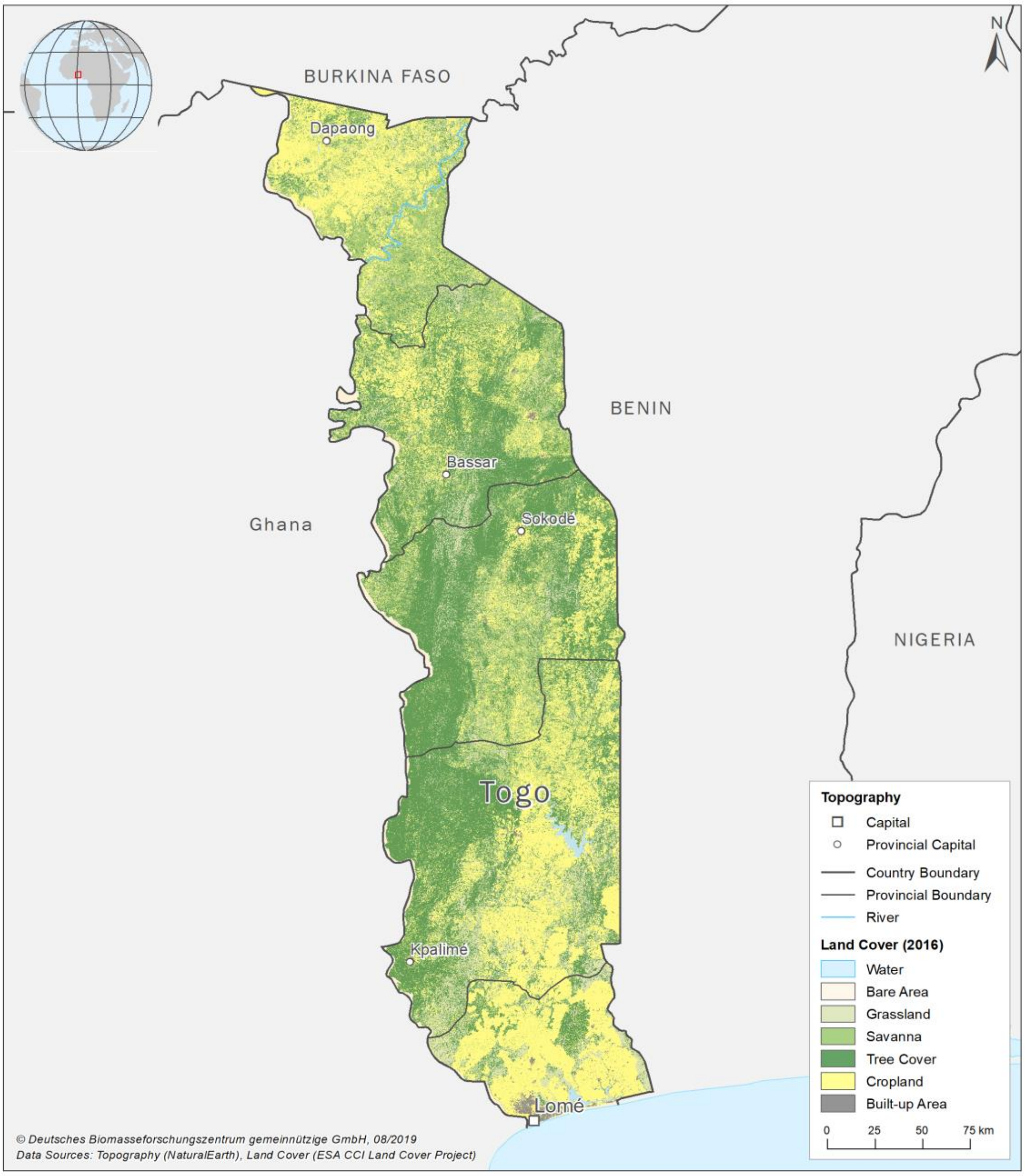
Deutsches Biomasseforschungszentrum
gemeinnützige GmbH

DBFZ

SCREENING: BIOMETHANE FROM RESIDUES

Status: 08/2019

TOGO



CONTENT

REMARK

The document "Screening: Biomethane from residues" is a very first and quick option to get an overview of available information on biomass resources in the selected country/region. Results are based on statistics, literature or surveys and calculations made by DBFZ/Germany. The document contains all conversion factors to reproduce and to customize the calculations.

Because of insufficient data the results have to be interpreted with the awareness of uncertainties! The compilation makes no claim to completeness!

KEY FIGURES

based on FAOSTAT, World Bank, OECD/IEA and Global Carbon Project, FAO and WLPGA

KEY FIGURES		PRESENT		TREND 2010	TREND 1990
POPULATION					
Population, total	[million]	2017	8	20%	106%
Rural population	[million]	2017	4	13%	64%
Urban population	[million]	2017	3	30%	185%
ECONCOMY					
Gross domestic product (GDP) per capita	[US $]	2017	670	39%	192%
LAND USE					
Country area	[1.000 ha]	2016	5.679	-	-
Agricultural area	[1.000 ha]	2016	3.820	4%	20%
Arable land	[1.000 ha]	2016	2.650	8%	26%
Permanent crops	[1.000 ha]	2016	170	-17%	89%
Permanent pastures and meadows	[1.000 ha]	2016	1.000	0%	0%
Forest area	[1.000 ha]	2016	168	-41%	-75%
Inland waters	[1.000 ha]	2016	240	0%	0%
ENERGY					
Total primary energy supply (TPES)	[PJ]	2016	147	12%	177%
Total final consumption (TFC)	[PJ]	2016	96	12%	170%
Electricity	[PJ]	2016	5	50%	275%
Biofuels and waste	[PJ]	2016	64	19%	137%
Oil products	[PJ]	2016	27	-4%	277%
Access to electricity	[%]	2017	36	28%	no data
Access to clean fuels and technology for cooking	[%]	2017	10	96%	no data
CO_2-emissions per capita	[t]	2017	0,4	15%	208%
Total CO_2-emissions	[Mt]	2017	3	15%	208%

THEORETICAL BIOMETHANE POTENTIAL FROM RESIDUES

based on calculations made by DBFZ/Germany

37 PJ - What does that mean?

Potential Total Primary Energy Supply (TPES)		Gas cylinders (15kg)	Charcoal	Avoided Deforestation	Avoided Emissions	Remarks
Mobilisation rate	100%	50 million	1.300.000 t	up to 34.000 ha	Potential emissions highly depend on energy conversion efficiencies as well as the selection of a specific technology. It can be assumed that emission reductions between 40 and 60 % can be achieved.	Avoided deforestations constitute theoretical examples of reduction potentials and do not automatically relate to actual deforestation rates in Togo.
	50%	25 million	650.000 t	up to 17.000 ha		
	25%	13 million	325.000 t	up to 8.500 ha		Conversion losses were not considered. A lower heating value of 49 MJ/kg was used for methane and 28 MJ/kg for charcoal.
	10%	5 million	130.000 t	up to 3.400 ha		
		could be filled	could be replaced	when using biogas instead of charcoal		

LIST OF INVESTIGATED BIOMASSES - 2017

based on literature and calculations made by DBFZ/Germany

RESIDUE			PRODUCTION *		THEORETICAL BIOMETHANE POTENTIAL				
			t FM/a	Share	Dry matter content [%]	Biomethane yield [m³/t FM]	1,000 m³	PJ	ktoe
TOTAL			**7.003.147**	**100%**	**-**	**-**	**1.018.241**	**37**	**873**
1	Maize	stalk	1.440.151	21%	85,0	227,8	328.066	12	281
2	Food waste	-	913.578	13%	40,0	99,8	91.175	3	78
3	Cattle	solid manure	707.550	10%	25,0	49,5	35.024	1	30
4	Sorghum	straw	447.391	6%	85,0	242,3	108.380	4	93
5	Yams	straw	413.277	6%	85,0	142,0	58.665	2	50
6	Rice, paddy	straw	353.094	5%	84,5	223,1	78.768	3	68
7	Seed cotton	stalk	352.500	5%	88,0	198,0	69.795	3	60
8	Cassava	peel	307.296	4%	80,0	258,4	79.405	3	68
9	Chickens	solid manure	303.050	4%	15,0	32,2	9.755	0	8
10	Beans, dry	stem and leave	289.071	4%	no data	no data	no data	no data	no data
11	Goats	solid manure	284.475	4%	30,0	59,4	16.898	1	14
12	Sheep	solid manure	233.417	3%	30,0	59,4	13.865	0	12
13	Maize	corn cob	230.766	3%	92,0	320,2	73.882	3	63
14	Yams	peel	206.638	3%	no data	no data	no data	no data	no data
15	Pigs	solid manure	147.037	2%	22,5	44,6	6.558	0	6
16	Cassava	stalk	135.419	2%	80,0	153,6	20.800	1	18
17	Groundnuts, witl	straw	87.638	1%	81,1	124,9	10.946	0	9
18	Sorghum	husk	38.663	1%	no data	no data	no data	no data	no data
19	Oil palm fruit	empty fruit buncl	36.106	1%	40,0	101,2	3.654	0	3
20	Rice, paddy	husk	34.427	0%	87,0	201,8	6.949	0	6
21	Oil palm fruit	mesocarp fibre	21.708	0%	65,0	94,9	2.060	0	2
22	Groundnuts, witl	shell	18.050	0%	86,2	195,7	3.532	0	3
23	Horses	solid manure	1.846	0%	28,0	34,7	64	0	0
24									
25									
26									
27									
28									
29									
30									

* related to the average of the theoretical potential of residues

LHV Biomethane [MJ/m³]: 35,89

NOT INVESTIGATED BUT OF GREAT INTEREST

Sewage sludge................................ Sewage sludge from public water treatment

Industrial residues.......................... Wet agro-industrial waste

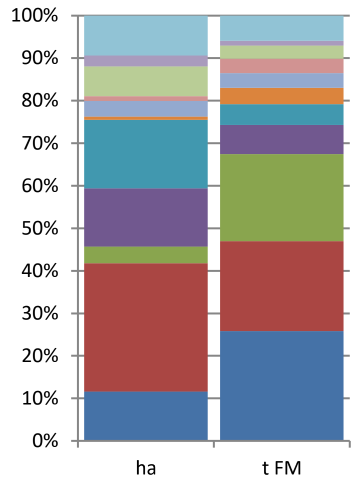
TOP 10 AGRICULTURAL MAIN PRODUCTS - 2017

based on FAOSTAT

	MAIN PRODUCT	AREA ha	PRODUCTION t FM/a	TREND -1y	TREND -5y
	Total	**2.301.663**	**4.038.404**	**3%**	**2%**
1.	Cassava	267.020	1.041.682	1%	9%
2.	Maize	694.422	854.689	3%	4%
3.	Yams	90.643	826.553	2%	-4%
4.	Sorghum	315.542	276.167	1%	10%
5.	Beans, dry	369.567	199.359	20%	50%
6.	Oil palm fruit	18.109	155.058	1%	3%
7.	Rice, paddy	84.395	140.519	2%	-13%
8.	Vegetables, fresh nes	26.867	136.454	0%	-6%
9.	Seed cotton	160.152	125.000	11%	55%
10.	Groundnuts, with shell	59.008	43.493	7%	0%
	Others	215.938	239.430	4%	-32%

Analysis includes **37** products

TOP 10 covers
94%
of total production



RESIDUES RELATED TO MAIN PRODUCTS - 2017

based on FAOSTAT and literature

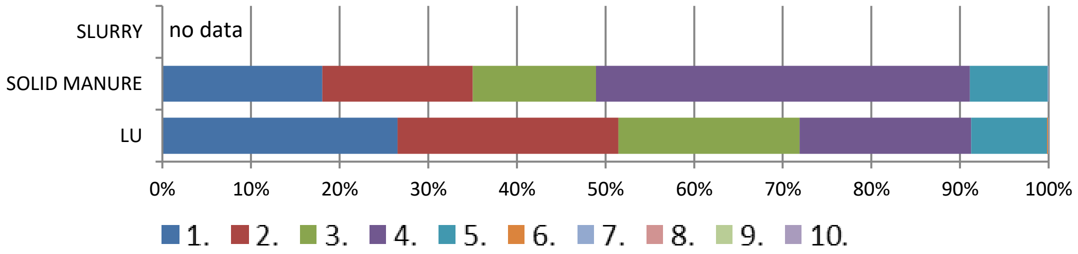
MAIN PRODUCT	RELATED RESIDUE TYPE *		CROP-RESIDUE-FACTOR min	-	max	THEORETICAL POTENTIAL OF RESIDUES t FM/a	-	
Total	**-**	**-**	**min**	**-**	**max**	**3.749.489**	**-**	**5.074.900**
Cassava	stalk	F	0,06	-	0,20	62.501	-	208.336
Cassava	peel	P	0,25	-	0,34	260.421	-	354.172
Maize	stalk	F	1,37	-	2,00	1.170.924	-	1.709.378
Maize	corn cob	P	0,25	-	0,29	213.672	-	247.860
Yams	straw	F	0,50	-	0,50	413.277	-	413.277
Yams	peel	P	0,25	-	0,25	206.638	-	206.638
Sorghum	straw	F	1,25	-	1,99	345.209	-	549.572
Sorghum	husk	P	0,14	-	0,14	38.663	-	38.663
Beans, dry	stem and leave	F	1,45	-	1,45	289.071	-	289.071
Oil palm fruit	empty fruit bunch	P	0,17	-	0,23	26.360	-	45.853
Oil palm fruit	mesocarp fibre	P	0,14	-	0,14	21.708	-	21.708
Rice, paddy	straw	F	1,66	-	3,05	233.262	-	472.927
Rice, paddy	husk	P	0,23	-	0,26	32.319	-	36.535
Vegetables, fresh nes	no data	-	no data	-	no data	no data	-	no data
Seed cotton	stalk	F	2,76	-	2,88	345.000	-	360.000
Groundnuts, with shell	straw	P	1,73	-	2,30	75.243	-	100.034
Groundnuts, with shell	shell	P	0,35	-	0,48	15.223	-	20.877

* F = field-based residue / P = processing residue

TOP 10 ANIMAL MANURE - 2017

based on FAOSTAT and literature

RANK	LIVESTOCK	LU	HEADS	TREND		SOLID MANURE		SLURRY	
				-1y	-5y	t/Head*a	$t_{solid\ manure}$	t/Head*a	t_{slurry}
	Total	**-**	**36.421.502**	**3%**	**25%**	**-**	**1.677.374**	**-**	**-**
1.	Chickens	303.050	30.305.000	4%	29%	0,01	303.050	no data	no data
2.	Goats	284.475	2.844.748	-5%	13%	0,10	284.475	no data	no data
3.	Sheep	233.417	2.334.166	-1%	9%	0,10	233.417	no data	no data
4.	Cattle	221.110	442.219	0%	3%	1,60	707.550	no data	no data
5.	Pigs	98.024	490.122	-1%	10%	0,30	147.037	no data	no data
6.	Asses	1.020	3.401	0%	2%	no data	no data	no data	no data
7.	Horses	923	1.846	2%	9%	1,00	1.846	no data	no data
8.									
9.									
10.									
	Others								



TOP 10 covers

100%

of total livestock

FOOD WASTE - 2017

based on FAOSTAT and IPCC

Population.. 7.797.694

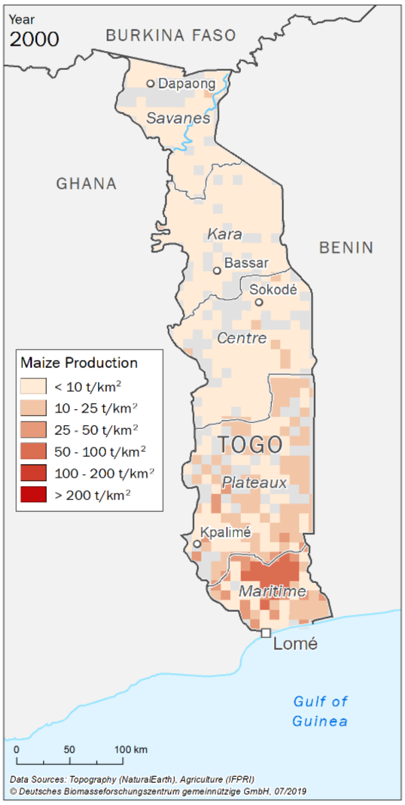
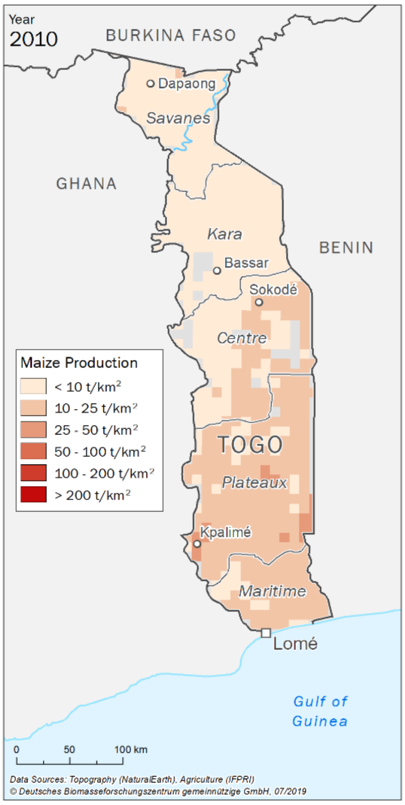
Municipal solid waste...................... 0,29 t/capita

Percentage food waste.................... 40,4%

Food waste...................................... 913.578 t FM/a

MAPPING: PRODUCTION OF MAIZE (2000-2010)

based on IFPRI

2000	2010
	

PREFERENCE REGIONS FOR MOBILIZING MAIZE RESIDUES

1. Plateaux
2. Centre
3. Maritime
4. Savanes
5. Kara

NEXT STEPS FOR RESEARCH

✓ Identify the most relevant biomasses for conversion.
✓ Find specific regions for most relevant biomasses.
3. Identify the most relevant restrictions for utilization.
4. Find specific locations for utilization.
5. Find sustainable concepts for biomass supply.

COMPARISON OF BIOGAS TECHNOLOGIES

based on literature and calculations made by DBFZ/Germany

SYSTEM MODULE	OPEX	CAPEX	LABOUR	COMPLEXITY	DURABILITY	YIELD
FERMENTATION						
Continuously stirred tank reactor	+	+ + +	+	+ + +	+ +	+ +
Plug-flow reactor	+	+ + +	+	+ +	+ +	+ + +
Garage-type reactor	+ +	+ +	+ + +	+ +	+ + +	+
Membrane reactor	+ +	+ +	+ +	+	+	+
Fixed-dome reactor	+	+	+ +	+ +	+ + +	+
BIOMASS RECEIPTION / PRETREATMENT						
Settling tank	+	+	+	+	+ + +	+
Chopper						
Swash plate	+ +	+ +	++	+ +	+ +	+ +
Flail chopper	+ +	+ +	++	+ + +	+ +	+ +
Grinder						
Ball mill	+ +	+ + +	+	+	+ + +	+ +
Roller mill	+ +	+ + +	+	+	+ + +	+ + +
DIGESTATE TREATMENT						
Drying						
Solar	+	+	+	+	+ + +	
Aux. Heat (e.g. CHP)	+ +	+ + +	+ +	+ + +	+ +	
Separation						
Screw press	+	+ +	+	+ +	+ + +	
Belt press	+ +	+ +	+	+ +	+ +	
Centrifuge	+ + +	+ + +	+ +	+ + +	+ +	
Sieve	+	+	+ + +	+	+ + +	
BIOGAS TREATMENT						
Desulphurisation						
Biological	+	+ + +	+	+	+ +	
Chemical	+ + +	+	+ +	+ +	+ + +	
BIOGAS CONVERSION						
CHP engine	+	+ +	+ +	+ + +	+ +	+ + +
Biomethane upgrading	+ +	+ + +	+	+ + +	+ +	+ +
Microgas grid	+	+ +	+	+ +	+ + +	+ + +
Biogas Bottling	+ + +	+ +	+ + +	+ +	+ +	+
Biogas Bag	+	+	+ + +	+	+	+ +

+ = low, + + = medium, + + + = high

POTENTIAL FEEDSTOCK MIXTURES

based on literature and calculations made by DBFZ/Germany

FEEDSTOCK MIX	PRODUCTION		THEORETICAL BIOMETHANE POTENTIAL				COMPONENTS		
	Ammount t FM / a	Dry Matter Content [%]	1.000 m3 / a	PJ /a	ktoe /a	Total Energy Utilisation		Type	Mass Ratio
MANURE EXLUDED									
Maize only	1.440.151	85%	328.066	11,8	281,2	32%	Cassava	peel	100%
Foodwaste/Maize	1.027.214	45%	94.198	3,4	80,7	8%	Food waste	waste	89%
							Maize	stalk	11%
Maize/Foodwaste	1.027.214	68%	129.483	4,6	111,0	14%	Food waste	waste	39%
							Maize	stalk	61%
MANURE INCLUDED									
Foodwaste/Cattle manure/Maize	2.088.961	45%	232.771	8,4	199,5	22%	Food waste	waste	44%
							Cattle	solid manure	34%
							Maize	stalk	22%
Cattle manure/Chicken manure/Maize	1.587.833	45%	176.276	6,3	151,1	16%	Chicken	solid manure	19%
							Cattle	solid manure	45%
							Maize	stalk	36%

= high energy gain

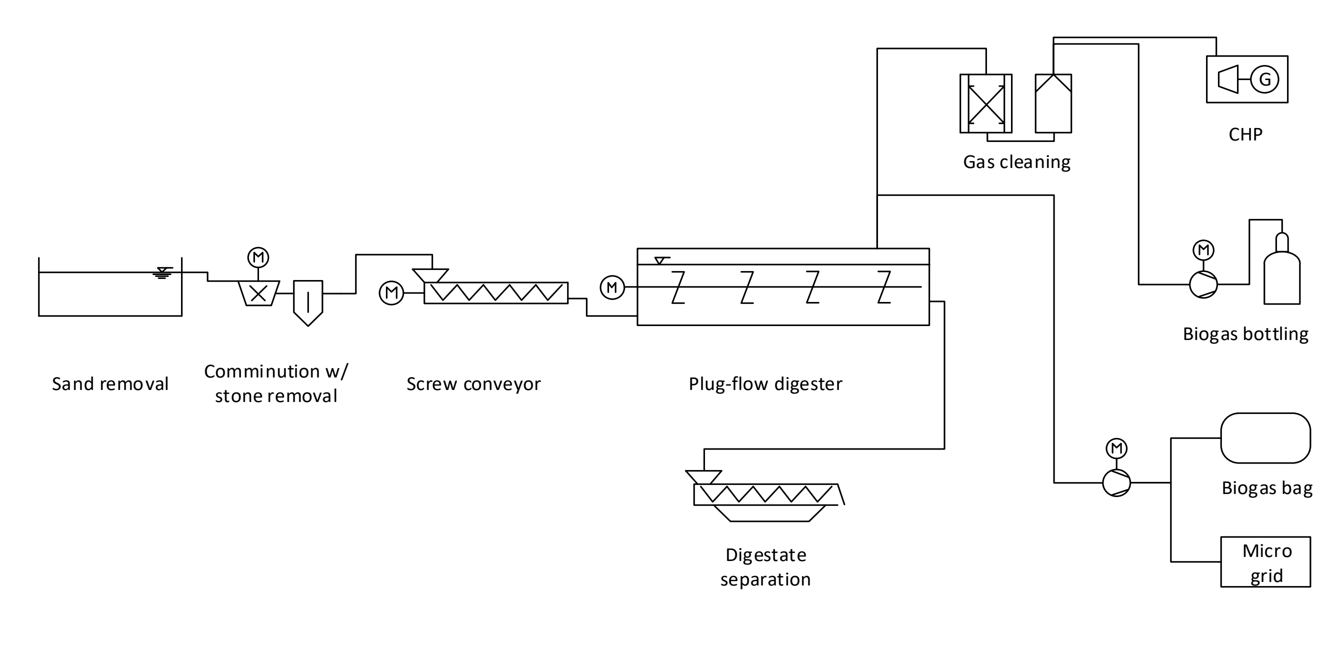
= optimal for technical use

= waste-based

POTENTIAL BIOGAS SYSTEMS 1/2

based on literature and calculations made by DBFZ/Germany

PLUG-FLOW REACTOR



The plug-flow digester is a continuous system which can be operated at higher dry matter contents (25 % < DM < 50 %) and organic loading rates as the in Europe more common conitinuously stirred tank reactors. The substrate transport along the horizontal axis of the digester prevent lack streams and therefore it delivers high effiencies and a good substrate utilisation.

It has to be considered, that the plug-flow digester is susceptible to stratification (sinking and floating layers). Therefore a suitable substrate preparation has to be included in the concept. This reactor type can be adapted to the substrate streams available by scaling of the reactor.

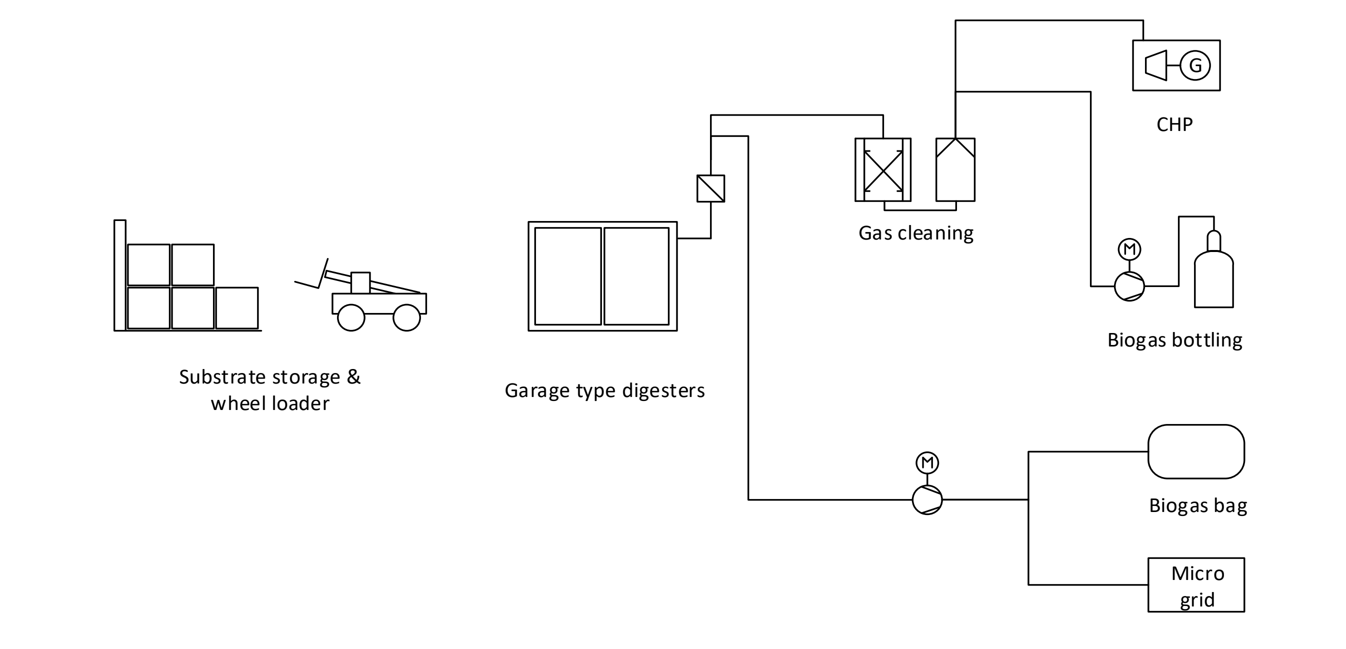
		Dry Matter Content [%]	Utilisible Feedstock Mixtures
manure excluded	maize only	85%	-
	foodwaste/ maize	45%	+
	maize/ foodwaste	68%	-
manure included	foodwaste/ cattle manure/ maize	45%	+
	foodwaste/ cattle manure/ cassava	45%	+

Legend (colour):
- yellow = high energy gain
- blue = optimal for technical use
- green = waste-based

POTENTIAL BIOGAS SYSTEMS 2/2

based on literature and calculations made by DBFZ/Germany

GARAGE-TYPE REACTOR



Garage-type digesters have the advantage over other common systems to take up high dry matter contents in the substrate. The substrate itself needs to be stackable and perfusible for the percolate, which transports the microorganisms needed into the process. Gas-tightness of the gates has to be assured at all times. Also, weak gas with low methane contents from the start-up phases needs to be treated to avoid GHG emissions.

Garage-type digesters are commonly built as modules in a certain size, which can be fed by a wheel loader. Therefore, they operate batch-wise and a contiuous biogas flow has to be established by a certain number of modules. Furthermore, adaptation to substrate amounts is carried out by numbering up of the garage modules rather than a scale up.

		Dry Matter Content [%]	Utilisible Feedstock Mixtures
manure excluded	maize only	85%	+
	foodwaste/ maize	45%	-
	maize/ foodwaste	68%	+
manure included	foodwaste/ cattle manure/ maize	45%	-
	foodwaste/ cattle manure/ cassava	45%	-

= high energy gain
= optimal for technical use
= waste-based

ASSESSMENT OF GAS UTILISATION

based on literature and calculations made by DBFZ/Germany

	CHP ENGINE	BIOMETHAN UPGRADING	BIOGAS BOTTELING	BIOGAS BAG	MICROGAS GRID
PERSONAL REQUIREMENTS					
Complexity	+ +	+ + +	+ +	+	+ +
Operators level of qualification	+ +	+ + +	+ +	+	+ +
GRID ABILITY					
On grid operation	+ + +	+ + +	+	+	+
Off grid operation	+ + +	+	+ + +	+ + +	+ + +
SPATIAL INTEGRATION					
Long distance supply	+	+ + +	+	+	+
Municipal supply	+ + +	+ + +	+ + +	+	+ +
Rural supply	+ +	+	+ + +	+ + +	+ + +
COMMERCIALISATION					
Products	electricity and heat	biomethane and carbon dioxide	gas cylinder with biogas for universal purpose	biogas bag with biogas as cooking gas	cooking gas
Sector of economy	industrial and household	industrial and household	household and traffic	household	household
Cost of production	+ + +	+ + +	+ +	+	+ +
Competitive product	petroleum gas, gasoline, diesel	petroleum gas	charcoal, petroleum gas, gasoline, diesel	charcoal	charcoal, petroleum gas

+ = low, + + = medium, + + + = high

ABBREVATIONS

FAOSTAT	Database of the Food and Agriculture Organization of the United Nations
FM	Fresh matter
IEA	International Energy Agency
IFPRI	International Food Policy Research Institute
IPCC	Intergovernmental Panal on Climate Change
ktoe	Tonne of oil equivalent
LHV	Lower Heating Value
LU	Livestock unit
MJ	Megajoule
Mt	Megatonne
OECD	Organisation for Economic Co-operation and Development
PJ	Petajoule

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