From Mid-East Oil to London Broil

A Comparison of Energy Inputs in Feedlot versus Grass-Fed Beef

by Jivan Lee, Diana Nezamutinova, and Todd Paul

Introduction

When Michael Pollan published “This Steer’s Life” in the March 2002 *New York Times Magazine*, he referred to the “reciprocal relationship between cows and grass” as “one of nature’s underappreciated wonders.” Of the feedlot system, Pollan lamented, “We have succeeded in industrializing the beef calf, transforming what was once a solar-powered ruminant into the very last thing we need: another fossil-fuel machine.”[1]

Pollan was referring to the dramatic changes that industrialized beef production in this country after World War II. For thousands of years, cows had lived on pasture in a simple but effective system that allowed humans to derive high-quality protein from grass-a short-term, solar-driven, renewable energy cycle. In foraging, cows distribute grass seed with their hooves and fertilize it with their manure; the excess nutrients they take up are returned to the soil directly. No pesticides or herbicides are needed, nor are antibiotics generally required by grass-fed cows, although hay, water, and a nutrient supplement may be needed during the winter in cold climates.

In place of this grass-driven system, most beef is now produced in Confined Animal Feeding Operations (CAFOs). CAFOs use corn and other grains to quickly fatten calves, which are confined in crowded pens. This rich diet makes cows sick, so antibiotics are added to the feed to keep them alive. The feed must be brought in by the truckload, and immense quantities of manure must be cleared out. Growing all that feed is itself fossil-fuel intensive, requiring oil to produce, transport and apply petrochemical fertilizers, water, herbicides and pesticides, and to sow and harvest the crops.

How much fossil fuel is required to produce a pound of beef on a feedlot? Figures from different sources vary widely. At one extreme is Cornell University researcher David Pimentel's contention that a feedlot-finished steer requires about 284 gallons of oil over its lifetime.[2] At the other end of the spectrum, a “Beef Industry ‘Factoid’ Fighter“ from November, 2003 calls Pimentel’s data “erroneous” and “outdated,” and contends that a more realistic figure is just 13.83 gallons of oil per steer, based on recent increases in agricultural productivity.

Against the backdrop of such divergent claims, we calculated our own fuel-to-beef equivalencies, arriving at the result of 208 gallons of crude oil per feedlot steer. Due to regional and temporal differences in soil productivity, rainfall, cattle breeds, agricultural practices, grain varieties, etc., the numbers presented here should be viewed as back-of-the-envelope calculations based on inputs representing broad averages for the industry.

This paper compares the fossil fuel inputs of feedlot versus grass-fed beef, discusses the implications for other inputs such as pasture and crop land, and makes policy recommendations for transitioning to a less fossil-fuel intensive beef production system. Calculations are divided into two sections corresponding to grass-fed and feedlot beef finishing operations. For the sake of simplicity, we base our feedlot energy-input calculations on corn, which makes up the largest portion of the grain fed to feedlot cattle. Our grass-fed cattle calculations assume the growth, harvest and transportation of hay represents the primary fossil fuel input.

Energy inputs for cows

There are two distinct stages of a beef cow’s life. During the first stage, the animal is raised from conception to a 414-lb calf on a grass-fed cow-calf operation (about six months). The second stage completes the calf’s growth to

1,000lb full sized animal in a process known as "finishing." The first stage of life is largely the same for all beef cattle, regardless of the type of finishing operation (grass-fed or CAFO) for which the calf is destined.

Raising one calf requires approximately 10 hours of labor or 25 Mcal (one hour of labor equals 2500 kcal); transportation, including depreciation of machinery and gasoline expenditures, amounting to 805 Mcal; and supplemental feed, amounting to 95 Mcal.[3] Thus, altogether around 925 Mcal is spent on raising a calf to a 414-lb animal.[4]

Grass-fed Finishing

Grass-fed cows require no corn, and because grass is seeded and fertilized by cows and grown in large part on-site, its production requires far fewer energy inputs (seed, fertilizer, energy, chemicals, custom work, hauling) than corn. In northern climates, however, grass-fed animals will likely require hay during the winter. Most states grow millions of tons of hay every year.[5] If beef producers grow their own hay, baling and storing will require significant energy, whereas if they purchase hay, it will need to be trucked in. We therefore assume that hay-making's primary energy inputs represent cutting, drying, baling, and intrastate transport.

If farmers truck in hay, a high estimate of average distance traveled might be 200 miles round trip. Generously assuming a Class 8 shipping truck uses a gallon of fuel every 8 miles,[6] a 200 mile trip would require 25 gallons of fuel. One gallon of diesel fuel contains roughly 130,500Btu.[i]

25 gallons * 130,500 Btu/diesel gallon = 3,262,500 Btu/trip

Therefore, one trip requires 3,262,500 Btu.

Assuming a trailer's load capacity is 55,000-60,000lbs, and a cow needs up to 26lbs of hay/day during the winter, then one load would provide 55,000 lbs/26 lbs/day =2,116 days worth of hay for one cow.

The Btu input for one cow to eat hay for one day is 3,262,500 Btu / 2,116 days = 1542 Btu/cow/day.

Doubling this figure to roughly account for the oil consumed in hay-making and harvesting, we arrive at a figure of 3,084 Btu/cow/day. In northernmost states, winter may last up to six months, or approximately 182 days.

182 days * 3,084 Btu/ cow/ day = 561,288 Btu/cow per winter.

If we assume a grass-fed beef cow will require 24 months (or two winters) of finishing before slaughter, the energy requirements double, amounting to approximately 1,122,576 Btu/cow. Therefore, in terms of approximate fossil fuel inputs,

1,222,576 Btu/cow = 9 gallons of diesel/cow = 18 gallons of crude oil/cow.

Adding in the 925 Mcal spent on raising a calf to a 414-lb animal,

925 Mcal = 27.98 diesel gallons = 55.96 crude oil gallons + 18 crude oil gallons (finishing) = 74 gallons crude oil/cow/lifetime.

If all the 33,398,271 beef cows in the US[7] were grass-fed, the total fossil fuel energy required for production would be

33,398,271 cows/industry * 74 gallons crude oil/cow/lifetime = 2,471,472,054 gallons of crude oil, or 56,169,819 barrels.[ii]

Feedlot finishing

Calves destined for the feedlot are sold at auction and may be transported as far as 500 miles to the CAFO.[8] Once there, they are finished quickly thanks in part to a nutrient-intensive diet based largely on corn. This is no small matter because corn production requires a significant amount of non-solar energy. The USDA Economic Research Service and Office of Energy Policy and New Uses estimates that producing one bushel of corn requires 57,476 Btu (1 lb corn = 280 kcal) (USDA 2002). This number represents a nine-state weighted average and includes Btu inputs representing seed, fertilizer (nitrogen, phosphate, potassium and lime), energy (Diesel, gasoline, LP gas, natural gas, electricity), chemicals, custom work, and input hauling.

One bushel of corn weighs 56 pounds, and a feedlot cow will consume that much, plus a protein supplement, every 1.5 to 2.5 days. This yields an energy input range of 22,990 to 38,317 Btu per cow per day from corn alone:

1 bushel = 57,476 Btu/2.5 days = 22,990 Btu/day)
1 bushel = 57,476 Btu/1.5 days = 38,317 Btu/day)

Animals at a feedlot are fed for 255 days.[9] The bulk part of the energy expenditures at feedlot operations, around 1,785 Mcal/animal, are in the feed (25 lb of feed per cow day, where 1 lb of feed = 0.28 Mcal).[10] Another 717 Mcal/animal is attributable to transportation, 7 Mcal to electricity, and only around 3 Mcal to labor.[11] We do not include energy spent on production of antibiotics or for cleaning water bodies contaminated by confined animal feeding operations. Hence, total energy consumption for raising a steer from 414 lb to 1,000 lb is about 2,513 Mcal.[12]

Altogether, there are 3,438 Mcal of energy spent on raising a 1,000-lb feedlot steer from conception to slaughtering (925 Mcal from conception to 414 lbs, and 2,513 Mcal for finishing).

3,438 Mcal = 13.6 Mbtu = energy to raise one cow = 104 gallons of diesel = 208 gallons of crude oil.

Overall, annual production of 33,398,271 beef cows in the US[13] requires 114,823,255,698 Mcal = 3,488,691,255 gallons of diesel,[iii] approximately 6,977,382,510 gallons of crude oil, or 158,576,875 barrels of crude oil.[iv]

Conclusion

On the face of it, even given the lowest estimates for fossil fuel inputs to feedlot beef production, grass-fed beef would appear to be the superior energy bargain, requiring a lifetime total expenditure of some 134 fewer gallons of crude oil per cow. However, there are arguments for the feedlot. One is speed: calves finished on corn are brought to slaughter in less than a third of the time required just two generations ago. The rich feedlot diet has a lot to do with this, although growth hormones must also be credited.

Another argument for the feedlot system has to do with land use, quality and availability. Pimentel has calculated that significant resources would have to be devoted to improving range lands in this country in order to switch from corn-based to grass-based beef, while keeping beef production at current levels. If lands currently devoted to grain were converted to silage production for a grass-fed beef system, Pimentel writes, land use would remain the same; labor would increase about 10%; but “The fossil energy input would be double that of the current beef system, primarily because large energy inputs would have to be expended to improve forest-range production and to increase the yield of nutrients.” This is primarily because animal feed, consisting of corn, soybean meal, alfalfa, beet pulp and molasses, has much more nutrient availability than grass; there are also significant differences in the ways different breeds of cow metabolize grass. Simply substituting an equivalent acreage of unimproved pasture for corn fields would not result in equivalent nutrient inputs for the current stock of cows in the U.S.

Transitioning the beef industry to a grass-fed system would cause production levels to fall dramatically and prices to rise, at least initially, as farmers transitioned to a new production paradigm and imported hardier, heftier breeds of range-adapted cows. This does not necessarily imply poor nutrition for consumers, since Americans typically consume twice the recommended daily level of protein, but it would necessitate increased consumption of other protein sources and could have significant economic and social impacts for a nation accustomed to cheap beef.

Inasmuch as the great majority of corn grown in this country is animal-grade, destined to be sold for livestock feed, and heavily subsidized, a switch to grass-fed beef could also be anticipated to cause a major disruption of the agricultural sector.

Policy options

In considering policy options, we recognize that transitioning quickly to a fully grass-fed beef system is probably unrealistic for a number of reasons, including consumer demand for cheap beef, quantity and quality limitations of pasture land, and the economic realities of agriculture subsidies in this country. With these limitations in mind, we offer the following three policy suggestions:

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1. 1. Eliminate corn subsidies and let the market dictate supply In 2002, the price of corn ($2.25/bushel) was 50 cents less than the cost of growing it.[15] Government subsidies lead to production surpluses that are siphoned into the livestock industry as feed. This constitutes an enormous hidden subsidy for feedlot beef production. If market forces dictated the price of feed-grade corn, industrial animal production would be less profitable and grass-fed beef would become more attractive. Since the profit margins of feedlot beef are already quite slim -- according to Cattle-Fax, a market-research firm, the return on feedlot cattle has averaged $3 per head over the last 20 years[16] -- ending or reducing corn subsidies would likely result in significant changes in the economies of feedlot beef production. Such a policy could be designed to phase in over a ten or twenty year period so as to avoid shocking the industrial beef and corn industries. However, as long as there is consumer demand for great quantities of cheap beef, feedlots would likely seek ways to continue industrial production-for example, by switching to other grains and relying more heavily on growth hormones-and ending corn subsidies would be politically difficult.

2. Promote less animal protein in the American diet Americans consume 75 grams of animal protein per person per day, plus 34 grams of available plant protein. This is twice the recommended daily protein allowance of 56 grams, and much more than is consumed by people in most other countries. America's high animal protein, high fat diet is largely responsible for increased incidences of heart disease and obesity. A campaign educating Americans about protein intake may aid in decreasing demand for animal protein. Decreased demand would cause beef prices to fall, ease production pressures and potentially increase the relative profitability of grass-fed beef operations.

   This is probably the most realistic policy option, although countering advertising by the powerful corn and beef industries would require a very well-funded educational campaign, and enough time for cultural norms to shift.

3. Subsidize grass-fed beef production America's own "Oil for Food" program would be an innovative, fossil-fuel-supported subsidy for grass-fed beef producers, based on the idea that non-renewable energy producers should better compensate the public for the extraction of coal, oil and natural gas from public lands. For every acre of public land leased by a non-renewable energy company, that company would be obligated to lease one additional acre of pasture for grass-fed livestock production. The resulting increases in pastureland could be quite significant. For example, the Associated Press reported last year that 40 million acres of public land were leased for oil and gas development in the 48 contiguous United States alone, at a lease rate of $2 to $3 per acre. At two acres per cow, had the Oil for Food program been in effect, this would have provided pasture for nearly twice the number of cows currently produced in this country, added some $100,000,000 to the federal treasury, and discouraged unproductive oil and gas prospecting on public land.

Jivan Lee, Diana Nezamutinova and Todd Paul are graduate students at the Bard Center for Environmental Policy, at Bard College. *They thank Professor Jennifer Phillips, PhD., for her inspiration and guidance in preparing this paper.*

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[i] One gallon of gasoline = 115,000 Btu. http://bioenergy.ornl.gov/papers/misc/energy_conv.html
One gallon of diesel = 130,500 Btu. http://bioenergy.ornl.gov/papers/misc/energy_conv.html.

[ii] Fossil fuel figures are calculated using gallons of oil equivalencies. One gallon of diesel is roughly equivalent to 1.33 gallons of gasoline because of higher energy content (diesel =130,500 Btu whereas gas = 115,000) and the higher efficiency of diesel engines (approximately 15-25% more efficient: see online at

http://www.eere.energy.gov/vehiclesandfuels/pdfs/basics/jtb_diesel_engine.pdf). One barrel of oil yields approximately 20 gallons of gasoline and 7 gallons of diesel. Seven gallons of diesel are roughly equal to 9 gasoline gallon equivalents (7 gallons diesel * 1.33 = 9.3 gasoline gallon equivalents), and 20 gallons of gasoline are roughly equal to 15 diesel gallon equivalents (20 gallons/1.33 = 15.03, or 15 diesel gallon equivalents). Therefore, one barrel of oil yields 22 diesel gallon equivalents (7 gallons diesel + 15 diesel gallon equivalents = 22 diesel gallon equivalents) or 29.3 gasoline gallon equivalents (20 gallons gasoline + 9.3 gasoline gallon equivalents). Total, one barrel of oil yields 44 gallons of refined product, 22 of which are diesel gallon equivalents, and this is a rough ratio of 2 gallons of oil for every 1 diesel gallon equivalent.

[iii] One gallon of diesel = 130500 Btu. Online Source:
http://bioenergy.ornl.gov/papers/misc/energy_conv.html

[iv] See footnote ii.
Source: http://www.bakewellrepro.com/oiltobroilarticle.html