NORA E^3 Sustainable Liquid Fuels Research

National OilHeat Research Alliance

NORA represents an important self-financing coordinated national oilheat industry program of research and development, training, and consumer education. NORA's programs provide necessary and important support for the industry, the general economy of the United States and millions of Americans who rely on oilheat for residential and commercial space and water heating.

Energy, Environmental and Economic (E^3) Series

Energy supply and demand are issues are in the forefront of national and global political discourse. The issue of America's economic and environmental sustainability is commonly discussed at our kitchen tables. NORA's E^3 Series of white papers are designed to provide Federal and State policy makers, the media and the general public with critical and timely information to make informed energy related decisions.

Brookhaven Study Uncovers Need to Retool Boiler Energy Efficiency Programs

Current Boiler Energy Efficiency Incentives

The current U.S. Federal minimum energy efficiency standard for boilers took effect in 1992. The standard requires that new residential 78%, hot-water boilers (heat input rate of less than 300,000 Btu/h) have a minimum Annual Fuel Utilization Efficiency (AFUE) of 80% and steam boilers a minimum AFUE of 75%. Most new boilers can be grouped into one of two general classes on the basis of efficiency: "power combustion" hot water boilers with AFUEs of 80-84%, and "condensing" boilers with AFUEs of over 85%.

Federal and State policies have centered on promoting the selection of appliances based on AFUE. However, that measure of performance provides an incomplete picture of performance with hydronic systems because: it does not consider the domestic hot water load which is typically integrated with a boiler system and it does not fully consider the impact of new control options such as outdoor reset and thermal post purge. The approach in this work addressed these and followed an input/output method being developed separately for commercial boilers by ASHRAE.

Brookhaven Results

Brookhaven's research reveals that the level of energy savings which can be achieved by retrofitting older boilers with top performing non-condensing boilers is on the order of 25 percent. The Brookhaven Report also found that "Condensing gas and oil boilers tested provided about 25% annual energy savings as did an oil-fired steel boiler with purge control and a well insulated oil-fired European boiler."

Review of the Brookhaven National Laboratory results show that these energy efficiency factors are not fully reflected in the AFUE numbers. Instead of focusing on just high AFUE values and condensing hydronic systems, energy policies should promote low energy losses during idle and low load periods and advanced controls. Given the higher cost of condensing appliances, this approach could make it more affordable to achieve energy savings associated with upgrades. For example, accelerating the replacement of older units with new, high efficiency non-condensing oil heating equipment in the Northeast would save 346,819,500 gallons annually. Using a home heating price of $2.60 / gallon (New York average price, March 2007) this is equivalent to an annual savings of $901,000,000.

Energy Efficiency Implications

The Brookhaven Report Reveals:

1. AFUE provides erroneous energy savings potential if applied to integrated heat and hot water) residential hydronic systems
2. The best oil, non-condensing systems tested are equivalent to the gas condensing system tested
3. An annual efficiency which considers domestic hot water as well as heating provides a better measure of performance than AFUE
4. NORA believes that a complete reevaluation of the AFUE measure for hydronic integrated systems is needed to help consumers achieve actual energy use reductions through affordable equipment replacement decisions.

Understanding Brookhaven Energy Efficiency Results

Tabulated Annual System Efficiency Results[1]

Description	Control	Annual Reduction in Relative Fuel Use	
Oil, steel boiler with purge control	Energy Recovery	24.8	SYSTEM 2000
Gas condensing modulating	Temperature Reset	24.5	
Oil, well insulated European boiler	Temperature Reset	23.7	*
Oil condensing boiler	Temperature Reset	23.5	
Oil, cast iron boiler with tankless	None	17.3	*
Oil, water heater used also for heating	None	15.1	*
Oil, Combination System	None	14.9	
Gas atmospheric with tankless	None	1.8	*
Oil, cast iron boiler with indirect	None	0.7	*
Gas boiler + separate gas water heater	None	0.4	*

*Products have additional draft regulating losses of 8 to 14%.

The table above provides critical information with respect to the equipment tested and can be extrapolated to all hydronic baseboard heating systems where domestic hot water is also fuel fired. The annual fuel reduction[2] percentages all are compared to an existing oil-fired cast iron boiler removed from the field after 22 years of service.

The comparison shows that oil non-condensing systems tested are virtually equal in annual efficiency to the high performance natural gas boiler tested. This occurs for two reasons: first, modest natural gas condensing steady-state thermal efficiency (88.5%) because of relatively high return water temperatures and second, high standby losses producing domestic hot water with a summertime efficiency of 58.7%. For example, versus the oil-fired steel boiler tested with purge control with steady-state thermal efficiency (86.5%) and a domestic hot water with a summertime efficiency of 79.6%.

So which energy efficiency policy is better?

1. Promote or incentivize the purchase of a condensing boiler with an AFUE of 95% versus a non-condensing AFUE 83% efficient boiler or

2. Promote upgrades generally by incentivizing replacement of old systems with new systems that may have AFUE efficiencies in the mid-80% range but with advanced controls?

The Brookhaven results provide a strong argument that replacing older units is the only thing that makes sense. In fact, the table above shows that choosing a condensing boiler versus a non-condensing boiler (with purge control) will actually be a slightly less energy efficient choice. BUT, this is exactly what Federal programs like Energy Star and many State programs promote and incentivize. Why continue encouraging less energy efficiency and buying more complex equipment (condensing appliances)?

Incentivising the change out of a 22 year-old boiler to a new non-condensing steel oil boiler with purge control would yield an efficiency improvement of almost 25% with a simple appliance that makes for an easy retrofit.

Continuing to support AFUE as a means of improving energy efficiency boiler installations seems problematic. Advancing the development of Annual System Efficiency as the residential boiler standard makes sense.

NORA is working with Brookhaven, NYSERDA, oil dealers, boiler manufacturers and policy makers to deliver truly sustainable energy solutions.

Why not encourage more energy efficient approaches?

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1 Table 4 "Performance of Integrated Hydronic Systems", May 2007, Brookhaven National Laboratory

2 Fuel savings are presented in percentage of oil equivalent for comparison purposes

3 Study Ignores draft regulating losses of 8-14% and electrical energy consumption

Fuel savings are presented in percentage of oil equivalent for comparison purposes

Items in red added for clarification by Energy Kinetics, Inc.