United Kingdom energy and protein feeding standards for growing and fattening cattle

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The relevant standards are published in MAFF Technical Bulletin 33, "Energy Allowances and Feeding Systems for Ruminants" and in ADAS Advisory Paper No. 11, 2nd Edition, "Nutrient Allowances and Composition of Feedingstuffs for Ruminants". Extracts from relevant Table are appended together with a glossary of terms and technical summary of the mathematical relationships used.

The experimental background to the energy standards is contained in the ARC Technical Review No. 2, Ruminants 1965, Section 6, and the feeding trial data summarised in the Proceeding of the 7th Nutrition Conference for Feed Manufacturers, p. 37-38, 1974.

Protein requirements are expressed as digestible crude protein and are metricated versions of standards attributed to J.H.B. Roy in the Proceedings of the Brighton Conference, 1959. They are given in the Table below :

DAILY DIGESTIBLE CRUDE PROTEIN REQUIREMENTS FOR GROWING AND FATTENING CATTLE (g/head/d)

Liveweight, kg	Rate of gain, kg/d				
	0.25	0.50	0.75	1.00	1.25
100	200	253	305	356	408
200	306	363	416	470	525
300	340	409	474	540	606
400	370	445	520	594	668
500	400	484	564	648	730

Terminology and symbols

APL	represents	Animal Production Level
DM	"	Dry Matter Content (g/kg)
DMI	"	Dry Matter Intake (kg/day)
EV_g	"	Energy Value of Gain (MJ/kg)
E_g	"	Net Energy Required for Body Gain (MJ/day)
E_m	"	Net Energy Required for Maintenance (MJ/day)
E_p	"	Net Energy Required for Production (MJ/day)
FM	"	Fasting Metabolism (MJ/day)
k_g	"	Efficiency of Utilisation of ME for Body Gain
k_m	"	Efficiency of Utilisation of ME for Maintenance
k_p	"	Efficiency of Utilisation of ME for Production
k_{mp}	"	Efficiency of Utilisation of ME for Maintenance and Production
LWG	"	Liveweight Gain (kg/day)
ME	"	Metabolisable Energy
MEF	"	ME of Food (MJ/kg)
MER	"	ME of Ration (MJ)

MEP	"	ME Available for Production (MJ/day)
M_g	"	ME Required for Body Gain (MJ/day)
M_m	"	ME Required for Maintenance (MJ/day)
M_p	"	ME Required for Production (MJ/day)
M/D	"	ME Concentration of Dry Matter (MJ/kg)
NE_g	"	Net Energy Value of a Food or Ration for Body Gain (MJ/kg)
NE_m	"	Net Energy Value of a Food or Ration for Maintenance (MJ/kg)
NE_p	"	Net Energy Value of a Food or Ration for Production (MJ/kg)
NE_{mp}	"	Net Energy Value of a Food or Ration for Maintenance and Production (MJ/kg)
W	"	Liveweight (kg)

Summary

Me system for performance prediction in beef cattle

Maintenance Requirements with no allowance for activity (including safety margin)

$$M_m = 8.3 + 0.091\ W \qquad \text{(Table 1)}$$

Production Requirements

ME available for production $\quad MEP = MER - M_m$

Efficiency of ME utilisation for gain $\quad k_g = 0.0435\ M/D$

Net energy stored $\quad E_g = MEP \times k_g$

Allowing for 0.05 safety margin, this becomes: $\quad E_g = 0.0414\ M/D \times MEP$ (Table 2)

Energy value of gain $\quad EV_g = 6.28 + 0.3\ E_g + 0.0188\ W$

Since predicted liveweight gain $LWG = \dfrac{E_g}{EV_g}$

$$\text{Predicted LWG} = \frac{E_g}{(6.28 + 0.3\ E_g + 0.0188\ W)} \qquad \text{(Table 3)}$$

TABLE 1

DAILY MAINTENANCE ALLOWANCE OF ME FOR BEEF CATTLE AND DAIRY COWS

Body weight kg	MJ/head
100	17
150	22
200	27
250	31
300	36
350	40
400	45
450	49
500	54
550	59
600	63

(including safety margin) Based on $M_m = 8.3 + 0.091\ W$

TABLE 2

MJ NET ENERGY STORED, E_g, FROM ME AVAILABLE FOR PRODUCTION, MEP, AT ENERGY CONCENTRATION M/D

MJ MEP	M/D Energy concentration MJ/kg DM							
	7	8	9	10	11	12	13	14
5	1.4	1.7	1.9	2.1	2.3	2.5	2.7	2.9
10	2.9	3.3	3.7	4.1	4.6	5.0	5.4	5.8
15	4.3	5.0	5.6	6.2	6.8	7.5	8.1	8.7
20	5.8	6.6	7.5	8.3	9.1	9.9	10.8	11.6
25	7.2	8.3	9.3	10.4	11.4	12.4	13.5	14.5
30	8.7	9.9	11.2	12.4	13.7	14.9	16.1	17.4
35	10.1	11.6	13.0	14.5	15.9	17.4	18.8	20.3
40	11.6	13.2	14.9	16.6	18.2	19.9	21.5	23.2
45	13.0	14.9	16.8	18.6	20.5	22.4	24.2	26.1
50	14.5	16.6	18.6	20.7	22.8	24.8	26.9	29.0
55	15.9	18.2	20.5	22.8	25.0	27.3	29.6	31.9
60	17.4	19.9	22.4	24.8	27.3	29.8	32.3	34.8
65	18.8	21.5	24.2	26.9	29.6	32.3	35.0	37.7
70	20.3	23.2	26.1	29.0	31.9	34.8	37.7	40.6
75	21.7	24.8	27.9	31.1	34.2	37.3	40.4	43.5
80	23.2	26.5	29.8	33.1	36.4	39.8	43.1	46.4

Example

Prediction of the liveweight gain of a 250 kg steer receiving the following ration:

		DMI (kg)	ME (MJ)
4.1 kg hay	(870 g/kg DM & 9.0 MJ/kg DM)	3.6	32.1
1.7 kg barley	(840 g/kg DM & 12.5 MJ/kg DM)	1.4	17.9
		5.0	50.0

M/D = 50/5 = 10 MJ/kg

M_m = 31 MJ (Table 1)

MEP = 50 — 31 = 19 MJ M/D 10 MJ/kg

E_g = 8 MJ (Table 2)

LWG = 0.60 kg/d (Table 3)

The ration supplies 50 MJ of ME at M/D 10 MJ/kg DM and will provide for maintenance and 0.6 kg liveweight gain per day.

TABLE 3

LIVEWEIGHT GAIN IN kg/DAY FOR MJ NET ENERGY STORED E_g IN ANIMALS OF LIVEWEIGHT W

E_g MJ	Liveweight W in kg										
	100	150	200	250	300	350	400	450	500	550	600
2	0.23	0.21	0.19	0.17	0.16	0.15	0.14	0.13	0.12	0.12	0.11
4	0.43	0.39	0.36	0.33	0.30	0.28	0.27	0.25	0.24	0.22	0.21
6	0.60	0.55	0.51	0.47	0.44	0.41	0.38	0.36	0.34	0.33	0.31
8	0.76	0.70	0.64	0.60	0.56	0.52	0.49	0.47	0.44	0.42	0.40
10	0.90	0.83	0.77	0.72	0.67	0.63	0.60	0.56	0.54	0.51	0.49
12	1.02	0.94	0.88	0.82	0.77	0.73	0.69	0.65	0.62	0.59	0.57
14		1.05	0.98	0.92	0.87	0.82	0.78	0.74	0.70	0.67	0.64
16			1.08	1.01	0.96	0.91	0.86	0.82	0.78	0.75	0.72
18			1.17	1.10	1.04	0.99	0.94	0.89	0.85	0.82	0.78
20				1.18	1.12	1.06	1.01	0.96	0.92	0.88	0.85
22				1.25	1.19	1.13	1.08	1.03	0.99	0.95	0.91
24					1.26	1.20	1.14	1.09	1.05	1.01	0.97
26					1.32	1.26	1.20	1.15	1.11	1.06	1.03
28						1.32	1.26	1.21	1.16	1.12	1.08
30						1.37	1.32	1.26	1.22	1.17	1.13
35							1.44	1.39	1.34	1.29	1.25
40								1.50	1.45	1.40	1.35
45									1.54	1.49	1.45
50										1.58	1.54

Based on LWG = $\dfrac{E_g}{(6.28 + 0.3\ E_g + 0.0188\ W)}$

Variable net energy system for ration formulation for beef cattle

Animal Production Level, APL = $\dfrac{E_m + E_p}{E_m} = 1 + \dfrac{E_p}{E_m}$

Given that $E_m = 5.67 + 0.061\ W$ (Table 5)

and $E_p = \dfrac{LWG\ (6.28 + 0.0188\ W)}{(1 - 0.30\ LWG)}$ (Table 5)

Then $APL = 1 + \left[\dfrac{LWG(6.28 + 0.0188\ W)}{(1 - 0.3\ LWG)(5.67 + 0.061\ W)}\right]$ (Table 6)

TABLE 4

DAILY ME ALLOWANCE FOR GROWING AND FATTENING CATTLE (MJ/HEAD)

Liveweight kg	Ration conc'n M/D	MJ/kg	Rate of gain kg/day 0	0.25	0.50	0.75	1.00	1.25	1.50
100	8		17	24					
	10		17	22	29				
	12		17	21	27	33			
	14		17	21	25	31	37		
200	8		27	35					
	10		27	34	41	51			
	12		27	33	39	47	56		
	14		27	32	37	45	52	62	74
300	8		36	46	57				
	10		36	44	53	64			
	12		36	43	50	59	70	84	
	14		36	42	48	56	65	77	92
400	8		45	56	70				
	10		45	54	65	77	93		
	12		45	53	61	72	85	101	
	14		45	51	59	68	79	93	110
500	8		54	67	82				
	10		54	64	76	91			
	12		54	63	73	85	99	117	
	14		54	61	70	80	93	108	128
600	8		63	77	94				
	10		63	75	88	104			
	12		63	73	84	97	114	134	
	14		63	71	81	92	106	124	146

TABLE 5

NET ENERGY VALUES FOR MAINTENANCE AND PRODUCTION, NE_{mp} (MJ/kg DM)

APL	Energy concentration of feed MEF MJ/kg DM						
	8	9	10	11	12	13	14
1.00	5.8	6.5	7.2	7.9	8.6	9.4	10.1
1.10	5.2	6.0	6.8	7.6	8.3	9.1	9.9
1.15	5.1	5.8	6.6	7.4	8.2	9.0	9.8
1.20	4.9	5.7	6.5	7.3	8.1	8.9	9.8
1.25	4.7	5.5	6.4	7.2	8.0	8.9	9.7
1.30	4.6	5.4	6.3	7.1	7.9	8.8	9.7
1.35	4.5	5.3	6.2	7.0	7.8	8.7	9.6
1.40	4.4	5.2	6.1	6.9	7.8	8.7	9.6
1.45	4.3	5.1	6.0	6.8	7.7	8.6	9.5
1.50	4.2	5.1	5.9	6.8	7.7	8.6	9.5
1.55	4.2	5.0	5.8	6.7	7.6	8.5	9.5
1.65	4.1	4.9	5.7	6.6	7.5	8.4	9.4
1.75	3.9	4.8	5.6	6.5	7.4	8.4	9.3
2.00	3.8	4.6	5.4	6.3	7.3	8.2	9.2
2.25	3.6	4.4	5.3	6.2	7.1	8.1	9.1

Based on $NE_{mp} = \dfrac{(MEF)^2 \times APL}{1.39\ MEF + 23\ (APL - 1)}$ (MJ/kg DM)

Efficiency of ME Utilisation for Maintenance and Production,

$$k_{mp} = \frac{MEF \times APL}{1.39\ MEF + 23\ (APL - 1)}$$

Net Energy of feed or ration

$$NE_{mp} = \frac{(MEF)^2 \times APL}{1.39\ MEF \times 23\ (APL - 1)}\ MJ/kg\ DM \qquad \text{(Table 7)}$$

TABLE 6

ANIMAL PRODUCTION LEVEL

Liveweight W, kg	Liveweight gain LWG, kg/day					
	0.25	0.50	0.75	1.00	1.25	1.50
100	1.19	1.40	1.66	1.98	-	-
150	1.16	1.36	1.59	1.87	-	-
200	1.15	1.33	1.54	1.79	2.11	-
250	1.14	1.30	1.50	1.74	2.03	-
300	1.13	1.29	1.47	1.70	1.97	2.33
350	1.13	1.27	1.45	1.67	1.93	2.27
400	1.12	1.26	1.43	1.64	1.90	2.22
450	1.12	1.26	1.42	1.62	1.87	2.18
500	1.11	1.25	1.41	1.60	1.84	2.15
550	1.11	1.24	1.40	1.59	1.83	2.13
600	1.11	1.24	1.39	1.58	1.81	2.13

Based on $APL = 1 + \sqrt{\frac{LWG\ (6.28 + 0.0188\ W)}{(1 - 0.3\ LWG)\ (5.67 + 0.061\ W)}}$

Example

Formulation of a ration for a 400 kg steer to gain 0.5 kg/day

Foods available : Hay (MEF 8 MJ/kg DM)
Cereal (MEF 13 MJ/kg DM)

APL = 1.26 (Table 6)

NE_{mp} of hay = 4.7 MJ/kg DM (Table 5)

NE_{mp} of cereal = 8.9 MJ/kg DM (Table 5)

Net energy requirement = 40.1 MJ/day (Table 7)

		DMI (kg)	NE (MJ)
6.6 kg hay	DM at 4.7 MJ/kg	6.6	31.0
1 kg cereal	DM at 8.9 MJ/kg	1.0	8.9
		7.6	39.9

Note

The variable net energy system *should not be used to predict animal performance*, since the animal's liveweight gain must be known in order to calculate APL and hence NE_{mp} values. The ME system must be used for performance prediction.

TABLE 7

MJ NET ENERGY ALLOWANCE FOR MAINTENANCE AND LIVEWEIGHT GAIN IN GROWING AND FATTENING ANIMALS

Gain in kg	Liveweight W in kg										
	100	150	200	250	300	350	400	450	500	550	600
0	12.4	15.6	18.8	22.0	25.2	28.4	31.6	34.8	38.0	41.2	44.4
0.1	13.3	16.6	19.9	23.2	26.5	29.8	33.1	36.4	39.7	43.0	46.3
0.2	14.2	17.6	21.0	24.5	27.9	31.3	34.7	38.1	41.5	44.9	48.3
0.3	15.2	18.8	22.3	25.8	29.3	32.9	36.4	39.9	43.4	47.0	50.5
0.4	16.3	19.9	23.6	27.2	30.9	34.5	38.2	41.8	45.5	49.1	52.8
0.5	17.4	21.2	25.0	28.8	32.6	36.3	40.1	43.9	47.7	51.5	55.2
0.6	18.7	22.6	26.5	30.4	34.4	38.3	42.2	46.1	50.2	54.0	57.9
0.7	20.0	24.2	28.1	32.2	36.3	40.4	44.4	48.5	52.6	56.7	60.7
0.8	21.4	25.7	29.9	34.1	38.4	42.6	46.9	51.1	55.3	59.6	63.8
0.9	23.0	27.4	31.8	36.2	40.6	45.0	49.5	53.9	58.3	62.7	67.1
1.0	24.6	29.3	33.9	38.5	43.1	47.7	52.3	56.9	61.5	66.1	70.7
1.1	-	31.3	36.1	40.9	45.7	50.6	55.4	60.2	65.0	69.9	74.7
1.2	-	-	38.6	43.6	48.7	53.7	58.8	63.8	68.9	73.9	79.0
1.3	-	-	-	46.6	51.9	57.2	62.5	67.8	73.1	78.4	83.7
1.4	-	-	-	-	55.4	61.0	66.6	72.2	77.7	83.3	88.9
1.5	-	-	-	-	-	65.2	71.1	77.0	82.9	88.8	94.7

(including safety margin)

Based on $E_m = 1.05 \left[5.67 + 0.061 \, W \right]$

and $E_g = 1.05 \left[\frac{LWG \, (6.28 + 0.0188 \, W)}{(1 - 0.3 \, LWG)} \right]$

Yugoslavia energy and protein feeding standards for growing and fattening cattle

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For the evaluation of feeds for ruminants, Kellner's Starch Equivalent system is generally accepted in Yugoslavia. In some parts of the country it is used as kilograms of SE, while in others it is expressed as "oat feed unit" which is based on 1 kg of oats = 0,6 kg SE.