μCHP 16

micro Cogeneration through biomass gasification

Bioenergy & Biofuels LAB

unibz
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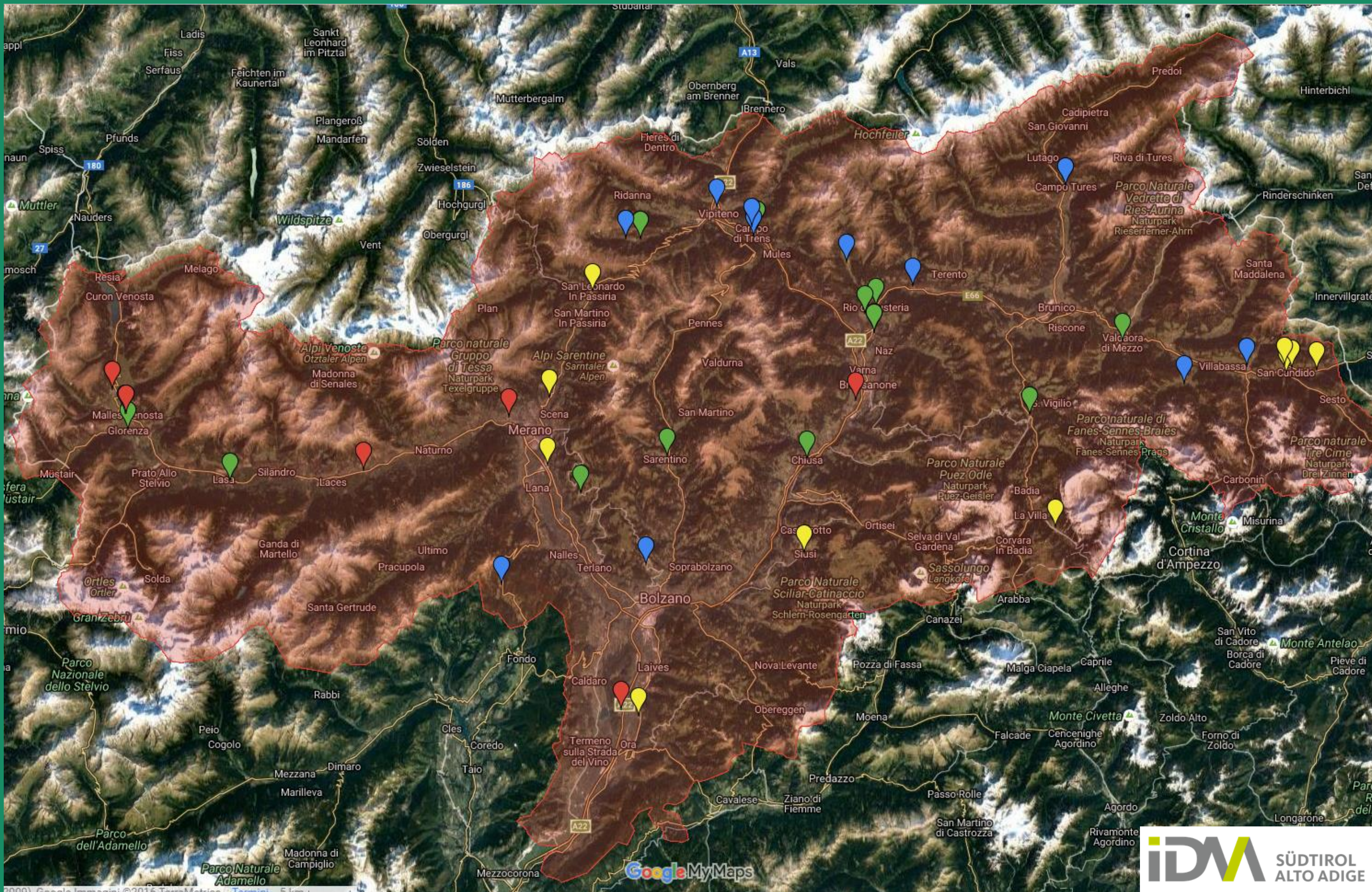
Libera Università di Bolzano
Università Liedia de Bulsan



2015 – Authorized gasification plants

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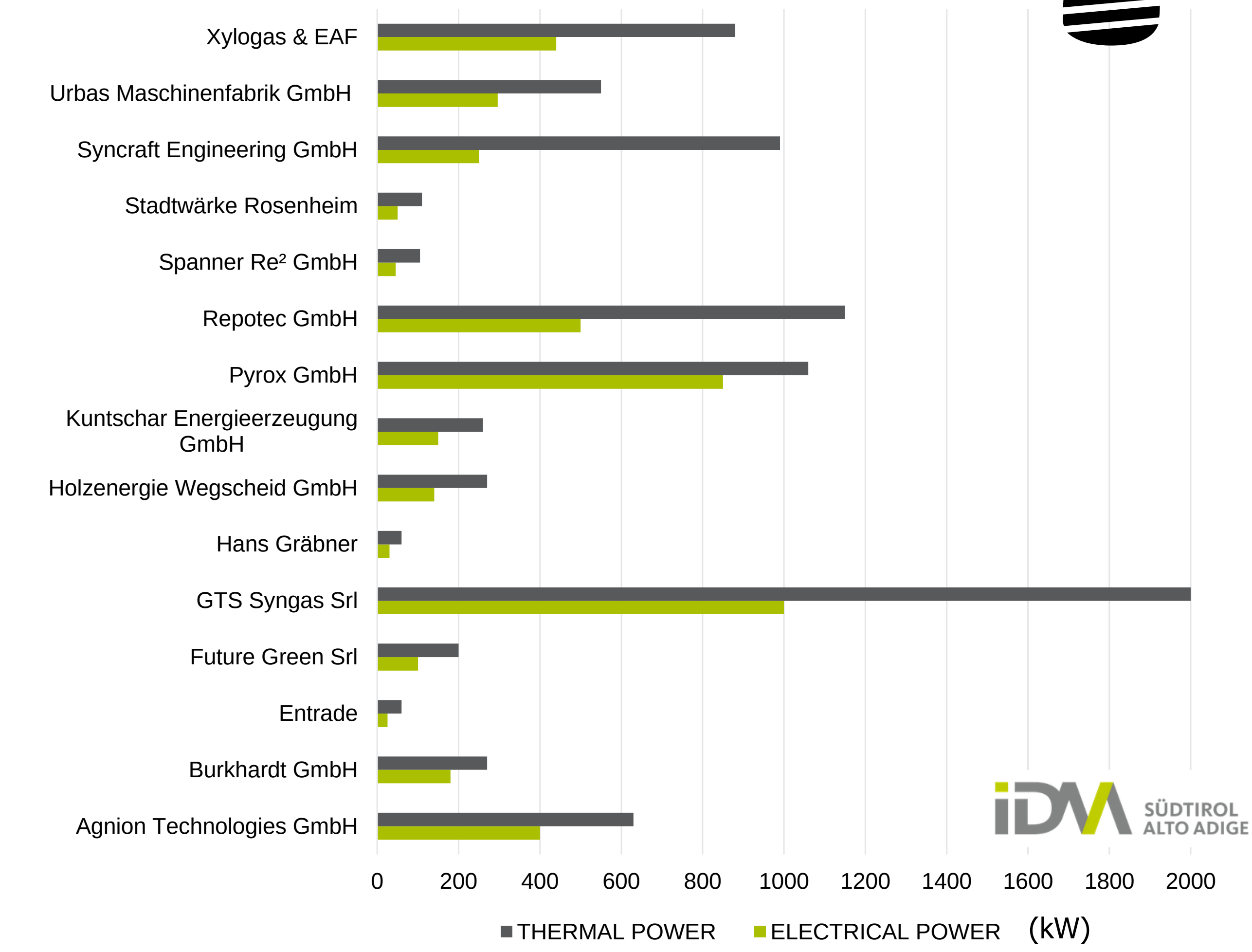
FACTS & FIGURES

Technology	Place
Agnion Technologies GmbH	Ora
Burkhardt GmbH	Ora
Burkhardt GmbH	Sinigo
Burkhardt GmbH	Campo di Trens
Burkhardt GmbH	Campo di Trens
Burkhardt GmbH	S. Genesio
Entrade	Terlano
Future Green Srl	Lagundo
Hans Gräbner	Campo Tures
Holzenergie Wegscheid GmbH	Rio di Pusteria
Kuntschar Energieerzeugung GmbH	Braies
Kuntschar Energieerzeugung GmbH	Senale San Felice
Kuntschar Energieerzeugung GmbH	Rio Pusteria
Pyrox GmbH	Lasa
Repotec GmbH	Malles
Spanner Re² GmbH	Badia (S. Cassiano)
Spanner Re² GmbH	Castelrotto (Siusi)
Spanner Re² GmbH	Riffiano
Spanner Re² GmbH	S. Candido
Spanner Re² GmbH	S. Candido
Spanner Re² GmbH	S. Candido
Spanner Re² GmbH	S. Leonardo i.P.
Spanner Re² GmbH	Campo di Trens
Spanner Re² GmbH	Chiusa (Latzfons)
Spanner Re² GmbH	Glorenza
Spanner Re² GmbH	Naz Sciaves
Spanner Re² GmbH	Naz Sciaves
Spanner Re² GmbH	Racines
Spanner Re² GmbH	Rio Pusteria (Spinga)
Spanner Re² GmbH	S. Martino i.B.
Spanner Re² GmbH	Sarentino
Spanner Re² GmbH	Valdaora
Spanner Re² GmbH	Verano
Spanner Re² GmbH	Dobbiaco
Spanner Re² GmbH	Malles
Spanner Re² GmbH	Racines
Spanner Re² GmbH	Vandoies
Spanner Re² GmbH	Lagundo (Aschbach)
Spanner Re² GmbH	Laimburg
Spanner Re² GmbH	n.p.
Stadtwärke Rosenheim	Bressanone
Syncraft Engineering GmbH	Versciaco
Urbas Maschinenfabrik GmbH	Valles
Urbas Maschinenfabrik GmbH	Castelbello
Urbas Maschinenfabrik GmbH	Malles
Xylogas & EAF	Val di Vizze



SÜDTIROL ALTO ADIGE

Introduction

Projects

GAST - "Experiences in biomass **Ga**sification in **S**outh **T**yrol: energy and environmental assessment"

NEXT GENERATION – **N**ovel **EXT**ension of biomass poly-**GENERATION** to small scale gasification systems in South-Tyrol

Funded by:
Autonomous Province of Bolzano

AUTONOME PROVINZ BOZEN - SÜDTIROL
Abteilung 40. Bildungsförderung, Universität und Forschung
PROVINCIA AUTONOMA DI BOLZANO - ALTO ADIGE
Ripartizione 40. Diritto allo Studio, Università e Ricerca scientifica

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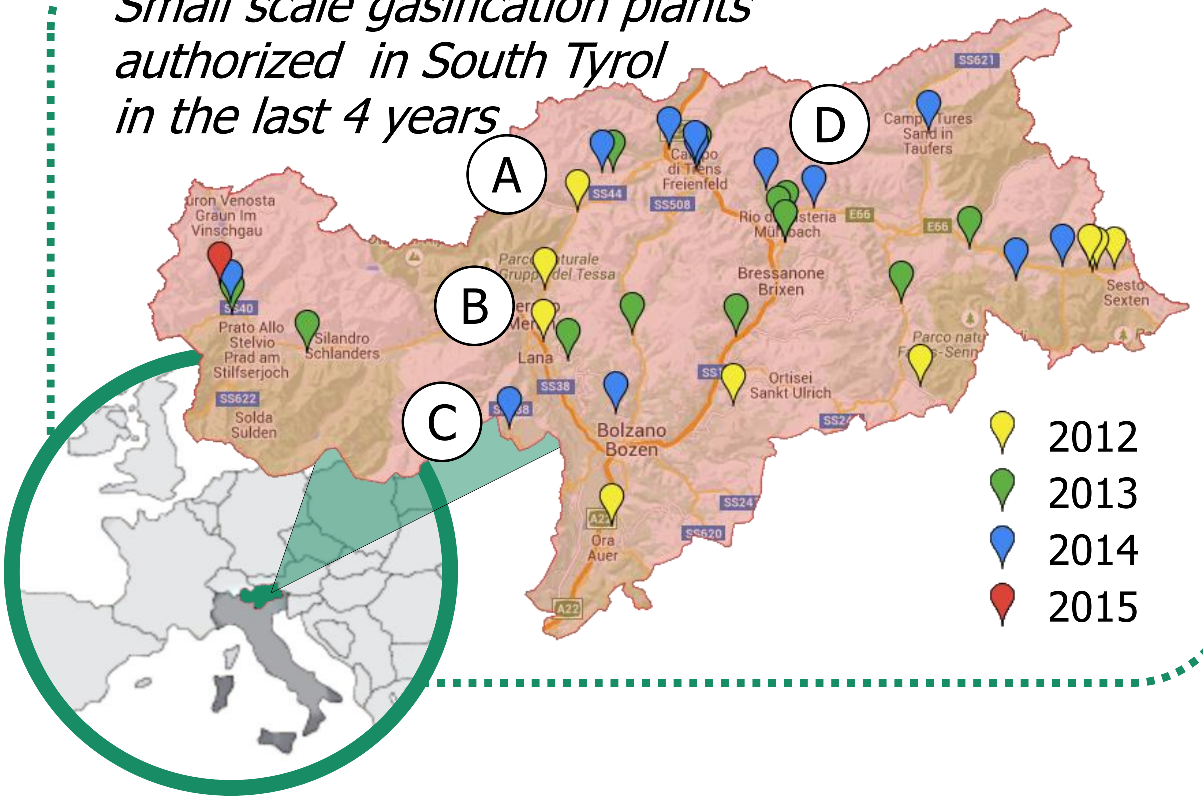
Small scale gasification plants authorized in South Tyrol in the last 4 years



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Investigated plant typologies

Technology	A	B	C	(D)
Fuel	wood chips	pellet	wood chips	wood chips
Feeding	from the top	from the bottom	from the top	from the top
Nominal power	45 kW_{el} / 120 kW_{th}	180-190 kW_{el} / 220-240 kW_{th}	100-150 kW_{el} / 200-250 kW_{th}	300 kW_{el} / 600 kW_{th}
Reactor	downdraft	rising co-current	downdraft	downdraft
Gas cleaning	dry, on the cold gas	dry, on the hot gas	dry, on the hot gas	dry, on the hot gas
Engine	turbo-compressed Otto cycle	dual-fuel Diesel cycle	modified Diesel cycle	modified Diesel cycle
Peculiarity	The (already quite dry) biomass is first dried in a separated vessel and then transported to the main reactor	• The biomass feeding from the bottom creates a vortex above the combustion zone • The engine is co-fed with colza oil for the auto-ignition	The wet wood chips are dried in a external drier suiting the excess of heat	The wet wood chips are dried in a external drier suiting the excess of heat

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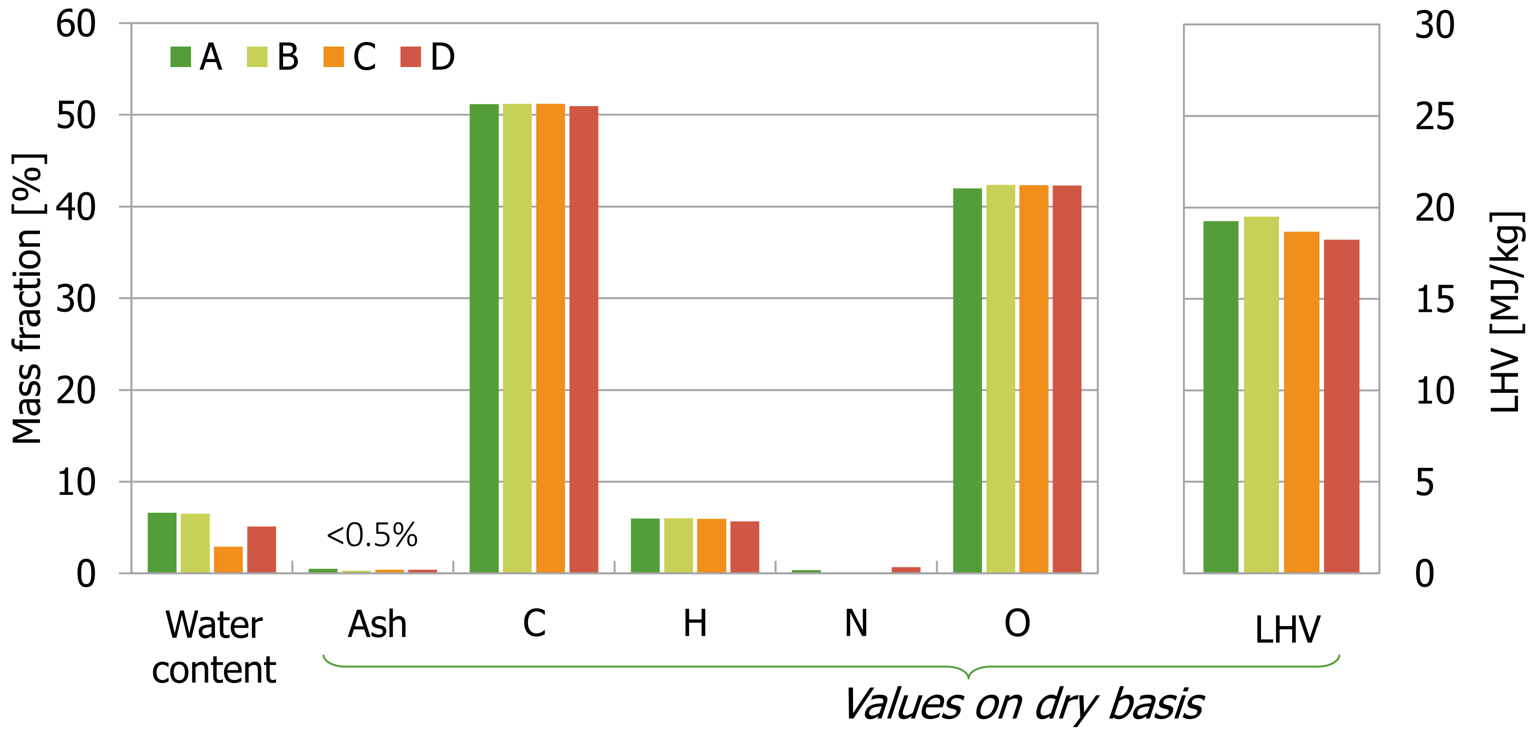
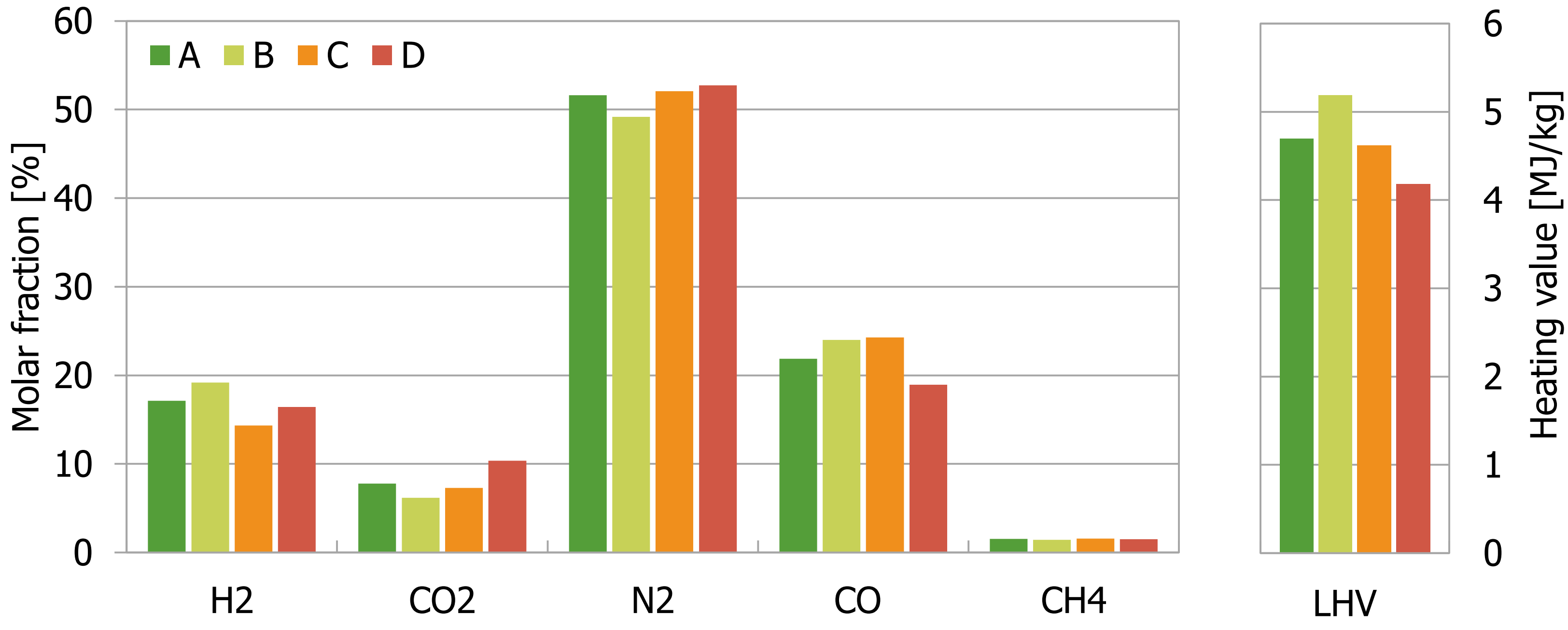
Characterisation of the input feedstock



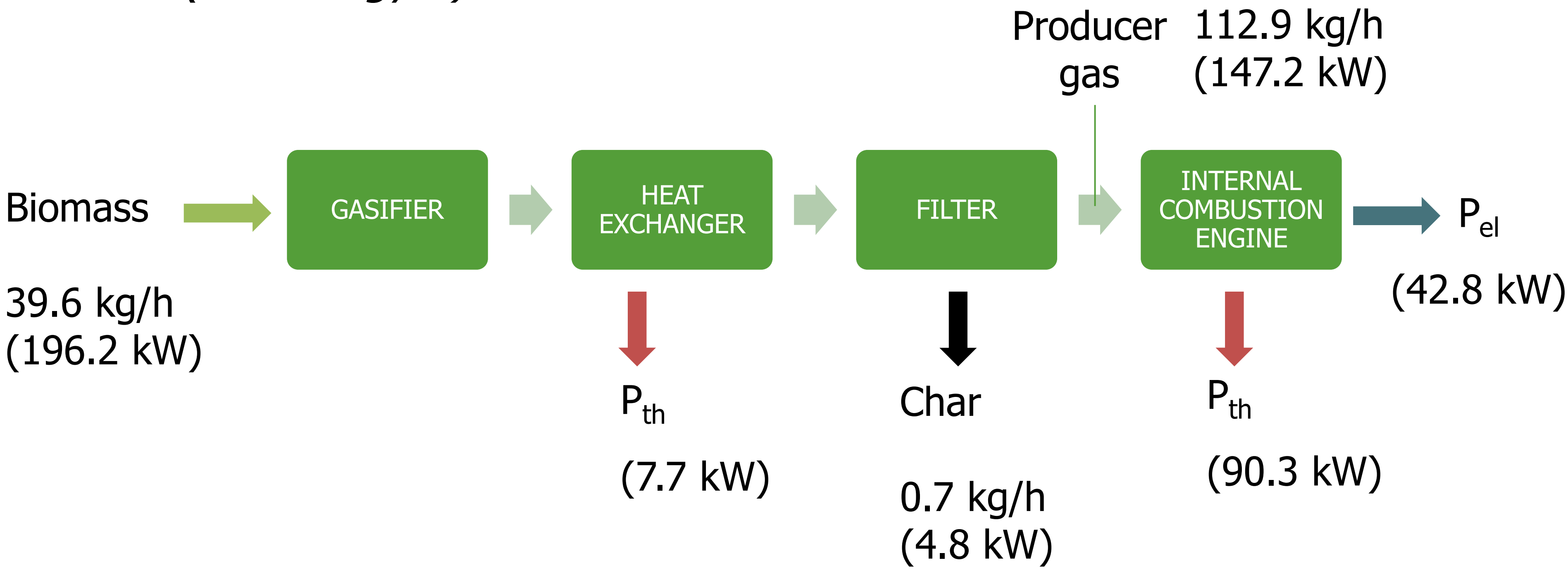
Producer gas composition

Values on dry basis



Mass and energy balance

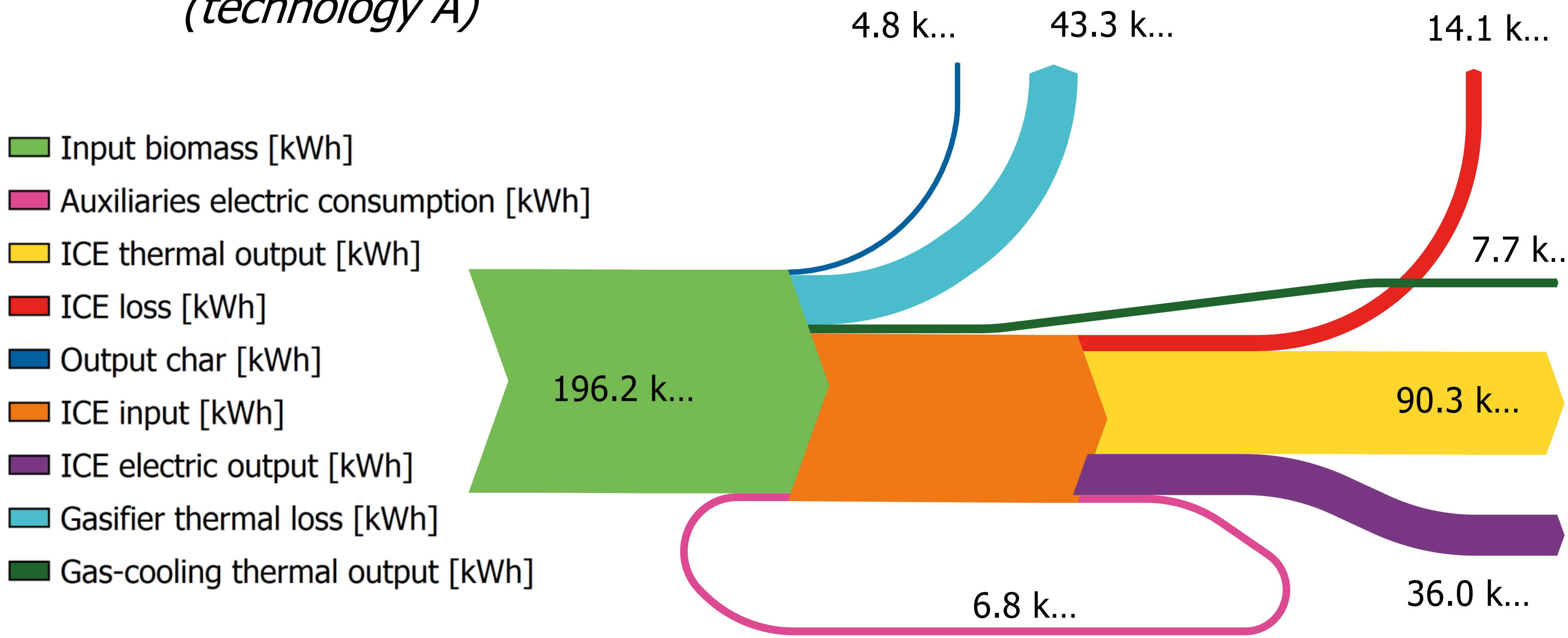
(technology A)



Energy balance

(technology A)

% respect to the biomass input

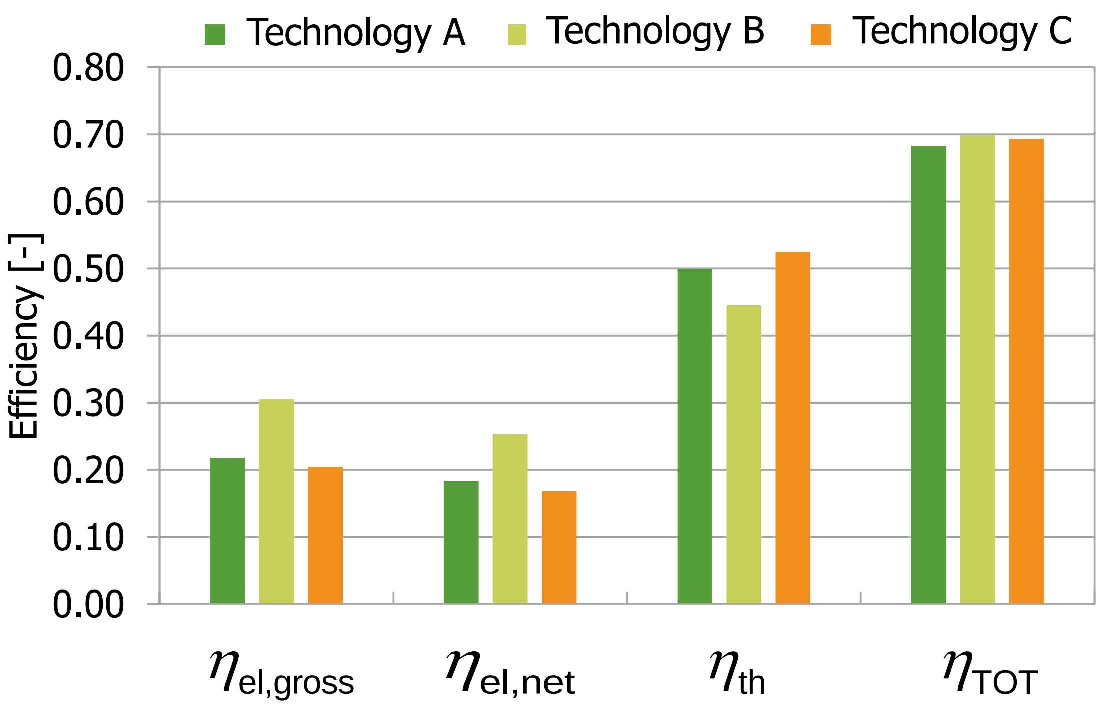


Energy balance

	Technology		
	A	**B***	**C**
Losses			
Char	2.4 %	1.5 %	1.9 %
Thermal gasifier	22.1 %	23.9 %	22.3 %
Thermal CHP	7.2 %	4.8 %	6.4 %
Useful			
Thermal gasifier	3.9 %	11.7 %	7.9 %
Net electric CHP	18.3 %	25.3 %	16.8 %
Thermal CHP	46.0 %	32.8 %	44.6 %
Electric self-consumption			
Auxiliary	15.9 %	17.0 %	17.6 %

*considers 3 l/h of colza oil as secondary fuel

Efficiencies

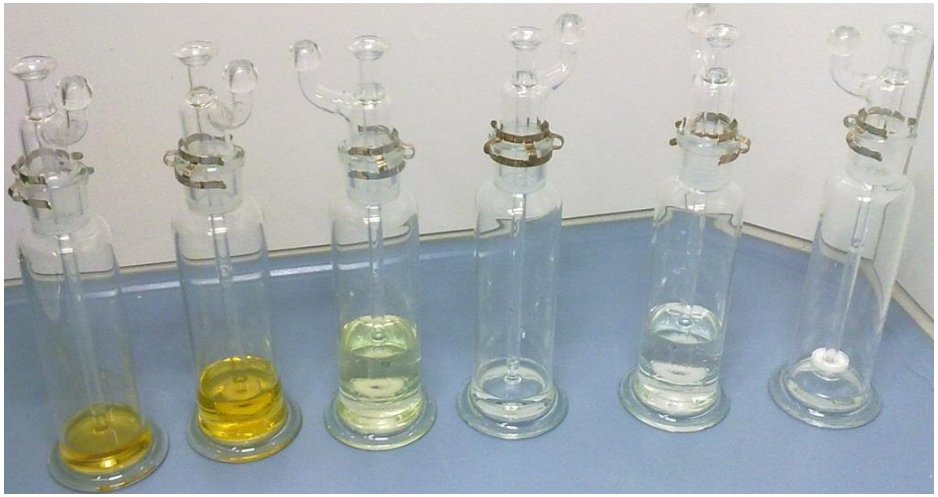


ONLINE_RESULTS

Tar in the producer gas

Suggested limit value for ICE: ≈ 100 mg/Nm³

Technology	A	B	C	(D)
Gravimetric tar (mg/Nm³)	650-750	200-300	150-250	150-250



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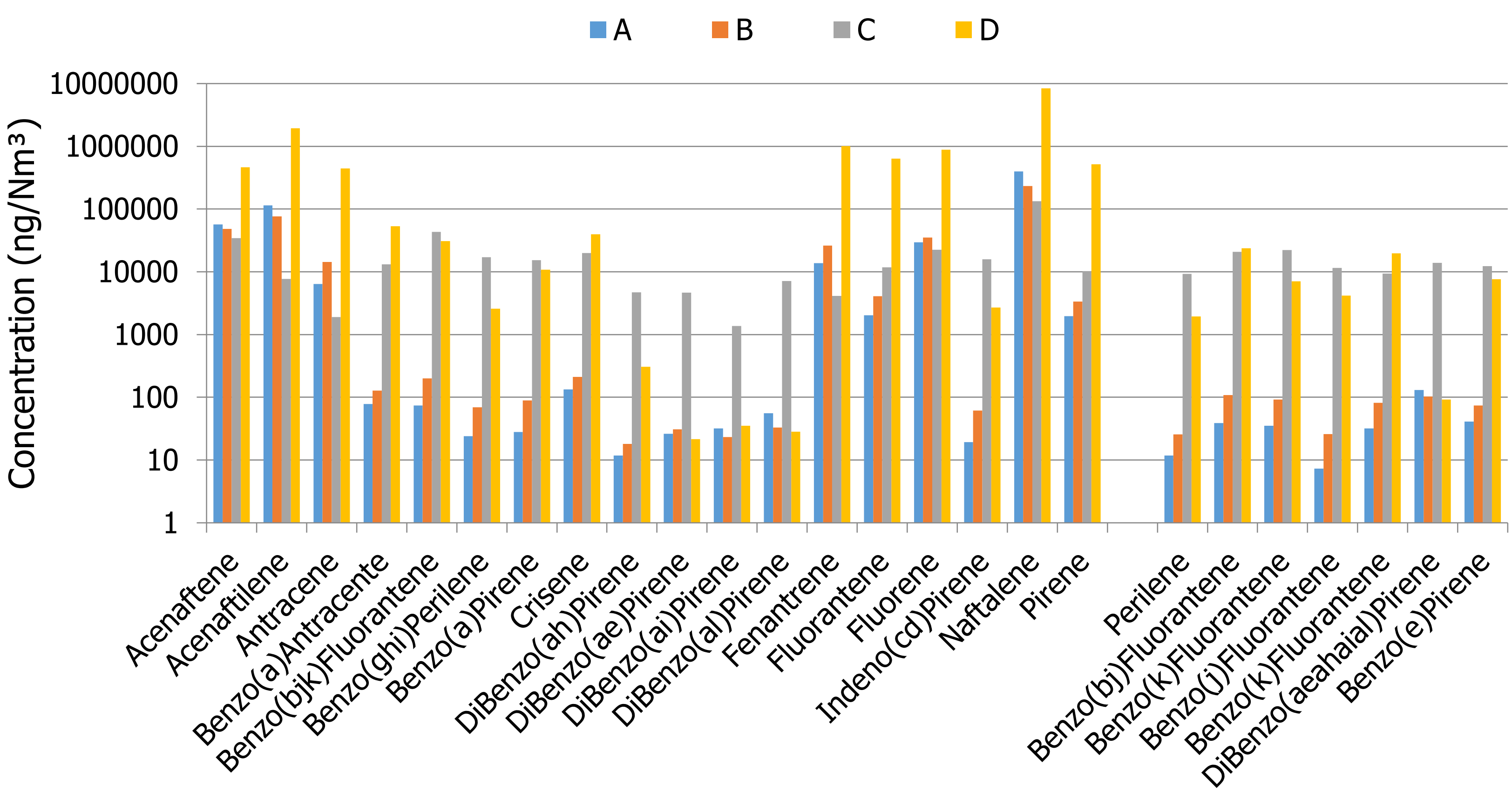
Tar in the producer gas



Conclusions

- Quite **reliable operation** of commercial small scale CHPs (< 200 kW_{el})
    - the plants ensure 7000 h/year of operation
    - similar overall efficiencies for the compared technologies (≈ 70%)
    - high electrical efficiency (20-30 %)

- but…
    - high quality feedstock (water content < 10 %)
    - **tar** content higher than the limit suggested in the scientific literature (frequent engine **maintenance** required)
    - phytotoxicity tests on **char** samples do not suggest that they could be used as soil improver

Future outlooks & open questions

By-products management

- About **2600 tons/year** of **char** disposed of as a waste with a high cost for **disposal** (total of approximately **373 k€ per year**)
- Need for **char valorization routes** (filtering medium, catalytic support, co-firing, …)

December 2nd

8.30-9.00 - Registration

9.00-9.45

Welcome speech
Fabrizio Mazzetto – Free University of Bozen-Bolzano
Vice-Dean for Research, Faculty of Science and Technology

Opening Address and Introduction
Marco Baratieri – Free University of Bozen-Bolzano

Morning keynote

9.45-10.30

"Small scale CHP for decentralised energy generation and grid balances: which challenges and opportunities for gasification?"
David Chiaramonti – University of Florence

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Chairs: *Elisabetta Arato – University of Genova*
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Tim Schulzke – Fraunhofer Institute

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Klas Engvall – KTH, Stockholm

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"20 years of research and demonstration experience with the dual fluidized bed steam gasification concept"
Walter Haslinger – BE2020+, Wieselburg

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"Gasification byproducts"
S. Dasappa – Indian Institute of Science, Bangalore

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Werner Tirler – EcoResearch

17.15-18.00

Round table: "The future of small-scale gasification"

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Guided tour to UNIBZ LABS

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With the financial support of

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(L.P., 13.12.2006, N. 14) Project "Novel EXTension of biomass poly-GENERATION to small scale gasification systems in South-Tyrol (NEXT GENERATION)" [CUP B56J16000780003]

December 3rd

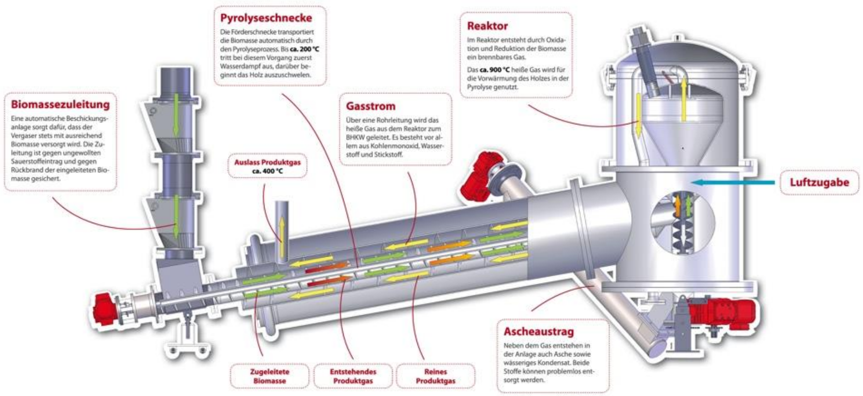
8.30 Coffee-to-go (UNI-BAR)

9.00-12.00 Visit to a commercial plant (on-site lab)

Distrct heating of Pairdorf (Brixen/Bressanone)

[dual stage; 50 kWel, 110 kWth]

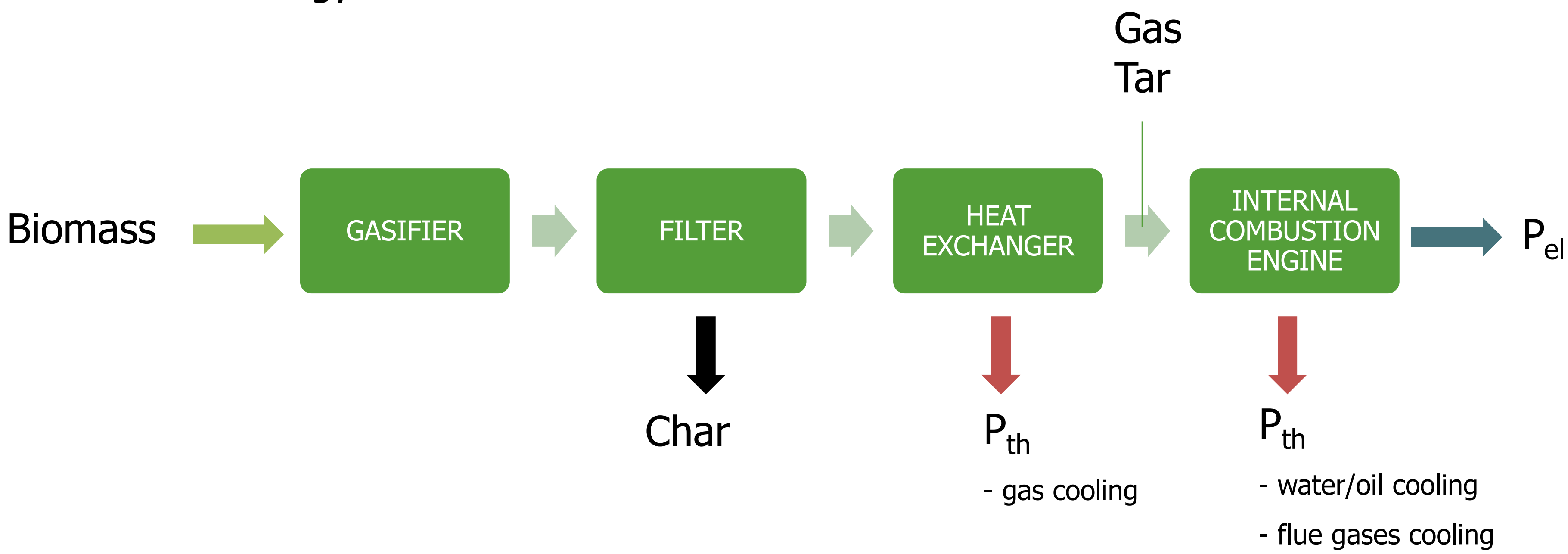
12.30 Return to Bolzano and leaving



IDM SÜDTIROL ALTO ADIGE

Analyzed parameters

- Feedstock and gasification products (gas, char e tar) characteristics
- Mass fluxes
- Energy fluxes



Applied methodologies

Mass fluxes

- Woody biomass flow rate
- Gasifying agent (air) flow rate
- Producer gas flow rate
- Char flow rate

Input biomass weighted and **manually fed** to the reactor…

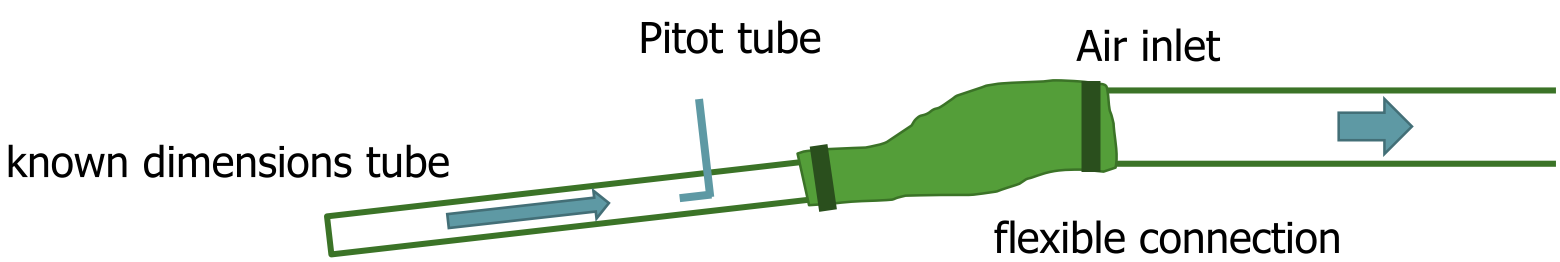
… or **inverse strategies** applied (e.g. maximum level of the storage used as reference)

Applied methodologies

Mass fluxes

- Woody biomass flow rate
- Gasifying agent (air) flow rate
- Producer gas flow rate
- Char flow rate

Determined by means of the **velocity in a known dimensions tube** connected to the air inlet. Velocity measured by means of a **Pitot tube**.



Applied methodologies

Mass fluxes

- Woody biomass flow rate
- Gasifying agent (air) flow rate
- Producer gas flow rate
- Char flow rate

Determined once measured the **gas composition** and the input **air flow rate**, assuming negligible the nitrogen content in the fuel.

$$\dot{V}_{gas} = \frac{x_{N_2}}{0.21} \dot{V}_{air}$$

Applied methodologies

Mass fluxes

- Woody biomass flow rate
- Gasifying agent (air) flow rate
- Producer gas flow rate
- Char flow rate

Determined collecting the char during the whole monitoring period.

All the parameters have been monitored for a continuous steady operation period of at least 5-6 hours.

Applied methodologies

Energy fluxes

- Energy related to the input fuel
- Energy related to the producer gas
- Produced electrical and thermal energy

Determined on the basis of the **biomass flow rate** and of its **Lower Heating Value (LHV)**, measured by means of calorimetric bomb.

$$P_{comb} = \dot{m}_{comb} \cdot LHV_{comb}$$

Applied methodologies

Energy fluxes

- Energy related to the input fuel
- Energy related to the producer gas
- Produced electrical and thermal energy

Producer gas LHV calculated on the basis of its **composition**, measured by means of a **portable gas chromatography system.**

$$P_{gas} = \dot{m}_{gas} \cdot LHV_{gas}$$

Applied methodologies

Energy fluxes

- Energy related to the input fuel
- Energy related to the producer gas
- Produced electrical and thermal energy

Electrical power measured by means of power analyser and/or integrated meter of the plant.

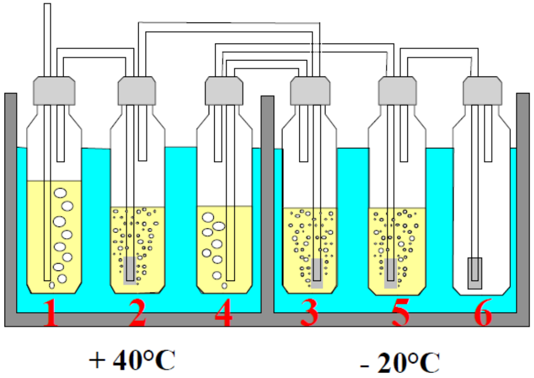
Thermal power estimated from:
- Medium flow rate (ultrasonic meter)
- Supply and return temperature (thermocouples type k)

Applied methodologies

By-products characterization

- Liquid: tar
- Solid: char

Tar in the producer gas sampled and analyzed according to **UNI CEN TS 15439** (bubbling in **isopropanol**)



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