Technical Brief

Technical potential for household biodigesters in Africa

Based on the FAOSTAT database, SNV Netherlands Development Organisation assessed the technical potential for household biodigesters by country in Africa. The findings indicate that the number of households qualifying for such digesters amounted to 32,9 million in 2018. This is an increase of not less than 78% compared to 2006. The rise is driven by the surge in the number of agricultural households with access to water and the strong growth of the dairy sector in Africa.

Defining technical potential

In this paper, "technical potential" is defined as the number of households that can meet the two basic requirements – sufficient availability of both dung and water – to run a biodigester (see figure 1).

Although biogas can be generated by a score of organic material, cattle dung[12] is arguably best suited as a substrate for small installations; the digestion process is robust and the material is abundantly available on many farmyards. For a biodigester to be attractive to a family, it should be able to provide at least 0.8 to 1 m^3 biogas daily. To generate this amount of biogas, the household should have at least 20 to 30 kg of fresh dung available on a daily basis. Such amount of biogas would provide about 2 to 3 "stove hours"; sufficient to prepare at least one family meal. Theoretically, two mature cattle would be able to produce this amount of dung, however for large parts of Africa zero-grazing is not common, therefore most African households would rather need at least 3 or 4 night-stabled heads of cattle[3].

To enable both the installation's micro-biological process as well as the hydraulic functioning, the feeding material, dung, has to be mixed with equal amounts of water[4]. This process water does not have to be of "drinking water" quality, but –in view of the significant amount needed on a daily basis, should be available in the vicinity[5] of the installation.

Thus, the two main drivers for the technical potential for household biodigester are the number of cattle (partly) on-yard and the number of agricultural households having access to water.

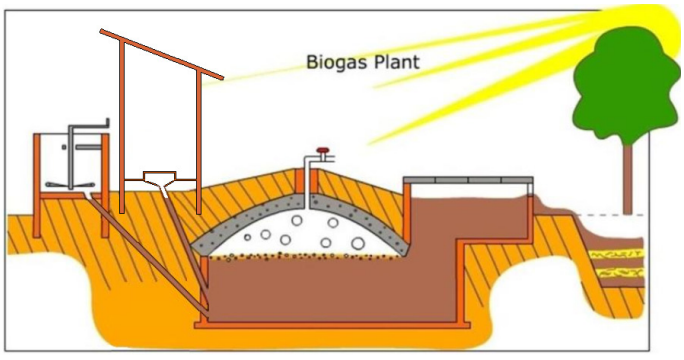


Figure 1 Household biodigester

Domestic cattle

Lacking data on the share of the total cattle population that is –at least- night stabled, it is assumed that domestic cattle[6] is equal to all dairy cattle plus a share of the non-dairy cattle (draft animals, local grazing) with all variables provided by FAOSTAT, as *per equation 1*.

[1] $Cattle_{dom} = Cattle_{dairy} + Cattle_{nondairy} * LUfactor$

Whereby:

$Cattle_{dom}$	Domestic cattle population
$Cattle_{dairy}$	Dairy cattle population
$Cattle_{nondairy}$	Non-dairy cattle population
LUfactor	Land use factor

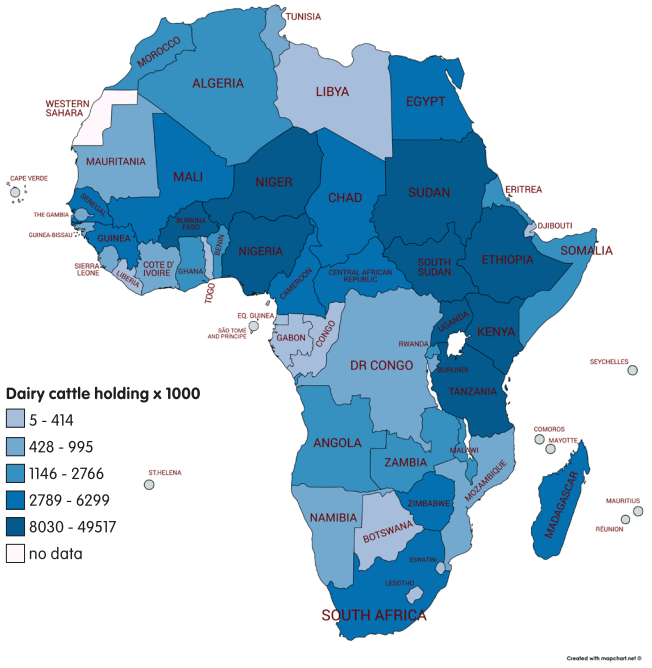
For an approximation of the share of non-dairy cattle that is night-stabled, the land-use factor based on the ratio arable / pastoral land area (as provided by FAOSTAT) is proposed as *per equation 2*.

[2] $$LU\ factor = \frac{Land_{arable}}{Land_{arable} + 20\% Land_{pastoral}}$$

Whereby:

LUfactor	Land use factor
$Land_{arable}$	Arable land
$Land_{pastoral}$	Pastoral land

Based on these assumptions, Africa is estimated to have some 70.6 million heads of domestic cattle. The division by country in Africa, in quintiles, is presented in map 1 below.



Map 1: Quintile division of domestic cattle by country in Africa

Agricultural household with access to water

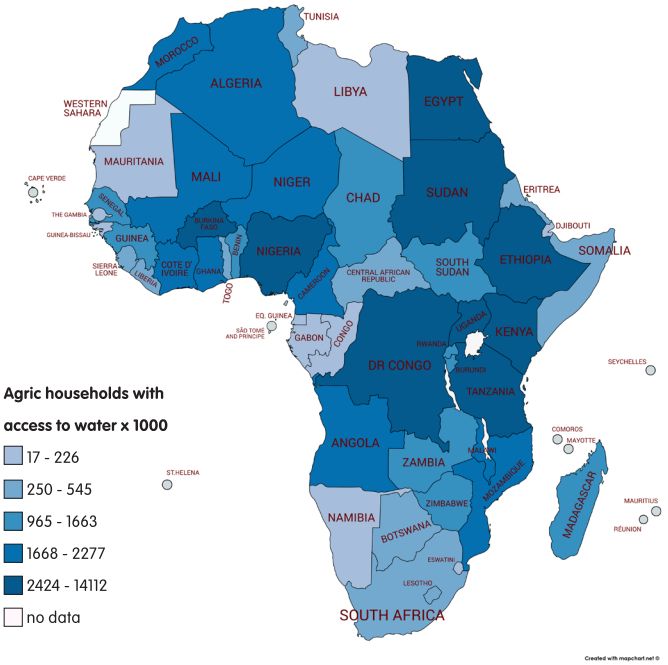
For this variable, the number of agricultural households as provided by FAOSTAT is adjusted for rural and urban water access as follows:

[3] $AH_{aw} = AH\ (\%WA_{rural} \times \%RH_{agric} + \%WA_{urban} * \%UH_{agric})$

Whereby:

AH_{aw}	Number of agricultural households with access to water
AH	Number of agricultural households
$\%\ WA_{rural}$	Share of rural population having access to safe drinking water
$\%\ WA_{urban}$	Share of urban population having access to safe drinking water
$\%\ RH_{agric}$	Share of rural households practicing agriculture, assumed 80%
$\%\ UH_{agric}$	Share of urban households practicing agriculture, assumed 20%

The above operation returns a total of 81.7 million agricultural households that have access to water in Africa. The division by country over Africa, in quintiles, is presented in map 2 below.

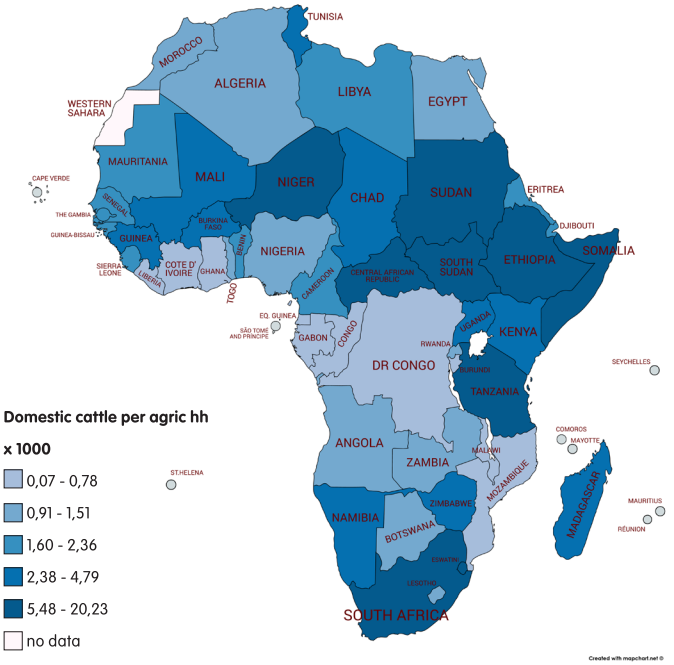


Map 2: Quintile division of agricultural households with access to water by country in Africa

Technical potential for household biodigesters

As explained above, for a biodigester to work satisfactorily, a household would need at least 3 heads of domestic cattle and good access to water. From the data it shows that on average an African agricultural household with access to water has 2.91 domestic cattle, with the country values, in quintiles, presented in map 3.

Even at country level, however, this would be a very rough indication of the technical potential of domestic biogas. To arrive at a more precise estimate of the technical potential, the number of agricultural households with access to water is multiplied with a cattle-holding factor, correcting the technical potential downwards for countries with a lower average cattle holding per agricultural household as per equation 4.



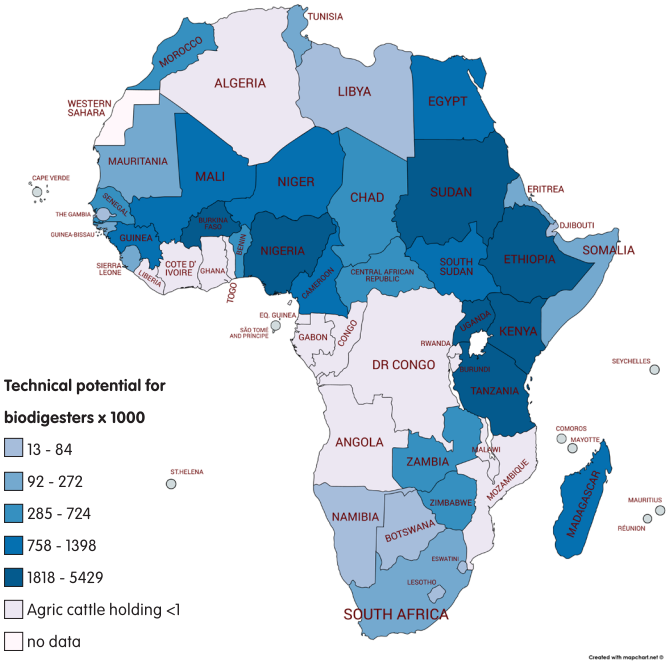
Map 3: Quintile division of average domestic cattle holding per agricultural per household with access to water by country in Africa

[4]*Techpot = AH_{aw} * CH factor*

Whereby:

Techpot	Technical potential for household biodigesters
AHaw	Number of agricultural households with access to water
CH factor	Cattle holding factor 0.75 with average cattle holding > 3 0.50 with average cattle holding >2 and <3 0.25 with average cattle holding >1 and <2 0.00 with average cattle holding <1

Processing the data along these lines, the technical potential for household biodigesters arrives at 32.9 million installations. Map 4 below presents the values per country. Annex 1 provides the data in tabulated form.



Map 4: Quintile division of the technical potential of household biodigesters by country in Africa

The top quintile of technical potential for household biodigesters consists of Ethiopia (5.4 million households), Uganda (3.1 million households), Tanzania (2.4 million households), Kenya (2.3 million households) and Sudan (2.2 million households) in East Africa and Nigeria (3.5 million households) and Burkina Faso (1.8 million households in West Africa.

Discussion

Although after 12 years the estimates from the 2006 assessment[7] appear to be fair, the assumptions made have never been verified. One could argue that:

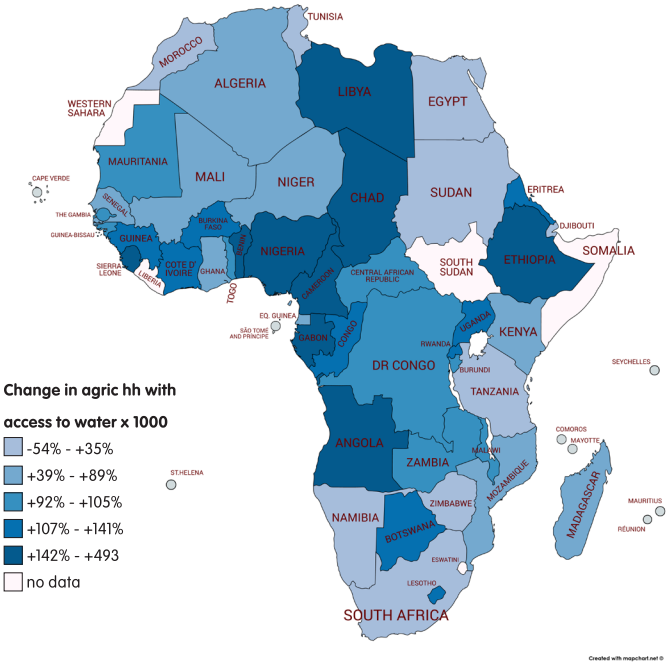
- With the growing pressure on grazing grounds, cattle increasingly appears to be night stabled; the "Land holding factor" may correct the technical potential downwards too much.
- As briefly explained in footnote 5, with the introduction of the Solid State Digester (SSD), water availability becomes much less critical. One may argue that with the SSD technology the presence of cattle warrants sufficient water to be disposable for the biodigester.
- The adjustments made by "Cattle holding factor" may seem logical but one could also argue that in particular areas with a low average domestic cattle holding, there could be a significant potential for household-scale biodigesters.

Clearly, the technical potential is only one factor determining the uptake of the technology. Other (very) important factors would include: the extent to which the full benefits of the technology are perceived and valued by smallholder farmers; the willingness and ability to pay for the investment (including the availability of appropriate financing arrangements); the role the private sector can play in the marketing, and; the extent to which a regulator can play a meaningful role in safeguarding the reputation of the technology. None of these factors have been taken into account in this assessment.

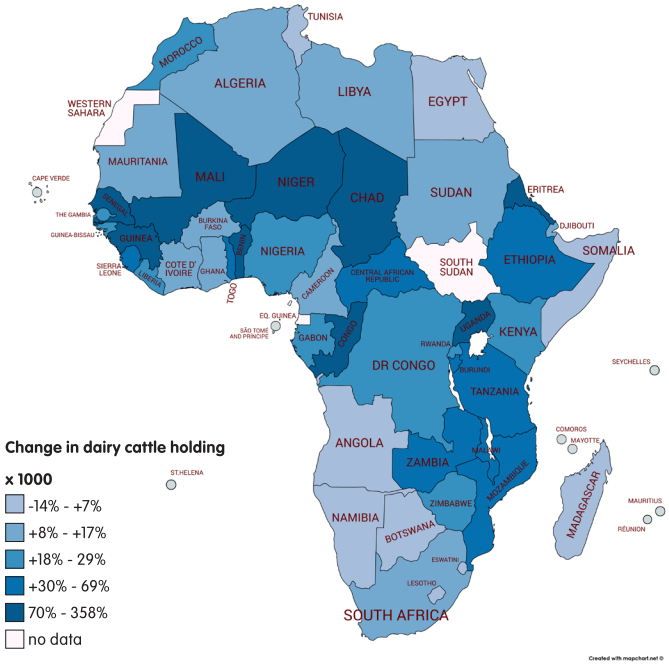
Developments over the period 2006 – 2018

Despite limitations mentioned in section 6, a strong development can be observed over the past 12 years between the first assessment (2006) and the current (2018) one. Most obvious is the increase of 78% (over 2006 value) of the total technical potential, from 18.5 million to 32.9 million biodigesters.

The main drivers for this increase are, apparently despite the ongoing urbanisation, the 103% increase of agricultural households with acces to water (highest growth in Sierra Leone, Angola, Gabon, Libya, Benin, Chad, Cameroon, Nigeria and Ethiopia, see map 5a), and the 54% increase of dairy cattle (highest growth in Guinea, the Congo, Uganda, Senegal, Mali, Benin, Chad, Eritrea, and Niger, see map 5b) across Africa.



Map 5a: Quintile division of growth of the number of agricultural households with access to water by country in Africa



Map 5b: Quintile division of growth of the number of dairy cattle by country in Africa

Annex 1 Data table used for the calculation of the technical potential of household biodigesters by country in Africa

	agricultural households	agric hh with access to water	non-dairy cattle	landuse factor arable vs pastoral land	calculated non-dairy domestic cattle	dairy cattle	total domestic cattle	cattle holding per agricultural household	75% of agric hh for avg holding >3	50% of agric hh for avg holding >2 but <3	**20% of agric hh for avg holding >1 but <2**			Biogas hh as share of agric hh
	[hh x 1000]	[hh x 1000]	[# of heads]	[arable / arable + 20% pastoral land]	[# of heads]	[# of heads]	[# of heads]	[heads of cattle/agric hh]	[biogas plant potential x 1000]	[biogas plant potential x 1000]	**[biogas plant potential x 1000]**	[biogas plant potential x 1000]	[biogas plant potential x 1000]	[bio_ahtot / agric hh] [%]
COUNTRY	**ah_tot**	**ah_wat**	**ani_cattle_non-dairy**	**arab/past**	**dom_cat_non-dairy**	**dom_cattle_dairy**	**dom_cat_tot**	**domcat/ah_wat**	**bio_ah>3**	**bio_ah>2**	**bio_ah>1**	**bio_ahtot**	**bio_ah-progtot**	**biohh/ah_shr**
ALGERIA	2.162	1.784	968.927	0,53	514.208	1.112.379	1.626.587	0,91	0	0	**0**	-	-	0%
ANGOLA	3.434	1.864	4.542.529	0,31	1.417.732	432.802	1.850.534	0,99	0	0	**0**	-	-	0%
BENIN	1.527	1.141	1.776.471	0,96	1.706.929	562.530	2.269.459	1,99	0	0	**285**	285	285	19%
BOTSWANA	279	262	1.703.319	0,07	123.143	271.661	394.804	1,51	0	0	**65**	65	65	23%
BURKINA FASO	2.840	2.424	8.201.686	0,83	6.834.738	1.194.780	8.029.518	3,31	1818	0	**0**	1.818	1.818	64%
BURUNDI	1.794	1.416	530.056	0,93	490.641	92.975	583.616	0,41	0	0	**0**	-	-	0%
CAMEROON	2.867	2.277	5.407.028	0,94	5.079.329	287.596	5.366.925	2,36	0	1139	**0**	1.139	1.139	40%
C. AFRICAN REPUBLIC	666	484	4.205.189	0,74	3.102.189	320.883	3.423.072	7,07	363	0	**0**	363	363	55%
CHAD	1.923	965	7.348.086	0,35	2.590.332	762.069	3.352.401	3,47	724	0	**0**	724	724	38%
CONGO, THE	289	148	356.502	0,22	76.893	3.896	80.789	0,55	0	0	**0**	-	-	0%
DJIBOUTI	123	88	276.238	0,64	177.076	25.499	202.575	2,30	0	44	**0**	44	44	36%
DRC-CONGO	10.018	4.126	915.333	0,66	605.108	7.505	612.613	0,15	0	0	**0**	-	-	0%
EGYPT	4.248	4.214	3.188.194	0,99	3.172.201	1.766.690	4.938.891	1,17	0	0	**1054**	1.054	1.054	25%
EQUATORIAL GUINEA	112	45	4.807	0,85	4.097	542	4.639	0,10	0	0	**0**	-	-	0%
ERITREA	951	545	1.398.605	0,33	466.202	720.493	1.186.695	2,18	0	272	**0**	272	272	29%
ETHIOPIA	12.589	7.239	47.653.488	0,79	37.683.618	11.833.179	49.516.797	6,84	5429	0	**0**	5.429	5.429	43%
GABON	195	142	30.428	0,26	7.861	7.417	15.278	0,11	0	0	**0**	-	-	0%
GAMBIA, THE	262	226	401.210	0,93	374.009	53.816	427.825	1,89	0	0	**57**	57	57	22%
GHANA	2.092	1.741	1.420.702	0,74	1.049.890	313.298	1.363.188	0,78	0	0	**0**	-	-	0%
GUINEA	1.643	1.190	5.668.636	0,59	3.353.582	749.784	4.103.366	3,45	893	0	**0**	893	893	54%
GUINEA-BISSAU	256	202	598.642	0,58	348.048	108.054	456.102	2,26	0	101	**0**	101	101	39%
IVORY COAST, THE	2.524	1.859	1.435.044	0,52	751.196	213.131	964.327	0,52	0	0	**0**	-	-	0%
KENYA	5.008	3.093	13.515.548	0,58	7.792.264	7.013.642	14.805.906	4,79	2320	0	**0**	2.320	2.320	46%
LESOTHO	310	250	457.116	0,41	185.145	99.792	284.937	1,14	0	0	**62**	62	62	20%
LIBERIA	552	375	36.808	0,56	20.449	6.597	27.046	0,07	0	0	**0**	-	-	0%
LIBYA	184	101	87.395	0,39	34.319	126.453	160.772	1,60	0	0	**25**	25	-	14%
MADAGASCAR	3.415	1.522	8.435.389	0,32	2.694.029	1.866.101	4.560.130	3,00	0	761	**0**	761	761	22%
MALAWI	1.864	1.686	1.358.058	0,91	1.237.559	112.837	1.350.396	0,80	0	0	**0**	-	-	0%
MALI	2.309	1.864	9.190.676	0,48	4.417.229	1.750.624	6.167.853	3,31	1398	0	**0**	1.398	1.398	61%
MAURITANIA	356	204	1.433.626	0,05	77.727	403.058	480.785	2,35	0	102	**0**	102	102	29%
MOROCCO	2.267	1.997	1.568.146	0,66	1.033.984	1.731.854	2.765.838	1,39	0	0	**499**	499	499	22%
MOZAMBIQUE	3.841	1.756	1.085.660	0,39	424.497	570.903	995.400	0,57	0	0	**0**	-	-	0%
NAMIBIA	128	112	2.519.845	0,10	239.985	237.319	477.304	4,27	84	0	**0**	84	84	65%
NIGER	3.020	1.778	10.675.880	0,74	7.951.392	2.107.668	10.059.060	5,66	1334	0	**0**	1.334	1.334	44%
NIGERIA	22.615	14.112	18.356.363	0,85	15.579.539	2.204.570	17.784.109	1,26	0	0	**3528**	3.528	3.528	16%
RWANDA	1.643	1.230	893.330	0,93	833.953	312.385	1.146.338	0,93	0	0	**0**	-	-	0%
SENEGAL	2.043	1.663	2.898.442	0,74	2.146.994	641.800	2.788.794	1,68	0	0	**416**	416	416	20%
SIERRA LEONE	667	368	673.186	0,78	526.841	143.630	670.471	1,82	0	0	**92**	92	92	14%
SOMALIA	1.394	292	3.652.204	0,11	414.167	1.186.131	1.600.298	5,48	219	0	**0**	219	219	16%
SOUTH AFRICA	415	353	12.390.272	0,43	5.288.551	1.010.000	6.298.551	17,83	265	0	**0**	265	265	64%
SOUTH SUDAN	1.717	1.011	4.449.853	1,00	4.449.853	7.380.947	11.830.800	11,71	758	0	**0**	758	758	44%
SUDAN	5.530	2.959	22.683.561	0,67	15.262.284	7.876.089	23.138.373	7,82	2219	0	**0**	2.219	2.219	40%
SWAZILAND	24	17	475.828	0,46	218.327	133.148	351.475	20,23	13	0	**0**	13	-	55%
TANZANIA	6.181	3.204	20.120.680	0,74	14.843.125	6.895.032	21.738.157	6,78	2403	0	**0**	2.403	2.403	39%
TOGO	816	438	374.649	0,93	348.358	66.074	414.432	0,95	0	0	**0**	-	-	0%
TUNISIA	283	267	35.100	0,75	26.315	611.000	637.315	2,38	0	134	**0**	134	134	47%
UGANDA	5.132	4.092	10.855.103	0,87	9.406.029	3.944.943	13.350.972	3,26	3069	0	**0**	3.069	3.069	60%
WESTERN SAHARA	54	-	-	0,00	-	-	-		0	0	**0**	-	-	0%
ZAMBIA	2.347	1.365	3.328.397	0,49	1.621.527	332.425	1.953.952	1,43	0	0	**341**	341	341	15%
ZIMBABWE	1.751	1.282	4.556.108	0,62	2.838.697	990.230	3.828.927	2,99	0	641	**0**	641	641	37%
	128.661	**81.772**	**254.138.343**		**169.842.162**	**70.596.231**	**240.438.393**	**2,94**	**23.308**	**3.194**	**6.424**	**32.927**	**32.889**	**26%**

Notes

[1] Read more about this subject on http://www.snv.org/sector/energy/topic/biogas

[2] Pig manure and poultry litter make a good anaerobic substrate as well, but densities of these animals in most countries of rural Africa is limited.

[3] To properly assess the availability of dung, the actual collected amount over a longer period (1 week) should be measured.

[4] The Africa Biogas Partnership Programme piloted and introduced successfully "Solid State Digesters". The design of these digesters allows installations to function properly with as little as a quarter of the amount of process water compared with the traditional design. This implies that the water criterion has become less critical. However, the traditional design is still "mainstream" in many countries and to allow for a comparison between the potential in 2006 and 2018 on equal grounds this brief is not taking this development into account.

[5] Biogas programmes in Nepal and Vietnam use the criterion that a suitable water source shall be within a walking distance of 20 minutes.

[6] Domestic cattle is in this paper defined as cattle that is at least kept stabled at the farmyard during the night.

[7] F. ter Heegde & K. Sonder: Domestic biogas in Africa; a first assessment of the potential and need. SNV, May 2007

SNV

www.snv.org

Felix ter Heegde. "Technical potential for household biodigesters in Africa". SNV 2019

SNV

SNV Netherlands Development Organisation is a not-for-profit international development organisation. We have a long-term, local presence in over 25 countries in Asia, Africa and Latin America. Our team of 1,300 specialists and generalists, nationals and internationals, males and females, young and more seasoned colleagues are the backbone of SNV. Only five percent of our team is based in the Netherlands, the country where we were established in 1965.

We provide practical know-how to make a lasting difference in the lives of people living in poverty by helping them raise incomes and access basic services.

FOR MORE INFORMATION

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