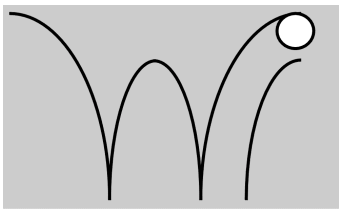


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# **A Methodical Approach on Eco-Balancing and EIA based on Material Flow Networks**

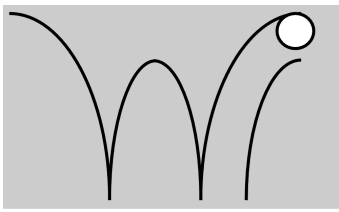
## **A Case Study on a German Beer Brewery**



# What has been achieved ?



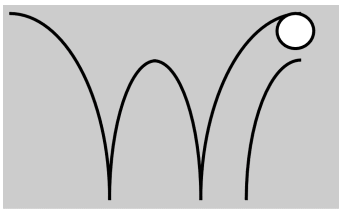
- All involved materials and energies within the production process and related departments have been detected.
- A complex material flow network of the beer production process was prepared.
- The company eco-balance and various sub-balances have been calculated.



# What remains open ?



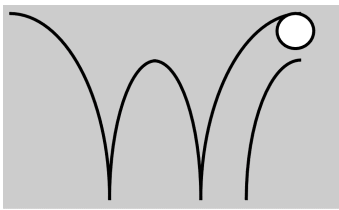
- Detection and documentation of environmental aspects and potential environmental effects associated with the production process
  - Identification of environmental deficits in the company
  - Elaboration of possibilities to eliminate environmental deficits



# Eco-Balance



- A financial balance compares assets and liabilities where these are weighted monetary
- Eco-balance: Comparison of inputs and outputs (materials and energies) on a quantity basis related to the object to be examined
  - Company eco-balance
  - Process balance
  - LCA (Life Cycle Assessment) or product-related eco-balance
- Normally the eco-balance is not equalized

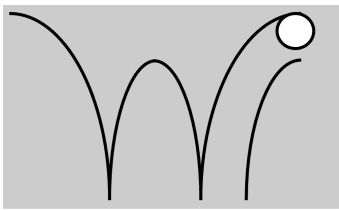


## ■ A method for documenting

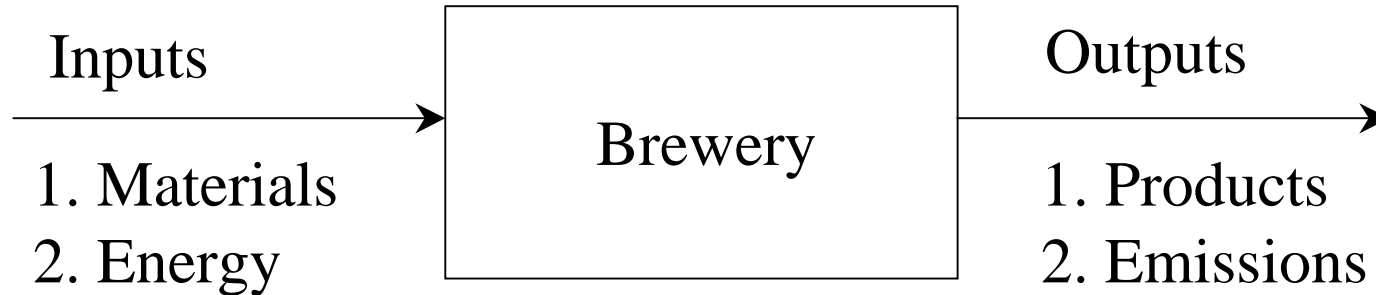
- Environmental aspects
- Potential environmental effects associated with a product or production process

## ■ This is done by

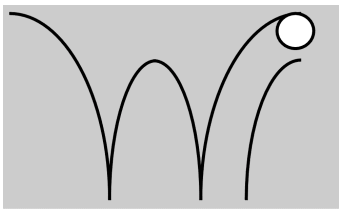
- compiling an actual balance of relevant input and output flows of a production system
- evaluating the potential environmental effects with these inputs and outputs
- interpreting the results of the actual balance and effects with regard to the objective of the study



# Company Eco-Balance



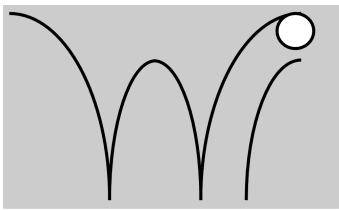
- Related to a place of production or business
- Company will be treated as „Black Box“
- No analysis of in-house operations takes place
- Balance concentrates on company's input and output of energy and materials and is referred to as the basis environmental report



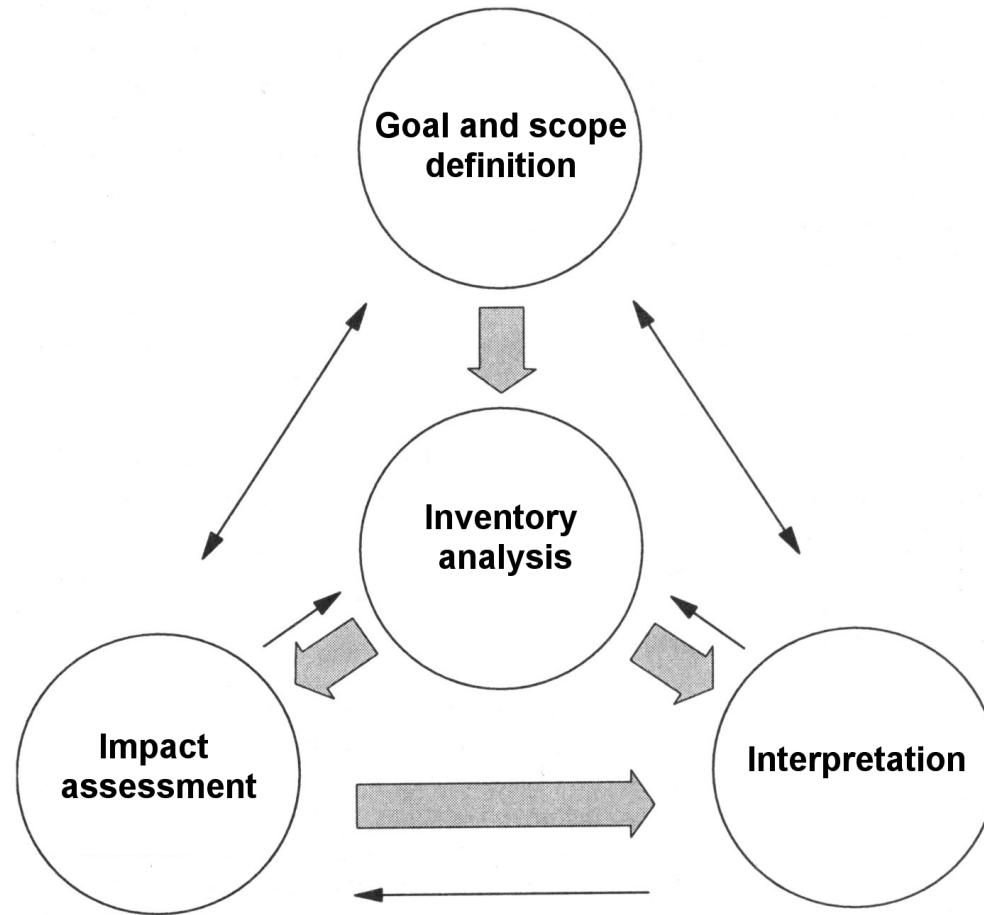
# Process Balance

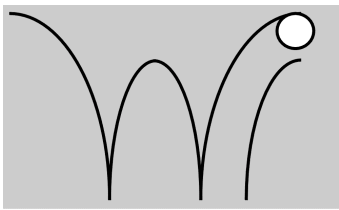


- Examines the flows of individual production steps specific to operation
- Makes a more precise look at the operational activities possible
- Focus on automated as well as manual processes
- Degree of ecological harmfulness of individual processes can be recognized in the total environmental pollution and gaps
- Potentials for optimization can be easily localized from this estimate



# Basic Elements according to ISO 14040



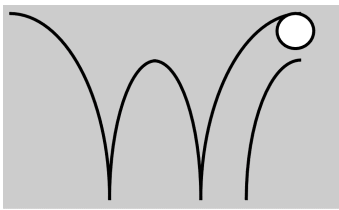


# Goal and Scope Definition



- Fundamental question formulations to carry out the eco-balance
  - Determination of goal and framework
  - Product description
  - Operational sequence of analysis
- Specifications
  - Functional unit (hl of retail beer)
  - Location (production site)
  - Time frame (brewing year)



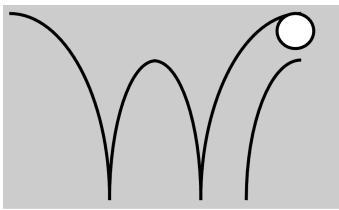


# Inventory Analysis



- Modeling the process structure
  - Data collection
  - Integrating data and process structure
  - Calculating the input-/output flows and reports





# Impact Assessment and Interpretation

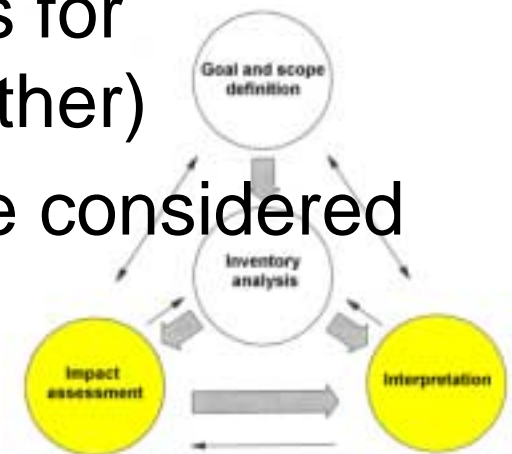


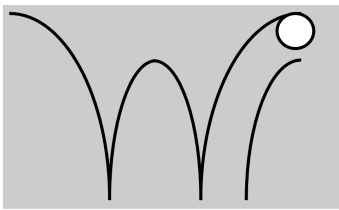
## ■ Impact Assessment

- Evaluating the potential environmental effects with inputs and outputs
- Scientific findings and knowledge

## ■ Interpretation

- Defining and weighting categories for environmental impacts (to each other)
- Aspects of society and politics are considered



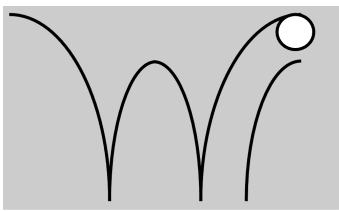


# Material Flow Networks



- A particularly flexible and efficient approach to model and represent material and energy flows of a system.
- System can be production locations and operations as well as stations in the life of a product.
- Consequently MFNs are suitable to prepare company balances as well as product balances.

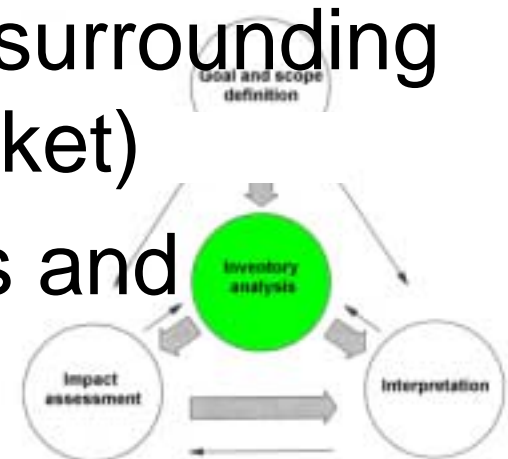


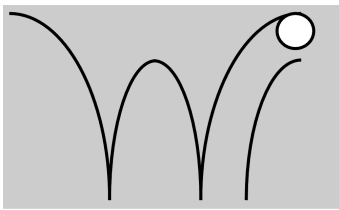


# Material Flow Networks II



- two types of procedures will be considered:
  - Processes for the transformation of materials
  - Processes for the storage of materials
- Procedures are linked with one another by connections
- MFNs provide the interfaces to surrounding systems (e.g. environment, market)
- No distinction between energies and materials





# Material Flow Networks and the Network Elements



■ Based on modified Petri-Nets

■ Transitions



■ Places

– Input-Place



– Output-Place

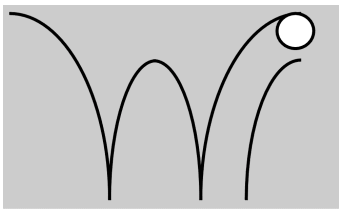


– Connection-Place

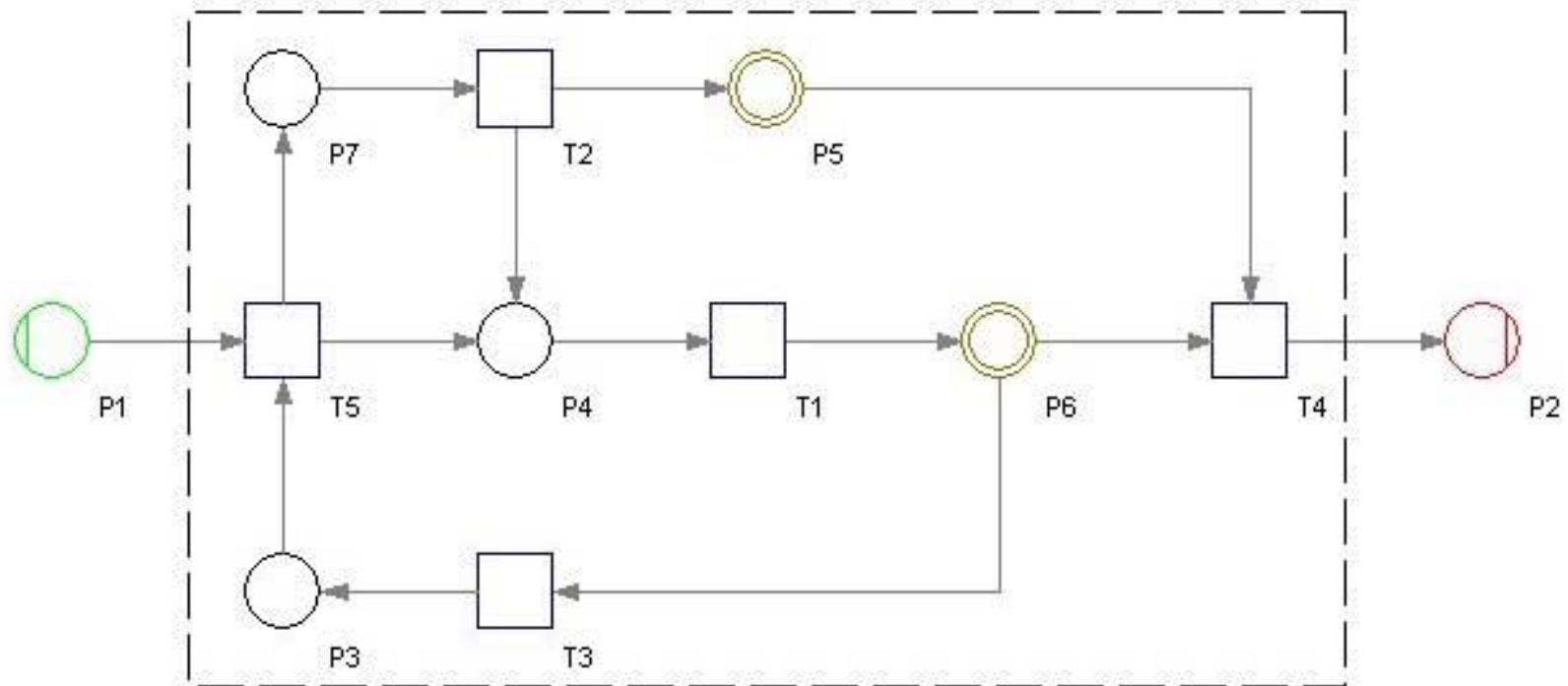


■ Connections or links

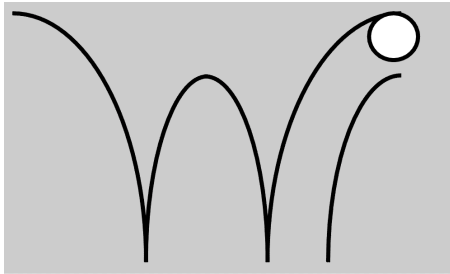




# Structure of Material Flow Networks



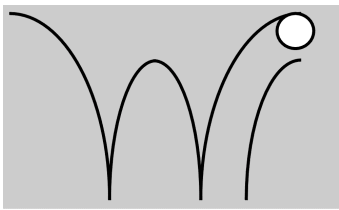
- Specification of transitions, places and connections



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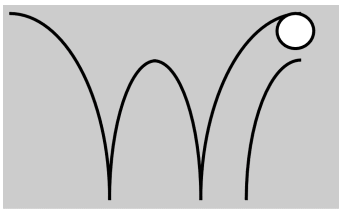
# Case Study



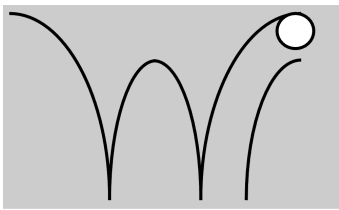
# Structure of Project



- Introduction
- Goal and scope definition
- Inventory analysis
- Impact assessment and interpretation
- Gap and optimization analysis



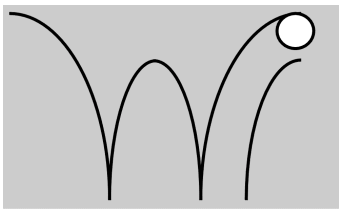
- A versatile and flexible software tool for LCA
- Preparation of eco-balance will be supported in all phases
- Based on the unique method of MFNs
- After specifying and entering data from production process material and energy balances will be generated automatically
- Evaluation in Umberto occurs according to different assessment methods and valuation procedures



# Goal and Scope Definition



- Objective of eco-balance:
  - to carry out a first comprehensive inventory and an evaluation of all environmentally relevant activities
- Product description („Premium Pils“)
- Operational sequence for study
- Level of detail (departments, machines)
- Specifications for impact assessment
- Functional unit (hectoliter of retail beer)



# Goal and Scope Definition II

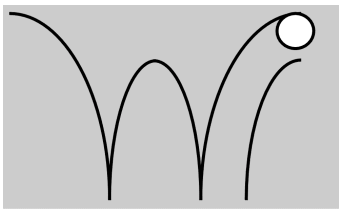


## ■ System specification

- location: production site „northwest“ Wernigerode
- time frame: brewing year i.e. chronological frame of reference (10/1998 to 9/1999)

## ■ Not included in eco-balance

- Transport processes not related to the production site (e.g. delivery, distribution)
- Materials not directly involved in the production process (e.g. office supply, equipment)
- Administration, canteen, dispatch



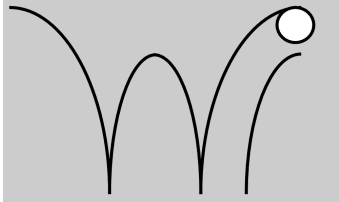
# Process Structure



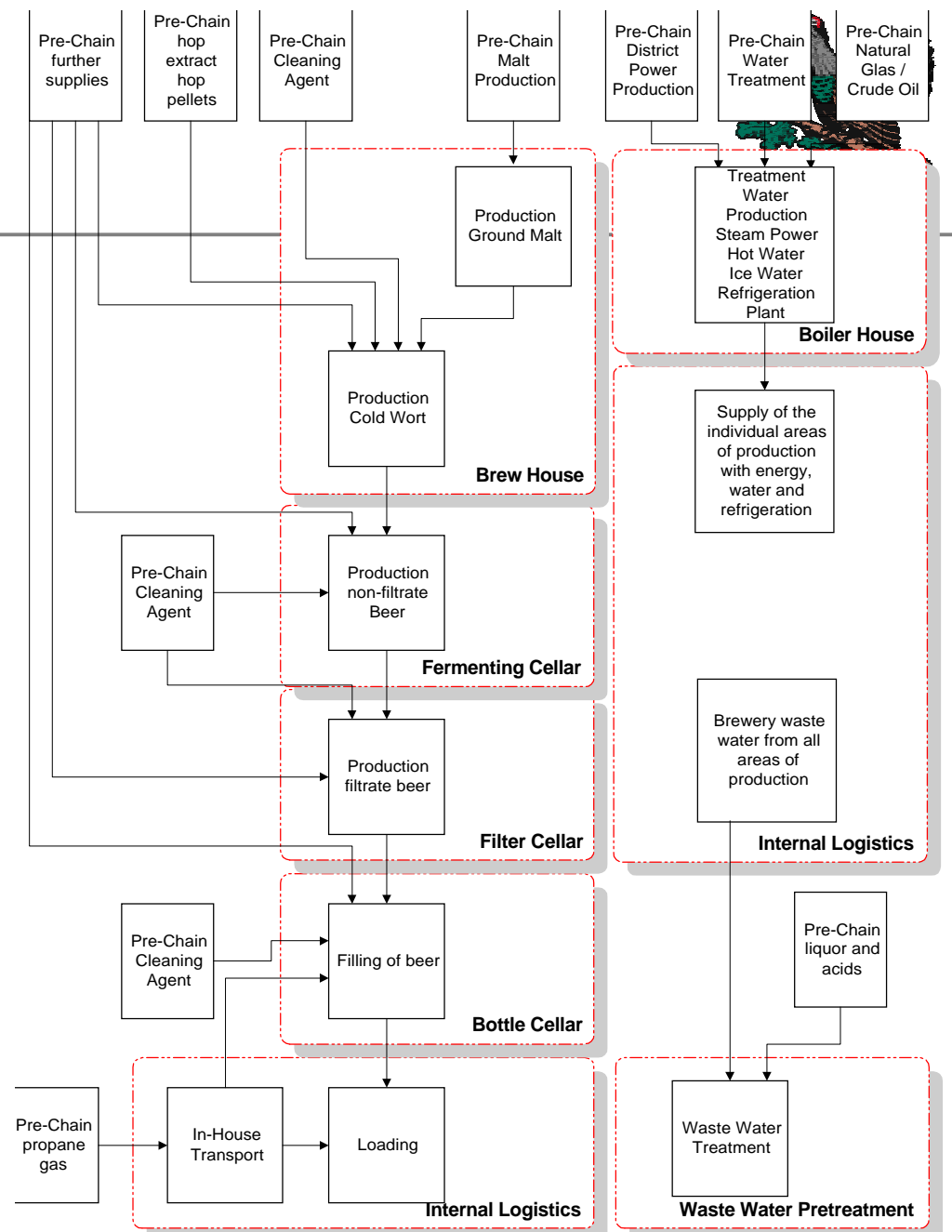
## ■ Description of the beer production process

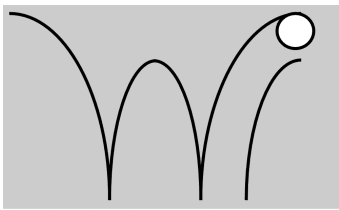
- Process figures
- Conversations
- Tracing/Tracking the in-house pipelines

➔ Preparation of the overall view/block diagram and basic models



# Block Diagram Production

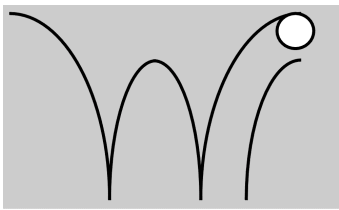




# Data Collection



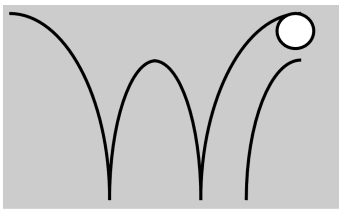
- Necessary to ascertain precise data about employed materials and energies, consumption and formation of materials
  - Protocols and reports from production
  - Measurements
  - Conversations with technical staff and production team
  - Technical documentation
  - Indications and information from type label
  - ...



# Model Adaptation



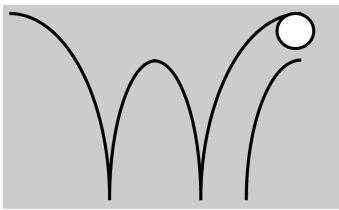
- After modeling of the production process the overall model must be completed with ascertained data
- Relative consumption's are from importance
- Model must be refined in some cases



# Calculation of Input and Output Flows



- Flow of material specification depending on the specific task
  - Hectoliter retail beer per brewing year
  - Consumption of fresh water in the quarter
  - ...
- Calculation of all material quantities
  - complete, department, process
- Comparison of input and output materials in a table (tabular form)



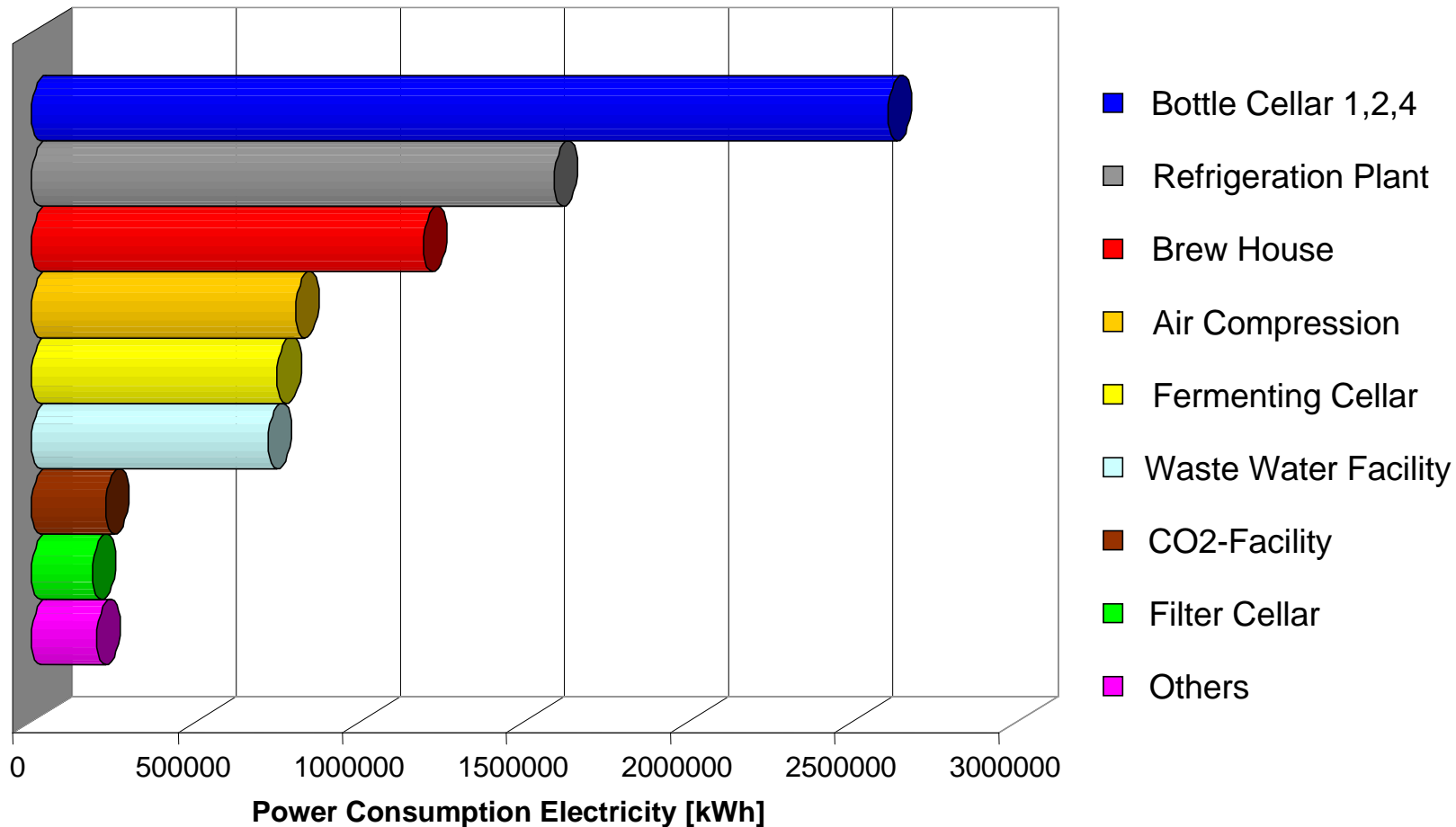
# Sub-Balance (Brewhouse 1998/99)

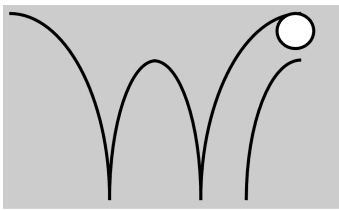


Input:			Output:		
Item	Quantity	Unit	Item	Quantity	Unit
▲ CaCl <sub>2</sub> -Lösung	541.300	hl	▲ Ausputz	251913.333	kg
▲ Calgonit 7013	16625.879	kg	▲ Brauereiabwasser	188578.591	hl
▲ Dampf	8322267.883	kg	▲ Treber	26731552.829	kg
▲ Energie, elektrisch	1195051.038	kWh	▲ Würze (Kalt-)	1397350.126	hl
▲ Farbebier	20918.035	kg			
▲ Hopfenextrakt	4724.907	kg			
▲ Hopfenpellets	6422.204	kg			
▲ Jalu Sauer	82805.933	kg			
▲ Laugenadditiv (LAD)	10583.633	kg			
▲ Malz	22974.334	t			
▲ NaOH 25%	698675.063	kg			
▲ Wasser	1727181.339	hl			

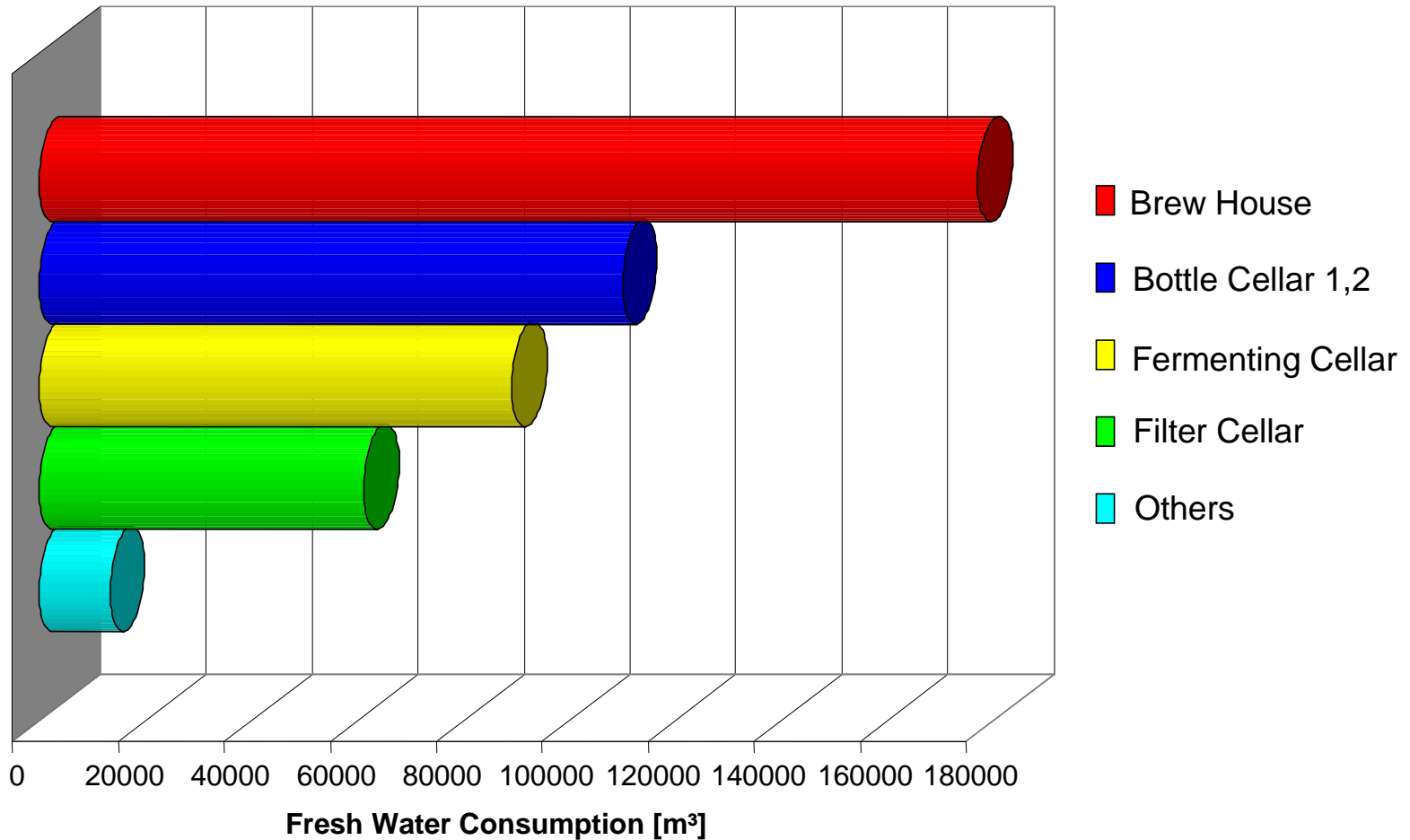
➔ Graphical representation

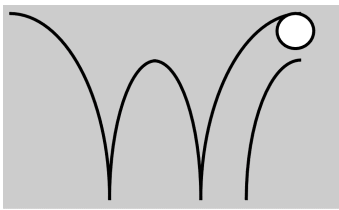
# Power Consumption Electricity (Machinery/Departments)



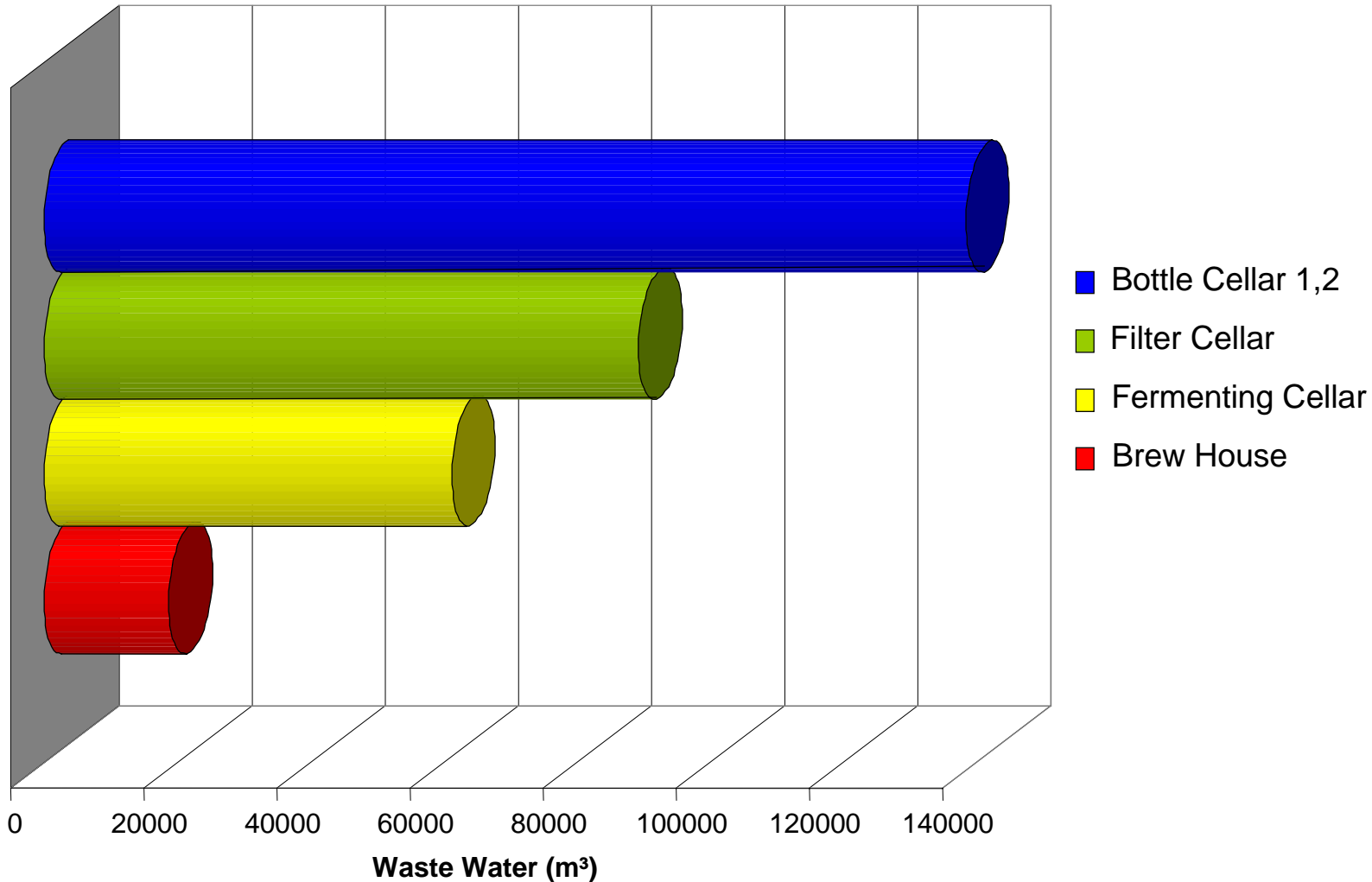


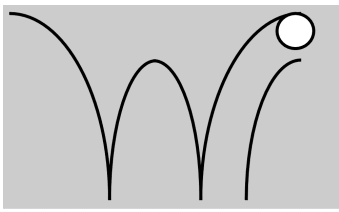
# Fresh Water Consumption (Departments)





# Waste Water (Departments)





# Impact Assessment and Interpretation



## ■ General problems

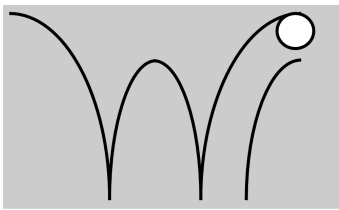
- Existing coefficient systems are not applicable
- Incomplete results

## ■ Specific problems

- Specific brewery materials cannot be allocated to coefficient systems

## ■ Coefficient systems in Umberto

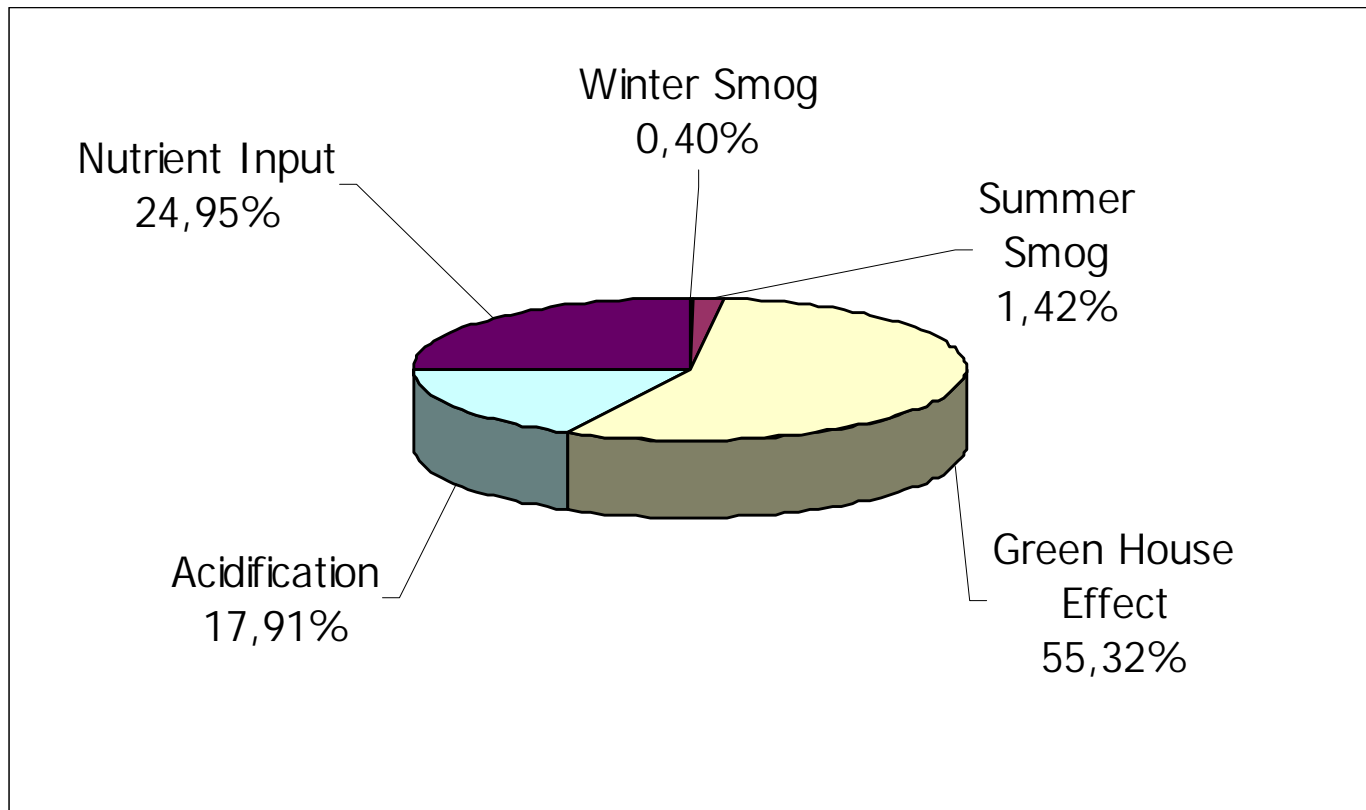
- Swiss Eco-Point Method
- UBA-Method of Federal Office for Environment
- Eco-Indicators 95-Method

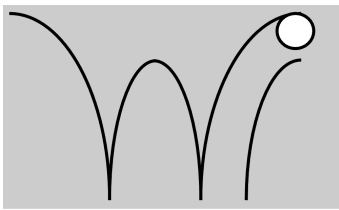


# Impact Assessment using Eco-Indicators 95-Method



## Percentage Pollutant Emission (Air and Water)

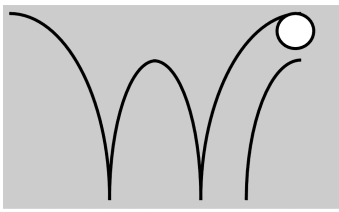




# Coefficient Systems

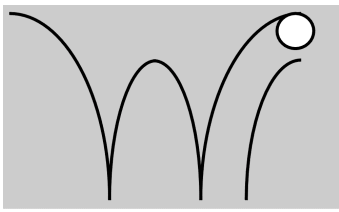


- Universally valid coefficient systems
  - Avoidance and/or reduction of allocation problems
  - Consideration of all environmental impacts
  - Subsequent project
    - » Existing methods of evaluation and coefficient systems are to be analyzed and expanded
    - » Harmfulness of certain materials must be revealed
    - » Detection of ecological gaps must be facilitated



# Gap and Optimization Analysis

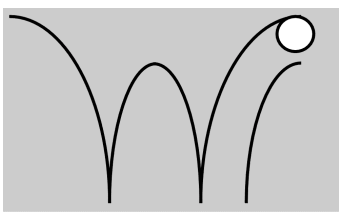
- Hasseröder Brewery Ltd. production site „northwest“
  - Very modern production facility
  - Installations correspond with newest state of technology
  - Brew processes evolved and have been improved over time
  - Brew processes cannot be optimized further without adequate knowledge about breweries



# Gap and Optimization Analysis II



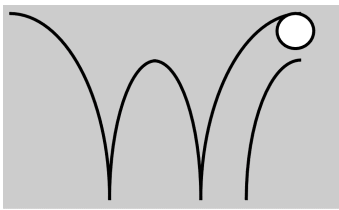
- Government environmental requirements will be met applying modern technologies and installations
- From ecological point of view a cost minimization can decisively contribute to environmental protection
- No conspicuous technical gaps have been encountered but this needs to be examined further and must undergo a detailed Analysis



# Conclusions and Outlook



- Extensive and detailed process model
  - Balancing refers to the complete network or to sub-networks (individual departments)
- Generated inventory analysis has to be continuously updated
- Improvement of documentation and data acquisition necessary
  - Qualifax<sup>®</sup>
  - Additional consumption counter



# Conclusions and Outlook II



- Interpretations of actual balance to identify primary sources of environmental pollution (ecological gaps)
- Future balances have to be compared with actual opening balance