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The HECA Numbers Game

Additional submitted attachment is included below.

The HECA Numbers Game

Peter Montague, Nov. 12, 2013; revised Nov. 14, 2013
Environmental Research Foundation
153 Nichol Ave.
New Brunswick, NJ 08901
Tel. 732-887-7234
pm8525@gmail.com

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Summary: The HECA project in Tupman, California will sequester only about 25% of its CO2 and CO2 equivalents, not the 90% that HECA proponents claim. This will remain true even if HECA's proposed carbon sequestration is completely successful and does not leak CO2 into the atmosphere for thousands of years (a big **if**).

Introduction

My information about the HECA project comes from two sources: (1) The HECA project's document, "Volume 1. Amended Application for Certification for Hydrogen Energy California (08-AFC-8A)," available on the California Energy Commission's web site, here: http://goo.gl/tDhC3. Unless otherwise noted, all the page numbers in my analysis refer to this document. So, "pg. 2-5" refers to page 2-5 of HECA's Volume 1 and "Appendix A" refers to the same Volume 1.)

My second source of information about the project is the California Energy Commission's web page titled "Hydrogen Energy California Power Plant Licensing Case," online here: http://goo.gl/lyIqq

Before diving into the numbers, you might want to look at note 1 on quantities, abbreviations, and conversion factors.[1]

On the California Energy Commission (CEC) web site (http://goo.gl/lyIqq), we find a set of numbers for HECA's CO2. CEC says HECA will capture 130 mmscfd [million standard cubic feet per day] CO2.

130e6 cu ft/day = 3.681e9 liters / 22.4 = 16.43e6 moles * 44 = 7.23e9 g, or 7970 short tons per day * 365 = 2.9e6 tons/yr CO2 sequestered. This accords well with the claim that HECA will sequester 3e6 tons CO2 per year.

As a check on these numbers, let's calculate CO2 production for ourselves, using other information given in HECA documents.

CO2 from coal and petcoke fuel (my calculations)

Pg. 2-15 says the project will use 4,580 stpd (short tons per day) of coal or "nominally" 1.6e6 short tons of coal per year.

As received, the coal is 15% moisture [Table 2-5], so dry weight = 3893 stpd or "nominally" 1.36e6 short tons per year.

HECA Vol. 1 Table 2-5 shows sub-bituminous coal (dry weight) is 60.4% carbon, so 3893 stpd contains 2351 tons of C, which will create 8620 stpd of CO2 * 365 = 3.1e6 short tons of CO2 per year, assuming that all the carbon in the coal is turned into CO2. With a capacity factor of 85%, HECA's coal would produce 2.6e6 tons of CO2 per year.

Pg. 2-16 says the project will use 1140 short tons per day of petcoke per day. Petcoke is about 15% moisture [Table 2-4], so its dry weight will be about 1140*.85 = 969 short tons per day or 353,685 short tons of petcoke per year. If 8% of this is carbon [Table 2-4], then 353,685 tons of petcoke will contain 300,632 tons of C, of 300,632*(44/12) = 1.1e6 tons CO2/yr. With a capacity factor of 0.85, CO2 production from petcoke will = 937,000 tons per year.

Therefore total CO2 production from fuel (coal + petcoke) = 2.6e6 + 0.937e6 = 3.5e6 tons CO2 per year.

If 3e6 tons of CO2 were sequestered each year, this would represent 3/3.5 = 86% of the carbon in the project fuel (coal plus petcoke), which is pretty close to the claimed "more than 90%" sequestration.

Oil recovered

HECA (pg. 2-9) says it will sequester 3 million tons of CO2 per year by pumping it below ground in the Elk Hills Oil Field, about 3 miles from the HECA site, for the purpose of releasing 5e6 barrels per year of trapped oil. The oil will be brought to the surface where we can assume that its carbon will eventually be turned into CO2.

[A side issue: The *Kern Business Journal* (Oct., 2012: http://goo.gl/qPzVo) says HECA will recover 6e6 barrels of oil per year. Is this a typographical error in *Kern Business Journal*, or is HECA giving one set of numbers to the government (5e6 barrels) and a different set of numbers to Kern County business people (6e6 barrels)? It seems a fair question.]

Pg. 2-9 says the project will recover 5 million (5e6) barrels of oil each year. Oak Ridge National Laboratory (ORNL) (http://goo.gl/khcG) says there are 7.2 barrels of oil per metric tonne (2205 lb), so 5e6 barrels of oil weighs 694,444 metric tonnes, or 765,625 short tons.

If we assume that oil is 85% carbon,[1] 765,600 short tons of oil will contain 650,760 tons of C, which, when oxidized, will produce 2.4e6 tons of CO_2 per year.

This 2.4 million tons of CO_2 per year seems to have escaped the notice of the HECA engineers calculating the project's CO_2 production.

HECA's contribution to global warming from nitrous oxide

One of HECA's "selling points" is that it will not only generate some electricity, it will also produce one million tons per year of nitrogen fertilizer. According to HECA project documents, this will take the form of ammonia, urea, and a combined product called UAN, a combination of urea, ammonium nitrate, and water.

Pg. 2-20 says the ammonia unit capacity is 2000 stpd with daily average production of 1500 stpd. Direct ammonia product will be 500 stpd. This 500 stpd * 365 * .85 (capacity factor) = 155,125 tons/yr. Ammonia is NH_3. There are 128,000 short tons of N in 155,125 tons of NH_3.

HECA will also produce urea pastilles, small solid pellets of urea -- 1700 stpd is the capacity and the expected production rate. (pg. 2-20) Urea is $CO(NH_2)_2$. So 527,425 tons/yr of urea will be produced (assuming an 85% capacity factor). In 527,425 short tons of urea, there are 246,000 short tons of nitrogen.

The UAN unit capacity is 1500 stpd and actual production is expected to be 1400 stpd * 365 *0.85 = 434,350 tons/yr. (pg. 2-20) There are typically three commercial grades of UAN -- 28, 30 and 32, the number indicating the percentage of nitrogen (by weight). Assuming that HECA's UAN would be UAN-30, 434,350 tons of UAN will contain 130,305 short tons of nitrogen.

So total nitrogen in HECA's ammonia, urea and UAN products = 128,000 + 246,000 + 130,305 = 504,305 tons of nitrogen per year. When nitrogen is applied to soil for agricultural purposes, 3 to 5% of it is converted into nitrous oxide (N_2O) {http://goo.gl/u1tKl}. If we assume that 4% of HECA's N goes to N_2O, then 20,172 tons of N_2O will be produced each year. N_2O has a 100-year global warming potential 296 times as great as that of CO_2,{http://goo.gl/u1tKl} so 20,172 tons of N_2O has a global warming potential equivalent to 6e6 tons of CO_2.

The 6e6 tons of CO_2 equivalent global warming potential released annually from HECA's fertilizer seems to have escaped the notice of HECA's engineers.

Calculating Total HECA Project CO2, End to End

Therefore, total annual CO2 production of the HECA project, end to end, will be 3.5e6 tons (from the coal and petcoke fuel) + 2.4e6 tons (from the oil released) + 6e6 tons of CO2 equivalent per year (from nitrogen converted to nitrous oxide) = 11.9e6 tons of CO2 equivalents. If 3e6 tons of this is sequestered each year, then 25% of HECA's total CO2 will be sequestered, not the 90% claimed on pg. 2-1. And 75% of the project's CO2 equivalents will be released into the atmosphere, where they will warm the planet for the next several hundred years at enormous cost to present and future generations.

For purposes of evaluating environmental impacts of the HECA project, do the consequences of producing CO2 and nitrogen fertilizers legitimately attach to the HECA project? Surely the answer is Yes. The National Environmental Policy Act (40 C.F.R. 1508.8) tells us that an "effect" of an action (such as spending federal taxpayer funds to support the HECA project) includes reasonably foreseeable consequences that may occur later in time or remote in distance from the action itself. HECA's engineering design and business plan anticipate sending CO2 to an oil field for the purpose of commercial oil production, and producing nitrogen fertilizer for commercial agricultural use. Therefore the consequences of using that oil and that fertilizer are "reasonably foreseeable" effects that must be factored into any assessment of the environment consequences of the HECA project.

One final point: in document TN 201026, a letter from Michael Carroll of Latham and Watkins, Mr. Carroll argues that HECA is really three projects -- one generating electricity, one manufacturing fertilizer, and one producing oil. Mr. Carroll then argues that greenhouse gases produced by all three components of HECA should not be considered for purposes of evaluating HECA's compliance with SB 1368's limit of 1100 tons of CO2 released per megawatt-hour of electricity.

In response, one might ask, "Could HECA's electricity-generating plant survive economically if it did not have the fertilizer plant and oil production units as integral parts of the project?" The answer is a resounding ***No***. (*The CEC should ask HECA to produce all documents that HECA has used to solicit investments in the project. Those documents will show clearly that the oil and fertilizer components of the project are what make it profitable.* In describing the project to potential investors, HECA is explicit about its clever combination of fertilizer manufacture and electricity generation. Indeed, HECA is not really a power plant that produces some chemicals. *HECA is really a coal-based chemical factory that also produces some electricity*.)

If we revise Table 4 in TN # 201026 to include the total greenhouse gas emissions from all three components of the HECA project (11.9 million tons per year), then we can calculate that HECA will release 8900 pounds of CO2 and CO2 equivalents for each megawatt-hour of electricity generated -- 8 times the emissions allowed under SB 1368.

Finally, the Carroll letter (TN #201026) says that HECA "fully supports an in-depth and rigorous examination of the Project's overall efficiency and carbon footprint...." Unfortunately, HECA has not produced such an examination. *The CEC should require HECA to produce this much-needed rigorous examination, and the CEC should produce such rigorous examination itself to check HECA's' numbers.* As it stands, HECA is pulling the wool over the eyes of the public, claiming it will bury 90% of its CO_2 when, in fact, it will bury only about 25% of its CO_2 and CO_2 equivalent greenhouse gas emissions.

The HECA project will contribute very substantially to the problem of global warming, year after year for the next 50 years. As they grow up, our young children and grandchildren will despise and denounce us if we allow the HECA project to proceed because we are doing it with full knowledge of the serious negative consequences. We cannot say "We didn't know." We know.

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[1] Analyzing a project like HECA requires a lot of conversions. You may be given cubic feet of CO_2 and you need to convert that to Liters of CO_2. Of you are given grams and you need to convert that to tons. A good place to do such conversions is the Wolfram Alpha web site. (Of course there are many other places on the web to do such conversions, but Wolfram Alpha is particularly truthworthy, in my opinion.)

In this essay, the word "ton" means a short ton (2000 pounds). The word "tonne" means a metric tonne (2205 pounds).

To express large numbers, I've used so-called "scientific notation." So "3 million" is written 3e6, meaning "3 exponent 6" or 3 x 10 raised to the power of 6, or 3,000,000. In the same way 3e9 = 3 billion and 3e12 = 3 trillion.

Gases (like CO_2 or hydrogen) can take up different volumes depending on temperature and pressure, so to simplify calculations, scientists and engineers standardize temperature to 0 deg. Celsius (32 degrees Fahrenheit) and pressure to one atmosphere. Avogadro's law tells us that one "mole" of any gas occupies 22.4 Liters (at standard temperature and pressure). One mole of a substance (such as CO_2 or hydrogen) is the molecular weight of the substance expressed in grams. Example: From Wolfram Alpha, we learn that one atom of carbon has an atomic weight of 12, and oxygen has an atomic weight of 16, so the weight of one molecule of CO_2 is the weight of one carbon atom (12) + the weight of two oxygen atoms, or 16 + 16) and 12+16+16 = 44. So one mole of CO_2 = 44 grams of CO_2. The concept of a "mole" helps us determine the weight of a gas such as CO_2 or hydrogen because at "standard temperature and pressure" because one mole of a gas occupies 22.4 liters of volume. Using this relationship, we can calculate the weight of a gas, given its volume, or the volume of a gas, given its weight.

mmscfd = million (mm) standard cubic feet (scf) per day (d). In this context, the word "standard" is engineers' shorthand for "standard temperature and pressure" (described above).

stpd = "short tons per day"

"Capacity factor" is the ratio of the actual output of a power plant over a period of time and its potential output if it had operated at full capacity the entire time. For example, a 1000 megawatt electric generator, operating 24/7 for a year, could produce 1000*365*24 = 8.76e6 megawatt-hours. But because of downtime for maintenance and breakdowns, such a plant might actually produce something like 7e6 megawatt-hours per year, for a "capacity factor" of about 7/8.76 = 80%. In this analysis, we assume the HECA project operates with a capacity factor of 85%.

L means Liter and cu. ft. means "cubic foot," g means "gram." J means joule, a measure of energy (there are 1055 joules in one British Thermal Unit [Btu], another measure of energy).

To calculate the weight of CO_2 emissions from burning fuel, you take the weight of the carbon in the fuel and multiply it by 44/12. So an amount of fuel containing 2 tons of carbon, when burned, will produce 2 * 44/12 = 7.4 tons of CO_2.

[2] Oak Ridge National Laboratory says typical crude oil is about 85% carbon. http://goo.gl/6kAO9b