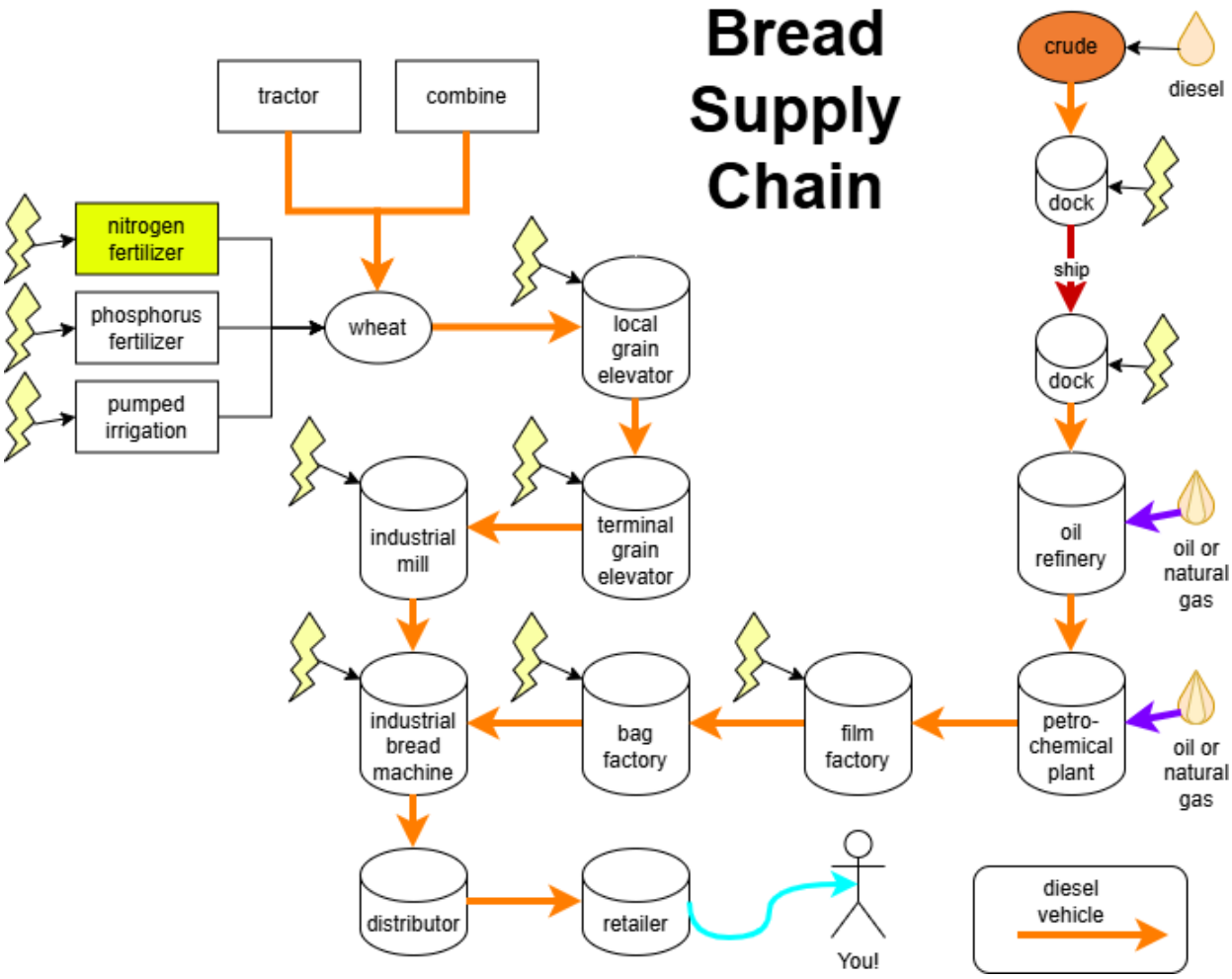
Still Drilling After All These Years

Here it is, the middle of 2025, with the average global temperature at least 1.55℃ above the pre-industrial average with CO_2 at 429.35 ppm, and yet we're still drilling for oil and gas.

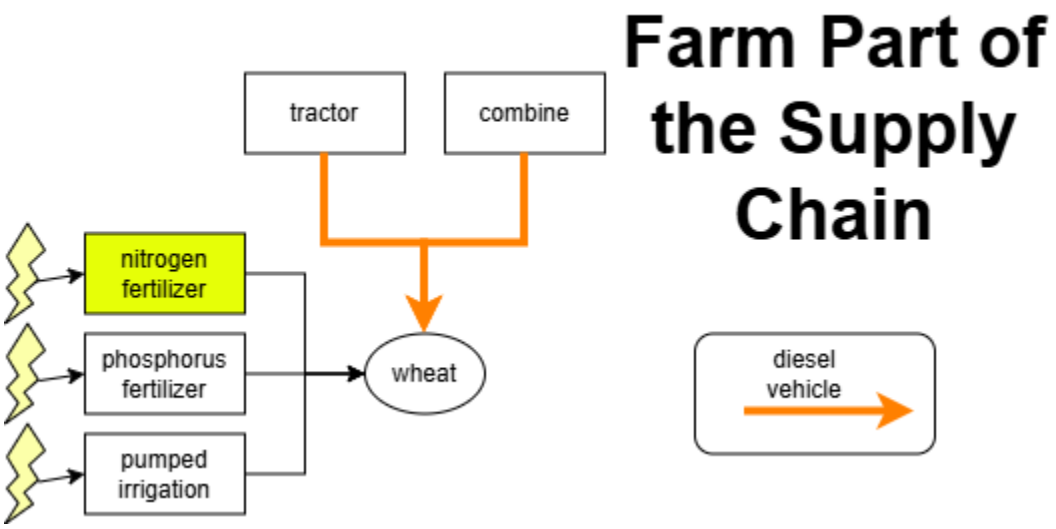
Many of us are asking, "Can't we just stop?" Surely if it were as simple as the optimists think when they tell us, "We know what to do. We just need the political will to do it," we would have done it, wouldn't we?

Maybe you're reading this posting over breakfast, maybe a very simple breakfast of toast and coffee, so let's just take a few minutes and meditate on your toast. Let's try to tell the story of your piece of toast. Or at least the wheat in it, the main ingredient.

If we were to try to illustrate the story, it would look something like this.


Bread Supply Chain
tractor
combine
nitrogen fertilizer
phosphorus fertilizer
pumped irrigation
wheat
local grain elevator
terminal grain elevator
industrial mill
industrial bread machine
distributor
retailer
You!
bag factory
film factory
petro-chemical plant
oil refinery
crude
diesel
dock
ship
dock
oil or natural gas
oil or natural gas
diesel vehicle

The Farm



Let's start with the land where the wheat grew. Do you know where it grew? I don't. Chances are, the wheat grew on a farm of at least 750 acres[1] in Montana, North Dakota, Kansas, or Washington. Wheat farming is expensive and risky, and requires great capital investment not only in the land, but in the diesel powered machinery.

Oh, yeah, diesel powered farm equipment. Diesel comes from oil.

We won't even mention the energy embodied in the manufacture of the farm equipment right now.

Chances are, the wheat was treated to Nitrogen fertilizer, made from ammonia using high pressure and temperature, fueled by natural gas.[2] Ammonia production is energy-intensive, accounting for 1% to 2% of global energy consumption, 1.3% of global carbon emissions, and 4% of global natural gas supply,[3] and requires a feedstock, most often natural gas.[4]

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[1] https://www.northernag.net/u-s-wheat-farms-have-dropped-significantly/, https://www.greatfallstribune.com/story/money/2016/05/11/bumper-wheat-crop-unlikely-help-montana-farmers/84200778/

[2] https://www.sciencedirect.com/science/article/pii/S0360319925009139#:~:text=Integrating%20the%20Haber%E2%80%93Bosch%20(HB,steam%20demand%20of%20the%20SOEC.

[3] iea.org/reports/ammonia-technology-roadmap/executive-summary; Ammonia Production from Clean Hydrogen and the Implications for Global Natural Gas Demand, Published: 13 January 2023 by Saygin, D et al. Sustainability 2023, 15, 1623. https:// doi.org/10.3390/su15021623

[4] en.wikipedia.org/wiki/Haber_process

Most likely, the wheat was also fertilized with a commercial Phosphorus preparation. The manufacturing process requires continuous supply of electrical power, in contrast to the intermittency of so-called renewables, most often powered by natural gas.[5,6]

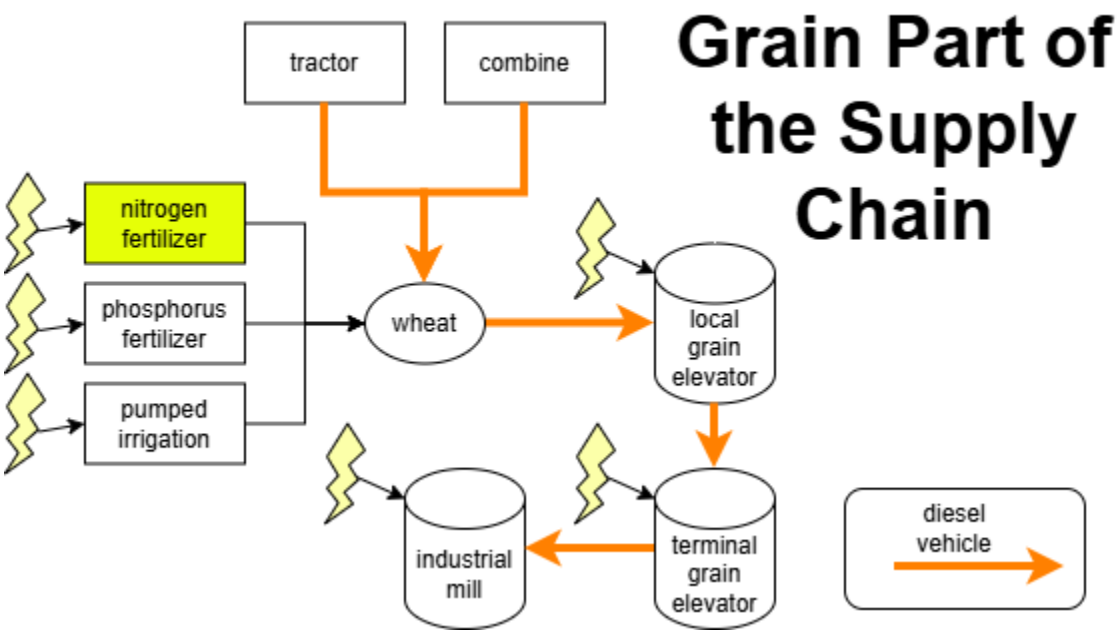
Most American wheat is irrigated, either with sprinkler systems or by flooding. Flooding is done via gravity and lots of labor. Sprinkler systems are generally pumped electrically.[7] Ironically, sprinkler and drip systems often lead to increased water consumption compared to flooding.[8] In other words, the higher tech irrigation solutions increase both water and energy consumption.

Wheat is harvested using a combine, which runs on diesel.[9] This beast weighs over 18 tons,[10] is even bigger than an 18-wheeler semi,[11] and is almost the size of a small single-wide mobile home.[12]

[5] https://patents.google.com/patent/US20230199924A1/en
[6] https://en.wikipedia.org/wiki/Gypsum
[7] https://www.montanawatercenter.org/irrigated#:~:text=FLOOD%20IRRIGATION%E2%80%93%20Water%20is%20applied,move%20away%20from%20flood%20irrigation.
[8] https://www.montanawatercenter.org/paradox
[9] https://www.producer.com/crops/john-deere-launches-t6-800-combine/
[10] https://www.allmachines.com/combine-harvesters/john-deere-t6-800
[11] https://truckreportgeeks.com/semi-truck-weigh/
[12] https://mobilehomeideas.com/typical-size-single-wide-mobile-home/

images from https://farmtario.com/machinery/john-deere-launches-t6-800-combine/ and https://mobilehomeideas.com/typical-size-single-wide-mobile-home/

Harvested Grain



The harvested wheat kernels are loaded onto a diesel semi truck, and taken to a local grain elevator for storage until the market price is “right”. Then it gets sold to a terminal elevator, another trip by diesel semi. The terminal elevator cleans the grain, separates it by value, and sells it to a domestic mill, yet another diesel semi trip. The mill grinds the wheat into flour, but then sells the flour to a food producer to bake it into bread, requiring, you guessed it, more diesel semi miles. So far, that’s four separate runs by diesel semi.[13]

Let’s drill down and see what happens at the local elevator. The grain is sampled for quality and weighed. An elevator bucket mechanism captures the grain and lifts it to the top of the elevator, where it is distributed into one of many storage bins.[14] The mechanism is automated by electricity, usually from the grid, but possibly augmented with solar panels. In Kansas, almost ⅔ of the grid’s power comes from natural gas and coal.[15] In Montana, natural gas and coal account for about 40%.[16]

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[13] https://eatwheat.org/learn/from-field-to-table/
[14] https://kansasfarmfoodconnection.org/spotlights/how-do-grain-elevators-work
[15] https://www.kec.coop/generation
[16] https://northwesternenergy.com/about-us/our-company/2024/03/05/providing-reliable-energy-to-customers-24-7

image from https://kansasfarmfoodconnection.org/spotlights/how-do-grain-elevators-work

Note that elevator loading happens twice, once for the local elevator and again for the terminal elevator, with energy use both times.

An industrial flour mill sorts the grain into different grades by many steps with specialized equipment, and packages the flour in bulk sacks for transportation to an industrial bakery.[17] Every step of the way requires electricity.

[17] https://www.seikograinmill.com/news/how-does-an-industrial-flour-mill-work.html

image from https://www.seikograinmill.com/news/how-does-an-industrial-flour-mill-work.html.

Note that the global flour milling industry is projected to grow at a compound annual rate of 4.7% from 2023 to 2030, driven by rising demand for processed foods, increasing urbanization, and technological advancements in milling equipment.[18] Urbanization increases the distance between people and their food. Demand for processed food rises not from rising population but rather from increasing demands on people's time in the workplace.

The Bread and its Baggage

Industrial bread machines automate the measuring and mixing, dividing and shaping of vast quantities of dough. After rising, the loaves are conveyed through tunnel ovens. Loading, unloading, slicing, and packaging are managed via robotics. Electricity powers every step to produce a perfectly uniform bundle of tastiness.[19]

These days, bread is always packaged in plastic. Since packaging is intrinsic to keeping the bread in good shape for you to buy, and since the packaging may be the most energy and pollution intensive part of the supply chain, we diverge from the story of the food itself to incorporate the food's baggage.

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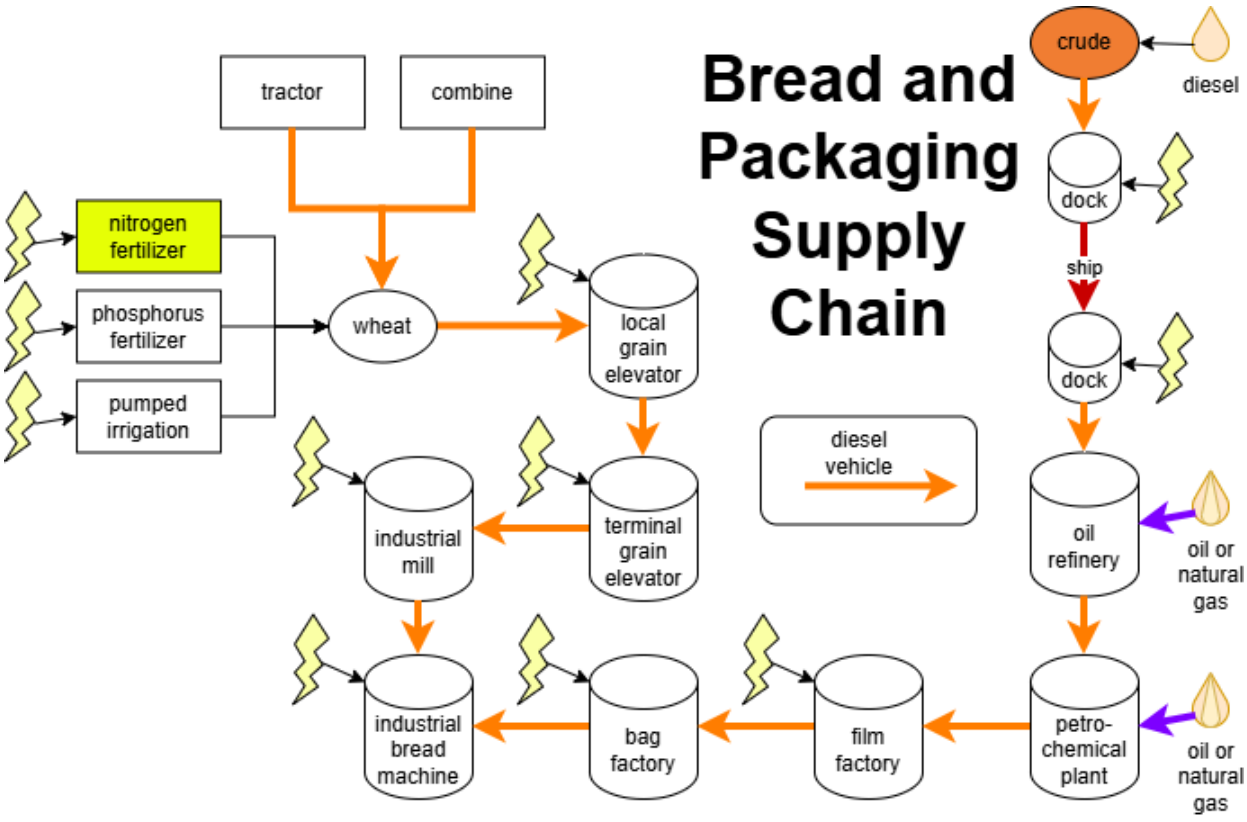
[18] ibid.
[19] https://www.gobte.com/advanced-bread-production-industrial-baking-systems-explained/



Let's assume that your bread came in a high density polyethylene (HDPE) bag. It started off in life as either natural gas liquids or crude oil, which was refined into ethylene, polymerized with heat, then melted, extruded, and cut into pellets.[20] Note that fossil hydrocarbons compose both the feedstock and the fuel for the processes. Polymerization might not take place at the original refinery,[21] which means the ethylene would be transported by either diesel truck or oil-powered ship. The polymerized pellets are then shipped to a film factory, also by either diesel semi or oil-powered ship. Cargo ships must be loaded and unloaded by diesel dock equipment, and their containers are then transported by diesel semi-trucks.

Next, the film factory melts the pellets at high heat to form a thin film, and blows a large bubble from the film. The bubble cools, solidifies, and passes through rollers to form it into a long, continuous film, wound onto rolls.

[20] https://plastic-pellet.com/blog/how-are-hdpe-pellets-manufactured/
[21] https://www1.eere.energy.gov/manufacturing/resources/chemicals/pdfs/profile_chap2.pdf

image from https://www.chovyting.com/industry-news/how-are-plastic-bags-made-step-by-step

The rolls are transported to a bag factory, where special machinery prints the film and constructs the bags, which are inspected, bundled, and boxed, incurring electricity consumption all along the way.[22]

Now we have truckloads of plastic-bagged bread, but it still hasn't reached your toaster. It hasn't even gotten to the store yet. We have two more steps in the supply chain.

First, the bread gets sold to a distributor. The distributor stores it, and sells it to the retailer.[23] The distributor is a necessary step because the supply cycle of the farm, mill, and bread factory does not necessarily match the demand cycle of the retail store.[24] Therefore, our story requires two more diesel truck deliveries—one to the distributor and another to your market. For the complete picture, see the diagram at the beginning of this essay.

The End of the Line

By now, your bread and its plastic packaging have probably experienced at least twelve segments of diesel truck transport, at least two passes by diesel farm equipment and at least one jaunt by heavy oil powered ship. We have not counted the crude oil pumping, refining, and

[22] https://www.chovyting.com/industry-news/how-are-plastic-bags-made-step-by-step
[23] https://www.supplychaintoday.com/grocery-supply-chain-how-23-foods-get-to-the-grocery-store/
[24] https://atlanticdominiondistributors.com/blog/how-the-grocery-supply-chain-works/

transport involved in fueling all those semis and boats, nor have we examined the road system, with its asphalt, steel, and concrete, necessary for the trucks, nor the electrical grid, required by every step of the way, including by the road system.

We can now leave it to you to meditate on how you picked up the bread, the electricity involved in toasting it, and the power generation for that electricity. We will omit consideration of the myriad other ingredients in the bread or of the butter or vegan oil product you spread on it. You have witnessed enough complexity for one day.

At this point, it is obvious what the consequences would be if industry “just stopped oil.” To put an end to the oil age, a completely different food system would have to be put in place. The same goes for everything else people depend on, from clothes to books. Some things we are accustomed to might have to go away, or become less common. This isn’t a hopeless doom pit. People built the system we’ve got, so people can build a different system. Discussion of what a genuinely sustainable system might look like will have to wait until a future blog post.