

Gas upgrading issues

Training Session 3

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Nova Energie



NOVA Energie

- Nova Energie Ltd is an internationally operating consulting company company located in Switzerland
- We have 20 collaborators including engineers, marketing specialists and journalists
- We work exclusively in the fields of renewable energy and rational energy utilisation.



Overview

- WWTP: One year experience with a PSA system
Beat Amman
- Commercial experiences with COOAB
Peter Thulin
- Cleaning of biogas
Arthur Wellinger
- Overview on upgrading technologies
Michael Beil & Uwe Hoffstede
- Panel discussion



Definition

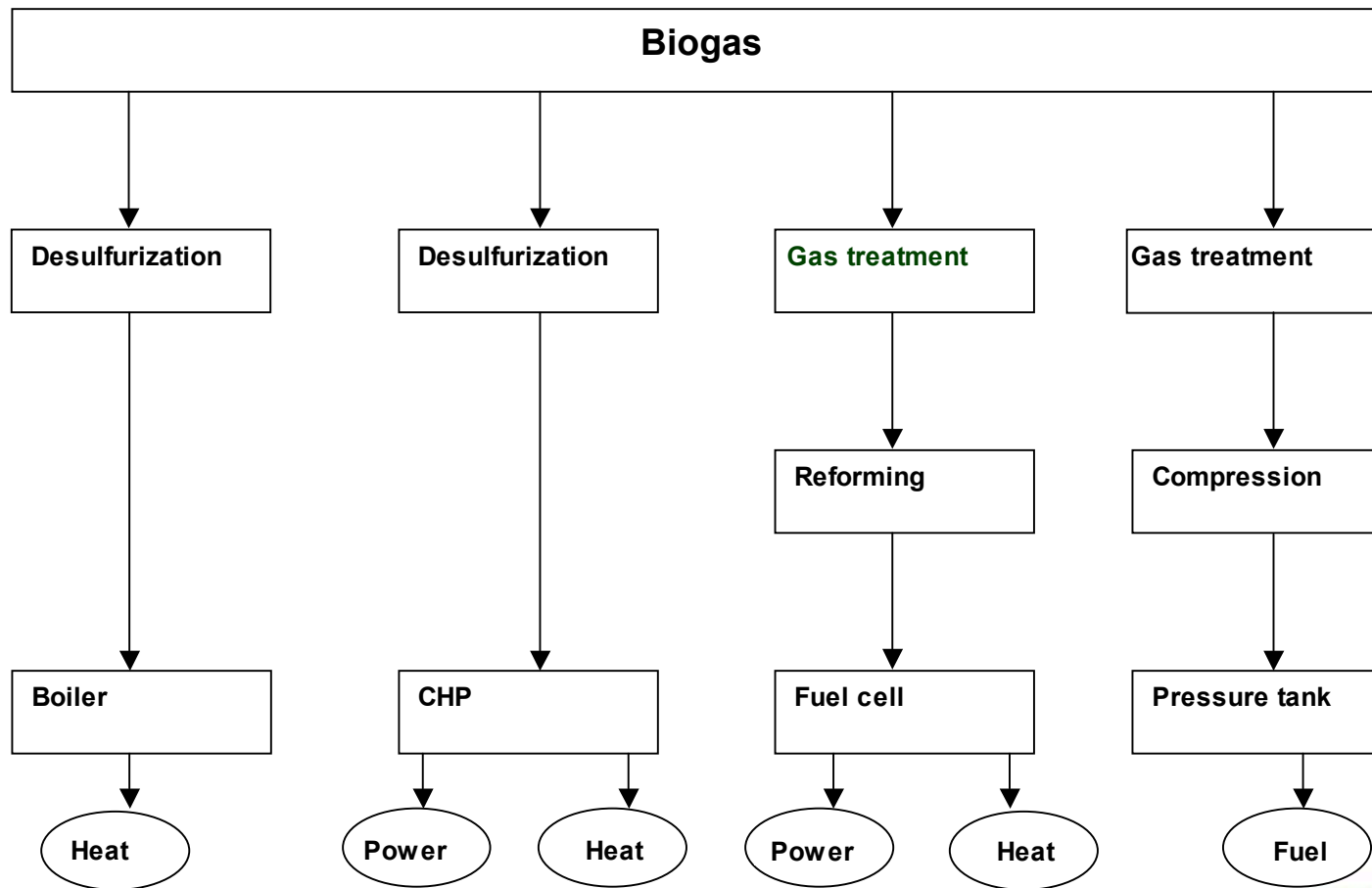
- **Biogas cleaning:**
Removal of undesired trace substances from the biogas like minerals, sulphide, ammonia, etc.
- **Biogas upgrading:**
Removal of CO₂ to reach natural gas like quality
- **Biomethane:**
Natural gas like, upgraded biogas for grid injection or vehicle fuel



- **Short introduction on biogas cleaning**
- **Aspects of methane slip**



Biogas Utilisation



Need for gas conditioning

Application	H₂S	CO₂	H₂O	Siloxane
Heating	< 1'000 ppm	no	no	no
Cooking	yes	no	no	no
Engine (CHP)	≤ 500 ppm	no	no condensation	yes
High pressure compression	yes	recommended	yes	no
Grid and fuel quality	yes	yes	yes	Eventually
Hot fuel cells	yes	No	No condensation	yes



Compound	Unit	France		Germany		Sweden	Switzerland		Austria
		L gas	H gas	L gas grid	H gas grid		Lim. inject.	Unlim. Inject.	
Higher Wobbe index	MJ/Nm ³	42.48-46.8	48.24-56.52	37.8-46.8 46.1-56.5					47.7-56.5
Methane content	Vol-%					95-99	>50	>96	
Carbon dioxide	Vol-%	<2		<6			<6		≤2 ⁸
Oxygene	Vol-%			<3			<0.5		≤0.5 ⁶
	ppm _v	<100							
Hydrogen	Vol-%	<6		≤5			<5		≤4 ⁴
CO ₂ +O ₂ +N ₂	Vol-%					<5			
Water dew point	°C	<-5 ¹		<t ²		<t ³ -5			<-8 ⁷
Relative humidity	Phi						<60 %		
Sulphur	mg/Nm ³	<100 ⁴		<30		<23	<30		≤5
		<75 ⁵							

¹At MOP (Maximal Operating Pressure) downstream from injection point

²Ground temperature

³Ambient temperature

⁴Maximum permitted

⁵Average content

⁶Mole percentage

⁷At 40 bars

➔ There is a need to standardization



Gas composition

Composition	Units	Natural gas (typical North Sea H)	Biogas	
			Anaerobic digester	Landfill
Methane	mol%	88.8 (86.6 - 88.8)	65.0 (50 - 80)	45.0 (30 - 60)
C2+ Hydrocarbons		8.3 (8.3 - 8.5)	-	-
Hydrogen		-	(0 - 2)	1.5 (0 - 2)
Carbon monoxide		-	-	-
Carbon dioxide		2.3 (1.9 - 2.3)	35.0 (15 - 50)	40.0 (15 - 40)
Nitrogen		1.1 (0.9 - 1.1)	0.2 (0 - 5)	15.0 (0 - 50)
Oxygen		< 0.01	(0 - 1)	1.0 (0 - 10)
Hydrogen sulphide		mg/m ³	1.5 (0 - 5)	< 600 (100 - 10000)
Ammonia	-		100 (0 - 100)	5 (0 - 5)
Total chlorine	-		(0 - 100)	(0 - 800)
Total fluorine	mg/m ³	-	0.5 (0 - 100)	10 (0 - 800)
Siloxanes	mg/m ³	-	0 - 50	0 - 50
Tar	g/m ³	-	-	-

Source: MARCO gas



Biogas cleaning

What are the crucial compounds ?

- **Hydrogen sulfide**
- **Water vapour**
- *Siloxanes*
- *Oxygen, nitrogen*
- *Halogenic compounds (Chlorides, Fluorides)*

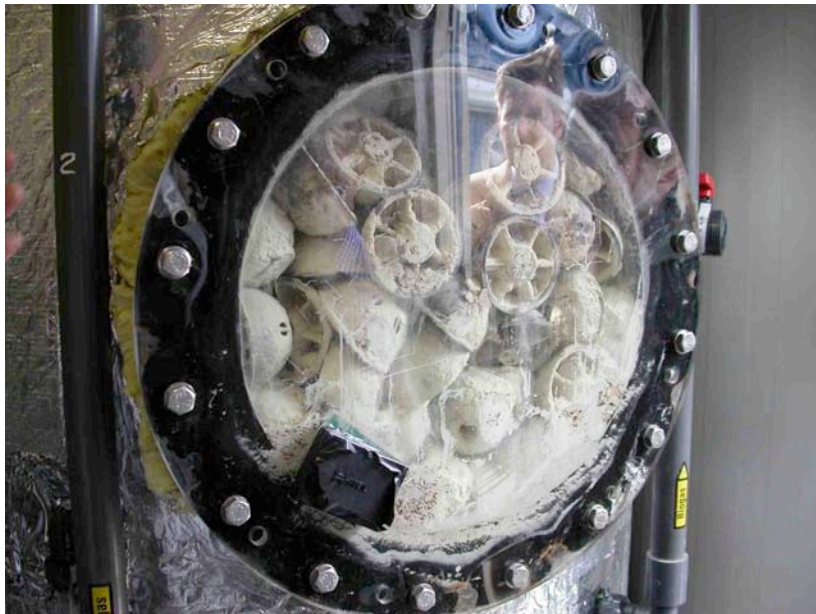
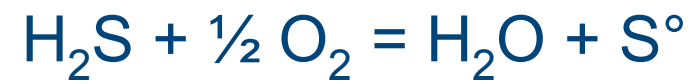


Hydrogene Sulfide Removal

- **Air/Oxygen dosing into the digester**
- **Biological oxidation on a filter bed**
- **Iron oxyde sponge**
- **Iron chloride dosing into the digester**
- **Activated carbon**
- **Washer (water, amines or glycoles)**
- **Sodium hydroxid**

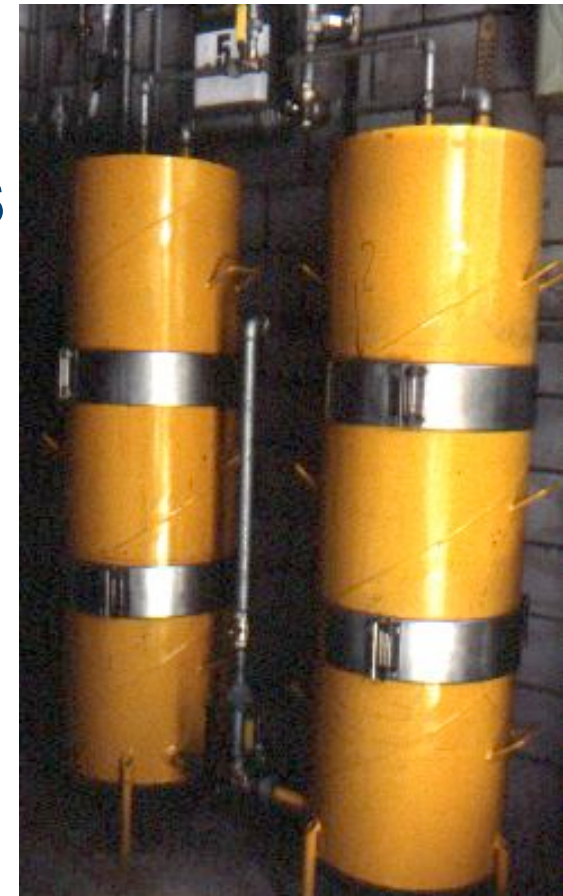


Biological Oxidation

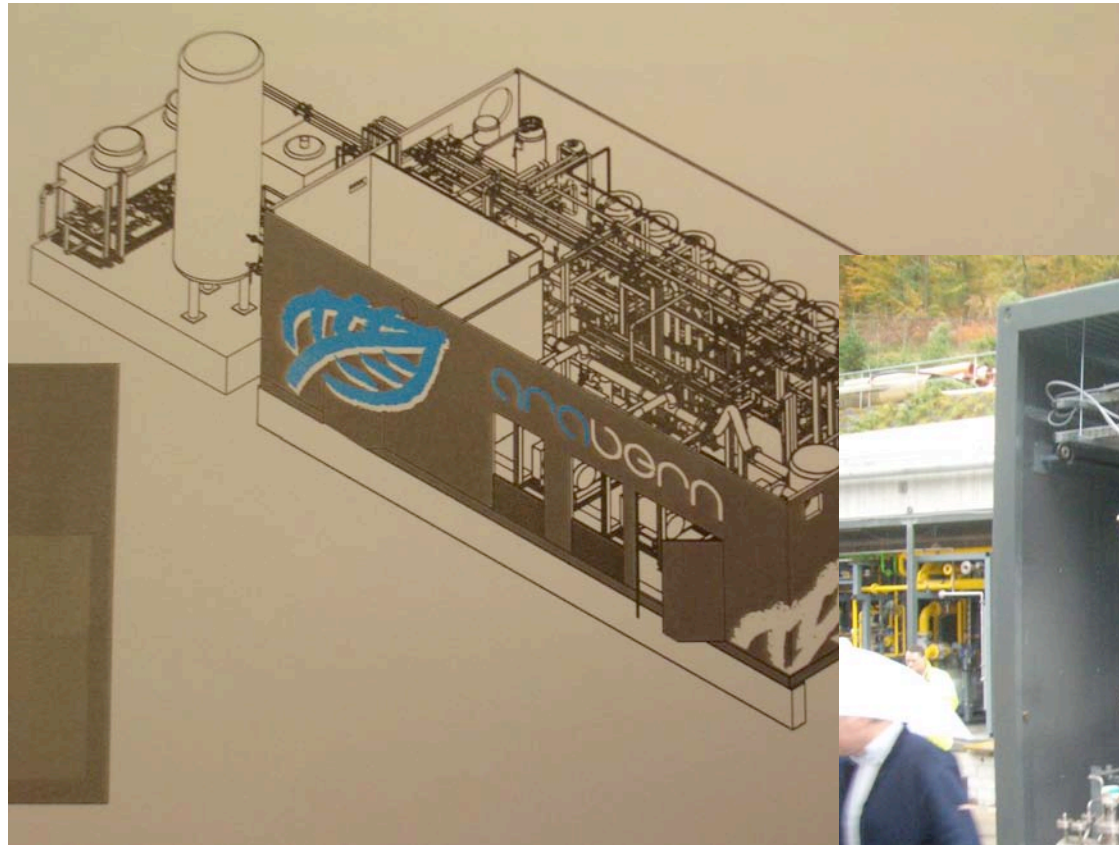


Chemical Oxidation

Chem. Adsorption on iron oxide:
Iron sulfide precipitation:



Adsorption on activated carbon

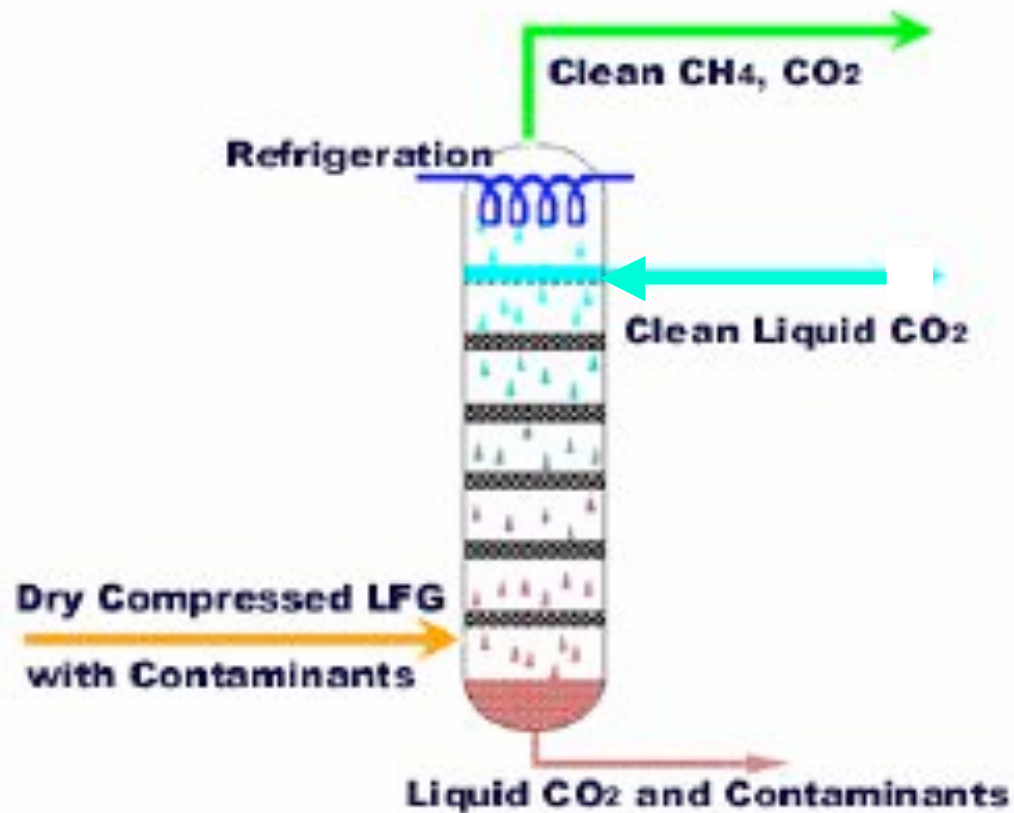


Siloxanes

At low concentrations and low flows (< 500m³ per hr) siloxanes are removed with activated carbon. At higher concentrations and voluminas by a combination of cooling and activated carbon



Combined cleaning



Biogas upgrading

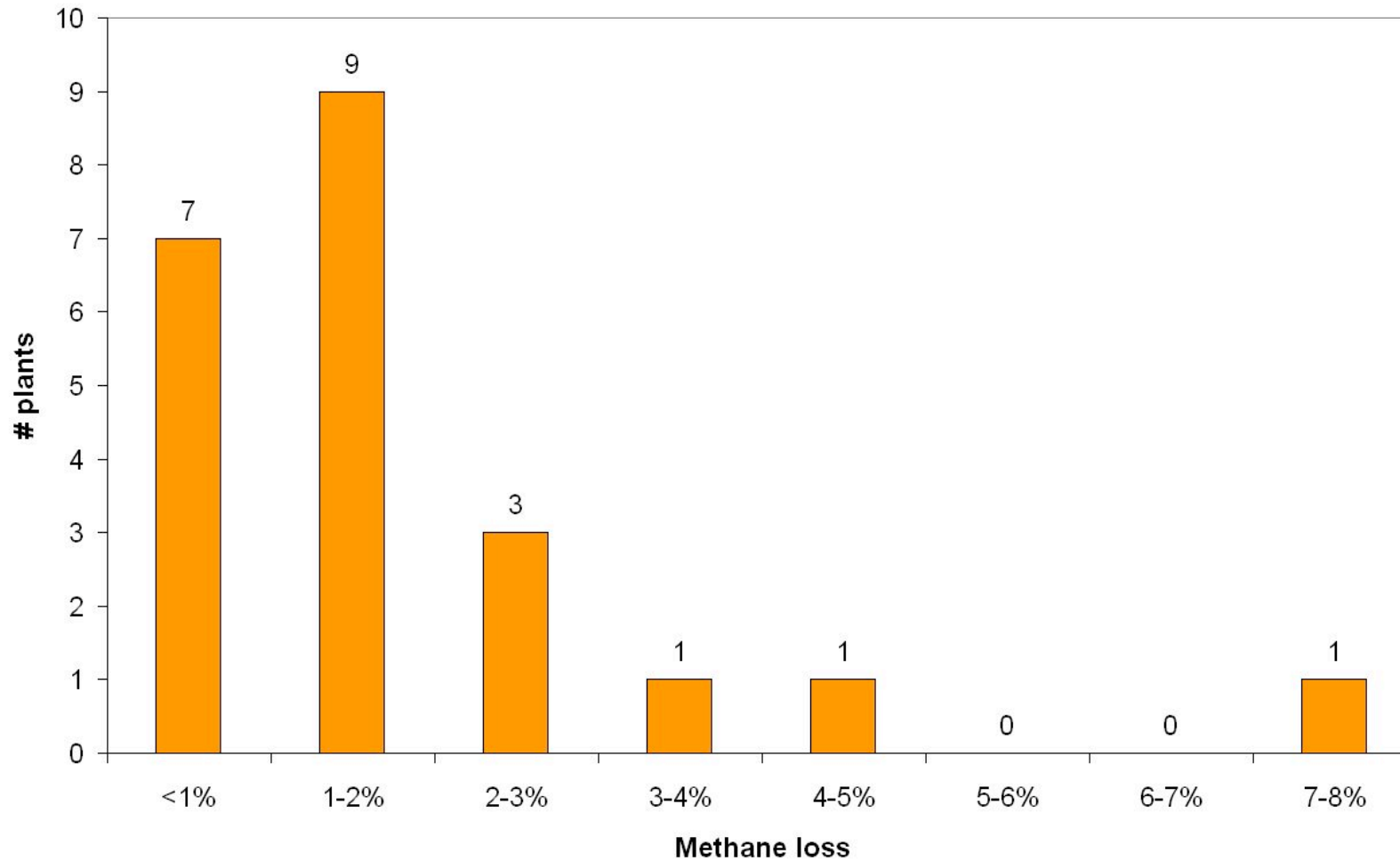
The crucial point of biogas upgrading is the methane emission or often called methane slip.

1% or more methane slip can reverse the positive environmental effect of biomethane when compared to petrol.

Methane is a 23 times stronger GHG than CO₂

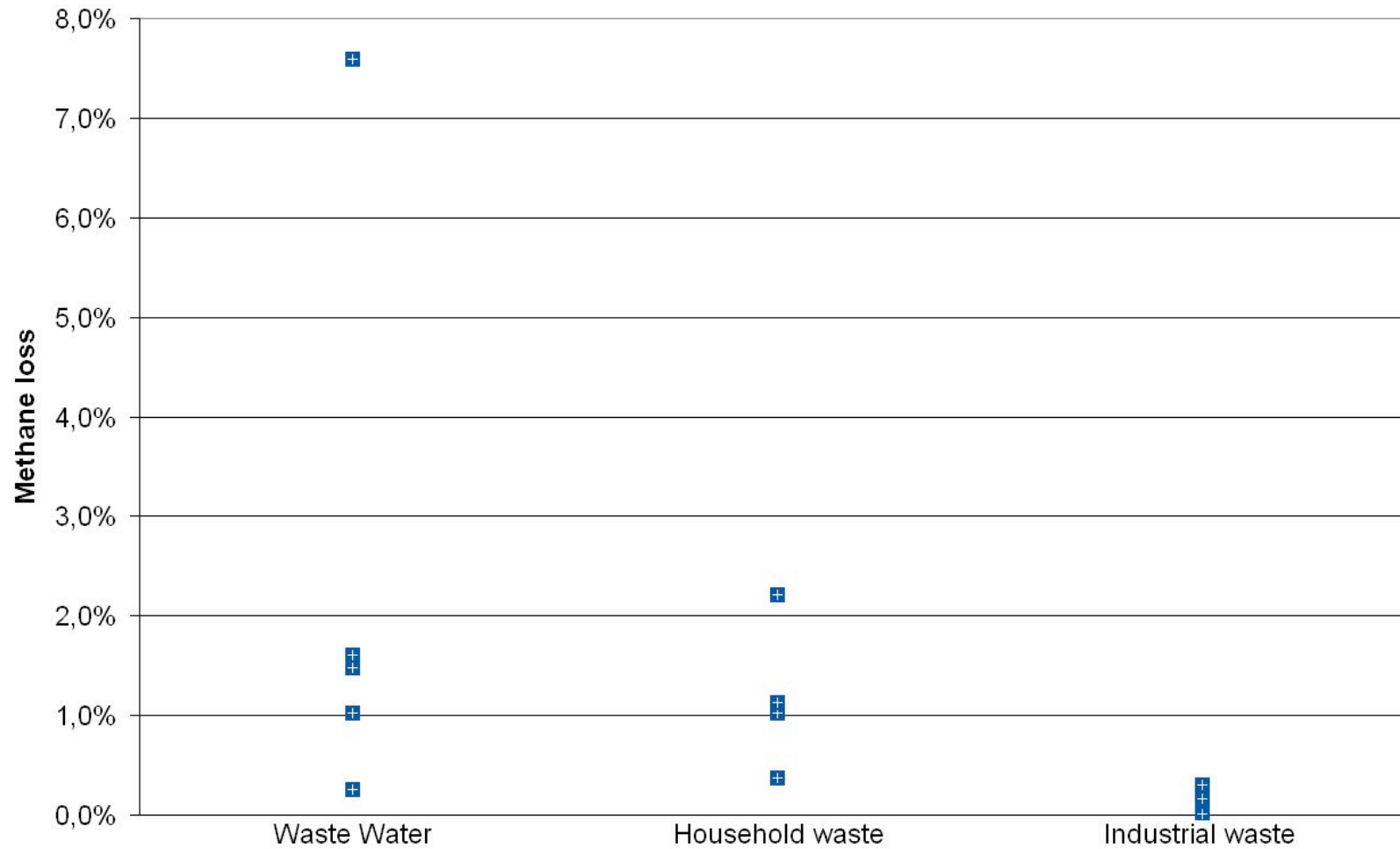


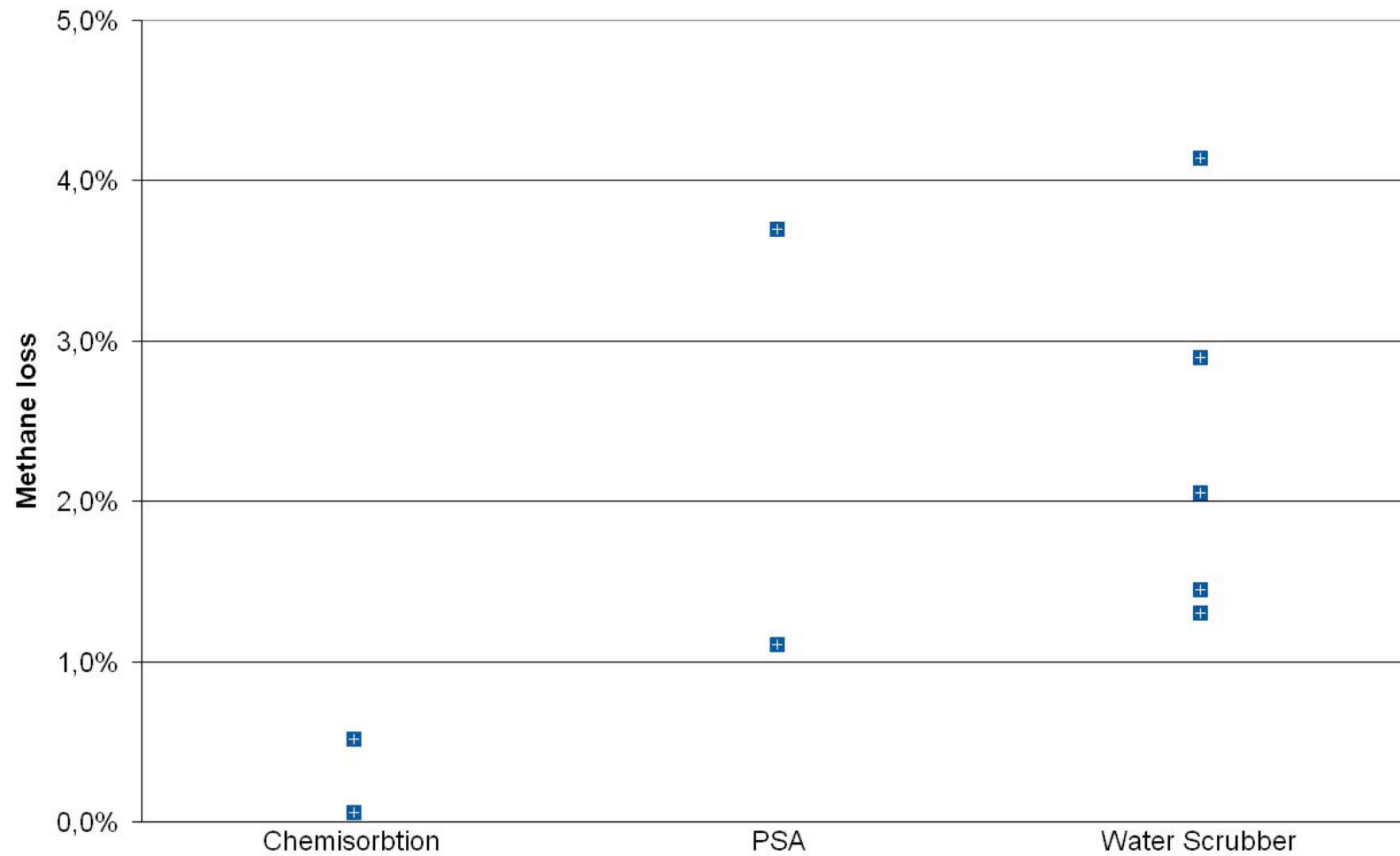
Monitoring of CH₄ slip in Sweden



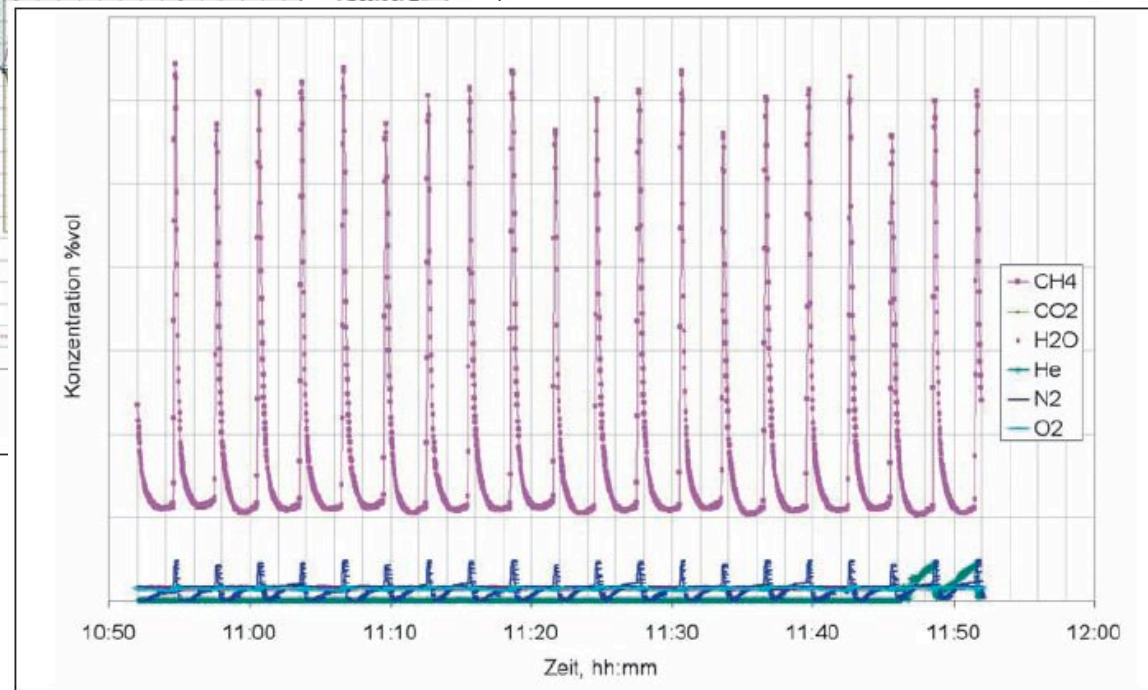
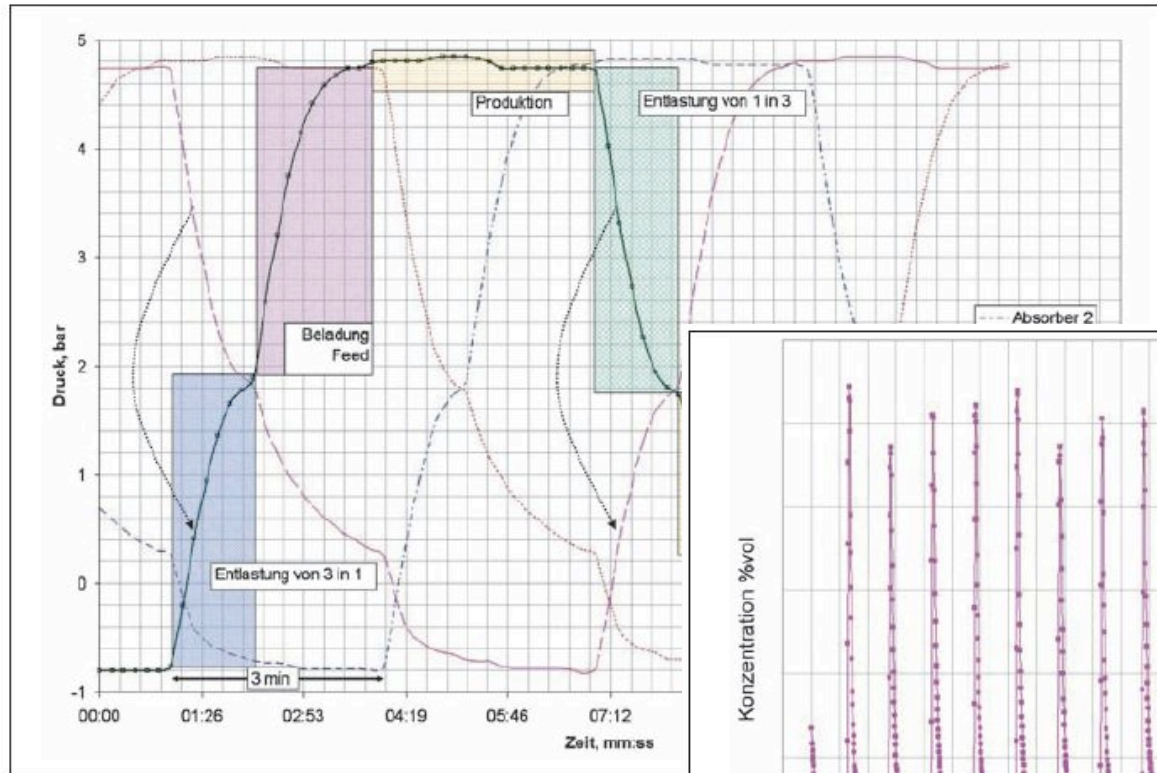
Source: Anneli Petersson, SGC





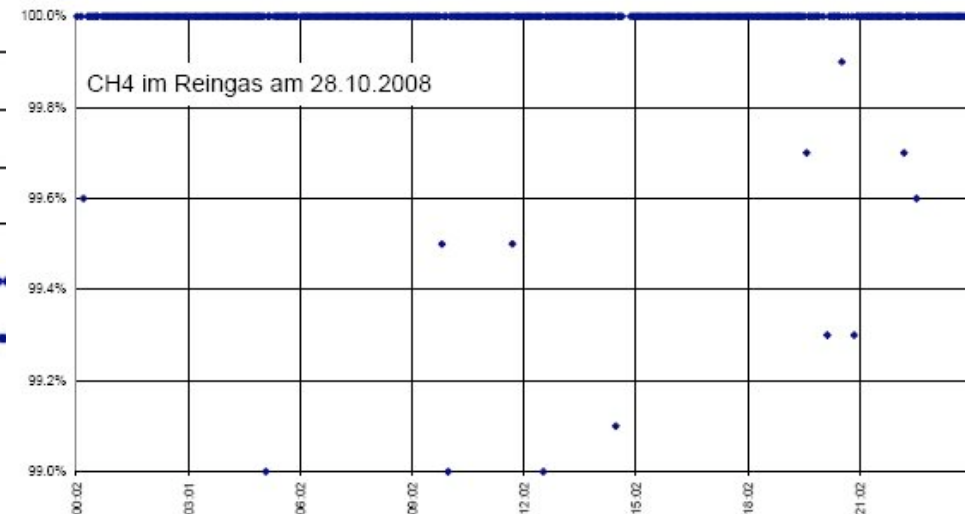
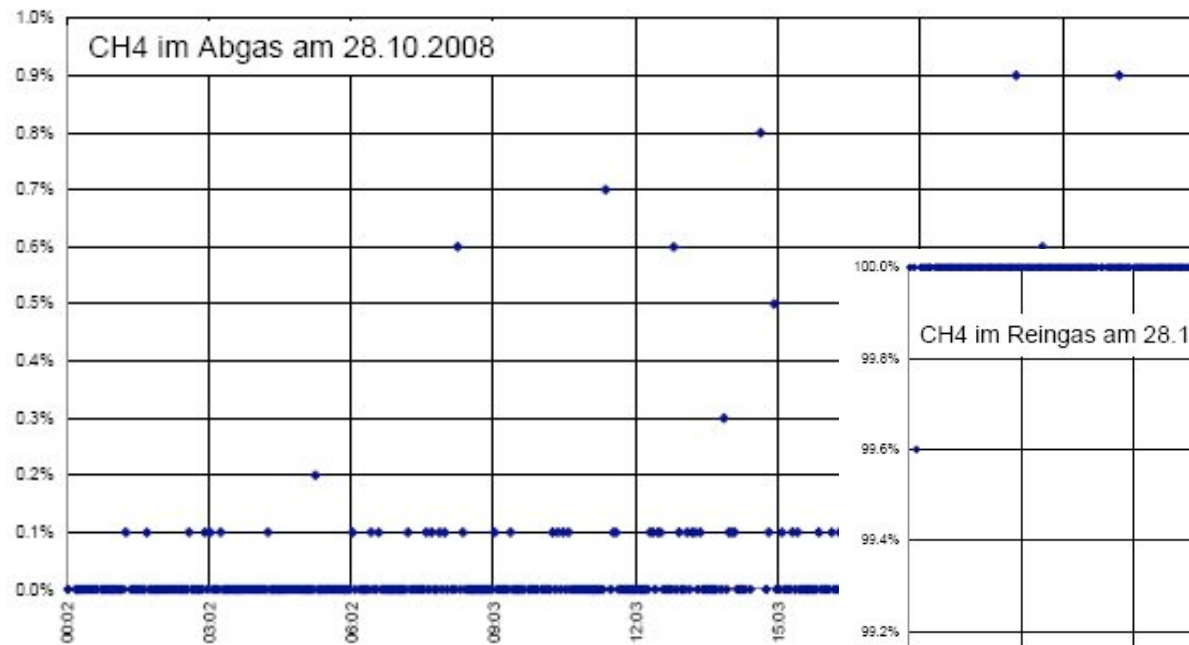


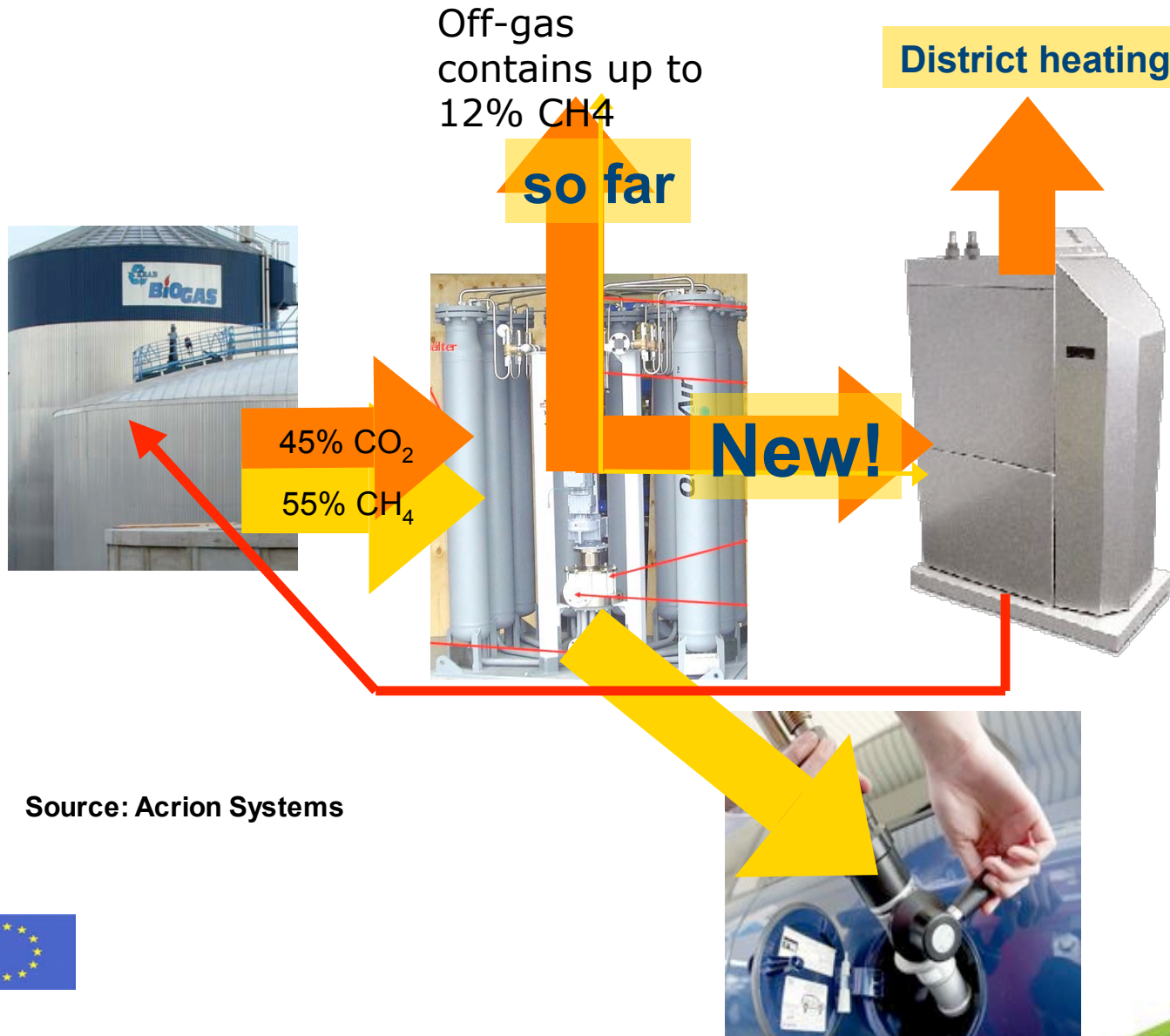
Methane emission from PSA installations



Methane emission from chemical absorption

			Mittelwert	Standardabweichung
Rohgas	CH ₄	vol%	62.9	2.2
	CO ₂	vol%	36.8	2.3
Reingas	CH ₄	vol%	99.6 ¹⁾	(0.8)
	CO ₂	vol%	0.37	(0.8)
Abgas	CH ₄	vol%	0.09 ²⁾	(0.4)
	CO ₂ (berechnet) ³⁾	vol%	> 95	-

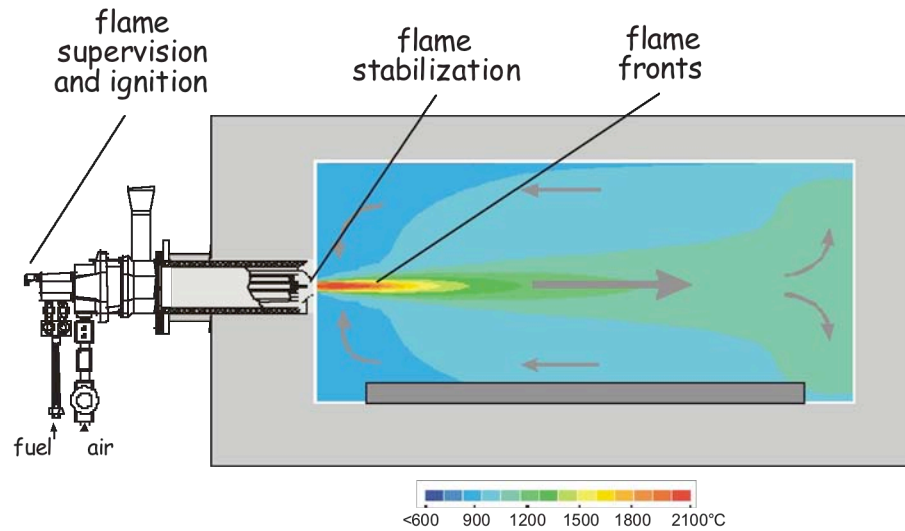




Source: Acrion Systems



How operates a FLOX® burner?



Flame operation

FLOX-operation

