# Net energy requirements of Holstein Friesian dairy cattle

Energy requirements for maintenance and milk production

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## Introduction (1)

- An energy evaluation system includes
  - Energy requirements
    - Maintenance, Pregnancy, Growth, Milk production
  - Energy values of feedstuffs
- Accurate energy evaluation system important for:
  - Improving feed efficiency / reducing nutrient losses
  - Valorization/ranking of feedstuffs
- Net energy (VEM) system (Van Es 1975, 1975)
  - Improvement over the TDN and starch equivalent system

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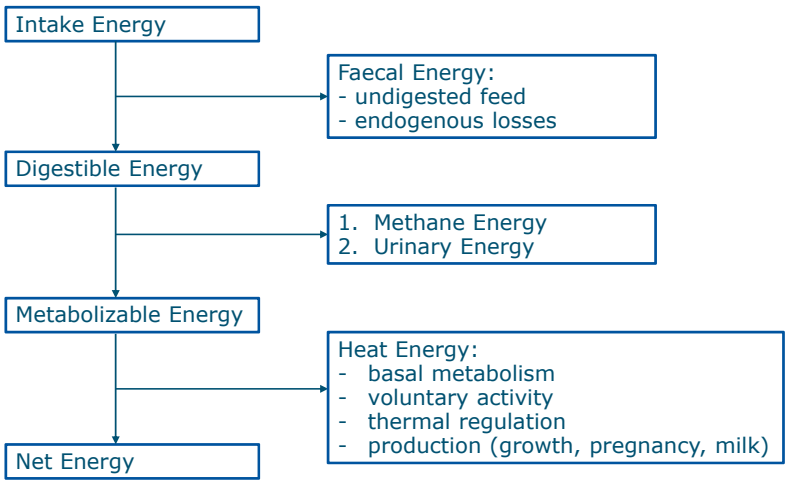
# Introduction (2)

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# Introduction (3)

- Van Es (1975)
  - NE requirement maintenance ($NE_m$: 293 KJ/kg $BW^{0.75}$)
  - Efficiency conversion ME → NE milk ($k_L$: 0.60)
  - ME requirement maintenance ($ME_m$: **488** KJ/kg $BW^{0.75}$)
    - $ME_m = NE_m / k_L = 293 / 0.6 = 488$ KJ/kg $BW^{0.75}$
- Dong et al. (2015) (1992 – 2010; n = 823; UK)
  - $ME_m$ = **688** KJ/kg $BW^{0.75}$ ; $k_L = 0.644$
- Moraes et al. (2015) (n = 1038; USA)
  - 1963 – 1973; $ME_m$ = **510** KJ/kg $BW^{0.75}$ ; $k_L = 0.60$
  - 1974 – 1983; $ME_m$ = **590** KJ/kg $BW^{0.75}$ ; $k_L = 0.63$
  - 1984 – 1995; $ME_m$ = **740** KJ/kg $BW^{0.75}$ ; $k_L = 0.70$

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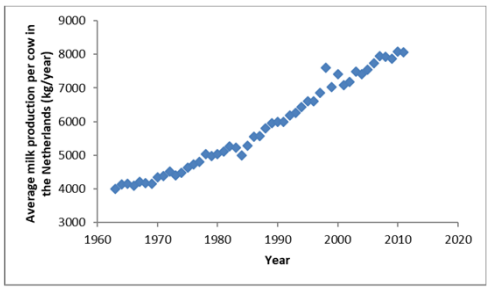
# Introduction (4)

- Increased $ME_m$ since 1975:
  - Doubled milk production per cow
  - Changed body composition
    - Higher (digestive) organ mass per kg $BW^{0.75}$
  - Increased blood flow

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# Introduction (5)

Project to update the VEM system

- PPS project (ZuivelNL, Overheid, WLR, WU, CVB)
  - Experiment in the CRC (2018)
    - Determination of energy requirements of dry and lactating non-pregnant HF cows
  - Meta-analysis with recent CRC experiments carried out in Wageningen (period 2004 – 2019) for estimating:
    - Net energy requirements
    - Net energy values of feedstuffs
  - Validation of results using production data

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# CRC experiment (M&M) (1)

- 24 HF non pregnant cows
  - 12 high producing (45 kg milk; 81 DIM)
  - 12 low producing (29 kg milk; 231 DIM)
    - First round in CRC low milk production (9 kg milk)
    - Second round in CRC as dry cows
- High versus low starch TMR diets
- 17-21 adaptation days
- 4 measurement days in CRC

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# CRC experiment (M&M) (2)

| | HP-Fibre | HP-Starch | LP-Fibre | LP-Starch |
|---|---|---|---|---|
| Ingredients (g/kg DM) | | | | |
| Grass silage | 351 | 234 | 689 | 377 |
| Maize silage | 135 | 311 | 114 | 389 |
| Wheat straw | 0 | 0 | 100 | 121 |
| Concentrate mixture | 514 | 455 | 97 | 113 |
| Analysed contents (g/kg DM unless otherwise mentioned | | | | |
| DM | 414 | 409 | 423 | 407 |
| Ash | 68 | 61 | 85 | 66 |
| OM | 932 | 939 | 915 | 934 |
| CP | 173 | 173 | 147 | 137 |
| Fat | 34 | 30 | 31 | 28 |
| **Starch** | **138** | **227** | **64** | **170** |
| Suiker | 64 | 56 | 80 | 51 |
| **NDF** | **415** | **349** | **503** | **450** |
| Crude fibre | 233 | 195 | 273 | 246 |
| Gross energy (MJ/kg DM) | 18.9 | 18.8 | 19.0 | 18.9 |
| Titanium | 1.42 | 1.38 | 1.32 | 1.28 |
| Calculated contents (g/kg DM) unless otherwise mentioned | | | | |
| DC-OM (%) | 82.4 | 82.2 | 74.9 | 74.2 |
| VEM (/kg DM) | 1044 | 1052 | 899 | 915 |
| DVE-07 | 101 | 102 | 65 | 62 |
| OEB-07 | 17 | 17 | 22 | 17 |

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## CRC experiment (M&M) (3)

- CRC measurements
  - DMI (intake minus residues)
  - Milk production (kg/d)
  - Milk contents (GE, fat, protein, lactose, urea)
  - Faecal digestibility (starch, protein, NDF, fat, OM)
  - Energy excretion (in milk, manure, faeces, methane)
  - Consumption of $O_2$
  - Production of $CO_2$
  - N balance (N-intake, N-excretion in faeces and manure, N-milk, $NH_3$)
  - BW

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## CRC experiment (M&M) (4)

Model:

If negative energy balance:

- $NE_L$ (KJ/d/kg $BW^{0.75}$) = $B_0 + B_l \times ME + B_3 \times Mob$

If positive energy balance:

- $NE_L$ (KJ/d/kg $LG^{0.75}$) = $B_0 + B_l \times (ME - (Ret / B_2))$

Where:

- $NE_L$ = energieoutput in melk (KJ/d/kg $LG^{0.75}$)
- ME = ME intake (KJ/d/kg $LG^{0.75}$)
- Ret = energy retention (KJ/d/kg $BW^{0.75}$)
- Mob = energy mobilisation (KJ/d/kg $BW^{0.75}$)

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# CRC experiment (Results) (2)

- $B_0$ = intercept value and equal to the estimated NE for maintenance
- $B_1$ = the efficiency of conversion of ME into $NE_L$.
- $B_2$ = the efficiency of conversion of ME into body reserves (predominantly fat)
- $B_3$ = the efficiency of conversion of body reserves (predominantly fat) into $NE_L$
- $B_2$ = 0.70 (Moraes et al., 2015)
- $B_3$ = 0.89 (Moraes et al., 2015)

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# CRC experiment (Results) (1)

| | HP-Fibre | HP-Starch | LP-Fibre lactating | LP-Starch lactating | LP-Fibre dry | LP-Starch dry |
|---|---|---|---|---|---|---|
| Milk (kg/d) | 37.2 | 38.1 | 9.9 | 9.7 | | |
| DMI (kg/d) | 21.4 | 22.8 | 11.1 | 10.4 | 10.9 | 10.9 |
| **Faecal digestibility (%)** | | | | | | |
| **OM** | **70.8** | **70.7** | **73.6** | **74.2** | **72.9** | **74.1** |
| Ash | 56.3 | 52.9 | 60.5 | 51.6 | 58.8 | 54.4 |
| CP | 65.0 | 67.6 | 68.4 | 69.1 | 67.5 | 70.9 |
| Fat | 67.5 | 68.6 | 57.0 | 63.1 | 53.5 | 66.6 |
| NDF | 65.1 | 58.4 | 74.7 | 69.4 | 73.9 | 68.1 |
| CF | 63.7 | 57.3 | 76.0 | 72.0 | 75.5 | 71.1 |
| Starch | 95.2 | 94.9 | 95.5 | 97.9 | 95.0 | 97.5 |
| GE | 68.4 | 68.6 | 70.4 | 71.2 | 69.4 | 71.4 |
| DC-OM predicted based on wethers fed at maintenance level (%) | | | | | | |
| | **82.4** | **82.2** | **74.9** | **74.2** | **74.9** | **74.2** |

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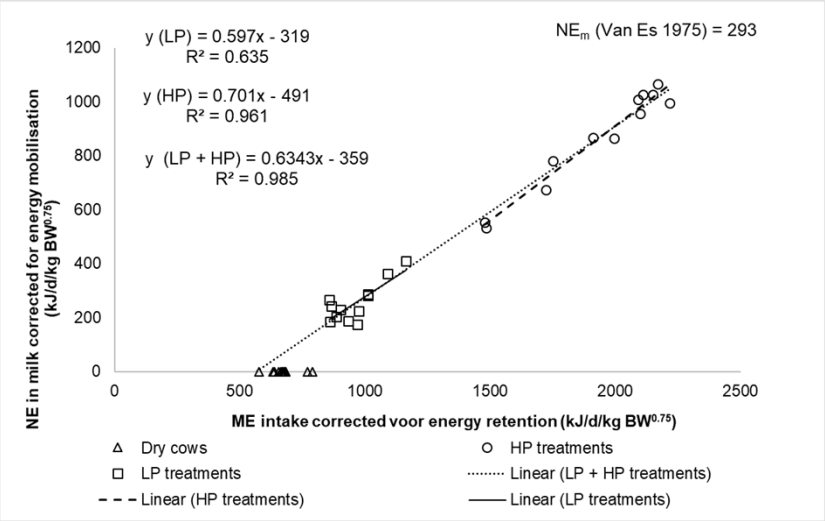
# CRC experiment (Results) (2)



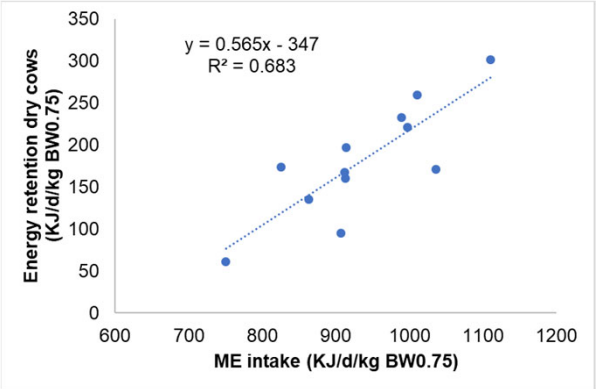



# CRC experiment (Results) (3)

| | $k_L$ | $ME_m$ (KJ/kg $BW^{0.75}$) | $NE_m$ (KJ/kg $BW^{0.75}$) | VEM* | Difference in VEM req. Relative to van Es (1975) |
|---|---|---|---|---|---|
| Van Es (1975) | 0.600 | 488 | 293 | 5464 | 0.0% |
| LP | 0.597 | 534 | 319 | 5981 | 9.5% |
| HP | 0.701 | 700 | 491 | 7841 | 43.5% |
| LP+HP | 0.634 | 566 | 359 | 6339 | 16.0% |
| Dry cows | *0.634* | 676 | 429 | 7575 | 38.6% |

*VEM requirement per day for a 650 kg BW cow

## CRC experiment (Results) (4)




Conversion of ME into body reserves is 0.57 instead of 0.70

$ME_m$ = 347/0.565 = 614 KJ/d/kg $BW^{0.75}$

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## CRC experiment (Results) (5)

| | $k_L$ | $ME_m$ (KJ/kg $BW^{0.75}$) | $NE_m$ (KJ/kg $BW^{0.75}$) | VEM* | Difference in VEM req. Relative to van Es (1975) |
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| HP | 0.701 | 700 | 491 | 7841 | 43.5% |
| LP+HP | 0.634 | 566 | 359 | 6339 | 16.0% |
| ~~Dry cows~~ | ~~*0.634*~~ | ~~676~~ | ~~429~~ | ~~7575~~ | ~~38.6%~~ |
| Dry cows | *0.565* | 614 | 347 | 6875 | 25.8% |

*VEM requirement per day for a 650 kg BW cow

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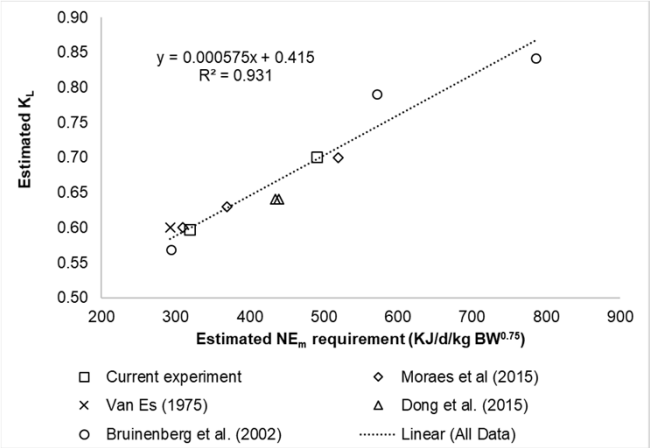
# CRC experiment (Discussion) (1)




Strong correlation between estimated $NE_m$ and $k_L$

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# CRC experiment (Discussion) (2)

Partial efficiencies

- Conversion efficiency of ME into body reserves
  - 0.70 for lactating cattle (Moraes et al., 2015)
  - 0.565 for dry cows (this experiment)
  - 0.747 for lactating cattle (Moe et al., 1981)
  - 0.644 for dry cows (Moe et al., 1982)
- Conversion efficiency of ME into body protein and body fat
  - 0.20 for body protein and 0.75 for body fat in beef cattle (Williams and Jenkins 2003)
- Source of dietary ME (conversion efficiency dietary ME in body energy of growing pigs (Van Milgen et al., 2001):
  - Fat, 88.3%; Starch 84.2%; Protein 52.0%

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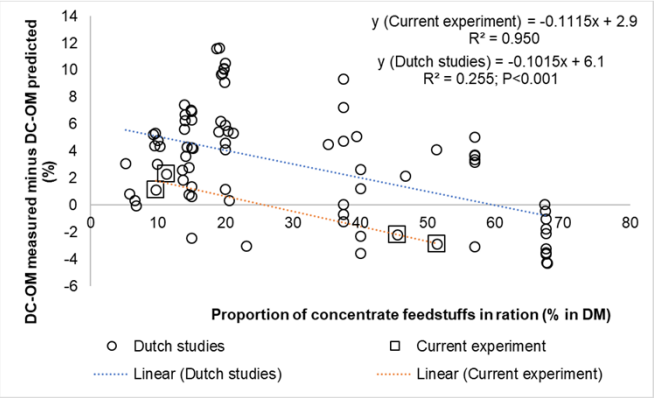
# CRC experiment (Discussion) (3)




1. Van Es (1975): 3% decrease in DC-OM per unit increase in feed level
2. Decrease in DC-OM also affected by concentrate %



# CRC experiment (Conclusions)

- $ME_m$ requirements of modern HF lactating dairy cattle (566 KJ/d/kg $BW^{0.75}$) are 16% higher then estimated by Van Es (1975)
- $ME_m$ requirements of modern HF dry cows (614 KJ/d/kg $BW^{0.75}$) are 26% higher then estimated by Van Es (1975)
- Results from this experiment are in line with the finding of Moe et al. (1981) that conversion of dietary ME in body reserves is less efficient in non lactating cattle compared to lactating dairy cattle

## Further steps

- Meta-analysis of large dataset of recent CRC studies (including the present study) for establishing energy requirements for lactating dairy cattle
- Updating the formula for predicting GE and ME in feedstuffs from:
  - GE (KJ/kg DM) = 24.14 * CP + 36.57 * FAT + 20.92 * CF + 16.99 * NFE
  - ME (KJ/kg DM) = 15.90 * DCP + 37.66 * DFAT + 13.81 * DCF + 14.64 * DNFE

  To:
  - GE (KJ/kg DM) = xx.xx * CP + xx.xx * FAT + xx.xx * **NDF** + xx.xx * sugar + xx.xx * **Starch** + xx.xx * RNSP
  - ME (KJ/kg DM) = xx.xx * DCP + xx.xx * DFAT + xx.xx * D**NDF** + xx.xx * sugar + xx.xx * **DStarch** + xx.xx * DRNSP

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## Thanks for listening!

Questions?


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## CRC experiment (Conclusions)

- $ME_m$ requirements of modern HF lactating dairy cattle (566 KJ/d/kg $BW^{0.75}$) are 16% higher then estimated by Van Es (1975)
- $ME_m$ requirements of modern HF dry cows (614 KJ/d/kg $BW^{0.75}$) are 26% higher then estimated by Van Es (1975)
- Results from this experiment confirm the findings of Moe et al. (1981) that conversion of dietary ME in body reserves is less efficient in dry cows compared to lactating dairy cattle
- Estimated $k_L$ and $NE_m$ values are highly correlated and should therefore be estimated simultaneously on the same dataset

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