




Outlook on bio-power technology developments

Reality Check on EU Bioenergy targets,

19-20 May 2008, Brussels

by

Herwig Ragossnig

European Biomass Association (AEBIOM)
ragossnig@aebiom.org

Content

- **What is AEBIOM?**
- **Main technological options to produce electricity from biomass**
- **Combustion with closed thermal cycles for power production (steam turbine, ORC, Stirling motor, Co-firing)**
- **Gasification for power generation**
- **Combined heat and power generation**
- **Anaerobic Digestion**
- **Pyrolysis**
- **Conclusions**

What is AEBIOM?

- The European Biomass Association (AEBIOM) is a **non profit Brussels-based international organization** founded in 1990. Its objective is to study and promote bioenergy in Europe

- Notably to **support any initiative at national and international level aiming at the promotion of the use of bioenergy** and to communicate to policy makers the opportunities and concerns regarding the development of bioenergy in Europe.

- Association: there are currently **31 full members, along with companies from all over Europe** who are engaged in the business of bioenergy

AEBIOM
European Biomass Association
www.aebiom.org

Main technological options to produce electricity from biomass

Conversion technology	Resource	Example of fuels	End Use	Technology status
Combustion Co-Firing	**Mainly solid biomass**	**Wood logs, chips, agricultural residues, energy crops**	**Heat, Electricity (Steam turbine, ORC, Stirling etc)**	**Commercial**
Gasification	**Mainly solid biomass**	**Wood chips and pellets, agricultural residues**	**Heat, electricity (gas engine, fuel cell, gas turbine)**	**Demonstration, early commercial**
Anaerobic digestion	**Wet biomass**	**Manure, sewage sludge**	**Heat, Electricity (combustion engine, fuel c.)**	**Commercial**
Pyrolysis	**Mainly solid biomass**	**Wood chips and pellets, agricultural residues**	**Heat, Electricity**	**Demonstration**

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Combustion with closed thermal cycles for power production ⇒ Steam turbines

- Capacities from **500 kW up to 500 MW**

Technological proven technology, **most biomass plants for power production use steam turbines**

- Heat generated in a combustion process is used to **produce high pressure steam** which is expanded to a lower pressure which delivers mechanical power to drive an electricity generator.
- **Small turbines** exhibit typically much **lower efficiencies** (< 15% whereas for large turbines up to 40%)
- Economic viability is highly **dependent on scale economies** because small and medium sized plants exhibit high specific investment costs.
- The **operation costs are very high**, because of high requirements of safety measures. Operation costs can be prohibitive for small-scale applications of steam plants.
- **Low part load efficiency**

Combustion with closed thermal cycles for power production ⇒ Organic Rankine Cycle (ORC)

- Capacities **from 300 kW to 1,5 MW** what makes it very suitable for decentralized biomass plants.
- Similar to the steam turbine process. However **instead of water organic oil** with a lower boiling temperature is used.
- Low **conversion efficiency of 10 to 14 %** which is higher than for a steam turbine of comparable size.
- This enables the operation at relatively **low temperatures** which significantly **reduces the operation costs**.
- Widespread us for geothermal installations and some with industrial waste heat. Few biomass applications.
- In comparison to conventional steam turbines **high part load efficiency.**
- **Mass production** will **reduce investment costs** and will make this technology very suitable for decentralized biomass power plants

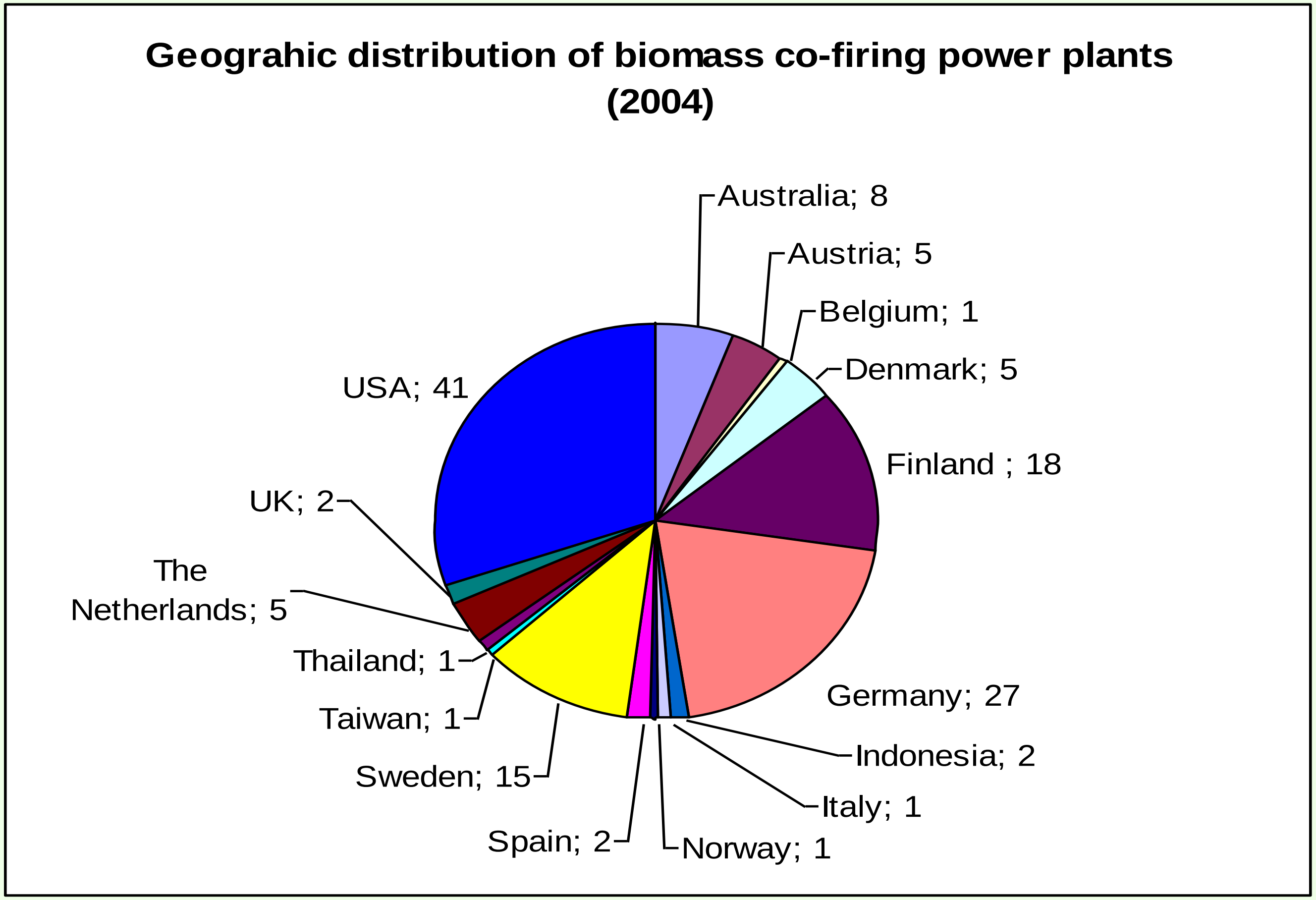
Combustion with closed thermal cycles for power production ⇒ Stirling Engine

- Stirling Engines are **indirectly fired gas engines** with air, helium or hydrogen as process medium.
- Small scale applications **(1-100 KW)**
- For applications **smaller than 100 KW** Stirling engines are the **only appropriate technology** for biomass use with acceptable efficiency levels.
- Can be fueled by **any heat source**. Also waste heat
- Efficiency of about **15 – 30 %**
- First commercial available models are available. The Renewable Energy House, where AEBIOM is based, will get probably this year a demonstration model from KWB

Co- Firing in coal power plants

- Co- Firing makes **use of the existing infrastructure** of fossil fueled power plants.
- Direct co-firing, indirect co-firing, parallel co-firing
- **Modest additional capital costs**.
- In most countries the co-firing of biomass is one of the **most economic technologies available to reduce CO_2 emissions**.
- For power production alone the most cost effective way due to the **high conversion efficiencies reached in large plants**. Therefore a high potential for CO2 abatement.
- **Co-firing of forest residues or energy crops** allows the use of higher amounts of biomass because of the positive effect on the corrosion problem. (Finland, peat)
- **Problematic:** In large plants the heat very often is not used what means a waste of the scarce resource biomass.

Co- Firing experiences 2004



Source: The handbook of biomass combustion and co-firing

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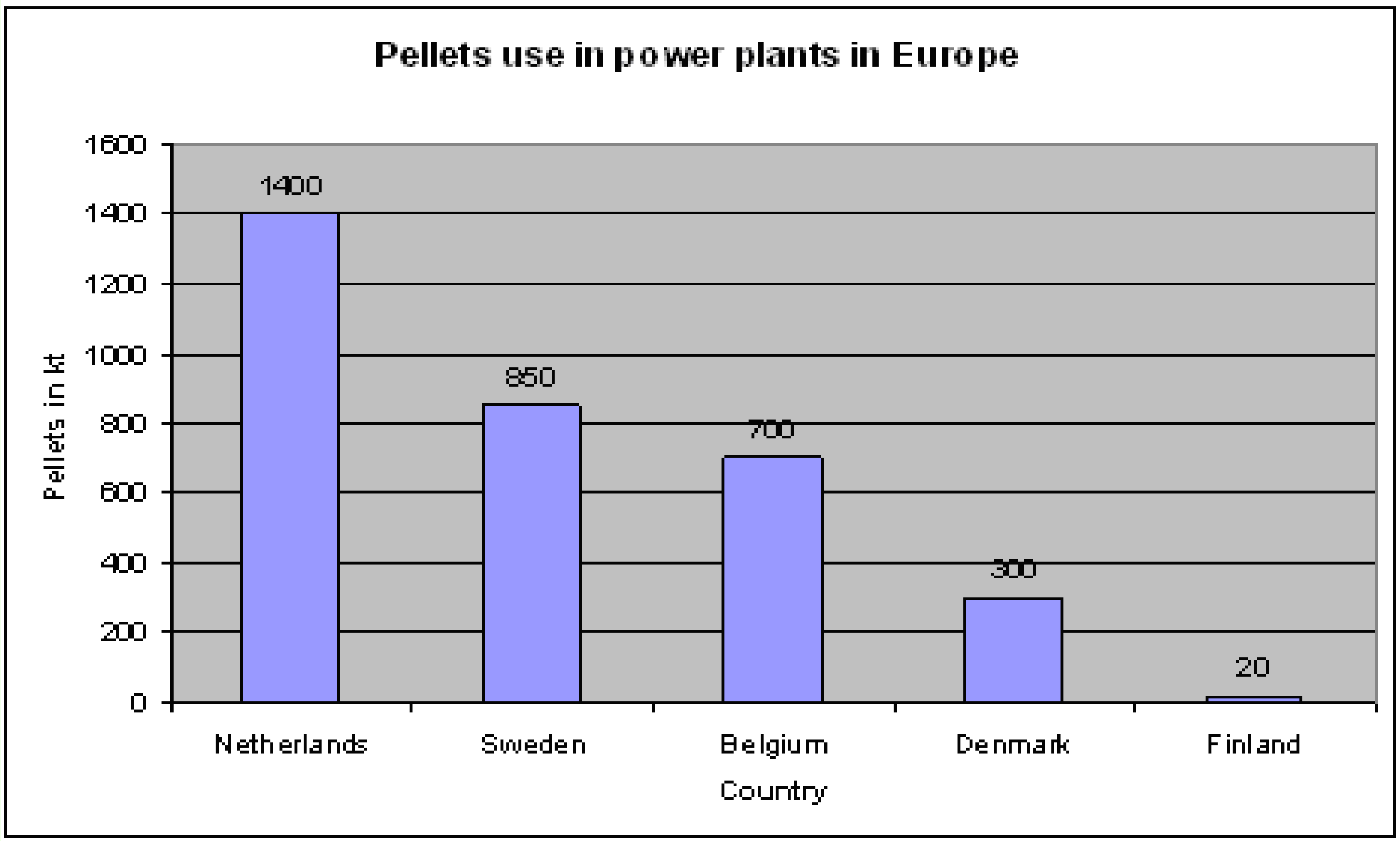
Pellet use in power plants in Europe in kt (2005)

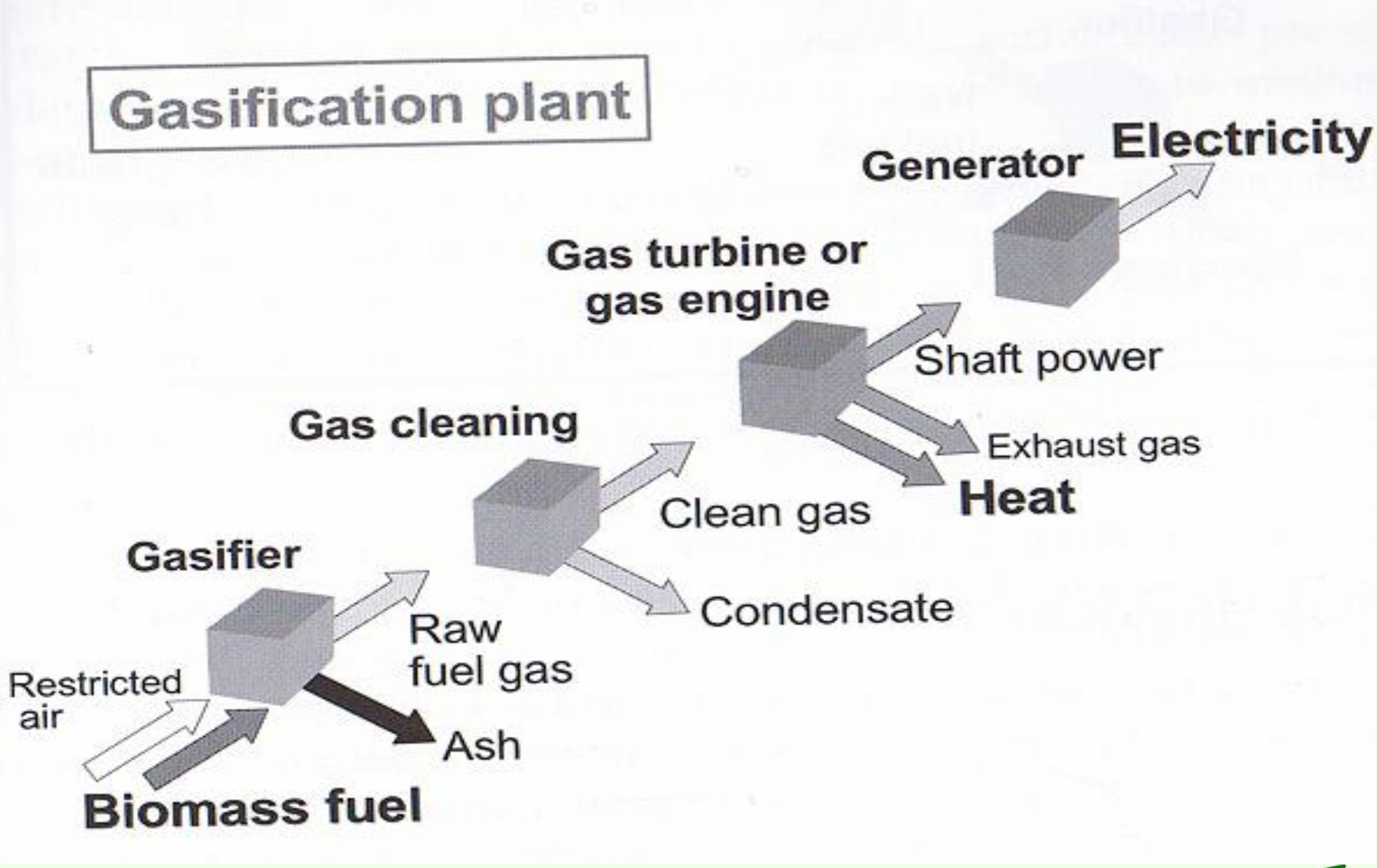


In some countries pellets are used for co-firing to produce electricity in order to comply with the directive for the promotion of green electricity.

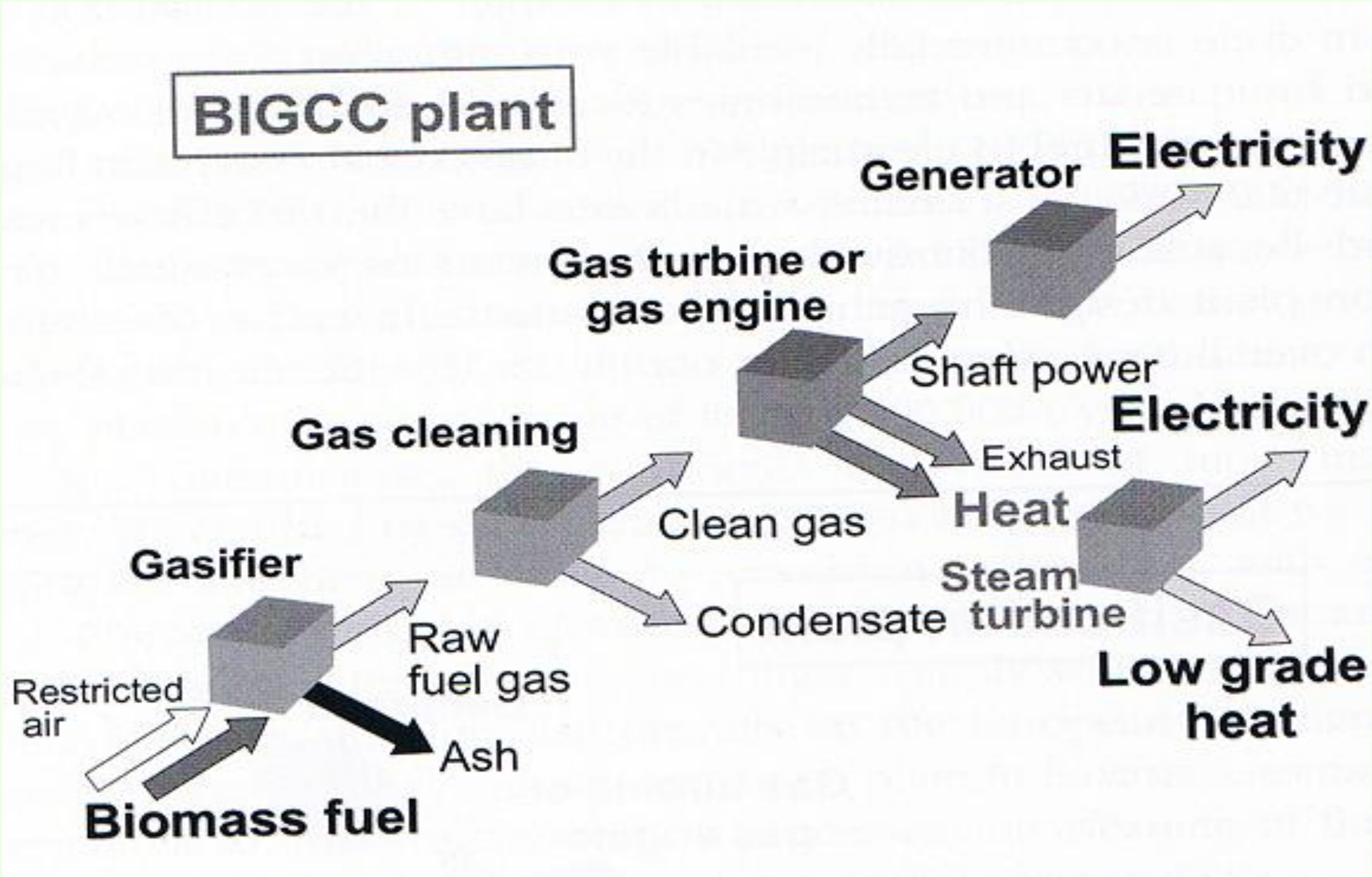
Gasification

- Gasification is the conversion by **partial oxidation** (restricted air supply) and elevated temperatures.
- The product is a gaseous fuel with a **heating value from about one- tenth to half that of natural gas**.
- The gas can be used to generate **heat or electricity** by firing in engines, turbines etc. or **liquid transport fuels**.
- **Advantages** compared to combustion in terms of economies of scale, higher electrical efficiencies of **up to 50%** are possible.
- Up to **25% efficiency in small scale applications** (between few tens of KW up to 5 MW) This makes gasification especially for small scale application interesting, because there is no efficient technology for solid biomass for power production available.
- **Gaseous or liquid fuels** in small applications can be **used much more efficient** in gas engines, gas turbines or explosion engines than combustion of solid biomass in combination with steam turbines, which are inefficient for small plants.
- **Carbon capture and storage** (CCS) requires gasification in order to separate CO_2 from the flue gas. CCS combined with biomass as fuel could become an interesting alternative in the long term.

Scheme of a gasification to power process



Scheme of a gasification to power combined cycle process



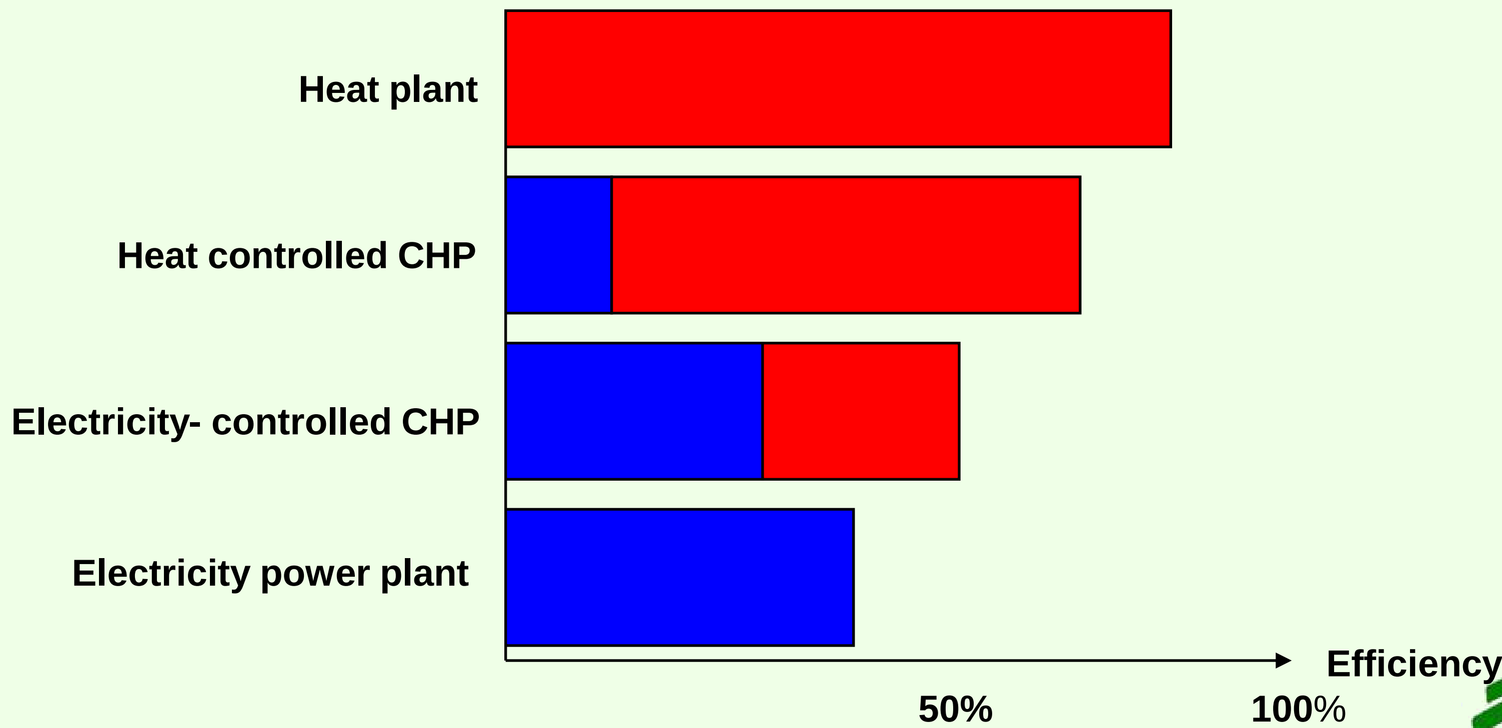
BIGCC= Biomass integrated gasification combined cycle

Combined heat and power generation

- Biomass plants are, due to the **widespread distribution of the feedstock**, of **decentralized nature** with smaller capacities than fossil fuel plants. This **decreases the conversion efficiency.**
- The use of the **heat increases the economic viability** of biomass plants.
- **Essential is a demand for heat**. This makes cogeneration attractive for wood processing industry, pulp and paper industry, district heating etc.
- For some CHP technologies the **use of the heat doesn't decrease the electrical conversion efficiency** (gas turbines, combustion engines, where the temperature of the accumulated heat is high)
- In the case where heat is used which normally would be used for power production, as in the case for steam turbines, the efficiency with CHP decreases.

The efficiency benefits of CHP technologies

The conversion efficiency also depends on which energy service is preferred. Very useful are plants which can switch between heat and power according to need and spot price for electricity.



Anaerobic Digestion - Biogas

- Wet biomass can be converted by an **anaerobic process to a methane rich gas** with approx. half the heating value from natural gas.
- In some European countries the biogas technology developed in the last years very impressive (Germany, Austria, Sweden). **In Europe it increased by 35% between 2004 and 2006**.
- With up to **6 toe/ha the production of biogas is very efficient** in order to replace fossil fuels. (1st generation biofuels just 1 toe/ha)
- Biogas to electricity just makes sense if there is a **demand for the heat**. (Cogeneration)
- There is a clear trend to large scale biogas installations, where the biogas is **upgraded to bio-methane** and injected into gas pipelines, as well as **biogas as transport fuel**. (Sweden as a successful example)

Pyrolysis I

- Fast pyrolysis is a technology where **biomass is decomposed into bio-oil, char and gas by thermal decomposition** occurring in the absence of oxygen.

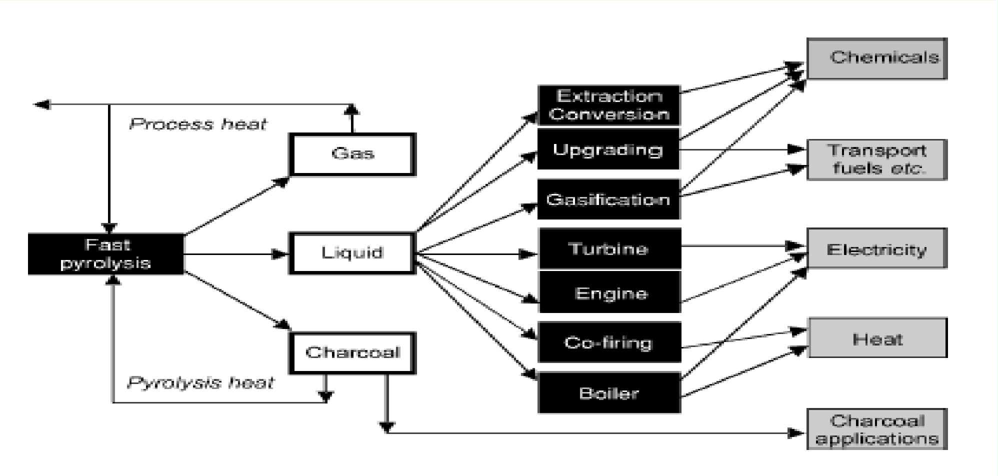
- **Depending on the process parameters the share of products can be influenced:**

Process	Conditions	Liquid	Char	Gas
Fast pyrolysis	Moderate temperature, short residence time particularly vapour	75%	12%	13%
Carbonisation	Low temperature, very long residence time	30%	35%	35%
Gasification	High temperature, long residence times	5%	10%	85%

Source: Biomass fast pyrolysis, by Anthony V. Bridgwater

Pyrolysis II

- The main advantages compared to combustion or gasification is the fact that the main **product is a liquid with high energy content, easy to store and transport**, and can be used for different uses
- **Different ways to produce electricity with pyrolysis oil:**
  - Application in a stationary diesel engine
  - Combustion in gas turbines
  - Combustion in Stirling Engines
  - Co-combustion of pyrolysis oils



Fast pyrolysis and usage of products

Source: Biomass fast pyrolysis, by Anthony V. Bridgwater

Conclusions

- So far **almost all bio-electricity is produced with steam turbines** due to the old and reliable technology
- There are a **number of technologies** available; not all of them are mature, but they reach this stage soon.
- Optimal biomass projects are **integrated decentralized projects** with secure fuel supply, need for heat and electricity

Thank you for your attention!

Contact:

Herwig Ragossnig

Tel: + 32 24 00 10 61
Fax: + 32 25 46 19 34
Email: ragossnig@aebiom.org

European Biomass Association
www.aebiom.org