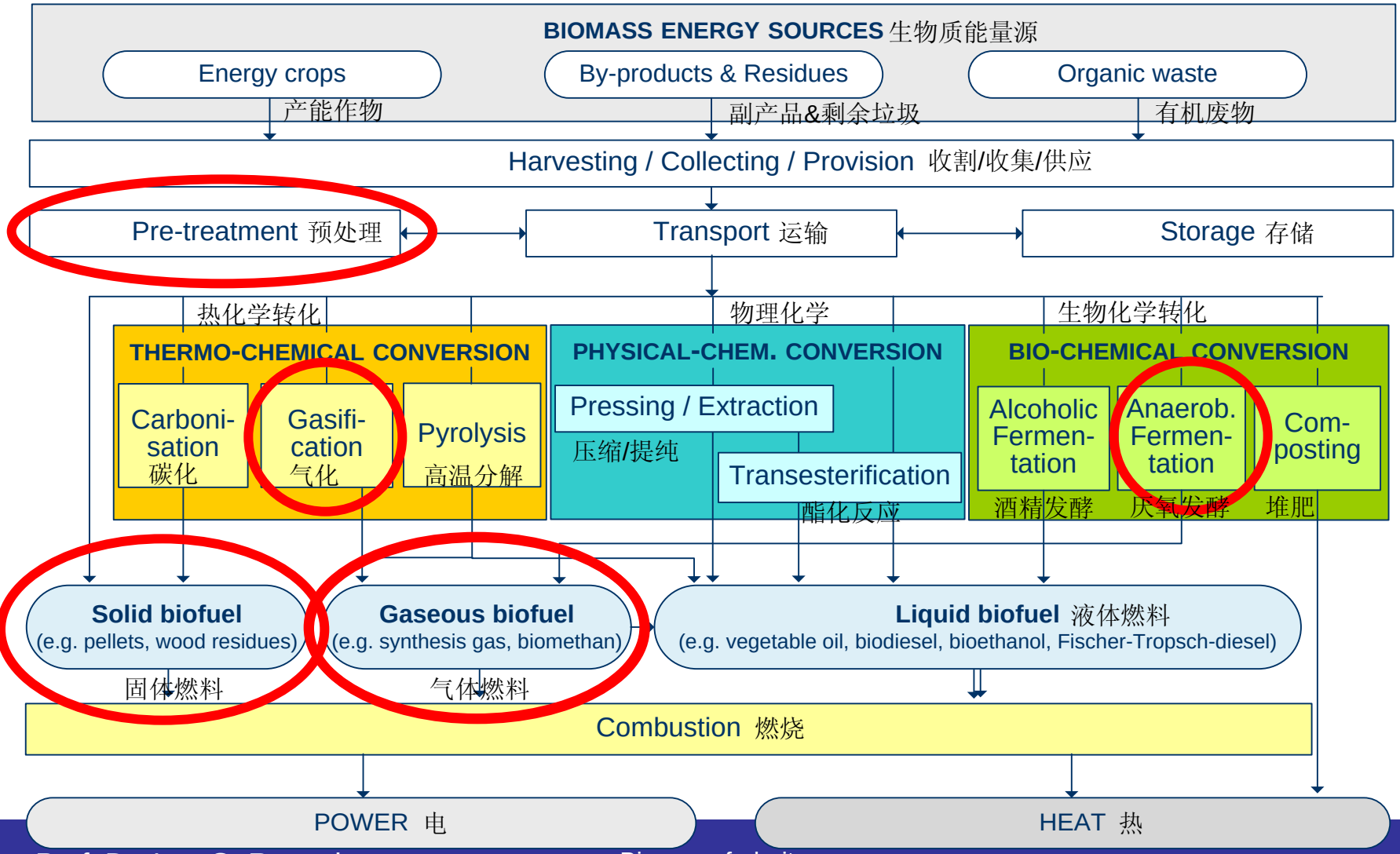
Realisation of political targets: Biomass Conversion Options
政治目标的实现：生物质转化方案



Utilisation chain of a biogas plant
生物气工厂的利用链

Is upgradation an alternative ?
输送是否可以作为可选项?

KNOTEN WEIMAR

Elec-tricity
电

Heat
热

Electricity and heat production 电和热的生产

Residue transport
残余物运输

Storage
储存

Biogas-production
生物气生产

Fuel
燃料

Upgrading 压缩

Fertilization
堆肥

Natural gas grid
天然气输电网

Transport 运输

Waste / Production of Substrates

废物 / 物质的生产

Storage 存储

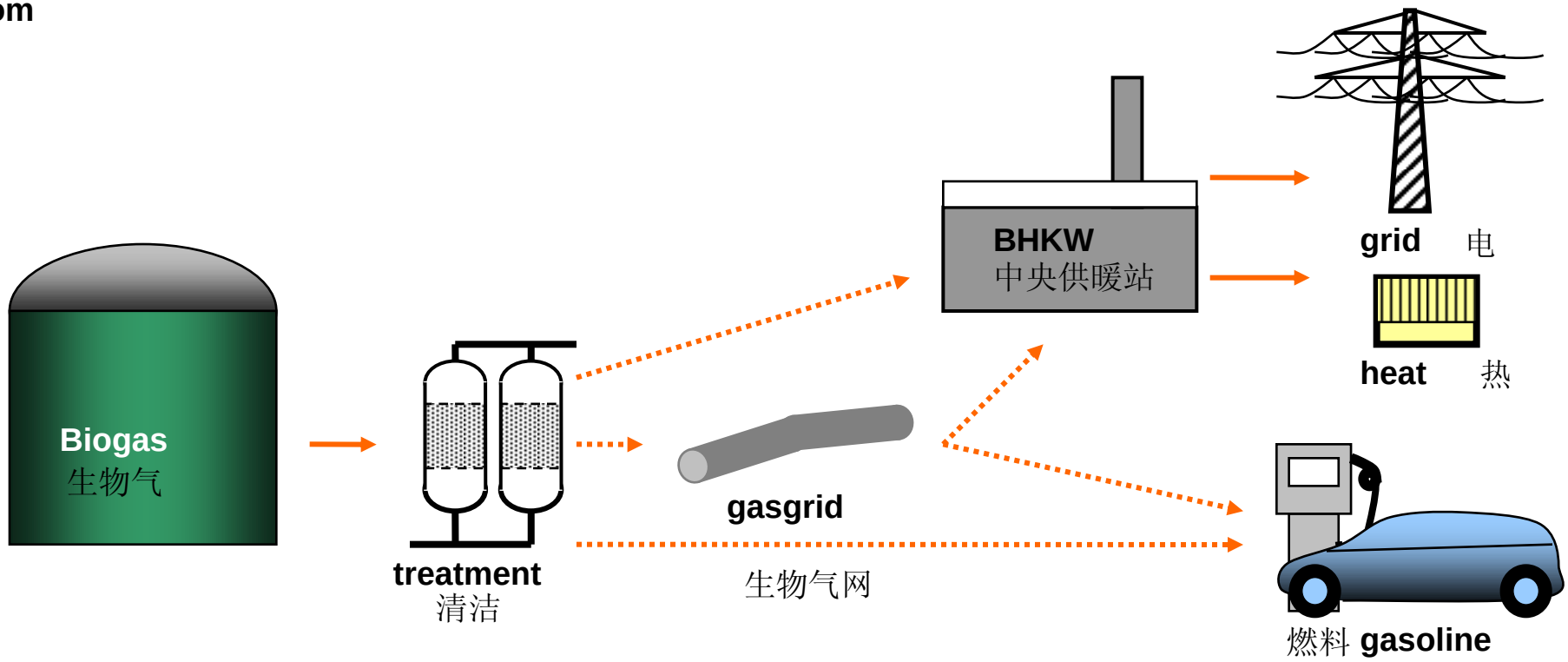
Elec-tricity
电

Electricity and Heat production 电 和热

Heat

How is the use of biogas?
如何更好的使用生物气

trom



Biogasproduktion	Gastreatment	Gastransport	Gasutilization
生物气生产	生物气预处理	生物气运输	生物气使用

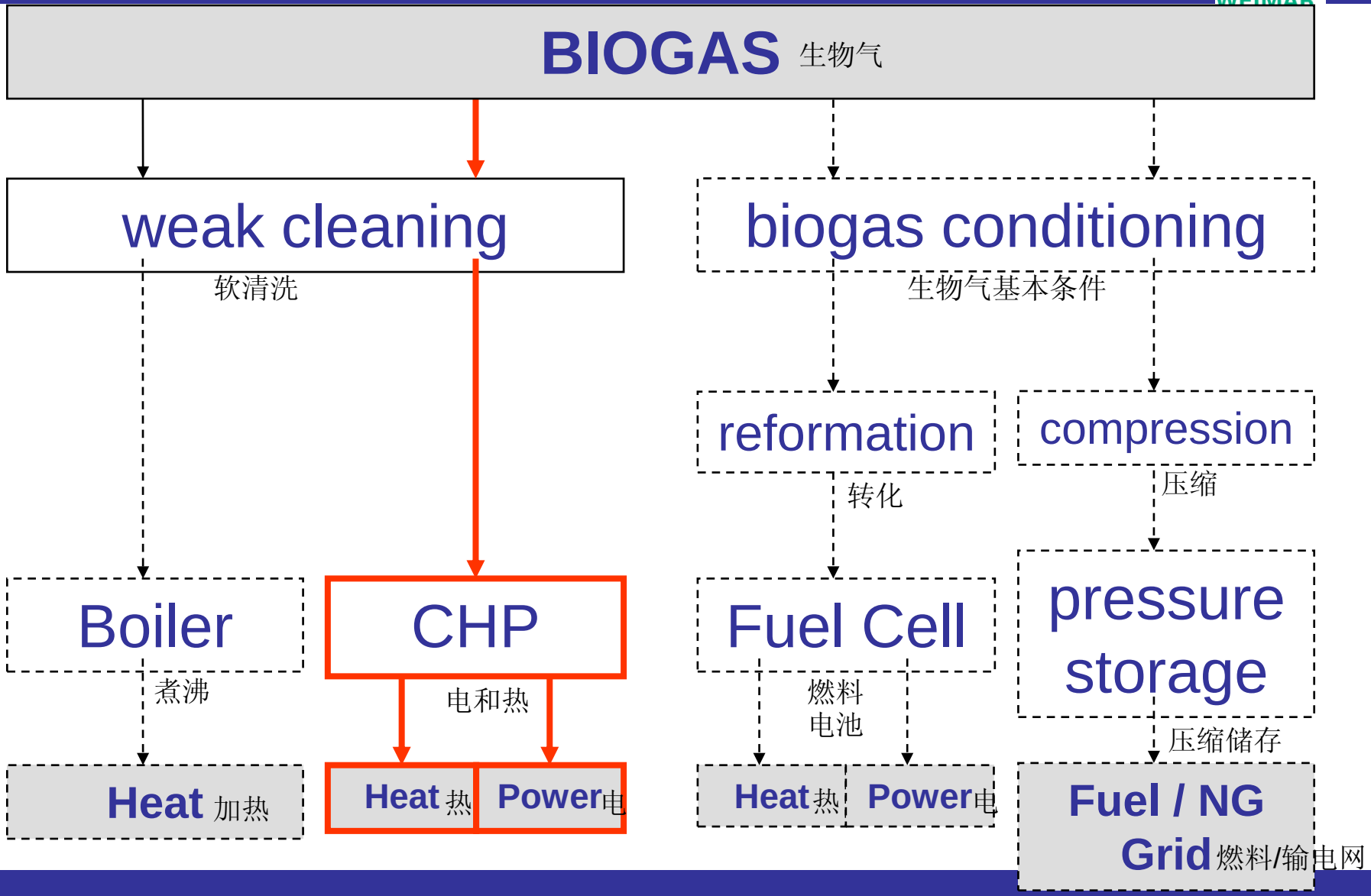
Biogas can be used in different ways.

Treatement as an alternative → better efficiency because of heat use

预处理　　生物气的使用方法不一。 可选方法之一→高效率热的利用

Pathways for biogas treatment

生物气处理途径



Composition of Biogas

气体组成

Substanz 物质	Biogas生物气	Natural gas 天然气
Methane CH_4	50-70 %	93-98 %
Carbon-dioxide CO_2	25-40 %	1 %
Nitrogen N_2	< 3 %	1 %
Oxygen O_2	< 2 %	-
Hydrogen H_2	trace	-
Hydro-sulfur H_2S	Up to 4000 ppm	-
Ammonia 氨水	trace	-
Ethane 乙烷	-	< 3 %
Propane 丙烷	-	< 2 %
Siloxane 硅氧烷	trace	-

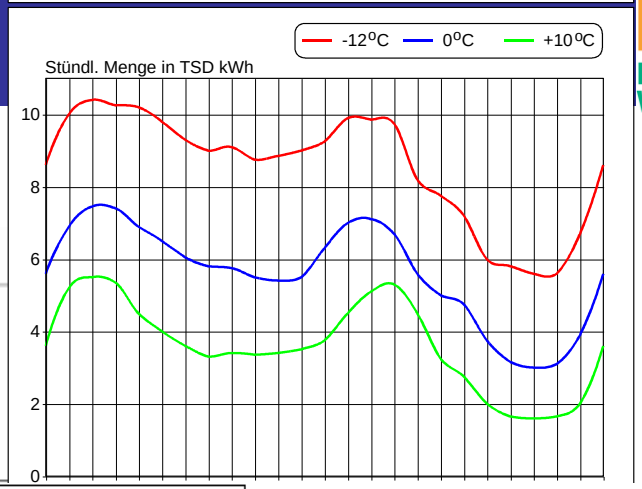
Biogas contains less energy an various trace constituents.

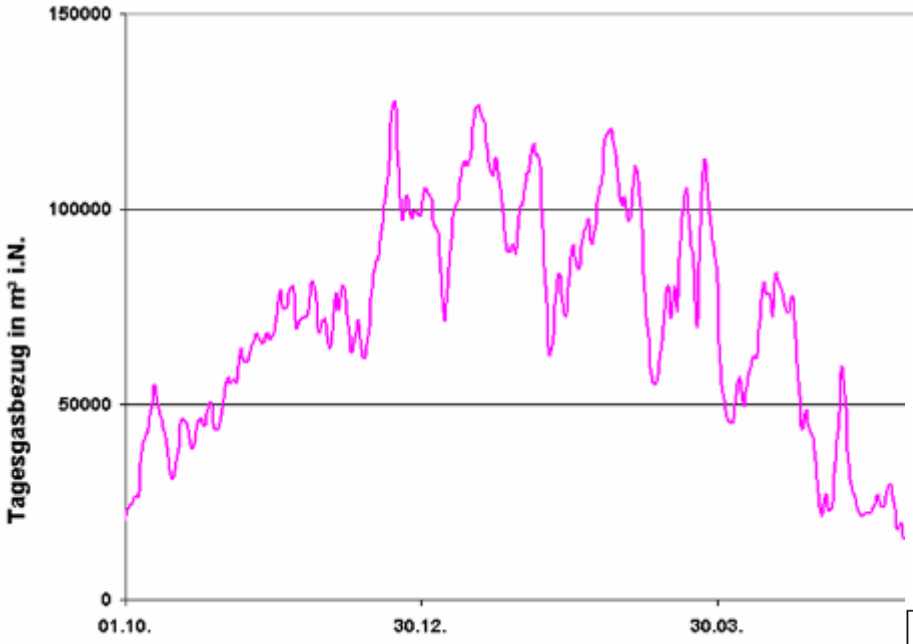
生物气显现出能量不足
并且含有不同的
其他混合物

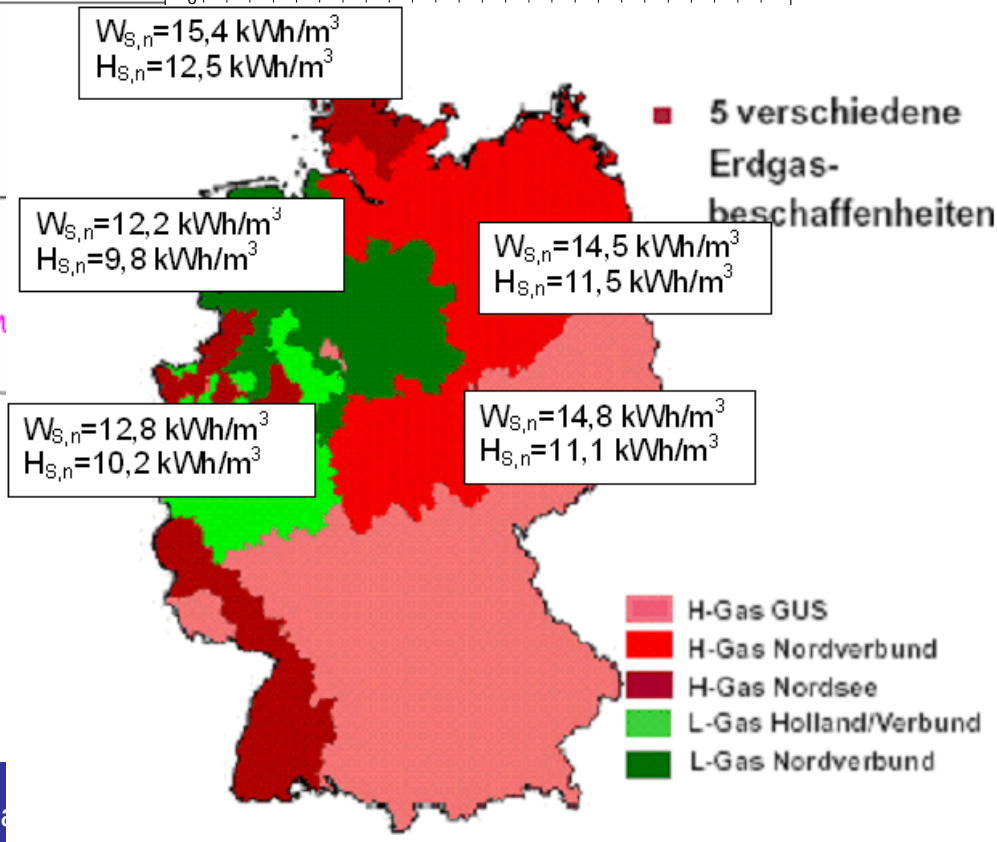
Substance 物质	Biogas 生物气	WWTP gas 污水处理厂气体	Natural gas 天然气
Methane CH_4	50-70 %	60-70 %	93-98 %
C.Dioxide CO_2	25-40 %	30-40 %	1 %
Nitrogen 氮	< 3 %	4 %	1 %
Oxygen O_2	< 2 %	1 %	-
Hydrogen H_2	Traces 微量	Traces 微量	-
H_2S	Up to 4000 ppm	Up to 1000 ppm	-
Ammonia 氨	Traces	Traces	-
Ethane 乙烷	-	-	< 3 %
Propane 丙烷	-	-	< 2 %
Siloxane 硅氧烷	Traces	< 6mg/m³	-

Restrictions for feed in

供应的限制







Biogasaufbereitungsanlagen in Europa

欧洲生物气预处理工厂

Schweden: 瑞典 ☆☆☆☆☆☆☆☆☆☆☆☆☆☆☆☆☆☆☆☆☆☆☆☆☆☆☆☆☆☆☆☆☆☆☆

Deutschland: 德国 ☆☆☆☆☆☆☆☆☆☆☆☆☆☆☆☆☆☆☆☆☆

Schweiz: 瑞士 ☆☆☆☆☆☆☆☆☆☆

Niederlande: 尼德兰 ☆☆☆☆

Österreich: 奥地利 ☆☆☆

Frankreich: 法国 ☆☆☆

Spanien: 西班牙 ☆☆

Norwegen: 挪威 ☆

Island: 爱尔兰 ☆

State of biogas treatment
生物气预处理现状

- Biogastreatement is state of the art 生物气预处理是技术的立足点
- Various treatment technologies are available at the market:
  现存在不同种类的预处理技术：
  - Wet Absorption (water washing process) and Pressure Swing Adsorption = PSA)
    湿法吸收（压力水水洗法DWW）变压吸收法（PSA）
  - Chemical Absorption (Amino washing process, f.e. MEA, DEA), membrane technologies, cryogenic separation
    化学吸收法（胺洗法，例如 MEA, DEA ）膜处理法，冷凝分离法
- There are very best long term experiences with use as fuel for vehicels bestehen sehr gute langjährige Erfahrungen as substitute for natural gas :
  长年以来在欧洲一直是很好的技术经验：作为运输燃料和天然气替代品使用
- Public guidelines for the gas quality has to be considered (Gasquality, pressure, flow, quality assurance)
  DVGW法规中的指导方针是要注意确保气体质量，压力，体积流和质量保证
- Projects in Germany: operation by the gas supplier/ in cooperation (size between 1-20 MW_{el}; average: 1,5-3 $MW_{el.}$)
  在德国输送工程：由燃气公司运行/合作（ 工厂大小在1-20 MWel， 平均1,5-3 MWel）
- The legas frame was improved by new regulations extremly (EEG, GasNZV) and gives strong incentives for a further development
  法律框架是通过不断更新，制定清晰的法规而实现的（新能源法，气体入网法）以及为日后提供强有力拆除计划

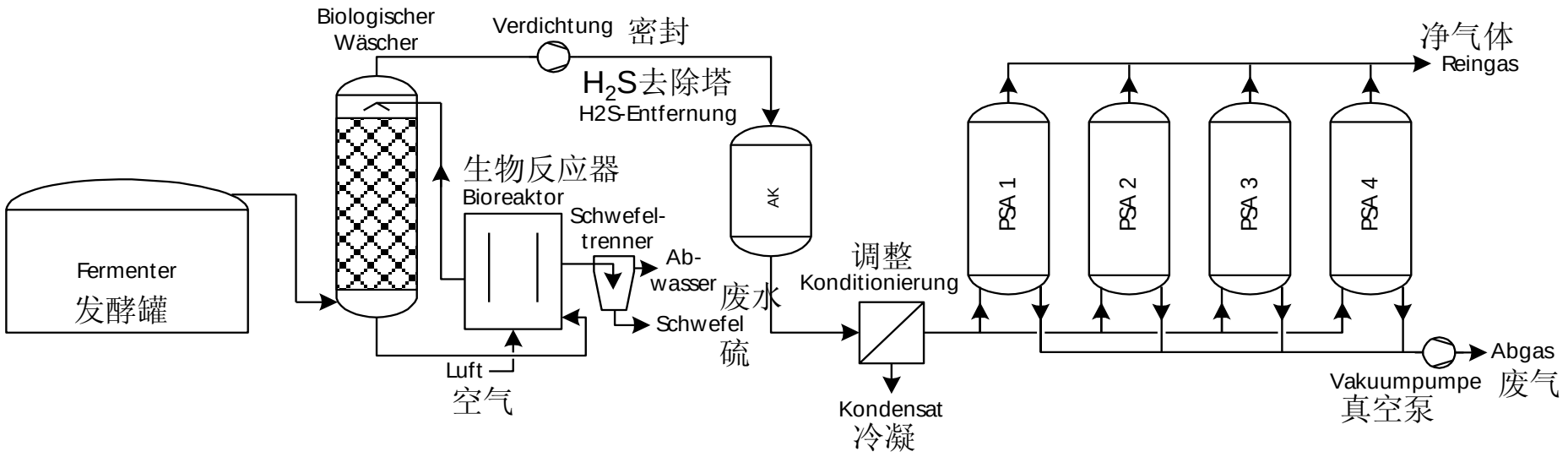
Gas quality demand

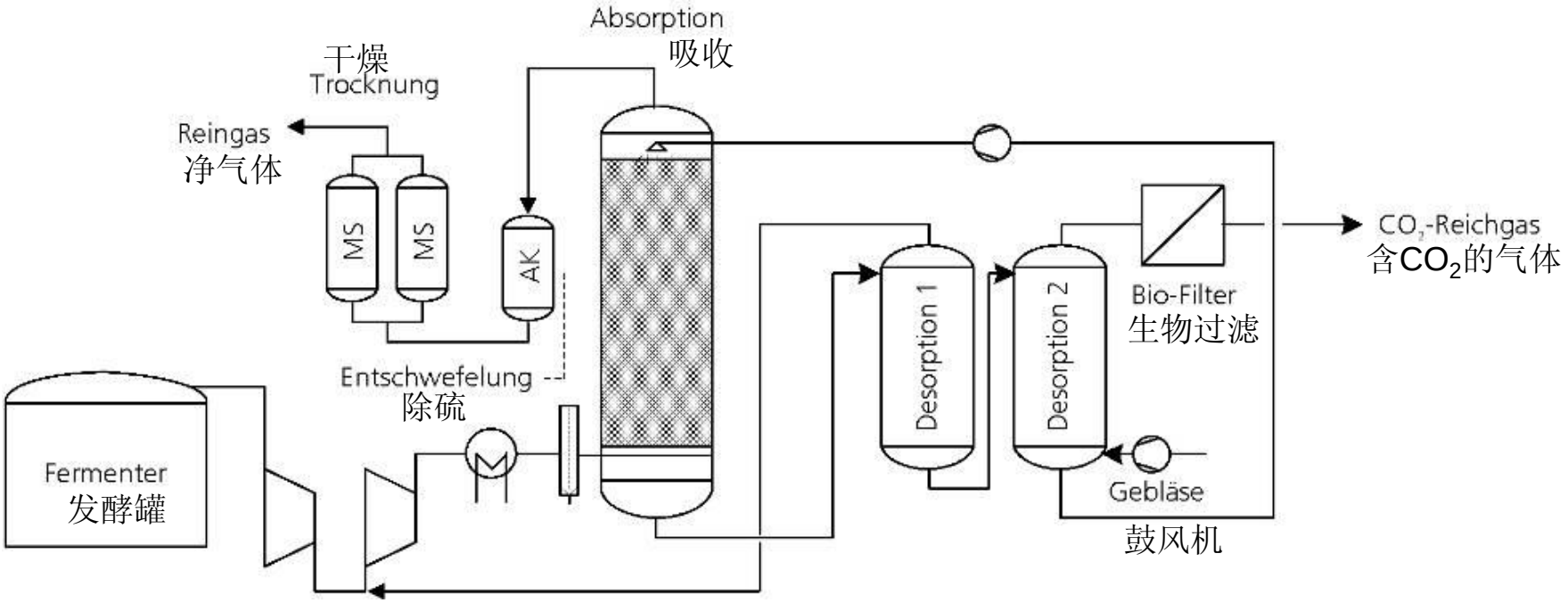
气体质量要求

- Quality demand: DVGW-directives are basis
  质量要求：DVGW 是基础的指令
- Regularly: feed in at the same quality as existing in the grid
  通常：输入和现有工艺一样质量的气体
- Exception: feed in at lower quality depending on natural gas flow
  除此以外：根据天然气质量可输入较低质量的气体
- Main parameters: Heating value, relative density, wobbe index, methane number
  主要参数：热值， 相对密度， 沃布指数， 甲烷量
- Gas components: oxygen, sulphur compounds, hydrocarbons, vaporized water, siloxane
  气体组成： 氧气，含硫化合物， 碳氢化合物， 水蒸气， 硅氧烷
- Odorisation
  有味气体的产生
- Pressure adaption
  适合的压力
- Methane losses during upgradation
  在输送过程中的甲烷损耗
- Generally: demands can be fulfilled by available technologies
  一般：可根据现有技术实现所需要求

Treatement technologies

预处理技术


Biologischer
Wäscher
Verdichtung 密封
净气体
Reingas
H_2S去除塔
H2S-Entfernung
生物反应器
Bioreaktor
Schwefel-
trenner
Ab-
wasser
废水
Schwefel
硫
AK
PSA 1
PSA 2
PSA 3
PSA 4
调整
Konditionierung
Fermenter
发酵罐
Luft
空气
Kondensat
冷凝
Vakuumpumpe
真空泵
Abgas
废气


Absorption
吸收
干燥
Trocknung
Reingas
净气体
MS
MS
AK
Entschwefelung
除硫
Fermenter
发酵罐
Desorption 1
Desorption 2
Bio-Filter
生物过滤
Gebläse
鼓风机
CO2-Reichgas
含CO2的气体

Example – Könnern

举例-Könnern

Energy crops gas
1000 Nm³/h
能源作物气体
1000 Nm³/h
Raw gas (500 Nm³/h biomethane)
原料气体（500 Nm³ /h 生物甲烷气体）
Water scrubber
水洗
Operation since 2007
自2007年开始运行
Feed in into natural gas (russian quality) with LPG mix at 16 bar pressure
进气为16 bar压力条件下LPG混合的天然气（俄罗斯质量）

Example - Könnern

举例- Könnern

Energy crops gas
能源作物气体
1000 Nm³/h
Raw gas (500 Nm³/h biomethane)
原料气体（ 500 Nm³/h 生物甲烷气体）
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Feed in into natural gas (russian quality) with LPG mix at 16 bar pressure
进气为16 bar压力条件下LPG混合的天然气（俄罗斯质量）

- Chemical absorption (Amino washing process)

  化学吸收（胺处理）

  - washing column with gas flow against water flow

    逆向洗涤装置
  - solvent (water andMEA/ DEA etc.)

    洗涤液（水和MEA/ DEA 等）
  - CO_2 is solved in the solvent, CH_4 in the gas phase

    CO_2和其他物质溶解在洗涤液中，CH_4存在于气相中
  - without pressure, high purification rate, less loss of methane

    低压，高纯度甲烷，甲烷损耗少
  - high energy need for regeneration of the solvent

    然而，洗涤液再生需要较高的热量

Further treatment technologies
其他预处理技术

chemische Absorption (z.B. Aminwäsche / Selexolwäsche)

- Waschkolonne im Gegenstromprinzip
- Waschlösung (Wasser und MEA/ DEA etc.)
- CO_2 u.a. löst sich in der Waschlösung, CH_4 in Gasphase
- drucklos, hohe Methanreinheit, geringer Methanverlust
- jedoch hoher Wärmebedarf für Regeneration Waschlösung

Membrane technologies
膜工艺

- separation: difference in diffusion of different large gas molecules through membranes
  分离：不同大小的分子透过膜的速率不同
- small methane molecule faster than CO_2 or H_2S
  小分子甲烷比CO_2和H_2S的透过速率快
- kind of membrane, velocity, number of separation units …
  膜类型，流速和分离层数目

Further treatment technologies
其他处理技术

chemische Absorption (z.B. Aminwäsche / Selexolwäsche)

- Waschkolonne im Gegenstromprinzip
- Waschlösung (Wasser und MEA/ DEA etc.)
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- drucklos, hohe Methanreinheit, geringer Methanverlust
- jedoch hoher Wärmebedarf für Regeneration Waschlösung

Membranverfahren

- Trennung: unterschiedlich schnelle Diffusion verschieden großer Gasmoleküle durch die Membran
- kleines Methanmolekül schneller als CO_2 oder H_2S
- Art der Membran, Strömungsgeschwindigkeit, Anzahl Trennstufen …

Cryogenic separation

低温分离

- if low temperatures: different aggregate state or temperatures for condensation of the biogas compounds

  在低温下，不同凝聚态特别是生物气组成凝聚的温度

- CO_2 as solid (dry ice), CH_4 as gas

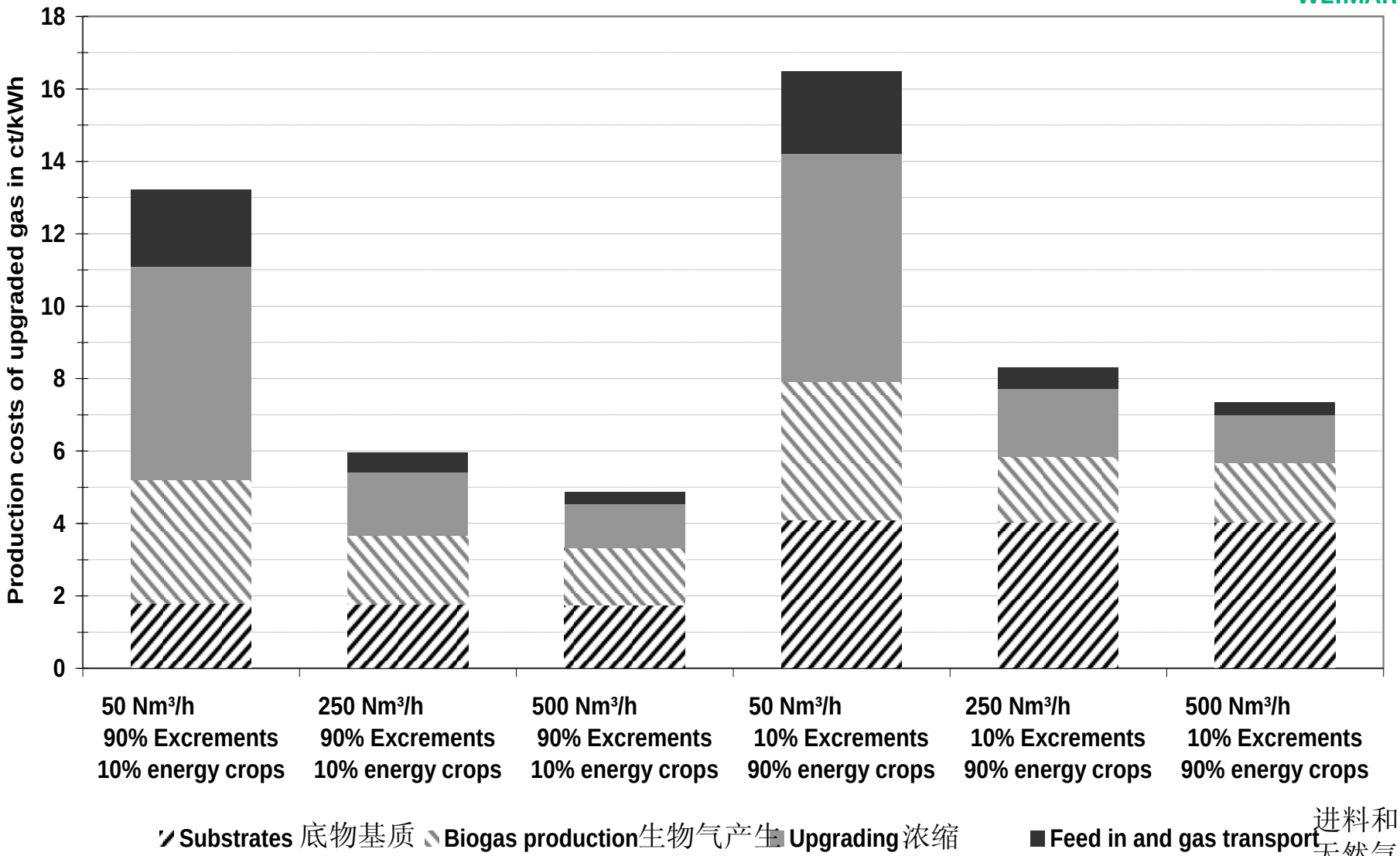
  CO_2以固态形式存在（干冰），CH_4是气态

Further requests for biogas treatment technologies
生物气预处理技术的发展要求

- Less methane loss
  降低甲烷损耗
- Less energy consumption for the treatment process
  降低甲烷预处理能源损耗
- High gas quality and reduction of process steps
  减少预处理步骤的同时提高产物纯度
- Flexibility for various loads/ differences in loads should be accepted
  气体输入/气体波动转化必须具有灵活的承受能力
- Reduction of treatement costs
  降低预处理费用
- Possible unit sizes under technical and economical conditions in a flow range < 250 m³ gas per hour
  生产效率在每小时250 m³原料生物气以内的经济可行性生产

Production costs of Biomethane

生物甲烷气产生费用

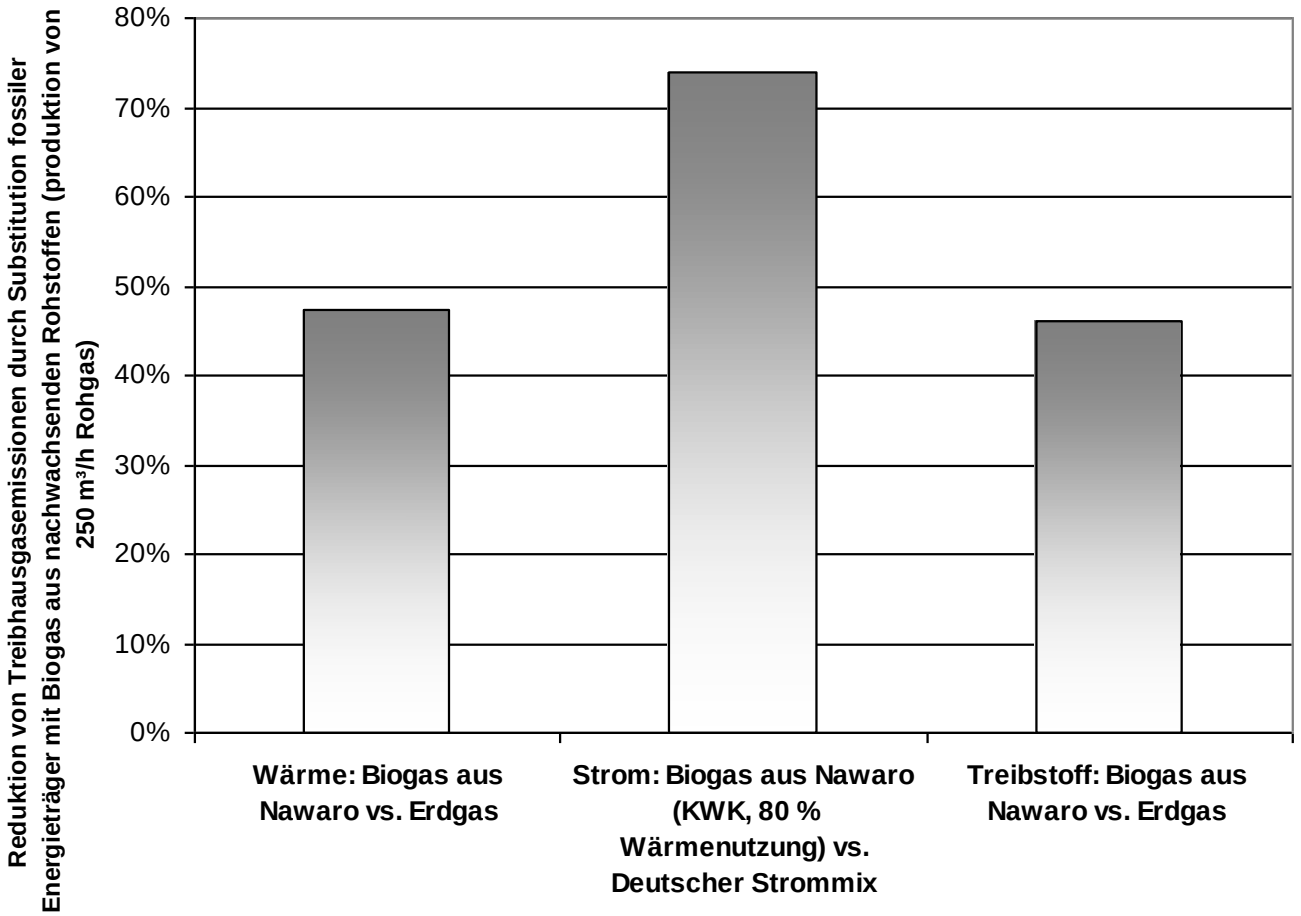


- **Special topics in the field of gas treatment**

气体预处理中的特殊问题

Is the biogas feed an acceptable alternative under ecological conditions?

生物气输送从生态角度来讲可选吗？

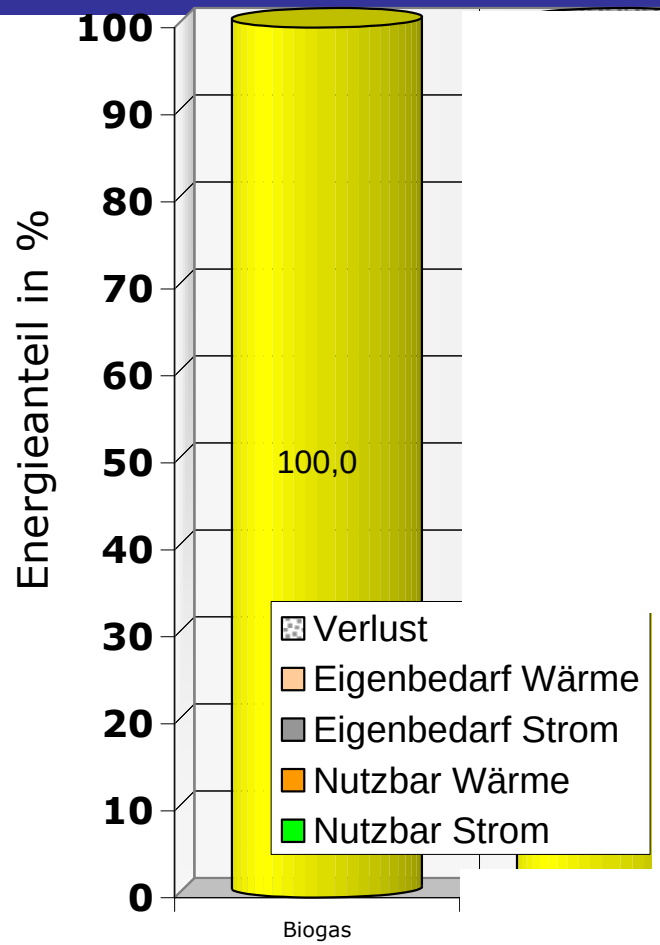


→For all possible uses the biogas feed in a public pipeline is the most
→advantageous in comparison to natural gas.

从各种使用角度来考虑，生物气输送比使用化石燃料对环境更有利

Is biogas treatment and feed useful under energetic conditions ? - what efficiency is possible in decentralized systems?

从能源角度讲生物气预处理和输送是否具意义？外界哪些是可能的？

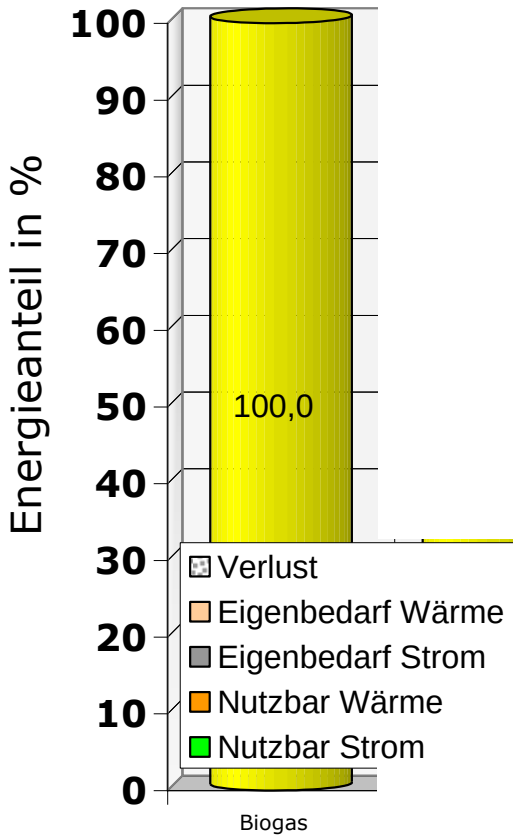


→Normally in a decentralized system 40 (30) – 65 % of the energy in the
→biogas can be used.

一般情况40 (30) – 65 % 的能源用作生物气（处理和输送）

Is biogas treatment and feed useful under energetic conditions ? - what efficiency is possible in decentralized systems?

从能源角度讲生物气预处理和输送是否具意义？外界哪些是可能的？



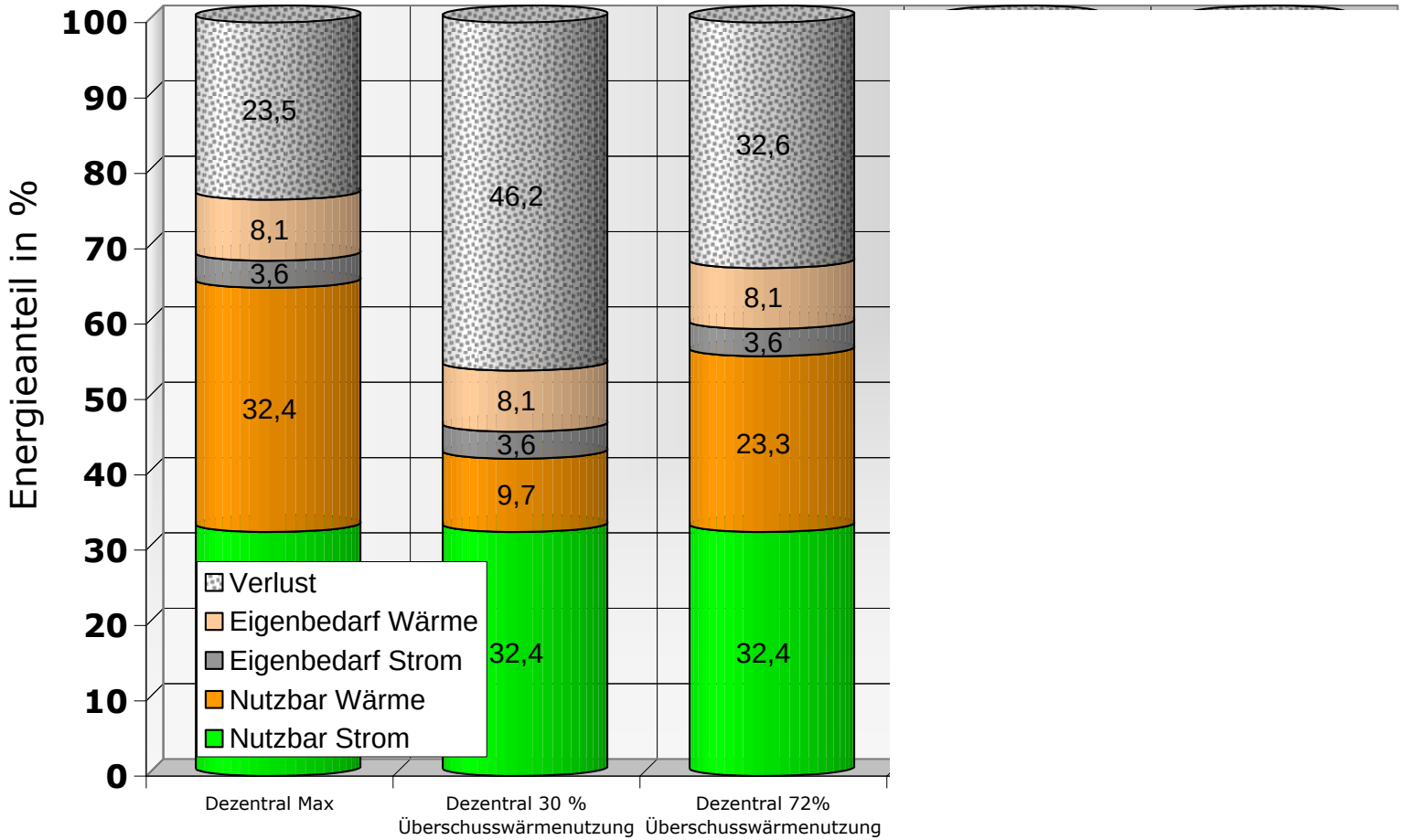
→In a centralized system , the efficiency effect can reach 55 to over 65 % in
→usual pressure ranges of a gas net.

重点在于：在通常输气网压力条件下，利用率达到55-65%。

Is biogas treatment and feed useful under energetic conditions?

生物气预处理和输送从能源角度讲是否有意义?

- options in comparison–选项比较



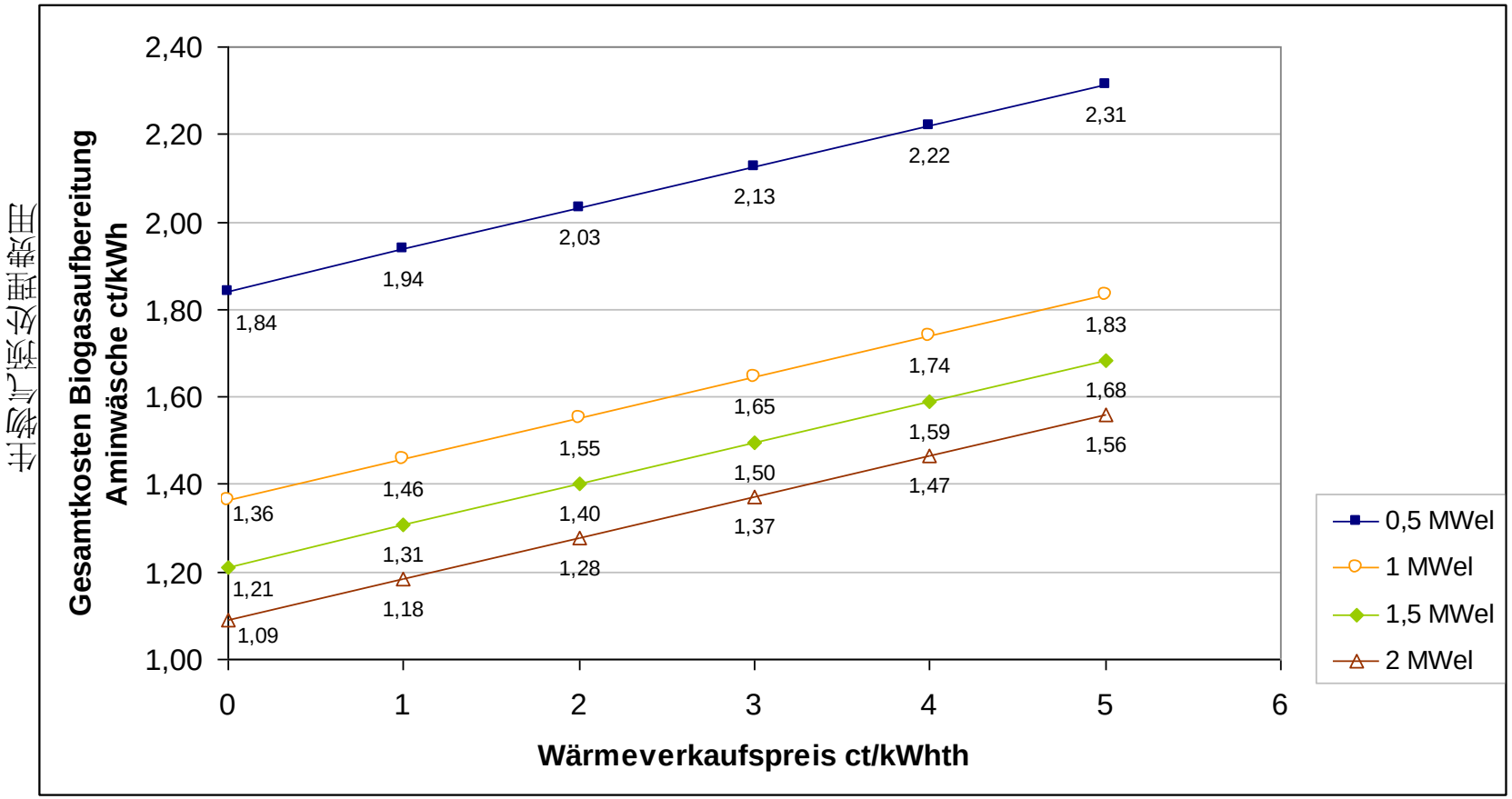
→If there is in decentralized plants

→only less need for heat projects with gas treatment and feed has the most energetic benefited

如果外部只消耗少部分热量时，从能源角度讲，设计好具有预处理和生物气输送的工程是很有益的。

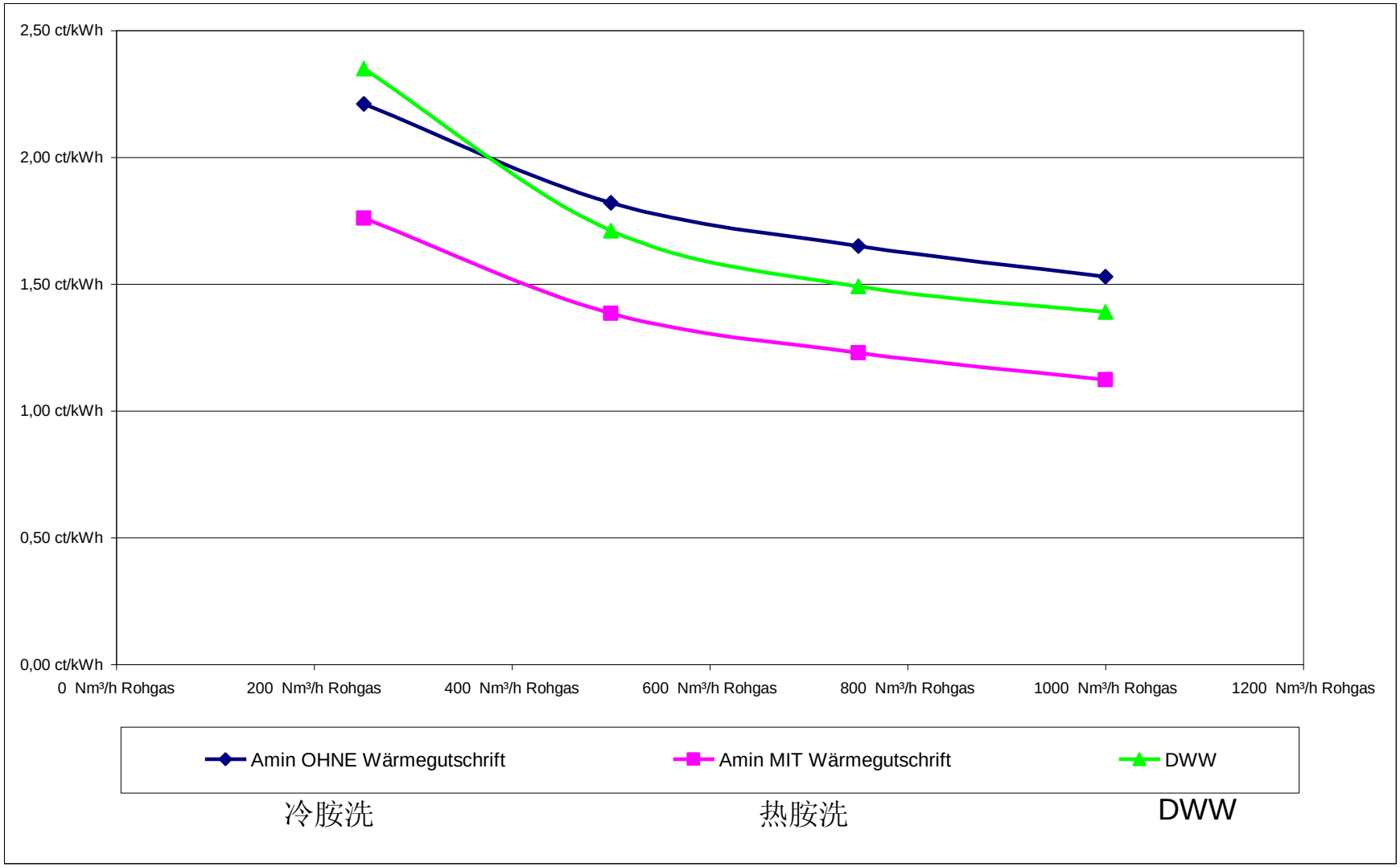
Treatment costs of amino washing process as a function of the price for heat

胺洗涤处理费用，取决于供热价格



Costs of treatment – comparison of amino washing an water washing

胺洗涤和压力水水洗法的处理价格比较



Profit without proceeds of gas sale
无气体出售而获得的利润收入

Anlagen-konzept	Kosten Biogas-anlage (BGA) [€ct kWh$_{Hi}$]	Kosten BHKW [€ct kWh$_{Hi}$]	Verfahren	Kosten Biomethan [€ct kWh$_{Hi}$]	Kosten Gesamt BGA+BHKW+ Biomethan (gemittelt) [€ct kWh$_{Hi}$]	Strom- u. Wärmeerlöse BHKW (gemittelt) [€ct kWh$_{Hi}$]	Gewinn (**ohne** Erlöse aus Gasverkauf) [€ct kWh$_{Hi}$]
1	4,72	1,25	Amin 250	2,29	6,23	4,57	-1,66
			DWW 250	2,43	6,27	4,40	-1,87
2		1,27	Amin 500	1,80	6,26	3,21	-3,05
			DWW 500	1,69	6,20	3,21	-2,99
3		1,28	Amin 750	1,63	6,26	1,51	-4,75
			DWW 750	1,47	6,14	1,51	-4,63
4		0,00	Amin 1000	1,50	6,22	0,00	-6,22
			DWW 1000	1,36	6,08	0,00	-6,08

Profit with proceeds of gas sale
气体出售获得的利润收入

Gasverkaufserlöse				5 €ct/kWh		6 €ct/kWh		7 €ct/kWh	
Anlagen-konzept	Aufberei-tungs-verfahren	Kosten BGA+BHKW+ Biomethan (gemittelt) [€ct kWh$_{Hi}$]	Strom- u. Wärme-erlöse BHKW (gemittelt) [€ct kWh$_{Hi}$]	Erlöse aus Gasverkauf (gemittelt) [€ct kWh$_{Hi}$]	Gewinn (**mit** Erlöse aus Gasverkauf) [€ct kWh$_{Hi}$]	Erlöse aus Gasverkauf (gemittelt) [€ct kWh$_{Hi}$]	Gewinn (**mit** Erlöse aus Gasverkauf) [€ct kWh$_{Hi}$]	Erlöse aus Gasverkauf (gemittelt) [€ct kWh$_{Hi}$]	Gewinn (**mit** Erlöse aus Gasverkauf) [€ct kWh$_{Hi}$]
1	Amin 250	6,23	4,57	1,25	-0,41	1,50	-0,16	1,75	0,09
	DWW 250	6,27	4,40	1,25	-0,62	1,50	-0,37	1,75	-0,12
2	Amin 500	6,26	3,21	2,50	-0,55	3,00	-0,05	3,50	0,45
	DWW 500	6,20	3,21	2,50	-0,49	3,00	0,01	3,50	0,51
3	Amin 750	6,26	1,51	3,75	-1,00	4,50	-0,25	5,25	0,50
	DWW 750	6,14	1,51	3,75	-0,88	4,50	-0,13	5,25	0,62
4	Amin 1000	6,22	0,00	5,00	-1,22	6,00	-0,22	7,00	0,78
	DWW 1000	6,08	0,00	5,00	-1,08	6,00	-0,08	7,00	0,92