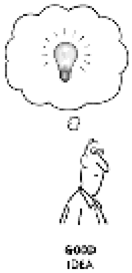
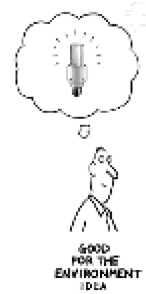




Understanding Efficiency and Efficiency Calculations

(with some pictures for us visual learners)

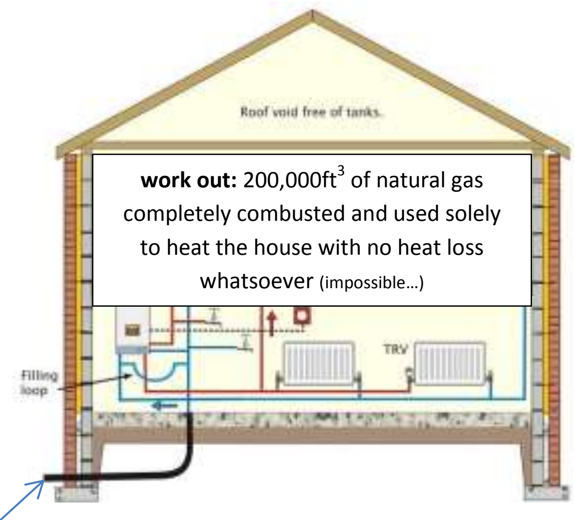
Just in case you are still having trouble processing the whole idea of efficiency, I put this together for you. If you understand efficiency, you can ignore this. But if you were having difficulties, I hope this will help. It really is no different than what I was explaining, but sometimes having it all laid out in front of you can make it even more clear.

So let's look at a situation where you have a 100% efficient heating system. You know that this would be in fantasy-land, because according to the 2nd Law of Thermodynamics, quality energy is always degraded to dispersed, wasted heat.

So off to the right, there is a picture of a space that needs to be heated. Let's say that there are 2500 square feet.

The black pipe in the lower left of the diagram indicates a gas line that comes into your house from the street providing you with natural gas that you pay National Grid for. This would be the input (or "work in" or "energy in").

If your system was 100% efficient, all of this energy input would convert o energy output. In a 100% efficient system work in = work out and you pay for exactly how much you need and use.



work in: 200,000ft^3 of natural gas

So by doing some fancy calculations, you determine that this imaginary 100% efficient heating system would require 200,000ft^3 of natural gas.

$$\frac{2500 \text{ sq ft}}{1} \times \frac{80{,}000\text{BTU}}{1 \text{ sq ft}} \times \frac{1 \text{ ft}^3 \text{ natural gas}}{1000 \text{ BTU}} = \mathbf{200{,}000ft^3 \text{ of natural gas}}$$

Now if this were the case, your payment to National Grid would be

$$\frac{200{,}000 \text{ ft}^3 \text{ natural gas}}{1} \times \frac{\$5.00}{1000 \text{ ft}^3 \text{ natural gas}} \quad \mathbf{\$1000.00}$$

Knowing that work in = work out and plugging the numbers into the efficiency formula, it reinforces that the system is 100% efficient.

$$\text{Percent efficiency} = \frac{\text{work out}}{\textbf{work in}} \times 100 = \frac{200{,}000\text{ft}^3 \text{ of natural gas}}{\mathbf{X}} \times 100 \quad \mathbf{= 100\% \text{ efficient}}$$

Since the system is 100% efficient and does not "lose" energy from the system, the work in = work out. **X** (work in) in the efficiency formula shown would then have to be 200,000ft^3.

Now let's consider REALITY. The second law of thermodynamics states that some energy is converted to low quality heat that is then dispersed; no device, machine, or system is 100% efficient.

Once the hypothetical output is calculated, we now need to figure out how much work/energy input is REALLY being put in based on the system's true efficiency rating.

The formula is easier than you think once you realize what the work in and work out are, but even if you are still a little confused, remember you will know what the work out is once you solve the problem. Then you will have to find the **actual work/energy put in** based on the stated efficiency rating – in this case 80%.

$$\text{Percent efficiency} = \frac{\text{work out}}{\textbf{work in}} \times 100 \qquad 80\% = \frac{200{,}000\text{ft}^3 \text{ of natural gas}}{\textbf{work in}} \times 100$$

Solving this algebraically leads to an answer of **250,000ft^3 of natural gas**.

Or using a proportion …

$$\frac{80}{100} = \frac{200{,}000\text{ft}^3 \text{ of natural gas}}{\mathbf{X}} \qquad \mathbf{X} = \mathbf{250{,}000ft^3 \text{ of natural gas}}.$$

This is actually how much gas you will need to heat your house, because 20% of the energy is being "lost" from the system.

This should make sense, because if the system is not 100% efficient, you have to compensate for losses by purchasing extra. And of course, the more inefficient your system is, the more you will end up paying for.

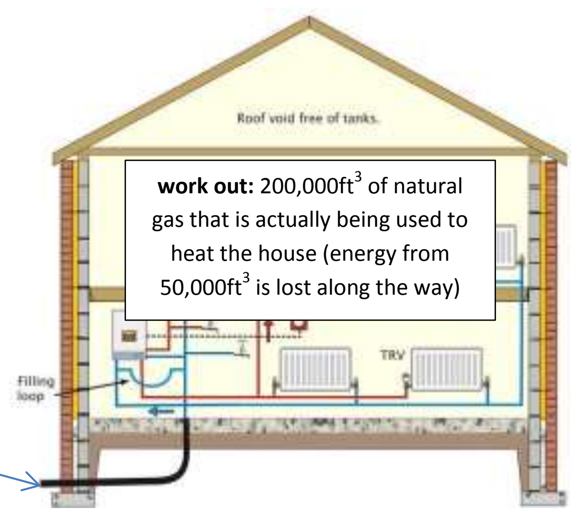
To calculate the true cost of natural gas, you have to use the amount that you will actually have to purchase to meeting the requirement of your system that lacks some efficiency.

$$\frac{250{,}000 \text{ ft}^3 \text{ natural gas}}{1} \times \frac{\$5.00}{1000 \text{ ft}^3 \text{ natural gas}} = \mathbf{\$1250.00}$$

work in:

According to second law of thermodynamics – work in must be GREATER than work out

250,000ft^3 of natural gas will be required because of energy losses throughout the system.



work out: 200,000ft^3 of natural gas that is actually being used to heat the house (energy from 50,000ft^3 is lost along the way)