Combination of biomethane filling stations and power generation to serve different profiles of fuel consumption

Jan Liebetrau, Rytec; Fatih Gökgöz, Michael Nelles (DBFZ)

BIOSWEET Annual Conference 09/10/2020

Rytec Abfalltechnologie und Energiekonzepte

Deutsches Biomasseforschungszentrum gemeinnützige GmbH DBFZ

Rytec- Waste technology and energy concepts

- Rytec offers a unique combination of innovative engineering and established experience in the operation of plants.
- Development, optimization, construction, retrofitting and control of process engineering systems in the energy and waste sectors.

In detail:

- Planning and Construction of Biogas plants, biological and thermal waste treatment, energy engineering as well as waste and landfill process engineering.
- Plant operations for CHP, AD plants, biomass power plants and waste water treatment plants.
- Consultancy for public and industry sector
- Emission monitoring, mitigation measures and measurement campaigns

Rytec
Abfalltechnologie
und Energiekonzepte

Outline

Background

—

Profiles and operational strategies

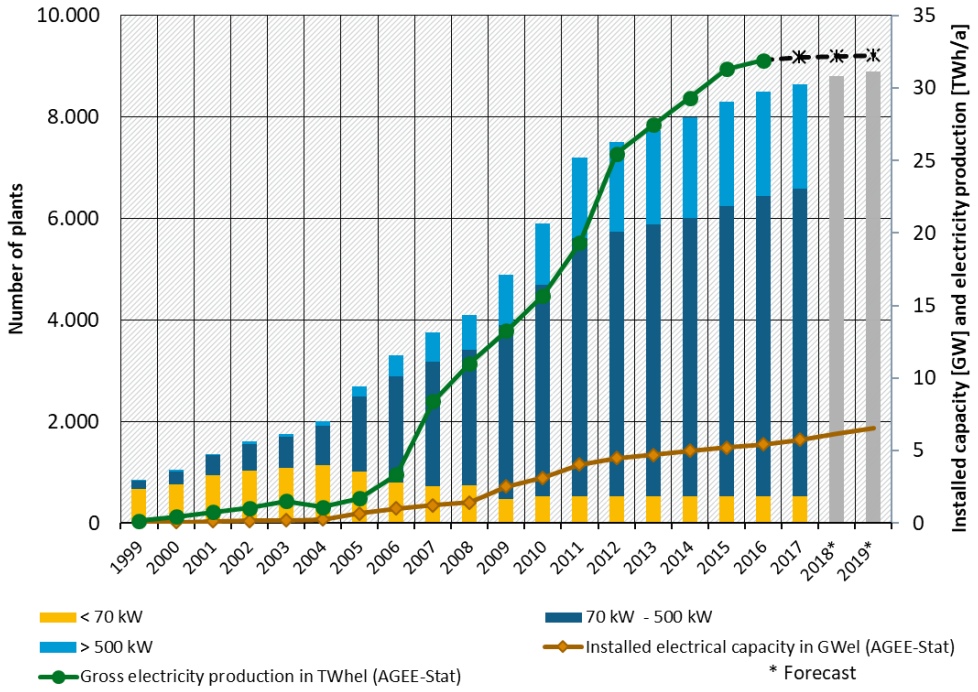
—

Results

—

Conclusion

Germany State of Biogas production



Source: DBFZ,2019. Database: Distribution of biogas plants by plant size on the basis of the DBFZ plant database; installed plant capacity and electricity generation according to AGEE-Stat 2/2019 (UBA 2019), *DBFZ forecast (modified according to Lenz et al. 2019)

- 2018: ~ 8,980 biogas production plants incl. upgrading plants for biomethane in operation
- No significant additional capacity since 2012
- **mainly flexibilisation of existing plants** (motivated by premium for flexible operation)
- New construction limited to **small scale manure plants** (< 75 kW_{el}) and few biowaste fermentation plants

Rytec Abfalltechnologie und Energiekonzepte

Biogas plant inventory

Plant type	Number of plants	Electricity production [1] [GWh/a]	Heat utilization [GWh/a]
Agriculture	8,270	27,978	12,677
Biowaste	336 (136 + 200) [2]	865	392
Biomethane	203	2,7	3,455
Sewage sludge	1,274 [3]	1,490	2,167
Landfill	468	300	122
Total	10,431	33,345	18,813

Data source: IEA country report

1) excluding efficiency losses;
2) Substrate input of 136 plants ≥ 90% of biowaste of the whole input amount per year (acc. to § 27a EEG 2012, § 45 EEG 2014, § 43 EEG 2017); biowaste is defined as separate collected municipal waste (e.g. kitchen waste, green waste); about 200 co-fermentation plants with substrate input < 90% of biowaste including plants using agro-industrial residues.
3) Federal Statistical Office (destatis): https://www.destatis.de/DE/Presse/Pressemitteilungen/2019/09/PD19_340_433.html

Biogas in Germany – current situation

- Utilization for electricity production dominates
- Change to tender system in 2017
- Cap installed for maximum capacity defined until 2022 (too low for the majority for the sector)
- Low maximum bidding prices, not attractive for plant operators (not much contribution to the tender yet)
- Numerous regulations under revision, changing and mostly increasing effort for plant operators
- No perspective for the sector and no ongoing discussion/urgency within authorities noticeable (e.g. biomethane market, manure based plants)
- Critical age pattern within operators/owners of plants

- Lack of perspective might lead to a severe deconstruction of the sector, even within plants with sustainable concepts

Biomethane in the fuel sector in Germany

- GHG gas reduction obligation (6 %) for fuel traders and high penalties if not achieved (470 €/tCO2)
- Established drop in fuels bioethanol and biodiesel

- Natural gas as fuel not very popular in Germany
- Biomethane production in Germany mainly based on energy crops
- Pressure on plant owners to find busisness case for the plants beyond phasing out incentives
- Unused potential in the manure and biowaste utilization
- Currently incentives to use natural gas in the transportation sector
- Newly established advanced fuel sector as chance for biomethane
- Biokraftstoffquote results in prices per t/CO2 of higher than 200 €/tCO2 (Numbers for waste material))

Quota price	€/t	200	250	300	350
Quota value for biomethane	ct/kWh	4.08	5.44	6.8	8.15

- No established market for biomethane yet but positive development expected

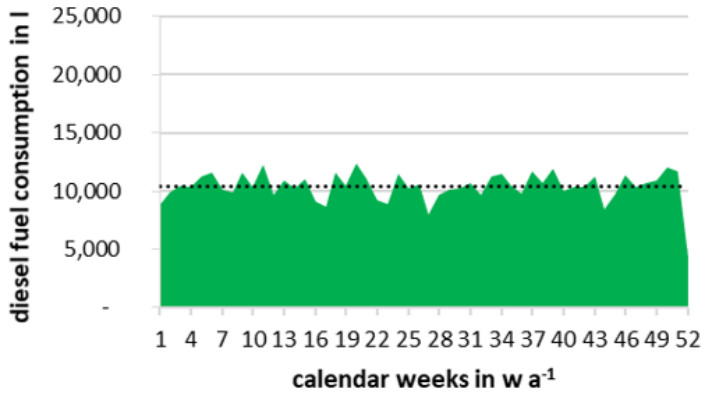
Specific case of fuel station on site

- Fuel station on site avoids feed in to grid
- Upgrading and fuel station required
- Biogas at farm might also cover farm demand
- Fuel demand is not continuous, biogas production is

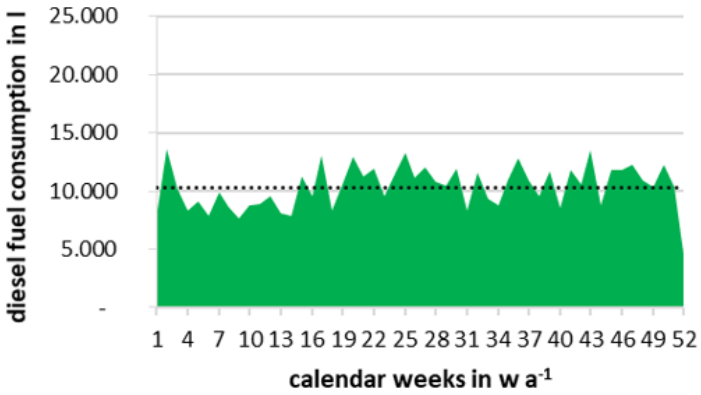
- Business model and plant design need to consider fuel demand in order to have guaranteed availability of fuel supply and all costs included

- In Germany combination of fuel and electricity productions offers an attractive combination since
  - Flexible electricity production is obligatory and incentivized
  - Required overcapacity for electricity can be provided by directing gas to the fuel supply

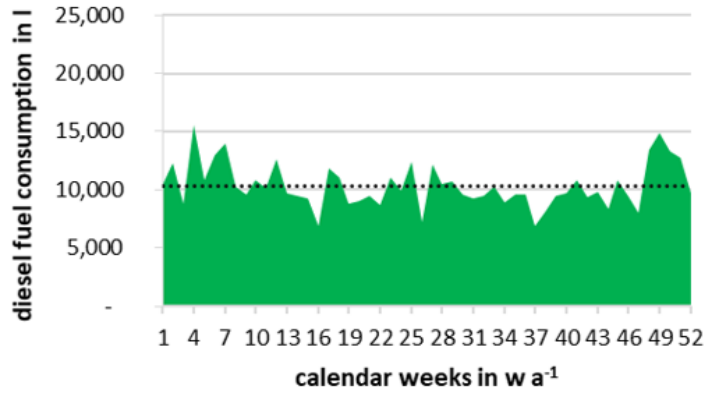
Demand profiles for fuel of several users



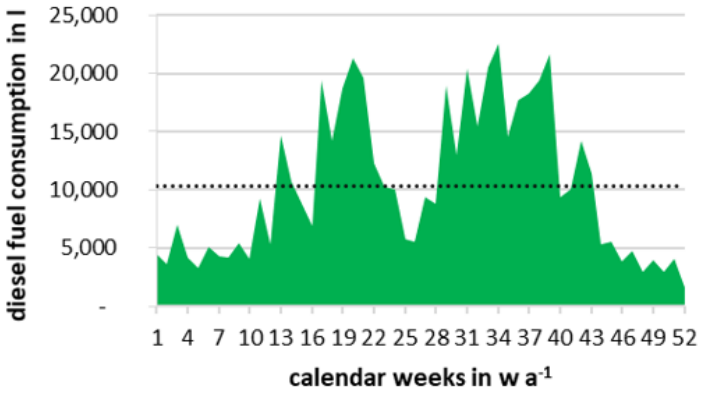
a) Logistic (trucks)



b) Waste disposal (mixed fleet)



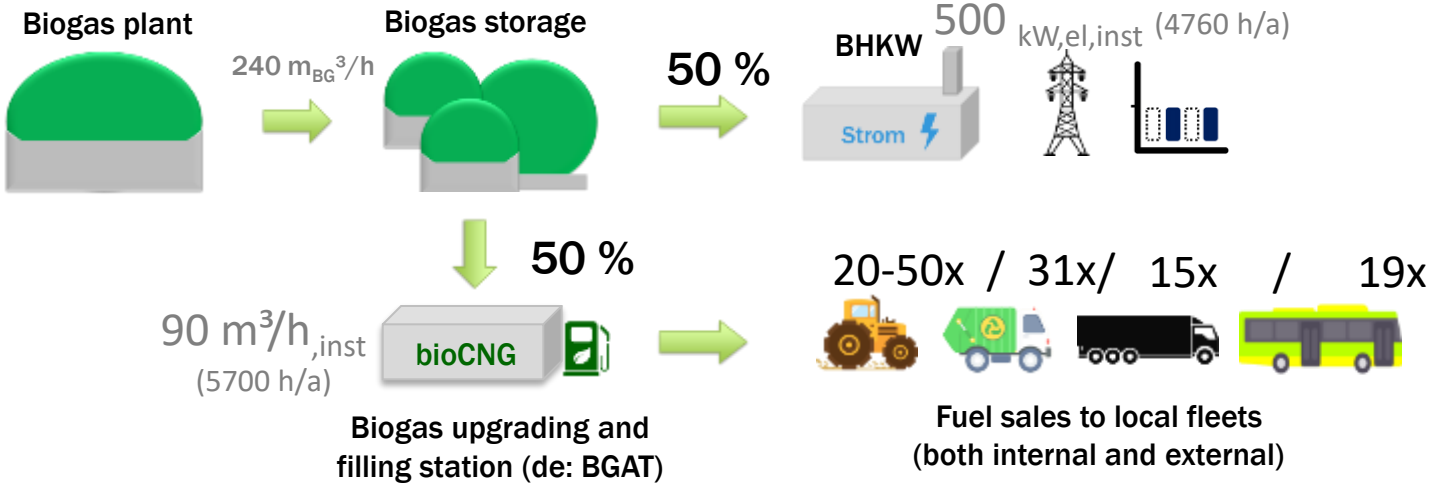
c) Taxi (cars)



d) Agriculture (tractors)

Source: Gökgöz et. Al. Combining electricity and fuel supply - operational strategies for biogas plants; Chemical Engineering & Technology, submitted ceat.202000268

Plant concept – Flexibilization with fuel



- Flexibilization approach

➢ Reduced power generation to 50 %

➢ Utilization of the remaining 50 % of biogas production in fuel production

→ flexibility requirement EEG 2017 ✔ and flexibility bonus ✔

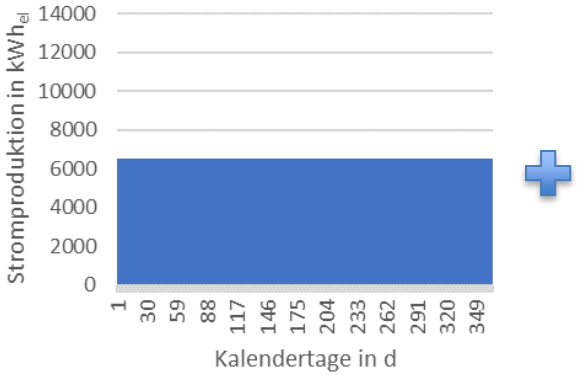
→ no additional Investments required ✔

→ additional EEG-independent income ✔

→ Advantageous offsetting of GHG savings from slurry to fuel production ✔

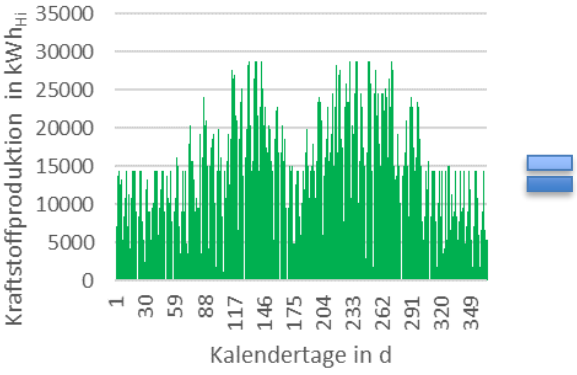
What has priority - electricity or fuel?

Electricity schedule

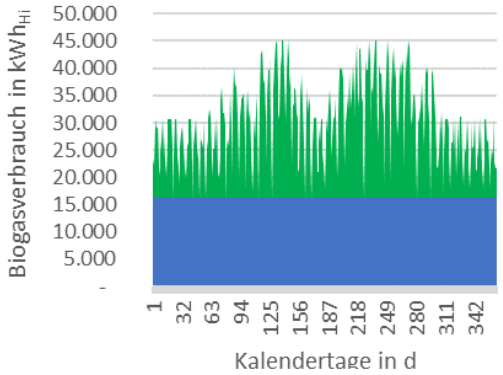


Constant per day and revenue oriented
(13h/d BHKW-Betrieb)

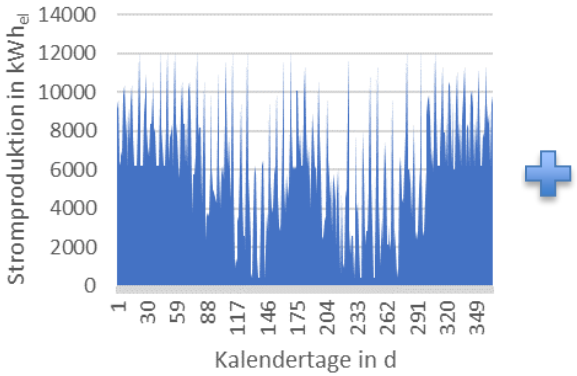
Fuel schedule



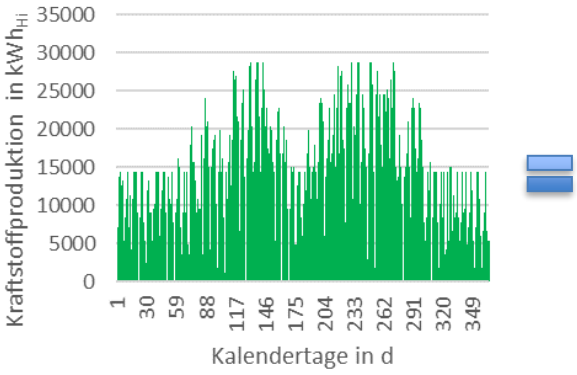
Resulting Biogas schedule

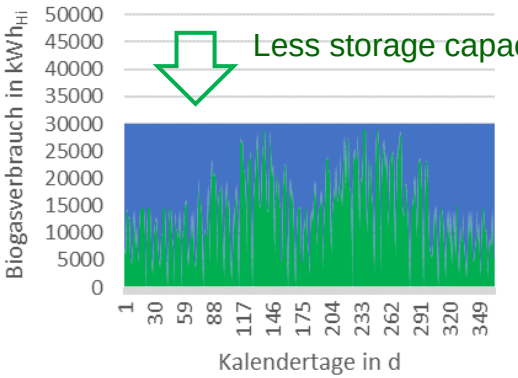


Electricity and Fuel independent optimised



Fuel led and revenue oriented
(1-24h/d BHKW-Betrieb)



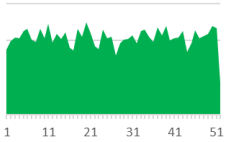
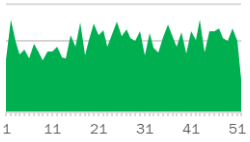
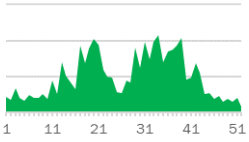


Fuel led operation

Source: Fatih Gökgöz

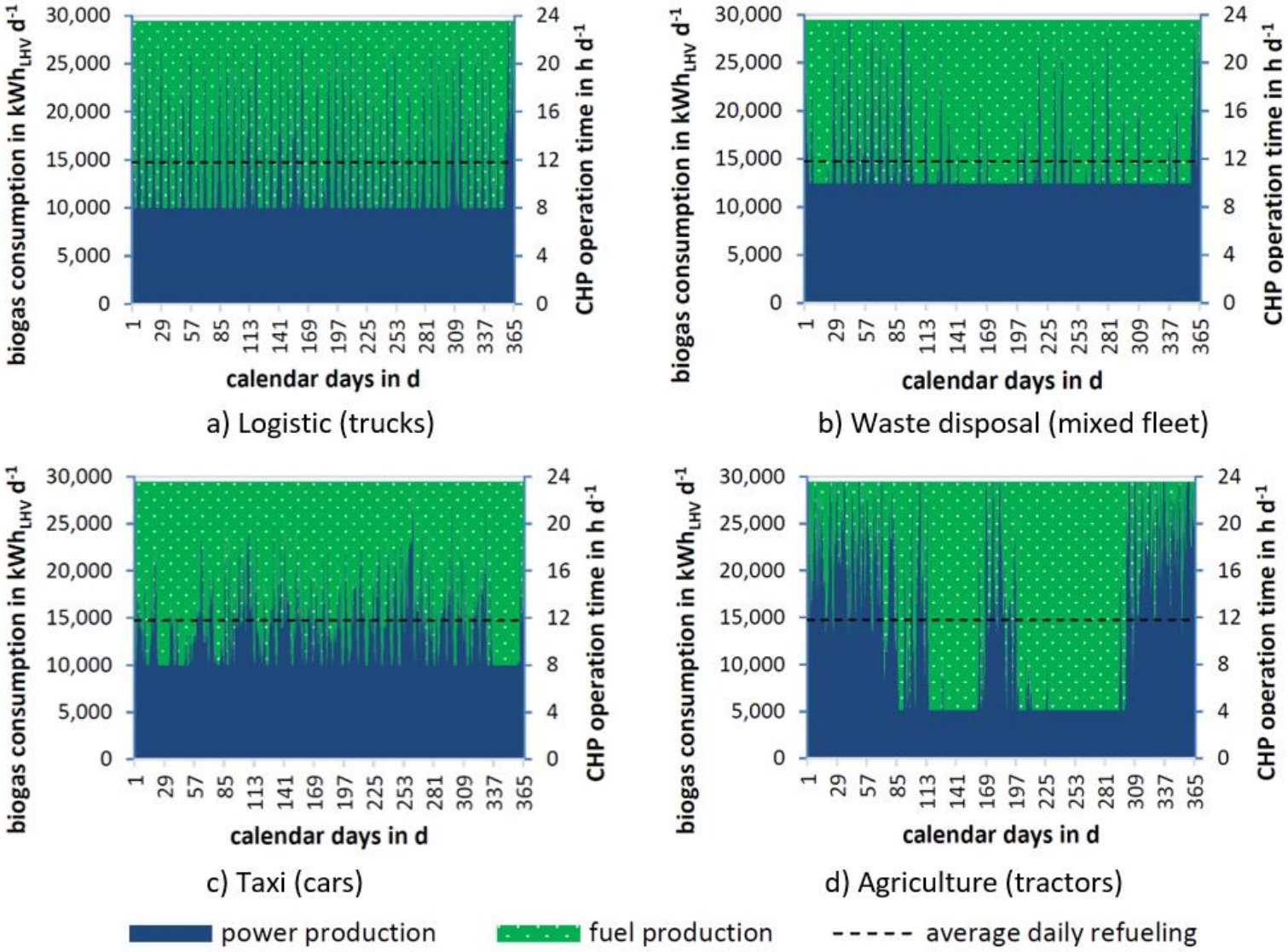
Technical design of fuel production

(250 kWel, eq) for 4 demand profiles with the same annual fuel production (electricity lead)

	Logistic (trucks)	Waste disposal (car, wheel loader, truck)	Agriculture (tractors)
Required system design			
System performance (capacity utilization)	80 Nm³/h (75,6%)	70 Nm³/h (86,4%)	100 Nm³/h (60,5%)
High pressure storage requirement	2.551 kg	4.207 kg	13.320 kg
Biogas storage demand	19.015 m³	15.318 m³	38.125 m³
Fluctuation	79 %	87 %	202 %
Cost factor	1,56	1,56	2,57
Plant investment	0,847 Mio. €	0,844 Mio. €	1,401 Mio. €

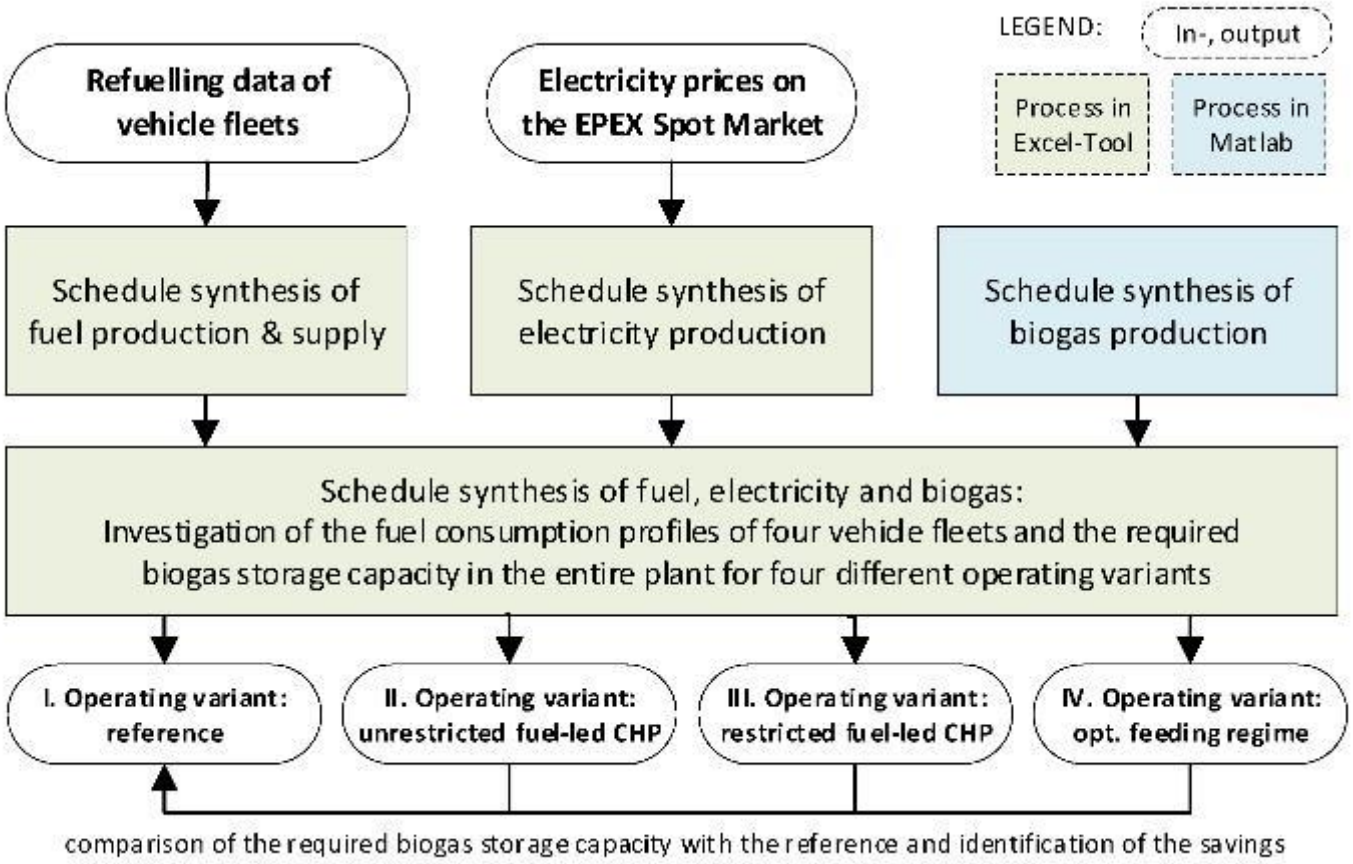
Source: Gökgöz et. Al. Combining electricity and fuel supply - operational strategies for biogas plants; Chemical Engineering & Technology, submitted ceat.202000268

Operational Investigation (unrestricted fuel lead)



Source: Gökgöz et. Al. Combining electricity and fuel supply - operational strategies for biogas plants; Chemical Engineering & Technology, submitted ceat.202000268

Operational investigations – METHODOLOGY



Source: Gökgöz et. Al. Combining electricity and fuel supply - operational strategies for biogas plants; Chemical Engineering & Technology, submitted ceat.202000268

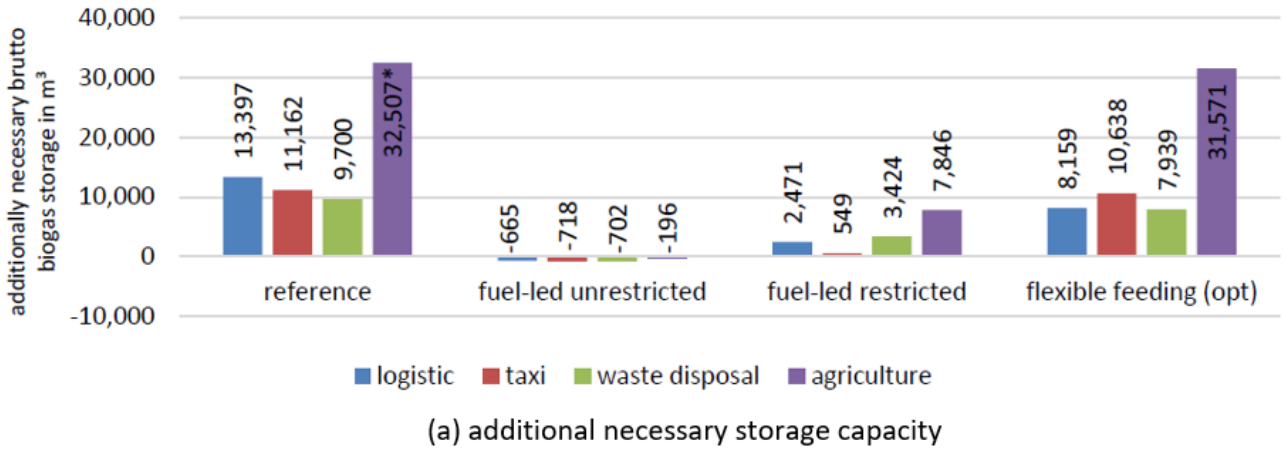
Rytec Abfalltechnologie und Energiekonzepte

Variations investigated

Operating variant	Controlled component	Description
electricity-led CHP with weekly feeding regime (reference)	CHP and fermenter	daily individually optimized CHP schedules for 365 days, with daily 12 hours CHP operation time [11] [21] and a weekly feeding regime with the same feeding quantity for each day of the week; **operation assumed as reference**
unrestricted fuel-led CHP	CHP	the electricity production can be freely varied daily between 1 and 24 hours, depending on how much biogas is left after the planned fuel production
restricted fuel-led CHP	CHP	Same as unrestricted fuel-led CHP, except that electricity production can only vary between 6 and 18 hours per day
electricity-led CHP with optimum feeding regime	CHP and fermenter	optimal feeding regime with completely over the year optimized flexible feeding

Source: Gökgöz et. Al. Combining electricity and fuel supply - operational strategies for biogas plants; Chemical Engineering & Technology, submitted ceat.202000268

Operational Investigation



(a) additional necessary storage capacity

Source: Gökgöz et. Al. Combining electricity and fuel supply - operational strategies for biogas plants; Chemical Engineering & Technology, submitted ceat.202000268

CONCLUSIONS

1. Biomethane production for fuel might have a future in Germany

2. Fuel consumption profiles and technical plant size
   - high fluctuations leads to oversizing of the plant and thus to increased costs
   - greatest oversizing by agricultural fleet -> not realistic with conventional approach
   - Fuel lead production reduces necessary overcapacities substantially
   - Combination with rather constant fleet demand balances fuel demand
3. Unrestricted fuel-led CHP (with 1-24 h CHP operations)
   - leads to constant biogas consumption -> existing gas storage is sufficient
   - best operation strategy to realize an off-grid decentral biomethane filling station
4. Restricted fuel-led CHP with 6-18 h CHP operations
   - leads to more fluctuating biogas consumption -> more storage requirement
   - Losses in electricity marketing are lower than in the unrestricted variant
5. Optimum flexible feeding
   - flexible feeding can not sufficiently supply strong fluctuations in biogas consumption
   - still it reduces the storage requirement and should be used ancillary

Thanks to all contributors to the presentation - and thank you for your interest.

Contact:

Jan Liebetrau
Rytec GmbH
Pariser Ring 37
D-76532 Baden-Baden
Tel.: +49 - (0)72 21 - 3 77 60 0
Fax: +49 - (0)72 21 - 3 77 60 29
E-mail: info@rytec.com