KUALA LUMPUR 2012 WORLD GAS CONFERENCE

25th world gas conference

"Gas: Sustaining Future Global Growth"

Renewable Gas - The sustainable energy solution

By: Elbert Huijzer, Sari Siitonen, François Cagnon, Sergey Shilnikov; PGC A

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Venue: Room 408/9

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Introduction

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Maarten van Blijderveen

Sari Siitonen

Sergey Shilnikov

Søren Hylleberg Sørensen

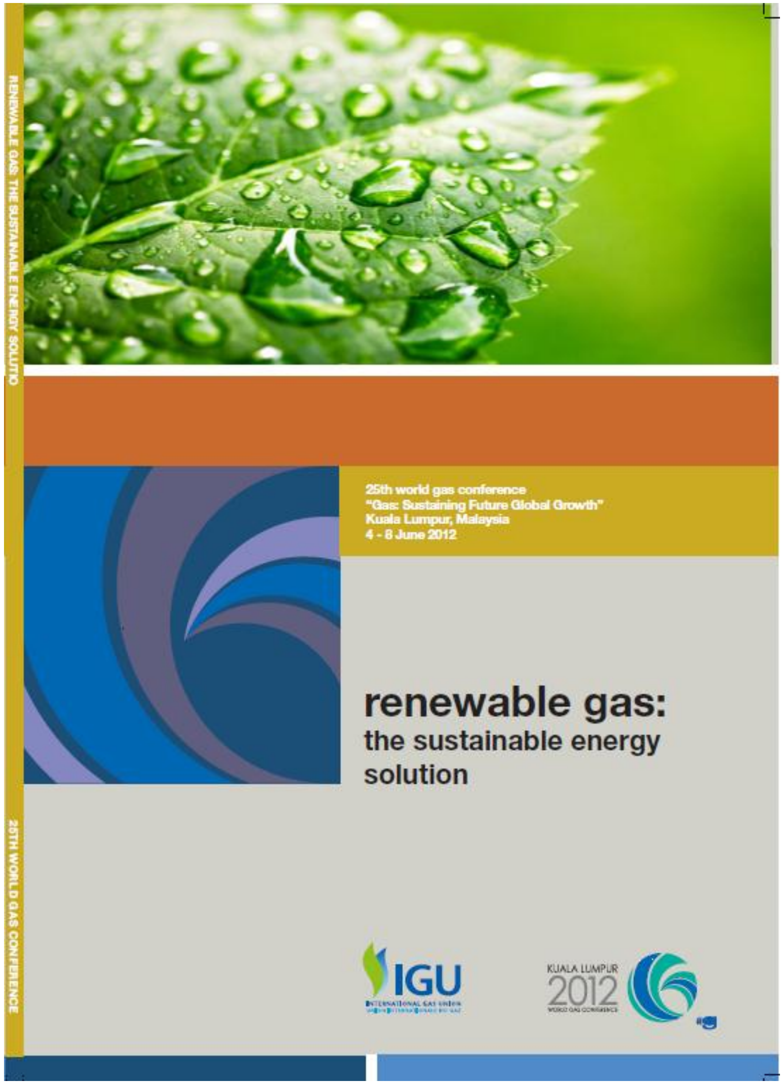
WOC 5:

Aksel Hauge Pedersen

Tatsuo Kume

PGC E:

Uwe Klaas



First speaker: Sari Siitonen

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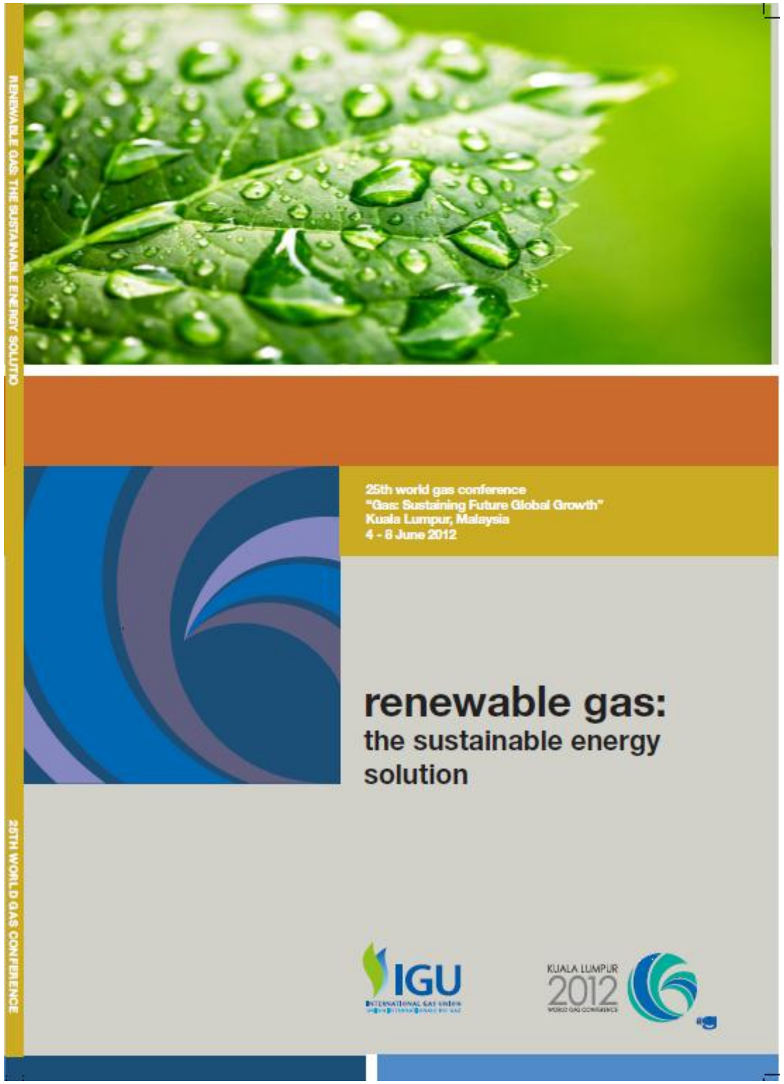
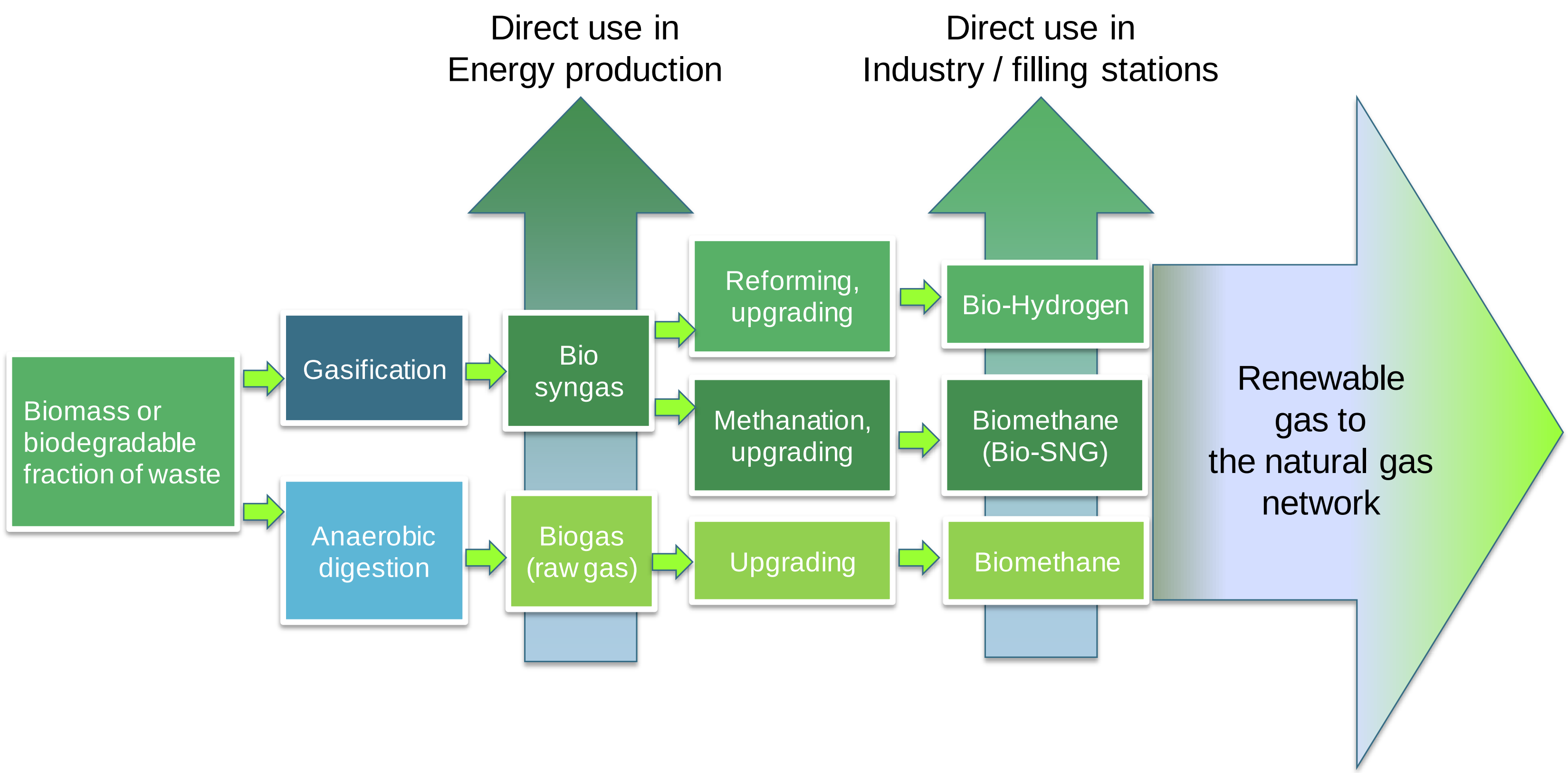


RENEWABLE GASES:
Definitions

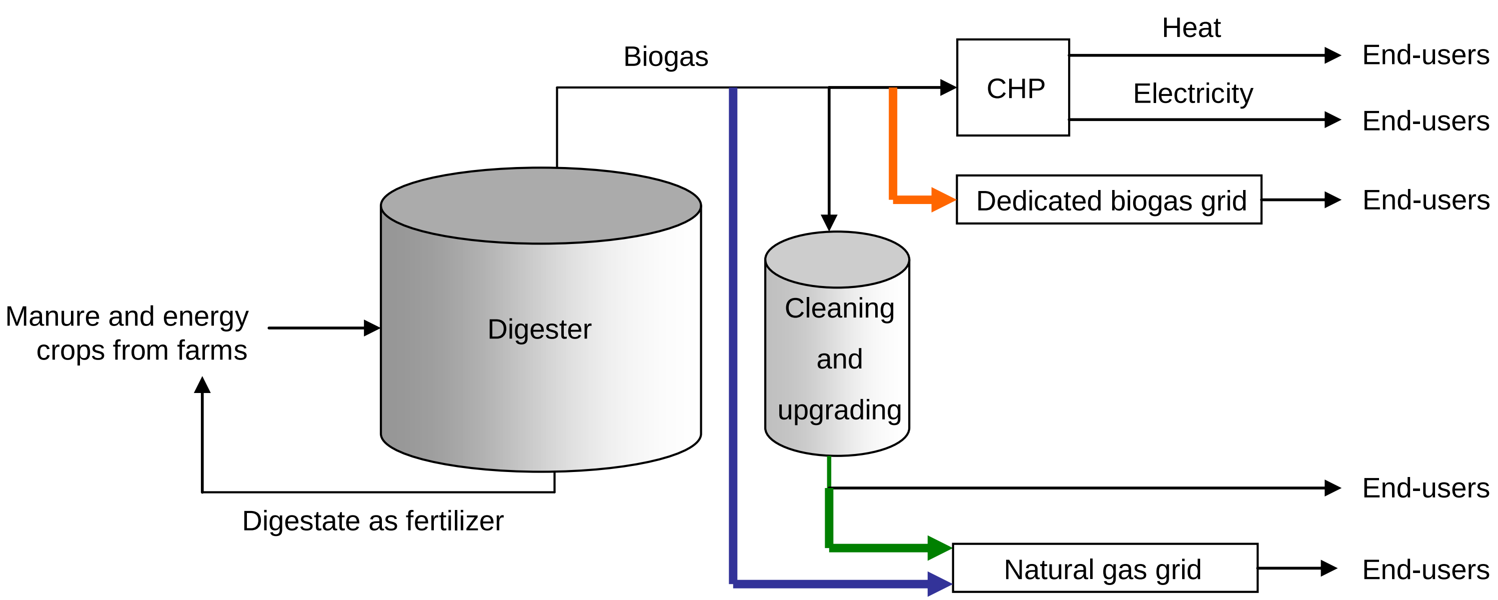
- **Biogas** is the raw product of the biological process of anaerobic fermentation.
  - Typically biogas consists of 35-65% methane.
- **Biomethane** is biogas that has been upgraded to resemble natural gas
  - It consists of 95-97% methane.
- **Bio syngas** is the product of the thermal process of gasifying the biomass.
  - It consists of a mixture of mainly hydrogen (H_2), carbon monoxide (CO), carbon dioxide (CO_2), water vapour (H_2O) and methane (CH_4).
- **Bio-SNG** (Bio-Synthetic Natural Gas) is bio syngas to which methanation is applied.
  - The methane content which can be obtained by this process is at least 95%.

Processes of renewable gas production



Anaerobic digestion

- Anaerobic digestion is a bacterial process that is carried out in the absence of oxygen.
  - The process can either be thermophilic digestion in which sludge is fermented in tanks at a temperature of 55°C or mesophilic, at a temperature of 30 to 40°C.
  - The methane generation is a key advantage of the anaerobic process.
  - The key disadvantage is the long time required for the process (up to 30 days) and the high capital cost.



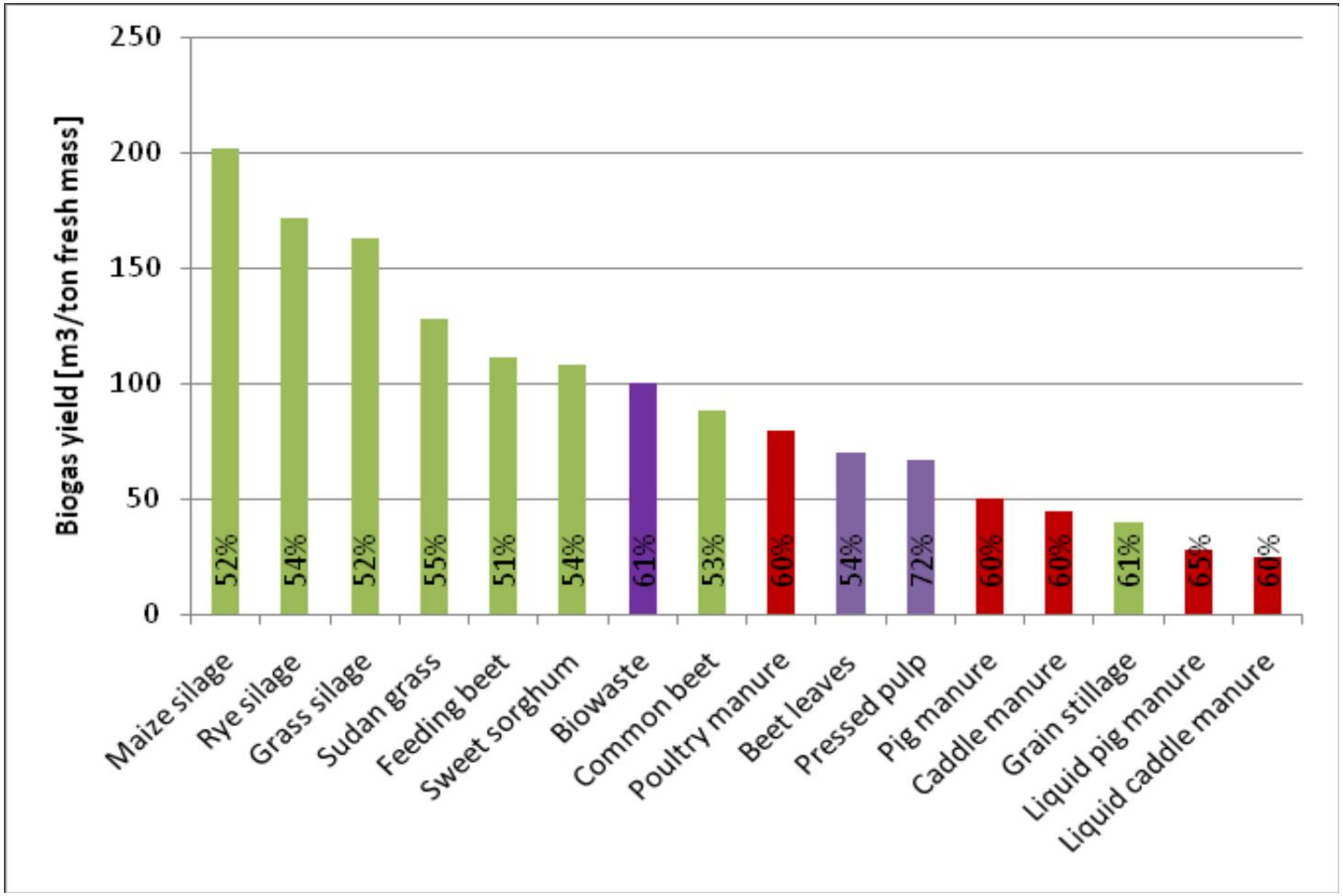
Biomass sources

- The following sources are most common for the production of biogas.
  - Cleaning of organic industrial waste streams, such as the waste streams of agricultural processing and food industries
  - Animal manure
  - Sewage treatment plants
  - Landfills
  - Grass and energy crops
  - Municipal organic waste
  - Algae

Component	Digestion plant	Sewage plant	Landfill
Methane [%]	60 – 70	55 - 65	35 - 55
Carbon dioxide [%]	30 – 40	balance	30 - 40
Nitrogen [%]	< 1	< 1	5 - 15
Hydrogen sulphide [ppm]	10 – 2000	10 - 40	50 - 300

Biomass sources

- Biogas yield from agricultural products

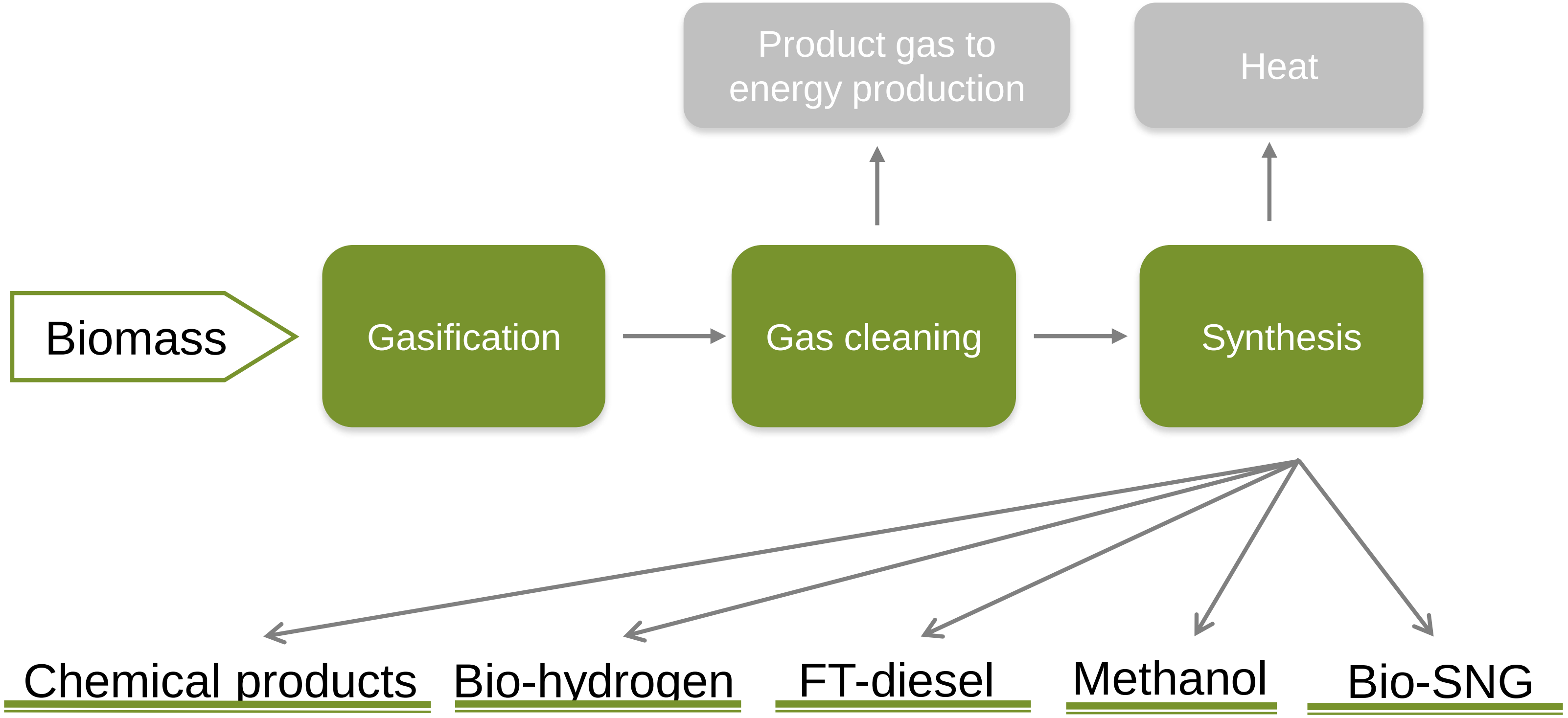


Source: AEBIOM

Cleaning and upgrading techniques

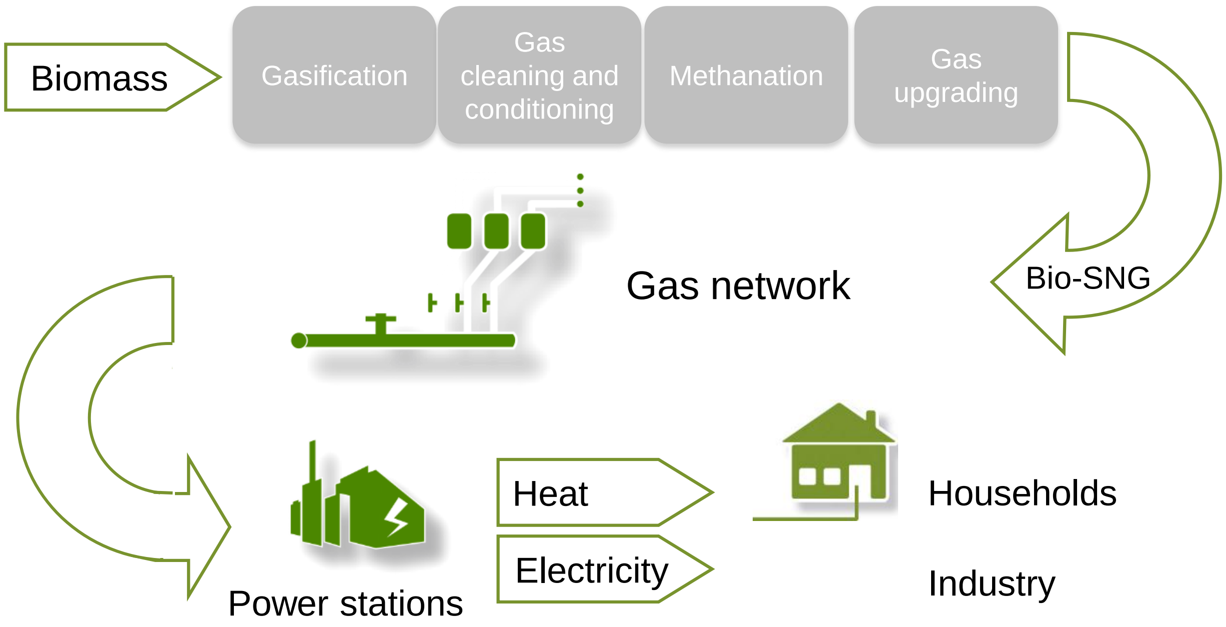
- Pressure Swing Adsorption
  - PSA purifies gas streams by means of adsorption of impurities on active coal or zeolites.
- Physical absorption
  - Water or another liquid such as alcohol can be used to bind carbon dioxide. When water is used, this is called water scrubbing or pressurised water wash (PWW).
- Chemical absorption
  - Chemical absorption is comparable to physical absorption. A liquid such as amine is chemically bonded to the carbon dioxide. In order to recycle the solution, a heat treatment has to be applied.
- Membrane separation
  - By means of semi-permeable membranes methane can be separated from carbon dioxide. The driving force can be a pressure difference, a concentration gradient or an electrical potential difference.
- Cryogenic separation
  - By cooling down the gas, trace gases and carbon dioxide are removed in various temperature steps. The remaining methane can be cooled down to liquid biogas (LBG).

Bio-SNG is one of the potential end products for a biorefinery



Bio-SNG is produced through the gasification of biomass

- The dried biomass is gasified in the gasifier using oxygen or/and steam as a gasification agent.
- Synthesis gas from the gasifier contains impurities such as sulfur and chlorine compounds that have to be removed.
- Methanation is a catalytic process where a synthesis gas of gasification is converted to methane using nickel-based catalysts.
- Gas is upgraded at least to a methane content of 95% by removing CO_2, water vapor and other impurities from the gas.



Second speaker: François Cagnon

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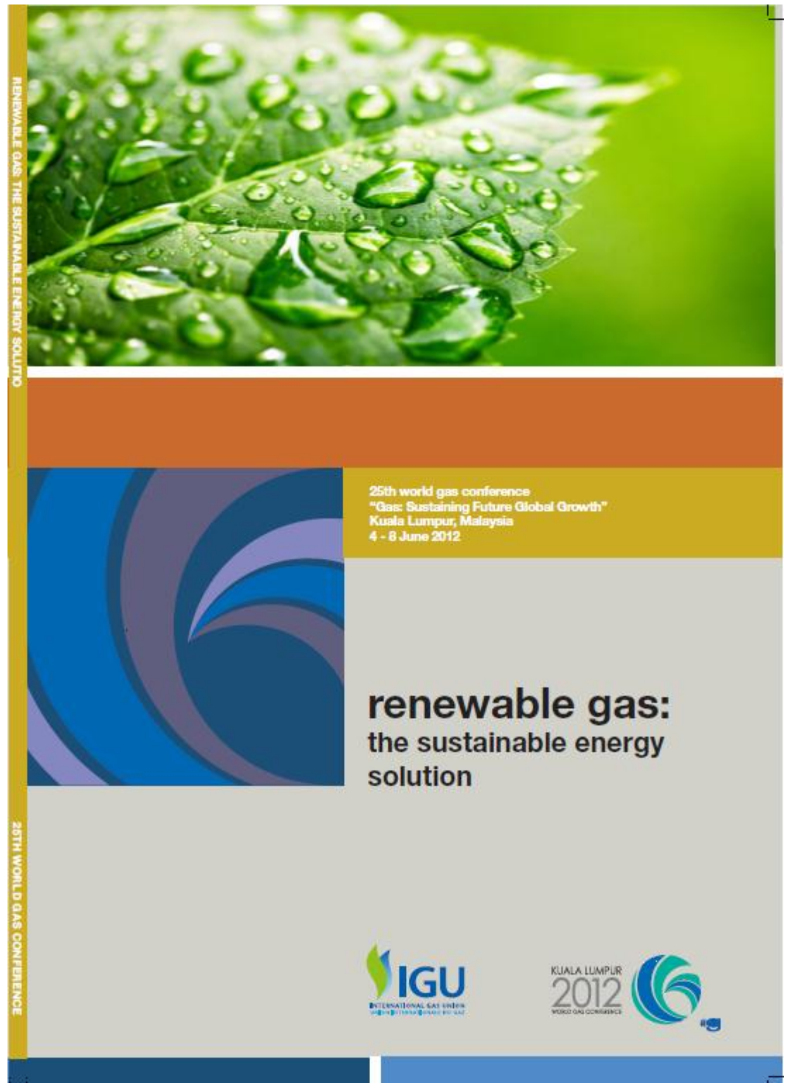
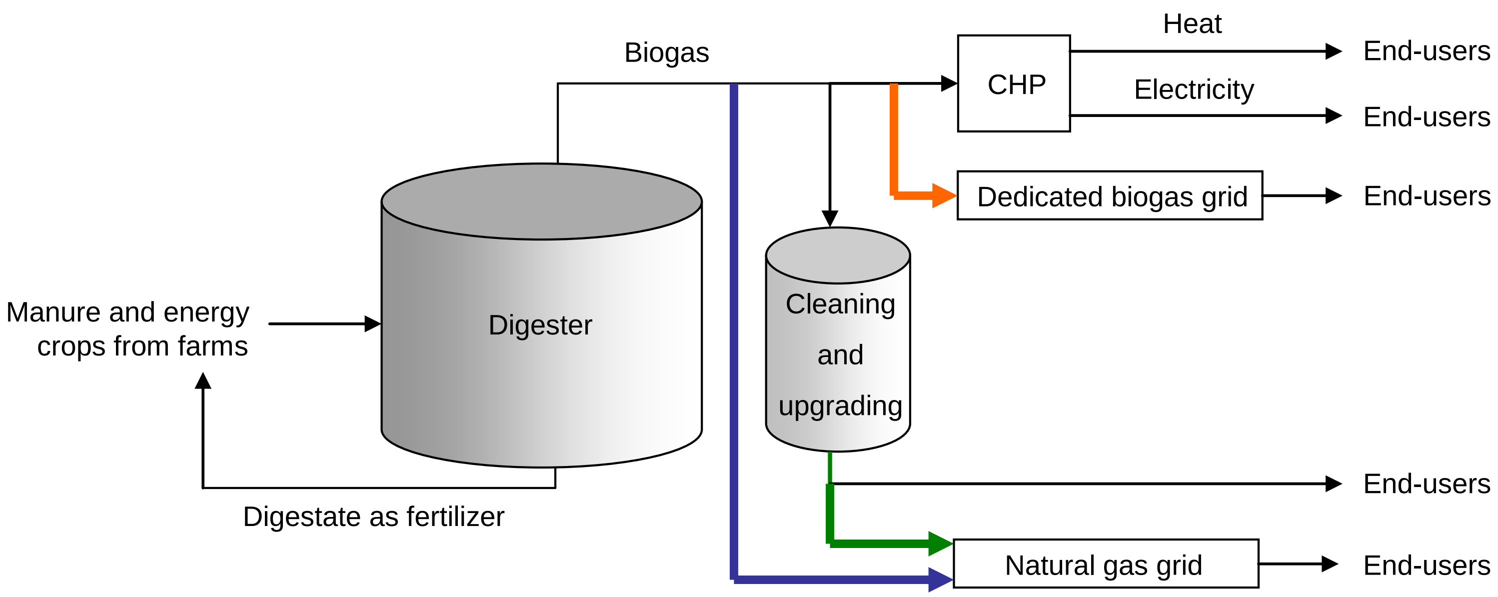


RENEWABLE GASES:
Transportation, distribution and utilisation

- Three options for grid injection
  - Upgrade to biomethane and injection in natural gas grid (green)
  - Biogas injection in natural gas grid (Blue)
  - Biogas injection in dedicated grid (Orange)

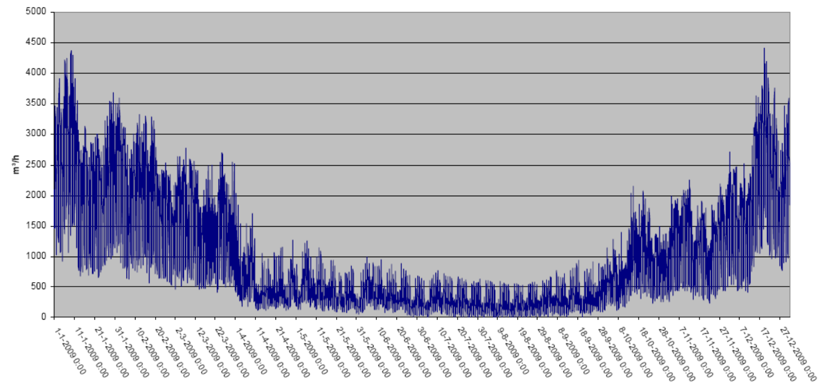


Biomethane injection in natural gas grid: Quality issues

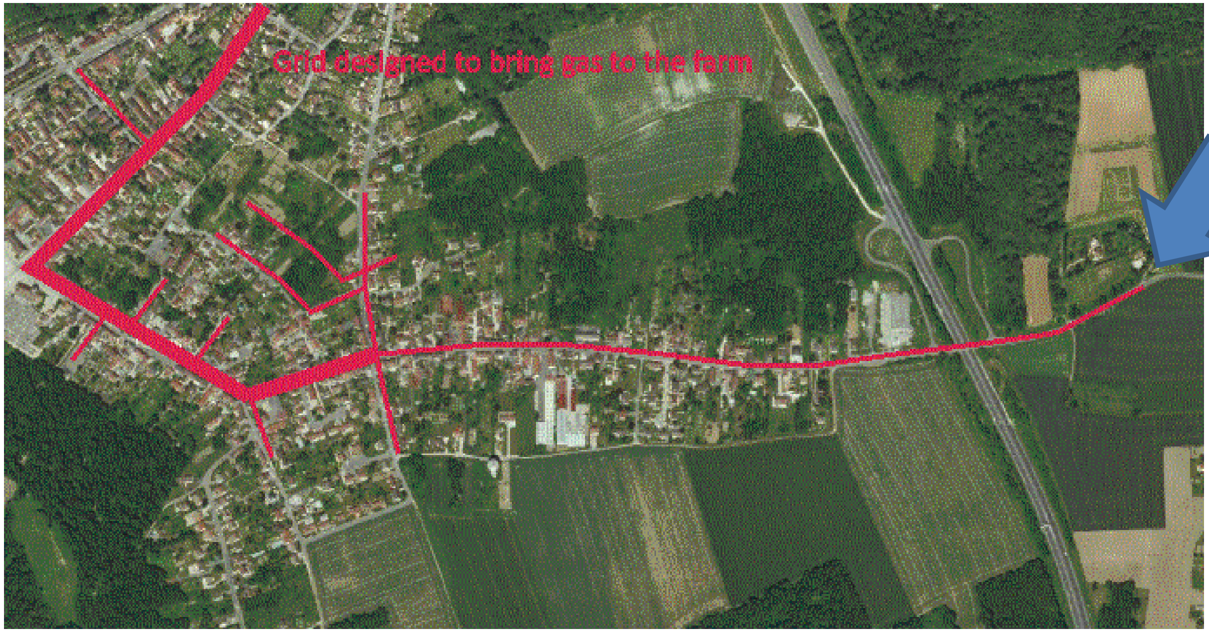
- Upgrading to biomethane → Full interchangeability with natural gas
  - No impact on network or end use
- Biomethane properties have to comply with natural gas specifications
  - Producer cleans the biogas (CO_2 and impurities removal)
  - Grid operator may have to adapt the biogas (GCV adjustment, odorisation)
- Control of biomethane properties VERY important
  - Once biomethane is in the grid it is in the customers house
  - Out of spec gas or gas with odd impurities may lead to safety issues
- Recommendation: **Grid operators keep a watchful eye on gas composition**

Biomethane injection in natural gas grid: Capacity issues

- Production is stable but demand is not



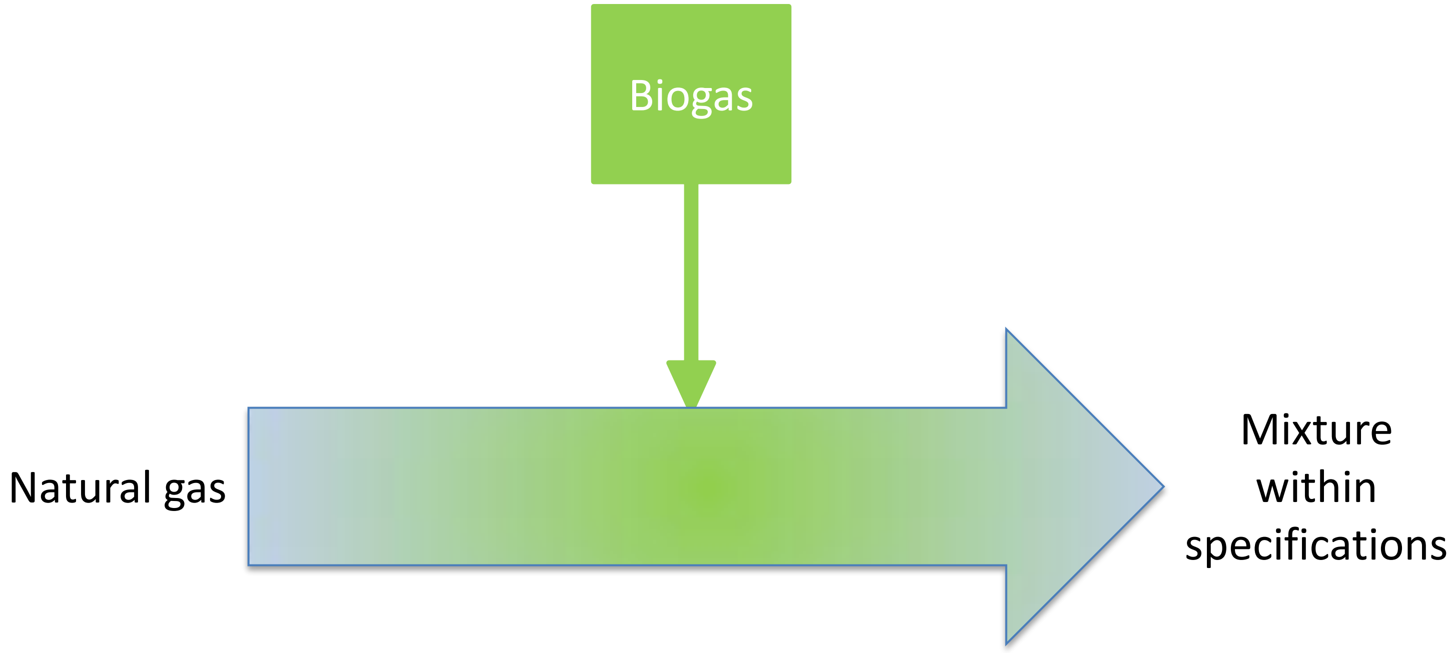
- Grid design may not be adequate.



Not the other way round

Biogas injection in natural gas grid

- No or partial upgrading of the biogas → Not within natural gas specifications
- Blending with natural gas → Resulting mixture within specifications
  - Biogas flow rate: Function of natural gas quality and flow rate
  - Specifications are controlled in the grid
- Close collaboration between producer and grid operator necessary



Biogas injection in natural gas grid

- Selected standard requirements for grid injection or for utilization as vehicle fuel

Compound	Unit	France		Germany		Sweden	Switzerland		Austria	The Netherlands
		L gas	H gas	L gas grid	H gas grid		Lim. inject.	Unlim. Inject		
Higher Wobbe index	MJ/Nm³	42.48–46.8	48.24–56.52	37.8–46.8 46.1–56.5					47.7–56.5	43.46–44.41
Methane content	Vol-%					95–99	> 50	> 96		> 80
Carbon dioxide	Vol-%	< 2		< 6			< 6		≤ 2[6]	
Oxygene	Vol-%			< 3			< 0.5		≤ 0.5[6]	
	ppmV	< 100								
	Mol%									< 0.5
Hydrogen	Vol-%	< 6		≤ 5			< 5		≤ 4[6]	< 12
$CO_2+O_2+N_2$	Vol-%					< 5				
Water dew point	°C	< -5[1]		< t[4]		< t[5]-5			< -8[7]	-10[8]
Relative humidity	ρ						< 60 %			
Sulphur	mg/Nm³	< 100[2] < 75[3]		< 30		< 23	< 30		≤ 5	< 45

[1] At MOP (Maximal Operating Pressure) downstream from injection point
[2] Maximum permitted
[3] Average content
[4] Ground temperature
[5] Ambient temperature
[6] Mole percentage
[7] At 40 bars
[8] At 10 bars

Source: IEA Bioenergy

Biogas used in dedicated grid

- No or partial upgrading of the biogas
  - Potential impact on infrastructure and end use
  - Need to customise network and end use
- Usually isolated grid
  - Balance between supply and demand needed

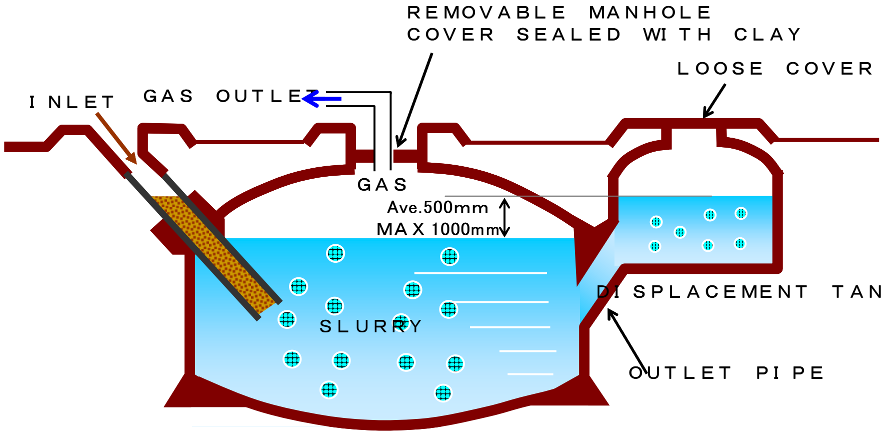
Custody transfer

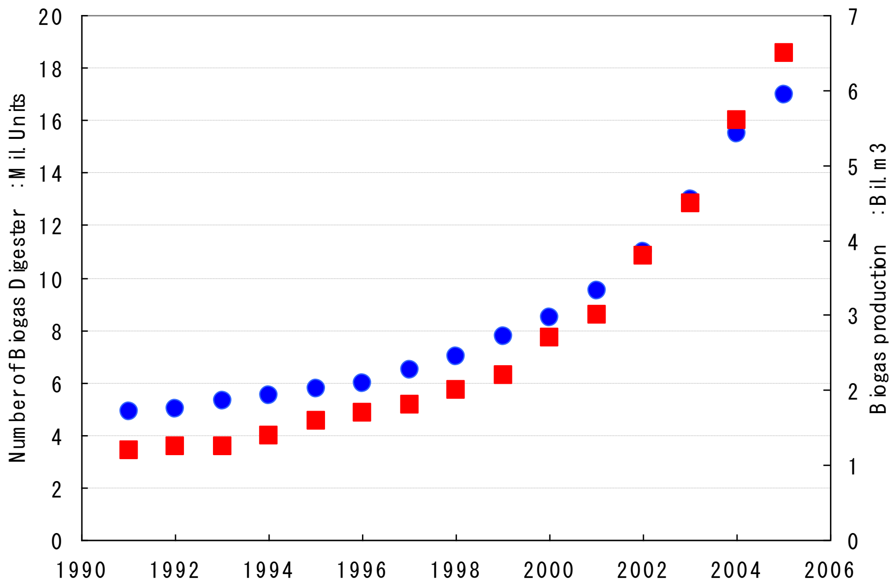
- Volume measurement: Similar to natural gas
- Energy content measurement
  - Gas analysis and
  - Calculation with ISO 6976, AGA 8, …
- Properties measurement (GCV, water content, etc)
  - Same technologies as natural gas available

- Cost issues
  - High investment for control laboratory
  - Needs minimum production for profitability

Utilisation
Direct use of raw biogas

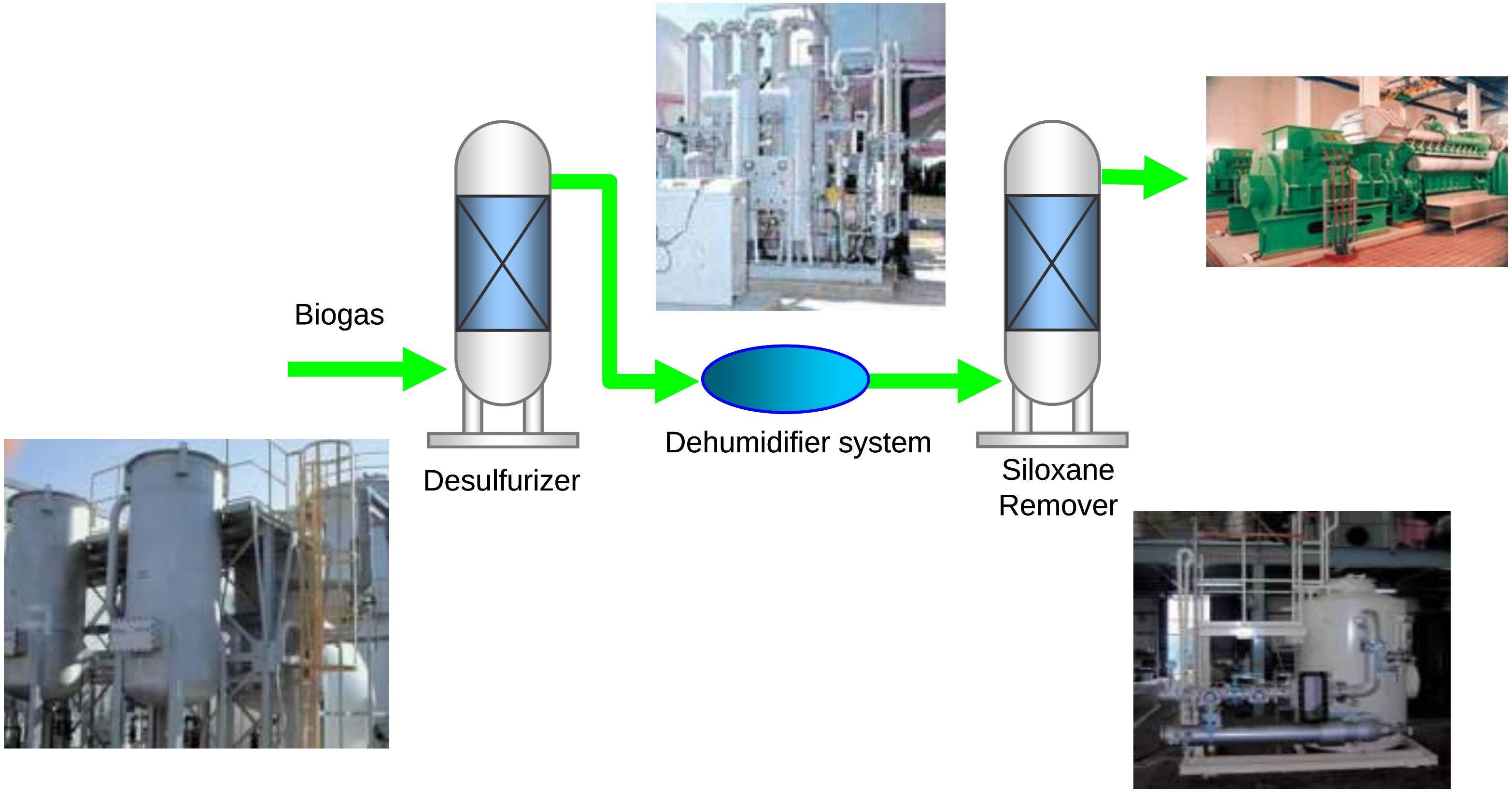
- Home production and use
  - Fast growing in India and China
  - Efficient but safety issues (H_2S, CO)





Utilisation
On site use of partially purified biogas

- Local use for electricity and heat production
  - Treatment is necessary for equipment protection



Third speaker: Sergey Shilnikov

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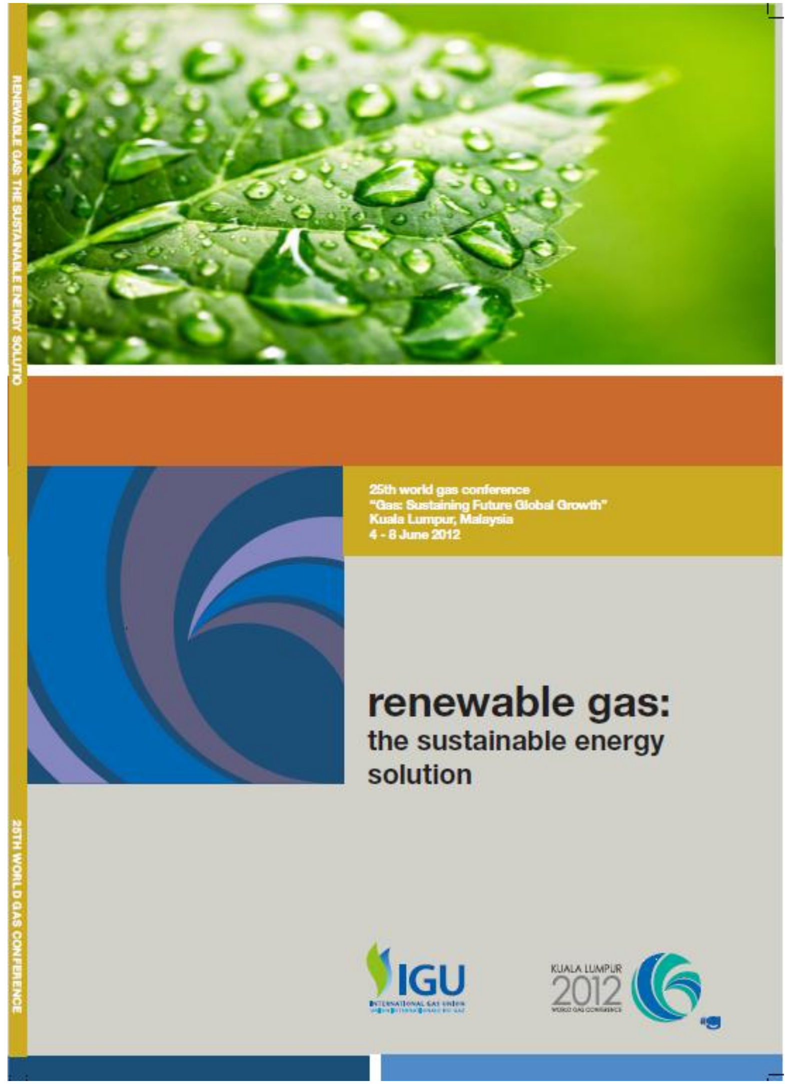
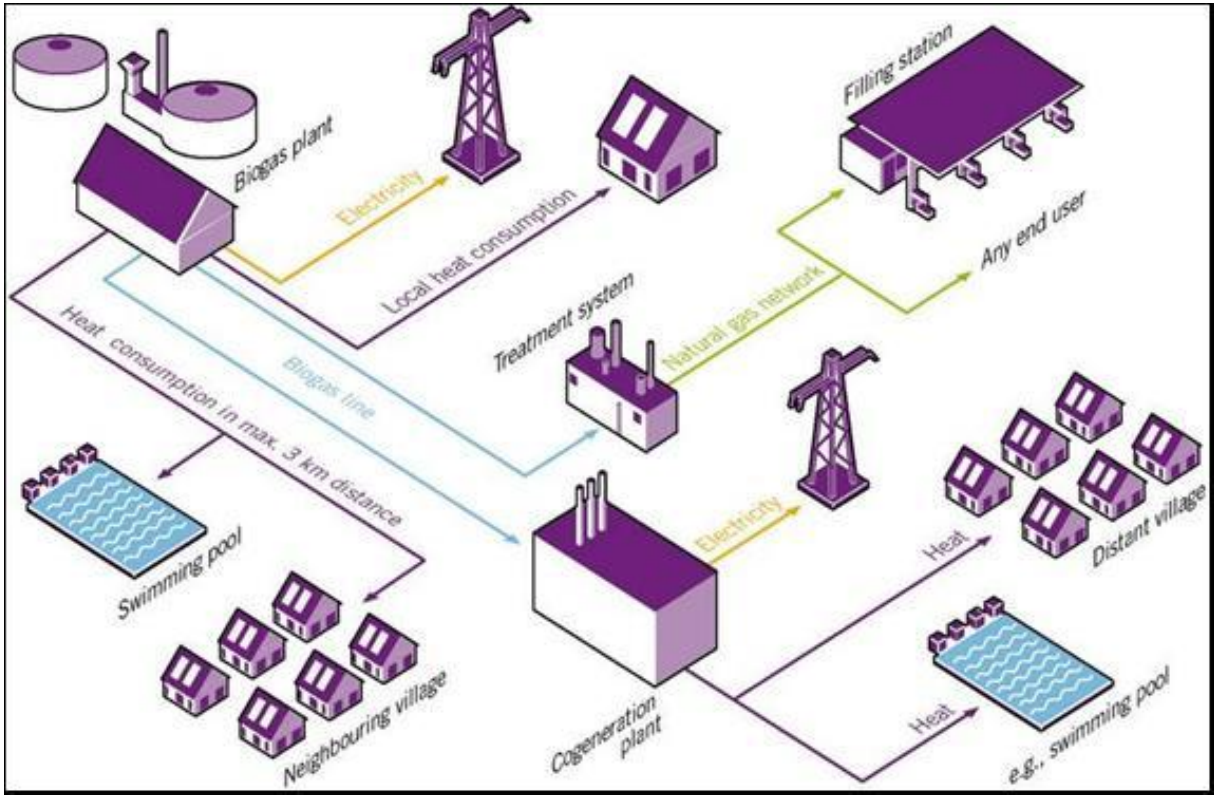


Biogas Utilisation

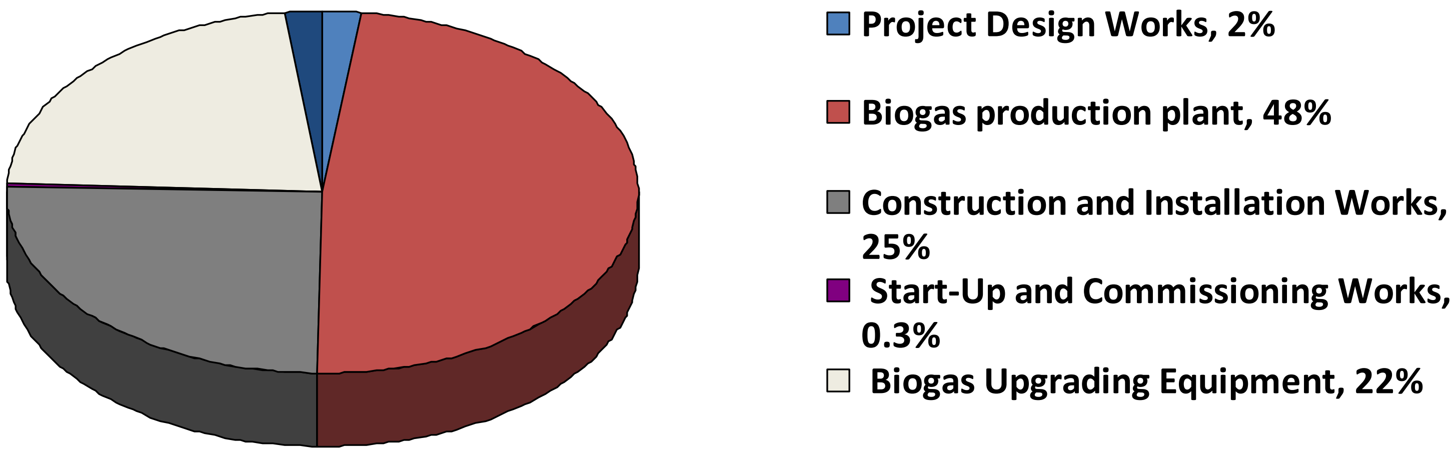
- Options for biogas utilisation
  - Local use
  - Supply of nearby customers
  - Sale of electric power to power grids
  - Injection in gas grids
  - Car fuel



Source: German Biogas Industry Association

Biogas Project Planning

- Capital Investment Structure for a biomethane production plant



- *Complete investment costs for a biogas plant - 300-600 Euro per m3 of bioreactor volume*
- *Additional equipment – CHP unit (800 – 1 000 th. Euro per 1 MW)*
- *Cost of land is not taken into account*

Source: Gazprom promgaz estimations for the project in Samara region Russian Federation

Biogas Project Planning

- Operational Expenditures:
  - O&M costs for AD plant and upgrading unit
  - O&M costs for CHP
  - Labor costs
  - Feed stock purchase*
  - Transport costs
  - Compost utilization costs*
  - Electricity
  - Certification costs
  - Taxes
  - Insurance

** - in some cases may be an option for income*

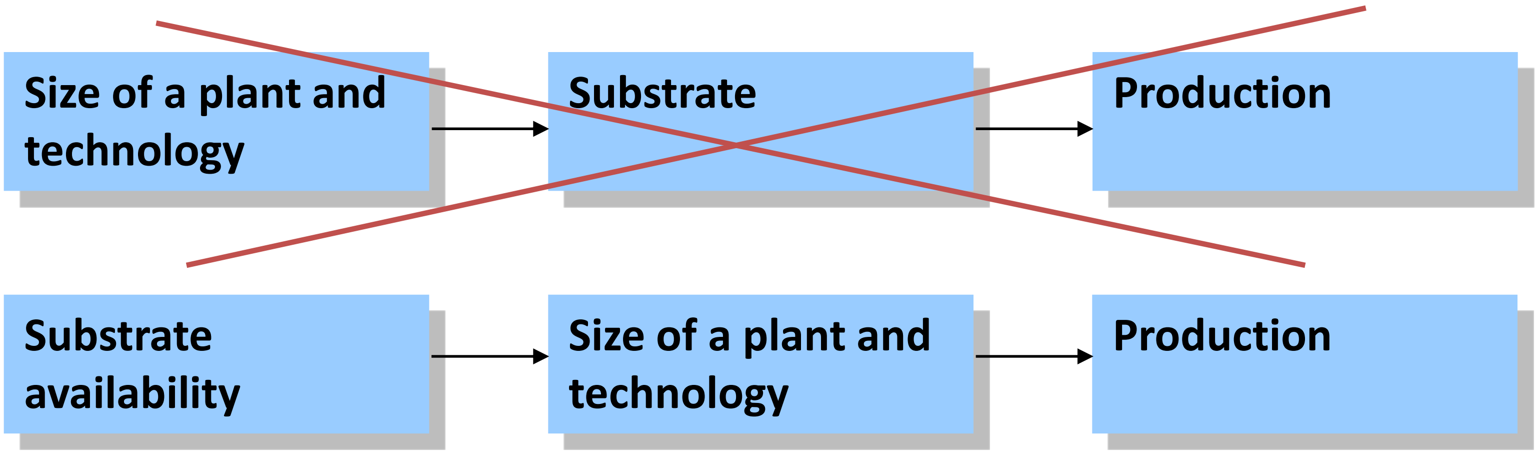
Biogas Project Planning

	500 kW plant	
1	Mixing pit under ground or partly under ground	100 m^3 net concrete vessel with concrete lid
1	Main digester	1665 m3 net/1885 m^3 brut concrete vessel open (20m dia. X 6m h)
1	Secondary digester	2015 m3 net/2281 m^3 brut concrete vessel open (22m dia. x 6m h)
2	Drying and storage ponds/plattforms	8,500 m^3 drying volume (7,400 m^2 x 1.15 m h)
	Site specific civil engineering	
	Site development	Water, electricity and telephone lines
	Road building	paved surface for access heavy vehicles
	Purchase of land	Avarage costs
	Earth works	initial earth movings
	Shanting area	paved surface for access heavy vehicles
	Leackage and drainage facilities	leackage and drainage shafts, according to local specification
	Grid connection	trenches for grid cables
	Transmission for electricity	Transformer station for 600 and 300 kW
	Labour costs for technicians and skilled labour	Average labour costs
	Electrical installations	Average labour costs
	Heating installations	Average labour costs
	Buildings	Average costs per m^3

Source: IBBK, FnBB e.V./GERBIO, Kirchberg/Jagst, Germany

Biogas Project Planning

- Availability of feedstock is the crucial factor



- Key factors to be analysed at biogas project planning
  - feedstock locations
  - frequency of substrate production
  - water consumption
  - fertilizer consumption
  - supply chain

Biogas Project Planning

- BASIC CRITERIA FOR BIOGAS TECHNOLGY CHOICE

  1. PROCESS HUMUDITY wet or dry fermentation
  2. PROCESS TEMPERATURE psychrophilic (10-25^{o}C), mesophilic (30-42^{o}C) or thermophile (55-60^{o}C) digestion
  3. PROCESS STEPS single- or multi-stage processes (pre-hydrolysis, multi-tank, post-digestion)

Biogas Project Planning

- Potential revenues:
  - Sales of energy to grids (electricity or gas)
    - Feed in tariffs
  - Supply of heat energy to local consumers
  - Sales of fertilizes to agricultural companies or in retail market
  - Collection of waste
  - State subsidies or tax exemptions
  - Green certificates

Biogas Project Development

- Decision on the project idea, targets and strategy
- Preliminary analysis of your current situation and availability of feedstock
- Consultations with an experienced consultant/engineer
- Preparation of a feasibility study with an in-depth inventory of all available organic material
- Finance search and attraction
- Permissions obtaining
- Detailed design and executive drawings will be made
- Equipment selection (tender procedure) and purchase
- Biogas plant construction
- Biogas plant commissioning and launch of production

European Green Gas market

- 8,3Mtoe in 2009, 25,2 TWh of electricity
- Appr. 8 000 biogas plants, 100 biogas upgrading plants (producing biomethane)
- Market potential by 2020 – ap. 30 bcm.
- Main drivers:
  - 20/20/20 Directive
  - increase in demand for green electricity, heat and car fuel.
- 10% premium to the price of natural gas for the “green” origin at industrial consumers sector
- 10%-12% of current residential consumers are willing to pay 5-10% premium for the green gas
- Biomethane – is a marketable product!

Conclusions

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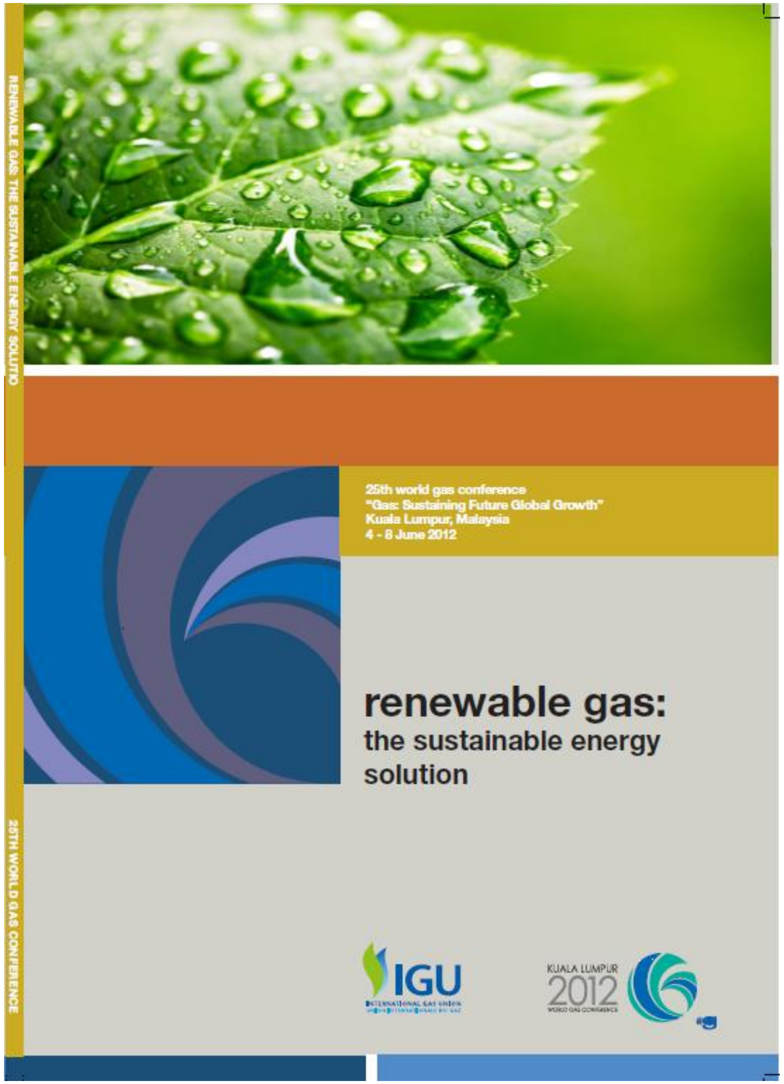

Conclusions and Recommendations

- Renewable gases are a supplementary opportunity for the gas sector in decreasing the environmental footprint and opening a new market;
- To produce and distribute renewable gases, many alternatives are already possible, but further development of production by gasification, smart gas grids, specifications and standards is encouraged;
- Renewable gases are environmentally friendly alternatives for petrol, coal, briquettes or kerosene, both for stationary applications and for mobility;
- The sustainability of the biomass and the Life Cycle Analysis of the renewable gas chain should be well investigated to prevent unwanted side-effects;
- Renewable gas production contributes significantly to sustainable development in rural areas, offering new business opportunities and local deployment.