By James E. Houck

PHOTO: ©2009 WALTER MYERS.

Sixty years ago, over half of the occupied housing units in the U.S. used coal for heating; future technology may one day allow us to utilize this national resource for residential heating once again.

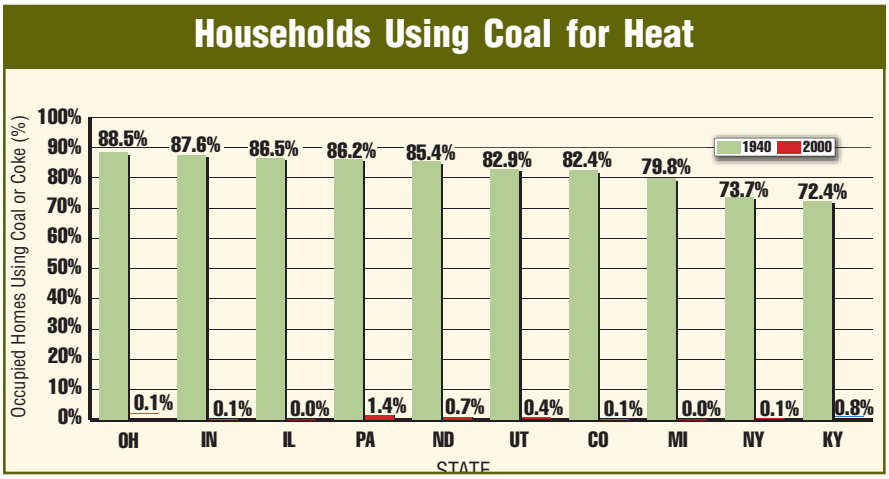
Coal is cheap, plentiful and domestic. Online coal forums are replete with personal testimonials of the cost savings realized from using coal for home heating in lieu of natural gas, LPG, fuel oil, electricity and even wood. Two downsides are: (1) coal carries an environmental stigma mostly from the historical burning of bituminous coal typically in old centralized furnaces and boilers, and (2) the deposits of the very best coal for home heating, anthracite, are almost exclusively limited to eastern Pennsylvania.

Coal – Yesterday

It's not like home heating with coal is a new idea. The history of coal heaters began in 1234 when the English granted the first coal mining charter to the town of Newcastle. By the 16th century coal was the major heating fuel in England. Closer to home, coal for residential heating became commonplace in North America in the early part of the 20th century, with over half of the occupied housing units in the U.S. using coal for heating by 1940.

Probably many of us don't realize (or remember) that not long ago coal was truly the "currency of the realm" in terms of home heating. More dramatic than the fact that more than one half of the total occupied housing units in the U.S. used coal for heat in 1940 is the fact that, in many states with coal deposits, the residents of over 80 percent of occupied housing units reported using coal for heat in the 1940 census.

The organic material that made coal was laid down from between 300 million to 360 million years ago.



The percentage of households using coal as a heating fuel in key coal using states in 1940 and 2000 (U.S. Census Bureau).

Coal – Today

Today coal is cheap and available. America has been called "the Saudi Arabia of coal" with the United States having 27 percent of the world's coal reserves. The cost of bulk anthracite coal adjusted for inflation is less today than it was in 1949. Cursory research into currently available freestanding coal stoves and fireplace inserts revealed 13 manufacturers with 58 models. There are also currently at least 24 suppliers of anthracite coal, six of which are major players.

Coal is not only supplied in bulk, but anthracite coal is shipped in clean, 50-lb. pound bags reminiscent of wood pellets. This coal is even often washed and supplied damp or sprayed with an oil mist to minimize in-home dust from handling. Bagged coal has been shipped nationwide, often by using back-haul carriers.

Bagged coal also is compatible with modern homes that don't have bulk storage capabilities, i.e., it can be stored like wood pellets, cleanly in a garage or basement without the need for a bin. In contrast and counter-intuitively to bagged coal shipments, the economics of bulk coal freight limits bulk coal shipment from the Pennsylvania anthracite coal fields to within several hundred miles.

Most coal stove models are designed to burn hard coal (anthracite) and a few are designed for soft coal (bituminous). Soft coal is less desirable as a home heating fuel primarily due to its higher air emissions. Its variability in properties from coal deposit to coal deposit also makes designing a generic bituminous coal stove challenging. The variability in volatile matter, fixed carbon and heat contents, as well as the differences in agglomerating and friability characteristics are substantial among bituminous coals from different deposits.

Anthracite coal, on the other hand, is relatively uniform in its make-up. Some hard coal stove models are stoker-fed, i.e., they automatically feed small pieces of coal, whereas others are hand-fed and burn larger pieces of coal. Soft coal stove models appear to be almost exclusively hand-fed. Modern coal stove models are safe, as they are generally tested to UL Standard 1482 and/or its Canadian counterpart ULC-S627.

NAME	SIZE (Inches)
Lump	Over $4^{3}/_{8}$
Broken	$3^{1}/_{4}$ – $4^{3}/_{8}$
Egg	$2^{7}/_{16}$ – $3^{1}/_{4}$
Stove	$1^{5}/_{8}$ – $2^{7}/_{16}$
Nut	$^{13}/_{16}$ – $1^{5}/_{8}$
Pea	$^{9}/_{16}$ – $^{13}/_{16}$
Buckwheat No.1	$^{5}/_{16}$ – $^{9}/_{16}$
No.2 (Rice)	$^{3}/_{16}$ – $^{5}/_{16}$
No.3 (Barley)	$^{3}/_{32}$ – $^{5}/_{16}$
No.4	$^{3}/_{64}$ – $^{3}/_{32}$
No.5	Less than $^{3}/_{64}$

Descriptive, colorful names have been coined to describe the different sizes of anthracite coal. Typically, pea, nut or stove sizes are for batch hand-fed models, whereas buckwheat sizes are for stoker models.

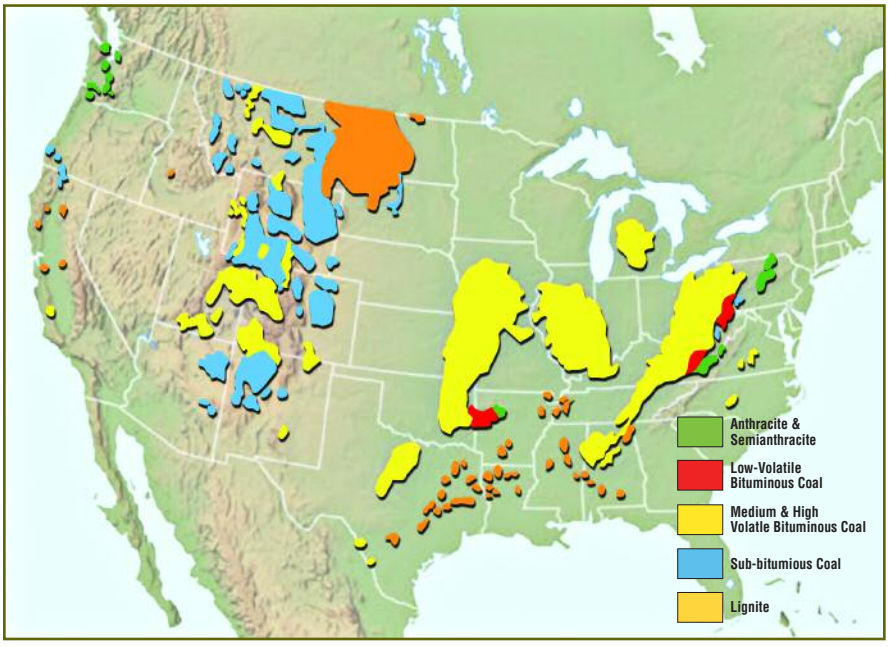
A ton of anthracite coal has about as much energy as 146 gallons of heating oil or about 20,000 cu. ft. of natural gas. Coal stoves, in contrast to centralized coal boilers or furnaces, are often compared to wood stoves as they look similar and have many of the same practical energy conservation advantages as other zone heaters. (See "In the Zone," *Hearth & Home* December 2008.)

When comparing coal and wood stoves it should be remembered that anthracite coal contains 12,000 to 14,000 Btu/lb (HHV) of energy as compared to about 8,500 to 9,000 Btu/lb (HHV) for wood. Consequently, if all else is equal, less coal is needed than wood for the same heating demand. Another consideration when comparing coal and wood is that coal contains far more ash than wood. Anthracite coal typically has about 13 percent ash as compared to less than one percent for most wood, meaning that more effort is associated with ash removal and disposal from the burning of coal than wood.

END USE	Trillion Btus of Energy from Coal
Electric Power Generation	20,461
Industrial	1914
Commercial	65
Residential*	6
Transportation	0

Today, in the U.S., less than three hundredth of one percent of the total energy provided by coal is directly used in residences (2006, U.S. Department of Energy).

The convenience and efficiency of fuel oil, natural gas, LPG and electricity has clearly supplanted the predominance of coal as a residential heating source since the 1940s. Most coal mined today is used by utilities for electric power generation, not direct home heating. In 2005, only 0.2 percent out of the over 124 million housing units in the United States used coal. Residents of 114,000 housing units reported using coal as their main heating fuel; 104,000 reported using coal as their secondary heating fuel; 4,000 reported using coal as a cooking fuel, and 22,000 reported using coal as a water heating fuel (2005,



Coal reserves in the United States.

U.S. Census Bureau, "American Housing Survey"). While these numbers are small in a relative sense when compared to 124 million total U.S. households, the sum of 244,000 households using coal for one purpose or another is still not insignificant.

Coal – Tomorrow

According to the American Coal Foundation, the U. S. has about a 245-year supply of coal and, according to the U.S. Department of Energy's Energy Information Administration, the growth in coal production is expected to average 0.6 percent nationally between 2007 and 2030, reaching over 1.2 billion tons annually. Further, it should not be forgotten that while the use of eastern Pennsylvania anthracite coal, unquestionably the most desirable coal type for home heating, appears to be limited by its restrictive geographical range, it is, in fact, in an economically acceptable transport range for many households. Because of the high population of the East coast, the Pennsylvania anthracite reserves are within several hundred miles of more than 25 percent of the total households in the United States.

The trifecta of low stable cost, abundance and domestic availability has appeal. Modern coal stoves are aesthetically attractive and are less labor intensive to operate than the centralized units of our grandparents. *The New York Times* (Dec. 27, 2008) succinctly identified the reemergence of coal as a home-heating fuel with the title of its recent article, "Coal is Returning to Home Furnaces."

Arguably two key questions will determine the future of home heating with coal: Can the lower grades of coal, i.e., bituminous and even lignite, be better utilized for home heating? and, Can the efficiency and air emissions characteristics of future coal heating devices, utilizing either hard or soft coal, be further improved?

(To view information and images of coal stoves and companies go to www.hearthandhome.com, click on Articles then on Coal Stoves.)

"Fair is foul, and foul is fair: hover through the fog and filthy air." Witches chant in Macbeth, *using a reference to the coal smoke of the time.*

Gil Wood.

Because coal stoves have not been regulated like wood stoves we asked Gil Wood, who is with the U.S. EPA office of Air Quality Planning and Standards and is the Staff Lead for the new federal standard known as the New Source Performance Standard (NSPS), what the future might hold for coal stoves. According to Wood, "EPA is currently gathering information on coal stoves and will consider developing regulations similar to the wood stove regulations. Several local agencies have expressed concern to us because some customers are buying coal stoves and such stoves currently are not regulated by the EPA. At this time, the (new NSPS) review is closely examining options to include all solid biomass and coal appliances, because these appliances are growing in popularity again."

— Gil Wood.

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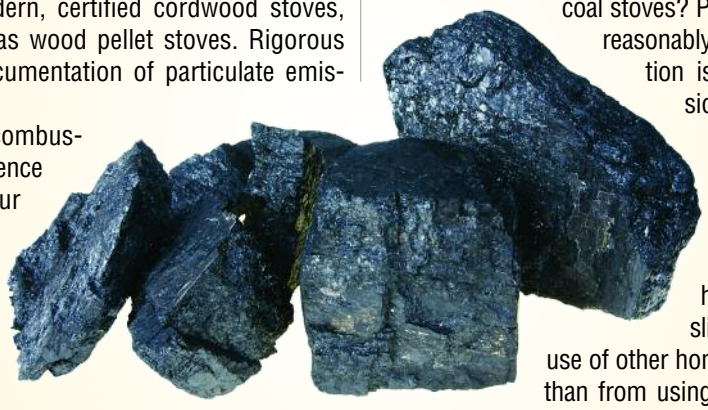
The Environment and Coal – *the* Issue

Air pollution, both real and perceived, from the residential burning of coal is the issue – period. Particles and sulfur dioxide emissions are where the rub lies.

Anthracite coal is often referred to as "smokeless" because of its low particulate emissions, particularly as compared to bituminous coal. Little independent testing has been done on air emissions from modern coal stoves because, unlike their wood stove cousins, emission certification has not been required by the U.S. EPA for their sale.

Some limited testing of coal stoves in the 1980s documented that the particulate emissions from anthracite coal stoves were much less than wood stoves of the time, and particulate emissions from bituminous coal stoves were higher than from these old uncertified wood stoves. Anecdotally, little visible smoke can be seen being emitted from a modern coal stove burning quality anthracite coal, hence the term "smokeless."

Visible smoke is the manifestation of fine particles causing light to be scattered. Bottom line – anthracite coal stoves produce fewer particles than bituminous coal stoves, probably fewer particles than modern, certified cordwood stoves, and maybe about the same as wood pellet stoves. Rigorous and widely disseminated documentation of particulate emissions is lacking.



Coal contains sulfur. At combustion temperatures, in the presence of oxygen in the air, this sulfur forms sulfur dioxide (SO_2) gas. Sulfur dioxide, along with lesser amounts of nitrous oxides (also formed during coal combustion), is responsible for acid rain and the formation of secondary atmospheric fine particles ($PM_{2.5}$). Sulfur dioxide smells and is toxic. Fine particles are health injurious and cause environmental degradation. Sulfur dioxide and $PM_{2.5}$ are federal criteria pollutants and there are ambient air quality standards for them. There is no way to sugar-coat this – these are facts.

Sulfur in coal is in two forms: iron pyrite and organic sulfur compounds. Iron pyrite is a mineral and can be separated from coal by crushing it with subsequent washing. This is the desulfurization that many of us have heard about. If the sulfur is in the form of organic sulfur compounds in a particular coal deposit nothing can be done to remove that sulfur as it is an integral part of the coal matrix.

Clean-burning coal technology that has received much press of late has little to do with residential coal-burning but rather has to do with the removal of sulfur dioxide gas in coal-fired power plants at a scale and technology level currently not suited for residential application.

The sulfur content of native coal is quite variable. For bituminous coal it ranges from less than one percent to 10 percent. For anthracite coal it is about 0.6 percent. Sulfur dioxide emissions from coal, even anthracite coal, are higher than other residential fuels. Some home occupants cannot detect the odor of sulfur dioxide from anthracite coal-burning, while others have likened the odor to "the smell of fireworks" due to the sulfur dioxide emissions. Again there is no way to sugar-coat this – coal has sulfur in it, more than other common home heating fuels.

A discussion of air emissions without a mention of greenhouse gases would be incomplete. Direct residential coal combustion has slightly more carbon dioxide emissions per unit of energy than other fossil fuels used in the home because its carbon to energy ratio is slightly higher. On the other hand, if a coal stove replaces electric heat there is a net decrease in greenhouse gas emissions since most of North America's electricity comes from burning coal in a power plant at low efficiency and with an associated transmission line loss while getting the energy to homes.

So what is the environmental bottom line on burning coal, particularly anthracite coal in the home in modern coal stoves? Particulate emissions seem to be reasonably low, albeit good documentation is lacking. Sulfur dioxide emissions are the highest compared to other common home-heating fuels. The use of low-sulfur coal such as anthracite does mitigate the problem significantly but not completely. Greenhouse gas emissions may be slightly higher than from the direct use of other home heating fossil fuels but lower than from using electricity for heating.

Can anything be done to improve environmental performance and acceptance of environmental claims? We believe further improvement in the design of modern coal stoves is still possible to reduce particulate emissions and improve efficiency. Improved efficiency is key since less fuel consumed for a given heating demand means less air emissions, even for emissions of pollutants such as sulfur dioxide which are otherwise difficult if not impossible to reduce.

Far less work has been done modernizing coal stove design than has been done for their solid-fuel wood stove cousins. Testing has been done on hundreds and hundreds of residential wood-burning units for air emissions and, to a lesser extent, efficiency since the late 1980s primarily in response to manufacturers' need to document low air emissions for regulatory compliance and to support marketing claims. In contrast, the number of coal-burning units that have been evaluated for air emissions and efficiency most likely number under a few dozen.

Finally, we hear much about new coal technologies. Let's hope there is a new technology not yet on our "radar screen" that allows us as a nation to utilize a huge national resource.

Alaska Stove Company

Brand: Alaska
Yrs. Manuf. Coal Stoves: 30
Retail Price Ranges: $1,279 to $3,154
Btus: 105,000
Sell Anthracite Models? Yes
Where? New England, Middle Atlantic, South Atlantic
Sell Bituminous Models? Yes
Where? New England, Middle Atlantic, South Atlantic
Sell Stoker Models? Yes
Sell Batch Models? Yes
Coal Stove Percent of Total Hearth Sales: 3%
Forecast for 2009? N/A

Kodiak Coal Stove.

Baker Stoves

Brand: Baker
Yrs. Manuf. Coal Stoves: 31
Retail Price Ranges: $2,000 to $3,100
Btus: 90,000 to 210,000
Sell Anthracite Models? Yes
Where? New England, Middle Atlantic, South Atlantic
Sell Bituminous Models? No
Sell Stoker Models? Yes
Sell Batch Models? No
Coal Stove Percent of Total Hearth Sales: 30%
Forecast for 2009? Up 30%

Heat King Coal.

Evolution Trade Group

Brand: Nestor Martin
Yrs. Manuf. Coal Stoves: 50
Retail Price Ranges: $2,499 to $2,599
Btus: 55,000
Sell Anthracite Models? Yes
Where? New England, Middle Atlantic, South Atlantic, Midwest
Sell Bituminous Models? No
Sell Stoker Models? No
Sell Batch Models? No
Coal Stove Percent of Total Hearth Sales: 20%
Forecast for 2009? Up 10%

Nestor Martin Bayard 312 by Evolution Trade Group.

Harman Stove Company

Yrs. Manuf. Coal Stoves: 30
Retail Price Ranges: Stoves: $1,279 to $2,505
Stokers: $3,100 to $3,600
Btus: 5,000 to 103,000 (Stokers)
Stoves: 48,000 to 120,000
Stokers: 5,000 to 103,000
Sell Anthracite Models? Yes
Where? New England, Middle Atlantic, South Atlantic
Sell Bituminous Models? Yes
Where? NewEngland, Middle Atlantic, South Atlantic
Sell Stoker Models? Yes
Sell Batch Models? No
Coal Stove Percent of Total Hearth Sales: 4%
Forecast for 2009? Up 20%

Super Magnum Stoker by Harman.

Hitzer

Brand: Hitzer
Yrs. Manuf. Coal Stoves: 34
Retail Price Ranges: $800 to $1,800
Btus: 11,000 to 95,000
Sell Anthracite Models? Yes
Where? Entire U.S.
Sell Bituminous Models? Yes
Where? Entire U.S.
Sell Stoker Models? Yes
Sell Batch Models? Yes
Coal Stove Percent of Total Hearth Sales: 98%
Forecast for 2009? No change

Stoker by Hitzer.

Keystoker Manufacturing

Brand: Keystoker
Yrs. Manuf. Coal Stoves: 102
Retail Price Ranges: $2,335 to $4,021
Btus: 75,00 to 160,000
Sell Anthracite Models? Yes
Where? New England, Middle Atlantic, South Atlantic, Midwest
Sell Bituminous Models? No
Sell Stoker Models? Yes
Sell Batch Models? Yes
Coal Stove Percent of Total Hearth Sales: 5%
Forecast for 2009? N/A

Keystoker by Keystone.

Monessen Hearth Systems

Company: Monessen Hearth Systems
Brand: Vermont Castings
Yrs. Manuf. Coal Stoves: 25
Retail Price Ranges: $1,744
Btus: 50,000 to 70,000
Sell Anthracite Models? Yes
Where? New England, Middle Atlantic, South Atlantic, Midwest, Mountain, Pacific
Sell Bituminous Models? Yes
Where? New England, Middle Atlantic, South Atlantic, Midwest, Mountain, Pacific
Sell Stoker Models? No
Sell Batch Models? Yes
Coal Stove Percent of Total Hearth Sales: 1.5%
Forecast for 2009? Up 15%

Vigilant coal stove by Vermont Castings.

Morsø

Brand: Morsø
Yrs. Manuf. Coal Stoves: 155
Retail Price Ranges: $1,000
Btus: 30,000
Sell Anthracite Models? Yes
Where? New England, Mountain
Sell Bituminous Models? No
Sell Stoker Models? No
Sell Batch Models? Yes
Coal Stove Percent of Total Hearth Sales: .5%
Forecast for 2009? Up 200%

1410 Coal or wood stove by Morsø.

Reading Stove Company

Brand: Reading
Yrs. Manuf. Coal Stoves: 5
Retail Price Ranges: $1,500 to $3,300
Btus: 45,000 to 175,000
Sell Anthracite Models? Yes
Where? New England, Middle Atlantic, Mouth Atlantic, South, Midwest
Sell Bituminous Models? No
Sell Stoker Models? Yes
Sell Batch Models? Yes
Coal Stove Percent of Total Hearth Sales: 100%
Forecast for 2009? No change

Allegheny by Reading Stove Company.

United States Stove

Brand: United States Stove Company
Yrs. Manuf. Coal Stoves: 160
Retail Price Ranges: $300
Btus: 8,000 to 160,000
Sell Anthracite Models? Yes
Where? Middle Atlantic
Sell Bituminous Models? Yes
Where? New England, Middle Atlantic, South Atlantic, South, Midwest
Sell Stoker Models? No
Sell Batch Models? No
Coal Stove Percent of Total Hearth Sales: 50%
Forecast for 2009? Up 30%

Wondercoal by United States Stove.