





First results of the H2020-LC-SC3-RES-11 BLAZE project: biomass low cost advanced zero emission small-to-medium scale integrated gasifier fuel cell combined heat and power plant

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Objectives: to develop Biomass, Low cost, Advanced and Zero Emission small-medium scale CHP plant «BLAZE» ø MPACTS (VERTECH, USGM, SP_YV, WP7: MARKET ASSESSMENT SOCIAL- ENVIRONMENTAL EPFL, HFC, WT, EUBIA) TESTING (EPFL, USGM, UNIVAQ, SP_YV, HYGEAR, WP2:GASIFICATION & WP4: MODELING & DESIGN WP3:SOFC TESTS CONDITIONING TESTS (SP_YV, EPFL, ENEA) (UNIVAQ, USGM, UNITE, HFC, WT, VERTECH) WP1: MANAGEMENT EUBIA, ENEA) (USGM and all) **BLAZE PROTOTYPE** WP5: INTEGRATION WP6: REAL & EXPLOITATION (EUBIA WP8: DISSEMINATION (HYGEAR, USGM, UNIVAQ, ENVIRONMENT TEST SP YV, EPFL, HTSF, HFC, (WT, USGM, UNIVAQ, WT, VERTECH) SP_YV, EPFL, HYGEAR, HFC and all)

Results: Breakthrough in the cost reduction and performance increase of biomass small and medium CHP

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CAPEX

САРЕХ	BLAZE	ICE	ORC
Input kWth	100	100	100
Biomass storage and feeding (spider, hopper, screw) cost ${f \in}$	6,000	6,000	6,000
Gasification (BLAZE or ICE/GT) or Combustion (ORC) cost €	90,000	90,000	70,000
€/kWth	960	960	760
Power generator size kWe	50	25	15
Power generator size kWth	40	50	65
SOFC-ICE/mGT–ORC cost €	100,000	37,500	30,000
€/kWe	2,000	1,500	2,000
System cost €	196,000	127,500	100,000
€/kWe (considering all CAPEX to only electric power)	3,920	5,100	6,667
100 kWth gas boiler with tubes and accessories €	50,000	50,000	50,000
Electric system cost €	170,000	110,000	82,000
€/kWe	3,400	4,400	5,467
Thermal system cost €	76,000	67,500	68,000
€/kWth	1,900	1,350	1,046





Because of this small size (i.e. a production from 45 to 150 MWhe) the CAPEXs are generally higher but the electricity price is also higher. In BLAZE the CAPEX per kWe produced is less than in the conventional solid biomass cases because, even if the gasification and SOFC CAPEX are higher, the electrical efficiency is double.

	€/year			
OPEX cost item	BLAZE	IC	E	ORC
Personnel (automated operation - 50 h/yr)	1,(000	1,000	1,000
Gasifier/Combustor, Gas Cleaning system, Boiler	1,3	300	1,300	1,000
Power generation (SOFC or ICE)	1,3	300	1,300	600
Biomass Cost	4,(000	7,000	7,000
Ash disposal cost	l	500	500	500
Other Costs (e.g. insurance, aux. consumptions)	1,(000	1,000	1,000
Total OPEX	9,2	100	12,100	11,100

As expected the higher OPEX costs for traditional CHP with respect to BLAZE are mainly due to the higher biomass cost.



BIOMASS CHP COST PER ELECTRIC KWh

	BLAZE		ICE		ORC	
Equivalent annual hours	3000	2500	3000	2500	3000	2500
OPEX €/kWh	0.06	0.03	0.16	0.04	0.20	0.04
CAPEX €/kWh	0.08	0.03	0.11	0.02	0.13	0.02
Tot CAPEX+OPEX €/kWh	0.14	0.06	0.27	0.06	0.33	0.06
Equivalent annual hours	7500	7500	7500	7500	7500	7500
OPEX €/kWh	0.04	0.02	0.12	0.03	0.14	0.03
CAPEX €/kWh	0.06	0.02	0.07	0.01	0.06	0.01
Tot CAPEX+OPEX €/kWh	0.10	0.04	0.19	0.04	0.20	0.04

The table shows that BLAZE is the only system that, in case of lower annual equivalent hours, has a competitive electricity generation cost, and that **BLAZE**, in case of high annual equivalent hours, **can reach electricity generation cost below 0.10 €/kWh**.



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Biomass selection and characterization

Feedstock	CATEGORY	Humidity (%- wt, as received)	LHV MJ/kg	Ash %wt, dry basis	S %wt, dry basis	Cl %wt, dry basis	Ash melting T (DT) (°C)
Subcoal	Municipal waste	3,20	21,68	15,60	0,10	1,00	1250,00
Olive pomace pitted	Secondary residues of industry utilising agricultural products	36,30	19,79	5,95	0,06	0,08	1290,00
Sawmill waste	Primary residues from forest	11,20	18,89	0,41	<0.01	<0.01	1300,00
Multi-essence wood chips	Waste from wood	24,50	17,88	1,45	0,02	<0,01	1370,00
Olive Prunings	Secondary residues from wood industries	14,90	17,76	1,55	<0.01	<0.01	1380,00
Almond shells	Secondary residues of industry utilising agricultural products	10,00	17,68	1,31	<0.01	<0.01	1000,00
Swarf and sawdust	Secondary residues from wood industries	6,60	17,14	0,43	<0.01	<0.01	>1385
Wood chips	Primary residues from forest	8,90	16,74	0,54	<0.01	<0.01	>1385
Corn cobs	Agricultural residues	9,00	16,62	3,04	0,03	0,44	645,00
Arundo Donax	Agricultural residues	10,10	16,25	3,43	0,11	0,29	1185,00
1- Wheat Straw (pellets 10 mm)	Agricultural residues	7,60	15,98	9,22	0,05	0,12	1065,00
2- Wheat Straw (pellets 6 mm)	Agricultural residues	7,60	15,40	13,29	0,08	0,21	1135,00
Rice husks	Secondary residues of industry utilising agricultural products	5,20	15,19	14,70	0,02	0,03	990,00
Digestate	Digestate from biogas production	71,20	12,69	25,81	0,97	0,10	1245,00
Black Liquor	Secondary residues from wood industries	20,60	11,20	48,28	0,74	0,12	680,00
Municipal solid waste	Municipal waste	23,00	10,22	47,01	0,20	0,40	1220,00



Gasification, conditioning and SOFC tests

A wide spectrum of biomass feedstock available in Europe is assessed and tested for bio-syngas production and compatibility with solid oxide fuel cells, tar removal, and hot gas cleaning and conditioning.





scheme of the 3 kWth BFB plant



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Micro and lab facility

Gasification, conditioning and SOFC tests

The benchmarking of kinetics, performance, and durability of SOFC cells is carried out in order to optimize the cell's response to the characteristics of the bio-syngas obtained from different types of biomass.



SOFC single cell test rig - gas and contaminants mixing stations (ENEA)



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SOFC short stack tests

MODELING



Global system ASPEN simulations have been already performed in order to identify the best layout considering freedoms various of system configurations, e.g., different options of: units, anode off-gas gas cleaning recirculation, heat exchangers, pressurised gasifier/combustor or different fan/blowers



Rome, 15 – 16 September 2020 The modelling activities will perform a full process and system design with detailed CFD and process flow diagram (PFD) from the viewpoints of process and system reliability, efficiency, cost and socio-environmental impacts

