Criteria for the Development and Assessment of Agricultural Procedures in Animal Production
(00-AP-035)

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Purpose
Engineering progress is characterised by criteria like productivity, cost effectiveness and - particularly in agriculture - working conditions. These criteria have mainly determined valuation and development till now. Recently further aspects have become more and more important like environment, ethology and social aspects. What matters for the third millennium is to raise the productivity of resources and to reconcile the different aspects with each other. Development needs good ideas, clear goals and clear criteria. On the basis of previous investigations of substance and energy flows in animal production criteria are proposed which should lead to consideration of several new and wider aspects in further development and research.

Method
The limits of the investigations reach from the field of feed production, the various keeping systems till manure application on the field. A main subject of the investigations so far has been the effects of animal production on the environment, as a result of ammonia, nitrous oxide, methane and carbon dioxide gas emissions. On the one hand, emission levels have to be determined and evaluated for the different management methods. On the other hand, ways of reducing emissions have to be identified and appraised.
Parallel to that, energy demand in animal production including feed production is analysed. Energy inputs are divided into direct and indirect energy utilisation and additional into fossil and renewable energy. The costs of the different procedures are calculated for various conditions. By considering these aspects simultaneously harmonised characteristic quantities are derived.

Results
The evaluations of the substance flows, especially of carbon and nitrogen, show significant ammonia and methane emissions from animal production. Nitrous oxide is worth mentioning only in some keeping systems (Berg, 1999).
The energy demands vary considerably between and within the several branches of animal production. Characteristic quantities can be the cumulative energy demand per product (e.g. kg meat or milk), the cumulative energy demand per agricultural acreage or the ratio of or difference between energy input and output (Table 1).
Under recent conditions, the production costs do not represent the energy demand in an adequate proportion (Fig. 1) (Berg & Scholz, 2000). Increasing prices for fossil energy would change these proportions.
Table 1: Cumulative energy demand for various products and reference quantities and produced nutritive value per acreage

<table>
<thead>
<tr>
<th>Product</th>
<th>Cumulative energy demand</th>
<th>Produced nutritive value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>in MJ/kg</td>
<td>in GJ/ha yr</td>
</tr>
<tr>
<td>Grain</td>
<td>2</td>
<td>12</td>
</tr>
<tr>
<td>Pork</td>
<td>15</td>
<td>30 1)</td>
</tr>
<tr>
<td>Milk</td>
<td>3</td>
<td>24 2)</td>
</tr>
<tr>
<td>Compound feed</td>
<td>3</td>
<td>18</td>
</tr>
<tr>
<td>Gras silage</td>
<td>1</td>
<td>18</td>
</tr>
<tr>
<td>Maize silage</td>
<td>0.4</td>
<td>14</td>
</tr>
</tbody>
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1) 1 hectare nourishes 24 pigs  2) 1 hectare nourishes 1.2 cows  3) NEL - net energy lactation

Fig. 1: Proportions of cumulative energy demand and costs within dairy cattle husbandry

Conclusions
The investigations emphasise the linkage of animal and plant production. Energy is not necessarily the limiting factor in agricultural procedures, especially since fossil energy is replaced by renewable. But agricultural acreage is just limited. Which and how goods should be produced at the acreage, human society has to decide in consensus on the basis of good criteria.

References