

Biomass Engineering Ltd. projects: Biomass and Wastes Gasification

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Technical consultant to:

Biomass Engineering Ltd.
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<http://www.biomass-uk.com/>

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Holywood, Northern Ireland

<http://www.care.demon.co.uk/>

Presentation Structure

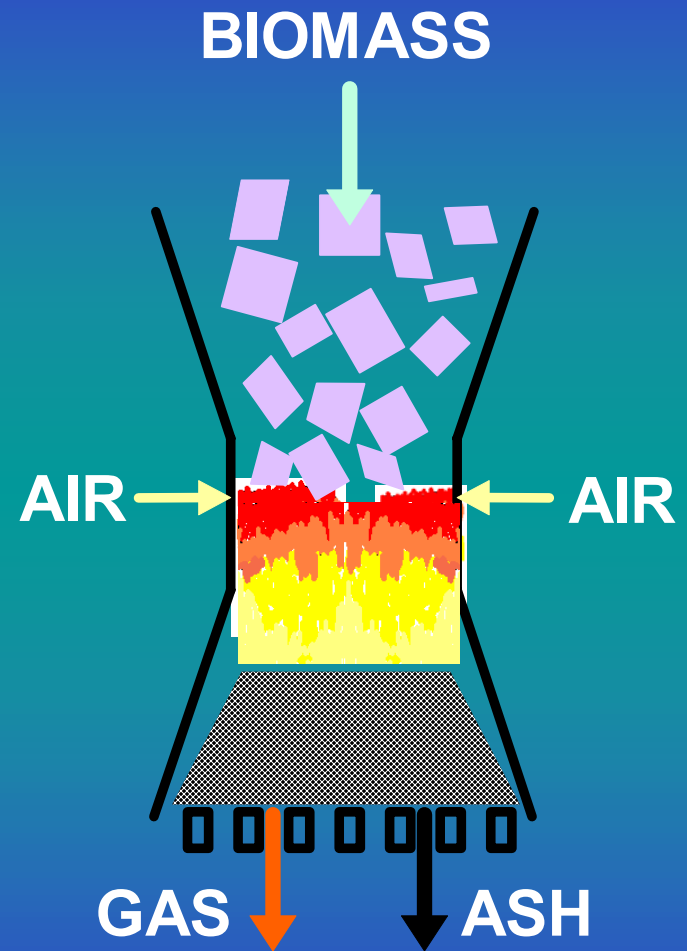
- Background to Biomass Engineering Ltd.
- 65 kWe Ballymena ECOS Centre [1999]
- 80 kg/h test gasifier [1996-present]
 - 90 kWe Engine testing
 - 30 kWe Capstone Micro-turbine testing
 - Fuels testing - various
- 50 kg/h BLC Leather wastes gasifier [2003-present]
- 250-300 kWe Farm based project [2003-2005]
- 85 kWe Jepsons Project [2005]
- Contract: conditions of sale
- Capital and Operating Costs
- Summary

Biomass Engineering Ltd. - background

- Subsidiary of Shawton Engineering Ltd. [160-180 employees]
- Biomass Eng. Ltd. formed as a separate company in 1996 to develop renewable energy systems for combined heat and power [13 employees].
- Biomass build, install and commission all units.
- Built 2 gasifiers in 1996/1997 [downdraft gasifier] ~80 kWe and ~35 kWe net.
- Won tender for 1st commercial project in 1998:
 $55-65\text{kW}_e/50\text{kW}_{th}$.
- Installed 1st commercial project in May 2000 at Ballymena ECOS Centre, Northern Ireland.
- Now on 5th gasifier, with 6 more orders for 3 MWe (250 and 500 kg/h plants).

Biomass Engineering Ltd. technology

- Throated, downdraft design.
- Only condensate and ash by-products.
- Operates under negative pressure [air sucked in by action of gas fan].
- Gasifier handles wide range of materials of varying quality.
- High gasifier efficiency [~80%].
- > 15,000 h gasifier operation
- > 5000 h power generation experience on spruce, pine, fir, beech, mahogany, oak, poplar, willow, leather wastes



Ballymena ECOS Centre [1999]

- Showcase for three technologies:
 - Wind: 20 kW_e turbine
 - Solar thermal: 12.5 kW_{th}
 - Gasification: 55-65 kW_e / ~50 kW_{th}
- Order placed late 1998
- Gasifier completed in 1999 – 500 h prior testing before delivery
- Gasifier installed May 2000
- Centre opened August 2000
- Operating for > 2500 hours
- Contract for 55kW_e, 8-10 hours daily, unmanned.



The ECOS Centre process



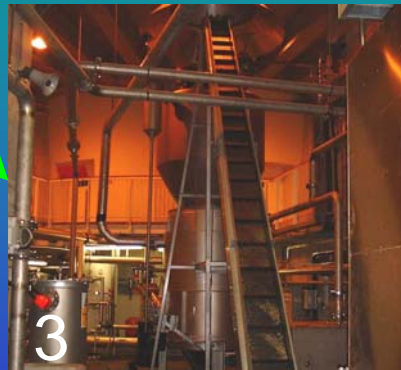
1. Biomass fuel (e.g. willow) is harvested. Other materials can also be used, e.g. sawmill wastes, forestry residues, waste wood.



2. Fuel is stored in building on a floor dryer [dilute engine exhaust used for heat]. Fuel can also be flash dried if relatively dry.

100 units

3. Fuel is fed to gasifier & turned into producer gas.



80 units



Electricity

28 units

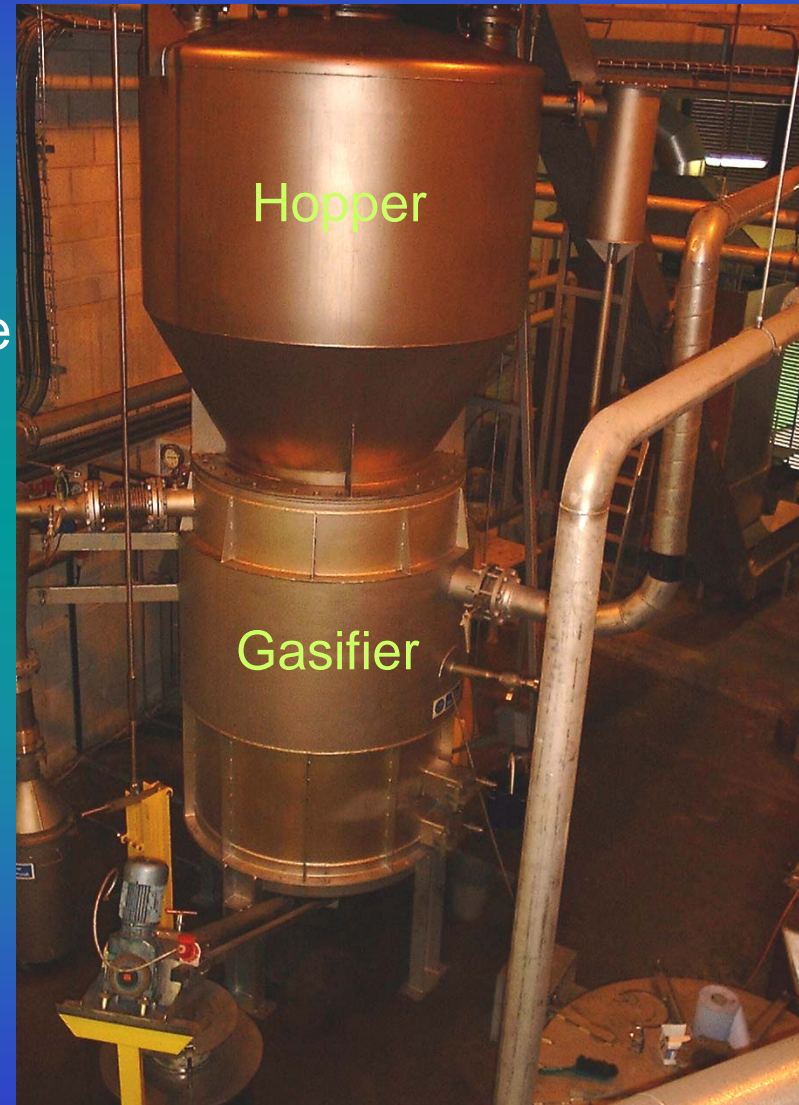
Heat

52 units

4. Producer gas burnt in engine

55-65 kWe Ballymena ECOS Centre

- Batch system [client specification], 8-10 hours, from chipping to CHP.
- Automatic riddling, ash and char removal, full process control.
- Integral wood drying [using dilute engine exhaust]
- Low tar, < 11 mg/Nm³, raw gas*.
- Low solids, < 50 mg/Nm³ raw gas*.
- Gasifier efficiency 75-80%.
- 55-65 kW_e/50 kW_{th} output
- Still operational, no modifications
- Servicing by Biomass Eng. Ltd. once a year.
- Power generation from ignition in 10-15 minutes maximum [Record < 3 min.]



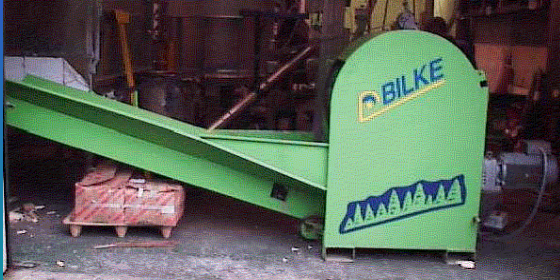
* CRE Group, 1999 to IEA Tar protocol

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Wood preparation and drying



Coppiced willow is chopped in onsite Bilke cutter to ~100 mm chips.

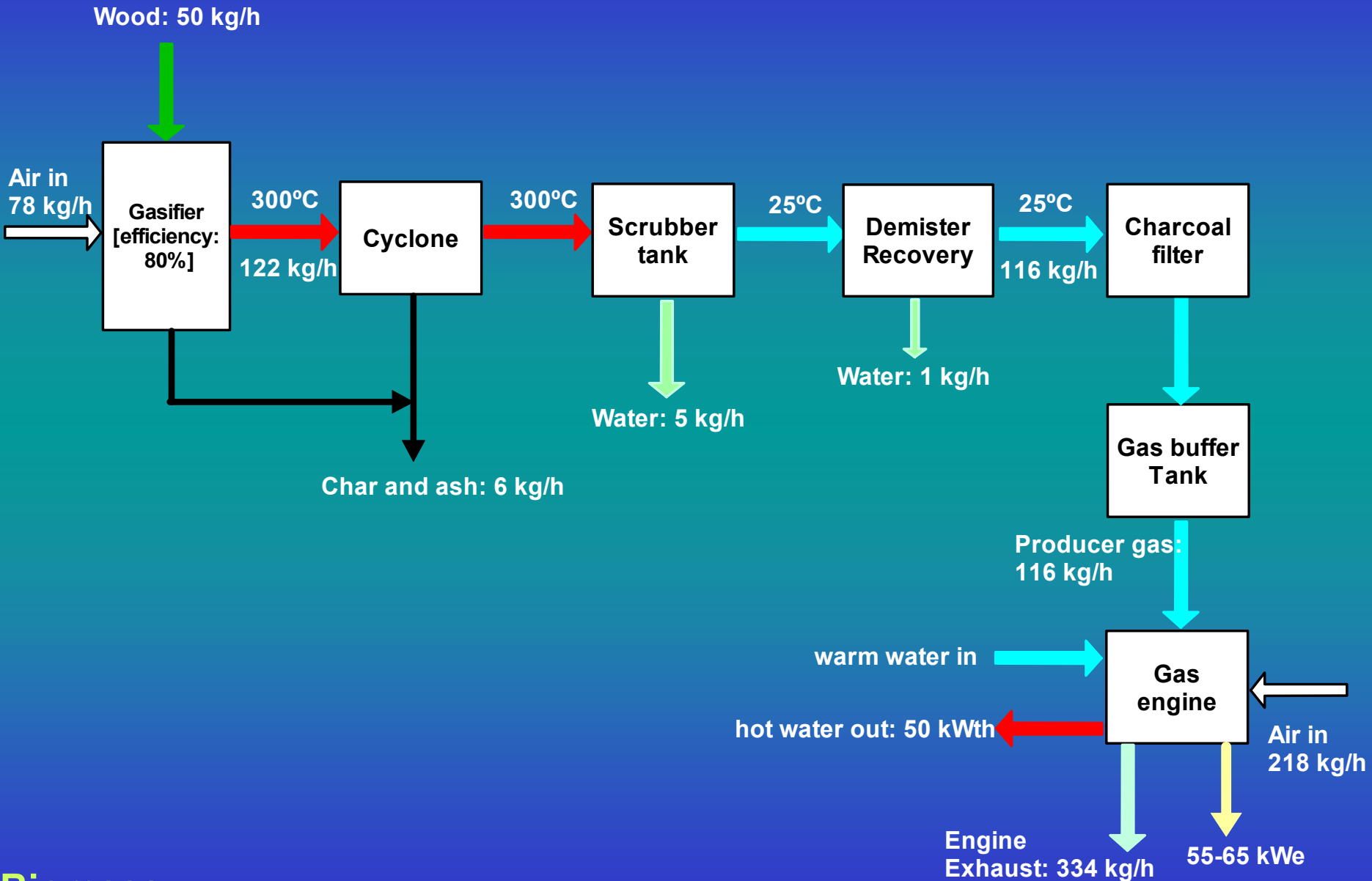


- Second flash dryer to "fine tune" moisture content.
- Used as buffer wood storage for 500-700 kg.



- Wood drops off cutter onto perforated floor. Wood is stored on dryer floor.
- Diluted engine exhaust dries wood.

ECOS Centre Mass Balance



Ballymena ECOS Centre Emissions

Char+ash

4-8 kg/h

	C	H	O	N	Ash
	82.2	1.0	0.92	0.5	15.3
δ_{dev}	1.8	0.1	--	0.1	2.38

Returned to
willow crop

Condensate

6 kg/h

BOD	1.15 g/l
COD	3.43 g/l
pH	8.5

Discharge to
foul sewer

Engine exhaust

670 kg/h

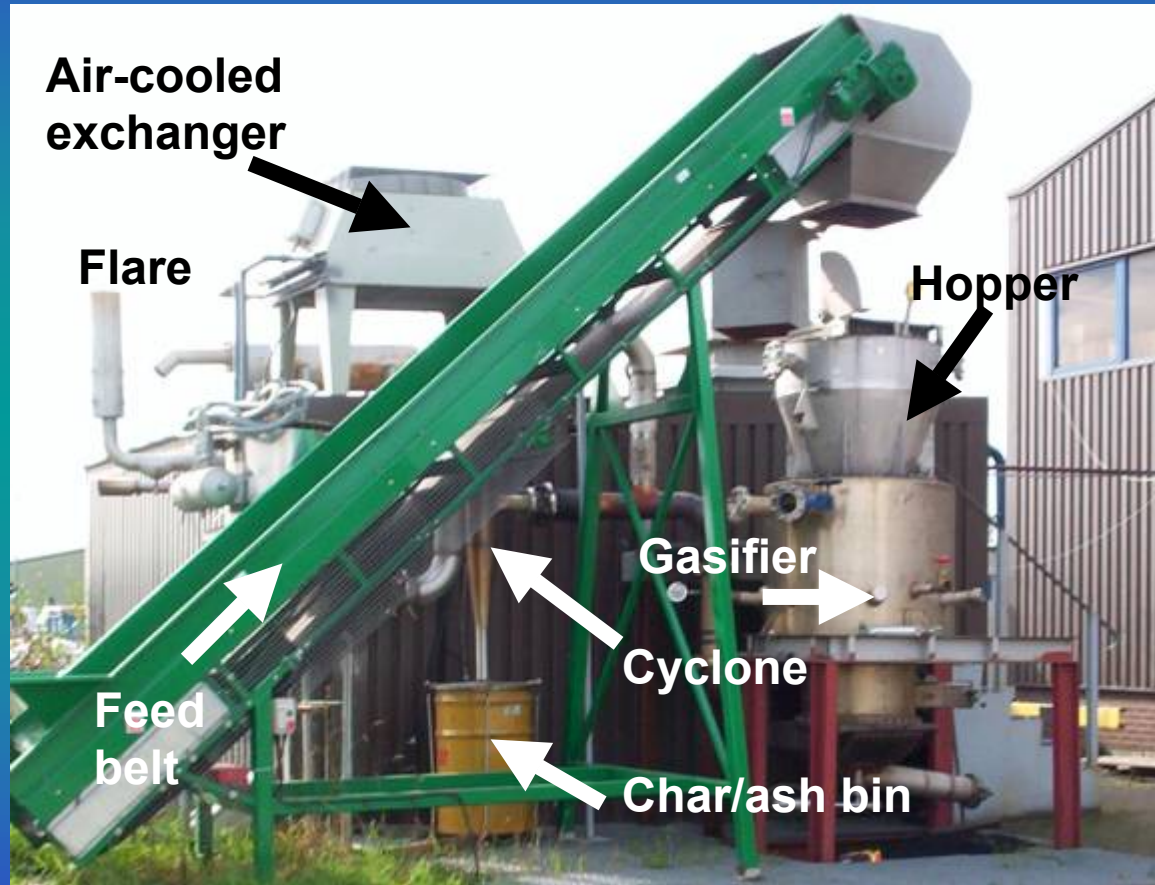
$[\lambda_{O_2} = 1.7]$

	mg/Nm ³	ppm
NO _x	59	49
SO ₂	71	27
CO	2111	1813
VOCs	4.8	1.4
CO ₂		5.4 vol%
O ₂		11.3 vol%

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80 kg/h test unit – Newton-le-Willows

- Constructed 1996
- Modified in 2000 to increase capacity from 35 kg/h to 80 kg/h
- Range of feedstocks tested [wood and wastes]
- Over 6000 hours operation
- Coupled to engine or turbine
- Batch fill – 1-2 hours
- Ongoing DTI contract for 3 woods and an MSW derived material.



30 kWe micro-turbine [2001-2003]

Aim:

- Test and operate a Capstone Model 330 micro-turbine on producer gas [30kWe] and test a catalytic combustor rig

Status:

- Contract completed.
- 300 hours operation on site.
- Turbine available for tests.

Results:

- Low turbine emissions
- Difficult to start on producer gas.
- High deration of 50%.



Emissions: 3ppm NO_x;
16 ppm CH₄; 25 ppm
CO; 2% CO₂

50 kg/h leather wastes gasification British Leather Corporation

Aim:

- Gasification of leather wastes for heat and Cr (III) recovery.

Status:

- Test campaign complete - demonstrated technical viability.

Results:

- Gas LHV of 4.3 MJ/Nm³
- Good Cr (III) recovery in char/ash byproduct. Minimal Cr(VI).
- 50 kg/h unit operated at Pittards, Leeds for over 300 hours in 2004 on buffing dust and blends of sludge cake and buffing dust.



Flare Emissions:

Dioxins: 0.11 ng/Nm³

TEQ \pm 80%,

HCl: 26 mg/Nm³

Particulates: 92 mg/Nm³

Cd: 0.0075 mg/Nm³

Cu, Pb, Ni: 0.047 mg/Nm³

VOC: 209 mg/Nm³

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BLC Flare emissions

Emission	EU WID [mg/Nm ³ , red 11% O ₂]	Biomass Eng. Ltd. results [mg/Nm ³]
SO ₂	50	1413
NOx	400 [< 6t/h]	532
Particulate	10	80.8-95.3
CO	50	1195
TOC	10	444.2 [VOCs]
HCl	10	13.1
HF	1	0.15
Hg	0.05	<0.0237
Heavy metals	0.5	Cr (III) < 0.229
PCDD/F, 1-TEQ	0.1 ng/Nm ³	0.000284 ng/Nm ³
Total metals	500 µg/Nm ³	974.7 µg/Nm ³
Hg, Cd, Pb		23.7 µg/Nm ³

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Producer gas compositions

Gas component	Willow 1999	Buffing dust Jan 2004	Buffing dust July 2003	Pine/bark 2004
CO	17.46	15.06	10.52	17.68
CO ₂	14.00	8.6	12.50	14.32
H ₂	17.63	11.1	13.31	15.49
CH ₄	1.85	1.1	1.44	1.80
C ₂ H ₄	0.34	0.3	1.31	0.45
C ₂ H ₆	0.07	0.01	0.16	0.05
C ₃ H ₆	0.05	NM	NM	0.03
N ₂	48.6	58.7	60.5	50.2
HHV [MJ/Nm ³]	5.6	3.9	4.7	5.3
LHV [MJ/Nm ³]	5.1	3.7	4.3	4.9

250 kWe Farm Project [2003-2005]

Background:

- DTI funded project to demonstrate technology.

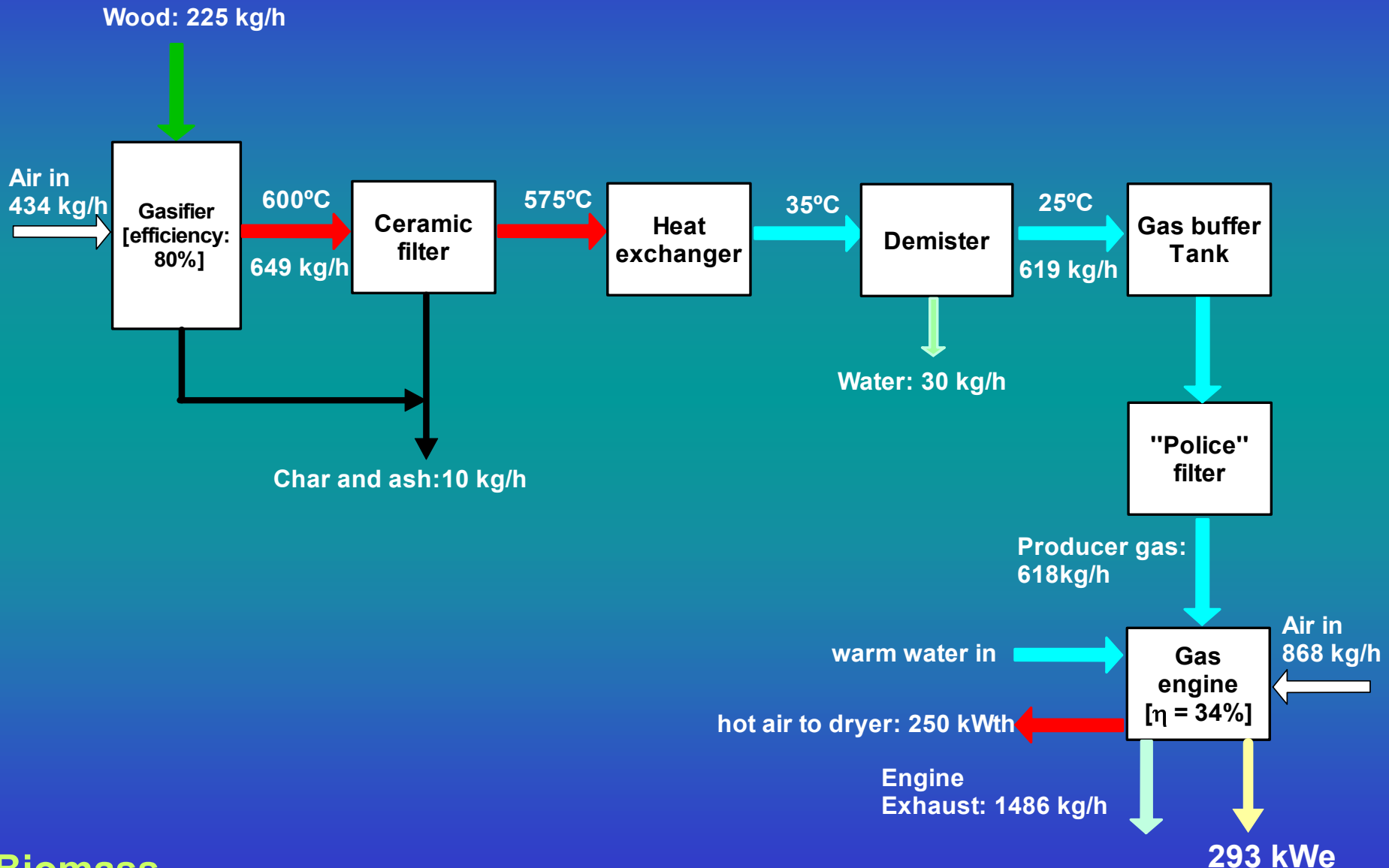
Aim:

- Demonstration of complete system on a farm for power generation – heat used to dry wood as required.
- 3500-4000 hours operation.
- > 28% electrical efficiency.

Status:

- Fully automated from wood feeding to power generation.
- Generating power to grid since March 2005.
- Gas LHV of 4.4-5.2 MJ/Nm³.
- Gas, char and condensate analysed.
- 1000+ hours gasifier operation.
- 200+ h on power production.
- Ultra clean gas – ppm levels of organics in gas to engine.
- Engine gas train being modified to give up to 300 kWe output.

250 kW_e Farm gasifier flowsheet



Wood Chip Preparation & Storage



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Wood Drying and Feeding

- Wood loaded into hopper with a front end loader twice a day.
- Wood dried with diluted engine exhaust
- Vibratory floor onto conveyor



Gasification and Gas cleaning

Gasification

- Wood fed automatically from hopper into gasifier on low level.
- LPG used to ignite gasifier for 1 minute at start-up only. Automatic ignition sequence.
- Air drawn in by gas fan.

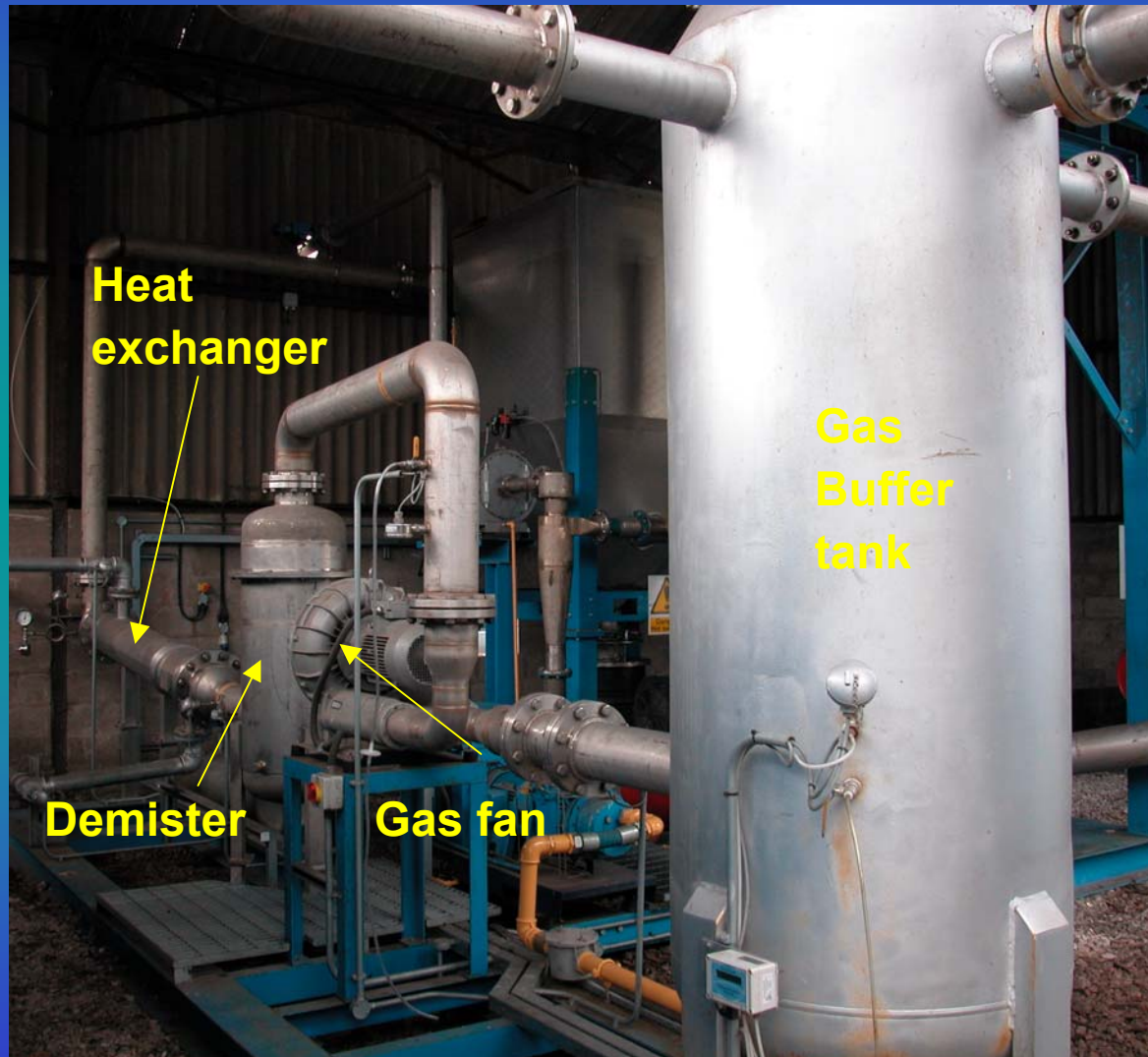
Gas cleaning

1. Ceramic filter – backpulsed with clean producer gas.
2. Hot gases from filter cooled in water –cooled shell and tube heat exchanger.
3. Water removed in demister column. Shipped off–site as no foul sewer.
4. Remaining gas to buffer tank prior to engines.



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Gas Cooling and Storage

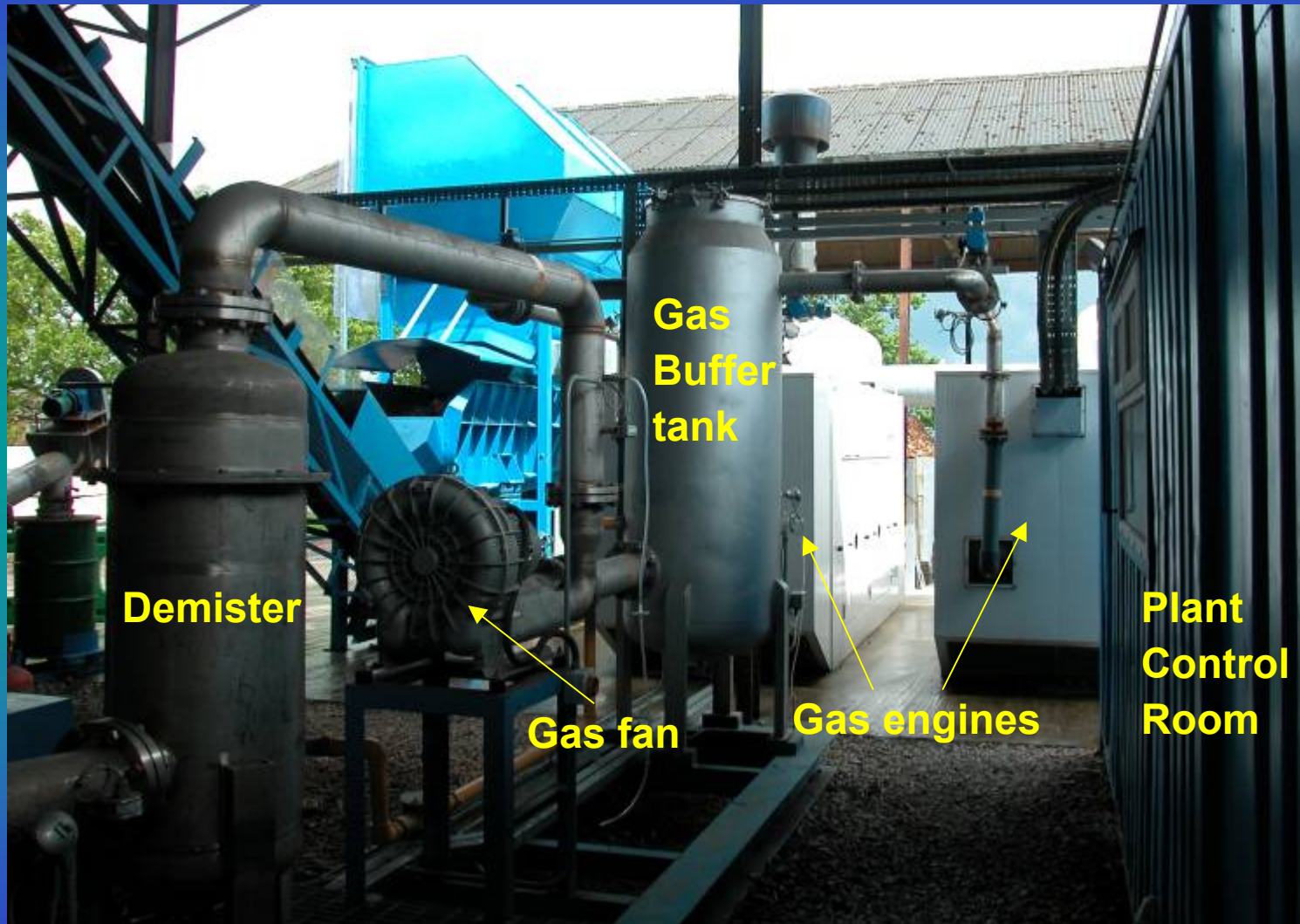


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Gas Storage and Power Generation

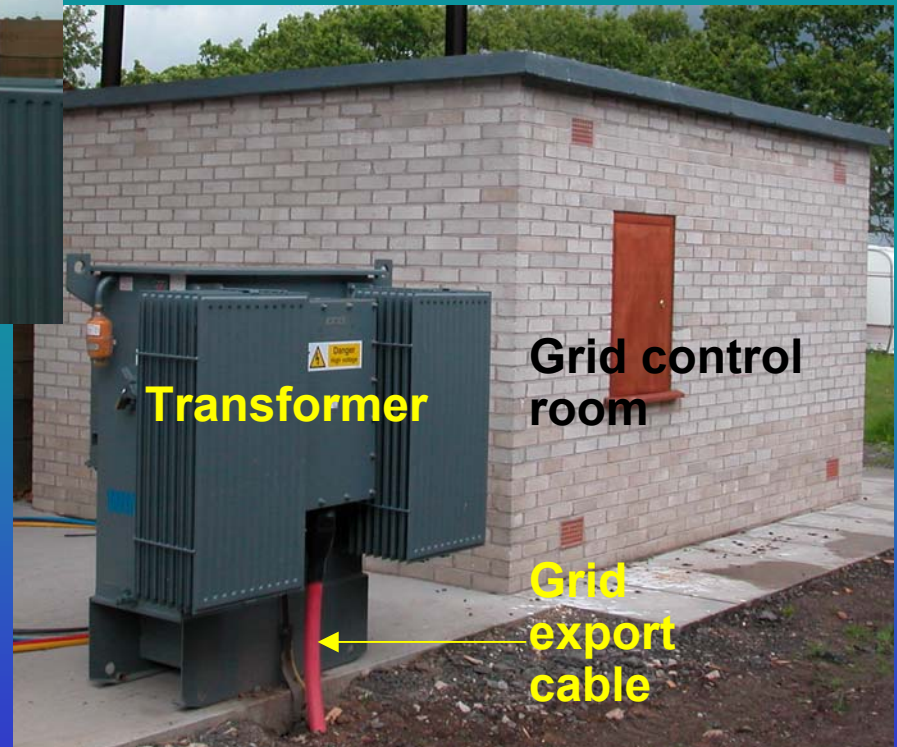


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Power Generation and Export



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Farm emissions and analyses

Char+ash

6-10 kg/h

C	H	O	N	Ash
28.0	3.0	--	0.1	72.5*

Returned to soil on farm

Condensate

30-35 kg/h

US EPA 16 PAH	4650 $\mu\text{g/l}$
Phenol	173000 $\mu\text{g/l}$
Naphthalene	3040 $\mu\text{g/l}$
2-Methylphenol	3640 $\mu\text{g/l}$
3-Methylphenol	14400 $\mu\text{g/l}$
4-Methylphenol	5150 $\mu\text{g/l}$
Σ rest	1132 $\mu\text{g/l}$
BOD	0.163 g/l
COD	0.642 g/l
pH	8.8

Shipped off-site for disposal

Engine

1500 kg/h

To be tested after fitting of catalytic oxidiser [reduce CO emissions]

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85 kWe Jepsons CHP plant – Phase 1

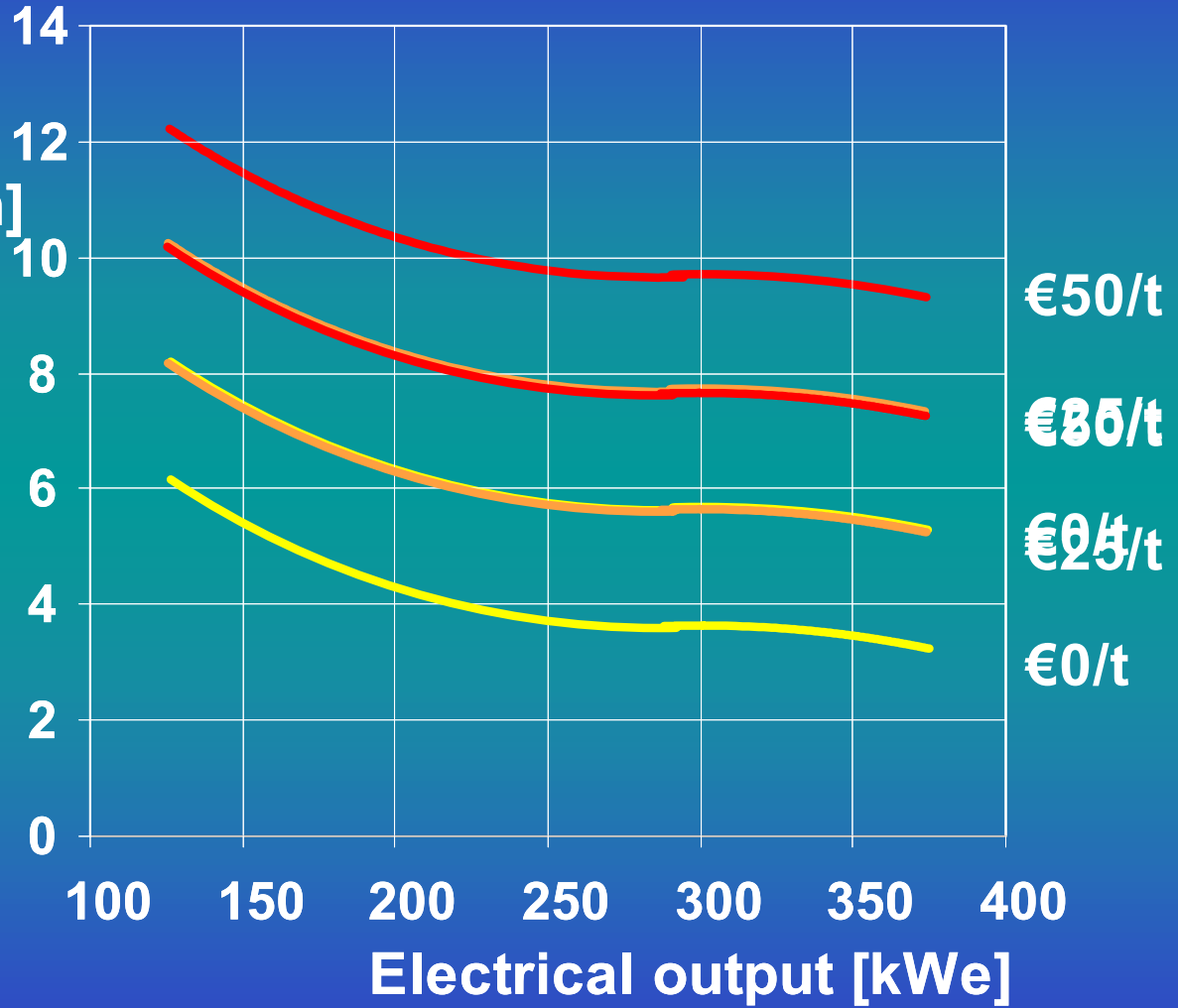
- Supply of complete system – from woodchip feeding to power generation.
- 85 kWe unit using on-site wood wastes.
- 100 kW_{th} used for wood drying.
- 80-90% availability.
- Electricity sold privately through grid.
- Planning permission approved.
- Power line to grid being installed under contract.
- System delivery and installation August 2005.
- Phase 2 is to increase in output to 250 kWe net in early 2006.

Biomass Gasifier Costs

- A 250 kg/h combined heat and power unit costs ~€700,000 [including wood preparation and gas engine and integrated wood drying]
- A 500 kg/h (2 x 250 kg/h) costs ~€1,300,000
- Biomass costs variable from €0 to €90,000/y [€0-50/t]
- Operational costs of €34,500/y
- Staff costs ~€19,500/y
- Exact costs subject to local conditions
- Other plants from 100 kWe possible, different configurations
- Payback time of ~5.5+ years if fully amortized capital including engine maintenance.

Electricity costs: downdraft gasification

Net electricity cost [€_{cent}/kWh]



BASIS

- Fully amortised capital costs over 20 years.
- From wood feed to power export.
- All servicing and operating costs included.
- Based on Iveco engines at 34% efficiency; dry gas cleaning system.
- No income from sale of heat and no tax credits or capital allowances.

Including sale of heat at €_{cent} 1.5/kWh

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Contract: conditions of sale

- Buyer must provide sufficient information to allow a proper project scope to be defined and costed.
- Fuel must meet specification defined by Biomass Eng. Ltd.
- Equipment tested prior to shipment to buyers [or independent experts] satisfaction – certificate of acceptance issued. If test not accepted, Biomass Engineering Ltd. will carry out changes to meet test requirements on their site.
- Performance figures given with small tolerances to account for small process variability within terms of guarantee. Project specific.
- Price quoted is in UK, Free On Board UK port.
- Erection not included in price unless requested and with suitable equipment provision on site as specified by Biomass Eng. Ltd. Mo onsite liability is accepted by Biomass Eng. Ltd.
- Handover to buyer is when equipment is installed on site. Ownership transferred to buyer only on completion of payment for plant.
- Warranty for 12 months after handover to buyer on equipment and performance.
- IPR owned by Biomass Eng. Ltd. in all cases.

Summary

- Biomass Engineering Ltd. can provide full turnkey biomass gasification systems with operation and maintenance contracts.
- Biomass Engineering Ltd. will install, commission units and train local staff in operation and maintenance.
- Modular systems from 100-300kWe.
- The company has over 5000 hours experience on its systems on power generation.
- Over 15,000 hours on gasifier operation.
- Units are environmentally compliant to relevant local and national legislation.
- Prepared to license systems and operate plants under a variety of options.

Questions?

