Statistical entropy quantifies resource efficiency: 
Case study on phosphorus use in Austria

Helmut RECHBERGER, David Laner, Ottavia Zoboli
Institute for Water Quality, Resource and Waste Management
Technische Universität Wien
Karlsplatz 13/226, 1040 Wien, Austria
E: helmut.rechberger@tuwien.ac.at
Introduction | Motivation | Science questions

Material Flow Analysis (MFA) as a basis to understand the industrial metabolism
Using time series to identify action points for optimization
Using Statistical Entropy (SE) as an indicator for resource efficiency

Implementation of entropy considerations in resource management

How can MFA be applied for decision making?
How can SE be applied to MFA results?
What is the benefit of an SE indicator?

→ Demonstrated for the Austrian phosphorus household
Analysis and Optimization of the System

1. Multi-year MFA of P/Austria

2. Analysis of time series → system understanding

3. Step-wise optimization

4. Optimized target system

Import dependency - 90%
Consumption of mineral fertilizer - 100%
Emissions to water bodies - 28%

Application of Statistical Entropy Analysis to the System

1. Reduction of complexity by merging flows → simplified system

Original MFA system: 56 processes

Simplified system: 6 processes

2. Transformation of MFA system (a) into stage diagram (b): theoretical framework

Result of Statistical Entropy Analysis for the Austrian P budget

P is used in a dissipative way
Significant improvement between 2000 (+40%) and 2010 (+30%)

Dissipative: Even in an optimal system (+13%)
But substantial optimization possible

Error bars indicate the uncertainty range from the 2.5 to the 97.5 percentile and are shown for the target system and the current state (2013).

Conclusions and recommendations

- SEA can be applied to complex MFA systems
- SEA indicates into the „right“ direction (reliable indicator)
- SEA considers quality of resource use and emissions (universal indicator)

- Application to multi-substance systems
- Combination with economic indicators (cost-benefit approach)