2015

A REVIEW ON PLASMA TECHNOLOGIES APPLIED TO THERMO-CHEMICAL BIOMASS CONVERSION

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ECI

Biorefinery I: Chemicals and Materials from Thermo-Chemical Biomass Conversion and Related Processes

A REVIEW ON PLASMA TECHNOLOGIES APPLIED TO THERMO-CHEMICAL BIOMASS CONVERSION

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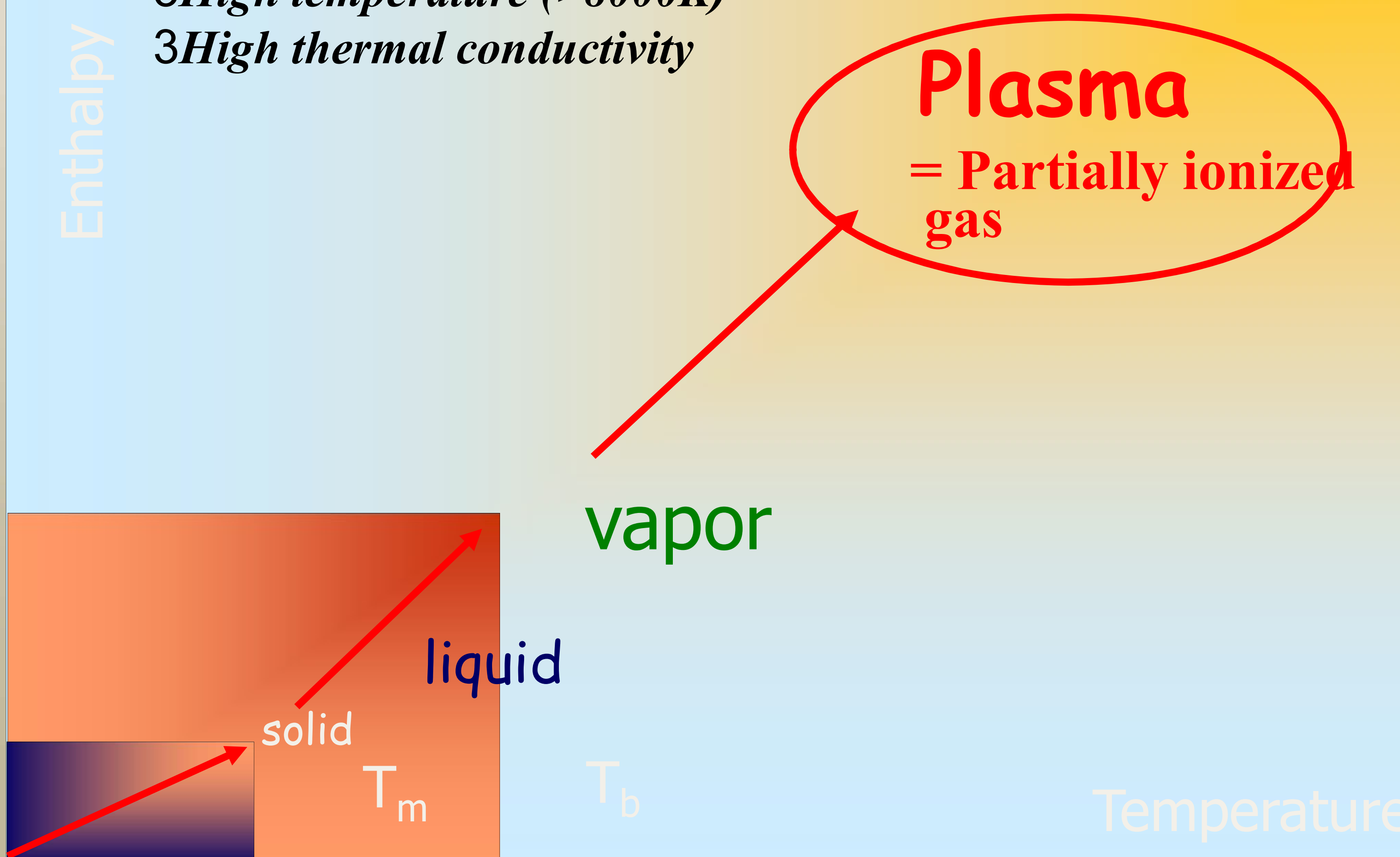
Outline

- Introduction
  - What is a plasma?
  - Different types of plasmas
- Plasma and Gasification
- Plasma and Tar Removal
- Plasma and Gas Treatment
- Examples of Industrial Projects
- Conclusion

What is a plasma?

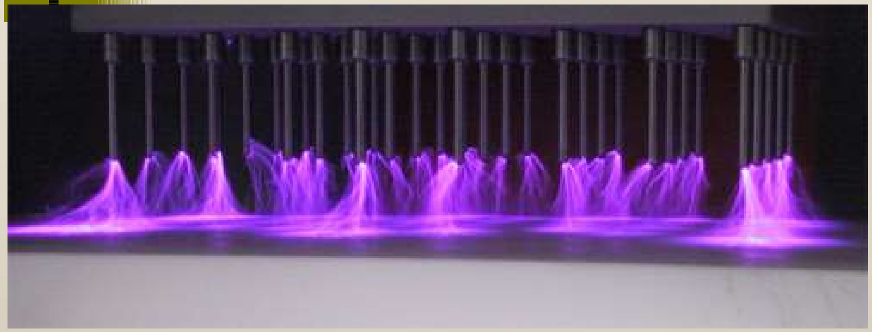
- *3High temperature (>8000K)*
- *3High thermal conductivity*

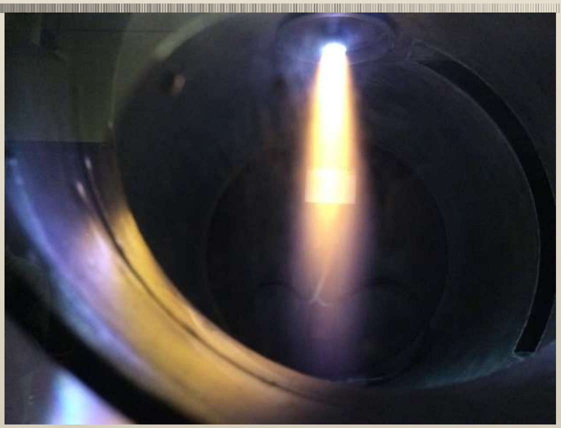


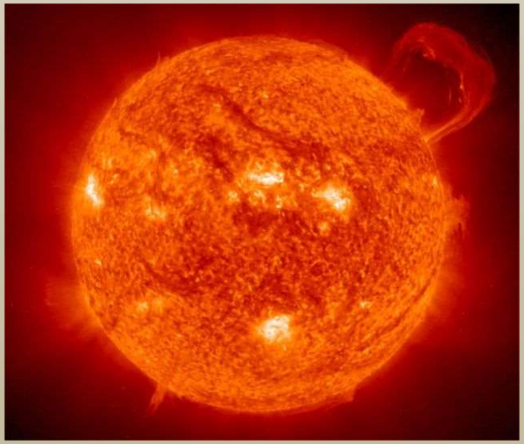
What is a Plasma?

- There are thermal plasmas (hot plasma) and non equilibrium plasmas (cold plasmas)
- Basic differences between cold and hot plasmas are related to ions and electrons energies and densities

Cold vs Thermal Plasmas







Images and composition from FNGSDS 2015

Électrons are energised

Électrons and Ions are energised

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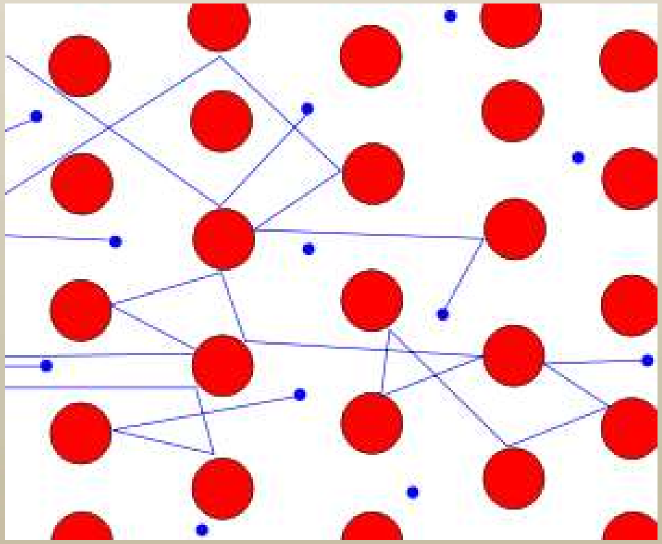
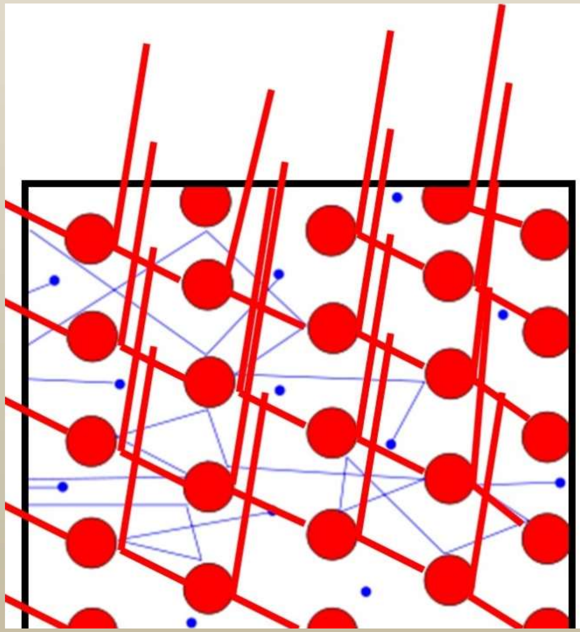
Cold vs Thermal Plasmas





Images and composition from FNGSDS 2015

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Thermal Plasma Pyrolysis and Gasification

- Thermal plasma is:
  - flexible (different gases),
  - scalable to multi megawatt,
  - as clean as the electricity it is produced from,
  - Instantly variable
  - high enthalpy density,
  - compact and can be retrofitted

Thermal Plasma Pyrolysis and Gasification

- Thermal plasma offers:
  - Better control of process temperature,
  - Higher process rates,
  - Lower reaction volume
  - Optimum composition of produced syngas.
  - Particles kinetic energy in the form of heat transfer is used for decomposing biomass.
  - Charged and excited species which renders the plasma environment highly reactive
  - Lower gas flow rates which can carry energy

Thermal Plasma Pyrolysis and Gasification

- Thermal plasma benefits:
  - Energy for gasification is supplied by plasma
  - Energy independent of the treated substances
    - flexibility, fast process control, broad range of biomass feedstock
  - No combustion gases generated
  - Easy reactor temperature controlled by plasma power and material feed rate.
  - High temperatures and homogeneous temperature distribution in reactor
  - Less production of higher hydrocarbons, tars

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Thermal Plasma Pyrolysis and Gasification

- Thermal plasma benefits:
  - Shorter residence times and large throughputs
  - Highly reactive environment and easy control of composition of reaction products
  - Low thermal inertia and easy feedback control
  - Much lower plasma gas input unit heating power
  - Lower amount of gases diluting produced syngas.

Thermal Plasma Pyrolysis and Gaseification

- Typical thermal plasma gases used:
  - Air with AC plasma generation
    - Low specific enthalpy
    - NOx production
  - Air/argon DC plasma generation
    - High specific enthalpy
    - NOx production
  - H_2O/argon DC plasma generation
    - High specific enthalpy
    - no Nox production
  - -- Possibility of using CO_2 plasma gas

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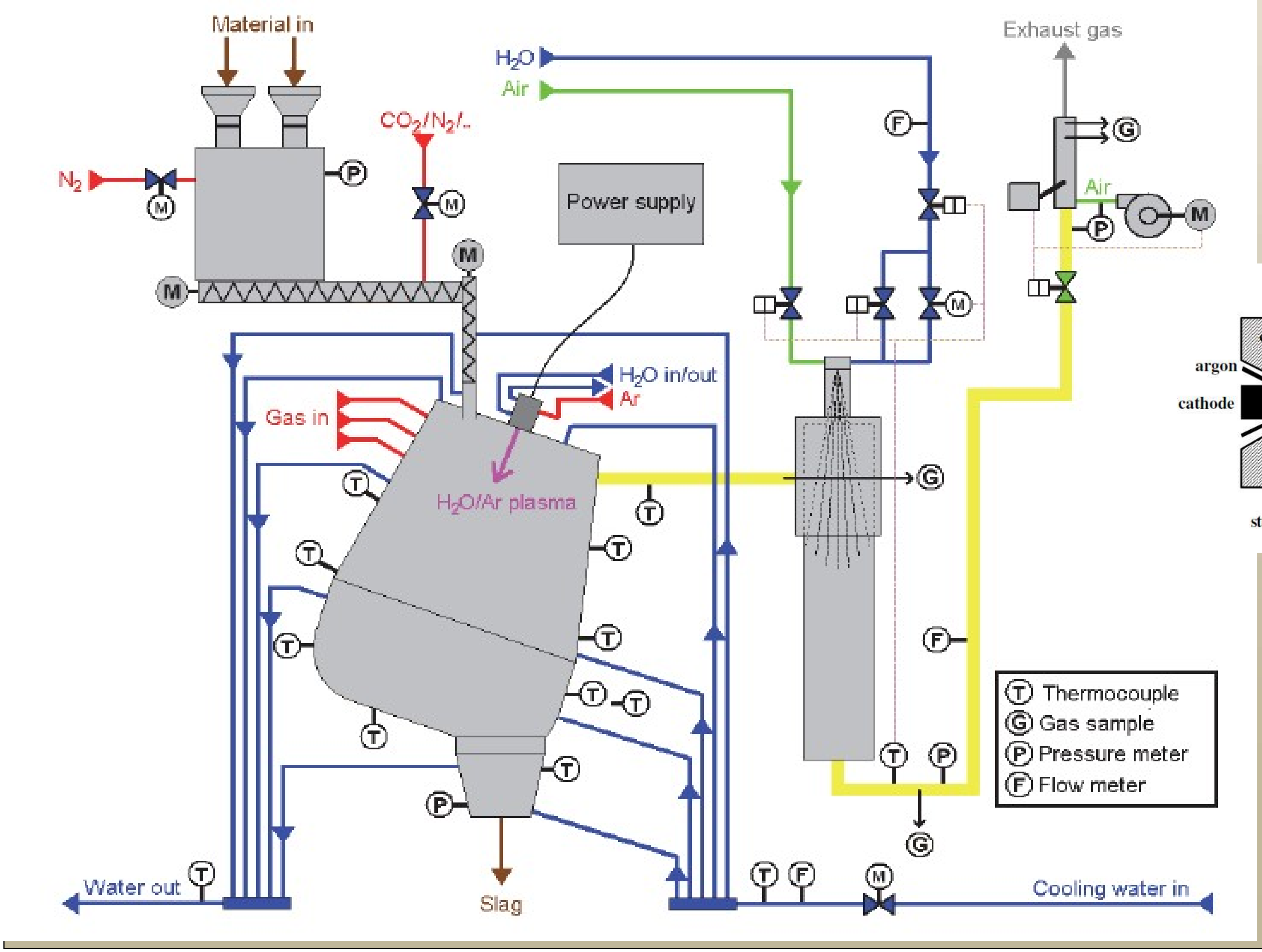
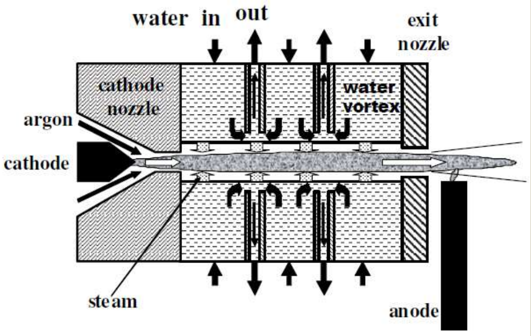
The Plasgas reactor





Progress in Biomass and Bioenergy Production, chap 3 Thermal gasification of Biomass by Milan Hrabovski 2011

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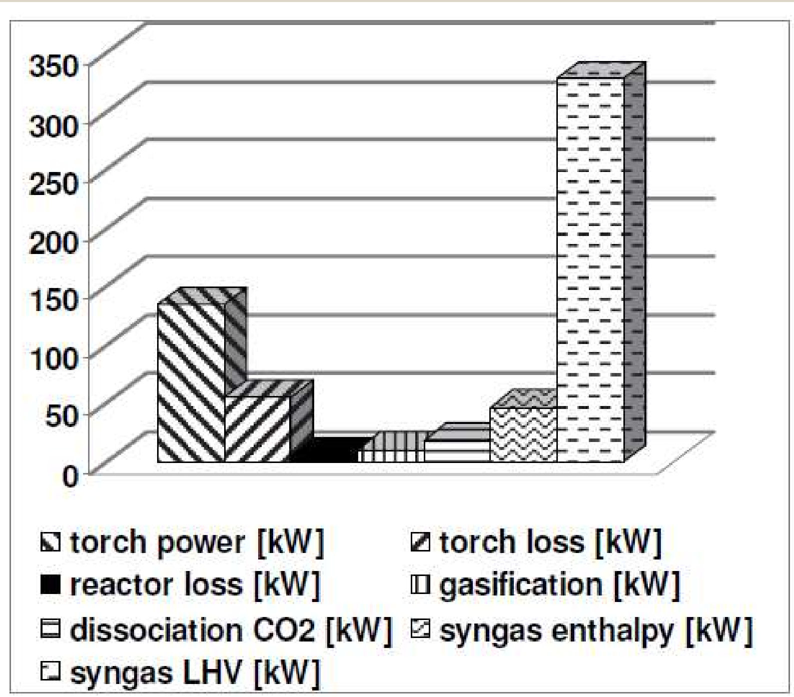
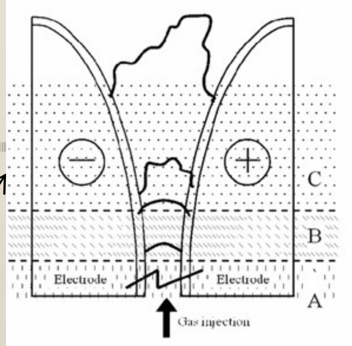
Plasgas results

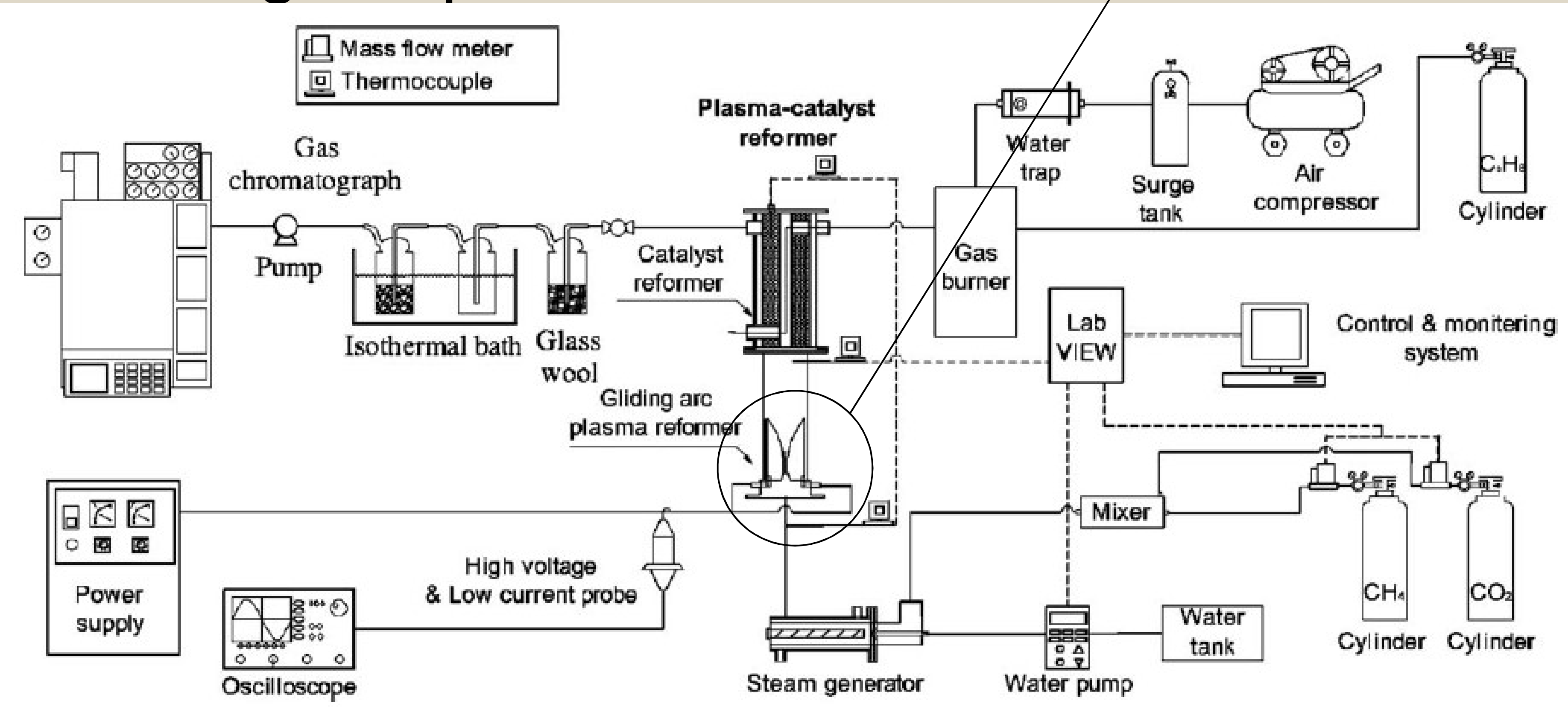
	material	% H2	% CO	% CO2	%CH4	% O2	C_{out}/C_{in}
1	wood	44,8	39,2	15,0	0,9	0,1	1,0
2	wood	41,5	42,5	14,9	1,0	0,1	0,9
3	wood	34,6	51,4	12,6	0,4	1,0	1,0
4	wood	41,5	54,1	3,3	0,3	0,8	1,0
5	wood	43,6	52,0	3,3	0,3	0,8	1,0
6	pellets	48,1	40,0	11,0	0,1	0,8	0,7
7	pellets	36,5	59,1	3,4	0,1	1,0	0,8
8	pellets	41,5	52,7	4,8	0,2	0,8	0,8
9	PE	29,9	41,3	27,1	0,0	1,7	1,0
10	PE	35,3	41,5	21,7	0,1	1,4	1,0
11	plastics	41,6	49,7	7,4	0,0	1,3	0,7



Cold Plasma Tar Decomposition



- Gliding arc plasma reformer



Catalysis Today 148 (2009) 283–289

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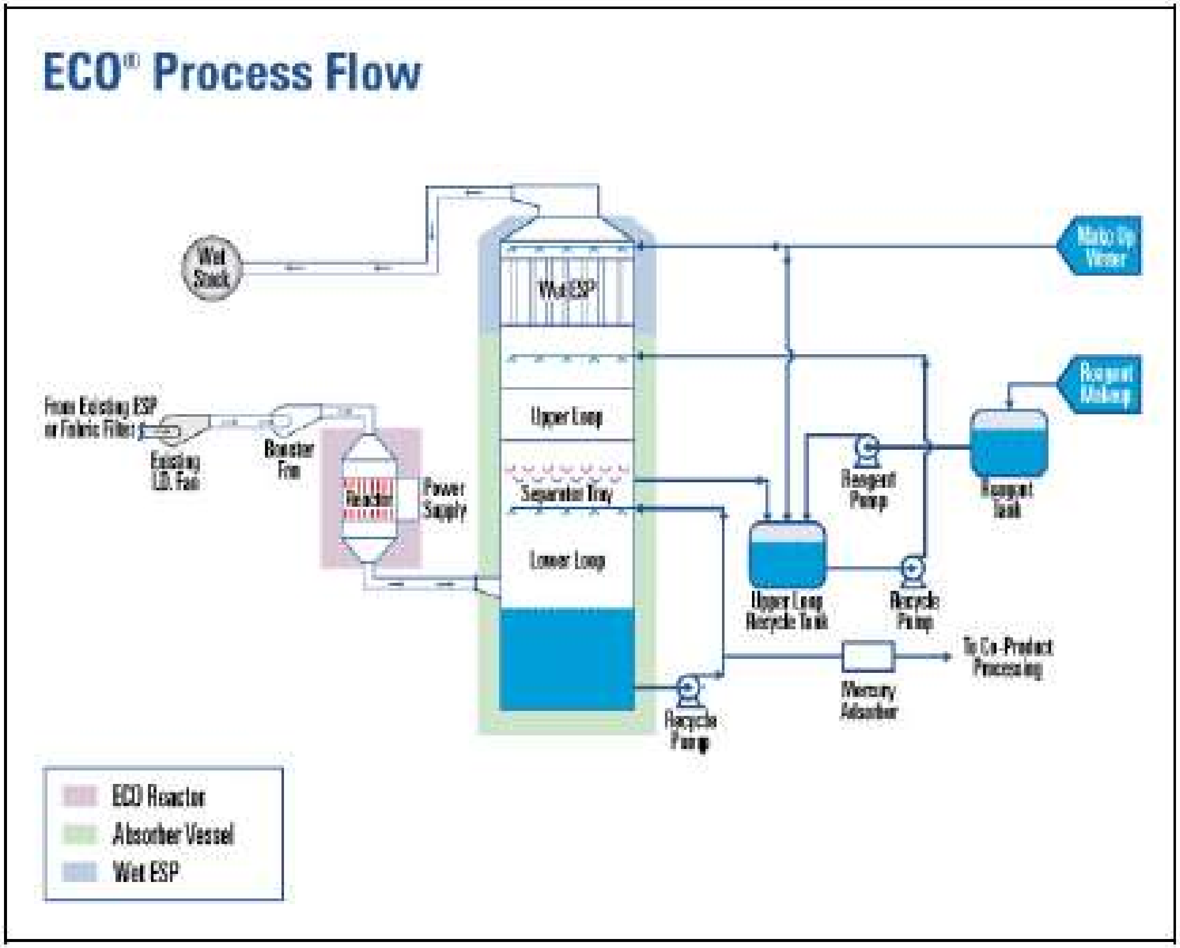
Cold Plasma Flue Gas Treatment



- o OECO reactor — oxidizes pollutants by DBD plasma
- o Absorber vessel — removes SO2, NO2, and oxidized mercury;
- o Wet electrostatic precipitator (wet-ESP) --- removes acid aerosols, air toxics, and fine particulate matter.

Industrial ECO plant at Bay Shore Plant in USA.

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Plasma Gasification Industrial Application

- Alter NRG
  - Location : Wuhan China
  - Westinghouse plasma technology
  - 1000 tons/day of biomass
  - Syngas → green diesel
  - Potential of 100 to 150 sites

Plasma Gasification Industrial Application

- C-H-O plasma
  - 51500 t/y (150 tpd) biomass
  - heat (18MWth) and electricity (12MWe) production

CHO Power test unit is located in Morcenx (Landes-France) equiped with Europlasma torch
www.cho-power.com

Plasma Gasification Industrial Application

- Pyrogenesis : Plasma Ressources Recovery reactor

PAWDS System from Pyrogenesis Inc. Montreal, Qc, Canada

Conclusion

- Thermal plasmas
  - Smaller plants than for conventional reactors due to high energy densities,
  - Lower gas flows, and volume reduction
  - Possibility of using high enthalpy water vapour
- Cold plasmas
  - Post processing of tar and flue gas cleaning
- Industrial applications are developping

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Thank-you for your attention!

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