Technical, Scientific and Economical Evaluation of state-aided Hessian Biogas Plants

- Results -

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Evaluation of state-aided Hessian Biogas Plants

- **Introduction**
- **Feedstock, Shares & Energy**
- **Utilisation Digester**
- **Biogas Quality**
- **Utilisation of CHPs**
- **Revenues and results**
- **Conclusion**

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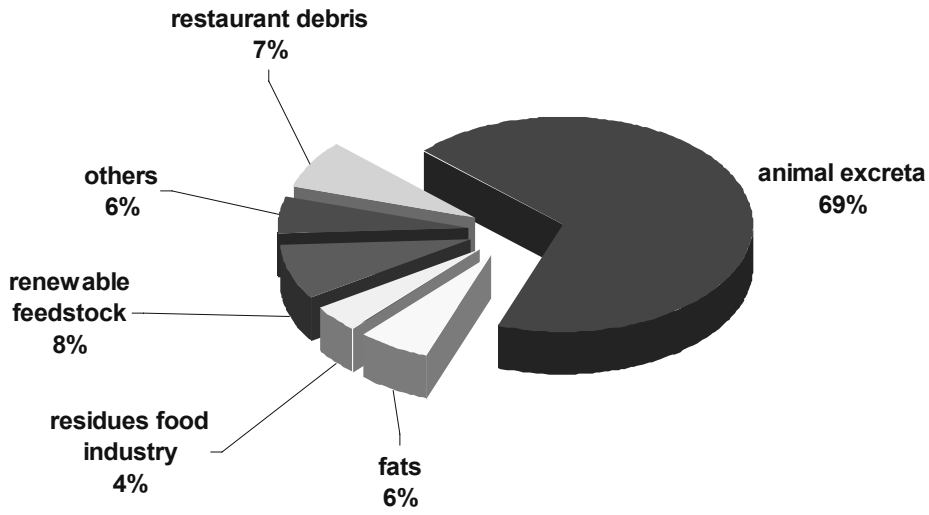
Evaluation of state-aided Hessian Biogas Plants
- The Project -

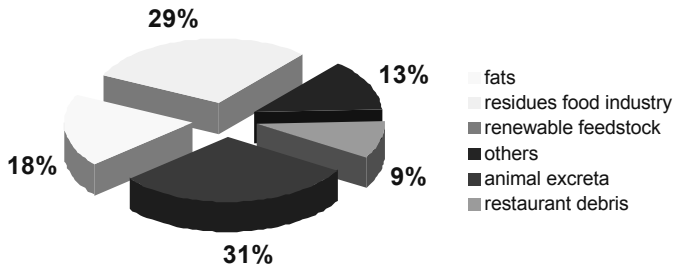
- **Employer: Hessian Ministry of Environment**
- **Partner: ISET - process technology, hessenENERGIE - economy**
- **Survey period: May 2002 until February 2004**
- **On-site investigations: monthly and quarterly cycle**
- **Biogas plants:**
  - Construction 1992 .. 2002
  - volume digester 260m³ .. >2,000m³
  - electrical capacity 15kW .. >500kW

Fractions of the Entirety of used Substrates

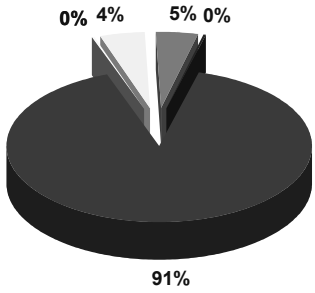


Variation of Substrate Compositions

Biogas Plant 01

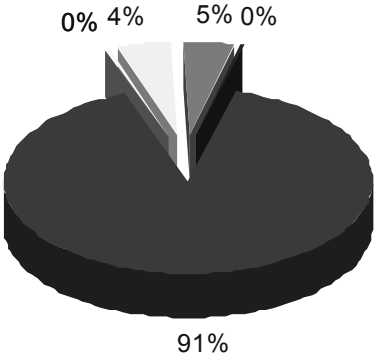


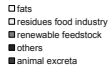
Biogas Plant 09



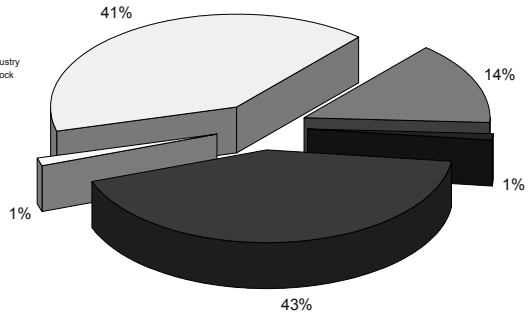
Substrates, Consumption & Energy – Biogas Plant 09

Percent by Weight

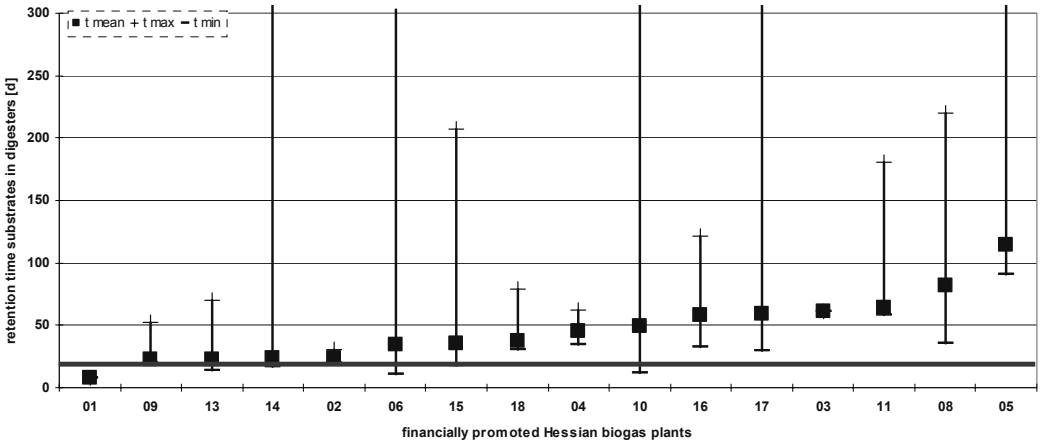




Percent by Energy

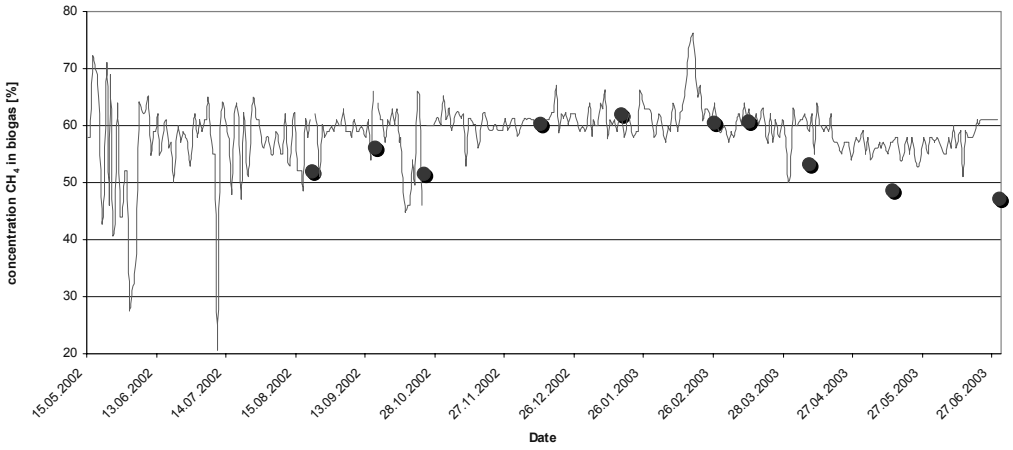


Hydraulic Load of Digesters

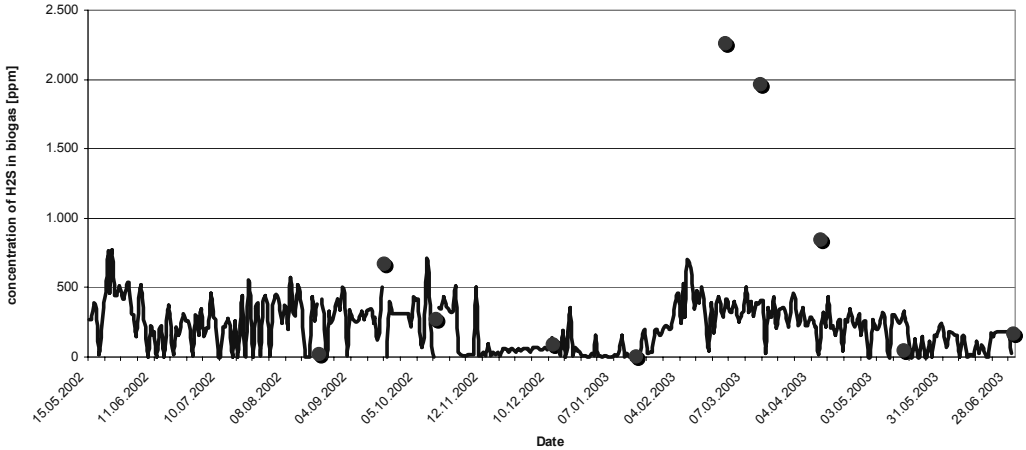


Quality of Biogas

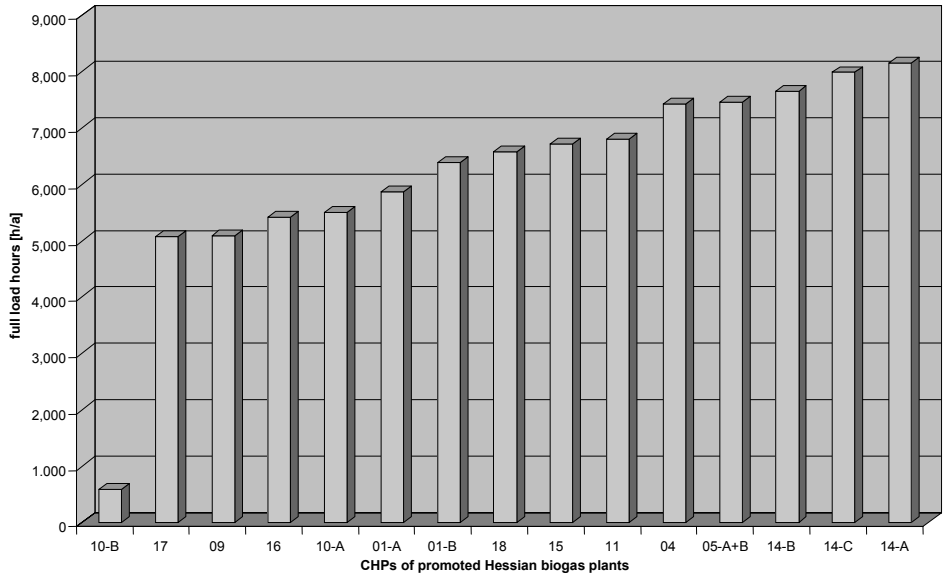
Analysis of Methane Concentration in Biogas – Biogas Plant 16



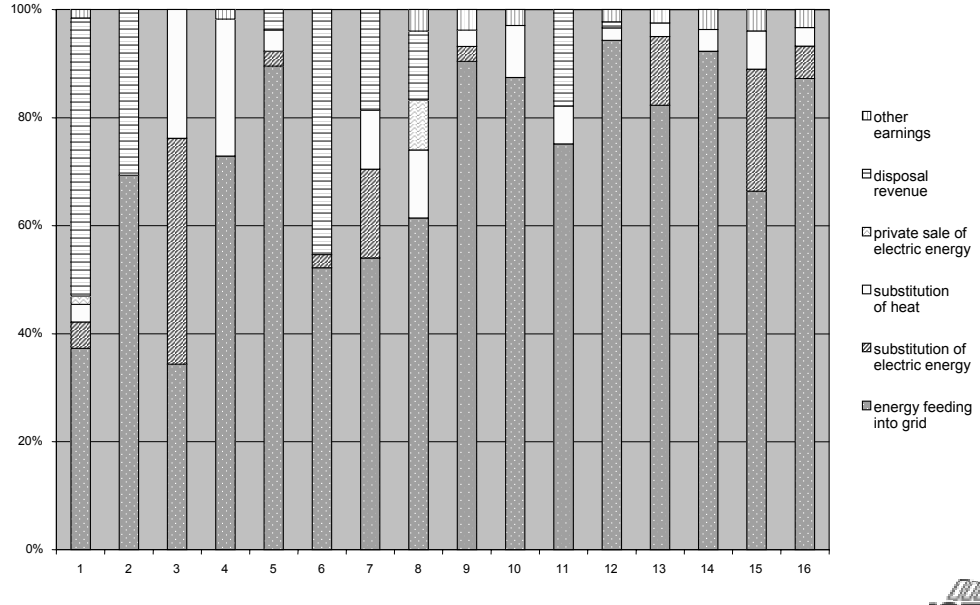
Analysis of H_2S in Biogas – Biogas Plant 16



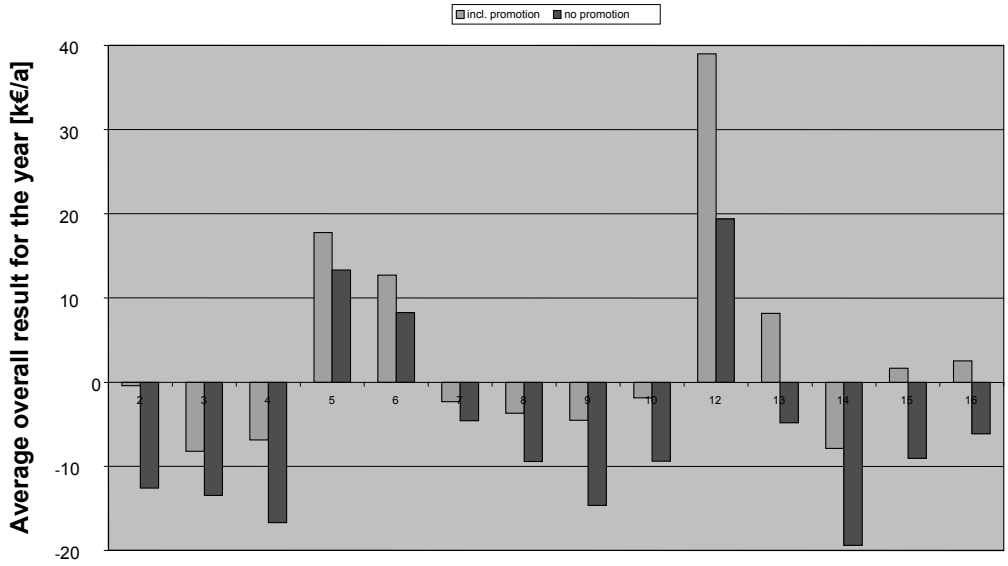
CHPs – Full Load Hours



Structure of Revenues of Hessian Biogas Plants



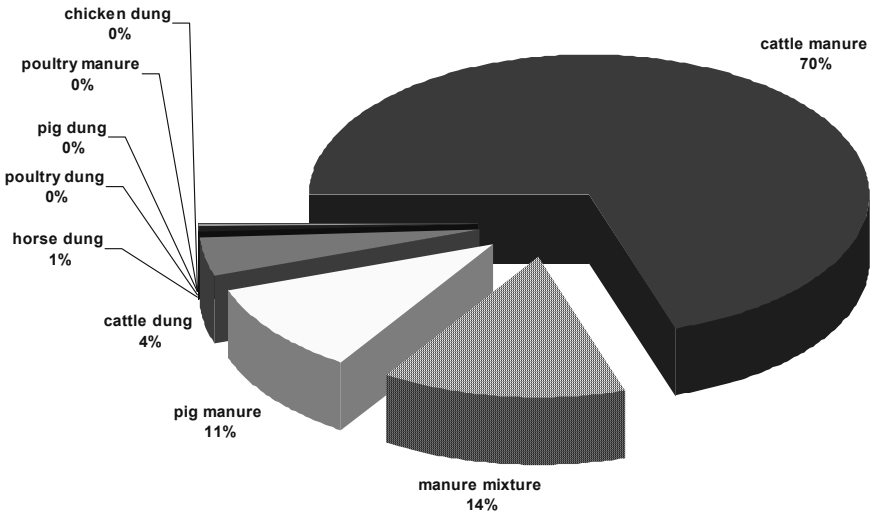
Economic Efficiency of Hessian Biogas Plants



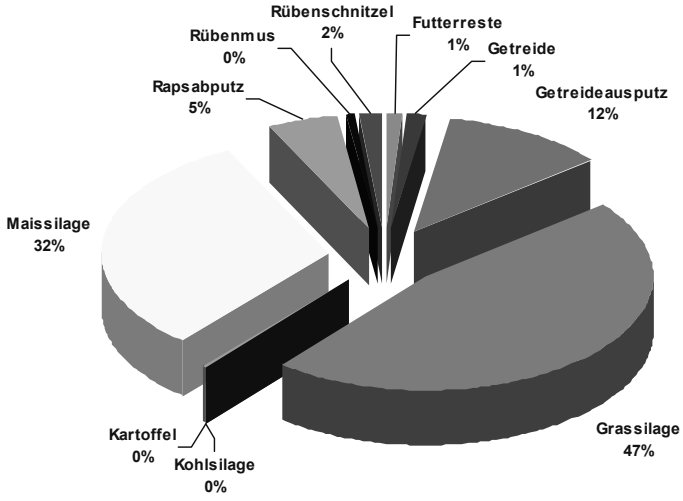
Evaluation of state-aided Hessian Biogas Plants - Conclusion -

- **Animal excreta are** THE **main substrate for (agricultural) biogas plant considering the mass flows**
- **Even small shares of external co-substrates contribute important energy yields**
- **Feeding digesters often suboptimal, knowledge or necessary devices are missing**
- **Energy content of biogas varying, CHPs run with decreased electrical efficiency**
- **Existing instrumentation very poor, improvement essential**
- **Economic profitability moderate; depending on financial promotion and acceptance of external co-substrate or higher revenues for renewable feedstock only**

Animal excreta – fractions in $\%_{mass}$



Renewable Feedstock – fractions in $\%_{mass}$



Hydraulic Load of Digester – Retention Time

- **Mean dwelling time of substratesin digester**
- **Unit: [d]**
- **Calculation: retention time t_R =** $\dfrac{\text{volume digester}\,[m^3]}{\text{flow rate}\,[m^3/d]}$

- **e.g. 1: Digester 500m³, manure 10m³/d, t_R = 50d**
- **e.g. 2: Digester 500m³, fat 10m³/d, t_R = 50d**

- **Retention time independent from quality of input**
- **High flow rate ◆ low retention time**

- **Lower critical retention time 20 days**
- **Flushing out of active bacteria**

Organic Load of digester – volume load

- **Daily organic load into digester**
- **unit: [kg_{oDS}/m^3_D*d]**
- **calculation: volume load B_R =** $\dfrac{\text{flow rate}\,[m^3/d] * \text{oDS}\,[kg_{oDS}/m^3]}{\text{volume digester}\,[m^3]}$

- **e.g. 1: digester 500m³, manure 10m³/d, oDS 70kg/m³,**
- **B_R = 1,4 kg_{oDS}/m^3_D*d**
- **e.g. 2: digester 500m³, fat 10m³/d, oDS 325kg/m³;**
- **B_R = 6,5 kg_{oDS}/m^3_D*d !!!**

- **Volume load dependant on quality of substrates**
- **High oDS-concentration ◆ high volume load**

- **Upper critical limit 5 kg_{oDS}/m^3_D*d**
- **Light load operation < 2 kg_{oDS}/m^3_R*d**

Hessian Biogas Plants – Key Figures

Ø capacity digesters per plant: 1,300 m³
Ø single digester volume: 650 m³
Ø CHP capacity per plant: 137 kW_{el}
Ø CHP full load hours: 5,400 h/a

Ø spec. plant investment per kWel: € 3,900
Ø spec. CHP investment per kWel: € 900
Ø maintenance & repair: 2% of investment / a
Ø plant energy consumption / energy output: 8%
Ø daily manpower: 1.7 h/d