ PreEng_____ Type of water heating (e.g. individual electric water heaters, central gas-fired tank-type heaters, or storage tanks served by space-heating boilers)
P) D/B_____ PreEng_____ Water heater efficiency
Q) D/B_____ PreEng_____ Type of ventilation system (e.g. separate bath fans in each unit vs rooftop exhaust fan serving multiple units)
R) D/B_____ PreEng_____ Ventilation performance & control (e.g. cfm or db)

Mechanical Systems--Detail *(Only ask mechanical firms)*

S) M*D/B*_____ *PreEng*_____ *Heating system sizing (e.g. radiator and boiler capacities or make & model)*
T) M*D/B*_____ *PreEng*_____ *Heating plant make & model*
U) M*D/B*_____ *PreEng*_____ *Water heater sizing*
V) M*D/B*_____ *PreEng*_____ *Water heater make & model*

In-Unit Items

W) D/B_____ PreEng_____ Plumbing fixture make & model or water flow limits
X) D/B_____ PreEng_____ Dishwasher make & model or water use & temp. limits
Y) D/B_____ PreEng_____ Laundry equipment make & model or its water use limits

LIGHTING (SKIP FOR MECHANICAL FOCUSED FIRMS)

Z) D/B_____ PreEng_____ General light fixture types (e.g. halls-CFLs & stairs-T8s)
AA) D/B_____ PreEng_____ Specific light fixtures and their locations
BB) D/B_____ PreEng_____ Desired light levels
CC) D/B_____ PreEng_____ Lighting control type

Other Items

DD) D/B_____ PreEng_____ Other _____
EE) D/B_____ PreEng_____ Other _____

7) When late-stage changes occur (e.g. due to changing budget constraints or cost overruns), how important of a role do each of the following play on a scale of 1 to 5 (5 most important) in proposing and/or approving design changes? *{"-" or #}*

A) D/B_____ PreEng_____ Architect
B) D/B_____ PreEng_____ Developer
C) D/B_____ PreEng_____ Eventual owner
D) D/B_____ PreEng_____ General contractor
E) D/B_____ PreEng_____ Mechanical contractor
F) D/B_____ PreEng_____ Mechanical engineer
G) D/B_____ PreEng_____ Electrical contractor
H) D/B_____ PreEng_____ Electrical engineer
I) D/B_____ PreEng_____ Construction manager
J) D/B_____ PreEng_____ Owners representative
K) D/B_____ PreEng_____ Other_____

8) *Are there specific areas where you feel better coordination between contractors and/or designers might reduce costs or improve building performance? (e.g. downsize water heating equipment based on the selection of low water use fixtures and appliances)

_____

_____

_____

9) {Only ask Developers/Generals} Which stages of design and construction have some level of independent technical quality review—other than the required minimum code inspection—by someone outside of the organization that receives most of the payment for the work (use the codes below)?

C1-commissioning agent #1
C2-commissioning agent #2
A1-lead architect for the project
A2-other architecture firm
G-general contractor
CM-construction manager
ME-mechanical engineer
EE-electrical engineer
TAB-test, adjust & balance contractor
O1-other _____

A) D/B_____ PreEng_____ Architectural design
B) D/B_____ PreEng_____ Structural design
C) D/B_____ PreEng_____ Landscape design
D) D/B_____ PreEng_____ Mechanical design
E) D/B_____ PreEng_____ Electrical/lighting design
F) D/B_____ PreEng_____ Structural construction
G) D/B_____ PreEng_____ Wall insulation, finish material & sealing
H) D/B_____ PreEng_____ Final grading, exterior cement & gutters
I) D/B_____ PreEng_____ Heating system installation
J) D/B_____ PreEng_____ Rough-in plumbing
K) D/B_____ PreEng_____ Plumbing fixture & plumbed appliance installation
L) D/B_____ PreEng_____ Ventilation equipment installation
M) D/B_____ PreEng_____ Lighting equipment installation

10) Have you seen any tendencies towards differences in the design and construction process between affordable multifamily housing in CenterPoint Energy Minnegasco's service territory and all multifamily housing throughout the state?_____

_____

_____

_____

11) *Are there any specific changes to the general design and construction process that you think might improve the building performance or reduce project costs? _____ What barriers are preventing this from happening now?_____

_____

_____

_____

Wrap-Up

1) *What types of problems with building construction, design and performance have you seen occur with recent multifamily projects? _____

_____

_____

_____

_____

_____

2) *Who else would you suggest we interview concerning multifamily construction practices?_____

_____

_____

_____

_____

3) *Are there any recent or current projects for which we may be able to review construction documents and/or perform an on-site inspection to better understand current practices in multifamily new construction projects? _

_____

_____

_____

Thank you very much for giving us some of your valuable time for this interview. Your help with the development of this program is greatly appreciated. Feel free to let us know if you have any other thoughts or questions about the program services. We expect to begin providing design assistance services by April and I hope that we will have the chance to work with you on a future project.

Projects Table

Individual ___________________________________ Date____________ Page ____ of ____

I'd like some basic information about each of the multifamily projects your organization has worked on in the last two years in Minnesota?

		{ Enter #Bldgs x #Units/Bldg }												
		Low-Rise (Typically Wood Frame)												
Project	City	1 story	2 Story	3 Story	4 Story	High Rise	Common Areas (Y/N)	For (Sale/Rent)	Market* (LI, Aff, Lx, Sr, AL)	Minnegasco Territory (Y/N?)	Bottom Level** (Slab, Split, Bsmt, CGH, CGU, IGH, IGU)	Square Feet	Ft^2 Basis	Status
													Per Unit OR Total Bldg	
													Per Unit OR Total Bldg	
													Per Unit OR Total Bldg	
													Per Unit OR Total Bldg	
													Per Unit OR Total Bldg	
													Per Unit OR Total Bldg	
													Per Unit OR Total Bldg	
													Per Unit OR Total Bldg	
													Per Unit OR Total Bldg	
													Per Unit OR Total Bldg	

*Market Key
- LI Low Income
- Aff Other Affordab
- Lx Luxury
- Sr Senior
- AL Assisted Living

**Bottom Level Key (Use all that apply)
- Slab Slab on Grade
- Split Split Level w/ Units on Lowest Level
- Bsmt Full Basement
- CGH Attached Common Garage, Heated
- CGU Attached Common Garage, Unheated
- IGH Attached Individual Garage, Heated
- IGU Attached Individual Garage, Unheated

Structure Detail

Individuals interviewed over-the-phone are only asked yellow-shaded questions **Skip these Tables for Mechanical + Lighting Firms*

How often are each of the following features incorporated into each of the types of multifamily buildings you've worked with?

(always, usually, often, seldom, never)		Townhomes		2-4 Story-Common Area		High Rise		Interest
		For Sale	Rental	For Sale	Rental	For Sale	Rental	(-5 to +5)
1) Construction Materials								
A	Wood frame							
B	Steel studs							
C	Masonry block construction (all levels)							
D	Concrete/steel construction							
E	Brick façade							
F	Metal or vinyl siding							
G	Siding with wood or wood product							
H	Other:							

		Townhomes		2-4 Story-Common Area		High Rise		Interest
		For Sale	Rental	For Sale	Rental	For Sale	Rental	(-5 to +5)
2) Insulation & Sealing								
A	Insulation at or near MF/commercial code							
B	Insulation at or near 1 & 2 family code							
C	Insulation significantly above 1 & 2 family code (e.g. attic>R42, wall/window Uo≤0.13, basemeent>R10)							
D	Exterior finish insulation							
E	Insulation between garage & building							
F	Insulation between garage & outside							
G	Continuous vapor barrier with details (e.g. roof/wall juncture) specified in the design							
H	Continuous air barrier—with details (e.g. roof/wall juncture) specified in the design							
I	Weather sealing details (e.g. flashing at top of windows) documented in the design							
J	Air sealing between apartment units beyond what is done for walls within a unit							
K	Other:							

Structure Detail – continued

Individuals interviewed over-the-phone are only asked yellow-shaded questions **Skip these Tables for Mechanical + Lighting Firms*

		Townhomes		2-4 Story-Common Area		High Rise		Interest
		For Sale	Rental	For Sale	Rental	For Sale	Rental	(-5 to +5)
3)	***Windows***							
A	Alumininum frames							
B	----Above Al windows have 3/8"+ thermal break							
C	Frames are wood or reinforced vinyl							
D	Frames are insulated fiberglass or vinyl							
E	Space between glas >= 1/2"							
F	Argon fill							
G	Low-e coating							

		Townhomes		2-4 Story-Common Area		High Rise		Interest
		For Sale	Rental	For Sale	Rental	For Sale	Rental	(-5 to +5)
3)	***Differences--Affordable & Territory***							
A	Have you seen any tendencies towards differences in the building structure & envelope between affordable multifamily housing in CenterPoint Energy Minnegasco's service territory and all multifamily housing throughout the state?							

		Townhomes		2-4 Story-Common Area		High Rise		Interest
4)	***Other Enhancements***	For Sale	Rental	For Sale	Rental	For Sale	Rental	(-5 to +5)
A	Are there any specific enhancements to the building structure & envelope that you think might improve the							
B	-----What barriers are preventing this from happening now?							

Mechanical Detail

**Non-mechanicals are only asked yellow-shaded questions; Mechanicals interviewed over-the-phone are only asked questions with arrows in left column.*

**Skip for lighting only firms*

How often are each of the following features incorporated into each of the types of multifamily buildings you've worked with?
(always, usually, often, seldom, never)

			Townhomes		2-4 Story-Common Area		High Rise		Interest
			For Sale	Rental	For Sale	Rental	For Sale	Rental	(-5 to +5)
→	1)	***Individual Heating Systems ----------> A)***							
→	*B*	Individual, ducted gas furnaces (& split or separate AC)							
→	*C*	-----above furnaces AFUE 90%+ (EnergyStar or condensing)							
→	*D1*	-----above furnaces Power draft or direct vent							
→	*D2*	-----above furnaces have common vents for multiple floors							
→	*E*	Individual packaged gas furnace & AC (e.g. Magic-Pak)							
→	*F*	-----above packaged furnace has AFUE 90%+ (Energy Star or condensing)							
→	*G*	Other individual heating system/feature							

			Townhomes		2-4 Story-Common Area		High Rise		Interest
			For Sale	Rental	For Sale	Rental	For Sale	Rental	(-5 to +5)
→	2)	***Central Boiler Systems ----------> A)***							
→	*D*	Dual-fuel burner(s)							
→	*E*	Boiler efficiencies of 85% to 89% (EnergyStar rated are 85%+)							
→	*F*	Boiler efficiencies of 90%+ (condensing)							
→	*G*	Multiple boilers with isolation of idle boilers (e.g. primary/secondary piping w/pump shutoff)							
→	*H*	Outdoor reset control (e.g. direct or 3-way valve) to reduce radiator temps in mild weather							
→	*J*	Outdoor cutout control (shuts down boilers and/or pumps in warm weather)							
	K	Modulating burner that also adjusts airflow							
	L	Vent damper(s)							
→	*M1*	Combustion air fan used							
→	*M2*	----above fan has airflow lockout for boilers							
→	*N*	Other central system/feature:							

Mechanical Detail - continued

**Non-mechanicals are only asked yellow-shaded questions; Mechanicals interviewed over-the-phone are only asked questions with arrows in left column.*

**Skip for lighting only firms*

		Townhomes		2-4 Story-Common Area		High Rise		Interest
		For Sale	Rental	For Sale	Rental	For Sale	Rental	(-5 to +5)
	3) In-Unit Heat Control							
	A Basic wall thermostat							
	B Setback thermostat							
	C Thermostatic control dial (e.g. 1-10)							
	D Other control:							
➔	*E** Heating cost allocation to each tenant based on monitoring							

		Townhomes		2-4 Story-Common Area		High Rise		Interest
		For Sale	Rental	For Sale	Rental	For Sale	Rental	(-5 to +5)
	4) Common Hallway Heat Control							
➔	*A* Continuous uncontrolled when heating system on							
	B Wall thermostat with temperature reading							
	C -----above wall thermostat has Automatic setback							
	D Thermostatic control dial (e.g. 1-10)							
	E Where controllable, tenant access to controls restricted (e.g. locking cover)							
	F Other control:							

		Townhomes		2-4 Story-Common Area		High Rise		Interest
		For Sale	Rental	For Sale	Rental	For Sale	Rental	(-5 to +5)
➔	***5) Individual Hot Water Systems ----------->A)***							
	B Gas-fired tank heater							
	C -----above heater has Energy Factor >=0.62							
	D Electric tank heater							
	E Other type/feature:							

Mechanical Detail - continued

**Non-mechanicals are only asked yellow-shaded questions; Mechanicals interviewed over-the-phone are only asked questions with arrows in left column.*

**Skip for lighting only firms*

			Townhomes		2-4 Story-Common Area		High Rise		Interest
			For Sale	Rental	For Sale	Rental	For Sale	Rental	(-5 to +5)
➔	6)	***Central Hot Water Systems ----------->A)***							
	B	Commercial tank heater(s) (electric controls; >75 MBH; or >100 gal)							
	C	Dedicate boiler/heater with separate storage tank(s)							
	D	Residential tank heater(s) (mV controls; <=75 MBH & <=100 gal)							
➔	*E*	Heat from space-heating boiler system							
➔	*F*	Water heater/boiler efficiency 83% to 89%							
➔	*G*	Water heater/boiler efficiency 90%+ (condensing)							
	H	Tempering valve on main supply							
	I	Tempering valves at individual fixtures							
➔	*J*	Recirculation loop pump							
➔	*K*	-----above loop pump Cycles (e.g. timer or return line aquastat)							
➔	*L*	Control that adjusts hot water temperature based on demand or time of day							
	M	Service hot water cost allocation to each unit based on monitoring							
	N	Other type/feature:							

			Townhomes		2-4 Story-Common Area		High Rise		Interest
			For Sale	Rental	For Sale	Rental	For Sale	Rental	(-5 to +5)
	7)	***Kitchen Ventilation***							
	A	Recirculating fan with odor control filters							
➔	*B*	Individual unit exhaust fans							
	C	-----above in-unit fans have Automatic control (e.g. tied to light, humidistat or timer)							
	D	-----above in-unit fans Operate continuously							
➔	*E*	Remote (e.g. rooftop) fans serving multiple units							
	F	-----above, remote multiple unit fans are automatically or manually controlled (e.g. timer)							
	G	Other:							

Mechanical Detail - continued

**Non-mechanicals are only asked yellow-shaded questions; Mechanicals interviewed over-the-phone are only asked questions with arrows in left column.*

**Skip for lighting only firms*

			Townhomes		2-4 Story-Common Area		High Rise		Interest
			For Sale	Rental	For Sale	Rental	For Sale	Rental	(-5 to +5)
	8)	***Bathroom Ventilation***							
	A	Recirculating fan with odor control filters & operable window							
➔	*B*	Individual unit exhaust fans							
➔	*C*	-----above in-unit fans have Automatic control (e.g. tied to light, humidistat or timer)							
➔	*D*	-----above in-unit fans Operate continuously							
➔	*E*	Remote (e.g. rooftop) fans serving multiple units							
	F	-----above, remote multiple unit fans are Automatically or manually controlled (e.g. timer)							
	G	Other:							

			Townhomes		2-4 Story-Common Area		High Rise		Interest
			For Sale	Rental	For Sale	Rental	For Sale	Rental	(-5 to +5)
	9)	***Individual Unit Exhaust Terminations***							
➔	*A*	All sidewall or combination sidewall & roof							
	B	All rooftop with separate ducts							
	C	All rooftop with multiple ducts from multiple units combined							
	D	Other:							

			Townhomes		2-4 Story-Common Area		High Rise		Interest
			For Sale	Rental	For Sale	Rental	For Sale	Rental	(-5 to +5)
	10)	***Fresh Air & Hallway Ventilation***							
➔	*A*	Mechanical fresh air supply to each unit							
	B	Mechanical ventilation of common hallways							
	C	Mechanical fresh air supply tocommon hallways							
	D	Mechanical exhaust from common hallways							
➔	*E*	Heat recovery from exhaust air used to preheat or temper *(circle* units *or* halls*)*							
	F	Fresh air /common area ventilation controlled automatically or with accessible manual switch							
	G	Other:							

Mechanical Detail - continued

**Non-mechanicals are only asked yellow-shaded questions; Mechanicals interviewed over-the-phone are only asked questions with arrows in left column.*

**Skip for lighting only firms*

		Townhomes		2-4 Story-Common Area		High Rise		Interest
		For Sale	Rental	For Sale	Rental	For Sale	Rental	(-5 to +5)
11)	***Underground Common Garage ----------> A)***							
B	Wet sprinkler system piping in garage							
C	Other freeze-prone piping in garage (e.g. waste piping)							
D	Heating unit(s) not connected with fresh air (e.g. unit heaters)							
E	Make-up air heating of garage							
➔ *F*	Heat recovery from exhaust air used to preheat or temper							
G	Both supply & exhaust ventilation							
H	Continuous exhaust ventilation							
➔ *I*	Ventilation cycled off based on carbon monoxide sensor(s)							
J	Other:							

		Townhomes		2-4 Story-Common Area		High Rise		Interest
		For Sale	Rental	For Sale	Rental	For Sale	Rental	(-5 to +5)
➔ **12)**	***Central Cooling System for Units ----------> A)***							
➔ *B*	-----central cooling system delivers air to each unit							
C	-----central cooling system w/ 2-pipe fan-coil units							
D	-----central cooling system w/ 4-pipe fan-coil units							

		Townhomes		2-4 Story-Common Area		High Rise		Interest
		For Sale	Rental	For Sale	Rental	For Sale	Rental	(-5 to +5)
13)	***Design Temperatures***							
➔ *A*	Boiler supply (to building) water temperature at winter design conditions	°F	°F	°F	°F	°F	°F	
➔ *B*	Boiler water temperature drop through heating distribution system	°F	°F	°F	°F	°F	°F	
➔ *C*	Minimum boiler return water temperature	°F	°F	°F	°F	°F	°F	
E	Service hot water tap temperature	°F	°F	°F	°F	°F	°F	
F	Service hot water storage tank temperature	°F	°F	°F	°F	°F	°F	
➔ *G*	Wintertime underground (or otherwise attached) common garage	°F	°F	°F	°F	°F	°F	

Mechanical Detail - continued

**Non-mechanicals are only asked yellow-shaded questions; Mechanicals interviewed over-the-phone are only asked questions with arrows in left column.*

**Skip for lighting only firms*

		Townhomes		2-4 Story-Common Area		High Rise		Interest
		For Sale	Rental	For Sale	Rental	For Sale	Rental	(-5 to +5)
14)	***Solid Info @ Time of Mechanical Design***							
A	Building ft^2 and insulation levels							
B	Window sizes and U-values							
D	Mechanical ventilation rates @ time of heating load calculation							
E	Shower, faucet & dishwasher flow rates							
F	Cooking equipment fuel @ time of ventilation design							
G	Acceptable exhaust & intake vent locations (e.g. sidewalks, frontage, parking defined)							

			Townhomes		2-4 Story-Common Area		High Rise		Interest
			For Sale	Rental	For Sale	Rental	For Sale	Rental	(-5 to +5)
➔	***15)***	***Differences--Affordable & Territory***							
➔	*A*	Have you seen any tendencies towards differences in the mechanical system features between affordable multifamily housing in CenterPoint Energy Minnegasco's service territory and all multifamily housing throughout the state?							

			Townhomes		2-4 Story-Common Area		High Rise		Interest
			For Sale	Rental	For Sale	Rental	For Sale	Rental	(-5 to +5)
➔	***16)***	***Other Enhancements***							
➔	*A*	Are there any specific enhancements to the mechanical systems or their controls that you think might improve the building performance or reduce project costs?							
➔	*B*	-----What barriers are preventing this from happening now?							

Appliance Unit Detail

**Individuals interviewed over-the-phone are only asked yellow-shaded questions*

How often are each of the following features incorporated into each of the types of multifamily buildings you've worked with?
(always, usually, often, seldom, never)

		Townhomes		2-4 Story-Common Area		High Rise		Interest
		For Sale	Rental	For Sale	Rental	For Sale	Rental	(-5 to +5)
1) Cooking Appliances								
A	Gas-fired cooktop or indoor BBQ							
B	-----exhaust ventilation for above cooktop/BBQ							
C	Gas-fired oven							
D	-----exhaust ventilation for above oven							
E	-----above oven self-cleaning							
F	Self-cleaning electric oven							
G	Other:							

		Townhomes		2-4 Story-Common Area		High Rise		Interest
		For Sale	Rental	For Sale	Rental	For Sale	Rental	(-5 to +5)
2) Other In-Unit Appliances								
A	Full-size refrigerator							
B	EnergyStar rated refrigerator							
C	Dishwasher							
D	------above dishwasher EnergyStar rated							
E	Laundry equipment in each unit							
F	------above in-unit washing machine EnergyStar or front load							
G	------above in-unit dryer gas-fired							
H	Window/through-the-wall air conditioners							
I	------above AC EnergyStar rated							
J	Other:							

		Townhomes		2-4 Story-Common Area		High Rise		Interest
		For Sale	Rental	For Sale	Rental	For Sale	Rental	(-5 to +5)
3) Common Coin-Operated Laundry----------> A)								
B	-----above commercial washer Energy Star or front-load							
C	-----above commercial dryer gas-fired							
D	----coin-op laundry equipment purchased as an integral part of the property assets							
E	----coin-op laundry equipment leased from laundry service company							
F	Other:							

Appliance Unit Detail - continued

**Individuals interviewed over-the-phone are only asked yellow-shaded questions*

		Townhomes		2-4 Story-Common Area		High Rise		Interest
		For Sale	Rental	For Sale	Rental	For Sale	Rental	(-5 to +5)
4) Plumbing Fixtures								
A	Low flow showerheads (<= 2.5 gpm [gallons per minute])							
B	Low flow bathroom faucets (~2 gpm)							
C	Low flow kithcen faucets (<= 2.4 gpm)							
D	Low flush toilets (<= 1.6 gallons per flush)							
E	Other:							

		Townhomes		2-4 Story-Common Area		High Rise		Interest
		For Sale	Rental	For Sale	Rental	For Sale	Rental	(-5 to +5)
5) Differences--Affordable & Territory								
A	Have you seen any tendencies towards differences in the appliances and other in-unit items between affordable multifamily housing in CenterPoint Energy Minnegasco's service territory and all multifamily housing throughout the state?							

		Townhomes		2-4 Story-Common Area		High Rise		Interest
		For Sale	Rental	For Sale	Rental	For Sale	Rental	(-5 to +5)
6) Other Enhancements								
A	Are there any specific enhancements to the appliances and other in-unit items that you think might improve the building performance or reduce project costs?							
B	-----What barriers are preventing this from happening now?							

Lighting Detail

**Non-lighting + individuals interviewed over-the-phone are only asked yellow-shaded questions.* **Skip for mechanical only firms.*

How often are each of the following features incorporated into each of the types of multifamily buildings you've worked with?
(always, usually, often, seldom, never)

		Townhomes		2-4 Story-Common Area		High Rise		Interest
		For Sale	Rental	For Sale	Rental	For Sale	Rental	(-5 to +5)
1)	***Common Area Fixtures--4+ hours/day***							
A	T12 Flourescent fixtures							
B	T8 Flourescent fixtures							
C	-----above T8 fixtures with Electronic Ballasts							
D	Incandescent bulbs							
E	Compact fluorescent fixtures, plug in type							
F	Other:							

		Townhomes		2-4 Story-Common Area		High Rise		Interest
		For Sale	Rental	For Sale	Rental	For Sale	Rental	(-5 to +5)
2)	***In-Unit Fixtures***							
A	T12 Flourescent fixtures							
B	T8 Flourescent fixtures							
C	-----above T8 fixtures with Electronic Ballasts							
D	Incandescent bulbs							
E	Compact fluorescent fixtures, plug in type							
F	Other:							

		Townhomes		2-4 Story-Common Area		High Rise		Interest
		For Sale	Rental	For Sale	Rental	For Sale	Rental	(-5 to +5)
3)	***Exit Signs***							
A	LED Fixtures							
B	-----above LED with lights on face							
C	Incandescent bulbs							
D	Compact fluorescent, plug in type							
E	Other:							

Lighting Detail - continued

**Non-lighting + individuals interviewed over-the-phone are only asked yellow-shaded questions.* **Skip for mechanical only firms.*

		Townhomes		2-4 Story-Common Area		High Rise		Interest
		For Sale	Rental	For Sale	Rental	For Sale	Rental	(-5 to +5)
4) Exterior Entry Fixtures								
A	Incandescent bulbs							
B	Compact fluorescent fixtures, plug in type							
C	Metal halide							
D	High pressure sodium							
E	Low pressure sodium							
F	Mercury vapor							
G	Other:							

		Townhomes		2-4 Story-Common Area		High Rise		Interest
		For Sale	Rental	For Sale	Rental	For Sale	Rental	(-5 to +5)
5) Site Lighting Fixtures								
A	Incandescent bulbs							
B	Compact fluorescent fixtures, plug in type							
C	Metal halide							
D	High pressure sodium							
E	Low pressure sodium							
F	Mercury vapor							
G	Other:							

		Townhomes		2-4 Story-Common Area		High Rise		Interest
		For Sale	Rental	For Sale	Rental	For Sale	Rental	(-5 to +5)
6) Exterior Light Controls								
A	Timeclock							
B	-----above timeclock with Battery Back-Up							
C	-----above timeclock with seasonal day-length adjustment							
D	Photocell							
E	Manual control							
F	Other:							

Lighting Detail - continued

**Non-lighting + individuals interviewed over-the-phone are only asked yellow-shaded questions.* **Skip for mechanical only firms.*

		Townhomes		2-4 Story-Common Area		High Rise		Interest
		For Sale	Rental	For Sale	Rental	For Sale	Rental	(-5 to +5)
7) Daylighting of Common Spaces								
A	Entrance or lobby areas have adequate natural light >50% of daylight hours							
B	-----above entrance/lobby areas have automatic control							
C	Stairwells have adequate natural light >50% of daylight hours							
D	-----above stairwells have automatic control							
E	Hallways have adequate natural light >50% of daylight hours							
F	-----above hallways have automatic control							
G	Other:							

		Townhomes		2-4 Story-Common Area		High Rise		Interest
		For Sale	Rental	For Sale	Rental	For Sale	Rental	(-5 to +5)
8) Differences--Affordable & Territory								
A	Have you seen any tendencies towards differences in the lighting systems between affordable multifamily housing in CenterPoint Energy Minnegasco's service territory and all multifamily housing throughout the state?							

		Townhomes		2-4 Story-Common Area		High Rise		Interest
		For Sale	Rental	For Sale	Rental	For Sale	Rental	(-5 to +5)
9) Other Enhancements								
A	Are there any specific enhancements to the lighting sysems or their controls that you think might improve the building performance or reduce project costs?							
B	-----What barriers are preventing this from happening now?							