# Let The Gas Flow

## A Marketing, Sales, and Equipment Handbook for the Natural Gas Industry

*Underwritten by PECO Energy Company*

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220 Meadow Road
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Library of Congress Catalog Card Number 97-92923

Printing 10 9 8 7 6 5 4 3 2 1

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ISBN 0-9656706-0-0

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Printed in the U.S.A.

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To Alice Powell Karg Jirkofsky

*In her elder years, she continues to be an inspiration for growth, courage, and humor*

# Acknowledgments

Many people contributed their time and expertise to help me complete *Let the Gas Flow: A Marketing, Sales, and Equipment Handbook for the Natural Gas Industry.* My thanks and appreciation go the following professionals and friends: Michael Fiazzo of PECO Energy Company, John Krigger of Saturn Resource Management, David Verboncoeur of Coastal Community Action Program, Mike Miller of Niagara Mohawk Power Corporation, and Jeff Morin of Energy North Natural Gas.

A special thanks to Gary Stockbridge of PECO Energy Company for agreeing to partially underwrite this project. Without his financial backing and belief in the eventual success of the book, it never would have been written.

I found *Principles of Marketing* by Philip Kotler and Gary Armstrong (Englewood Cliffs, NJ: Prentice-Hall, 1996) particularly helpful in formulating a basic framework for gas marketing. This book is an excellent resource for anyone in the marketing field.

Two periodicals I found to be very useful were *Public Utilities Fortnightly*, published by Public Utilities Reports, Inc. and *American Gas*, published by the American Gas Association. These are required reading for anyone wishing to keep up with changes in the natural gas industry.

Finally, thanks to my wife, Leslie, who endured my absence, my frequent preoccupation with the book, and regular queries regarding grammar and usage.

# Forward

As a result of federal deregulation, the natural gas business has changed dramatically in the last decade. Many gas utility managers are simply *reacting* to the changes—this worked in the past, but it will work no longer.

Today, natural gas utility managers must adopt a *proactive* posture, they must strategically plan, they must lead, and they must market if their companies are to survive in the more competitive gas market. This book is a practical guide for this fresh business approach.

*Let the Gas Flow: A Marketing, Sales, and Equipment Handbook for the Natural Gas Industry* is written to serve as a reliable and valuable reference for natural gas sales personnel, marketing representatives, marketing managers, and engineers. It is organized so that the reader can find important information quickly, without being overwhelmed with too much data.

As part of the effort to make the book a highly effective tool, natural gas marketing representatives and their managers were invited to take part in the selection of included topics, the organization, and the editing. Topics were selected with the primary objective of enhancing marketing and sales performance.

This book is a valuable resource that will help you match actual performance with the performance required to meet business objectives. Always carry it with you as a reminder that it is not natural gas that fuels the gas utility business, it is marketing.

Please contact us if you have comments or suggestions for future editions.

Richard Karg, March, 1997

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# 1. Introduction

## *A Bit of History*

In 1821 in Fedonia, New York, natural gas rising from a spring was ignited accidentally by a woman's lantern during the darkness of night. The first natural gas well in the United States was completed near this spring in the same year. The twenty-seven feet deep well furnished enough gas for thirty burners. In 1850 this well was deepened to seventy feet, and in 1888 another well was created close-by, furnishing enough gas for two hundred burners.

In 1854 the first gas well—a full 1200 feet deep—was drilled in Erie, Pennsylvania. Natural gas was used for commercial processes in East Liverpool, Ohio in 1863. In 1873 the town of Fairview, Pennsylvania was lighted by gas, and Titusville, Pennsylvania was supplied with gas from a two-inch pipe line five miles long. These were the beginnings of the natural gas industry.

Local distribution companies (LDCs) originated in the 19th century with the objectives of selling and distributing gas manufactured from coal and oil, often used for municipal street lighting.[1] With high fixed capital costs and dominating economies of scale, these first LDCs exhibited characteristics of natural monopolies. Because they were monopolies operating within city boundaries, they tended to be controlled by municipalities.[2] Cities issued sole franchises to the LDCs for use of street rights-of-way in exchange for rates set by the municipality.

This municipal regulation was effective until gas distribution expanded beyond the city boundaries to take

[1] See Richard J. Pierce, Jr., "Restructuring the Natural Gas Industry from Well-Head to Burnertip," *Energy Law Journal*, vol. 9, no. 1, 1988, pp. 1-57.

[2] Thanks to Jeffrey Showman for his help with LDC history. See Jeffrey Showman, "Notice of Inquiry: Examining Regulation of Local Distribution Companies in the Face of Change in the Natural Gas Industry (Docket No. UG-94-778)," Washington Utilities and Transportation Commission, August, 1995.

advantage of economies of scale. As a result, state utility regulatory agencies took over the regulatory process from the cities.

As the electric industry matured, the manufactured-gas LDCs were faced with competition. Natural gas had significant cost advantages over manufactured gas and, thus, was more cost-competitive with electricity, it only had to be extracted from the ground by producers, delivered to the city gate through pipelines, and distributed to customers by LDCs.[3] As a result of improved technology, pipelines began moving natural gas from producers to LDCs after World War I. During this period, natural gas was the ugly stepchild of the oil business, a by-product of the extraction of oil from the earth. It was often considered an annoyance; a product that had to be disposed of to get to the primary liquid resource.

When gas pipelines began crossing state boundaries, the federal government entered the regulatory sphere.

In 1935 the Federal Trade Commission found pipeline companies were abusing their monopoly power and recommended transportation-style regulation of pipelines as common carriers. However, as a result of heavy industry lobbying, in 1938 Congress adopted utility-style regulation. The most significant result of this legislation was the protection of pipelines from competition.[4]

In the 1940s and 1950s, the Federal Power Commission (FPC) tried to control collusion between pipeline purchases and affiliated natural gas producers.[5] As a

[3] For decades, the three natural gas industry components had been producers, who collected and processed natural gas; pipeline companies, which moved the gas from the places of production to the places of demand; and local distribution companies (LDCs), which accepted gas at the city gate and distributed it to retail customers. In the mid 1980s, a forth component—marketers—developed as a result of federal legislation. Gas marketers arrange for supply and transportation services (usually for large industrial consumers or smaller users aggregated into larger groups).

[4] See Richard H. K. Vietor, *Contrived Competition: Regulation and Deregulation in American*, (Boston: Belknap Press of Harvard University, 1994).

[5] The FPC, predecessor of the Federal Energy Regulatory Commission (FERC), was established in 1920.

response, the U.S. Supreme Court ruled in 1954 that all interstate producers' prices should be fixed by the FPC.[6] It was not until 1961 that the FPC made any real attempt to enforce the Court's ruling. This economic regulation of what had been a competitive industry created substantial administrative difficulties and price distortions.[7] This difficult situation led to acute, but temporary gas shortages.

The energy crises of the 1970s attracted increased attention to the problems of the natural gas industry. As a result, Congress passed the Natural Gas Policy Act of 1978. This legislation prescribed staged reform, creating many classes ("vintages") of gas, with some classes price-regulated and others deregulated. The industry response caused a crisis: over ten billion dollars in gas contracts for which pipeline companies were obligated to pay, but were unable to sell at comparable prices. During this period (1973 to 1986) the demand for natural gas fell by 26 percent.[8]

The Federal Energy Regulatory Commission (FERC) attempted to mitigate this crisis and to put the natural gas industry on sound economic footing. FERC Orders 436 and 500 (1985-1988) defined an "open access" policy, which allowed LDCs and industrial customers to purchase gas directly from pipeline companies or upstream suppliers. These orders led to the development of an independent gas marketing industry that arranged supply and transportation services, in competition with LDCs and pipeline companies.

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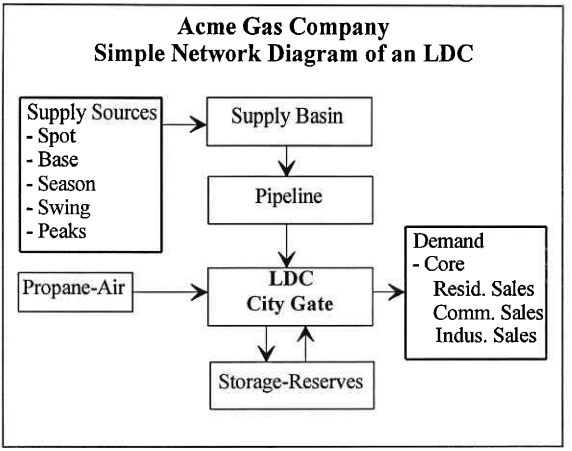
[6] *Phillips Petroleum v. Wisconsin*, 347 U.S. 672.

[7] "In 1947, the average cost of natural gas at the wellhead was 5¢ per mcf. By 1953, just prior to the Phillips Petroleum decision, the price was 9.1¢ per mcf. In 1961, when [the Federal Power] commission began enforcing the law, prices at the wellhead, which account for about half what the consumer must pay, skyrocketed to 16.3¢ per mcf." Source: Mel Wax, "The Wellhead Warriors" (1965), *America's Energy: Reports from The Nation on 100 Years of Struggles for the Democratic Control of Our Resources*, ed. by Robert Engler (New York: Pantheon Books, 1980), p. 193.

[8] Henry R. Linden, "The Future of the U.S. Natural Gas Market," *Public Utilities Fortnightly*, March 1, 1993, p. 23.

FERC Order 636—effective October 1993—made pipelines common carriers and cut the remaining linkages among producers, pipeline companies, and LDCs.[9] This order made LDCs entirely responsible for obtaining their own gas supply, transportation, and storage. The order also created a secondary market for releasing pipeline capacity, thus, increasing both the flexibility and the complexity of LDC gas-supply management.




The FERC philosophy underlying Order 636 was that competition for natural gas supply would promote the nation's economic growth. "[We] . . . remind the industry that it is in the nation's best interest and the industry's interest . . . to keep gas flowing and deliverable when and where needed and . . . not unreasonably inhibit the meeting of gas purchases and gas sellers in a competitive market."[10]

[9] For more details, see *Major Features of FERC Order 636* in the Appendix.
[10] FERC Order 636, p. 96.

The natural gas industry will be adjusting to this new order for years. The structure of the industry has been altered and will continue to evolve as federal and state regulatory agencies interpret the order; as producers, pipelines, marketers, and LDCs adjust and restructure; and as new players, such as energy service companies (ESCos), enter the industry.

The diagram on page 4 shows the flow of natural gas from wellhead to core customers for a simple LDC, after FERC Order 636.[11]

## *A More Vulnerable But Brighter Future*

Times have changed. The natural gas business, now more than ever, is more competitive and subject to free-market forces. Those in the industry who do not understand the changes or fail to make appropriate strategic adjustments will falter. "The imperative now is for marketing to emerge as a major driving force for change within utilities, just as it has been for airlines, railroads, telephone companies, brokerage firms, and other companies whose markets have been opened to greater competition."[12]

Not only is there a greater potential for competition within the gas industry, there is also an increased likelihood of competition from the electric industry. Changes in the regulation of electric utilities, in many ways similar to the changes impacting gas utilities, are likely to reduce the cost of electricity in many geographical areas, thus making it more competitive with natural gas.

Although LDCs are more vulnerable than ever to the inherent hazards of the competitive market, trends in the

[11] Based on J.F. Busch and G.A. Comnes, "Resource Planning for Gas Utilities: Using a Model to Analyze Pivotal Issues" (LBL-37717), Lawrence Berkeley Laboratory, Energy and Environment Division, November, 1995, p. 19.

[12] William R. Murray, "Marketing: Today's Imperative," *Fortnightly*, March 15, 1994, p. 33.

industry foretell an upbeat and bright future for those who survive. Major reasons for optimism include:

- "Gas cooling, natural gas for electricity generation, and NGVs are all examples of how our industry is coming together to meet specific marketing goals. Those new technologies are crucial to our future."[13]
- "Until recently, [natural gas's] main role was as a source of heat in industry and buildings. Efficient new technologies such as natural gas-powered cooling systems and heat pumps are challenging electricity's dominance of some of the fastest-growing energy uses."[14] Besides new technologies, existing technologies, such as gas furnaces, have become much more efficient and competitive over the last two decades.
- "The competitive position of commercial gas cooling also has been enhanced by new technologies developed by the major equipment manufacturers. These technologies have greatly reduced the first-cost premium over electric air conditioning and roughly doubled the efficiency of gas cooling. The imminent restrictions on the use of choloroflurocarbons (CFCs) will further enhance the competitive position of gas-fired absorption and desiccant cooling and gas-absorption heat pumps that require neither the use of CFCs nor their contemporary substitutes, hydrocholoroflurocarbons (HCFCs)."[15]
- Of the major fuels, natural gas has the most benign pollution profile ($CO_2$, $SO_2$, and NOx).
- "The biggest potential gas market is in the utility-owned power generation and independent power

[13] David R. Jones, "New Horizons," *Fortnightly*, October 15, 1993, p. 23.
[14] Christopher Flavin, "Natural Gas Production Expands," *Vital Signs: The Trends That are Shaping Our Future*, (New York: W.W. Norton, 1994) p.56.
[15] Henry R. Linden, "The Future of the U.S. Natural Gas Market," *Public Utilities Fortnightly*, March 1, 1993, pp. 26-27.

production, including cogeneration."[16] "The new gas-fired generating units (basically jet engines) . . . will produce electricity at dramatically lower costs. . . . By the end of the 1990s, the gas-fired generators coming on line will be profitable at a benchmark wholesale electricity market price of 3.5 cents per kilowatt-hour, FOB the high-voltage transmission network."[17] "Clean burning natural gas will be just what many electricity generators are looking for to meet the demands of the Clean Air Act Amendments and the Energy Policy Act."[18] These new "combined cycle" natural gas generation plants use a gas turbine and a steam turbine that is driven by the waste heat from the gas turbine. "Gas-fired plants cost only about half as much to build as coal plants do."[19] "New gas-turbine-based plants have efficiencies of more than 50 percent."[20]

- "There is little question that the Clean Air Act Amendment of 1990 and the rapid progress in the development and commercialization of dedicated compressed natural gas vehicles make natural gas the most attractive alternative fuel choice for automotive fleets on the basis of economic and compliance considerations."[21] An industry study estimates that as many as 4 million natural gas vehicles could be on U.S. roads by 2005.[22]

[16] Henry R. Linden, "The Future of the U.S. Natural Gas Market," *Public Utilities Fortnightly*, March 1, 1993, p. 27.
[17] Vinod K. Dar, "The Electric and Gas Industries are Converging: What Does it Mean?" *Public Utilities Fortnightly*, April 1, 1995, p. 22.
[18] David R. Jones, "New Horizons," *Fortnightly*, October 15, 1993, p. 23.
[19] Steve Collins, "Special Report: Gas-Fired Power Plants," *Power Magazine*, February, 1993.
[20] Christopher Flavin, "Natural Gas Production Edges Up," *Vital Signs: The Trends That are Shaping Our Future*, (New York: W.W. Norton, 1996), p.50.
[21] Henry R. Linden, "The Future of the U.S. Natural Gas Market," *Public Utilities Fortnightly*, March 1, 1993, p. 26.
[22] AGA Planning and Analysis Group, "Projected Natural Gas Demand from Vehicles under the Mobile Source Provisions of the Clean Air Act Amendments," Washington, D.C., January 30, 1991.

- "A device called a fuel cell will soon offer an even more versatile and efficient way to convert natural gas to electricity. . . . They are highly efficient and relatively nonpolluting, and in the future will be economical even at a very small scale, offering the possibility of generating electricity inside buildings and using the waste heat for water and space heating."[23]
- "Since world oil production is likely to grow only modestly from the current level, and then decline, natural gas could become the most important fossil fuel by 2010—building a long-term bridge to an energy economy that is fueled by hydrogen gas generated from solar energy."[24]
- The price of natural gas is projected to remain stable through the year 2015.[25]
- Demand for natural gas is projected to increase in all sectors over the next twenty years.[26]
- The supply of natural gas will probably remain abundant for generations. In the U.S., the second largest producer of natural gas in the world, the volume of natural gas is estimated to be equivalent to 78 years of production at the 1994 level.[27]
- "The new structure that has evolved under Order 636 has placed the natural gas market in a better position to compete in the current energy market."[28]
- "The industry completed the restructuring mandated by . . . Order 636 in time for the 1993-94 heating

[23] Christopher Flavin, "Natural Gas Production Edges Up," *Vital Signs: The Trends That are Shaping Our Future*, (New York: W.W. Norton, 1996) p.50.
[24] Christopher Flavin, "Natural Gas Production Expands," *Vital Signs: The Trends That are Shaping Our Future*, (New York: W.W. Norton, 1994) p.56.
[25] Jay E. Hakes, "Outlook for Natural Gas Markets," Federal Energy Information Administration, May, 1996.
[26] *Ibid.*
[27] Energy Information Administration, *Natural Gas 1995: Issues and Trends*, DOE/EIA-0560(95) (Washington, DC, November, 1995), p.21. It is estimated that 60 percent of this amount is recoverable by conventional means.
[28] Energy Information Administration, *Natural Gas 1994: Issues and Trends*, DOE/EIA-0560(94) (Washington, DC, November, 1994), p. ix.

> season and was quickly tested by severe weather in January 1994. Initial concern about the operation of the gas network was substantially allayed when the system delivered record amounts of gas to the eastern half of the country during extreme weather."[29]

There is much good news to report about the near future of the natural gas industry. New technologies are increasing and diversifying demand, the combustion characteristics of natural gas comply with clean air laws, supply is abundant, price is stable, and evidence shows that the troublesome impact of FERC Order 636 is being successfully addressed by most of those industry businesses it directly effected.

The future is bright, but the rules and culture of the industry are changing. Supplying gas reliably is no longer the primary activity assuring the survival of LDCs. "The basis for success within the utility industry is shifting from operations reliability to competitive positioning. The new success model requires utilities to be market-driven, produce customer value, provide competitive versus justifiable pricing, focus more on cost productivity than on costs in rate base, and increasingly look toward forging partnerships with others."[30]

Marketing should become the primary business process by which the company creates, satisfies, and retains customers while making a profit. Competitive marketing methods must be adopted, always focusing on the individual needs of the customer.

Marketing activities should move away from sales support and take a leadership roll. Marketing representatives need to have time and managerial support to market and sell, rather than being required to concentrate on service-related activities. Key account marketing activities should

[29] Energy Information Administration, *Natural Gas 1994: Issues and Trends*, DOE/EIA-0560(94) (Washington, DC, November, 1994), p. vii.
[30] William R. Murray, "Competitive Positioning," *Fortnightly*, July 1, 1994, p. 18.

be proactive, strategic, account-specific, and customer-oriented. Relationships with trade and professional allies should be developed for the benefit of the customer, as well as for the benefit of allies and the utility. Service personnel should understand that their interaction with customers is more important than the actual service work they perform. Market research must be done to determine what customers want. Products and services should be tailored to satisfy individual customer's needs. LDCs should consider entry into new and related business ventures, such as energy management, gas brokering, and environmental consulting.

The culture of the utility must change from that of an operations-oriented, protected monopoly, to that of a robust, market-oriented, private business operating in a competitive market where the consumer is dominant.

LDC managers with the intelligence, knowledge, and the courage to step out in front will reap the profits flowing from deregulation's new opportunities.

## *New Needs, New Answers*

*What business are you in?* Take a moment to think about it. Do you sell, distribute, or transport natural gas? Do you sell appliances? Do you service appliances? Do you sell energy management services? Your company might engage in some or all of these activities.

Now, think *beyond* the activities in which your company is engaged. Try to put yourself inside of your customer's head. A question related to, but more pertinent than, the question above: *What need is your customer fulfilling when they buy from you?* This seems like a simple question, but it can be a very difficult one to answer. Take a moment to think about your answer.

What benefit is the customer buying—comfort, convenience, reliability, security, a better looking balance sheet, peace of mind?

If you can answer this question, you are a long way toward understanding modern marketing. Natural gas is a commodity for satisfying customers' needs. As marketing people, we must think beyond delivery of the commodity (operations people will care for this) by focusing on customer needs.

In this new age of market-driven, customer-oriented utilities, we should first ask the right questions if we expect to find the right answers. If we expect to be successful in our business activities, we should place customers at the center of our strategies and plans, and continue to increase our understanding of their needs. Moving beyond customer satisfaction; we should make a passionate commitment to them and find unique solutions to their problems.[31]

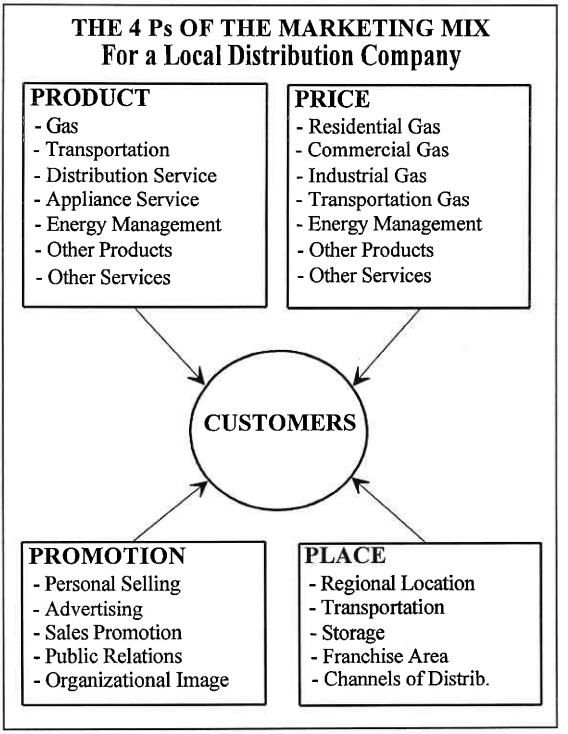
## *Perspectives of Marketing*

A few visual tools can help you gain perspective of the marketing process and give you a brief preview of what is addressed in this book.

First, on page 12, "The 4 Ps of the Marketing Mix" shows the set of marketing elements for a typical LDC business that work together to affect the marketplace. Sales can be increased by altering one or more of the marketing-mix elements.

The four Ps of the mix—Product, Price, Promotion, and Place—all impact the customer at the center of the diagram. This marketing concept is useful for defining your responsibilities in the organization. For example, if you are a marketing or sales representative, you fall within the "promotion" box in the "4 Ps" diagram, and you are probably spending most of your time on the activity of "personal selling." Chances are high that you have no control over any of the other remaining "Ps" in the

[31] Stan Rapp and Thomas L. Collins, *Beyond MaxiMarketing: The New Power of Caring and Daring* (New York: McGraw Hill, 1994), pp. 308-313.




diagram, but you have many other marketing tools to use, such as prospecting for leads, qualifying leads, presentation to prospective customers, and more.

The diagram symbolizes how company-encompassing the 4 Ps of the marketing mix are; they include all aspects of company activities, always with the customer in sharp focus.

Marketing is the primary unifier among the many departments of the business. Gas utilities are moving beyond merely supplying gas to customers. A marketing culture

should be fostered and thoughtfully supported by upper management.

The second visual aid, on page 14, is a conceptual and organizational chart for Acme Gas Company, a hypothetical LDC. This chart demonstrates how the marketing process begins with the mission statement, then moves to the strategic plan, then to the adoption of a marketing philosophy. These upper boxes of the diagram are conceptual, showing the flow of ideas and information for the development of the company marketing framework.

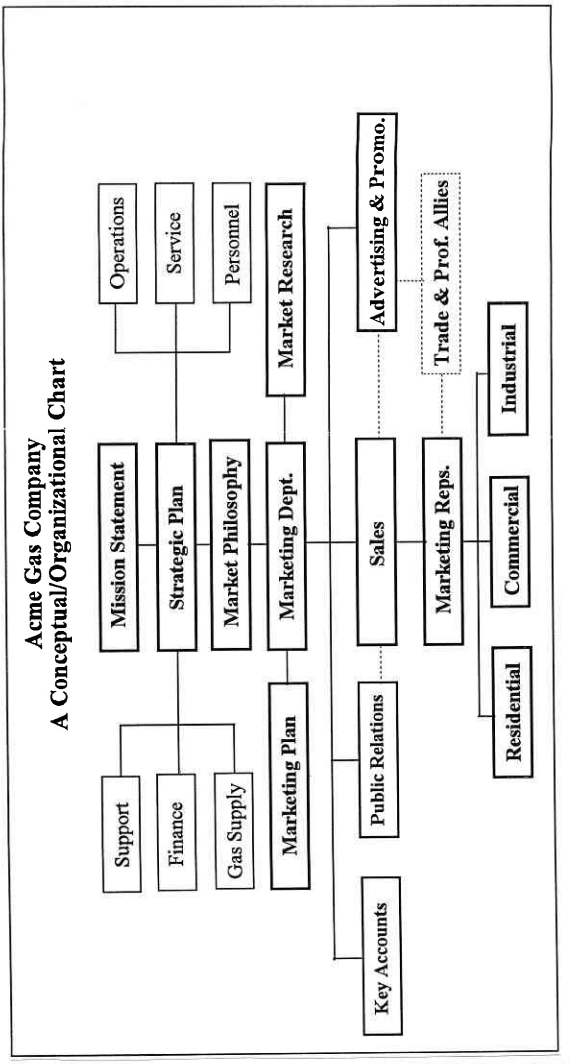
Seven business divisions are connected to the strategic plan box: support, finance, and gas supply on the left; operations, service, and personnel on the right; and marketing department on the bottom. The business divisions to the left and right are printed in a lighter typeface, indicating that they are not addressed in this book. All boxes printed with bold typeface are addressed.

To the left and right of the "marketing dept." box are "marketing plan" and "market research," each being a very important part of the marketing organization.

From the box "marketing dept." and downward, the diagram is a generalized organizational chart, showing the hierarchical structure of personnel involved with marketing functions.

Trade and professional allies ("Trade & Prof. Allies" box) are not part of the organization, but are ancillary personnel important to the organization's marketing success.

Because marketing is the subject of this book, the conceptual/organizational chart is drawn with a bias for the marketing functions and departments of the hypothetical LDC.


Acme Gas Company
A Conceptual/Organizational Chart
Support
Finance
Gas Supply
Marketing Plan
Key Accounts
Public Relations
Mission Statement
Strategic Plan
Market Philosophy
Marketing Dept.
Sales
Marketing Reps.
Residential
Commercial
Industrial
Operations
Service
Personnel
Market Research
Advertising & Promo.
Trade & Prof. Allies

## *How to Use this Book*

The business your utility was engaged in five years ago has now changed dramatically. The natural gas utility business is just beyond the beginning of an exciting, albeit risky, period. New needs require new questions, answers, and information. This book is an attempt to fill these needs.

The core chapter of this book is Chapter 2, Natural Gas Marketing and Sales. Use this chapter for information on modern marketing methods. The tone is set by a belief that purchases are based on satisfaction of needs and the customers' perception of the social benefit created by the seller. Knowledge and practice of modern marketing methods are vital for the survival of the LDC in today's competitive environment.

Use Chapter 3, Description of Natural Gas Equipment, for descriptions of natural gas utilization equipment, from large commercial absorption chillers to common backyard gas barbecue grilles.

Gas equipment has come a long way from the first gas lights fired with manufactured gas. There is much more to know and there are many more opportunities for increasing gas load. Today manufacturers continue to improve high-efficiency furnaces and environmentally friendly gas-fired absorption and desiccant cooling units.

Chapter 3 characterizes all gas utilization equipment, with size ranges, sub-types, and sources of manufacturers. Use this chapter as a reference for your marketing and sales activities. Take the time to learn as much as you can about gas utilization equipment.

For an introduction to Gas Equipment Applications, see Chapter 4. Fifteen building facility types are discussed, each with appropriate gas equipment applications. Facility energy-systems requirements are listed, along with advantages of natural gas equipment and items to consider

before installing this equipment. Not only will this information help you sell natural gas, it will help you communicate with building owners, managers, and related trade personnel.

This chapter also includes many tables listing natural gas energy intensity values for ten commercial facility types and for U.S. households. Values are also included for natural gas use for water heating and appliances in households. These tables can be very helpful for determining 1) which facility types to approach for selling natural gas and 2) the potential for natural gas load increase as a result of converting an existing building or installing natural gas in a new building.

For numerical sales tools, see Chapter 5, Energy Economics. Equipment purchases by building owners and managers are often based on financial considerations. For example, if gas absorption cooling is more costly to install than electric vapor compression cooling, is the additional cost a good investment? The energy economics methods in this chapter can help answer such a question.

Elementary methods, such as simple payback and also more advanced discounted methods, such as uniform annual cost, are explained. A common example covers each of the included energy economics procedures.

Chapter 6, Useful Information and Calculations, contains technical data and mathematical methods useful for natural gas marketing and sales. For example, this chapter includes a method for calculating the savings of natural gas food service equipment over electric equipment (Table 6-13).

This book is far from conclusive in the areas of marketing, sales, and natural gas equipment and utilization. If you require more in-depth information, see Chapter 7, Resources for Natural Gas Marketing. This chapter lists organizations, books, periodicals, and online services that will be helpful for finding other sources of information.

Gas utilization equipment, marketing, and sales terms are defined in Chapter 8, a glossary. The entries have been selected for their relevance to the marketing and sales of natural gas in today's competitive market. The Appendix includes comparisons of major fuels: Natural gas compared with propane, oil, and electricity. Advantages and disadvantages of each fuel are listed, along with myths—and the facts—about some of the competing fuels. This is useful information for marketing and selling natural gas.

The major features of the Federal Energy Regulatory Commission Order 636 are discussed in the Appendix because of the order's vital importance.

Also included in the Appendix is the American Marketing Association Code of Ethics. This ethical code is deserving of consideration as a model for the marketing department of your company.

◆ ◆ ◆

This book does not suggest serving the customer at the expense of profits. To the contrary, it suggests that putting the customer first and fostering a long-term relationship with the customer is the *best* way to increase profits and insure long-term financial viability.[32]

[32] Customer-oriented marketing is not an untested paradigm, many companies have proven it to be the most effective marketing paradigm. For stories of business successes, see Stan Rapp and Thomas L. Collins, *Beyond MaxiMarketing: The New Power of Caring and Daring* (New York: McGraw Hill, 1994).

# 2. Natural Gas Marketing and Sales

## *Introduction*

Marketing is *everything* your company does to promote business, from the conception of an original idea to the selling a new account. Simply put, marketing is understanding what people want and giving it to them at a profit.

The broad scope of marketing includes the optimum mix of personal selling, sales promotion, advertising, and public relations. The details include the company logo, the color of the trucks, company location, the telephone etiquette of the personnel at the call center, your knowledge of the gas business, service personnel's manners with customers, your relationship with customers, and much more.

Historically, natural gas utilities were protected from the threats of competitive-market forces by their monopoly status. This resulted in a monopolistic or complacent management philosophy, embedded in *status quo* actions rather than progressive management activities. Federal legislation during the last decade has removed much of this monopoly protection, exposing gas utilities to the perils of the free market. As a result, the vestiges of the complacent management philosophy must be quickly shed and replaced by a foreword-thinking marketing philosophy. This is what gas utilities must do to survive the next decade.

Marketing must now be the engine that runs the natural gas business. Satisfying customers is the fuel for the this marketing engine.[33] Profitability will follow closely behind.

[33] Historically, the operations departments have held "ownership" of utilities. If utilities are to survive, this "ownership" must move to the marketing departments, with the operations departments taking an equal or subordinate roll. See Brian Regli, "The Battle for the Company," *Public Utilities Fortnightly*, July 1, 1996, pp. 14-15.

Unfortunately, some natural gas utilities are still characterized by outmoded management philosophies and activities. Ten years ago this resulted in retarded load growth and general deficient performance. In today's more competitive and changing business environment, the results of adhering to anything but a marketing philosophy could be disastrous.

Unless there is purposeful and thoughtful progressive change in management philosophy *and* company culture, any attempt to adopt more progressive policies and activities will be ineffectual in the long-term.

Please refer to the conceptual/organizational chart of a hypothetical LDC on page 14. This chart is a helpful visual aid for one's understanding of the marketing framework.

## *The Changing Market*

Of the one hundred largest businesses in 1900, only sixteen are still doing business today. This is a sobering reminder that businesses must adjust to societal, economic, and market changes to survive.

We live in an era of consumer-oriented business. This means that we must be vitally concerned with the wishes of our customers, we must work with them, we must do our best to satisfy their needs and expectations.

As options for energy suppliers increase, gas customers become more discerning and discriminating. As a result, marketing efforts by local gas distribution companies (LDCs) must become more focused and energetic if they are to retain or increase their market share.

One significant factor of the changing gas market has been Order 636, the October 1993 Federal Energy Regulatory Commission directive that deregulated and unbundled pipeline transportation and services.[34] As a result of this order, gas marketing companies (other than LDCs) are

[34] See *Major Features of FERC Order 636* in the Appendix.

undertaking business in new areas, many of which historically have been occupied exclusively by LDCs.[35] These areas include:

- Assisting customers with conserving both gas and electricity.
- Marketing fuels that compete with natural gas.
- Laying pipelines to serve industrial customers that LDCs have not been able to serve economically.
- Selling natural gas to aggregated groups of individual commercial and residential customers.

In addition, LDCs have begun soliciting customers in franchise areas other than their own.

These changes, along with electric industry deregulation and restructuring, are making the natural gas business more competitive. Market forces are pushing the gas business toward a high-volume, low-margin industry. Ensuing economies of scale will result in mergers and other structural changes within the industry.

The keys to survival are:

- Controlling and reducing costs.
- Eliminating unnecessary business activities.
- Improving service activities. Responding quickly and consistently to customer's needs.
- Enhancing public relations.
- Understanding that the relationship with the customer will become more important.
- Clearly identifying customers' needs.
- Identifying and developing niche markets.
- Reducing profit margins.

"The imperative now is for marketing to emerge as a major driving force for change within utilities, just as it has been for airlines, railroads, telephone companies, brokerage firms, and other companies whose markets have opened to greater competition. . . . Marketing can no

[35] These business types include gas marketers, gas brokers, gas aggregators, energy service companies (ESCos), and retail energy service companies (RESCos).

longer be seen as a department that principally provides sales support. Instead, marketing must be viewed as the critical business process by which the company creates, satisfies, and keeps customers . . . at a profit."[36] ". . . gas LDCs can choose to be arrogant and unresponsive to their customers, or they can choose to be proactive and represent their customers' interests. Their choice will determine the effectiveness of gas marketers and brokers. In effect, well-run gas LDCs represent the biggest threat to gas marketers and brokers. A highly customer-responsive LDC, with substantial gas transportation and purchasing power, can excel against many potential competitors."[37]

## *Market Trends*

The average price of natural gas through the year 2015 is projected to be stable while demand for natural gas will increase in all sectors (Federal Energy Information Administration, 1996).

Price will remain stable because:

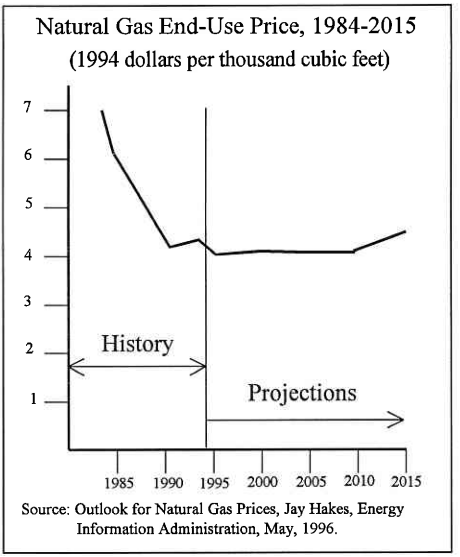
- Growth will be primarily in the industrial and electric generation sectors that benefit from lower prices because of their large volume use and level loads.

**Average Residential Gas Customer Usage***

| *Year* | *Usage, million Btu* |
|---|---|
| 1970 | 129.2 MMBtu |
| 1980 | 111 MMBtu |
| 1993 | 96.5 MMBtu |

* The amount of gas used by the average residential customer has be declining since the energy crisis of the early 1970s as a result of more energy-efficient homes and increases in the efficiency of gas appliances.

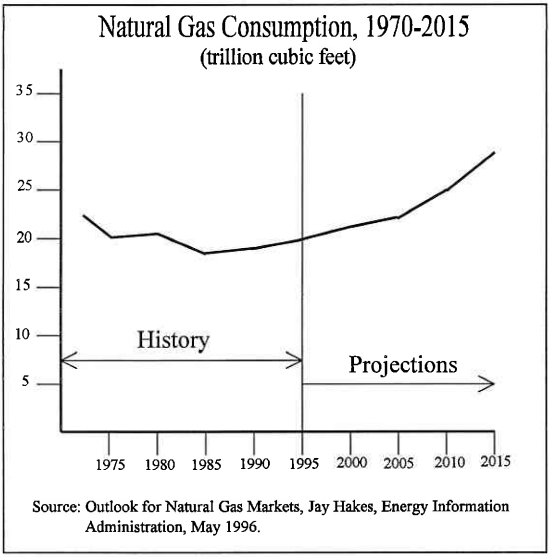
[36] William R. Murray, "Marketing: Today's Imperative," *Fortnightly,* March 15, 1994, p. 33.
[37] James Schretter, "1995 Gas Executives' Forum," *Public Utilities Fortnightly,* September 15, 1995, p. 36.




Source: Outlook for Natural Gas Prices, Jay Hakes, Energy Information Administration, May, 1996.

- Growth within these two sectors provides for greater load diversity.
- Pipeline utilization will improve over the next few decades.
- Efficiency improvements in gas transportation will hold down the city-gate price (the point at which an LDC receives gas from a pipeline company).
- Retail competition will increase.
- Capital costs will decrease.

Growth in consumption is not expected to be significant until the year 2000 when predicted real growth will be from 1.1 to 1.6 percent per year. Consumption is expected to reach 28.7 trillion cubic feet by the year 2015, as projected by the Energy Information Administration (EIA). The EIA has found that growth in natural gas consumption is highly dependent on general economic growth.




Source: Outlook for Natural Gas Markets, Jay Hakes, Energy Information Administration, May 1996.

Marketing research and market forecasting personnel at gas LDCs often determine the trends for natural gas demand. Please refer to "Marketing Research and Analysis" in this chapter for more information.

## *The Marketing Process*

*If the marketing process is to be successful, the customers' needs must be at its center.* This process is an exercise in matching the customers' needs with the companies realistic capabilities and goals.

Many gas utility managers have not followed marketing principles because of their monopoly position in the market. As a utility's monopoly position weakens as a result of legislation and market forces, adopting marketing methods becomes vital for survival.

The modern marketing approach includes the following activities:

- *Demand Analysis and Forecasting.* In this first step of the marketing process, the size of the current market is estimated and forecasts of future growth are made.
- *Market Segment Identification.* This involves the identification of distinct groups of consumers in the marketplace. Generally, the finer the detail of each segment's characteristics, the better. In the natural gas business these market segments are often simply identified as residential, commercial, and industrial. However, more detailed segmentation analysis—customer profiles—can be beneficial. Standard Industrial Classification (SIC) Codes and function codes can provide valuable information for targeted marketing. These codes can be assigned to commercial and industrial gas accounts to 1) categorize the economic activities of commercial and industrial customers and 2) to define the building type and energy uses. Once the segments are identified, the characteristics, including needs and wants, of each group can be determined. However, "more and more, . . . utilities are moving away from Standard Industrial Code and needs-based segments, and adopting segmentation schemes that focus on customers with a similar decisionmaking [*sic*] process or similar risk of loss."[38] In 1993, Southern California Gas Company (SoCalGas) determined their residential customers fit into these segments:[39]

[38] William R. Murray, "Competitive Positioning," *Fortnightly*, July 1, 1994, p.20.
[39] Richard M. Morrow, "What Do Your Customers Really Want?" *Public Utilities Fortnightly*, January 1, 1996, p. 17.

- "*Service Seekers*—little company contact; seeking more.
- *High Contact*—two subgroups; frequently seek service; prefer that service costs be embedded in rates.
- *Been There, Done That*—older, established households; aware of company; prefer to do for themselves; little need for additional contact, products, or services.
- *Single and Carefree*—singles; usually renters; lowest interest in products and services.
- *Low Flow*—mostly use electricity."

In the same study, SoCalGas found that their commercial customers fit into these segments:[40]

- "*Help Me Grow*—smaller customers seeking help with energy operations.
- *Sophisticated Service Seekers*—large institutions that want more sophisticated assistance.
- *Status Quo*—largest customers; frequent company contact.
- *Divided Responsibility*—larger consumers, often part of national or regional operations; decision-makers not located at local facilities.
- *Low Interest*—little need for additional contact.
- *Almost Residential*—smaller, less sophisticated customers; low gas usage. . ."

- *Market Segment Targeting.* Once the segments are determined, the next step is to decide which of the segments to target or pursue. The segment's attractiveness must be measured. This process includes determining whether a segment already contains aggressive competition, deciding whether new entrants are expected into the market, and analyzing buyers' price sensitivity. After the option's

[40] Richard M. Morrow, "What Do Your Customers Really Want?" *Public Utilities Fortnightly*, January 1, 1996, p. 17.

**Marketing Related Activities**

***Planning***
- Rates and pricing
- Preparation of marketing plans
- New services
- Market development

***Market Research and Analysis***
- Research of markets
- Research of competitors
- Advertising research
- Economic research
- Sales analysis and forecasting
- Marketing information systems (MIS)
- Focus Groups

***Sales***
- Sales to national or key accounts
- Sales to industrial, commercial, and residential accounts
- Transportation sales
- Sales or rental of gas equipment
- Alliances with trade and professional groups
- Service department management and training
- Customer service management and training
- Sales training

***Advertising and Promotion***
- Product and service advertising
- Advertising policy decisions
- Public relations decisions
- Media selection

attractiveness has been assessed, it then must be determined if the company can serve a particular segment. For the natural gas business, this process often manifests itself as determining the degree of aggressiveness of pursuit, rather than whether to target the segment or not.

- *Product or Service Positioning.* This is the process of designing the product or service to fit the needs of a market segment. Positioning involves differentiating the company's products or services from those of its competitors by customizing the product or service mix in response to the segment characteristics.
- *Customer Satisfaction Measurement.* Business schools now teach that customer satisfaction is the most important component for the long-term viability of a business. Gas utilities must constantly determine to what extent their customers are satisfied or dissatisfied. Methods that are working should be retained and those not working should be rejected. "Gauging customer satisfaction is an ongoing activity. Some customer groups, such as new residential builders that operate in the volatile housing market, need to be surveyed semiannually. Large industrial customers, however, can be surveyed annually."[41]
- *Improving Customer Retention Rates.* It always costs more—as much as six times more—to win a new customer than to retain a current one. Steps involved with improving your company's customer retention rate include 1) measuring the retention rate, 2) identifying the major causes of customer defection, 3) determining how much your company loses when a customer defects (customer "lifetime value"), 4) calculating the cost of reducing the defection rate, and 5) determining whether the cost of reducing the defection rate is less that the customer's lifetime value. Once these factors are determined, strategies should be implemented to improve customer retention. These may include financial rewards, personalized service, and better rates. However, the most

[41] Richard M. Morrow, "What Do Your Customers Really Want?" *Public Utilities Fortnightly*, January 1, 1996, p. 17.

effective and enduring way to improve customer retention is to satisfy customers consistently.

- *Societal Benefit.* Customers today are expecting business organizations to be socially responsible. In the present business environment, it is wise for the long-term relationship with customers—and for long-term profitability—to determine socially responsible and ethical ways to conduct business.

## *Company Mission Statement*

All other company strategies, plans, and policies originate from the company mission statement; it is the cornerstone of the organization. It is a concise document describing the objectives of the business for the next decade or two.

In the organizational chart on page 14, you can see that the mission statement is at the top, indicating that it is the guiding vision or objective of the company.

The statement should include a definition of organizational purpose, be market oriented, realistic, motivating, visionary, fit the market environment, and be based on the organization's distinctive characteristics. It should be revised during the periodic strategic planning process.

Here is a sample mission statement for an LDC:

> Acme Gas Company will safely and reliably supply natural gas and related energy services to residential, commercial, and industrial customers within its franchise area, while earning an above average return for its stockholders. Energy and services shall be supplied in an exceptional manner, focusing on the needs and full satisfaction of its customers, the benefit of the natural environment, and the good of society.

The strategic plan flows from the mission statement, although the mission statement is generally included as a part of the strategic plan.

## *Strategic Planning*

Strategic planning helps determine how the company can best take advantage of its strengths in the changing business environment. Strategic planning gives direction to the company, setting the stage for the other planning activities of the organization. A strategic plan may span anywhere from three to twenty years. By comparison, marketing plans usually span just one year.

Many business planners believe that the most important part of the plan is the process of creation, rather than the plan itself.

The steps of the strategic planning process include:[42]

- *Development of Mission Statement.* This should include a definition of organizational purpose for the next ten to twenty years. It should be market oriented, realistic, motivating, visionary, fit the market environment, and be based on the organization's distinctive characteristics. A sample can be found on the previous page.
- *Determine the Company's Objectives and Goals.* Each manager should develop realistic objectives for her or his business unit. Marketing strategies should be developed to support these objectives and goals. Overall company objectives and goals should then be developed.
- *Analyze Business Portfolio* (The business portfolio is a collection of products and services that make up the company). Managers should find the best fit of products and services for the company's strengths and weaknesses. In addition, managers should analyze the current business and market situation and determine where to increase or decrease business resources.

[42] Based on Philip Kotler and Gary Armstrong, *Principles of Marketing* (7th ed.: Englewood Cliffs, NJ: Prentice-Hall, 1996), pp. 36-44. Adapted by permission of Prentice-Hall Inc., Upper Saddle River, NJ.

- *Develop Strategies for Business Growth.* Growth strategies should be formulated for new business. Possibilities for increased market penetration, market development, product and service development, and diversification should be investigated. Growth topics as diverse as gas line extensions and the funding a private energy marketing or service company are possibilities here.
- *Develop Strategies For Each Business Unit.* Functional strategies for the natural gas unit and its parallel and sub-units must be developed. These strategies should be coordinated among business units and relate to the overall strategic plan.

## *Competitor Analysis and Strategies*

Regulatory changes, most importantly FERC Order 636, have made LDCs much more vulnerable to the competition of the free market. As a result, it is more important than ever that the management and staff of gas utilities know all they can about competitors. Ignoring competitors is similar to a boxer closing his eyes during a boxing match. Years ago this strategy worked because nobody else was in the boxing ring with LDCs.

The general business of selling energy is likely to become more complex as time passes, making competitor analysis more difficult and more important.

Analyzing competitors includes these activities:[43]

- *Identify the LDC's competitors.* Other competitors selling natural gas can include gas marketing companies, other LDCs, and energy service companies (ESCos). Another type of competition, those selling fuels that compete with natural gas, include electric utilities, large and small oil companies, and propane

[43] Based on Philip Kotler and Gary Armstrong, *Principles of Marketing* (7th ed.: Englewood Cliffs, NJ: Prentice-Hall, 1996), pp. 595-602. Adapted by permission of Prentice-Hall Inc., Upper Saddle River, NJ.

companies. Gasoline-fueled vehicles are competitors for natural gas vehicles.

- *Determine Competitors' Objectives.* What are they trying to do? Of course, competitors are seeking profits, short-term or long-term. The business of selling energy and associated services often requires large capital investment. As a result, short term losses might be tolerated by competitors for the sake of long-term financial viability. This characteristic of the energy business can influence competitors objectives and strategies.
- *Identify Competitors' Business Strategies.* The closer the overall characteristics of two businesses are, the more closely aligned their business strategies will be. As a result, competitors can be classified into strategic groups. All ESCos, having the same basic business strategies, belong to a strategic group, as do all medium to small sized oil dealers. The most intense competition occurs within the strategic group, one ESCo against another or one oil dealer against another. The better your company identifies the strategies of your competitors, the more successful it will be.
- *Determine Competitors' Strengths and Weaknesses.* By making this determination, a company can decide how its strategies best fit within the environment of its competitors. Benchmarking is used by progressive companies to determine how and why some companies perform tasks better than others. A company using benchmarking attempts to imitate or, better yet, improve on the best practices of competing companies.
- *Decide which Competitors to Avoid and Which to Compete with.* Management of most companies will choose to challenge weak rather than strong competitors. Most will compete with companies having

similar characteristics rather than dissimilar characteristics.

Once competitor analysis is complete, management must select effective competitive marketing strategies. No one strategy is best for all companies; the strengths and weaknesses of the business and the market environment must be considered before determining the best strategies.

In 1980, Michael Porter suggested some basic competitive strategies.[44]

- *Overall Cost Leadership*. The company offers the lowest costs in its industry or geographical area.
- *Product or Service Differentiation.* The company works to offer a highly differentiated product line and marketing scheme. This a possible, but difficult for an LDC.
- *Focus on Market Segments, Rather than the Whole Market*. The company concentrates on market segments for which it has an advantage or can create an advantage. This is a good strategy for a gas company in today's market.

Years latter, Michael Treacy and Fred Wiersema added some competitive strategies to the above list:[45]

- *Operational Excellence*. The company offers substantial benefits to customers by leading the industry in price and convenience. LDCs often can offer substantial benefits to customers.
- *Customer Intimacy*. The company tailors its products and services to the targeted customers and builds long-term customer loyalty. This strategy fits well with the overall concept of progressive marketing methods.

[44] Michael Porter, *Competitive Strategy: Techniques for Analyzing Industries and Competitors* (New York: Free Press, 1980).

[45] Michael Treacy and Fred Wiersema, "Customer Intimacy and Other Value Disciplines," *Harvard Business Review*, January-February, 1993, pp. 84-93; and "How Market Leaders Keep Their Edge," *Fortune*, February 6, 1995, pp. 88-98.

- *Product and Service Leadership.* The business offers a continuing stream of innovative products and services that make their own and competitors products and services obsolete. This is not easy to do in the energy business.

Kotler and Armstrong use a different and instructive perspective.[46] They categorize competitive positions and associated competitive strategies according to the roll a business plays in the target market:

- *Market-Leader Strategies.* LDCs are market leaders within their franchise areas. They will lose market share to gas marketing companies and energy service companies, but they will probably remain the market leaders. Competitive strategies include:
  - *Expanding the Market.* For LDCs this means increased gas use or use of services. This can happen as a result of new users, new uses, or increased demand from existing users.
  - *Protecting Existing Market Share.* LDCs must be innovative here. Strategies can include 1) protecting the current position and market share; 2) protecting weak market segments; 3) attacking a competitor before being attacked; 4) striking back when attacked; 5) moving into new markets; and 6) pulling out of some segments with the objective of becoming stronger in remaining segments.
  - *Increasing Market Share.* Generally, for private businesses, when market share increases, profitability increases. Because most activities engaged in by LDCs benefit from economics of scale, increased market share lowers costs and makes the business more competitive.

[46] Philip Kotler and Gary Armstrong, *Principles of Marketing* (7th ed.: Englewood Cliffs, NJ: Prentice-Hall, 1996), pp. 605-614. Adapted by permission of Prentice-Hall Inc., Upper Saddle River, NJ.

- *Market-Challenger Strategies.* LDCs are leaders within their franchise areas, but in some market segments, such as energy management services, they might be challengers or followers. In any area of business where an LDC is not a leader, aggressive objectives and strategies must be selected. Active strategies can include: 1) attacking a competitor's strengths; 2) attacking a competitor's weaknesses; 3) simultaneously attacking a competitor's strengths and weaknesses; 4) surpassing a competitor's product or service and moving into easier markets; and 5) short-lived attacking to demoralize or harass a competitor.
- *Market-Follower Strategies.* LDCs are not market-followers today within their franchise areas, but some might fall to this position if sound strategies are not used. However, it is likely that an energy service company (ESCo) operating under the umbrella of an LDC is a market-follower. A follower must carefully watch market leaders and challengers with the objective of learning from their market strategies.
- *Market-Nicher Strategies.* LDCs are more likely to be a target for market-nichers rather than to be market-nichers themselves. Market-nichers find small, but profitable, market segments. Market-nichers tend to be small, responsive firms, who have an intimate knowledge of their narrow target market. ESCos operating under the umbrella of an LDC can pursue market niches more easily than the parent LDC.

## *Marketing Management Philosophies*

Today there are six marketing management philosophies adhered to by businesses. Your company may select one or any combination of the six. Most progressive businesses today are adhering to the *marketing* or *societal* management philosophies. Rather than operating haphazardly, it is important that the overall management of a gas utility operate with purposeful direction or philosophy.

The *monopolistic or complacent philosophy* is characterized by management thinking that the revenue and customers will still be there tomorrow because there is little, if any, competition and that the product is a necessity to the users. The actions of management are characterized by ignorance of marketing methods, insensitivity to the needs of customers, belief that the customer does not know what she or he wants, feelings of insulation and invulnerability from competition and the changing market environment, and belief that the *status quo* will prevail.

If your organization is doing business based on this management philosophy, do your best to get it to move in a more progressive direction. Select two or three progressive utilities as models for your own. Contact the marketing managers at these utilities and ask them what they are doing and how change in management philosophy has taken place.

The *production philosophy* holds that consumers favor products that are available and affordable. Management focuses on improving production and distribution efficiency. Under this paradigm, the gas operations department runs the show.

The *product philosophy* holds that consumers favor products and services that offer the greatest quality, features and performance. Management is primarily concerned with making on-going product improvements.

Under this paradigm, again, the gas operations department runs the show.

The *selling philosophy* holds that consumers will not purchase enough of the company's products without large-scale promotion and selling effort. Management's focus is on promotion, selling, and conquest of the buyer. Under this paradigm the gas operations department runs the show, but marketing and selling increase in importance. The sales force serves the gas operations department.

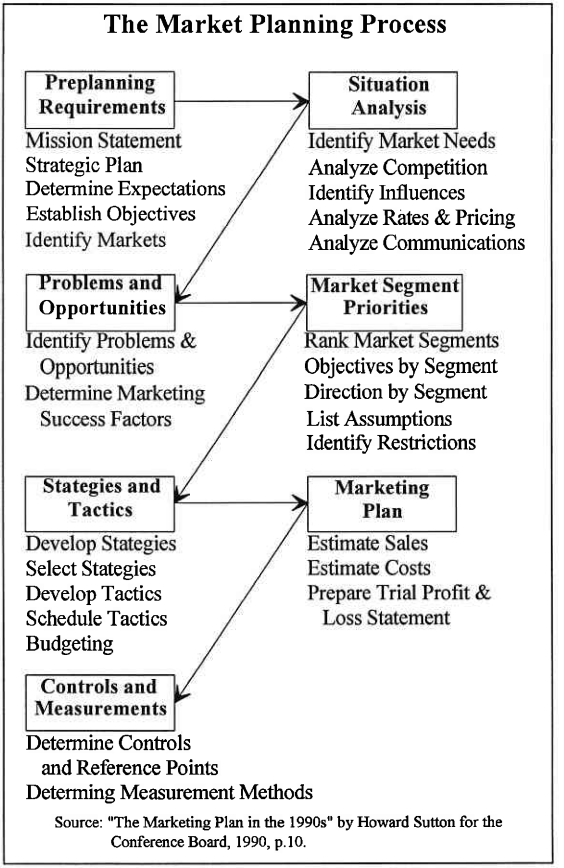
The *marketing philosophy* holds that customers' purchases are based on the satisfaction of their needs, wants, and long-term trust of the seller. Management focuses on defining the market, determining customer needs, coordinating marketing activities, affecting customers, and aiming for long-term customer satisfaction. In addition, management attempts to establish a long-term, trusting relationship with the buyer. Under this paradigm, the gas marketing department runs the show.

The *societal marketing philosophy* encompasses the marketing philosophy with the added features of societal responsibility and welfare. It holds that customers purchases are based on the satisfaction of needs, wants, long-term trust of the seller, *and* the customers' idea of the societal benefit created by the seller. Under this paradigm, again, the gas marketing department runs the show.

The discussion of other topics in this chapter is based on the premise that the societal marketing philosophy is the most appropriate choice for gas utilities today.

## *Marketing Planning*

Marketing planning is the process of selecting market strategies that will help the company reach its overall objectives. A marketing plan is a core element of strategic planning.




Source: "The Marketing Plan in the 1990s" by Howard Sutton for the Conference Board, 1990, p.10.

The plan has three purposes: to communicate the planners' intentions to top management, to justify budget requests, and to give the marketing department points of reference for measuring progress.[47]

[47] Howard Sutton, *The Marketing Plan in the 1990s*, The Conference Board, 1990, p.9.

Marketing plans can cover various lengths of time. Annual plans are short-term marketing plans that describe the current situation and a strategy for the short-term. Long-range plans cover the same topics but cover several years. Although long-range plans address several years, they should be updated annually.

Conducting business without a marketing plan is similar to going on a long journey without awareness of where you are going or how you are going to get there. A marketing plan is a must-do activity.

If you are developing a comprehensive marketing plan for you gas company, your approach will be different from that used to develop a subsidiary plan for a particular department or a specific geographical area.

The major topics included in a marketing plan are:

- *Executive Summary.* This should be a brief statement of primary goals and recommendations.
- *Overview of Market Place*. This section should include a market description, product or service review, characteristics of the competition, and strategy for products or services marketing.
- *Competition and Opportunities*. This should cover competition, threats to products or services, and an analysis of each, as well as discussion of product or service opportunities and an evaluation of each. For example, this section could include an analysis of how much of a particular utility's customer base will be eroded by independent energy service companies (ESCos).[48]
- *Objectives and Issues*. Include objectives stated as goals to be achieved during the term of the marketing plan.

[48] Many utilities are buying or creating their own ESCos or energy marketing companies as a means of retaining customers, expanding operations into other territories, and diversifying business operations. Today there are few, if any, utilities that do not have an ESCo, do not have an interest in one, or are not developing one.

- *Competitive Strategies.* Explain the methods by which marketing goals and objectives will be reached. Strategies for advertising, sales promotion, public relations, and personal selling can be included here.
- *Action Plans.* This section should describe ways to turn market strategy into action—the what, when, who, and how of the plan.
- *Marketing Research.* In this section, discuss research needs and objectives.
- *Marketing Budgets.* Formulate a projected profit-loss statement for action programs. Cash flow projections, pricing strategies, and budget constraints might also be included here.
- *Marketing Controls.* List feed-back loops, controls, and adjustment methods for marketing efforts.
- *Other topics* included might be supply constraints, regulatory constraints, and new product/service development.

## *Marketing Plan Implementation*

If the marketing plan is not written in a realistic manner or if it is not taken seriously, implementation of the plan will prove to be difficult.

Studies of marketing plan implementation have demonstrated some common problems making implementation difficult. These problems include unrealistic plans, plans that are too general, and plans missing important parts, such as competitive or customer analysis.

Market plan implementation requires:

- Management that believes in the marketing process and takes the marketing plan seriously.
- Effective leadership for plan implementation.
- A plan for action. Who will do what and how will they do it. With responsibility for action must go authority to expedite the appropriate actions.

- Organizational structure and philosophy favorable to the marketing goals. On the surface, the characteristics of the organization might not seem like an impediment to action, but they often are. The structure and philosophy should be analyzed thoroughly as part of the market plan implementation process.
- Decision and reward systems, including, compensation, and human resource planning.
- A good fit between adopted marketing strategies and company culture. Company culture can be very difficult to change. It is made up of the beliefs, ethics, values, and identity shared by the people of the organization.

## *Marketing Research and Analysis*

Marketing research and analysis are vital parts of any forward-thinking organization. These activities include the systematic and purposeful 1) determination of the range of information necessary for making informed marketing decisions; 2) acquisition of this information from internal sources, market intelligence, and market research; 3) thorough analysis of records, intelligence, and research; and 4) distribution of information to marketing managers so that they are able to make intelligent marketing decisions.

A Market Information System (MIS) is often the core of the market research process. The MIS is made up of personnel; equipment; and procedures to acquire, sort, analyze, and distribute information required for making timely and appropriate marketing decisions.

Market information systems must include:

- A means of determining information needs. Not too much, not too little, just the right quality and quantity.
- Methods of developing information from internal records, market intelligence, and market research.

- Methods for analysis of records, intelligence, and research.
- Means of distributing information to marketing managers in the right form at the proper time so that they can make intelligent marketing decisions.

The market research process includes:

- *Defining Problems and Research Objectives.* What do we need to know, how are we going to find out, what information is needed, and what are we going to do with it? This can be a very challenging task.
- *Formulating a Research Plan.* Where can we get the information, what are our specific needs, what will be the primary and secondary information sources, what research methods will we use, and what personnel are needed for obtaining information and analyzing the results.
- *Carrying Out the Research Plan.* Who will do what within what time-frame?
- *Deciphering and Reporting the Research Findings.* Who will interpret the results and who needs the report for marketing decision making?
- *Determining whether the Research Results Satisfy the Objectives.* If they do not, reasons must be found and adjustments made.

Market forecasting is often included in the marketing research and analysis process. It is the estimation of existing demand or future demand for a product or service by anticipating what buyers are likely to do under certain market conditions.

## *Sales Philosophy*

Rather than *pushing* the sale with the primary need of the seller—to sell and profit—the new relationship sales philosophy is based on a longer term perspective: Discover the potential customer's needs, cooperate, serve as a consultant and helper, and then follow through after the

sale. The customer's satisfaction and trust will then *pull* the sale *and* lead to more repeat sales in the future. This sales philosophy rewards people for being customers; this is vitally important for the vitality and longevity of natural gas utilities today.

Developing a consistent sales philosophy within your company is important, for it communicates the attitudes and general ideas of the selling process to the sales personnel. Sales philosophy is subordinate to the marketing management philosophy

Different levels of interaction can be fostered between the customer and the organization by the sales person and organization. These include:

- *Basic Interaction.* No seller-initiated contact takes place after the sale.
- *Reactive Interaction.* The customer is encouraged to contact the sales person if there are any questions or problems with the product or service.
- *Accountable Interaction.* The sales person contacts the customer a short time after the sale to check to see if the customer is satisfied and to ask how the product might be improved.
- *Proactive Interaction.* The sales person's efforts go beyond the initial sales interaction by making regular after-sale contact to suggest new uses for the product or to inform of new products.
- *Relational Interaction.* The sales person works repeatedly with the customer to find new ways to improve the product and to establish a strong, on-going relationship.

The most common method used today by progressive companies is relational interaction.

The traditional method of "Let's take what we have to sell and convince somebody to buy it" has been rejected and replaced by "Let's find out what our customers need and fill those needs to the best of our ability." This is a

significant change in the philosophy of selling that has occurred over the last two decades.

## *Sales Force Management*

Narrower in scope than marketing, selling involves moving a finished product or service from the seller to the buyer.

As gas utilities move toward market-oriented business, sales personnel (marketing representatives, sales representatives, account executives, sales consultants, sales engineers, etc.) will be required to become more market-focused and customer-oriented. The sales person must represent the organization *and* the customer.

The manager of the sales force must be cognizant of all sales force activities, including planning, analysis, implementation, and control.

The major functions of sales force management include:[49]

- *Determining Structure and Strategy.* This includes the size of the sales force, whether sales representatives should work alone or in teams, how they should interact with customers, specific duties and responsibilities, sales territories, and whether to use an inside sales force, outside sales force, or both.
- *Recruiting and Hiring.* Choices must be made regarding recruitment methods, candidates' required qualifications, and the means of employee selection.
- *Training.* This ongoing process is usually divided into three major areas: company procedures, gas equipment applications, and sales methods. A permanent, comprehensive training program should be implemented and regularly evaluated.

[49] Based on Philip Kotler and Gary Armstrong, *Principles of Marketing* (7th ed.: Englewood Cliffs, NJ: Prentice-Hall, 1996), pp. 533-547. Adapted by permission of Prentice-Hall Inc., Upper Saddle River, NJ.

- *Compensating Sales Personnel.* The compensation package should remunerate sales people in a way that channels their efforts in a manner consistent with the overall marketing objectives, including behaviors and goals.
- *Supervising the Sales Force.* With supervision, sales managers direct and motivate sales people to reach the company's marketing objectives.
- *Evaluating Sales Personnel.* Methods must be in place for the fair evaluation of sales people. These methods must be fully disclosed to all members of the sales force. Evaluation methods may compare one sales person to another or they may compare past sales with present sales, or they may be a combination of the two.

## *Personal Selling*

Personal selling is one of the four major elements of the promotion mix. The other three are advertising, sometimes referred to as impersonal selling; sales promotion; and public relations (closely aligned with organization marketing).

Personal selling is based on a number of interactive steps that take place between the seller and the potential buyer. The buyer's needs, satisfaction, and perceived value of the product or service always are the foundation for the encounter. The customer-oriented or relationship method of personal selling includes the following steps:

- *Prospecting.* Identifying potential customers for your products and services.
- *Qualifying.* Deciding which prospects are worthy of your efforts.
- *Call Preparation or Preapproach.* Knowing your prospect. Do your homework. Prepare for contact.
- *Account Contact or Approach.* Whether face-to-face or over the telephone, have your script ready.

- *Probing for Information.* Attempting to uncover prospect's needs. Find solutions to their problems.
- *Presentation.* A more formal presentation (contact), if necessary, that should be based on a needs/satisfaction approach.
- *Handling Difficult Responses.* Being ready to handle objections, complaints, excuses, or indifference.
- *Gaining Commitment/Closing the Sale.* Asking for action that requires commitment from the prospect.
- *Assuring the Customer.* Keeping an active relationship with your new customer. Repeat business is the least expensive sale you can make and word-of-mouth advertising from a satisfied customer is free.

The characteristics of a good gas utility marketing or sales representative include:

- Keeping the potential buyer's needs and satisfaction at the center of the interaction.
- Helping the customer solve her problems.
- Being a good listener and not talking too much.
- Helping the customer feel good.
- Using humor in an appropriate way.
- Never wasting the customer's time.
- Always trying to schedule appointments convenient for the customer.
- Offering help *after* the sale.
- Offering honest information about competing fuels and products.
- Knowing how to correct problems created by their own gas company (must have the authority to do so).
- Never being afraid to apologize for a problem.
- Knowing the business of the residential, commercial, or industrial customer.
- Being aware of the long-term importance of the relationship with each customer.

- Understanding the importance of customer's perceptions and expectations.
- Giving the customer more than she expects.
- Putting an element of amazement into marketing presentations and relationships.
- Striving to delight each customer.

## *Personal Selling and Building Construction*

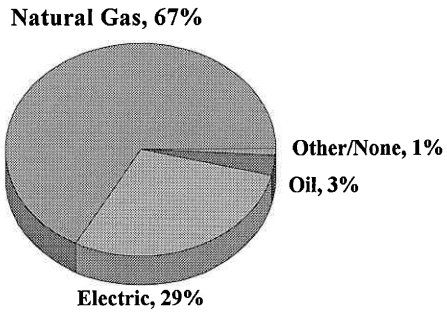
Selling gas to those involved with building new construction projects requires unique prospecting and qualifying methods. Sales representatives should understand the chronology of the development/planning process—parceling and zoning of land, initial developing of land, initial designing and planning of the project, construction of the building, and commissioning.

Also, it is important that the representative network with developers, building officials, realtors, and commercial and residential land developers. This allows him to prospect for leads, qualify leads, prepare strategy, and influence equipment choices at the most effective time during the plan/build process.

During the initial stages of building design and planning, important decisions are made regarding the energy sources and equipment use. This is the most opportune time for the marketing representative to attempt to sell major gas equipment, for this is the time the project decision makers select equipment. If this opportunity is missed, it is more difficult to impact equipment decisions later in the plan/build process.

Single-family homes are either built speculatively or custom-built. Speculatively built homes are sold after construction begins or is completed. Thus, the choices regarding energy and equipment use are made by the developer or building contractor. To affect the selection process, the gas sales representative must meet with the key decision makers during the initial stages of design process to point

**Heating-Fuel Market Share for New Single-Family Homes in 1994**




Source: US Bureau of Census, 1994.

out the advantages to using natural gas. The sales representative's strategy should include:

- Acquiring knowledge about building projects *before* the preliminary design phase begins—during the initial stages of design and site location. Sources of information are realtors, newspapers, trade organizations, town offices, and, of course, the developers themselves.
- Gathering information about the building project. The project might be one house or hundreds of houses.
- Studying the information.
- Determining ways that gas equipment can benefit the developer and the house buyer. In addition to space heating, also make the decision makers aware of the benefits of collateral gas appliances.
- Offering to give consultative assistance to the developer. The representative should attempt to make the developer's work easier and make the project more successful. This might be as simple as suggesting

sources of gas equipment to as complex as preparing a life-cycle cost comparison or working with the gas planning or engineering department for gas line extensions.

- Knowing the LDC's distribution network (Will the new project require a line extension?)

If the sales representative initially becomes involved with the key decision makers of the project *after* the initial design phase—during the preliminary or final design stages—it is more difficult to affect the process. However, attempts should still be made to advise, assist, and increase gas load.

Custom-built homes are contracted by the owner or the owner's agent (architect, designer, realtor, or construction project manager). The key decision makers for the custom-build house process are the owners. The sales representative must interact with them before or during the initial design phase.

Because it is difficult to find custom-built home projects and because the potential increase in gas load from one residential structure is slight, it is usually not worth the sales representative's time to pursue face-to-face interaction with the owners. It is more expedient to affect potential custom-built home owners at home shows, with advertising, and through alliances with trade groups (HVAC and building contractors) and professional groups (architects and realtors).

Commercial building projects have essentially the same basic phases of planning and design as large residential developments. Therefore, the commercial sales representative should use the same strategy as those listed above. However, unlike single-family residential structures, architects and engineers are usually involved during all the phases of design. As a result, the gas sales representative should determine which key decision makers to

contact. For some projects, the owner will make all the decisions, for others the owner will favor the architect or engineer making all the decisions.

As with residential design, it is best to become involved with the process in the initial stages, rather than during preliminary design or during the final stages of design.

## *Advertising*

Advertising includes the use of any media with the primary objective of selling a product or service. The media may include newspaper or magazine ads, radio or television spots, bill-stuffers, and signs on vehicles. The objectives of advertising are generally to inform, to persuade, or to remind.

Advertising may be done by in-house personnel or outside advertising firms.

Utility managers of advertising activities should:

- *Set Advertising Objectives and Goals.* Selecting objectives is guided by deciding what needs to be communicated to what audience at what time. As mentioned above, these objectives are meant to inform, persuade, or remind.
- *Formulate the Advertising Budget.* The role of advertising is to increase demand for products and services. Management must determine how much to spend to attain department goals.
- *Determine Advertising Strategy.* The two major components here are the message and the advertising media. What message will fulfill the objectives and which medium will be most effective?
- *Determine How to Evaluate the Advertising Program.* Both communication effects and sales effects should be measured regularly. Have the efforts satisfied the objectives? Strategies should then be adjusted accordingly.

## *Sales Promotion*

Sales promotion includes activities to encourage purchases of products or services. Examples include coupons, rebates to contractors or the end-user, financing incentives, door prizes, introductory offers, and caps or pens inscribed with the company name.

Gas utility sales promotion can be carried out in three distinct areas: customer promotion, trade promotion, and sales force promotion.

Trade promotion is designed to gain support from allied trades and professions, such as HVAC and building contractors, realtors, architects, and engineers. This is done with the purpose of improving the relationship with these groups and improving their sales efforts regarding natural gas. Trade promotion can include rebates, sales leads, cooperative advertising, free advertising, training programs, or tickets to sports events.

Sales force promotion is intended to motivate the in-house sales force to sell more effectively. Sales force promotion can include bonuses, contests, notoriety, and other benefits.

The activities required for a successful sales promotion program are similar to these needed for and advertising or public relations program:

- *Set Promotion Program Objectives.* These will be different for customer, trade, and sales force promotion.
- *Formulate the Promotion Budget.*
- *Determine the Promotion Strategy.* Promotion tools must be selected—what will be offered to the customer, trade ally, or sales force member.
- *Determine How to Evaluate Promotion Program.* Both communication effects and sales effects should be measured regularly. The program should then be adjusted accordingly.

## *Public Relations*

Public relations involve building positive relationships with customers, regulatory agencies, politicians, and the general public. Public relations tools include press releases, lobbying, social activities, sponsoring public events, and public appearances of company officials. Gas utilities should use public relations to promote not only products, but also company personnel, activities, and the organization itself.

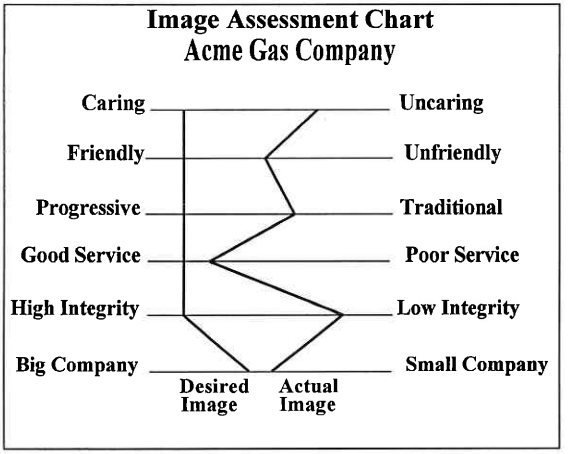
Utility managers of public relations departments should:

- *Set Public Relations Objectives.* Selecting objectives is guided by deciding what needs to be communicated to what audience at what time.
- *Formulate the Public Relations Budget.* The role of public relations is to enhance the relations between the utility and the public. Management must determine how much to spend to attain the objectives.
- *Select Public Relations Messages.* What strategy and messages will best fulfill the public relations objectives?
- *Determine How to Evaluate the Public Relations Program.* Both communication effects and sales effects should be measured regularly. Strategies should then be adjusted accordingly.

## *Organization Marketing*

Many utilities have poor public images. They are thought of as uncaring organizations that charge too much and take forever to supply gas to a customer. Organizational marketing, which is closely aligned with public relations, can help. It is a thoughtful process by an organization to improve its image in the minds of its customers.

Organization marketing requires two basic activities. First, the current image of the organization must be




determined. This can be assessed using any criteria, for example, do the customers see the organization as friendly or unfriendly, caring or uncaring, knowledgeable or unknowing, large or small, progressive or traditional?

Second, the organization must engage in planning and controlling its image. The managers of the organization must determine what the image is to be and then take steps to create that image. It must be aligned with the philosophies of marketing management, sales, and service management if image planning and control are to be successful. Organizational marketing will only work if the organization lives up to its desired image, otherwise customer mistrust will result.

Organizational images can be altered with the use of corporate image advertising, public service activities, and image enhancing slogans.

The image assessment chart above gives an example of the image characteristics that might be considered.[50] Use

[50] Based on Philip Kotler and Gary Armstrong, *Principles of Marketing* (7th ed.; Englewood Cliffs, NJ: Prentice-Hall, 1996), p. 671. Adapted by permission of Prentice-Hall Inc., Upper Saddle River, NJ.

of the chart makes it easier to formulate a strategy for image planning and control activities.

## *Alliances with Trade and Professional Groups*

Forming alliances with trade allies and professional groups can be a powerful aid to a gas utility's marketing and promotional mix.

"Simple business economics argues that because the costs of selling to smaller core customers are high, substantially more of this activity should be outsourced to trade allies with lower cost structures and better customer-contact capabilities. To date, many utilities have focused their trade-ally activities only on builders."[51]

Trade allies include heating, ventilation, and air conditioning (HVAC) contractors, building contractors, design-build contractors, and appliance suppliers. Professional groups include realtors, architects, engineers, and energy managers.

Trade allies can play an influential roll in a customer's decision-making process, especially on the residential level. Methods being used by gas utilities today to foster a close working relationship between the utility and trade allies include:

- *Providing Referrals to HVAC Contractors.* Before the HVAC contractor qualifies for the utility referral program, quality standards are usually required of contractors. Some programs require prerequisite work, for example, two leads given to a trade ally for each electric water heater converted to gas.
- *Cooperative Advertising and Home-Show Exhibits.* Some LDCs will share the cost of advertising and home-show exhibits with trade and professional allies.

[51] William R. Murray, "Marketing: Today's Imperative," *Fortnightly*, March 15, 1994, p. 34.

- *Support of Trade Association Activities.* This can include utility membership, providing speakers for association meeting, sponsoring dinners, and other activities.
- *Support of Trade Associations.* This can be done with bill-stuffers suggesting that utility customers patronize association members.
- *Informational Newsletters.* Newsletters work best if they contain information that is useful to the trade or professional allies, rather than articles only promoting utility marketing activities.
- *Training.* This can include technical training, sales training, and business management training. Some utilities offer occasional training sessions, others offer comprehensive courses of study.

Architects and engineers generally have more influence at the commercial and industrial level than at the residential level (however, they are likely to exert influence over a residential customer when designing a house).

Another professional group, realtors, can also influence residential customers when homes and condominiums are bought and sold and when apartments are rented.

Utility marketing representatives can foster alliances with architects, engineers, and realtors using these methods:

- Call on them regularly.
- Assist architects and engineers with design and engineering of gas equipment. Assist realtors with energy problems and questions, whether they pertain to natural gas or not.
- Inform them of the advantages of natural gas over other fuel choices.
- Remind realtors that buildings with natural gas appliances often have higher resale values and higher occupancy rates than those with other fuels.

**Test for Commercial Sales Representatives**

1. Name three architects who know you.
2. Name three engineers who know you.
3. Name six commercial HVAC contractors who know you.
4. What HVAC trade magazines do you read regularly?
5. What food service magazines do you read regularly?
6. What trade shows did you attend in the last year?
7. What conferences and training did you attend in the last year (technical, sales/marketing, company procedures, rates)?
8. Is your professional knowledge evolving as you wish?
   a. Technical (HVAC, food service, etc.)?
   b. Marketing methods?

- Attend their professional association meetings. Become a member, if possible.
- Offer to assist realtors with the sale of homes or condominiums having natural gas appliances.
- Offer cooperative advertising plans for new natural gas homes and condominiums.
- Consider offering operating-cost analysis comparing natural gas equipment to equipment using other fuels.
- Inform architects and engineers of new gas equipment and of successful applications of existing equipment.
- Make up case-study promotion sheets of architects' and engineers' work with natural gas equipment. Distribute these promotional pieces to commercial and industrial building owners and managers, and to other architects and engineers.

- Offer operating-cost analysis comparing gas and electric equipment, including food service, space heating, water heating, and cooling.

Your attempts to foster alliances with these groups should be guided by the desire to help make them successful in the work *they* are doing. By helping them, you will be helping yourself.

The foremost objective of the gas utility and the ally relationship should be customer satisfaction. The partnership with the ally should be the second priority. The third priority should be the profitability of the utility. If the first two priorities are being attended to, the third will take care of itself.

## *Marketing for National or Key Accounts*

National or key accounts are regional or national multi-unit accounts. They are sometimes called chain accounts. Marketing activities for these accounts require different emphasis, efforts, and skills than marketing to smaller customers.

The American Gas Association has a key-account program that can be very helpful when approaching a national account. AGA attempts to provide a direct link between national chain executives and AGA members.

"With their customers vulnerable to competitors, utilities must restructure their key account programs. The goal: become more proactive, strategic, account-specific, and oriented toward producing value for both the customer and the utility."[52]

National account activities and functions at gas utilities should include:

- *Developing National Account Policies and Procedures.* These policies and procedures will be

[52] William R. Murray, "Marketing Process Management," *Public Utilities Fortnightly*, October 1, 1994, p. 15.

different, for the most part, from those of the general marketing unit.

- *Providing High-Level Presentations to National Accounts.* These might be written or oral. The national account sales representatives, thus, become key spokespersons for the gas utility.
- *Monitoring and Controlling National Account Contracts and Relationships.* The national account representatives at the gas utility must track and control national account contact with coordinated teamwork.
- *Developing, Maintaining, and Disseminating Information Regarding National Accounts.* This information flow is important to the success of the national account marketing efforts.

The factors for the success of national account marketing activities include:[53]

- *Understanding and Support of Senior Management.* Senior officers of the organization must be aware of national account marketing activities and results. Without their support, key account marketing efforts are likely to fail.
- *Necessity of Well-Defined Mission, Responsibilities, and Authority of National Account Unit.* A national account plan should be an integral part of the overall marketing plan.
- *Presence of Capable, Experienced People in National Account Positions.* Personnel must be knowledgeable of natural gas and equipment applications, but must also be skilled in orchestrating the company resources to serve major customers.
- *Integration into the Mainstream of the Organization's Marketing Efforts.* National account mangers must be a part of the overall marketing personnel network. In

[53] General Source: Linda Cardillo Platzer, *Managing National Accounts*, Report No. 850, The Conference Board, 1984.

addition, information flow between the national account marketing section and the overall marketing section must be effective and well managed.

## *Industrial Sector Marketing*

The industrial sector represents more than 40% of the natural gas delivered in North America. Of the three major sectors (residential, commercial, and industrial), the industrial sector shows the greatest potential for growth, according to the U.S. Energy Information Administration (EIA). The EIA projects that industrial gas consumption will increase from just under eight trillion cubic feet in 1995, to just less than ten trillion cubic feet in 2015.

The industrial sector is critical to the natural gas industry because:

- It represents significant revenue (exceeded $25 billion in 1993).
- It is a significant sector in all geographical regions of North America.
- It is primarily a non-seasonal load with a high load factor.
- It represents a substantial foundation for strong LDC commercial and residential sectors by lowering unit costs and increasing the rate base.

Industrial customers are unique in that their energy costs are often a significant component of the cost of doing business, thus, management must seriously consider locating operations in an area where energy costs are low. Relocation to an area of lower energy costs can make the difference between business success and failure. This means that industrial sector marketing departments at gas utilities must:

- Monitor their industrial accounts regularly to make certain they are receiving competitive gas rates and service. This requires ongoing analysis of the competition across the country.

**Most Common Economic Development Services Offered to Existing Industrial Customers by Utilities**

| Service | % Offering Service |
|---|---|
| Retention Services | 70 |
| Evaluation Programs | 66 |
| Economic Development Incentive Rates | 62 |
| Computerized Site Inventory | 52 |
| Energy Cost Analysis | 32 |
| Comparative Rate Analysis | 30 |
| Energy Conservation Analysis | 29 |
| Area Location Analysis | 29 |

Source: *Site Selection* magazine, August, 1992.

**Most Common Retention and Expansion Services Offered to Existing Industrial Customers by Utilities**

| Service | % Offering Service |
|---|---|
| Energy Conservation Audits | 100 |
| Load Management Training and Assistance | 75 |
| Engineering/Manufacturing Technical Assistance | 58 |
| Rebates for Conservation Measures and Equipment | 42 |
| Financial Incentives for Facility Expansion | 33 |
| Assistance for State-of-Art Equipment | 33 |

Source: *Site Selection* magazine, August, 1992.

- Market to firms located in other gas service territories with the objective of attracting those firms to the local utility's territory.
- Coordinate the marketing activities of local organizations wishing to attract industries. These organizations might include chambers of commerce and local governments. The economic development activities

might include site inventory analysis and area location analysis. (See the tables on page 60 listing economic development and retention services offered to industrial customers by gas utilities).

- Provide in-depth research and analysis for industrial customers and potential customers. These activities might include, energy cost analysis and energy conservation analysis.
- Inform industrial customers of new gas technologies that might help them lower costs or increase productivity. The Industrial Gas Technology Commercialization Center can be very helpful with this service.[54]

## *Services Marketing*

All natural gas utilities sell natural gas and many sell or lease gas appliances. These are products, not services. Initially, marketing practices were developed for products, but it is vital to understand that the services offered by natural gas utilities must be marketed also. Because services are intangible, some of the marketing methods are different from those of product marketing.

A service is an activity that is intended to benefit the buyer and does not result in ownership of anything. It is an intangible that a seller can offer to the buyer. LDC services generally include setting meters and servicing appliances; these services are part of the overall activity of selling gas. However, they should be considered activities distinct from the product for the sake of strategic planning, hiring, training, compensation, and evaluation.

The success of the service activities of a gas utility is very important to the overall success of fulfilling marketing objectives.

[54] See Chapter 7 for the address and telephone number of this organization.

The characteristics of service activities are different from those for tangible products. These distinct characteristics are:

- *Services are Strongly Identified with Their Providers.* This is sometimes referred to as inseparability. For example, the service of repairing a gas appliance cannot be separated from the service representative doing the repair. The service provider's interaction with the customer is as important to the customer's opinion of the service as the service itself; the service and the provider are identified as one. A service representative may be technically astute, but if he or she has poor rapport with customers, it is bad for business. The recruiting, hiring, and training of service representatives must reflect this fact.
- *Services Activities are Intangible.* Because of this, the service provider must attempt to make the service tangible with images. An example is a truck panel slogan "Fast, Prompt Service, Always with a Smile" under a picture of a smiling service person wearing the Acme Gas Company jacket. Another example is service trucks that are always clean and in good condition.
- *Quality of Service is Variable.* Unlike a tangible product manufactured to specific standards, quality of service depends on how it is provided, who provides it, and where and when it is provided. Service activities within gas utilities should be managed so that service variability is minimized. This can be done through consistent management, training, incentive programs, soliciting customer feedback, and correction activities.
- *Service Activities are Perishable.* Unlike products, services cannot be put on a shelf for later use, thus, they are perishable. If a service crew arrives for an appointment to set a gas meter, but nobody is there to

let them in, time is lost—perished—and cannot be regained. Some utilities, realizing the perishability of service, charge customers a fee for missed appointments.

## *Marketing Strategies for Service Departments*

Because service activities differ from tangible products, they require different marketing approaches. When engaged in service activities, the customer and the service representative interact to affect the quality of service. Because of this, gas service representatives must interact effectively with customers to create a positive experience during service encounters.

Service organizations and departments should focus on both service representatives and on customers. Studies have shown that service profits depend on customer *and* employee satisfaction. If gas service employees are to be satisfied with and effective in their work, they must be cared for by management.

Management must effectively train and motivate its gas service representatives and all supporting service people to work as a team to achieve a high level of customer satisfaction.

The customer's perception of service quality depends on the quality of the customer's/service representative's interaction during the service encounter. Customers judge the value of service not only by the quality of the activity performed, but also by the quality of the interaction with the service provider. As a result of this fact, service representatives must not only become skilled at the technical aspects of the services they provide, but also must master the dynamics of interacting effectively with customers.

Service organizations and departments should consider three major marketing tasks: Service differentiation, service quality, and service productivity.[55]

*Service differentiation* is the strategic activity of causing the customer to perceive the service as different from that offered by other service providers. This is often done by developing a differentiated—unique—service offer, service delivery, or image.

*Service quality* can be used to differentiate a utility's service if it constantly delivers higher quality service than competitors. The key to successful service is delivering a quality of service that exceeds the customer's expectations. If the *perceived* service quality provided exceeds the *expected* service quality, the customer will be happy, use the service again, and probably pass on favorable word-of-mouth publicity.

Studies show that a typical unhappy customer will tell eight to ten other people about the problem that caused the unhappiness. It is estimated that twelve *favorable* service incidents are required to make up for one negative one.

Service department management must determine the expectations of customers and communicate their findings to all levels in the service department.

Delivering high quality service depends on:

- Management giving authority to gas service representatives to tend to customers' needs and correct any problems caused by the gas service department.
- Top management must be committed to high quality service.
- Management must set high service quality standards for all involved with offering service.

[55] Based on Philip Kotler and Gary Armstrong, *Principles of Marketing* (7th ed.: Englewood Cliffs, NJ: Prentice-Hall, 1996), pp. 666-668. Adapted by permission of Prentice-Hall Inc., Upper Saddle River, NJ.

- Service department performance must be monitored closely and performance feedback must be provided to all members of the service department.
- All employees of the gas service department must have the opportunity to give feedback directly to service department managers.

*Service productivity* should be improved whenever possible. This can result from better training, improved technical service methods, employment of more skilled service representatives, or sacrificing quality for improved productivity. However, productivity increases should not be pushed so hard that there is a reduction in the customers' perception of service quality.

## *Socially Responsible and Ethical Marketing*

Socially responsible and ethical marketing practices must be directed toward the best *long-term* performance of the company. As consumers become more demanding about responsible marketing and business activities, gas utilities must become more responsive.

Each manager in the organization, beginning at the top, must be able to look beyond what is legal and expedient and develop personal and ethical standards based on integrity, corporate conscience, and long-term consumer and societal welfare. Many businesses have developed codes of ethics as a guide for employees.[56] Socially responsible and ethical business marketing should be characterized by the following:[57]

- *Consumer-Oriented Marketing.* Gas utilities should approach their marketing strategies and activities from the consumers' perspective.

[56] As a sample of such a code, the American Management Association Code of Ethics in included in the Appendix.

[57] Based on Philip Kotler and Gary Armstrong, *Principles of Marketing* (7th ed.: Englewood Cliffs, NJ: Prentice-Hall, 1996), pp. 698-700. Adapted by permission of Prentice-Hall Inc., Upper Saddle River, NJ.

- *Innovative Marketing.* The gas utility should continually search for ways to improve business and marketing activities.
- *Marketing that Increases the Value of Products and Services.* The customers' perceived value of products and services should be a high priority of the organization. Continuing efforts should be made to increase the value each customer receives.
- *Sense-of-Mission Marketing.* The business organization should publicly define its mission in broad social terms rather than in terms of products and services. This not only projects the notion of social responsibility to customers, but also gives employees a clear sense of direction. Refer to the discussion of Company Mission Statement on page 29 of this chapter.
- *Marketing for Social Benefit.* Marketing activities must be guided by customers' needs, the business's requirements *and* the long-term interests of society. Care of the environment and ethical business practices are a part of this paradigm.

## *Solving Marketing Strategy Problems*

Marketing strategy problems do occur; the sooner they are solved, the better. Of course, the first step toward solving a problem is identifying it. Unfortunately, this is sometimes difficult to do.

Anyone involved with marketing functions from upper-level management to sales representative must not only be skilled at taking affirmative action, but must also be skilled at spotting and solving problems. Some simple suggestions can help:

- Never alter strategies that are working, change only strategies that are not working.
- When a losing strategy has been identified, dissect it into small components. This process will assist in determining the core problem with the strategy.

- When a losing strategy has been identified, do not adopt a replacement strategy without thoughtfully comparing it with the rejected one.
- When replacing a losing strategy, seek direction and advice from others before taking action.
- As soon as practicable, test any replacement marketing strategy for viability.

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# 3. Description of Natural Gas Equipment

## *Introduction*

The use of natural gas is always dependent on gas utilization equipment. If a marketing representative is successful at selling gas, she is knowledgeable of gas equipment.

A good marketing representative should know what types of equipment are commonly required by particular businesses and building types. For example, banks require space conditioning, but they do not require baking and laundry equipment. Bakeries require baking equipment, but do not require space cooling, except for office space.

This chapter describes gas utilization equipment in an introductory manner. For more detailed information refer to other sources, such as those listed in Chapter 7, Resources for Natural Gas Marketing. Chapter 4, Gas Equipment Applications, discusses typical applications for gas utilization equipment.

Notice that after each equipment heading there is an "R, C," or "I" in brackets. These letters indicate the types of facilities—Residential, Commercial, and Industrial—that normally utilize that type of equipment.

## *Heating Equipment*

### Central Heating Equipment

- Central heating equipment provides heat from a central point in a building, usually from a mechanical room or rooms. Because it is located centrally, distribution of the produced thermal energy must be provided. This is in the form of air distribution, water distribution, a combination of air and water distribution or steam distribution.

- Advantages of central systems over unitary units (factory-assembled, complete packages) include:
  - Often has longer service life.
  - Higher part-load efficiency.
  - Reserve capacity is inexpensive to install.
  - Equipment confined to mechanical room(s).

**Forced Air Systems (Furnaces)** [R,C,I][58]

- Governed by ANSI Standard Z21.47 and Z21.64.
- Listed in Section 6.3 of NFPA 54.
- Covered by *Installation of Warm Air Heating and Air Conditioning Systems*, NFPA 90B.
- Heat air for distribution to the conditioned space.
- Consist of 1) cabinet, 2) heat exchanger, 3) combustion system with the necessary controls, 4) vent systems that carries combustion gases to outside of building, 5) distribution motor and blower, and 6) air filter.
- Usually easy to add cooling equipment to a furnace.
- Easy to add special filters, electronic air cleaners, humidifiers, and dehumidifiers.
- May be upflow, downflow, or horizontal, depending upon the direction the distribution air flows.
- May be mid- (78-83% AFUE) or high-efficiency (88-97% AFUE). (Less than 78% AFUE became illegal to manufacture after 1990, due to federal law.)
- May be conventionally vented (natural or atmospheric draft), induced draft, or forced draft.
- Many late model furnaces—since 1985—are condensing units.
- Pulse combustion units are available.

[58] The letters *R, C,* and *I* after the equipment headings indicate Residential, Commercial, and Industrial, designating the areas of the market in which the equipment is used.

- Residential furnaces are available in models with heating capacities from 25,000 (26,376) to 175,000 Btu/hr (184,635 kJ/hr).
- Commercial models range in capacity from 150,000 (158,258) to 2,000,000 Btu/hr (2,110,111 kJ/hr).
- Furnaces with capacities of less than 320,000 Btu/hr (337,617 kJ/hr) are classified as light commercial.
- Furnaces with capacities of more than 320,000 Btu/hr (337,617 kJ/hr) are classified as large commercial units.
- Commercial units are constructed of heavier materials than residential units.
- Roof-top furnaces are a common type of gas furnace, often also providing gas- or electric-driven vapor compression cooling. The larger roof-top units are available as multi-zone or VAV units and can be used as central systems.
- Residential central furnaces seldom serve more than one zone.
- Commercial central furnaces may serve more than one zone with the use of proper devices and controls.
- **For Manufacturers of gas-fired furnaces see:**
  - *Directory of Certified Appliances and Accessories* by AGA Laboratories (International Approval Services).
  - *Consumer's Directory of Certified Efficiency Ratings for Residential Heating and Water Heating Equipment ("GAMA Directory")* by GAMA.
  - *HVAC Directory & Source Guide* by Business News Publishing Company.

**Forced Hot Water Systems** [R,C,I]

- Governed by ANSI Standard Z21.13.
- Listed in section 6.3 of NFPA 54.

- Forced hot water boilers heat water to a temperature of from 140°F (60°C) to above 250°F (121°C) for distribution to heating coils (with or without fans) for space heating, for domestic or service hot water, or for process hot water.
- Hot water boilers may be condensing or non-condensing. (Condensing units capture much of the latent heat from the water vapor in the flue gas that would otherwise be lost through the venting system.)
- Boilers are classified according to pressure and temperature. Low-pressure units have a maximum working pressure of 160 psi (1100 kPa) and are limited to 250°F (121°C). High pressure units have a minimum operating pressure of 160 psi (1100 kPa) and a water temperature above 250°F (121°C).
- Hot water boilers are available in sizes ranging from 30,000 Btuh (31,651 kJ/hr) for the smallest residential unit to 100,000,000 (105,505,946 kJ/hr) Btuh for the largest commercial/industrial unit.
- Pulse combustion units are available in capacities up to 1,000,000 Btu/hr (1,055,056 kJ/hr).
- Boilers are made with cast-iron, steel, and copper heat exchangers.
- Dual-fuel hot water boilers—natural gas and oil or natural gas and propane—are available for commercial and industrial use. These are an advantage if a gas utility offers a lower cost interruptible service.
- Cast iron boilers may be wet leg, dry leg, or dry base.
- Hot water boiler controls are usually activated by the water temperature inside the boiler.
- Terminal units for hot water boilers can be baseboard convection units, radiant panels, tubes in ceilings or floors, radiators, fan coils, or hot water coils.

- Hot water distribution is easy to zone with a circulator pump or a zone valve for each zone.
- It is often cost-effective to convert oil-fired hot water boilers to natural gas-fired.
- It is usually easy to adapt hot water boilers so that they can also supply domestic or service hot water by means of indirect-fired hot water storage (circulating water heater system).
- **For manufacturers of gas-fired hot water boilers see:**
  - *Directory of Certified Appliances and Accessories* by AGA Laboratories (International Approval Services).
  - *Consumer's Directory of Certified Efficiency Ratings for Residential Heating and Water Heating Equipment ("GAMA Directory")* by GAMA.
  - *HVAC Directory & Source Guide* by Business News Publishing Company.

**Steam Systems** [R,C,I]

- Governed by ANSI Standard Z21.13.
- Listed in Section 6.3 of NFPA 54.
- Steam boilers vaporize (evaporate) water for steam distribution to conditioned spaces, provide thermal energy for heating coils and domestic or service hot water, and provide steam for process heat energy.
- Steam boilers are classified according to pressure. Low-pressure steam boilers have a maximum working pressure of 15 psi (103 kPa). High-pressure steam boilers operate at pressures above 15 psi (103 kPa).
- Steam boiler sizes range from 50,000 (52,753) to 100,000,000 Btu/hr (105,505,946 kJ/hr).
- Dual-fuel steam boilers—natural gas and oil or natural gas and propane—are available for commercial and

industrial use. These are an advantage if a gas utility offers a lower cost interruptible service.

- Steam cast iron boilers may be wet leg, dry leg, or dry base.
- Steam boiler controls are activated by the pressure inside the boiler.
- Oil-fired steam boilers can usually be converted to natural gas.
- Steam distribution is a good choice where heat is needed for space conditioning and process in facilities such as hospitals, restaurants, dry-cleaning establishments, laundries, and industrial facilities.
- **For manufacturers of gas-fired steam boilers see:**
  - *Directory of Certified Appliances and Accessories* by AGA Laboratories (International Approval Services).
  - *Consumer's Directory of Certified Efficiency Ratings for Residential Heating and Water Heating Equipment ("GAMA Directory")* by GAMA.
  - *HVAC Directory & Source Guide* by Business News Publishing Company.

**Unitary Gas Heating Equipment**

- Unitary natural gas heating units are complete factory-assembled packages available for single zone or multi-zone applications. These units are usually available with integral cooling capabilities.
- Although unitary equipment is usually more expensive to operate than central equipment, it does have advantages over central heating equipment, including:
  - Usually require less ductwork than central equipment, lowing installation costs.
  - Individual room or zone control is inexpensive and easy to achieve.

- Installation on the roof or through the wall saves space.
- They allow for individual unit control. This is an advantage in lodging facilities and apartment buildings.
- Equipment breakdowns do not affect a large area.
- Lower first cost as compared to central systems.

**Roof-Top Units** [R,C,I]

- Governed by ANSI Standards Z21.47 and Z21.64.
- Installed on flat or sloped roofs.
- Usually heat with gas-fired hot air and cool with electrically-driven, vapor compression apparatus. (Gas-fired, engine-driven vapor compression units are now available for cooling.)
- Gas engine-driven heat pump roof-top units are available for heating and cooling.
- Roof-top units are the most common unitary type of commercial gas heating.
- Gas heating/electric cooling units range in size from 1.5 (5.275) to 110 tons (387 kw).
- Good choice for small shopping centers, schools, computer rooms, hospital operating rooms, and other single story or low-rise buildings.
- Advantages of gas-fired roof-top units include:
  - Easy to install and maintain.
  - No machinery room required.
  - Packaged units guaranteed by manufacturer.
  - Allow individual owners or tenants to install, maintain, and meter their own equipment.
  - Lower first costs compared to central systems.
- **For manufacturers of gas-fired roof-top units see:**
  - *Directory of Certified Appliances and Accessories* by AGA Laboratories (International Approval Services).

- *HVAC Directory & Source Guide* by Business News Publishing Company.

**Make-Up Air Units (Industrial Air Heaters)** [C,I]

- Governed by ANSI Standards Z83.4 (direct gas-fired make-up air heaters) and Z83.18 (direct gas-fired industrial air heaters).
- Listed in Section 6.8 of NFPA 54.
- Make-up air units are designed to condition ventilation air supplied to a space, usually as a replacement of exhausted air. They may be mounted on a roof, outside a wall, or on a ground platform.
- Can be designed to heat, cool, humidify, dehumidify, or filter make-up air.
- Available in capacities of from 2,000 (944) to 100,000 cfm (47,200 L/s).
- Heating capacities range from 16,000 (16,880) to 2,875,000 Btu/hr (3,033,286 kJ/hr).
- Direct-fired units utilize unvented combustion and, therefore, have high efficiencies. These units are not suitable in some cases, for example, where condensation might be a problem or where there is low infiltration or makeup air.
- Indirect-fired units are vented to the outside (not covered by the above listed ANSI standards).
- Make-up air units are often used in commercial kitchens and warehouses to replace exhausted air.
- Can be installed indoors or outdoors.
- **For manufacturers of gas-fired make-up air units see:**
  - *Directory of Certified Appliances and Accessories* by AGA Laboratories (International Approval Services).
  - *HVAC Directory & Source Guide* by Business News Publishing Company.

**Direct Gas-Fired Circulating Heaters for Agricultural Buildings** [C]

- Governed by AGA Requirements 5.88.
- Unvented heaters intended for use in agricultural buildings and greenhouses.
- Input ratings range from 40,000 (42,202) to 225,000 Bth/hr (237,388 kJ/hr).
- **For manufacturers of direct gas-fired circulating heaters of agricultural buildings see:**
  - *Directory of Certified Appliances and Accessories* by AGA Laboratories (International Approval Services).

**Through-The-Wall Units (PTAC, PTHP, PT)** [R,C]

- Packaged Terminal Air Conditioners (PTACs), Packaged Terminal Heat Pumps (PTHPs), and Packaged Terminal heaters (PTs) are made to heat or to heat and cool. These units mount on a wall, inside or outside, or extend through a wall, housed in a wall sleeve.
- Are primarily used for commercial installations, in areas such as hotel rooms, nursing homes, and office buildings.
- Gas/electric PTACs are available with heating capacities of 12,000 (12,661) and 20,000 Btu/hr (21,101 kJ/hr) and cooling capacities of 9,000 (2.64) and 12,000 Btu/hr (3.5 kW).
- Gas/electric PTACs are a replacement for electric/electric units. They are quieter during heating mode (no compressor) and operating costs for heating are usually lower. The existing wall sleeve will typically accommodate the replacement gas/electric unit.
- Gas-fired models of PTHPs are not available at the time of this writing.

- Gas/electric PTACs are a viable replacement for electric/electric PTHPs. The gas/electric PTACs are more comfortable in heating mode because of the higher air-discharge temperature.
- **For manufacturers of gas/electric PTACs see:**
  - *Directory of Certified Appliances and Accessories* by AGA Laboratories (International Approval Services).
  - *HVAC Directory & Source Guide* by Business News Publishing Company.

**Vented Room Heaters** [R,C]

- Governed by ANSI Standard Z21.11.1.
- Listed in Section 6.24 of NFPA 54.
- A self-contained, free-standing, non-recessed heating appliance.
- Some models contain circulation fans.
- Include a vent safety shutoff system that will shut down the main burners if the appliance is not venting properly.
- Input rates vary from 5,000 (5275) to 33,000 Btu/hr (34,817 kJ/hr).
- **For manufacturers of vented room heaters see:**
  - *Directory of Certified Appliances and Accessories* by AGA Laboratories (International Approval Services).

**Vent-Free (Unvented) Room Heaters** [R]

- Governed by ANSI Standard Z21.11.2 and AGA Requirements 2-79 (unvented room heaters with oxygen depletion safety shutoff systems).
- Listed in Section 6.24 of NFPA 54.
- Unvented, self-contained, free-standing appliances designed to heat the space in which they are installed.

- Have oxygen depletion safety shutoff systems that will shut off main burner if oxygen supply in room is low.
- Circulator type may include radiating material and normally have input ratings or 40,000 Btu/hr (42,202 kJ/hr) or less.
- Wall heater type has a closed front and is made to be attached to a wall. Input ratings are usually less than 25,000 Btu/hr (26,376 kJ/hr).
- Codes in some geographical areas prohibit use.
- **For manufacturers of unvented room heaters see:**
  - *Directory of Certified Appliances and Accessories* by AGA Laboratories (International Approval Services).

**Wall Furnaces** [R]

- Governed by ANSI Standard Z21.49 (vented wall furnaces) and Z21.44 (direct vent wall furnaces).
- Listed in Section 6.29 of NFPA 54.
- Made to be installed as an integral part of an outside wall, usually between wall studs.
- Heated air may be circulated by gravity or fan-forced.
- May include vapor compression cooling also.
- Some units are direct vent.
- Heating input range is from 15,000 (15,825) to 65,000 Btu/hr (68,579 kJ/hr).
- **For manufacturers of wall furnaces see:**
  - *Directory of Certified Appliances and Accessories* by AGA Laboratories (International Approval Services).
  - *Consumer's Directory of Certified Efficiency Ratings for Residential Heating and Water Heating Equipment ("GAMA Directory")* by GAMA.

**Large Industrial-Type Ductless Furnaces (Air-Rotation® Units[59]) [C,I]**

- These units are essentially large furnaces without supply ductwork attached. They are located within the space they are intended to heat and are vented to the outside.
- Return distribution air enters the unit near the bottom and heated supply air is fan-forced out of the unit near the top.
- This equipment is usually set up to recirculate indoor air, but can be set up to use make-up air.
- The fan(s) in the equipment can be used to circulate unconditioned air during the summer months.
- This equipment works well in large open spaces, such as warehouses and large warehouse retailing facilities, indoor tennis courts, and factories.
- Vertical heating units can be fired with any of the major fuels. Duel fuel—natural gas and oil or natural gas and propane—units are available.
- Equipment capacities range from 260,000 Bth/hr (274,314 kJ/hr) and 6,000 cfm (2832 L/s) to 6,000,000 Btu/hr (6,330,335 kJ/hr) and 100,000 cfm (47,200 L/s).

**Unit Heaters** [C,I]

- Governed by ANSI Standard Z83.8.
- Listed in Section 6.28 of NFPA 54.
- A unit heater is a vented, self-contained device suspended from a ceiling, pole, or wall and is intended to heat the space in which it is located, without the use of ducts.
- Usually are air units, but are available in a hot water variant (similar to hot water coil).

[59] Air-Rotation® is a registered trademark of Johnson Heater Corp., St. Louis, MO.

- Unit heaters can project heated air for a considerable distance and are, therefore, a good choice for large open spaces.
- This equipment is often used to heat factories, warehouses, garages, showrooms, stores, and greenhouses.
- Natural gas units are available as conventional types, high-efficiency types with primary and secondary heat exchangers, and as direct-vent units.
- Input ratings range from 25,000 (26,376) to 400,000 Btu/hr (422,022 kJ/hr).
- **For manufacturers of gas unit heaters see:**
  - *Directory of Certified Appliances and Accessories* by AGA Laboratories (International Approval Services).
  - *HVAC Directory & Source Guide* by Business News Publishing Company.

**Duct Furnaces** [C,I]

- Governed by ANSI Standard Z83.9.
- Listed in Section 6.10 of NFPA 54.
- A duct furnace is a unit heater without a blower, intended to be mounted in a duct distribution system—indoors or outdoors—where air-moving equipment is supplied separately.
- These gas-fired units must be vented to the outside.
- Input range varies from 20,000 (21,101) to 1,200,000 Btu/hr (1,266,068 kJ/hr).
- Duct furnaces should be installed far enough downstream of cooling coils to prevent condensation forming on the heat exchanger of the duct furnace.
- **For manufacturers of gas duct furnaces see:**
  - *Directory of Certified Appliances and Accessories* by AGA Laboratories (International Approval Services).

**Infrared (Radiant) Heaters** [R,C,I]

- Governed by ANSI Standard Z83.6 (vented and unvented).
- Governed by AGA Requirements 5.90 (Gas-Fired Infrared Patio Heaters).
- Listed in Section 6.19 of NFPA 54.
- These gas-fired units emit infrared radiation, similar to that from the sun. This energy readily passes through transparent materials such as air, but is absorbed by opaque objects such as floors, walls, and people.
- Low intensity gas infrared (radiant tube type) has source temperatures of from 500 (260) to 800°F (427°C). These units are usually vented directly to the outside. They are approximately 80 percent efficient. Output of this type can be as high as 100,000 Btu/hr (105,505 kJ/hr).
- High intensity gas infrared (surface combustion type) has source temperatures of from 1600 (871) to 1900°F (1038°C). These units are usually not vented directly to the outside and, thus, require make up air for combustion. Because they are not vented, burner efficiencies are high, approximately 90 to 92 percent. However, because outside make-up air must be introduced into the space, overall efficiency is lower. Output of this type ranges from 20,000 (21,101) to 200,000 Btu/hr (211,011 kJ/hr).
- Radiant heating is effective for both spot or task heating, or for heating entire building spaces.
- Particularly useful for buildings with high ceilings, large volumes of air, and high air-leakage rates.
- For old buildings with low insulation levels and high air leakage areas, infrared heating will cost less to operate than conventional forms of space heating.

- Appropriate for heating workers in spaces with high air-leakage rates, such as loading docks, warehouses, highway garages, aircraft hangers, church sanctuaries, greenhouses, car washes, bus shelters, skating rinks, indoor tennis courts, milking parlors, or factories.
- Good choice for heating people outdoors during cool or cold weather. Examples include racetrack stands and stadiums.
- Radiant heaters mounted on the top of poles and covered by a reflector are being used successfully to extend the season for outdoor dining areas, commercial or residential. These units can provide heat for a diameter from twelve to twenty feet.
- **For manufacturers of gas-fired infrared heating see:**
  - *Directory of Certified Appliances and Accessories* by AGA Laboratories (International Approval Services).
  - *HVAC Directory & Source Guide* by Business News Publishing Company.

**Construction Heaters** [C]

- Governed by ANSI Standard Z83.7.
- Unvented gas-fired heaters are intended for temporary use in buildings under construction.
- Input ratings range from 10,000 (10550) to 2,250,000 Btu/hr (2,373,875 kJ/hr).
- **For manufacturers of gas-fired construction heaters see:**
  - *Directory of Certified Appliances and Accessories* by AGA Laboratories (International Approval Services).

**Floor Furnaces** [R]

- Governed by ANSI Standard Z21.48.
- Listed in Section 6.11 of NFPA 54.
- Gas-fired floor furnaces are self-contained units suspended from the floor of the space being heating.
- These furnaces may use gravity- or fan-type distribution.
- These units are usually used for residential applications and are controlled by integral or remote thermostats.
- In some geographical, areas their use is prohibited.
- Input range varies from 30,000 (31,652) to 75,000 Btu/hr (79,129 kJ/hr).
- **For manufacturers of gas-fired floor furnaces see:**
  - *Directory of Certified Appliances and Accessories* by AGA Laboratories (International Approval Services).
  - *Consumer's Directory of Certified Efficiency Ratings for Residential Heating and Water Heating Equipment ("GAMA Directory")* by GAMA.

## *Cogeneration Equipment* [C,I]

- Governed by AGA Requirements 2.89.
- This equipment allows energy from a single source (natural gas, process heat, etc.) to be used for the production of heat and electricity.
- A cogeneration facility using a topping cycle is one in which the energy input is first used to generate electricity, the rejected heat then being used for other purposes such as space heat, process heat, or absorption cooling.
- A cogeneration facility using a bottoming cycle is one in which the energy input is first used for other processes, the rejected heat is then used to generate electricity.

- Several manufacturers make packaged, pre-engineered cogeneration systems that include a natural gas engine (prime mover), the generator, heat recovery devices, switchgear, and enclosure.
- **For manufacturers of gas-fired, engine-driven cogeneration appliances see:**
  - *Directory of Certified Appliances and Accessories* by AGA Laboratories (International Approval Services).

## *Gas Incineration* [R,C,I]

- Governed by NFPA 82, *Incinerators and Waste and Linen Handling Systems and Equipment.*
- Listed in Section 6.18 (domestic incinerators) of NFPA 54.
- Both residential (domestic) and commercial incinerators are available.
- Commercial units are sometimes used for hospitals (15 pounds of waste per day per bed) or large nursing homes (5 pounds of waste per day per bed).
- Paybacks at large hospitals can be as short as 18 months, when fuel and waste disposal savings are considered.
- Up to 60% of the waste heat can be captured and used for space heat, process hot water, absorption cooling, or desiccant dehumidification.

## *Gas Water Heating Equipment*

- Service or domestic water heating systems are always composed of four parts 1) a heat energy source such as natural gas, 2) a heat transfer device, 3) a means of distribution, and 4) hot water usage devices such as dishwashers and showers.
- Heat transfer equipment can be either direct or indirect. One or more heat exchangers are used, either air-to-water or water-to-water. The major types of

equipment are 1) automatic direct-fired storage, 2) instantaneous (can be tankless coil in boiler), 3) indirect-fired storage (includes both circulating systems and boiler-fired with remote water storage), and 4) booster heaters. These are listed below.

- Most often, copper piping is used for distribution.
- Models are available for both indoor and outdoor installation.
- If hot water in a commercial installation is required at a remote location at a constant and reliable supply temperature (such as for lodging facility rooms), circulation piping is often called for (supply line, return line, and circulation pump). The pump is installed on the return line. The circulation pump is usually controlled by a thermostat. These systems are also often used in commercial kitchens.
- Commercial foodservice facilities usually require dual temperature hot water, 140°F (60°C) for all tasks except dish-washer rinse, which requires at least 180°F (82°C) for sterilization.

**Automatic Direct-Fired Storage Water Heaters** [R,C,I]

- Governed by ANSI Standard Z21.10.1 (input ratings of 75,000 Btu/hr or less) and Z21.10.3 (input ratings of more than 75,000 Btu/hr).
- Listed in Section 6.30 of NFPA 54.
- Have input rates of less than 4,000 Btu/hr (4220 kJ/hr) per gallon of stored water.
- This is the most common residential gas-fired water heater type.
- Input rates of residential units are generally around 40,000 Btu/hr (42,202 kJ/hr).
- Input rates of commercial units are as high as 2,500,000 Btu/hr (2,637,625 kJ/hr).

- Includes a storage tank with a gas burner at the bottom of the tank. Combustion gases vent up through the middle of the storage tank and then are vented to the outdoors.
- Available in direct vent, natural draft, induced draft, and forced draft models.
- Good choice for variable hot water demand.
- **For manufacturers of residential automatic direct-fired storage models see:**
  - *Directory of Certified Appliances and Accessories* by AGA Laboratories (International Approval Services).
  - *HVAC Directory & Source Guide* by Business News Publishing Company.
- **For manufacturers of commercial automatic direct-fired storage models see:**
  - *HVAC Directory & Source Guide* by Business News Publishing Company.
  - *Foodservice Gas Equipment Catalog*, by CP Publishing.

**Instantaneous Gas-Fired Water Heaters** [R,C,I]

- Governed by ANSI Standard Z21.10.3 (input ratings of more than 75,000 Btu/hr).
- Listed in Section 6.30 of NFPA 54.
- These units are boilers used specifically for heating domestic or service hot water.
- Have input rates of more than 4,000 Btu/hr (4220 kJ/hr) per gallon of stored water.
- This equipment is used for both residential and commercial applications. Input rates for residential units are as high as 125,000 Btu/hr (131,882 kJ/hr). Input rates for commercial models vary widely, but can be as high as 725,000 Btu/hr (764,916 kJ/hr).

- These water heater types are best suited for constant hot water demands for there is no storage to accommodate unusually high peak usage.
- A tankless coil, a type of instantaneous water heater, consists of a water-to-water heat exchanger in the hot water reservoir of a steam or hot water boiler. The water is heated to service temperature—or above—instantly as it flows through the device. This type of water heater is sometimes referred to as indirect instantaneous. The gross output of the boiler must be adequate to meet all the loads placed on the boiler, both for space heating and service water heating.
- **For manufacturers of gas-fired instantaneous water heaters see:**
  - *Directory of Certified Appliances and Accessories* by AGA Laboratories (International Approval Services).

**Circulating Water Heaters (Indirect-Fired Storage Water Heaters)** [R,C,I]

- Governed by ANSI Standard Z21.10.3 (input ratings of more than 75,000 Btu/hr).
- Listed in Section 6.30 of NFPA 54.
- A gas-fired water heater that furnishes hot water that is stored in a separate vessel. Domestic or service hot water may be directly heated by the circulating water heater or it may be indirectly heated with a water-to-water heat exchanger.
- When used for residential applications, the water-heating boiler often is used to supply space heat also.
- For commercial units, input rates range from 82,000 (86,514) to 1,000,000 Bth/hr (1,055,056 kJ/hr).

- **For manufacturers of circulating water heaters see:**
  - *Directory of Certified Appliances and Accessories* by AGA Laboratories (International Approval Services).
  - *Foodservice Gas Equipment Catalog*, by CP Publishing.

**Booster Water Heaters** [C,I]

- Governed by ANSI Standard Z21.13.
- Listed in Section 6.3 of NFPA 54.
- Any type of water heater that "boosts" the temperature of heated water to a higher level. Generally, merely a boiler with a copper heat exchanger.
- Booster water heaters are often used in commercial food service facilities to increase the temperature of hot water to 180°F (82°C) or above for the rinse/sterilization cycle of automatic dish washers.
- Booster water heaters can be direct-fired storage or instantaneous types.
- Some residential and commercial automatic dishwashers have integral booster heaters.
- **For manufacturers of water heaters that can be used as booster heaters see:**
  - *Directory of Certified Appliances and Accessories* by AGA Laboratories (International Approval Services).
  - *Foodservice Gas Equipment Catalog*, by CP Publishing.

**Pool Heaters** [R,C]

- Governed by ANSI Standard Z21.56.
- Listed in Section 6.22 of NFPA 54.
- Pool heaters are designed for heating water for swimming pools, spas, and hot tubs.

- Models are available for both indoor and outdoor installations.
- Input rates vary from 60,000 (63,303) to 825,000 Btu/hr (870,421 kJ/hr).
- **For manufacturers of pool heaters see:**
  - *Directory of Certified Appliances and Accessories* by AGA Laboratories (International Approval Services).

## *Gas-Fired Laundry Equipment*

**Clothes Drying Equipment** [R,C]

- Governed by ANSI Standard Z21.5.1 (Type 1, primarily for private use) and Z21.5.2 (Type 2, for commercial and public use).
- Listed in Section 6.4 (Types 1 and 2) of NFPA 54.
- Gas dryers must be vented by code (NFPA 54).
- Commercial laundries are the best target for commercial gas dryer sales.
- At commercial laundry facilities, gas dryers and gas water heaters are a natural match.
- **For manufacturers of gas clothes dryers see:**
  - *Directory of Certified Appliances and Accessories* by AGA Laboratories (International Approval Services).

**Gas-Fired Pressing Equipment** [C]

- Used in commercial facilities such as large laundries, hotels, hospitals, and residential nursing facilities.
- For bedding sheets, table cloths and other large items that require pressing.
- Items to be pressed are put on equipment while still damp from washing. Equipment presses and dries items.

## *Commercial and Residential Food Service Equipment*

**Gas Ranges** [R,C]

- Governed by ANSI Standard Z21.1 (household cooking appliances) and Z83.11 (commercial food service ranges and unit broilers).
- Listed in Section 6.15 (household cooking appliances) of NFPA 54.
- The grades of gas ranges are domestic (residential), restaurant (commercial), and heavy-duty (commercial).
- There are many different types of commercial gas ranges, including oven ranges (with integral oven), Chinese wok ranges, candy ranges, stock-pot ranges, taco ranges, etc.
- Commercial range-top burners may be open burners, griddles/grills, hot tops, char broilers.
- Commercial range-top burners vary in input rates from 14,500 (15,298) to 30,000 Btu/hr (31,652 kJ/hr) with integral ovens ranging from 30,000 (31,652) to 55,000 Btu/hr (58,028 kJ/hr). Design input rates for gas range/oven units range from 92,000 (97,065) to 195,000 Btu/hr (205,736 kJ/hr).
- **For manufacturers of commercial gas ranges and gas range/ovens see:**
  - *Directory of Certified Appliances and Accessories* by AGA Laboratories (International Approval Services).
  - *Foodservice Gas Equipment Catalog*, by CP Publishing.

**Baking and Roasting Ovens** [R,C]

- Governed by ANSI Standard Z83.12.
- These appliances are seldom used in residential kitchens.

- Types of commercial ovens include convection ovens (with air-circulating fans), deck/pizza ovens (usually stackable), conveyor ovens, rack/tray ovens (racks usually revolve), barbecue/rotisserie ovens, combination ovens (dry convection heat, steam heat, or combination of the two).
- **For manufacturers of commercial gas baking and roasting ovens see:**
  - *Directory of Certified Appliances and Accessories* by AGA Laboratories (International Approval Services).
  - *Foodservice Gas Equipment Catalog*, by CP Publishing.

**Deep Fat Fryers** [C]

- Governed by ANSI Standard Z83.13.
- Intended for commercial use only.
- Open fryers range in size from 15 (6.8) to 140 pounds (64 kg) of fat (oil) capacity.
- The two major types are open fryers and pressure fryers (air-sealed lids).
- Open fryers are available in both counter models—27,500 (29,140) to 48,000 Btu/hr (50,643 kJ/hr)—and floor models—84,000 (88,625) to 212,000 Btu/hr (223,672 kJ/hr).
- A doughnut fryer is a special type of open fryer.
- **For manufacturers of commercial deep fat fryers see:**
  - *Directory of Certified Appliances and Accessories* by AGA Laboratories (International Approval Services).
  - *Foodservice Gas Equipment Catalog*, by CP Publishing.

**Steam Cooking Equipment** [C]

- Governed by ANSI Standard Z83.15.
- Used primarily by commercial food service facilities.
- Equipment categories include compartment steamers (either atmospheric or pressurized) and steam jacketed kettles.
- Compartment steamers cook food by convective heat transfer and the condensation of steam on food (latent heat transfer).
- In steam jacketed kettles, the steam does not come in direct contact with the food.
- Some models generate their own steam from an integral gas burner, others may use steam produced in a separate gas boiler (steam generator).
- **For manufacturers of commercial steam cooking equipment see:**
  - *Directory of Certified Appliances and Accessories* by AGA Laboratories (International Approval Services).
  - *Foodservice Gas Equipment Catalog*, by CP Publishing.

**Counter Appliances** [C]

- Governed by ANSI Standard Z83.14.
- These gas-fired appliances include hot plates and griddles, food and dish warmers, bain maries, coffee brewing equipment, and toasters.
- Hot plates and griddles have flat steel tops with one or more gas burners underneath.
- Food and dish warmers are designed to keep precooked food warm (or keep plates warm). Some of these units warm food with steam produced by gas burners, others utilize dry heat produced by the burners.
- Bain maries are similar to steam food warming appliances, but are located in the kitchen for the

convenience of the chef. Rather than having places for standard pots, as a steam table does, the bain marie has a rack for the placement of dishes.

- Coffee brewing equipment (coffee urns) can brew up to 28 gallons (106 liters) of coffee per hour.
- The only gas-fired commercial toaster is made by Savory. Its capacity is 1,200 slices per hour.
- **For manufacturers of commercial gas-fired counter appliances see:**
  - *Directory of Certified Appliances and Accessories* by AGA Laboratories (International Approval Services).
  - *Foodservice Gas Equipment Catalog*, by CP Publishing.

## *Gas Cooling*

- There are various reasons for the move to natural gas cooling in North America. These include the availability of more efficient gas cooling equipment, relatively low natural gas prices, the need to improve the environment and switch to CFC-free equipment (gas-fired absorption equipment is CFC-free), and the need to lower operating costs by cutting energy costs and lowering electric demand charges.

**Gas Engine-Driven Vapor Compression Cooling** [R,C,I]

- Governed by AGA Requirements 4-89 (Gas-Fired, Engine-Driven Air Conditioning and Heat Pump Appliances).
- Listed in Section 6.2 of NFPA 54.
- Natural gas engine-driven systems operate in a manner similar to conventional electric-driven vapor compression systems, the difference being that the gas-driven engine takes the place of the electric

motor—the compressor is run by a gas-driven prime mover (engine) rather than an electric motor.

- Packaged chillers and direct expansion (DX) units are available.
- The York Triathlon heat pump is an example of a small (three tons), gas engine-driven cooling and heating unit appropriate for residential and small commercial applications.
- Generally, the compressors used in vapor compression equipment are reciprocating (usually 200 tons—703 kw—or less), screw (usually 100 to 1250 tons—352 to 4,395 kw), or centrifugal (usually 100 to 10,000 tons—352 to 35,160 kw).
- Natural gas powered turbines and engines are often used to power cogeneration systems in hospitals and other large facilities.
- **For manufacturers of gas engine-driven equipment see:**
  - *Natural Gas Cooling Equipment Guide* by The American Gas Cooling Center.

**Absorption Cooling** [R,C,I]

- Governed by ANSI Standard Z21.40.1 and AGA Requirements 10-90.
- Natural gas-fired absorption cooling has many advantages over conventional electric motor-driven vapor compression cooling with a separate boiler, including low maintenance, high reliability, quieter operation, CFC-free refrigerants, lower pressure requirements, and fewer moving parts.
- Absorption and vapor compression refrigeration cycles have in common the evaporation and condensation of the refrigerant at two different pressure levels within the cycles. The two cycles differ in that the absorption process uses a pump and a thermal energy-operated generator to achieve the pressure

differential, whereas the vapor compression process uses a compressor. Both processes require energy for operation; the absorption cycle uses thermal energy, the vapor compression cycle uses mechanical energy.

- Residential units are available from Robur Corporation (Servel). These units are available in sizes from 3 (11) to 5 tons (18 kw) of cooling capacity with matched heating capacity.
- In the most common absorption systems, lithium bromide acts as the absorbent and water as the refrigerant. Another type of system uses water as the absorbent and ammonia as the refrigerant.
- Double-effect (two-stage) absorption units are more efficient and costly than single effect (single-stage) units. Double-effect and single-effect units have a first-stage generator where the refrigerant is vaporized from the absorbent with thermal energy. Double-effect units also have a second-stage generator where the hot refrigerant vapor from the first-stage generator supplies heat for further refrigerant vaporization from the absorbent.
- Absorption chillers can be either direct-fired, where the heat source applied directly to the generator (3 to 1500 tons or 11 to 5,274 kw) or indirect-fired where the heat source is hot water or steam produced at another location (5 to 1500 tons or 18 to 5,274 kw).
- Units are available that also heat; they are called chiller/heaters. Some of these models allow simultaneous cooling and heating.
- Absorption equipment can be designed and installed to provide complete cooling and heating, can be installed to serve as a peak-shaver to reduce electric demand charges (or as a precooler in series with an electric chiller), or can be installed as an integral part of a cogeneration system.

- Facilities served by older single-effect chillers are good candidates for absorption chiller modernization.
- Facilities served by high pressure steam are good candidates for indirect-fired, double-effect, absorption chillers.
- **For manufacturers of gas-fired absorption cooling systems see:**
  - *Natural Gas Cooling Equipment Guide* by The American Gas Cooling Center.

**Desiccant Dehumidification (Cooling)** [C,I]

- Governed by AGA Requirements 9-90.
- Gas-fired desiccant systems remove water vapor from the air, in other words, they provide latent cooling. Desiccants do not directly cool air (sensible cooling) they only remove water vapor (latent cooling).
- Desiccant systems allow separate control of sensible and latent cooling, an important advantage in some facilities, such as supermarkets.
- The desiccant is regenerated (reactivated) by heating it, often with a natural gas-fired unit, thus driving off the water and allowing the desiccant to absorb moisture (water vapor) again.
- Good choice when low relative humidity or precise control over relative humidity is needed; easy to produce relative humidity levels below 50%.
- Usually used as commercial and industrial equipment. Some residential equipment is being tested.
- Appropriate applications include supermarkets, ice rinks, refrigerated warehouses, hospital operating rooms, laboratories, and various manufacturing processes.
- Gas systems available with supply cfm rates from 1,000 to 90,000 (470 to 42,480 L/s).

- **For manufactures of gas-fired absorption units see:**
  - *Natural Gas Cooling Equipment Guide* by The American Gas Cooling Center.

**Industrial Refrigeration** [C,I]

- Gas engine-driven vapor compression refrigeration, primarily for the food industry.
- This equipment is beneficial where there is a need for heat recovery. Nearly one-half of the heat of the gas fuel can be recovered to be used for other purposes.
- Economic benefits are available from electric peak-shaving.
- Used for ice making, cold storage, and process cooling in dairies, breweries, wineries, and bakeries.
- **For manufactures of gas-engine driven refrigeration packages see:**
  - *Natural Gas Cooling Equipment Guide* by The American Gas Cooling Center.

**Gas-Fired Refrigerators** [R]

- Governed by ANSI Standard Z21.19 and Z21.74.
- Listed in Section 6.23 of NFPA 54.
- Made for residential or recreational use.
- These refrigeration appliances use the absorption process and require no electricity.
- Gas-fired refrigerators are not vented.
- Input rates range from 800 to 2,200 Btu/hr.
- **For manufacturers of gas-fired refrigerators see:**
  - *Directory of Certified Appliances and Accessories* by AGA Laboratories (International Approval Services).

## *Natural Gas Vehicles (NGV)*

- Governed by AGA Requirements 2-90, Natural Gas Vehicle Fueling Appliances; AGA Requirements 1-90, Natural Gas Vehicle Fueling Connection

Devices; AGA Requirements 1-85, Natural Gas Vehicle Conversion Kits; AGA Requirements 7-93, Fuel System Components for Natural Gas Vehicles; AGA Requirements ANSI NGV2 (fuel containers); NFPA 52, *Compressed Natural Gas (CNG) Vehicular Fuel Systems*; and NFPA 57, *Liquefied Natural Gas (LNG) Vehicular Fuel Systems.*

- Natural gas-fueled buses have been in operation in the U.S. since 1988.
- The most active market segments for NGVs over the last decade have been vehicle fleets and buses.
- Items to consider for NGV use:
  - Vehicle conversion costs.
  - Fueling costs.
  - Location and density of fueling stations.
  - Operating cost comparisons (the more the miles per year, the greater the advantage of NGVs over gasoline- and diesel-fueled vehicles).
  - NGVs produce 1% to 64% of the air emissions that gasoline-powered vehicles do.
  - NGVs require from 5,940 (10,086) to 6,750 Btu/mile (11,461 kJ/km), including energy for extraction, processing, generation, transmission, distribution, vehicle filling, and vehicle use. NGVs are more energy efficient than gasoline—6,990 Btu/mile (11,869 kJ/km), methonal—9,400 Btu/mile (15,961 kJ/km), and electricity—10,920 Btu/mile (18,542 kJ/km).
  - Compressed natural gas (CNG) is a safe vehicular fuel.
  - CNG fuel cylinders are manufactured to rigorous safely standards.
  - Compressed natural gas is immune to theft.

- Natural gas has an octane rating of 130. Octane ratings of gasoline are from the low eighties to the low nineties.
- Conversion costs for light- or medium-duty vehicles can range from $2,500 to $5,000. The conversion cost, to a large part, is dependent on the size of the CNG fuel tank(s) and the number of tanks.
- Most converted vehicles are designed to operate on more than one fuel, for example, CNG and gasoline. These are called bi-fuel systems and are advantageous for drivers who do not always have access to an CNG fueling station. These systems are used on lighter duty vehicles. Tanks for each fuel type are required.
- Dual-fuel systems operate by mixing fuels and injecting the mix into the combustion chamber. These systems are used on heavy duty, diesel trucks. Tanks for each fuel type are required.
- CNG tanks are usually located under the body or in the trunk of the vehicle. A vehicle may use one or more tanks.
- There are two basic types of refueling systems for CNG vehicles—slow-fill and fast-fill. The slow-fill method uses a compressor to directly compress the natural gas from the pipeline and then dispenses it to the on-board fuel tank. It can take up to 14 hours to fill a vehicle's tank(s). The fast-fill method requires the same amount of time to fill as a conventional gasoline tank, from three to five minutes.
- Converted vehicles drive very much like conventional gasoline-powerd vehicles, however, the driver might experience a 10 to 15% decrease in power.
- A light-duty vehicle can travel from 80 to 100 miles on one tank of CNG.

- **For manufactures of NGV vehicles and related equipment see:**
  - *Directory of Certified Appliances and Accessories* by AGA Laboratories (International Approval Services).
  - GASWEB on the internet, http://www.apk.net/gasweb/

## *Miscellaneous Gas Equipment*

**Gas-Fired Conversion Burners** [R,C,I]

- Governed by ANSI Standard Z21.17.
- American National Standard Installation of Domestic Gas Conversion Burners, ANSI Z21.8, governs the installation of these burners.
- Manufactured to replace coal and oil burners.
- **For manufacturers of gas conversion burners see:**
  - *Directory of Certified Appliances and Accessories* by AGA Laboratories (International Approval Services).

**Gas-Fired Decorative Appliances** [R]

- Governed by ANSI Standard Z21.50 and Z21.60.
- Listed in Section 6.6 (installed in vented fireplaces) and 6.7 (vented) of NFPA 54.
- AGA defines a Decorative Gas Appliance as "a self-contained, free-standing, gas-burning appliance designed for installation only in a solid-fuel burning fireplace and whose primary function lies in the aesthetic effect of the flame."
- AGA categorizes decorative gas appliances as:
  - Coal Basket—An open-flame type appliance consisting of a metal basket filled with simulated coals that gives the appearance of a coal fire when in operation. Must be installed in a vented fireplace.

  - Gas Logs—Vented in an existing fireplace with damper fixed in the open position. If glass doors are used, they must be open while appliance is in operation. Do not provide much heat.
  - Gas Fireplace Insert—Complete unit fits into existing fireplace and includes gas logs. May be conventionally vented, mechanically vented, or direct vented. Provide radiant heat and might provide some convective heat.
  - Radiant Appliance—Open-front appliance designed to convert the energy in the gas to radiant heat by means of refractory materials on the face of the unit. Must be installed in a vented fireplace.
- **For manufacturers of decorative gas appliances see:**
  - *Directory of Certified Appliances and Accessories* by AGA Laboratories (International Approval Services).
  - *Foodservice Gas Equipment Catalog*, by CP Publishing.

**Outdoor Cooking Appliances** [R]

- Governed by ANSI Standard Z21.58.
- Listed in Section 6.21 of NFPA 54.
- These appliances are to be used outdoors.
- They may be portable or stationary.
- Outdoor gas grilles are designed to broil foods using radiant and convective energy.
- **For manufacturers of outdoor cooking appliances see:**
  - *Directory of Certified Appliances and Accessories* by AGA Laboratories (International Approval Services).

**Gas-Fired Toilets** [R]

- Governed by ANSI Standard Z21.61.
- Listed in Section 6.27 of NFPA 54.
- These appliances incinerate human waste.
- Input rating is usually 40,000 Btu/hr.
- **For manufacturers of gas-fired toilets see:**
  - *Directory of Certified Appliances and Accessories* by AGA Laboratories (International Approval Services).

**Gas-Fired Illuminating Appliances** [R,C]

- Governed by ANSI Standard Z21.42.
- Input ratings range from 1,800 to 10,000 Btu/hr.
- U.S. Gaslight offers a gaslight with a battery-operated, solar-charged power source that turns the gaslight on at dusk and off at dawn
- **For manufacturers of gas-fired illuminating appliances see:**
  - *Foodservice Gas Equipment Catalog*, by CP Publishing.
  - *Directory of Certified Appliances and Accessories* by AGA Laboratories (International Approval Services).

**Gas-Fired Ceramic Kilns** [C]

- Governed by AGA Requirements 1-94.
- Gas-fired appliance for firing ceramic products.
- Input ratings range from 50,000 (52,752) to 1,200,000 Btu/hr (1,266,067 kJ/hr).
- **For manufacturers of gas-fired kilns see:**
  - *Directory of Certified Appliances and Accessories* by AGA Laboratories (International Approval Services).

## *Notes*

1. The letters *R, C,* and *I* after the equipment headings indicate Residential, Commercial, and Industrial, designating the sectors of the market in which the equipment is used.
2. NFPA 54 is the *National Fuel Gas Code*. It is also know as ANSI Z223.1. It is published and approved by the National Fire Protection Association (NFPA), American National Standards Institute (ANSI), and International Approval Services (formerly American Gas Association Laboratories).
3. See Chapter 7, "Resources for Natural Gas Marketing" for listings of organizations, books and periodicals, and online services.
4. See *ASHRAE Fundamentals Handbook*, Chapter 38, "Codes and Standards" for an extensive listing of the codes and standards that govern the equipment discussed in this chapter.

# 4. Gas Equipment Applications

## *Facilities Types Covered*

***Buildings of Assembly*** (Churches, Theaters and Concert Halls, Arenas, Convention Centers).
***Commercial-Industrial Buildings*** (Manufacturing Facilities, Factories, Laboratories).
***Health Care Facilities*** (Hospitals, Mental Facilities).
***Households: Single-Family Buildings.***
***Households: Multifamily Dwellings*** (Apartments, Condominiums).
***Lodging Facilities*** (Motels, Hotels).
***Office Buildings*** (Doctor/Dentist/Professional, Larger Office Buildings).
***Retail Stores*** (Mercantile, Department Stores, Pharmacies, Shoe Repair Shops, Etc.).
***Restaurants and Food Service Facilities*** (Fast Food, Larger Sit-Down Establishments, Diners, Bakeries).
***Recreational Facilities*** (Bowling Centers, Gyms, Racquet-Sports Facilities, Swimming Pools, Roller Skating Rinks).
***School Buildings*** (Classrooms, Offices, Gymnasiums).
***Shopping Complexes*** (Mercantile, Covered Malls, Strip Malls).
***Supermarkets/Food Stores.***
***Warehouses.***

## *Introduction*

This chapter is a general gas equipment application guide for natural gas sales and marketing.[60] The fifteen facility types covered include the major residential and commercial users of natural gas. Industrial applications are varied enough to warrant case-by-case analysis.

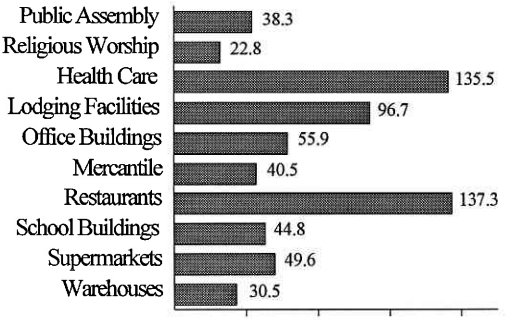
[60] As a result of space limitations, not all alternatives are listed in this chapter.

To find the most accurate and detailed information regarding the facility type you are considering, you might need to use two or more of the listings. For example, if you are trying to convert an existing hotel to natural gas, use the "Lodging Facilities" listing for the guest rooms and the conference rooms and use the "Restaurant and Food Service Facilities" listing for the hotel restaurant.

Energy intensity values are included in tables for most of the facility types listed in this chapter. These values are useful for estimating the natural gas use—load—for a particular facility type. As a result of more energy-efficient building envelopes, new buildings tend to use less natural gas per square foot of area for space heating than older buildings.

Below is a composite table of energy intensity values for ten building facility types. Notice that restaurants had the highest energy intensity value, 137.3 cubic feet of natural gas per square foot of building area. This high

**Natural Gas Energy Intensity, 1992**
**For Commercial Buildings Heated with Natural Gas**
**(Cubic Feet of Gas per Square Foot of Building Area)**




Source: Commercial Buildings Energy Consumption and Expenditures, 1992, U.S. Energy Information Administration.

value may have been due to the fact that these buildings were usually smaller (87% of all food service buildings were 10,000 square feet or less), and tended to have more weekly operating hours (57% were open 85 hours per week or more). In addition, food service buildings using natural gas usually used it for cooking—86%.

For each of the facility types, the "Comments" area lists the system types required and systems sometimes required for the facility type. Characteristics of the facility type and information regarding system loads, etc., are also included.

"Competitive Equipment for Space Conditioning" lists electric and oil-fired equipment—along with suggested replacement natural gas equipment—likely to be found in the facility type. The replacement natural gas equipment suggestions are also appropriate for new construction.

"Competitive Equipment for Additional Applications" lists electric and oil-fired equipment, other than for space conditioning—along with suggested replacement natural gas equipment—likely to be found in the facility type. The replacement natural gas equipment suggestions are also appropriate for new construction.

The symbols in the box below are used in this chapter to expedite your search for information. For your convenience, they appear on every fourth page .

The "Notes" section at the end of this chapter explains the details of the energy intensity tables that appear in the chapter.

***Symbol Definitions:***

📖 Information and features.

➔ Replacement or new gas equipment possibilities.

👍 Advantages of gas over competitive equipment.

Consider (look at) before installing gas.

## *Buildings of Assembly* (Churches, Theaters and Concert Halls, Arenas, Convention Centers)

**Comments**

- *Required Systems:* Space heating and cooling, service hot water, and ventilation. *Sometimes Required:* Food service, dehumidification, outdoor gas-fired lighting, and pool heating.
- Characterized by periodic, high density occupancy.
- Use and size vary widely among buildings of assembly.
- Ancillary facilities such as office space, kitchens, and apartments for clergy are usually a part of assembly buildings.
- Occupants generate the major cooling and ventilation loads.

**Buildings for Public Assembly***
**Energy Intensity Values, 1992**

| | Region | | | |
|---|---|---|---|---|
| | Northeast | Midwest | South | West |
| CF Gas per $Ft^2$, Region | 36.3 | 55.5 | 23.5 | 41.5 |
| 95% confidence range | 21 - 52 | 40 - 71 | 9 - 38 | 22 - 61 |
| | Building Size, $Ft^2$ | | | All Buildings Heated with Natural Gas |
| | 1,001 - 10,000 | 10,001 - 100,000 | over 100,000 | |
| CF Gas per $Ft^2$, U.S. | 49.1 | 39.1 | 26.3 | 38.3 |
| 95% confidence range | 35 - 63 | 23 - 55 | 15 - 38 | 28 - 49 |
| | Natural Gas End Use | | | |
| | Space Heating | Water Heating | Food Service | Other |
| MBtu per $Ft^2$, U.S. | 21.6 | 5.7 | 1.9 | 1 |

- Source: *Commercial Buildings Energy Consumption and Expenditures, 1992,* DOE/EIA-0318 (92), U.S. Energy Information Administration.
* Buildings in which people gather, in private or public meeting halls, for social, cultural, or recreational activities. Includes art galleries, libraries, concert halls, night clubs, radio/TV stations, movie theaters, bowling alleys, indoor pools, skating rinks, auditoriums, lecture halls, funeral homes, and student unions.
- 95% confidence range values indicate that there is a 95% certainty that the actual gas consumption was within the given range in 1992.
- See "Notes" at the end of this chapter for geographical region definitions and comments.

- Characterized by large load swings for space cooling and service hot water.
- Pre-cooling assembly areas is sometimes practiced.
- Cooling loads are increased by air destratification methods, such as ceiling fans. Heating loads are sometimes reduced by air destratification methods.

**Competitive Equipment for Space Conditioning**

- *Electric heating/electric cooling roof-top units.*
  - ➔ Gas heating/electric cooling roof-top units, Gas heating/gas cooling roof-top units, Outdoor gas boiler and hot water coil retrofit for heating, Duct furnace retrofit for heating.
  - 👍 Lower fuel bills, Reduced electric demand, Fast pick-up.
  - 👎 Gas piping, District piping, Venting, Conversion costs, Savings.
- *Electric air-source heat pump roof-top units.*
  - ➔ Gas heating/electric cooling roof-top units, Gas heating/gas cooling roof-top units, Outdoor gas

**Buildings for Religious Worship***
**Energy Intensity Values, 1992**

| | Region | | | |
|---|---|---|---|---|
| | Northeast | Midwest | South | West |
| CF Gas per $Ft^2$, Region<br>95% confidence range | 22<br>13 - 31 | 30<br>22 - 39 | 15.4<br>6 - 25 | 17.2<br>9 - 25 |
| | Building Size, $Ft^2$ | | | All Buildings Heated with Natural Gas |
| | 1,001 - 10,000 | 10,001 - 100,000 | over 100,000 | |
| CF Gas per $Ft^2$, U.S.<br>95% confidence range | 34.4<br>28 - 41 | 24.1<br>18 - 37 | No Data | 22.8<br>17 - 28 |

- Source: *Commercial Buildings Energy Consumption and Expenditures, 1992*, DOE/EIA-0318 (92), U.S. Energy Information Administration.

* Buildings in which people gather for religious activities. Includes chapels, churches, mosques, synagogues, temples.

- 95% confidence range values indicate that there is a 95% certainty that the actual gas consumption was within the given range in 1992.
- See "Notes" at the end of this chapter for geographical region definitions and comments.

boiler and hot water coil retrofit for heating, Duct furnace retrofit for heating.

- Lower fuel bills; Reduced electric demand; Fast pick-up; Higher supply-air temperature during heating season, thus, fewer complaints.
- Gas piping, Distribution piping, Venting, Ductwork, Conversion costs, Savings.

- *Electric resistance heat.*
  - → Gas heating/electric cooling PTACs, Gas-fired boiler with hot water baseboard distribution, Gas infrared, Gas-fired make-up air units (indirect or direct, if appropriate).
  - Lower maintenance costs, Lower heating bills, Faster pick-up.
  - Gas piping, Venting, Ventilation if direct-fired make-up air units or high-intensity gas-fire infrared units are used, Conversion costs, Savings.
- *Electric or oil-fired boiler with hot water baseboard distribution.*
  - → Gas-fired boiler with hot water baseboard distribution, Gas-fired make-up air units (indirect or direct, if appropriate).
  - Lower heating bills and demand changes if replacing electric, Faster pick-up than electric, Possible lower heating bills if replacing oil-fired.
  - Gas piping, Venting, Ventilation if direct-fired make-up air units are used, Conversion costs, Distribution, Savings.
- *Electric or oil-fired furnace with ducted distribution.*
  - → Gas-fired furnace with ducted distribution, Gas-fired make-up air units (indirect or direct, if appropriate).

👍 Lower heating bills and demand changes if replacing electric, Faster pick-up than electric, Possible lower heating bills if replacing oil-fired.

Gas piping, Venting, Ductwork, Ventilation if direct-fired make-up air units are used, Conversion costs, Savings.

- *Electric infrared spot heating.*

➔ Gas-fired infrared, vented or unvented (if situation allows), Gas-fired make-up air units (indirect or direct, if appropriate), Gas unit heater.

👍 Lower heating bills and demand change, More comfortable spectators/customers.

Gas piping, Venting, Ventilation if direct-fired make-up air units or high-intensity infrared units are used, Conversion costs, Savings.

- *Any means of cooling.*

➔ Gas-fired desiccant dehumidification added to cooling.

📖 Often cost-effective for ice skating rinks.

👍 Separate control of sensible cooling (from electric vapor compression) and latent cooling (from desiccant dehumidification system), Less fog or mist above ice surface, Allows extension of season, Higher quality ice, Less ice refinishing required, More comfortable customers, Lower electric demand charges (usually able to deactivate some existing electrically-driven vapor compression cooling).

***Symbol Definitions:***

📖 Information and features.

➔ Replacement or new gas equipment possibilities.

👍 Advantages of gas over competitive equipment.

Consider (look at) before installing gas.

Gas piping, Venting, Advantage of having precise control of relative humidity, Installation costs.

**Competitive Equipment for Additional Applications**

- *Electric or oil-fired service water heating.*
  - ➔ Gas-fired storage water heating, Circulating water heater.
  - Lower fuel bills, Greater first-hour capacity of water heater (compared with electric), Faster recovery rate (compared with electric).
  - Gas piping, Venting of gas-fired equipment, Conversion costs, Savings.
- *Electric food service equipment.*
  - ➔ Gas-fired food service equipment.
  - Lower fuel bills, Greater control over food preparation process, Higher kitchen staff satisfaction, Higher patron satisfaction.
  - Gas piping, Kitchen ventilation (some building codes require more kitchen ventilation for gas appliances), Conversion costs, Savings.
- *Electric or oil-fired pool heater.*
  - ➔ Gas-fired pool heater.
  - Lower fuel bills, Less maintenance.
  - Gas piping, Venting, Conversion costs, Savings.
- *Outdoor electric lighting.*
  - ➔ Gas-fired lighting.
  - Very pleasant illumination.
  - Gas piping, Installation cost.

## *Commercial/Industrial Buildings* (Manufacturing Facilities, Factories, Laboratories)

**Comments**

- *Required Systems:* Space heating, space cooling, and ventilation. *Sometimes Required:* Service water heating; dehumidification; process and manufacturing requiring hot air, hot water, steam, ventilation, or laboratory ventilation hoods.
- Multi-purpose occupancy is common, for example, offices, production areas, parts storage, shop areas, lunch rooms, lockers, storage areas, etc.
- Providing consistent thermal comfort in production areas can be difficult because of waste heat from production and the variation of many production processes.

**Competitive Equipment**

- Because of the inherent variation among industrial and factory use and processes, necessary equipment must be analyzed on a case-by-case basis. Utilize gas-fired equipment whenever possible.
- *Desiccant dehumidification, gas-fired.*

  📖 Often cost-effective for various manufacturing processes, including candy making, photographic film manufacturing and processing, battery manufacturing, and plastic soda bottle manufacturing. Also used for commercial freezers (prevents evaporator icing).

***Energy Intensity Values for the Manufacturing Sector***

U.S. Government energy intensity values for the manufacturing sector are too detailed to list here. The U.S. Energy Information Administration (EIA) gathers and reports energy intensity values by standard industrial codes (SIC) in various publications. These include *Manufacturing Consumption of Energy 1991*, DOE/EIA-0512(91) and *Changes in Energy Intensity in the Manufacturing Sector 1985-1991*, DOE/EIA-0552(85-91). Most EIA publications can be downloaded from the EIA internet web site. See Chapter 7 for the web address.

- 👍 Separate control of sensible cooling (from electric vapor compression) and latent cooling (from desiccant dehumidification system), More comfortable staff, Lower electric demand charges (usually able to deactivate or downsize some existing electrically-driven vapor compression cooling).
- 👎 Gas piping, Venting, Advantage of having precise control of relative humidity, Installation costs.

• *Cogeneration.*

- 📖 Industrial facilities probably use cogeneration more than any other facility type.
- 👍 Lower operating costs, Independence from electric utility power grid, Environmental cleanliness.

## ***Health Care Facilities*** (Hospitals, Mental Facilities)

**Comments**

- *Required Systems:* Space heating and cooling, service hot water, food service, and ventilation. *Sometimes Required:* Dehumidification, incineration, cogeneration, and therapy-pool heating.
- Vary greatly in size.
- Space conditioning and quality of air is important.
- Hospitals often require backup systems for continuity of life support systems and other services.
- The greatest portion of energy costs of a hospital goes for the operation of the HVAC systems.
- Steam is needed in hospitals for heating air and water, for sterilization, and can also be used for indirect absorption cooling.

**Competitive Equipment for Space Conditioning**

- *Electric heating/electric cooling roof-top units/Oil roof-top units.*
  - ➔ Gas heating/electric cooling roof-top units. Gas heating/gas cooling roof-top units, Outdoor gas boiler and hot water coil retrofit for heating, Duct furnace retrofit for heating.
  - 👍 Lower fuel bills, Reduced electric demand, Fast pick-up, No concerns about oil storage.
  - 👓 Gas piping, Ductwork, Air filtration, Conversion costs, Savings.
- *Electric furnace.*
  - ➔ Gas-fired furnace.
  - 👍 Lower fuel bills, Reduced electric demand, Fast pick-up.
  - 👓 Gas piping, Venting, Ductwork, Air filtration, Conversion costs, Savings.
- *Electric air-source heat pump.*
  - ➔ Gas heating/electric cooling roof-top units. Gas heating/gas cooling roof-top units, Outdoor gas boiler and hot water coil retrofit for heating, Duct furnace retrofit for heating.
  - 👍 Lower heating costs; Reduced electric demand in winter; Less maintenance; Fast pick-up; Warmer space-heating air, thus, fewer complaints.
  - 👓 Gas piping, Venting, Ductwork, Air filtration, Conversion costs, Savings.

***Symbol Definitions:***

📖 Information and features.

➔ Replacement or new gas equipment possibilities.

👍 Advantages of gas over competitive equipment.

👓 Consider (look at) before installing gas.

- *Electric resistance baseboard units/Oil-fired boiler with hot water baseboard distribution.*
  - ➔ Gas boiler with hot water baseboard distribution, Gas-fired direct-vent room heaters.
  - 👍 Lower heating costs if replacing electric, Reduced electric demand in winter, Longer equipment life than electric baseboard, No oil storage concerns.
  - 👎 Gas piping, Venting, Conversion costs, Savings.
- *Central electric chiller with resistance heat air-handling units.*
  - ➔ Gas-fired direct absorption chiller, Gas-fired indirect absorption chiller, Gas boiler/electric chiller with hot-water-coil air handling units.

**Buildings for Health Care***
**Energy Intensity Values, 1992**

| | Region | | | |
|---|---|---|---|---|
| | Northeast | Midwest | South | West |
| CF Gas per Ft², Region<br>95% confidence range | 106.4<br>56 - 157 | 148.7<br>102 - 195 | 129.3<br>41 - 217 | 59.8<br>29 - 91 |
| | Building Size, Ft² | | | All Buildings Heated with Natural Gas |
| | 1,001 - 10,000 | 10,001 - 100,000 | over 100,000 | |
| CF Gas per Ft², U.S.<br>95% confidence range | 58.8<br>40 - 78 | 74.9<br>41 - 109 | 135.1<br>67 - 203 | 135.5<br>90 - 181 |
| | Natural Gas End Use | | | |
| | Space Heating | Water Heating | Food Service | Other |
| MBtu Gas per Ft², U.S. | 41.9 | 51 | 13.4 | 16.3 |

- Source: *Commercial Buildings Energy Consumption and Expenditures, 1992*, DOE/EIA-0318 (92), U.S. Energy Information Administration.
* Buildings used as diagnostic and treatment facilities, both inpatient and outpatient. Includes hospitals, mental facilities, rehabilitation facilities, and veterinary clinics. Excludes residential care facilities—nursing homes (these are included with Lodging Facilities).
- 95% confidence range values indicate that there is a 95% certainty that the actual gas consumption was within the given range in 1992.
- See "Notes" at the end of this chapter for geographical region definitions and comments.

- Lower heating costs, Reduced electric demand in winter, Lower maintenance costs.
- Gas piping, Distribution piping, Venting, Equipment space requirements, Conversion costs, Savings.

• *Water-source heat pump with electric boiler.*

- ➔ Gas engine-driven vapor compression heat pump, Gas boiler/electric chiller with air handling units, Gas boiler and hot water coil retrofit for heating, Duct furnace retrofit for heating.
- Lower heating costs, Reduced electric demand in winter, Lower maintenance costs.
- Gas piping, Venting, Equipment space requirements, Conversion costs, Savings, Distribution piping.

• *Any means of cooling.*

- ➔ Gas-fired desiccant dehumidification added to cooling.
- Often cost-effective for hospital operating rooms.
- Separate control of sensible cooling (from electric vapor compression) and latent cooling (from desiccant dehumidification system), More comfortable surgeons and nurses, Reduces chance of microbial contamination, Lower electric demand charges (usually able to deactivate some existing electrically-driven vapor compression cooling), Easy to retrofit to existing hospitals having moisture or cooling problems.
- Gas piping, Venting, Advantage of having precise control of relative humidity, Installation costs.

**Competitive Equipment for Additional Applications**

- *Electric or oil-fired service hot water.*
  - ➔ Gas-fired water heating equipment (direct-fired storage, instantaneous, circulating, booster).
  - 👍 Lower operating costs, Higher first-hour rating per gallon of storage (compared with electric).
  - ✍ Gas piping, Venting, Conversion costs, Savings.
- *Electric food service equipment.*
  - ➔ Gas food service equipment.
  - 👍 Lower operating costs, Greater level of control during preparation.
  - ✍ Gas piping, Ventilation, Conversion costs, Savings.
- *Electric or oil-fired therapy-pool heater.*
  - ➔ Gas-fired therapy-pool heater.
  - 👍 Lower operating costs.
  - ✍ Piping, Venting, Conversion costs, Savings.
- *Electric clothes dyers.*
  - ➔ Gas-fired clothes dryers.
  - 👍 Lower operating costs, Shorter drying time, More productive staff.
  - ✍ Piping, Venting, Conversion costs, Savings.
- *Electric pressing machine for laundry service.*
  - 🕮 Used for bedding and tablecloths.
  - ➔ Gas-fired pressing machine.
  - 👍 Lower operating costs, Shorter drying time, More productive staff.
  - ✍ Piping, Venting, Conversion costs, Savings.
- *Gas-fired incineration.*
  - 🕮 Conventional type for hospitals and residential nursing homes (hospitals produce about 15

pounds (6.8 kg) of waste per bed per day, nursing homes about 5 pounds (2.23 kg) per bed per day.

🕮 Type IV Pathological Waste Incinerator is a specialized type for combusting organic tissue. One hundred pounds (45.36 kg) of pathological waste is reduced to approximately five pounds (2.23 kg) of sterile ash.

🕮 A ton (907 kg) of waste can contain the equivalent of 168 therms (17,724,938 kJ) that can be captured for space heating, steam or hot water process, or desiccant dehumidification. Up to 60% of the waste heat can be captured.

👍 Lower operating costs, Lowers disposal fees, Reduces risk of contamination.

Gas piping, Venting, Air-quality compliance, Installation cost.

- *Cogeneration.*

🕮 Hospitals require hot water for food service, laundries, sterilization, physical therapy pools and have large central heating and cooling systems. They also have large electrical-use requirements. Large hospitals are good candidates for cogeneration equipment.

👍 Lower operating costs, Independence from electric utility power grid, Environmental cleanliness.

Gas piping, Venting, Air-quality compliance, Installation cost.

***Symbol Definitions:***

🕮 Information and features.

➔ Replacement or new gas equipment possibilities.

👍 Advantages of gas over competitive equipment.

Consider (look at) before installing gas.

## *Households: Single-Family Residential*

### Comments

- *Required Systems:* Space heating, domestic hot water, kitchen equipment, and clothes drying. *Sometimes Required:* Space cooling, ventilation, outdoor gas barbecue, outdoor gas-fired lighting, and pool heating.
- Greatest energy use is usually space conditioning, next, water heating.
- Energy and systems decisions are more likely to be made based on comfort and initial costs, rather than durability and life-cycle costs.

### Competitive Equipment for Space Conditioning

- *Electric or oil-fired boiler.*
  - ➔ Gas conversion burner (to replace oil-fired boiler), Gas-fired boiler.
  - 👍 Lower maintenance costs, Fuel bills might be lower, No concern about oil storage or delivery, Conversion costs, Savings.
  - 👎 Gas piping, Venting, Conversion costs, Savings.
- *Electric or oil-fired furnace.*
  - ➔ Gas-fired furnace, Gas engine-driven heat pump, Gas absorption heating/cooling package.
  - 👍 Lower maintenance costs, Fuel bills might be lower, Conversion costs, Savings.
  - 👎 Gas piping, Venting, Conversion costs, Savings.
- *Electric resistance heat.*
  - ➔ Gas-fired boiler, Gas-fired furnace, Gas engine-driven heat pump, Gas absorption heating/cooling package, Gas-fired direct-vent wall heaters.
  - 👍 Lower fuel bills, Greater comfort level.

| Natural Gas Energy Intensity, Space Heating, U.S. Households, 1993 | | |
|---|---|---|
| Geographical Region | CF Gas/ HDD/1000 $Ft^2$ | Btu/HDD/$Ft^2$ |
| U.S., Total Households | 8.4 | 8.6 |
| Northeast | 7.9 | 8.1 |
| Midwest | 7.2 | 7.4 |
| South | 11.2 | 11.5 |
| West | 8.5 | 8.8 |
| Type of Housing Unit | | |
| Single Family | 8.1 | 8.3 |
| Single Family Detached | 8.2 | 8.4 |
| Single Family Attached | 7.8 | 8 |
| Mobile Home | 10.7 | 11 |
| Multifamily, 2 to 4 units | 13 | 13.4 |
| Multifamily, 5 or more units | 7.1 | 7.3 |
| Main Heating Equipment Using Natural Gas | | |
| Central Warm-Air Furnace | 7.7 | 7.9 |
| Steam or Hot Water Boiler | 9.3 | 9.6 |
| Room Heater/Other | 12.8 | 13.2 |
| Year of Construction | | |
| 1939 or Before | 9.5 | 9.8 |
| 1940 to 1949 | 9.8 | 10 |
| 1950 to 1959 | 9.8 | 10 |
| 1960 to 1969 | 8.4 | 8.7 |
| 1970 to 1979 | 7.3 | 7.5 |
| 1980 to 1984 | 6.8 | 7 |
| 1985 to 1987 | 6.5 | 6.7 |
| 1988 to 1990 | 5.2 | 5.4 |
| 1991 through 1992 | 5.5 | 5.7 |

- Source: *Household Energy Consumption and Expenditures, 1993*, U.S. Energy Information Administration, October, 1995.
- HDD is an abbreviation for Heating Degree Days. Refer to the ASHRAE *Handbook of Fundamentals* or other reliable weather data for local heating degree day values.
- $Ft^2$ refers to square feet of heated floor space.
- See "Notes" at the end of this chapter for geographical region definitions and comments.

- Gas piping, Venting, Distribution, Conversion costs, Savings.

**Competitive Equipment for Additional Applications**

- *Electric or oil-fired storage water heater.*
  - → Gas-fired storage water heater.
  - Lower fuel bills, Greater first-hour capacity of water heater (compared with electric), Faster recovery rate (compared with electric).
  - Gas piping, Venting, Conversion costs, Savings.

| Natural Gas Consumption for Water Heating, per U.S. Household, 1993 | |
|---|---|
| Geographical Region | Thousand Cubic Feet of Gas |
| U.S., Total Households | 24.8 |
| Northeast | 24.9 |
| Midwest | 27.2 |
| South | 25 |
| West | 21.6 |
| Type of Housing Unit | |
| Single Family | 25.4 |
| Single Family Detached | 25.6 |
| Single Family Attached | 24.4 |
| Mobile Home | 22.9 |
| Multifamily, 2 to 4 units | 26.5 |
| Multifamily, 5 or more units | 21 |
| Household Size | |
| 1 Person | 15.5 |
| 2 Persons | 22.2 |
| 3 Persons | 28.5 |
| 4 Persons | 31.8 |
| 5 Persons | 33.3 |
| 6 or More Persons | 39.1 |

Source: *Household Energy Consumption and Expenditures, 1993*, U.S. Energy Information Administration, October, 1995.
- See "Notes" at the end of this chapter for geographical region definitions and comments.

- *Electric range/oven.*
  - ➔ Gas range/oven.
  - 👍 Lower fuel bills, Better control of cooking, Higher resale value.
  - 👓 Gas piping, Ventilation fan, Conversion costs, Savings.
- *Electric clothes dryer.*
  - ➔ Gas clothes dryer.
  - 👍 Lower fuel bills.
  - 👓 Gas piping, Venting, Conversion costs, Savings.
- *Electric or oil-fired pool heater.*
  - ➔ Gas-fired pool heater.
  - 👍 Lower fuel bills, Lower maintenance, Higher resale value.
  - 👓 Gas piping, Venting, Conversion costs, Savings.
- *Outdoor electric lighting.*
  - ➔ Gas lighting.
  - 👍 Very pleasant illumination.
  - 👓 Gas piping, Installation cost.

## ***Households: Multifamily Dwellings*** (Apartments, Condominiums)

**Comments**

- *Required Systems:* Space heating and cooling, kitchen equipment, and domestic hot water. *Sometimes Required:* Ventilation, laundry facilities, outdoor gas-fired lights, outdoor gas barbecue, and pool heater.

***Symbol Definitions:***

📖 Information and features.

➔ Replacement or new gas equipment possibilities.

👍 Advantages of gas over competitive equipment.

👓 Consider (look at) before installing gas.

- Greatest energy use is usually space conditioning, next, service water heating.
- Control of space temperature required in each apartment unit.
- In areas of high electric rates, occupancy rates are higher in gas-heated buildings than in electrically-heated buildings.
- Type of unit ownership (apartment, condominium, etc.) might influence fuel-use choices.

**Natural Gas Consumption for Appliances, per U.S. Household, 1993***

| | Thousand Cubic Feet of Gas |
|---|---|
| Geographical Region | |
| U.S., Total Households | 7.5 |
| Northeast | 7.4 |
| Midwest | 7.3 |
| South | 8.5 |
| West | 6.6 |
| Type of Housing Unit | |
| Single Family | 7.8 |
| Single Family Detached | 7.9 |
| Single Family Attached | 7.2 |
| Mobile Home | 6.2 |
| Multifamily, 2 to 4 units | 7.6 |
| Multifamily, 5 or more units | 5.8 |
| Household Size | |
| 1 Person | 4.4 |
| 2 Persons | 7.1 |
| 3 Persons | 8.4 |
| 4 Persons | 9.3 |
| 5 Persons | 11 |
| 6 or More Persons | 12.3 |

- Source: *Household Energy Consumption and Expenditures, 1993*, U.S. Energy Information Administration, October, 1995.
- Natural gas appliances include clothes dryers, cooking appliances, outdoor grills, outdoor lights, and heaters for hot tubs or swimming pools.
- See "Notes" at the end of this chapter for geographical region definitions and comments.

**Competitive Equipment for Space Conditioning**

- *Electric furnace.*
  - ➔ Individual gas-fired furnace, Gas-fired direct-vent wall unit.
  - 👍 Lower fuel bills, Reduce electric demand in winter, Higher occupancy rates.
  - 👎 Gas piping, Venting, Ductwork, Conversion costs, Savings.
- *Oil-fired furnace.*
  - ➔ Gas-fired furnace, Gas-fired direct-vent wall unit.
  - 👍 Lower maintenance costs, Fuel bills might be lower, No environmental concerns about oil storage and filling.
  - 👎 Gas piping, Venting, Ductwork, Conversion cost, Savings.
- *Oil-fired boiler.*
  - ➔ Gas-fired boiler, Gas-fired direct-vent wall unit.
  - 👍 Lower maintenance costs, Fuel bills might be lower, No environmental concerns about oil storage and filling.
  - 👎 Gas piping, Venting, Distribution, Conversion cost, Savings.
- *Electric resistance baseboard.*
  - ➔ Gas-fired boiler or furnace, Gas-fired direct-vent wall unit.
  - 👍 Lower fuel bills, Reduced electric demand in winter, Greater heating capacity available, Higher occupancy rates.
  - 👎 Gas piping, Venting, Distribution piping, Conversion cost, Savings.

- *Electric air-source heat pump.*
  - ➔ Individual gas furnace with air conditioning, Gas engine-driven heat pump, Gas absorption heating/cooling package.
  - 👍 Lower fuel bills, Reduced electric demand in winter, Lower maintenance, Higher supply air temperature during heating season, Fewer complaints regarding thermal discomfort during heating season, Longer equipment life.
  - 👎 Gas piping, Venting, Distribution, Conversion cost, Savings.
- *Packaged terminal electric heating units.*
  - ➔ Through-the-wall units with gas-fired heat.
  - 👍 Lower fuel bills, Greater heating capacity available, Higher occupancy rates.
  - 👎 Gas piping, Venting, Conversion cost, Savings.
- *Central chiller with fan coil units and electric resistance heat.*
  - ➔ Central gas boiler with gas or electric chiller and fan-coil units.
  - 👍 Lower fuel bills, Reduced electric demand in winter.
  - 👎 Gas piping, Venting, Equipment space requirements, Distribution, Conversion cost, Savings.
- *Water-source heat pump with electric boiler as back-up heat source.*
  - ➔ Central gas-fired boiler with gas or electric chiller and separate air handling units for each dwelling unit.
  - 👍 Longer equipment life, Lower maintenance, Reduced electric demand in winter and summer with gas chiller.

Gas piping, Venting, Equipment space requirements, Distribution piping, Conversion cost, Savings.

**Competitive Equipment for Additional Applications**

- *Electric or oil-fired service water heating.*
  - → Gas-fired storage water heating, Circulating water heater.
  - Lower fuel bills, Greater first-hour capacity of water heater (compared with electric), Faster recovery rate (compared with electric), Higher occupancy rates.
  - Gas piping, Venting, Conversion cost, Savings.
- *Electric range/oven.*
  - → Gas-fired range/oven.
  - Lower fuel bills, Better control of cooking, Higher occupancy rates.
  - Gas piping, Ventilation at range/oven, Conversion cost, Savings.
- *Electric clothes dryer.*
  - → Gas-fired clothes dryer.
  - Lower fuel bills, Shorter drying time, More productive staff.
  - Gas piping, Venting, Conversion costs, Savings.
- *Electric or oil-fired pool heater.*
  - → Gas-fired pool heater.
  - Lower fuel bills, less maintenance.
  - Gas piping, Conversion costs, Savings.

***Symbol Definitions:***

- Information and features.
- → Replacement or new gas equipment possibilities.
- Advantages of gas over competitive equipment.
- Consider (look at) before installing gas.

- *Outdoor electric lighting.*
  - ➔ Gas-fired lighting.
  - 👍 Very pleasant illumination.
  - ✍ Gas piping, Installation cost.

## *Lodging Facilities* (Motels and Hotels)

**Comments**

- *Required Systems:* Space heating and cooling, service hot water, and ventilation. *Sometimes Required:* Food service, meeting rooms, laundry facilities, pool heating, and outdoor gas-fired lighting.
- Important that each guest have individual control over space conditioning in guest rooms.
- Vital that each guest room have ample supply of service hot water at comfortable temperature.
- Many lodging facilities have many different types of spaces requiring different space conditioning and temperature controls. These might include guest rooms, lobbies, conference areas, dining rooms, kitchens, laundry areas, indoor swimming pools, exercise rooms, and offices. Equipment choices should be made according to the use of each of the areas.
- The noise made by the HVAC equipment is an important consideration for the design of guest rooms.

**Competitive Equipment for Space Conditioning of Guest Rooms**

- *Electric heating/electric cooling PTACs.*
  - ➔ Gas heating/electric cooling PTACs.
  - 👍 Lower maintenance costs, Lower heating bills, Faster pick-up, Quieter operation during heating season.
  - ✍ Gas piping, Wall sleeve size, Conversion costs, Savings.

- *High-Rise fan coil unit, four pipe, electric chiller.*
  - ➔ Gas absorption chiller for cooling, gas boiler for heating.
  - 👍 Lower heating cost, Lower cooling costs, Reduced electric demand.
  - 👎 Gas piping, Venting, Conversion costs, Savings.
- *Electric packaged terminal heat pumps.*
  - ➔ Gas heating/electric cooling PTACs.
  - 👍 Lower maintenance costs; Lower heating bills, Faster pick-up; Warmer heating air, thus, fewer complaints from guests; Quieter operation during heating season.
  - 👎 Gas piping, Wall sleeve size, Conversion costs, Savings.

**Lodging Facilities***
**Energy Intensity Values, 1992**

| | Region | | | |
|---|---|---|---|---|
| | Northeast | Midwest | South | West |
| CF Gas per $Ft^2$, Region<br>95% confidence range | 104.1<br>56 - 152 | 76.2<br>53 - 100 | 73<br>25 - 126 | 90.4<br>44 - 137 |
| | Building Size, $Ft^2$ | | | All Buildings Heated with Natural Gas |
| | 1,001 - 10,000 | 10,001 - 100,000 | over 100,000 | |
| CF Gas per $Ft^2$, U.S.<br>95% confidence range | 130.4<br>91 - 170 | 91<br>51 - 131 | 52.4<br>27 - 76 | 96.7<br>57 - 137 |
| | Natural Gas End Use | | | |
| | Space Heating | Water Heating | Food Service | Other |
| MBtu Gas per $Ft^2$, U.S | 29.6 | 43.1 | 3.4 | 10.2 |

- Source: *Commercial Buildings Energy Consumption and Expenditures, 1992*, DOE/EIA-0318 (92), U.S. Energy Information Administration.
* Buildings used to offer multiple accommodations for short-term or long-term residents. Includes hotels, motels, inns, tourist homes, boarding houses, nursing homes, convents, monasteries, dormitories, sororities, and fraternities.
- 95% confidence range values indicate that there is a 95% certainty that the actual gas consumption was within the given range in 1992.
- See "Notes" at the end of this chapter for geographical region definitions and comments.

- *Electric resistance heat.*
  - ➔ Gas heating/electric cooling PTACs.
  - 👍 Lower maintenance costs, Lower heating bills, Faster pick-up.
  - 👎 Gas piping, Wall sleeve size, Conversion costs, Savings.
- *Water-source heat pumps with electric or oil-fired boiler.*
  - ➔ Gas heating/electric cooling PTACs.
  - 👍 Lower maintenance costs, Possibly lower heating bills, Faster pick-up.
  - 👎 Gas piping, Wall sleeve size, Conversion costs, Savings.
  - ➔ Gas-fired boiler as backup for heat pump system.
  - 👍 Lower heating bills, Interruptible gas rate possible with gas/oil or gas/propane.
  - 👎 Gas piping, Venting, Conversion costs, Savings.
  - ➔ Central gas-fired absorption chiller/heater with air-handling units.
  - 👍 Lower fuel bills, reduced electric demand in winter.
  - 👎 Gas piping, Oil as a backup if interruptible gas rate applies, Equipment space requirements, Distribution piping, Conversion costs, Savings.
- *Electric boiler.*
  - ➔ Gas-fired boiler.
  - 👍 Lower maintenance costs, Lower fuel bills, Lower electric demand charge in winter.
  - 👎 Gas piping, Venting, Conversion costs, Savings.
- *Oil-fired boiler.*
  - ➔ Gas-fired boiler.

👍 Possibly lower space heating costs, Less maintenance.

Gas piping, Venting, Conversion costs, Savings.

**Competitive Equipment for Space Conditioning of Public Areas**

- *Electric heating/electric cooling roof-top unit.*

➔ Gas heating/electric cooling roof-top units, Gas heating/gas cooling roof-top units.

👍 Fast pick-up, Reduced electric demand in winter, Lower heating costs.

Gas piping, Conversion costs, Savings.

➔ Gas boiler with hot water coil for heating, Gas-fired duct furnace added to electric/electric roof-top units for heating.

👍 Lower fuel costs, Lower electric demand in winter.

Gas piping, Venting, Conversion costs, Savings.

- *Central electric chiller with resistance heating coils.*

➔ Gas-fired direct absorption chiller, Gas-fired indirect absorption chiller, Gas boiler/electric chiller with air handling units.

👍 Lower heating costs, Lower cooling costs, Reduced electric demand.

Gas piping, Venting, Conversion costs, Savings.

***Symbol Definitions:***

📖 Information and features.

➔ Replacement or new gas equipment possibilities.

👍 Advantages of gas over competitive equipment.

Consider (look at) before installing gas.

- *Water-source heat pump with electric boiler.*
  - ➔ Gas engine-driven vapor compression heat pump, Gas boiler/electric chiller with air handling units, Gas boiler and hot water coil retrofit for heating, Duct furnace retrofit for heating.
  - 👍 Lower heating costs, Lower cooling costs, Reduced electric demand.
  - 👎 Gas piping, Venting, Ductwork, Conversion costs, Savings.

**Competitive Equipment for Additional Applications**

- *Electric or oil-fired service water heating.*
  - ➔ Gas-fired storage water heating, Circulating water heater.
  - 👍 Lower fuel bills, Greater first-hour capacity of water heater (compared with electric), Faster recovery rate (compared with electric), Higher occupancy rates.
  - 👎 Gas piping, Venting, Conversion costs, Savings.
- *Electric food service equipment.*
  - ➔ Gas-fired food service equipment.
  - 👍 Lower fuel bills, Greater control over food preparation process, Higher kitchen staff satisfaction, Greater patron satisfaction.
  - 👎 Gas piping, kitchen ventilation (some building codes require more kitchen ventilation for gas appliances), Conversion costs, Savings.
- *Electric clothes dryers.*
  - ➔ Gas-fired clothes dryers.
  - 👍 Lower fuel bills, Shorter drying time, More productive staff.
  - 👎 Gas piping, Venting, Conversion costs, Savings.

- *Electric pressing machines for laundry service.*
  - 🕮 Used for bedding and tablecloths.
  - ➔ Gas-fired pressing machines.
  - 👍 Lower operating costs, Shorter drying time, More productive staff.
  - 🖋 Gas piping, Venting, Conversion costs, Savings.
- *Electric or oil-fired pool heater.*
  - ➔ Gas-fired pool heater.
  - 👍 Lower fuel bills, Less maintenance.
  - 🖋 Gas piping, Venting, Conversion costs, Savings.
- *Outdoor electric lighting.*
  - ➔ Gas-fired lighting.
  - 👍 Very pleasant illumination.
  - 🖋 Gas piping, Installation cost.
- *Electric infrared heater.*
  - ➔ Gas-fired infrared heater, high-intensity (unvented) or low intensity (vented).
  - 👍 Lower fuel bills, Reduced electric demand in winter, Fast pick-up, Able to spot-heat work areas.
  - 🖋 Gas piping, Venting, Ventilation if unvented infrared is used, Conversion costs, Savings.

## ***Office Buildings*** (Doctor/Dentist/Professional, Larger Office Buildings)

**Comments**

- *Required Systems:* Space heating, space cooling, and ventilation. *Sometimes Required:* food service, service hot water, and dehumidification.
- Vary greatly in size, from small buildings the size of single-family residences to large multi-story skyscrapers.

- Larger office buildings have peripheral and interior space conditioning zones.
  - Peripheral zones are assumed to extend from 12 to 18 feet inward from the perimeter of the building exterior. Cooling loads in the peripheral zones vary greatly according to solar gain. During winter months, peripheral zones require heating.
  - Interior zones require cooling throughout the year because the thermal loads result from lights, office equipment, and occupants.
- Space conditioning is the most important concern.
- Outdoor air is important for economizer cycle and ventilation air for acceptable indoor air quality.
- Entrances and lobbies are often served by a separate system.

**Office Buildings***
**Energy Intensity Values, 1992**

| | Region | | | |
|---|---|---|---|---|
| | Northeast | Midwest | South | West |
| CF Gas per $Ft^2$, Region<br>95% confidence range | 24<br>17 - 32 | 49<br>39 - 59 | 76<br>42 - 110 | 28<br>19 - 38 |
| | Building Size, $Ft^2$ | | | All Buildings Heated with Natural Gas |
| | 1,001 - 10,000 | 10,001 - 100,000 | over 100,000 | |
| CF Gas per $Ft^2$, U.S.<br>95% confidence range | 76.7<br>55 - 98 | 69<br>41 - 97 | 17.6<br>10 - 25 | 55.9<br>38 - 74 |
| | Natural Gas End Use | | | |
| | Space Heating | Water Heating | Food Service | Other |
| MBtu Gas per $Ft^2$, U.S. | 35.4 | 6.2 | 1.8 | 6 |

- Source: *Commercial Buildings Energy Consumption and Expenditures, 1992*, DOE/EIA-0318 (92), U.S. Energy Information Administration.
* Buildings used for general office space, professional offices, and administrative offices. Includes banks, computer centers, real estate offices, architectural and engineering offices, medical offices, and law offices.
- 95% confidence range values indicate that there is a 95% certainty that the actual gas consumption was within the given range in 1992.
- See "Notes" at the end of this chapter for geographical region definitions and comments.

**Competitive Equipment for Space Conditioning**

- *Central electric chiller with resistance heat in air-handling units and variable air volume (VAV) boxes.*
  - ➔ Central gas boiler with electric chiller and air-handling units, Central gas-fired absorption chiller/heater with air-handling units.
  - 👍 Lower fuel bills, Reduced electric demand in winter and summer with gas chiller.
  - 👓 Gas piping, Distribution piping from boiler, Venting, Equipment space requirements, Oil as a backup if interruptible gas rate applies, Conversion costs, Savings.
- *Water-source heat pump.*
  - ➔ Central gas boiler with electric chiller and air-handling units, Central gas-fired absorption chiller/heater with air-handling units.
  - 👍 Lower noise level, Reduced electric demand in winter, Less maintenance.
  - 👓 Gas piping, Venting, Equipment space requirements, Oil as a backup if interruptible gas rate applies, Conversion costs, Savings.
- *Electric heating/electric cooling roof-top unit.*
  - ➔ Gas-fired heating/electric cooling roof-top, Gas heating/gas cooling roof-top.
  - 👍 Fast pick-up, Reduced electric demand in winter (and summer if gas cooling), Lower heating costs.
  - 👓 Gas piping, Conversion costs, Savings.

***Symbol Definitions:***

📖 Information and features.

➔ Replacement or new gas equipment possibilities.

👍 Advantages of gas over competitive equipment.

👓 Consider (look at) before installing gas.

➔ Outdoor gas boiler with hot water coil for heating added to existing electric roof-top unit, Gas-fired duct furnace added to electric/electric roof-top units for heating.

Lower fuel costs, Lower electric demand in winter.

Gas piping, Venting, Ductwork, Conversion costs, Savings.

- *Electric baseboard resistance/Oil-fired boiler with hot water distribution.*

➔ Central gas-fired boiler with baseboard hot water distribution.

Longer equipment life, Reduced electric demand in winter, Lower heating costs if replacing electric.

Gas piping, Distribution piping, Venting, Oil as a backup if interruptible gas rate applies, Conversion costs, Savings.

***Recreational Facilities*** (Bowling Centers, Gyms, Racquet-Sports Facilities, Swimming Pools, Roller Skating Rinks)

**Comments**

- *Required Systems:* Space heating and cooling, service hot water, and ventilation. *Sometimes Required:* food service equipment, pool heater, and dehumidification.
- Cooling loads, and to a lesser extent, heating loads, are affected greatly by the number of occupants and their activities.
- Cooling might be required in areas of high activity during all seasons of the year.
- High levels of ventilation are often required.
- Economizer cycle can save significant amounts of cooling energy.

- Office, day care, food service, and meeting areas require separate consideration for HVAC design.
- Roof-top units with economizer cycle are a good choice for high activity recreational spaces.
- Some uses, such as ice arenas, benefit from desiccant dehumidification.

**Competitive Equipment for Space Conditioning**

- *Electric resistance heat or electric air handling units.*
  - ➔ Gas heating/electric cooling roof-top units, Gas heating/gas cooling roof-top units, Direct-vent space heaters with separate air conditioning.
  - 👍 Lower fuel bills, Fast pick-up, Reduced electric demand in winter (and summer if gas cooling).
  - 👎 Gas piping, Venting, Ductwork, Conversion costs, Savings.
- *Electric heating/electric cooling roof-top units.*
  - ➔ Gas heating/electric cooling roof-top units, Gas heating/gas cooling roof-top units, Gas-fired boiler with hot water coil(s) added to existing units, Gas-fired duct furnace added to existing units.
  - 👍 Lower fuel bills, Fast pick-up, Reduced electric demand in winter (and summer if gas cooling).
  - 👎 Gas piping, Venting, Ductwork, Conversion costs, Savings.
- *Electric heat pump.*
  - ➔ Outdoor gas boiler and hot water coil(s) added to heat pump, Gas duct furnace added to heat pump ductwork.
  - 👍 Lower fuel bills, Higher supply-air temperature in winter, Fast pick-up, Reduced electric demand in winter.
  - 👎 Gas piping, Venting, Conversion costs, Savings.

➔ Gas-engine driven heat pump for both heating and cooling.

👍 Lower fuel bills, Higher supply-air temperature in winter, Fast pick-up, Reduced electric demand in winter and summer.

✍ Gas piping, Venting, Conversion costs, Savings.

- *Oil-fired furnace.*

➔ Gas-fired furnace, Gas heating/electric cooling roof-top units, Gas heating/gas cooling roof-top units.

👍 Might experience lower fuel bills, No concerns about oil storage or spillage.

✍ Gas piping, Venting, Ductwork, Conversion costs, Savings.

- *Oil-fired boiler.*

➔ Gas-fired boiler.

👍 Might experience lower fuel bills, No concerns about oil storage or spillage.

✍ Gas piping, Venting, Conversion costs, Savings.

- *Electric or oil-fired make-up air units serving high-activity spaces.*

➔ Gas-fired make-up air heaters, indirect-fired or direct-fired (if appropriate).

👍 Lower fuel bills, No concerns about oil storage.

✍ Gas piping, Venting, Ductwork, Conversion costs, Savings.

**Competitive Equipment for Additional Applications**

- *Electric or oil-fired service water heating.*

➔ Gas-fired storage water heating, Circulating water heater.

👍 Lower fuel bills, Greater first-hour capacity of water heater (compared with electric), Faster

recovery rate (compared with electric), Higher occupancy rates.

↷ Gas piping, Venting, Conversion costs, Savings.

- *Electric food service equipment.*

  ➔ Gas-fired food service equipment.

  👍 Lower fuel bills, Greater control over food preparation process, Higher kitchen staff satisfaction, Higher patron satisfaction.

  ↷ Gas piping, Kitchen ventilation (some building codes require more kitchen ventilation for gas appliances), Conversion costs, Savings.

- *Electric or Oil-fired pool heater.*

  ➔ Gas-fired pool heater.

  👍 Lower fuel bills if electric pool heater (possibly lower fuel bills if oil-fired pool heater), Less maintenance.

  ↷ Gas piping, Venting, Conversion costs, Savings.

## ***Restaurants and Food Service Facilities*** (Fast Food, Larger Sit-Down Dining Establishments, Diners, Bakeries)

**Comments**

- *Required Systems:* Space heating and cooling, service hot water, food service, and ventilation. *Sometimes Required:* Make-up air for kitchen, dehumidification, outdoor gas-fired lighting, and outdoor gas barbecue.

***Symbol Definitions:***

📖 Information and features.

➔ Replacement or new gas equipment possibilities.

👍 Advantages of gas over competitive equipment.

↷ Consider (look at) before installing gas.

- Dining areas and food preparation areas should be individually conditioned. Peak loads in the dining area are different in magnitude and timing from those in the kitchen.
- Dual temperature service hot water is usually required for the commercial food service activities.
- Chefs usually prefer gas-fired appliances over electric.
- Because customer satisfaction is vital to the success of these establishments, thermal comfort is very important.
- Small establishments can best be served by packaged units.
- Larger establishments are best served by central systems.
- Economizer cycle can lower cooling costs.

**Restaurants and Food Service Facilities***
**Energy Intensity Values, 1992**

| | Region | | | |
|---|---|---|---|---|
| | Northeast | Midwest | South | West |
| CF Gas per $Ft^2$, Region<br>95% confidence range | 99.8<br>61 - 139 | 123.7<br>91 - 156 | 142.9<br>62 - 224 | 189.1<br>107 - 272 |
| | Building Size, $Ft^2$ | | | All Buildings Heated with Natural Gas |
| | 1,001 - 10,000 | 10,001 - 100,000 | over 100,000 | |
| CF Gas per $Ft^2$, U.S.<br>95% confidence range | 183.8<br>140 - 228 | 73.9<br>49 - 99 | No Data | 137.3<br>100 - 175 |
| | Natural Gas End Use | | | |
| | Space Heating | Water Heating | Food Service | Other |
| MBtu Gas per $Ft^2$, U.S. | 27.7 | 26.3 | 81.7 | 1 |

- Source: *Commercial Buildings Energy Consumption and Expenditures, 1992*, DOE/EIA-0318 (92), U.S. Energy Information Administration.
* Buildings used for preparation and sale of prepared food and beverages for consumption. Includes full-service restaurants, pizza parlors, coffee shops, fast-food establishments, cafeterias, and sandwich shops.
- 95% confidence range values indicate that there is a 95% certainty that the actual gas consumption was within the given range in 1992.
- See "Notes" at the end of this chapter for geographical region definitions and comments.

- See Chapter 6, page 195 for method for comparing the cost of natural gas and electric food service equipment.

**Competitive Equipment for Space Conditioning**

- *Electric resistance heat or electric air handling units.*
  - ➔ Gas heating/electric cooling roof-top units, Gas heating/gas cooling roof-top units.
  - 👍 Lower fuel bills, Fast pick-up, Reduced electric demand in winter.
  - 👎 Gas piping, Venting, Ductwork, Conversion costs, Savings.
- *Electric heating/electric cooling roof-top units.*
  - ➔ Gas heating/electric cooling roof-top units, Gas heating/gas cooling roof-top units, Gas-fired boiler with hot water coil(s) added to existing units, Gas-fired duct furnace added to existing units.
  - 👍 Lower fuel bills, Fast pick-up, Reduced electric demand in winter (and in summer if gas cooling).
  - 👎 Gas piping, Venting, Ductwork, Conversion costs, Savings.
- *Electric heat pump.*
  - ➔ Gas boiler and hot water coil(s) added to heat pump, Gas duct furnace added to heat pump ductwork.
  - 👍 Lower fuel bills, Higher supply-air temperature in winter, Fast pick-up, Reduced electric demand in winter.
  - 👎 Gas piping, Venting, Conversion costs, Savings.
  - ➔ Gas-engine driven heat pump for both heating and cooling.

👍 Lower fuel bills, Higher supply-air temperature in winter, Fast pick-up, Reduced electric demand in winter.

🔗 Gas piping, Venting, Conversion costs, Savings.

- *Oil-fired furnace.*

➔ Gas furnace, Gas heating/electric cooling roof-top unit, Gas heating/gas cooling roof-top unit.

👍 Might experience lower fuel bills, No concerns about oil storage or spillage.

🔗 Gas piping, Venting, Ductwork, Conversion costs, Savings.

- *Oil-fired boiler.*

➔ Gas-fired boiler.

👍 Might experience lower fuel bills, No concerns about oil storage or spillage.

🔗 Gas piping, Venting, Distribution, Conversion costs, Savings.

- *Electric or oil-fired make-up air units serving kitchen.*

📖 Some studies have demonstrated that an increase in kitchen ventilation can decrease cooling costs.

➔ Gas-fired make-up air heaters, indirect-fired or direct-fired (if appropriate).

👍 Lower fuel bills, No concerns about oil storage.

🔗 Gas piping, Venting, Ductwork, Conversion costs, Savings.

**Competitive Equipment for Additional Applications**

- *Electric or oil-fired service water heating.*

➔ Gas-fired storage water heating, Circulating water heater, Gas-fired booster water heater (dish washer rinse).

- 👍 Lower fuel bills, Greater first-hour capacity of water heater (compared with electric), Faster recovery rate (compared with electric).
- 👀 Gas piping, Venting, Conversion costs, Savings.

• *Electric food service equipment.*
- ➔ Gas-fired food service equipment.
- 👍 Lower fuel bills, Greater control over food preparation process, Higher kitchen staff satisfaction, Greater patron satisfaction.
- 👀 Gas piping, Kitchen ventilation (some building codes require more kitchen ventilation for gas appliances), Conversion costs, Savings.

• *Outdoor electric lighting.*
- ➔ Gas-fired lighting.
- 👍 Very pleasant illumination.
- 👀 Gas piping, Installation cost.

***Retail Stores*** (Department Stores, Pharmacies, Shoe Repair Shops)

**Comments**

• *Required Systems*: Space heating and cooling, and ventilation. *Sometimes Required:* Service hot water and food service.
• Space heating and cooling are usually the most important considerations.
• Sometimes tenants are responsible for selecting energy systems.

***Symbol Definitions:***
📖 Information and features.
➔ Replacement or new gas equipment possibilities.
👍 Advantages of gas over competitive equipment.
👀 Consider (look at) before installing gas.

- Decisions often based on cash flow rather than life-cycle costs.
- Systems and distribution are usually on roof and above suspended ceiling.

**Competitive Equipment for Space Conditioning**

- *Electric resistance heat or electric air handling units.*
  - ➔ Gas-fired roof-top units, Replace electric coils with hot water coils and outdoor boiler.
  - 👍 Lower fuel bills, Fast pick-up, Reduced electric demand in winter, Higher occupancy rates.
  - 👎 Gas piping, Distribution piping, Venting, Duct-work, Conversion costs, Savings.
- *Oil heat.*
  - ➔ Gas-fired roof-top units.
  - 👍 Might experience lower fuel bills.

**Mercantile and Service Facilities***
**Energy Intensity Values, 1992**

| | Region | | | |
|---|---|---|---|---|
| | Northeast | Midwest | South | West |
| CF Gas per $Ft^2$, Region<br>95% confidence range | 30.3<br>18 - 42 | 45<br>33 - 57 | 41.8<br>18 - 66 | 38.2<br>22 - 55 |
| | Building Size, $Ft^2$ | | | All Buildings Heated with Natural Gas |
| | 1,001 - 10,000 | 10,001 - 100,000 | over 100,000 | |
| CF Gas per $Ft^2$, U.S.<br>95% confidence range | 56.1<br>45 - 68 | 51.1<br>36 - 66 | 14.4<br>10 - 19 | 40.5<br>30 - 51 |
| | Natural Gas End Use | | | |
| | Space Heating | Water Heating | Food Service | Other |
| MBtu Gas per $Ft^2$, U.S. | 25.6 | 12.2 | 1.6 | 1.4 |

- Source: *Commercial Buildings Energy Consumption and Expenditures, 1992*, DOE/EIA-0318 (92), U.S. Energy Information Administration.
* Buildings used for sales and displays of goods or services—excluding food. Includes retail stores, department stores, drugstores, gasoline stations, motor vehicle repair/service, shopping malls, strip malls, post offices, personal service establishments, laundries, and wholesale goods establishments.
- 95% confidence range values indicate that there is a 95% certainty that the actual gas consumption was within the given range in 1992.
- See "Notes" at the end of this chapter for geographical region definitions and comments.

Gas piping; Venting; Ductwork; Conversion costs; Savings; Oil storage problems such as periodic registration fees, spillage cleanup, or tank disposal fees.

- *Electric heating/electric cooling roof-top units.*

  → Gas heating/electric cooling roof-top units, Gas heating/gas cooling roof-top units, Gas engine-driven heat pump, Gas absorption heating/cooling package, Gas boiler and hot water coil(s), Gas duct furnace added to heat pump ductwork.

  Lower fuel bills, Fast pick-up, Reduced electric demand in winter, Higher occupancy rates.

  Gas piping, Venting, Ductwork, Conversion costs, Savings.

- *Electric heat pump.*

  → Gas heating/electric cooling roof-top units, Gas heating/gas cooling roof-top units, Gas engine-driven heat pump, Gas absorption heating/cooling package, Gas boiler and hot water coil(s), Gas duct furnace added to heat pump ductwork.

  Lower fuel bills, Higher supply-air temperature in winter, Fast pick-up, Reduced electric demand in winter.

  Gas piping, Venting, Ductwork, Conversion costs, Savings.

## ***School Buildings*** (Classrooms, Offices, Gymnasiums)

**Comments**

- *Required Systems:* Space heating, service hot water, and ventilation. *Sometimes Required:* Space cooling, food service, and pool heating.

- Heating and cooling loads vary greatly with student occupancy.
- HVAC flexibility is becoming more important as school systems attempt to schedule full-use of buildings throughout the calendar year.
- Systems can be complicated because of the varied use of spaces, for example, classrooms, gymnasiums, cafeterias, offices, locker rooms, etc.
- Heat is needed for ventilation air. Heating requirements vary according to climate.
- Economizer cycle can save significant amounts of cooling energy.
- Indoor air quality should be considered.
- Not all school buildings have food service facilities. Some are served from central food service facilities within the same district.

**School Buildings***
**Energy Intensity Values, 1992**

| | Region | | | |
|---|---|---|---|---|
| | Northeast | Midwest | South | West |
| CF Gas per $Ft^2$, Region<br>95% confidence range | 43.9<br>31 - 57 | 49.4<br>39 - 59 | 32.6<br>18 - 47 | 36.6<br>24 - 49 |
| | Building Size, $Ft^2$ | | | All Buildings Heated with Natural Gas |
| | 1,001 - 10,000 | 10,001 - 100,000 | over 100,000 | |
| CF Gas per $Ft^2$, U.S.<br>95% confidence range | 41.9<br>33 - 50 | 47.7<br>34 - 61 | 33.8<br>23 - 45 | 44.8<br>36 - 53 |
| | Natural Gas End Use | | | |
| | Space Heating | Water Heating | Food Service | Other |
| MBtu Gas per $Ft^2$, U.S. | 33.4 | 5.3 | 0.9 | 2.9 |

- Source: *Commercial Buildings Energy Consumption and Expenditures, 1992*, DOE/EIA-0318 (92), U.S. Energy Information Administration.
* Buildings used for academic or technical classroom instruction. Includes preschools, elementary, junior high, and senior high schools.
- 95% confidence range values indicate that there is a 95% certainty that the actual gas consumption was within the given range in 1992.
- See "Notes" at the end of this chapter for geographical region definitions and comments.

**Competitive Equipment for Space Conditioning**

- *Electric resistance heat or electric air handling units.*
  - ➔ Gas heating/electric cooling roof-top units, Gas heating/gas cooling roof-top units, Gas heating/electric cooling PTACs, Direct-vent gas-fired wall heaters.
  - 👍 Lower fuel bills, Fast pick-up, Reduced electric demand in winter.
  - 👓 Gas piping, Venting, Ductwork, Conversion costs, Savings.
- *Electric resistance roof-top with cooling.*
  - ➔ Gas heating/electric cooling roof-top units, Gas heating/gas cooling roof-top units, Gas-fired boiler with hot water coil(s) added to existing units, Gas-fired duct furnace added to existing units.
  - 👍 Lower fuel bills, Fast pick-up, Reduced electric demand in winter.
  - 👓 Gas piping, Ductwork, Conversion costs, Savings.
- *Electric heat pump.*
  - ➔ Gas boiler and hot water coil(s) added to heat pump, Gas duct furnace added to heat pump ductwork.
  - 👍 Lower fuel bills, Higher supply-air temperature in winter, Fast pick-up, Reduced electric demand in winter.
  - 👓 Gas piping, Venting, Ductwork, Conversion costs, Savings.

***Symbol Definitions:***

📖 Information and features.

➔ Replacement or new gas equipment possibilities.

👍 Advantages of gas over competitive equipment.

👓 Consider (look at) before installing gas.

➔ Gas-engine driven heat pump for both heating and cooling.

Lower fuel bills, Higher supply-air temperature in winter, Fast pick-up, Reduced electric demand in winter.

Gas piping, Venting, Conversion costs, Savings.

- *Oil-fired furnace.*

➔ Gas-fired furnace, Gas heating/electric cooling roof-top units, Gas heating/gas cooling roof-top units.

Might experience lower fuel bills, No concerns about oil storage or spillage.

Gas piping, Venting, Ductwork, Conversion costs, Savings.

- *Oil-fired boiler.*

➔ Gas-fired boiler.

Might experience lower fuel bills, No concerns about oil storage or spillage.

Gas piping, Venting, Conversion costs, Savings.

- *Electric or oil-fired make-up air units serving gymnasiums or kitchens.*

➔ Gas-fired make-up air heaters, indirect-fired or direct-fired (if appropriate).

Lower fuel bills, No concerns about oil storage.

Gas piping, Venting, Ventilation, Ductwork, Conversion costs, Savings.

**Competitive Equipment for Additional Applications**

- *Electric or oil-fired service water heating.*

➔ Gas-fired storage water heating, Circulating water heater, Gas-fired booster water heater for food service.

- Lower fuel bills, Greater first-hour capacity of water heater (compared with electric), Faster recovery rate (compared with electric), Higher occupancy rates.
- Gas Piping, Venting, Conversion costs, Savings.

• *Electric food service equipment.*
- → Gas-fired food service equipment.
- Lower fuel bills, Greater control over food preparation process, Higher kitchen staff satisfaction, Higher student satisfaction.
- Gas piping, Kitchen ventilation (some building codes require more kitchen ventilation for gas appliances), Conversion costs, Savings.

• *Electric or Oil-fired pool heater.*
- → Gas-fired pool heater.
- Lower fuel bills, Less maintenance.
- Gas piping, Venting, Conversion costs, Savings.

## ***Shopping Complexes*** (Covered Malls, Strip Malls)

**Comments**

- *Required Systems:* Space heating and cooling, service hot water, and ventilation. *Sometimes Required:* food service, outdoor gas-fired lighting, and dehumidification.
- Common areas conditioned by owners of building.
- Individual retail stores might be conditioned by building owners or by retail tenants.
- Space conditioning is usually the most important concern.
- Food court areas require special consideration.
- Outdoor air is important for economizer cycle and ventilation air.
- Usually sub-metered for tenant billing.

**Competitive Equipment for Space Conditioning**

- *Electric heating/electric cooling roof-top unit.*
  - ➔ Gas heating/electric cooling roof-top units, Gas heating/gas cooling roof-top units.
  - 👍 Fast pick-up, Reduced electric demand in winter (and summer if gas cooling), Lower heating costs.
  - 👎 Gas piping, Conversion costs, Savings.
  - ➔ Outdoor gas boiler with hot water coil for heating, Gas-fired duct furnace added to electric/electric roof-top units for heating.
  - 👍 Lower fuel costs, Lower electric demand in winter.
  - 👎 Gas piping, Venting, Conversion costs, Savings.

**Mercantile and Service Facilities***
**Energy Intensity Values, 1992**

| | Region | | | |
|---|---|---|---|---|
| | Northeast | Midwest | South | West |
| CF Gas per $Ft^2$, Region<br>95% confidence range | 30.3<br>18 - 42 | 45<br>33 - 57 | 41.8<br>18 - 66 | 38.2<br>22 - 55 |
| | Building Size, $Ft^2$ | | | All Buildings Heated with Natural Gas |
| | 1,001 - 10,000 | 10,001 - 100,000 | over 100,000 | |
| CF Gas per $Ft^2$, U.S.<br>95% confidence range | 56.1<br>45 - 68 | 51.1<br>36 - 66 | 14.4<br>10 - 19 | 40.5<br>30 - 51 |
| | Natural Gas End Use | | | |
| | Space Heating | Water Heating | Food Service | Other |
| MBtu Gas per $Ft^2$, U.S. | 25.6 | 12.2 | 1.6 | 1.4 |

- Source: *Commercial Buildings Energy Consumption and Expenditures, 1992*, DOE/EIA-0318 (92), U.S. Energy Information Administration.
* Buildings used for sales and displays of goods or services—excluding food. Includes retail stores, department stores, drugstores, gasoline stations, motor vehicle repair/service, shopping malls, strip malls, post offices, personal service establishments, laundries, and wholesale goods establishments.
- 95% confidence range values indicate that there is a 95% certainty that the actual gas consumption was within the given range in 1992.
- See "Notes" at the end of this chapter for geographical region definitions and comments.

- *Central electric chiller with resistance heating coils.*
  - ➔ Gas-fired direct absorption chiller, Gas-fired indirect absorption chiller, Gas boiler/electric chiller with air handling units, Gas engine-driven chiller.
  - 👍 Lower heating costs, Lower cooling costs, Reduced electric demand.
  - 👓 Gas piping, Venting, Conversion costs, Savings.
- *Water-source heat pump with electric boiler.*
  - ➔ Gas engine-driven vapor compression heat pump, Gas boiler/electric chiller with air handling units, Gas boiler and hot water coil retrofit for heating, Duct furnace retrofit for heating.
  - 👍 Lower heating costs, Lower cooling costs, Reduced electric demand.
  - 👓 Gas piping, Venting, Ductwork, Conversion costs, Savings.
- *Central electric chiller with resistance heat in air-handling units.*
  - ➔ Central gas boiler with electric chiller and air-handling units, Central gas absorption chiller/heater with air-handling units, Gas engine-driven chiller.
  - 👍 Lower fuel bills, Reduced electric demand in winter.
  - 👓 Gas piping, Venting, Ductwork, Oil as a backup if interruptible gas rate applies, Conversion costs, Savings, Distribution piping.

***Symbol Definitions:***

📖 Information and features.

➔ Replacement or new gas equipment possibilities.

👍 Advantages of gas over competitive equipment.

👓 Consider (look at) before installing gas.

- *Water-source heat pump.*
  - ➔ Gas engine-driven vapor compression chiller/heater.
  - 👍 Longer equipment life, Less maintenance, Reduced electric demand in winter.
  - ✍ Gas piping, Venting, Conversion costs, Savings.

## *Supermarkets/Food Stores*

**Comments**

- *Required Systems:* Space heating and cooling, refrigeration, dehumidification, and ventilation. *Sometimes Required:* Service hot water and food service.
- Some larger supermarkets have bakeries.
- Outdoor air is important for economizer cycle and ventilation air.
- Good application for gas-fired desiccant dehumidification. Allows separate control of sensible (temperature) and latent (relative humidity) cooling.
- The comfort of shoppers is important.
- The appearance of the product is important. Frozen food containers should not have a covering of frost; refrigerated case glass doors should not be covered with condensation. Desiccant dehumidification can prevent these problems.

**Competitive Equipment for Space Conditioning**

- *Electric heating/electric cooling roof-top units/Electric heat pump roof-top units.*
  - ➔ Gas heating/electric cooling roof-top units, Gas heating/gas cooling roof-top units.
  - 👍 Lower fuel costs, Lower electric demand in summer and winter.
  - ✍ Gas piping, Ductwork, Conversion costs, Savings.

➔ Gas boiler with hot water coil for heating, Gas-fired duct furnace added to electric/electric roof-top units for heating.

Lower fuel costs, Lower electric demand in winter.

Gas piping, Venting, Ductwork, Conversion costs, Savings.

➔ Gas-fired desiccant dehumidification added to cooling.

Separate control of sensible cooling (from electric vapor compression) and latent cooling (from desiccant dehumidification system), Less product frost-up/improved product quality, More comfortable customers, Lower summer electric demand charges (usually able to deactivate some existing electrically-driven vapor compression

**Supermarkets/Food Stores***
**Energy Intensity Values, 1992**

| | Region | | | |
|---|---|---|---|---|
| | Northeast | Midwest | South | West |
| CF Gas per Ft², Region<br>95% confidence range | No Data | No Data | No Data | No Data |

| | Building Size, Ft² | | | All Buildings Heated with Natural Gas |
|---|---|---|---|---|
| | 1,001 - 10,000 | 10,001 - 100,000 | over 100,000 | |
| CF Gas per Ft², U.S.<br>95% confidence range | 51.2<br>22 - 81 | No Data | No Data | 49.6<br>27 - 72 |

| | Natural Gas End Use | | | |
|---|---|---|---|---|
| | Space Heating | Water Heating | Food Service | Other |
| MBtu Gas per Ft², U.S. | 26.4 | 5.3 | 8.2 | 7.3 |

- Source: *Commercial Buildings Energy Consumption and Expenditures, 1992*, DOE/EIA-0318 (92), U.S. Energy Information Administration.
* Buildings used for wholesale or retail sale of food. Includes convenience stores, supermarkets, retail bakeries, farmer's markets.
- 95% confidence range values indicate that there is a 95% certainty that the actual gas consumption was within the given range in 1992.
- See "Notes" at the end of this chapter for geographical region definitions and comments.

cooling), Lower refrigeration operating costs, Reduced anti-sweat heater operation.

✍ Gas piping, Venting, Precise control of relative humidity, Installation costs.

- *Gas heating/electric cooling roof-top units.*

➔ Gas heating/gas cooling roof-top units.

$ Lower fuel costs, Lower summer electric demand.

✍ Conversion costs, Conversion costs, Savings.

## *Warehouses*

**Comments**

- *Required Systems:* Space heating and ventilation. *Sometimes Required:* Space cooling, service hot water, dehumidification, and refrigeration.
- Vary greatly in size.
- Storage area of building often is not served by cooling equipment.
- Required inside temperature during winter months depends on stored products, might be as low as 40°F (4.4°C), just high enough to insure that sprinkler system and stored products do not freeze.
- Office area is often served by separate HVAC systems.
- Some warehouses have refrigerated areas.

**Competitive Equipment for Space Conditioning**

- *Electric resistance unit heaters.*

➔ Gas-fired unit heaters, Gas-fired make-up air heaters (direct- or indirect-fired), Gas boiler with unit heaters (hot water coils).

$ Lower fuel bills, Reduced electric demand in winter, Fast pick-up.

✍ Gas piping, Venting, Conversion costs, Savings.

➔ Gas-fired floor-mounted vertical furnaces.

- Lower fuel bills, Reduced electric demand in winter, Fast pick-up, Dual-fuel capabilities.
- Gas piping, Venting, Conversion costs, Savings.

• *Electric infrared heater.*

- ➔ Gas-fired infrared, high-intensity (unvented) or low intensity (vented).
- Lower fuel bills, reduced electric demand in winter, Fast pick-up, Able to spot-heat work areas.
- Gas piping, Venting, Ventilation (if unvented gas units used), Conversion costs, Savings.

• *Any means of cooling.*

- ➔ Gas-fired desiccant system to dehumidify.
- Reduces chance of spoilage and hazards due to condensation on floors and ramps.

**Warehouses***
**Energy Intensity Values, 1992**

| | Region | | | |
|---|---|---|---|---|
| | Northeast | Midwest | South | West |
| CF Gas per $Ft^2$, Region<br>95% confidence range | 29.5<br>16 - 43 | 39.7<br>28 - 51 | 27.1<br>10 - 46 | 14.5<br>7 - 22 |
| | Building Size, $Ft^2$ | | | All Buildings Heated with Natural Gas |
| | 1,001 - 10,000 | 10,001 - 100,000 | over 100,000 | |
| CF Gas per $Ft^2$, U.S.<br>95% confidence range | 50<br>38 - 62 | 34.8<br>23 - 46 | 21.7<br>14 - 30 | 30.5<br>23 - 38 |
| | Natural Gas End Use | | | |
| | Space Heating | Water Heating | Food Service | Other |
| MBtu Gas per $Ft^2$, U.S. | 24.5 | 2.6 | 0.4 | 3.4 |

• Source: *Commercial Buildings Energy Consumption and Expenditures, 1992*, DOE/EIA-0318 (92), U.S. Energy Information Administration.
* Buildings used to store goods, manufactured products, merchandise, or raw materials. Includes refrigerated and non-refrigerated storage.
• 95% confidence range values indicate that there is a 95% certainty that the actual gas consumption was within the given range in 1992.
• See "Notes" at the end of this chapter for geographical region definitions and comments.

- Decreased loss of stored products, Lower liability, Higher comfort level.
- Gas piping, Venting, Installation cost.

**Competitive Equipment for Additional Applications**

- *Electric vapor compression refrigeration.*
  - → Gas engine driven ammonia refrigeration; Absorption cooling to pre-cool area; Gas-fired desiccant system to dehumidify, thus, reducing total cooling load.
  - Lower fuel bills, Reduced electric demand, Fast pick-up.
  - Gas piping, Venting, Conversion costs, Savings.

## *Notes Regarding Energy Intensity Tables*

- Geographical regions are defined as follows:

| | |
|---|---|
| Northeast | Connecticut, Maine, Massachusetts, New Hampshire, New Jersey, New York, Pennsylvania, Vermont, Rhode Island |
| Midwest | Illinois, Indiana, Iowa, Kansas, Michigan, Minnesota, Missouri, Nebraska, North Dakota, Ohio, South Dakota, Wisconsin |
| South | Alabama, Arkansas, Delaware, District of Columbia, Florida, Georgia, Kentucky, Louisiana, Maryland, Mississippi, North Carolina, Oklahoma, South Carolina, Tennessee, Texas, Virginia, West Virginia |
| West | Arizona, Alaska, California, Colorado, Hawaii, Idaho, Montana, Nevada, New Mexico, Oregon, Utah, Washington, Wyoming |

Source: *Commercial Buildings Energy Consumption and Expenditures, 1992*, DOE/EIA-0318 (92), U.S. Energy Information Administration.

- For most commercial building types, the larger the building, the less intensively it used natural gas. This was probably due to the use of natural gas mostly for space heating. Because the ratio of exterior surface to total

floorspace is smaller in larger buildings, building interiors require less space heating to maintain comfortable temperatures.

- For most commercial facility types, natural gas intensities were highest in the Midwest region. This is probably because natural gas was the dominant space heating fuel in the Midwest.
- For residential and commercial buildings, the newer the building, the less intensively it used natural gas, possibly due to higher efficiency heating equipment or improvements in the building thermal envelope.
- For residential buildings, natural gas was the predominant space heating fuel (1993). U.S. Households consumed almost three times as much natural gas as electricity and they paid, on average, 54 percent more for electricity.

**U.S. Residential End-Use Consumption of Natural Gas, 1993**

| | Percent of Households |
|---|---|
| Main Space Heating | 69 |
| Secondary Space Heating | > 0.5 |
| Water Heating | 25 |
| Air-Conditioning | > 0.5 |
| Appliances | 5 |

Source: *Household Energy Consumption and Expenditures*, 1993, U.S. Energy Information Administration, 1995.
Gas Appliances include ranges, ovens, clothes dryers, outdoor gas grills, gas lights, and hot tub and swimming pool heaters.

# 5. ENERGY ECONOMICS

## *Introduction*

Natural gas equipment often has a higher initial cost than competing equipment, but may improve cash flow as a result of lower operating and maintenance costs. Energy economics can be a useful tool for convincing decision-makers that natural gas equipment can enhance cash flow and the financial viability of a business.

*Economic* efficiency is not the same as *engineering* efficiency. For example, one boiler might be more efficient than another (engineering efficiency), but overall, it might be more expensive to operate and maintain (economic efficiency). This chapter defines important energy economics terms, presents calculation methods, and calculates examples using each of the analysis methods.

Energy economics calculations are often left to engineers. This chapter presents simple methods to serve as functional tools for marketing representatives and other non-engineers. Become familiar with the terms and methods so that you are able to understand the methods and discuss them with others, even if you will not be required to perform the calculations.

When analyzing the cost-effectiveness of a natural gas equipment option, remember to consider the collateral equipment loads and benefits.[61] For example, calculating the value of replacing an oil-fired boiler with a residential gas-fired boiler might not yield results favorable to the replacement. If collateral gas equipment is included in the calculations—such as also replacing an electric water heater with a gas water heater—the economics of bringing gas to the house to replace the oil-fired boiler are likely to look very favorable.

[61] Collateral load is an accompanying gas load or appliance connected concurrently with or peripherally to a primary gas load or appliance.

## *Discounting*

The costs of installing new gas equipment usually include only those incurred during the time of initial design and construction or retrofitting. On the other hand, the benefits of gas equipment accrue over its useful life in the form of yearly savings in energy and maintenance costs. To perform a realistic economic energy analysis, it is necessary to compare costs and benefits realized at different times. Discounting allows a time-equivalent comparison of cash flows occurring during different periods.

The value of money is time-dependent for two reasons. First, inflation erodes the buying power of money, or the real value of the dollar decreases as prices for goods and services increase. Second, money can be invested today to yield a return equal to or greater than the rate of inflation.

Discounting methods are used to determine present value, the equivalent value of past and future dollars corresponding to the dollar value today.

## *Discount Rate*

The discount rate is the rate of interest used to convert costs and benefits occurring at different times to a common time, usually the present (present value or present worth). The selected discount rate for an analysis may be guided by the 1) level of return on alternative investment opportunities, 2) cost of borrowing money, or 3) mandated requirements (for non-governmental analysis, the first or second choice is used).

Discount rates may be expressed as either nominal or real. Nominal discount rates include the effects of general inflation; real discount rates are adjusted for the effects of inflation and, therefore, include only the real earning power of money. Market interest rates are nominal because they include the effects of general inflation in addition to the real earning power of money.

Use care when selecting a discount rate, for your choice can dramatically affect the results of an analysis. As the discount rate increases, the present value of any stream of costs and benefits becomes smaller. Projects with quick payoffs gain an advantage over projects with longer payoffs as the discount rate increases.

### *Inflation Rate of Fuel*

As the costs of competing fuels increase over time, the present value or benefit of a future stream of savings from natural gas equipment increases. Like the discount rate, the inflation rate of fuel can be expressed in nominal terms (including the general inflation rate) or in real terms (adjusted for the general inflation rate). If the nominal inflation rate of a fuel is 8% and the general inflation rate is 3%, the real inflation rate of the fuel is 5%.

The economic values used for an analysis must be consistent with one another. For example, if the real discount rate is used, the real inflation rate of fuel must be used. On the other hand, if the nominal discount rate is used, the nominal inflation rate of fuel should be used.

### *Simple Payback Method*

Simple payback is the easiest energy economics calculation. This calculation determines the number of years required for the accumulated savings in energy costs to offset the initial investment cost. This calculation does not include the life of the subject equipment nor does it include discounting.

The advantages of this method are its simplicity and speed. It is useful when fast recovery of investment funds is required; the shorter the payback period, the better.

For the investment is to be viable, the payback period must be shorter than 1) the desired investment recovery period and 2) the life of the subject equipment.

Caution: Do not use the simple payback method for ranking various investment options, for an investment with a longer payback period may prove more profitable than an investment with a shorter payback if it continues to produce savings for a longer period.

The equation for simple payback is:

$$\text{Payback} = \frac{\text{Differential Installed Cost}}{\text{Reduction in Energy Costs}}$$

For example: Installing an electrically driven centrifugal chiller costs $120,000. Installing a competitive gas-fired absorption chiller costs $275,000 and saves $12,219 the first year over the electrically driven chiller. The simple payback is:

$$\text{Payback} = \frac{\$275{,}000 - \$120{,}000}{\$12{,}219}$$
$$= 12.69 \text{ years}$$

## *Benefit/Cost Ratio Method*

For the benefit/cost ratio method—also referred to as the savings-to-investment ratio method—all benefits are divided by all costs. The project is acceptable if the benefit/cost ratio is greater than one. This method may be calculated in a simple manner without discounting or with the use of discounted values.

The method allows the determination of whether a project is an acceptable investment or not, without having to compare it to another project. It should not be used to rank competing projects.

The simple benefit/cost ratio equation, without discounting is:

$$\text{B/C} = \frac{\text{Differential Energy Cost x Life of Equipment}}{\text{Differential Installed Cost}}$$

For example, installing a gas-fired absorption chiller with a median life of 23 years at a cost $275,000 uses $19,401 of energy the first year. An electric centrifugal chiller costing $120,000 to install uses $31,620 of energy the first year. The simple benefit/cost ratio is:

$$B/C = \frac{(\$31,620 - \$19,401) \times 23 \text{ years}}{(\$275,000 - \$120,000)}$$
$$= 1.81$$

In other words, over the life of the gas equipment, the return will be $1.81 for every $1.00 invested in the gas equipment in excess of the electric equipment investment.

This simple formula is adequate for initial analysis and marketing, but it would be judged inadequate by financial analysts because the values are not discounted.

The discounted benefit/cost ratio can be determined with this formula:

$$B/C = (E-M)/(P-S+R)$$

Where:

E = present value reduction in energy costs due to gas equipment. This is the present value of the calculated savings in energy cost resulting from the gas equipment during the expected life of the equipment.

M = present value of differential maintenance and repair costs.

P = differential purchase and installation costs.

S = present value of differential salvage costs.

R = present value of differential replacement costs.

All costs must be in present value dollars and adjusted for taxes and incentives, if any. Purchase and installation costs need not be discounted for they are already present value costs. An example of the benefit/cost ratio method is calculated on line sixteen of the Discounted Energy Economics Form on page 175.

## *Life-Cycle Cost Method*

Life-cycle cost (LCC) analysis is a method for evaluating the economic performance of alternative mechanical systems for a building. The LCC method allows one to calculate an alternative's present worth or value. The alternative with the lowest life-cycle cost, while meeting the investor's objective and constraints, is the preferred option.

This method must only be used for comparing projects competing for the same purpose. These types of investments are often called mutually exclusive because undertaking one generally precludes undertaking the other.

In addition, LCC analysis can be used to find the economically efficient size of an investment—if the LCC falls with increased investment, it is profitable to increase the investment level.

Life-cycle cost analysis can help determine, among other things, whether a natural gas heating system is a better option than other fuels for heating.

The LCC equation below shows that the LCC of a project alternative is the sum of its initial investment costs *I*, present value of replacement costs *R*, base year energy costs *E*, and the present value of operation, maintenance, and repair *(OM&R)* costs, minus the present value of salvage *S* (sometimes referred to as resale value or residual value).

$$LCC = I + R + E + OM\&R - S$$

When using the LCC method, it is important to use the same discount rate and analysis period for each alternative. To equate analysis periods, you might have to include replacement costs for shorter-lived alternatives and account for salvage value for some alternatives.

The steps in the LCC process include:

1. Identify acceptable alternatives.

2. Establish common assumptions—discount rate, analysis period, expected life of alternatives, and inflation rate of energy.
3. Estimate all costs and benefits of all project alternatives.
4. Discount future costs and benefits to find present values.
5. Compute the LCC of each alternative.
6. Identify alternative with the lowest LCC.
7. Consider unquantifiable costs and benefits.
8. Consider any uncertainties of analysis
9. Compute supplementary measures of relative economic performance, if required.
10. Select best alternative.

An example of the life-cycle cost method is found on page 175, where the LCC values for the two example alternatives are calculated on line seventeen of the Discounted Energy Economics Form.

### *Net Present Value of Savings Method*

This method is very similar to the life-cycle cost method, having the same advantages and disadvantages. The Net Present Value of Savings of one alternative over another is the differential savings of one alternative over the other, less the differential costs.

This method is used for mutually exclusive projects, because undertaking one precludes undertaking the other.

On the Discounted Energy Economics Form on page 175, line eighteen, the Net Present Value of Savings is worked out for the example problem.

### *Uniform Annual Cost Method*

For the Uniform Annual Cost Method all past, present, and future costs and benefits are converted to an equivalent, constant annual amount. This method is used for

mutually exclusive alternatives having lives of the same or differing duration.

The basic procedure for determining uniform annual cost 1) is to determine the present value life-cycle cost of an alternative and 2) apply the appropriate capital recovery factor to determine equal payments over the period of analysis. On page 175, line nineteen of the Discounted Energy Economics Form, this is done for the example problem.

## *Example of Energy Economics Methods*

For examples of the energy economics methods discussed above, assume the two options for providing cooling for an office building are as follows:

*Alternative 1:*

- Gas absorption chiller, direct-fired, two-stage.
- COP = 1.05.
- Gas cost of operation = $4.15/1000 CF ($0.403 per therm).
- Chiller uses 11 CF of natural gas per ton of cooling.
- Chiller size is 500 tons.
- Chiller operates an average of 850 full ton hours per year.
- Expected life of gas absorption chiller = 23 years.
- Salvage value at end of 23rd year = $4,500.
- Annual OM&R costs = $1,000.
- Cost of chiller = $275,000 ($550 per ton).

*Alternative 2:*

- Electrically driven centrifugal chiller.
- COP = 5.0.
- Electric cost of operation, including demand charges = $0.12/kWh.
- Chiller uses 0.62 kW per ton of cooling.
- Chiller size is 500 tons.

- Chiller operates an average of 850 full ton hours per year.
- Expected life of electric chiller = 20 years.
- Replacement cost at 20 years = $200,000.
- Salvage value at end of 23rd year = $80,000.
- Annual OM&R costs = $1000.
- Cost of chiller = $120,000 ($240 per ton).

The operating costs of the two chillers can be estimated with the following equation:

$$C = H \times T \times E \times R$$

Where:

$C$ = annual energy costs, in dollars.
$H$ = equivalent full hours of operation.
$T$ = rated capacity of chiller, in tons.
$E$ = chiller energy use at full load.
$R$ = cost of chiller fuel per unit.

The estimated energy cost for the direct-fired, two-stage, gas chiller is:

$$C = H \times T \times E \times R$$
$$= 850 \times 500 \times 11.0 \times \$4.15/1000$$
$$= \$19,401$$

The estimated energy cost for the electric centrifugal chiller is:

$$C = H \times T \times E \times R$$
$$= 850 \times 500 \times 0.62 \times \$0.12$$
$$= \$31,620$$

It will be assumed that the real discount rate is 10%, the fuel-price inflation rate for both electricity and natural gas is 5%, and the period of the analysis is 23 years.

Refer to the Discounted Energy Economics Form on page 175 to follow along with the calculation of 1) discounted benefit/cost ratio, 2) life-cycle cost present value

of alternatives, 3) net present value of savings, and 4) uniform annual cost of alternatives.

Notice that the 1) two equipment alternatives, 2) period of analysis, 3) discount rate, and 4) inflation rate of energy costs have been entered on the first four lines of the Discounted Energy Economics Form.

Column "a" must be used for the alternative that is most expensive to install and the least expensive to operate. Column "b" must be use for the alternative that is the least expensive to install and the most expensive to operate.

On line five, the installed cost of each alternative is entered, for the example, $275,000 for the gas absorption chiller and $120,000 for the electric centrifugal chiller. These values do not require discounting for they are present costs. Costs for chilled water distribution, fan coils, etc. need not be included here because these costs are the same for each of the two options. In the right-most column of the form, the difference between column "a" and "b" is entered; $155,000. Notice that just below the value $155,000 is the instruction for the calculation of the differential value, [5a - 5b].

On line six, enter replacement cost if replacement is predicted during the period of analysis. For the gas equipment this value is zero, for the electric equipment it is $200,000. This is the cost of a new electric chiller less the salvage value for the old electric chiller (net replacement cost).

On line seven, the year of replacement in entered. The gas alternative entry is zero, the electric entry is the 20th year because it is estimated that the electric chiller will require replacement at this time for a net replacement cost of $200,000.

The entries for columns "a" and "b" of line eight are calculated with the use of a present value table. This line is the present value of the replacement cost that will be expended years from now. For the gas equipment there is

no calculation because there is no predicted replacement during the analysis period. However, for the electric equipment there is a $200,000 expected replacement during the 20th year. Multiply this projected expenditure by the *single present worth factor* in Table 5-8 (page 183), using the appropriate discount rate (10%) and year of replacement (20). The single present worth factor is 0.15, therefore, for the electric chiller, the present value of the $200,000 replacement cost at 20 years is 0.15 x $200,000 = $30,000. This is the present value of this single payment to be made in the future.

In the Δ column of line 8, ($30,000) is entered as the differential present value of replacement costs, [8a - 8b]. The parenthesis indicates this is a negative value for the example.

Line nine is for the entry of the annual energy costs of each alternative. Both of these values were figured previously—$19,401 for the gas chiller and $31,620 for the electric chiller. The difference between these two energy costs the first year is entered in cell 9Δ, $12,219.

Line ten is for the calculation of the present value of the energy costs for each option. Unlike the one-time replacement cost of the electric chiller, these costs are experienced each year during the analysis period. Use the *modified uniform present worth factor* from Table 5-3, which is calculated for a 10% discount rate. The modified uniform present worth factor for 23 years and an energy price escalation rate of 5% is 13.8. For the gas chiller, the present value of energy costs is 13.8 x $19,401 = $267,734. For the electric chiller, 13.8 x $31,620 = $436,356. The present value of differential energy costs—$168,622— is entered in cell 10Δ, [10b - 10a].

On line 11 are the operation, maintenance, and repair costs (OM&R)—$1,000 for each alternative.

Line 12 is the present value of the annual OM&R costs. As with the recurring energy costs, these are annually expenditures. The modified uniform present worth factor from Table 5-3 is used here. The modified uniform present worth factor for 23 years and an energy price escalation rate of 5% is 13.8. For the gas chiller the present value of OM&R costs is 13.8 x $1,000 = $13,800. For the electric chiller the present value of OM&R costs is 13.8 x $1,000 = 13,800. In cell 12Δ is the value for the differential OM&R costs—$0, [12b - 12a].

The salvage value for each alternative, if any, is entered on line thirteen. For the gas chiller this is expected to be $4,500 at the end of 23 years. Since the *period of analysis* is 23 years and the *expected life* of the electric chiller is only 20 years, the electric chiller must be replaced after the twentieth year. This is reflected on lines six and seven of the form.

The replacement electric chiller will have been in service for only three years by the end of the 23 year analysis period. Its salvage value is expected to be $80,000. The year the salvage value will be received is entered on line fourteen.

The one-time receipt of $4,500 for the gas chiller's salvage and $80,000 for the electric chiller are calculated with the use of Table 5-8, *single present worth factors*. The factor for 23 years at 10% discount rate is 0.11. Thus, for the gas chiller the present value of the salvage is $4,500 x 0.11 = $495. For the electric chiller the present value of the salvage is $80,000 x 0.11 = $8,800. These values are entered on line fifteen. The differential salvage value of $8305 is entered in cell 15Δ, [15a - 15b].

The discounted benefit/cost ratio of 1.26 is calculated and entered on line sixteen of the form. The numbers in-parentheses in the right-most column represent negative

values. The equation for the calculation listed on line sixteen in the form works out as follows:

$$\text{B/C Ratio} = \frac{\$168,622-\$0}{\$155,000-(-\$8305)+(-\$30,000)} = 1.26$$

This ratio indicates that for each dollar invested in the gas-fired chiller in excess of the cost of the electric chiller, the benefit over the life will be $1.26.

The life-cycle cost present value of the two alternatives is calculated on line seventeen (add lines 5, 8, 10, 12, and subtract line 15). The lowest LCC present value is the favored option. The gas chiller has an LCC of $556,039; the electric chiller has a LCC of $591,356. Therefore, the gas chiller is the favored option. These two values are calculated as follows:

$$\text{LCC} = \$275,000+\$0+\$267,734+\$13,800-\$495 = \$556,039$$

$$\text{LCC} = \$120,000+\$30,000+\$436,356+\$13,800-\$8,800 = \$591,356$$

The net present value of savings—$35,317—is on line eighteen. It is found by using the differential values in the right-most column of the form. The equation is worked out as follows:

$$\text{NPV} = \$168,622-[\$155,000-(-\$8305)+\$0+(-30,000)] = \$35,317$$

This is the net present value of the savings of the gas chiller over the electric chiller during the analysis period.

Finally, the uniform annual cost is found on line nineteen. This is all past, present, and future costs and benefits converted to an equivalent constant, annual amount recurring over the period of analysis. The uniform annual cost for each of the alternatives is found by multiplying the

LCC present value by the uniform capital recovery factor in Table 5-9, using the appropriate discount rate and analysis period. The uniform present worth factor for 10% and 23 years is 0.113. Thus, the uniform annual cost for the gas chiller is $556,039 x 0.113 = $62,832. The uniform annual cost for the electric chiller is $591,356 x 0.113 = $66,823. The alternative with the lowest uniform annual cost is the favored option.[62]

A blank Discounted Energy Economics Form appears on page 186 of this chapter. Use it as a guide for your energy economics calculations. Contact the author if you wish to obtain a spreadsheet template of this form.[63]

[62] Software programs are available to conduct economic and rate analysis in a manner that is more detailed and advanced than what is discussed here. One is "Market Manager™" from SRC Systems, Inc., 1300 Clay Street, Suite 850, Oakland, CA 94612. Telephone: 510-839-2700. Another is "System Analyzer™" from C.D.S Network, 3600 Pammel Creek Road, La Crosse, WI 54601. Telephone 608-787-3926.

[63] The author's address can be found at the front and the back of this book.

| DISCOUNTED ENERGY ECONOMICS FORM | | | |
|---|---|---|---|
| | Equipment Alternatives | | Δ Amounts |
| **Costs And Benefits** | **a** | **b** | **Δ** |
| 1. Equipment Alternative [Option a: highest installed cost, lowest operating cost. Option b: lowest installed cost, highest operating cost.] | Gas, D-F, 2-S, Ab., 500 ton | Electric Centrifug 500 ton | B/C Ratio Differential Amounts |
| 2. Period of Analysis | 23 | 23 | |
| 3. Discount Rate | 10% | 10% | |
| 4. Inflation Rate of Energy Costs | 5% | 5% | |
| ***5. Investment Costs*** [Equipment and Installation Costs] | ***$275,000*** | ***$120,000*** | ***$155,000*** [5a - 5b] |
| 6. Net Replacement Cost | 0 | $200,000 | |
| 7. Year of Replacement | 0 | 20 | |
| ***8. Present Value of Replacement Cost*** [Table 5-8 value times 7a and 7b] | ***0*** | ***$30,000*** | ***($30,000)*** [8a - 8b] |
| 9. Energy Costs, Base Year | $19,401 | $31,620 | $12,219 |
| ***10. Present Value of Energy Costs*** [Tables 5-1 through 5-7 value times 9a and 9b] | ***$267,734*** | ***$436,356*** | ***$168,622*** [10b - 10a] |
| 11. OM&R Costs | $1,000 | $1000 | |
| ***12. Present Value of OM&R Costs*** [Tables 5-1 through 5-7 value times 11a and 11b] | ***$13,800*** | ***$13,800*** | ***$0*** [12b - 12a] |
| 13. Salvage Value | $4,500 | $80,000 | |
| 14. Year of Salvage | 23 | 23 | |
| ***15. Present Value of Salvage*** [Table 5-8 value times 13a and 13b] | ***$495*** | ***$8800*** | ***($8305)*** [15a - 15b] |
| **16. Discounted Benefit/Cost Ratio** [(Δ10-Δ12)/(Δ5-Δ15+Δ8)] | | | **1.26** |
| **17. LCC Present Value of Alternatives** [ 5+8+10+12-15] | | | |
| | **$556,039** | **$591,356** | |
| **18. Net Present Value of Savings** [Δ10-(Δ5-Δ15+Δ12+Δ8)] | | | **$35,317** |
| **19. Uniform Annual Cost of Alternatives** | | | |

## *Tables for Discounting*

**MODIFIED UNIFORM PRESENT WORTH (UPW) VALUES**
**6% DISCOUNT RATE**

**TABLE 5-1**

| N | RATE OF ENERGY PRICE ESCALATION | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 1% | 2% | 3% | 4% | 5% | 6% | 7% | 8% | 9% | 10% |
| 1 | 0.95 | 0.96 | 0.97 | 0.98 | 0.99 | 1 | 1.01 | 1.02 | 1.03 | 1.04 |
| 2 | 1.86 | 1.89 | 1.92 | 1.94 | 1.97 | 2 | 2.03 | 2.06 | 2.09 | 2.12 |
| 3 | 2.73 | 2.78 | 2.83 | 2.89 | 2.94 | 3 | 3.06 | 3.12 | 3.17 | 3.23 |
| 4 | 3.55 | 3.64 | 3.73 | 3.82 | 3.91 | 4 | 4.1 | 4.19 | 4.29 | 4.39 |
| 5 | 4.34 | 4.46 | 4.59 | 4.72 | 4.86 | 5 | 5.14 | 5.29 | 5.44 | 5.6 |
| 6 | 5.08 | 5.26 | 5.43 | 5.62 | 5.81 | 6 | 6.2 | 6.41 | 6.62 | 6.84 |
| 7 | 5.8 | 6.02 | 6.25 | 6.49 | 6.74 | 7 | 7.27 | 7.55 | 7.84 | 8.14 |
| 8 | 6.48 | 6.76 | 7.05 | 7.35 | 7.67 | 8 | 8.35 | 8.71 | 9.09 | 9.48 |
| 9 | 7.12 | 7.46 | 7.82 | 8.19 | 8.59 | 9 | 9.44 | 9.89 | 10.38 | 10.88 |
| 10 | 7.74 | 8.14 | 8.57 | 9.02 | 9.5 | 10 | 10.53 | 11.1 | 11.7 | 12.33 |
| 11 | 8.33 | 8.8 | 9.3 | 9.83 | 10.4 | 11 | 11.64 | 12.33 | 13.06 | 13.83 |
| 12 | 8.89 | 9.43 | 10.01 | 10.63 | 11.29 | 12 | 12.76 | 13.58 | 14.45 | 15.39 |
| 13 | 9.42 | 10.03 | 10.7 | 11.41 | 12.17 | 13 | 13.89 | 14.85 | 15.89 | 17.01 |
| 14 | 9.93 | 10.62 | 11.36 | 12.17 | 13.05 | 14 | 15.03 | 16.15 | 17.37 | 18.69 |
| 15 | 10.41 | 11.18 | 12.01 | 12.92 | 13.92 | 15 | 16.18 | 17.48 | 18.89 | 20.43 |
| 16 | 10.88 | 11.72 | 12.65 | 13.66 | 14.78 | 16 | 17.35 | 18.83 | 20.45 | 22.24 |
| 17 | 11.32 | 12.24 | 13.26 | 14.38 | 15.63 | 17 | 18.52 | 20.2 | 22.06 | 24.12 |
| 18 | 11.74 | 12.74 | 13.86 | 15.09 | 16.47 | 18 | 19.7 | 21.6 | 23.71 | 26.07 |
| 19 | 12.13 | 13.22 | 14.44 | 15.79 | 17.31 | 19 | 20.9 | 23.03 | 25.41 | 28.09 |
| 20 | 12.52 | 13.69 | 15 | 16.47 | 18.13 | 20 | 22.11 | 24.48 | 27.16 | 30.19 |
| 21 | 12.88 | 14.13 | 15.55 | 17.14 | 18.95 | 21 | 23.32 | 25.96 | 28.96 | 32.36 |
| 22 | 13.22 | 14.56 | 16.08 | 17.8 | 19.76 | 22 | 24.55 | 27.47 | 30.8 | 34.62 |
| 23 | 13.55 | 14.97 | 16.59 | 18.45 | 20.57 | 23 | 25.79 | 29.01 | 32.7 | 36.97 |
| 24 | 13.87 | 15.37 | 17.1 | 19.08 | 21.36 | 24 | 27.05 | 30.57 | 34.66 | 39.4 |
| 25 | 14.16 | 15.75 | 17.58 | 19.7 | 22.15 | 25 | 28.31 | 32.17 | 36.67 | 41.92 |
| 26 | 14.45 | 16.12 | 18.06 | 20.31 | 22.94 | 26 | 29.59 | 33.79 | 38.73 | 44.54 |
| 27 | 14.72 | 16.47 | 18.52 | 20.91 | 23.71 | 27 | 30.88 | 35.45 | 40.86 | 47.26 |
| 28 | 14.98 | 16.82 | 18.97 | 21.5 | 24.48 | 28 | 32.18 | 37.14 | 43.04 | 50.08 |
| 29 | 15.23 | 17.14 | 19.4 | 22.07 | 25.24 | 29 | 33.49 | 38.86 | 45.29 | 53.01 |
| 30 | 15.46 | 17.46 | 19.82 | 22.64 | 25.99 | 30 | 34.82 | 40.61 | 47.6 | 56.05 |

An end-of-base-year payment times the UPW value for the approriate energy price escalation rate gives the present value of a sum of money at the discount rate of 6% over N discount periods. This table is used for a equal multiple payments over a number of years. See "Notes" at the end of this chapter for the equation from which the values in this table were derived.

**MODIFIED UNIFORM PRESENT WORTH (UPW) VALUES**
**8% DISCOUNT RATE**

**TABLE 5-2**

| N | RATE OF ENERGY PRICE ESCALATION | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 1% | 2% | 3% | 4% | 5% | 6% | 7% | 8% | 9% | 10% |
| 1 | 0.94 | 0.94 | 0.95 | 0.96 | 0.97 | 0.98 | 0.99 | 1 | 1.01 | 1.02 |
| 2 | 1.81 | 1.84 | 1.86 | 1.89 | 1.92 | 1.95 | 1.97 | 2 | 2.03 | 2.06 |
| 3 | 2.63 | 2.68 | 2.73 | 2.78 | 2.84 | 2.89 | 2.95 | 3 | 3.06 | 3.11 |
| 4 | 3.39 | 3.47 | 3.56 | 3.64 | 3.73 | 3.82 | 3.91 | 4 | 4.09 | 4.19 |
| 5 | 4.11 | 4.23 | 4.35 | 4.47 | 4.6 | 4.73 | 4.86 | 5 | 5.14 | 5.29 |
| 6 | 4.78 | 4.94 | 5.1 | 5.27 | 5.44 | 5.62 | 5.81 | 6 | 6.2 | 6.4 |
| 7 | 5.4 | 5.61 | 5.82 | 6.04 | 6.26 | 6.5 | 6.75 | 7 | 7.26 | 7.54 |
| 8 | 5.99 | 6.24 | 6.5 | 6.78 | 7.06 | 7.36 | 7.67 | 8 | 8.34 | 8.7 |
| 9 | 6.53 | 6.84 | 7.15 | 7.49 | 7.84 | 8.21 | 8.59 | 9 | 9.43 | 9.88 |
| 10 | 7.05 | 7.4 | 7.78 | 8.17 | 8.59 | 9.04 | 9.51 | 10 | 10.52 | 11.08 |
| 11 | 7.53 | 7.94 | 8.37 | 8.83 | 9.33 | 9.85 | 10.41 | 11 | 11.63 | 12.3 |
| 12 | 7.97 | 8.44 | 8.94 | 9.47 | 10.04 | 10.65 | 11.3 | 12 | 12.75 | 13.55 |
| 13 | 8.39 | 8.91 | 9.48 | 10.08 | 10.73 | 11.43 | 12.19 | 13 | 13.88 | 14.82 |
| 14 | 8.78 | 9.36 | 9.99 | 10.67 | 11.41 | 12.2 | 13.07 | 14 | 15.01 | 16.11 |
| 15 | 9.15 | 9.79 | 10.48 | 11.24 | 12.06 | 12.96 | 13.94 | 15 | 16.16 | 17.43 |
| 16 | 9.49 | 10.19 | 10.95 | 11.79 | 12.7 | 13.7 | 14.8 | 16 | 17.32 | 18.77 |
| 17 | 9.81 | 10.57 | 11.4 | 12.31 | 13.32 | 14.43 | 15.65 | 17 | 18.49 | 20.13 |
| 18 | 10.11 | 10.92 | 11.82 | 12.82 | 13.92 | 15.14 | 16.5 | 18 | 19.67 | 21.53 |
| 19 | 10.39 | 11.26 | 12.23 | 13.31 | 14.51 | 15.84 | 17.34 | 19 | 20.86 | 22.94 |
| 20 | 10.65 | 11.58 | 12.62 | 13.78 | 15.08 | 16.53 | 18.17 | 20 | 22.06 | 24.39 |
| 21 | 10.9 | 11.88 | 12.99 | 14.23 | 15.63 | 17.21 | 18.99 | 21 | 23.28 | 25.86 |
| 22 | 11.13 | 12.17 | 13.34 | 14.67 | 16.17 | 17.87 | 19.8 | 22 | 24.5 | 27.35 |
| 23 | 11.34 | 12.43 | 13.68 | 15.09 | 16.69 | 18.52 | 20.61 | 23 | 25.74 | 28.88 |
| 24 | 11.54 | 12.69 | 14 | 15.49 | 17.2 | 19.16 | 21.41 | 24 | 26.99 | 30.43 |
| 25 | 11.73 | 12.93 | 14.3 | 15.88 | 17.69 | 19.79 | 22.2 | 25 | 28.25 | 32.01 |
| 26 | 11.9 | 13.15 | 14.59 | 16.25 | 18.17 | 20.4 | 22.99 | 26 | 29.52 | 33.63 |
| 27 | 12.07 | 13.37 | 14.87 | 16.62 | 18.64 | 21 | 23.77 | 27 | 30.8 | 35.27 |
| 28 | 12.22 | 13.57 | 15.14 | 16.96 | 19.1 | 21.6 | 24.54 | 28 | 32.09 | 36.94 |
| 29 | 12.36 | 13.76 | 15.39 | 17.3 | 19.54 | 22.18 | 25.3 | 29 | 33.4 | 38.64 |
| 30 | 12.5 | 13.94 | 15.63 | 17.62 | 19.97 | 22.75 | 26.06 | 30 | 34.72 | 40.37 |

An end-of-base-year payment times the UPW value for the approriate energy price escalation rate gives the present value of a sum of money at the discount rate of 8% over N discount periods. This table is used for a equal multiple payments over a number of years. See "Notes" at the end of this chapter for the equation from which the values in this table were derived.

**MODIFIED UNIFORM PRESENT WORTH (UPW) VALUES**
**10% DISCOUNT RATE**

**TABLE 5-3**

| N | RATE OF ENERGY PRICE ESCALATION | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 1% | 2% | 3% | 4% | 5% | 6% | 7% | 8% | 9% | 10% |
| 1 | 0.92 | 0.93 | 0.94 | 0.95 | 0.96 | 0.96 | 0.97 | 0.98 | 0.99 | 1 |
| 2 | 1.76 | 1.79 | 1.81 | 1.84 | 1.87 | 1.89 | 1.92 | 1.95 | 1.97 | 2 |
| 3 | 2.54 | 2.58 | 2.63 | 2.68 | 2.74 | 2.79 | 2.84 | 2.89 | 2.95 | 3 |
| 4 | 3.25 | 3.32 | 3.4 | 3.48 | 3.57 | 3.65 | 3.73 | 3.82 | 3.91 | 4 |
| 5 | 3.9 | 4.01 | 4.12 | 4.24 | 4.36 | 4.48 | 4.61 | 4.73 | 4.87 | 5 |
| 6 | 4.5 | 4.65 | 4.8 | 4.95 | 5.12 | 5.28 | 5.45 | 5.63 | 5.81 | 6 |
| 7 | 5.05 | 5.23 | 5.43 | 5.63 | 5.84 | 6.05 | 6.28 | 6.51 | 6.75 | 7 |
| 8 | 5.55 | 5.78 | 6.02 | 6.27 | 6.53 | 6.8 | 7.08 | 7.37 | 7.68 | 8 |
| 9 | 6.02 | 6.29 | 6.57 | 6.87 | 7.18 | 7.51 | 7.86 | 8.22 | 8.6 | 9 |
| 10 | 6.44 | 6.76 | 7.09 | 7.44 | 7.81 | 8.2 | 8.62 | 9.05 | 9.51 | 10 |
| 11 | 6.83 | 7.19 | 7.58 | 7.98 | 8.41 | 8.87 | 9.35 | 9.87 | 10.42 | 11 |
| 12 | 7.19 | 7.6 | 8.03 | 8.49 | 8.98 | 9.51 | 10.07 | 10.67 | 11.31 | 12 |
| 13 | 7.52 | 7.97 | 8.46 | 8.97 | 9.53 | 10.13 | 10.77 | 11.46 | 12.2 | 13 |
| 14 | 7.83 | 8.32 | 8.85 | 9.43 | 10.05 | 10.72 | 11.45 | 12.23 | 13.08 | 14 |
| 15 | 8.1 | 8.64 | 9.23 | 9.86 | 10.55 | 11.3 | 12.11 | 12.99 | 13.95 | 15 |
| 16 | 8.36 | 8.94 | 9.58 | 10.27 | 11.27 | 11.85 | 12.75 | 13.74 | 14.82 | 16 |
| 17 | 8.59 | 9.22 | 9.9 | 10.65 | 11.48 | 12.38 | 13.38 | 14.47 | 15.67 | 17 |
| 18 | 8.81 | 9.48 | 10.21 | 11.02 | 11.91 | 12.9 | 13.98 | 15.19 | 16.52 | 18 |
| 19 | 9 | 9.71 | 10.5 | 11.36 | 12.32 | 13.39 | 14.58 | 15.9 | 17.36 | 19 |
| 20 | 9.19 | 9.93 | 10.76 | 10.69 | 12.72 | 13.87 | 15.15 | 16.59 | 18.2 | 20 |
| 21 | 9.35 | 10.14 | 11.02 | 12 | 13.09 | 14.33 | 15.71 | 17.27 | 19.02 | 21 |
| 22 | 9.5 | 10.33 | 11.25 | 12.29 | 13.45 | 14.77 | 16.26 | 17.94 | 19.84 | 22 |
| 23 | 9.65 | 10.51 | 11.47 | 12.56 | 13.8 | 15.2 | 16.78 | 18.59 | 20.65 | 23 |
| 24 | 9.77 | 10.67 | 11.68 | 12.82 | 14.12 | 15.61 | 17.3 | 19.24 | 21.45 | 24 |
| 25 | 9.89 | 10.82 | 11.87 | 13.07 | 14.44 | 16 | 17.8 | 19.87 | 22.25 | 25 |
| 26 | 10 | 10.96 | 12.05 | 13.3 | 14.74 | 16.38 | 18.29 | 20.49 | 23.04 | 26 |
| 27 | 10.1 | 11.09 | 12.22 | 13.52 | 15.02 | 16.75 | 18.76 | 21.1 | 23.82 | 27 |
| 28 | 10.19 | 11.21 | 12.38 | 13.73 | 15.29 | 17.11 | 19.22 | 21.7 | 24.59 | 28 |
| 29 | 10.28 | 11.32 | 12.53 | 13.93 | 15.55 | 17.45 | 19.67 | 22.28 | 25.36 | 29 |
| 30 | 10.36 | 11.43 | 12.67 | 14.11 | 15.8 | 17.78 | 20.11 | 22.86 | 26.12 | 30 |

An end-of-base-year payment times the UPW value for the approriate energy price escalation rate gives the present value of a sum of money at the discount rate of 10% over N discount periods. This table is used for a equal multiple payments over a number of years. See "Notes" at the end of this chapter for the equation from which the values in this table were derived.

**MODIFIED UNIFORM PRESENT WORTH (UPW) VALUES**
**12% DISCOUNT RATE**

**TABLE 5-4**

| N | RATE OF ENERGY PRICE ESCALATION | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 1% | 2% | 3% | 4% | 5% | 6% | 7% | 8% | 9% | 10% |
| 1 | 0.9 | 0.91 | 0.92 | 0.93 | 0.94 | 0.95 | 0.96 | 0.96 | 0.97 | 0.98 |
| 2 | 1.72 | 1.74 | 1.77 | 1.79 | 1.82 | 1.84 | 1.87 | 1.89 | 1.92 | 1.95 |
| 3 | 2.45 | 2.5 | 2.54 | 2.59 | 2.64 | 2.69 | 2.74 | 2.79 | 2.84 | 2.89 |
| 4 | 3.11 | 3.18 | 3.26 | 3.34 | 3.41 | 3.49 | 3.57 | 3.66 | 3.74 | 3.83 |
| 5 | 3.71 | 3.81 | 3.92 | 4.03 | 4.14 | 4.25 | 4.37 | 4.49 | 4.61 | 4.74 |
| 6 | 4.24 | 4.38 | 4.52 | 4.67 | 4.82 | 4.97 | 5.13 | 5.29 | 5.46 | 5.64 |
| 7 | 4.73 | 4.9 | 5.08 | 5.26 | 5.45 | 5.65 | 5.86 | 6.07 | 6.29 | 6.52 |
| 8 | 5.17 | 5.37 | 5.59 | 5.81 | 6.05 | 6.29 | 6.55 | 6.82 | 7.09 | 7.38 |
| 9 | 5.56 | 5.8 | 6.06 | 6.33 | 6.61 | 6.9 | 7.21 | 7.54 | 7.88 | 8.23 |
| 10 | 5.92 | 6.2 | 6.49 | 6.8 | 7.13 | 7.48 | 7.85 | 8.23 | 8.64 | 9.07 |
| 11 | 6.24 | 6.55 | 6.89 | 7.25 | 7.63 | 8.03 | 8.45 | 8.9 | 9.38 | 9.89 |
| 12 | 6.53 | 6.88 | 7.26 | 7.66 | 8.09 | 8.54 | 9.03 | 9.55 | 10.1 | 10.69 |
| 13 | 6.79 | 7.18 | 7.59 | 8.04 | 8.52 | 9.03 | 9.58 | 10.17 | 10.81 | 11.49 |
| 14 | 7.02 | 7.45 | 7.9 | 8.39 | 8.92 | 9.49 | 10.11 | 10.77 | 11.49 | 12.26 |
| 15 | 7.23 | 7.69 | 8.19 | 8.72 | 9.3 | 9.93 | 10.61 | 11.35 | 12.16 | 13.03 |
| 16 | 7.43 | 7.92 | 8.45 | 9.03 | 9.66 | 10.35 | 11.1 | 11.91 | 12.8 | 13.78 |
| 17 | 7.6 | 8.12 | 8.69 | 9.31 | 9.99 | 10.74 | 11.56 | 12.45 | 13.43 | 14.51 |
| 18 | 7.75 | 8.31 | 8.91 | 9.57 | 10.31 | 11.11 | 11.99 | 12.97 | 14.05 | 15.23 |
| 19 | 7.89 | 8.48 | 9.11 | 9.82 | 10.6 | 11.46 | 12.41 | 13.47 | 14.64 | 15.95 |
| 20 | 8.02 | 8.63 | 9.3 | 10.05 | 10.87 | 11.79 | 12.82 | 13.95 | 15.22 | 16.64 |
| 21 | 8.13 | 8.77 | 9.47 | 10.26 | 11.13 | 12.11 | 13.2 | 14.42 | 15.79 | 17.33 |
| 22 | 8.24 | 8.9 | 9.63 | 10.45 | 11.37 | 12.41 | 13.57 | 14.87 | 16.34 | 18 |
| 23 | 8.33 | 9.01 | 9.78 | 10.64 | 11.6 | 12.69 | 13.91 | 15.3 | 16.88 | 18.66 |
| 24 | 8.41 | 9.12 | 9.91 | 10.81 | 11.81 | 12.95 | 14.25 | 15.72 | 17.4 | 19.31 |
| 25 | 8.49 | 9.22 | 10.04 | 10.96 | 12.01 | 13.21 | 14.57 | 16.12 | 17.9 | 19.95 |
| 26 | 8.56 | 9.3 | 10.15 | 11.11 | 12.2 | 13.45 | 14.87 | 16.51 | 18.4 | 20.57 |
| 27 | 8.62 | 9.38 | 10.25 | 11.24 | 12.37 | 13.67 | 15.16 | 16.89 | 18.88 | 21.19 |
| 28 | 8.67 | 9.46 | 10.35 | 11.37 | 12.54 | 13.89 | 15.44 | 17.25 | 19.35 | 21.79 |
| 29 | 8.72 | 9.52 | 10.44 | 11.48 | 12.69 | 14.09 | 15.71 | 17.6 | 19.8 | 22.38 |
| 30 | 8.77 | 9.58 | 10.52 | 11.59 | 12.84 | 14.28 | 15.96 | 17.93 | 20.24 | 22.97 |

An end-of-base-year payment times the UPW value for the approriate energy price escalation rate gives the present value of a sum of money at the discount rate of 12% over N discount periods. This table is used for a equal multiple payments over a number of years. See "Notes" at the end of this chapter for the equation from which the values in this table were derived.

## MODIFIED UNIFORM PRESENT WORTH (UPW) VALUES 15% DISCOUNT RATE

**TABLE 5-5**

| N | RATE OF ENERGY PRICE ESCALATION | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 1% | 2% | 3% | 4% | 5% | 6% | 7% | 8% | 9% | 10% |
| 1 | 0.88 | 0.89 | 0.9 | 0.9 | 0.91 | 0.92 | 0.93 | 0.94 | 0.95 | 0.96 |
| 2 | 1.65 | 1.67 | 1.7 | 1.72 | 1.75 | 1.77 | 1.8 | 1.82 | 1.85 | 1.87 |
| 3 | 2.33 | 2.37 | 2.42 | 2.46 | 2.51 | 2.55 | 2.6 | 2.65 | 2.7 | 2.75 |
| 4 | 2.92 | 2.99 | 3.06 | 3.13 | 3.2 | 3.28 | 3.35 | 3.43 | 3.51 | 3.58 |
| 5 | 3.45 | 3.54 | 3.64 | 3.74 | 3.84 | 3.94 | 4.05 | 4.16 | 4.27 | 4.38 |
| 6 | 3.9 | 4.03 | 4.15 | 4.28 | 4.42 | 4.56 | 4.7 | 4.84 | 5 | 5.15 |
| 7 | 4.31 | 4.46 | 4.62 | 4.78 | 4.95 | 5.12 | 5.3 | 5.49 | 5.68 | 5.88 |
| 8 | 4.66 | 4.84 | 5.03 | 5.23 | 5.43 | 5.64 | 5.86 | 6.09 | 6.33 | 6.58 |
| 9 | 4.97 | 5.18 | 5.4 | 5.63 | 5.87 | 6.12 | 6.39 | 6.66 | 6.95 | 7.25 |
| 10 | 5.24 | 5.48 | 5.73 | 6 | 6.27 | 6.56 | 6.87 | 7.2 | 7.54 | 7.9 |
| 11 | 5.48 | 5.75 | 6.03 | 6.33 | 6.64 | 6.97 | 7.32 | 7.7 | 8.09 | 8.51 |
| 12 | 5.7 | 5.99 | 6.3 | 6.63 | 6.98 | 7.35 | 7.75 | 8.17 | 8.62 | 9.1 |
| 13 | 5.88 | 6.2 | 6.54 | 6.9 | 7.28 | 7.7 | 8.14 | 8.61 | 9.12 | 9.66 |
| 14 | 6.04 | 6.38 | 6.75 | 7.14 | 7.56 | 8.01 | 8.5 | 9.02 | 9.59 | 10.19 |
| 15 | 6.19 | 6.55 | 6.94 | 7.36 | 7.82 | 8.31 | 8.84 | 9.41 | 10.04 | 10.71 |
| 16 | 6.31 | 6.7 | 7.11 | 7.56 | 8.05 | 8.58 | 9.15 | 9.78 | 10.46 | 11.2 |
| 17 | 6.42 | 6.83 | 7.27 | 7.74 | 8.26 | 8.83 | 9.45 | 10.12 | 10.86 | 11.67 |
| 18 | 6.52 | 6.94 | 7.4 | 7.91 | 8.46 | 9.06 | 9.72 | 10.45 | 11.24 | 12.12 |
| 19 | 6.6 | 7.04 | 7.53 | 8.06 | 8.64 | 9.27 | 9.98 | 10.75 | 11.6 | 12.55 |
| 20 | 6.68 | 7.13 | 7.64 | 8.19 | 8.8 | 9.47 | 10.21 | 11.04 | 11.95 | 12.96 |
| 21 | 6.74 | 7.21 | 7.74 | 8.31 | 8.95 | 9.65 | 10.43 | 11.3 | 12.27 | 13.35 |
| 22 | 6.8 | 7.29 | 7.82 | 8.42 | 9.08 | 9.82 | 10.64 | 11.55 | 12.58 | 13.73 |
| 23 | 6.85 | 7.35 | 7.9 | 8.52 | 9.2 | 9.97 | 10.83 | 11.79 | 12.87 | 14.09 |
| 24 | 6.89 | 7.41 | 7.97 | 8.61 | 9.32 | 10.11 | 11.01 | 12.01 | 13.15 | 14.43 |
| 25 | 6.93 | 7.46 | 8.04 | 8.69 | 9.42 | 10.24 | 11.17 | 12.22 | 13.41 | 14.76 |
| 26 | 6.97 | 7.5 | 8.09 | 8.76 | 9.51 | 10.36 | 11.32 | 12.41 | 13.66 | 15.07 |
| 27 | 7 | 7.54 | 8.15 | 8.83 | 9.6 | 10.47 | 11.47 | 12.6 | 13.89 | 15.38 |
| 28 | 7.02 | 7.57 | 8.19 | 8.89 | 9.68 | 10.58 | 11.6 | 12.77 | 14.12 | 15.66 |
| 29 | 7.05 | 7.6 | 8.23 | 8.94 | 9.75 | 10.67 | 11.72 | 12.93 | 14.33 | 15.94 |
| 30 | 7.07 | 7.63 | 8.27 | 8.99 | 9.82 | 10.76 | 11.84 | 13.08 | 14.53 | 16.2 |

An end-of-base-year payment times the UPW value for the approriate energy price escalation rate gives the present value of a sum of money at the discount rate of 15% over N discount periods. This table is used for a equal multiple payments over a number of years. See "Notes" at the end of this chapter for the equation from which the values in this table were derived.

## MODIFIED UNIFORM PRESENT WORTH (UPW) VALUES
## 20% DISCOUNT RATE

**TABLE 5-6**

| N | RATE OF ENERGY PRICE ESCALATION | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 1% | 2% | 3% | 4% | 5% | 6% | 7% | 8% | 9% | 10% |
| 1 | 0.84 | 0.85 | 0.86 | 0.87 | 0.88 | 0.88 | 0.89 | 0.9 | 0.91 | 0.92 |
| 2 | 1.55 | 1.57 | 1.6 | 1.62 | 1.64 | 1.66 | 1.69 | 1.71 | 1.73 | 1.76 |
| 3 | 2.15 | 2.19 | 2.23 | 2.27 | 2.31 | 2.35 | 2.4 | 2.44 | 2.48 | 2.53 |
| 4 | 2.65 | 2.71 | 2.77 | 2.83 | 2.9 | 2.96 | 3.03 | 3.1 | 3.16 | 3.23 |
| 5 | 3.07 | 3.15 | 3.24 | 3.32 | 3.41 | 3.5 | 3.59 | 3.69 | 3.78 | 3.88 |
| 6 | 3.43 | 3.53 | 3.64 | 3.75 | 3.86 | 3.98 | 4.09 | 4.22 | 4.34 | 4.47 |
| 7 | 3.73 | 3.85 | 3.98 | 4.11 | 4.25 | 4.39 | 4.54 | 4.7 | 4.85 | 5.02 |
| 8 | 3.98 | 4.12 | 4.27 | 4.43 | 4.6 | 4.77 | 4.94 | 5.13 | 5.32 | 5.52 |
| 9 | 4.19 | 4.35 | 4.53 | 4.71 | 4.9 | 5.09 | 5.3 | 5.51 | 5.74 | 5.97 |
| 10 | 4.37 | 4.55 | 4.74 | 4.95 | 5.16 | 5.38 | 5.62 | 5.86 | 6.12 | 6.39 |
| 11 | 4.52 | 4.72 | 4.93 | 5.15 | 5.39 | 5.64 | 5.9 | 6.18 | 6.47 | 6.78 |
| 12 | 4.64 | 4.86 | 5.09 | 5.33 | 5.59 | 5.86 | 6.15 | 6.46 | 6.78 | 7.13 |
| 13 | 4.75 | 4.98 | 5.23 | 5.49 | 5.77 | 6.06 | 6.38 | 6.71 | 7.07 | 7.45 |
| 14 | 4.84 | 5.08 | 5.35 | 5.62 | 5.92 | 6.24 | 6.58 | 6.94 | 7.33 | 7.75 |
| 15 | 4.92 | 5.17 | 5.45 | 5.74 | 6.06 | 6.39 | 6.76 | 7.15 | 7.57 | 8.02 |
| 16 | 4.98 | 5.25 | 5.53 | 5.84 | 6.17 | 6.53 | 6.92 | 7.33 | 7.78 | 8.27 |
| 17 | 5.03 | 5.31 | 5.61 | 5.93 | 6.28 | 6.65 | 7.06 | 7.5 | 7.98 | 8.49 |
| 18 | 5.08 | 5.36 | 5.67 | 6.01 | 6.37 | 6.76 | 7.19 | 7.65 | 8.15 | 8.7 |
| 19 | 5.12 | 5.41 | 5.73 | 6.07 | 6.45 | 6.85 | 7.3 | 7.78 | 8.31 | 8.89 |
| 20 | 5.15 | 5.45 | 5.77 | 6.13 | 6.52 | 6.94 | 7.4 | 7.91 | 8.46 | 9.07 |
| 21 | 5.17 | 5.48 | 5.81 | 6.18 | 6.58 | 7.01 | 7.49 | 8.02 | 8.59 | 9.23 |
| 22 | 5.2 | 5.51 | 5.85 | 6.22 | 6.63 | 7.08 | 7.57 | 8.11 | 8.71 | 9.38 |
| 23 | 5.22 | 5.53 | 5.88 | 6.26 | 6.68 | 7.14 | 7.64 | 8.2 | 8.82 | 9.51 |
| 24 | 5.23 | 5.55 | 5.9 | 6.29 | 6.72 | 7.19 | 7.71 | 8.28 | 8.92 | 9.64 |
| 25 | 5.24 | 5.57 | 5.93 | 6.32 | 6.75 | 7.23 | 7.76 | 8.35 | 9.01 | 9.75 |
| 26 | 5.26 | 5.58 | 5.95 | 6.34 | 6.78 | 7.27 | 7.81 | 8.42 | 9.1 | 9.86 |
| 27 | 5.27 | 5.6 | 5.96 | 6.36 | 6.81 | 7.31 | 7.86 | 8.48 | 9.17 | 9.95 |
| 28 | 5.27 | 5.61 | 5.98 | 6.38 | 6.83 | 7.34 | 7.9 | 8.53 | 9.24 | 10.04 |
| 29 | 5.28 | 5.62 | 5.99 | 6.4 | 6.85 | 7.36 | 7.94 | 8.58 | 9.3 | 10.12 |
| 30 | 5.29 | 5.62 | 6 | 6.41 | 6.87 | 7.39 | 7.97 | 8.62 | 9.36 | 10.19 |

An end-of-base-year payment times the UPW value for the approriate energy price escalation rate gives the present value of a sum of money at the discount rate of 20% over N discount periods. This table is used for a equal multiple payments over a number of years. See "Notes" at the end of this chapter for the equation from which the values in this table were derived.

**MODIFIED UNIFORM PRESENT WORTH (UPW) VALUES**
**25% DISCOUNT RATE**

**TABLE 5-7**

| N | RATE OF ENERGY PRICE ESCALATION | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 1% | 2% | 3% | 4% | 5% | 6% | 7% | 8% | 9% | 10% |
| 1 | 0.81 | 0.82 | 0.82 | 0.83 | 0.84 | 0.85 | 0.86 | 0.86 | 0.87 | 0.88 |
| 2 | 1.46 | 1.48 | 1.5 | 1.52 | 1.55 | 1.57 | 1.59 | 1.61 | 1.63 | 1.65 |
| 3 | 1.99 | 2.03 | 2.06 | 2.1 | 2.14 | 2.18 | 2.22 | 2.26 | 2.3 | 2.34 |
| 4 | 2.42 | 2.47 | 2.52 | 2.58 | 2.64 | 2.69 | 2.75 | 2.81 | 2.87 | 2.94 |
| 5 | 2.76 | 2.83 | 2.9 | 2.98 | 3.05 | 3.13 | 3.21 | 3.29 | 3.38 | 3.46 |
| 6 | 3.04 | 3.13 | 3.22 | 3.31 | 3.41 | 3.5 | 3.61 | 3.71 | 3.82 | 3.93 |
| 7 | 3.26 | 3.37 | 3.47 | 3.59 | 3.7 | 3.82 | 3.94 | 4.07 | 4.2 | 4.34 |
| 8 | 3.44 | 3.56 | 3.69 | 3.82 | 3.95 | 4.09 | 4.23 | 4.38 | 4.54 | 4.7 |
| 9 | 3.59 | 3.72 | 3.86 | 4.01 | 4.16 | 4.31 | 4.48 | 4.65 | 4.83 | 5.01 |
| 10 | 3.71 | 3.85 | 4.01 | 4.17 | 4.33 | 4.51 | 4.69 | 4.88 | 5.08 | 5.29 |
| 11 | 3.81 | 3.96 | 4.13 | 4.3 | 4.48 | 4.67 | 4.87 | 5.08 | 5.3 | 5.54 |
| 12 | 3.88 | 4.05 | 4.22 | 4.41 | 4.6 | 4.81 | 5.02 | 5.25 | 5.5 | 5.75 |
| 13 | 3.95 | 4.12 | 4.3 | 4.5 | 4.71 | 4.93 | 5.16 | 5.4 | 5.66 | 5.94 |
| 14 | 4 | 4.18 | 4.37 | 4.58 | 4.79 | 5.02 | 5.27 | 5.53 | 5.81 | 6.11 |
| 15 | 4.04 | 4.23 | 4.43 | 4.64 | 4.87 | 5.11 | 5.37 | 5.64 | 5.94 | 6.26 |
| 16 | 4.07 | 4.26 | 4.47 | 4.69 | 4.93 | 5.18 | 5.45 | 5.74 | 6.05 | 6.39 |
| 17 | 4.1 | 4.3 | 4.51 | 4.74 | 4.98 | 5.24 | 5.52 | 5.82 | 6.15 | 6.5 |
| 18 | 4.12 | 4.32 | 4.54 | 4.77 | 5.02 | 5.29 | 5.58 | 5.9 | 6.23 | 6.6 |
| 19 | 4.14 | 4.34 | 4.56 | 4.8 | 5.06 | 5.34 | 5.64 | 5.96 | 6.31 | 6.69 |
| 20 | 4.15 | 4.36 | 4.58 | 4.83 | 5.09 | 5.37 | 5.68 | 6.01 | 6.37 | 6.77 |
| 21 | 4.16 | 4.37 | 4.6 | 4.85 | 5.12 | 5.4 | 5.72 | 6.06 | 6.43 | 6.83 |
| 22 | 4.17 | 4.38 | 4.62 | 4.87 | 5.14 | 5.43 | 5.75 | 6.1 | 6.48 | 6.89 |
| 23 | 4.18 | 4.39 | 4.63 | 4.88 | 5.16 | 5.45 | 5.78 | 6.13 | 6.52 | 6.95 |
| 24 | 4.18 | 4.4 | 4.64 | 4.89 | 5.17 | 5.47 | 5.8 | 6.16 | 6.56 | 6.99 |
| 25 | 4.19 | 4.41 | 4.65 | 4.9 | 5.18 | 5.49 | 5.82 | 6.19 | 6.59 | 7.03 |
| 26 | 4.19 | 4.41 | 4.65 | 4.91 | 5.19 | 5.5 | 5.84 | 6.21 | 6.62 | 7.07 |
| 27 | 4.2 | 4.42 | 4.66 | 4.92 | 5.2 | 5.51 | 5.86 | 6.23 | 6.64 | 7.1 |
| 28 | 4.2 | 4.42 | 4.66 | 4.92 | 5.21 | 5.52 | 5.87 | 6.25 | 6.67 | 7.13 |
| 29 | 4.2 | 4.42 | 4.67 | 4.93 | 5.22 | 5.53 | 5.88 | 6.26 | 6.68 | 7.15 |
| 30 | 4.2 | 4.43 | 4.67 | 4.93 | 5.22 | 5.54 | 5.89 | 6.27 | 6.7 | 7.18 |

An end-of-base-year payment times the UPW value for the approriate energy price escalation rate gives the present value of a sum of money at the discount rate of 25% over N discount periods. This table is used for a equal multiple payments over a number of years. See "Notes" at the end of this chapter for the equation from which the values in this table were derived.

**SINGLE PRESENT WORTH VALUES**

**TABLE 5-8**

| N | DISCOUNT RATE | | | | | | |
|---|---|---|---|---|---|---|---|
| | 6% | 8% | 10% | 12% | 15% | 20% | 25% |
| 1 | 0.94 | 0.93 | 0.91 | 0.89 | 0.87 | 0.83 | 0.8 |
| 2 | 0.89 | 0.86 | 0.83 | 0.8 | 0.76 | 0.69 | 0.64 |
| 3 | 0.84 | 0.79 | 0.75 | 0.71 | 0.66 | 0.58 | 0.51 |
| 4 | 0.79 | 0.74 | 0.68 | 0.64 | 0.57 | 0.48 | 0.41 |
| 5 | 0.75 | 0.68 | 0.62 | 0.57 | 0.5 | 0.4 | 0.33 |
| 6 | 0.71 | 0.63 | 0.56 | 0.51 | 0.43 | 0.34 | 0.26 |
| 7 | 0.67 | 0.58 | 0.51 | 0.45 | 0.38 | 0.28 | 0.21 |
| 8 | 0.63 | 0.54 | 0.47 | 0.4 | 0.33 | 0.23 | 0.17 |
| 9 | 0.59 | 0.5 | 0.42 | 0.36 | 0.28 | 0.19 | 0.13 |
| 10 | 0.56 | 0.46 | 0.39 | 0.32 | 0.25 | 0.16 | 0.11 |
| 11 | 0.53 | 0.43 | 0.35 | 0.29 | 0.22 | 0.14 | 0.09 |
| 12 | 0.5 | 0.4 | 0.32 | 0.26 | 0.19 | 0.11 | 0.07 |
| 13 | 0.47 | 0.37 | 0.29 | 0.23 | 0.16 | 0.09 | 0.06 |
| 14 | 0.44 | 0.34 | 0.26 | 0.21 | 0.14 | 0.08 | 0.04 |
| 15 | 0.42 | 0.32 | 0.24 | 0.18 | 0.12 | 0.07 | 0.04 |
| 16 | 0.39 | 0.29 | 0.22 | 0.16 | 0.11 | 0.05 | 0.03 |
| 17 | 0.37 | 0.27 | 0.2 | 0.15 | 0.09 | 0.05 | 0.02 |
| 18 | 0.35 | 0.25 | 0.18 | 0.13 | 0.08 | 0.04 | 0.02 |
| 19 | 0.33 | 0.23 | 0.16 | 0.12 | 0.07 | 0.03 | 0.01 |
| 20 | 0.31 | 0.22 | 0.15 | 0.1 | 0.06 | 0.03 | 0.01 |
| 21 | 0.29 | 0.2 | 0.14 | 0.09 | 0.05 | 0.02 | 0.01 |
| 22 | 0.28 | 0.18 | 0.12 | 0.08 | 0.05 | 0.02 | 0.01 |
| 23 | 0.26 | 0.17 | 0.11 | 0.07 | 0.04 | 0.02 | 0.01 |
| 24 | 0.25 | 0.16 | 0.1 | 0.07 | 0.04 | 0.01 | 0.01 |
| 25 | 0.23 | 0.15 | 0.09 | 0.06 | 0.03 | 0.01 | 0 |
| 26 | 0.22 | 0.14 | 0.08 | 0.05 | 0.03 | 0.01 | 0 |
| 27 | 0.21 | 0.13 | 0.08 | 0.05 | 0.02 | 0.01 | 0 |
| 28 | 0.2 | 0.12 | 0.07 | 0.04 | 0.02 | 0.01 | 0 |
| 29 | 0.19 | 0.11 | 0.06 | 0.04 | 0.02 | 0.01 | 0 |
| 30 | 0.17 | 0.1 | 0.06 | 0.03 | 0.02 | 0 | 0 |

A future amount of money times the values in this table, at the appropriate discount rate, gives the present value of the amount of money.
See "Notes" at the end of this chapter for the equation from which the values in this table were derived.

## UNIFORM CAPITAL RECOVERY VALUES

**TABLE 5-9**

| N | DISCOUNT RATE | | | | | | |
|---|---|---|---|---|---|---|---|
| | 6% | 8% | 10% | 12% | 15% | 20% | 25% |
| 1 | 1.06 | 1.08 | 1.1 | 1.12 | 1.15 | 1.2 | 1.25 |
| 2 | 0.545 | 0.561 | 0.576 | 0.592 | 0.615 | 0.655 | 0.694 |
| 3 | 0.374 | 0.388 | 0.402 | 0.416 | 0.438 | 0.475 | 0.512 |
| 4 | 0.289 | 0.302 | 0.315 | 0.329 | 0.35 | 0.386 | 0.423 |
| 5 | 0.237 | 0.25 | 0.264 | 0.277 | 0.298 | 0.334 | 0.372 |
| 6 | 0.203 | 0.216 | 0.23 | 0.243 | 0.264 | 0.301 | 0.339 |
| 7 | 0.179 | 0.192 | 0.205 | 0.219 | 0.24 | 0.277 | 0.316 |
| 8 | 0.161 | 0.174 | 0.187 | 0.201 | 0.223 | 0.261 | 0.3 |
| 9 | 0.147 | 0.16 | 0.174 | 0.188 | 0.21 | 0.248 | 0.289 |
| 10 | 0.136 | 0.149 | 0.163 | 0.177 | 0.199 | 0.239 | 0.28 |
| 11 | 0.127 | 0.14 | 0.154 | 0.168 | 0.191 | 0.231 | 0.273 |
| 12 | 0.119 | 0.133 | 0.147 | 0.161 | 0.184 | 0.225 | 0.268 |
| 13 | 0.113 | 0.127 | 0.141 | 0.156 | 0.179 | 0.221 | 0.265 |
| 14 | 0.108 | 0.121 | 0.136 | 0.151 | 0.175 | 0.217 | 0.262 |
| 15 | 0.103 | 0.117 | 0.131 | 0.147 | 0.171 | 0.214 | 0.259 |
| 16 | 0.099 | 0.113 | 0.128 | 0.143 | 0.168 | 0.211 | 0.257 |
| 17 | 0.095 | 0.11 | 0.125 | 0.14 | 0.165 | 0.209 | 0.256 |
| 18 | 0.092 | 0.107 | 0.122 | 0.138 | 0.163 | 0.208 | 0.255 |
| 19 | 0.09 | 0.104 | 0.12 | 0.136 | 0.161 | 0.206 | 0.254 |
| 20 | 0.087 | 0.102 | 0.117 | 0.134 | 0.16 | 0.205 | 0.253 |
| 21 | 0.085 | 0.1 | 0.116 | 0.132 | 0.158 | 0.204 | 0.252 |
| 22 | 0.083 | 0.098 | 0.114 | 0.131 | 0.157 | 0.204 | 0.252 |
| 23 | 0.081 | 0.096 | 0.113 | 0.13 | 0.156 | 0.203 | 0.251 |
| 24 | 0.08 | 0.095 | 0.111 | 0.128 | 0.155 | 0.203 | 0.251 |
| 25 | 0.078 | 0.094 | 0.11 | 0.127 | 0.155 | 0.202 | 0.251 |
| 26 | 0.077 | 0.093 | 0.109 | 0.127 | 0.154 | 0.202 | 0.251 |
| 27 | 0.076 | 0.091 | 0.108 | 0.126 | 0.154 | 0.201 | 0.251 |
| 28 | 0.075 | 0.09 | 0.107 | 0.125 | 0.153 | 0.201 | 0.25 |
| 29 | 0.074 | 0.09 | 0.107 | 0.125 | 0.153 | 0.201 | 0.25 |
| 30 | 0.073 | 0.089 | 0.106 | 0.124 | 0.152 | 0.201 | 0.25 |

A present sum of money—present value—times the values in this table, at the appropriate discount rate, over the number of discount periods, gives the annual value equivalent.
See "Notes" at the end of this chapter for the equation from which the values in this table were derived.

## *Notes*

The values in Tables 5-1 through 5-7 were derived from the following equation:

$$P = A\left[\frac{(1+e)}{(i-e)}\right]\left[1-\left(\frac{1+e}{1+i}\right)^{N}\right]$$

The values in Table 5-8 were derived from the following equation:

$$P = F\frac{1}{(1+i)^{N}}$$

The values in Table 5-9 were derived from the following equation:

$$A = P\frac{i(1+i)^{N}}{(1+i)^{N}-1}$$

Where:
P = a present sum of money.
A = end-of-base-year payment.
e = percentage price escalation above general inflation, as a decimal.
i = percentage discount rate, as a decimal.
N = number of discount periods.
F = a future sum of money.

| DISCOUNTED ENERGY ECONOMICS FORM | | | |
|---|---|---|---|
| | Equipment Alternatives | | Δ Amounts |
| **Costs And Benefits** | **a** | **b** | **Δ** |
| 1. Equipment Alternative [Option a: highest installed cost, lowest operating cost. Option b: lowest installed cost, highest operating cost.] | | | B/C Ratio Differential Amounts |
| 2. Period of Analysis | | | |
| 3. Discount Rate | | | |
| 4. Inflation Rate of Energy Costs | | | |
| ***5. Investment Costs*** [Equipment and Installation Costs] | | | [5a - 5b] |
| 6. Net Replacement Cost | | | |
| 7. Year of Replacement | | | |
| ***8. Present Value of Replacement Cost*** [Table 5-8 value times 7a and 7b] | | | [8a - 8b] |
| 9. Energy Costs, Base Year | | | |
| ***10. Present Value of Energy Costs*** [Tables 5-1 through 5-7 value times 9a and 9b] | | | [10b - 10a] |
| 11. OM&R Costs | | | |
| ***12. Present Value of OM&R Costs*** [Tables 5-1 through 5-7 value times 11a and 11b] | | | [12b - 12a] |
| 13. Salvage Value | | | |
| 14. Year of Salvage | | | |
| ***15. Present Value of Salvage*** [Table 5-8 value times 13a and 13b] | | | [15a - 15b] |
| **16. Discounted Benefit/Cost Ratio** [(Δ10-Δ12)/(Δ5-Δ15+Δ8)] | | | |
| **17. LCC Present Value of Alternatives** [5+8+10+12-15] | | | |
| | | | |
| **18. Net Present Value of Savings** [Δ10-(Δ5-Δ15+Δ12+Δ8)] | | | |
| **19. Uniform Annual Cost of Alternatives** | | | |

# 6. Useful Information and Calculations

***Table 6-1. Typical Natural Gas Distribution Pressures***

Gas distribution pressures vary from one gas company to another and sometimes within one gas distribution territory.

| Typical Natural Gas Distribution Pressures | |
|---|---|
| Low | 5 to 14 inches water |
| Medium | 3 to 10 pounds/in$^2$ gauge |
| Intermediate | 11 to 65 pounds/in$^2$ gauge |
| High | 66 to 175 pounds/in$^2$ gauge |
| Note: 1 pound/in$^2$ = 27.68 inches water | |

***Table 6-2. Approximate Input Values for Common Gas Appliances***

For precise Btu/hr input values, check with the manufacturer of the gas appliance.

| Approximate Input Values For Common Gas Appliances | |
|---|---|
| *Appliance* | *Btu/hr Input, Approximate* |
| Range, free standing, res. | 65,000 |
| Built-in oven/broiler, res. | 25,000 |
| Built-in range-top unit | 40,000 |
| Water heater, 30 to 40 gal | 45,000 |
| Water heater, 50 gal. | 55,000 |
| Fireplace/Gas log | 21,000-55,000 |
| Grille | 30,000-40,000 |
| Clothes dryer, residential | 20,000-35,000 |
| Gas light | 2,500 |
| Incinerator, residential | 35,000 |

***Table 6-3. Energy Budgets for Commercial Buildings***

An energy budget is a range of projected energy use for a particular building facility type. Energy budgets vary according to climate, envelope characteristics, usage, etc., therefore, the values should be used with caution.

If a building is located in a more moderate climate and is built using relatively energy-efficient standards, it will be nearer the lower end of the energy budget range.

| **Energy Budgets For Commercial And Public Facilities** | |
|---|---|
| *Facility Type* | *Energy Budget, $10^3$ Btu/$ft^2$,yr* |
| Dining & Entertainment | |
| Cafeterias | 50 to 400 |
| Restaurants | 50 to 500 |
| Bars | 50 to 400 |
| Night Clubs | 20 to 250 |
| Commercial Kitchens | 100 to 400 |
| Office Buildings | 25 to 300 |
| Libraries, Museums | |
| Average | 150 to 250 |
| Archival | 25 to 100 |
| Communications | |
| Telephone Terminal | 150 to 500 |
| Teletype Centers | 50 to 150 |
| Radio & TV Studios | 100 to 200 |
| Transportation Centers | |
| Airport Terminals | 100 to 150 |
| Ship Docks | 25 to 100 |
| Bus Terminals | 150 to 250 |
| Garages | 20 to 200 |
| Warehouses | 20 to 350 |

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***Table 6-4. Btu Equivalent Fuel Input Values***

The "Btu Equivalent" values in the following table are input values, not output values—combustion efficiencies are not included. Many of the values vary according to the source of the fuel or the refining methods. For example, the Btu value of natural gas may be as low as 950 or as high as 1100 Btu per cubic foot. The value for No. 2 oil may be as low as 138,000 or as high as 140,000 Btu per gallon.

| Fuel | Btu Equivalent | Unit |
|---|---|---|
| Natural Gas | 1,030 | Cubic Foot |
| No. 1 Oil | 135,000 | Gallon |
| No. 2 Oil | 139,000 | Gallon |
| No. 4 Oil | 145,600 | Gallon |
| No. 5L Oil | 148,400 | Gallon |
| No. 5H Oil | 150,700 | Gallon |
| No. 6 Oil | 153,600 | Gallon |
| Propane | 91,600 | Gallon |
| Electricity | 3,412 | Kilowatt hour |
| District Heat | 1,000 | Pound |

***Table 6-5. Equipment Service Life Values***

Equipment service life values are often needed for a feasibility or energy-economics study of the installation of new equipment or the replacement of existing equipment.

If, while talking with a potential customer, you become aware that a piece of equipment is near or past the end of its median service life (listed in the table below), there is good reason to bring it to the attention of the manager or owner.

For example, if you find that an electrically-driven centrifugal packaged chiller (median service life of 23 years) has been in operation for 24 years, it would be a good time to convert to a gas absorption chiller, better than if

the electrically-driven chiller had been in operation for only five years.

The numbers listed in the table are *median* values, not average values. Thus, of the equipment surveyed, one-half of the pieces of equipment had longer service lives than that listed and one-half had shorter service lives.

The service life values are based on a 1986 study.

| **Equipment Service Life** | |
|---|---|
| *Equipment* | *Median Years* |
| Air Conditioners, Commercial | 15 |
| Air Conditioner, Window Unit | 10 |
| Air Conditioner, Water-Cooled Package | 15 |
| Boiler, Hot Water, Fire-Tube | 25 |
| Boiler, Hot Water, Water-Tube | 24 |
| Coils, DX, Water, or Steam | 20 |
| Compressors, Reciprocating | 20 |
| Condensers, Air-Cooled | 20 |
| Condensers, Evaporative | 20 |
| Cooling Tower, Metal | 20 |
| Cooling Tower, Ceramic | 34 |
| Engines, Reciprocating | 20 |
| Furnaces, Gas- or Oil-Fired | 18 |
| Heat Pump, Commercial, Air-to-Air | 15 |
| Heat Pump, Commercial, Water-to-Air | 19 |
| Package Chiller, Absorption | 23 |
| Package Chiller, Reciprocating | 20 |
| Package Chiller, Centrifugal | 23 |
| Roof-Top AC, Multizone | 15 |
| Roof-Top AC, Single Zone | 15 |
| Unit Heaters, Gas or Electric | 13 |
| Water Heaters, Gas & Electric | 13 |
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Equipment Service Life Values

***Table 6-6. Gas Boiler Conversion Factors***

This table is for converting boiler horsepower (bhp) to MCF (1,000 cubic feet) of natural gas per hour.

| **Gas Boiler Conversion Factors (Boiler Demands @ 80% Efficiency) (Natural Gas at 1,030,000 Btu/MCF)** | |
|---|---|
| *Boiler Horse Power* | *Gas Demand* |
| 10 bhp | 0.41 MCF/hr |
| 25 bhp | 1.02 MCF/hr |
| 30 bhp | 1.22 MCF/hr |
| 40 bhp | 1.63 MCF/hr |
| 50 bhp | 2.03 MCF/hr |
| 75 bhp | 3.05 MCF/hr |
| 100 bhp | 4.06 MCF/hr |
| 200 bhp | 8.13 MCF/hr |
| 250 bhp | 10.16 MCF/hr |
| 300 bhp | 12.19 MCF/hr |
| 400 bhp | 16.25 MCF/hr |
| 500 bhp | 20.31 MCF/hr |

33,475 Btu = 1 boiler horsepower

$\frac{33,475}{0.80}$ = 41,844 Btu/bhp input at 80% efficiency

$\frac{41,844 \text{ Btu/bhp input}}{1,030,000 \text{ Btu/MCF}}$ = 0.04062 MCF/bhp input

250 bhp x 0.04062 MCF/bhp = 10.16 MCF/hr

***Table 6-7. Efficiency/Output/Input Equations***

Use these simple equations for space heating systems.

$$\text{Efficiency} = \frac{\text{Output}}{\text{Input}}$$

$$\text{Output} = \text{Input} \times \text{Efficiency}$$

$$\text{Input} = \frac{\text{Output}}{\text{Efficiency}}$$

***Table 6-8. Cooling Load Quick-Check Figures***

These are quick-check figures only, used to check if a load calculation is within range. *Do not use these values for sizing cooling equipment.*

| Btu's/hr per $Ft^2$ of Floor Area & $Ft^2$ per Ton of Air Conditioning | | |
|---|---|---|
| *Facility Type* | *Btu/$Ft^2$* | *$Ft^2$/Ton* |
| Apartments, High Rise | 26 | 450 |
| Apartment, Corridors | 22 | 550 |
| Auditoriums & Theaters | | 18* |
| Banks | 50 | 240 |
| Barber Shops | 48 | 250 |
| Bars and Taverns | 133 | 90 |
| Beauty Parlors | 66 | 180 |
| Bowling Alleys | 68 | 175 |
| Churches | | 20* |
| Cocktail Lounges | 68 | 175 |
| Computer Rooms | 141 | 85 |
| Dental offices | 52 | 230 |
| Department Stores, Basement | 34 | 350 |
| Main Floor | 40 | 300 |
| Upper Floor | 30 | 400 |
| Dormitories, Rooms | 40 | 300 |
| Corridors | 30 | 400 |
| Dress Shops | 43 | 280 |
| Drug Stores | 80 | 150 |
| Educational Facilities, Classrooms | | 150 |
| Factories, Assembly Areas | | 150 |
| Light Manufacturing | | 150 |
| Heavy Manufacturing | | 80 |
| High Rise Offices, External Rooms | 46 | 263 |
| Interior Rooms | 37 | 325 |
| (continued) | | |

| Btu's/hr per $Ft^2$ of Floor Area & $Ft^2$ per Ton of Air Conditioning (continued) | | |
|---|---|---|
| *Facility Type* | *Btu/$Ft^2$* | *$Ft^2$/Ton* |
| Hospitals, Patient Rooms | | 220 |
| Public Areas | | 140 |
| Hotels, Dormitories, Guest Rooms | 44 | 275 |
| Public Spaces | 55 | 220 |
| Corridors | 30 | 400 |
| Libraries & Museums | | 280 |
| Medical Centers | 28 | 425 |
| Motels | 28 | 425 |
| Office Buildings, General | 43 | 280 |
| Residences | 20 | 600 |
| Restaurants | 60 | 200 |
| Retail Stores | 55 | 220 |
| Shoe Stores | 55 | 220 |
| Shopping Centers | 34 | 350 |
| Specialty Shops | 60 | 200 |
| *Persons per ton. One ton = 12,000 Btu/hr. Sizing will vary with age of building, structure, amount of insulation, and amount of glass. | | |

## *Table 6-9. Electric Compressor Energy Use*

| Electric Compressor Energy Consumption | |
|---|---|
| *Compressor Type* | *Electrical Consumption* |
| Centravac | ~ 0.51 - 0.65 kW/ton |
| Reciprocating Water Cooled | ~ 0.95 kW/ton |
| Reciprocating Air Cooled | ~ 1.20 kW/ton |
| Incremental Unit | ~ 1.50 kW/ton |
| Scroll, Water Cooled | ~ 0.84 kW/ton |
| Series R, Water Cooled | ~ 0.80 kW/ton |

***Table 6-10. Condenser Data***

| Condenser Data | |
|---|---|
| *Condenser Flow Rate* | |
| CTV/Reciprocating | ~ 3.0 gpm/ton |
| ABS | ~ 3.6 - 4.5 gpm/ton |
| *Heat Rejection* | |
| Water Cooled | ~ 1.25 x Evaporator Btu |
| Air Cooled | ~ 1.30 x Evaporator Btu |

***Table 6-11. Evaporator Data***

| Evaporator Data | |
|---|---|
| Evaporator Flow Rate | ~ 2.4 gpm/ton |

***Table 6-12. Absorption Cooling and Vapor-Compression Cooling Cycles Compared***

Absorption cooling and vapor-compression cooling cycles perform the same basic operations, but in different ways. This table compares the two cycles.

| Absorption Cooling and Vapor-Compression Cooling Cycles Compared | | |
|---|---|---|
| | *Absorption Cooling Cycle* | *Vapor-Compression Cooling Cycle* |
| *Energy Source* | Gas, Steam, or Electricity | Electricity or Natural Gas-Driven Engine |
| *Energy Input* | Generator (Boiler) | Compressor |
| *Heat Removed* | Absorber and Condenser | Compressor and Condenser |
| *Refrigerant* | Ammonia or Water | Halocarbon or Ammonia |

### *Table 6-13. Comparison of Gas & Electric Food Service Equipment Operating Costs*[64]

The comparative operating costs of gas and electric food service equipment can be determined by using the information in the table below. The equation for comparison is included at the bottom of the table. Food service equipment energy ratios, needed for the comparison, are listed in the table.

| Comparison of Gas & Electric Food Service Equipment Operating Costs | |
|---|---|
| *Equipment* | *Energy Ratio* |
| Broiler | 2 |
| Braising Pan | 1.7 |
| Fryer, Standard | 2.2 |
| Fryer, Pressure | 2.3* |
| Griddle, Flat | 2.1 |
| Griddle, Grooved | 1.4* |
| Oven, Convection | 1.8 |
| Oven, Deck | 2.2* |
| Range, Hot Top | 2.2 |
| Range, Open Burner | 2.3 |
| Steam Kettle | 1.7* |
| Steamer, Atmospheric | 2 |
| Steamer, Pressure | 2.1* |

**Operating Cost Ratio Calculation**

$$= \text{Energy Ratio} \times \frac{\text{Gas cost}}{\text{Elec. cost}} \times 0.03412$$

For example, a hot top range:

$$= 2.2 \times \frac{\$0.60/\text{Therm}}{\$0.07/\text{kWh}} \times 0.03412 = 64\%$$

Therefore, the cost of operating this appliance with natural gas is 64% the cost of operating it with electricity.

Sources: *University of Minnesota, 1982 and *Efficient Use of Natural Gas in Hotels and Motels*, AGA, 1984, p. 12. Pacific Gas & Electric Company study, 1987.

[64] A computer program called "kitchenCOST" calculates food service equipment operating costs, ventilation rates, and heating and cooling loads. This software is available from AGA Research, Cleveland, Ohio 44131-5575. Telephone: 216-524-4995.

***Table 6-14. Sizing Residential Storage Water Heaters***

Residential storage water heaters are sized by matching the peak first-hour demand with the rated first-hour rating of the appliance.

Use this table to determine the peak first-hour demand for a household. Multiply the usage in gallons (column 2) by the number of times used (column 3) during the peak-hot-water-use hour. Record the result in column 4. Add the gallons used in one hour (column 4 values) to find the total peak first-hour demand in gallons. A typical peak first-hour demand for a family of three to four people is 66 to 74 gallons (250 to 280 liters).

After determining the peak first-hour demand, select a water heater having a first-hour rating within one to two gallons of the calculated peak first-hour demand. First-hour ratings for gas-fired storage water heaters are listed in the *Consumers' Directory of Certified Efficiency Ratings for Residential Heating and Water Heating Equipment* (GAMA *Directory*), published by GAMA.

**First-Hour Demand Calculation for Residential Storage Water Heaters**

| (1) Hot Water Use | (2) Gallons of Hot Water Per Usage | (3) Times Used During One Hour | (4) Gallons Used in One Hour |
|---|---|---|---|
| Shower | 20 | x = | |
| Bath | 20 | x = | |
| Shaving | 2 | x = | |
| Hands & Face Washing | 4 | x = | |
| Hair Shampoo | 4 | x = | |
| Hand Dish Washing | 4 | x = | |
| Automatic Dishwasher | 14 | x = | |
| Food Preparation | 5 | x = | |
| Automatic Clothes Washer | 32 | x = | |
| TOTAL (peak first-hour demand, gallons) | | | |

Source: *Consumers' Directory of Certified Efficiency Ratings for Residential Heating and Water Heating Equipment*, by GAMA.

As an example of a typical residential sizing calculation, see the sizing chart below. A water heater with a first-hour rating from 68 to 72 gallons should be chosen for this case.

**First-Hour Demand Calculation for Residential Storage Water Heaters**

| (1) Hot Water Use | (2) Gallons of Hot Water Per Usage | | (3) Times Used During One Hour | | (4) Gallons Used in One Hour |
|---|---|---|---|---|---|
| Shower | 20 | x | 3 | = | 60 |
| Bath | 20 | x | | = | |
| Shaving | 2 | x | 1 | = | 2 |
| Hands & Face Washing | 4 | x | 1 | = | 4 |
| Hair Shampoo | 4 | x | 1 | = | 4 |
| Hand Dish Washing | 4 | x | | = | |
| Automatic Dishwasher | 14 | x | | = | |
| Food Preparation | 5 | x | | = | |
| Automatic Clothes Washer | 32 | x | | = | |
| TOTAL (peak first-hour demand, gallons) | | | | | 70 |

Source: *Consumers' Directory of Certified Efficiency Ratings for Residential Heating and Water Heating Equipment*, by GAMA.

### *Table 6-15. Storage Water Heater Comparisons*

These are good values for natural gas and electric cost comparisons. See the GAMA *Directory* for other values.

**Operating Cost Comparisons for Storage Water Heating Systems**

| *Equip.* | *EF** | *Annual Energy Used* | *Annual Operating Costs* |
|---|---|---|---|
| Nat. Gas | 0.7 | 214 therms | $134 |
| Nat. Gas | 0.53 | 283 therms | $177 |
| Electric | 0.95 | 4662 kWh | $397 |
| Electric | 0.84 | 5227 kWh | $450 |

*Energy Factor. See GAMA *Directory* for list of energy factors.
Source: U.S. Dept. of Energy, Feb. 1995.
Based on equipment with 65 to 74 gallon first-hour rating (typical for residential use).
Energy Costs per unit: Natural gas, $0.63/therm ($0.649/ccf); electricity,

### *Table 6-16. Operating Cost Comparisons for Heating Systems*

These are good values for natural gas, oil and electric cost comparisons. See *Consumers' Directory of Certified Efficiency Ratings for Residential Heating and Water Heating Equipment* (GAMA *Directory*) for a method of determining space heating costs.

| Operating Cost Comparisons for Heating Systems | | | | | |
|---|---|---|---|---|---|
| | | | *Annual Operating Costs* | | |
| *Equip.* | *Eff.* | *Annual Energy Used* | *Fuel* | *Elec.* | *Total* |
| Nat. Gas | 78% | 921 therms/695 kWh | $577 | $60 | $637 |
| Nat. Gas | 94% | 752 therms/142 kWh | $471 | $12 | $483 |
| Oil, #2 | 80% | 633 gallons/839 kWh | $582 | $72 | $654 |
| Oil, #2 | 87% | 608 gallons/475 kWh | $559 | $41 | $600 |
| Electric | 99% | 20,087 kWh | — | $1727 | $1727 |
| Heat Pump | 8.0* | 8812 kWh | — | $758 | $758 |

*Heating Season Performance Factor (HSPF).
Analysis based on 2100 square foot, well-insulated home in St. Louis, MO.
Energy Costs: Natural gas, $0.63/therm ($0.649/ccf); electricity, $0.0867/kWh; No. 2 oil, $1.008/gallon. Source: U.S. Dept. of Energy, Feb. 1995.

### *Table 6-17. Average Costs for Residential Energy, 1995*

These U.S. Department of Energy figures show that natural gas was the least expensive energy in 1995. This is likely to continue during the next two decades.

| Average Costs for Residential Energy in the U.S., 1995 | | |
|---|---|---|
| *Energy Form* | *Cost/Unit* | *$/Million Btu* |
| Natural Gas | $0.63/therm | $6.30 |
| No. 2 Heating Oil | $1.008/gallon | $7.27 |
| Kerosene | 1.094/gallon | $8.10 |
| Propane | 0.985/gallon | $10.79 |
| Electricity | $0.086/kWh | $25.41 |
| Source: U.S. Dept. of Energy, Feb. 1995. | | |

### *Annual Heating Cost, From Fuel X to Natural Gas*

Use the following equation to find the cost of space heating with natural gas in a building that has been heated with a alternative fuel. You must know the cost of heating the building with the alternative fuel, the cost of the alternative fuel per unit, the cost of natural gas per unit, the efficiency of the alternative space heating system, and the efficiency of the replacement gas system.

This procedure uses the cost of gas per therm, rather than per CCF or MCF. If you need to convert from either of these units to therms, please see "Converting from CCF and MCF to Therms" in this chapter.

$$Total\ Gas\ Cost = \left[\frac{\sum Cost\ Alt}{\$/Unit\ Alt}\right]\left[\frac{Eff.\ Alt}{Eff.\ Gas}\right] x\ \beta\ x\ \$/Therm$$

Where:

Total Gas Cost = Equivalent annual cost of space heating with natural gas.

$\Sigma$Cost Alt = Total cost of space heating building with the alternative fuel.

$/Unit Alt = Cost of alternative space-heating fuel in kWh or gallons (oil or propane).

Eff Alt = Original seasonal efficiency of alternative system.

Eff Gas = Seasonal efficiency of replacement natural gas heating system.

$\beta$ = Therms per unit of alternative fuel, from table below.

$/Therm = Cost of natural gas per therm.

Note: $/Therm = $/CCF x [100,000/(Btu per CCF)].

| Alternative Fuel | Value of $\beta$ |
|---|---|
| Electricity | 0.034 |
| No. 2 Oil | 1.39 |
| No. 4 Oil | 1.5 |
| No. 5 Oil | 1.52 |
| No. 6 Oil | 1.53 |
| Propane, LPG | 0.916 |

**Example:** If it has cost $12,000 per year to heat a building with electric resistance heat, what will be the approximate cost to heat the same building with natural gas? The cost of gas is $.70 per therm, the electric cost has been $0.11 per kWh, electric heat efficiency is 100%, and gas heating system efficiency is 80%. Using the equation from the previous page,

$$Total\ Gas\ Cost = \left[\frac{\$12{,}000}{\$0.11}\right]\left[\frac{1.00}{0.8}\right] x\ 0.034\ x\ \$0.70$$

$$Total\ Gas\ Cost = \$3245$$

This method is fast, but it is for approximation only. You can see that the saving from converting to natural gas from electricity is substantial ($12,000 - $3245 = $8755 savings). The equation on the previous page can be used to find the estimated saving of natural gas over any major competing fuel.

***Cost Per Therm of Fuel***

If you wish to calculate the per therm cost of fuels for a comparison, the equation below will help. The answer, cost per therm of output, incorporates the seasonal efficiency of the appliances being considered. For example, heating system seasonal efficiencies might average 100% for electricity, 72% - 85% for oil-fired, and 72% - 95% for natural gas and propane.

Use a realistic per unit fuel cost for the fuel and facility under consideration. A few examples are worked out below. Refer to Table 6-4 Btu Conversion Factors, on page 189 for Btu values per unit of fuel.

$$Cost\ per\ Therm\ of\ Output = \frac{\$\ Per\ Unit\ x\ 100{,}000\ Btu/Therm}{Btu/Unit\ x\ Seasonal\ Efficiency}$$

If No. 2 oil costs $0.96 per gallon and the seasonal efficiency (similar to AFUE) of an the oil-fired furnace is 82%, the cost per therm of output is figured like this:

$$Cost\ per\ Therm\ of\ Output = \frac{\$0.96/gal \times 100{,}000\ Btu/Therm}{139{,}000\ Btu/gal \times 0.82}$$

$$Cost\ per\ Therm\ of\ Output = \$0.84$$

If natural gas costs $0.66 per *therm* and the seasonal efficiency (similar to AFUE) of an the natural gas furnace is 94%, the cost per therm of output is figured like this:

$$Cost\ per\ Therm\ of\ Output = \frac{\$0.66/Therm \times 100{,}000\ Btu/Therm}{100{,}000\ Btu/Therm \times 0.94}$$

$$Cost\ per\ Therm\ of\ Output = \$0.70$$

If natural gas costs $0.64 *per CCF* and the seasonal efficiency (similar to AFUE) of an the natural gas furnace is 94%, the cost per therm of output is figured like this (assuming the natural gas is 103,000 Btu/CCF):

$$Cost\ per\ Therm\ of\ Output = \frac{\$0.64/CCF \times 100{,}000\ Btu/Therm}{103{,}000\ Btu/CCF \times 0.94}$$

$$Cost\ per\ Therm\ of\ Output = \$0.66$$

If electricity costs $0.084 per kWh and the seasonal efficiency is 100%, the cost per therm of output is figured like this:

$$Cost\ per\ Therm\ of\ Output = \frac{\$0.084/kWh \times 100{,}000\ Btu/Therm}{3412\ Btu/kWh \times 1.0}$$

$$Cost\ per\ Therm\ of\ Output = \$2.46$$

***Break-Even Price of a Fuel***

The break-even price of fuels is the cost at which using one fuel at a given efficiency will just equal the cost of using another fuel. If you know the cost per therm of one fuel (the alternative fuel) and wish to find the break-even price of another fuel (the base fuel), use the following equation.

$$\$/Unit_{B-E} = \frac{Btu/Unit \times Seasonal\ Efficiency \times \$/Therm\ of\ Alternative}{100{,}000}$$

Where:

$\$/Unit_{B\text{-}E}$ = Break-even price of base fuel, based on a per therm cost of an alternative fuel.

*Btu/Unit* = British thermal units per unit of the base fuel.

*Seasonal Efficiency* = Seasonal efficiency for the base fuel. Usually the same seasonal efficiency used for calculating the cost per therm of the alternative fuel is used here, but this is not required.

*$/Therm of Alternative* = Calculated cost per therm of alternative fuel. See "Cost per Therm of Fuel" section above for this calculation procedure.

For example, if the price of No. 2 heating oil is $0.96 per gallon, what is the break-even price of heating with natural gas, if the seasonal efficiencies of both the gas and the oil heating units is 82%? In the previous section, the cost per therm of No. 2 heating oil at $0.96 per gallon and 82% seasonal efficiency is calculated to cost $0.84 per therm of output. Thus,

$$\$/Unit_{B\text{-}E} = \frac{100{,}000 \times 0.82 \times \$0.84}{100{,}000}$$

$$\$/Unit_{B\text{-}E} = \$0.69$$

This result indicates that natural gas has a price advantage over $0.96 per gallon No. 2 oil if the price of natural gas is less than $0.69 per therm (assuming the seasonal efficiencies of the oil and natural gas heating systems are 82%). If the price of natural gas is more than $0.69 per therm, No. 2 oil at $0.96 has a price advantage. In other words, the break-even price of natural gas compared to No. 2 oil priced at $0.96 per gallon ($0.84 cost per therm of output) is $0.69 per therm.

***Converting from CCF and MCF to Therms***

Natural gas is billed to customers in CCF or therms. At various times it is necessary to convert from one unit to another.

Note: CCF = 100 CF, MCF = 1000 CF, MCF = 10 CCF.

$$Therms = CCF\ x\ \frac{Btu/CCF}{100{,}000\ Btu/therm}$$

$$Therms = MCF\ x\ \frac{Btu/CCF}{100{,}000\ Btu/therm\ x\ 10}$$

$$CCF = therms\ x\ \frac{100{,}000\ Btu/therm}{Btu/CCF}$$

$$MCF = therms\ x\ \frac{100{,}000\ Btu/therm\ x\ 10}{Btu/CCF}$$

For example, if a customer is being billed for 897 CCF, how many therms is the customer being billed for if one CCF is equal to 103,000 Btu?

$$Therms = 897\ CCF\ x\ \frac{103{,}000\ Btu/CCF}{100{,}000}$$

$$Therms = 924$$

## *Conversion Factors*

| *Multiply* | *By* | *To Obtain* |
|---|---|---|
| Btu | 777.649 | ft-lb |
| Btu | 251.9957 | calories, gm |
| Btu | 0.000029 | hp/hr (boiler) |
| Btu | 0.2931 | W/hr |
| Btu | 0.2520 | Calories, kg |
| Btu | 1,055.06 | Joule |
| Btu | 0.0002931 | kWh |
| Btu | 1.055 | kJ |
| Btu/hr | 0.2931 | Watt |
| Btu/hr | 0.0002931 | kW |
| Calories, kg | 3088 | ft-lb |
| Calories, kg | 3.9683 | Btu |
| Calories, kg | 1000 | calories, gm |
| Calories, kg | 4187 | Joule |
| calories, gm | 0.00396832 | Btu |
| calories, gm | 0.001 | Calories, kg |
| calories, gm | 4.187 | Joule |
| Celsius | (1.8°C) + 32 | Fahrenheit |
| centimeter | 0.3937 | inch |
| COP | 3.367 | EER |
| dekameter | 10.0 | meter |
| dekatherm | 10.0 | therm |
| EER | 0.297 | COP |
| Fahrenheit | (°F - 32)/1.8 | Celsius |
| feet | 0.3048 | meter |
| feet | 304.8 | mm |
| feet | 0.3048 | meter |
| Ft-lb | 0.001285 | Btu |
| ft-lb | $3.766 \times 10^{-7}$ | kW/hr |
| ft-lb (work) | 1.35582 | Joule |
| ft/min | 0.00508 | m/s |

| *Multiply* | *By* | *To Obtain* |
|---|---|---|
| $ft^2$ | 0.0929 | $m^2$ |
| $ft^3$ | 0.0283 | $m^3$ |
| $ft^3$ | 28.32 | liter |
| $ft^3$/min, cfm | 0.4719 | L/sec |
| $ft^3$/sec, cfs | 28.32 | L/sec |
| gallon (US) $H_2O$@60°F | 8.32823 | lb of $H_2O$ |
| gallons (US) liquid | 3.7853 | liter |
| gallons | 8.0 | pint |
| gph | 1.05 | mL/s |
| gpm | 0.0631 | L/s |
| grain | 0.000142857 | pound |
| gram | 0.0022046 | pound |
| horsepower (boiler) | 13.337 | hp (metric) |
| horsepower (boiler) | 9.809 | kW |
| horsepower (boiler) | 9809.5 | Joules/sec |
| horsepower (boiler) | 33,479 | Btu/hr |
| horsepower (boiler) | 13.149 | hp (electric) |
| horsepower (boiler) | 13.149 | hp (water) |
| horsepower (boiler) | 13.155 | hp (mech) |
| horsepower (mechanical) | 2542.48 | Btu/hr |
| horsepower (mechanical) | 745.7 | Joules/sec |
| horsepower (mechanical) | 1,980,000 | ft-lb/hr |
| in $H_2O$ | 0.036127 | lb/$in^2$ |
| in $H_2O$ | 249.08 | Pascal |
| in $H_2O$ | 0.249 | kPa |
| inch | 0.0254 | meter |
| inch | 25.4 | mm |
| inch | 2.54 | cm |
| Joule (abs) | 0.73756 | ft-lb |
| Joule | 0.0009478 | Btu |
| Joule | 1.0 | Watt/sec |
| Joule | 0.2388 | calories, gm |
| Joule | 0.000239 | Calories, kg |
| Joule/sec | 0.0001 | hp (boiler) |

| *Multiply* | *By* | *To Obtain* |
|---|---|---|
| kg | 2.2046 | pound |
| kilometer | 0.621 | mile |
| kiloWatt | 1000 | Watt |
| km | 0.621 | mile |
| kW | 0.102 | hp (boiler) |
| kW | $3.6 \times 10^6$ | Joule/hr |
| kW | 1000 | Joule/sec |
| kW | 3412.14 | Btu/hr |
| kW/1000 cfm | 2.12 | J/L |
| kW/hr | 3.6 | MJ |
| kW/hr | 3412.14 | Btu |
| kW/hr | 3,600,000 | Joules |
| kW/hr | 2,655,222 | ft-lb |
| L/sec | 2.119 | $ft^3$/min, cfm |
| L/sec | 15.8478 | gpm |
| L/sec | 0.0353 | $ft^3$/sec, cfs |
| liter | 1.0567 | quart |
| liter | 0.2641 | gallon |
| liter | 0.03531 | $ft^3$ |
| liter | 0.001 | $m^3$ |
| liter | 0.264 | gallon (US) |
| m/s | 196.85 | ft/min |
| $m^2$ | 10.7643 | $ft^2$ |
| $m^3$ | 1000 | liter |
| $m^3$ | 35.3357 | $ft^3$ |
| megabyte | 1,048,576 | byte |
| meter | 39.3701 | inch |
| meter | 3.28084 | feet |
| meter/sec | 2.2369 | mile/hr |
| mile | 1.61 | km |
| miles/hr | 1.466 | ft/sec |
| miles/hr | 88 | ft/min |
| miles/hr | 0.447 | m/s |

| *Multiply* | *By* | *To Obtain* |
|---|---|---|
| mL/sec | 0.9524 | gph |
| mm | 0.00328 | ft |
| mm | 0.03937 | inch |
| parts/million, ppm | 0.0001 | percent |
| Pascal | 1.0 | $N/m^2$ |
| Pascal | 0.001 | kPa |
| Pascal | 0.000145 | $lb/in^2$ |
| Pascal | 0.00401463 | in $H_2O$ |
| pound | 7000 | grain |
| pound | 453.6 | gram |
| pound | 0.45359 | kg |
| $pound/in^2$ | 6.89476 | kPa |
| $pound/in^2$ | 6894.76 | Pascal |
| $pound/in^2$ | 27.68 | in $H_2O$ |
| quart (U.S.) | 0.946 | liter |
| therm | 100,000 | Btu |
| therm | 105.505 | MJ |
| tons of refrigeration | 12,000 | Btu/hr |
| tons of refrigeration | 3.52 | kW |
| Watt | 0.0002843 | tons refrig. |
| Watt/hr | 3.41214 | Btu |
| Watt | 0.0001 | hp (boiler) |
| Watt | 3.41214 | Btu/hr |
| Watt | 1.0 | Joule/sec |
| Watt | 0.001 | kiloWatt |
| Watt/sec | 1.0 | Joule |
| year | 8765.81277 | hours |

# 7. Resources for Natural Gas Marketing

## *Organizations*

**AGA Research, A Division of Energy International, Inc.** 8501 East Pleasant Valley Road, Cleveland, OH 44131. Telephone: 216-524-4995, Fax: 216-328-8101. Publishes software and conducts research related to natural gas use and marketing.

**Air Conditioning Contractors of America (ACCA)**, 1513 16th Street, NW, Washington, DC 20036. Telephone: 202-483-9370, Fax: 202-234-4721, E-mail: accaordr@acca.org, The ACCA internet web address is: http://www.acca.org. Publishes many manuals useful to the natural gas industry, for example, *Manual J* (residential heating and cooling systems sizing), *Manual D* (low velocity duct design and sizing), *Manual N* (heating and cooling sizing for low-rise commercial buildings), *and Manual S* (equipment selection).

**Air-Conditioning and Refrigeration Institute (ARI)**, 4301 North Fairfax Drive, Suite 425, Arlington, VA 22203. Telephone: 703-524-8800. Internet web address: http://www.ari.org. Publishes the *ARI Unitary Directory: Directory of Certified Unitary Air-Conditioners, Unitary Air-Source Heat Pumps, Sound-Rated Outdoor Unitary Equipment.* Also publishes *ARI Directory of Certified Applied Air-Conditioning Products.*

**American Gas Association (AGA)**, 1515 Wilson Blvd., Arlington, VA 22209-9828. Telephone: 703-841-8400. Publishes books, videos, brochures, magazines; gathers data, does market research; does demand forecasting, coordinates key accounts; and holds educational sessions and conferences for the natural gas industry.

**American Gas Cooling Center (AGCC)**, 1515 Wilson Boulevard, Arlington, VA 22209. Telephone: 703-841-8409. Publishes books, sponsors research, gathers data, and coordinates marketing activities for natural gas cooling equipment.

**American National Standards Institute (ANSI)**, 11 West 42nd Street, New York, NY 10036. Telephone: 212-354-3300. Publishes standards for industry, such as ANSI Z223.1, commonly called the *National Fuel Gas Code.*

**American Marketing Association.** 250 South Wacker Drive, Chicago, IL 60606-5819. Telephone: 800-262-1150, Fax: 312-648-5625, E-Mail: info@ama.org, Internet web address: http://www.ama.org. Publishes periodicals for marketing, sponsors educational activities, does market research.

**American Society of Heating, Refrigerating, and Air-Conditioning Engineers, Inc. (ASHRAE)**, 1791 Tullie Circle, NE, Atlanta, GA 30329. Telephone: 404-636-8400, Fax: 404-321-5478, Internet web address: http://www.ashrae.org. Publishes HVAC & R books and manuals, writes standards for the industry, and holds annual conferences.

**Canadian Gas Research Association**, 55 Scarsdale Road, Don Mills, Ontario M3B 2R3, Canada. Telephone: 416-447-6661.

**Canadian Gas Association (CGA)**, 243 Consumers Road, Suite 1200, North York, Ontario M2J 5E3, Canada. Telephone: 416-498-1994.

**Compressed Gas Association**, Crystal Square 2, Suite 1004, 1725 Jefferson Davis Highway, Arlington, VA 22202-4102. Telephone: 703-412-0900.

**ETL Testing Laboratories, Inc.,** 3933 U.S. Route 11, Cortland, NY 13045. Telephone: 607-753-6711. ETL Labs. tests gas appliances and publishes the *Consumer's Directory of Certified Efficiency Ratings for Residential*

*Heating and Water Heating Equipment* (GAMA Directory), every April and October.

**Gas Appliance Manufacturers Association, Inc. (GAMA)**, P.O. Box 9245, 1901 North Moore Street, Arlington, VA 22219. Telephone: 703-525-9565.

**Gas Research Institute (GRI)**, 8600 West Bryn Mawr Avenue, Chicago, IL 60631. Telephone: 312-399-8100.

**Industrial Gas Technology Commercialization Center**, 1515 Wilson Boulevard, Arlington, VA 22209. Telephone: 703-841-8463. Started in 1991 to help introduce gas-fired equipment into the *industrial* marketplace.

**International Approval Services - Canada, Inc.**, 55 Scarsdale Road, Don Mills, Ontario M3B 2R3, Canada. Telephone: 416-447-6468. Call to find out if a gas appliance is certified. Publishes the *Directory of Appliances and Accessories* (updated twice annually, January and July).

**International Approval Services - U.S., Inc. (formerly American Gas Association Laboratories)**, 8501 East Pleasant Valley Road, Cleveland, OH 44131. Telephone: 216-524-4990. Call to find out if a gas appliance is certified. Publishes the *Directory of Appliances and Accessories* (updated twice annually, January and July).

**National Fire Protection Association (NFPA)**, One Batterymarch Park, Quincy, MA 02269. Telephone: 617-770-3000 and 800-344-3555, Fax: 800-593-6372. Publishes the *National Fuel Gas Code* (NFPA 54, ANSI Z223.1) and other codes important to the natural gas industry.

**Natural Gas Vehicle Coalition**, 1515 Wilson Blvd., Arlington, VA 22209. Telephone: 703-527-3022.

**Natural Gas Vehicle Producers Association,** 1300 L Street, N.W., Suite 1050, Washington, DC 20005. Telephone: 202-371-1322.

## *Books and Periodicals*

***Principles of Marketing***, 7th ed. by Philip Kotler and Gary Armstrong. Published by Prentice-Hall, Englewood Cliffs, NJ, 1996. ISBN 0-13-190208-3. Probably the best marketing textbook available. Good for an overview of the discipline of marketing as it is taught at business schools.

***National Fuel Gas Code, 1996*** (NFPA 54, ANSI Z223.1) by National Fire Protection Association (NFPA). The national code for natural gas and propane appliance installation and venting. Available from NFPA, 1 Batterymarch Park, Quincy, MA 02269. [Natural Gas and Propane Equipment Information]

***National Electrical Code, 1993*** (NFPA 70) by National Fire Protection Association (NFPA). Available from NFPA, 1 Batterymarch Park, Quincy, MA 02269.

***Consumers' Directory of Certified Efficiency Ratings for Residential Heating and Water Heating Equipment*** (often referred to as the "GAMA Directory") by Gas Appliance Manufactures Association (GAMA). Includes current listings of all certified central residential gas- and oil-fired furnaces and boilers; gas vented direct heating equipment; and all certified residential electric, gas-fired, and oil-fired storage water heaters. Also included are methods for comparing costs of space heating, sizing water heaters, and comparing costs of water heating with different fuels. Published each April and October. Available from GAMA Efficiency Certification Program, ETL Testing Laboratories, Inc., 3933 U.S. Route 11, Cortland, NY 13045. [Gas/Electric Equipment Information]

***Directory of Certified Appliances and Accessories*** by International Approval Services (American Gas Association Laboratories). Includes current listings of all certified gas appliances and accessories, manufacturers, model numbers, input and output ratings. Available from

International Approval Services (AGA Laboratories), 8501 East Pleasant Valley Road, Cleveland, OH 44131. [Natural Gas Equipment Information]

***Commercial Gas Sales Reference Manual*** by Richard Karg. Includes descriptions of commercial natural gas equipment, gas equipment applications for fourteen commercial facility types, glossary, and helpful calculation procedures. Available from Niagara Mohawk Power Corp., 300 Erie Boulevard West, Syracuse, NY 13202 or R.J. Karg Associates, 220 Meadow Road, Topsham, ME 04086. Telephone: 207-725-6723, Fax: 207-725-7818. [Natural Gas Equipment Information and Applications]

***Natural Gas Cooling Equipment Guide*** by American Gas Cooling Center. Includes description and manufacture listings for 1) absorption systems, 2) gas engine-driven systems, 3) desiccant systems, 4) hybrid systems, and 5) systems under development. Available from American Gas Cooling Center, 1515 Wilson Boulevard, Arlington, VA 22209. [Natural Gas Equipment Information]

***Foodservice Gas Equipment Catalog*** by CP Publishing. Catalog of commercial gas foodservice equipment listed by appliance type with descriptions and specifications. Regularly updated. Available from CP Publishing, 104 S. Main Street, 7th Floor, P.O. Box 267, Fond du Lac, WI 54936-0267. Telephone: 414-923-3700. [Natural Gas Equipment Information]

***HVAC Directory & Source Guide*** by Business News Publishing Co. Includes gas & electric HVAC/R products, manufacturers, and where to buy products. Updated annually. Available from Business News Publishing Company, P.O. Box 2600, Troy, Mich. 48007. Telephone: 810-362-3700, Fax: 810-362-0317. [Gas/Electric Equipment Information]

***A Guide to Natural Gas Cooling*** by American Gas Association, edited by Richard Itteilag. Includes overview of gas engine-driven cooling, gas desiccant cooling, gas absorption cooling, gas rooftop systems, utility support for gas cooling, and gas cooling equipment and the environment. Economic analysis for each gas technology is included. Available from Fairmont Press, Inc., 700 Indian Trail, Lilburn, GA 30247. [Natural Gas Equipment Information]

**ASHRAE Handbooks** include four volumes, one is revised each year: ***Fundamentals; HVAC Systems and Equipment; HVAC Applications;*** and ***Refrigeration***. All by American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE). These are the most popular handbooks for HVAC/R engineers and designers. Available from ASHRAE, 1791 Tullie Circle, N.E., Atlanta, GA 30329. [Gas/Electric Equipment Information]

***Glossary for the Gas Industry*** by American Gas Association. Available from AGA, 1515 Wilson Boulevard, Arlington, VA 22209. [Natural Gas Information]

***ASHRAE Terminology of Heating, Ventilation, Air Conditioning, and Refrigeration*** by American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE). A glossary. Available from ASHRAE, 1791 Tullie Circle, N.E., Atlanta, GA 30329. [Gas/Electric Equipment Information]

***Ventilation for Acceptable Indoor Air Quality: ASHRAE Standard 62-1989*** by American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE). The accepted standard for commercial and residential ventilation guidelines. Available from ASHRAE, 1791 Tullie Circle, N.E., Atlanta, GA 30329.

***Means Mechanical Cost Data*** (revised annually) by R. S. Means Company. Includes costs for installing HVAC/R equipment, materials and labor. Available from R. S.

Means Company, 100 Construction Plaza, P.O. Box 800, Kingston, MA 02364-0800. Telephone: 800-334-3509, Fax: 800-632-6732. [Gas/Electric Equipment Information]

***Commercial Applications, Systems and Equipment: Manual CS*** by Air Conditioning Contractors of America (ACCA). Includes overview of design procedure, system selection, application by building type, load analysis, selecting cooling and heating equipment, radiant heat, humidification equipment, all-air systems, water systems, unitary systems, and more. Available from ACCA, 1712 New Hampshire Avenue, NW, Washington, DC 20009. [Gas/Electric Equipment Information]

***Residential Load Calculation: Manual J*** by Air Conditioning Contractors of America (ACCA). This is the most commonly used method for calculating cooling and heating loads for the purpose of sizing cooling and heating systems. Available from ACCA, 1712 New Hampshire Avenue, NW, Washington, DC 20009.

***Commercial Load Calculation: Manual N*** by Air Conditioning Contractors of America (ACCA). Method for calculating cooling and heating loads for low-rise commercial buildings. Available from ACCA, 1712 New Hampshire Avenue, NW, Washington, DC 20009.

***Cooling and Heating Load Calculation Manual***, 2nd ed., 1992 by American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE). Method for calculating cooling and heating loads for all commercial buildings. Available from ASHRAE, 1791 Tullie Circle, N.E., Atlanta, GA 30329.

***Residential Duct System Design, Manual D*** by Air Conditioning Contractors of America (ACCA). Method for designing and sizing ductwork (equal friction method) for residential and small commercial buildings. Available from ACCA, 1712 New Hampshire Avenue, NW, Washington, DC 20009.

***Air Distribution Basics for Residential and Small Commercial Buildings: Manual T*** by Air Conditioning Contractors of America (ACCA). Good, non-mathematical overview of the basics. Available from ACCA, 1712 New Hampshire Avenue, NW, Washington, DC 20009.

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**American Gas**, the monthly magazine of the American Gas Association, 1515 Wilson Blvd., Arlington, VA 22209.

**Air Conditioning, Heating and Refrigeration News (The News)**, a weekly magazine by Business News Publishing Company, P.O. Box 2600, Troy, Michigan 48007. Telephone: 810-362-3700.

**ASHRAE Journal**, the monthly magazine of the American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc., 1791 Tullie Circle, N.E., Atlanta, GA 30329.

**Consulting-Specifying Engineer**, a monthly magazine for engineers specifying equipment for buildings. Published by Cahners Publishing Company, 8773 South Ridgeline Blvd., Highlands Ranch, CO 80126-2329. Telephone: 847-635-8800.

**Engineered Systems**, monthly magazine regarding HVAC equipment by Business News Publishing Company, P.O. Box 7016, Troy, MI 48007. Telephone: 810-362-3700.

**Heating/Piping/AirConditioning (HPAC),** a monthly magazine covering mechanical systems. By Penion Publishing, P.O. Box 96732, Chicago, IL 60693. Telephone: 312-861-0880.

**Home Energy**, a bi-monthly magazine covering residential and multifamily energy use. 2124 Kittredge Street, No. 95, Berkeley, CA 94702. Telephone: 510-524-5405.

**Public Utilities Fortnightly**, a semi-monthly magazine about utility regulation, marketing, structural changes, and case studies. P.O. Box 84, Spencerville, MD 20868-0084. Telephone: 800-421-4494.

## *Online Services*

Online services change quickly. At this time in the early years of the internet, many new sites are being added weekly. Listed here are the internet sites that were found to be the most useful for natural gas marketing information and activities.

There are two ways you can find new sites not listed here. First, you can use one of the search engines on the world wide web. Second, you will find that many of the sites you visit will be linked to other relevant sites, allowing you to move to another site with the click of your mouse button.

It is easy to waste time on the internet. It is a good idea to use the fastest modem available and to know what you are looking for.

**American Council for an Energy Efficient Economy,** maintained by ACEEE. A nonprofit organization involved with research, publishing, and consulting. Keywords: energy efficiency, gas and electric demand-side management, utilities. Internet web address: http://crest.org/aceee/

**American Gas Online,** maintained by the American Gas Association. Includes industry information, consumer information, and access to Gas Industry Online Network (subscription required). Keywords: natural gas, gas utilities, natural gas applications, appliances. Internet web address: http://www.aga.com/

**Alternative Fuels Data Center**, maintained by the United States Department of Energy. Good resource for CNG and LNG vehicle topics. Keywords: fuels, natural gas vehicles, compressed natural gas (CNG), liquefied natural gas

(LNG), alternative fuels. Internet web address: http://www.afdc.nrel.gov/

**ASHRAE Online,** maintained by the American Society of Heating, Refrigerating and Air-Conditioning Engineers. Keywords: standards, energy calculations, heating systems, cooling systems, ventilation, information systems. Internet web address: http://www.ashrae.org/

**Association of Energy Services Professionals (AESP),** maintained by AESP. Good place to look for consulting services or to communicate with consultants. Maintains the AESP-Net mailing list for utility personnel and energy service professionals. Keywords: energy, energy services, energy consultants, public utilities. Internet web address: http://www.dnai.com:80/AESP/

**Energy Information on Internet (EII),** maintained by Netherlands Energy Research Foundation (in English). Listing of over 250 web sites related to energy and public utilities. Keywords: energy, web-sites. Internet web address: http://www.ecn.nl/eii/main.html/

**EnergySource Desktop, Clean Fuel Network,** maintained by Tech 2000 Worldwide, Inc. Keywords: natural gas, information services, product information, market information. Under heading of "Natural Gas Marketplace," lists gas sales market trends and forecasts for ten geographical divisions of the U.S. market. Internet web address: http://www.naturalgas.com/

**Gas Industry On-Line (GIO),** maintained by the American Gas Association. The online link to AGA. *Subscription fee required.* Keywords: natural gas, databases. Internet web address: http://www.gio.com/

**Gas Research Institute**, maintained by GRI. Keywords: natural gas, research, databases. Internet web address: http://www.gri.org/

**GASWEB**, maintained by International Approval Services (AGA Laboratories). Keywords: natural gas, gas utilities, NGV, gas appliances, manufacturers, research. Internet web address: http://www.apk.net/gasweb/

**GRI NET**, maintained by the Gas Research Institute. *Subscription fee required.* Keywords: natural gas, NGV, power generation, exploration, distribution, safety, research. Internet web address: http://www.gri.org/

**Institute for Gas Technology**, maintained by IGT. Keywords: information services, energy, environment, natural gas. Internet web address: http://www.igt.org/

**United States Department of Energy**, maintained by DOE. Keywords: energy, information services. Internet web address: http://web.fie.com/web/fed/doe/

**United States Energy Efficiency and Renewable Energy Network**, maintained by DOE. Keywords: energy, renewable energy, transportation, utilities. Internet web address: http://www.eren.doe.gov/

**United States Energy Information Administration**, maintained by DOE. Good information for natural gas marketing. Keywords: energy, natural gas, data bases, marketing. Internet web address: http://www.eia.doe.gov/

# 8. Glossary

**Absorption Refrigeration Cycle.** This basic refrigeration cycle involves the repeated absorption, separation, condensation, vaporization and reabsorption of the refrigerant. Heat energy rather than mechanical energy moves the refrigerant. The two most common types of absorption systems use water as the refrigerant and lithium bromide as the absorber, and ammonia as the refrigerant and water as the absorber. These systems are relatively simple and require little maintenance. Natural gas is often used to supply the heat for absorption refrigeration.

**Absorption Chiller.** A refrigeration device used to transfer heat between fluids. An absorption chiller refrigeration device uses heat energy, such as that from natural gas combustion, and an absorption unit to produce chilled water. See *Chiller* and *Chilled Water*.

**AFUE.** See *Annual Fuel Utilization Efficiency.*

**Air-And-Water System.** Refers to a central conditioning system for a medium to large building. These systems condition spaces by distributing air and water from a central mechanical area to terminal units installed in the conditioned spaces. The air supplied to the conditioned spaces is called primary air, the hot or chilled water supplied is called secondary water. Ducting is relatively simple. Secondary water distribution can be installed as two-pipe, three-pipe, or four-pipe systems.

**Air-Handling Unit.** A device, usually connected to ductwork and containing a blower to move conditioned or ventilation air through the ductwork.

**All-Air System.** Refers to a central conditioning system for a medium to large building. All heating and cooling (sensible and latent) energy is carried by the distribution air from the central plant to the zones or rooms. These systems may be single zone (often roof-top), reheat,

variable-air-volume (VAV), dual duct, or multizone. Contrast with *Air-and-Water system* and *All-Water System.*

**All-Water System.** Refers to a central conditioning system for a medium to large building. Hot or chilled water is supplied from a central plant to the conditioned spaces through the water distribution system. Individual air handlers with hot water and chilled water coils supply the spaces with conditioning. It is quite easy to install these systems in existing buildings because the distribution pipes do not require much space.

**Annual Fuel Utilization Efficiency (AFUE).** A value derived by a standard test procedure (NBSIR 78-1543 or ANSI/ASHRAE Standard 103-1988) which is meant to estimate the seasonal efficiency of a combustion heating system. May be expressed as the total heating output divided by the total energy or fuel input.

**Atmospheric Steamer.** A pressure-less steam cooker made to operate at normal atmospheric pressure.

**Base Load, Residential Gas.** The gas consumed by all gas appliances—clothes dryers, water heaters, and ranges—excluding space conditioning appliances.

**Bio-Gas.** Methane gas produced by the decomposition and processing of organic materials.

**Boiler Horsepower.** A unit used for rated boiler input and output. One boiler horsepower equals 33,475 Btuh.

**Boiler Trim.** Apparatus, usually for safety, connected to the pressure side of the boiler. Examples are steam gages, water gages, and pressure safety valve.

**Boiler, Dry-Base.** A boiler with a firebox below all the water-filled areas of the heat exchanger. Water-filled areas are only above the firebox.

**Boiler, Wet-Base.** A boiler with a firebox surrounded by water-filled sections of the heat exchanger, except for necessary openings. Water-filled areas are above, on all sides, and below the firebox.

**Boiler, Wet-Leg.** A boiler with a firebox having water-filled sections above, and on the sides, but not below.

**Booster Water Heater.** An auxiliary water heater used to raise water temperature from 140°F to above 180°F for commercial kitchen dish washer rinse cycles.

**British Thermal Unit (Btu).** The amount of thermal energy (heat) required to increase the temperature of one pound of water by one degree Fahrenheit.

**Broker.** A natural gas wholesaler who does not take title to gas, whose function is to bring gas buyers and sellers together and assist in negotiation.

**Btu.** See *British Thermal Unit.*

**CCF.** One hundred cubit feet. A common unit for metering natural gas.

**CFM.** Cubic Feet per Minute. Often used to measure airflow.

**Char Broiler.** A broiler with an open grill over charcoal or ceramics, most often natural gas-fired. Gas input rates are usually 40,000 to 100,000 Btu/hr.

**Chilled Water.** Water of 42°F to 45°F circulated through water coils for space cooling and dehumidification.

**Chiller.** A refrigeration device used to transfer heat between fluids. An absorption chiller refrigeration device uses heat energy, such as that from natural gas combustion, and an absorption unit to generate chilled water. A mechanical chiller refrigeration device uses mechanical energy input to generate chilled water.

**Chinese Range.** A specialized gas range with integral range top racks for woks (a Chinese pot).

**City Gate.** The point at which a gas distribution company receives gas from a pipeline company.

**Coefficient Of Performance (COP).** The ratio of usable output energy divided by input energy. The total heating output of a heat pump includes the heat generated by the circulating fan but excludes supplemental resistance heat.

**Cogeneration.** The use of a single fuel source to simultaneously produce electricity and heat (steam or hot water).

**Coil.** A device made up of a configuration of tubes or pipes through which steam, hot water or chilled water flows. Used for heating or cooling air.

**Collateral Appliance.** See *Collateral Load.*

**Collateral Load.** Accompanying gas loads or appliances connected concurrently with or peripherally to another gas load or appliance. The economic advantages of these collateral loads are often included as part of the benefits of a primary load or appliance.

**Combination Oven/Steamer.** A convection oven and steam cooker integrated into one compartment.

**Commissioning.** A set of procedures to ensure that building components and systems are installed and operating in an optimal fashion to meet or exceed the designed intent.

**Compartment Steamer.** A device that rapidly cooks food by direct contact with steam. Either low or high pressure steam. The compartments vary from 30 to 100 pounds in capacity.

**Compressor.** A device used for mechanically increasing the pressure of a gas, such as a refrigerant.

**Condensate.** A liquid formed by the condensation of vapor (phase change from vapor to liquid).

**Condenser.** A heat exchanger upon which water vapor condenses (changes state) as a result of the coil temperature being below the dew point temperature of the air passing through. A heat exchanger in which high pressure refrigerant gas is condensed by transferring thermal energy to a cooling medium.

**Condensing Unit.** A high-efficiency heating unit—most often a furnace, but sometimes a boiler—that has an exhaust temperature below the dew point temperature of the

exhaust gases (about 130°F). The slightly acidic condensate must be discharged from the appliance.

**Conditioned Space.** The space within a building that is intentionally heated or cooled.

**Convection Oven.** An oven in which heated air is rapidly circulated by a fan. Allows for the even baking of foods. The gas input rate for most convection ovens is from 50,000 to 110,000 Btu/hr.

**Conversion Gas Burner.** A gas burner designed to be installed in an appliance originally intended to use another fuel.

**Conveyorized Oven.** Ovens that use gas-fired infrared burners and forced convection. A conveyor mechanism carries the food to be baked, often pizza, through the oven over a specified time for proper baking.

**Cooling Capacity.** The total cooling capacity of a cooling device. Usually includes the latent cooling capacity (removal of water vapor) and sensible cooling capacity (reduction of air temperature).

**Cooling Tower.** A heat transfer device or structure, often tower-like, used for air-cooling warm water, usually by evaporation. There are many types of cooling towers.

**Cooling Load.** The amount of cooling needed by a building at design conditions during a given period, usually one hour.

**Cooling Tower Ton.** The total heat rejection capacity of a cooling tower, equal to 15,000 Btu/hr (12,000Btu/hr x 1.25% = 15,000Btu/hr). Based on 25% compressor heat added to one ton of refrigeration capacity.

**Deck Type Oven.** Ovens that may be placed one above another in various configurations. Depending upon the type and number of deck ovens in a configuration, total gas input rates can be from 30,000 to 240,000 Btu/hr, the average being 100,000 Btu/hr or under.

**Deep Fat Fryer.** A deep fat fryer consists of a deep kettle that is filled with oil or fat and is heated from the underside by gas burners. The appliance is used for making French fries, fried chicken, etc. These fryers are available as floor and counter appliances. Counter fryers require from 27,500 to 48,000 Btu/hr Larger units require from 84,000 to 212,000 Btu/hr.

**Degree Day, Heating.** See *Heating Degree Day.*

**Dehumidification.** The process of removing water vapor from the air.

**Dehumidifier.** An air cooler, absorption, or adsorption device used for removing water vapor from the air.

**Dekatherm.** The equivalent heating value of 1,000,000 Btu's or 10 therms.

**Demand Meter.** An electric meter that measures demand charge and kilowatt hours used.

**Demand Charge.** A charge for gas or electric service based on actual or estimated peak daily (or hourly, weekly, monthly) usage of a customer.

**Desiccant.** A substance in an air-conditioning system that dehumidifies by absorption or adsorption.

**Direct Purchase Gas.** Gas purchased by a user directly from the source rather than from the local natural gas company. Also called transportation gas, spot market gas, and gas transported for the account of others. In 1989, 12% of all gas consumed in commercial buildings was direct purchase gas.

**Direct Vent Appliance.** Appliance constructed and installed so that all combustion gases are vented to the outside *and* all combustion supply air is derived directly from the outside through a dedicated pipe or passageway.

**Direct-Expansion Refrigeration System.** A refrigeration system that uses a compressor and expansion valve to produce a cooling effect. Sometimes referred to as a DX

system. Split systems, roof-top units, and window units are typically DX devices.

**District Heat.** Steam or hot water from an outside source used as an energy source for space heating or another end use in a building. The steam or hot water is heated at a central plant and piped to buildings for use.

**Diversity Factor.** The ratio of the maximum probable demand to the maximum possible demand.

**Draft.** The flow of combustion gases through a vent system caused by differences in pressure. *Natural draft* is created by the difference between the density of the flue gases and the density of the outside air. The difference in density is created by the temperature differences. Negative pressure is created in the vent system. *Induced draft* is mechanically created by a fan located at the point of exit of the flue gases to the outside. Negative pressure is created in the vent system. *Forced draft* is mechanically created by a fan, integral to the combustion appliance, creating positive pressure in the vent system.

**Draft Diverter.** A draft regulation device either built into a gas appliance or added to a vent system. Also referred to as a draft hood.

**Draft Hood.** See *Draft Diverter.*

**Draft, Forced.** Forced draft is mechanically created by a fan, integral to the combustion appliance, creating positive pressure in the vent system. The fan is always installed by the manufacturer of the appliance and may not be installed in the field.

**Draft, Induced.** Induced draft is mechanically created by a fan located at the point of exit of the flue gases to the outside. Negative pressure is created in the vent system. An induced draft fan can be added to most natural draft gas appliances, thereby converting them to induced draft appliances. Generally, this is not a violation of the *National Fuel Gas Code.*

**Draft, Natural.** Natural draft is created by the difference between the density of the flue gases and the density of the outside air. The difference in density is created by the temperature differences. Negative pressure is created in the vent system.

**Dry-Base Boiler.** See *Boiler, Dry-Base.*

**Dual-Duct System.** An air conditioning system having a central plant that produces air at two temperatures and humidities, that is distributed through two distinct duct systems to the conditioned spaces where mixing may be carried out to achieve desired temperatures.

**Dual Temperature Water Heating.** A system for supplying hot water at two temperatures, usually 140°F and 180°F, used in commercial kitchens. There are various ways of supplying two water temperatures, including booster water heaters and water heaters with hot/cold water mixing valves.

**Duct Heater.** A heat source installed inside of a duct used to heat the area served by the duct.

**Economizer Cycle.** A cycle or stage of a cooling system that reduces the mechanical cooling requirements, usually accomplished with the controlled use of outdoor air.

**Energy Efficiency Ratio.** A ratio calculated by dividing the cooling capacity, in Btu's per hour (Btuh), by the power input, in watthours, at any given set of rating conditions, expressed in Btuh per watt-hour (Btuh/watt-hour).

**Energy Factor.** A measure of overall efficiency—energy output compared to energy consumption over a 24-hour period. Used primarily for direct-fired storage water heaters.

**Energy Management.** The systematic planning and implementation of building or facility energy requirements for optimum performance.

**Energy Service Company (ESCo).** Companies that offer customers pricing options and contracts; information services; efficient lighting, heating, cooling, and drive power; maintenance; and financing for energy equipment investments. These companies develop and coordinate energy projects, similar to a real estate developer. Many ESCos are unregulated subsidiaries of gas or electric utilities.

**Envelope.** The outer skin of a building that separates conditioned air from unconditioned outside air. Sometimes referred to the insulated envelope or insulated shell.

**Equipment Service Life.** The expected useful life of a piece of equipment, usually expressed in years. Equipment service life is necessary for the calculation of the life cycle cost of a particular piece of equipment. Also, if a piece of equipment has reached the end of its predicted useful life, replacement should be planned.

**Evaporative Cooling.** The cooling of water and/or surrounding air by evaporating a portion of the water.

**Evaporator.** A heat exchanger in which a refrigerant evaporates by absorbing thermal energy from a medium to be cooled.

**Fan, Induced Draft.** A fan used for exhausting hot combustion gases by suction. Such a fan creates negative pressure in the vent connector of the combustion appliance.

**Fan-Assisted Combustion.** An appliance equipped with a fan to either draw air through the combustion chamber (induced combustion fan creating negative pressure) or force air through the combustion chamber (forced combustion fan creating positive pressure).

**Firm Gas Rates**. Rates given to high-priority customers whose service cannot be interrupted.

**First Hour Rating.** The maximum number of gallons a water heater can supply in one hour. First hour rating values for all residential water heaters currently manufactured may be found in the *Consumer's Directory of*

*Certified Efficiency Ratings for Residential Heating and Water Heating Equipment*, the "GAMA *Directory*," by the Gas Appliance Manufacturers Association. The first hour rating of a water heater should be matched with the peak hour demand of the occupants.

**Food Warmer.** An insulated container used to keep food at serving temperature, either mobile or stationary.

**Forced Air Furnace.** A furnace equipped with a fan or blower that circulates the distribution air for heating space. Downflow furnace discharges the circulation air downward near the bottom or the furnace. Upflow furnace discharges the circulation air upward near the top of the furnace. Horizontal furnace moves the circulation air sideways, from one end of the furnace to the other.

**Fry Top Range.** A gas range with a flat metal surface for a top with provision for carrying excess grease to a receptacle.

**Fuel Charge.** The fuel charge represents the variance in the cost of generation fuel—gas, coal, or oil—used for the production of electricity. This charge is passed on to the consumer.

**Furnace.** A heating system that heats, and usually forcefully distributes, air. Often used as a general term for a central heating system of any type.

**Gas Transported For The Account Of Others.** Gas purchased by a user directly from the source rather than from the local natural gas company. Also called transportation gas, direct purchase gas, and spot market gas. In 1989, 12% of all gas consumed in commercial buildings was gas transported for the account of others.

**Gate Station.** A receiving and pumping station operated by a gas utility.

**Griddle.** A flat metal surface on which food is cooked by dry heat. The average commercial gas range (griddle) burner has an input rating of 24,000 to 30,000 Btu/hr. Most griddles have two burners.

**Grill.** A cooking device with a top and bottom heating element used for making grilled cheese sandwiches, etc. Also, a term used for a griddle. The average commercial gas range (grill) burner has an input rating of 24,000 to 30,000 Btu/hr. Most grills have two burners.

**Heat Pump, Air Source.** A refrigeration system that cools and heats, using the outside air as a heat sink during cooling operation and as a heat source for heating the conditioned space. Air source heat pumps have five basic parts: Outdoor coil (condenser coil for cooling, evaporator coil for heating); indoor coil (evaporator coil for heating, condenser coil for cooling); the compressor; the expansion or metering device; and the four-way valve or reversing mechanism.

**Heat Pump, Ground Source.** Also referred to as ground water, water source, and geothermal heat pumps. A heat pump for which the "outdoor" coil (condenser coil for cooling, evaporator coil for heating the condition space) exchanges heat with water, using the water as a heat sink for cooling and as a heat source for heating the conditioned space. Ground source heat pumps have five basic parts: Water coil (condenser coil for cooling, evaporator coil for heating); indoor coil (evaporator coil for heating, condenser coil for cooling); the compressor; the expansion or metering device; and the four-way valve or reversing mechanism. In open loop-systems, the water flows through the water coil (analogous to the outdoor coil of an air source heat pump) from a well, pond, steam, or municipal water supply. In closed-loop systems the water that flows through the water coil is reused indefinitely. The closed-loop, usually made of plastic pipe, is buried in the ground surrounding the conditioned building.

**Heat Recovery Ventilator.** Air-To-Air Heat Exchanger. A heat exchanger that transfers thermal energy from an exhaust air-stream (stale air) to an isolated supply air-stream (fresh air).

**Heated Space Or Conditioned Space.** The space within a building that is intentionally heated.

**Heater, Make-Up Air.** A self-contained, gas-fired space heater that heats air from the outside and directs it into a building.

**Heating Degree Day (HDD).** The average temperature of a twenty-four hour day subtracted from 65°F. The heating degree day value for a weather year (July 1 through June 30) is the sum of the heating degree day values for each day of the year.

**Heating Seasonal Performance Factor (HSPF).** The total heating output of a heat pump during its normal operating season, in Btu, divided by the total electric input during the same period.

**Heating Load (Design Heat Load).** The heat required by a building at design conditions for a specific duration, usually one hour.

**Heavy Duty Range.** Range designed for heavy commercial use, usually made in modular sections that may be joined. Gas range burners have input ratings from 14,500 to 30,000 Btu/hr and oven input ratings are 30,000 to 55,000 Btu/hr. Design input for a gas range/oven is from 92,000 to 195,000 Btu/hr.

**Horsepower, Boiler.** Equivalent to 33,475 Btu per hour or the evaporation of 34.5 pounds of water at 212°F and above.

**Hot Top Range.** A gas range with a flat metal surface for a top. Once it is brought up to operating temperature, the entire surface can be used for cooking.

**HSPF.** See *Heating Seasonal Performance Factor.*

**HVAC.** Heating, Ventilating, and Air Conditioning.

**HVAC & R.** Heating, Ventilating, Air Conditioning and Refrigeration.

**IAQ.** Indoor Air Quality. An often used guide for indoor air quality is *Ventilation for Acceptable Indoor Air Quality* (ASHRAE 62-1989).

**Incineration.** The process of reducing refuse to ash.

**Infiltration.** Uncontrolled air leaking into a building through the building envelope or shell.

**Infrared Broiler.** A broiler using infrared heat energy for cooking. The infrared burner consists of a ceramic, perforated core, that is heated by a gas flame.

**Infrared Heater.** A heater that transmits a substantial amount of its heat energy in the form of infrared energy. Gas infrared heaters may be of the vented or unvented type. Sometimes referred to as radiant heaters.

**Instantaneous Water Heater.** A domestic or commercial water heater with a relatively high energy input designed to heat water quickly. Does not store water (so no storage energy losses).

**Interruptible Service.** A service which many utilities offer to large commercial and industrial customers allowing reduced pricing on gas consumption if the customer agrees to switch temporarily to another fuel whenever a peak load on the system creates a risk that the utility might not be able to serve all customers. This risk usually only arises during cold weather.

**Joule (J).** The work done by the force of one Newton acting over a distance of one meter or the work done by one ampere flowing through a resistance of one ohm for a period of one second.

**Latent Cooling Load.** The part of a cooling load associated with the removal of water vapor—dehumidification—from the air.

**Liquefied Natural Gas (LNG).** Natural gas that has been liquefied by lowering its temperature to negative 260°F.

**Load Factor.** The ratio of a gas customer's average annual load to their peak demand.

**Loads, Connected.** The sum of the rated Btu input of gas appliances connected to a piping system.

**Make-Up Air.** Air that is brought in from the outside to replace exhausted air.

**Manifolding.** Piping of a series of lines to one common intersection for distribution to other components. Sometimes used for the installation of multiple gas boilers serving one building.

**Manufactured Gas.** Gas that is made from coal or other hydrocarbon fuels.

**Market.** A group of potential buyers of a product or service.

**Market Positioning.** Planning for a product or service to occupy a clear, distinctive, and desirable place relative to competing products or services in the minds of the target consumers.

**Market Targeting.** The process of evaluating each market segment's appeal and selecting one or more segments to enter.

**Marketing.** A social and managerial process by which individuals and groups obtain what they need and want through creating and exchanging products, service, and value with others.

**Marketing Strategy.** The means of marketing by which the company managers intend to achieve their marketing objectives.

**MBH.** One thousand Btu per hour.

**MBtu.** One thousand Btu.

**MCF.** One thousand cubic feet. Common unit for metering natural gas.

**Mechanical Chiller.** A refrigeration device used to transfer heat between fluids. A mechanical chiller refrigeration device uses mechanical energy input to generate chilled water.

**Mechanical Refrigeration Cycle.** Also called vapor-compression refrigeration cycle. A common refrigeration method using a special refrigerant (usually a chlorofluorocarbon or ammonia) which is compressed by a compressor, condensed in a condenser, and vaporized in an evaporator. The refrigerant is moved by mechanical means. A direct-expansion refrigerating system is a type of vapor-compression system.

**Meter Bar.** A setup tool (spacer bar) used by gas utilities to assist field installers in the connection of the building gas piping to the gas meter. The meter bar is installed on the piping system before the gas meter is connected and insures that the gas meter will fit on the piping system at the time of connection.

**Methane.** The first of the paraffin series of hydrocarbons, $CH_4$. The primary constituent of natural gas.

**Mission Statement.** A statement of the company's purpose—what it wants to accomplish in the larger environment.

**MMBtu.** One million Btu.

**Multizone.** Various spaces of a building over which the conditioning system may be controlled independently of other spaces or zones. More than one zone.

**Natural Gas.** A naturally occurring gaseous hydrocarbon with a specific gravity of 0.6 and a heat content of about 1030 Btu per cubic foot. Its primary component is methane. The chemical formula for methane (natural gas) is $CH_4$.

**Net Savings.** The difference between savings and costs, where both are discounted to present or annual values. The net savings method of economic analysis can be used as a measure of project worth.

**Open Top Range.** Gas ranges with grates on the top upon which pots are set directly over the burners.

**Packaged Terminal Air Conditioner (PTAC).** A self-contained, factory-ready, air conditioning system for through-the-wall installation. Commonly found in motel and hotel rooms.

**Packaged Unit.** A refrigeration or heating system for which all the major components are located in one cabinet. Packaged units are in contrast to engineer-specified units built up from individual components for use in a building.

**Part-Load Efficiency Or Value.** The efficiency of a device, usually a space heating or cooling system, at a load less than full load.

**Peak Hour Demand.** The maximum demand for hot water by the occupants of a building during a one hour period. The first hour rating of a water heater should be matched with the peak hour demand.

**Peel Oven.** This type of gas oven gets its name from the long paddle or peel used to load and unload the baked goods. These ovens are site-constructed of fire brick and other materials and usually have capacities of from 80 to 200 one-pound bread loaves per baking.

**Pickup Load.** The load imposed on a space conditioning system after the period of temperature setback ends. The size of conditioning systems is often increased to accommodate the pickup load and shorten the pickup time.

**Pickup Time.** The time required for conditioned space temperature to rise to the set temperature after a period of temperature setback ends.

**Pilot.** A small gas burner used to light a larger gas burner.

**Pizza Oven.** A deck type oven arrangement with a high temperature baking capacity with somewhat lower hearth temperature. Most pizza ovens require a gas input rate of from 50,00 to 140,000 Btu/hr.

**PPM.** Parts per million.

**Present Worth Or Value.** The time-equivalent value at a specified base time—the present—of past, present, and future cash flows.

**Pressure, Atmospheric.** The pressure of the weight of air and its contained water vapor exerted on the surface of the earth at sea level, approximately 14.7 pounds per square inch or 29.921 inches of mercury at 32°F.

**Process Air.** In the process of desiccant dehumidification, this is the air to be dehumidified.

**Propane Gas (LPG).** A colorless, flammable fuel gas produced from petroleum. Propane has a specific gravity of 1.52 and a heat content of 2500 Btu per cubic foot. The chemical formula for propane is $C_3H_8$.

**PTAC.** See *Packaged Terminal Air Conditioner*.

**Pulse Combustion.** A type of gas combustion characterized by the controlled chain reaction of 60 to 70 explosions (pulses) per second in a special combustion chamber.

**Quick-Disconnect Coupling.** A pipe coupling with a shut off valve. This type of connection allows gas appliances to be easily connected and disconnected for moving and cleaning. Commonly used in commercial kitchens.

**Radiant Heater.** See *Infrared Heater*.

**Range Oven.** A heavy duty or restaurant range with an oven under the range top. Gas range burners have input ratings from 14,500 to 30,000 Btu/hr and oven input ratings are 30,000 to 55,000 Btu/hr. Design input for a gas range/oven are from 92,000 to 195,000 Btu/hr.

**Reactivation Air (Regeneration Air).** In the process of desiccant dehumidification, the heated air used to dry (reactivate or regenerate) the saturated desiccant. The heat for reactivation air can be supplied by natural gas combustion and/or waste heat.

**Recirculation Pump.** A pump used to circulate service hot water within a large building, often used in hotels or motels, or commercial kitchens.

**Refrigerant.** In a refrigeration system, the heat transfer medium that absorbs heat by the process of vaporization and releases heat by the process of condensation. Refrigerants may be chlorofluorocarbons, halocarbons, ammonia, water, etc.

**Refrigeration System.** A heat transfer device that moves heat from a heat source (evaporator) to a heat sink (condenser) with the use of a heat transfer fluid or refrigerant.

**Refrigeration, Absorption.** This basic refrigeration cycle involves the repeated absorption, separation, condensation, vaporization and reabsorption of the refrigerant. Heat energy, rather than mechanical energy, moves the refrigerant . The two most common types of absorption systems use water as the refrigerant and lithium bromide as the absorber, and ammonia as the refrigerant and water as the absorber. These systems are simple and require little maintenance. Natural gas is often used to supply the heat for absorption refrigeration process.

**Reheat Coil.** A heating coil installed downstream of a cooling coil.

**Reheat System.** An air system where sensible heat is added to air that has been previously cooled to a temperature below that desired for the conditioned space. These systems are being used less because of their high energy consumption.

**Relationship Marketing.** The process of creating, maintaining, and enhancing strong, mutually beneficial relationships with customers.

**Retailing.** All activities involved in selling goods or services directly to the final consumers.

**Restaurant Range.** Range designed for heavy use but not as durable as a heavy duty range and usually not made to be joined together as modules. Gas range burners have input ratings from 14,500 to 30,000 Btu/hr and oven input ratings are 30,000 to 55,000 Btu/hr. Design input for a gas range/oven is from 92,000 to 195,000 Btu/hr.

**Revolving Tray Oven.** An oven with revolving trays suspended from wheels.

**Roof-Top Air Conditioning Unit.** A packaged heater/cooling unit mounted on the roof of a building, the air from the unit being directed into the building, usually through ductwork.

**Rotisserie Broiler.** This type of gas broiler is designed for food service establishments that barbecue in a prominent part of the facility. It is a vertical broiler heated by refractory, infrared, gas burners located at the back of the unit. The capacity can be as much as 28 whole chickens per loading. Input rates are 30,000 Btu/hr per burner; there are usually one to three burners.

**Rotary Meter.** A high-capacity gas meter that uses the gas passing through its impellers to measure gas volume.

**Salamander.** A small broiler or cheese melter mounted over a heavy duty cooking range. Gas input varies from 30,000 to 66,000 Btu/hr.

**Sanitize Cycle.** The rinse/sanitize cycle used in commercial dish washers. This cycles use either water at a temperature at or above 180°F or chemicals such as bleaches to sanitize the dishes.

**Sealed Combustion.** See *Direct Vent Appliance.*

**Seasonal Efficiency.** The efficiency of combustion, usually space heating, over an entire heating season. Accounts for losses in the vent systems, absorption by the unit, and stand-by losses. Annual Fuel Utilization Efficiency (AFUE) is an estimate of seasonal efficiency.

**Seasonal Energy Efficiency Ratio.** The total cooling capacity of a central unitary air conditioner or unitary heat pump, in Btu's, during its normal annual usage period for cooling, divided by the total electric energy input, in watt-hours, during the same period.

**Sensible Heat Ratio (SHR).** The ratio of the sensible cooling load to the total cooling load (sensible cooling load plus latent cooling load). Sometimes referred to as the Sensible Load Ratio.

**Sensible Load Ratio (SLR).** See *Sensible Heat Ratio.*

**Sensible Cooling Load.** The part of cooling load associated with lowering the temperature of the air. See *Latent Cooling Load* and *Sensible Heat Ratio.*

**Service Line.** Underground gas line running from the gas main to a gas meter.

**Service Regulator.** A pressure regulator used to reduce and regulate service line gas pressure at the meter. Usually is the property of the gas utility.

**Service Water Heating.** The heating of water for domestic or commercial use other than for space heating.

**SI Units.** Le Systeme International d'Unites. The international agreement on the use of the metric system of units.

**Spot Market, Gas.** Gas purchased by a user directly from the source rather than from the local natural gas company. Also called transportation gas, direct purchase gas, and gas transported for the account of others. In 1989, 12% of all gas consumed in commercial buildings was spot market gas.

**Steam Cooker.** A gas appliance that defrosts and cooks food by direct contact with steam.

**Steam Jacket.** The outer shell of a large kettle in which steam is circulated under pressure so that the steam does not come in contact with the food. Steam jacketed kettles are used to braise, boil or simmer foods. A medium capacity steam-jacketed kettle has a gas input rating of 100,000 Btu/hr.

**Steam Table (Food Warmer).** This device is used to warm foods. It consists of a shallow water reservoir with a cover(s) that can accommodate standard meat trays, vegetable crocks, gravy boats and roll warmers. Gas-fired steam tables required an input rate of 3,500 Btu/hr per compartment.

**Stock Pot Range.** A specialized gas range into which a stock pot can be inserted for heating and cooking.

**Strategic Planning.** The process of developing and maintaining an effective fit between the company's goals and changing marketing opportunities.

**Supply Air.** For an air distribution system, the conditioned air entering the conditioned space from the air handler, heating appliance, or cooling appliance.

**Terminal Unit Or Element.** The means by which the energy of a system is finally delivered. Examples are registers, baseboard units, diffusers, radiators, and radiant floor panels.

**Therm.** The equivalent of 100,000 Btu or approximately 100 cubic feet of natural gas.

**Tilting Braising Pan.** A griddle pan mounted on pins so that it can tilt to dispense the food prepared in it. Gas input rates required vary from 36,000 to 240,000 Btu/hr.

**Toaster, Commercial.** This common gas appliance consists of a motor driven conveyor that carries the bread through a thermostatically controlled toasting compartment. The toasted bread is automatically discharged at the end of the toasting cycle. The average gas input rate is 32,000 Btu/hr.

**Ton Of Refrigeration.** The equivalent of 12,000 Btu/hr of cooling capacity. Based on the number of Btu/hr required to make or melt one ton of ice over a 24 hour period.

**Transportation Gas.** Gas purchased by a user directly from the source rather than from the local natural gas company. Also called direct purchase gas, spot market gas, and gas transported for the account of others. In 1989, 12% of all gas consumed in commercial buildings was transportation gas.

**Trunnion Kettle.** A steam-jacketed kettle mounted on pins so that it can tilt to dispense the food prepared in it.

**Turndown Ratio.** The safe operating range of a burner; the ratio of the maximum input over the minimum input. If a burner has a safe operating range of 200,000 to 40,000 Btuh, the turndown ratio is 5:1.

**Unit Heater.** A self-contained, automatically regulated, vented space heater. May be installed without ductwork attached (Low-static pressure unit heater) or may be installed with ductwork attached (High-static pressure unit heater). Also called air heater or forced convection heater.

**Utility Gases.** Natural gas, liquefied petroleum gas, manufactured gas, or mixtures of any of these gases.

**Vapor-Compression Refrigeration Cycle.** See *Mechanical Refrigeration Cycle.*

**Variable-Air-Volume System (VAV).** Variable-air-volume systems accomplish cooling and heating by keeping the distribution air temperature constant and varying the air volume delivered to the conditioned space.

**Vented Gas Appliance Categories.** *Category I* is made up of appliances which operate with negative pressure and relatively high temperatures in the vent connector, high enough to prevent excessive condensation from forming. The *National Fuel Gas Code* addresses Category I appliances. *Category II* is made up of appliances which operate

with negative pressure and relatively low temperatures in the vent connector, low enough to cause excessive condensation. There are few, if any, Category II appliances on the market. *Category III* gas appliances operate with positive pressure and relatively high temperatures in the vent connector, high enough to prevent excessive condensation from forming. *Category IV* gas appliances operate with positive pressure and relatively low temperatures in the vent connector, low enough to cause excessive condensation.

**Water Heater.** An appliance that supplies hot water for domestic or commercial purposes, usually for purposes other than space heating. There are several types of water heaters. Direct-fired storage, residential units heat and store water at a controlled temperature for delivery on demand. The input rating does not exceed 75,000 Btu per hour. Direct-fired storage, commercial units heat and store water at a controlled temperature for delivery on demand. The input rating exceeds 75,000 Btu per hour. An indirect-fired storage water heating system obtains thermal energy for heating water from a space heating boiler and stores the water in a vessel remote from the boiler. This vessel often contains a water-to-water heat exchanger that separates the boiler water from the stored water used for domestic or commercial purposes. An instantaneous water heater heats water instantly as it passes through the device. There is no storage area for hot water.

**Waterless Food Warmer.** This gas appliance is similar to a steam table food warmer, but it uses warm air rather than steam for keeping food warm. The gas input rate for each of the burners is approximately 3,500 Btu/hr.

**Wet-Base Boiler.** See *Boiler, Wet-Base.*

**Wet-Leg Boiler**. *See Boiler, Wet-Leg.*

**Yard Line.** A underground gas pipe running from one building to another, neither end being connected directly to a gas meter.

**Zone.** A designated part of a building in which the heating and cooling requirements are controlled by a single control device, such as a thermostat.

# Appendix

## *Comparisons of Major Fuels*

When marketing and selling, it is important to be aware of the advantages and disadvantages of natural gas compared with other common fuels. Fortunately, natural gas has many more advantages than disadvantages.

This section also includes myths—and the facts—about the major fuels.

**Natural Gas and Propane**

- **Advantages of Natural Gas Over Propane**
  - Natural gas costs less.
  - Natural gas does not require storage space.
  - Do not have to pay for before it is consumed.
  - Natural gas is lighter than air and, therefore, in many situations will be safer than propane which is heavier than air.
  - Many people perceive that natural gas is safer than propane.
- **Advantages of Propane Over Natural Gas**
  - Propane is available in remote areas.
  - Propane dealers are smaller and local (this may or may not be an advantage).
- **Myths about Propane**
  - An appliance converted from natural gas to propane produces more heat. *Fact:* It will produce the same amount of heat at the same efficiency.
- **Considerations for Conversions from Propane to Natural Gas**
  - Input rate.
    - The manifold pressure of the appliance must be reduced.
    - The orifice(s) size must be increased.

- The input rate (firing rate) after the conversion to natural gas must be very close to what is was before the conversion.
- Gas to building.
  - Communication between utility and owner.
  - Hook-up from street to building.
  - Proper meter sizing.
  - Codes and utility regulations.
- Gas Piping.
  - From service entry to appliance(s).
  - Proper sizing (NFPA 54, Part 10).
  - Pipe material: steel, CSST, rigid plastic
- For most conversions, the venting materials will not require alteration.

**Natural Gas and Oil**

- **Advantages of Natural Gas over Oil**
  - Natural gas use is promoted by some state regulatory agencies.
  - Often results in higher resale value of building.
  - Because there is no storage, there is no possible environmental damage from spills or leakage.
  - No storage tank regulations or fees.
  - No fuel storage space is required.
  - Do not have to pay for before it is consumed.
  - Natural gas is a cleaner burning fuel and is less likely to cause environmental damage. It emits 115 pounds and No. 2 fuel oil emits 170 pounds of carbon dioxide per MMBtu of energy consumed.[65]
  - Natural gas is cleaner burning and, as a result, natural gas appliances require less maintenance than oil-burning appliances.
  - Natural gas exhibits greater seasonal price stability than oil.

[65] U.S. Environmental Protection Agency.

- Natural gas heating equipment can be more efficient than oil-burning equipment. In late 1996, the highest efficiency gas-fired furnace had a listed AFUE of 96%, the highest oil-fired, 84%. The highest listed efficiency for gas-fired boilers was 90%, the highest for oil-fired was 88%.[66]
- Lower firing rates are available.
- More venting options are available.
- Direct venting appliances are readily available.
- No oil smell from over-fill of oil tank.
- Generally quieter than oil-burning appliances.
- Usually lower life-cycle cost that oil-fired appliances.
- Natural gas is regulated be state utility commissions. Most feel this is an advantage.
- Approximately 90% of the natural gas used in the U.S. is produced domestically. Less than 50% of the oil used in the U.S. is produced domestically. This makes oil more vulnerable to foreign influences.
- Oil imports represent a major element of the U.S. international trade imbalance. Natural gas does not contribute to this trade imbalance.
- Natural gas heating systems do not require as high a sizing multiplier as oil-fired systems. This is because gas-fired systems are not as likely to become dirty and go out of tune as quickly as oil-fired systems.
- Natural gas is usually available at less expensive interruptible rates for high-volume users.
- Other gas appliances—collateral load or collateral appliances—are a convenient option once natural gas is supplied to building.

[66] *Consumers' Directory of Certified Efficiency Ratings for Residential Heating and Water Heating Equipment* (often referred to as the "GAMA Directory") by Gas Appliance Manufactures Association (GAMA), October, 1996.

- The supplier is regulated, therefore, consumer is protected.

- **Advantages of Oil Over Natural Gas**
  - Oil is available in remote areas.
  - Oil dealers are smaller and local (this may or may not be an advantage).
  - Little perceived chance of explosion.
  - Smells if backdrafting, so if occupants are awake, carbon monoxide is usually detectable.
  - Storage gives some users a feeling of security.
  - Can buy oil in bulk when prices are low.
  - Can alter firing rate simply by changing nozzle size.
  - Choice of fuel suppliers.
  - Natural gas is a strong greenhouse gas when released unburned into the atmosphere. [67]

- **Myths about Oil**
  - Oil is more efficient than natural gas. *Fact:* A particular oil heating system or water heater might be more efficient than a particular natural gas unit, but the most efficient natural gas units on the market have significantly higher efficiencies than the most efficient oil units.
  - Oil has more British thermal units (Btu). *Fact:* Oil is a more concentrated fuel—a one gallon bucket of No. 2 fuel oil contains about 139,000 Btu of thermal energy, whereas, the same bucket would only hold about 1,000 Btu of natural gas—but this line of thought is faulty. The truth is that one Btu of oil contains the same amount of thermal energy as one Btu of natural gas. An oil

[67] Methane, the primary component of natural gas, is a greenhouse gas 20 times more potent than carbon dioxide. It is estimated that less than 1 percent of all gas that flows through U.S. pipelines and distribution systems is released into the atmosphere. Efforts by the U.S. Environmental Protection Agency, pipeline companies, and LDCs are underway to reduce this release. For comparison, it is estimated that 17 percent is released from the natural gas pipe system in the Russian city of Moscow.

furnace that has an output of 80,000 Btu/hr produces exactly the same amount of heat as a natural gas furnace with the same output.

- Oil produces more heat. *Fact:* An oil furnace that has an output of 80,000 Btu/hr produces exactly the same amount of heat as a natural gas furnace with the same output.
- Better service with oil. *Fact*: This might be true in some areas, but it does not have to be. In most areas the service is the same because the same independent contractors service both oil and gas appliances.

- **Considerations for Conversions from Oil to Natural Gas**
  - Gas to building.
    - Communication between utility and owner.
    - Hook-up from street to building.
    - Proper meter sizing.
    - Codes and utility regulations.
  - Gas Piping.
    - From service entry to appliance(s).
    - Proper sizing (NFPA 54, Part 10).
    - Pipe material: carbon steel, CSST, rigid plastic.
  - Gas Venting.
    - Chimney venting.
    - Through-the-wall venting.
    - Direct venting.
    - Proper vent sizing (NFPA 54, Part 11).
    - Vent connector materials.
  - Disposal of old oil equipment.
    - Furnace or boiler.
    - Oil tanks, under ground or above ground.
    - Oil-spill cleanup.

**Natural Gas and Electricity**

- **Advantages of Natural Gas Over Electricity**
  - Natural gas is less expensive than electricity.
  - On a full-energy-cycle basis, a typical natural gas home requires 35 to 45% *less* total energy production than a comparable electric home.
  - Less damaging to the environment than electricity. Natural gas homes are responsible for 99% *less* sulfur dioxide, 90% *less* nitrogen oxides, 95% *less* particulates, and 40 to 50% *less* carbon monoxide than a comparable electric home.
  - Significantly faster recovery rates for gas storage water heaters (firing rate is about 40,000 Btu/hr) than for electric water heaters (firing rate is about 15,000 Btu/hr).
  - Easier to rent apartments if heated with natural gas rather than electric resistance.
  - Electric use of commercial and industrial applications is usually subject to demand changes, natural gas is not.
  - Commercial and industrial facilities can often take advantage of lower rates—interruptible rates—from natural gas utilities. There is no similar advantage for electric users.
- **Advantages of Electricity Over Natural Gas**
  - Usually less costly to hook up an electric appliance.
  - No chance of carbon monoxide poisoning with electric appliances in a home, however, high-temperature cleaning of electric ovens has been known to lead to dangerous levels of ambient carbon monoxide.
  - It is easy to meter electricity for multifamily housing buildings.

- **Myths about Electricity**
  - Electricity is a clean-burning fuel. *Fact:* Electricity is clean at the site, but if an analysis is done on a full-energy-cycle basis, natural gas homes are responsible for 99% *less* sulfur dioxide, 90% *less* nitrogen oxides, 95% *less* particulate matter, and 40 to 50% *less* carbon monoxide than a comparable electric home.
  - Electric appliances are more efficient than natural gas appliances. *Fact:* If analyzed on a full-energy-cycle basis, natural gas homes require about 35 to 45% *less* total energy than what is required by a comparable all electric home. This is because 91% of the gas energy produced makes it to the dwelling. Only 27% of the energy used to generate electrical power with fossil fuels reaches the meter at the dwelling.
- **Considerations for Conversions from Electricity to Natural Gas**
  - Gas to building.
    - Communication between utility and owner.
    - Hook-up from street to building.
    - Proper meter sizing.
    - Codes and utility regulations.
  - Gas Piping.
    - From service entry to appliance(s).
    - Proper sizing (NFPA 54, Part 10).
    - Pipe material: carbon steel, CSST, rigid plastic.
  - Gas Venting.
    - Chimney venting.
    - Through-the-wall venting.
    - Direct venting.
    - Vent sizing/materials (NFPA 54, Part 11).

## *Major Features of FERC Order 636*

Order 636, issued by the Federal Energy Regulatory Commission (FERC) on April 8, 1992, has transformed the interstate natural gas pipeline industry. Under this order, interstate pipeline companies were required to separate their merchant and transportation functions by November 1, 1993, the unofficial start of the winter heating season.[68] Because this order has had and will have a major influence on the natural gas industry, the important features of the order are listed below.

- Local gas distribution companies are entirely responsible for obtaining needed gas supply, transportation, and storage. "Order 636 mandates the unbundling—separation—of pipeline sales, transportation, and storage services and makes all LDCs responsible for sourcing and arranging for the delivery of their own interstate gas. This marks a radical change from the past, when many LDCs could rely entirely on the interstate pipelines to supply, virtually instantaneously, all the gas that was needed."[69]
- Prices are market driven. Financial contracts are used to manage price risk.
- Interstate natural gas pipeline companies must provide transportation services unbundled—separate—from sales services.
- Interstate natural gas companies can sell natural gas at market-based rates.
- Purchase contracts are between producers and 1) end users; 2) LDCs, 3) marketers, who sell to end users and LDCs; and 4) pipeline companies.

[68] Energy Information Administration, *Natural Gas 1994: Issues and Trends*, DOE/EIA-0560(94) (Washington, DC, November, 1994), p.37.
[69] William P. Boswell, "The New Competitive Monopoly: A Thundering Silence," *Public Utilities Fortnightly*, October 1, 1992, p. 28.

- Pipeline companies must provide open-access transportation that is equal in quality for all gas supplies whether purchased from the pipeline company or not.
- Pipeline companies must provide customers with open access to storage.
- Customers are responsible for maintaining adequate storage to meet their peak requirements.
- Customers determine the most economical combination of transportation route and location of gas purchase.
- Tariff provisions cannot inhibit the development of market centers or production pooling areas.
- Generic capacity assignment mechanisms require pipelines to provide firm downstream shippers with access to their upstream capacity and to provide for the reallocation of unwanted capacity—capacity release.
- In most cases, the straight fixed-variable rate design must be used for billing and allocation purposes. "Under this approach, all of a pipeline's fixed costs, including return on equity and associated taxes, will fall within the *demand* (or reservation fee) component of rates, while the purely variable costs are recovered through the commodity rate."[70] This means that customers who use most of their gas on peak, typically residential and small commercial customers, will pay a bigger share of system costs. Those who use large amounts of gas spaced out evenly, such as most large industrial customers, will pay less.[71]
- Pipeline customers are liable for penalties if they do not meet scheduled volumes.

[70] William P. Boswell, "The New Competitive Monopoly: A Thundering Silence," *Public Utilities Fortnightly*, October 1, 1992, p. 29.
[71] See "Courts and Commissions: Major Issues Remain for States as Order 636 Arrives," *Fortnightly*, November 1, 1993, p. 58.

- Customers aggregate supplies or contract with producers or marketing companies for this service.
- Pipeline companies may abandon sales and interruptible transportation service to any existing customer upon expiration or termination of the contact without seeking case-by-case approval from the Federal Energy Regulatory Commission.

The restructuring process has been closely supervised by FERC and has led to extensive changes throughout the natural gas industry:[72]

- "It [forced] us collectively and individually to operate more like traditional competitive business sectors."[73]
- Corporate changes have occurred as pipeline companies have shed their sales functions or reorganized them into marketing subsidiaries.
- Additional marketing companies have formed to coordinate the sales and transportation services for customers who prefer that type of arrangement.
- Pipeline company customers with contracts for gas supply have now become shippers with contracts for pipeline transportation capacity; they must arrange separately to purchase the gas itself.
- Customers have had to become more knowledgeable about operational aspects of the pipeline industry, even as pipeline operations have been radically altered.
- It is easier for industrial customers to completely bypass LDCs by taking interstate pipeline service directly.[74]

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[72] Energy Information Administration, *Natural Gas 1994: Issues and Trends*, DOE/EIA-0560(94) (Washington, DC, November, 1994), p.37. All the bulleted items, except those indicated otherwise, are directly quoted from this source.

[73] Erroll B. Davis Jr., Wisconsin Power & Light Co., "1992 Gas Executives' Forum," *Public Utilities Fortnightly*, October 1, 1992, p. 70.

[74] J.F. Busch and G.A. Comnes, " Resource Planning for Gas Utilities: Using a Model to Analyze Pivotal Issues," Lawrence Berkeley Laboratory, Energy & Environment Division, November, 1995, p. 5.

- In addition, core customers (small commercial and residential) are attempting to move to transport-only service through core aggregation programs.[75]
- Service options have become more flexible and diverse.
- Pipeline capacity can now be traded among customers in a capacity release program administered by the pipeline companies.
- Changes in pipeline rates have affected how services are priced and who pays for them. Each service now has a separate charge, and transportation and storage rates are generally required to follow the straight fixed-variable (SFV) rate design methodology.
- The development of gas market hubs are increasing competition and market liquidity. Hubs are points of supply, storage, or pipeline interconnections where multiple sellers offer gas.[76]
- LDC resource planners and modelers face new and sometimes conflicting forces. On the one hand, LDCs face more resource choices. On the other hand, increased competition and unbundling make it harder to forecast the future.[77]
- Industry restructuring has resulted in an additional $2 billion in transition costs as of mid 1995.
- Electronic bulletin boards are the primary link between customers and pipeline companies, allowing transactions to be rapidly and efficiently completed.

[75] J.F. Busch and G.A. Comnes, " Resource Planning for Gas Utilities: Using a Model to Analyze Pivotal Issues," Lawrence Berkeley Laboratory, Energy & Environment Division, November, 1995, p. 5
[76] *Ibid*, p.5.
[77] *Ibid*, p. 9.

## *American Marketing Association Code of Ethics*[78]

Members of the American Marketing Association are committed to ethical, professional conduct. They have joined together in subscribing to this Code of Ethics embracing the following topics:

**Responsibilities of the Marketer**
Marketers must accept responsibility for the consequences of their activities and make every effort to ensure that their decisions, recommendations, and actions function to identify, serve, and satisfy all relevant publics: customers, organizations and society.

**Marketers' professional conduct must be guided by:**
1. The basic rule of professional ethics: not knowingly to do harm;
2. The adherence to all applicable laws and regulations;
3. The accurate representation of their education, training and experience; and
4. The active support, practice, and promotion of this Code of Ethics.

**Honesty and Fairness**
Marketers shall uphold and advance the integrity, honor, and dignity of the marketing profession by:
1. Being honest in serving consumers, clients, employees, suppliers, distributors, and the public;
2. Not knowingly participating in conflict of interest without prior notice to all parties involved; and
3. Establishing equitable fee schedules including the payment or receipt of usual, customary, and/or legal compensation for marketing exchanges.

[78] Reproduced with the permission of the American Marketing Association (AMA). Please see Chapter 7 for information about the AMA.

**Rights and Duties of Parties in the Marketing Exchange Process**

Participants in the marketing exchange process should be able to expect that:

1. Products and services offered are safe and fit for their intended uses;
2. Communications about offered products and services are not deceptive;
3. All parties intend to discharge their obligations, financial and otherwise, in good faith; and
4. Appropriate internal methods exist for equitable adjustment and/or redress of grievances concerning purchases.

**It is understood that the above would include, but is not limited to, the following responsibilities of the marketer:**

**In the area of product development and management,**

- disclosure of all substantial risks associated with product or service usage;
- identification of any product component substitution that might materially change the product or impact on the buyer's purchase decision;
- identification of extra cost-added features.

**In the area of promotions,**

- avoidance of false and misleading advertising;
- rejection of high pressure manipulations, or misleading sales tactics;
- avoidance of sales promotions that use deception or manipulation.

**In the area of distribution,**

- not manipulating the availability of a product for purpose of exploitation;
- not using coercion in the marketing channel;
- not exerting undue influence over the reseller's choice to handle a product.

**In the area of pricing,**

- not engaging in price fixing;
- not practicing predatory pricing;
- disclosing the full price associated with any purchase.

**In the area of marketing research,**

- prohibiting selling or fundraising under the guise of conducting research;
- maintaining research integrity by avoiding misrepresentation and omission of pertinent research data;
- treating outside clients and suppliers fairly.

**Organizational Relationships**

Marketers should be aware of how their behavior may influence or impact on the behavior of others in organizational relationships. They should not demand, encourage, or apply coercion to obtain unethical behavior in their relationships with others, such as employees, suppliers, or customers.

1. Apply confidentiality and anonymity in professional relationships with regard to privileged information;
2. Meet their obligations and responsibilities in contracts and mutual agreements in a timely manner;
3. Avoid taking the work of others, in whole, or in part, and represent this work as their own or directly benefit from it without compensation or consent of the originator or owner;
4. Avoid manipulation to take advantage of situations to maximize personal welfare in a way that unfairly deprives or damages the organization of others.

Any AMA member found to be in violation of any provision of this Code of Ethics may have his or her Association membership suspended or revoked.

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## About the Author

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