

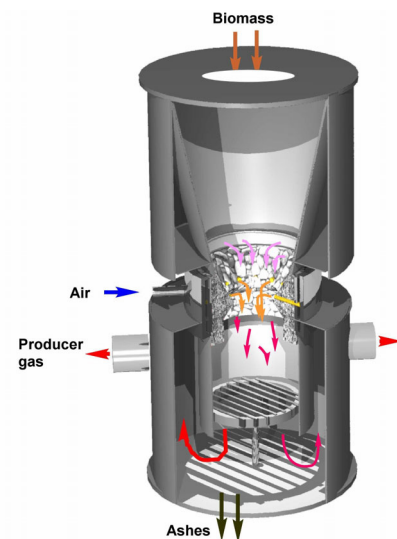
## REVIEW OF SMALL-SCALE BIOMASS GASIFICATION

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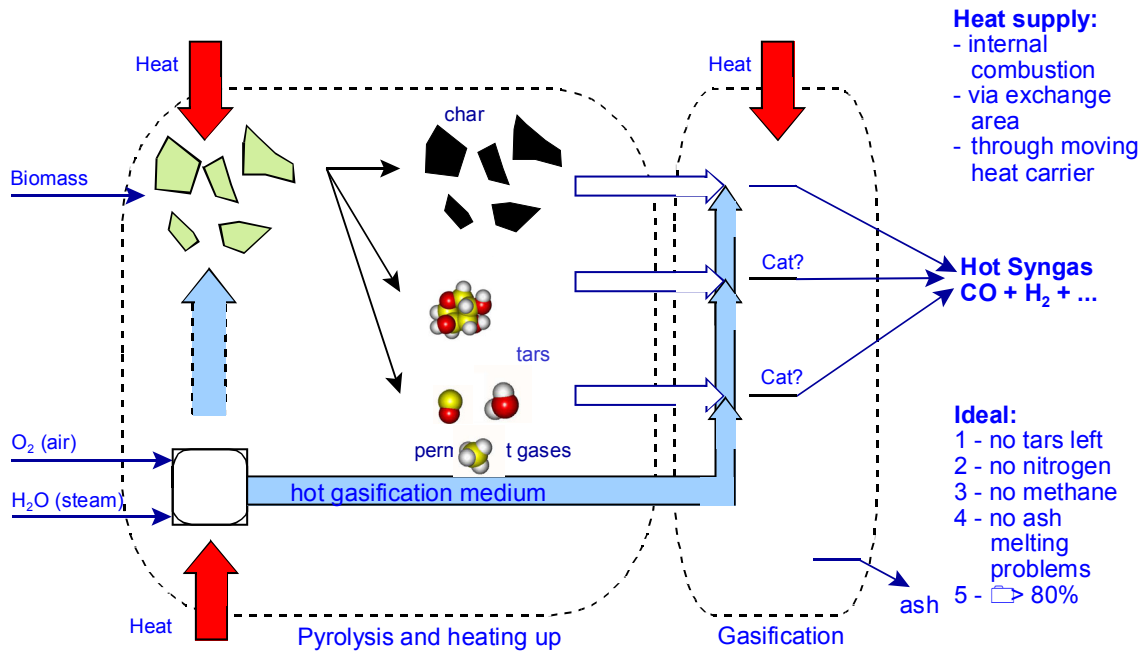


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## What is gasification?



## Gasifier types

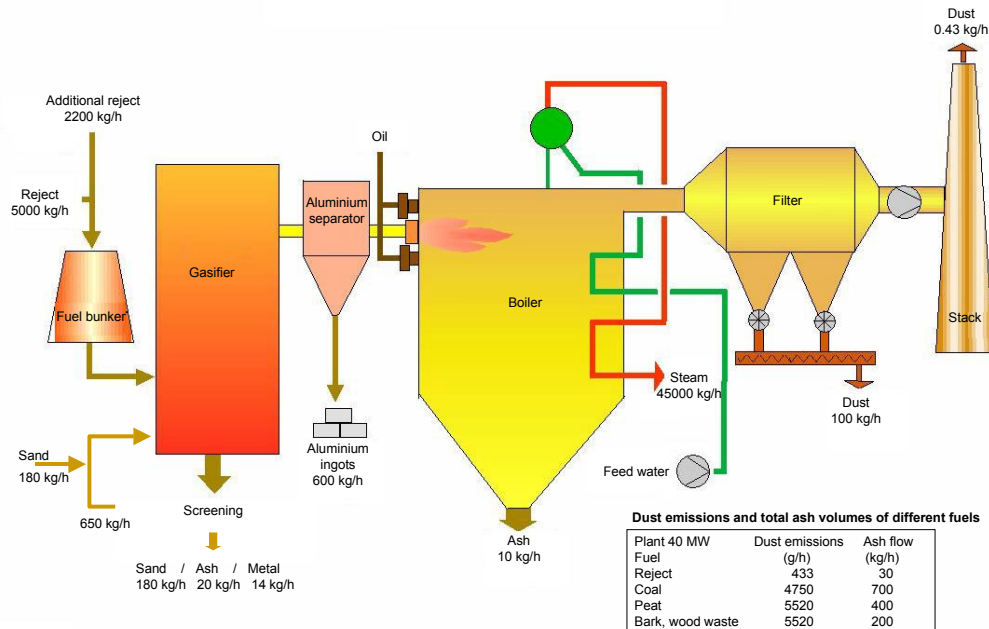
	Moving beds		Fluid beds		Entrained beds
	Co-current	Counter current	dense	circulating	
T°C	700-1200	700-900	< 900	< 900	~1500
tars	low	very high	intermediate	intermediate	absent
control	easy	very easy	intermediate	intermediate	very complex
scale	< 5 MW <sub>t</sub>	< 20 M <sub>t</sub>	10<MW <sub>t</sub> <100	20<MW <sub>t</sub> <?	> 100 MW <sub>t</sub>
feedstock	very critical	critical	less critical	less critical	very fine particles

Heat gasifiers

Suppliers	Number in operation	Type	Main application
Bioneer	10	Updraft	District heating
PRM Energy	18	Updraft	Industrial heating
Foster Wheeler	4	CFB	Lime kilns
Lurgi Umwelt	3	CFB	Lime kiln, cement
Several	hundreds	Downdraft	Cooking, drying

Heat gasifiers

Varkaus gasification plant



Power gasifiers

Eckenförde  
Germany

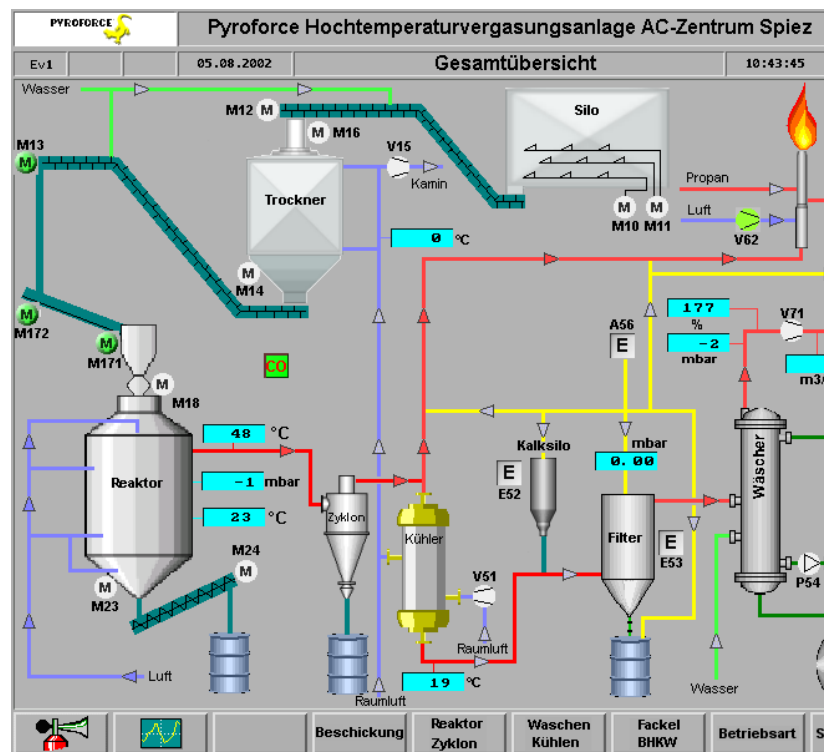


Pyrolysis and Gasification of Biomass and Waste Expert Meeting, Strasbourg, France

Power gasifiers

Pyroforce

Control system



Pyrolysis and Gasification of Biomass and Waste Expert Meeting, Strasbourg, France

**Power gasifiers**

Xylowatt, Bulle

200 kWe  
Just installed



**Power gasifiers**

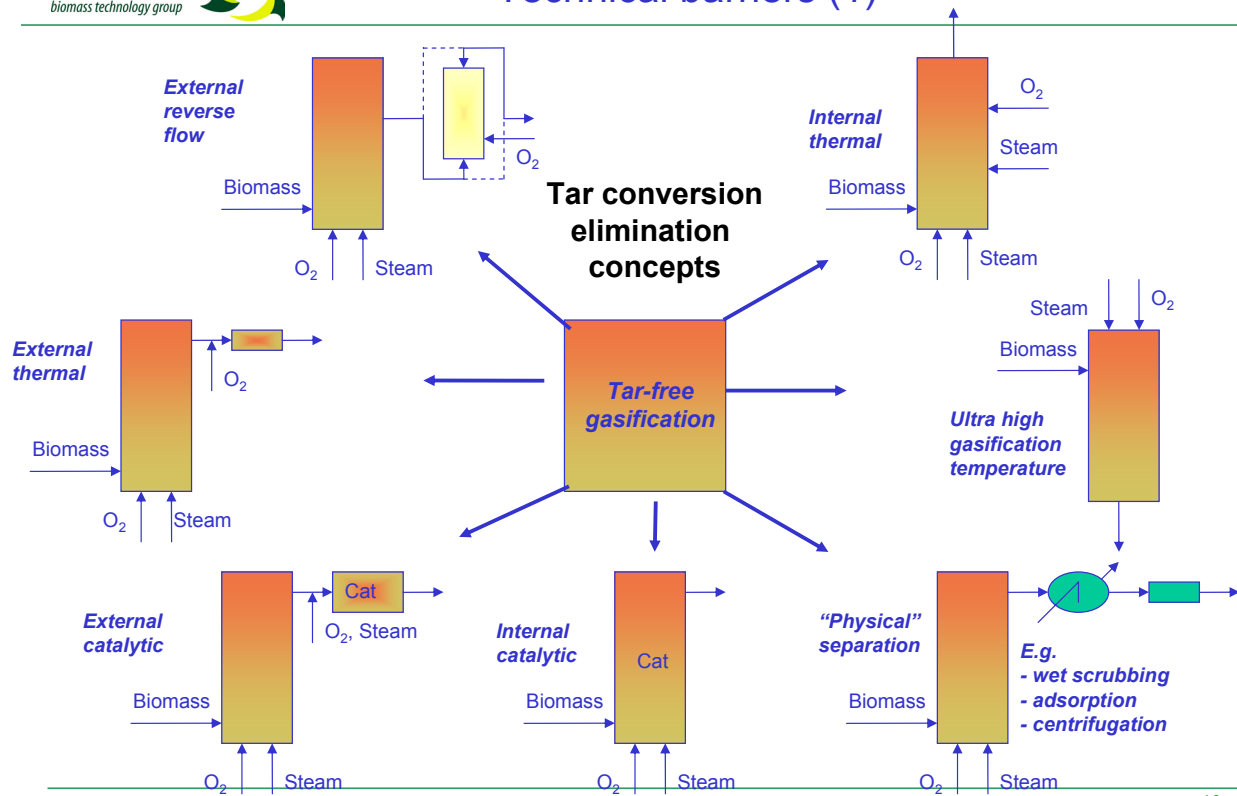
Viking, DTU

17 kWe  
Just installed



- > 100 units installed in Europe, USA, Switzerland
- Hundreds are installed in developing countries
- Maximum cap. for downdraft gasifier: 10 MWt
- Separation of pyrolysis, combustion and reduction in 2 and 3-stage processes
- Gasifiers for “difficult” fuels (poultry litter, straw)
- New gas cleaning devices (ESP, RPS, RFR scrubbers, solid bed filters, fabric filter)
- Cleaning of condensate water

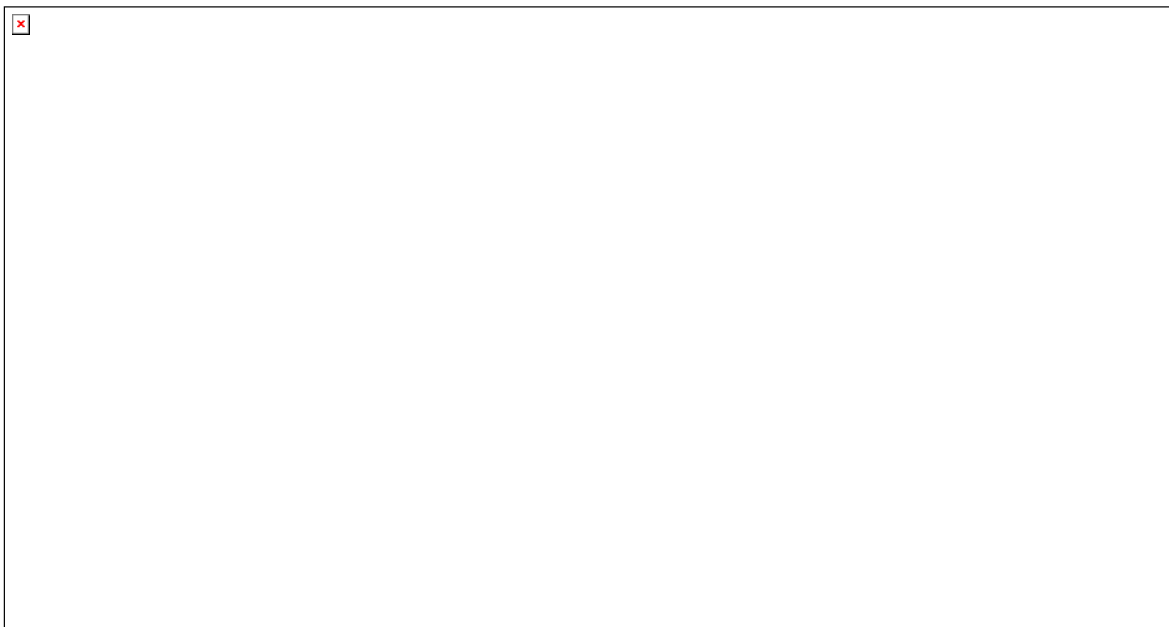
- Feedstock characterisation for biomass gasification
- Fully automatic control for continuous operation
- Standard methods for monitoring
- Exchange of knowledge and experience by networks
- Commercial operation of several community fixed bed gasifiers
- Avoidance of condensate by keeping the gas temperature above the dewpoint
- Fiscal measures to stimulate biomass gasification



- Ash melting (slag formation)
- Low gas heating value (power de-rating, flame stability)
- Sustainable feedstock supply (characteristics, price, pretreatment, logistics, long-term contracting, standardization, quality-control)
- Gas cleaning (technical/economic evaluation of options)
- Prime mover (unclear specs, strict emission limits)
- Reliability (lack of confidence, operating experience)

- Financial aspects
  - High initial investment
  - Limited private investments
  - Remuneration of CHP
  - Feedstock availability
  - Small subsidies are not stimulating
- Permitting procedures & emission limits
  - Complex, time consuming
  - Unknown technology to authorities
  - Strict emission limits from incineration
  - No one common legislation
- Safety, health & environment
  - Which directive is valid to gasification?
  - Guideline for safe operation and construction is needed

### Health & Safety Impact





- Technology implemented must be mature
  - Proven prototype models
  - Long-term duration tests
- Adequate infrastructure
  - Local manufacturing capacity
  - After-sale service
  - Training facilities
- Motivated & skilled labor
  - Operators
  - Management
  - Incentives
- Scale-up, demonstration, replication, optimization
  - Economy of numbers
  - Reduced capital costs
  - Improvement from learning by doing

- Information & knowledge exchange
  - Performance, limitations, opportunities
  - Evaluation with competing options
  - Set-up monitoring program of successes in India, China
- Loan finance for customers
  - Reduce risk for 'first-of-its-kind'
- Clear regulations
  - Permitting procedures
  - Emission according to "ALARA"
  - HSE
- Sale of electricity and heat
  - Any legal obstacle should be removed
  - Long-term fixed price is prerequisite

- Product quality must meet client specifications
  - **Technical performance**
  - **Financial/economic performance**
  - **Operational performance**
- Certification
  - **stimulation**
  - **product must meet defined quality standards**
- Standardization
  - **Technology, components**
  - **Acceptance tests, guarantee measurements**
  - **Ultimately one dominant design**