

Embodied Energy Comparisons - Light Weight Aggregates and Pumice

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Study 1 – Expanded Shale, Clay and Slate

Foundational Elements

1. A Based on information provided by the Expanded Shale, Clay and Slate Institute, (ESCSI), the embodied energy number for expanded shale, clay and slate as a category is 1.34 million BTU's. Note this number covers the production process from the point of mining to the point where the expanded shale, clay and slate is ready to be shipped to the wholesaler or end user.

Mining and Hauling of SCS Aggregate to Kiln + Kiln Process, Screen & Sort = (Expend) 1.34 million BTU's / cu yard

1.B Based on information provided by the Portland Cement Association (1990) the embodied energy for mining and hauling crushed stone and/or aggregate is 100,000 BTU's/ cu yd. Local product suppliers (Alpine Rockeries –Woodinville WA and Makenakos Inc --Preston WA) equate a yard of aggregate to about 1.3 tons (2600 lbs.). According to TXI Aggregates out of Colorado, it takes 1350 lbs. of aggregate going into the kiln process to manufacture 1 cu yd of expanded shale, clay and slate. Washington State is shale, but the weight holds true for clay and slate as well.

If it takes 100,000 BTUs to bring 2600 lbs. of aggregate to the kiln facility, then it should be reasonable to assume bringing 51.9% of that amount (1350 lbs.) would expend 51.9% of the 100,000 BTUs figure or 51,900 BTUs. This figure of 51,900 BTUs then represents the energy expended to mine and haul enough aggregate to manufacture 1 cu yd of expanded shale, clay and slate.

If we factor in a margin of error of 10% plus or minus, for gains in efficiency of equipment or losses in efficiency due to size of new mining and hauling machinery, etc., then the 51,900 BTU figure could vary from 46,710 to 57,090 BTUs / cu yd.

**Mining and Hauling of SCS Aggregate to Kiln = 51,090 BTU's /cu yard
Mining and Hauling of SCS Aggregate to Kiln +/- 10% = 46,710 to 57,090 BTU's /cu yard**

Assuming the maximum expended here, so as not to inflate the energy value that belongs to the kiln process, we will use the figure 57,090 BTU's / cu yard for calculating value for mining and hauling enough aggregate to manufacture 1 cu yard of lightweight aggregate (expanded shale, clay and slate).

Calculations

2. A Working from the figure 1.34 million BTUs/cubic yard as the embodied energy for the process from mining to final product FOB the plant, and removing (subtracting) the 57,090 BTU's expended to mine and haul the raw material to produce 1 cu yd of expanded shale, clay and slate, we have a balance of 1,282,910 BTUs of embodied energy that represent the kiln process (including the screening and sorting of the finished product.)

1.34 million BTU's/cu yard - Mining and Hauling of SCS Aggregate to Kiln (57,090 BTU's/ cu yard) = Kiln process with Sorting/Screening included 1,282,910 BTU's cu yard

Mining / Hauling = 57,090 BTU's / cu yard (4.3%)
Kiln / Sort/Screen = 1,282,910 BTU's / cu yard (95.7%)

Total process = 1,340,000 BTU's / cu yard (100%)

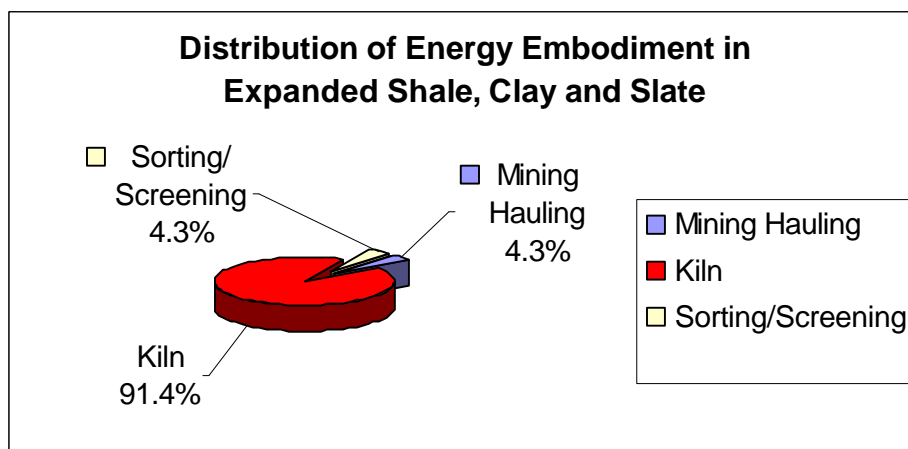
Most noteworthy here is that is that the **Kiln process (with Sorting and Screening included) makes up for about 95% of the embodied energy expenditure** in the manufacturing of expanded shale, clay and slate.

2. B This second calculation assigns a safe estimate to the energy consumption of the Sorting/ Screening process. The Sort and Screening process is a relatively low energy demanding process and while exact figures are not available at this time, it is likely not to exceed the energy expended to mine and haul the aggregate. Most likely it will be considerably less in fact not likely to even be half of the Mining and Hauling process. Nevertheless for the sake of the argument, if we use the same figure for Sorting and Screening as we use for Mining and Hauling we are without doubt understating the energy consumption value attributed to the Kiln process.

With the assumed over-estimated value (*) for the "Sort/Screen" process separated out;

Mining /Hauling = 57,090 BTU's / cu yard (4.3%)
Kiln = 1,225,820 BTU's / cu yard (91.4%)
Sort/Screen * = 57,090 BTU's / cu yard (4.3%)

Total process = 1,340,000 BTU's / cu yard (100%)



In this scenario the **kiln process still consumes 91.4% of the energy expended to manufacture expanded shale, clay and slate.**

Study 2 – Pumice

Foundational Elements and Calculations combined

1. A According to Great Pacific Pumice Inc. (Vancouver BC) at average moisture content in stockpiles, pumice has a density of 625 – 650 kg/m³. Assuming an arbitrary midpoint of 640kg/m³ and converting to lbs. and cu yards (1kg = 2.2 lbs.) and (1 cu meter = 1.308 cu yd):

The result is that 640kg x 2.2 (conversion) = 1410.9 lbs per cu meter.

The following equation converts from pounds per cu meter to pounds per cu yard:
1410.9 lbs. / x = 1.308 cu yd / 1 cu yd; solving for x; x = 1078.67 lbs per cu yard.

Therefore, a cubic yard of Pumice weighs roughly 1079 lbs.

1. B Working with weight as the driver in mining and hauling energy expenditures rather than volume, the following measurements provide for an approximate embodied energy for the Mining and Hauling of Pumice.

This equation solves for BTU's needed to Mine and Haul Pumice based on weight ratios for BTU's used to Mine enough aggregate to produce a cu yard of expanded shale, clay and slate.
1079 lbs. / 1350 lbs. = x / 57,090 BTUs solving for x; x = 45,629.7 or about 45,630 BTU's.

Mining and Hauling of SCS Aggregate (1350 lbs) to Kiln = 57,090 BTU's
Mining and Hauling of Pumice (1079 lbs) to Ship point = 45,630 BTU's

Therefore, it takes 45,629 BTU's to Mine and Haul 1 cu yard of Pumice.

1. C Assuming the screening and sorting of the pumice to desired sizes expends the same energy as the sorting / screening of the expanded shale, clay and slate (note: a heavy estimate) 57,090BTU's / cu yard, **the embodied energy of the Pumice would be about 102,700 BTU's / cu yd.**

Given that Pumice is available regionally, the BT U's required to bring a cu yard to the "ship to end-user" stage is roughly 7.7% of what it takes to bring a cu yard of Expanded Shale, Clay or Slate.