Deutsches Biomasseforschungszentrum
gemeinnützige GmbH

DBFZ

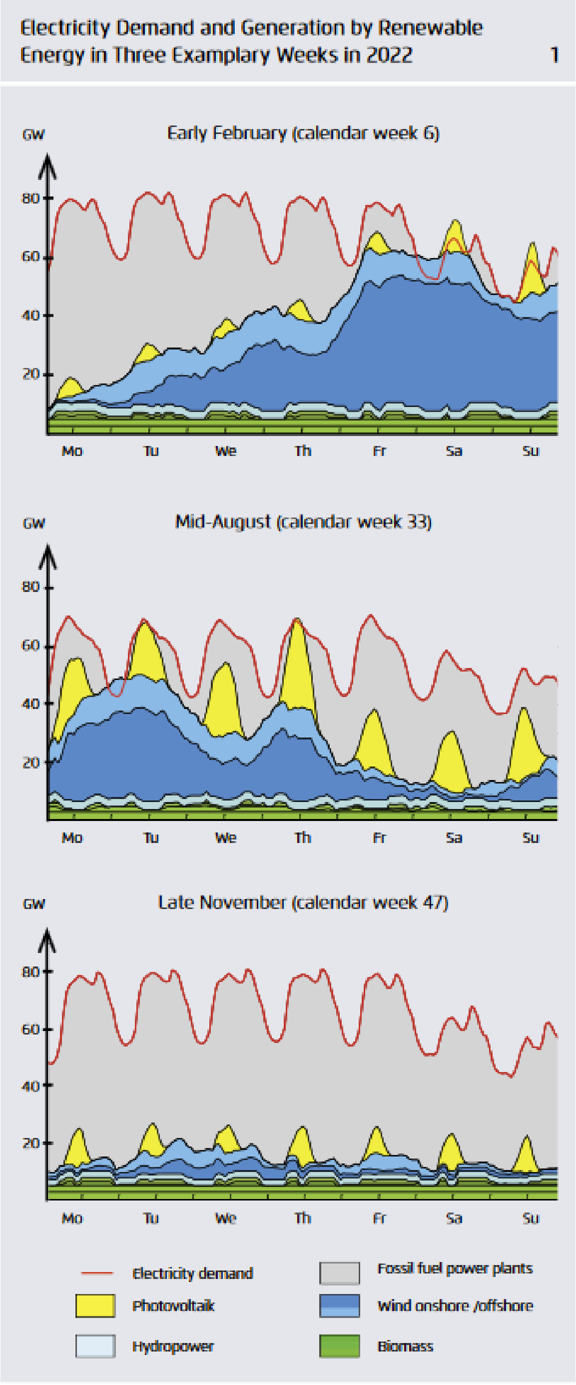
Flexibilisation of biogas plants and impact on the grid operation

Jan Liebetrau,

Marcus Trommler, Eric Mauky, Tino Barchmann, Martin Dotzauer




Biogas Workshop, Vlijmen, April 5th 2017



Electricity provision – future scenarios

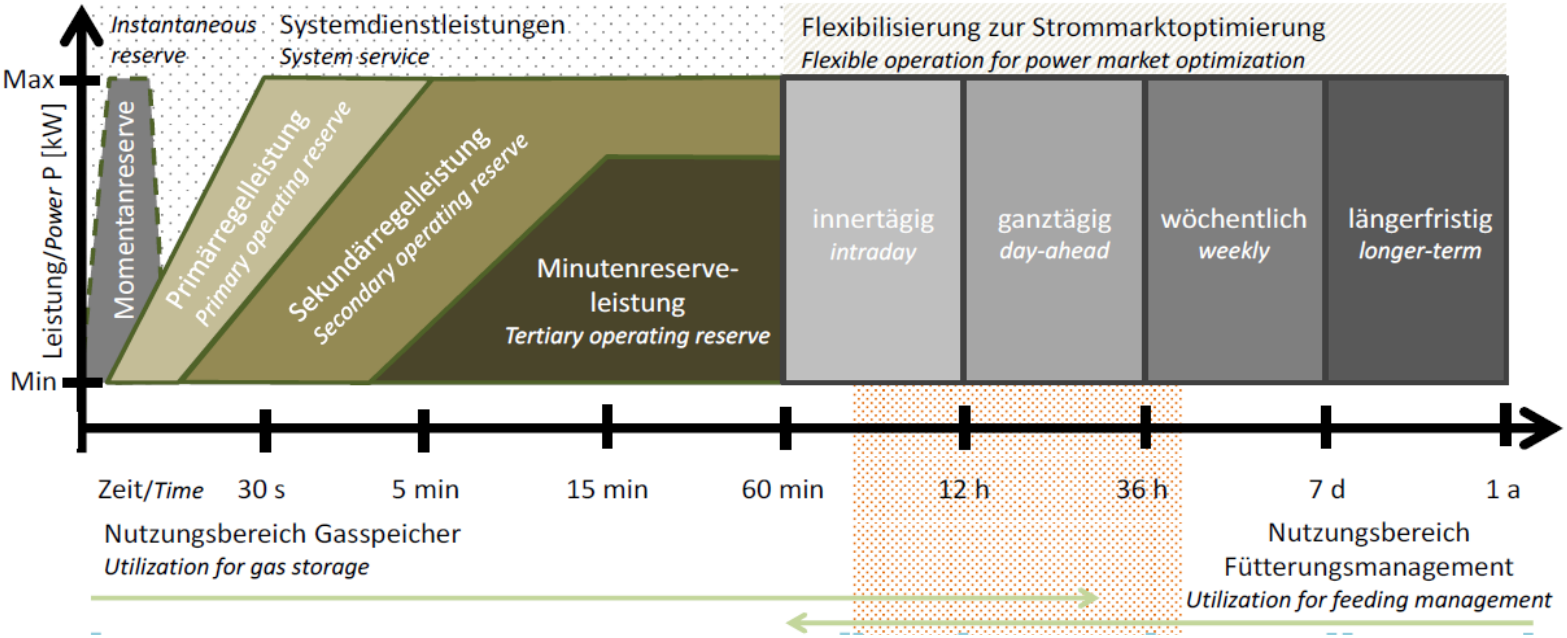
Biogas is in comparison expensive

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

Conditions for flexible operation

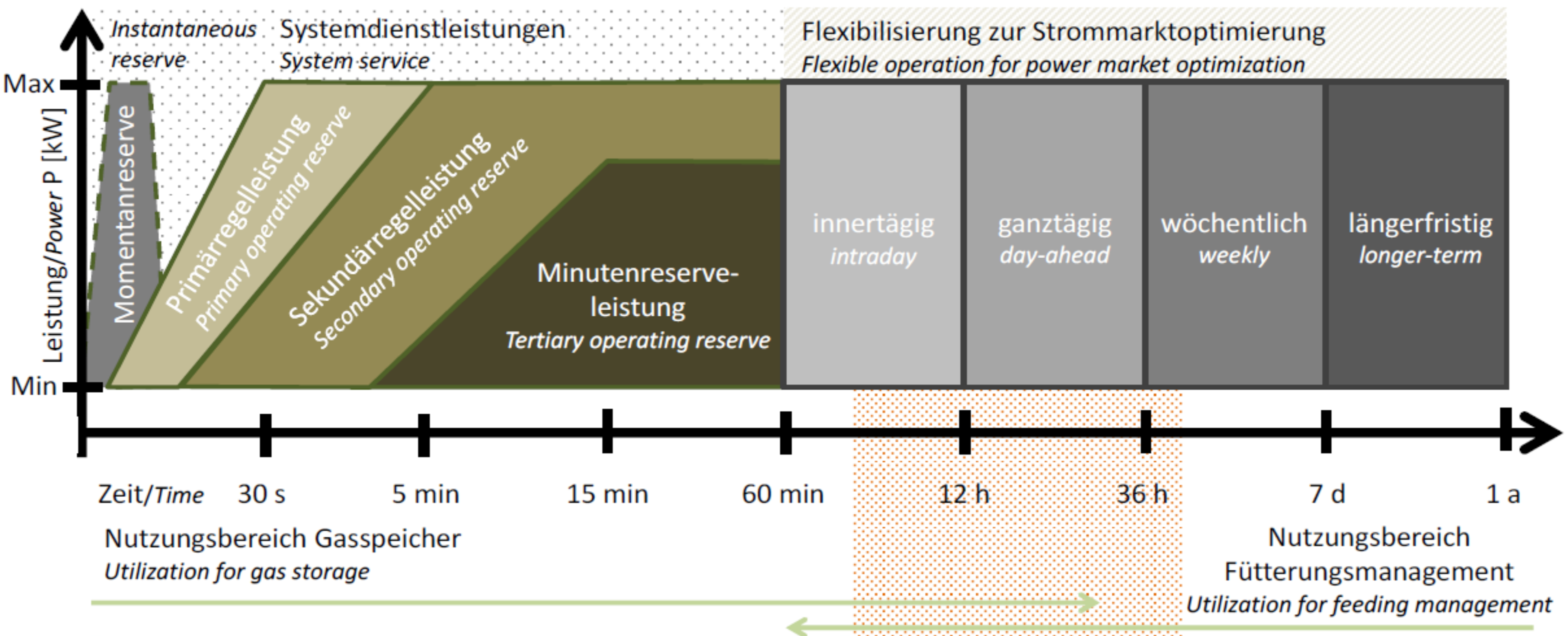


Different market options with different requirements for participation

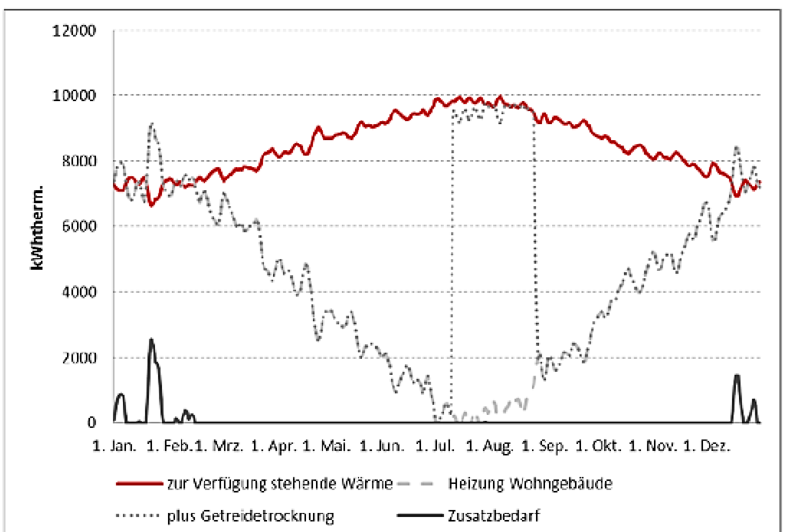
Biogas plants have individual constructive and operational design which define the limits of flexibility

Barchmann et. al. 2016

Conditions for flexible operation



Barchmann et. al. 2016

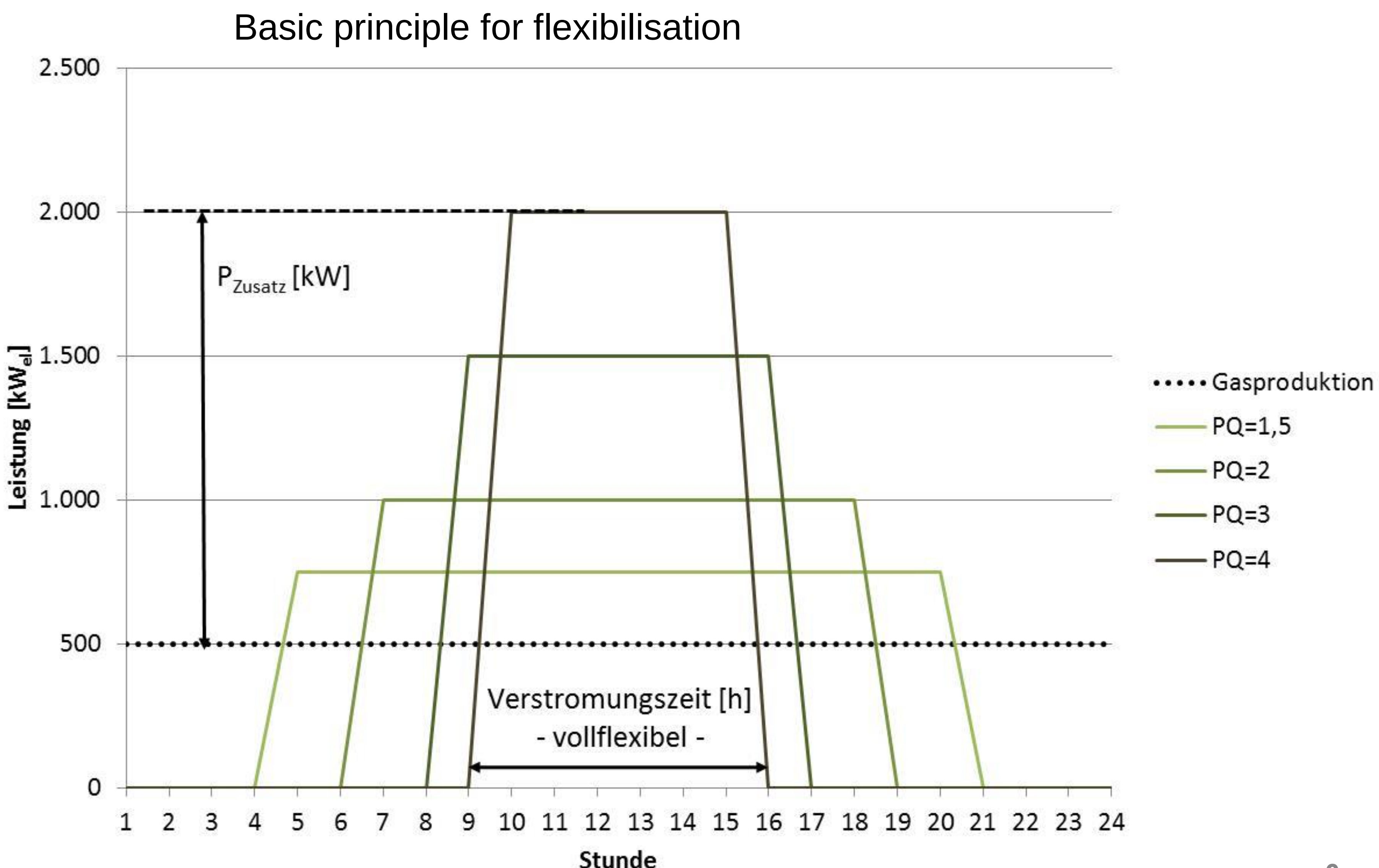


[Fuchs 2012]

Conclusion - why do we need to operate biogas plants flexible?

- **provide energy when needed (electricity and heat)**
    - Market price oriented, increase utilization
    - Grid stabilization oriented
- **reduces losses at specific operational conditions (e.g. maintenance shutdown, weather changes)**
- **respond to substrate changes in amount and quality**

Flexibilisation



Technical options for flexibility, services to the grid and sector coupling on site

- Increase of CHP capacity (and grid access) - in case of constant annual energy output
- Increase of gas storage capacity
- Control of biogas production rate
(controlled feeding, storage of intermediates)

- Power to heat
- Biomethane
- Power to gas

Financial support for flexible concepts

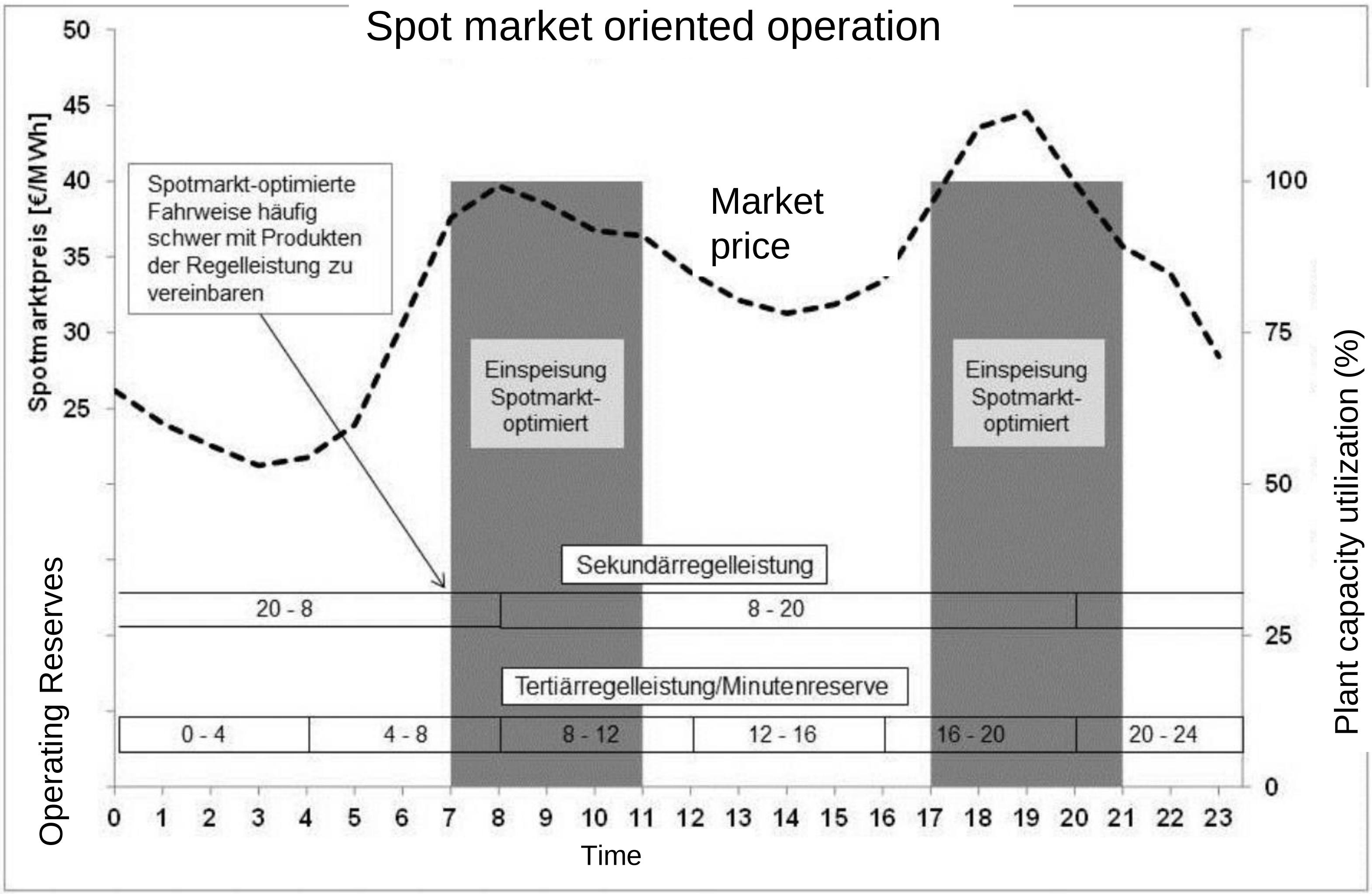
- **EEG 2014:**
- **§ 54 Flexibility bonus for existing plants**
  - 130 €/kW/a (Allocation to produced electricity) for 10 years
- **Appendix 3 Number I:**
  - Direct marketing compulsory
  - $P_{average} \leq 0,2*P_{inst}$
  - $P_{added} = \text{max. } 0,5*P_{inst}$
  - Registration and expert statement
- **„Average capacitiy“ (§ 101 EEG 2014) limited**
- **EEG 2017:**
- **Obligation to have twice as much capacity installed in relation to average capacity**
- **40€/kW installed for existing plants**

Motivation for flexible operation

- **Financial motivation**
  1. Flexibility bonus
  2. Efficiency increase (larger and newer CHP)
  3. Additional income from direct marketing and services(EPEX)

- **Costs for flexibilisation**
  1. Invest (CHP, Gas-, Heat storage, Infrastructure, Grid access, Transformer)
  2. Planning, permission, e.g. StröfallVO
  3. More maintenance, Wear out, Stand-by losses

Markets and prices

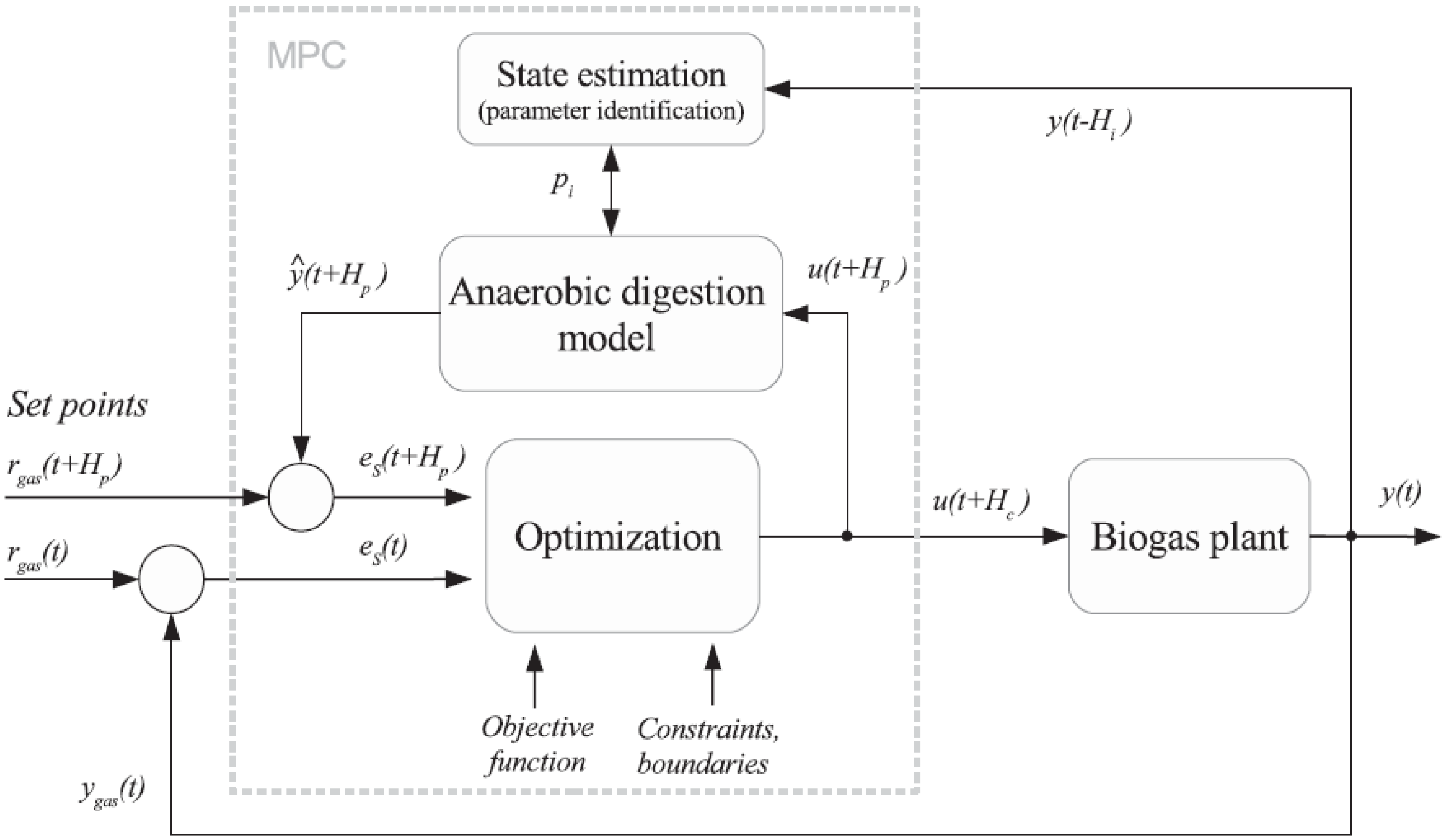


(Trommler et al 2016)

Case study –

control of biogas production rate

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

Experimental setup

(Plant A) DBFZ - Research biogas plant

Source: DBFZ

190 m³ (165 m³ active volume)

Used substrates:

- Maize silage,
- Cattle slurry,
- Sugar beet silage

(Plant B) Biogas plant „Unterer Lindenhof“
(University of Hohenheim)

Source: Novatech

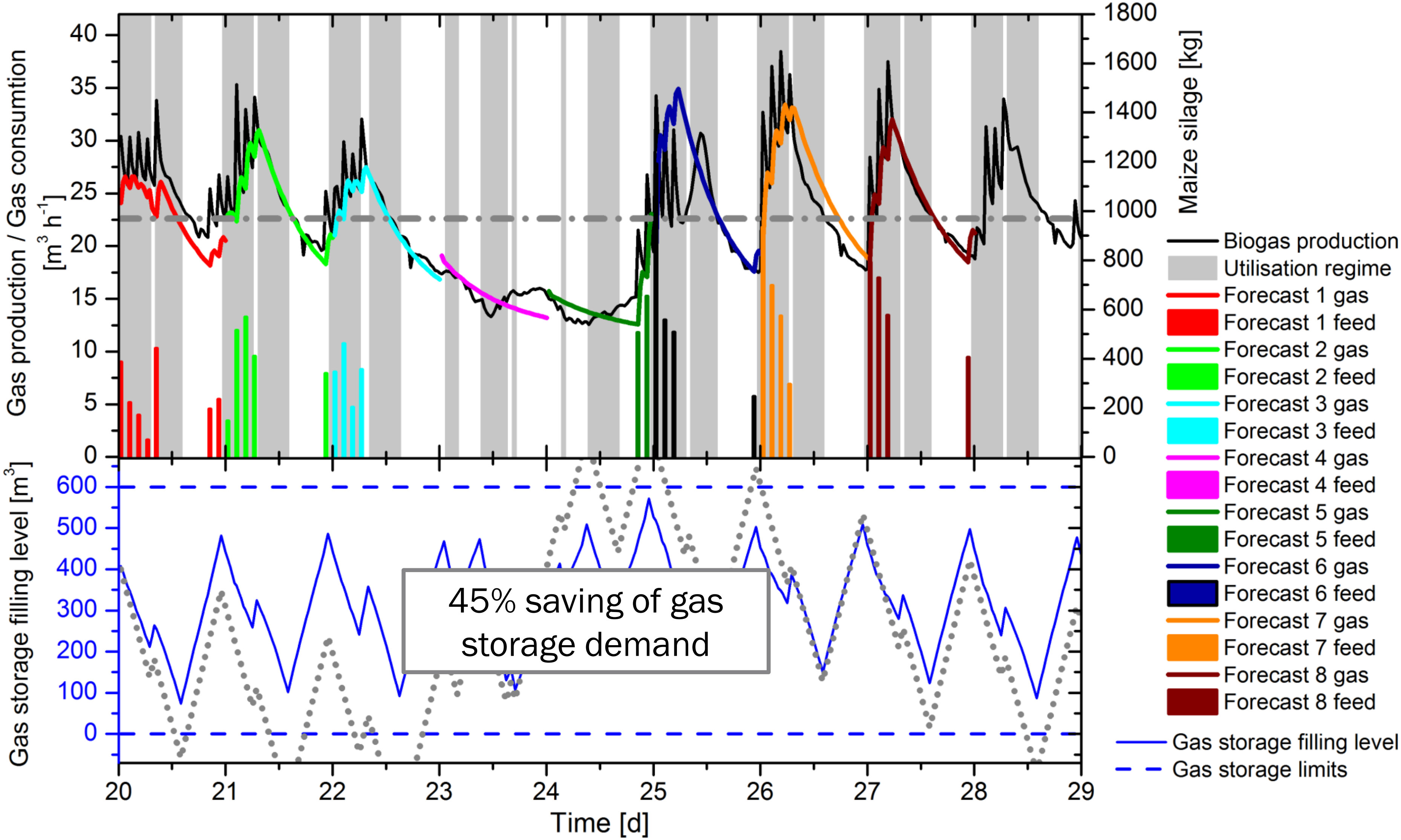
923 m³ (800 m³ active volume)

Used substrates:

- Maize silage,
- Grass silage,
- Wheat meal

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

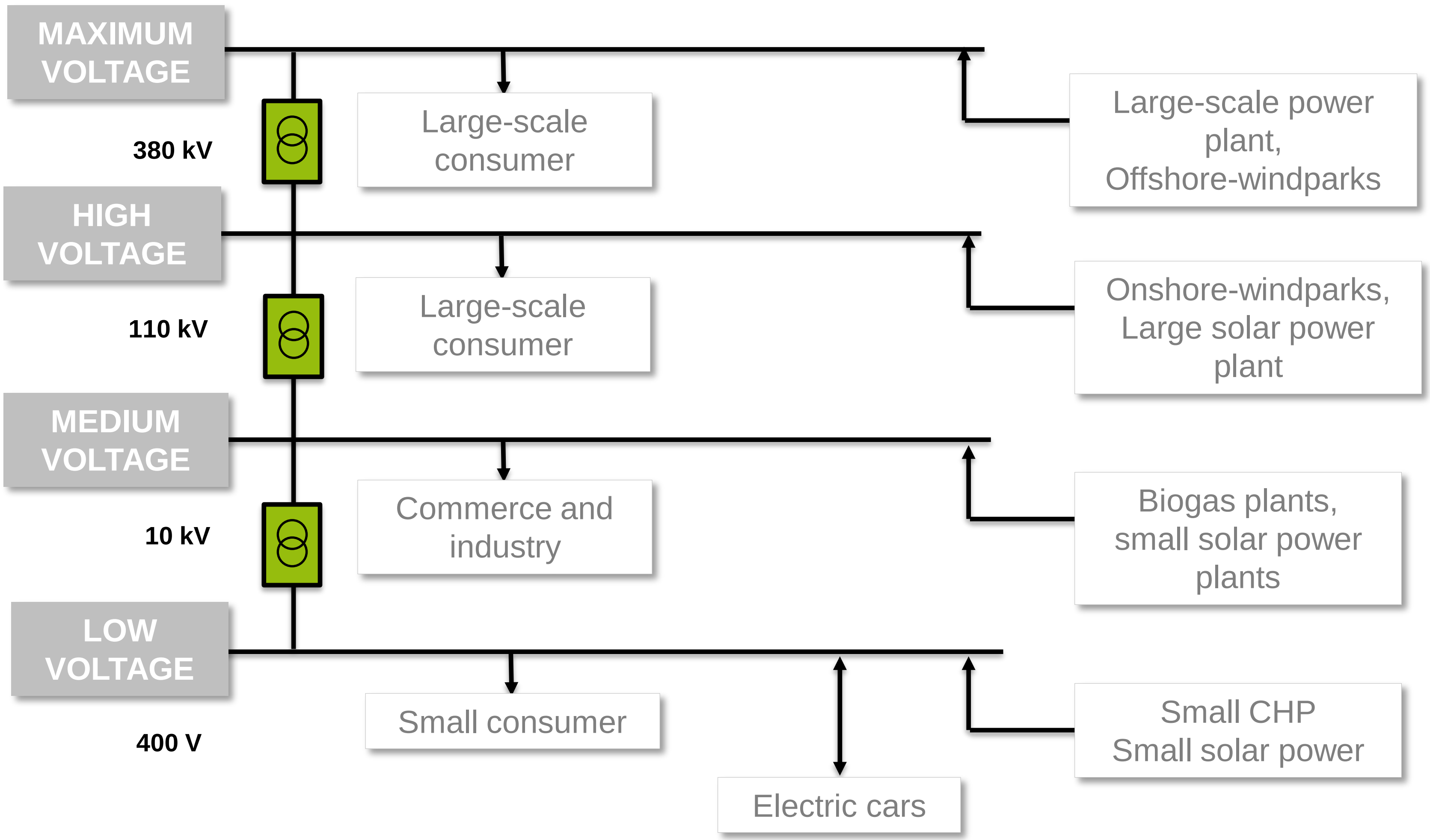
Model predictive feed control
(Plant A - DBFZ Research biogas plant)



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

Grid stabilization

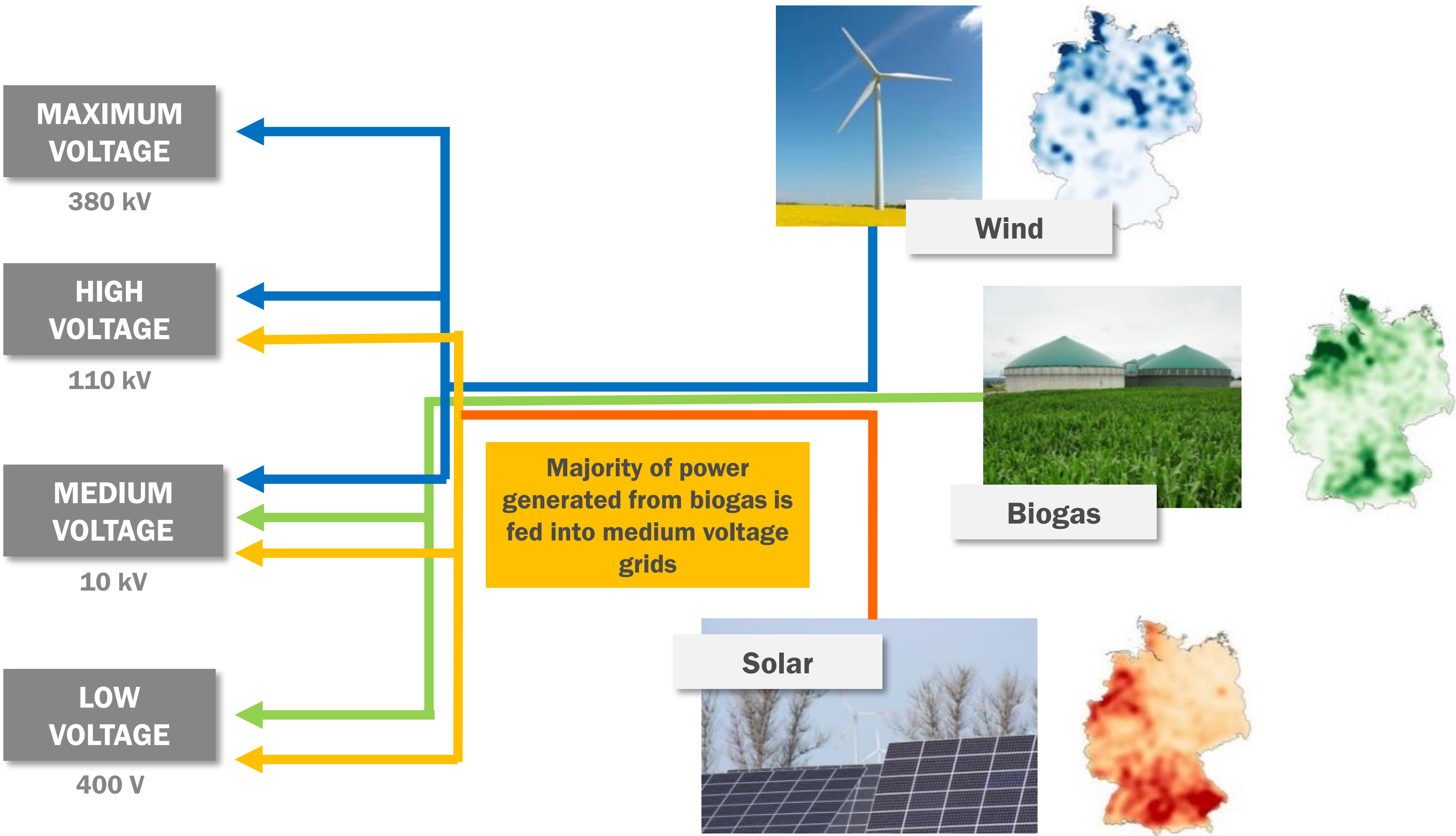
Renewables feed-in into power grids



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)

Structure of Power Grid Infrastructure

SD in medium voltage as subject matter



Source: Own diagram based on www.energie-lexikon.info

Picture credits: Uwe Schlick/pixelio.de (Solar), Martin Dotzauer/DBFZ (Biogas and maps), Petra Bork/pixelio.de (Wind)

Flexible Bioenergy as a regional balancing option for power distribution grids

DBFZ

Project: RegioBalance

Partner:

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

Supported by:

Bundesministerium für Wirtschaft und Energie

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

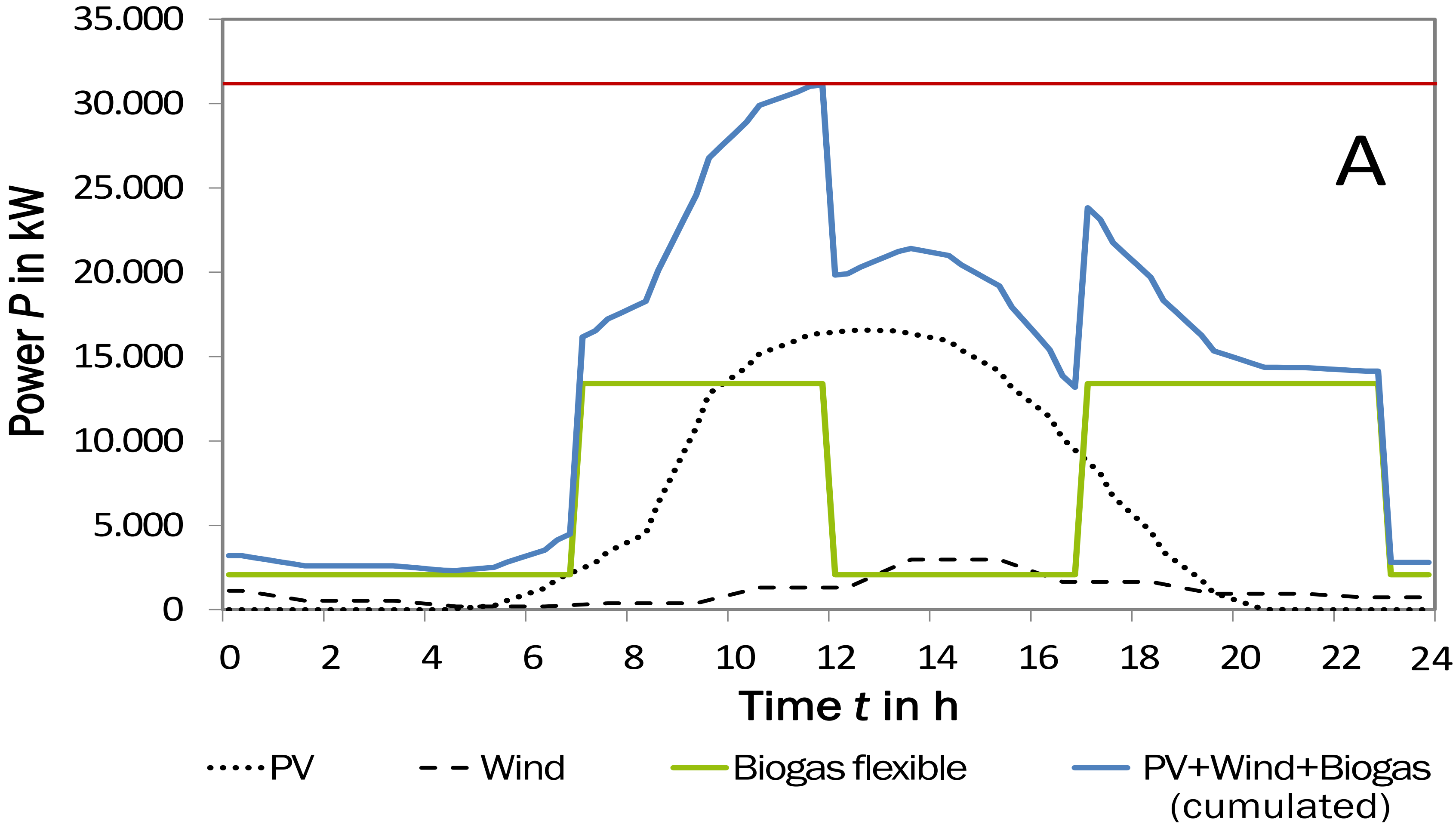
Projektträger Jülich Forschungszentrum Jülich

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**

Modelled Load Profile (EPEX-optimised)

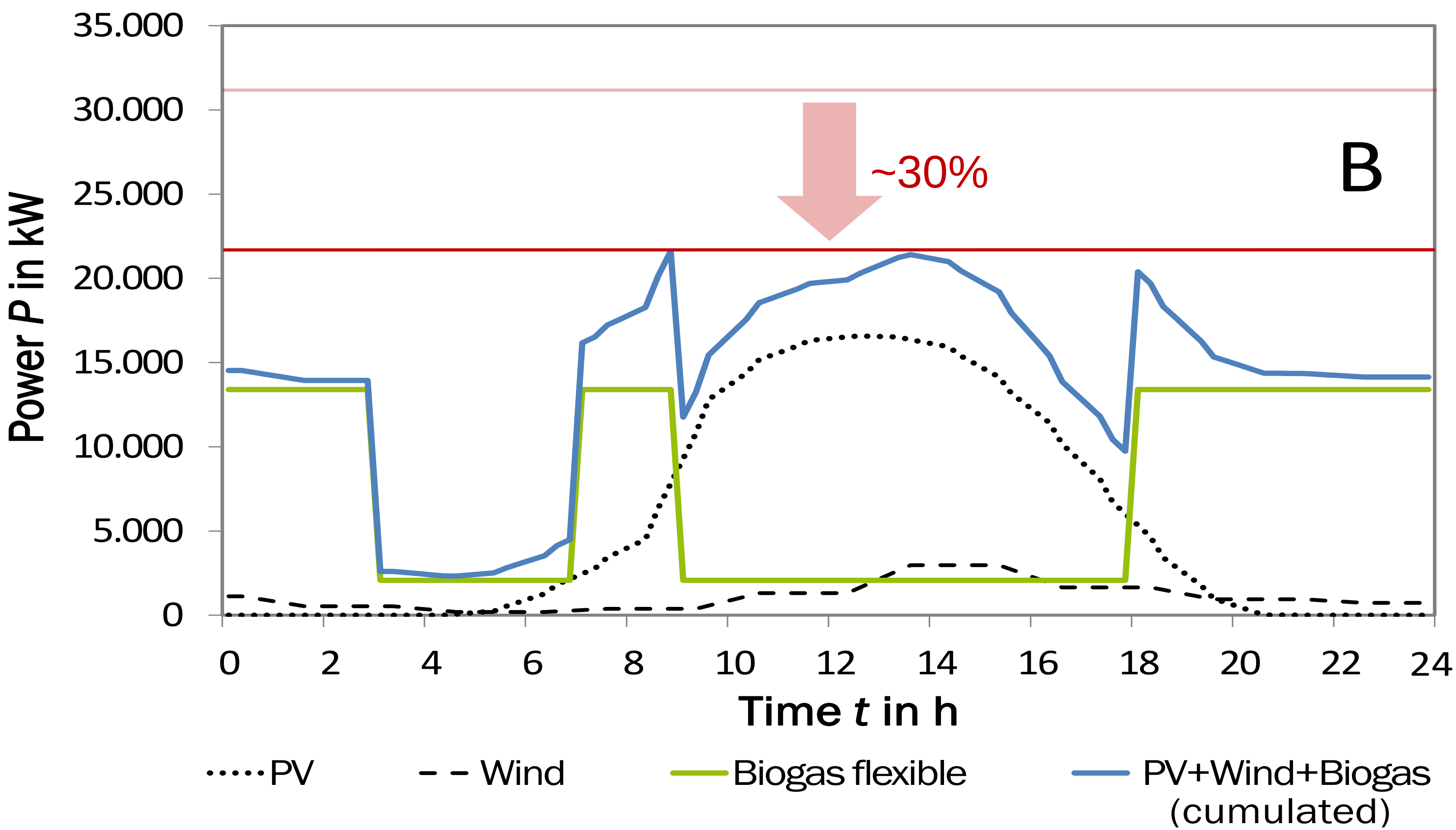
Flexible operation **without** consideration of grid restrictions (A)



Source: modified based on Trommler et al. 2017: Can Biogas Plants Contribute to Lower the Demand for Power Grid Expansion?, Chem. Eng. Technol. 2017, 40, No. 2, 359–366 , DOI: 10.1002/ceat.201600230

Modelled Load Profile (EPEX-optimised)

Flexible operation **with** consideration of grid restrictions (B)



Source: modified based on Trommler et al. 2017: Can Biogas Plants Contribute to Lower the Demand for Power Grid Expansion?, Chem. Eng. Technol. 2017, 40, No. 2, 359–366 , DOI: 10.1002/ceat.201600230

Methodological Procedure

Structure of grid areas

Parameter	Substation district **East Germany**		Substation district **North Germany**	
Grid type	Multiple ring networks		Radial network with rings	
Total cable length	17 km		83 km	
Connected load	Photovoltaics	29 MW	Photovoltaics	12 MW
	Wind	0 MW	Wind	42 MW
	Biogas	6.7 MW	Biogas	16 MW
	Other renewable energies	7 MW	Other renewable energies	0 MW
	Conventional energies	12 MW	Conventional energies	0 MW
Maximal demand	14 MW		46 MW	
30% of max. = minimum demand	4.2 MW		14 MW	
Transformers	2 x 31.5 MVA		1x 63 MVA, 1 x 50 MVA, 1 x 40 MVA	

Source: Trommler et al, 2017: Can Biogas Plants Contribute to Lower the Demand for Power Grid Expansion?, Chem. Eng. Technol. 2017, 40, No. 2, 359–366 , DOI: 10.1002/ceat.201600230

Research Results – Substation district North Germany

Scenarios for a substation district in North-East Germany	Voltage band		Cable loading - utilization rate (current)	Transformer stations (three) – utilization rate (apparent power)			Losses (of power P)	Backfeeding of active power P into the 110 kV grid
Unit	[p.u.]	[p.u.]	[%]	[%]	[%]	[%]	[MW]	[MW]
I 2015 Status quo	0.99	1.05	87	39	70	53	1.78	75
II 2020 Biogas unchanged compared to Scenario I	0.99	1.08	105	56	71	80	2.85	97
IIIa 2020 Biogas 100 % load	0.97	1.07	130	72	72	99	3.82	112
IIIb 2020 Biogas 25 % load	0.98	1.07	99	50	71	73	2.65	90
IVa 2025 Biogas 100 % load	0.97	1.09	145	86	73	122	5.49	130
IVb 2025 Biogas 25 % load	0.98	1.09	120	65	71	99	4.07	107
Va 2025 Biogas 100 % load incl. PtG	0.97	1.09	145	86	60	122	5.49	123
Vb 2025 Biogas 25 % flexible incl. PtG	0.98	1.09	120	65	59	99	4.07	101

Trommler et al, 2016, subm.

Research Results – Substation district East Germany

Scenarios for a substation district in East Germany	Cable loading – utilization rate (current)	Transformer stations (two) – utilization rate (apparent power)		Losses (of power *P*)	Backfeeding of active power *P* into the 110 kV grid
Unit	[%]	[%]	[%]	[MW]	[MW]
I 2015 Status quo	72	94	68	0.88	47
II 2020 Biogas unchanged compared to Scenario I	94	111	84	1.33	58
IIIa 2020 Biogas 100 % load	99	120	102	1.65	65
IIIb 2020 Biogas 25 % load	91	107	76	1.22	54
IVa 2025 Biogas 100 % load	120	133	117	2.15	75
IVb 2025 Biogas 25 % load	113	121	92	1.71	63
Va 2025 Biogas 100 % load incl. PtG	119	113	116	2.07	68
Vb 2025 Biogas 25 % load incl. PtG	113	101	92	1.63	57

Trommler et al, 2016, subm.

Concept of a pro-active Feed-in Management (paFeedMan)

DBFZ

- Conventional feed-in management: The grid operators will reduce the performance of generating plants if limit value violations for grid operating equipment are expected
- Concept paFeedMan: Controllable generating plants (here: flexible AD plants) are able to avoid limit value violations (e.g. voltage band) **already day-ahead (24 h in advance) by taking grid restrictions** into consideration in their **schedule design of the CHPs.**

→ Especially flexible producers can "**compensate" load peaks** caused by simultaneous high feed-in of wind and photovoltaics to reduce the maximal cumulated load of renewable energies

→ Benefit of paFeedMan in grid planning: **calculation with a lower maximal feed-in power** → required grid expansion can be reduced

Economic Evaluation Approaches

DBFZ

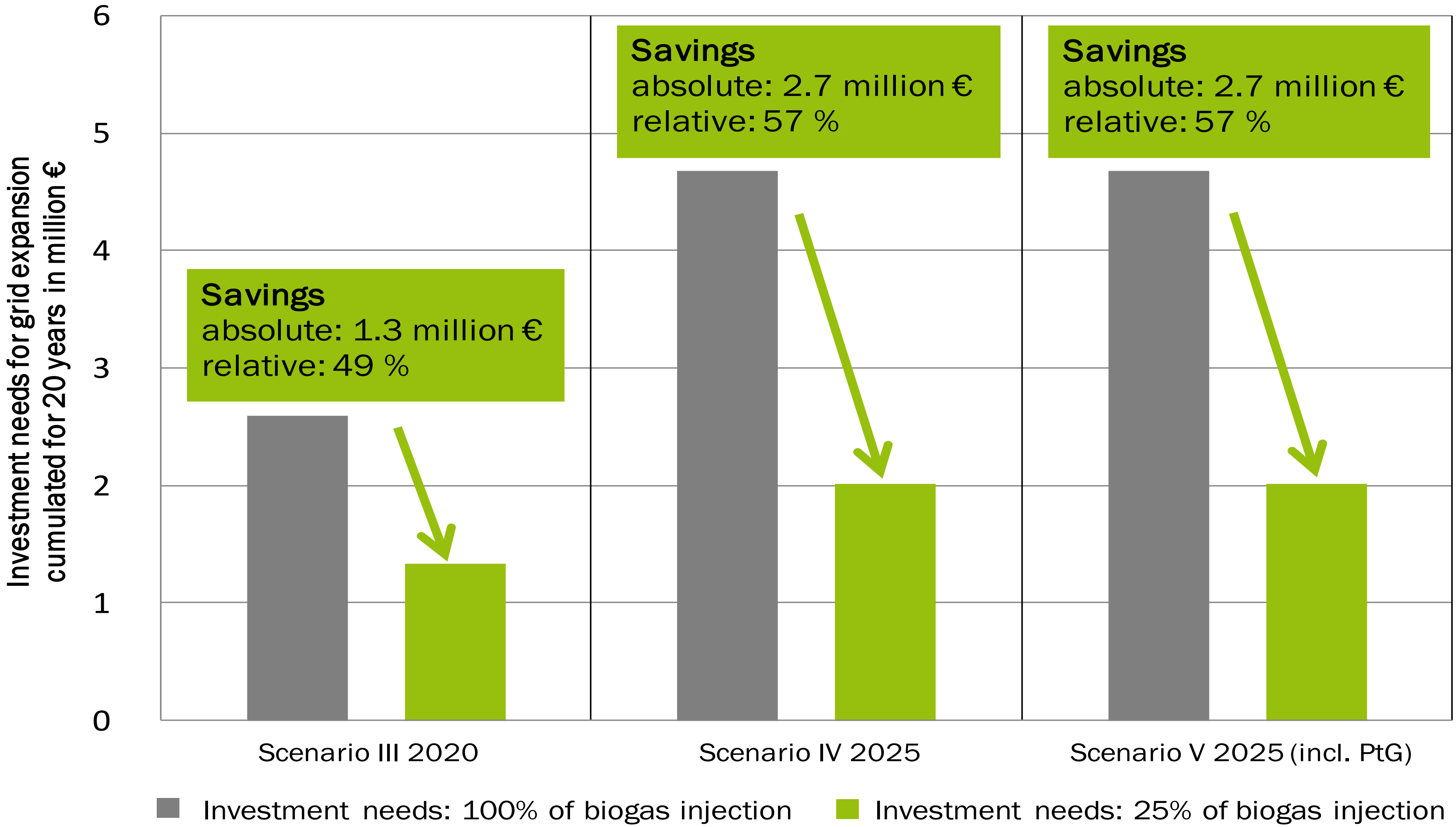
- The core of the economic evaluation approach is a **calculation of opportunity costs.** These costs as well as lost profits of an AD plant that is operated beneficially to the grid and the expenses for implementing and realising of paFeedMan are compared to the savings potential of future grid expansions.
- The results show that **in many investigated cases opportunity costs including costs for implementation and operation of paFeedMan for flexible AD plants are significantly lower (at least by a factor of 5) than the costs for grid expansion.**

→ Considerable savings at grid expansion can be generated

→ Options for smart grid planning and grid management can be economically reasonable and should be considered in the course of legal revisions in the future (e.g. in the Ordinance on Incentive Regulation (ARegV))

Cost Savings for grid expansion

within the frame of a paFeedMan-concept for SD North



SD= substation district

Source: DBFZ, 2016

Conclusion

Flexible Operation of biogas plants is possible
(and compulsory in the future)

Control of biogas production offers more flexibility

On the basis of real power grids it has been shown that flexible biogas plants are able to reduce power grid operation concerning several parameters:

- **Reduction of cable and transformer load, reduced grid losses, less reduction of renewable energy plant performances (conventional feed-in management) as well as reduced back-feeding in the higher grid level (110 kV)**

- **The use of flexibility options (such as biogas) shows significant cost advantages in comparison with conventional grid expansion in the investigated grids**

  - Biogas plants can make a difference

Deutsches Biomasseforschungszentrum
gemeinnützige GmbH

DBFZ

Smart Bioenergy – innovations for a sustainable future
Come and join us!

Contacts

Prof. Dr. mont. Michael Nelles
Daniel Mayer
Prof. Dr.-Ing. Daniela Thrän
Dr.-Ing. Jan Liebetrau
Dr.-Ing. Volker Lenz
Dr.-Ing. Franziska Müller-Langer
Dr. rer. nat. Ingo Hartmann

DBFZ Deutsches Biomasseforschungszentrum gemeinnützige GmbH

Torgauer Straße 116
D-04347 Leipzig
Phone: +49 (0)341 2434 – 112
E-Mail: info@dbfz.de
www.dbfz.de