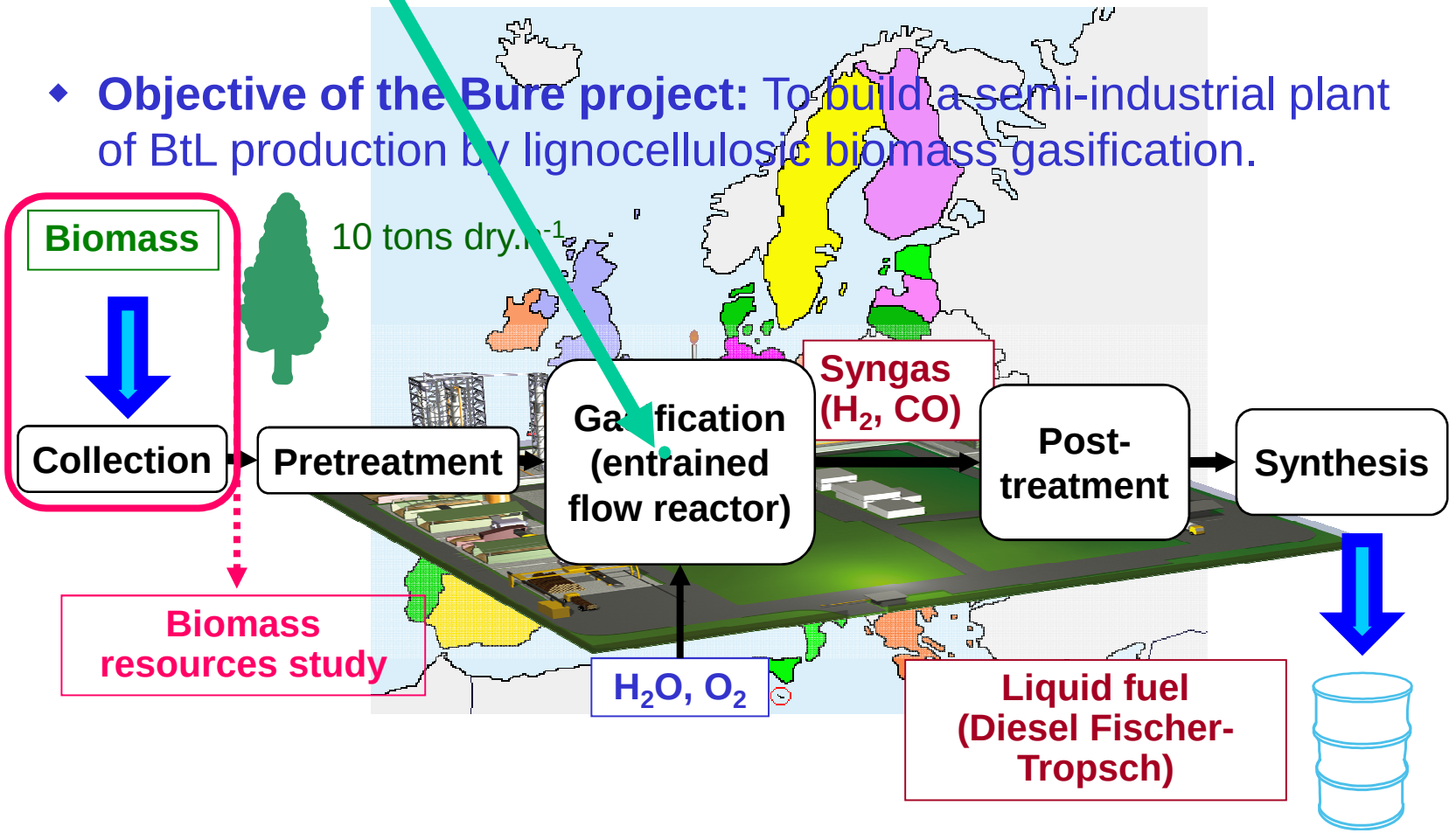
Suitability of Wood Chips from Forestry & Different Biomass Feedstocks for Use in a Semi-industrial Plant of BtL Production by Gasification

Capucine DUPONT, Sylvie ROUGE, Alain BERTHELOT, Denilson DASILVAPEREZ, Ambroise GRAFFIN, Françoise LABALETTE, Céline LABOUBEE, Jean-Claude MITHOUARD, Sophie PITOCCHI

The Bure project

- **Where is Bure?**

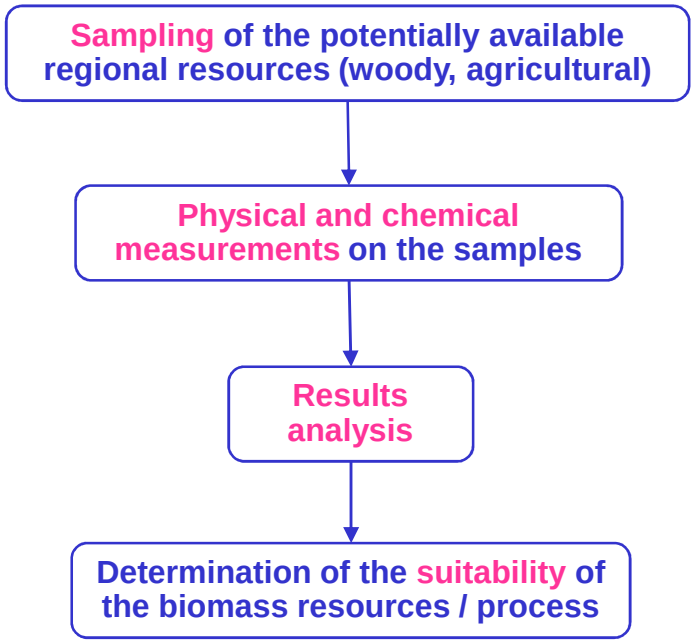
- **Objective of the Bure project:** To build a semi-industrial plant of BtL production by lignocellulosic biomass gasification.



Biomass regional resources study

1. Resources potential availability and supply feasibility
   - Resources partners
2. Suitability biomass resources / process
   - Process partners: CEA

- Working plan:



Biomass regional samples

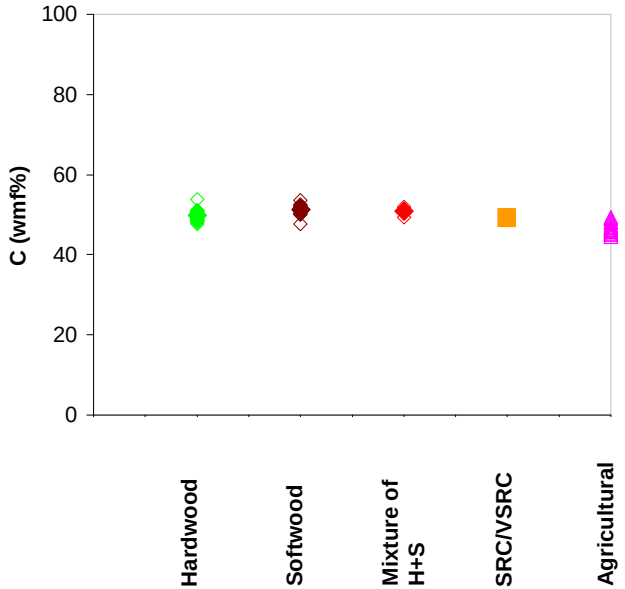
- 92 samples gathered into 3 main families:
  - 60 Wood chips from forestry:
    - Alder, ash tree, aspen, beech, birch, false acacia, hornbeam, lime, oak, poplar, Scot pine, spruce, willow

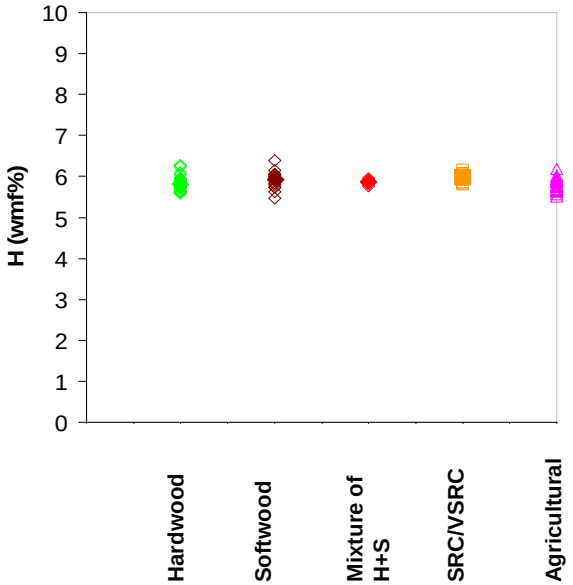

  - 11 Wood chips from (Very) Short Rotation Coppice:
    - Poplar (5 VSRC, 4 SRC)
    - Willow (2 VSRC)

  - 21 Agricultural raw materials:
    - Straw: barley, corn (3), rape, wheat (2)

    - Energy crops: alfalfa, miscanthus (6), sweet and fiber sorghum, switchgrass (3), tall fescue, triticale.


Major elements

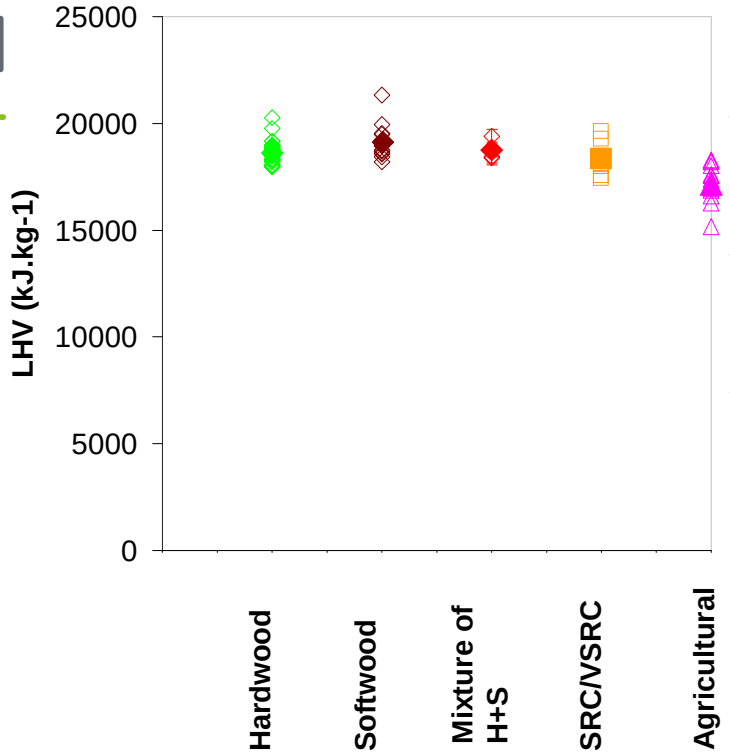




O calculated by difference

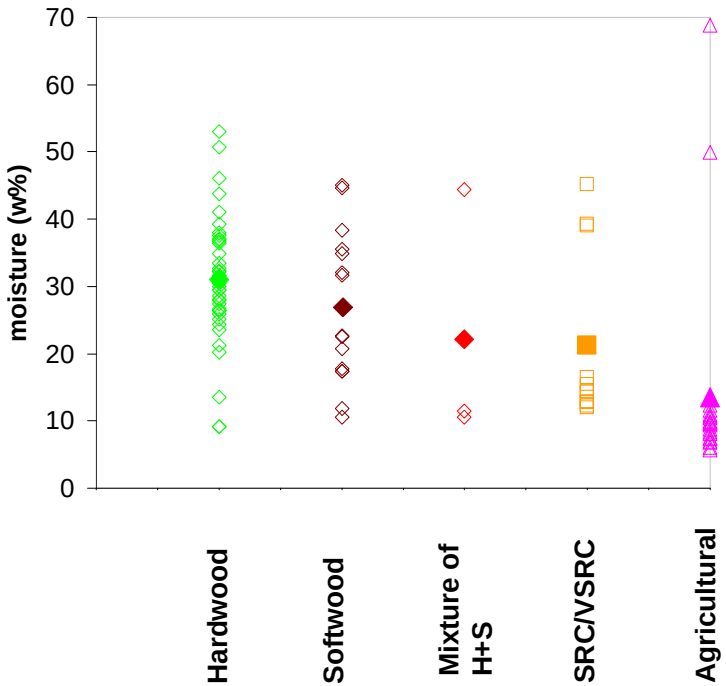
- Very little variability
- Average value: C: 49 wmf% H: 5.9 wmf% O: 42.3 wmf%

Lower Heating Value (LHV)



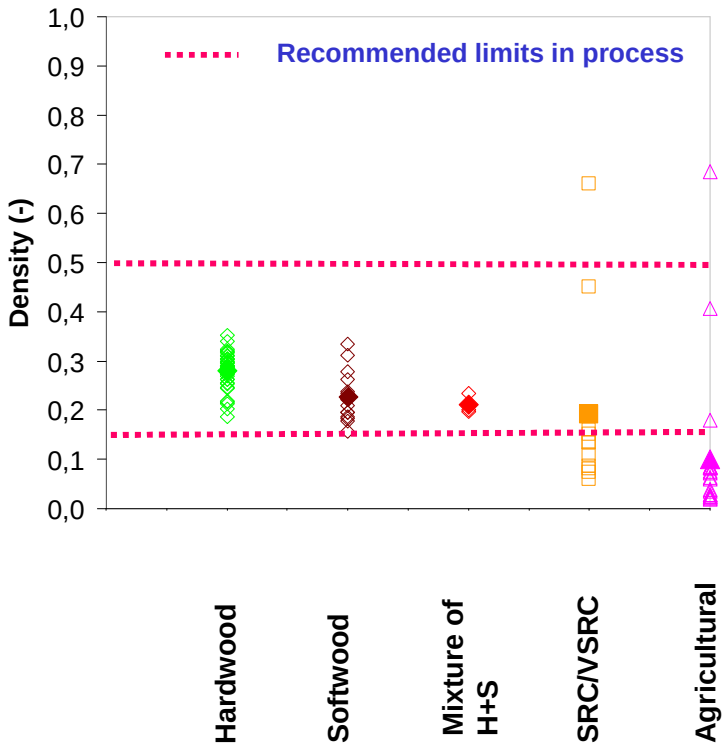
- Little variability
- LHV (forestry)=LHV ((V)SRC)= 18.8 MJ.kg^{-1}
- LHV (agricultural)=LHV (wood)-1 MJ.kg^{-1}

Moisture content



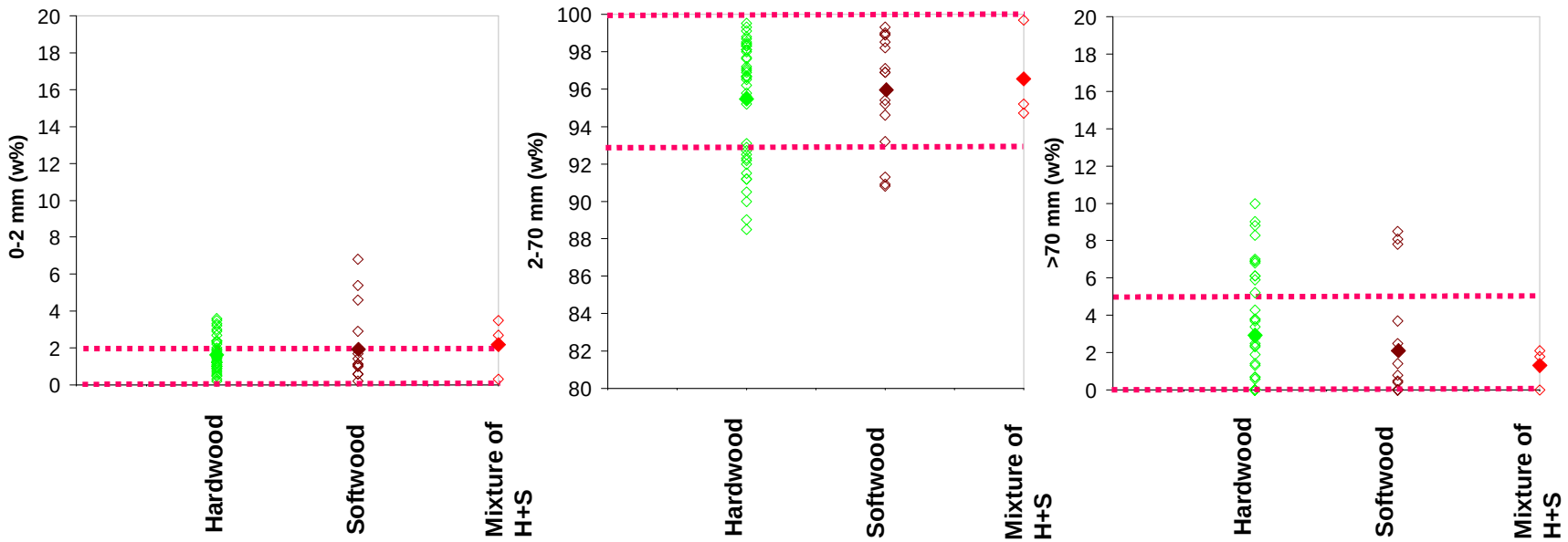
- Large variability (5→70 w%)
- Related to:
  - The drying time for wood
  - The harvesting date for agricultural biomass (miscanthus, switchgrass)
    - Before or after winter
- No strict process constraint
    - Dryer on the unit
- Wood chips: 30-50 w%

Apparent density



- Correlated with:
  - moisture
  - sample form
- Not significant on (V)SRC
- Wood: little variability
  - Average value : 0.25
    - ↳ Process: OK
- Agricultural biomass: too low<0.1
  - ↳ Densification needed

Wood chips size

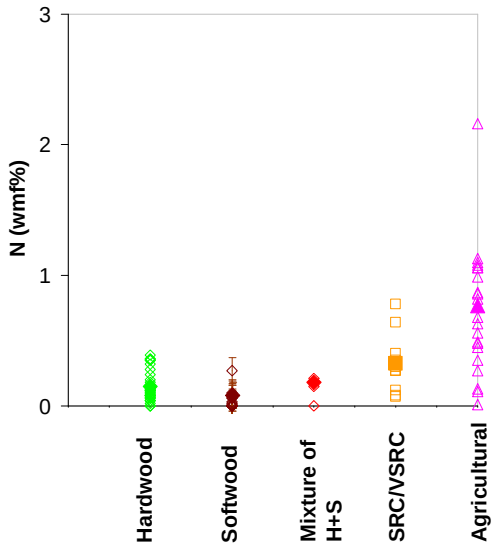


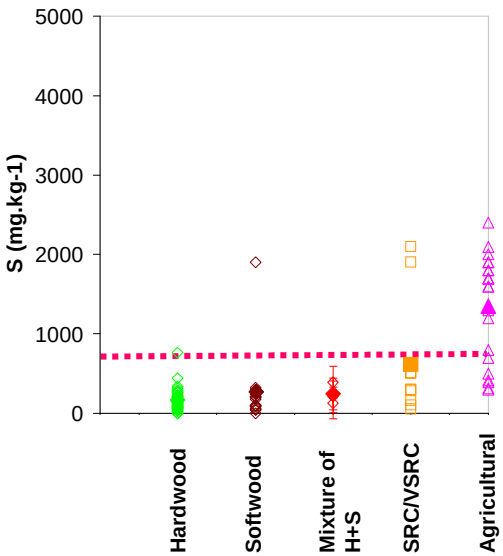
- Too many fine particles (<2 mm)
- Too many large particles (>70 mm)

↳ To be checked by suppliers

Minor elements (1)

Recommended maximum in process

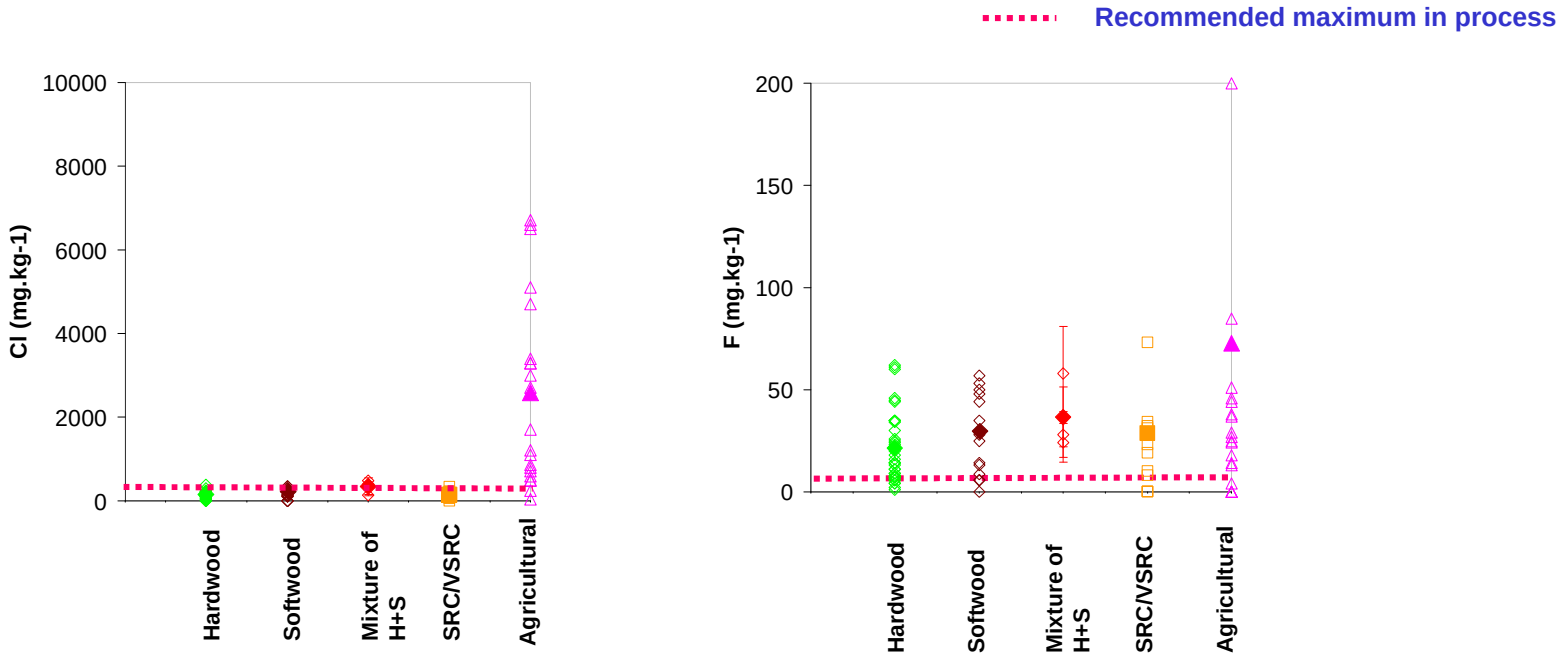




- **Nitrogen:** relatively low amount (<1 wmf% except in alfalfa)
  - Wood: little variability (average: 0.4 wmf%)
  - Agricultural biomass (1 wmf%)> wood (forestry, VSRC)
    - ↳ Fertilizers
  - No strict process constraint

- **Sulfur:** <0.2 wmf% in nearly all samples
  - Wood (forestry, VSRC): OK in most samples
  - Agricultural biomass: slightly higher than specifications in most samples

Minor elements (2)



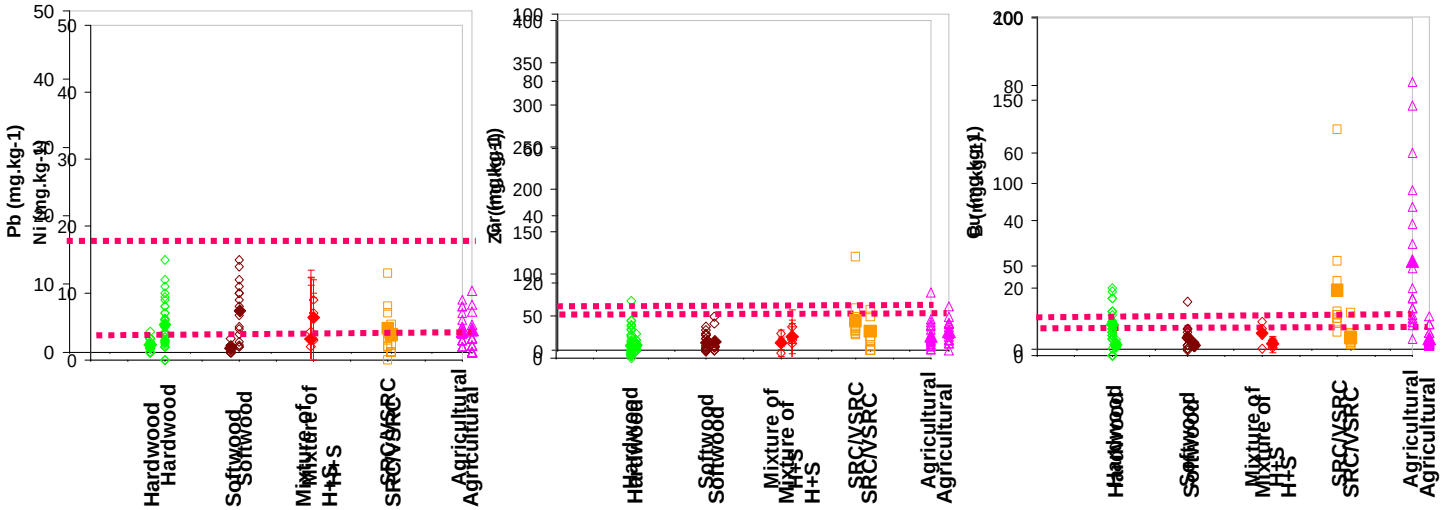
- **Chlorine:** Strong difference between wood (forestry, VSRC) / agricultural biomass
  - Wood (forestry, VSRC): OK – little variability (50→240 ppm)
  - Agricultural: much higher than specifications in nearly all samples (average: 2500 ppm)

- **Fluorine:** little variability (about 35 ppm)
  - Very harmful for the process even in low amount

Metals

Recommended maximum in process

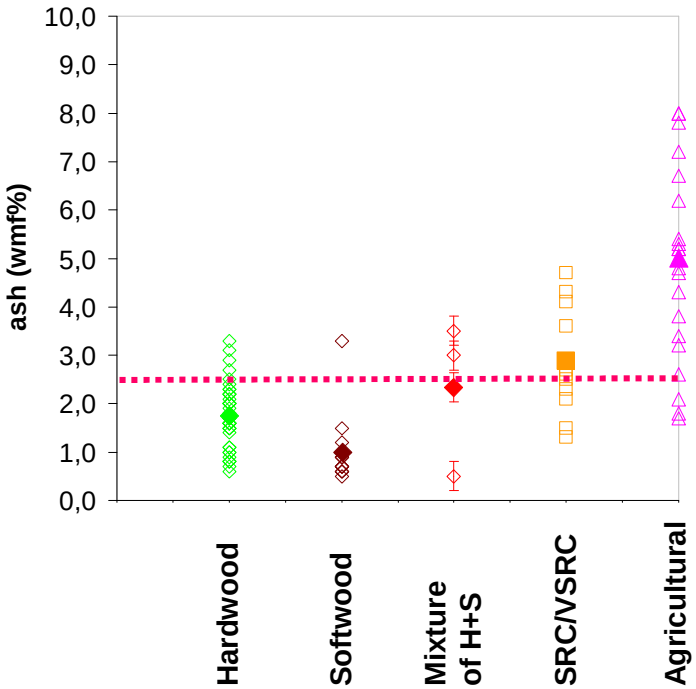
- **Arsenic, Cadmium, Mercury**: below detection limit - OK



- **Chromium, Lead, Copper:** near measurement uncertainty - OK
- **Nickel:** Very low amount allowed →Some samples slightly higher than specifications
- **Zinc:** OK except in poplar from forestry and willow (VSRC)
- **Boron:** OK – slightly high in some VSRC and agricultural samples

Metals content: <100 mg.kg^{-1} →OK except in a few samples

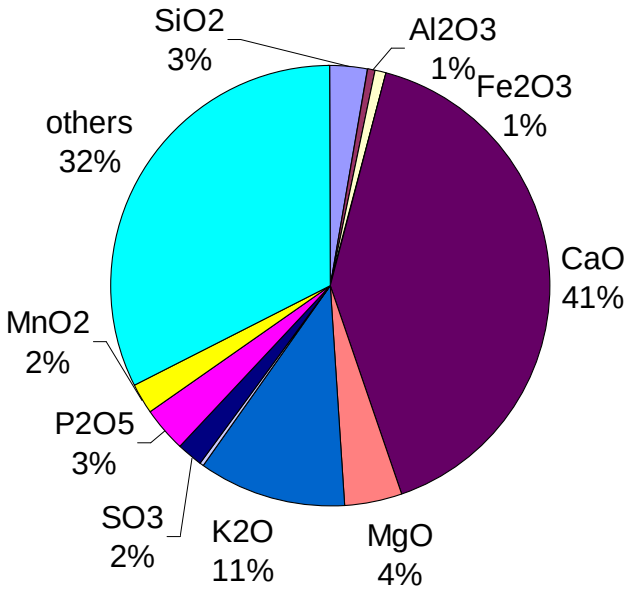
Ash content



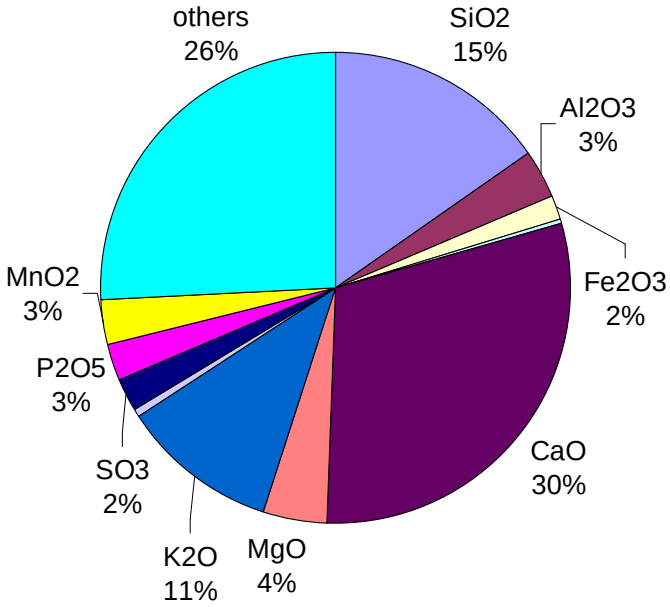
Recommended maximum in process

- Ash (forestry)<ash (VSRC)<ash (agricultural)
- Forestry wood: OK in nearly all samples (1-2 wmf%)
- (V)SRC: higher than specifications in most samples (~3 wmf%)
  - Less ash in willow (1.5 w%)
- Agricultural: higher than specifications in nearly all samples (~5 wmf%)
  - No link between species and ash content
  - Influence of the harvesting modality

Ash composition: woody biomass



Case 1



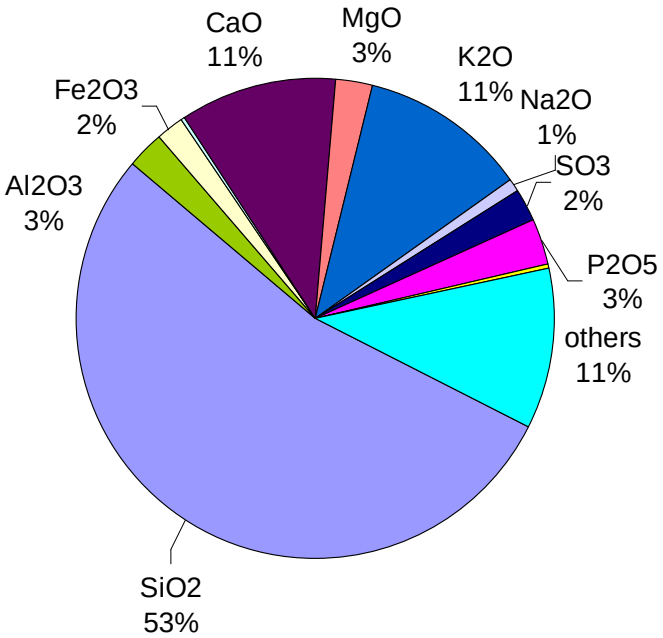
Case 2

- Little variability – 2 main cases:

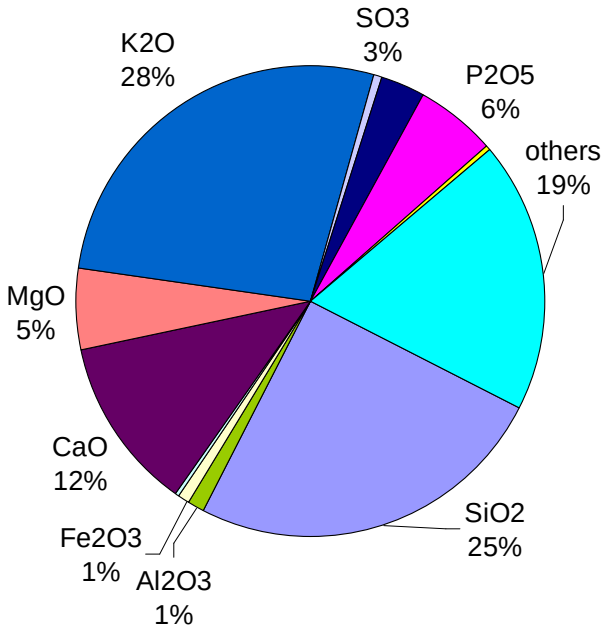
1. Most samples (including (V)SRC): CaO >> K_2O>SiO_2
2. 1/3 of the samples: CaO >SiO_2 >K_2O

- CaO tends to increase woody ash melting point

Ash composition: agricultural biomass



Miscanthus, switchgrass, wheat straw



Other agricultural biomasses
(except rape and alfalfa)

- Two main families:
  - SiO_2>>CaO et K_2O
  - SiO_2=K_2O>CaO
- SiO_2 and K_2O tend to decrease agricultural biomass ash melting point

Synthesis of the results

✓ Good suitability of most properties in all biomasses

✓ Little variability inside each family (forestry, (V)SRC, agricultural)

☒ Problematic properties:

- Density: too low in agricultural biomass
- Particle size: too many fines in wood chips
- S, F: too high amount in most samples
- Cl: too high amount in agricultural samples
- Zn, B: slightly too high amount in some samples
- Ash content: slightly too high in VSRC – too high in agricultural
- Ash melting point: linked with ash composition→probably lower for agricultural biomass

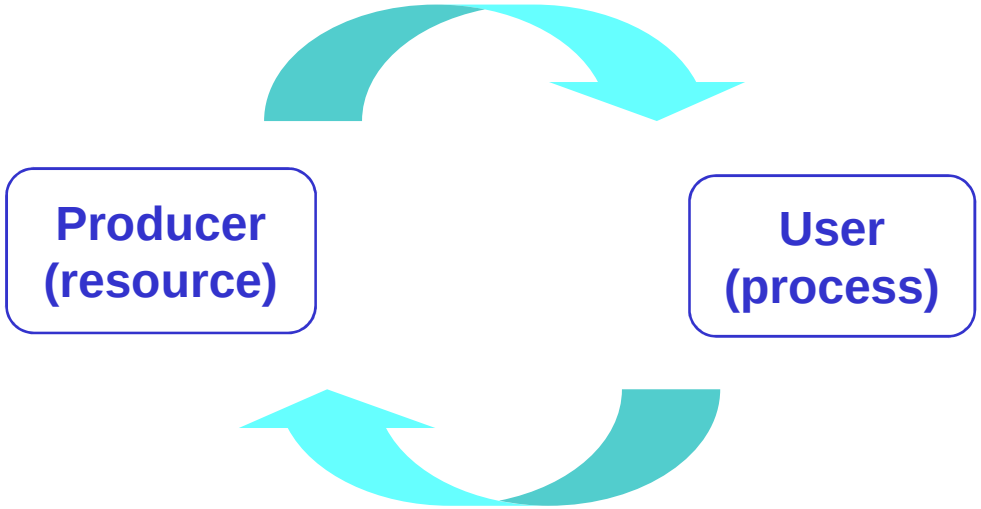
Conclusion

- Suitability biomass resources / process?
  - Wood chips from forestry: the most suitable
    - Starting feedstock for the process
  - Wood chips from (V)SRC: relatively close to wood from forestry
    - Problematic issue: ash content
    - Short-term alternative
  - Agricultural material: more difficult
    - Problematic issues: density, Cl content, ash content and melting point
    - Short to mid-term option used in mixture

Further work

Biomass quality improvement:

- ✓**Cultivation method (fertilizer, harvesting date…)**
- ✓**Species**



Process flexibility improvement:

- ✓**Pretreatment (torrefaction, pelletization…)**
- ✓**Use of biomass mixtures**

Obrigada !

Thank you !

Merci !

If you have any questions, please contact:

capucine.dupont@cea.fr