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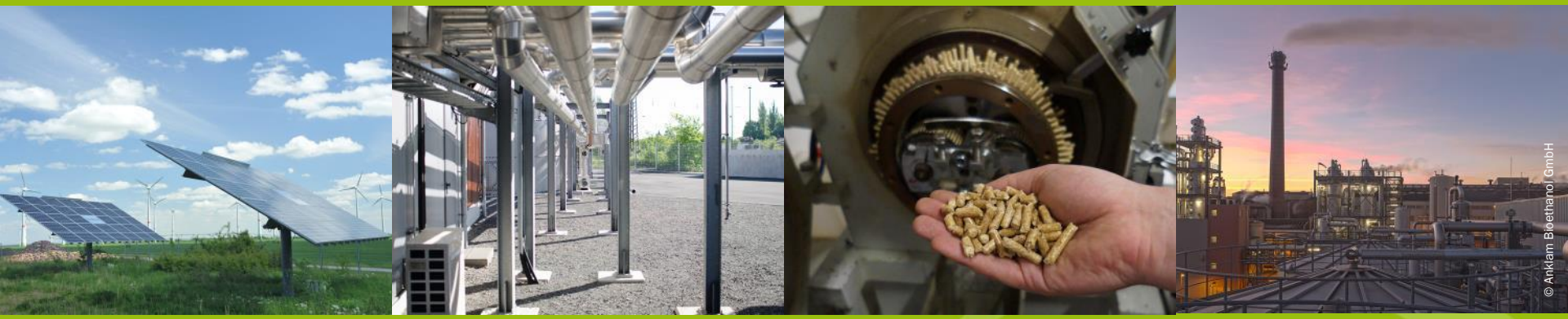
DBFZ

Biogas production on the way towards competitiveness – process optimization options and requirements

Jan Liebetrau



4th Inter Baltic Biogas Arena Workshop

Esbjerg, 25 – 26 August 2016

Background

Competitiveness – within which criteria?

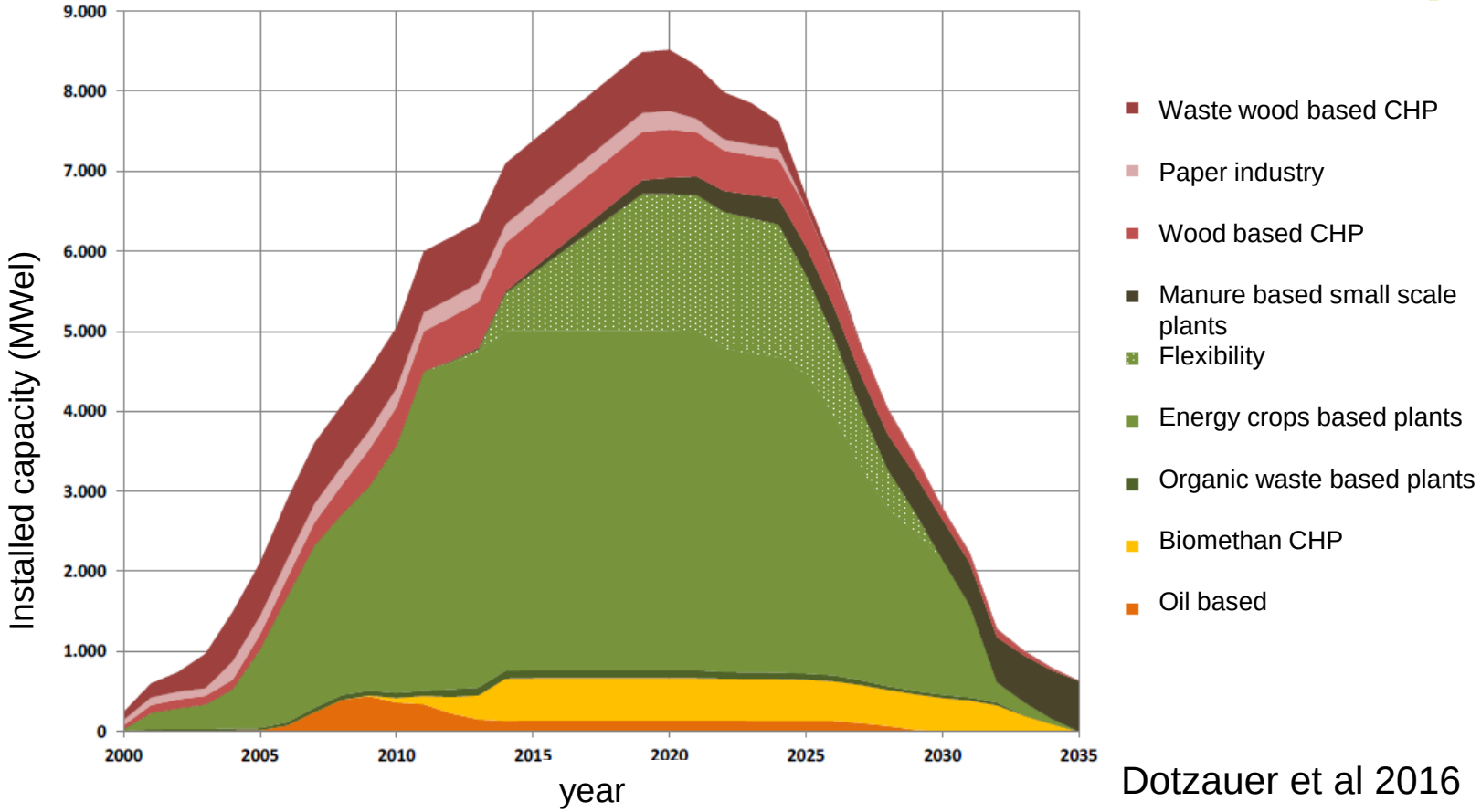
- **Cheap electricity and heat?**
- **Cheap waste treatment?**
- **GHG mitigation?**
- **Circular economy?**

Options:

Optimization of cost structure (e.g. substrates, technology)

Generating new income (electricity markets, heat, material production)

Background – Germany perspective



Dotzauer et al 2016

- Political support currently rather low, future perspective highly unclear
- Discussion about time beyond Feed in tariffs has started – new economic perspectives are needed –and/or relevance for safe electricity provision has to be proven

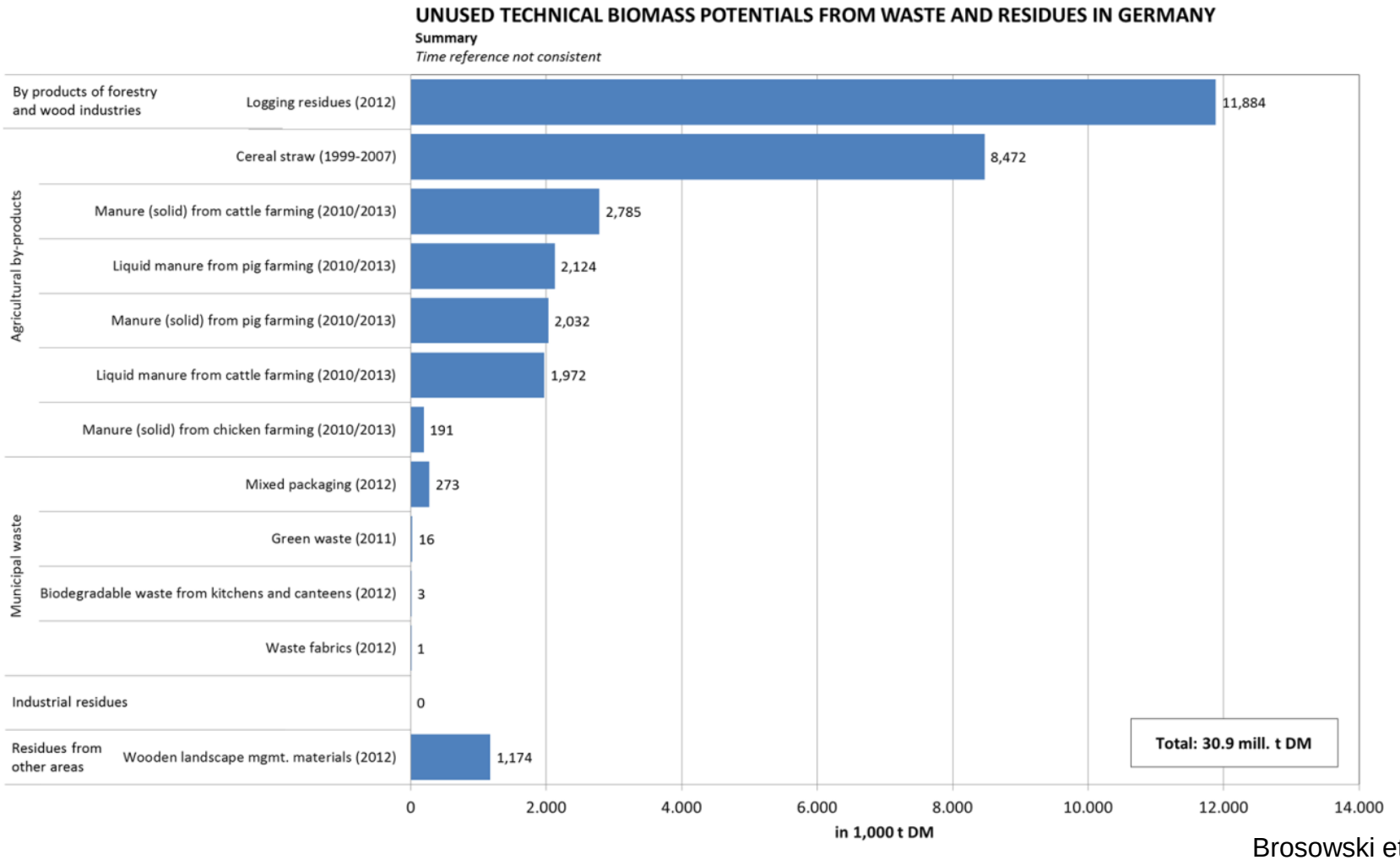
Substrates

Biogas plants cost structure

- Different situation in different plant configurations
  - High share of costs for energy crops (agricultural plants)
  - High investment costs (in particular waste treating plants)
  - High specific investment costs (manure based plants)
- High maintenance and replacement costs
  (effect of depreciation is limited)
- Increasing requirements from authorities

- Difference between feed in tariff and market price is for energy crop based and manure based plants currently not conceivable
- Waste based plants on the free market difficult

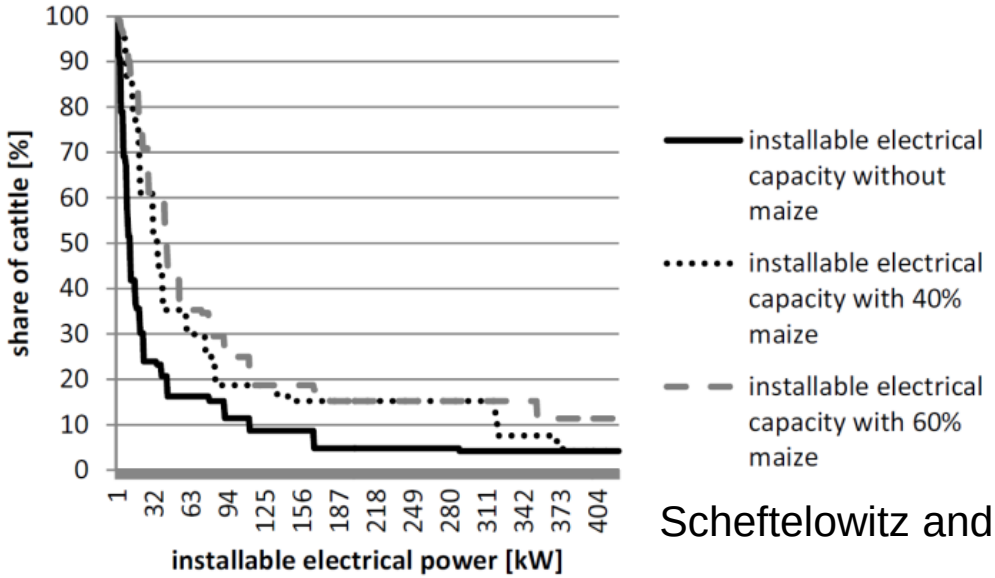
Residue availability in Germany



Brosowski et al 2015

151,1 Mill.t Potential, 65 % usable, 69 % in use (30.9 Mill t DM available)
Use of waste is not easy: examples glycerin, stillage, chicken manure

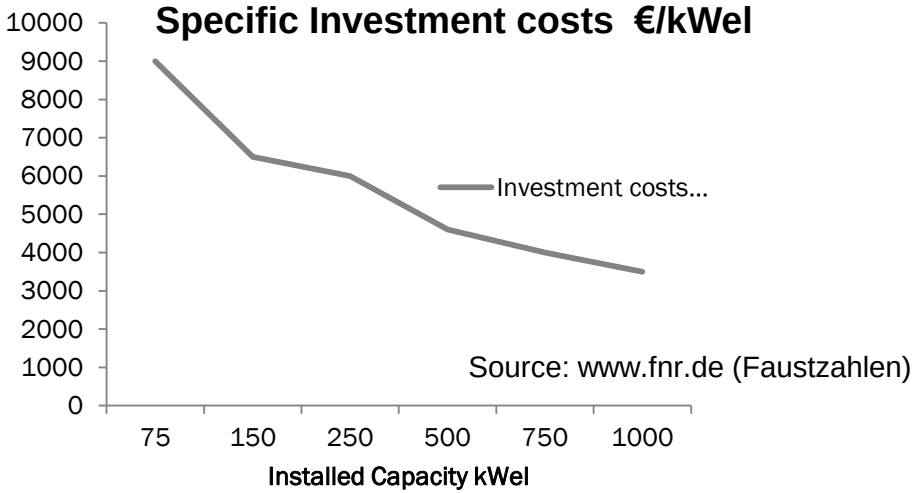
Manure in Germany



Scheftelowitz and Thrän 2016

Cheap substrate (low biogas potential) – but small plants
Not easy to unlock the potential, easy accessible amounts are in use

Regional effects -
adding maize adds problems!!



Substrate characteristics

Municipal solid waste

Separately collected biowaste

Kitchen waste, industrial residues

Agricultural residues, food processing

Energy crops

+  **-**

Content of impurities (Sand, plastics)
Quality of end products (e.g. Heavy metals)
Necessity of pretreatment
Water content
Homogeneity
Gas potential
Structure, porosity

Technical requirements and requirements from authorities

Residue/ waste materials?

- In Germany substitution of energy crops in significant amounts difficult
- Putting incentives on the market might lead to replacement in other markets
- Regional effects are important to monitor

- But: currently accessible (technical and economic) waste streams are in use (RESA is supporting this for years)

Limited potential of alternative substrates, energy crops
no option (?) – combined material and energy production?

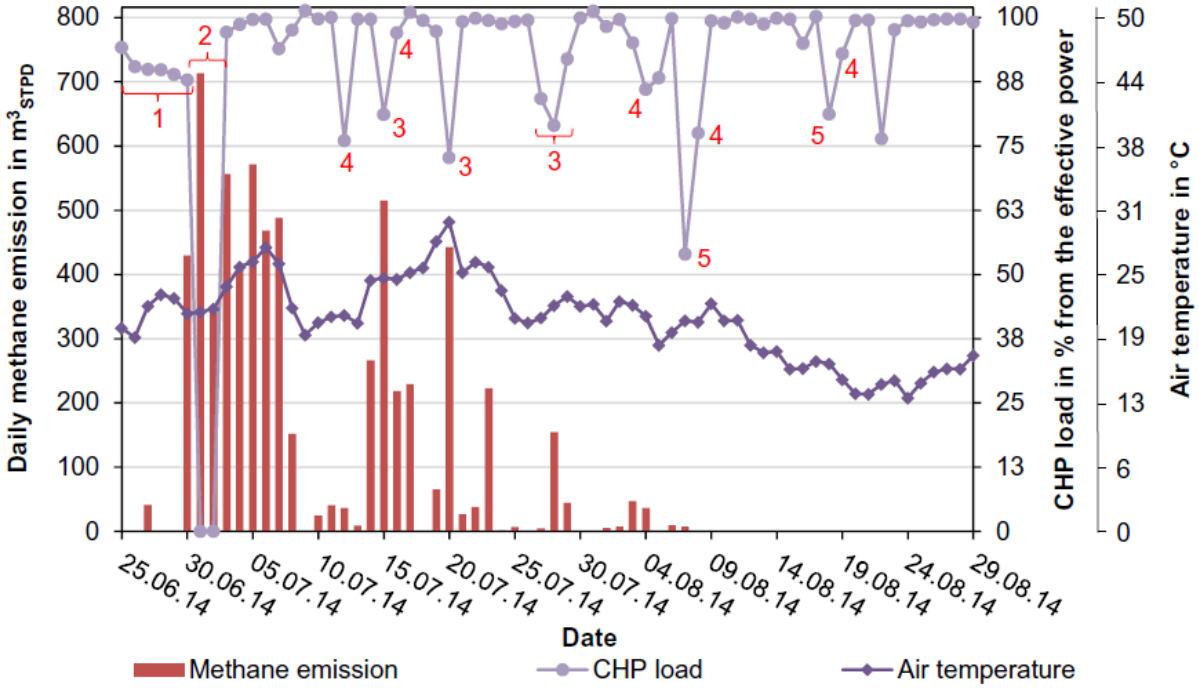
Plant economics in comparison

	Waste	Manure	Energy crops
Capacity (kWel)	1200 (534 Av.out)	75 (68.5 Av out)	1 000 (456 Av.out)
Investment costs €/kWel	12700	6550	5500 (4600)
Substrate costs €/t	-34	33 maize, 1 manure (transportation)	35 maize
Heat utilization (% excess heat) 3 c€/kWh	60	20	56
Own heat demand	30	60	20
Substrates	Biowaste	15 % Maize, 85% manure	60% maize, 30 cereal silage, 10 % manure
Production costs (c€/kWh)	16,77	25,39	20,37

Barchmann, DBFZ, 2014 unpublished

Biogas production on the way towards competitiveness – 2 aspects of plant optimization

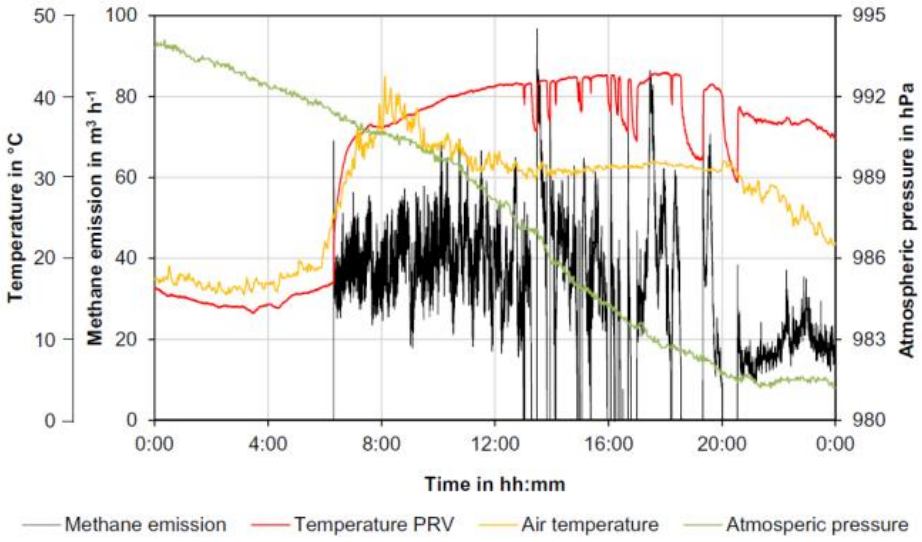
Technical challenges:
Losses on biogas plants



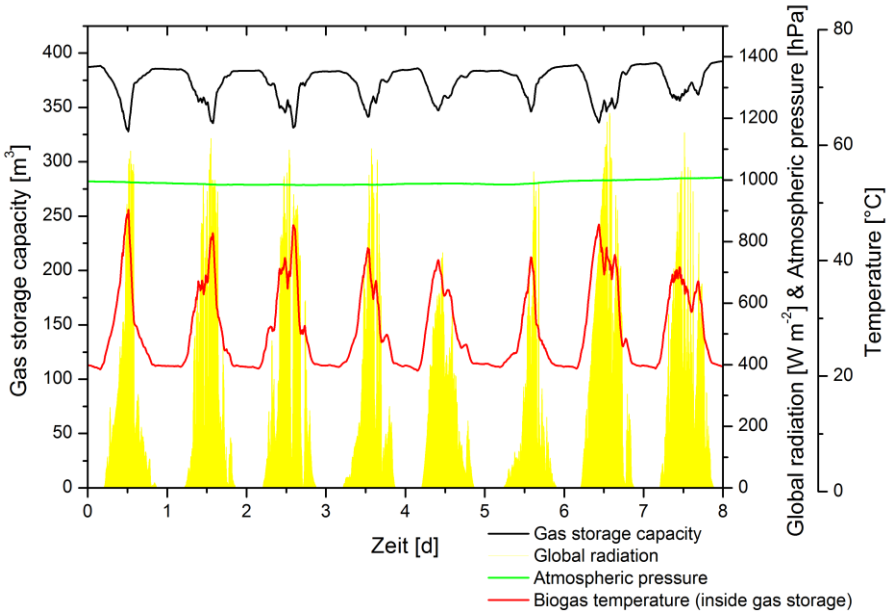
1 ... Power reduction of CHP 2 caused by the change of an agitator of the digestate storage
2 ... CHP shutdown; biogas flare in operation; caused by flushing of the digestate storage with biogas
3 ... CHP power reduction caused by overheating
4 ... CHP power reduction caused by maintenance
5 ... CHP power reduction caused by technical defects

Reinelt et al: Analysis of operational methane emissions from pressure relief valves from biogas storages of biogas plants
Bioresource Technology, Vol. 217, 2016, Pages 257–264

Influence of temperature on gas storage capacity



Weather conditions cause PRV release (Reinelt et al 2016)



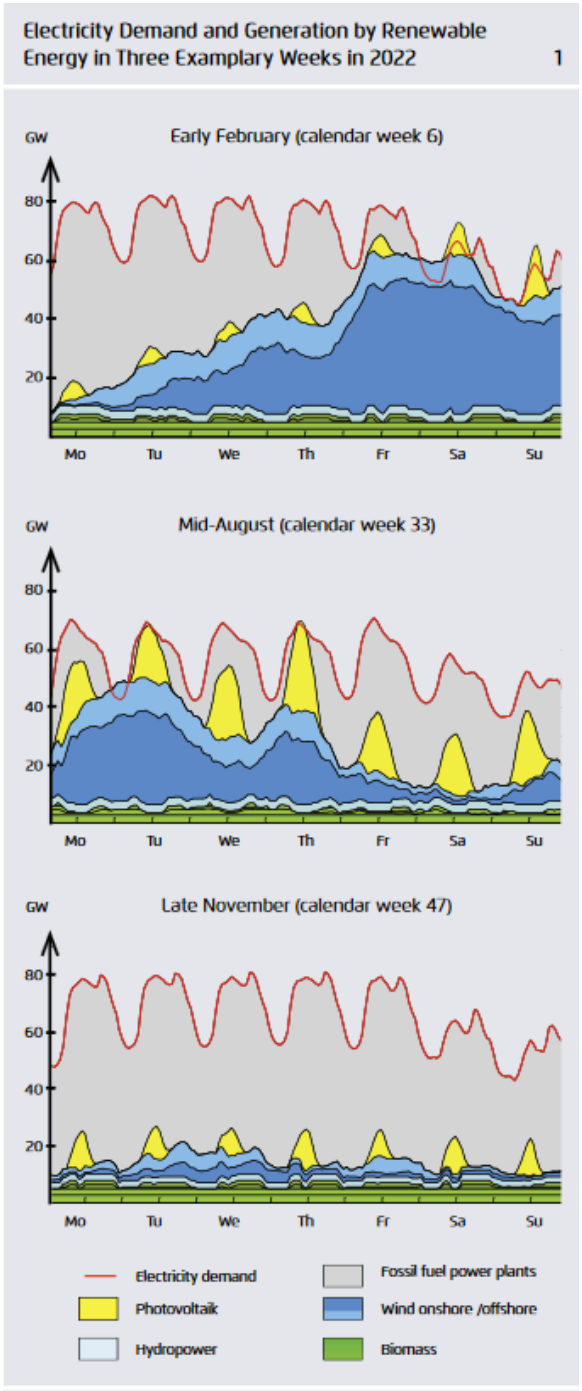
17 % difference in available gas storage capacity

Reinelt et al: Analysis of operational methane emissions from pressure relief valves from biogas storages of biogas plants
Bioresource Technology, Vol. 217, 2016,
Pages 257–264

Energy markets

Electricity market – energy provision and prices

https://www.agora-energiewende.de/en/topics/-agothem-/Produkt/produkt/76/Agorameter/



Electricity provision – future scenarios

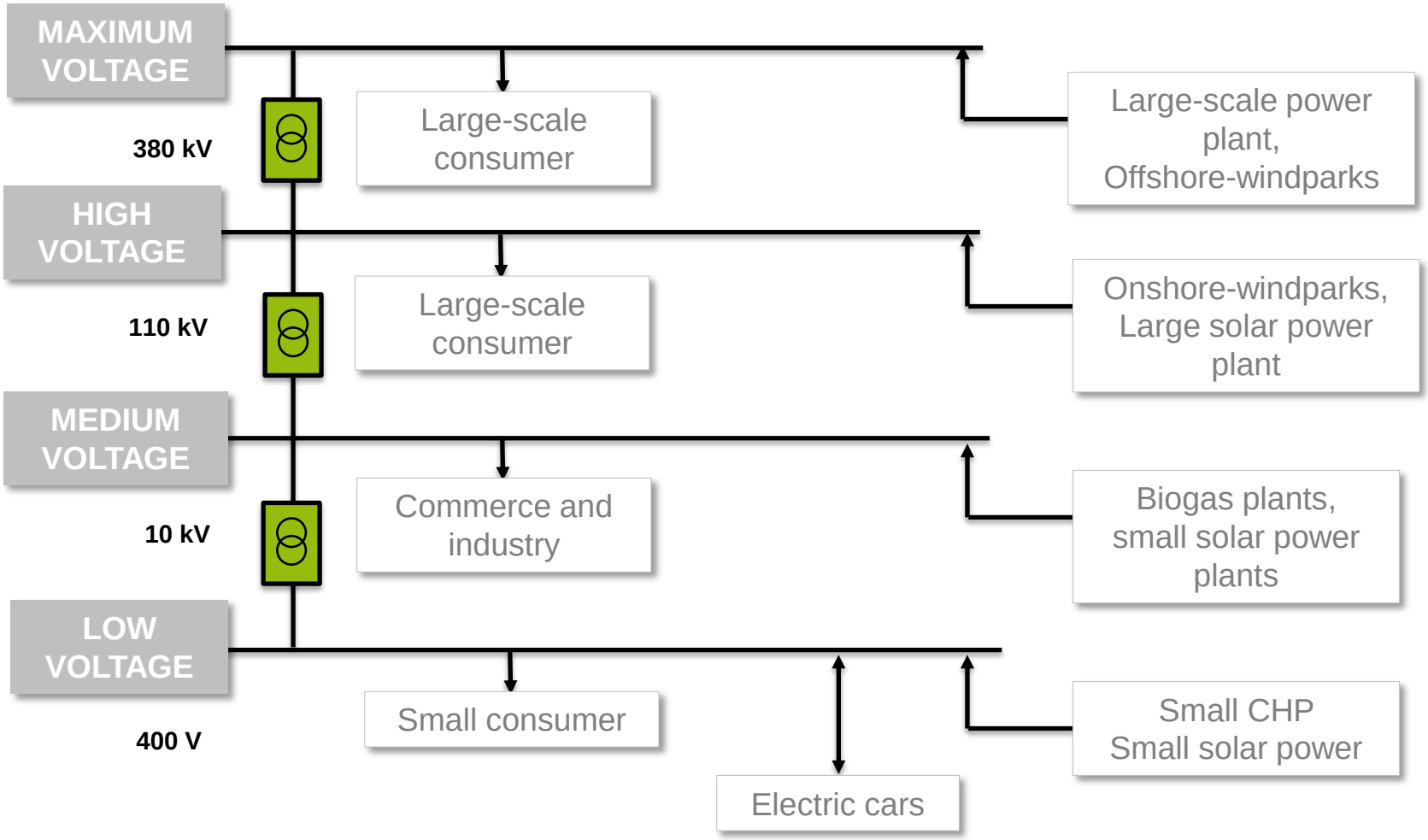
Biogas is in comparison expensive

There will be times of excess energy and lack of energy

→ Flexibility will be a must for Biogas

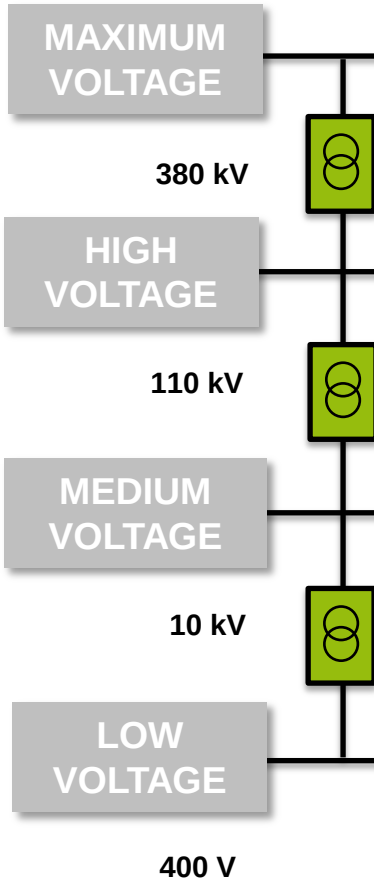
Agora Energiewende: 12 insights on Germany's Energiewende February 2013

Renewables feed-in into power grids



Source: own illustration after www.energie-lexikon.info
pirctures: Uwe Schlick/pixelio.de (Solar), Martin Dotzauer/DBFZ (Biogas and maps), Petra Bork/pixelio.de (Wind)

Renewables feed-in into power grids



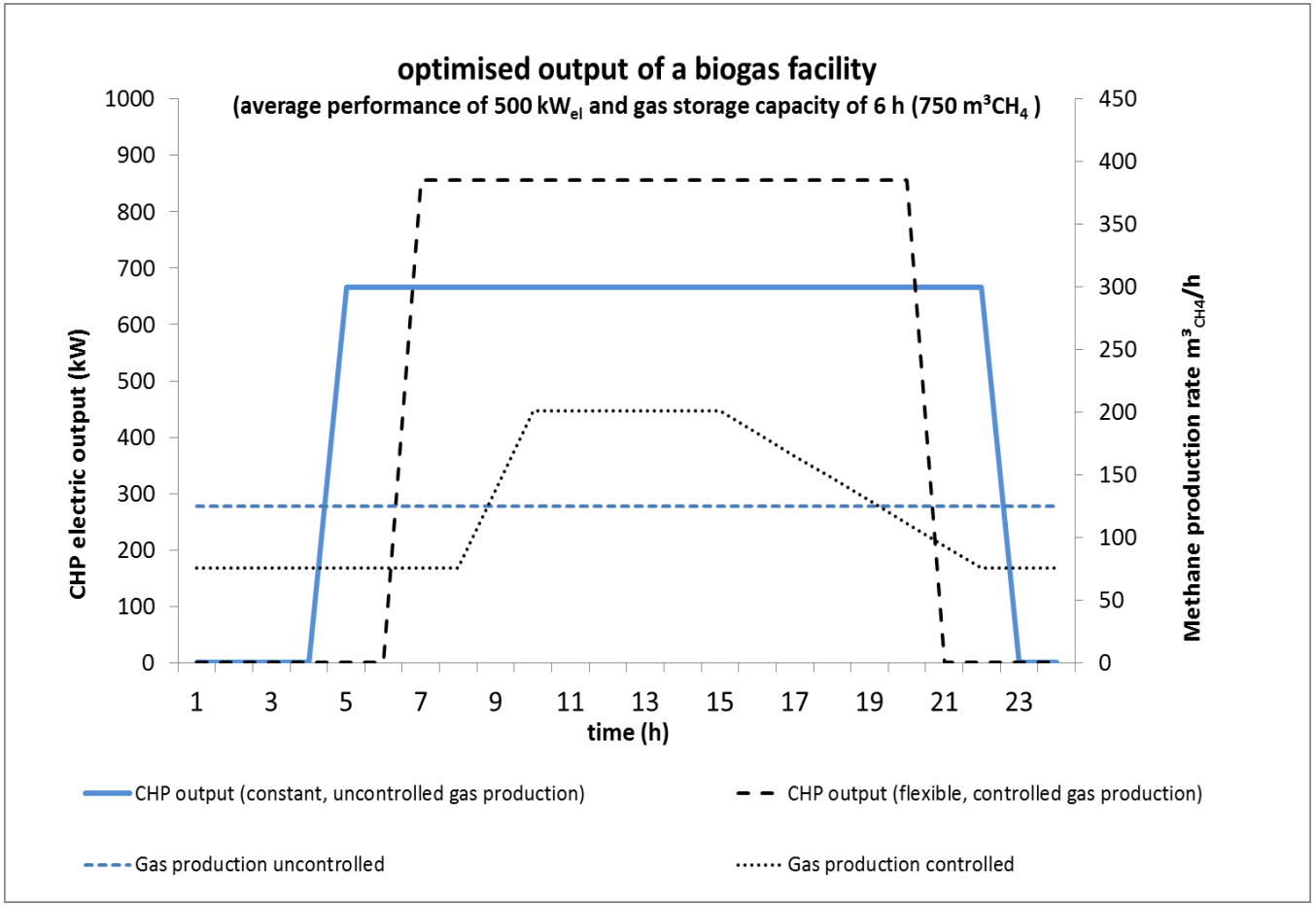
The bulk of electricity based on biogas is fed in medium voltage grids

Source: own illustration after www.energie-lexikon.info
pirctures: Uwe Schlick/pixelio.de (Solar), Martin Dotzauer/DBFZ (Biogas and maps), Petra Bork/pixelio.de (Wind)

Case study –

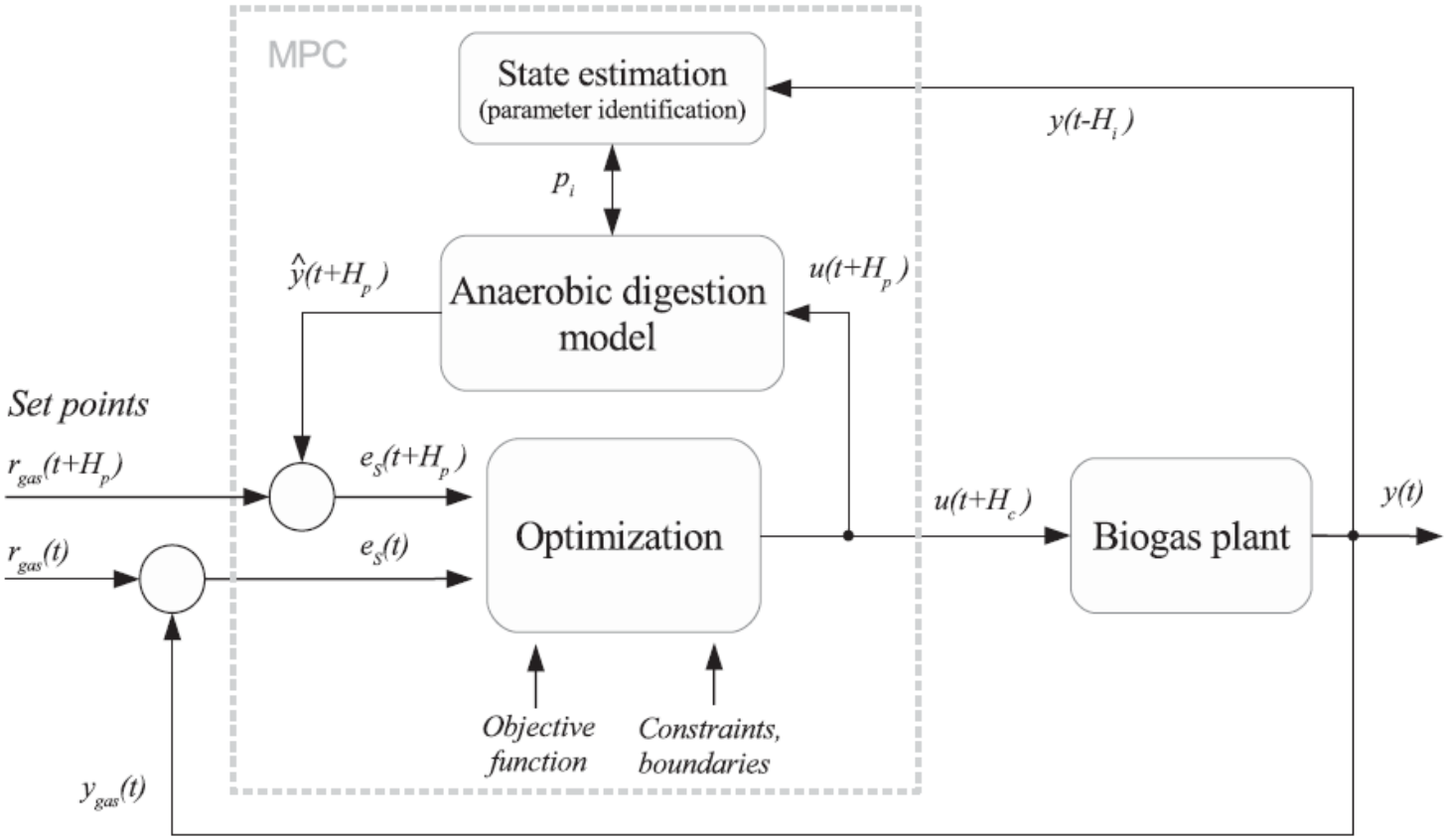
control of biogas production rate

Effect of manipulated gas production rate



Thrän et al 2015

Process control



(Mauky et al: Chem. Eng. Technol. 2016, 39, No. 4, 652–664., DOI: 10.1002/ceat.201500412

Set variable: substrate and feeding amount

Controlled process variable: gas storage filling level

Demonstration test

DBFZ- Pilot plant facility

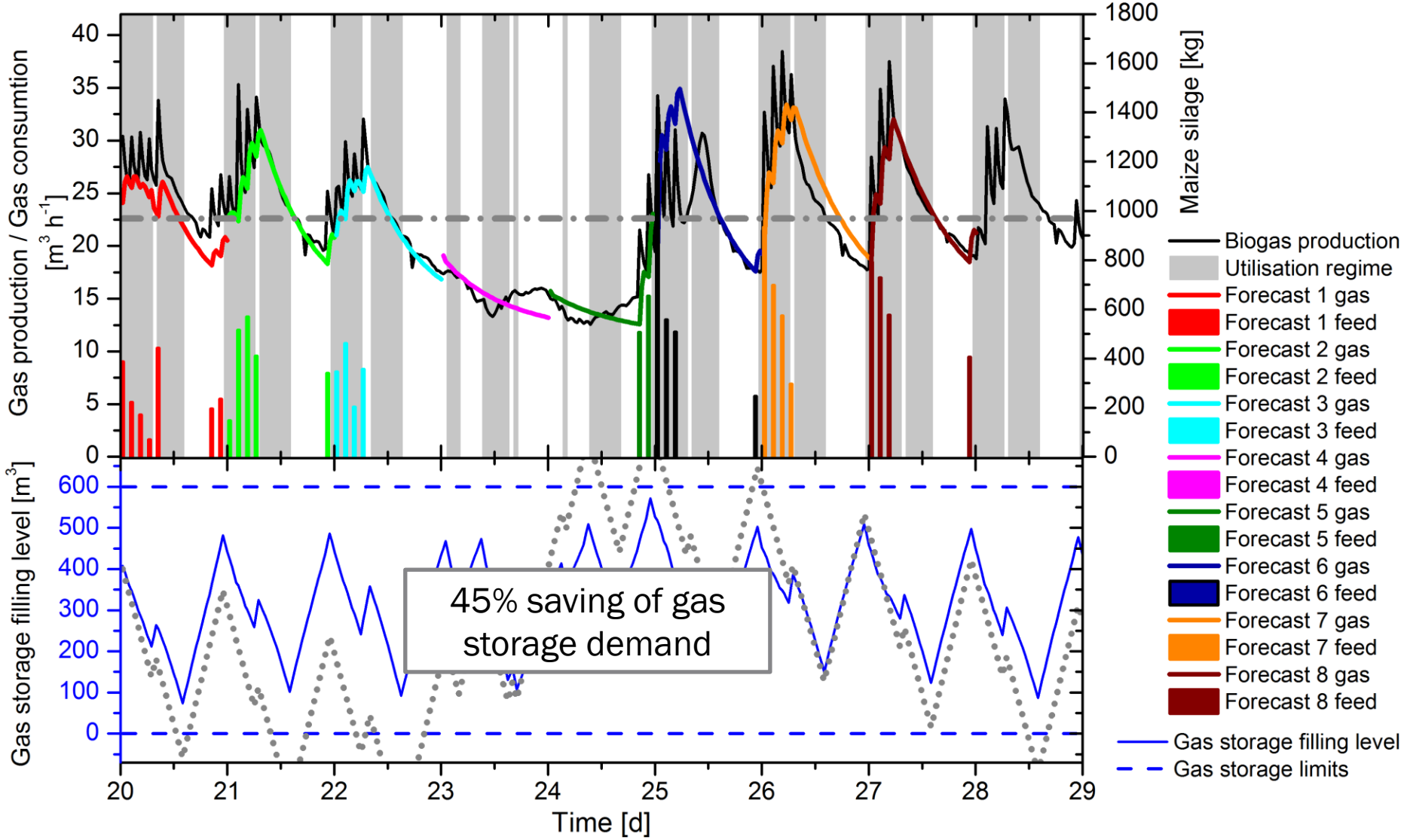
Source: DBFZ

Main digester:
190 m^3 (165 m^3 reaction volume)

Substrates:

- Corn silage,
- Cow manure,
- Sugar beet silage

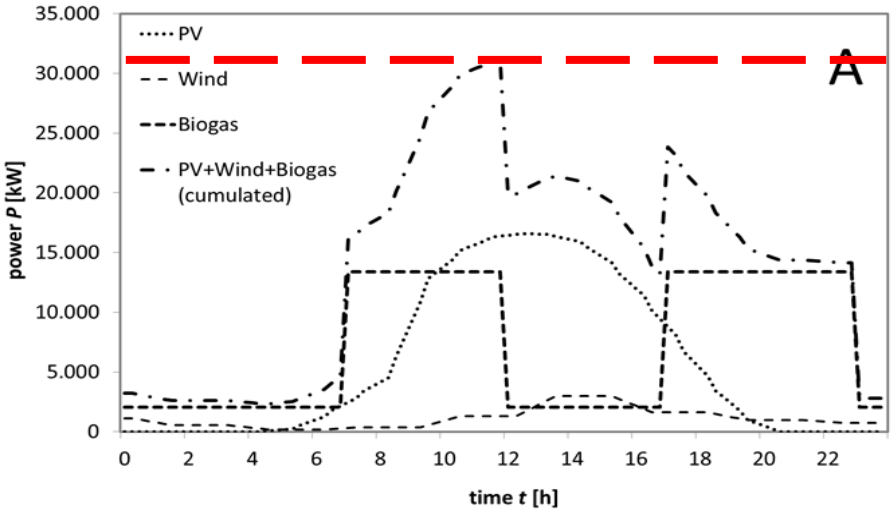
Model predictive feed control
(Plant A - DBFZ Research biogas plant)

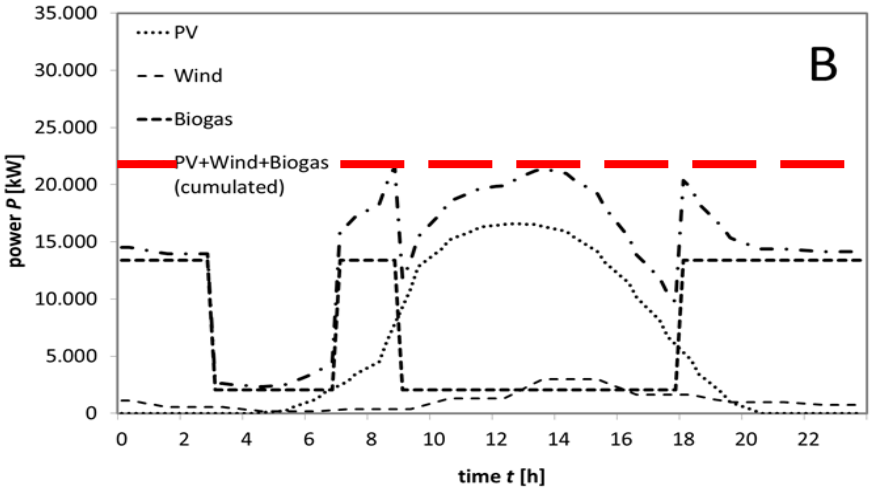


(Mauky et al: Chem. Eng. Technol. 2016, 39, No. 4, 652–664., DOI: 10.1002/ceat.201500412)

Grid stabilization

Status quo of feed-in of renewables A intelligent feed in of power from biogas B





Trommler et al, 2016, subm.

Market prices and grid operation does not fit necessarily together

Matching both can reduce peak situations in distribution networks and therefore reduces:

Imbalances, losses, necessary extension of cables and transformers, feeding into higher level grids

Flexible Bioenergy as a regional balancing option for power distribution grids

Project: RegioBalance

Partner:

- DBFZ
- Energy2markets
- 50Hertz GmbH
- Uniper Technologies GmbH (formerly E.ON Technologies GmbH)

Supported by:

- Federal Ministry for Economic Affairs and Energy
- Funding Agency: Projekträger Jülich

Project RegioBalance at a glance

- **Aim:**
  - **Can Biogas plants support balancing of distribution grids?**
  - **Show the ability of biogas plants to balance the operation of power distribution grids.**
- **Approach:**
  - **Scenario calculation for 2020 and 2025 based on real grid data for 2 grid parts, one in North on in East Germany**
- **Results: significant improvements for grid related parameter**
  - **Voltage band, Cable loading, Transformer station utilization rate, Losses, Backfeeding of active Power**

Research Approach – 2) Characteristics of grid parts for substation districts in East and North Germany.

Substation District East Germany	Substation District North Germany
Grid type: multiple ring network	**Grid type:** radial network with rings
Total line length l: 17 km	**Total line length l:** 83 km
Connected load: Photovoltaics 29 MW Wind 0 MW Biogas 6.7 MW Other renewable energy 7 MW Conventional Energy 12 MW	**Connected load:** Photovoltaics 12 MW Wind 42 MW Biogas 16 MW Other renewable energy 0 MW Conventional energy 0 MW
Maximum demand / thereof 30 %: 14 MW/4.2 MW All calculations are conducted with a minimum demand of 4.2 MW.	**Maximum demand / thereof 30 %:** 46 MW/ 14 MW All calculations are conducted with a minimum demand of 14 MW.
Transformers: 2 x 31.5 MVA	**Transformers:** 1x 63 MVA, 1 x 50 MVA, 1 x 40 MVA

Trommler et al, 2016, subm.

Research Approach – 1) Scenario Framework for grid calculation

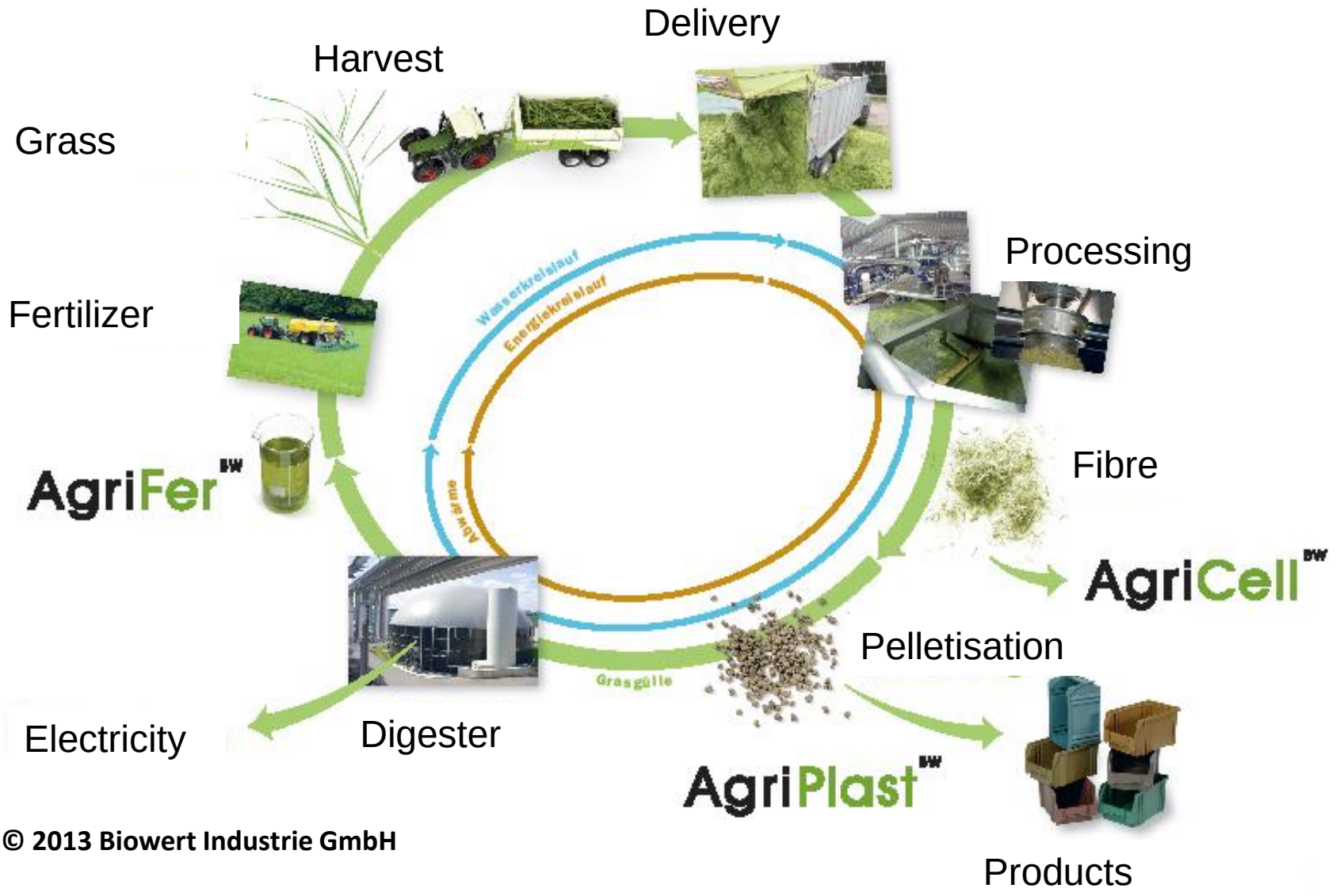
Scenario	Biogas plants P_{el} > 200 kW	Increase of Power by Photovoltaics	Increase of Power by Wind onshore	Increase of Power by Fossil based CHP units	Reduction of Gross electricity consumption	Power-to-Gas
Unit	[%]	[%]	[%]	[%]	[%]	[-]
I 2015 Status quo	Individual values for each transformer substation district: e.g. grid topology, plant pool, power demand. Scenario I is set 100% for each parameter.					----
II 2020 Biogas unchanged compared to Scenariol	no amendments	132	134	111.8	92.7	-----
III a/b 2020 Biogas 100 % load	200	132	134	111.8	92.7	-----
IV a/b 2025 Biogas 25 % load	200	165	168	113.4	85.9	-----
V a/b 2025 Biogas 100 % flexible incl. PtG	200	165	168	113.4	85.9	1 plant with P_{el} = 6.3 MW

Trommler et al, 2016, subm.

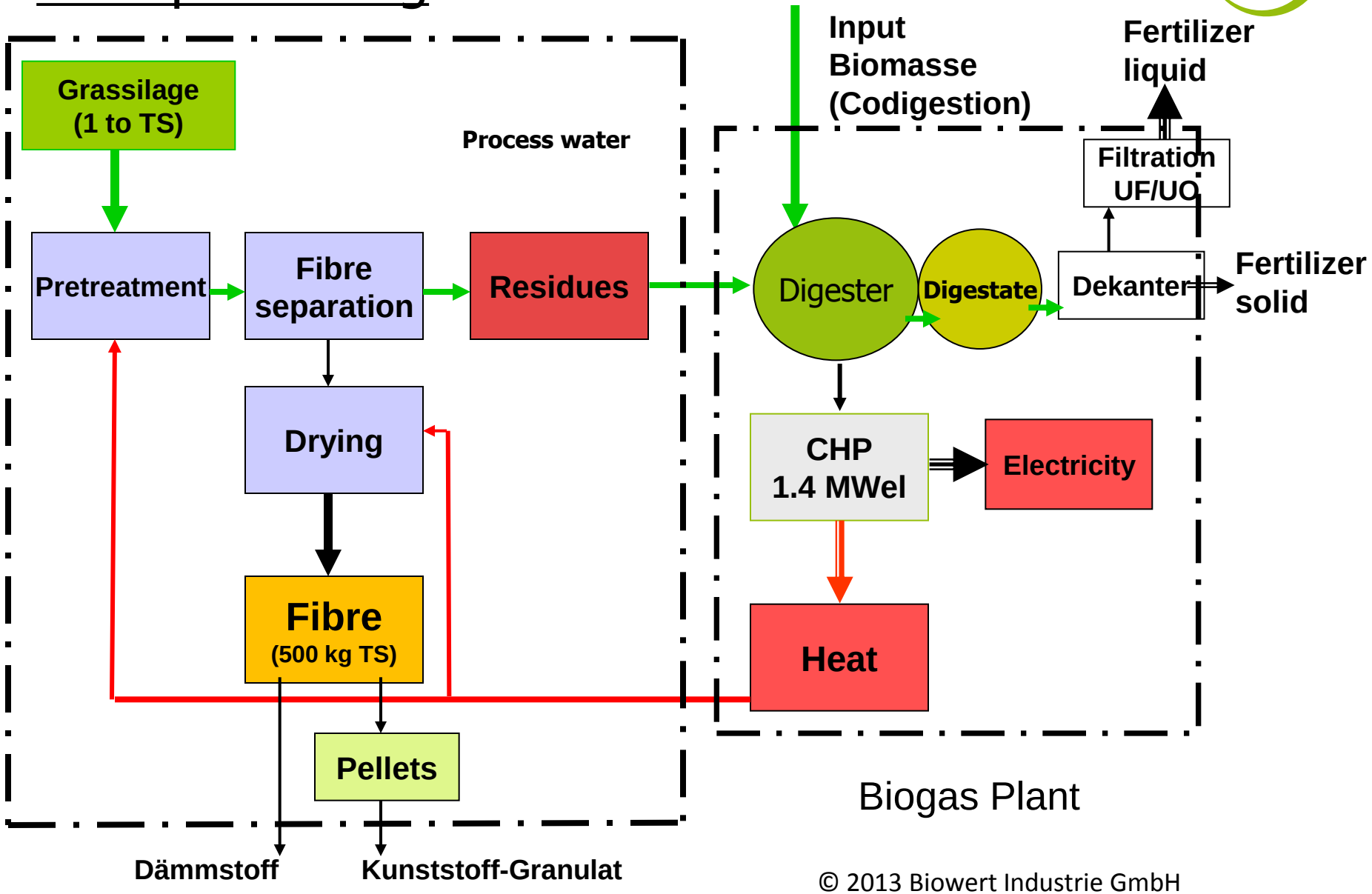
Combined material production and energy provision

Combined energy and material production

The BIOWERT Circle



Grassprocessing



Conclusion - Biogas production on the way towards competitiveness

Significant reduction of costs is not very likely

Alternative substrates require close look on overall conditions

Future electricity market and improved heat utilization can help to improve economics, biogas has also a valuable relevance for grid stabilisation

Combination material and energy production needs to become more often applied

INVITATION AND
CALL FOR ABSTRACTS

III. Conference on "Monitoring & Process Control of Anaerobic Digestion Plants"

Present your work and submit an abstract until Sept 20, 2016!

EARLY BIRD BY JAN 20, 2017

SPECIAL EVENT
AquaMak + Record Biomap

RECORD BIOMAP NETWORK

Biomass energy use

MARCH 29 — 30
2017 IN LEIPZIG

INVITATION AND CALL FOR ABSTRACTS

III. Conference on "Monitoring & Process Control of Anaerobic Digestion Plants"

TOPICS OF THE CONFERENCE

- Sensor concepts & applications
- Process simulation & control
- Monitoring and control of plant efficiency
- Practical experience of process monitoring and control
- Laboratory measurements: Reliability & validity
- Monitoring for safety and emission reduction purposes
- Microbiological analysis: Potential for process characterization and optimization

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SPECIAL EVENTS

March 30 — 31, 2017
Tagung AquaMak (in German): Aquatische Makrophyten – ökologisch und ökonomisch optimierte Nutzung (BMEL / FNR)

March 28, 2017
Workshop Record Biomap: Biomethane production in small and medium scale units (EU-HORIZON)

- Poster presentation award
- Exhibition featuring companies' products and services

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