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Using Net Energy to Formulate Beef Cattle Rations

Homer B. Sewell
Animal Science Department
College of Agriculture

Feed energy measures are used to estimate the energy required for a specific animal at various performance levels and to evaluate feeds to supply this energy. The most frequently used measures of feed energy are

- total digestible nutrients (TDN),
- digestible energy (DE),
- metabolizable energy (ME), and
- net energy (NE).

Figure 1 shows energy losses during the digestion and metabolism of food. Note the losses that are accounted for in the various dietary energy measures.

Total Digestible Nutrients (TDN). TDN is the energy measure with which cattle producers are most familiar. It is a measure of the digestibility of the nutrients in a feed and their comparative, metabolic, caloric value. The apparent digestibilities of carbohydrates, protein, and fat are determined in a digestion trial. Then, TDN is calculated by **TDN = digestible protein + digestible crude fiber + digestible nitrogen-free extract + (2.25 × digestible fat).** TDN does take into consideration some urinary loss since the caloric value of digestible protein is actually 1.3 times that of carbohydrates (5.2 versus 4.0 kilocalories per gram).

TDN is limited as a measure of food energy because it does not account for the energy lost in rumen gases (methane, etc.) expelled during digestion. These losses are relatively larger for roughages than concentrates. Thus, the TDN system over estimates the productive energy value of roughages in relation to concentrates.

Scientists prefer to use the energy measures of digestible energy (DE), metabolizable energy (ME), and net energy (NE) rather than TDN for measuring food energy and describing the requirements of animals. With DE, ME, and NE the calorie is the unit which measures heat or energy, while the pound, a weight measure, is the unit for TDN.

Digestible Energy (DE). DE takes into account only the digestible losses. Apparent digestible energy is determined in a digestion trial by measuring the intake of gross energy in the feed (IE) and the gross energy in the feces (FE) with a bomb calorimeter. **DE = IE − FE.**

Figure 1. Partition of dietary energy.

Intake of Gross Energy in Food (IE)
↓ energy loss in feces (FE)
Digestible Energy (DE)
↓ energy loss in urine (UE)
Total Digestible Nutrients (TDN)
↓ energy loss in fermentation gases, methane, etc. (GE)
TDN is not energy, but theoretically fits roughly in this part of the scheme.
Metabolizable Energy (ME)
↓ energy lost as heat increment (HI) or specific dynamic action (SDA)
Net Energy
↓ energy required for maintenance - NEm
Net Energy
energy required for production - NEm used for gains, reproduction, milk, work, etc.

There is a constant relationship between DE and TDN. DE can be estimated from the TDN values of feed by the formula **2 megacalories of DE per pound of TDN or the percent of TDN multiplied by .02 = the megacalories of DE per pound of feed.** The ability of TDN and DE to predict animal performance is equal, and their limitations are the same.

Metabolizable Energy (ME). ME accounts for urinary, fecal, and with herbivores, the energy losses of combustible reticulorumen gases (GE). **ME = IE − (FE + UE + GE).**

ME is superior to DE as a measure to express feed values and energy requirements because it considers losses of

energy in the urine (UE) and combustible gases (GE). However, ME has many of the same deficiencies as DE because UE and GE are predictable from DE. Therefore, 1 megacalorie ME is considered to be equal to 0.82 megacalorie DE. There is 1.64 megacalorie ME per pound of TDN (2 megacalories × .82).

ME accounts for all losses expect for heat loss in metabolizing the absorbed nutrients. The increase in heat production after the consumption of food is called heat increment (HI). In a very cold environment, the heat increment may be used to maintain body temperature. In this case, the ME value approaches the net energy value of the feed or ration.

Net Energy (NE). NE accounts for all losses in metabolism and is the most exact measure of food energy. It is the portion of the food energy left for the animal to use for maintenance and production of meat, milk, wool, work, fur, etc. **NE = ME − HI.**

The net energy system for growing and finishing beef cattle separates the energy required for maintenance and for gain. The net energy system takes into account the higher energy value when feeds are used for maintenance than when the same feed is used to produce gain. (See UMC Guide 3051, "Feed Composition Tables.")

However, if cattle are lactating, the partial efficiencies of ME use for maintenance and fattening are similar to lactation. Thus, a single energy value, net energy for lactation (NE_L), is used to define all requirements for the lactating cow and to describe the energy value of feeds. The energy requirements for mature, pregnant and lactating beef cows are expressed in net energy for maintenance levels in the 1976 Nutrient Requirements of Beef Cattle. (See tables in UMC Guide 2067.)

The net energy requirement for maintenance (NEm) is related to the body weight of an animal. It is the energy needed to maintain life or the heat produced by an animal at rest and not consuming food. The NEm requirements for beef cattle, listed in the 1976 Nutrient Requirements of Beef Cattle, were established by the relationship $NEm = 0.77W^{0.75}$. Because NEm values are related to the actual weight of the cattle, they are likely to be similar for the various breeds of cattle. However, fat animals will have a slightly lower maintenance energy requirement than lean animals of the same weight because fat tissue is more static than lean tissue. Thus, fat tissue requires less energy for maintenance. Extreme temperatures, rain, mud, and abrupt changes in weather affect the maintenance requirements of animals.

The net energy for gain (NEg) requirements of cattle varies with sex and with the energy content of the gain produced. It takes more energy for a 1,000-pound steer to gain 1 pound a day than for a 350-pound steer to gain a pound. The gain on the 1,000-pound steer will be mostly fat, while the gain on the 350-pound steer will be mostly protein and water. This difference in the energy content of the gain is the reason that species, breed, body size, rate of growing and sex affects the NEg required for a pound of gain. Because heifers mature at a lighter weight than steers, a separate set of tables are used for each.

The value for NEg listed in the tables are for steers that will yield grade 2.5 to 3.0 and grade choice at 1,000 to 1,100 pounds and for heifers that weigh 850 to 950 pounds at these carcass grades. The smaller breeds of cattle will have a larger portion of their daily gain as fat than those given in the table, especially when they weigh from 750 to 1,000 pounds. On the other hand, the larger maturity cattle will have less NEg requirement for a unit of gain at these heavier weights than values given in the tables. Thus, when estimating the performance of these cattle, use the NEm values given for their weight. But use the NEg values given for cattle 100 to 150 pounds heavier when calculating the performance of small maturity cattle. When working with large maturity cattle, (Simmental, Charolais, etc.) use gain values listed on the tables for cattle 100 to 150 pounds lighter.

Using the Net Energy System

The net energy system is popular because of its improved prediction of animal performance by determining whether the feed energy is being used for maintenance (NEm) or growth (NEg). The main problem in using net energy values is in predicting feed intake and the proportion of the daily feed intake that will be used for maintenance or growth. Some producers have used only NEg in formulating rations. But if you use NEg alone to formulate rations, you will overestimate the feeding value of concentrates relative to roughages. Other producers have used the NEm plus the NEg. (NEm + g). This value applies only if half of the daily feed intake is used for maintenance.

High energy finishing rations are often formulated only on the basis of net energy for gain with a value of NEg of .60 to .62 megacalorie per pound of ration dry matter.

The most accurate way to use these NE values to formulate rations is to use the NEm value, plus a multiplier, times the NEg, divided by one, plus the multiplier. The multiplier is the pounds of feed intake above maintenance and then divided by maintenance. For example, if a 750-pound steer is expected to eat 18 pounds of feed, 8 pounds of which will be required for maintenance, then the NE value of the ration would be

$$NE = \frac{NEm + (10/8)\,(NEg).}{1 + (10/8)}$$

This formula, which is used to arrive at a composite net energy value, must be applied to the NEm and NEg value for the ration and for each of the feed ingredients used in the ration formulation. Remember, however, that this particular composite net energy value applies to an animal of a specified weight, consuming a specified amount of this ration daily. The proportion of the daily feed used for maintenance will change if feed intake or the weight of the animal changes for a particular ration.

Using the Net Energy System To Predict Performance

The ration must be balanced for the protein, minerals and

Net energy requirement tables for growing and finishing cattle.

Body wt., lbs.	300 NEm		400 NEm		500 NEm		600 NEm	
	3.10		3.85		4.55		5.21	
Daily gain lbs.	*NEg*		*NEg*		*NEg*		*NEg*	
	Steers	*Heifers*	*Steers*	*Heifers*	*Steers*	*Heifers*	*Steers*	*Heifers*
	Megacalories/day							
.5	.47	.52	.59	.64	.72	.78	.83	.90
.6	.59	.64	.73	.80	.87	.95	1.00	1.09
.7	.68	.74	.84	.92	1.02	1.12	1.17	1.28
.8	.79	.87	.98	1.08	1.17	1.29	1.34	1.48
.9	.88	.97	1.10	1.21	1.33	1.46	1.52	1.68
1.0	1.00	1.11	1.24	1.38	1.48	1.64	1.70	1.88
1.1	1.12	1.24	1.39	1.54	1.64	1.82	1.88	2.09
1.2	1.21	1.35	1.51	1.68	1.80	2.00	2.06	2.30
1.3	1.33	1.49	1.66	1.86	1.96	2.19	2.24	2.51
1.4	1.43	1.61	1.78	2.00	2.12	2.38	2.43	2.73
1.5	1.55	1.75	1.93	2.18	2.28	2.57	2.62	2.95
1.6	1.65	1.87	2.06	2.32	2.45	2.77	2.81	3.17
1.7	1.78	2.02	2.21	2.51	2.61	2.97	3.00	3.40
1.8	1.88	2.14	2.34	2.66	2.78	3.17	3.19	3.63
1.9	2.01	2.29	2.50	2.85	2.95	3.37	3.39	3.87
2.0	2.14	2.42	2.63	3.01	3.12	3.58	3.58	4.11
2.1	2.24	2.57	2.79	3.20	3.30	3.79	3.78	4.35
2.2	2.37	2.74	2.95	3.40	3.47	4.01	3.98	4.59
2.3	2.48	2.87	3.08	3.57	3.65	4.22	4.18	4.84
2.4	2.61	3.03	3.25	3.77	3.83	4.44	4.39	5.09
2.5	2.72	3.17	3.38	3.93	4.01	4.66	4.59	5.35
2.6	2.86	3.33	3.55	4.15	4.19	4.89	4.80	5.61
2.7	2.97	3.47	3.69	4.32	4.37	5.12	5.01	5.87
2.8	3.11	3.65	3.86	4.54	4.56	5.35	5.22	6.14
2.9	3.22	3.79	4.00	4.71	4.74	5.59	5.44	6.40
3.0	3.36	3.97	4.18	4.94	4.93	5.82	5.65	6.68
3.1	3.47	4.11	4.32	5.12	5.12	6.06	5.87	6.95
3.2	3.62	4.30	4.50	5.34	5.31	6.31	6.09	7.23
3.3	3.76	4.48	4.68	5.51	5.51	6.56	6.31	7.52
3.4	3.88	4.63	4.83	5.76	5.70	6.81	6.54	7.80

	NEm megacalorie/ pound	NEg megacalorie/ pound
Alfalfa hay	.50	.23
Requirements for 500-pound steer (4.55 megacalorie NEm)		
Pounds hay for maintenance	9.1	(4.55 ÷ .50)
Pounds hay left for gain	7.9	(17 − 7.9)
NEg, megacalorie	1.82	(7.9 × .23)
Daily gain	1.20	(See table)

vitamins for adequate projection of performance with net energy values.

To illustrate the use of the system, let's estimate the daily gain of a 500-pound steer consuming 17 pounds of alfalfa hay (early bloom). Net energy value for feeds are given in UMC Guide 2051, ''Feed Consumption Tables.'' Notice above that it takes 9.1 pounds of hay for maintenance, which leaves 7.9 pounds of hay for gain. The 7.9 pounds of hay would supply 1.82 megacalorie NEg, which would give 1.2 pounds daily gain for the 500-pound steer. Some good quality alfalfa hays would have a higher level of energy than given for this hay and thus would support a higher level of gain when consumed at this amount.

The following example shows how the NEm and NEg are computed for a mixed ration and used to project the daily gain of 800-pound cattle consuming 22 pounds of the ration daily.

Sample Calculations

- A cattle producer is feeding the following ration to his cattle. How much NEm and NEg does it contain?

- The producer has a group of 800-pound steers on this ration. They are consuming 22 pounds (as fed basis) of the above ration. What is the expected daily gain?

Net energy requirement tables for growing and finishing cattle.

Body wt., lbs.	700 NEm		800 NEm		900 NEm		1000 NEm		1100 NEm
	5.85		6.47		7.05		7.65		8.14
Daily Gain	*NEg*		*NEg*		*NEg*		*NEg*		*NEg*
lbs.	*Steers*	*Heifers*	*Steers*	*Heifers*	*Steers*	*Heifers*	*Steers*	*Heifers*	*Steers*
	Megacalories/day								
.5	.93	1.01	1.02	1.11	1.12	1.22	1.21	1.32	1.30
.6	1.12	1.22	1.24	1.35	1.35	1.47	1.46	1.59	1.57
.7	1.31	1.44	1.45	1.59	1.58	1.73	1.71	1.88	1.84
.8	1.51	1.66	1.67	1.83	1.82	2.00	1.97	2.17	2.12
.9	1.71	1.88	1.89	2.08	2.06	2.27	2.23	2.46	2.39
1.0	1.91	2.11	2.11	2.33	2.30	2.55	2.49	2.76	2.68
1.1	2.11	2.34	2.33	2.59	2.55	2.83	2.76	3.06	2.96
1.2	2.31	2.58	2.56	2.85	2.79	3.11	3.02	3.37	3.25
1.3	2.52	2.82	2.78	3.12	3.04	3.40	3.29	3.68	3.54
1.4	2.73	3.06	3.01	3.39	3.29	3.70	3.56	4.00	3.83
1.5	2.94	3.31	3.25	3.66	3.55	4.00	3.84	4.33	4.12
1.6	3.15	3.56	3.48	3.94	3.80	4.30	4.12	4.66	4.42
1.7	3.37	3.82	3.72	4.22	4.06	4.61	4.40	4.99	4.72
1.8	3.58	4.08	3.96	4.51	4.33	4.92	4.68	5.33	5.03
1.9	3.80	4.34	4.20	4.80	4.59	5.24	4.97	5.67	5.34
2.0	4.02	4.61	4.45	5.09	4.86	5.57	5.26	6.02	5.65
2.1	4.25	4.88	4.69	5.39	5.13	5.89	5.55	6.38	5.96
2.2	4.47	5.16	4.94	5.70	5.40	6.23	5.84	6.74	6.28
2.3	4.70	5.44	5.19	6.01	5.67	6.56	6.14	7.10	6.59
2.4	4.93	5.72	5.45	6.32	5.95	6.90	6.44	7.47	6.92
2.5	5.16	6.01	5.70	6.64	6.23	7.25	6.74	7.85	7.24
2.6	5.39	6.30	5.96	6.96	6.51	7.60	7.05	8.23	7.57
2.7	5.63	6.59	6.22	7.28	6.80	7.96	7.35	8.61	7.90
2.8	5.87	6.89	6.48	7.61	7.08	8.32	7.67	9.00	8.23
2.9	6.11	7.19	6.75	7.95	7.37	8.68	7.98	9.40	8.57
3.0	6.35	7.50	7.02	8.29	7.67	9.05	8.30	9.80	8.91
3.1	6.59	7.81	7.29	8.63	7.96	9.43	8.61	10.20	9.25
3.2	6.84	8.12	7.56	8.98	8.26	9.81	8.94	10.61	9.60
3.3	7.09	8.44	7.83	9.33	8.56	10.19	9.26	11.03	9.95
3.4	7.34	8.76	8.11	9.68	8.86	10.58	9.59	11.45	10.30

	% As fed	NEm/ cwt ration*	Supplied NEm	Composition NEg/pound	Supplied NEg
Corn silage	15	.28	4.20	.18	2.70
Corn (No. 2)	78	.92	71.76	.60	46.80
SBM (Solv.)	5	.78	3.90	.53	2.65
Alfalfa meal	2	.56	1.12	.31	0.62
Total	100	XXX	81.98	XXX	52.77
Answer:	NEm is	.82	Megacalorie per pound		
	NEg is	.53	Megacalorie per pound		

*Composition of feedstuff (megacalories/pound).

Solution

1. NEm required is 6.57 megacalories.
2. Pounds of feed required for maintenance:

$$\frac{\text{NEm requirement}}{\text{NEm per pounds of feed for maintenance}} = \text{pound feed required}$$

$$\frac{6.47}{.82} = 7.89$$

3. Pounds of feed left for gain. Daily feed intake minus feed required for maintenance is 22 − 7.89 = 14.11.
4. NEg/pound of feed × lbs feed remaining is 0.53 × 14.11 = 7.48 megacalories NEg.
5. Expected daily gain is 3.17 (see table).

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