Mid-Atlantic Masonry Heat
Tulikivi Soapstone Design & Distribution
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My name is Doug Hargrave. For the last twenty years I have been involved (if not consumed) with the promotion of the Tulikivi soapstone fireplace which I believe to the most practical, comfortable and environmentally friendly home heating system available today. The generic name for this type of heat system is a masonry heater …..but what is a masonry heater?

Masonry heaters allow you to heat your home with a wood fire in a unique way. The main thing that distinguishes them from other wood burning appliances is their **ability to store large amounts of heat**. This means that you can rapidly burn a large load of wood without overheating your home. The heat from the rapid fire is stored in the thermal mass of the masonry heater, and then slowly radiates from the mass, like sunshine, comfortably warming your home for the next 12 to 24 hours.

Many years ago Mark Twain during his travels through Europe made the following observation about masonry heaters. "To the uninstructed stranger it promises nothing. It has a [small] door…which seems foolishly out of proportion to the rest of the edifice. Small-sized fuel is used, and marvelously little of that. The process of firing is quick and simple. At half past seven, on a cold morning, the servant brings a small basketful of slender pine sticks…lights them with a match and closes the door. They burn out...and all day long and until past midnight all parts of the room will be delightfully warm and comfortable…the surface [of the heater] is not hot, you may put your hand on it anywhere and not get burnt. America could adopt this, but does America do it? The American wood stove, of whatever breed, is a terror. It requires more attention than a baby. It has to be fed every little while, it has to be watched all the time; and. You are roasted half your time and frozen the other half."

If you burn wood fairly rapidly, it is a clean fuel. However, if you try to burn it too slowly, the fire will change from flaming to smoldering combustion. This results in an incomplete burning process that produces tars and dramatically increases atmospheric pollution. One of the biggest problems with using traditional wood burning stoves, in the relatively mild climate of the Mid-Atlantic and South Eastern region of the country, is that most of the heating season is actually spring and fall weather with real winter weather only a few weeks long…..not months in duration as compared to the Northern regions of the country. This is an important consideration. Much of the time, the average energy demand of your house will be quite low. For older conventional woodstoves, this energy demand will be below their "critical burn rate" or the point where they start to smolder. With the newer more efficient wood stoves now on the market, where the burn rate can not be adjusted, the BTU output will most likely be greater than comfort allows during the spring and fall portion of the heating season. A new EPA approved wood stove will only work satisfactorily when it is fairly cold outside. It will produce too much heat during the lengthy fall and spring heating seasons in the southern regions of the country.

In order to avoid this problem, masonry heaters fill the bill perfectly. If you need even a very small amount of heat, such as in the early Fall or late Spring when you only want to take the chill off the air, you simply burn a smaller fuel load-yet still burn it quickly as possible. If you sit near the door of a Tulikivi masonry heater you will get immediate heat through the glass door, but most of the heat from the fire will be stored in the thermal mass of the fireplace and will over a long period of time provide gentle "radiant sunshine" within your home. Unlike a traditional wood stove, the masonry heater will not make the room it is located in too warm, resulting in the need to open your doors or windows to vent the hot convection air. Rather you have a premium radiant heating system with an even and comfort temperature level that simply cannot be equaled by traditional wood stoves or for that matter the convection heat of forced air furnace and heat pump systems.

The only heat system that is comparable in comfort with a masonry heater would be an in-floor radiant system of many hundreds of square feet. Even here the masonry heater has advantages, the main one being that during the transition seasons of early fall and late spring the heat you need to take the chill off the air is delivered much more quickly than in a large radiant floor system that runs cooler and takes more time to make its effects felt. Another big advantage is when the power goes off…a masonry heater does not need electricity to operate. Needless to say you will not be able to enjoy looking at the fire heating your in-floor radiant system the way you will be able to enjoy the fire viewing provided by your Tulikivi masonry heater.

My first encounter with masonry heaters dates back to the early 1980's when I designed and built a passive solar home for my family in central Virginia. I read and studied the passive solar literature of the time and incorporated many of the ideas into our home. Almost as an afterthought I decided to include a masonry heater in the project. After all, I figured, we will not have enough sun every day during the heating season to heat the home. Boy was I right about that! In fact most of the time December through early March is pretty overcast and while the passive solar aspects of the home did produce usable heat it was never enough to get us through our relatively mild heating season in Virginia.

This is when we discovered first hand how amazing a masonry heater really is. The five-run masonry heater constructed from brick sitting near the center of our 2500 sq/ft home totally heated the home. Most days we burned one load of pine wood slabs which were left over from a sawmill operation near our home. On the colder days we would burn two loads of pine slabs. In the early fall and late spring we might burn one load every other day. While I was delighted with the efficiency and the clean burning aspects of the masonry heater I marveled at the even comfort it provided throughout the home. How was this possible? After all, I wasn't circulating the heat to all the rooms in the home. Why was the air temperature throughout the home so even? Why wasn't it hotter in the upstairs balcony than on the masonry floor at the ground level of the home? Why were we so comfortable? It seemed too good to be true. To this day I have not found a clear or concise explanation for these questions. The best I can do is to share my observations that have been confirmed by twenty years experience with Tulikivi masonry heaters in this Mid-Atlantic and South Eastern region of the country.

- *How can the warmth of a masonry heater reach beyond the room in which it is located*?

The assumption of the person asking this question usually is that, unless air is being forced from one room to the next, even heating of adjoining rooms will not take place and that the room with the masonry heater will be very warm or even hot in comparison to the surrounding rooms. This is, in fact, what happens when a wood stove (rather than a mass storage heater) is used for heating. Since most people in this country are familiar with wood stoves, and very few familiar with mass storage heaters, it is not surprising that people are skeptical when told that the air temperature, between the room with the masonry heater and the adjoining rooms, will be quite even if not the same temperature.

- *So why is a masonry heater able to heat more than one room relatively evenly*?

The answer lies in the way heat (BTU) is transferred to the living area by a masonry heater versus a traditional wood stove (or for that matter any forced air system). With a masonry heater most of the heat is transferred to the living area by radiation rather than convection. Instead of heating the air directly the radiation from the masonry heater passes through the air in the room, and warms all of the solid surfaces in the room that it "shines" on. In effect, the masonry heater becomes a miniature "sun" in your living area, warming those surfaces evenly to, for example, 72 degrees. The surface areas warmed, now effectively heating the room, can add up to many hundreds of square feet. The amount of mass, now effectively acting as a thermal flywheel stabilizing the room temperature, can equal many thousands of pounds.

- *So what causes heat from a masonry heater to migrate to adjoining rooms*?
- *Don't you need fans to move heat from the masonry heater to other rooms*?
- *Would it be a good idea to place the cold air return near the masonry heater in order to circulate its heat throughout the house*?

The answer to these questions, which assume that heated air must be moved mechanically, is actually no. The secret lies in the fact that the surface temperatures in the adjoining rooms (i.e. ceilings, walls and floors) are slightly cooler than in the room directly heated by the masonry heater. The laws of thermal dynamics dictate that heat flows from warm surfaces to cool surfaces. This occurs through convection of air between rooms. As long as there is an opening between rooms the air temperate will equalize naturally. The natural convection process will continue until the wall surfaces in both rooms are equal. Convection between rooms will not stop until the masonry heater stops radiating to the surfaces of the room in which it is located (normally between 12 to 24 hours). When you walk from one room to the next it will be similar to walking from the direct rays of the sun in to the shade. When you walk into an adjoining room you will lose the direct warmth of the masonry heater's "sunshine" but the air temperature will change very little if at all.

I am often asked how big the masonry heater should be to heat, say 2000 square feet. While it is possible to calculate the BTU output of a masonry heater, using that number to determine the size of the heater needed is only one factor in considering what would be appropriate. The amount (size) of the thermal mass in the heater, the location of the heater, the floor plan of the living space in which the heater is located and the materials used in the construction of the home are all significant factors.

In thinking about **the size of the masonry heater needed**, I feel it is best to think of the masonry heater as a heat storage battery that is charged by the fire and discharge by its gentle sun-like radiation over an extended period of time. The greater the difference between the ambient air temperature and the surface temperature of the masonry heater the faster it will discharge its stored heat. The larger the heated mass of a masonry heater, the greater its ability to heat (remain charged) for an extended time. In other words, when you have a larger masonry heater you don't have to light a fire as often. You can also burn more wood and thereby put more heat into storage. If the masonry heater is too small for the space you want to heat, the result is most likely to be that you would have to burn fires more frequently than once or twice a day and that the extended heating impact area to adjoining rooms would be reduced, particularly as the weather got colder outside.

Norbert Senf, who is the current president of the Masonry Heater Association of North America , shared with me his answer to a customer who asked the size question.
CUSTOMER QUESTION:
We are currently in the process of designing a masonry stove for a house in Vermont. The future home will be 2,800 square feet and relatively efficient (R- 30+ walls, R-50 ceilings, U-.35 windows etc.). The house also has a good amount of passive solar gain with accompanying thermal mass for storage. How can we get a good sense of what size heater would be best for this house?

ANSWER by Norbert Senf
For our masonry heater the maximum heat output with 2 fires per day (100 lbs of wood, total, per day), is 20,000 BTU/hr (6 kW). Typical usage is with a single 60 lb fire per day, which gives you 3.5 kW, or 12,000 BTU/hr.

CUSTOMER FOLLOW-UP QUESTION:
In trying to get a sense of how much heat we should expect from the heater our draftsman did a heat load analysis and found that our home will require 65,000 BTU/hr. This does not look good beside the number you provided to me for heat output of the heater, but my understanding has been that a heater should provide ample warmth for a house even of our size. Is there something that I am missing?

FOLLOW-UP ANSWER by Norbert Senf
The heat load analysis provides the heating requirement for the coldest day of the year. In fact, the coldest day in the last 10 years, pre-global warming. In normal practice with fossil fuel equipment, you just double the size as a ballpark, to cover yourself - so they'd probably install a 100,000 BTU/hr furnace.

A masonry heater is normally used with a backup system of some kind, which covers the part of the load that the masonry heater can't. Also, the heat load calculation assumes that you are heating every single square foot of your house, including remote bedrooms, to 72F, around the clock, including on the coldest day of the year. So, your average heat load will be substantially lower. The average heat load of the average house in the US is somewhere around 12,000 BTU/hr. Because these numbers are all over the map, I find it misleading when manufacturers quote "will heat xx square feet" numbers. House size, house efficiency, and climate vary widely.

It is a very common misconception that masonry heaters have a high output, because they are large. Traditionally in Europe, they were only ever used as room heaters, and nobody ever tried to heat a whole house with one. Our heater is about twice the output of the average European heater. You can build them larger, but it gets very expensive, because of the high stresses that start to happen in the firebox. Also, higher output means burning correspondingly more wood to cut or buy, store in a woodshed, and carry in.

One thing that a heater can do, similar to a hydronic floor, that a hot air system can't, is keep a large central space comfortable, no matter what the rest of the house is doing.
So, it doesn't necessarily compute well in standard ASHRAE (American Society of Heating, Refrigerating and Air-Conditioning Engineers) calculations, which are based on cheap fossil fuel.

It is a really good idea to address this issue by lowering the heating load of the house in the design and construction stage, rather that address it with a larger sized heating plant, in other words, higher fuel consumption.
In practical terms, clients address this in a number of ways:
- lower the heat load of the house at the design stage
- test air tightness to confirm design spec
- let remote bedrooms be cooler during the day
- small backup systems - electric baseboard, small boiler or demand water heater, etc.
- some clients do a full fledged second system, which is the least cost effective, in my opinion
- run an extra flue to the basement and hook up a small regular stove, which is burned occasionally as needed
- my wife and I have a 2500 sq ft reasonably efficient house in Quebec that we built in 1981, and have a heater and a wood fired cookstove, which has worked great for us for nearly 30 years. The cookstove consumes about as much wood as the heater (total consumption is about 3.5 cords/year).
- a moderate amount of passive solar, if architecturally integrated into the house design.
- lay out the house so that the heater is central, and near where people will be most of the time. With this strategy, you can be warm even in an old house that is "unheatable" by conventional ASHRAE standards. We have an installation like that here in Quebec, a large old, uninsulated, solid brick house.

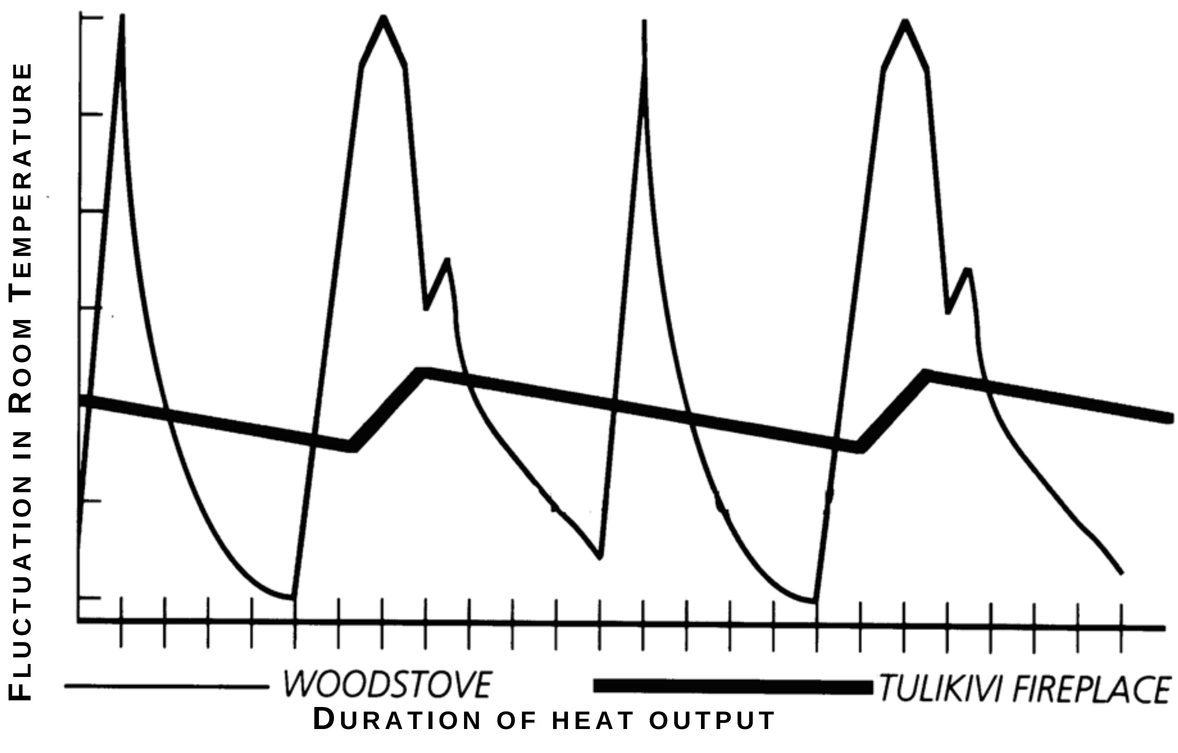
The **location of the masonry heater in the living space** will affect its impact on the heating needs for the home. There are two aspects of location which need to be discussed. First, the size of the room in which the heater is located in comparison to the size of the adjoining rooms and second, the location within the room itself. Remember that the masonry heater does not heat the air directly but rather the solid surfaces and objects in the room, these surfaces and objects in turn warm the air. The greater the surface area that the heater can radiate to and warm, the greater will be its impact in meeting the heating needs of the home because all this surface area will be able to warm and stabilize the temperate of a larger volume of air in the primary room which will then circulate to the adjoining rooms. The rule of thumb is - locate the masonry heater in a relatively large room with smaller adjoining rooms; don’t locate it in a small room with an adjoining large room space if you want to maximize its heating impact. This is why in the Mid-Atlantic and South Eastern region of the country Tulikivi masonry heaters have been so successful impacting the heating requirements of large cathedral ceiling great rooms as well as the smaller adjoining rooms surrounding the great room. It is not unusual in this part of the country to see successful heating impacts of 2000 to 3000 square feet. Of course, if the temperature outside goes down to below zero and stays there this heating impact area will be significantly reduced as it would be in a climate like in Alaska or Finland.

The **position of the heater in the room** in which it is located also has an affect on its heating impact of the home, but in our experience to a lesser extent than the previous discussion above. The Tulikivi literature recommends location of the heater in the center of the room when possible and recommends avoiding placement on outside walls. This is wise advice if you are building in Alaska or Finland but it does not carry the same weight if you are building in the Mid-Atlantic and South Eastern region of the country. Since our winter temperature are much milder, there is much less heat loss from the outside walls and ceilings, the placement of the Tulikivi on an outside wall does not seem to make that much of a difference in its heating impact. While the placement in the center of the room is better, we would recommend giving more consideration to the needs of your floor plan in locating the heater. From our experience, you should avoid locating the heater under a balcony in a great room or placing it in any kind of alcove that restricts its ability to radiate to the surfaces and objects in the room.

The **design of the floor plan** has a significant affect on the heating impact of the masonry heater. Masonry heaters have a greater impact in relatively open floor plans with adjoining rooms than on ranch house type floor plans with long hallways. Whatever your floor plan we highly recommend that you consider placing additional in-floor radiant heat in your bathroom locations. Regardless of the heat system you end up with you need an elevated temperature in these areas for comfort. This is easily achieved by using electric mats under tile. The cost of operation is minimal and the comfort of a warm bathroom floor is unsurpassed.

Why are radiant heat systems so comfortable? The stability and evenness of the room to room temperature in the home which we have already discussed is certainly one of the main factors. Another factor is the **stability of the relative humidity** of the air within the home during the heating season. Anyone who has heated with a wood stove or has a forced air furnace is familiar with the uncomfortable dry air one encounters during the heating season. Your throat is dry and irritated, your furniture dries out and falls apart, your house plants die, you are not comfortable. To counter the effect of the dry air, wood stove burners put pots of water on top of the stove and forced air systems employ humidifiers to attempt to restore the air moisture (relative humidity) that these heat systems remove when they are operating. What causes the air to dry out? Is it because air comes in contact with hot surfaces and looses its moisture? If so where does that moisture go? If you stop to think about this you realize that cold surfaces NOT hot surfaces cause moisture to condense out of the air. Hot surfaces would convert water (moisture) into steam and increase the relative humidity of the air, not lower it. So where do we find cold surfaces that cause the humidity to condense out of the air during the heating season? Have you ever noticed, on a cold day, water condensing on a window in your home? This is certainly one place that we should look. Another place is within your walls, but this condensation is hidden from view usually within the insulation of the walls. The condensation takes place at the “dew point” in the wall and ceiling insulation and eventually passes out of the home. This occurs because woodstoves and forced air systems create hot air which then, by convection, comes in contact with the relatively cool wall and ceiling surfaces setting up a dew point behind these surfaces and drying out the air in the home. With a radiant heat system you don't have hot air against cold walls you have warm walls heating the air to the same temperature as the wall surface. While the dew point in the wall is not total eliminated, the amount of condensation in the wall is significantly reduced. You do not feel the need to artificially humidify the air. In the summer time when it is humid you are uncomfortable and welcome the movement of the air from a fan. In the winter time you are comfortable when there is humidity in the air and very little movement of air or draftiness from your heating system.

Another factory to consider in the comfort of your home heating system is the **stability of the temperature** over time. The more stability of temperature between rooms, which we have already discussed, and the more stability of temperature over time, the more comfortable the heat system will be.



In a space warmed by the radiant heat of a Tulikivi fireplace, the fluctuation of the ambient air temperature typically varies usually less than 5 degrees Fahrenheit. Looking at the HEAVY line in the graph above, means that the coolest ambient air temperature (just before a fire is burned) might be 68 degrees and the warmest ambient air temperature (after the fire is out) would be about 73 degrees. On the other hand, the fluctuation of temperature resulting from the convection heat of a woodstove (thin line) is much greater and much more uneven.

Depending on the outside temperature, the duration of heat output from a Tulikivi fireplace will last 12 to 24 hours (48 hours in early fall & late spring). Its warmth will radiate from the stone warming the surfaces in the room just as the rays of the sun warm the earth. During that time there will be no fire to attend to, just slow, steady, even heat to enjoy.

A final aspect of home heating comfort that I would like to bring to your attention is that of movement of air. **Gentle natural convection (movement) of air between rooms is not uncomfortable. Accelerated (forced) convection of air within a room is uncomfortable.** Why is this? If you think in terms of "wind chill" the difference begins to make more sense. If you are skiing on a sunny winter day with the temperature below freezing, but no wind, you may need to unzip your ski jacket for comfort. However, if the wind starts to blow, yet the temperature and the sunshine remain the same, you will probably need to zip up your jacket for comfort. The only difference in your perception of comfort is the speed of the wind (air movement), known as the wind chill factor.

Radiant heat systems do not introduce "wind chill" into the home, traditional woodstoves and forced air systems do. In a radiantly heated room the walls, ceiling and floor are nearly if not the same temperature. The "sunshine" from the masonry heater warms all surfaces it shines on equally. With traditional woodstoves and force air systems hot air is generated. This air rises to the ceiling comes in contact with the coolest outside wall in the room settles to the floor, sweeps across the floor creating a draft on its way back to the conventional woodstove or the cold air return of the forced air system. The colder it is out side, the greater the need for more hot air, the greater the speed of convection (air movement) in the room, the greater the "wind chill" in the room, the less comfortable you are in the room. Often with a convection type heat system, the only solution for comfort is to rap a blanket around you as you read a book or watch television. On the other hand, with a radiant system you just sit in the sunshine.

I would like to relate to you one more question that I am often asked about movement of air in the room. The question is, "Wouldn't it be a good idea to us a ceiling fan to blow the hot air near the ceiling down to the floor?" People asking this question perceive a need to equalize the floor and ceiling temperature. Of course they are thinking of the problem that is created by a traditional wood stove or forced air system, not a radiant masonry heater. On closer examination, the solution (promoted by forced air heating industry) of using a ceiling fan to equalize the temperature in the room and "blow" the hot air at the ceiling to the floor could come right out of the pages of Alice in Wonderland. When the ceiling fan is used in the winter time to "blow" the air down you almost always can see the blades of the fan, which means it is not really blowing the air down but rather just stirring it up at the ceiling level. If the fan were actually run at a high enough speed to blow the air down, the cure to the stratification problem would be worse that the disease (problem) itself. The wind chill factor would increase and your comfort would decrease. On the other hand, in the summer time, when you have hot air at the ceiling and relatively cooler air at the floor, you can turn on the ceiling fan, force the hot air down on you and the wind chill will make you feel cooler and more comfortable. The fan cools in winter and it cools in summer, period.

I hope some of these thoughts and observations will help the reader to better understand some of the unique and valuable aspects of using a masonry heater for your home heating system. Please give us a call with any questions of concerns you might have about these radiant masonry heaters.