House- and community-on-site biogas and fertilizer production

solar support for low temperature countries

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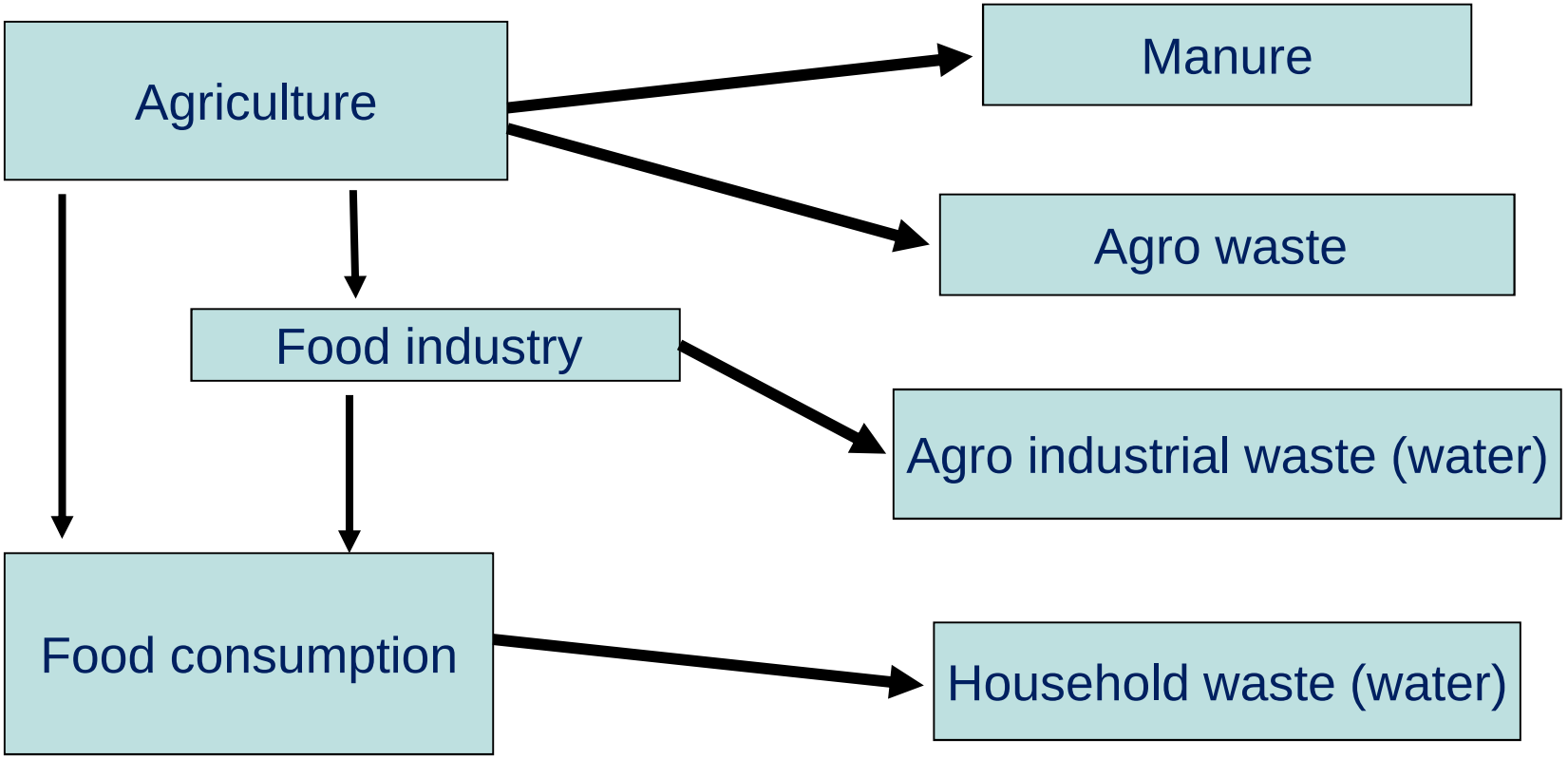
Presentation Content

- Why anaerobic digestion of human and animal waste?
- potential yields (biogas, N and P)
- House and community-on-site examples in tropical countries

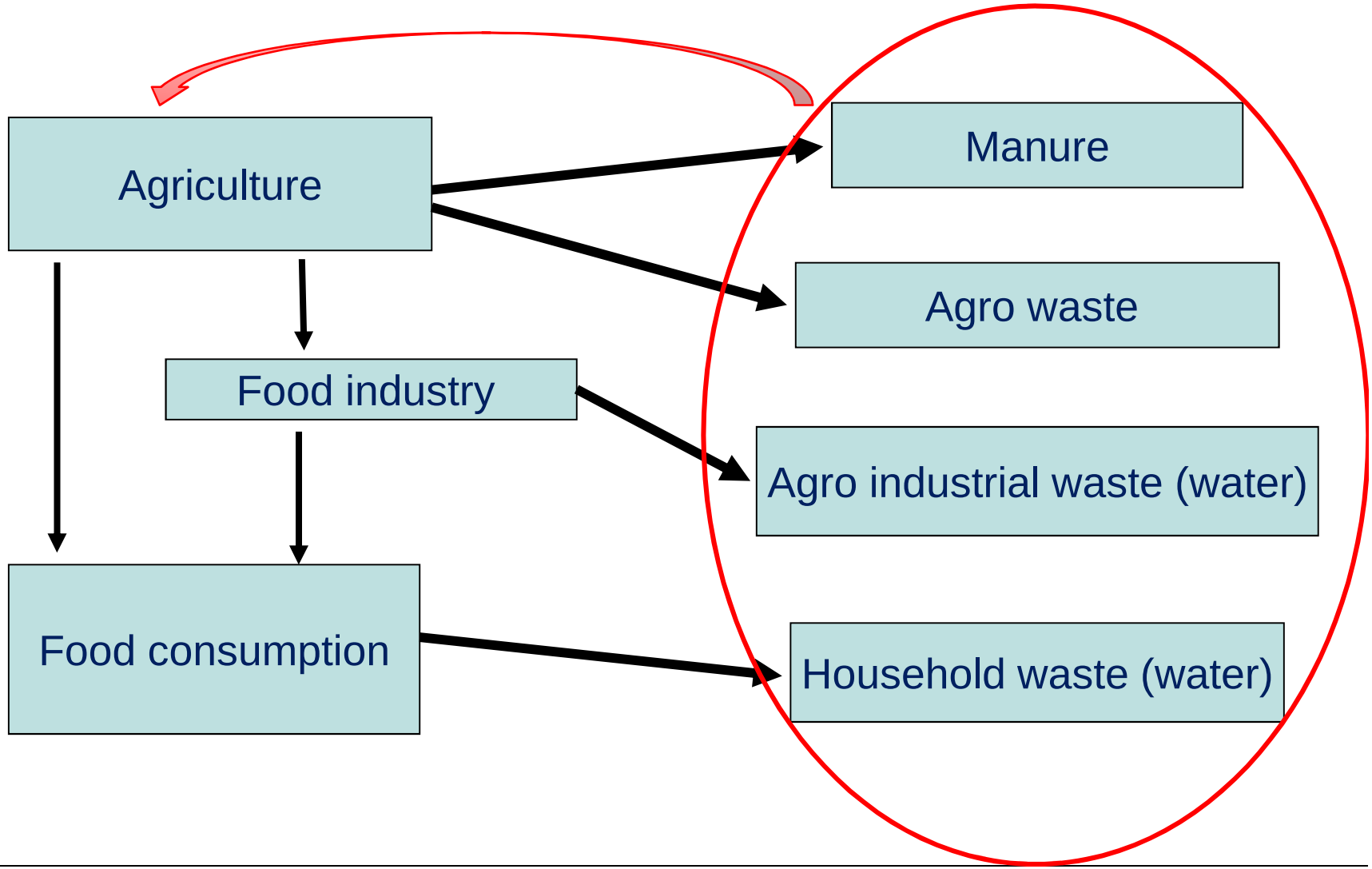
Presentation Content

- Challenge in low temperature countries
- Solar supported biogas production
- Application of energy and nutrient recovery in European urban situation

Food Production



C2C based Food production



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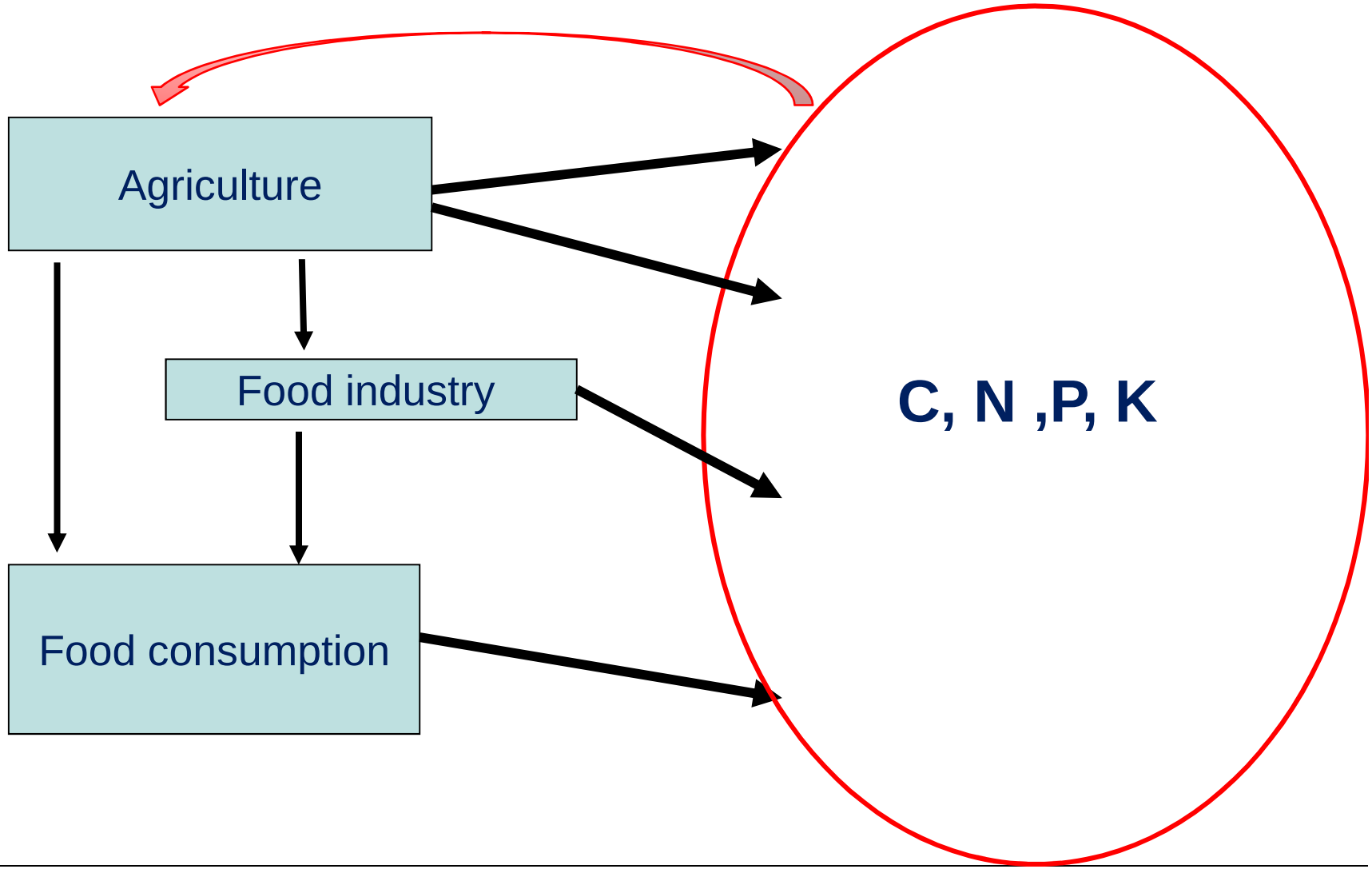
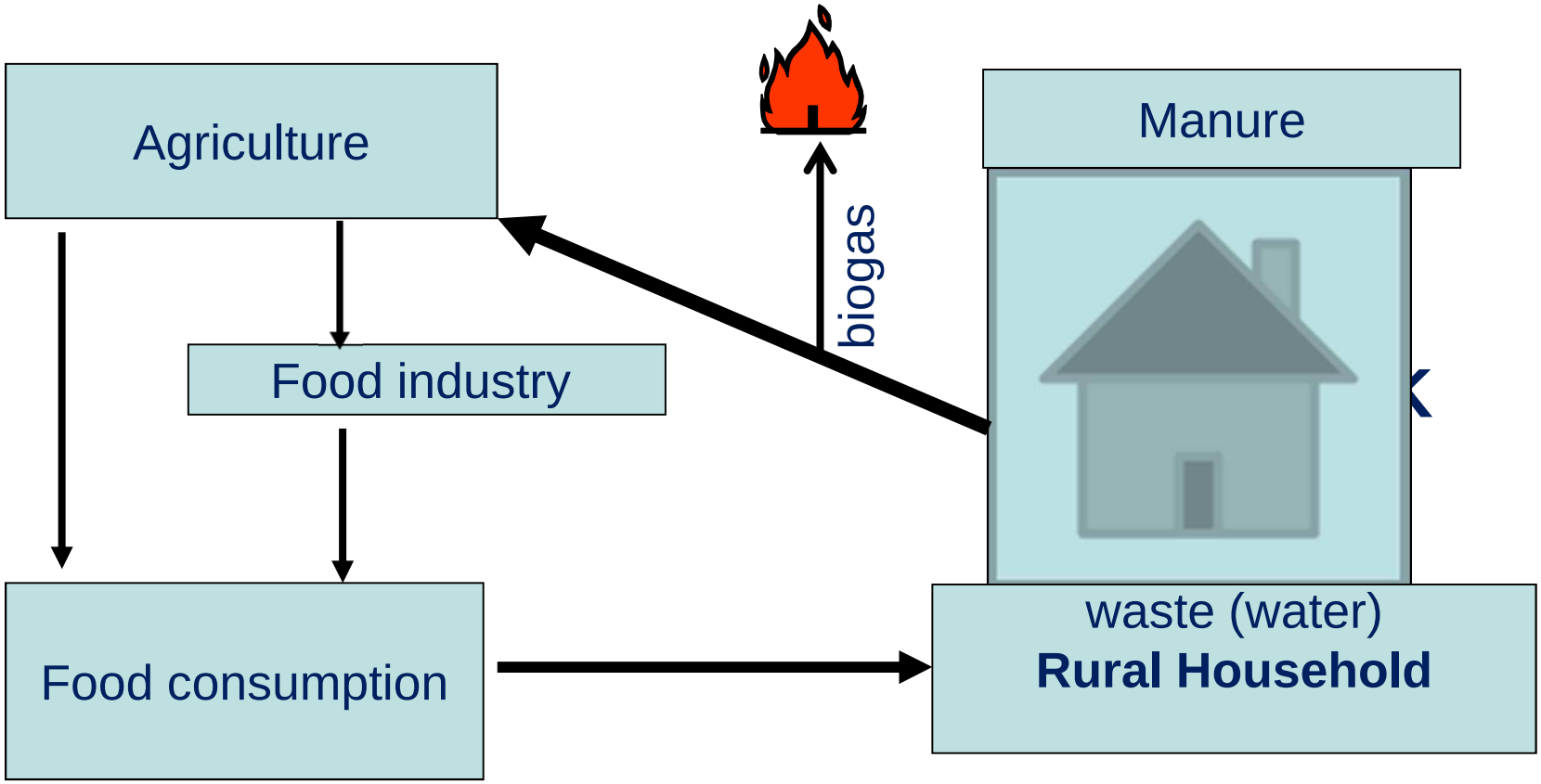


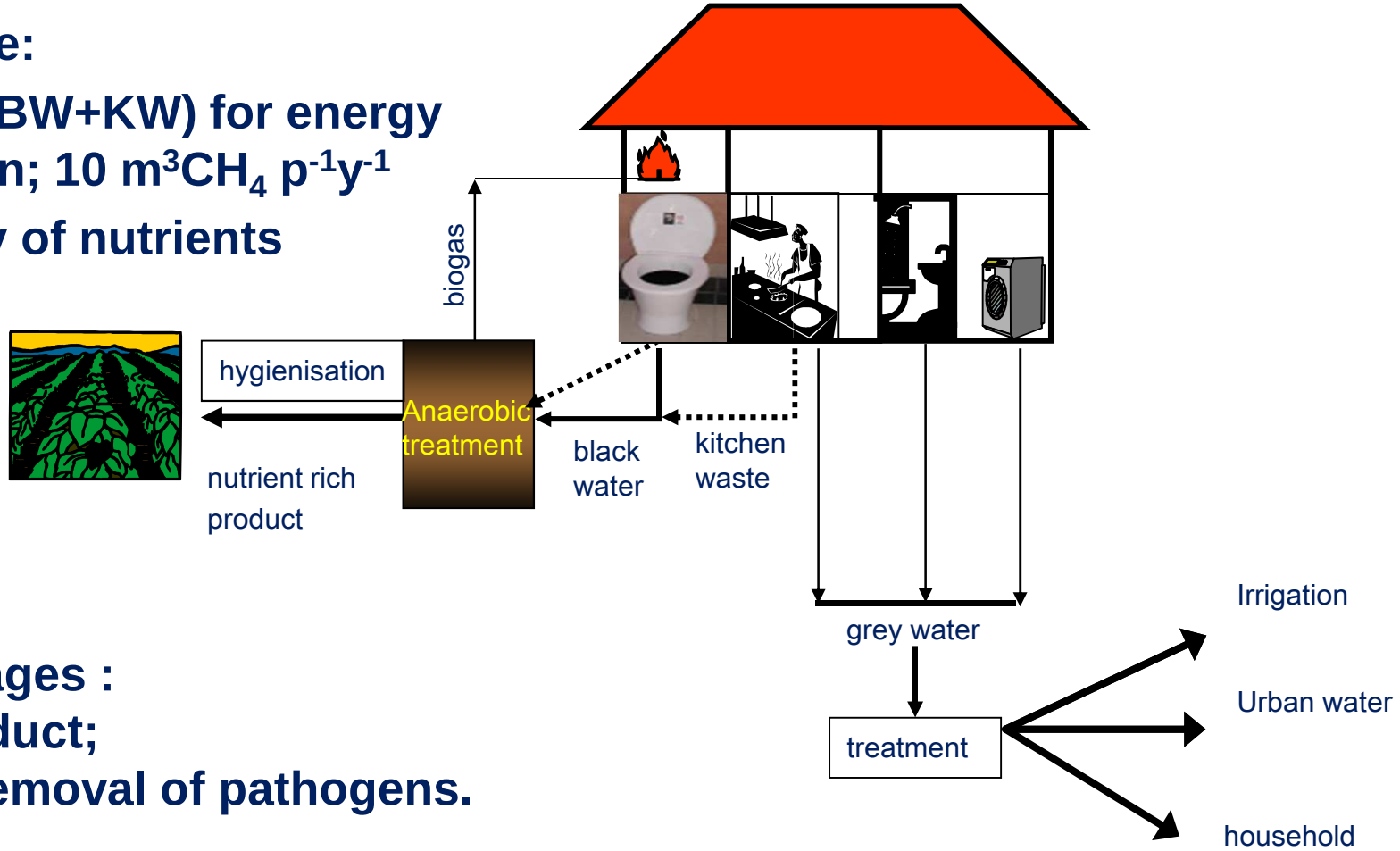
C2C based Food production



Anaerobic treatment of black waste(water) house on-site

Advantage:

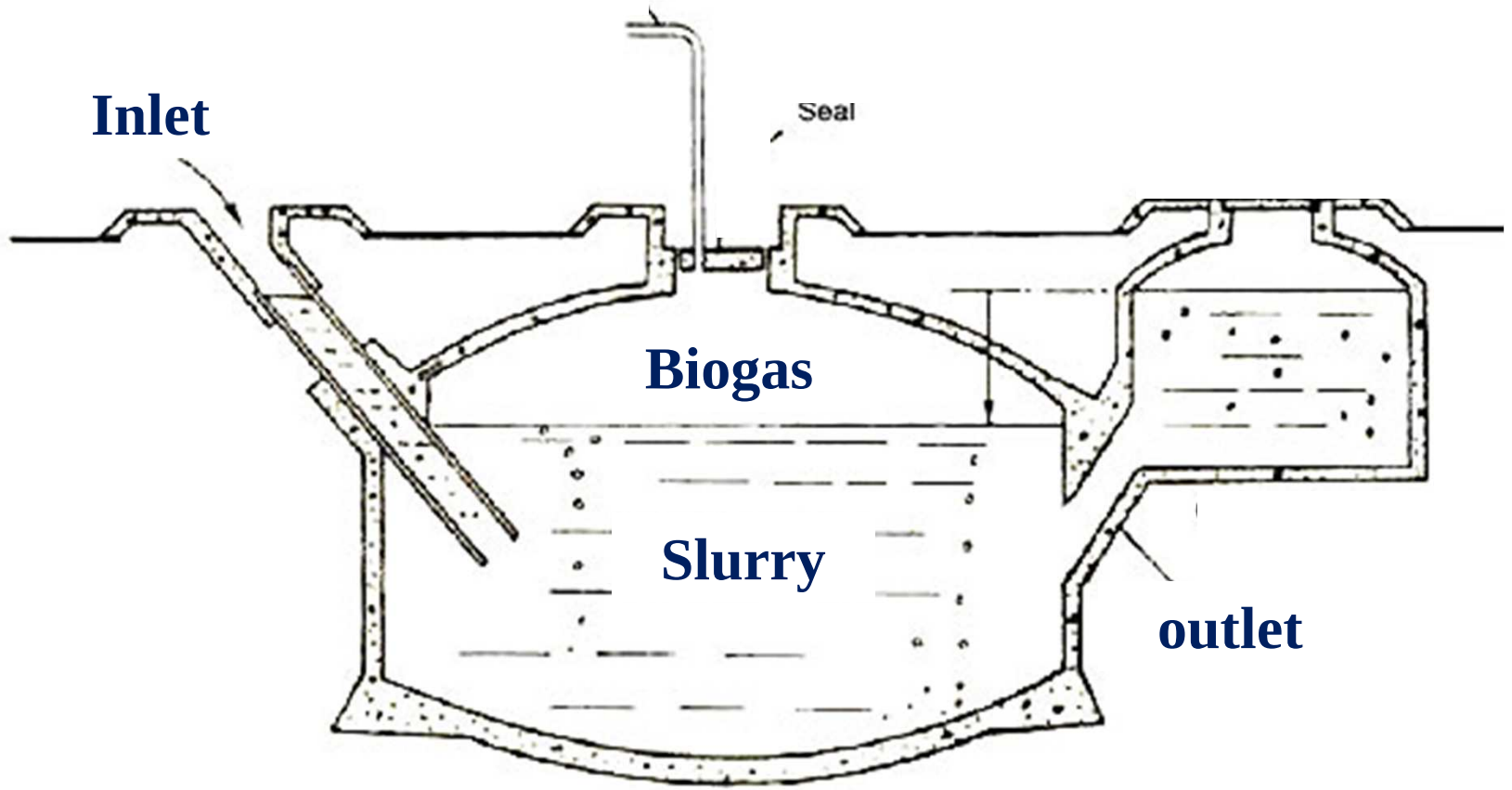
- **Biogas (BW+KW) for energy production; 10 m^3CH_4 $p^{-1}y^{-1}$**
- **Recovery of nutrients**



Disdvantages :

- **Wet product;**
- **Partial removal of pathogens.**

Chinese dome digester house on-site



Chinese dome digester in Pingyao

Chinese dome digester in Pingyao

Anaerobic treatment of black waste(water) in Tanzania; house on-site

Sustainable environmental protection using modified pit-latrines (PhD thesis, WUR-ETE)
Chaggu, E.J. \ 2004

Pollution load in black waste(water) & kitchen waste (K)

	Urine + Feces+ Kitchen waste (g/p/d)	% of total domestic ww + K
N	12.3 g	92
P	1.6 g	80
K	3.9 g	84
COD	111 g	69

Phosphorus and nitrogen production (BW+ KW) and worldwide artificial fertilizer use

	in BW + K (tons/year)	Fertiliser use (tons/year)	% coverage
Phosphorus	*$3.9*10^6$	#$14.9*10^6$	27
Nitrogen	*$30.9*10^6$	##$121*10^6$	25

World population: 6,911,750,810 people (http://www.census.gov/main/www/popclock.html)
#Cordell, D., Drangert, J.-O., and White, S. (2009). The story of phosphorus: Global food security and food for thought. Global Environmental Change, 19, 292-305.

COD (black water + kitchen waste) and potential Energy production --- Worldwide

	in BW + K	*CH_4	Biogas (60% CH_4)	# Yearly stove Burning Hrs. (@400Lit/ Hr)
COD	**$280*10^6$ (tons per year)	$69*10^9$ (m^3 per year)	$114*10^9$ (m^3 per year)	$286*10^9$ (hours)

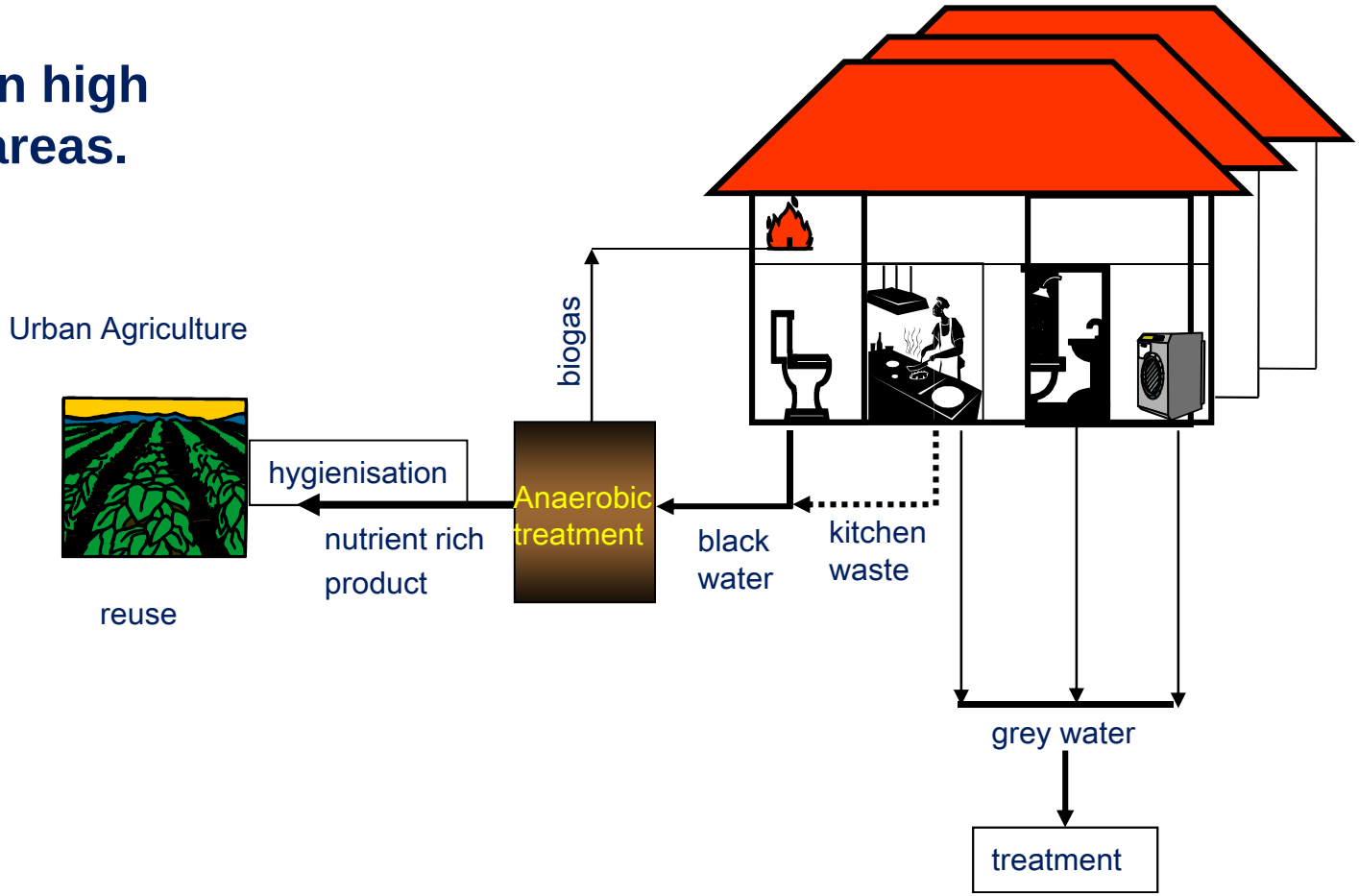
**World population: 6,911,750,810 people (http://www.census.gov/main/www/popclock.html);
*anaerobic treatment:70% conversion; #http://www.bspnepal.org.np./biogas-design.

Coking for a family of 5 persons

- ca. 0.6 hours per day (family's BW & KW)
- cooking 2-3 meals for a 5 p. family: 1.5 m3 biogas
- Addition of 36 liters cow manure (16% TS) per day
- Ca. 2 cows

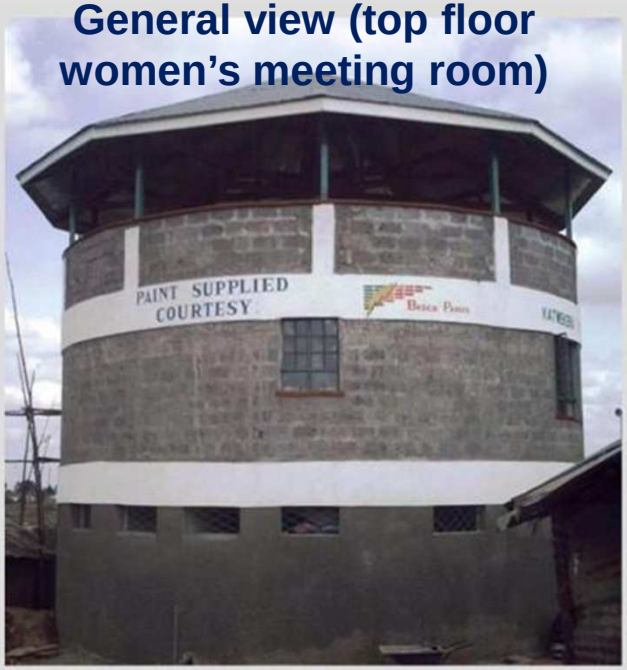
Anaerobic treatment of black waste(water); community on-site

Toilets blocks in high density urban areas.

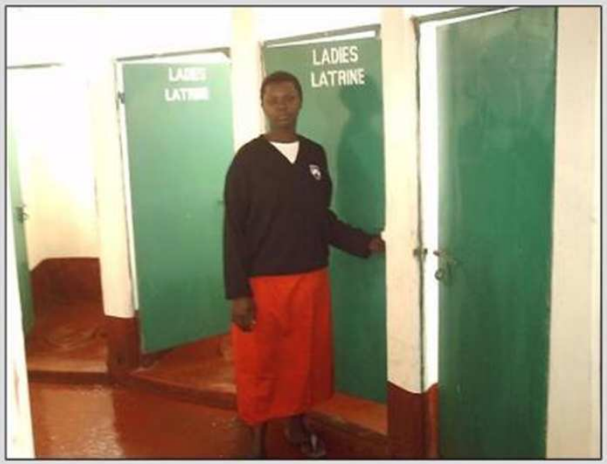


The SPARC-style sanitation block in Kibera, Nairobi, managed by the community women

General view (top floor women's meeting room)



Women's toilets



Anaerobic digester beneath the toilets;

Biogas for cooking.

Photographs courtesy of Rob Clarke, Halcrow/ Water and Sanitation for the Urban Poor.

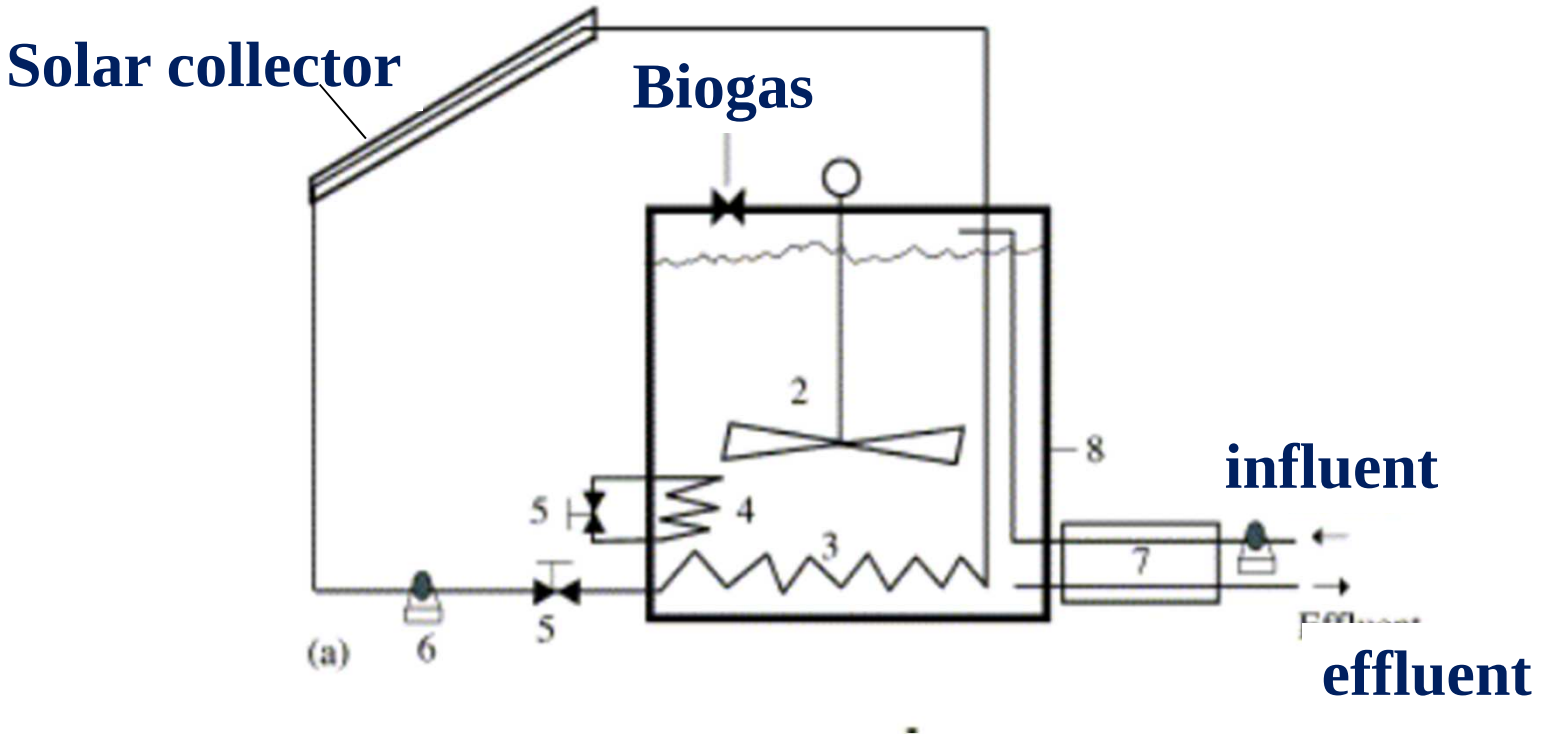
School Sanitation block in Dares Salam, Tanzania

Photographs Thobias Bigambo

Low temperature conditions

- Sodha, Ram et al. 1987; Gupta, Rai et al. 1988; GTZ, 1999:
  - Temperature <15°C: insignificant biogas
- Safley and Westerman (1990):
  - 15°C digester volume 2,7* > 25 °C digester volume
- Zeeman (1991)
  - 15°C: lower gas production, even at large digester volumes

Solar supported biogas



Possible combination of solar collector and anaerobic digesters (El-Mashad, et al. 2004)

Collector area for minimal 15°C ; digester volume 4.1 m^3

	Collector area (m^2) *(τα=0,92)	Winter temperature**	Worst Case Insolation ($kWh/m^2.day$)
Romania	11,2	-1.5°C	2
Kyrgyzstan	5,0	-3°C	4
Bolivia	4,8	5°C	4,5
Georgia	4,5	3°C	3

* τα= transmission adsorption product; **1st of January average temperature from BBC weather ** (Peel, Finlayson et al. 2007).

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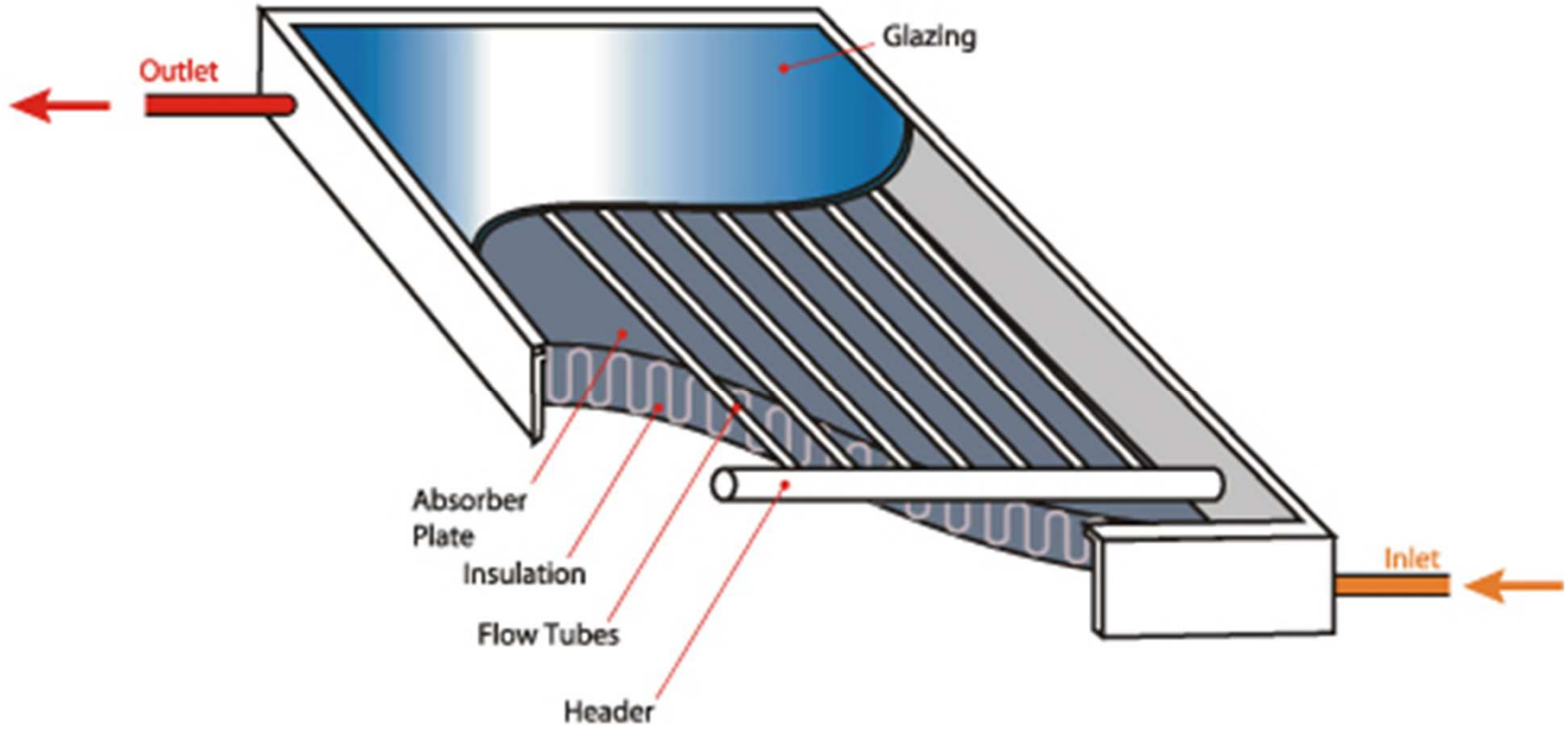
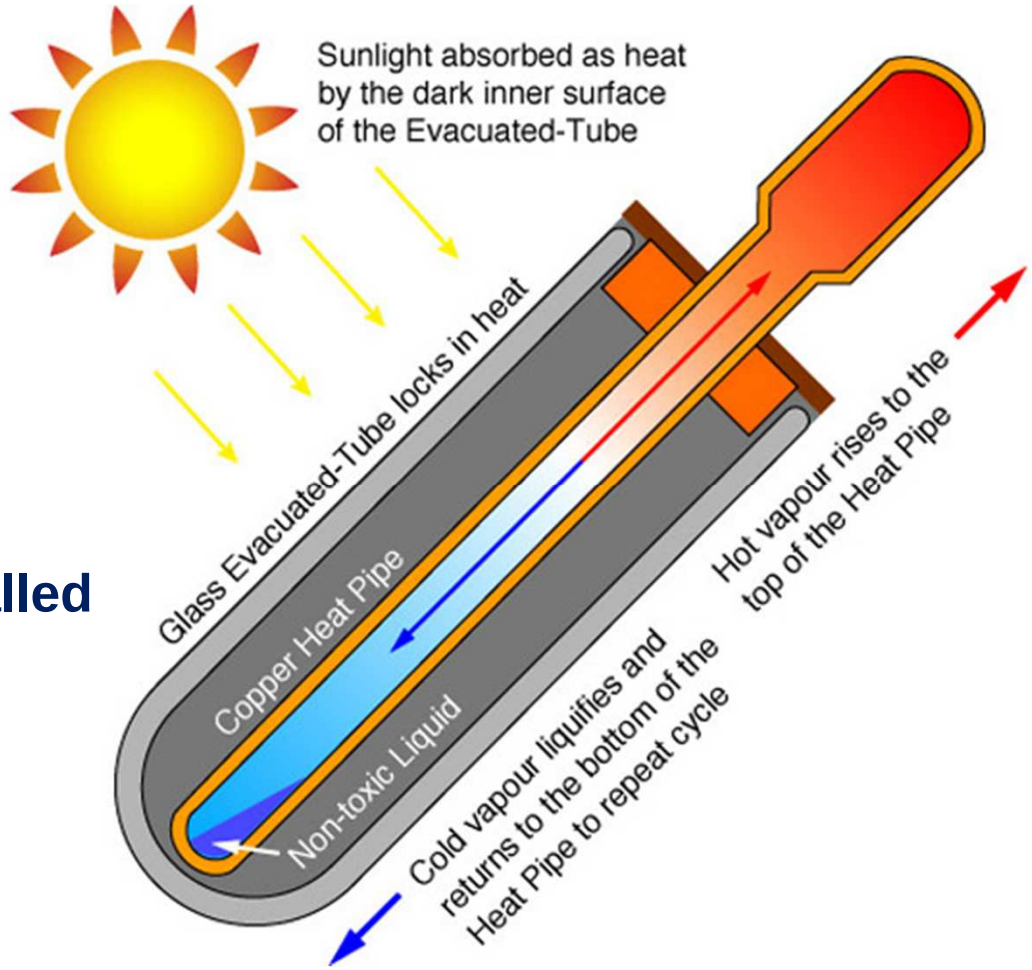


Flat plate collector (Southface, 2011)

Solar supported biogas

in China in 2008
22GW was installed



Evacuated tube collector (Sunmaxxsolar, 2011)

Comparison and evaluation of different solar collection technologies

Solar technology	Investment	Efficiency	Maintenance	Additional benefits
Flat plate solar collector	++	++	+	Warm water
Evacuated tube collectors	+++	+++	+	Warm water
Greenhouse covering**	+	+	++	Improved agricultural production, heating ,animal shelter

*+ = small, ++ medium and +++ = high** plastic greenhouse

Community on-site urban application in Europe

Black Waste(water)/Grey Water separation

- Anaerobic treatment; biogas production
- Fertilizer production (N &P)
- (Grey) Water reuse

32 houses

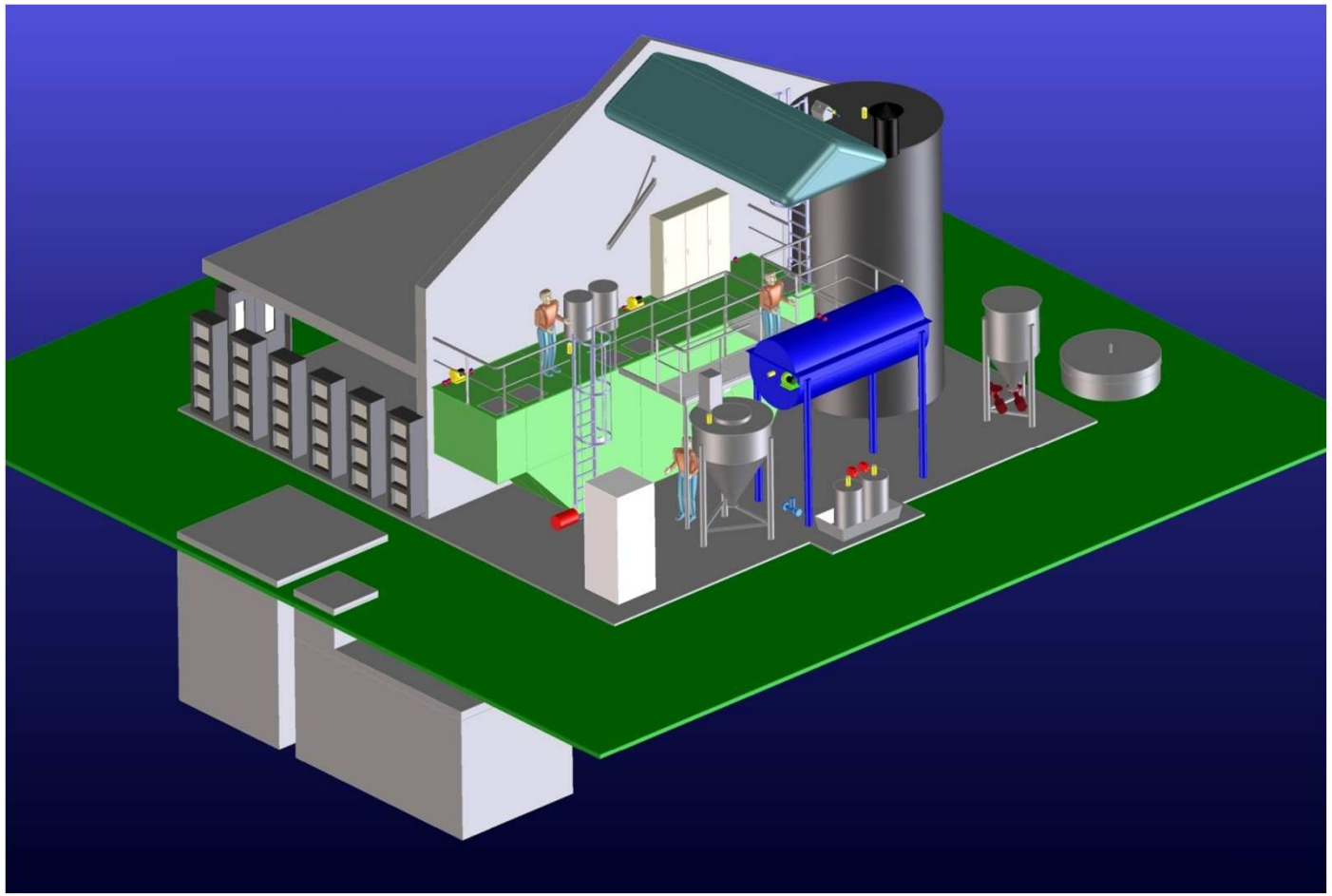
WAGENINGEN UNIVERSITY
Environmental Technology

Letting Associates
Foundation

Boarding school Ukraine

Implementation of source separation in Ukraine

Under construction in NL 250 houses in Sneek



NIOO building in Wageningen
BW UASB + algae

Villa Flora Venlo, Floriade 2012

Conclusions

A five persons family can cook ca. 0.6 hours per day on the family's BW + KW

A five persons family needs ca. 36 liters cow manure for cooking 2-3 meals

Resp. 27 and 25 % of the worldwide N & P artificial fertilizer production can be covered with BW & KW

Conclusions

House-one site biogas production in low temperature countries becomes possible by application of a solar supported digester

Community-on-site treatment of source separated black water in urban situations in Europe is a true alternative for conventional sanitation