Finnish feed evaluation system and Feed Tables

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Feed evaluation is the cornerstone of animal science and practical feeding management.

- The need to compare feeds in a rational way initiated the development of Animal Science.
- The history of feed evaluation from Nordic perspective was covered in a presentation given at the 1st Nordic Feed Science Conference.

Models and miscellaneous

The history of feed evaluation for ruminants, with special emphasis on the Nordic countries

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³Norwegian University of Life Sciences, Ås, Norway.

The history of feed evaluation

Energy evaluation.

It has been known for centuries that different feedstuffs have different values for animals. Thaer (1754-1828) was probably one of the first to attempt to quantify feed value. Chemical fractionation by Neuberg, used in combination with calorimetric measurement of digestible energy, is one means of differentiating feed components (Weende analysis). The Weende analysis has been the basis for all feed evaluation schemes.

SLU

Proceedings of the 1st Nordic Feed Science Conference, Uppsala, Sweden
The role of feed values in Finland is stated in the legislation:

Jord- och skogsbruksministeriets förordning om bedrivande av verksamhet inom foderbranschen
Luke (previously MTT Agrifood Research Finland) is responsible for publishing the basis of feed value calculations and constants such as digestibility coefficients and efficient protein degradability (EPD) values for feeds.

Presenting energy and protein values is voluntary at EU level, but if they are presented in Finland, they need to be calculated as described by Luke.

Feed tables in English

This web service consists of the Feed tables and nutrient requirements of farm animals used in Finland. It is published by Natural Resources Institute Finland (Luke) (formerly MTT Agrifood Research Finland) based on a mandate from the Finnish Ministry of Agriculture and Forestry. The animal species covered include ruminants (cattle, sheep and goats), pigs, poultry (chicken and turkeys), fur animals (fox and mink) and horses.

The contents of the website is divided into three major parts, which can be accessed from the top of the page:

- Feed Tables
- Nutrient requirements
- Offical principals of calculating feed values as commissioned by the Ministry of Agriculture and Forestry
- Feed Tables
- Nutrient requirements
An edited version of the Feed Tables and Nutrient Requirements is produced intermittently in Finnish.

Feed Tables are published by Luke as a freely available pdf.

Last edition from 2015
We also use Facebook to keep in touch with the users.
Feed value work coordination

- Statutory Service in Luke
- Supported by a permanent working group
  - Marketta Rinne, Luke (chair)
  - Kaisa Kuoppala, Luke (secretary)
  - Eeva Saarisalo, Ministry of Agriculture and Forestry
  - Markku Saastamoinen, Luke (horses)
  - Hilkka Siljander-Rasi, Luke (pigs and poultry)
  - Jarmo Valaja, University of Helsinki (pigs, poultry and fur animals)
  - Aila Vanhatalo, University of Helsinki (ruminants)
Dairy cow diet in Finland in 2016
Source: ProAgria

Up to 72 % produced on-farm

- Silage and pasture: 55%
- Commercial concentrates and by-products: 28%
- Cereal grains: 17%
- Up to 72 % produced on-farm
Finnish environmental conditions dictate the type and quality of on-farm produced feeds

* Grass silage (timothy, meadow fescue, red clover)
* Cereals (barley, oats) as dried or crimped grains or as whole crop silage – practically no maize silage produced in Finland
Typical Finnish grass silage is well preserved and digestible

Source: Farm silage samples analysed by Valio Ltd. laboratory


<table>
<thead>
<tr>
<th>Grass silages (1998-2012)</th>
<th>n</th>
<th>Mean</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dry matter (DM; g/kg)</td>
<td>110192</td>
<td>321</td>
<td>108.9</td>
</tr>
<tr>
<td>In DM (g/kg)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Crude protein</td>
<td>110190</td>
<td>147</td>
<td>26.6</td>
</tr>
<tr>
<td>NDF</td>
<td>100094</td>
<td>541</td>
<td>46.1</td>
</tr>
<tr>
<td>Indigestible NDF</td>
<td>57723</td>
<td>79</td>
<td>26.8</td>
</tr>
<tr>
<td>D-value</td>
<td>110188</td>
<td>674</td>
<td>35.0</td>
</tr>
<tr>
<td>pH</td>
<td>110094</td>
<td>4.2</td>
<td>0.44</td>
</tr>
<tr>
<td>In DM (g/kg)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lactic acid</td>
<td>110084</td>
<td>44.6</td>
<td>21.24</td>
</tr>
<tr>
<td>Volatile fatty acids</td>
<td>110094</td>
<td>12.8</td>
<td>10.40</td>
</tr>
<tr>
<td>Water sol. carbohydrates</td>
<td>110106</td>
<td>60.8</td>
<td>45.70</td>
</tr>
<tr>
<td>In N (g/kg)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ammonium N</td>
<td>110092</td>
<td>44</td>
<td>24.8</td>
</tr>
<tr>
<td>Soluble N</td>
<td>110092</td>
<td>413</td>
<td>129.9</td>
</tr>
<tr>
<td>Silage DM intake index</td>
<td>109353</td>
<td>102.5</td>
<td>8.24</td>
</tr>
</tbody>
</table>
Ruminants

The Feed Table includes data on ca. 200 feeds, which can be accessed in two ways:
a) using a search phrase

Choose output data

- Energy and protein values
- Composition and digestibility
- All data available in Feed Tables

Feed group: All feeds

Name of feed: E.g. silage

Search
Feed values of homegrown silages are critical for farm success

- Different species and mixtures
- Different stages of maturity
- These are examples and farm silages should be analysed

Feed Table for ruminants - energy and protein values

<table>
<thead>
<tr>
<th>Feed code</th>
<th>Feed</th>
<th>DM (g/kg)</th>
<th>ME (MJ/kg DM)</th>
<th>AAT (g/kg DM)</th>
<th>PBV (g/kg DM)</th>
<th>EPD (g/kg DM)</th>
<th>D-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>07001</td>
<td>Grass silage, early 1st cut</td>
<td>250</td>
<td>11.5</td>
<td>88</td>
<td>39</td>
<td>0.85</td>
<td>720</td>
</tr>
<tr>
<td>07002</td>
<td>Grass silage, average/early 1st cut</td>
<td>250</td>
<td>11.0</td>
<td>84</td>
<td>35</td>
<td>0.85</td>
<td>690</td>
</tr>
<tr>
<td>07003</td>
<td>Grass silage, average/late 1st cut</td>
<td>250</td>
<td>10.6</td>
<td>80</td>
<td>26</td>
<td>0.85</td>
<td>660</td>
</tr>
<tr>
<td>07004</td>
<td>Grass silage, late 1st cut</td>
<td>250</td>
<td>10.1</td>
<td>75</td>
<td>18</td>
<td>0.85</td>
<td>630</td>
</tr>
<tr>
<td>07005</td>
<td>Grass silage, very late 1st cut</td>
<td>250</td>
<td>9.6</td>
<td>71</td>
<td>14</td>
<td>0.85</td>
<td>600</td>
</tr>
<tr>
<td>07006</td>
<td>Grass silage, high digestibility 2nd cut</td>
<td>250</td>
<td>10.9</td>
<td>84</td>
<td>45</td>
<td>0.85</td>
<td>680</td>
</tr>
<tr>
<td>07007</td>
<td>Grass silage, average digestibility 2nd</td>
<td>250</td>
<td>10.4</td>
<td>80</td>
<td>36</td>
<td>0.85</td>
<td>650</td>
</tr>
<tr>
<td>07008</td>
<td>Grass silage, low digestibility 2nd cut</td>
<td>250</td>
<td>9.9</td>
<td>76</td>
<td>32</td>
<td>0.85</td>
<td>620</td>
</tr>
<tr>
<td>07009</td>
<td>Grass silage, 3rd cut</td>
<td>250</td>
<td>11.2</td>
<td>87</td>
<td>46</td>
<td>0.85</td>
<td>700</td>
</tr>
<tr>
<td>07010</td>
<td>Italian ryegrass silage</td>
<td>340</td>
<td>10.6</td>
<td>82</td>
<td>40</td>
<td>0.85</td>
<td>661</td>
</tr>
<tr>
<td>07021</td>
<td>Red clover silage, early cut</td>
<td>250</td>
<td>11.2</td>
<td>101</td>
<td>85</td>
<td>0.80</td>
<td>700</td>
</tr>
<tr>
<td>07022</td>
<td>Red clover silage, average cut</td>
<td>250</td>
<td>10.4</td>
<td>93</td>
<td>71</td>
<td>0.80</td>
<td>650</td>
</tr>
<tr>
<td>07023</td>
<td>Red clover silage, late cut</td>
<td>250</td>
<td>9.6</td>
<td>85</td>
<td>62</td>
<td>0.80</td>
<td>600</td>
</tr>
<tr>
<td>07024</td>
<td>Red clover (0.25) silage, early 1st cut</td>
<td>250</td>
<td>10.7</td>
<td>89</td>
<td>35</td>
<td>0.80</td>
<td>670</td>
</tr>
<tr>
<td>07025</td>
<td>Red clover (0.25) silage, normal 1st cut</td>
<td>250</td>
<td>10.2</td>
<td>84</td>
<td>27</td>
<td>0.80</td>
<td>640</td>
</tr>
<tr>
<td>07026</td>
<td>Red clover (0.25) silage, late 1st cut</td>
<td>250</td>
<td>9.6</td>
<td>78</td>
<td>21</td>
<td>0.80</td>
<td>600</td>
</tr>
<tr>
<td>07027</td>
<td>Red clover (0.50) silage, early 1st cut</td>
<td>250</td>
<td>10.9</td>
<td>93</td>
<td>54</td>
<td>0.80</td>
<td>680</td>
</tr>
</tbody>
</table>
All values for a single feed in one view

**Composition**

<table>
<thead>
<tr>
<th>Composition</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dry matter</td>
<td>250 g/kg</td>
</tr>
<tr>
<td>Crude protein</td>
<td>160 g/kg DM</td>
</tr>
<tr>
<td>Crude fat</td>
<td>40 g/kg DM</td>
</tr>
<tr>
<td>Crude fibre</td>
<td>330 g/kg DM</td>
</tr>
<tr>
<td>Nitrogen-free extract</td>
<td>390 g/kg DM</td>
</tr>
<tr>
<td>Fibre (NDF)</td>
<td>550 g/kg DM</td>
</tr>
<tr>
<td>Indigestible fibre</td>
<td>67 g/kg DM</td>
</tr>
<tr>
<td>Ash</td>
<td>89 g/kg DM</td>
</tr>
<tr>
<td>Starch</td>
<td>0 g/kg DM</td>
</tr>
<tr>
<td>Sugar</td>
<td>50 g/kg DM</td>
</tr>
</tbody>
</table>

**Feed**

- Grass silage, average/early 1st c
- Feed code: 07002
- Feed group: 07 Grass silages

**Energy and protein values**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>ME (metabolisable energy)</td>
<td>11,0</td>
</tr>
<tr>
<td>Feed units (FU)</td>
<td>0.94</td>
</tr>
<tr>
<td>AAT (amino acids absorbed from the small intestine)</td>
<td>84 g/kg DM</td>
</tr>
<tr>
<td>PBV (protein balance in the rumen)</td>
<td>35 g/kg DM</td>
</tr>
<tr>
<td>Effective protein degradability</td>
<td>0.85</td>
</tr>
<tr>
<td>D-value</td>
<td>650 g/kg DM</td>
</tr>
</tbody>
</table>

**Digestibility coefficients**

- Crude protein digestibility: 0.75
- Crude fat digestibility: 0.58
- Crude fibre digestibility: 0.76
- Nitrogen-free extract digestibility: 0.76
- Organic matter digestibility: 0.75

**Mineral concentrations**

<table>
<thead>
<tr>
<th>Mineral</th>
<th>Concentration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Calcium (Ca)</td>
<td>3.8 g/kg DM</td>
</tr>
<tr>
<td>Phosphorus (P)</td>
<td>3.2 g/kg DM</td>
</tr>
<tr>
<td>Magnesium (Mg)</td>
<td>1.7 g/kg DM</td>
</tr>
<tr>
<td>Natrium (Na)</td>
<td>0.2 g/kg DM</td>
</tr>
<tr>
<td>Potassium (K)</td>
<td>31 g/kg DM</td>
</tr>
<tr>
<td>Sulfur (S)</td>
<td>2.0 g/kg DM</td>
</tr>
<tr>
<td>Chlorine (Cl)</td>
<td>11.0 g/kg DM</td>
</tr>
<tr>
<td>Iron (Fe)</td>
<td>180 mg/kg DM</td>
</tr>
<tr>
<td>Copper (Cu)</td>
<td>7 mg/kg DM</td>
</tr>
<tr>
<td>Zink (Zn)</td>
<td>31 mg/kg DM</td>
</tr>
<tr>
<td>Mangan (Mn)</td>
<td>61 mg/kg DM</td>
</tr>
<tr>
<td>Molybdenum (Nb)</td>
<td>mg/kg DM</td>
</tr>
<tr>
<td>Selenium (Se)</td>
<td>0.31 mg/kg DM</td>
</tr>
</tbody>
</table>

**Amino acid concentrations**

<table>
<thead>
<tr>
<th>Amino Acid</th>
<th>Concentration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arginine</td>
<td>4.7 g/100 g CP</td>
</tr>
<tr>
<td>Phenylalanine</td>
<td>5.0 g/100 g CP</td>
</tr>
<tr>
<td>Histidine</td>
<td>2.0 g/100 g CP</td>
</tr>
<tr>
<td>Isoleucine</td>
<td>4.3 g/100 g CP</td>
</tr>
<tr>
<td>Leucine</td>
<td>7.4 g/100 g CP</td>
</tr>
<tr>
<td>Lysine</td>
<td>4.6 g/100 g CP</td>
</tr>
<tr>
<td>Methionine</td>
<td>1.7 g/100 g CP</td>
</tr>
<tr>
<td>Threonine</td>
<td>4.4 g/100 g CP</td>
</tr>
<tr>
<td>Tryptophan</td>
<td>1.3 g/100 g CP</td>
</tr>
<tr>
<td>Valine</td>
<td>5.5 g/100 g CP</td>
</tr>
<tr>
<td>Alanine</td>
<td>5.9 g/100 g CP</td>
</tr>
<tr>
<td>Aspartic acid</td>
<td>10.9 g/100 g CP</td>
</tr>
<tr>
<td>Glutamic acid</td>
<td>7.4 g/100 g CP</td>
</tr>
<tr>
<td>Glycine</td>
<td>4.9 g/100 g CP</td>
</tr>
<tr>
<td>Cystine</td>
<td>1.1 g/100 g CP</td>
</tr>
<tr>
<td>Proline</td>
<td>6.3 g/100 g CP</td>
</tr>
<tr>
<td>Serine</td>
<td>4.1 g/100 g CP</td>
</tr>
<tr>
<td>Tyrosine</td>
<td>3.2 g/100 g CP</td>
</tr>
</tbody>
</table>

**Horses**

**Energy and protein values**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>ME (metabolisable energy)</td>
<td>11.0</td>
</tr>
<tr>
<td>Feed units (FU)</td>
<td>0.94</td>
</tr>
<tr>
<td>Feed units (FU)</td>
<td>0.24</td>
</tr>
<tr>
<td>Digestible crude protein</td>
<td>120 g/kg DM</td>
</tr>
<tr>
<td>D-value</td>
<td>650 g/kg DM</td>
</tr>
</tbody>
</table>

**Digestibility coefficients**

- Crude protein digestibility: 0.75
- Crude fat digestibility: 0.58
- Crude fibre digestibility: 0.76
- Nitrogen-free extract digestibility: 0.76
- Organic matter digestibility: 0.75

**Vitamin concentrations**

<table>
<thead>
<tr>
<th>Vitamin</th>
<th>Concentration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vitamin D</td>
<td>125 IU</td>
</tr>
<tr>
<td>Carotene²</td>
<td>125 mg/kg DM</td>
</tr>
<tr>
<td>Vitamin E³</td>
<td>125 mg/kg DM</td>
</tr>
<tr>
<td>Thiamin</td>
<td>mg/kg DM</td>
</tr>
<tr>
<td>Riboflavin</td>
<td>mg/kg DM</td>
</tr>
<tr>
<td>Pyridoxine</td>
<td>mg/kg DM</td>
</tr>
<tr>
<td>Cobalamin</td>
<td>mg/kg DM</td>
</tr>
<tr>
<td>Nicotinic acid</td>
<td>mg/kg DM</td>
</tr>
<tr>
<td>Pantothenic acid</td>
<td>mg/kg DM</td>
</tr>
<tr>
<td>Folic acid</td>
<td>mg/kg DM</td>
</tr>
<tr>
<td>Biotin</td>
<td>mg/kg DM</td>
</tr>
<tr>
<td>Choline</td>
<td>mg/kg DM</td>
</tr>
</tbody>
</table>

¹ Vitamin D: IU = 0.025 μg vitamin D
² Or corresponding concentration of vita
³ The sum of active tocopherols. Vitamin
Cereals are classified by hectolitre weight

Feed Table for ruminants - energy and protein values

If a value is missing, it is unavailable.

<table>
<thead>
<tr>
<th>Feed code</th>
<th>Feed</th>
<th>Dry matter</th>
<th>ME (metabolisable energy)</th>
<th>AAT</th>
<th>PBV</th>
<th>Effective protein degradability</th>
<th>D-value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>g/kg</td>
<td>MJ/kg DM</td>
<td>g/kg DM</td>
<td>g/kg DM</td>
<td></td>
<td>g/kg DM</td>
</tr>
<tr>
<td>01000</td>
<td>Barley, over 69 kg/hl</td>
<td>860</td>
<td>13,2</td>
<td>96</td>
<td>-31</td>
<td>0,80</td>
<td>822</td>
</tr>
<tr>
<td>01001</td>
<td>Barley, 64 - 69 kg/hl</td>
<td>860</td>
<td>13,2</td>
<td>96</td>
<td>-29</td>
<td>0,80</td>
<td>821</td>
</tr>
<tr>
<td>01002</td>
<td>Barley, 60 - 64 kg/hl</td>
<td>860</td>
<td>13,2</td>
<td>96</td>
<td>-25</td>
<td>0,80</td>
<td>817</td>
</tr>
<tr>
<td>01003</td>
<td>Barley, 57 - 60 kg/hl</td>
<td>860</td>
<td>12,9</td>
<td>95</td>
<td>-20</td>
<td>0,80</td>
<td>801</td>
</tr>
<tr>
<td>01004</td>
<td>Barley, alle 57 kg/hl</td>
<td>860</td>
<td>12,5</td>
<td>94</td>
<td>-13</td>
<td>0,80</td>
<td>777</td>
</tr>
<tr>
<td>01005</td>
<td>Barley, naked</td>
<td>860</td>
<td>13,8</td>
<td>104</td>
<td>-5</td>
<td>0,80</td>
<td>849</td>
</tr>
<tr>
<td>01011</td>
<td>Oats, over 58 kg/hl</td>
<td>860</td>
<td>12,4</td>
<td>93</td>
<td>-12</td>
<td>0,75</td>
<td>729</td>
</tr>
<tr>
<td>01012</td>
<td>Oats, 54 - 58 kg/hl</td>
<td>860</td>
<td>12,1</td>
<td>92</td>
<td>-8</td>
<td>0,75</td>
<td>711</td>
</tr>
<tr>
<td>01013</td>
<td>Oats, 45 - 54 kg/hl</td>
<td>860</td>
<td>11,5</td>
<td>89</td>
<td>0</td>
<td>0,75</td>
<td>677</td>
</tr>
<tr>
<td>01014</td>
<td>Oats, 35 - 45 kg/hl</td>
<td>860</td>
<td>10,4</td>
<td>80</td>
<td>2</td>
<td>0,75</td>
<td>606</td>
</tr>
<tr>
<td>01015</td>
<td>Oats, hulless or hulled</td>
<td>860</td>
<td>14,2</td>
<td>107</td>
<td>6</td>
<td>0,75</td>
<td>802</td>
</tr>
<tr>
<td>01021</td>
<td>Mixed grain (barley and oats 1:1)</td>
<td>860</td>
<td>12,6</td>
<td>94</td>
<td>-19</td>
<td>0,78</td>
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<td>01030</td>
<td>Wheat, over 80 kg/hl</td>
<td>860</td>
<td>13,6</td>
<td>96</td>
<td>-12</td>
<td>0,85</td>
<td>843</td>
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<td>01031</td>
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<td>96</td>
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<td>-33</td>
<td>0,85</td>
<td>848</td>
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</table>
Recent trends in feed consumption and milk production in Finland (source: ProAgria)
Long term development of dairy cow feeding in Finland. Source: ProAgria.
Feed intake, nutrient supply and production response equations are incorporated into Lypsikki® model which is the core of ration optimizing in CowCompass.
Basis of CowCompass feed optimizing/monitoring

- Feed intake index – best in Europe!!
- Basis of optimizing (the most popular):
  - Milk revenue – feed costs
- One optimizing – the average herd
Feed values used by CowCompass

- Dry matter content (g/kg)
- Ash, crude protein, NDF (g/kg DM)
- So called NFC ("non fiber carbohydrates") is calculated as:
  \[ = 1000 \text{ – ash – crude protein – crude fat – NDF } \]
- Feed values according to the Finnish system
  - Protein values AAT, PBV, EPD
  - Metabolizable energy (MJ)
- Silage dry matter intake index
  - DM, D-value, CP, EPD, NDF, total fermentation acids, plant species (grass, legume or whole crop cereal silage), season (primary growth or regrowth of grass)
Coverage of CowCompass in Finland, % of farms belonging to milk recording*

<table>
<thead>
<tr>
<th></th>
<th>2013</th>
<th>2014</th>
<th>2015</th>
<th>2016</th>
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</thead>
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<tr>
<td>Diet formulation for cows</td>
<td>73</td>
<td>70</td>
<td>65</td>
<td>67</td>
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<tr>
<td>Diet formulation for heifers</td>
<td>39</td>
<td>50</td>
<td>54</td>
<td>55</td>
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<tr>
<td>Number of diet formulations per farm (cows)</td>
<td>3.0</td>
<td>3.2</td>
<td>3.9</td>
<td>4.4</td>
</tr>
</tbody>
</table>

*Over 80 % of cows in Finland belonged to milk recording in 2016. The number of dairy farms in milk recording was 5 329.
Case: Metabolizable protein (AAT) values of protein supplements

• The ultimate value of the feed is the production response it can elicit
• The laboratory methods such as the nylon bag technique in determining EPD have limitations
• The EPD values for the Finnish Feed Tables are derived from multiple sources
• If the EPD value of a feed is modified by e.g. chemical or heat treatment, the production responses need to be verified by milk production trials
Case: Higher milk and protein production responses to rapeseed compared to soya bean expeller

Feed Table data is used in numerous applications, models and inventories as default values

- Manure excretion estimates
- Ammonia emission calculations
- Green house gas inventories
- Nutritional, environmental and economic calculations, simulations and models
Contributions NFSC 2017

Last changed: 08 June 2017


Proceedings will be published here after the conference. Proceedings from earlier conferences can be found here:

Proceedings from 2010 - 2016

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