



Lecture 19

Anaerobic Digestion

A world overview

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When considering the potential for AD application we should think about (at least) two scenarios



Areas/Regions with “concentrated” feedstocks:

- **A well established system for wastewater and waste management**
- **Intensive agriculture and livestock husbandry**

Areas/Regions with “diluted” feedstocks:

- **A sanitation system to develop**
- **Extensive agriculture / zootechny**

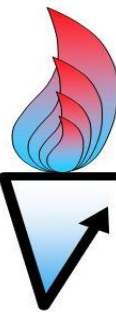




AD for different feedstock (and different objectives)



Widely used for sludge stabilisation in WWTPs



Widely used for sludge stabilisation in WWTPs





AD of industrial or municipal food waste from separate collection



Shredded food waste





AD of cattle manure



Maize



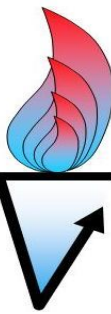
Sorghum



AD of energy crops



Triticale



AD of agro-waste from food crops processing



Sweet corn



Beans



Tomato peel



Peas





AD outputs and benefits





1 - Biological stabilisation (reduction of the putrescible fraction) and pathogens reduction



1 - Stabilisation and pathogens reduction

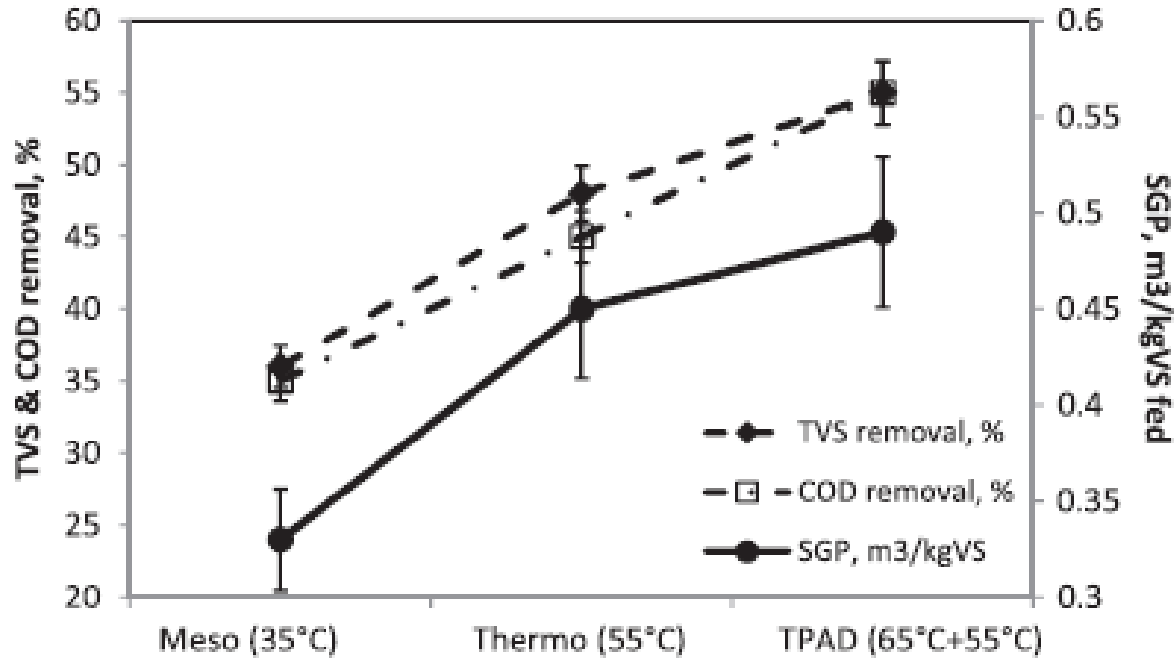


Fig. 1. Yields of the system along the different experimental runs.



1 - Stabilisation and pathogens reduction

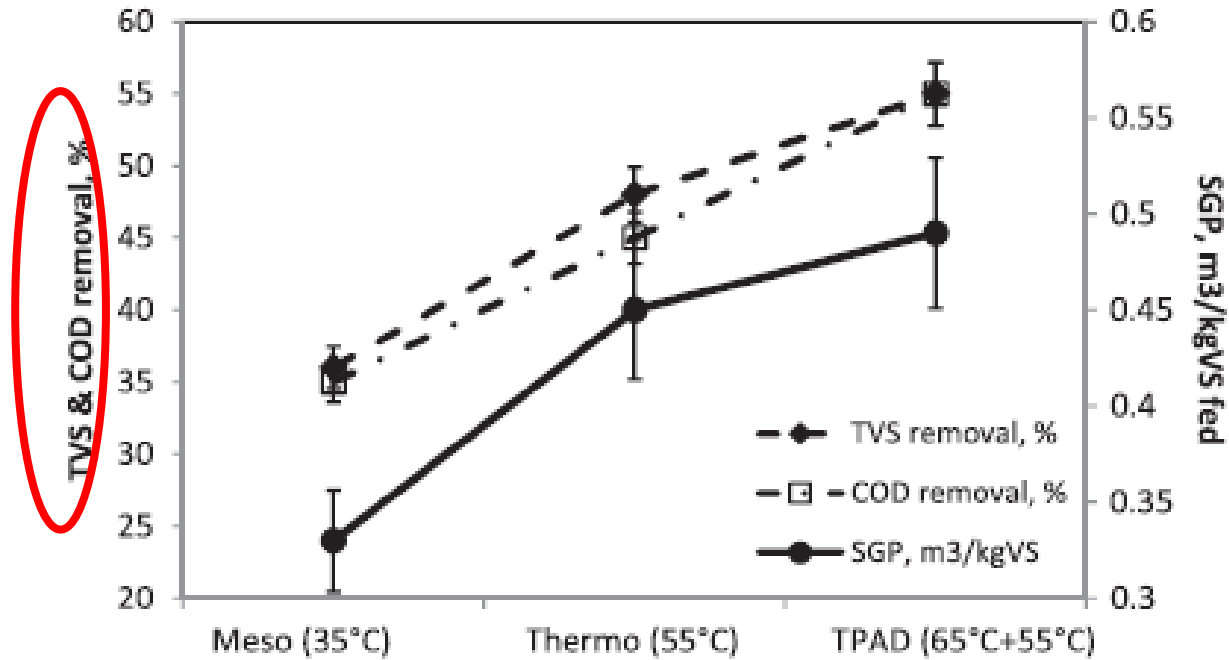


Fig. 1. Yields of the system along the different experimental runs.

COD and VS removal in AD of waste activated sludge The worst scenario !



1 - Stabilisation and pathogens reduction

Waste activated sludge AD treatment, OLR 2,5 kgVS/m³ per day and HRT 20 days



Temperature		WAS	37°C	55°C
Total coliforms	CFU/g	6.75E+05	3.63E+04	1.86E+04
E.coli	CFU/g	1.00E+05	2.75E+03	3.33E+02
Salmonella spp.	presence	33%	Absent*	Absent*

* Absent in 25 g of sample (WW)

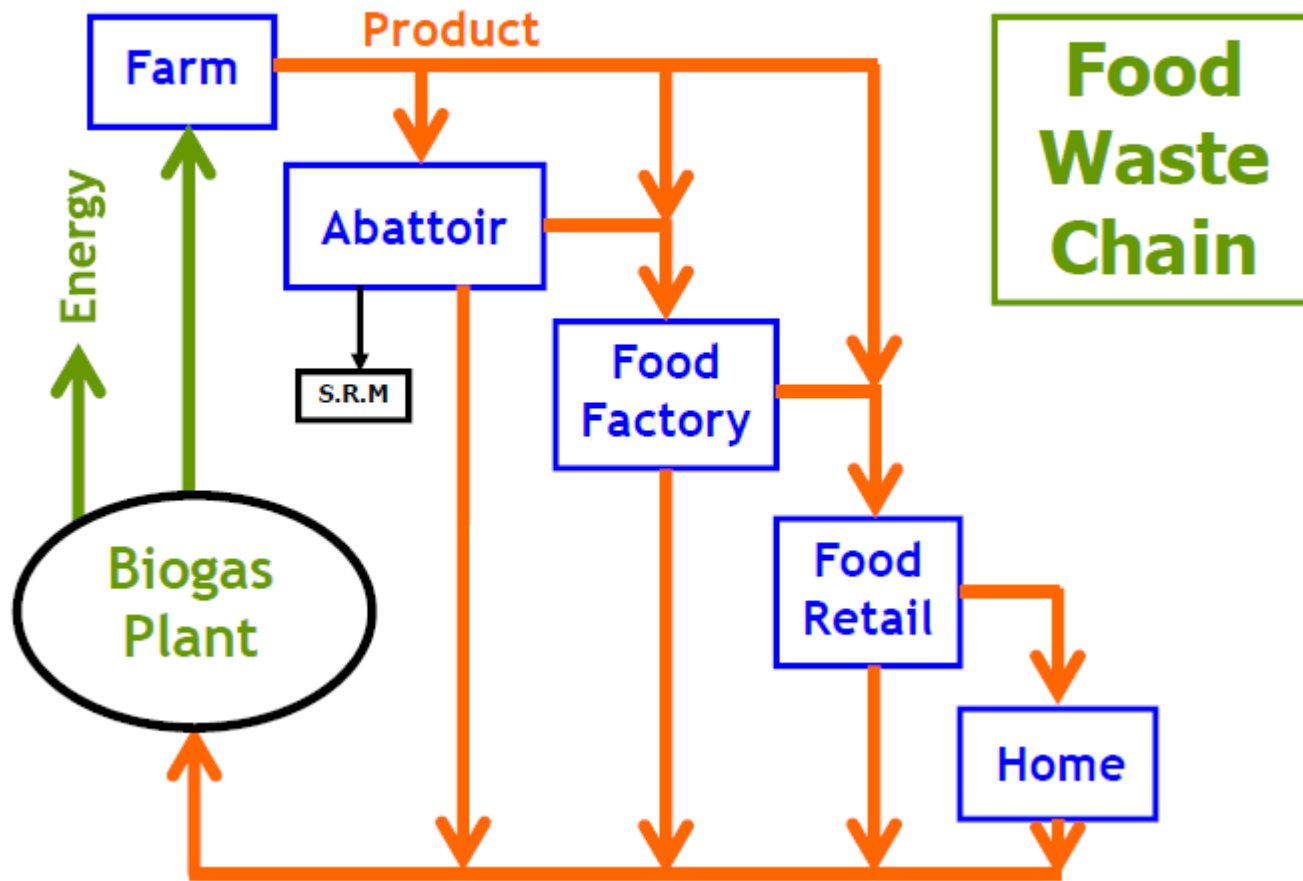
E.coli < 1000 CFU only in thermophilic conditions



2 - Nutrients recovery



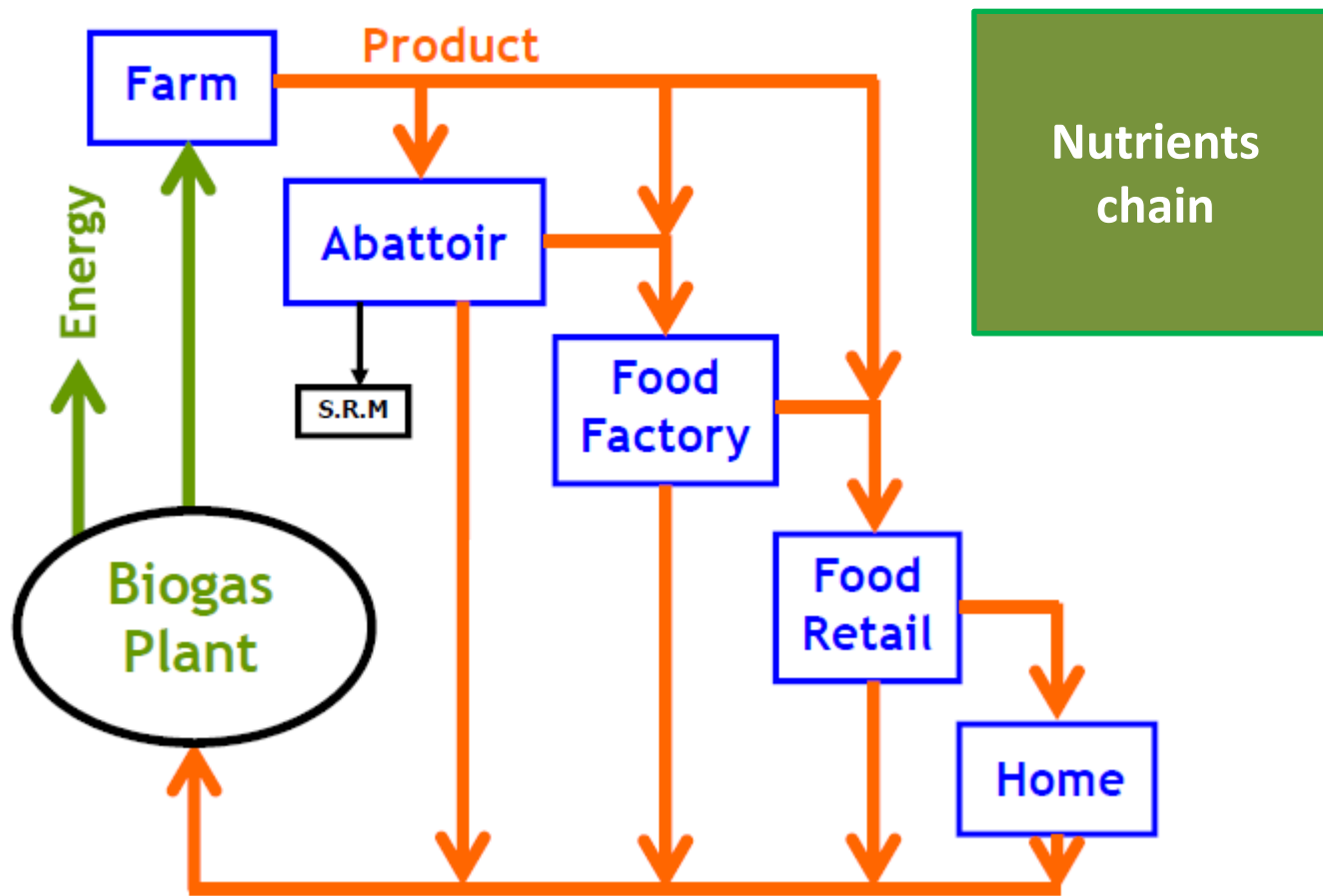
2 – Nutrients recycle and recovery



Credits: M. Chesshire



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Liquid digestate (rich in N and K, partially in P)



Spreading digestate at Twinwoods, Bedfordshire



Solid fertiliser (rich in C and organic N & P)



Solid biofertiliser



Nitrogen recovery (as ammonia sulfate, nitrate, phosphate)



Stripping column



Membrane filtration



Nutrients (N,P,K) recovery in reverse osmosis concentrate





Evaporation unit



Nutrients recovery and concentration in a semi-solid phase and ammonia sulfate, or all in a «semi-solid form»



Please, note that this is all «ideal»

In fact, the reuse of digestate or nutrients recovered from digestate is often stopped by local regulations ...

(see PASS 110, End of Waste criteria)





3 - Energy recovery



3 – Energy recovery



AD for renewable electric energy production

But, unless you don't have a really interesting tariff, this is not (and can't be) the driver

Just a side-stream effect



3 – Energy recovery

1 m³ biogas is equivalent to 6 kWh



80 kW_{ee}



999 kW_{ee}

Electric energy yield 25-45%, heat yield 35-55%, loss some 15%



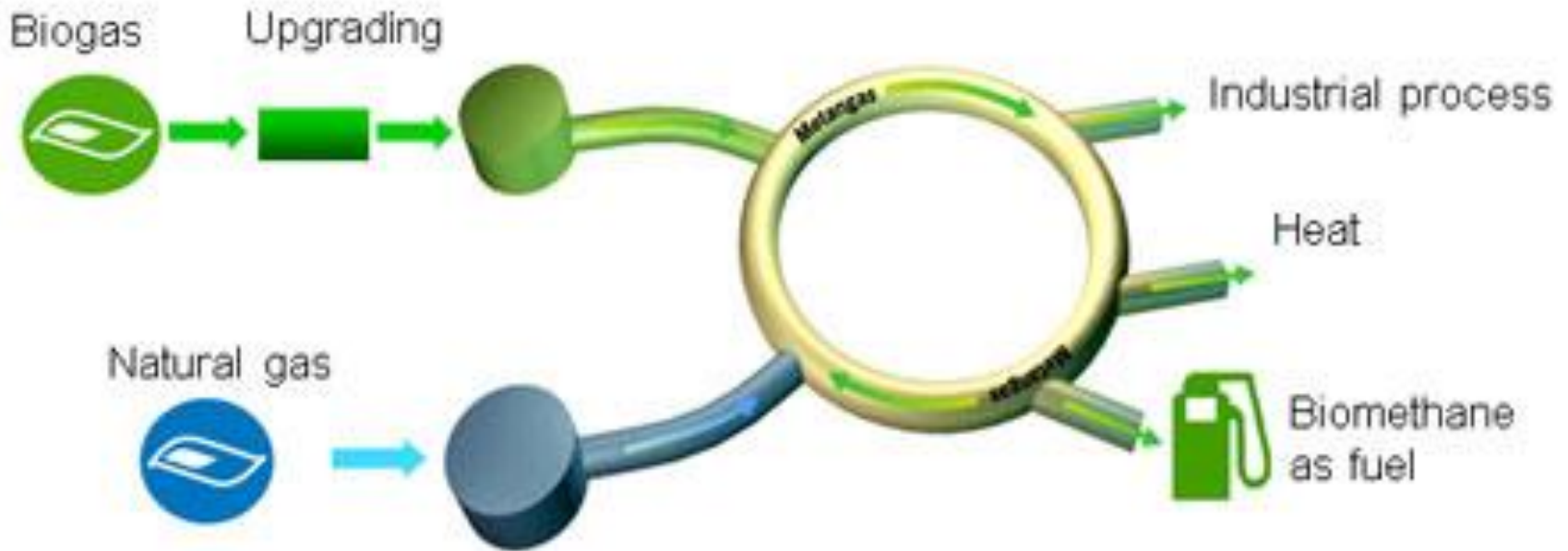
3 – Energy recovery

Up-grade to biomethane (flexible energy vector) in large AD plants

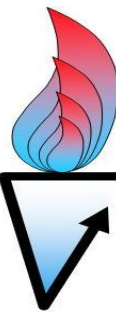




Biomethane and direct grid injection (mixed with natural gas)

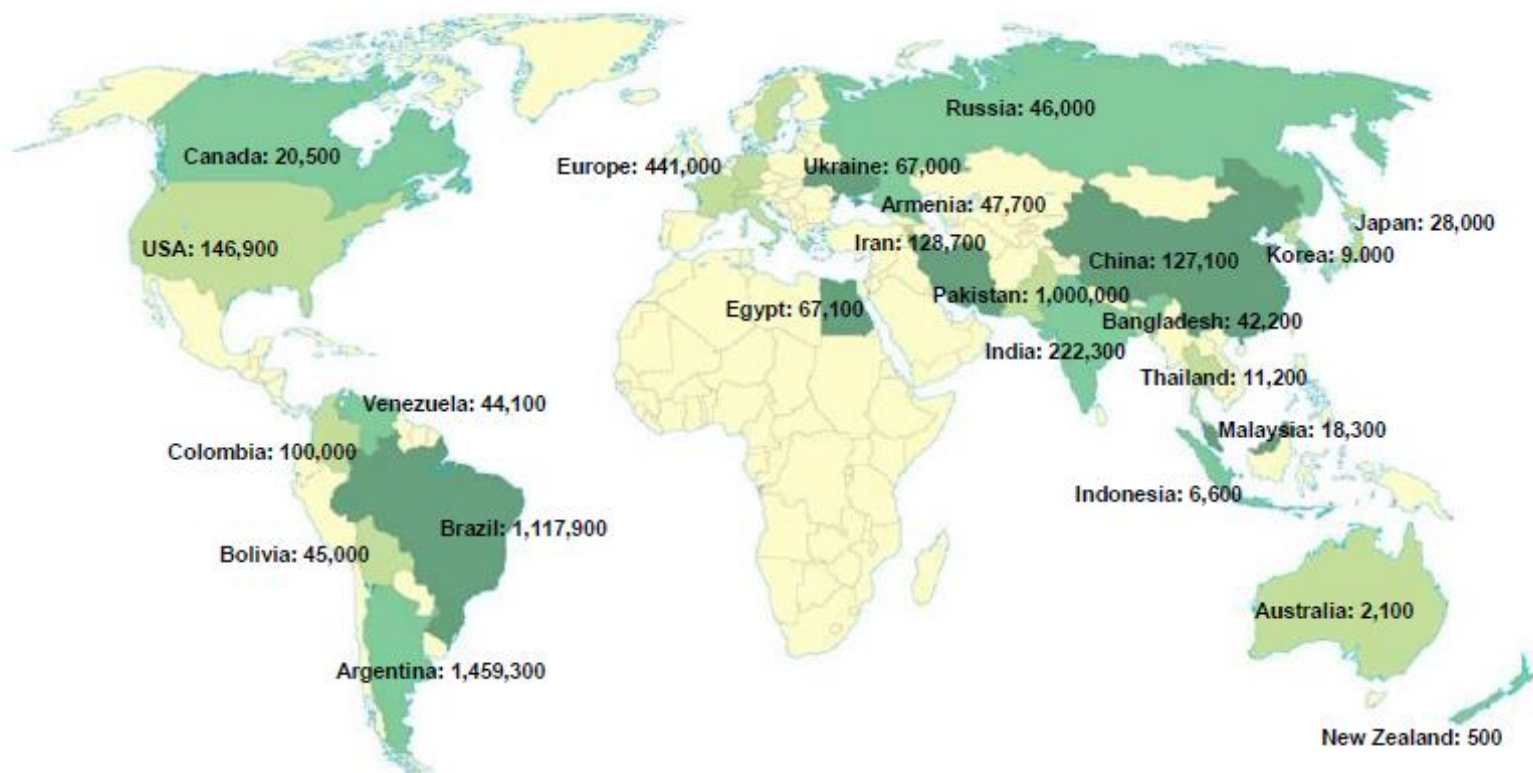


Biomethane and vehicles (the automotive sector)





5.3 MILLION NGVs WORLDWIDE



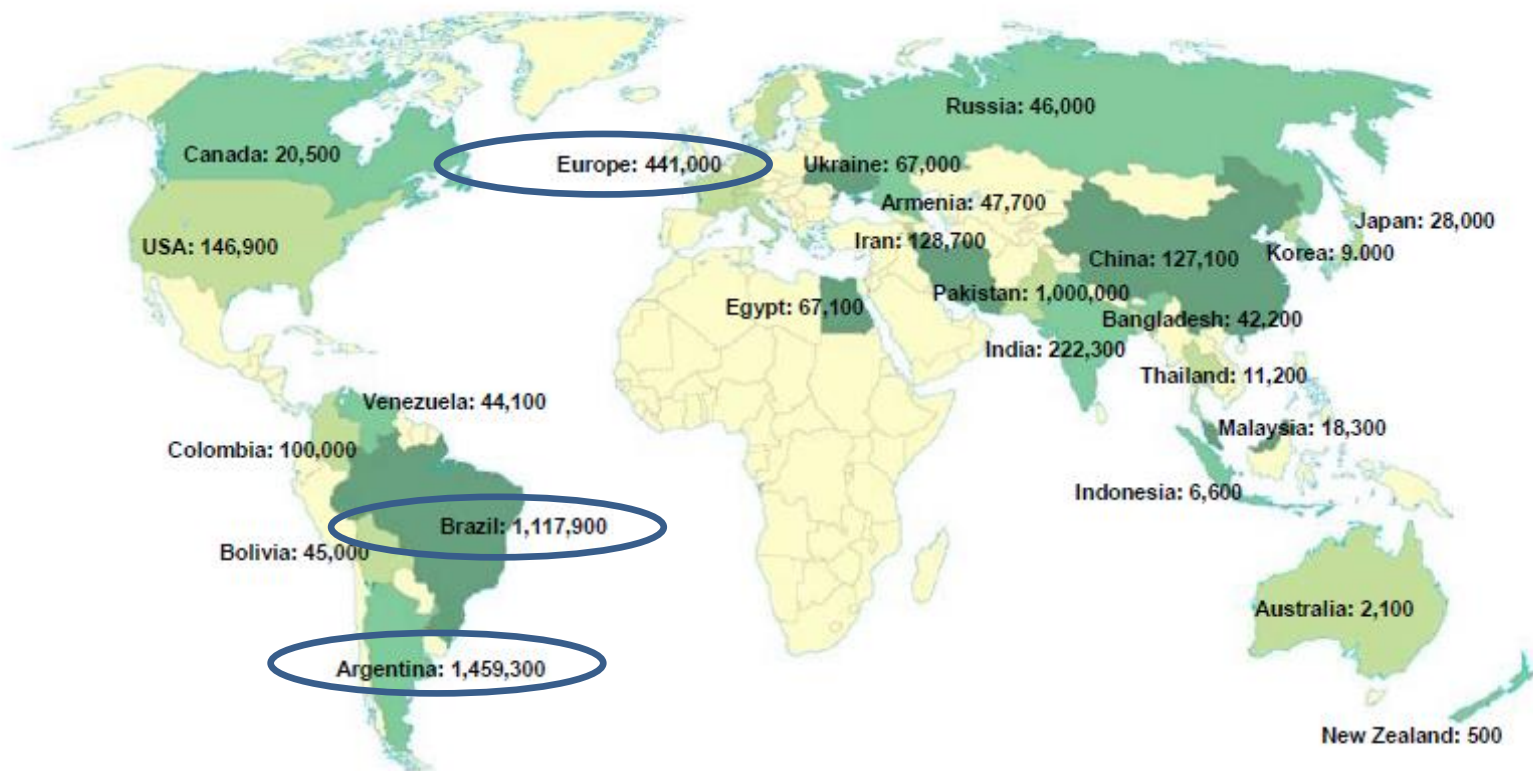
120,000 buses, 100,000 trucks, 5,100,000 cars

Source: The GVR, July 2006





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120,000 buses, 100,000 trucks, 5,100,000 cars

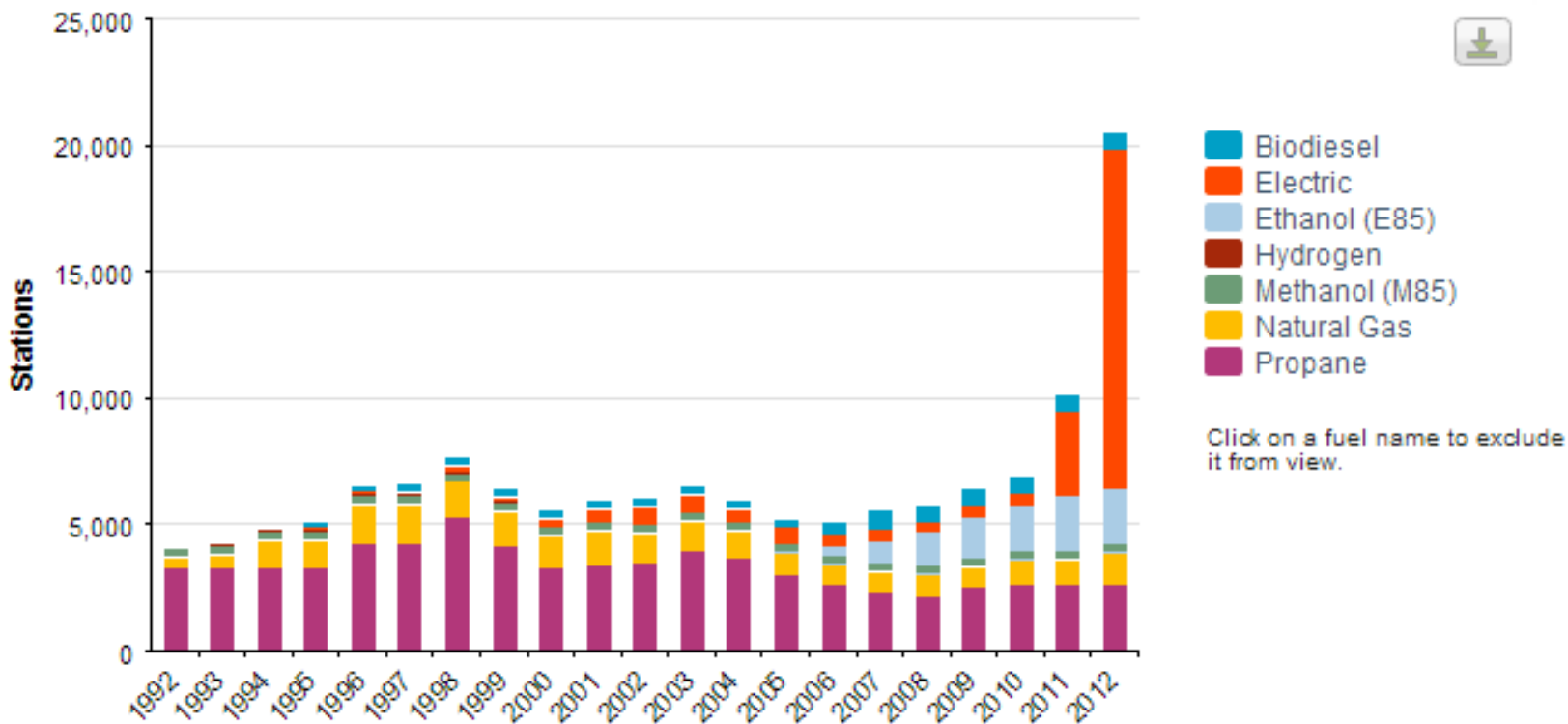
Source: The GVR, July 2006



.... fast changing



U.S. Alternative Fueling Station Inventory



Today's drivers can find thousands of fueling stations across the country that provide natural gas, electricity, ethanol, and other alternative fuels. *Source: [Alternative Fuels Data Center](#)*





Areas/Regions with a «extensive» availability of feedstock





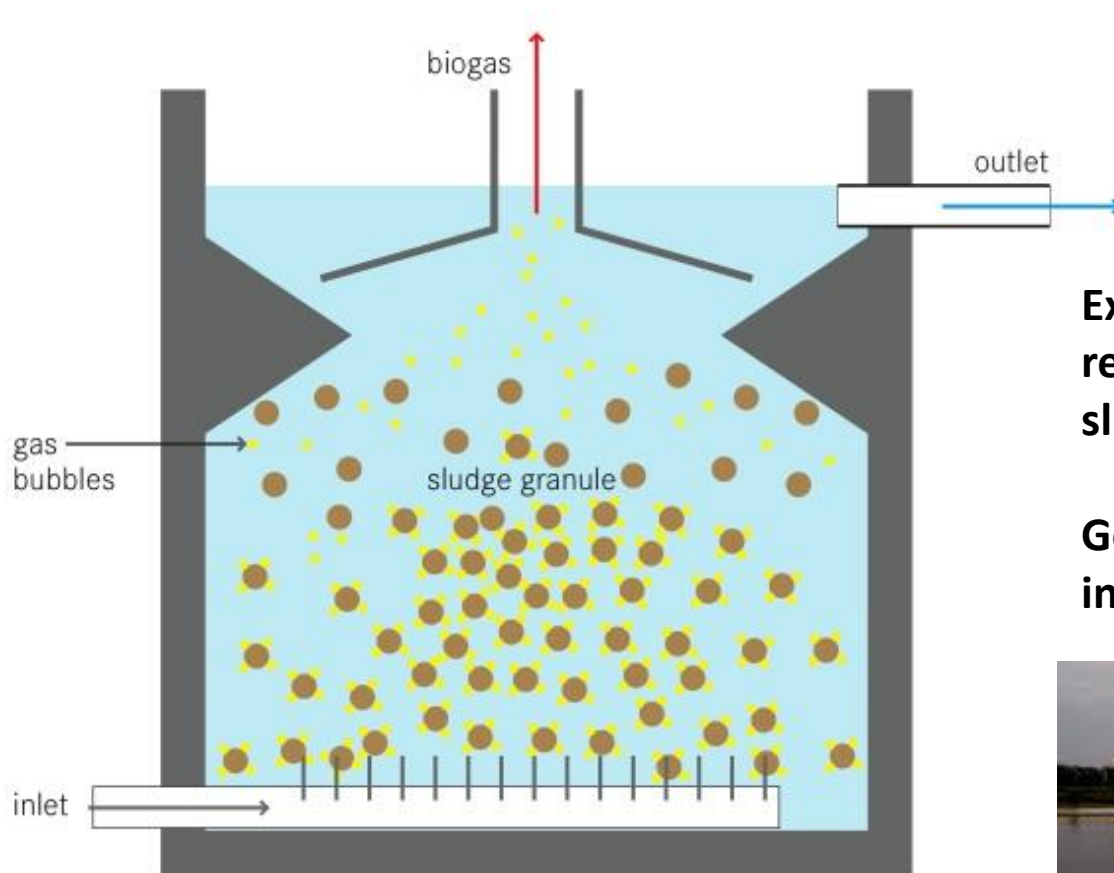
Credits: M. Chesshire



At least methane loss is (partially) prevented !



First driver – sanitation !



UASB reactor for wastewater treatment

Excellent COD removal with low sludge production

Good performances in warm conditions





Taubate, San Paulo State, Brazil



Anaerobic digestion of kitchen waste at household level in Dar es Salaam, Tanzania



Photo 2: ARTI biogas plant in Dar es Salaam, Tanzania.



credits: www.sandec.ch





Photo 1: BIOTECH biogas plant fed with canteen waste (30 kg/d) in Trivandrum, India.

credits: www.sandec.ch





Picture 19: A BIOTECH plant treating organic solid waste on an institutional level.



Picture 20: BIOTECH plant treating organic solid waste on a domestic level.

credits: www.sandec.ch





Credits: M. Chesshire



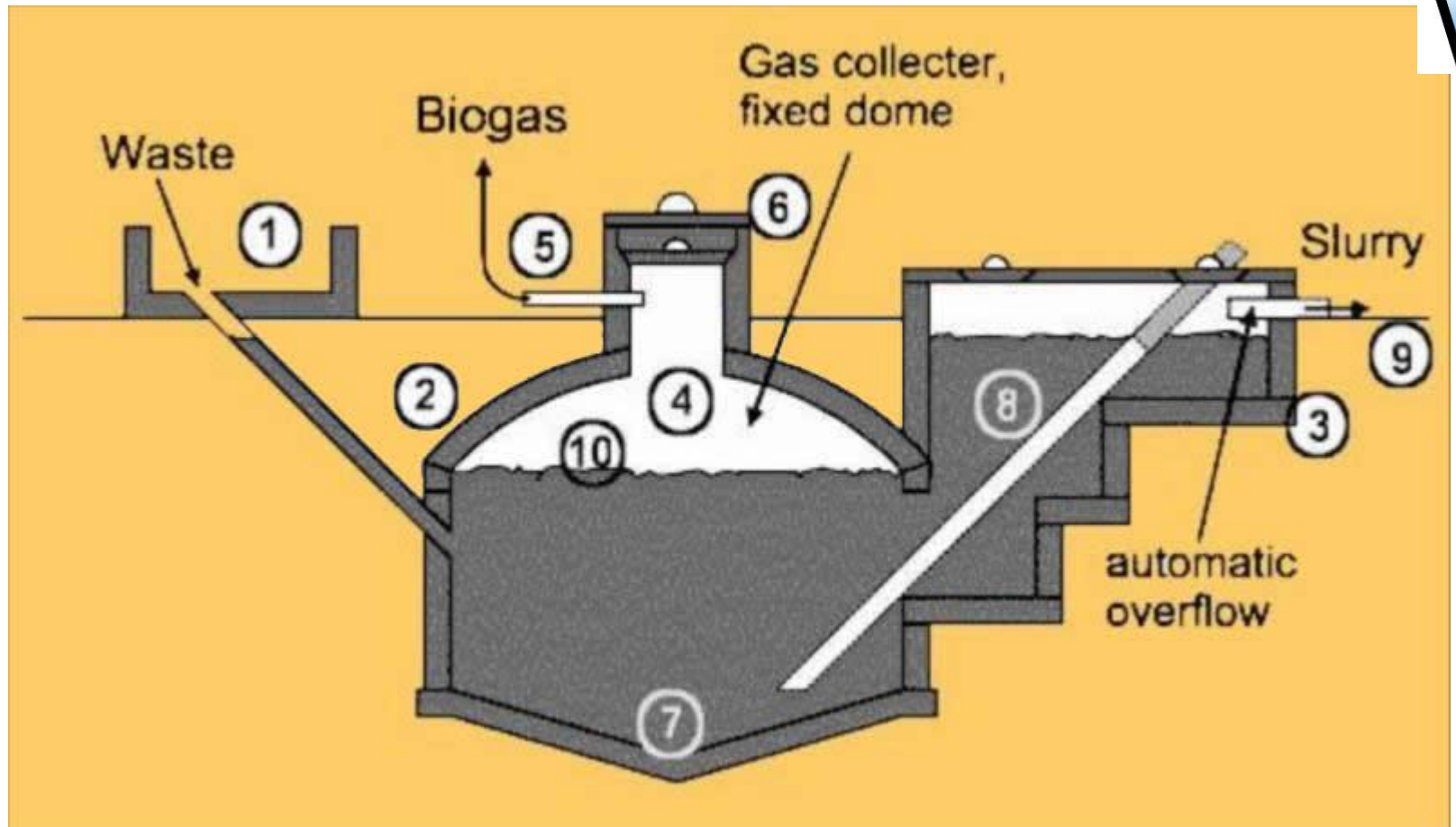


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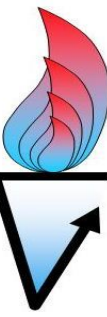




Village scale



Village scale



When the biogas production is sufficiently high, also upgrading can be considered







**Anaerobic digestion (and biogas) is
always a powerful tool !**

