Biomass Gasification for Small-Scale Heat and Power

Dr Gabriel Gallagher

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Presentation overview

- Introduction to organisation and project experience in biomass heat and power sector
- Weighing up - biomass gasification for heat and power generation
- Barriers and challenges
- Project example
- Conclusions

Biomass project experience

- Consultants for development of 12.5MWe biomass power plant
- Design and build of biomass district heating
- Partnership with leading CHP company to commercialise small scale gasification biomass CHP technology

Biomass for heat and power

- Biomass co-fired in existing coal fired stations
  - Drax up to co-firing 400MWe by 2010
- Dedicated biomass power Rankine cycle
  - Several UK plants installed 12MWe to 40MWe
- Small scale combustion and heat engines
  - 100kWe to 1MWe
- Gasification combined cycle or gasification/combustion Rankine cycle
  - Multi-megawatt waste gasification
- Small scale gasification CHP
  - Several UK sites in development 250kWe to 2MWe

Co-firing in existing coal fired stations

- ❖ Electrical conversion efficiency higher than dedicated biomass combustion plants
- ❖ High level of flue gas cleaning already installed produces low level of biomass related particulates
- – High capacity on single site requires transport of high volumes of low energy density fuel, infrastructure can be limiting factor
- – No heat utilisation

Biomass for heat and power

Large scale biomass power Rankine cycle

- Proven technology - biomass boilers and steam turbines
- Can be located near to biomass supply or transport infrastructure
  - Low energy density of fuel incurs high transport costs
  - Reliant on long term wood fuel supply contracts

Small scale combustion and heat engines

- ❖ Utilisation of heat and power increases overall efficiency compared to dedicated biomass power plants
  - – Low conversion efficiency affects viability due to low electrical output and low CHP QI

Gasification Combined Cycle

- ❖Potential for high electrical efficiencies ~ 35% to 40%
- – Little proven commercial success

Gasification – combustion/Rankine cycle

- ❖Combustion of producer gas provides better process control achieving lower emissions and thus attractive for energy from waste plants
- – Expensive technology

Small scale gasification CHP

- ❖ Higher conversion efficiencies than small combustion based systems
- ❖ Combined with widely used gas engine systems
- ❖ Highest potential for CO_2 reduction
- ❖ Increased incentives under the Renewables Obligation
  - – Still not proven technology
  - – Reliability issues

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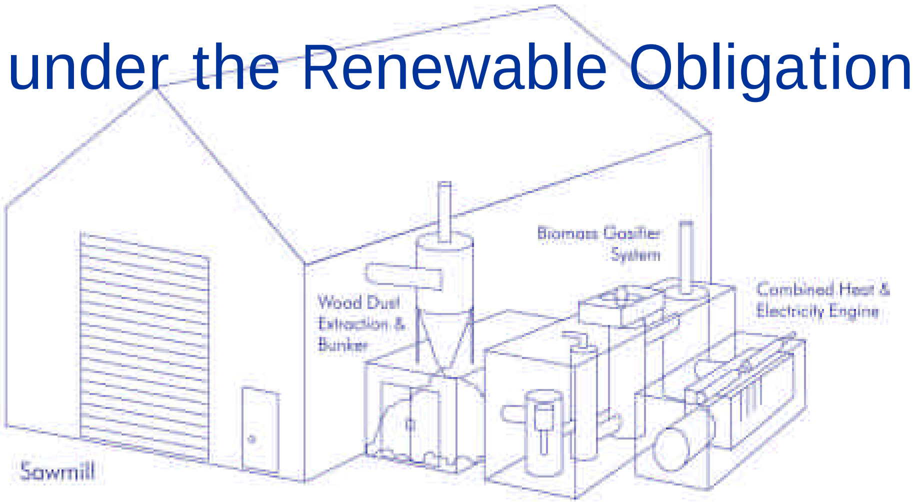
Environmental impacts

	Tonnes CO_2 saved per tonne biomass	Transport requirement	Local emissions (particulate, NOx, PAH)
Co-firing with coal (>50MW)	0.69 to 0.79	high	low
Dedicated combustion Rankine cycle (>10MW)	0.52 to 0.56	medium/low	low
Small scale combustion CHP (<1MW)	0.52 to 0.73	low/none	high
Gasification IGCC / combustion (>10MW)	0.60 to 0.82	high	low
Gasification CHP with gas engine (<2MW)	0.76 to 0.89	low/none	medium

CO_2 emissions ~ Electricity = 0.537kg/kWh ; Heat (Gas) = 0.185kg/kWh

Case for on-site gasification CHP

- Highest Carbon Dioxide savings
- Can be sited at origin of biomass feedstock
  - Reducing transport and fuel storage
- Sited to supply heat and power direct to consumer
  - Higher value for on-site power than wholesale
- Increased levels of support under the Renewable Obligation



Barriers to gasification CHP

- Heavy tars and particulates present fouling problems for gas engines
- Gas cleaning produces solid and liquid waste streams
- Waste streams contain energy content reducing conversion efficiency
- These waste streams require treatment or removal from site at a cost

Gas contaminants

Producer gas also contains:

- Particulates
  - Ash
  - Char
- Alkali (80% in ash and 20% in Tar)
- Tars (PAH, Polynuclear Aromatic Hydrocarbons)
  - Heavy tars (problematic, cause fouling)
  - Light tars (advantageous as they increase energy content)
- Ammonia & NOx
- Sulphur containing species

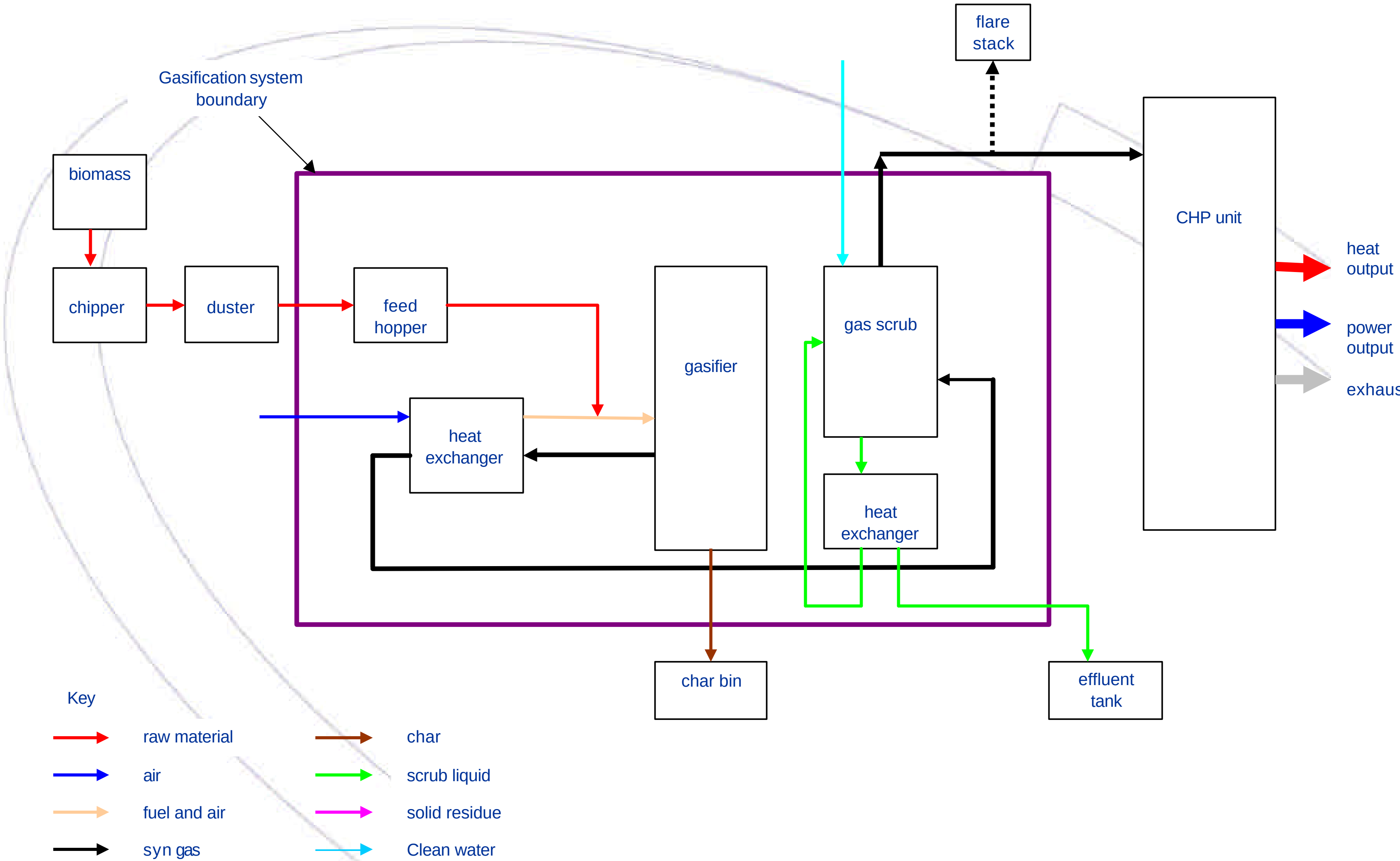
Prime movers

- **Gas Engine** – cold gas, low tar & low particulate
- **Gas Turbine** – hot gas, tars not problematic, low alkali salts, pressurised gas
- **Fuel Cell** – hot gas, low sulphur, low particulate

Project example

Biomass CHP installed on-site at furniture manufacturer

System schematic



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Producer gas composition

Air/steam Blown gasification

CO = 15%

H_2 = 15%

CH_4 = 2%

C_xH_x <1%

N_2 = 50%

CO_2 = 17%

Calorific Value ~ 5MJ/m3

Project figures

- 200kg/hr wood throughput
- 600m3/hr cold gas production
- 250kW electricity generation
- 450kW usable heat to factory

The project aims to divert 1500 tonnes of waste from landfill, consumes 1.2GWh electricity and 1.4GWh heat. 650MWh exported to Grid. CO_2 reduction of 770 tonne pa

CHP operation

CHP Engine

- Spark ignition reciprocating engine.
- Remote monitoring and control
- Partner to supply service and maintenance contracts
- Engine sizes from 0.25MWe to 1MWe

Cogenco
purepower

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Current status

- System in commissioning stages
- Working with Cardiff University in the area of biomass fuels
  - Study of biomass and waste fuels to inform future project developments
  - Analyse gas composition in respect of species and contaminant levels

Conclusion

- Highest Carbon Dioxide savings
- Reduced transport and fuel storage
- Higher value for on-site power than wholesale
- Increased levels of support under the Renewable Obligation
- But technology not proven commercially
  - Difficult gas cleaning
  - Engine reliability