# Critical Evaluation of Substitution of Natural Gas by Biogas


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# Synopsis

- Aims and Measures
- Potential
- Usage Pathways for Biogas
- Efficiency Criteria of Usage Pathways
- Location Analysis
- Parameter of Raw Biogas & Regular Distribution Grid
- Process Chain for Biogas Upgrading
- Criteria for Process Evaluation
- Results and Outlook

# Aims and Measures

- Biogas use in Germany‘s distribution grid is regulated by the federal Integrated Energy and Climate Programme (IEKP)
- Key measures influencing the biogas feed-in are:
  - Core regulation regarding the feed-in of biogas
  - Changes to the EEG (Act granting feed-in preference for electricity generated from renewable energies)
  - Regulation for heat supply from renewable energies
  - Regulations regarding bio-fuels
- Core regulation became effective April 12, 2008
- **Present aims of the core regulation**:
  - Feed-in of **6 billion m³ (~ 60 TWh - PE 2005: 3.936 TWh) in 2020, 10 billion m³ (~ 100 TWh) in 2030**
  - Increasing use of biogas for CHP and as fuel

# Potential for Biogas Generation and its Feed-In

- Consumption of natural gas in Germany 2006: ~ 855 TWh
- Generation of biogas in Germany 2006: 22,4 TWh
- Biogas potential available for feed-in is estimated with 24 billion m³/a (240 TWh) until 2030

➡ Germany‘s federal government aims at using a significant part of that potential amount until 2030

➡ The conflict-of-usage between food and fuel needs to be settled

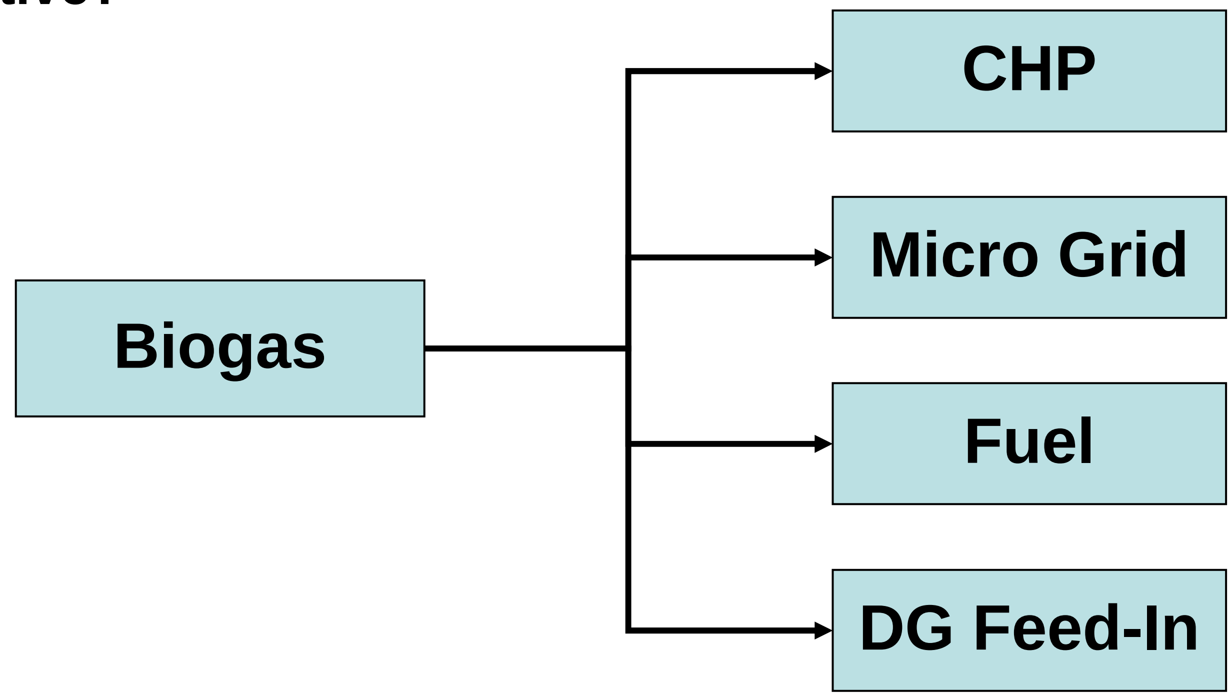
➡ The conflicts between various usage pathways for biomass also need to be identified and settled

# Current Feed-In Situation

- **In spring of 2008 11 biogas systems to be used for feed-in were operational in Germany**
- **Raw-capacity of these systems: ~** 40.000 Nm³/h (max. 350,4 Mio. Nm³/a, 1,75 TWh) corresponding ~ 5 % of the overall agricultural biogas-capacity (just short of 3 % of the capacity planned for 2020)
- **Output equivalent to an electrical power of ~80 MW**
- **20 additional system planned or under construction**

# Pathways for Biogas Usage

**Key question: Which pathways will be sustainable under what boundary conditions from both an economic and an ecological perspective?**




**Comparison of Efficiency**

# Comparison of the Efficiency of Different Pathways for Biogas Usage

| Criteria for Efficiency | |
|---|---|
| **CHP** | High number of operational hours p.a.<br>Need for a heat sink available year round |
| **Micro Grid** | Extension of the grid; necessary adaption of available infrastructure (Wobbeindex)<br>Fluctuation over the year in usage |
| **Fuel** | Complex pre-processing<br>Ratio Production/Sales<br>Storage |
| **DG Feed-In** | Complex pre-processing<br>Location of the feed-in point<br>Feed-in conditions |

→ **Location- and pathway-specific analysis necessary to identify the most efficient usage of biogas**

# Criteria for Decision of Location

- Biomass potential in the region and long-term available amount of substrate
- Transport logistics
- Costs for feed-in into the electricity or gas grid / Feed-in conditions
- Determination of usage profiles including potential heat sinks
- Demand for transportation fuel in the region / Potential competition
- Gas analysis with original substrates / Identification of the complexity of the gas cleaning and adaption
- Comparison of investments needed for different pathways
- Revenues / Potential subsidies
- Establishment of energy balances for the different pathways

**Based on these criteria a possible location and most efficient usage pathway can be identified**

**Special situations (unsual subsidies, tax breaks etc) may lead to a non-optimal decision with respect to the efficiency criteria given**

# Feed-In of Biogas

**Feed-in is the preferred situation if:**

- No usable heat-sink is available
- Good availability of a distribution grid and good feed-in conditions

**Selection of the biogas processing:**

**Biogas** → **Processing and Feed-In** → **Gas Grid**

Each biogas has a different composition!

Each gas grid has different parameters!

→ **Processing selection is driven by the biogas properties as well as the gas-grid conditions**

# Parameters of Influence

**Biogas**

- Substrate
- Combination of substrates
- Reactor load
- $CH_4$ concentration
- Raw product flow-rate
- Impurities
  - $H_2S$, $H_2O$, $NH_3$, $CO_2$ etc.

**Gas Grid**

- DVGW G 260
- H-Gas; L-Gas
- Pressure level
- Exchange or additional gases
- Conditioning
- Odoration
- Wobbeindex

**Analysis of the biogas and the grid parameters define the conditions for the raw-gas processing step**

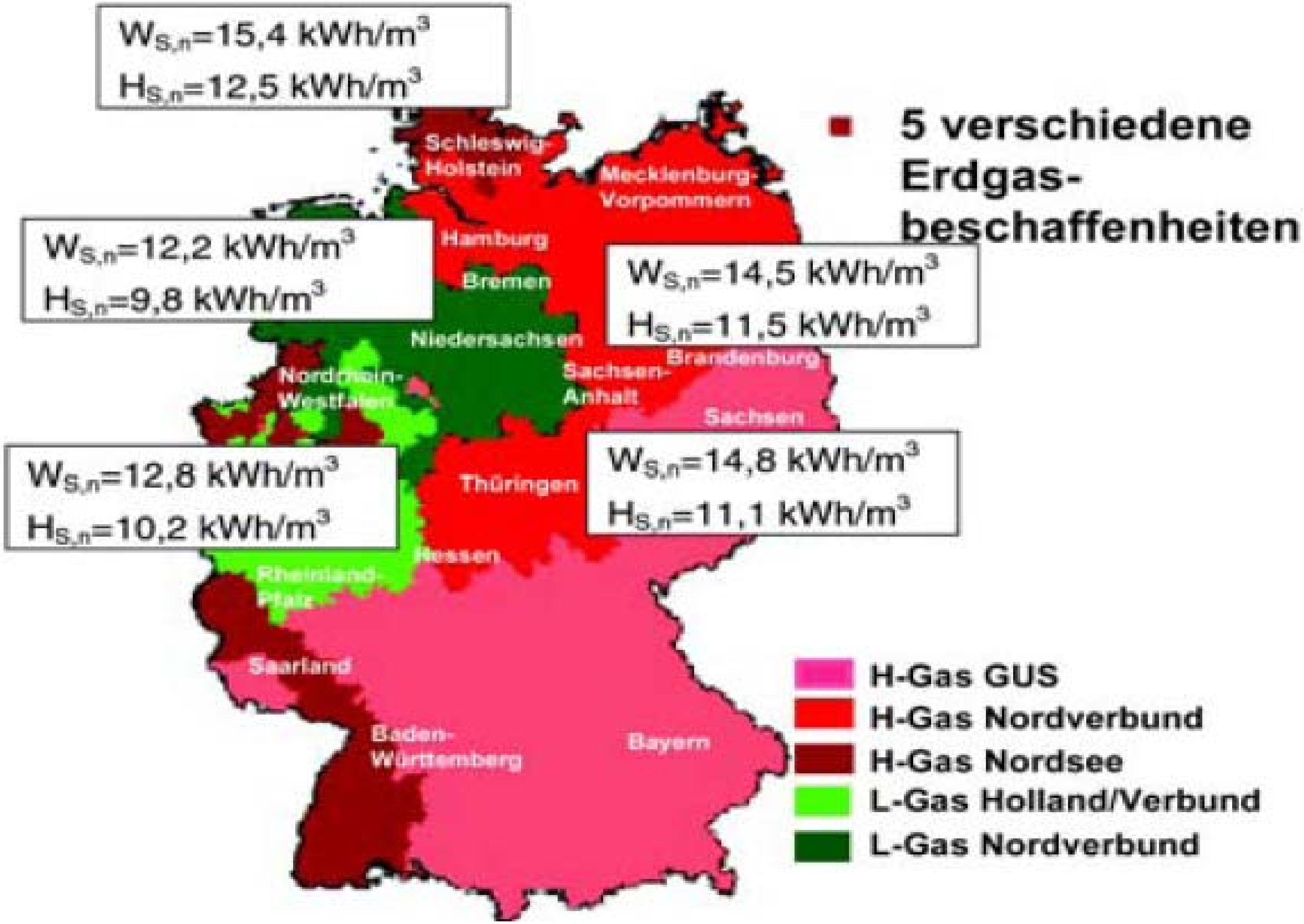
→ **The most efficient treatment can be chosen**

# Spezification Biogas / H-Gas / L-Gas

| Komponente | Symbol | Rohbiogas | Erdgas H-Gas Russland gem. DVGW G 260 | Erdgas L-Gas Holland I gem. DVGW G 260 |
|---|---|---|---|---|
| Methan | $CH_4$ | 40 - 75 % | 98,3 Vol. % | 81,3 Vol. % |
| Kohlendioxid | $CO_2$ | 25 - 55 % | 0,1 Vol. % | 1,0 Vol. % |
| Stickstoff | $N_2$ | < 2 % | 0,8 Vol. % | 14,2 Vol. % |
| Sauerstoff | $O_2$ | < 0,5 % | 0 Vol. % | 0 Vol. % |
| Schwefelwasserstoff | $H_2S$ | < 500 ppm v | | |
| Siloxane | $SiO_x$ | < 100 mg/m³ | | |
| Kohlenwasserstoffe | $C_xH_y$ | < 100 ppm v | | |
| Wasser | $H_2O$ | Gesättigt | | |
| Brennwert | $H_{S,N}$ | 6 - 7,5 kWh/m³ | 11,1 kWh/m³ | 9,8 kWh/m³ |
| Wobbeindex | $W_{S,N}$ | 6 - 10 kWh/m³ | 14,8 kWh/m³ | 12,2 kWh/m³ |

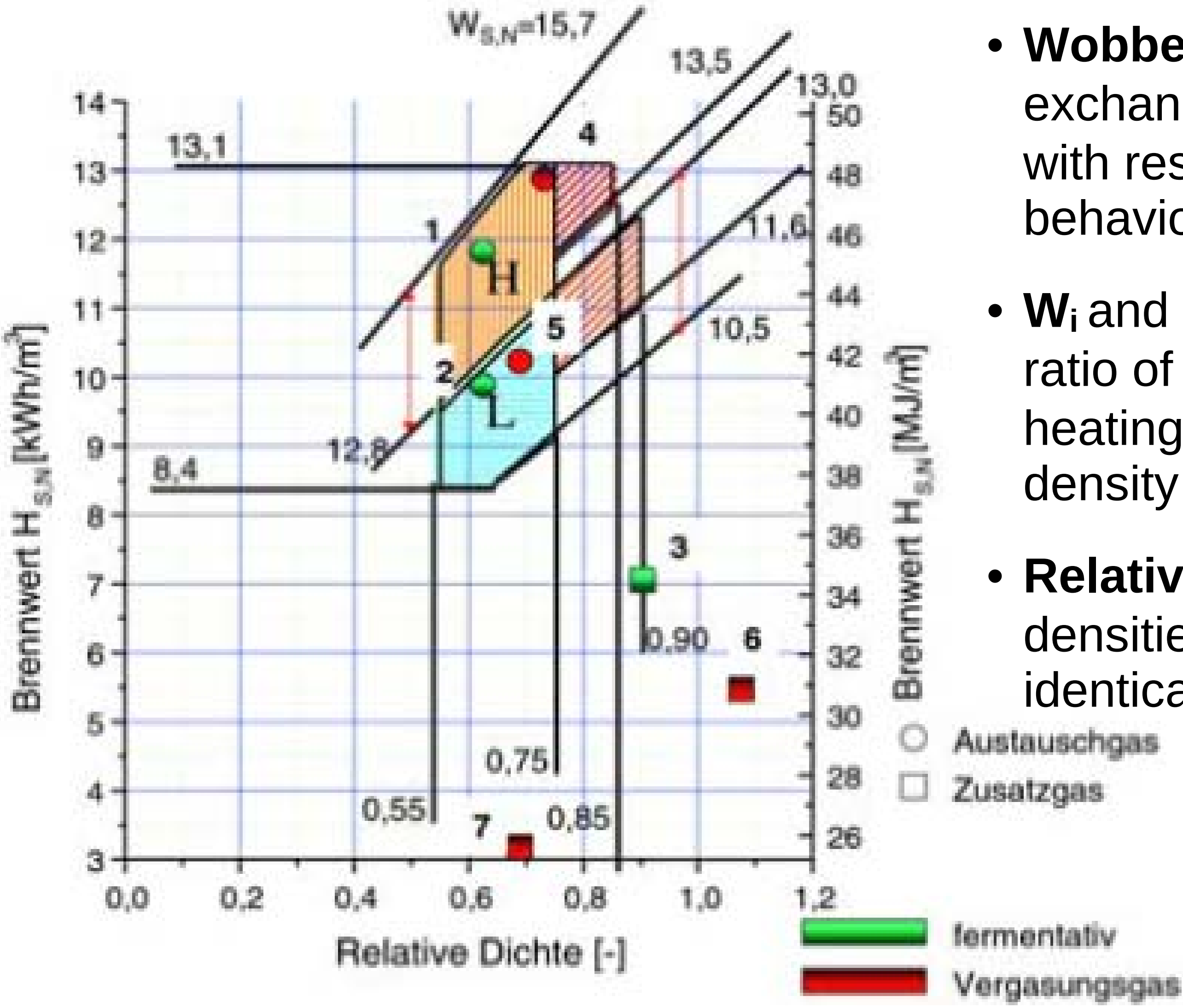
**Source: ASUE**

# Natural-Gas Specifications in Germany




Source: FNR

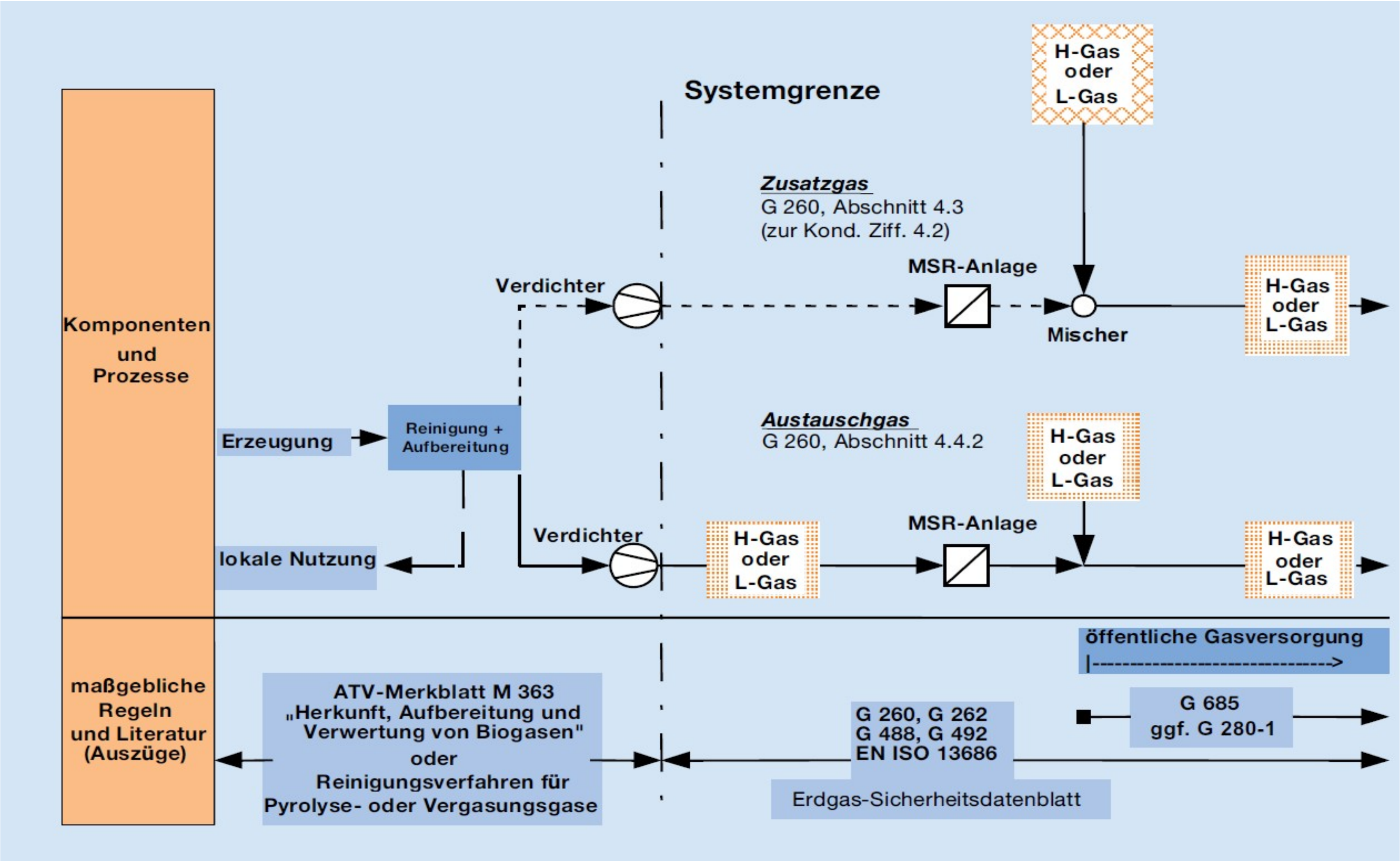
# Wobbe-Index




- **Wobbe-Index** defines the exchangebility of different gases with respect to the burning behaviour and heat load
- **$W_i$** and **$W_s$**, respectively, are the ratio of the higher or lower heating value and the relative density
- **Relative Density**: Ratio of the densities of the gas and air at identical p und T

**Quelle: FNR**

# System Boundaries of the Public Gas Grid




Source: DVGW Arbeitsblatt G 262 Anhang A

# Selection of Processing Steps for Raw Biogas

**Problem:**

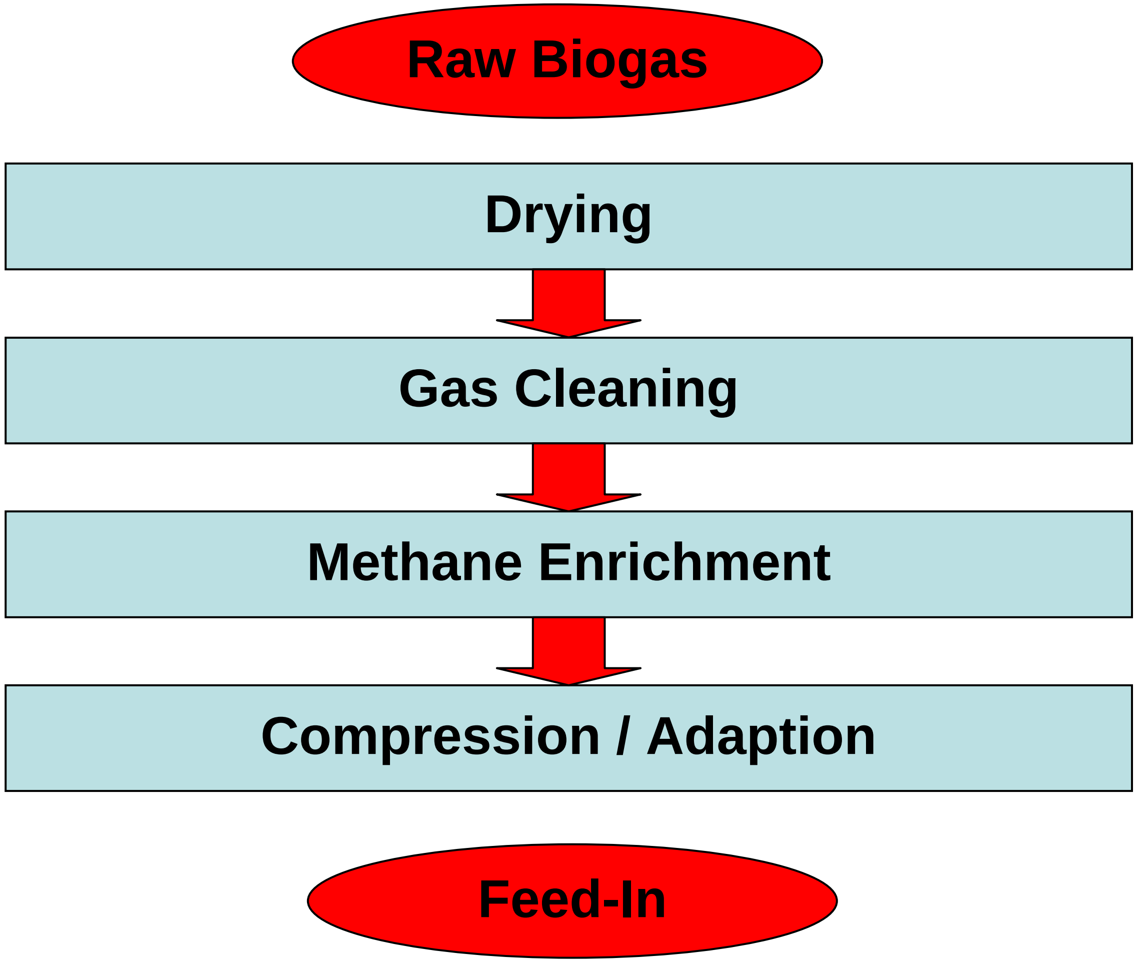
- A large number of different processes is available
- Many combinations can be realized in principle
- Many of those processes have not been tested in a large-scale system

**How can for a given situation with respect to economy and ecology the most efficient approach be identified?**

**Available processes need to be evaluated in a holistic sense:**

- The processing needs to be split into separate modules
- Evaluation criteria need to be agreed on
- Life-cycle-costs (LCC) have to be calculated and an eco balance needs to be established (Life-cycle-assessment; LCA)

# Process Chain of Raw-Gas Conditioning



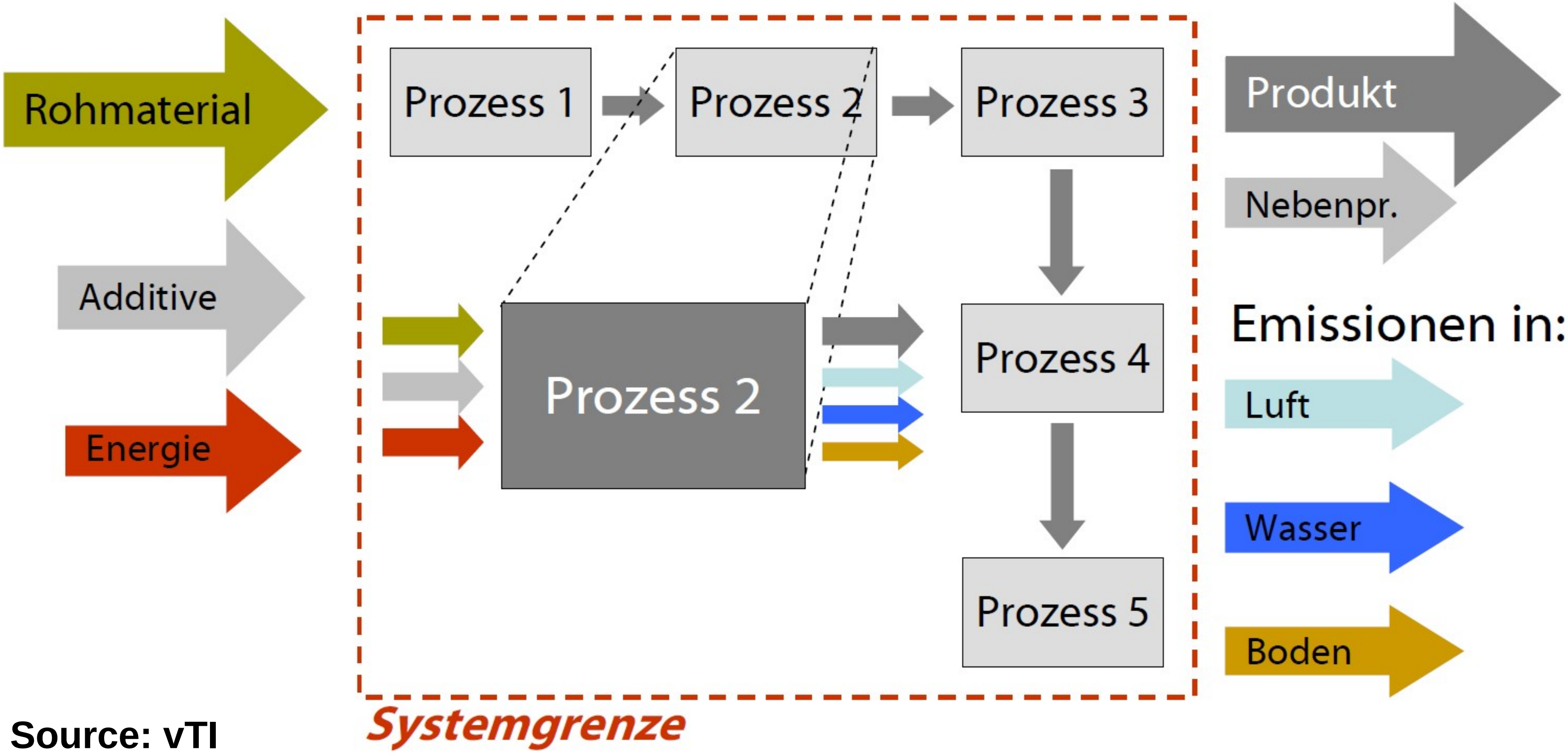

- Split-up of the process chain into four modules
- Evaluation of relevant process options for each module
- Sequence depending on the raw biogas and the process option chosen
- Depending on the process options multiple steps can be combined

# Evaluation Criteria

- Energy consumption (Electricity, heat)
- Use of ressources (Water, chemicals, etc.)
- Availability
- Operational practicabilty
- Applicabilty (Concentrations of impurities, mass flows)
- Flexibility
- Cleaning efficiency depending on the mass flux
- Life-cycle-costs

# Eco Balances

An **eco balance** includes the summation and evaluation of all energy and material fluxes and all environmentally relevant effects of the process chain under consideration (ISO EN 14040 and 14044)




Source: vTI

# Result

- Finally costs and environmental relevance of biogas-processing can be compared over the complete life cycle for various pathways and configurations
- This represents an excellent and very flexible planning tools
- Subsidies and related measures can be focussed on the most efficient pathways

# Result of the Evaluation/the Assessment

- **The top-runner approach**: the three most efficient process chains at a given moment in time define the new standard to be reached by the competitors who otherwise would be penalized in the future
- System producers may become motivated to develop modular processing systems with a high degree of adaptability to the parameters of a given situation („Lego approach")

➡ Additional gains in efficiency are possible

# Thank you very much for your attention