CFB GASIFICATION OF BIOMASS AND WASTE AT PILOT AND COMMERCIAL SCALE

Timothée NOCQUET, Tudor FLOREA, Charlotte MARTY, Mazen AL HADDAD

LEROUX & LOTZ
Groupe Altawest

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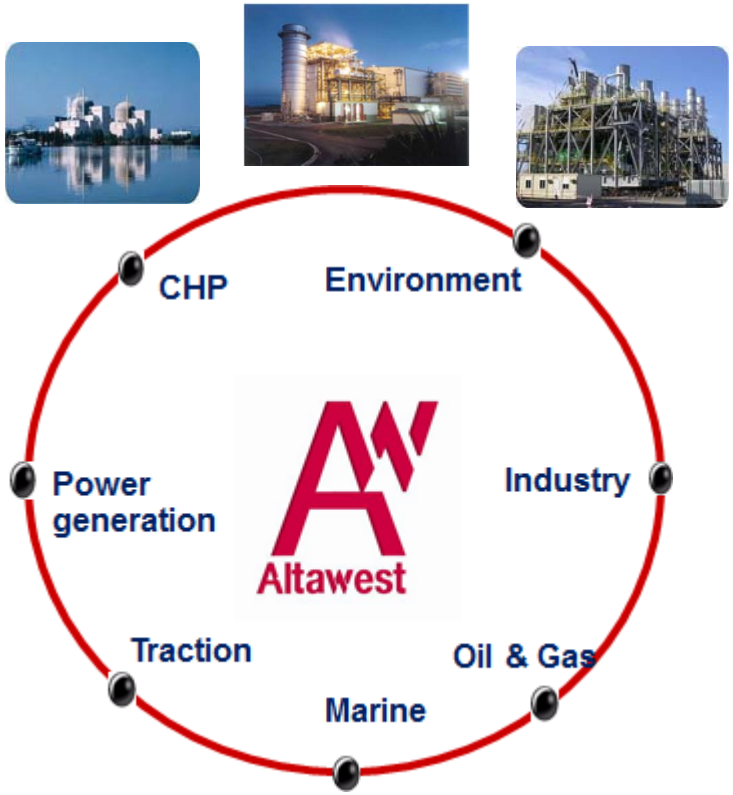
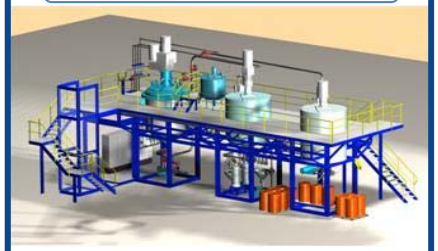
Altawest Group – LLT Solutions



- *Jeumont electrique*
- *Inova*
- *Leroux & Lotz Technologies*
- *Leroux & Lotz Timolor*
- *Leroux & Lotz Turbomachine*
- *Leroux & Lotz Maintys*

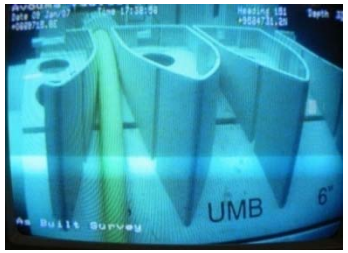
Leroux & Lotz Technologies

Modular plants



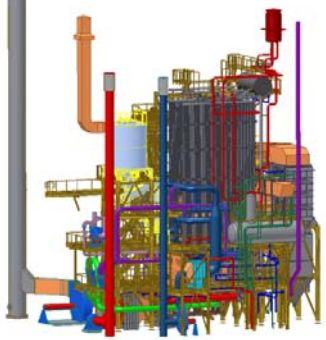
Special heavy Machines

Subsea Equipments



Industrial boilers & EnfW

Biomass boiler Islands



Industry Division

Heat & Power Division

LLT Heat & Power Division

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- **Commercial & Industrial range:**
  - *Boiler range for **Waste and RDF: 10** to **150 MW_{th}***
  - *Boiler range for biomass*
    - ***FT** range : **1** to **15 MW_{th}***
    - ***WT** range : **15** to **150 MW_{th} (up to 540 °C, 130 bars)***

- **Custom Combustion System**
  - *Biomass Burner (BioSwirl ™ , MultiFuel)*
  - *Bubbling Fluidised Bed (BFB)*
  - *Step type Grate*
  - *Spreader stoker (with partner)*
  - *Watercooled reciprocating grate (with partners)*

- **Custom Gasification System**
  - *Bubbling Fluidised Bed (BFB)*
  - *Circulating Fluidized Bed (CFB)*

Global solution provider for energy generation

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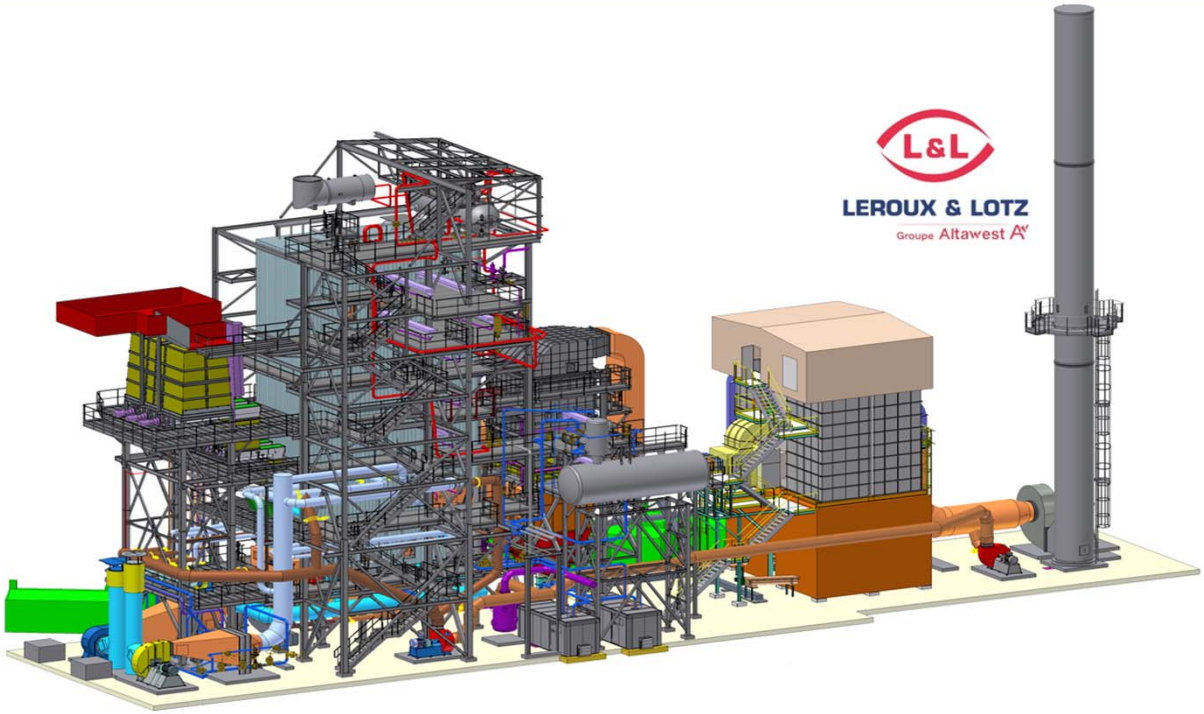
Fuel Handling → Combustion system → Heat/ Steam generation → Flue gas treatment → Ash extraction → Control & Regulation



Customer requirements → Basic & detail engineering → Execution → Erection → Commisioning → After sale service

Context & objectives

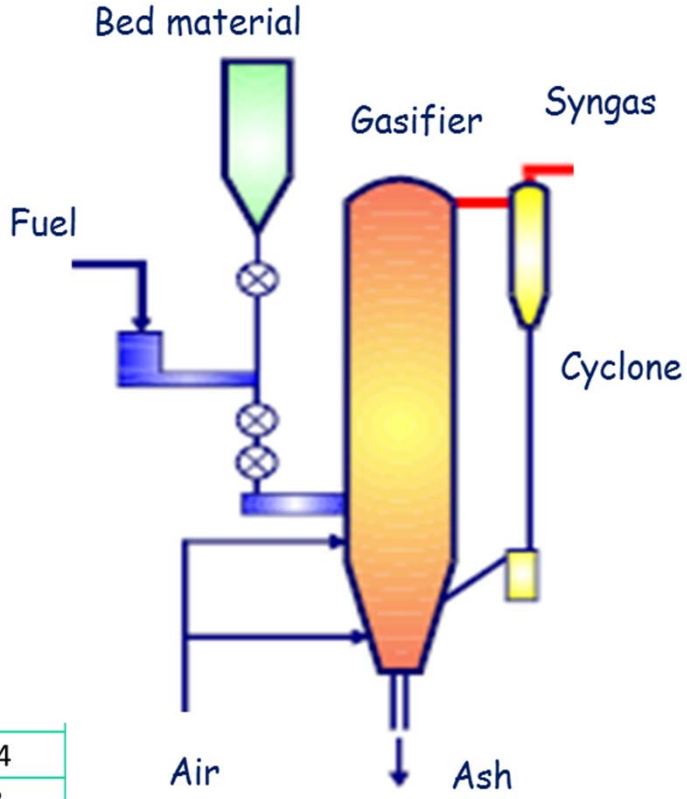
- Gasification
  - Efficient thermal treatment to convert various solid fuels (wood, agricultural residues, wastes) into valuable syngas
  - Various applications: power/CHP generation, biofuels production…

- Technical barriers
  - Variability of the feedstock → fuel injection, reactivity, agglomeration in FB…
  - Syngas cleaning stage before its valorization

- Present works target
  - Feedback on a 2 MW_{th} pilot CFBG and on an industrial 15 MW_{th} gasifier – the Greve in Chianti plant (set up by TPS)
    - Process characteristics
    - Mass balance
    - Technical barriers encountered and solutions organized

Material & Methods: 2MW$_{th}$ CFBG

- Design in 1985 for operation with 500 kg/h of biomass or waste fuels
- Feedstock: RDF
- Operated between 820 and 880°C
- Air blown CFB gasifier, atmospheric conditions
- Connected to a tar cracker (900-950°C)
- Gas analysis of the syngas:
  - heated extraction pipe and sintered metal filter maintained at 400°C,
  - cooling system and gas analyzer (GC)



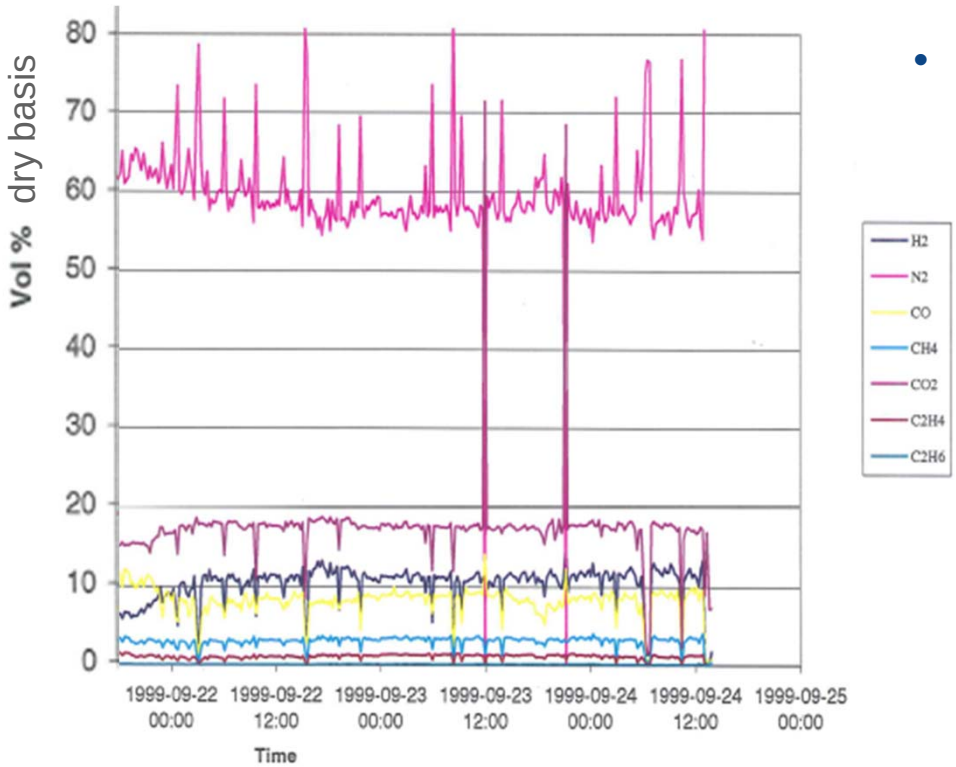
Moisture (% wt.)	13.4
Volatile matter (% wt.db.)	75.2
Ash (% wt. db.)	5,7
Fixed carbon (% wt. db.)	19.1

RDF analysis

C (% wt. db.)	46.4
H (% wt. db.)	5.8
N (% wt. db.)	7
S (% wt. db.)	0.06
Cl (% wt. db.)	0.06
O (% wt. db.)	35.1

Results: 2MW$_{th}$ CFBG

- **3 days syngas composition after the gasifier**



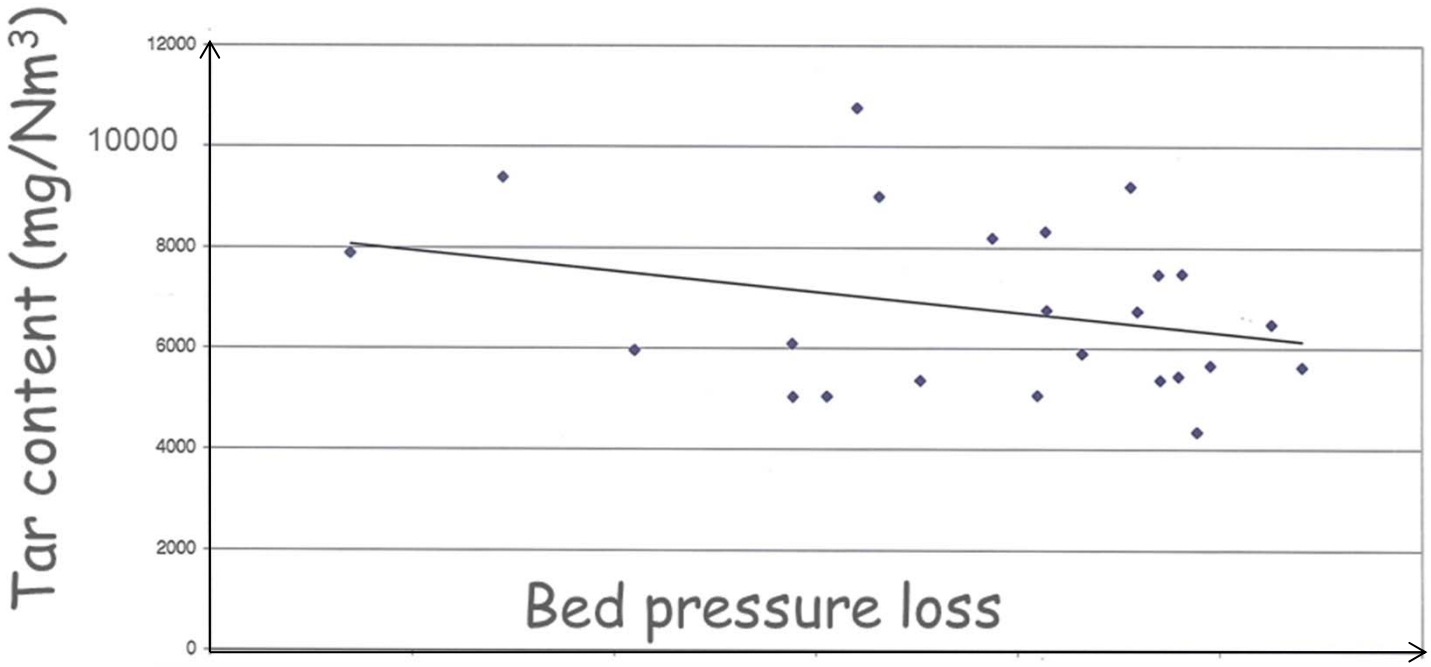
- Raw gas calorific value: ~5 MJ/Nm^3
  - N_2: ~58% vol.
  - CO_2: ~17% vol
  - H_2: ~11%vol
  - CO: ~8%vol
  - CH_4: ~4%

- **NH_3:** 28-32g/Nm^3 - Corresponds to about 70-80% of fuel nitrogen converted to ammonia (N content in fuel: about 7% wt. on dry basis)

- **Tars emissions:** 4.3 – 10.7 g/Nm^3

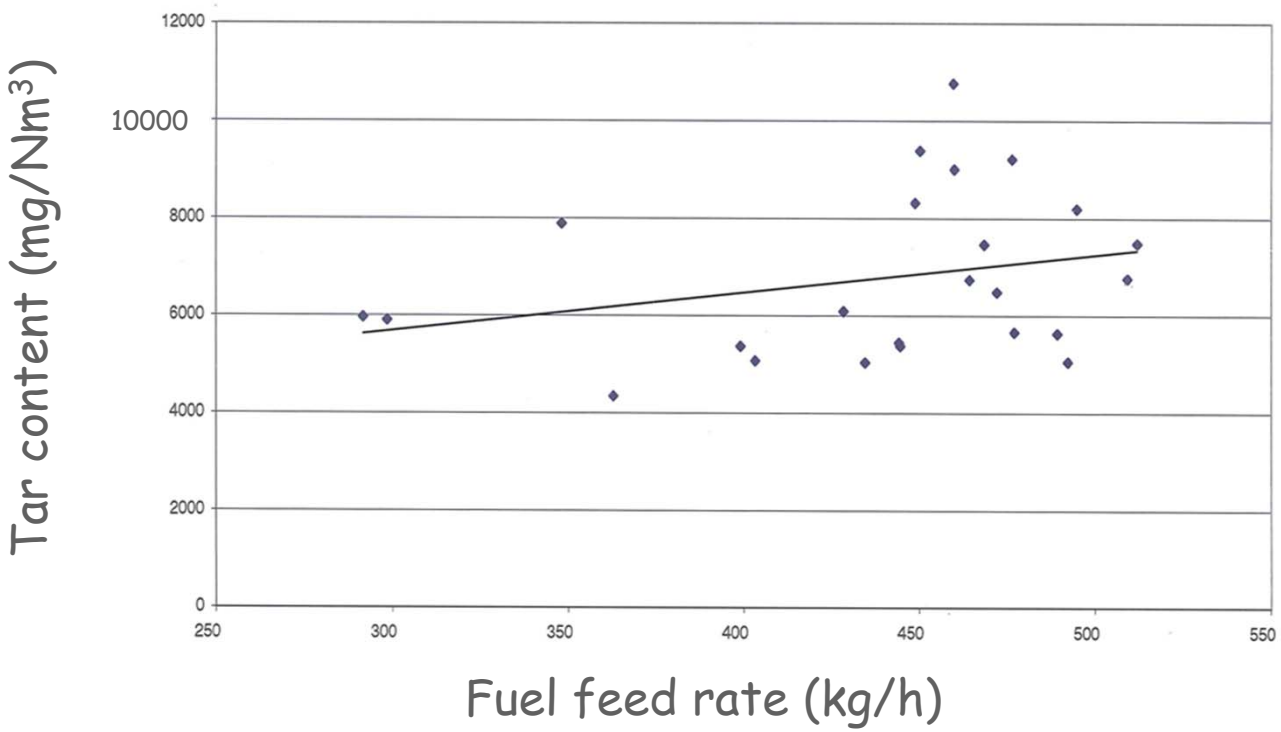
Results: 2MW$_{th}$ CFBG

- **Tars emissions:**
  - An increase of the gasifier temperature leads to a slight decrease of the amount of tars
  - The level of tars decreases with increasing bed pressure loss in the gasifier



Results: 2MW$_{th}$ CFBG

- **Tar emissions:**
  - Amount of tar from gasifier is increasing with increasing fuel feed rate (slightly lower heat up rate of the fuel fed)
  - A lower amount of tars with dolomite as bed material



Greve in Chianti plant: historical aspects

- **The Greve in Chianti plant case: an installation operated for about 10 years**
  - Commissioning of the plant in 1993
  - Two 15 MW_{th} circulating fluidized beds to provide syngas used in a cement kiln and in a boiler for power generation
  - Plant stopped in 2004

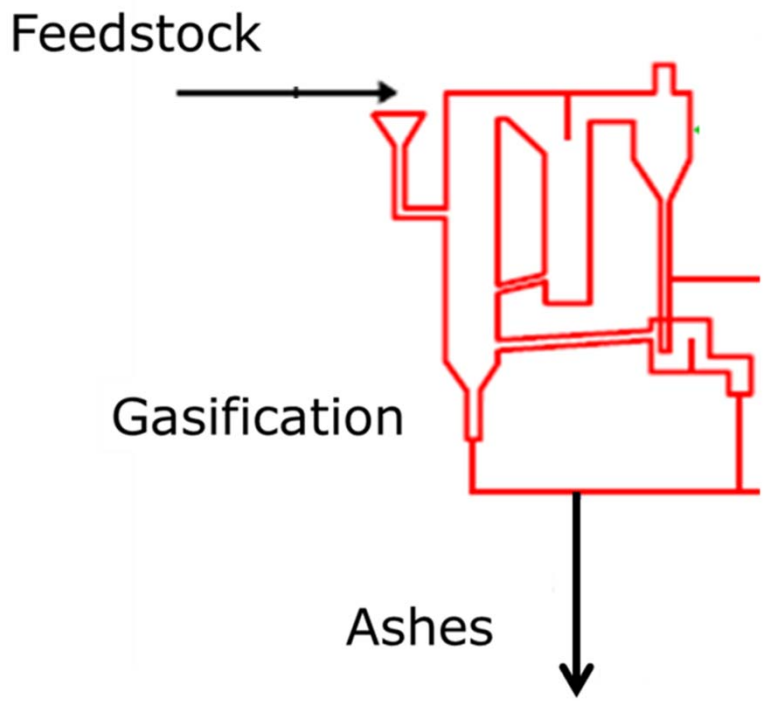
Material & Methods: the Greve in Chianti plant

- **Feedstock**

  Pellets of RDF (LCV = 19.4 MJ/kg)

Moisture (% wt.)	3.2
Volatile matter (% wt.)	73.7
Ash (% wt.)	12
Fixed carbon (% wt.)	11.1
C (% wt.)	43.1
H (% wt.)	7.7
N (% wt.)	0.9
S (% wt.)	0.3
Cl (% wt.)	0.8
O (% wt.)	32

(Greve in Chianti RDF analysis - June 2000)

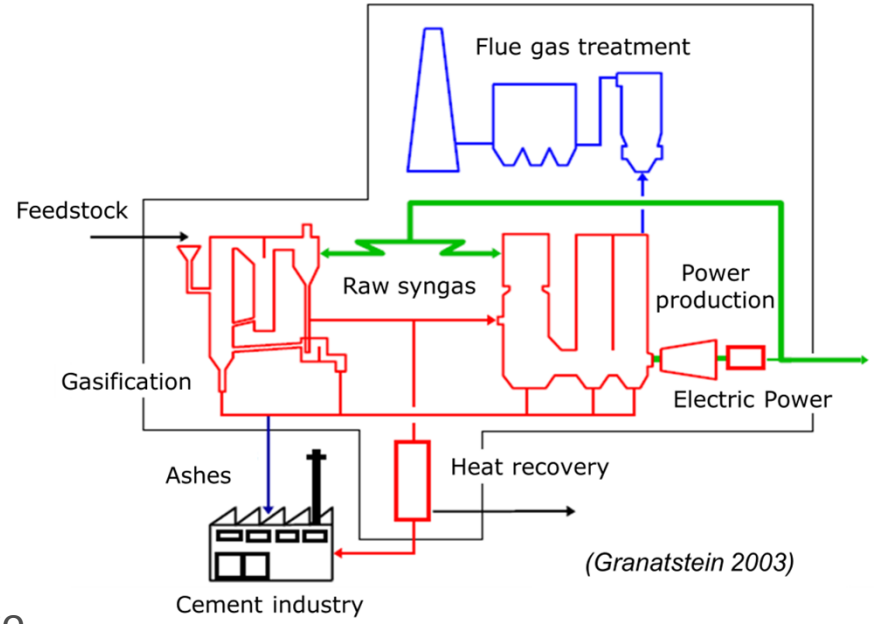


- **Gasification**
  - 800-880°C
  - Atmospheric pressure
  - Air-blown CFB gasifier
  - Solid separation units: U-Beam chamber + cyclone
  - Bottom ash discharged by gravity

Material & Methods: the Greve in Chianti plant

- **Application 1: cement industry**
  - Syngas temperature for transportation: 450°C

- **Application 2: power generation**
  - Syngas combustion in a boiler -> temperature of 1050-1200°C
  - Supplement of methane in a post combustion chamber (2 s at T > 850°C)
  - Subsequent urea injection to limit NOx emissions
  - Steam generation (380°C – 42 bar)
  - Steam turbine for electricity production (up to 6.7 MWe)



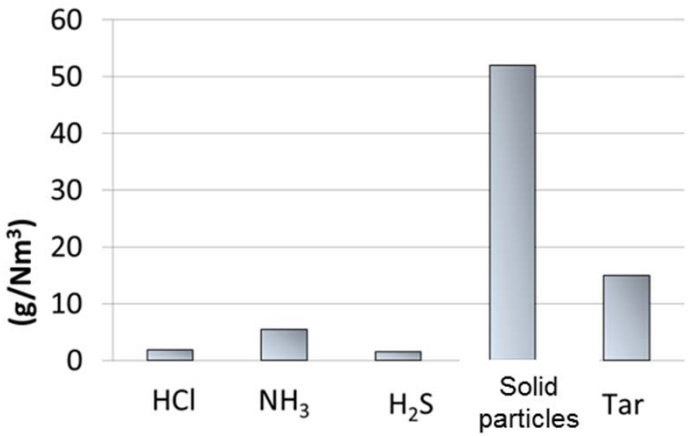
(Granatstein 2003)

Results: the 15MW$_{th}$ gasifier

- Syngas characteristics
  - Raw gas calorific value: 6.6 MJ/Nm^3
  - High content of solid particles and tars
  - Cl and S mainly converted to HCl and H_2S

H_2O (% vol.)	CO (% vol.)	CO_2 (% vol.)	CH_4 (% vol.)	H_2 (% vol.)	N_2 (% vol.)	O_2 (% vol.)	Other (% vol.)
16.5	6.5	11.4	2.9	12.1	46.4	1.6	2.6

Syngas composition (gasification at about 800°C, June 2000)

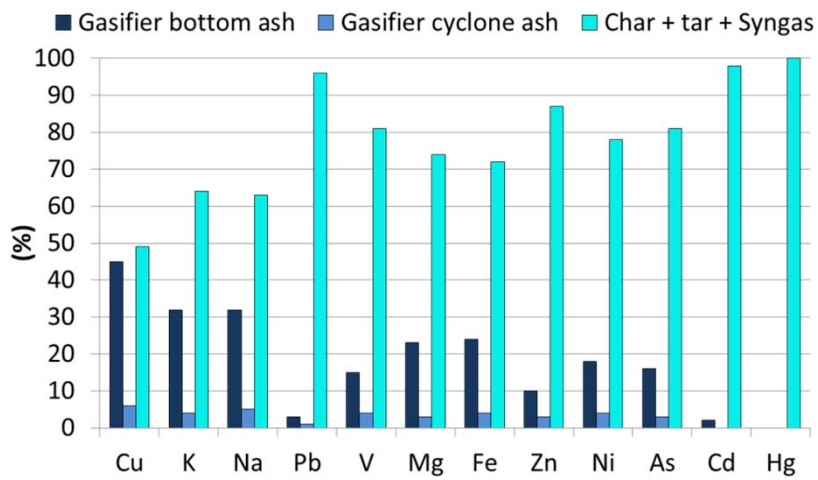


Results: the 15MW$_{th}$ gasifier

- Ashes characteristics
  - No unburned material in gasifier bottom ashes
- Inorganics partition
  - High volatile metals – as Hg, Cd and Pb – 100% contained in raw syngas
  - Only 20-30% of alkaline metal input is discharged by gasifier and cyclone

	Gasifier bottom ash	Cyclone bottom ash
Moisture (%)		0.20
Ash (%)	99.86	94.06
C (%)	0.67	5.97
H (%)	-	0.11
N (%)	-	0.12
S (%)	0.23	0.24
Cl (%)	2.22	2.57

Bottom ashes characteristics



Inorganics partition in syngas, in gasifier and cyclone ashes

15MW$_{th}$ gasifier: technical barriers and solutions

- No major problems related to the gasifier
  - Difficulties with fuel injection (when used with fluff)
    → design of a low density fuel feeding system
  - Bed sintering during commissioning, due to the injection of too much primary air into the gasifier
    → respect of the design stoichiometric ratio
  - Particle concentration in the syngas higher than expected
    → addition of a second cyclone
  - Bottom ash extraction system blocked because of metal pieces in RDF
    → continuous unloading at lower velocity

Conclusions

- RDF gasification at pilot scale (2 MW_{th})
  - Validation of the design of the CFBG and of the operating conditions

- RDF gasification at commercial scale (15 MW_{th})
  - Production of a syngas with a calorific value of about 6MJ/Nm^3
  - Syngas valorized in a cement kiln and for power generation
  - No major problems related to the gasifier after the commissioning of the installation

- Extensive feedback for LLT from the design, commissioning and operation of a RDF gasifier
  - Design, process characteristics and mass balance
  - Solutions organized (fluff fuel injection, bottom ash extraction…)

Thank you for your attention!

timothee.nocquet@lerouxlotz.com