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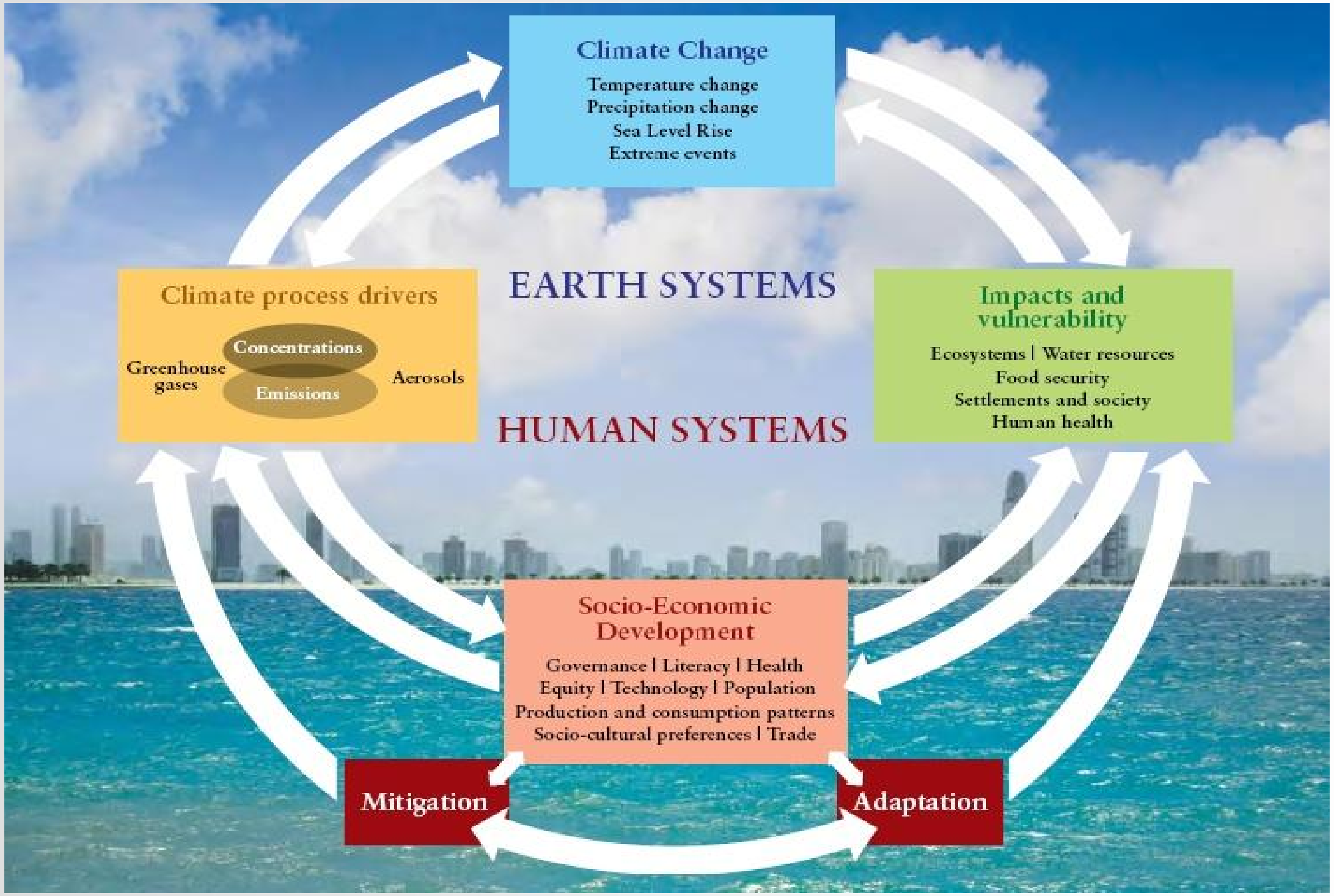
Effluent from Household Biogas Plants

– a valuable by-product or a problem for the plant owner and the environment

Eschborn 30.06.2009

Dishna Schwarz

OE 4504


Climate Change
Temperature change
Precipitation change
Sea Level Rise
Extreme events
Climate process drivers
Greenhouse gases
Concentrations
Emissions
Aerosols
EARTH SYSTEMS
HUMAN SYSTEMS
Impacts and vulnerability
Ecosystems | Water resources
Food security
Settlements and society
Human health
Socio-Economic Development
Governance | Literacy | Health
Equity | Technology | Population
Production and consumption patterns
Socio-cultural preferences | Trade
Mitigation
Adaptation

IPCC

Scenarios for GHG emissions from 2000 to 2100 in the absence of additional climate policies

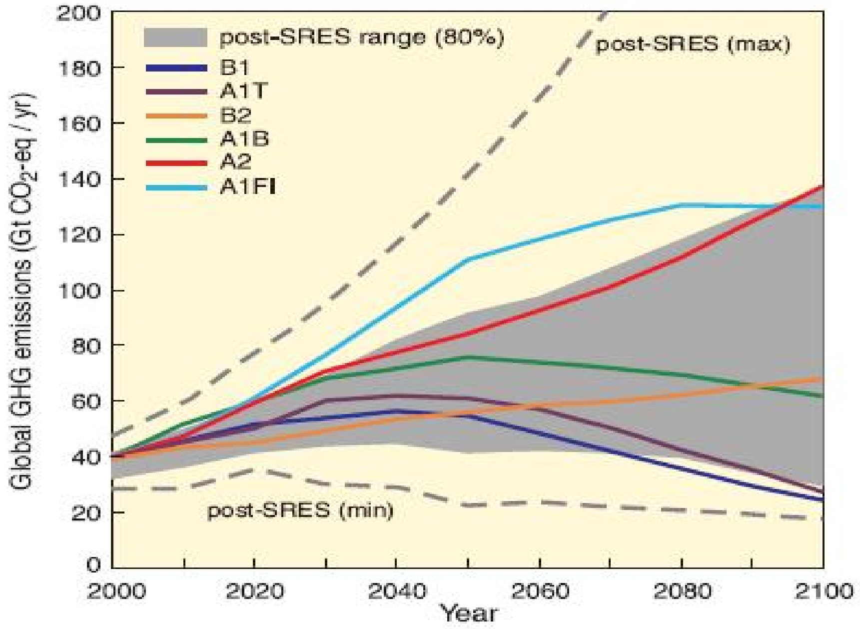


Figure 3.1. *Global GHG emissions (in $GtCO_2$-eq per year) in the absence of additional climate policies: six illustrative SRES marker scenarios (coloured lines) and 80th percentile range of recent scenarios published since SRES (post-SRES) (gray shaded area). Dashed lines show the full range of post-SRES scenarios. The emissions include CO_2, CH_4, N_2O and F-gases. {WGIII 1.3, 3.2, Figure SPM.4}*

Atmosphere-Ocean General Circulation Model projections of surface warming

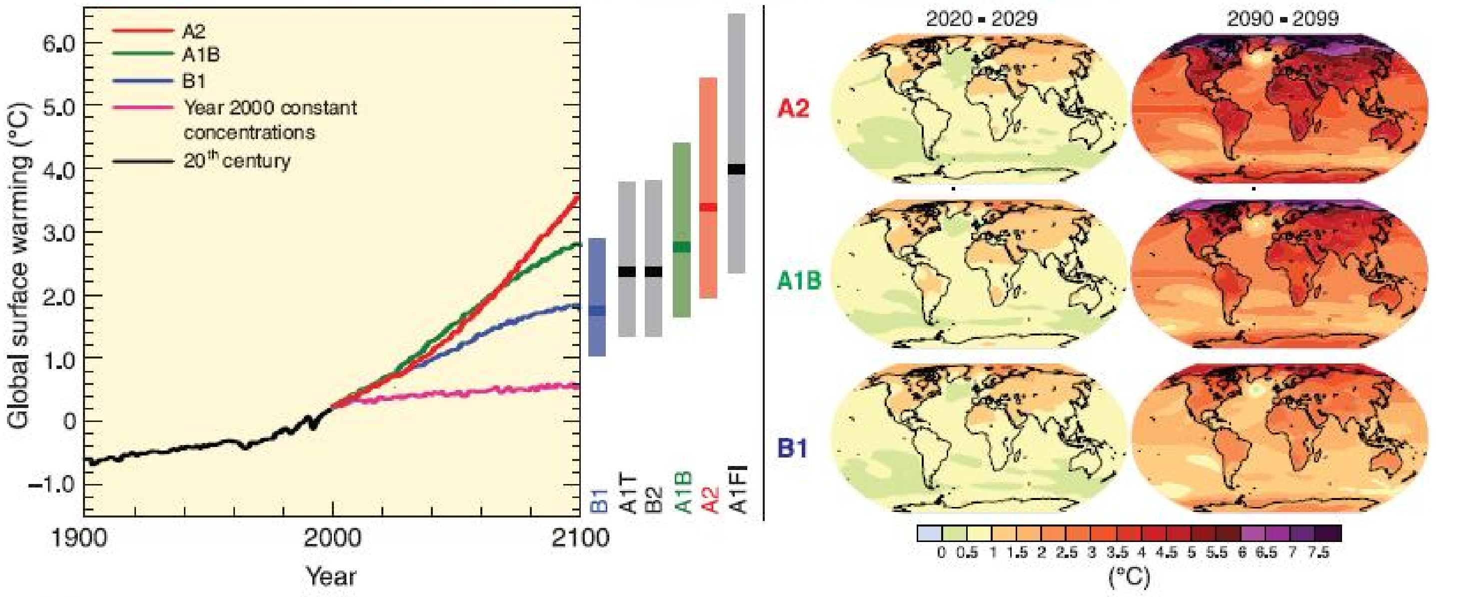


Figure 3.2. ***Left panel:*** *Solid lines are multi-model global averages of surface warming (relative to 1980-1999) for the SRES scenarios A2, A1B and B1, shown as continuations of the 20th century simulations. The orange line is for the experiment where concentrations were held constant at year 2000 values. The bars in the middle of the figure indicate the best estimate (solid line within each bar) and the likely range assessed for the six SRES marker scenarios at 2090-2099 relative to 1980-1999. The assessment of the best estimate and likely ranges in the bars includes the Atmosphere-Ocean General Circulation Models (AOGCMs) in the left part of the figure, as well as results from a hierarchy of independent models and observational constraints.* ***Right panels:*** *Projected surface temperature changes for the early and late 21st century relative to the period 1980-1999. The panels show the multi-AOGCM average projections for the A2 (top), A1B (middle) and B1 (bottom) SRES scenarios averaged over decades 2020-2029 (left) and 2090-2099 (right). {WGI 10.4, 10.8, Figures 10.28, 10.29, SPM}*

CO_2 emissions and equilibrium temperature increases for a range of stabilisation levels

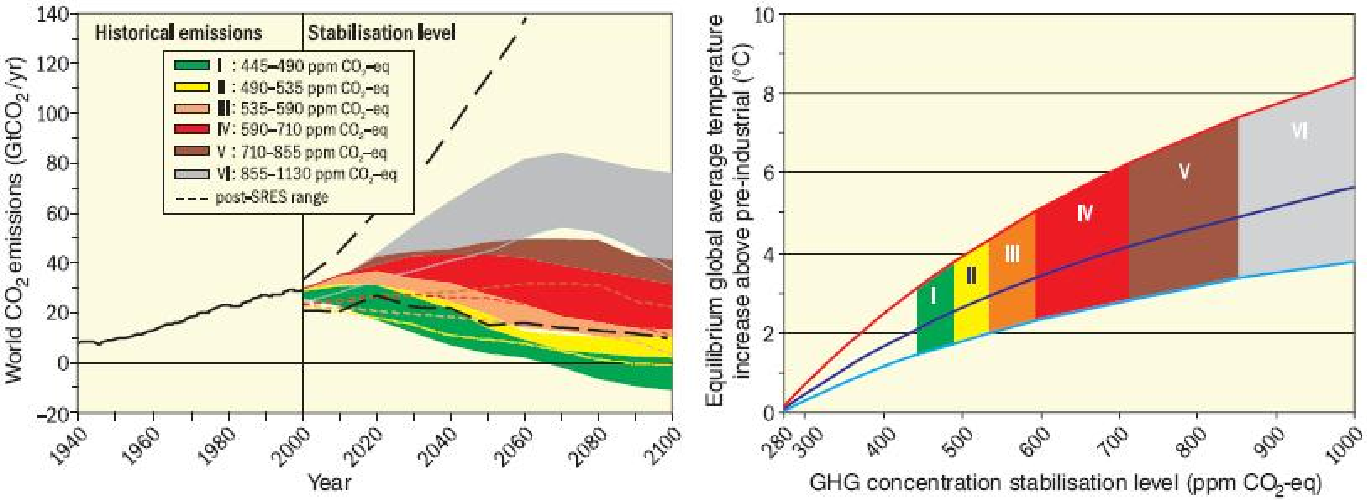


Figure 5.1. Global CO_2 emissions for 1940 to 2000 and emissions ranges for categories of stabilisation scenarios from 2000 to 2100 (left-hand panel); and the corresponding relationship between the stabilisation target and the likely equilibrium global average temperature increase above pre-industrial (right-hand panel). Approaching equilibrium can take several centuries, especially for scenarios with higher levels of stabilisation. Coloured shadings show stabilisation scenarios grouped according to different targets (stabilisation category I to VI). The right-hand panel shows ranges of global average temperature change above pre-industrial, using (i) 'best estimate' climate sensitivity of 3°C (black line in middle of shaded area), (ii) upper bound of likely range of climate sensitivity of 4.5°C (red line at top of shaded area) (iii) lower bound of likely range of climate sensitivity of 2°C (blue line at bottom of shaded area). Black dashed lines in the left panel give the emissions range of recent baseline scenarios published since the SRES (2000). Emissions ranges of the stabilisation scenarios comprise CO_2-only and multigas scenarios and correspond to the 10^{th} to 90^{th} percentile of the full scenario distribution. Note: CO_2 emissions in most models do not include emissions from decay of above ground biomass that remains after logging and deforestation, and from peat fires and drained peat soils. {WGIII Figures SPM.7 and SPM.8}

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Avantages of anaerobic fermentation

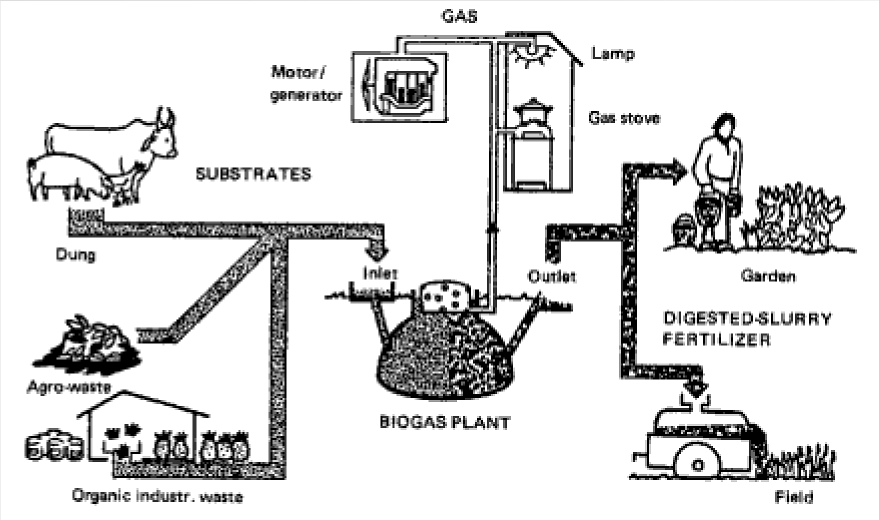
§ A reliable and simple technology

§ Many forms of uses from the produced gas (cooking, light, industrials water heater, combustion engine)

§ Appropriate technology: individual systems to large production systems depending on many parameters

§ A neutral bioenergy for environnement

A typical biogas system configuration



Feedstock/Substrate

- Animal dung
- Fisch waste
- Slaughter house waste
- Leaves, Water Hyacinth, Banana leaves & stem
- Food waste / Market waste
- Straw
- Municipal Waste(waste water, sludge and solid wastes)
- Human exctreta

Biogas impacts

- **Energy**
  - Cooking
  - Lighting
  - Heating
- **Saving of fire wood**
  - Environmental protection through reduced deforestation
  - For women: more time for literacy and other income generating activities
- **Agricultural improvements in terms of plant and animal production yields**
  - Increased household income
- **Fertiliser production**
  - protection and/or recovering of soil fertility
- **Sanitation**
  - Controled disposal of animal manure and organic waste
  - Greywater collection and reuse
  - Improved hygiene and sanitary conditions
- **Health**
  - Reduction of diseases related to wastewater and solid waste
  - Reduction of exposure to smoke while cooking
- **Climate protection**

Composition of biogas

Substance	Symbol	Percentage
Methane	CH_4	50 - 70
Cabon Dioxide	CO_2	30 - 40
Hydrogen	H_2	5 - 10
Nitrogen	N_2	1 - 2
Water vapour	H_2O	0,3
Hydrogen Sulphide	H2S	Traces

* Erd gas – 80-90% CH_4

Biogas guideline data

Suitabl digesting temperature	20 – 35°
Retention time	40-100 days
Biogas energy content	6 kWh/m³ = 0.6 l diesel fuel
1 cow yields	9-15 kg dung/d = 0.4m³ gas/d
1 pig yields	2-3 kg dung/d = 0.15 m³ gas/d
gas requirement for cooking	0.1-0.3 m³ /person
1 lamp	0.5 m³ /d (about 0.13-0.15m³/h)
1 kWh electricity	1 m³ gas

The maximum of biogas production from a given amount of raw material depends on the type of substrate

Biogas guideline data

1 Kg firewood => 0.2 m³ biogas

1 Kg dried cow dung => 0.1 m³ biogas

1 Kg Charcoal => 0.5 m³ biogas

1 Litre Kerosine => 2.0 m³ biogas

Biogas guideline data

- 8 – 10 m³ biogas plant produces 1.5-2 m³ gas and 100 litres digested slurry per day using dung from 3-5 cattle or 8-12 pigs.

- With that much biogas, a 6-8 person family can:

  - cook 2-3 meals
  - operate one refrigerator all day
  - burn two lamps for 3 hours
  - operate a 3 kw motor generator for 1 hour

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Types of biogas plants

- **Batch type plants** are filled and then emptied completely after a fixed reteition time. They are used for large scale application.High labour input, gas output not steady.

- **Continuous plants** are fed and emptied continuously.They empty automatically through the overflow whenever new material is filled in. They are best suited for small-scale domestic applications.

- If straw and dung are to be digested together , the plant can be operated on a **Semi Batch basis.** The slowly digested straw-type material is fed in about twice a year as a batch load.The dung is added and removed regularly.

Types of Biodigesters

- Floating Drum
- Fixed Dome

- Bag Digester
- Plastic Digester
- Plug Flow Digester

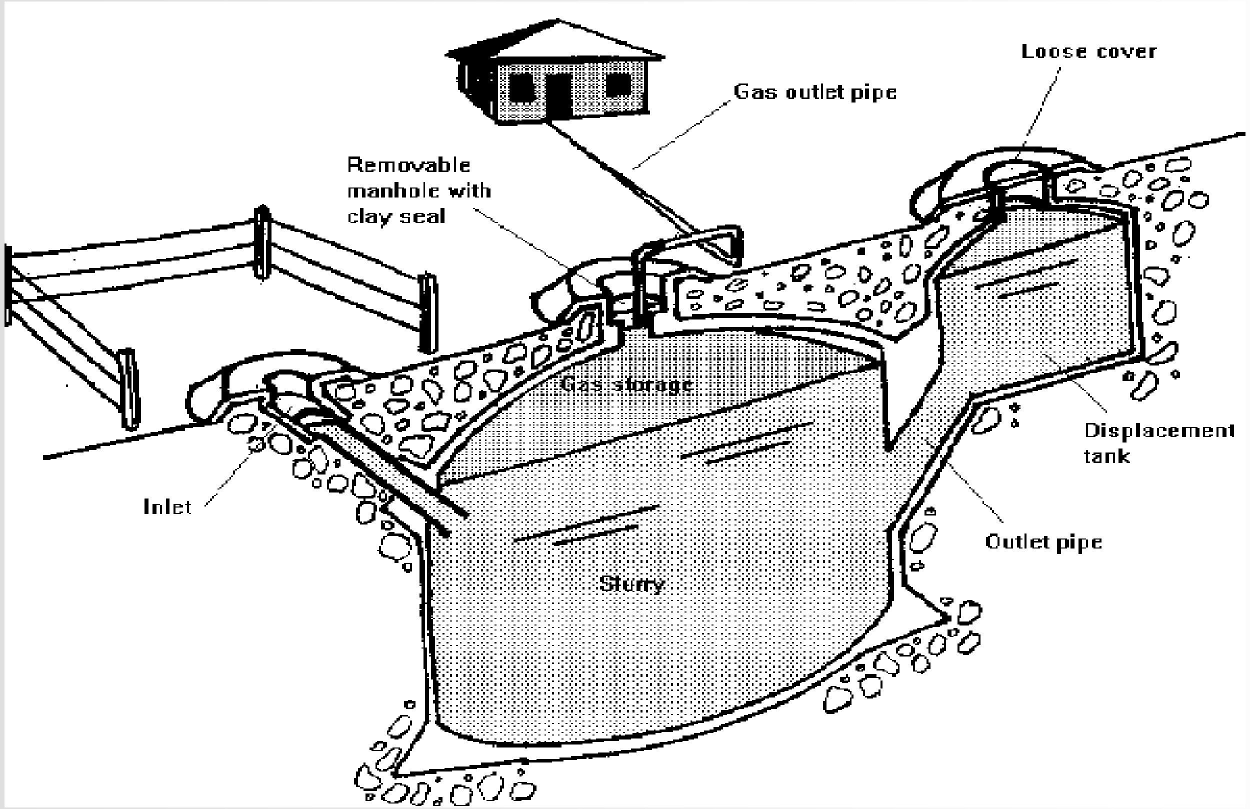
- Anaerobic Filter
- UASB (Uplift Anaerobic Sludge Blanket) Digester

Fixed dome digester

- Fixed dome Chinese model biogas plant as built in China as early as 1936. It consists of an underground brick masonry compartment (fermentation chamber) with a dome on the top for gas storage. In this design, the fermentation chamber and gas holder are combined as one unit. This design eliminates the use of costlier mild steel gas holder which is susceptible to corrosion. The life of fixed dome type plant is longer (from 20 to 50 years) .

  Based on the principles of fixed dome model from China, Gobar Gas and Agricultural Equipment Development Company (GGC) of Nepal has developed a design and has been popularizing it since the last 17 years. The concrete dome is the main characteristic of GGC design .

Fixed dome digester (Chinese model)



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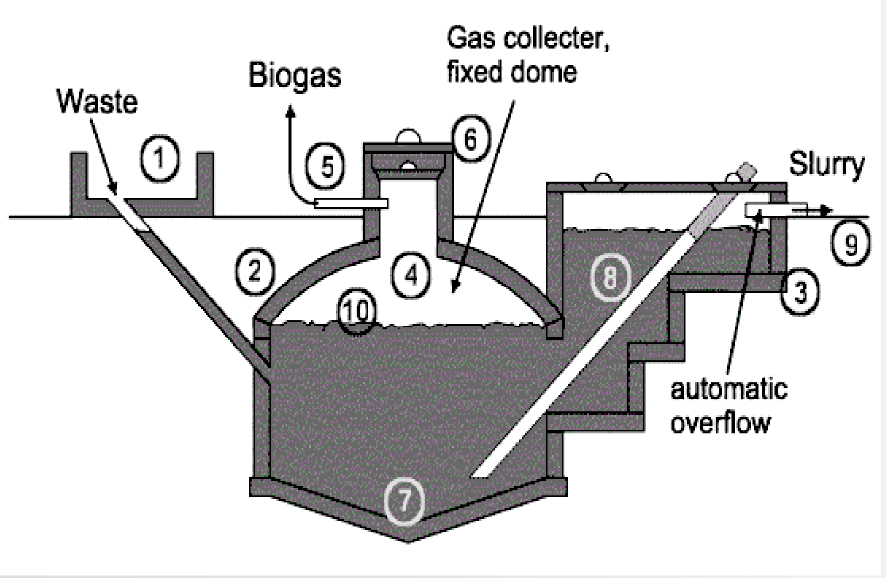
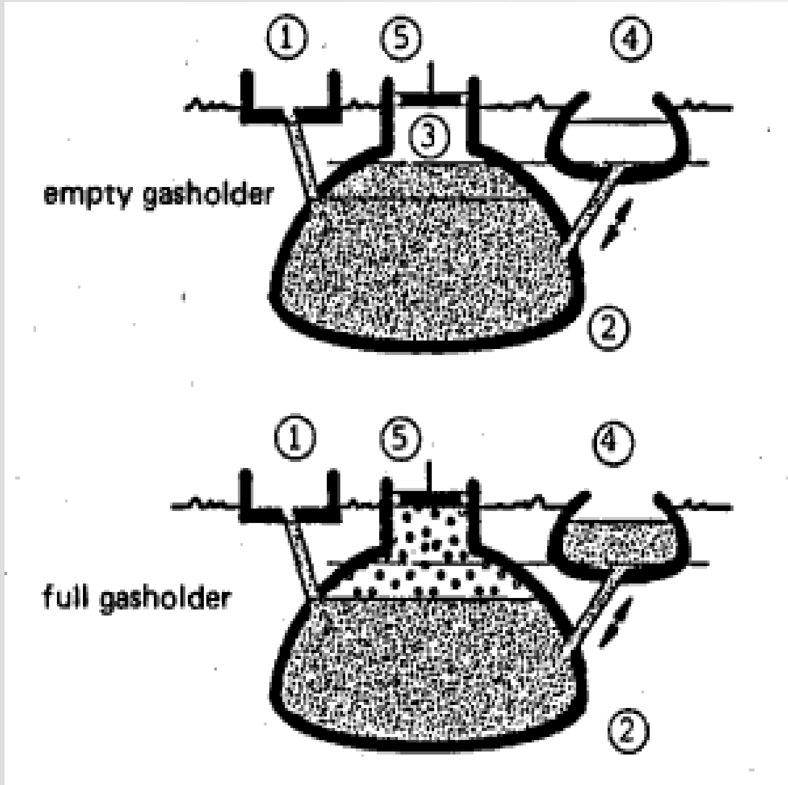
Fixed dome plant design



1. Mixing tank with inlet pipe and sand trap.
2. Digester.
3. Compensation and removal tank.
4. Gasholder.
5. Gas pipe.
6. Entry hatch, with gastight seal.
7. Accumulation of thick sludge.
8. Outlet pipe.
9. Reference level.

Digester Volume VD = SD x RT
(SD = daily substrate input m³/d,
RT = rretention time in d)

Basic function of a fixed-dome biogas plant



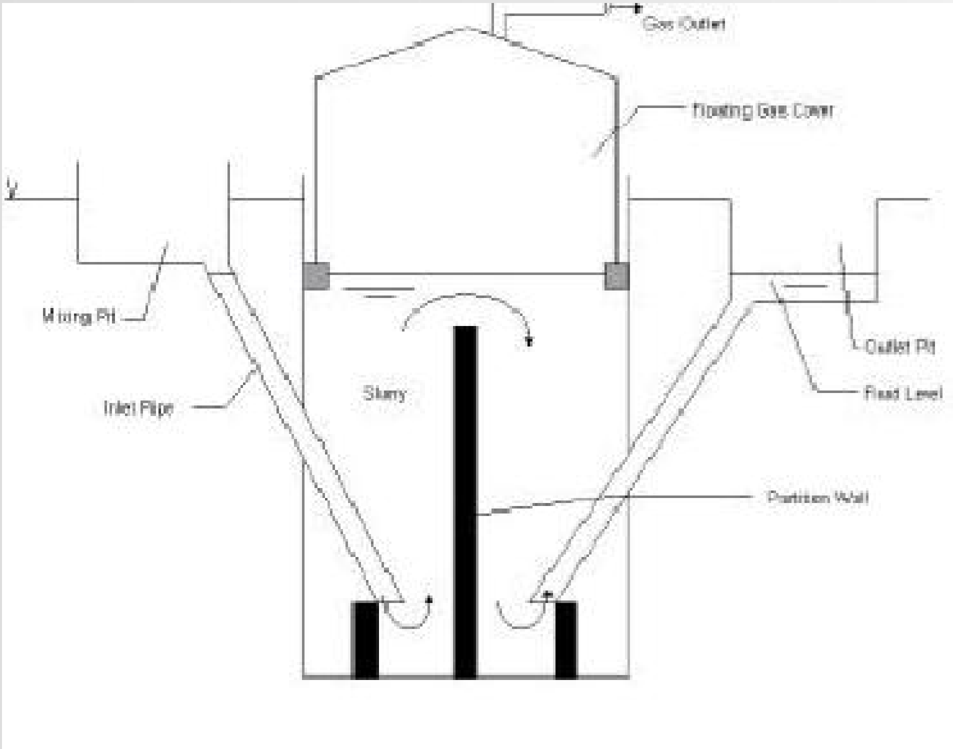
1. Mixing pit,
2. Digester,
3. Gasholder,
4. Displacement pit,
5. Gas pipe

Floating drum digester

- Experiment on biogas technology in India began in 1937. In 1956, Jashu Bhai J Patel developed a design of floating drum biogas plant popularly known as Gobar Gas plant. In 1962, Patel's design was approved by the Khadi and Village Industries Commission (KVIC) of India and this design soon became popular in India and the world.

  In this design, the digester chamber is made of brick masonry in cement mortar. A mild steel drum is placed on top of the digester to collect the biogas produced from the digester. Thus, there are two separate structures for gas production and collection. With the introduction of fixed dome Chinese model plant, the floating drum plants became obsolete because of comparatively high investment and maintenance cost along with other design weaknesses.

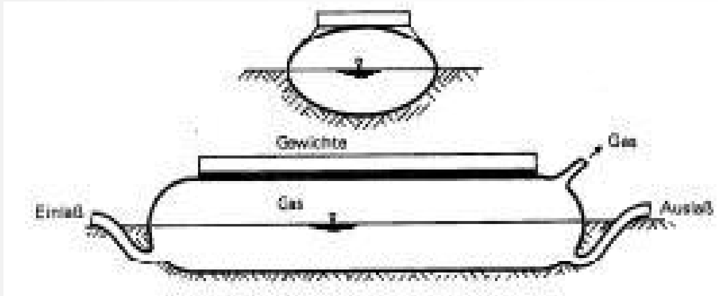
Floating drum digester (Indian model)



Bag digester

- This design was developed in 1960s in Taiwan. It consists of a long cylinder made of PVC or red mud plastic. The bag digester was developed to solve the problems experienced with brick and metal digesters. A PVC bag digester was also tested in Nepal by GGC at Butwal from April to June 1986.
- The study concluded that the plastic bag biodigester could be successful only if PVC bag is easily available, pressure inside the digester is increased and welding facilities are easily available. Such conditions are difficult to meet in most of the rural areas in developing countries.

Bag Digester



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Plug flow digester

- The plug flow digester is similar to the bag digester. It consists of a trench (trench length has to be considerably greater than the width and depth) lined with concrete or an impermeable membrane. The reactor is covered with either a flexible cover gas holder anchored to the ground, concrete or galvanized iron (GI) top. The first documented use of this type of design was in South Africa in 1957

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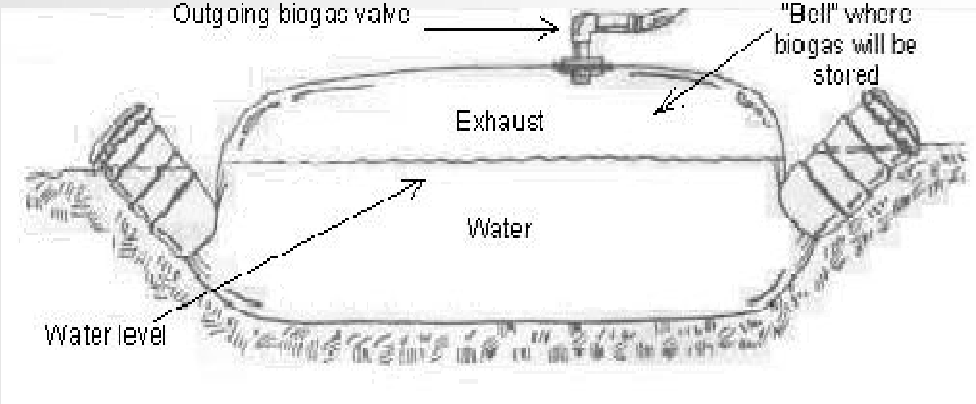
Plug flow digester



Plug-flow digesters are suitable for ruminant animal manure that has a solids concentration of 11 percent to 13 percent. New material added to the tank at one end pushes older material to the opposite end. Coarse solids in ruminant Manure form a viscous material as they are digested, limiting solids separation in the digester tank. As a result, the material flows through the tank in a "plug.„ Average retention time (the time a manure "plug" remains in the digester) is 20 to 30 days.

Plugflow digester model

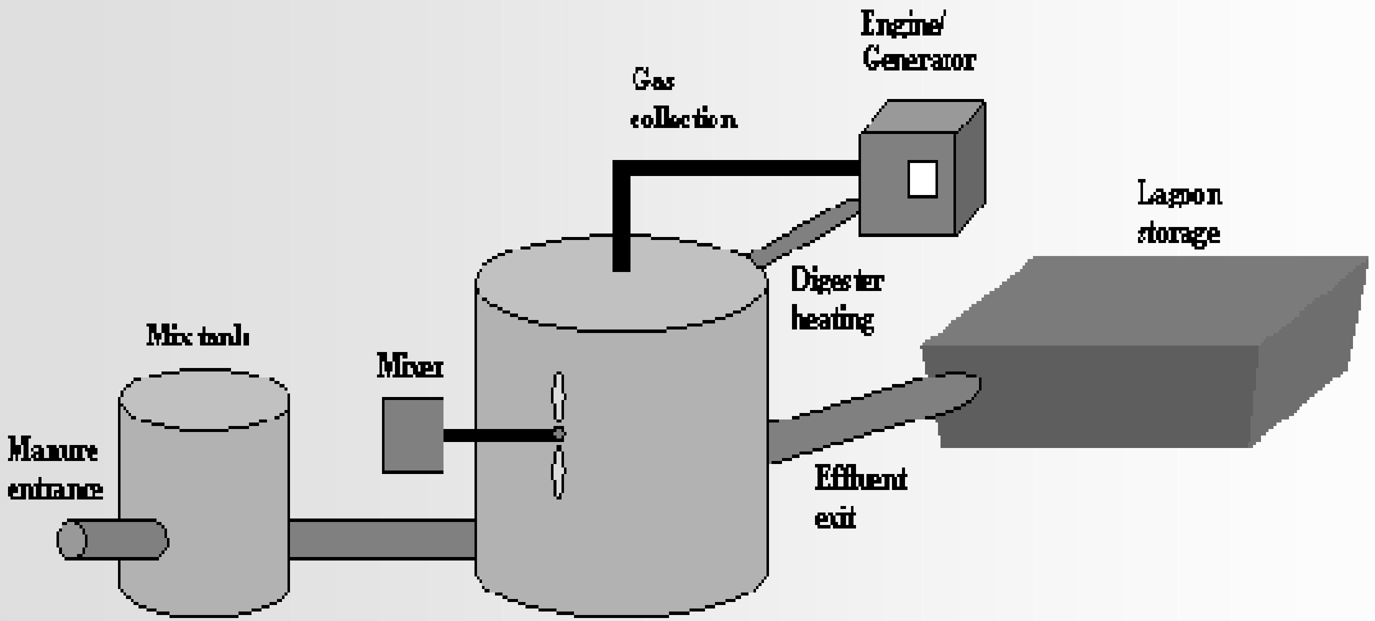
Anaerobic filter

- This type of digester was developed in the 1950's to use relatively dilute and soluble waste water with low level of suspended solids. It is one of the earliest and simplest type of design developed to reduce the reactor volume. It consists of a column filled with a packing medium. A great variety of non-biodegradable materials have been used as packing media for anaerobic filter reactors such as stones, plastic, coral, mussel shells, reeds, and bamboo rings. The methane forming bacteria form a film on the large surface of the packing medium and are not carried out of the digester with the effluent. For this reason, these reactors are also known as "fixed film" or "retained film" digesters

Upflow anaerobic sludge blanket –UASB plants

- This UASB design was developed in 1980 in the Netherlands. It is similar to the anaerobic filter in that it involves a high concentration of immobilized bacteria in the reactor. However, the UASB reactors contain no packing medium, instead, the methane forming bacteria are concentrated in the dense granules of sludge blanket which covers the lower part of the reactor. The feed liquid enters from the bottom of the reactor and biogas is produced while liquid flows up through the sludge blanket. Many full-scale UASB plants are in operation in Europe using wastewater from sugar beet processing and other dilute wastes that contain mainly soluble carbohydrates.

UASB plant


Engine/
Generator
Gas
collection
Lagoon
storage
Digester
heating
Mix tank
Mixer
Manure
entrance
Effluent
exit

Parameters for process optimisation

- Substrate temparature
- Available nutrients
- Retention time (flow through time)
- PH level
- Nitrogen inhibition and C/N ratio
- Substrate solid content and agitation
- Inhibitory factors

Substrate temperature

Temperature range of anaerobic fermentation

- Anaerobic fermentation is in principle possible between 3°C and approximately 70°C. Differentiation is generally made between three temperature ranges:

- The *psychrophilic temperature range* lies below 20°C
- the *mesophilic temperature range* between 20°C and 40°C
- the *thermophilic temperature range between* 40°C and 55 °C
- Ideal temparature 20 °C – 28°C
- If the temperature of the bio-mass is below 15°C, gas production will be so low that the biogas plant is no longer economically feasible.

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Available nutrient

- In order to grow, bacteria need more than just a supply of organic substances as a source of carbon and energy
- Requires an adequate supply of *nitrogen, sulfur, phosphorous, potassium, calcium, magnesium* and a number of trace elements such as *iron, manganese, molybdenum, zinc, cobalt, selenium, tungsten, nickel* etc
- "Normal" substrates such as agricultural residues or municipal sewage usually contain adequate amounts of the mentioned elements.
- Higher concentration of any individual substance usually has an inhibitory effect, so that analyses are recommended on a case-to-case basis to determine which amount of which nutrients, if any, still needs to be added.

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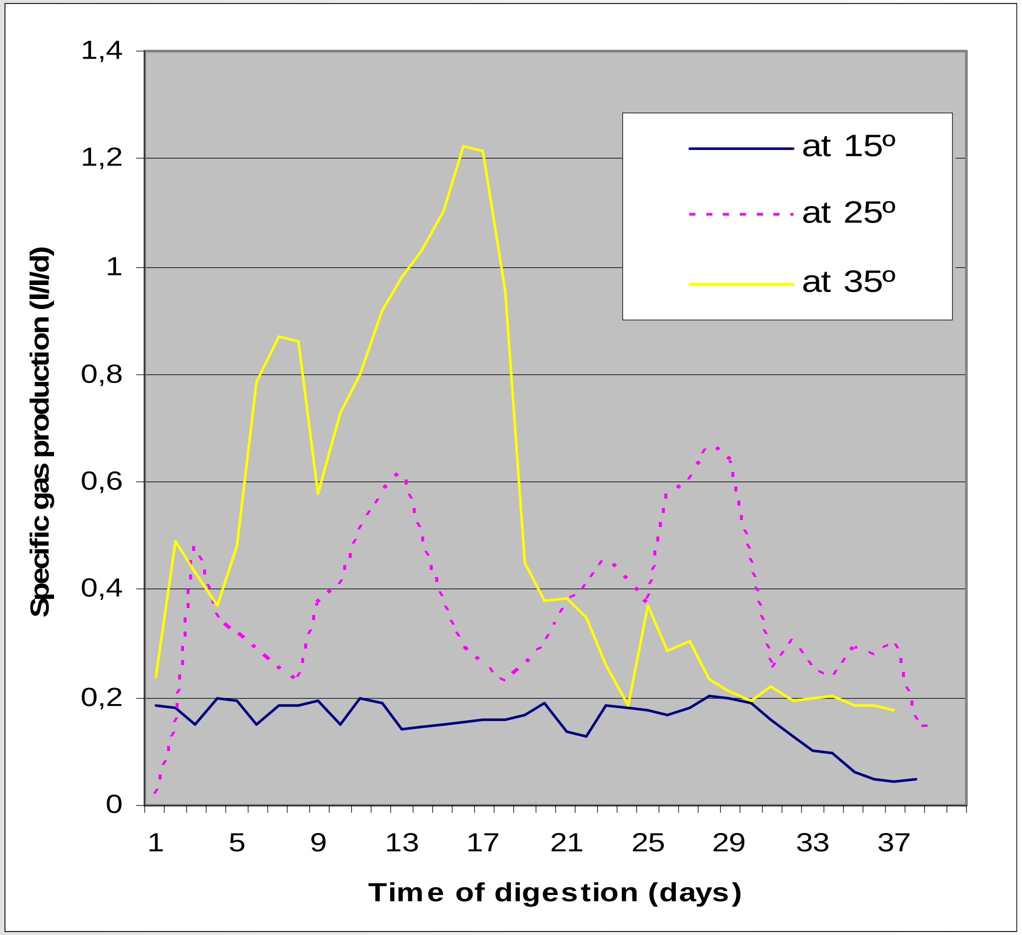
Retention time

- can only be accurately defined in batch-type facilities. For continuous systems, the mean retention time is approximated by dividing the digester volume by the daily influent rate.
- Depending on the vessel geometry, the means of mixing, etc., the effective retention time may vary widely for the individual substrate constituents.
- Selection of a suitable retention time thus depends not only on the process temperature, but also on the type of substrate used.

Substrate

- For liquid manure undergoing fermentation in the mesophilic temperature range, the following approximate values apply:
- liquid cow manure: 20-30 days
- liquid pig manure: 15-25 days
- liquid chicken manure: 20-40 days
- animal manure mixed with plant material: 50-80 days

Gas production vs retention time



PH value

- The methane-producing bacteria live best under neutral to slightly alkaline conditions. Once the process of fermentation has stabilized under anaerobic conditions, the pH will normally take on a value of between 7 and 8.5.

- If the pH value drops below 6.2, the medium will have a toxic effect on the methanogenic bacteria.

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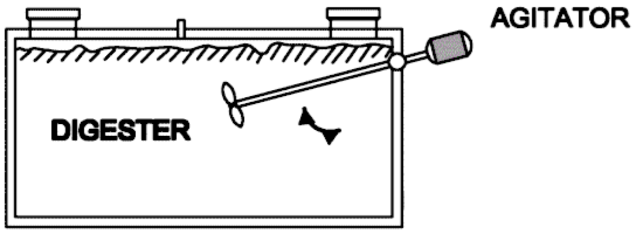
Nitrogen-content and C/N-ratio of organic substrates

Biodegradable material	N (%)	C/N
Night Soil	6.0	5.9-10
Cow manure	1.7	16.6-25
Pig manure	3.8	6.2-12.5
Chicken dropings	6.3	5-7.1
Hay	4.0	12.5-25
Water hyacinth	2.9	11.4
Kitchen waste	1.9	28.60
Rice straw	0.6	67
Bagasse	0.3	150
Fallen leaves	1.0	50
Sea weed	1.9	79
Sawdust	0.1	200 - 500

§ metabolic activity of methanogenic bacteria can be optimized at a C/N ratio of approximately 8-20, whereby the optimum point varies from case to case, depending on the nature of the substrate.

§ Substrate can be mixed to get the optimum C/N ratio

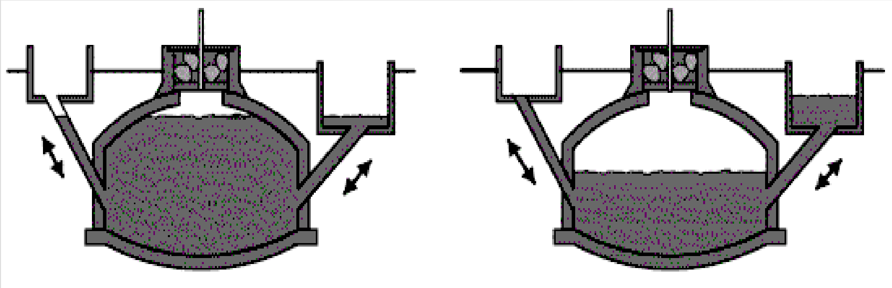
Substrate agitation



Agitation

different ways of homogenising the substrate or mixing it with water and co-substrate

- Mixing and homogenizing the substrate in the mixing chamber
- Agitation inside the digester
- Poking through the in- and outlet pipes (small scale plants)



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Solids content

Dry solid matter

- Substrate after the withdrawal of water
- For AD suitable solid waste range : 10 % - 40%

Organic dry solid matter content

- Organic share of the dry matter (for anaerobic digestion it should exceed 50%)

Structure material

- Substrate with high content of lignin- a type of carbon - (wood, shrub/tree cut offs)
- Low content : advantageous for AD
- High : Composting

Toxic substances

- Hinder digestion process
- Should be kept low

Protein content

- Should not exceed 50%

Inhibitory factors

- The presence of heavy metals, antibiotics and detergents used in livestock husbandry can have an inhibitory effect on the process of bio-methanation.
- The following table lists the limit concentrations (mg/l) for various inhibitors.

Substance	[mg/l]
Copper	10-250
Calcium	8000
Sodium	8000
Magnesium	3000
Nickel	100-1000
Zinc	350-1000
Chromium	200-2000
Sulfide (as Sulfur)	200
Cyanide	2

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Biogas appliances – small scale

Domestic plants

- Gas cookers
- Gas Lamps

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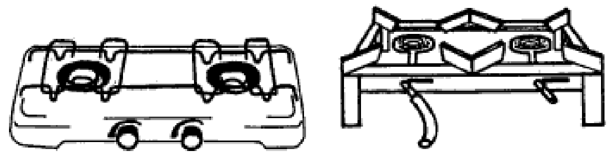
Gas cookers



- **basic requirements**:
- simple and easy operation
- versatility, e.g. for pots of various size, for cooking and broiling
- easy to clean
- acceptable cost and easy repair
- good burning properties, i.e. stable flame, high efficiency

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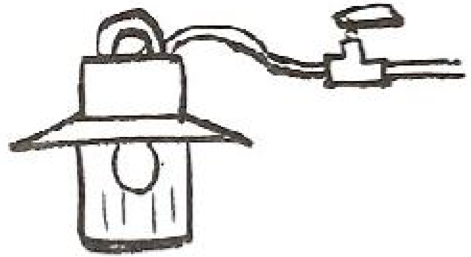
Biogas lamps



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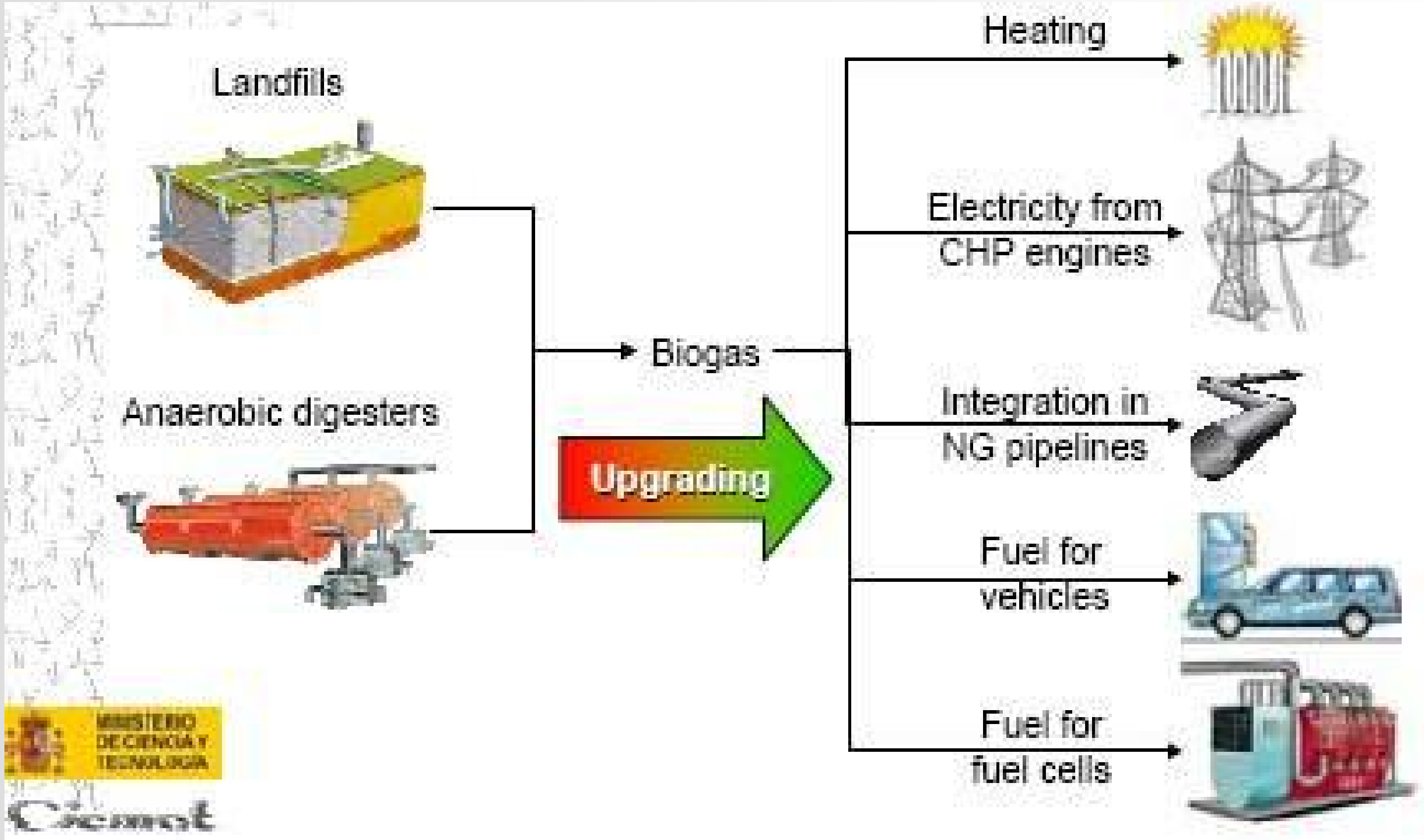
Biogas lamps

- Not very efficient
- Get very hot
- Mantel last not long
- Gas & air should be properly mixed before entering the mantel - biogas lamps are controlled by adjusting the supply of gas and primary air. The aim is to make the gas mantle burn with uniform brightness and a steady,
- Less lumen output
- 1 lamp needs ca 120 – 150 L /day

Options of biogas utilisation



Options of biogas utilisation

- Gas-engine electricity generation needs medium-grade biogas purification (removal of moisture and trace gases)
- Biogas needs to be high-graded with carbon-dioxide removal to natural gas standards
- Utilisation of biogas for vehicles needs high-upgraded biogas with a quality compared to LNG/CNG

Biogas as a sanitation option- Ecosan concept

- Human excreta from dry or low flush toilets and biodegradable organic fraction of household waste could enter a (on-site or off-site) anaerobic (wet or dry) digester to be treated and to produce biogas
- The concentration of nitrogen in the black water could be so high, that the digestion process could be stopped. Ammonia from the urine will be transformed by enzymes in urea, carbon dioxide and ammoniac. Urea will be toxic to the bacteria (self-intoxification).

  Solution : Urin separation
- from an energy point of view, its better to have some animal manure or additional feed of organic waste to optimize the retention time / construction volume related to energy output

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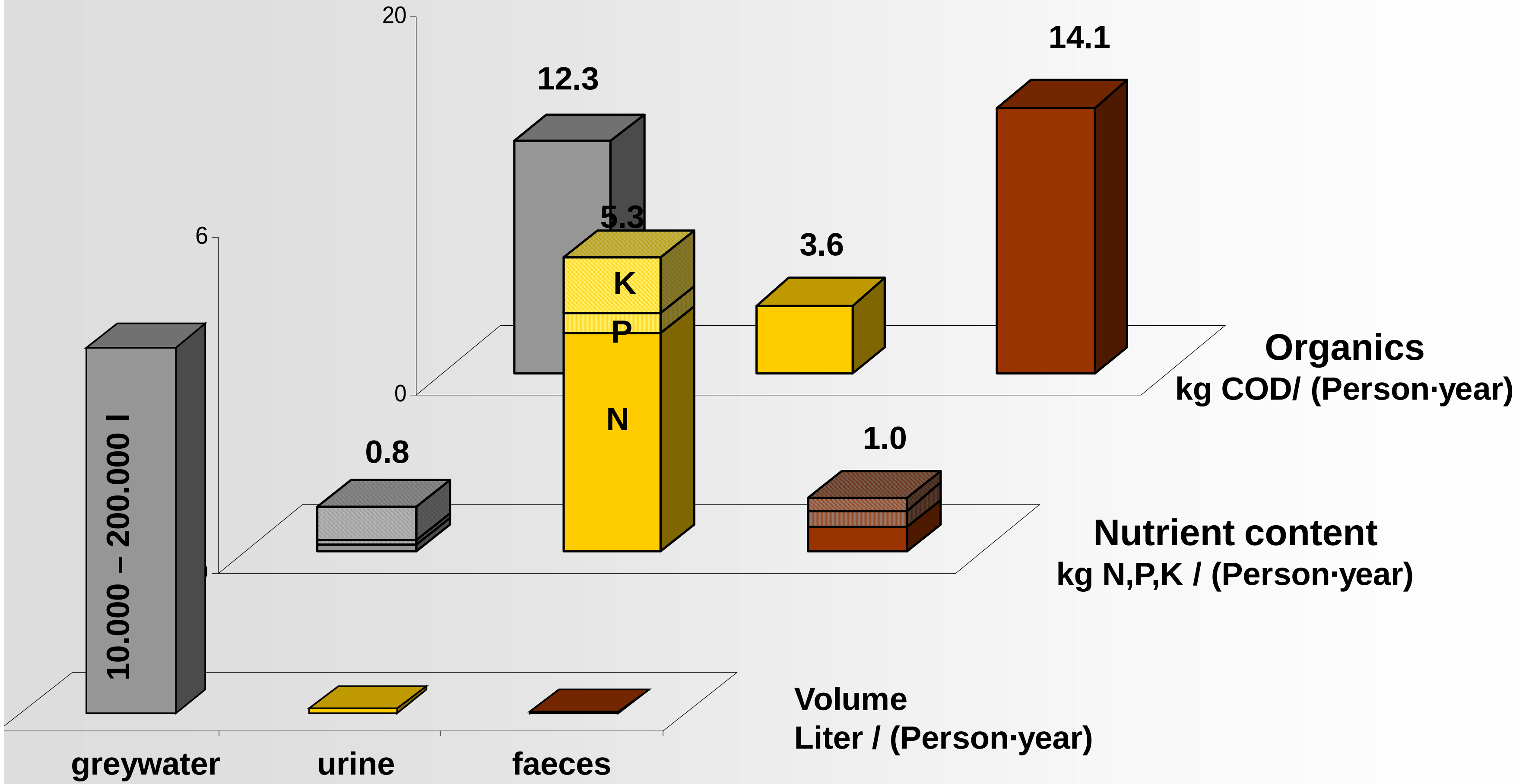
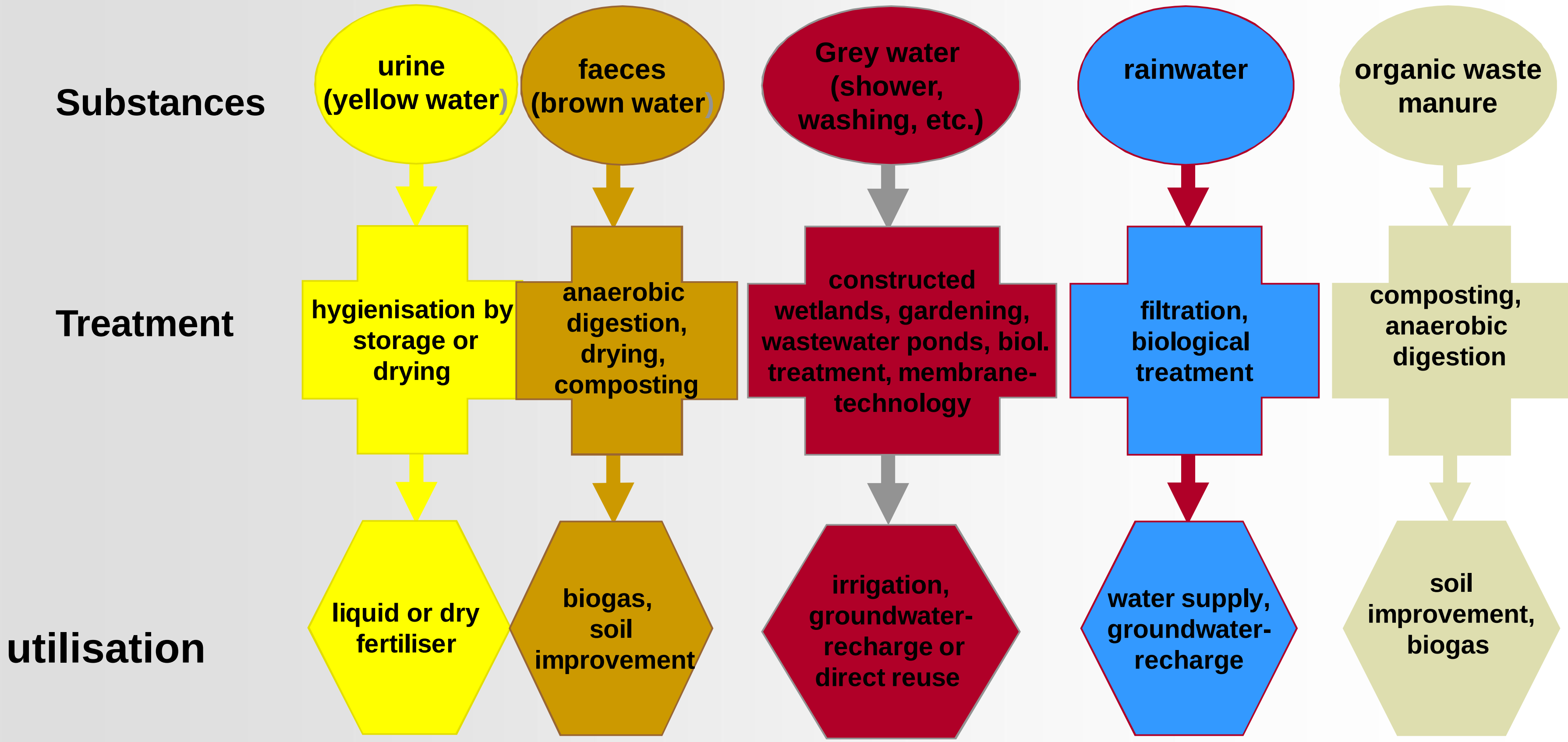
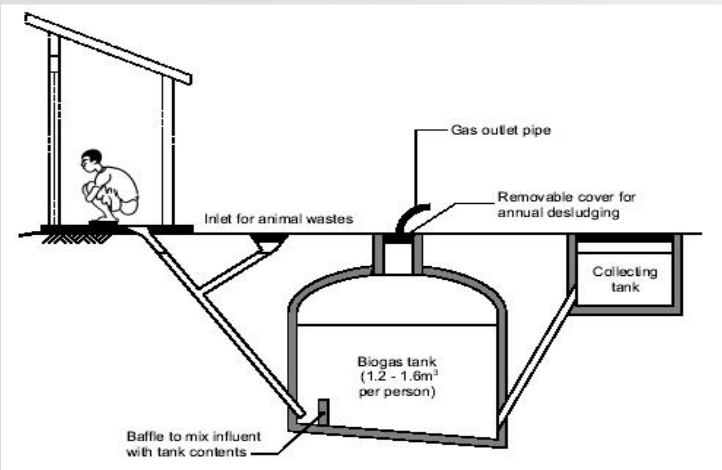
Composition of household wastewater



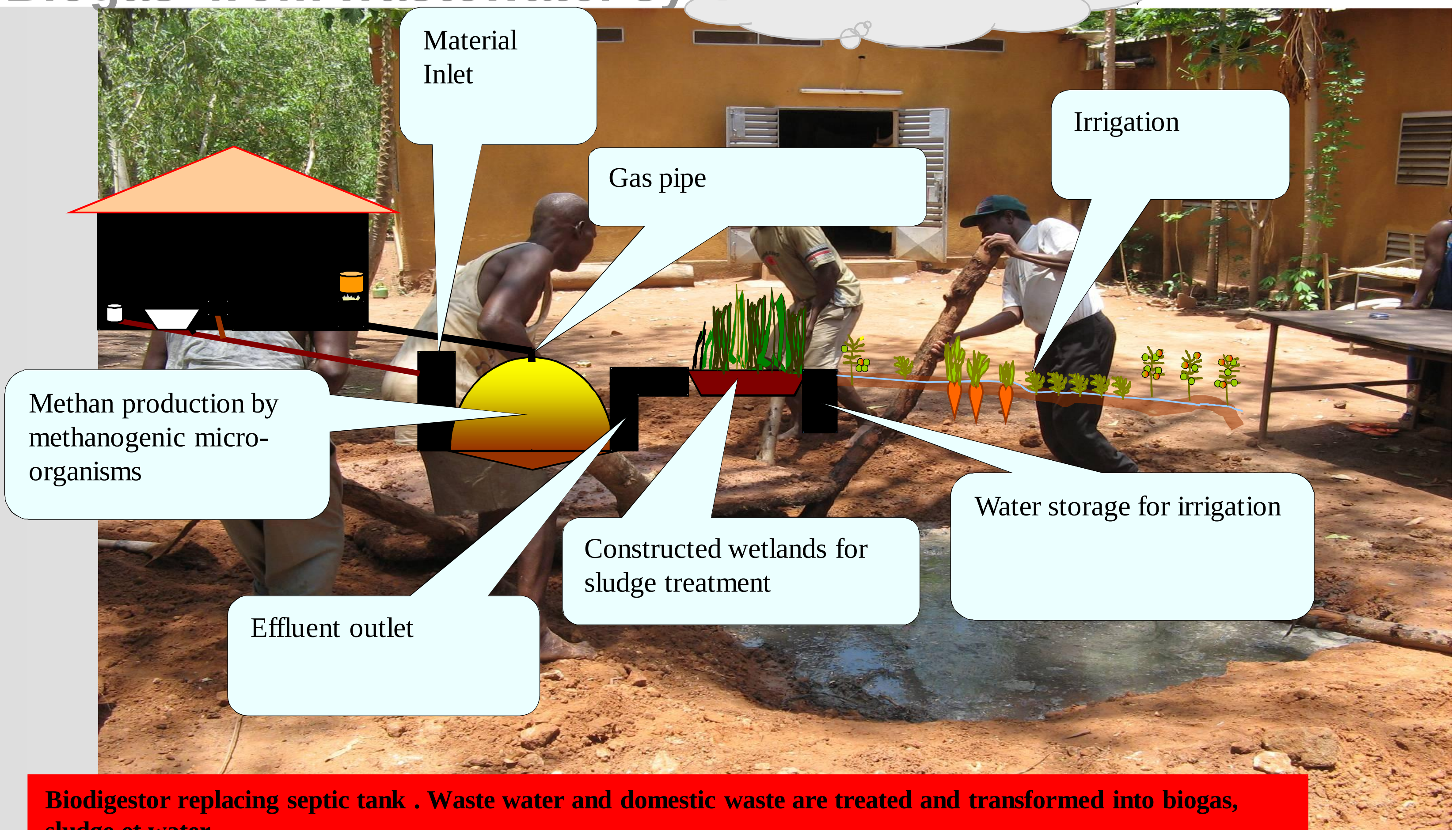

Substances
Treatment
utilisation
urine (yellow water)
faeces (brown water)
Grey water (shower, washing, etc.)
rainwater
organic waste manure
hygienisation by storage or drying
anaerobic digestion, drying, composting
constructed wetlands, gardening, wastewater ponds, biol. treatment, membrane-technology
filtration, biological treatment
composting, anaerobic digestion
liquid or dry fertiliser
biogas, soil improvement
irrigation, groundwater-recharge or direct reuse
water supply, groundwater-recharge
soil improvement, biogas

Anaerobic treatment with biogas production

small-scale biogas plants: decentralized treatment of household wastewater with or without agricultural waste



Biogas from wastewater sy



Biodigestor replacing septic tank . Waste water and domestic waste are treated and transformed into biogas, sludge et water.
Advantages: no work requested to empty septic tanks, waste reuse for energy, fertilizer, irrigation water, cash flow saving

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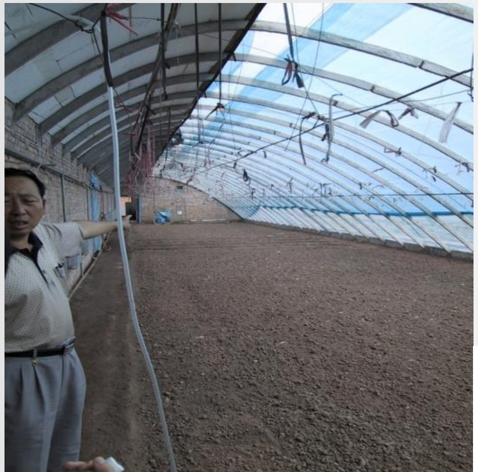
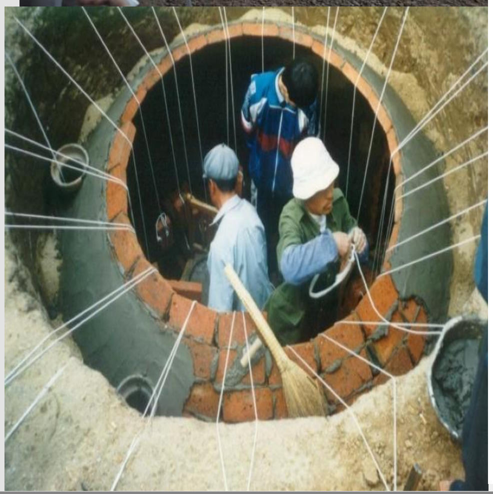
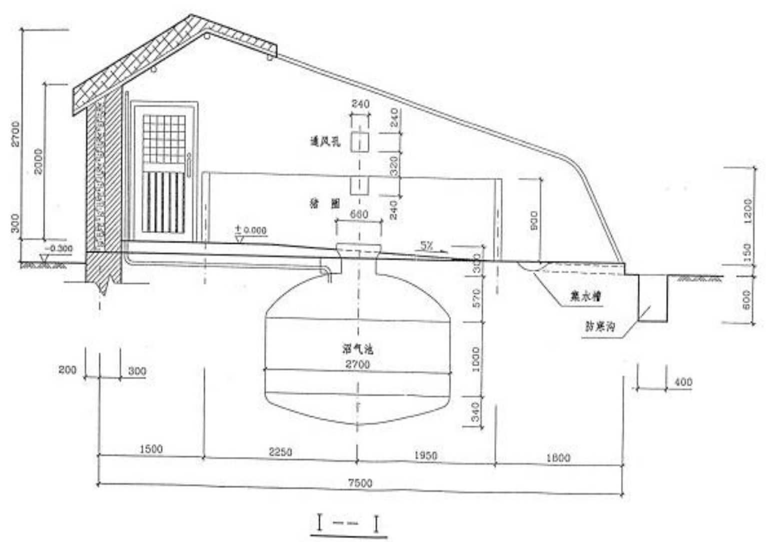
Chinese „four in one“ model



pig – toilet – biogas – vegetable
combined with Greenhouse Production
more than 1,000,000 times in peri-urban areas
of Megacities in Northern China .





Navsarjan Trust ecosan pilot project – DSK, India

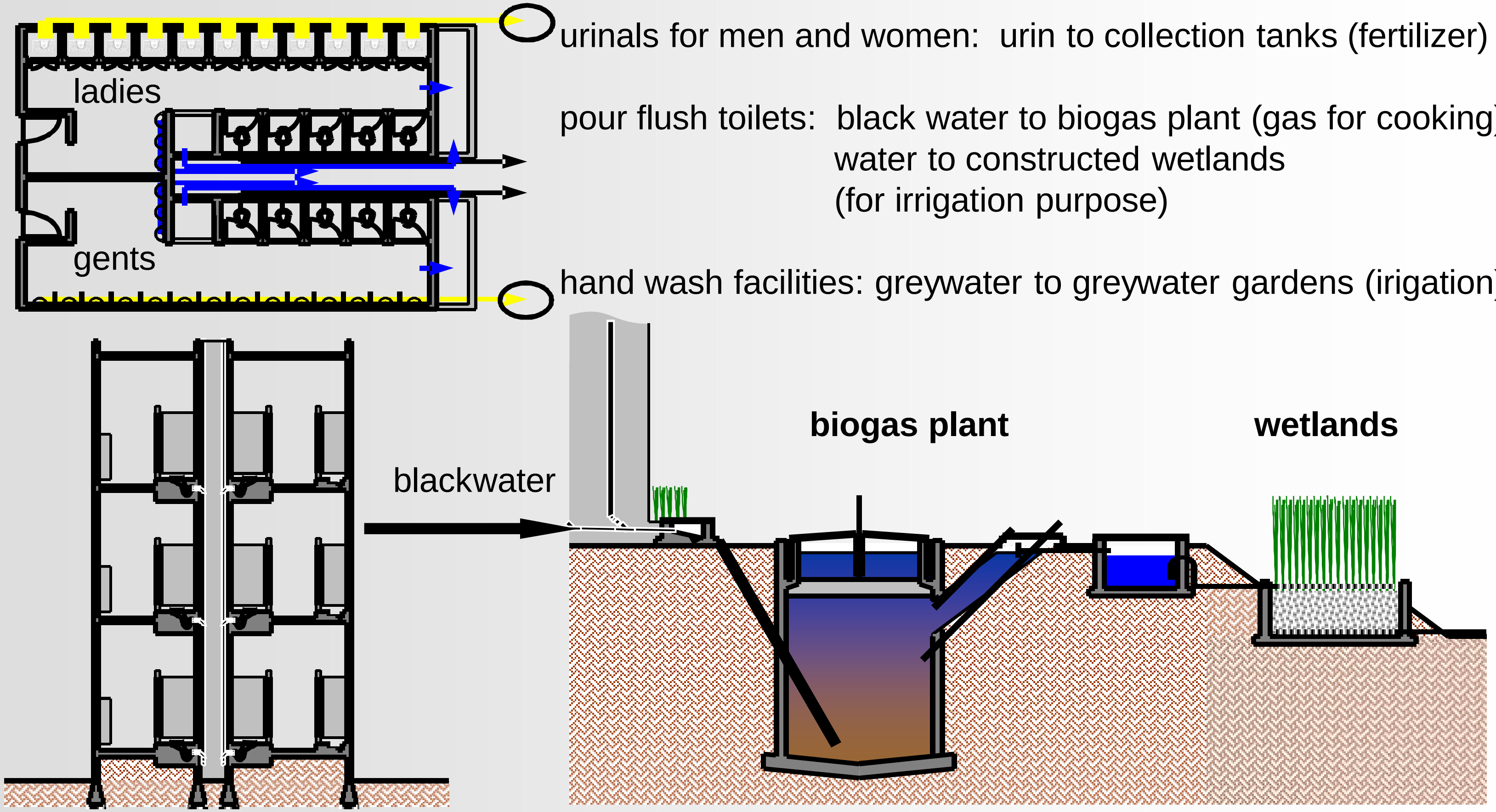
construction of the night-soil based biogas plant

inlet chamber for toilet water

biogasreactor in the center of the building

Adarsh Vidya Mandir school, Badlapur, India

sketch of the three storeyed sanitation block



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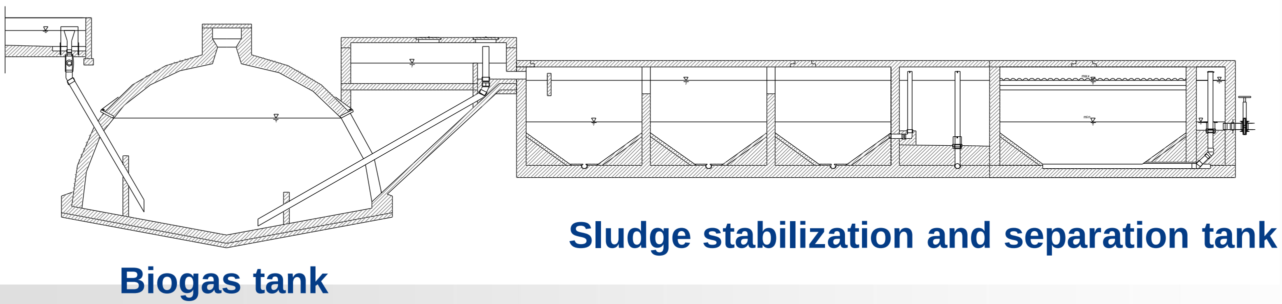
Biogas from household wastewater - China

137,000 community biogas septic tanks (DEWATS) for purification of household wastewater with more than 0.5 billion tons of wastewater treated annually

Septic tanks

nt



GTZ biogas experiences

In the Past

- In 1970 s first trials with the technology
- 1983-1990 Biogas extension service
- 1988 & 1992 - Biogas survey with BORDA
- 1992 – 1994 SEP biogas components
- 1996 - promotion of Anaerobic Technology for the Treatment of municipal and industrial wastewater (experiences and recommendations from more than 20 countries have been analysed and documented
- 1996 – 2006 GATE biogas information service and biogas homepage

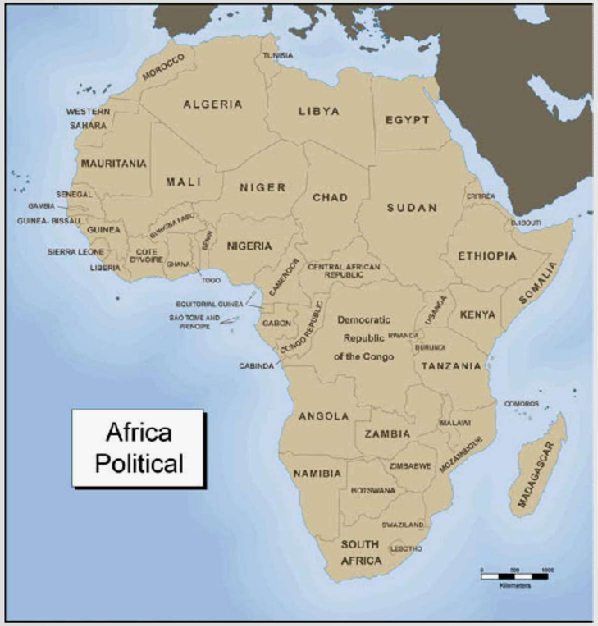
On going

- Ecosan biogas projects
- Some PPP projects

Future

- „Biogas for a better life „ (feasibility studies for Tanzania & Burkina Faso) ?????

GTZ - Biogas experiences in Africa



- **East Africa**

  Kenya, Tanzania, Ethiopia (first GTZ -biogas project in 1977)

- **West Africa**

  Burkina Faso, Ivory coast, Mali

- **Central Africa**

  Cameroon, Burundi, Rwanda

- **North Africa**

  Morrocco, Tunisia

- **South Africa**

  Lesotho

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Number of biogas plants installed

Country	**Pilot plants/ Number of plants**	**Dissemination projects/ Number of plants**
Burkina Faso	6	
Burundi		over 300
Cameroon	43	
Ethiopia		over 100
Kenya		over 300
Lesotho		65
Mali	34	
Morocco		over 100
Ivory Coast		80
Rwanda	2 large plants	
Tanzania		over 300
Tunisia	30	

Das BIOTECH model India – 2007 Ashden Award 1. prize winner

- 12000 domestic plants
- 160 with latrine connection
- 220 institutional plants
- 17 municipal plants

- Feedstock : food waste/market waste
- Small domestic plants gives 1 -2 hrs gas for cooking
- Households replace about 30% of LPG or about 44 kg per year, saving Rs1,200 per year
- Municipal plants generate electricity for the markets

Das SKG Sangha model India – 2007 Ashden Award 2.prize winner

- **43,000 household plants**
- **vermi-composting system (mixing the slurry with solid waste -straw, green and dried leaves)**

- **save about 4 tonnes/year of CO2 and around 3.5 tonnes/year of fuel wood.**
- **200 bags of vermiculture manure a year ,**
- **earning Rs90 (1,20€) for a 30kg bag**

Das ARTI model Indien- Ashden prize winner 2006

- 700 household plants
- Digester and the gas holder made out of recycled plastic
  (water tanks available in the market – 1m³ and 0.75m³)
- Needs only 1 Kg feedstock
  for 500 litres of biogas
- Quick digestion process (48 hrs instead of 40 days)
- Feedstock: food waste, rotten fruit,spoilt milk and grains, oil cake

Biogas plant Galha - Srilanka

Biogas plant GSS – Galaha Srilank

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Biogas plant Galaha - Srilanka

Biogas plant GSS - Galaha Srilanka

Vegetable garden and composting

Biogas plant GSS – Galaha Srilanka -

Vegetable Garden

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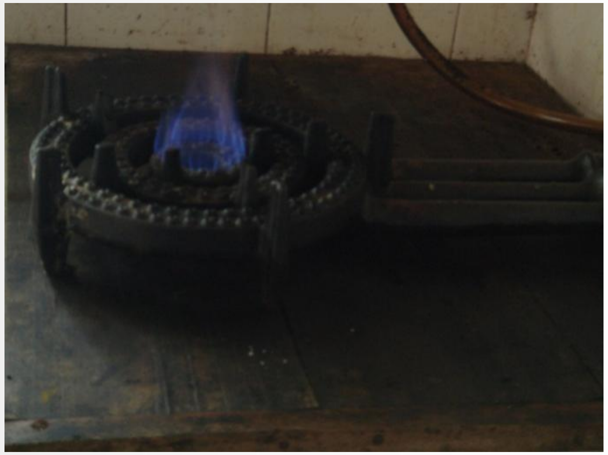
Biogas plant GSS- Galaha Srilanka



Gas cooker

Biogas plant Bawlana Srilanka

Biogas plant Bawlana Srilanka

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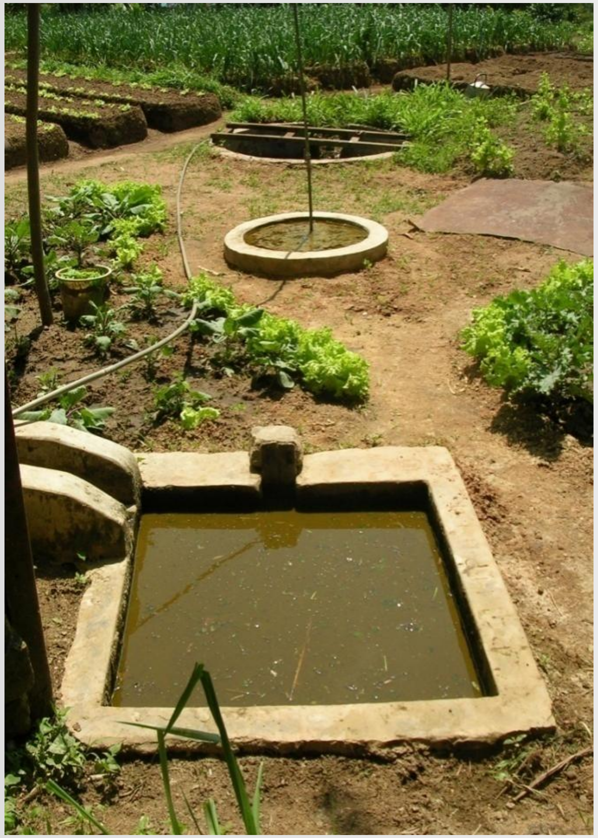
Biogas plant –Masgolla Srilanka

Biogas plant Masgolla Srilanka



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Biogas situation in Germany

Basic Facts

- Average size of the plants – 350 kw
- Many 150 Kw plants in agricultural sector
- Few 550 Kw plants in 2006/2007
- Most of the plants are concentrated in Bavaria
- 850 plants in 1999, 3280 in plants 2006, 3900 plants in 2007
- 1300 MW in 2007

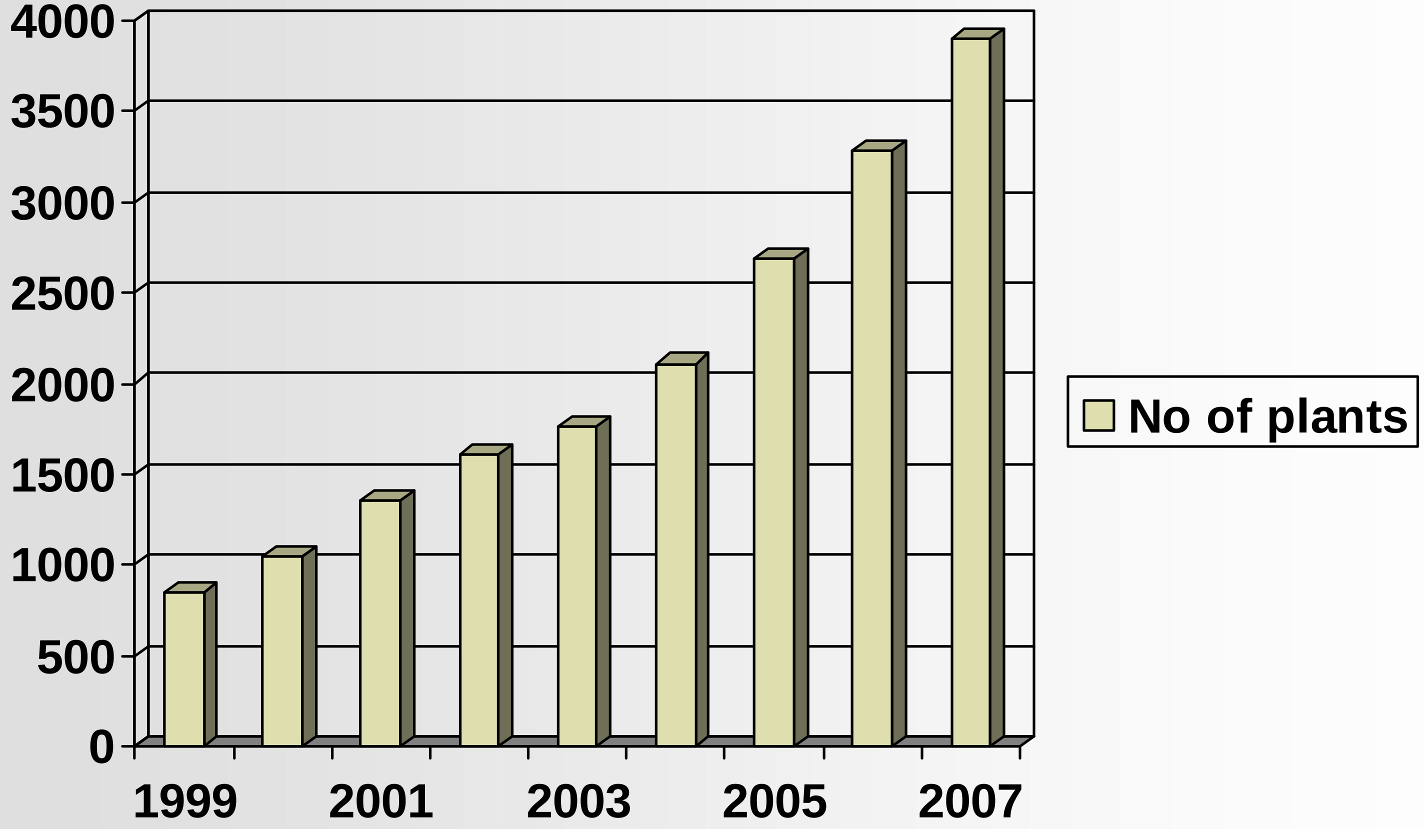
Gas utilisation

- to produce electric and thermal energy (BHKW)

(efficiency electric 28-38% , thermal 42-58%)

20 – 40% of the thermal energy gained is required maintain the process temparature in the digester .

Biogas plants in Germany



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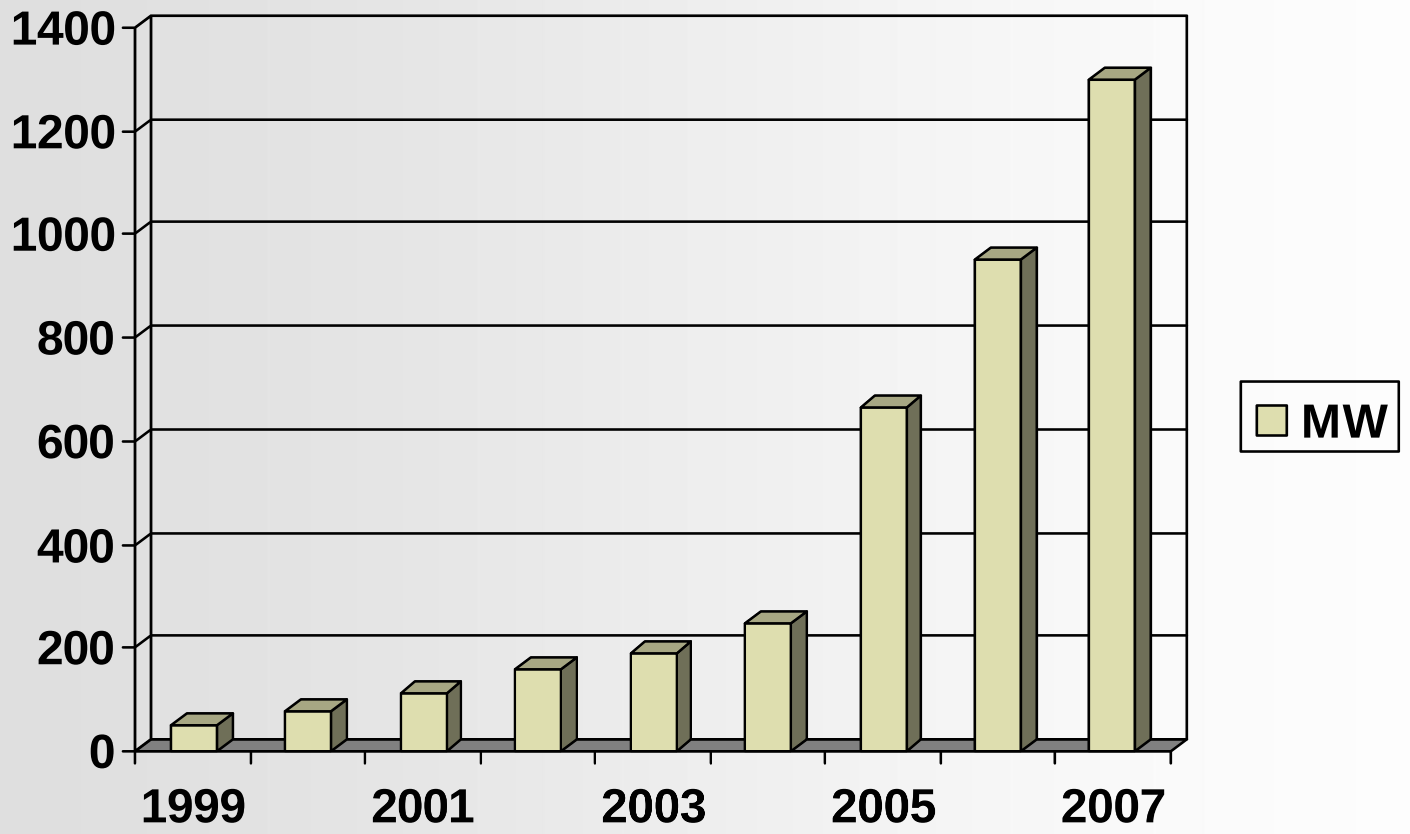
Biogas plants in Germany . Energy production



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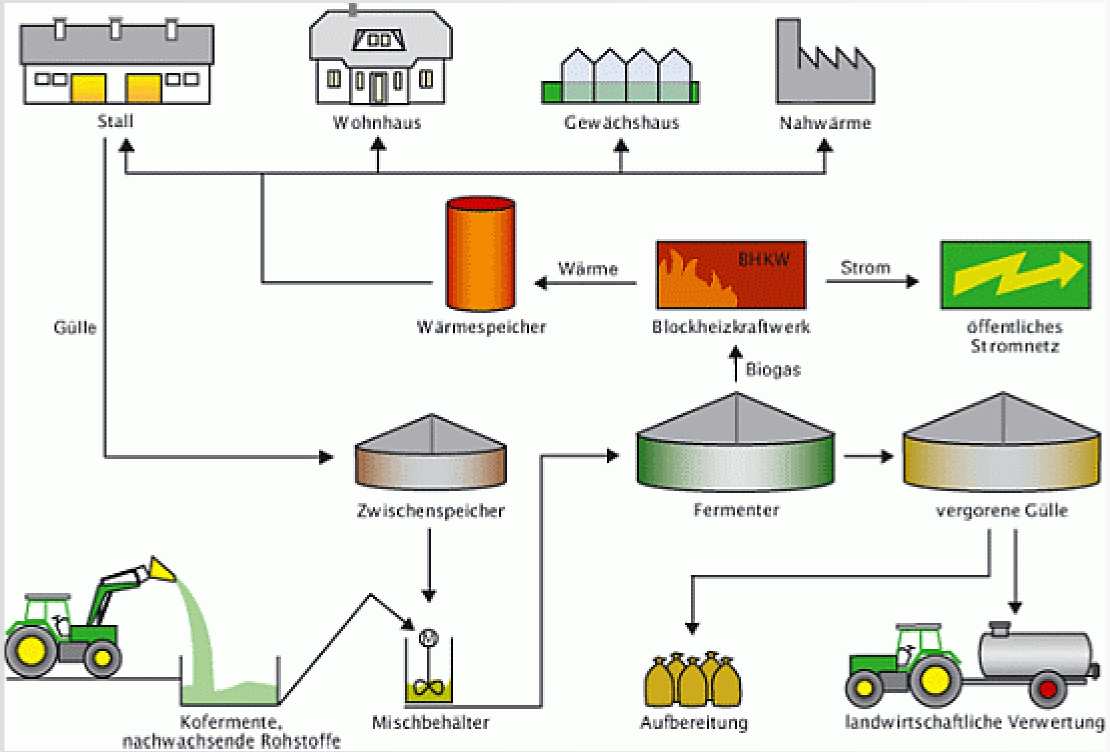
Large scale biogas plant Germany

§ Flow chart (farm)



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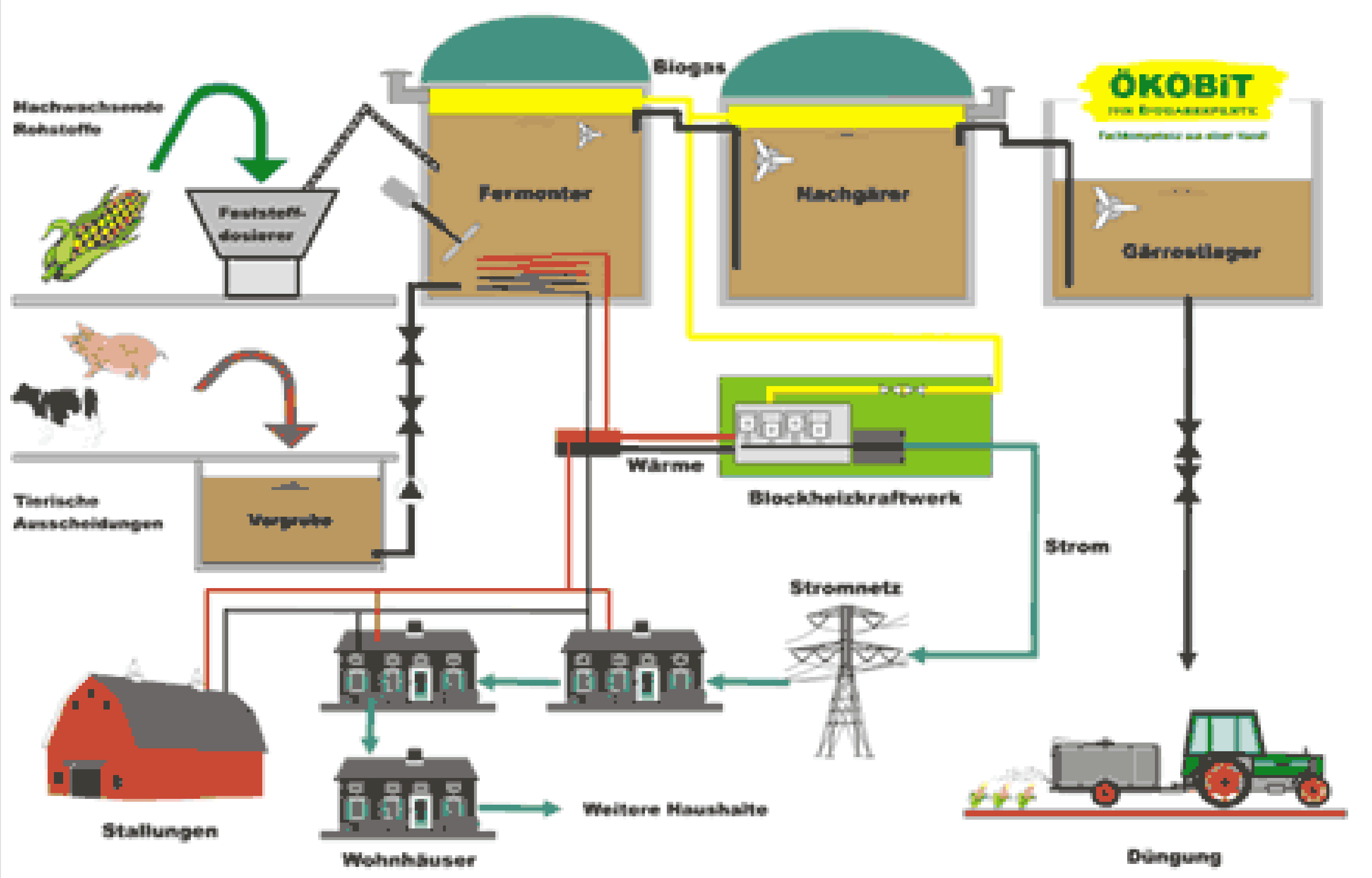
Large scale biogas plant Germany



Stromvergütung

- **Stromvergütung nach Erneuerbare Energien Gesetz (EEG), dessen Neuerung am 01.08.2004 in Kraft trat beträgt für Biogasanlagen, die nach dem 31.12.2004 erstmals einspeisen wie folgt:**
- **bis einschließlich einer Leistung von 150 kW mindestens 11,3 Cent/kWh elektr.**
- **bis einschließlich einer Leistung von 500 kW mindestens 9,7 Cent/kWh elektr.**
- **bis einschließlich einer Leistung von 5.000 kW mindestens 8,7 Cent/kWh elektr.**
- **Empfehlung für die Zukunft: Verringerung der Grundvergütung um 0, 50 Cent, Erhöhung der Prämie für die Kraft-Wärme-Kopplung um 1 Cent**

Biogasanlagen in Deutschland müssen ungefähr eine Leistung von 600 -700 KW erbringen um rentable zu sein

Successful biogas programs

- BSP Nepal from 1992 – to date

  existing design, fixed dome 4^3 – $10m^3$ subsidy , giant PR campaigns, government involvement in all policy decisions, yearly user satisfaction survey, systematic after sales services, upto now 165 plants , use only for cooking

- TED biogas project Lesotho from 2003 – to date)

  modified DATWAS system, fixed dome $8m^3$ - $32m^3$, no subsidy, marginal government involvement,upto now 80 plants on demand, final guarantee service, use multiple

- Biogas projects in India & China (different concepts & models)

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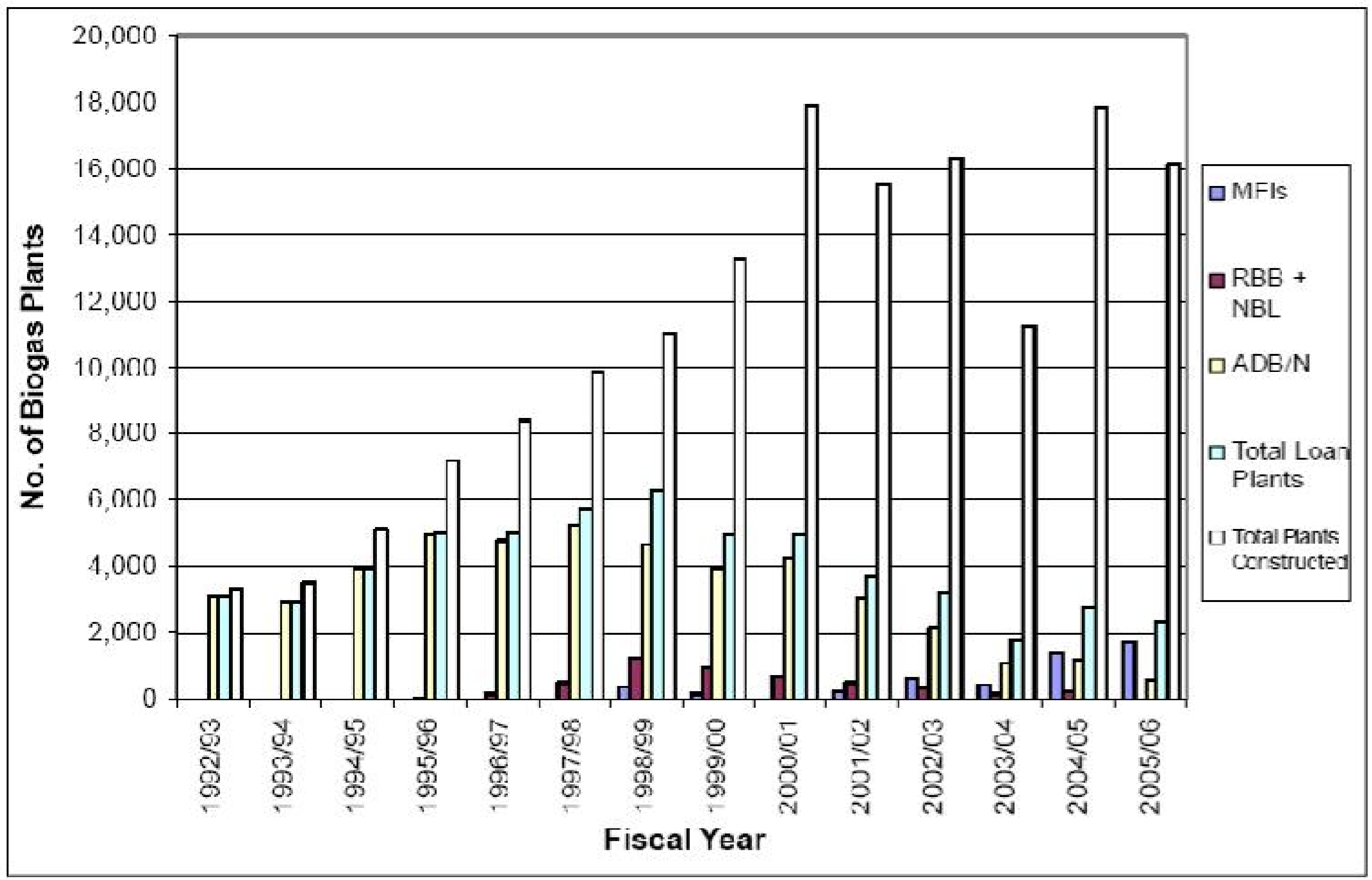
BSP Nepal

- upto now 165.000 plants
- existing design, GC 2047 , fixed dome 4^3 – $10m^3$
- subsidy
- giant PR campaigns through radio, TV, booklets etc
- government involvement in all levels of policy decisions
- yearly user satisfaction survey
- systematic after sales services
- Target group households with minimum requirements
- gas only for cooking

Progress of the biogas plant construction – BSP Nepal



Current subsidy flow – BSP Nepal

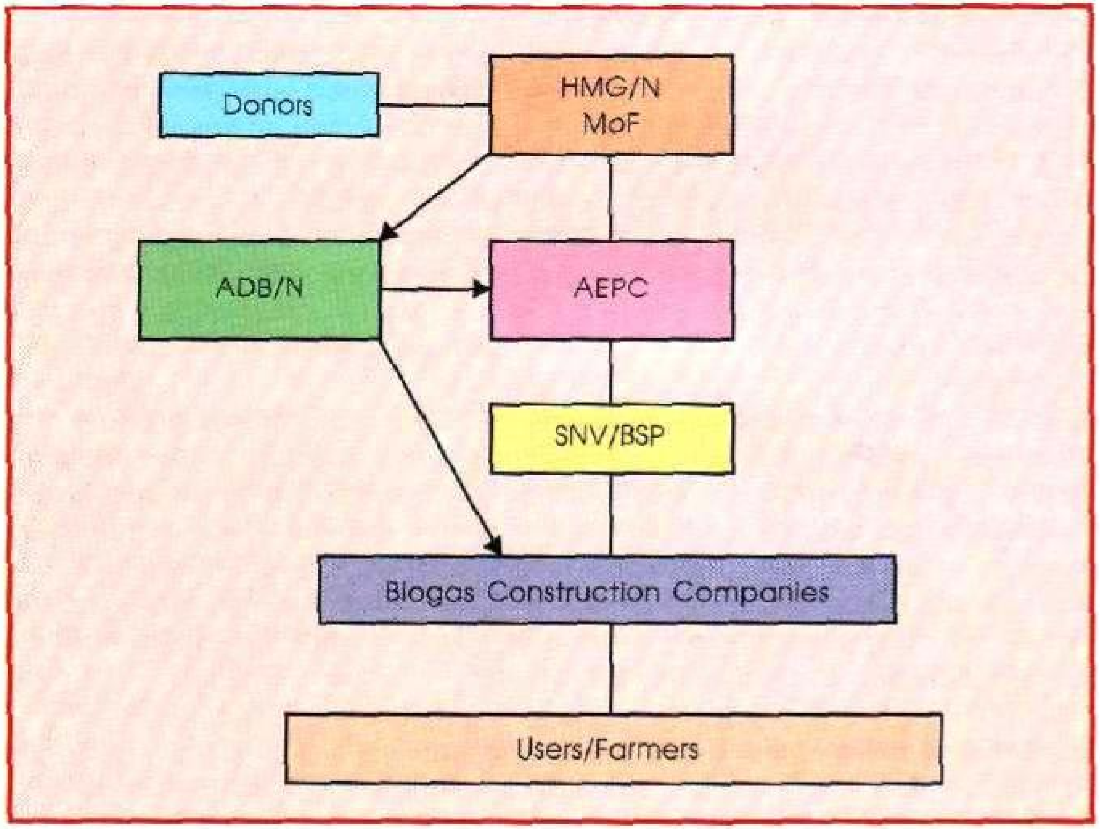
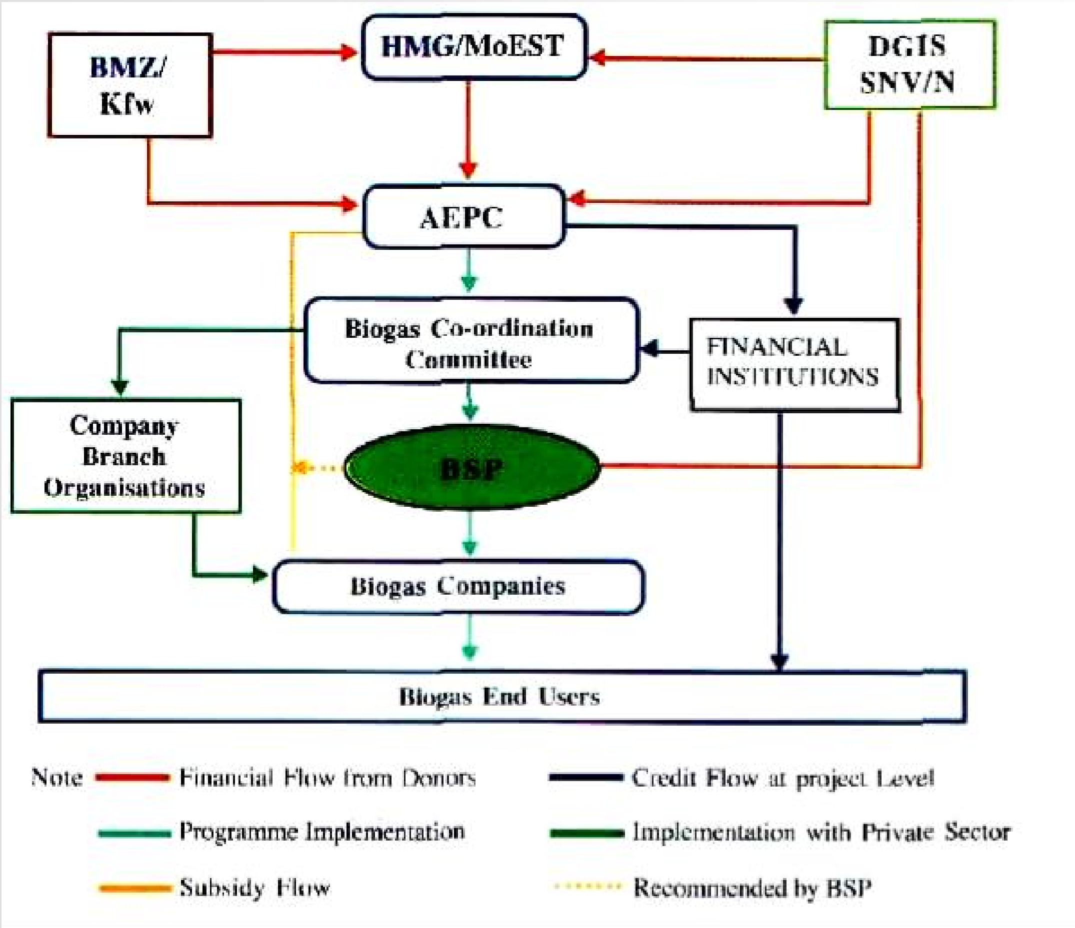
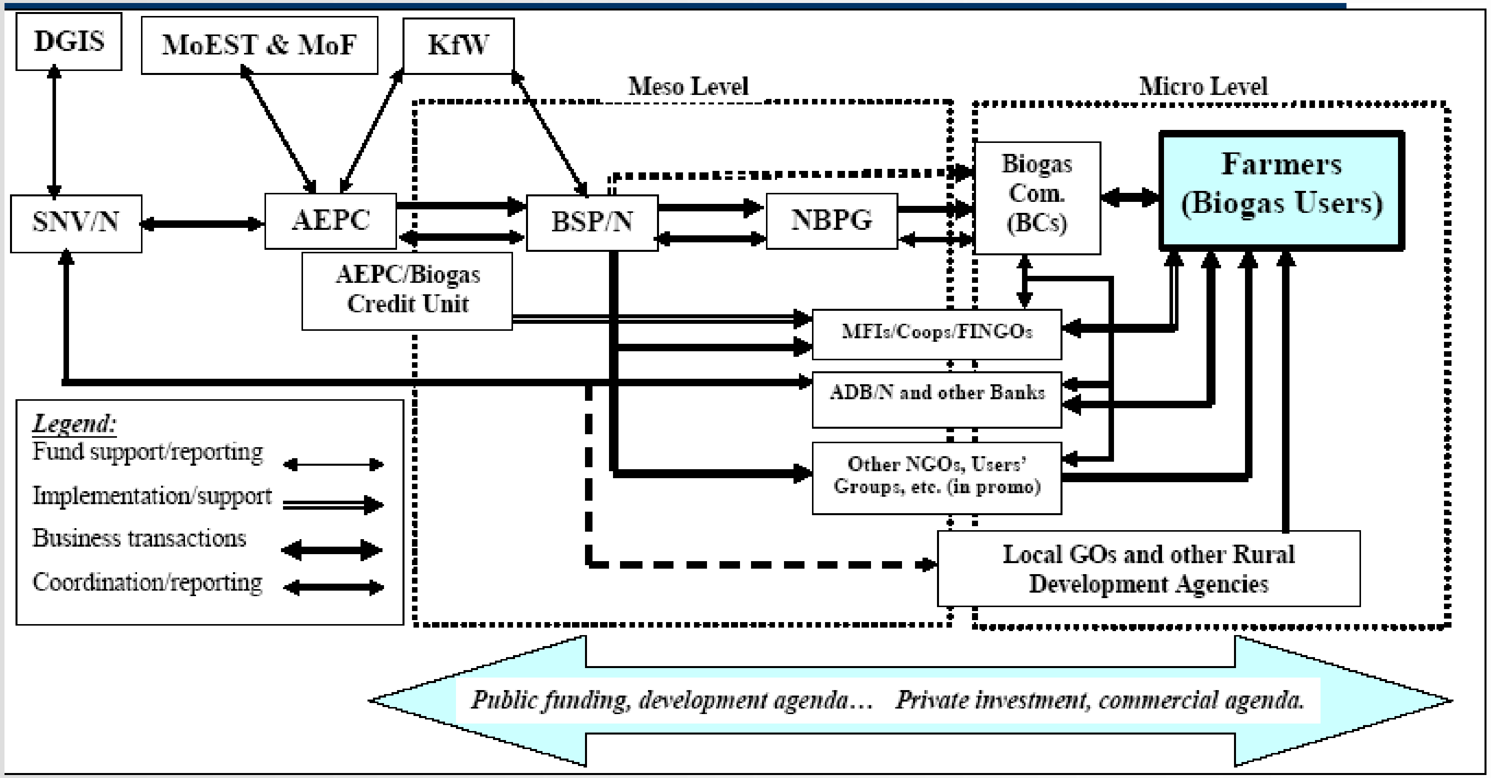


Figure 3.1: Flow of biogas subsidy

Institutional set up – BSP Nepal



National implementation structure BSP-Nepal



Calculation example – BSP Nepal – 8 m³ plant

Costs in NRP

- Capital costs 26,070
- Annual maintenance costs 261 - 1 % of capital costs
- Subsidy 10,000
- Net costs 16,070
- Down payment 1,607 - 10% of net costs
- Loan amount 14,463
- Annual loan payment 3,687 - 17% interest, 7 years term

MAIN SUCCESS FACTORS – BSP Nepal

- Integrated farming system, which combines crop production and animal husbandry.
- Supportive government policy
- Long-term donor commitment
- Collaboration between international organisations
- Carefully defined quality and design standards
- Guarantee of after sales service
- Transparency in the implementation of the program
- Uniform technology - the fixed dome biogas digester
- Farmer-to farmer promotion to friends and neighbours about the benefits
- Institutional development and strengthening
- Capacity building

Biogas in Lesotho

So far only 80 fixed dome plants (DEWATS - Decentralised Wastewater Treatment Systems)

- Digester also serves as on-site sanitation solution and replaces malfunctioning septic tanks
- TED's construction activities are completely demand driven and not subsidized
- never a proper definition of a target group. The interested customers are those who feel they have a problem especially with their sewage
- Interested individuals and groups frequently visit the first site where a biogas plant is constructed
- TED advertises with all means available within the daily context and not expensive

Main success factors- TED biogas plants Lesotho

- The core of the technology is mature
- The execution of the work gives high priority to quality
- The technological set up offered solves a problem that the people really feel and has impacted on their pocket
- A customer has to actively demand the technology
- Potential customers see an example of the technology in the negotiation phase
- Many avenues in the daily context are used for advertisement

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Launching biogas programmes

Excluding factors

- Too cold or too dry region
- Irregular or no gas demand
- Less than 20 kg dung/day available
- No stabling or livestock in large pens where dung cannot be collected
- No building materials available locally
- Integration of the biogas plant into the household and farm routines not possible
- No suitable institution can be found for dissemination

Launching biogas programmes

Critical factors

- low income or unstable economic situation f the target group
- Good energy supply through the year
- Gas appliances not available regionally or nationally
- High building costs
- No substantial interest of the government is evident over the medium term
- Counterpart organisation has only indirect access to the target group
- Low qualification of maisons/ technicians
- Unfavourable macro and microeconomic coefficients

Launching biogas programmes

Ideal factors

- Daily temparatures over 20° throughout the year
- Regular gas demand
- Full stabling of animals (on solid floors as far as possible)
- At least 30 kg / day dung available per plant
- Dairy farming
- Use of organic fertiliser is normal
- Insufficient supply of fossile sources of energy
- Efficient counterpart organisations with the ability of cooperating with the private sector
- Political will (government) towards biogas technology as well as strengthening small and medium scale farm systems
- Secured financing of the dissemination structure
- Gas utilisation and attendance of the plant can be clearly regulated within the household

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Launching biogas programmes

Lessons lerned

- Long term programmes are needed for market development and dissemination of the technology
- Investment subsidy and credits on reasonable terms necessary (use and strengthen existing finance institutes and programmes)
- Appropriate technology (fixed dome plants are suitable for many African countries) and make the technology cheaper and affordable for poor households (introduce new technologies)
- Offer standardised plants for selection (6m³, 10m³ , 15m³ etc.) and define quality standards
- Provide capacity building and awareness raising for all actors involved (governments, engineers/technicians, banks, private sector, masons, farmers/households)
- Support to create local market structures/business development to deal with construction materials, gas appliances and spare parts etc.

Launching biogas programmes

Failures

- Biogas plant is still an expensive energy option for many rural households
- Lack of government commitment and suitable market structure to develop a sustainable dissemination of the technology
- Bad experiences and poor image created by many failed biogas plants
- No feed material/water available continuously (low gas production)
- Poor design/construction (gas leakages), wrong operation and lack of maintenance services
- Gas appliances and spare parts are not available in the local market
- Cooking habits (fuel wood and kerosene are preferred to prepare traditional food) and farming practises (refuse to use organic fertilizer)

Launching biogas programmes

Success factors

- Strong government commitment and private sector involvement
- Appropriate financing mechanisms for poor households
- High quality construction work
- Low price of plant in relation to the income of the target group
- Acceptance of the technology (gas as energy source for cooking and lighting, slurry as fertilizer)
- Households/farmers re trained in the proper use/operation of biogas plants
- Skilled engineers/technicians and masons
- Reliable and professional construction / after sales service
- Efficient counterpart organisations with the possibility of cooperating with the private sector
- willingness among potential users to handle animal dung and to attach a toilet to the plant

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Favourable conditions to setup biogas programs

- **technology corresponds to the geographic, economic and particularly the agricultural framework**
- **Scarcity of traditional cooking fuels**
- **Government involvement incentives or subsidies for energy from RE**
- **Long term programmes** -at least 5 years
- **Access to credits under attractive conditions or subsidies on material**
- **Potential biogas customers are scattered through out the region**
- **Adequate maintenance/repair service**
- **Qualification, mainly of the mason**
- **local availability of suitable building materials**
- **Availability of gas appliances and spare parts**
- **Standard sizes of biogas plants** (6 m^3, 8 m^3 etc.)

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Necessary actions for setting up biogas Implementation Programmes

- In depth analysis of favourable conditions to initiate national biogas programmes (water, climate, density of households/farms, size of the farm, household energy consumption patterns, availability of construction materials, skilled man power etc).
- Market research on available energy sources and substitutes, economic benefits, social acceptance, technological viability and sustainability
- Check on government incentives or subsidies for energy from renewable energy sources, potential of local entrepreneurs
- Research on available designs and appliances according to the specific regional conditions
- Study on recent developments and new approaches
- Awareness raising and promotion campaigns