



Understanding Efficiency and Efficiency Calculations

(with some pictures for us visual learners)



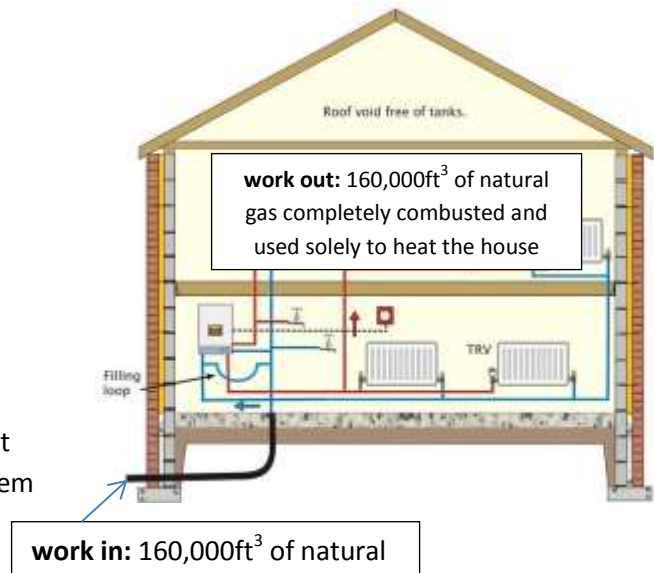
Just in case you are still having trouble processing the whole idea of efficiency, I had a little time between classes to put this together for you. If you understand efficiency, you can ignore this. But if you were having difficulties, I hope this will help. It really is no different than what I was 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 is 2000 square feet (hmmm... that number sounds familiar).

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 to energy output. In a 100% efficient system work in = work out and you pay for exactly how much you need and use.



So by doing some fancy calculations, you determine that this imaginary 100% efficient heating system would require 160,000ft³ of natural gas.

$$\frac{2000 \text{ sq ft}}{1} \times \frac{80,000 \text{ BTU}}{1 \text{ sq ft}} \times \frac{1 \text{ ft}^3 \text{ natural gas}}{1000 \text{ BTU}} = 160,000 \text{ ft}^3 \text{ of natural gas}$$

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

$$\frac{160,000 \text{ ft}^3 \text{ natural gas}}{1} \times \frac{\$5.00}{1000 \text{ ft}^3 \text{ natural gas}} = \$800.00$$

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

$$\text{Percent efficiency} = \frac{\text{work out}}{\text{work in}} \times 100 = \frac{160,000 \text{ ft}^3 \text{ of natural gas}}{160,000 \text{ ft}^3 \text{ of natural gas}} \times 100 = 100\% \text{ efficient}$$

Now let's consider REALITY. It is the 2nd LAW of thermodynamics and NO 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%.

$$\text{Percent efficiency} = \frac{\text{work out}}{\text{work in}} \times 100 \quad 80\% = \frac{160,000\text{ft}^3 \text{ of natural gas}}{\text{work in}} \times 100$$

Solving this algebraically leads to an answer of **200,000ft³ of natural gas**.

To try and help you avoid the algebra, I manipulated the formula so it was set up and ready to solve.

$$\text{Work in} = \frac{\text{work out}}{\text{percent efficiency}} \times 100 = \frac{160,000\text{ft}^3 \text{ of natural gas}}{80} \times 100 = \mathbf{200,000\text{ft}^3 \text{ of natural gas}}$$

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.

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

or

$$80\% = \frac{\$800.00}{\mathbf{\$ \$ \text{ in}}} \times 100 = \mathbf{\$1000.00}$$

work in:

According to 2nd Law of Thermodynamics – work in must be GREATER than work out

200,000ft³ of natural gas will be required because of energy losses throughout the system.

