

Cultural Energy Expended in Range Meat and Fiber Production

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Highlight: *Range livestock production requires more cultural energy than commonly believed. However the cultural energy expended for range meat and fiber is considerably less than that required in confined fattening procedures. Complementing rangelands with dryland forages offers great promise in decreasing the cost of fossil fuel to produce a pound of red meat for human consumption, compared to feedlot fattening.*

Oil and gas in the United States are finite resources and predictions are that there are only a 50-year supply of gas and a 75-year supply of oil at the present rate of usage. It is true that we have several hundred years' supply of coal and a rather vast energy reserve in oil shale and nuclear material, but they too are finite and expensive to develop as substitutes for gas and oil. Therefore the public is becoming conscious of the use of fossil fuels, whether it be for pleasure or for the production of food. In the latter case, a close correlation will develop between the cost of a product and the expenditure of cultural energy to produce it.

It is of interest to evaluate the cultural energy expended in the production of food and particularly meat because meat comes from the second feeding level in the food chain and therefore requires more subsidized energy in the conversion of solar energy than do plant foods.

Measures of Cultural Energy

Cultural or subsidized energy is the energy other than solar energy needed to produce food and fiber. Cultural energy includes labor, manufacture of machinery, transportation, tillage, production of fertilizers and herbicides, processing material, and finally marketing the product (Cook et al., 1976).

Calculations of cultural energy input for labor were 2,500 kcal per hour, for depreciation and maintenance of large machinery were 45,000 kcal per hour of operation, gasoline per gallon contains 31,056 kcal, transportation requires 4 kcal per pound per mile (Cook et al., 1976). Electricity was calculated to be about 860 kcal per kilowatt hour (Table 1). Electricity was calculated as being only 40% efficient because it requires 2.5 more BTU's of coal to produce the equivalent kilowatt hours of electricity. This is a result of the loss of

energy in heat when steam is used to produce power to turn the turbines. This does not include the cultural energy required to mine the coal and transport it to the generating sites or the loss in transmission lines. In the Central Plains area it was determined that about 80% of the electricity comes from steam generators and 20% from hydroelectric sources. Sorghum produced on summer-fallowed ground for grazing required 495.7 Mcal per acre and feeds used in supplements and rations varied from 350 to 500 kcal per pound (Cook et al., 1976).

Range Sheep Production in the Intermountain Great Basin

The sheep ranches included in the study were typical of many operations in Utah, Nevada, and southern Idaho, where sheep graze desert ranges during the winter from about November 1 until about April 1, after which they are trailed onto foothill range where they lamb on crested wheatgrass and/or native grass-sagebrush types. About the middle of June they are moved into mountain brush types and subsequently into higher mountain zones.

In this study all lambs were black-face crosses. All cultural energy expenditures were made on the basis of a 1,800 mature ewe herd with 200 replacements, 36 bucks, and 3 to 4 horses. From these operations about 70% of the lambs were sold as grass-fat choice lambs weighing about 90 lb with a 50.9 dressing percentage. The dressed carcass was 16.2% protein and 23.4% fat. The remaining 30% of the lambs weighed 75 lb and sold as feeders which dressed 47.5% with 17.1% protein and 18.8% fat.

All carcass protein was considered to possess 5.7 kcal of gross energy per gram and all fat was calculated as having 9.4 kcal per gram.

The sheep, while on the desert ranges, were supplemented from December 15 until March 15 at the rate of one-half pound per head every other day. The supplement consisted of 45% alfalfa, 25% barley, and 30% soybean meal. The cultural energy in the alfalfa, barley, and soybean meal was 272 kcal, 411 kcal, and 658 kcal per pound of material respectively. The mixture was fed in pelleted form and was purchased at a feed mill and transported to the desert range about 48 miles away.

It was calculated that 2.24 kcal of cultural energy was expended for each kilocalorie in dressed carcass meat and 1.54 Mcal of cultural energy was used for each pound of live weight of lamb produced (Table 2).

Table 1. Average cultural energy expended for various range sheep and cattle operations compared to typical feedlot operations on the eastern slope of the Rocky Mountains.

	Intermountain Great Basin				Central Great Plains						Central Plains	
	Range sheep ¹ 2,000 female herd		Range cows ¹ 250 female herd		Range-sorghum ¹ 250 cow operation		Range cows ¹ 250 female herd		Range-sorghum 400 steer operation		15,000 feedlot operation	
	Quantity	Mcal	Quantity	Mcal	Quantity	Mcal	Quantity	Mcal	Quantity	Mcal	Quantity	Mcal
Labor (hour)	6,080	15,200	3,170	7,925	2,737	6,842	2,737	6,842	3,780	9,450	16,320	40,800
Machinery (hour)	1,500	67,500	1,200	54,000	1,744	78,480	1,744	78,480	1,900	85,500	16,370	734,400
Gasoline (gal)	5,166	160,435	3,500	108,696	3,959	122,951	3,959	122,951	4,500	139,752	29,070	902,798
Transportation (miles × lb)	2,305,000	9,200	2,380,000	9,520	27,257	109	27,257	109	194,444	778	2,253 × 10 ⁶	9,012,000
Electricity (KW hour)	—	—	—	—	—	—	—	—	—	—	122,559	105,400
Feed (lb)	45,000	19,350	45,000	22,500	67,500	23,490	67,500	23,490	180,000	62,640	133,875,000	59,440,500
Sorghum pasture (acre)	—	—	—	—	109	54,035	—	—	171	84,769	—	—
Total cultural energy (Mcal)	—	271,705	—	202,641	—	285,907	—	231,872	—	382,889	—	70,235,898

¹ These calculations include the expenditures of cultural energy required to operate the entire ranching enterprise.

There were 130,410 lb of choice lamb, which sold for 44 ¢ a pound, totaling \$57,380.00; 46,575 lb of feeder lamb, which sold for 42 ¢ for a total gross income of \$19,561.00; and 20,000 lb of wool, which brought 72 ¢ or a total of \$14,400.00. Thus 84% of the sales came from lambs and 16% from wool. Therefore 16% of the total Mcal of cultural energy (16 × 271,705 Mcal) or 43,473 Mcal can be assessed to wool production. The Mcal of cultural energy for shearing was calculated as follows: 184 man hours amounting to 460 Mcal, machinery totaling 4,259 Mcal, the transportation of wool to market amounted to 14,400 Mcal, and finally the scouring using 3,600 Mcal. The total expenditure of cultural energy for shearing, handling, and processing wool was 22,719 Mcal. Thus the addition of 43,473 Mcal of cultural energy resulting from 16% of the general operational energy costs and the 22,719 Mcal expended in actual shearing, transportation, and scouring of the wool would be 66,192 Mcal for 8,000 lb of clean wool or 8.27 Mcal/lb of scoured wool.

In a recent report by the National Cotton Council of America (Gatewood, 1973) it was estimated that cultural energy consumed in a pound of cotton lint was 3.22 Mcal and the cultural energy cost for noncellulosic and cellulosic synthetic fibers per pound was 15.17 and 20.38 Mcal, respectively. The noncellulosic fiber included polyester, nylon, and acrylic material, which are petro-chemicals or derived from petroleum or natural gas.

Cotton has a significant advantage in the amount of cultural energy required for fiber production since the cotton plant not only produces fiber but also produces cotton seed oil and cotton seed meal. Wool, like cotton, is a by-product or a dual product of the sheep industry and requires considerably less cultural energy than synthetic fibers.

Range Cattle Production in the Intermountain Great Basin

The 250-head cattle ranches that were analyzed in the

Intermountain Great Basin area operate somewhat similarly to sheep ranches of the region. Typical cow-calf operations throughout Utah, Nevada, and southern Idaho, like sheep operations, run on desert ranges during the winter from about November 1 to April 1 and are grazed on crested wheatgrass and/or native range during calving and until about the third week in June, when they move to mountain ranges until about October 1.

The supplement for cattle consisted of 30% alfalfa, 20% barley, and 50% soybean meal. This was fed to cattle in pelleted form for 90 days at the rate of 2 lb/day per animal. The supplement was hauled about 48 miles from the feed mill to the range where it was fed.

The percent calf crop was 93% and all calves were Hereford × Angus crosses, which sold at weaning time as good grade grass-fat calves weighing 405 lb. They dressed at 57.9% with the carcass containing 11.2% fat and 16.6% protein that totaled 212,437 kcal.

The expenditure of cultural energy per pound of weaning weight was 2.15 Mcal; the ratio of cultural energy used per increment of food energy produced in the dressed carcass was 4.09 (Table 2).

Range Cattle Production in the Central Plains

In the central plains states of Nebraska, Kansas, Oklahoma, northern New Mexico, and eastern Colorado, a typical cow-calf operation remains on the range all or most of the year with only a few pounds of supplement fed during the winter months. Calves are dropped in mid-April generally. Cows, during calving, continue to receive a supplement until green growth starts on the ranges, which occurs during early May. The cow-calf unit is grazed on rangelands until about the middle of October, when the calves are weaned and sold.

In some cases forage sorghums are planted for summer grazing from about July 15 until weaning time. This is referred

Table 2. Average output of meat and energy compared to cultural energy input from various range sheep and cattle ranches and typical feedlot operations in the western range area.

	Intermountain Great Basin		Central Great Plains			Central Plains 15,000 feedlot operation
	Range sheep 2,000 female herd	Range cows 250 female herd	Range-sorghum 250 cow operation	Range cows 250 female herd	Range-sorghum 400 steer operation	
Market weight or gain (lb)	85.5 ¹	405 ²	445 ³	414	396	586
Calf or lamb crop (%)	103.5	93	93	92	98 ⁴	99 ⁵
Total energy in carcass (Mcal)	121,382	49,498	54,423	50,578	138,138	13,186,800
No. marketed	2,070	233	233	230	392	14,850
Live weight marketed (lb)	176,985	94,365	103,685	95,220	155,232	8,702,100
Cultural energy/food energy	2.24	4.09	5.25	4.58	2.77	5.33
Mcal cultural energy/lb of live weight	1.54	2.15	2.76	2.44	2.47	8.07

¹ 70% sold as choice fat lambs at 90 lb and 30% sold as feed lambs at 75 lb.

² All sold as good grass fat calves.

³ 70% sold as choice grass fat calves.

⁴ Percent death loss was 2%, therefore 98% was marketed, all sold as good grade grass fat steers weighing 810 lb.

⁵ Percent death loss was 1%, therefore 99% was marketed, 70% sold as choice and 30% as good grade fed beef weighing an average of 1,000 lb.

to as a range-sorghum operation for producing grass-fat weaner calves that sell as choice grade feeder calves and weigh about 445 lb. For practical purposes the dressing percentage and the percent fat and protein in the carcass were considered the same as for the calves produced to choice grass-fat feeders in the Intermountain Great Basin area discussed previously.

The ratio of cultural energy used to produce an increment of food energy in meat was 5.25 for the cow-calf units that grazed range in conjunction with forage sorghum pastures for fat weaner calf production and 4.58 for the typical cow-calf range operation in the Central Plains region. The range-sorghum grazing system expended 2.76 Mcal of cultural energy per pound of weaner calf compared to 2.44 Mcal/lb of calf gain for the conventional range cow-calf operation (Table 2). The development of the forage sorghum pastures increased the expenditure of cultural energy because of the tillage and plantings of these pastures.

In all cases winter supplement was fed to the breeding cow herd from about the middle of December until about May 1 at the rate of 2 lb per head per day. The supplement used in the calculations consisted of 60% alfalfa, 20% soybean meal, and 20% milo, which averaged 348 kcal of cultural energy per pound of pelleted feed mixture.

The weaning weight from the range-sorghum grazing system produced calves weighing 445 lb at weaning about October 15; the conventional range cow-calf operation produced weaner calves weighing 414 lb. All of the weaner calves in the range-sorghum feeding system were graded as choice grass fat feeder calves, whereas only 70% of the calves produced solely from range forage sold as choice.

Steer Operations in the Central Plains

Many ranchers of the western range region have shifted from a cow-calf operation to an enterprise of growing steers. These animals are purchased as weaner calves and sold in the spring and summer as feeders. However, more and more operators are fattening such steers on mountain summer ranges or summer-fallowed forage sorghum pastures in the Central Great Plains area. If properly managed, the steers can be sold from these systems weighing over 800 lb at 17 to 18 months of age and grading as good for block meat. Such meat is now marketed by many chain stores under various trade names.

Experiments in Colorado showed that these steers gained from 414 lb as weaners to 810 lb when sold from the forage sorghum pastures in late summer. These 800-lb steers dress at 58.0% with 20.1% fat and 14.4% protein in the carcass. Again it was calculated that fat contained 9.4 kcal/g and protein contained 5.7 kcal/g.

In this study range steers were fed 3 lb of supplement per day from December 15 to May 15. The pelleted supplement contained 60% alfalfa, 20% soybean meal, and 20% barley, which had a cultural energy cost of 348 kcal/lb.

From the 400-steer operation analyzed it was calculated that 2.77 kcal of cultural energy were required for each kilocalorie of dressed meat produced and 2.47 Mcal of cultural energy for each pound of steer gain (Table 2).

Feedlot Operations

A typical 15,000 feedlot capacity operation in the plains area near Denver, Colorado, was analyzed in this study. The animals fed consisted of 62% steers and 38% heifers. They were fed for 255 days, starting with an average weight of 414

lb and finishing at 1,000 lb. Thus the overall daily gain was 2.3 lb/day.

The ration the first 122 days was about 60% roughage, consisting of corn silage, chopped alfalfa, and beet pulp along with 40% dry rolled corn and soybean meal. During the next 133 days the ration was about 65% concentrates, consisting of dry rolled corn and soybean meal, along with 30% corn silage and 5% molasses. All silage was raised near the feeding operation and 40% of the corn was raised on the owned land. The remainder of the feed was hauled onto the farm feedlot from feed mills 15 miles away.

The average cultural energy for the ration during the first 122 days was 389 kcal of cultural energy per pound of feed and for the ration fed during the next 133 days was 495 kcal of cultural energy per pound of feed. The average for the entire 255-day feeding period was 444 kcal/lb of feed. The average daily intake per animal over the 255-day feeding period was 35 lb. During the early feeding period, daily consumption was 22 lb but was as high as 39 lb during the latter part of the feeding period.

The heifers dressed at 60.5% and the steers dressed at 62.5%, which was a weighted average of 61.7% for the 14,850 head marketed. Approximately 79% graded choice and 21% graded good.

It was calculated that an average 1,000-lb animal dressed at 62% with a 4% shrink and the carcass containing 35% fat and 11.8% protein, which yielded 1,108 Mcal of energy per dressed carcass. The dressed carcass of the 414-lb weaner range calf had 220 Mcal; therefore the 255-day feeding period produced 888 Mcal per carcass from the 586 pounds gained per animal. With a 1% death loss the total Mcal from the dressed carcass was 13,186,800 for 14,850 animals marketed (Table 2).

Under a fattening program under confinement feeding, 5.33 kcal of cultural energy were required to produce a kilocalorie of dressed carcass meat. Each pound gained required 8.07 Mcal of cultural energy (Table 2). These figures were considerably higher than those for a combination of range and forage-sorghum pastures, which were 2.77 and 2.47 Mcal of cultural energy for a Mcal of meat and per pound of gain, respectively.

Complete Systems from Conception to Marketing

The total expenditure of cultural energy including the cow-calf and ewe-lamb operations until animals reached various marketable weights and ages is shown in Table 3. Sheep are considerably more efficient than cattle. This is a result of multiple births, faster growth rate, and ability to fatten to choice grade on range forage without grain. A ewe produces almost 62% of her weight as weaner lamb and a cow produces only about 45% of her weight as weaner calf in the same period. The cow-calf unit can be most competitive with the ewe-lamb unit in the production of red meat from forage by finishing steer calves to good grade on sorghum pastures.

The expenditure of cultural energy to produce a choice grade beef from conception to a 1,000-lb animal was of course the most inefficient in the use of cultural energy because of the use of harvested roughage and grain.

In the present study it required 5.74 Mcal of cultural energy to produce 1 lb of fattened choice grade beef. Comparable figures by Lockeretz (1975) showed that 4.54 Mcal per pound of beef from birth to feedlot fattening was required. In the same study for use of irrigated pastures along with feedlot finishing in Oklahoma, 11.6 Mcal of cultural energy were required to produce a pound of finished beef.

Table 3. Average production of live weight along with expenditure of cultural energy per increment of energy produced and per pound of live weight gain for various systems of producing marketable lamb and beef on an individual basis at the source of production.

	Lamb ¹ production	Weaner calf ² production	Steer ³ production on forage	Feedlot ³ fattening
Weight produced (lb)	85.5	414	810	1000
Energy in dressed carcass (Mcal)	58.6	220	527	1108
Cultural energy expended (Mcal)	131.3	1010	1987	5740
Cultural energy in/energy out	2.24	4.58	3.47	5.18
Cultural energy in/lb of live weight (Mcal)	1.54	2.44	2.45	5.74

¹ Ewes were white-face crosses weighing an average of 139 lb.

² Cows were good grade Hereford cows weighing an average of 914 lb.

³ Calculated for an animal including the cow-calf operation until finished either on forage or in the feedlot.

Summary

The sheep industry has the advantage of producing choice grade meat directly off the range at a cost of only 2.24 kcal of cultural energy per kilocalorie of dressed carcass compared to cattle which required approximately 4.5 kcal per kilocalorie of dressed meat for weaner calves.

By using range along with forage-sorghum pastures, a good grade animal that was raised from a calf to a steer weighing 810 lb can be produced for an expenditure of about 3.5 kcal of cultural energy for each kilocalorie of dressed carcass and a choice weaner calf weighing 445 lb can be produced on range and forage sorghums for a cost of 5.25 kcal of cultural energy per kilocalorie of dressed meat. By intensive management of a cow-calf operation in the Intermountain Great Basin area, where crested wheatgrass is used for early spring grazing and good mountain range is used from June 15 to September 15, a

kilocalorie of dressed choice weaner-calf meat can be produced at a cost of 4.09 kcal of cultural energy.

Thus it appears that the lowest expenditure of cultural energy per kilocalorie of table meat is from lamb and meat from steers produced to good grade largely from range and forage-sorghum pastures.

The expenditure of cultural energy per pound of live weight gain of marketable animals was only 1.54 kcal/lb of gain for a ewe-lamb operation and 2.15 kcal/lb of gain for a cow-calf operation in the Intermountain Great Basin area, compared to 2.76 and 2.44 kcal/lb of gain in the Central Great Plains where forage sorghums are used for summer grazing and the conventional range operation for weaner calf production, respectively.

The steer operation that starts from birth and makes use of range and forage sorghums to a weight of 810 lb required 2.45 kcal of cultural energy per pound of body gain. Feedlot operations that start from birth and feed the weaner calf for 255 days to a final weight of 1,000 lb required 5.74 kcal of cultural energy per pound of live weight gain.

The relative cost of cultural energy per pound of body gain under the various livestock operations follows the same ranking as the kilocalories of cultural energy expended per kilocalorie of dressed meat. A ewe-lamb operation is most efficient, with a steer operation next. These are followed by the conventional range cow-calf operation, the range-sorghum pasture grazing system, and finally the feedlot fattening procedure.

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