January 13, 2015

Bram,

This is a detailed response to your email of January 13, 2015, and I want it entered into the record as formal comments on the Alternative Portfolio Standard, so I am including your email to me here.

I had asked you in an earlier phone conversation and an email the other day about whether the regulations would continue to treat pellet fuels as if they had the same GHG emissions as green chips, considering the emissions associated with wood harvesting and pellet manufacture.

You responded thus:

"The available scientific information indicates that the energy needed to manufacture wood pellets is factors lower than the energy being generated by burning the pellets. Chips require less energy to manufacture than pellets, but they are less dense, which leads to more transport energy. They are also less uniform in size and composition, which causes operational challenges for the heating equipment. Chip systems also have higher PM emissions. We do see a role for both fuels, and see benefits and drawbacks to both.

The GHG calculations for woody biomass do indeed not take into account the manufacturing and transport energy. The calculation is taking the forest regeneration rate, and the energy efficiency of the energy generation equipment, as you know. Doing a full lifecycle GHG calculation including the production and transport energy use, is effectively impractical. The data on the wood products side is incomplete. It would also require full lifecycle data for all the fossil fuel systems that the GHG reductions are compared with, and I imagine you are aware of the contentious ongoing debate around methane emissions from hydraulic fracturing for gas and shale oil, to quote only one issue. It would then presumably also lead to the need to do the same assessment for all the materials that make the heating appliances. None of this data is available.

Moreover, there are separate and dedicated climate and clean energy strategies for the manufacturing and transport sectors which are meant to reduce the GHG impact of those sectors, including the manufacturing of pellets and chips and their transport. So it is hard to see what if any the actual added value would be of including upstream energy use in the GHG balance calculations in the renewable thermal regulatory language."

The following is a response to your statements, and, a demonstration that the CO_2 emissions associated with pellet wood harvesting and manufacture are significantly greater than burning green chips.

Energy for pellet manufacturing is significant

First, I don't think your statement is correct, that "The energy needed to manufacture wood pellets is **factors lower** than the energy being generated by burning the pellets." The lifecycle studies I've seen indicate that manufacturing energy alone is upwards of 20% of the energy that is in a ton of wood pellets. I'll paste the calculations at the end of this letter so you can work through them, but the bottom line is, the energy used for drying and manufacturing pellets is around 25% of the energy in the fuel, by my calculations, not "factors lower."

I use two different approaches - one in the appendix I included at the end of this letter, and one in my spreadsheet. In the spreadsheet, I use a value from the attached lifecycle study by Craven, which estimates energy expenditures for pellet manufacturing. This study assumed they were starting with wood that was already dried down to 20% moisture content, so, it underestimates the actual energy expenditure. The expenditure was about 3,800 MJ per tonne of pellets produced. As I show in the spreadsheet, if all this energy comes from natural gas, this translates to about 0.19 tons of CO_2 per ton of pellets produced; if it comes from burning wood and bark, the emissions are about 0.34 tons CO_2 per ton of pellets.

Transport emissions aren't relevant, but manufacturing emissions are

Your statement that "Chips require less energy to manufacture than pellets, but they are less dense, which leads to more transport energy," isn't relevant to the question of GHG emissions by your own logic, because, as you say, "The GHG calculations for woody biomass do indeed not take into account the manufacturing and transport energy."

However, I don't think your statement about the regulations not including manufacturing emissions is correct. The regulations are *supposed* to take manufacturing emissions into account. They state, at 14.05(1)(a)(7)(f)(iii) that

"The Department shall provide in the Overall Efficiency and Greenhouse Gas Analysis Guideline as part of the Statement of Qualification Application a standard analytical methodology to meet this requirement, **including a full accounting of greenhouse gas emissions associated with any fuel processing."**

So if the existing biomass fuel GHG estimator isn't doing that, then it's not compliant with the regulation and it needs to be fixed. I'd appreciate you looking into this and getting back to me about whether the estimator includes this estimate, and how it's going to be fixed, if it does not.

Pellets require more wood than green chips per MMBtu, leading to higher CO_2 emissions

When we discussed how you were looking into wood use for pellets back in late November/early December, I was not in fact referring to emissions associated with manufacturing and transport, or requesting a full lifecycle analysis. **I was talking about the actual wood that goes into the pellet-making process, the carbon debt that is created by harvesting wood for pellets.** The emissions associated with manufacture are not "upstream" emissions – they are integral to the calculations of the carbon footprint of the fuel, as specified in the spreadsheets that were issued with the initial biomass regulations.

Industry manufacturing numbers for pellets make it clear that a great deal of wood that is harvested never ends up in the pellets – instead, it's left on-site, or collected and burned for heat during the manufacturing process, or sold for other purposes (eg to biomass plants that primarily burn bark).

Forisk (report attached) uses industry number of 2.2 tons of green roundwood to make a ton of pellets (see attached). This number has been extensively documented, and changing it from the 2 tons wood per ton pellet value that they previously used was probably embarrassing for them, to admit such an error. The value is is simply the estimate of what the roundwood weighs before it's debarked and pelletized - thus, it does **not** account for the parts of the tree that are killed in the course of harvesting, but aren't used as feedstock for pellets – ie, the tops, limbs, and belowground biomass. Tops and limbs add about another 25% to the biomass estimate. Considering the belowground biomass that is killed adds at least another 20 – 30% of biomass. (Yes, some New England pellet manufacturers use mill waste as feedstock – I am not talking about them. They can't keep up with pellet demand now, and there is no way pellet demand can increase without driving new forest harvesting).

I only considered aboveground biomass in the calculations on the spreadsheet I included. The calculations find that for the scenario where you are comparing debarked roundwood as pellet feedstock to green chips as fuel, the emissions are 0.14 tons CO_2 per MMBtu of fuel energy for the pellets, versus 0.11 tons CO_2/MMBtu for green chips. So the penalty simply from wood used to create the pellet fuel, even when you take the differing fuel energy contents into consideration, is 27%. If you compare all the aboveground biomass cut in the course of making pellets (tops and limbs), the emissions rate is 0.19 tons CO_2/MMBtu for pellets, so that's a 73% penalty.

Please note that when I estimated fuel energy, I used a value of 7,990 MMBtu/lb for pellets at 6% moisture content, consistent with data from the "Biomass Energy Data Book" values included in the spreadsheet. However, DOER's own estimate of energy in pellets is lower – at 7,750 MMBtu/lb (page 7 of DOER's 2007 "Wood Pellet Heating Guidebook.") So if the lower value provided by DOER were used, the CO_2 emissions rate per MMBtu of energy would be even higher.

Then, on top of that, you add the manufacturing emissions. The impact of the manufacturing CO_2 emissions relative to the CO_2 embodied in the fuel may not be as great as the relative impact of manufacturing energy on fuel energy, because burning natural gas to dry the pellets produces less CO_2 per unit energy than burning wood.

Additionally, if waste wood from pellet harvesting is burned to generate heat at the plant, the emissions should not be double-counted if that carbon was already factored in at the beginning, in the estimate of the total green tons required to produce one ton of pellets. On the other hand, it's also possible that tops and limbs are left at the harvest site, or that bark is disposed of in some way. In any case, many if not most modern pellet plants use at least some natural gas for drying the pellets, leaving an open question as to the fate of all the wood that does not end up in the pellets. And, given your concern with PM emissions as stated in your email, if wood and barks is burned at the facility, this can be tremendously polluting – pellet dryers tend to be quite

poorly controlled. While Massachusetts will likely outsource much of this pollution to other states with far poorer emissions standards for pellet manufacturing facilities than we have, claiming that pellets are so much "cleaner" without accounting for these manufacturing emissions is unjustified.

Pellets need separate and scientifically valid carbon accounting

Overall, this admittedly rough calculation of carbon costs finds that emissions from green chips are around 213 lb CO_2/MMbtu, while emissions from harvesting and manufacturing pellet fuel may range from 300 – 400 lb CO_2 per MMBtu of fuel energy. While a true value is probably somewhere in that range, even the average value is 64% higher than the emissions from green chips. And this has just been a discussion of stack emissions, with no consideration of the impact of accelerated whole-tree harvesting for pellets and the long-term carbon debt that creates.

If you can find some error or problem in these estimates, or care to refine them further, please let me know. Meanwhile, as required by the existing regulations, DOER should ensure that all manufacturing emissions are included in the lifecycle accounting for pellets; and just as importantly if not more so, as DOER is so very keen to promote use of pellets for thermal energy, the new regulations and lifecycle accounting must take all these emissions associated with pellet manufacture into account as well.

Best regards,

Mary Booth

Appendix: Energy expended during pellet manufacturing

According to Katers and Kaurich, the reference the Manomet Study used, the energy of vaporization is about 1,115 Btu to evaporate one pound of water (see page 6 of the K&K study for the numbers I use below).

You need about 1.71 tons of green wood chips (with no bark) at 45% moisture content to get 1 ton of pellets at 6% moisture content. Looks like:

.94
.55 ÷

1.709

Each pound of that wood needs to be dried down, driving off 0.39 pounds of water as you go from 45% mc to 6% mc:
.45
.06 -

0.39

In a ton of wood, there will be 780 lb of water that need to be driven off, and in the 1.709 tons of wood you need to produce one ton of pellets (again, remember, this is minus bark), you will have 1,333.09 pounds of water to vaporize.

Multiply this by 1,115 Btu required to drive off one pound of water:

1,333.09
1,115 ×

You get 1,486,396.36 Btu, or 1.486 MMBtu required to simply dry the wood in one ton of finished pellets.

Now, look at other pellet facility operations. Katers and Kaurich show a couple of examples on page 6, a high-efficiency operation, and a low-efficiency operation. In the first, plant operations (separate from water vaporization) require 29,760 Btu and water vaporization requires 19,535 Btu. **So plant operations require 1.52 times the energy used in drying the fuel.** So, combining these factors and multiplying by the 1.486 MMBtu derived above, it's (1.486 + (1.52 x 1.486)) = **3.74 MMBtu of total facility energy expenditures for manufacturing one ton of pellets.**

I calculate that a ton of pellets has 15.98 MMBtu of energy (see my spreadsheet); so the ratio of energy expended is 3.74/15.98 = 0.234 – in other words, manufacturing expends an amount of energy than is close to **25%** of the energy that is inherent in the fuel.

I used a different approach in my spreadsheet, employing the pellet manufacturing energy expenditure figure from Craven, also attached. This comes in slightly lower than the K&K estimate, but, the supplementary material for their paper indicates that they were drying down from 20%, not 45%, so, naturally they would not calculate as big an energy cost as the more realistic scenario of going from green chips to pellets. They don't disaggregate the energy of vaporization and the other plant operations, which is why it's good to use the K &K calculations as a check.

But in neither case is the energy expended in pellet manufacture "factors lower" than the energy inherent in the fuel.