ASA

Annie Searle & Associates LLC

Research Note

Food for Energy or Energy for Food: A Chemical Dependency

Jeffrey Seward

November 2016

Keywords: energy; critical infrastructure; food & agriculture

Abstract: This paper explores the risks and the long-term impact of the Oil and Gas Sector on the Food and Agriculture Sector. Agriculture needs the Oil and Gas Sector in order to produce at current levels. If oil and gas were eliminated overnight, our very ability to produce food crops would be gone along with it. One of the most important risks to look at is need to eat versus need consume oil and gas. The relationship between these two critical infrastructure sectors will have implications on American commerce and the country's food supply.

"Energy cannot be created or destroyed; rather, it transforms from one form to another." –

Law of Conservation of Energy

Energy surrounds us from the sun shining above, to the chemical stores harvested beneath the ground. We, not unlike other plants and animals, consume energy, transform it for our purposes, and release the byproducts of those transformations. Just as we followed the cycle of sun energy to plants, up to our end consumption of food that makes us able to function from day to day, energy influences us in ways that are truly hard to comprehend. However, it takes energy to make energy. Centuries ago, farming took animal and

manpower weeks, months even, to bring bounties of crops from seed sown in the ground to seed harvested for our consumption. With the advent of modern technology, we moved from manpower to machine power, thus enabling each farmer to plant more acres and harvest more crops. Those machines were powered by coal-fired steam engines, then combustible fuels like gasoline and diesel. Even getting those crops to storage facilities, manufacturing sites, and end production takes millions of gallons of fuel. The Energy Sector, specifically the oil and gas sector, is what helps America's famers ensure that crops will have the energy stores necessary to plant, tend, and harvest those crops. However, what happens when the necessity of one sector threatens the survival of another sector, and may even be at odds with that sector? I will examine the risk and impact of the Oil and Gas Sector on the Food and Agriculture Sector and what that means for us in terms of commerce and our ability to feed others and ourselves.

The Oil and Gas sector employed almost 180,000 people in extraction in February of 2016.[1] While this is a smaller subsector of the mining, quarrying, and oil and gas extraction, the necessity of this sector to keep the country running is no doubt crucial. In fact, without the Oil and Gas sector, it becomes impossible for agriculture to take place at the level allowed currently by technology. To illustrate this dependency, let us look at a small farm case for their production and usage to understand how necessary oil and gas is to ensure food production.

One farm in eastern Montana planted 4,000 acres, or 6.25 square miles, of land into

wheat production for the 2015 harvest year. This farm utilizes some of the latest technologies for minimizing fuel usage such as updated machinery and GPS tracking of vehicles and equipment to minimize overlap, thus increasing coverage and decreasing fuel expended due to double coverage of areas. This farm had a final harvest of 140,000 bushels of wheat, working out to a harvest of 35 bushels per acre. This yield would feed approximately 84,000 people if the entire crop were dedicated to food production. However, if that seed were dedicated to being planted, given a 92% germination rate of seed, there is the potential to use that crop to feed 1.5 million people in the next year.

Seems impressive, but now let us look at the expenses of that farm for the same year. That farm spent $24,600 on fuel for tractors, combines, and trucks that carried out operations of hauling equipment, seed for planting, and harvested seed for storage and sale. That same 6.25 square miles also requires $109,000 in chemicals to treat the crops to reduce losses and $207,200 in fertilizer to ensure proper growing conditions to maximize yield. When all is said and done, the operation expenses for that farm alone work out to be $340,800. This means that just to cover the operation costs given the yield of the farm, the price of wheat needs to be $2.43. This does not cover any taxes, land payments, machinery payments that would also potentially need to be made.

Now to factor in what that fuel consumption does to the environment, the very thing agricultural production depends upon. Using the average price of fuel in 2015, one can estimate that at total fuel cost of $24,600 and an average diesel price of $2.12 per gallon,

the farm in eastern Montana used approximately 11,600 gallons of diesel fuel. Using calculation from the U.S. Energy Information Administration,[2] each gallon of fuel burned created 22.38 pounds of carbon dioxide, making for a total of almost 260,000 pounds of carbon dioxide put into the air during a single farming season. While there are studies that show wheat yields benefit from increased carbon dioxide in the air,[3] it is also noted that there is a tipping point in which that no longer becomes the case. Unfortunately, at the time of writing this document, there was no information that could be found on how much carbon sequestering wheat is capable to offset the amount of carbon production during the planting cycle.

The sheer amount of CO_2 created by one small farm in eastern Montana is truly incredible; however, in the grand scale of that production, agriculture only accounts for 9% of CO_2 emissions [4] while the transportation industry accounts for 26%. Electrical generation creates 30% of CO_2 emissions. It is run on a mixture of coal and natural gas. For this paper, I am focusing on the oil and gas sector alone. There would be an element of the electrical generation side that would need to be investigated to determine how much electrical generation is done through natural gas, as it is a significant source of heating and electrical power generation.

The impact that the oil and gas sector has had on CO_2 outputs is impressive in that it does account for the 26% of emissions that come from the transportation sector. Given that it is also source of CO_2 generation that has only existed in the last 110 years, it is clear the

kind of impact it has in conjunction with the amount of CO_2 generated with each gallon of diesel and gasoline.[5] The climbing rate of CO_2 has been a source of concern for scientists with concentrations rising significantly since the start of measurements on Mauna Loa.[6] As stated previously, increased CO_2 does help increase yield in wheat,[7] that limit can be reached very easily. That part alone would stifle crop production, even lending to production to fall significantly before the discussion of other environmental impacts takes place.

Agriculture needs the Oil and Gas Sector in order to produce at current levels. Even for that small farm, planting, fertilizing, spraying, harvesting, and transporting crops over for production that takes place on 6.25 square miles would be impossible without the power of oil and gas. It is part of what allows our country to have the lowest expenses in terms of disposable income used to buy food. However, when it comes to reaching threshold CO_2 levels and crop production, we find ourselves in a conundrum that may force us to define who we are. Agriculture's dependence on oil and gas is like that of a chemical dependency. There is the need for it to be able to function at current capacities. If oil and gas were eliminated overnight, our very ability to produce food crops would be gone along with it. To say that it would be like going back to the days before powered machinery would be an understatement. Currently, there are no all-electric farm machinery options available. The power requirements of food and agriculture need oil and gas in order to assure production. Until companies like John Deere, Case International, and Caterpillar

develop more hybrid or all electric options, and power storage for electrical vehicles improve, agriculture will have to maintain its status quo for powering itself.

One of the most important elements to look at is what Food and Agriculture views as risks versus what the Energy sector, specifically Oil and Gas views as risks. Food and Agriculture says in their risks that, "Climate change poses a major challenge to U.S. agriculture because of the critical dependence of the agricultural system on climate and the complex role that agriculture plays in rural and national social and economic systems.[8]" The Oil and Gas sector does not admit to climate change being part of its risk profile, coming closest with its risk assessment of, "Natural disasters and extreme weather conditions.[9]" By these two critical infrastructures not being in alignment as to a very critical risk, it presents a unique problem in which there could be could be a detrimental relationship.

One of the most important risks to look at is need to eat versus need consume oil and gas. If food prices rise at a similar pace as oil and gas did before reaching its heights, people will not likely cut back on food the way they would cut back on oil and gas consumption. For Oil and Gas, this is a risk that is not accounted very well by the fact that climate change has already begun to affect the way in which crops are produced. Fuel prices forced farmers to change their practices as much as possible to take advantage of lowering their operational expenses. However, should food prices become subject to the same kinds of volatility experienced during the expansion of oil exploration, the general

public will ensure they will be able to eat as it is one of the five necessary needs.

Another risk of climate change that has not been accounted for by the Oil and Gas sector is that more state governments are stepping up to ensure a diverse energy portfolio. As more states adopt measures to reduce the carbon impacts of their states, oil and gas could see significant regulatory issues pop up for them. Currently, Oil and Gas only looks at, "regulatory and legislative changes—including environmental and health—as well as increased cost of compliance."[10] This is far from factoring in climate change as a true risk to the sector. States will continue to legislate based on environmental and health issues, however, more will legislate on climate issues in the future, thus affecting Oil and Gas in a way that has not necessarily been accounted. The risks will be anything from moratoriums on extraction to energy diversification that targets removal of Oil and Gas from a state's energy portfolio.

Another risk factor to the Oil and Gas sector is the expansion of alternative energy sources. While this may not seem immediately apparent, the market shift of autos to electric has had other consequences. Many users are seeing the value of having their vehicle powered by renewable energy sources as well. Because of the increased production of renewable energy sources, the price of building and supplying that source has become more accessible. It is now easier than ever to include solar cells or home wind turbines as part of the purchase of a home. The tax incentives for adding these mechanisms make it more plausible to invest in these sources that would allow them to power their electric

vehicles, cutting out the need for Oil and Gas or significantly reducing their dependence on the sector. As these technologies become cheaper, it will be easier for consumers to justify these expenses for their home and vehicles as a cheaper, cleaner power source.

While it would take time for states to move away from oil and gas, a critical component has shown that Oil and Gas may not be as vital as it was once. The market has been shifting towards hybrid vehicles and now all-electric vehicles. All-electric was once considered impractical due to the inability to store enough power within a vehicle or the cumbersome batteries that were either inefficient or unsafe. As engineers have made strides to create a more appropriate battery that supplied the power necessary, auto makers have moved toward a diversified line of hybrid and electric vehicles. Even heavier transport vehicles are now starting to make the shift to all-electric. BMW released their electric tractor-trailer in July of 2015.[11] While it is certainly not capable of the range that tractor-trailers have currently, it shows that there is an application for these vehicles. As battery solutions continue to develop, that range will soon be like current all-electric cars now and be comparable to their predecessors. It is also more attractive as an option due to the tax breaks companies can receive and the fact that it is cheaper to "fill the tank" on an electric car than it is to do the same with a gasoline engine. As storage or interchangeable batteries become more practical and have better distance, the limitations for the agricultural sector will begin to get smaller, and thus making all-electric power for transportation a more viable option.

The large machinery such as combines, tractors, and other heavy equipment will eventually benefit from hybrid technology. John Deere has already begun to release a line of hybrid combines that will help farmers benefit from a power source many major industries already use. While the amount of power is small compared to the power needed to operate a machine, the 224 kW powered battery will undoubtedly provide a benefit to farmers in two manners. First, there will be the reduction of fuel used during the course of harvest. Second, as more hybrid combines come available with larger, more powerful batteries, the impact that the agriculture industry has on CO_2 production will diminish so long as the engines remain entirely powered by diesel engines. Should these vehicles become plug in hybrids, there will need to be a method of power generation by alternative energy sources that would offset the need for increased energy production.

What we have to keep in mind is that the Agriculture sector only accounts for 9% of CO_2 emissions.[12] The other major sources of emissions would need to be trimmed from the Transportation sector and from other sources of electrical generation that use natural gas as its source. Overall, it should be the goal of the Energy sector as a whole to ensure that its mission also helps align with our country's need to continue being self-sufficient in agricultural production. As long these two sectors do not align with the science of what drives climate change, the Energy sector will do irreparable harm to the Food and Agriculture sector. This risk will ultimately drive up the cost of food and even have an effect on the Oil and Gas sector's ability to be profitable. People will make cuts in many areas;

however, there will be a lot of cuts made to people's consumption of transportation. Telecommuting to work is becoming a more viable option for many people, and given the option and ability, it could end up being far more viable for those individuals seeking to make changes in order to assure their ability to eat.

Mitigation of the risks to the Oil and Gas sector is very tricky. This sector needs consumption in order to survive. However, the consumption as it stands currently is doing damage to the environment and threatening the ability of Food and Agriculture to sustain its output. Food and Agriculture needs Oil and Gas right now because it currently could not produce at the level needed. As agriculture continues to expand and diversify its power source, it will help reduce the risk to itself by using Oil and Gas. More importantly, as auto and Ag machinery makers continue to diversify their energy sources, either it will force Oil and Gas to become a more environmentally stable power source, or it will be forced out of the picture entirely. Oil and Gas would have to find a way to become a near zero-emission product. The progress that it has made to clean up the emissions created from gasoline, diesel, and natural gas has been an important first step. That work will most likely be for naught.

As solar, wind, and hydro-electric become more widely used and batteries become more powerful, the uses of brute force power will be minimized. Even in the brute force side of combustion engines, work on hydrogen combustion engines has made a remarkable leap in terms of potential. What makes hydrogen so unique is that it is a powerful

combustion fuel source that would only have water and water vapor as its byproducts. The power created by this combustion fuel source could leave Oil and Gas behind as it would no longer be necessary to burn complex carbon chains that have known negative effects on the environment. It would most likely even be possible to use these engines in a hybrid capacity as well, allowing for minimal impact.

The Oil and Gas sector's CO_2 emissions will surely be shrunk as scientific advancements allow alternative energy to become the cheaper fuel source. While CO_2 is important for sustaining plant life, it is also very clear that once a certain threshold is surpassed, the yield of wheat will decrease. Couple that with the damage to the climate that is creating weather patterns that make prolonged droughts, devastating floods, and fire seasons that start earlier and last longer, Oil and Gas sector is looking at changing landscape that threatens its very existence. Now add in the fact that it has been and will continue to affect Food and Agriculture to the point where production will cap, then decrease due to CO_2 levels, weather patterns that make production more difficult, and a world population that needs to eat, Oil and Gas finds themselves in a position where their sector is doing more harm to the world populace every year, and that harm can eventually hit a tipping point that would send our planet into a tailspin.

The risks presenting in regards to the Food and Agriculture sector by the Oil and Gas sector are very real threats that are happening at this very moment. The science is sound, the risks are real, and the consequences of inaction would have long reaching effects that

would make the world population choose between power and food. The alignment of the Oil and Gas to the Food and Agriculture sector is that of a chemical dependency. It is keeping an industry going while doing irreparable damage to it and at some point, that damage will be permanent and there will be no way to mitigate these risks.

---

[1] Bureau of Labor and Statistics. Retrieved May 27, 2016, from http://data.bls.gov/timeseries/CES1021100001?data_tool=XGtable

[2] U.S. Energy Information Administration. Retrieved May 27, 2016, at http://www.eia.gov/tools/faqs/faq.cfm?id=307&t=11

[3] Bugbee, B. et al. *CO2 crop growth enhancement and toxicity in wheat and rice.* Retrieved June 1, 2016 from http://www.ncbi.nlm.nih.gov/pubmed/11540191

[4] U.S. Environmental Protection Agency, Retrieved June 1, 2016, from https://www3.epa.gov/climatechange/ghgemissions/sources.html

[5] U.S. Energy Information Administration. Retrieved May 27, 2016, at http://www.eia.gov/tools/faqs/faq.cfm?id=307&t=11

[6] Earth System Research Laboratory. National Oceanic and Atmospheric Administration. Retrieved June 1, 2016, from http://www.esrl.noaa.gov/gmd/ccgg/trends/full.html

[7] Bugbee, B. et al. *CO2 crop growth enhancement and toxicity in wheat and rice.* Retrieved June 1, 2016 from http://www.ncbi.nlm.nih.gov/pubmed/11540191

[8] Food and Agriculture – Sector Specific Plan 2015. Retrieved May 27, 2016, from https://www.dhs.gov/food-and-agriculture-sector

[9] Energy Sector – Specific Plan 2015. Retrieved May 27, 2016, from https://www.dhs.gov/energy-sector

[10] Energy Sector – Specific Plan 2015. Retrieved May 27, 2016, from https://www.dhs.gov/energy-sector

[11] Hard, A. 18 wheels, zero emissions: BMW premiers all-electric material transport truck in Germany. Retrieved June 1, 2016, from http://www.digitaltrends.com/cars/bmw-all-electric-semi-truck-pictures-news-tractor-trailers/#:j-A51FMMwcVAKA

[12] United States Environmental Protection Agency, Retrieved June 1, 2016, from https://www3.epa.gov/climatechange/ghgemissions/sources.html