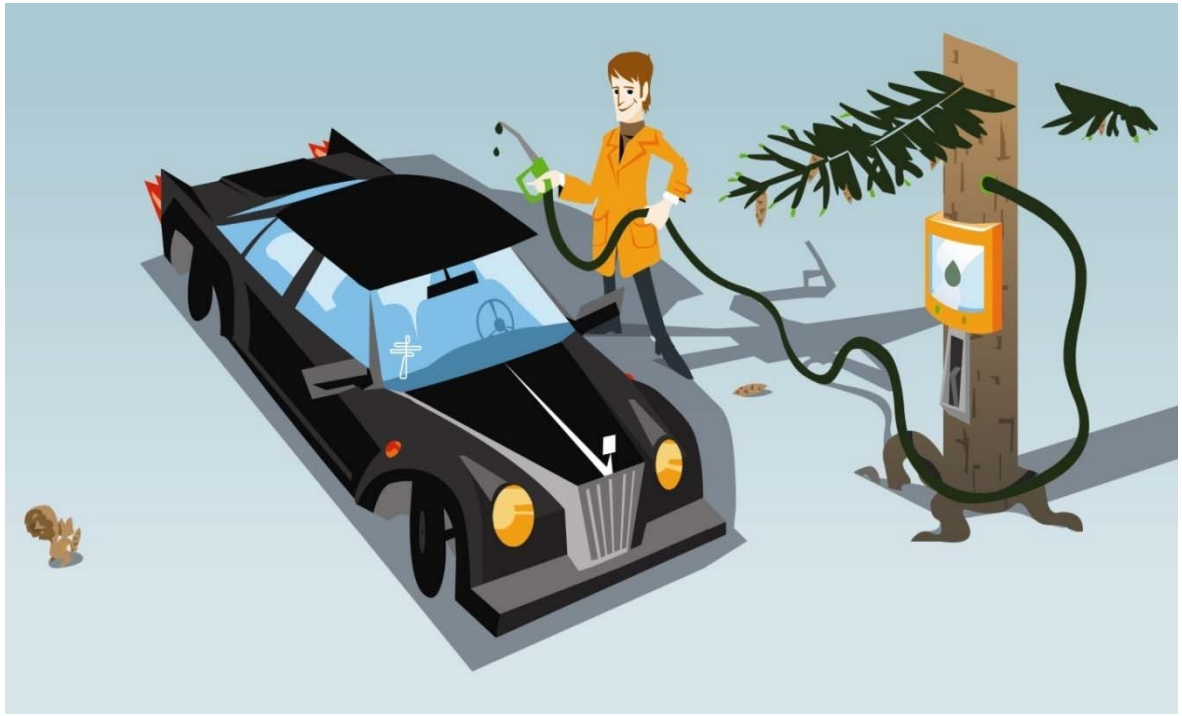
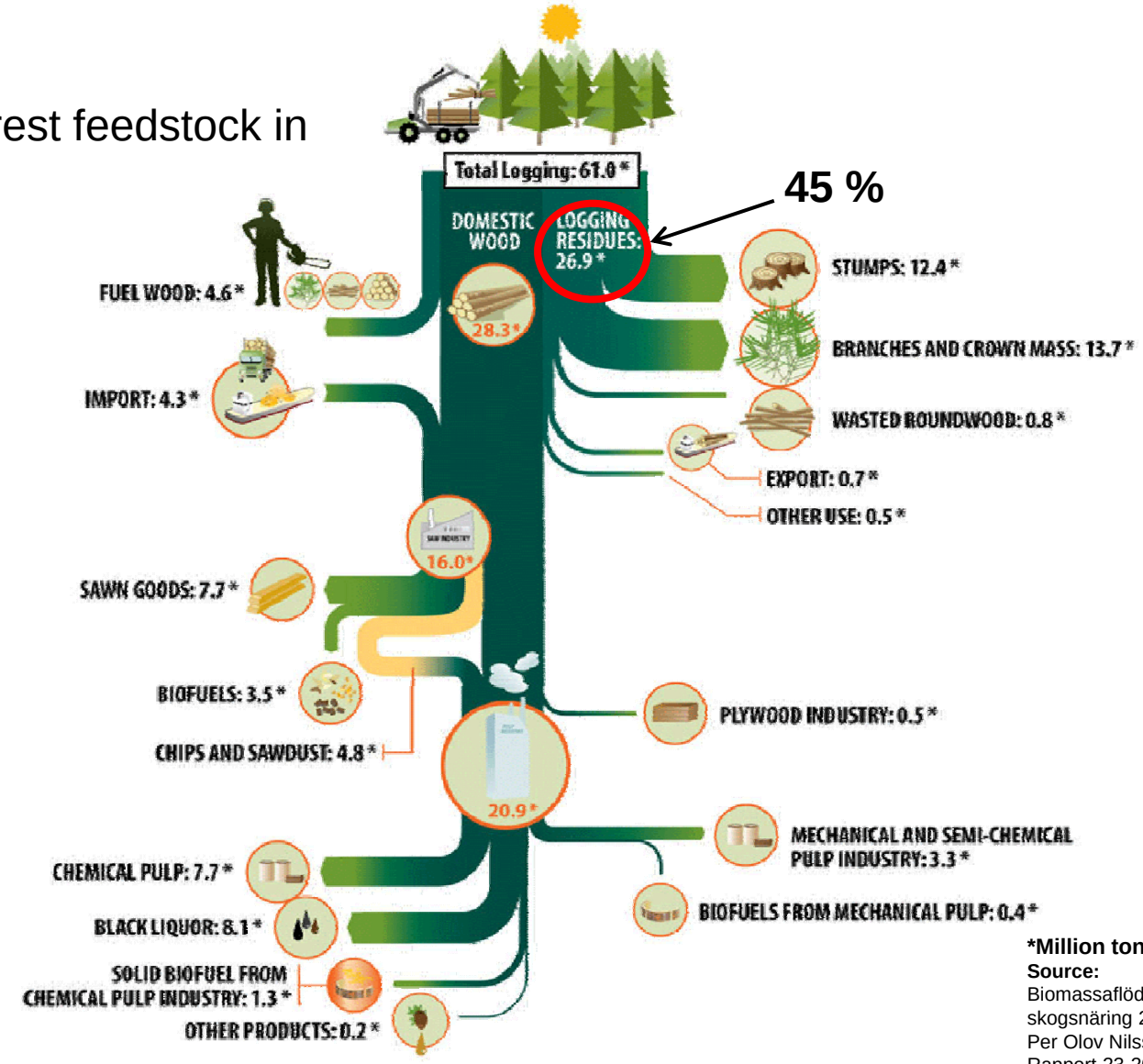
Renewable motor fuels from the forest industry via Pressurized Entrained flow Biomass Gasification (PEBG)



Introduction

Use of forest feedstock in Sweden



***Million tons dry biomass**

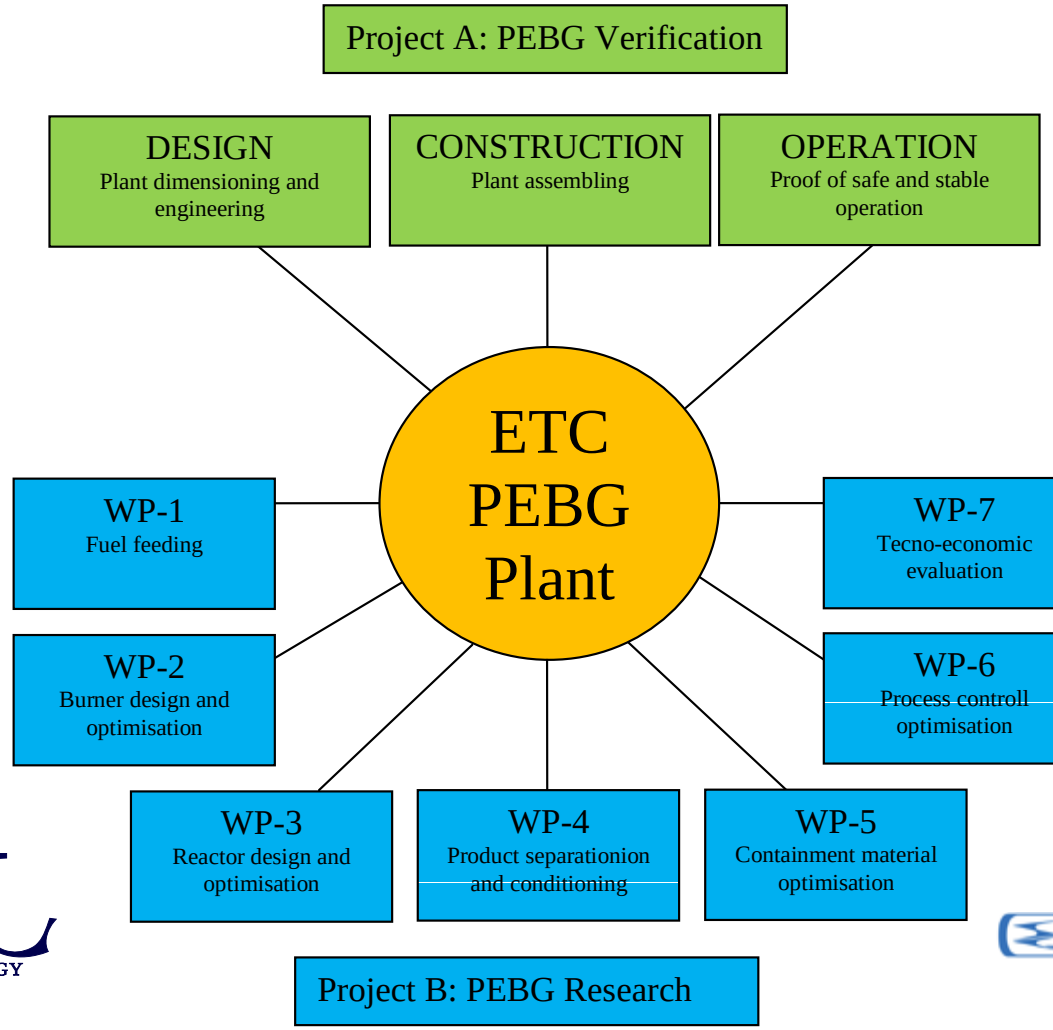
Source:
Biomassaflöden i svensk skogsnäring 2004,
Per Olov Nilsson.
Rapport 23-2006
Skogsstyrelsen
ISSN 1100-0295

PEBG Project

“Transportation Fuels from Forest Residues via PEBG”

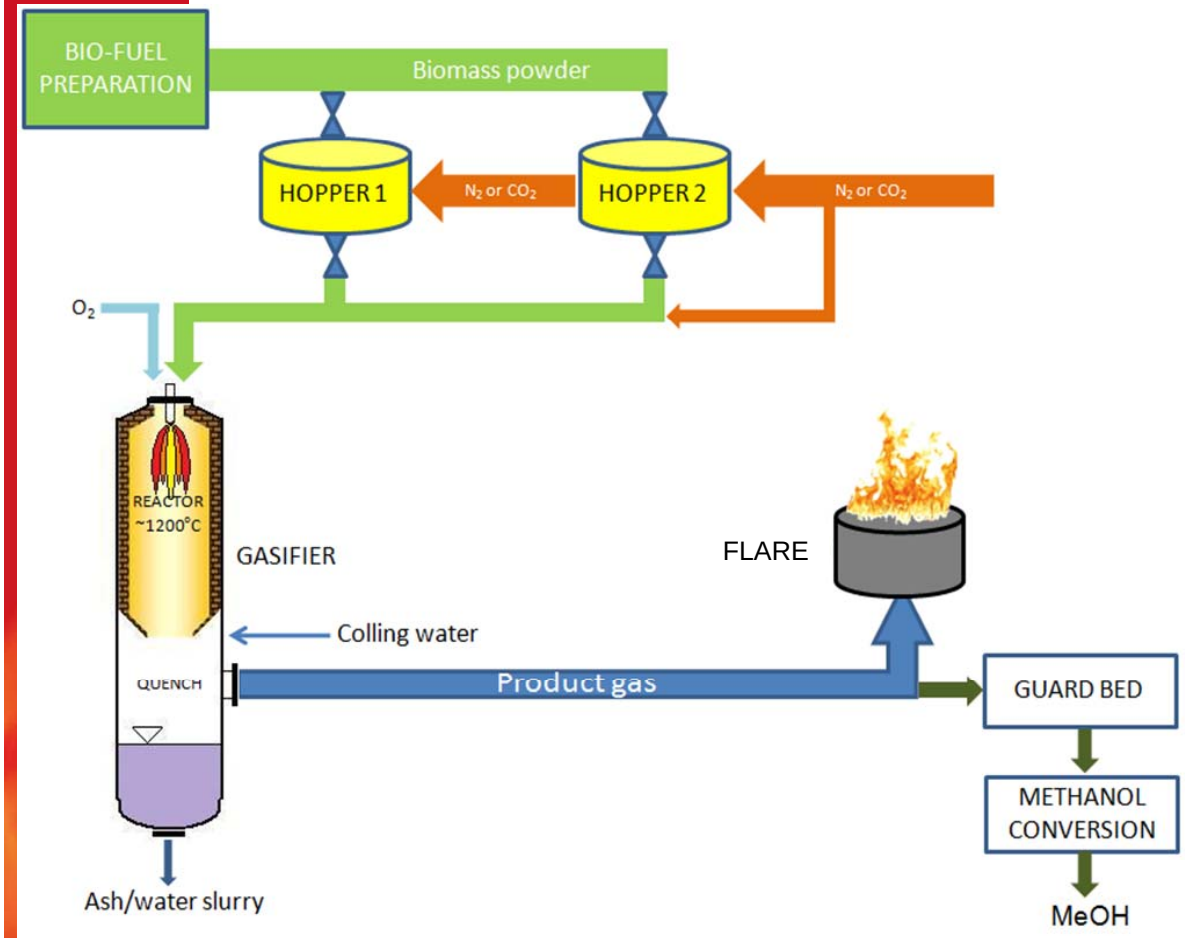
- **Project period 2009 – 2012**
- **PEBG – Pressurised Entrained flow Biomass Gasification**
- **Combining Research, Industry and Society (Triple Helix)**
- **Slagging entrained flow gasification of low grade wood-powder**
- **Applied research and process development around a pilot plant with the objectives to provide:**
  - **I. Proof-of-concept**
  - **II. Scientific basis for a continuous development**
- **Close collaboration with industry**

PEBG Project



Total funding: 2.5 M€

Plant



- ✓ **Nominal plant capacity: 1 MW at 10 bar**
- ✓ **Oxygen blown gasification**
- ✓ **Refractory lined reactor operating at 1200–1500 °C**
- ✓ **Bubbling quench for cooling and separation**
- ✓ **Flaring of the product gas (side stream for analysis)**

Direct biomass gasification

IVAB Gasifier

- ✓ **Pilot plant for direct gasification of biomass powder to syngas (CO + H_2)**
- ✓ **Situated in ETC Gasification Centre**
- ✓ **Based on the PEBG concept**
- ✓ **R&D perfomed by ETC and LTU**
- ✓ **Objective: To verify the technology concept for future commercialization**

PEBG Process

Potential in Sweden

I. **Gasification and synthesis of black liquor (BLG) and biomass (PEBG) to motor fuels in 2050: 23 (BLG) + 20 (PEBG) = 43 TWh/yr (45 % of fossil use)**

II. **Decrease of the Swedish CO2 emissions by 20% or 12 million Tonnes/year**

III. **Production costs comparable to fossil based fuels (~5-8 SEK/litre diesel eq.)**

IV. **Great business opportunities for the forest industry**

PEBG Process

Main Challanges

- ✓ **Efficient fuel preparation**
- ✓ **Robust and flexible fuel feeding**
- ✓ **Durable construction materials**
- ✓ **Part optimisation (burner, reactor, quench etc.)**
- ✓ **Process control optimisation**
- ✓ **Fuel and additive chemistry (ash properties)**

Plant Commissioning

Steps:

1.1 Cold process with just nitrogen throughput at atmospheric pressure.
1.2 Calibration tests of the feeding and burner system in the plant.
1.3 Cold process with just nitrogen throughput at 5 bara pressure.
1.4 Cold process with nitrogen and steam wood powder at atmospheric pressure.
1.5 Controlled heat up of lining to 1000 C.
1.6 Warm process with just nitrogen throughput at 5 bara pressure.
1.7 Warm process with 'synthetic air' (oxygen/nitrogen blended) and stem wood powder at atmospheric pressure.
1.8 Warm process with 'oxygen enriched synthetic air' (oxygen/nitrogen blended) and stem wood powder at 2 bara pressure.
1.9 Warm process with pure oxygen and different wood powders up to 5 bara pressure

Primarily, bark, stumps and wood residues from pulp mills will be tested.

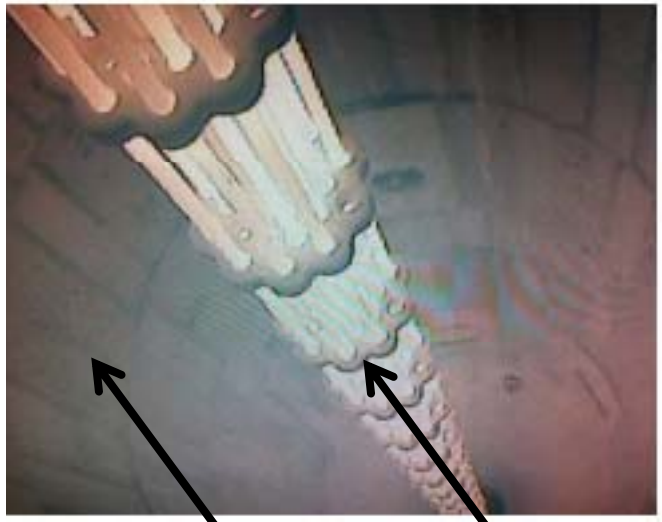
Plant Commissioning

So far:

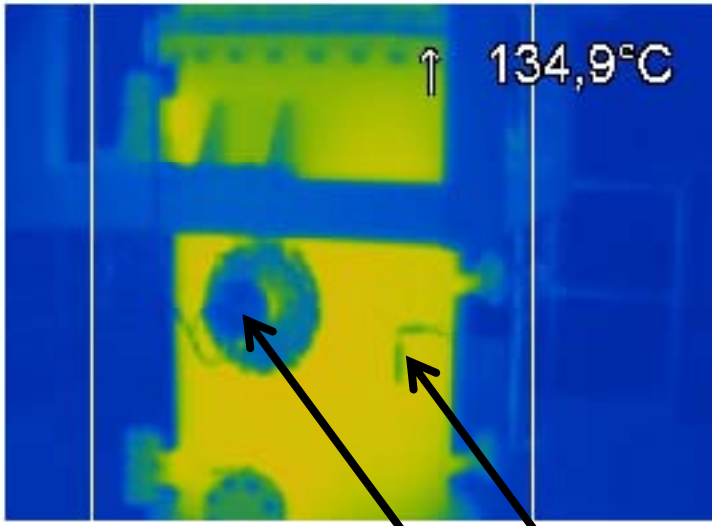
- ✓ Gasification experiments with 40% oxygen performed
- ✓ ~28 h accumulated runtime
- ✓ Improved control and stability achieved
- ✓ Highest operated temperature so far 1350 °C
- ✓ Slightly pressurized ~ 2 bar(a)

Plant Commissioning

Camera view in reactor during heating



Reactor shell temperature

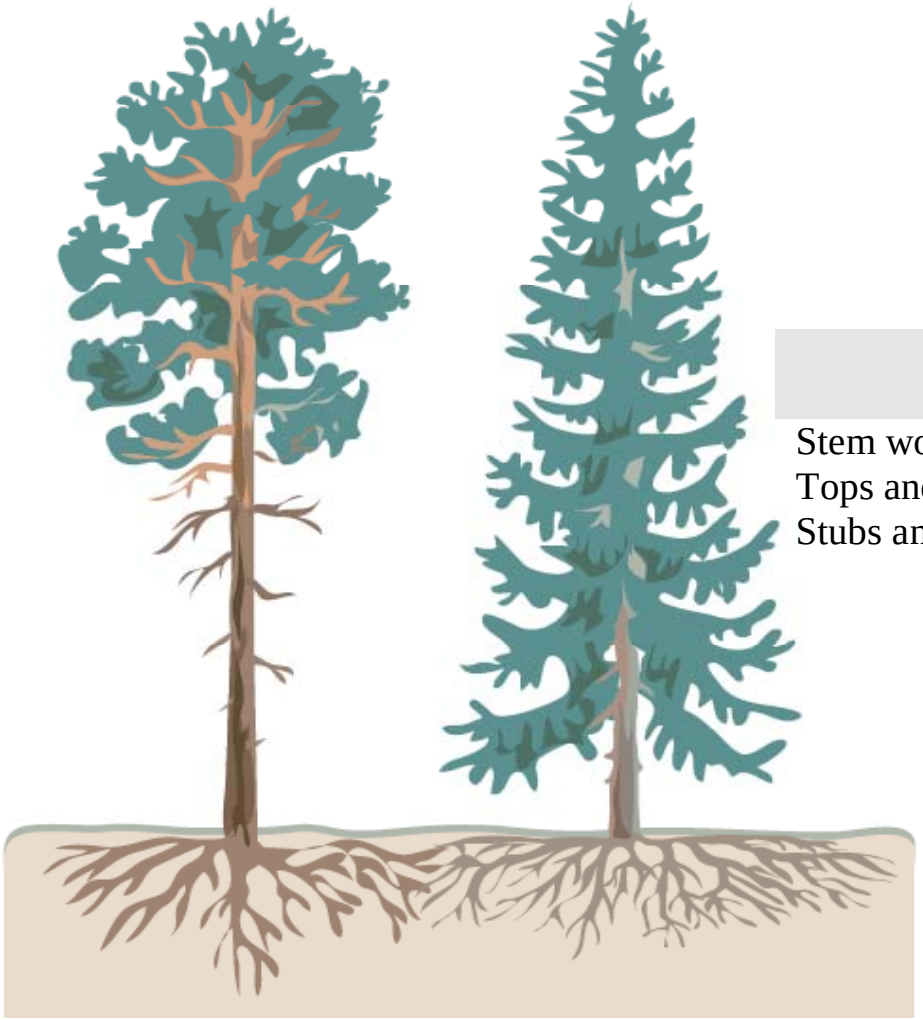


Fuel materials

Logging residues

- ✓ **Make out ~45 % of total logging**
- ✓ **Difficult to handle during logging**
- ✓ **Special pretreatment required before the gasification process**
- ✓ **The content and composition of the ash can vary in wide ranges**
- ✓ **Increased use of wood residues will demand for more recyclable ashes**

Fuel materials



	Pine [wt-%] dry basis	Spruce [wt-%] dry basis
Stem wood	69	59
Tops and branches	16	27
Stubs and roots	15	14

Fuel materials

	Stem wood[1]	Bark	Stumps	Wood chips	Wood pellets
Ash [dry wt-%]	**0.4-0.5**	**3.5-8**	**1.5-17.8**	**0.8-1.4**	**0.4-1.5**
Moisture [wt%]	5-60	45-65	26-57	20-50	7-12
Lower heating value, LCV [MJ/kg]	18.5-20	18.0-23		19.2-19.4	16.2-19
Density [kg/m^3]	390-640	320		250-350, 320-450[2]	500-780
Volatile matter [wt-%]	>70	69.6-77.2		76-86	>70
Ash melting point [°C]	1400-1700	1300-1700		1000-1400	>1120
C [dry wt-%]	48-52	48-52	50-53	47-52	48-52
H [dry wt-%]	6.2-6.4	4.6-6.8	5.7-7.2	6.1-6.3	6.0-6.4
N [dry wt-%]	0.1-0.5	0.3-0.8	0.1-0.2	<0.3	0.27-0.9
O [dry wt-%]	38-42	24.3-42.4	40-42	38-45	~40
S [dry wt-%]	<0.05	<0.05	0.01-0.03	<0.05	0.04-0.08
Cl [dry wt-%]	0.01-0.03	0.01-0.03	0.00-0.20	~0.02	0.02-0.04
K [dry wt-%]	0.02-0.05	0.1-0.4	0.02-0.06	~0.02	n.a.
Ca [dry wt-%]	0.1-1.5	0.02-0.08		~0.04	n.a.

[1] Without bark

[2] The first figure is for softwood and the second for hardwood

Summary

Main Conclusions

I. Great potential for the forest residues

II. PEBG – A nice example of Triple helix R&D projects

III. Successful start up of the pilot plant in April 2011

IV. Robust and stable plant control and safety system

V. Unique experimental data

ongoing experiments 2011 – 2012

VI. Research is carried out in 7 WPs

Questions?