Residential Gas Heating

Initiative Description

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Terms of Use

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1 Background

Space heating is a major use of energy in US and Canadian homes. It accounts for 42 percent of energy consumption in US households, and 50 percent of US homes use natural gas as their primary fuel for space heating.[1] In Canada, space heating accounts for 63 percent of residential energy use;[2] natural gas is the primary heating fuel in 50 percent of homes.[3] In the early 1990s, when CEE first analyzed the natural gas heating market, less than 20 percent of furnaces sold were high efficiency models. By 2011, the share of high efficiency shipments increased to 55 percent.[4] The market penetration of high efficiency boilers has also risen, from 31 percent in 2003 to 57 percent in 2012.[5] To address this significant end use and the market barriers to increased efficiency, CEE launched the *CEE℠ Residential Gas Heating Initiative* in 1998. The purpose of this Initiative Description is to: a) provide market focus through the promotion of a common definition of high efficiency for residential gas heating equipment and b) build awareness of the benefits of high efficiency equipment and quality installation. The CEE Board of Directors originally adopted this Initiative Description in 1997; this version was updated in 2014.

2 Initiative Goals and Objectives

The goal of the *CEE℠ Residential Gas Heating Initiative* is to increase the market penetration and quality installation of high efficiency residential gas furnaces and boilers.

The initiative will achieve this goal when:

- High efficiency equipment is requested by consumers
- High efficiency equipment is promoted to consumers by contractors
- Quality installation is requested by customers
- Quality installation is provided by contractors

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[1] U.S. Department of Energy—Energy Information Agency, "Residential Energy Consumption Survey (RECS), 2009 RECS Survey Data," accessed November 14, 2013, http://www.eia.gov/consumption/residential/data/2009/.

[2] Natural Resources Canada, "Energy Efficiency Trends in Canada, 1990 to 2009," accessed November 13, 2013, http://oee.rncan.gc.ca/publications/statistics/trends11/chapter3.cfm.

[3] Statistics Canada, "Type of main heating fuel used, by province, 2011," accessed November 14, 2013, http://www.statcan.gc.ca/pub/11-526-s/2013002/t002-eng.htm.

[4] U.S. Environmental Protection Agency, "ENERGY STAR® Unit Shipment and Market Penetration Report," Calendar Year 2011 Summary.

[5] Ibid.

The initiative's primary objectives are to:

- Increase the percentage of sales of high efficiency equipment
- Reduce the cost of high efficiency equipment
- Increase the number of contractors who promote high efficiency equipment
- Increase consumer awareness of the components of a quality installation
- Increase the number of quality installations

3 Market Overview

3.1 Market Structure

Following the typical market channel, a furnace or boiler goes from manufacturer to wholesale distributor to HVAC contractor to consumer. Alternative paths may include a retailer, a builder, or otherwise bypass one of the above market actors. The bullets below describe the various market players.

- **Manufacturers** While there are more than 40 gas furnace manufacturers selling under more than a hundred brand names, six manufacturers make up more than 90 percent of market share.[6] The top three manufacturers, by sales, of gas furnace equipment are Carrier®, Goodman®, and Lennox®.[7] There are approximately 40 manufacturers and more than 70 brands of residential gas boilers; more than a quarter of available models are made by Slant/Fin Corporation® and ECR International, under the Argo, Dunkirk, Pennco Boilers, and Utica Boilers lines.[8]
- **Wholesale Distributors** There are both independent and manufacturer-owned distributors. Some manufacturers use independent wholesalers exclusively, some own all of their wholesale operation, and others use a combination of both. Buying groups, also known as purchasing alliances or marketing cooperatives, offer greater purchasing power and lower product costs to independent distributors.
- **HVAC Contractors** HVAC contractors are a key link in the sales chain because they have direct contact with the customer and therefore have the greatest opportunity to influence equipment purchase decisions.
- **Retailers** Retailers include national mass merchandisers, national retailers, and retail dealers. National mass merchandisers and retailers typically purchase equipment directly from manufacturers and sell directly to customers, using their own affiliated contractors for installation since most states require licenses for installation of gas equipment.
- **Builders and Developers** Home builders and developers are also important players in the sale of residential heating equipment since they sell equipment to customers as part of home purchases. They may make decisions about equipment selection without offering the homebuyer high efficiency options.

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[6] U.S. Department of Energy, "Chapter 3 Market and Technology Assessment," *Residential Furnaces, Central Air Conditioners and Heat Pumps Technical Support Document*, 2011.
[7] Ibid.
[8] Air-Conditioning, Heating, and Refrigeration Institute, "Directory of Certified Product Performance," 2013, accessed November 14, 2013, http://www.ahridirectory.org.

3.2 Market Barriers to Improved Efficiency

The key barriers to increasing market penetration of efficient, gas-fired heating equipment and achieving more quality installations are listed below.

HVAC contractors often do not have the appropriate marketing tools and are not proficient in selling high efficiency equipment. Lowest bid quotes strongly drive the residential HVAC equipment sales industry. Contractors, however, have an opportunity to sell high efficiency equipment by educating customers about the life cycle benefits of that investment. This equipment may be more costly upfront but may also offer a higher profit margin to installers. Many HVAC contractors lack the training and tools to educate consumers effectively and to promote the benefits and cost-effectiveness of high efficiency equipment.

- **Consumers are unaware of the benefits of investing in high efficiency equipment.** The majority of heating equipment sales occurs in the replacement market where consumers often need to replace equipment quickly. Consumers lack information to make informed decisions on equipment and rely on the contractor as an expert to guide them through the purchase.
- **Consumers are unaware of what constitutes a "quality installation"** or which contractors provide quality services. There is lack of consistent or clear criteria for what constitutes a "quality installation" that maximizes system efficiency. Most consumers are unaware that installation can affect the operating efficiency of heating equipment. Even if consumers are aware of this fact, they do not know how to achieve a quality installation.
- **Contractors have limited reasons to provide a quality installation.** If consumers do not demand a quality installation, contractors are most likely to provide a low cost installation to support a competitive quote. Other factors that limit the use of quality installation practices are: perceived high first cost in a low bid industry, contractors not fully understanding key aspects of good installation, high turnover and easy entry into the industry, and skepticism or misunderstanding of some of methods, for example, ACCA Manual J calculation.
- **Split incentives—building owners versus tenants.** Building owners lack the incentive to purchase higher priced, energy efficient equipment since they are typically not responsible for the energy bills for that equipment.
- **Split incentives—builders versus homebuyers.** Homebuilders are responsible for upfront equipment costs but not ongoing fuel costs. Builders can reduce their expenses by choosing lower efficiency equipment. Premium features tend to be highly visible to consumers, such as kitchen finishes and bath features. Heating appliances are less visible.

3.3 Market Trends

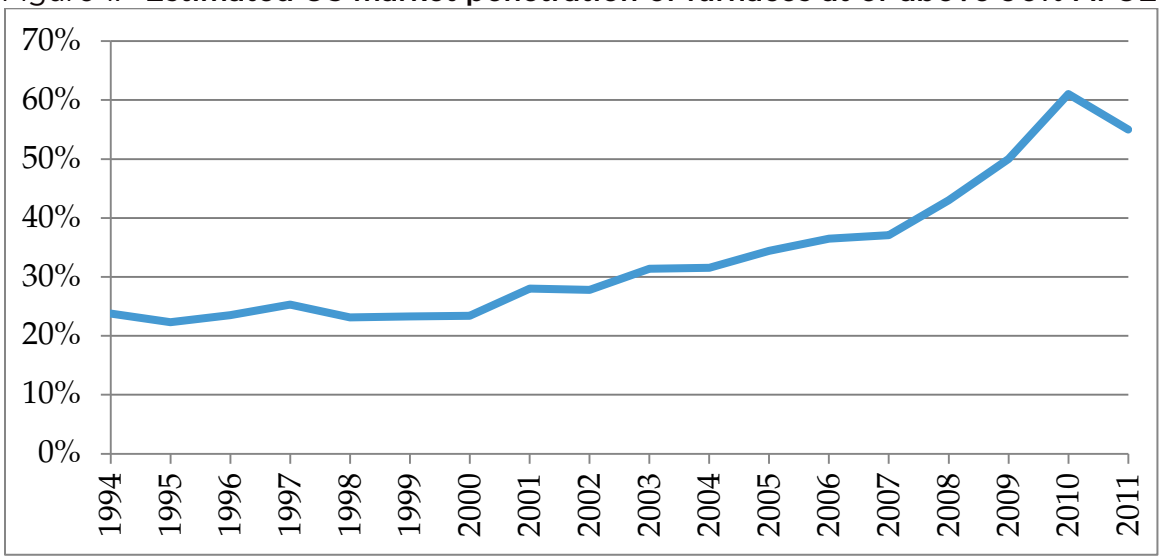
3.3.1 Furnaces

The availability of high efficiency equipment has increased significantly since the initiative began. As of November 2013, 50 percent of all available non-weatherized gas furnace models qualified for the CEE Tier 1 fuel efficiency specification, up from just 12 percent of models in 1998 and 29 percent in 2009. In addition, 35 percent of models meet or exceed the CEE Tier 2 specification of 95 percent AFUE, and 5 percent meet or exceed the CEE Tier 3

specification of 97 percent.[9] Increased availability of efficient equipment improves awareness and increases the likelihood that contractors will market these products. Despite this increased availability, high efficiency models continue to be more expensive. This may be due to the fact that high efficiency is commonly marketed as a premium feature that may provide some value to consumers but not impact the core cost effectiveness of the unit.

Since this initiative began, the penetration rate of high efficiency furnaces has increased significantly, rising from 23 percent of all US shipments in 1998 to 61 percent in 2010 and to 55 percent of shipments in 2011.[10, 11] Figure 1 illustrates the recent changes in the estimated market penetration of condensing furnaces in the US market.

Figure 1. **Estimated US market penetration of furnaces at or above 90% AFUE[12]**



These national averages, however, mask the true impact that efficiency programs can have. For example, in some regions of North America where the heating season is long and where condensing furnaces have been widely promoted by efficiency programs, penetration rates are significantly higher. This includes the state of Wisconsin, where 90 percent of sales are high efficiency units.[13] The national average in the US is affected by states with little heating demand—where condensing furnaces may not yet be cost-effective—and by states where there is little promotion or understanding of the benefits of high efficiency equipment. By leveraging the efforts of active programs with a consistent specification, the initiative aims to increase the penetration rate further in all markets.

[9] Ibid.
[10] This decrease from 2010–2011 may be explained by the expiration of a $1,500 federal tax credit.
[11] U.S. Environmental Protection Agency, "ENERGY STAR® Unit Shipment and Market Penetration Report," Calendar Year 2011 Summary.
[12] Data from 1994 to 2007 are extracted from shipment data provided by the Gas Appliance Manufacturers Association. Data from 2008 to 2011 are extracted from ENERGY STAR® Unit Shipment and Market Penetration Reports.
[13] Energy Center of Wisconsin, *Wisconsin Residential HVAC Equipment Market, Q4 2011*, 2012, accessed November 14, 2013, http://www.ecw.org/ecwresults/FACTS2011Q4.pdf.

3.3.2 Boilers

The availability and market penetration of high efficiency boilers has also risen. In 1998, four boiler manufacturers produced a total of only 15 models of condensing boilers.[14] As of November 2013, 32 manufacturers produce 227 condensing boiler models.[15] The estimated market penetration of high efficiency boilers, 85 percent AFUE or greater, has grown from 31 percent in 2003 to 57 percent in 2012.[16]

Table 1. **Model availability of high efficiency boilers**

Level	2009		2013	
	# of Available Models	% of Available Models	# of Available Models	% of Available Models
All Models[17]	1,095	100%	1,097	100%
85% AFUE and higher	262	24%	440	40%
90% AFUE and higher	153	14%	334	30%

The boiler market is smaller than the furnace market and is concentrated in the Northeast United States. Table 2 provides some regional insight on the overall market for boilers, including both hot water and steam systems.

Table 2. **US households with boilers for space heating in millions**

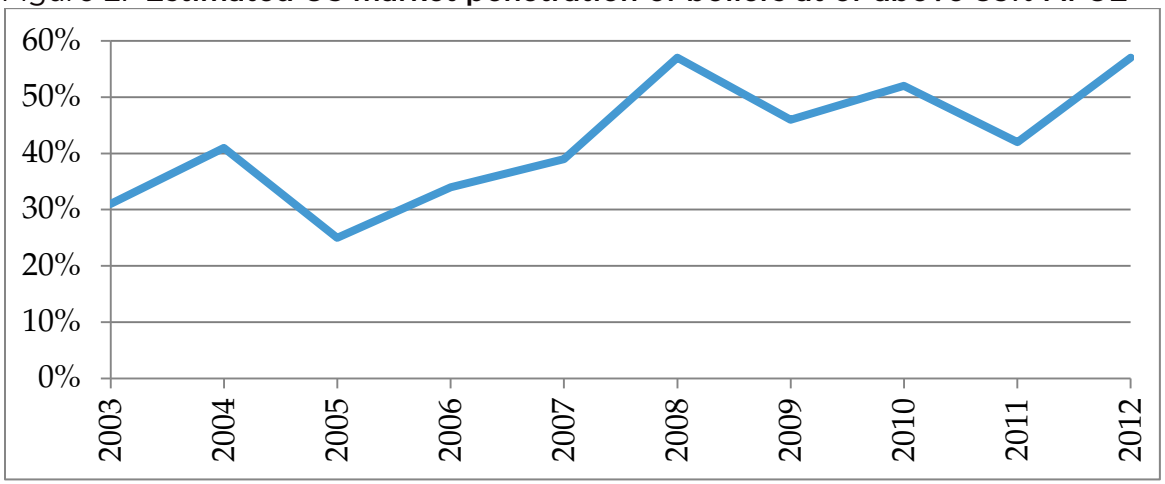
Year	Entire US[18]		Northeast		Midwest		South		West	
	House -holds	%	House -holds	%	House -holds	%	House -holds	%	House -holds	%
1993	8.7	9%	4.3	22%	2.9	12%	0.7	2%	0.8	4%
1997	7.3	7%	3.6	18%	2.5	10%	0.5	1%	0.7	3%
2001	7.9	7%	4.3	21%	2.3	9%	0.6	2%	0.7	3%
2005	8.2	7%	4.9	24%	1.6	6%	1.0	2%	0.6	3%
2009	6.9	6%	4.3	21%	1.7	7%	0.4	1%	0.4	2%

[14] Stanonik, Frank, "Condensing Boilers: A Key to Success," *AHRI Trends*, Fall/Winter 2008.
[15] Air-Conditioning, Heating, and Refrigeration Institute, "Directory of Certified Product Performance," 2013, accessed November 14, 2013, http://www.ahridirectory.org.
[16] U.S. Environmental Protection Agency, "ENERGY STAR® Unit Shipment and Market Penetration Reports," calendar years 2003 and 2012.
[17] This represents the total number of "approved" models of gas-fired hot water boilers available based on October 2009 and November 2013 searches of the AHRI Directory of Certified Product Performance.
[18] U.S. Department of Energy—Energy Information Agency, "Residential Energy Consumption Surveys, 1993, 1997, 2001, 2005, 2009," accessed November 14, 2013, http://www.eia.gov/consumption/residential.

Table 3. **Canadian households with boilers for space heating in millions**

Year	Canadian Households	%
2003 [19]	1.2	11%
2007 [20]	1.4	11%

Figure 2. **Estimated US market penetration of boilers at or above 85% AFUE**[21]



4 Product Overview

The following three subsections detail the technology behind high efficiency furnaces and boilers. They also quantify the potential energy savings from both types of equipment, as well as a proper installation that ensures efficient operation.

4.1 Furnaces

Furnaces are the most commonly used residential heating system in the US, with 50 percent of households relying on natural gas furnaces for primary space heating.[22] Additionally, furnaces account for 52 percent of total annual residential gas consumption and 78 percent

[19] Natural Resources Canada, "2003 Survey of Household Energy Use," accessed November 14, 2013, http://oee.nrcan.gc.ca/Publications/statistics/sheu03/index.cfm.
[20] Natural Resource Canada, "2007 Survey of Household Energy Use," accessed November 14, 2013, http://oee.nrcan.gc.ca/Publications/statistics/sheu-summary07/space-heating.cfm.
[21] Data from 2003 to 2012 are extracted from ENERGY STAR Unit Shipment and Market Penetration Reports.
[22] U.S. Department of Energy—Energy Information Agency, "Residential Energy Consumption Survey, 2009 Data," accessed November 14, 2013, http://www.eia.gov/consumption/residential/data/2009/.

of annual residential gas heating consumption.[23] The average equipment life is 15 years, meaning that savings from efficiency persist for many years after installation.[24]

Standard efficiency furnace technology uses a natural draft venting process to eliminate the combustion products through a vertical vent such as a chimney. This is possibly due to the buoyancy of the hot gas combustion products. The open vent allows a substantial amount of heat to be lost through the chimney, lowering the efficiency. High efficiency equipment removes extra heat from the combustion byproducts, recovering an estimated 10 to 20 percent of the heat energy from flue gases formed during the combustion of the natural gas. As the heat is removed, the water vapor in the flue gases condenses, yielding a corrosive condensate that requires a corrosion resistant drainage system. In addition to the drain, condensing furnaces, as they are known, typically incorporate a fan to power vent the exhaust. The drainage and venting requirements are the primary sources of higher equipment and installation costs.

The national minimum standard in the US is currently 80% AFUE. Canada established a minimum standard of 90% AFUE in 2010.[25] Compared to a furnace of 80% AFUE, the annual energy savings for condensing gas-fired furnaces of 90%, 95%, and 97% AFUE are 13 percent, 17 percent, and 19 percent, respectively. Increasing the market penetration of high efficiency units meeting the Tier 1 specification of 90% AFUE from 60 to 80% would save approximately 1,813,000 MMBtu annually, enough to provide all the natural gas needs for 25,000 houses annually. Greater market penetration of Tier 2 and Tier 3 units would lead to even greater savings.

Furnaces use electric fans to circulate heated air. Estimates of electric savings for a furnace meeting the CEE specification for electrical efficiency indicate that on average these units save 500 kWh during the heating season and 200 kWh during the cooling season if the central air-conditioning system uses the same air handler.[26] These estimates are for the average US household; actual savings depend on many factors, including climate, equipment sizing, and duct pressure. Savings analyses should acknowledge the slight increase in gas used in systems with efficient motors that is necessary to make up for lost heat generated from an inefficient motor.

4.2 Boilers

Boilers represent a smaller percentage of national heating equipment than furnaces. As indicated in Table 2 above, 7 percent of US households and 11 percent of Canadian households rely on natural gas boilers for primary space heating. In the Northeast US census region, approximately 21 percent of households have boilers.

Effective September 1, 2012, the US minimum standard for boiler efficiency is 82% AFUE for gas-fired water boilers and 80% AFUE for gas fired steam boilers. This standard also requires that the design for hot water systems incorporate an automatic means for adjusting

[23] Ibid.
[24] Appliance Magazine, "The Life Expectancy/Replacement Picture," September 2009.
[25] Natural Resources Canada, "Energy Efficiency Regulations– Gas Furnaces," accessed November 13, 2013, http://oee.nrcan.gc.ca/regulations/products/13141.
[26] Sachs, H.M. and Smith, S., "Saving Energy with Efficient Residential Furnace Air Handlers: A Status Report and Program Recommendations," April 2003.

water temperature and a non-constant burning pilot.[27] Most boilers are made with cast iron heat exchangers and have efficiencies between 82% and 84% AFUE. The most efficient boilers, like furnaces, use condensing technology that removes additional heat from the flue gases and condenses hot water vapor from those gases, which increases the installation cost of these units. Condensing boiler efficiency begins at 90% AFUE with units available with efficiencies up to 96% AFUE.[28]

Energy efficient boilers achieving 85% AFUE provide six percent annual energy savings compared to the minimally compliant unit. The upgrade to a condensing boiler of 90% AFUE provides 11 percent annual energy savings over baseline and adds additional equipment and installation costs. The additional equipment costs result from increased expense of materials necessary to handle corrosive condensation and added installation costs to ensure proper disposal of the condensate. Boiler lifetime savings allow ample opportunity to pay for increased first costs, particularly in climates with a longer heating season.

4.3 Equipment Installation

While high efficiency equipment can achieve significant energy savings, poor installation can significantly reduce the overall system efficiency. ENERGY STAR® estimates that up to 30 percent of system efficiency can be lost through improper installation, including sizing, and maintenance.[29] Even high efficiency furnaces can have very low system operating efficiencies when uninsulated, leaky ducts are installed in unconditioned spaces. Furthermore, oversized equipment costs the consumer more up front and operates less efficiently than a properly sized unit. Contractor errors in setting airflow rates can also cause a system to operate inefficiently and deliver less comfort to the consumer. A proper installation yields a system that operates efficiently and safely and provides the highest possible level of comfort to the homeowner.

This initiative aims to increase the market demand for quality installation. A customer's ability to identify contractors that provide quality services may also foster increased demand. To address this opportunity, in May 2007 CEE adopted the Air Conditioning Contractors of America (ACCA) standard for quality installation. The American National Standards Institute (ANSI) recognized the specification in March 2007. The current specification, ANSI/ACCA 5 QI-2010, outlines energy efficient installation practices for residential and light commercial HVAC systems.

Currently, ACCA and CEE recommend following manufacturer instructions and local code when installing any equipment. CEE will continue to work with appropriate groups like ACCA and NATE (North American Technical Excellence, a professional organization) to address this market barrier of quality installation and contractor training.

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[27] US Department of Energy, "Energy Conservation Program for Consumer Products: Energy Conservation Standards for Residential Furnaces and Boilers, Final rule and technical amendment" *Federal Register*, Volume 73, Number 145 (July 28, 2008), pages 43611-43613..

[28] Air-Conditioning, Heating, and Refrigeration Institute, "Directory of Certified Product Performance," 2013 accessed November 14, 2013, http://www.ahridirectory.org.

[29] ENERGY STAR, "Heat and Cool Efficiently," Accessed November 14, 2013, http://www.energystar.gov/index.cfm?c=heat_cool.pr_hvac.

5 Initiative Approach

The approach advocated by this initiative consists of identifying and encouraging the purchase of energy efficient, gas-fired furnaces and boilers. To achieve the savings described above and overcome the market barriers identified by CEE, the initiative consists of four major components: common equipment specifications and three efforts to build awareness.

5.1 Common Efficiency Specification

Historical success with this initiative and others shows that widespread adoption of a common efficiency specification provides a consistent signal to all market actors. This initiative originally adopted fuel efficiency levels consistent with the Environmental Protection Agency's ENERGY STAR Residential Heating and Cooling program. The specification has since been updated to include additional fuel efficiency tiers, as well as an optional electrical efficiency specification for furnaces. The initiative promotes equipment that meets or exceeds these efficiency levels. The test procedure for furnaces and boilers is ASHRAE 103-1993, Methods of Testing for Annual Fuel Utilization Efficiency of Residential Central Furnaces and Boilers.

The original specifications of the initiative, adopted in 1998, addressed fuel efficiency and coincided with the ENERGY STAR performance criteria, requiring furnaces to have an AFUE of 90% or higher and hot water boilers an AFUE of at least 85%. In 2002, to reflect the increased availability and penetration of high efficiency furnaces, CEE revised the fuel efficiency specification to add two additional tiers for furnaces, at 92% and 94% AFUE. The CEE fuel efficiency specification was again revised in 2010 to add an additional tier for hot water boilers at 90% AFUE. The most recent change occurred in 2014 with the revision of Tier 2 and Tier 3 for furnaces to the 95% and 97% AFUE levels, respectively.

In addition to developing advanced tiers, CEE added an optional specification for electricity use by gas furnaces in November 2003. Power use for air handling, which uses a furnace fan to move heated air through the ducts into the house, represents a large proportion of the electricity drawn by furnaces.[30] The optional furnace fan efficiency specification requires that the annual fan electricity use must be less than or equal to two percent of the total energy used by the furnace. This specification applies only to furnaces that meet or exceed the fuel efficiency specifications set in Tier 1, Tier 2, or Tier 3. There is no federal minimum for furnace electricity use. In 2014, CEE adopted the approach for determining furnace fan efficiency referenced in ENERGY STAR Program Requirements for Furnaces Version 4.0. The current specifications are detailed in Tables 4 and 5.

[30] Energy Center of Wisconsin, *Electricity Use by New Furnaces—A Wisconsin Field Study*, October 2003:1, www.doa.state.wi.us/docview.asp?docid=1812.

Table 4. **CEE fuel efficiency specifications**

Equipment Type	Tier Level	Fuel Efficiency Level (AFUE)
Gas Furnaces	Tier 1	90%
	Tier 2	95%
	Tier 3	97%
Gas Boilers	Tier 1	85%
	Tier 2	90%

Table 5. **Optional CEE furnace fan efficiency specification**

Equipment Type	Furnace Fan Efficiency Level
Gas Furnaces with a minimum of 90% AFUE	***e* = ≤2% of Total Furnace Energy Use** as calculated by approach referenced in ENERGY STAR Program Requirements for Furnaces Version 4.0

5.2 Consumer Education and Awareness

Consumer education and awareness play a critical role in the market penetration of high efficiency equipment. Programs should provide a consumer awareness campaign on the benefits of choosing high efficiency residential heating equipment. An effective campaign will target both the replacement and new construction markets. Successful campaigns may include the use of customer brochures, bill stuffers, fact sheets, or advertisements. Education and awareness materials targeted at contractors and installers serve as an additional opportunity to promote the benefits of efficient equipment to key influencers in purchasing decisions.

5.3 Quality Installation Practices

When this initiative was first launched in 1998, there was no common definition used in programs for quality installation practices. CEE pledged to research quality installation definitions and practices and to work with EPA to quantify potential energy saving measures. To address this opportunity, CEE adopted ANSI/ACCA 5 QI-2010, a standard which outlines energy efficient installation practices for residential and light commercial HVAC systems. This specification is a comprehensive document providing consistent guidelines that can be incorporated into an efficiency program with the goal of maximizing energy savings through correct installations. The ACCA specification was most recently updated in 2010.[31] CEE continues to advance quality installations through partnerships with the ACCA and NATE, as well as other industry groups and the ENERGY STAR program.

[31] The standards can be downloaded at from ENERGY STAR at http://www.energystar.gov/ia/home_improvement/home_contractors/qispec.pdf.

5.4 Contractor Training

The replacement market is the largest market for furnaces and boilers. Contractors represent the primary market channel for the sale of this equipment. The HVAC contractor has significant influence on the consumer's decision about what heating equipment to purchase. Early in its history, the initiative took advantage of resources provided by EPA, including an HVAC contractor training course and materials packet, to provide contractors with the skills and tools to sell high efficiency equipment. CEE arranged for initiative implementers to attend EPA sponsored "train-the-trainer" courses, enabling utility staff to gain the skills needed to provide similar workshops to their local contractors. Initiative participants are now encouraged to sponsor HVAC contractor training opportunities that focus on promoting high efficiency gas heating equipment and the principles of selling and performing quality installations based on ANSI/ACCA 5 QI-2010. Education offerings should refer contractors to manufacturers for additional guidance on advanced venting and condensate drains required for condensing boilers and furnaces.

6 Initiative Participation

As with all initiatives of CEE, participation in the *CEE℠ Residential Gas Heating Initiative* is voluntary. To be considered an initiative participant, the following actions are required:

- Incorporate at least one of the CEE fuel efficiency specifications for furnaces or boilers in an educational or incentive program
- Undertake an awareness measure related to the benefits of high efficiency equipment, contractor training, or system optimization including quality installation, quality operations and maintenance.

Promotion of the furnace fan efficiency specification is optional for initiative participation, though it is encouraged, particularly where cost effective for consumers.

7 CEE Role in Initiative Promotion

Since 1998, CEE has supported members in their promotion of the initiative by encouraging adoption of the specification within voluntary programs, developing guidelines for quality installation, and assisting with awareness-building efforts. In 2003, CEE began investigating the availability of product information needed by initiative participants for developing product lists of equipment that met the specifications. Since 2005, CEE has developed, maintained, and distributed lists of furnaces and boilers that meet the fuel efficiency and electricity specifications of the initiative. CEE works closely with manufacturers and industry associations to make information about equipment efficiency available to members.