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Potential of Wastewater Treatment Plants for Long-Term-Storage Options via Power-to-Gas

Background & Approach

Background

- Integration of renewable energy sources and storage options in the frame of energy system transition.
- Increasing part of **renewable energy production** (2016: 32%) of the German energy mix leads to an increasing need of **flexibility** to compensate severely fluctuating power generation.
- Regional water management is able to provide storage capacities and power generation to take part in the German energy transition.

Approach

- Integration of widely available wastewater treatment plants (WWTP) with anaerobic sludge digestion into an optimized control reserve and storage concept to counterbalance those new challenges and take a more active part in energy grids.

Table 1: Analysed plant concepts for WWTPs to provide system services

	Concepts	Flexible CHP	Flexible WWTP aggregates	Additional aggregates for aeration	Electrolysis	Methanisation	Gas quality (%-CH_4)	Flexibility potential
0	**Status Quo**	-	-	-	-	-	Digester gas (65%)	no
I	**Status Quo Flex**	X	X	-	-	-	Digester gas (65%)	low
IIa	**PSA**	X	X	X	-	-	Digester gas (65%)	medium
IIb	**Compressed air**	X	X	X	-	-	Digester gas (65%)	medium
IIIa	**H_2-usage in CHP (10%)**	X	X	-	X	-	Digester gas (65%) + H_2	medium
IIIb	**H_2-usage in H_2-CHP**	X	X	-	X	-	Digester gas (65%) + H_2	medium
IV	**H_2-feed-in GI**	X	X	-	X	-	Digester gas (65%)	high
V	**Biological methanisation, feed-in GI**	-	X	-	X	X	Methane (98%)	high

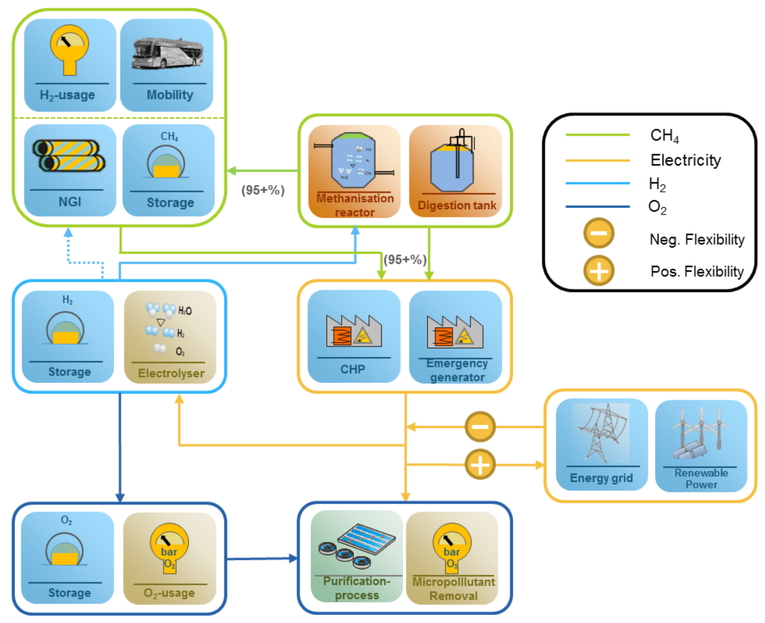
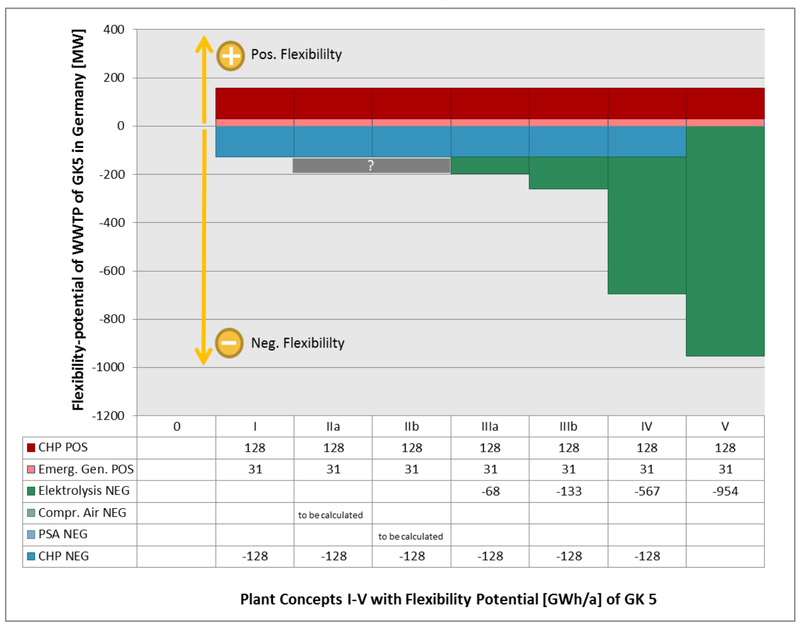


Figure 1: Plant concept V: biological methanisation in an external reactor on WWTP

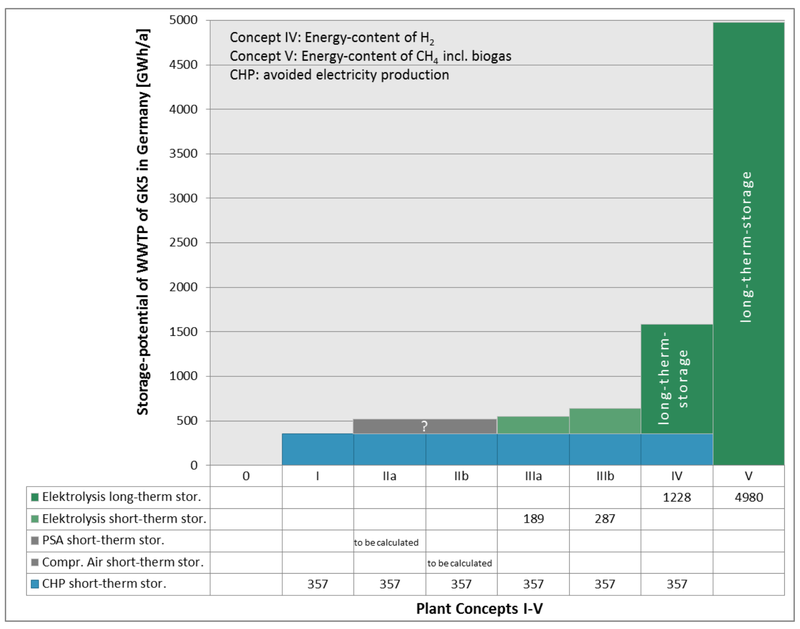
Flexibility and Storage Potential of GK5-WWTP



	0	I	IIa	IIb	IIIa	IIIb	IV	V
CHP POS		128	128	128	128	128	128	128
Emerg. Gen. POS		31	31	31	31	31	31	31
Elektrolysis NEG					-68	-133	-567	-954
Compr. Air NEG			to be calculated					
PSA NEG				to be calculated				
CHP NEG		-128	-128	-128	-128	-128	-128	

Plant Concepts I-V with Flexibility Potential [GWh/a] of GK 5

Figure 2: Theoretical *flexibility* potential of German WWTP GK5 (WWTP > 100 000 PE; WWTP with 64,1 Mio PE)



	0	I	IIa	IIb	IIIa	IIIb	IV	V
Elektrolysis long-therm stor.							1228	4980
Elektrolysis short-therm stor.					189	287		
PSA short-therm stor.			to be calculated					
Compr. Air short-therm stor.				to be calculated				
CHP short-therm stor.		357	357	357	357	357	357	

Plant Concepts I-V

Figure 3: Theoretical *storage* potential of German WWTP GK5 (WWTP > 100 000 PE; WWTP with 64,1 Mio PE)

Flexibility Potential of WWTP GK5

- Fundamental flexibility of status quo: CHP and WWTP aggregates (e. g. aeration, dewatering, and others) can be activated with low cost and integrated into virtual power plants
- Increasing potential depending on realised concept
- Electrolysis concepts can increase negative CHP-flexibility-potential by factor 7

Storage Potential of WWTP GK5

- Concept I-III provide flexibility and short-time storage
- Concept IV & V: Long-term storage options by using NGI
- Electrolysis design depends on many factors → storage-capacity is variable
- Assuming total methanisation of CO_2-content in digester gas: 2,4 TWh of H_2 are necessary to be produced by electrolysis (concept V), 5 TWh of CH_4 can be stored.

Table 2: Concept Profile of Concept V

Implementing criteria	CHP:	Conncection to gas supply	
	Power consumers:	Flexibility of consumers has to be	
	Methane feeding in:	Feed-in criteria have to be fullfilled	
Relevante flexibility planes	Power consumers	X	
	Aggregates-management	X	
	Innovative plant technologies	X	
Flexibility units		*Type of Flexibility*	
	CHP	POS ⊕	
	Emergency Power System	POS ⊕	
	Compressor & others	POS ⊕	NEG ⊖
	Elektrolysis		NEG ⊖
Concept level	Status-Quo	-	
	Hydrogen	X	
	Methanisierung	X	
Efficiency	Power consumption	100	[%]
	Power-to-Gas	51%	Methan
	PtGtP | incl. Heat	74%	GtP: Gas&SteamTurbine
Theorectical potential of POS flexibility	...spezific	2,5	[W/PE]
	...national	159.000	[kW]
Theoretical potential of NEG flexibility	...spezific	14,9	[W/PE]
	...national	954.000	[kW]
Storage options	short-term	existing gas storage & new H2-storage	
	long-term	GI	
	others	-	
Theoretical Storage Capacity	short-term ...spezific	-	[kWh/E]
	short-term ...national	-	[kWh]
	long-term ...spezific	77,6	[kWh/E]
	long-term ...national	5,0	[TWh]

Description of concept V:

- Combination of electrolysis and methanisation by using CO_2 from digester gas and H_2 of electrolysis in a separated reactor: Biological methanisation
- Feed-in into gas grid of high quality methane
- Use of O_2 on the plant (aeration, micropollutant removal)
- Option of decentral CHP on the plant for electricity generation from produced gas in case of demand of positive flexibility

→ High resource efficiency by using H_2, O_2 and heat from electrolyser and CO_2 from digester gas.

Energy Balance of a Future Oriented Storage Concept

- Gas is stored in GI → real long-time-storage
- Storage gas is converted into electricity by efficient gas-steam-turbine
- CHP is optional (depends on efficiency)
- Need of adapted legal framework to make such concepts possible
- All electrolysis products can be used on the plant
- Electricity (in excess) as well as biogas are storable due to biological methanisation
- **WWTP of GK5 can theoretically provide 5 TWh of long-term storable CH_4**

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