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New 2G process for ethanol from wood

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43º Congresso e Exposição Internacional de Celulose e Papel

43rd Pulp and Paper International Congress & Exhibition

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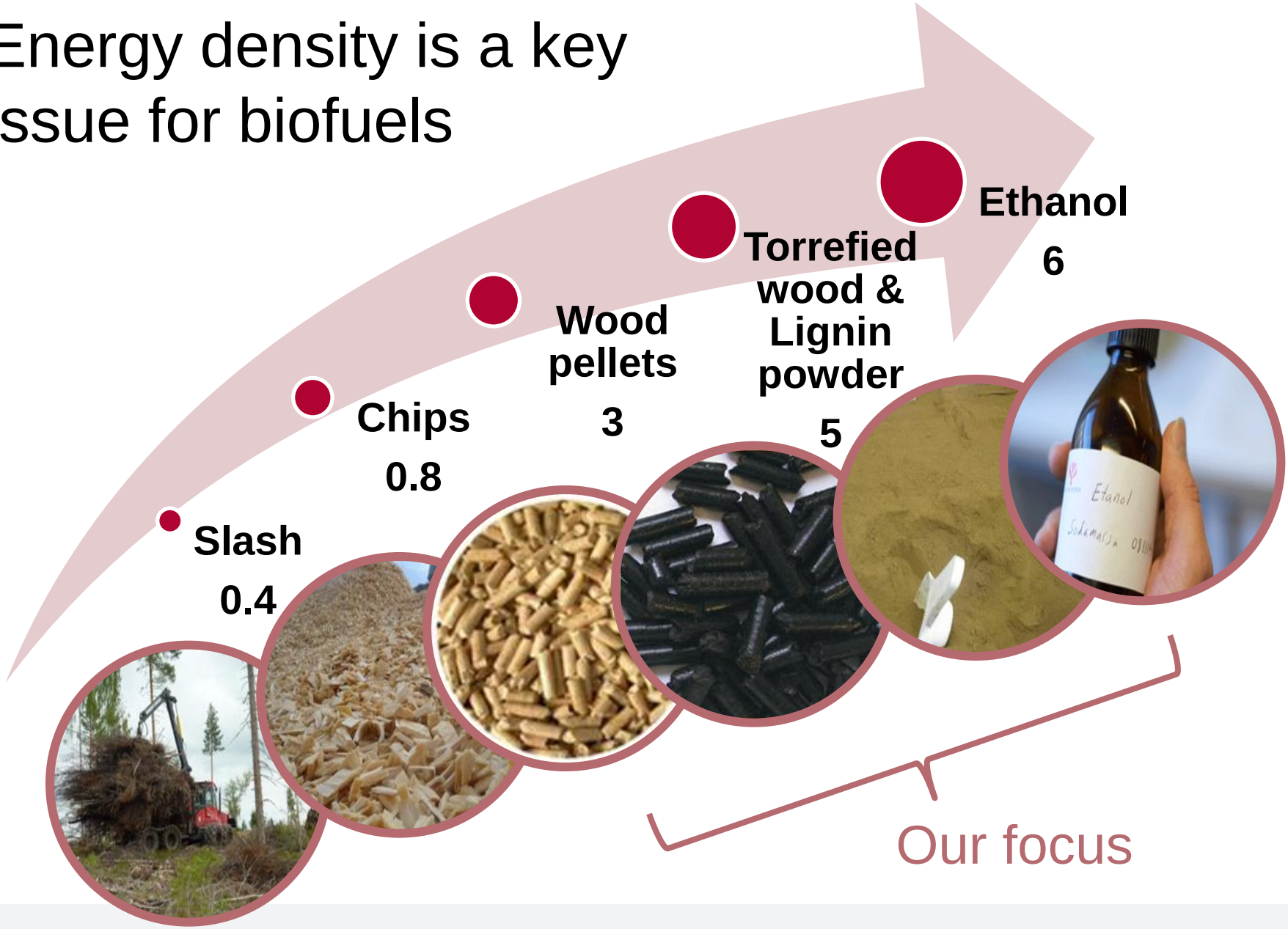
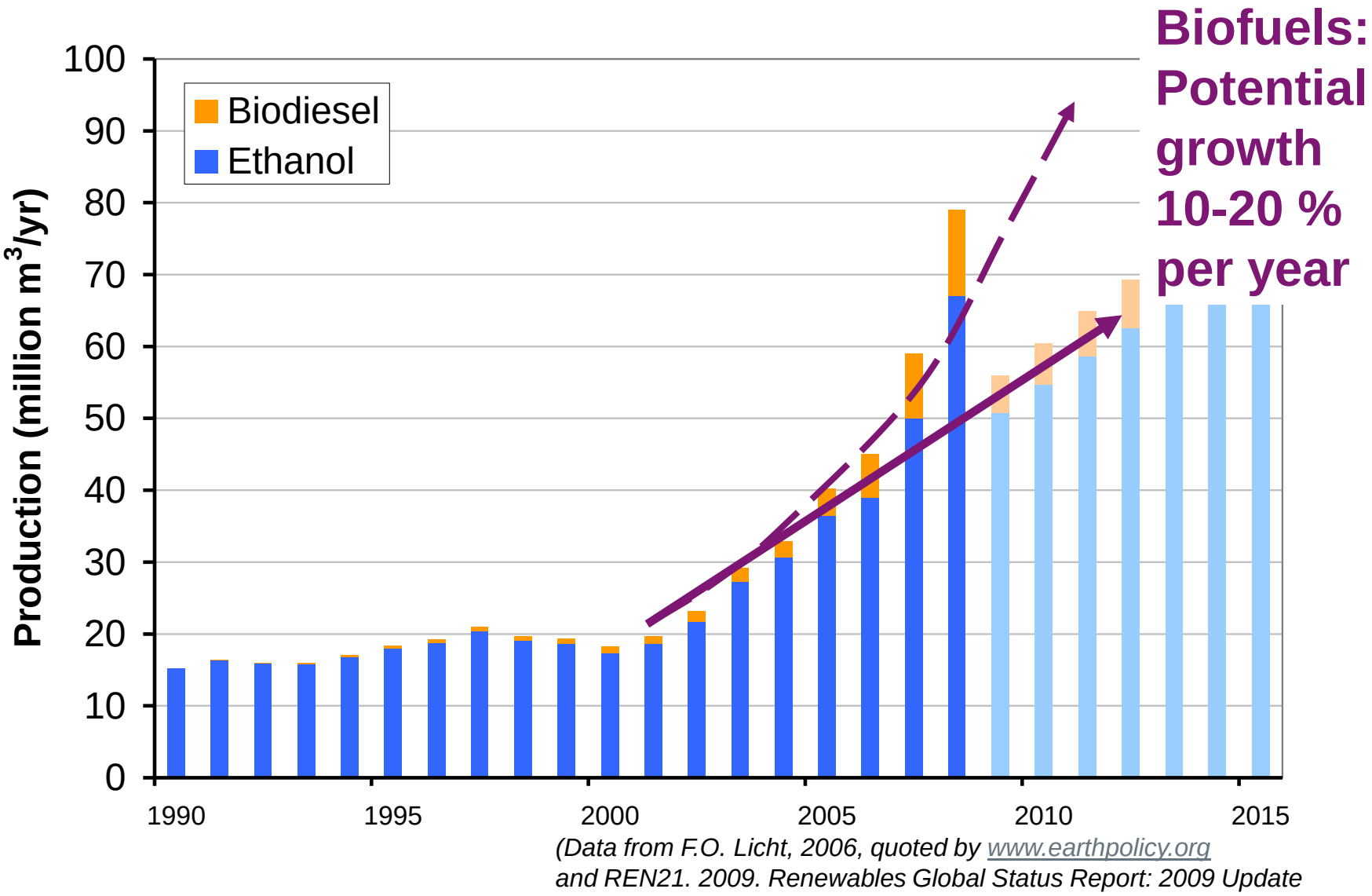
TAPPI


JOHN DEERE

Energy density is a key issue for biofuels





(Data from F.O. Licht, 2006, quoted by www.earthpolicy.org and REN21. 2009. Renewables Global Status Report: 2009 Update

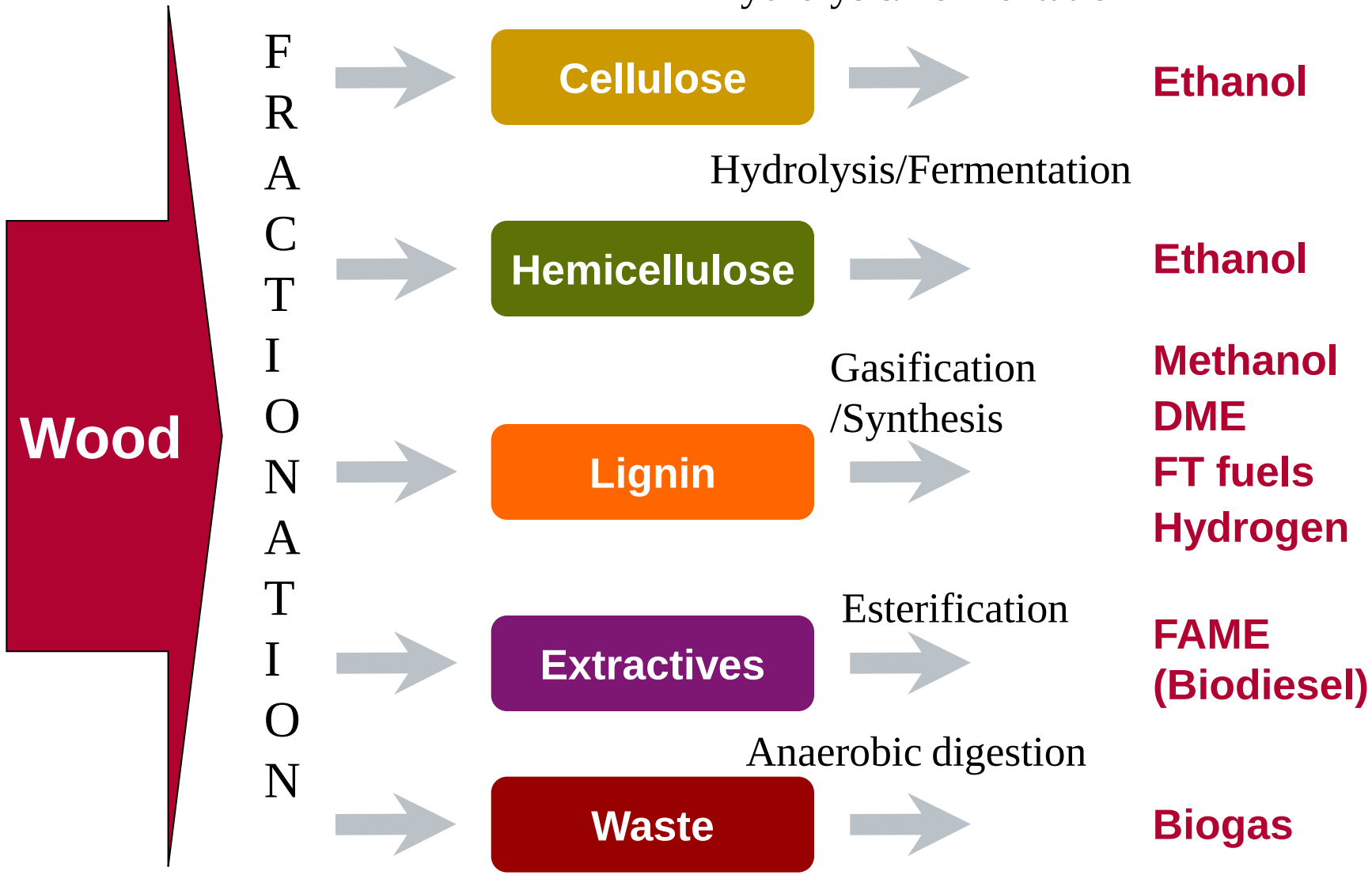
Outline

- Driving forces
- Process concept
- Large scale trial
- Conclusions

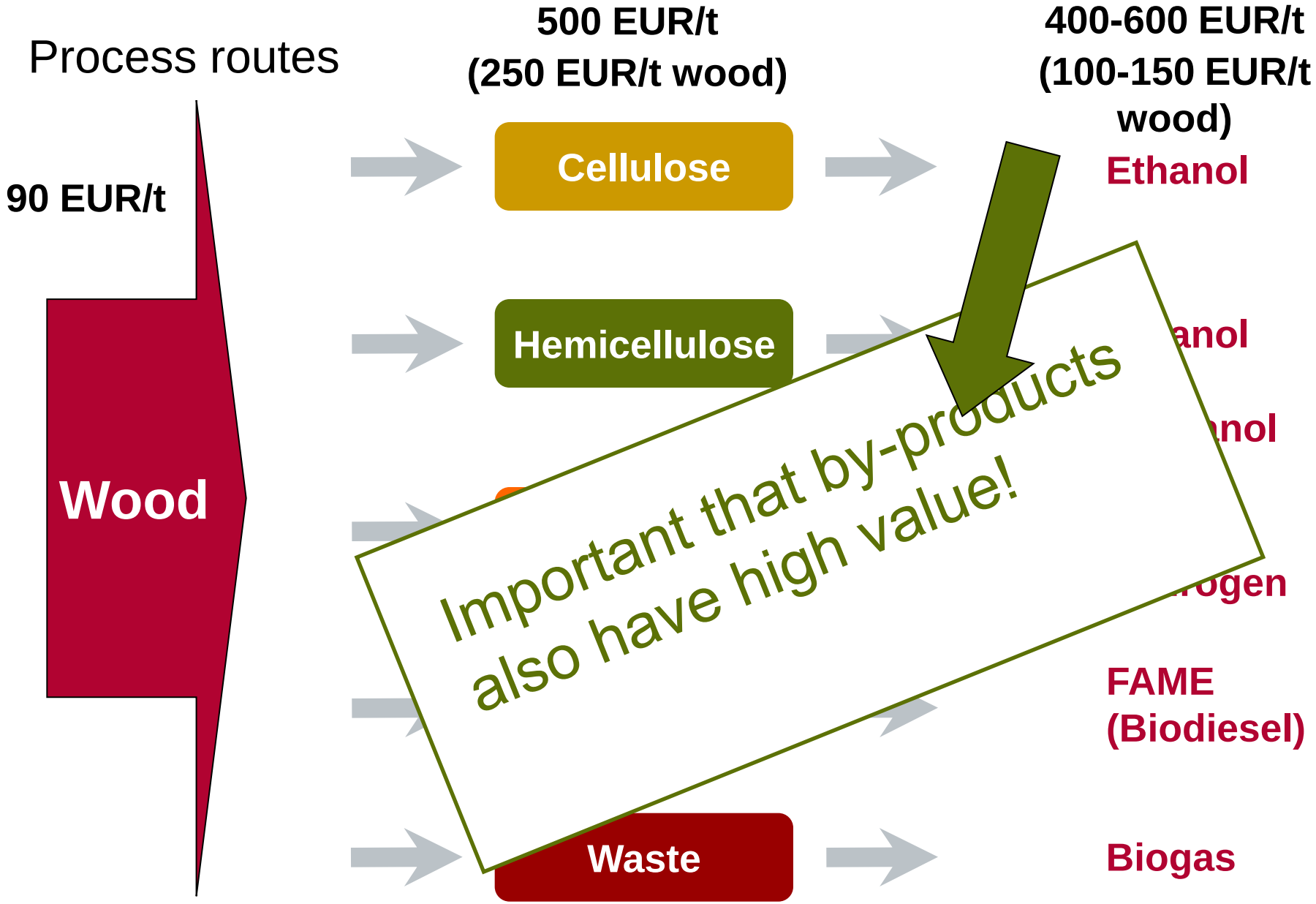
What would be the role of the P&P industry?

- Demand for solid and liquid biofuels will increase rapidly in the coming years
- Pulp and paper industry has potential to be an important actor with several advantages:
  - Raw materials handling
  - Process knowhow
  - Integration possibilities
  - Existing infrastructure

Process routes



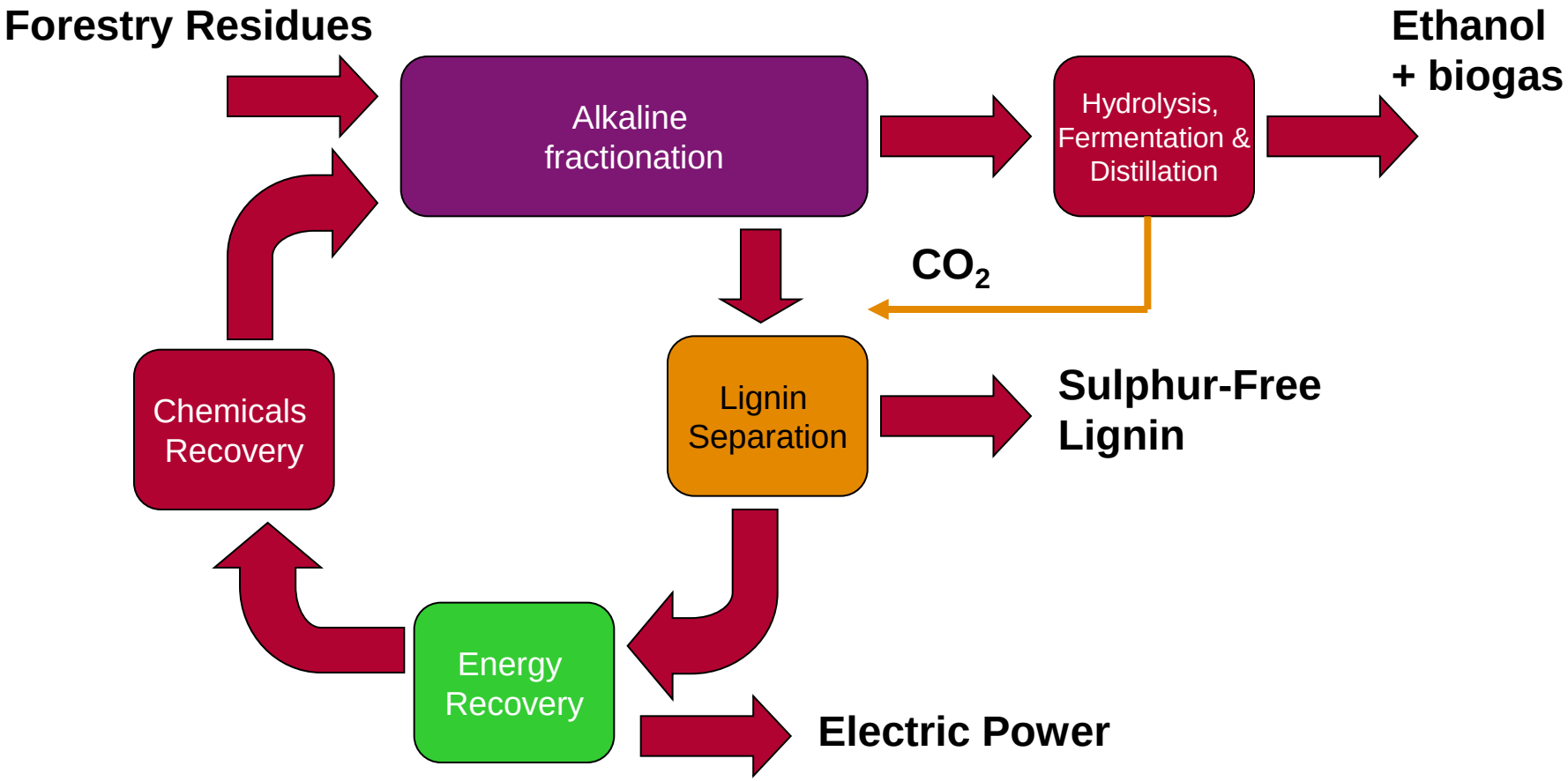
Process routes



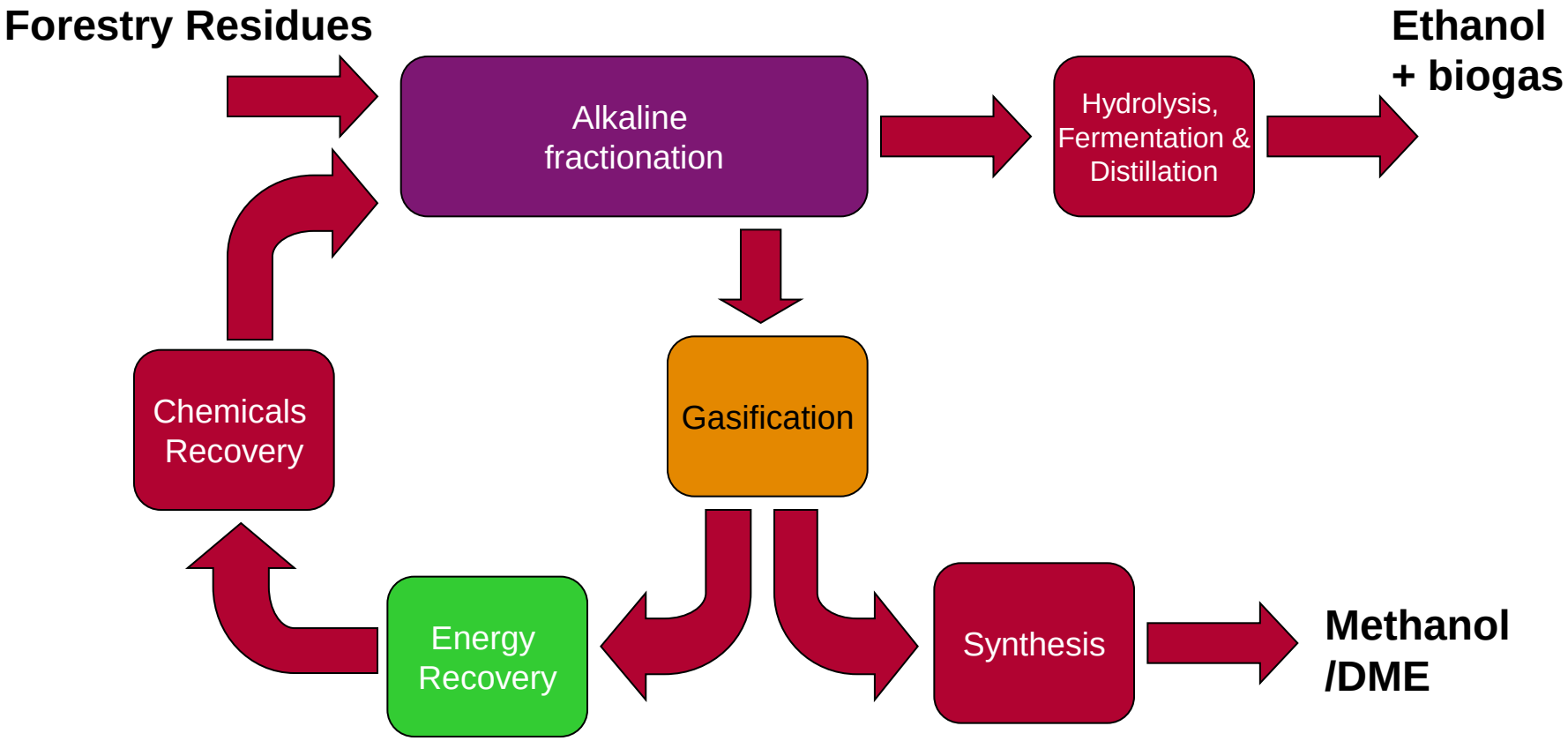
Wish list

- Several value-added products
- Robust with respect to raw material
- Minimize capital expenditure
- Closed cycle
- Minimize waste
- Profit from integration

Alkaline route from wood to ethanol



Process concept with gasification

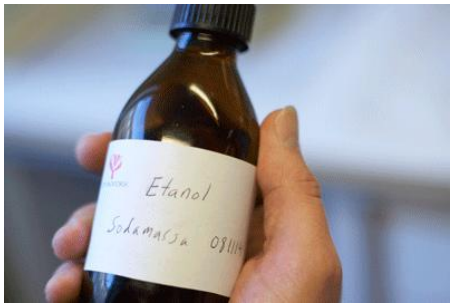


Results from system study

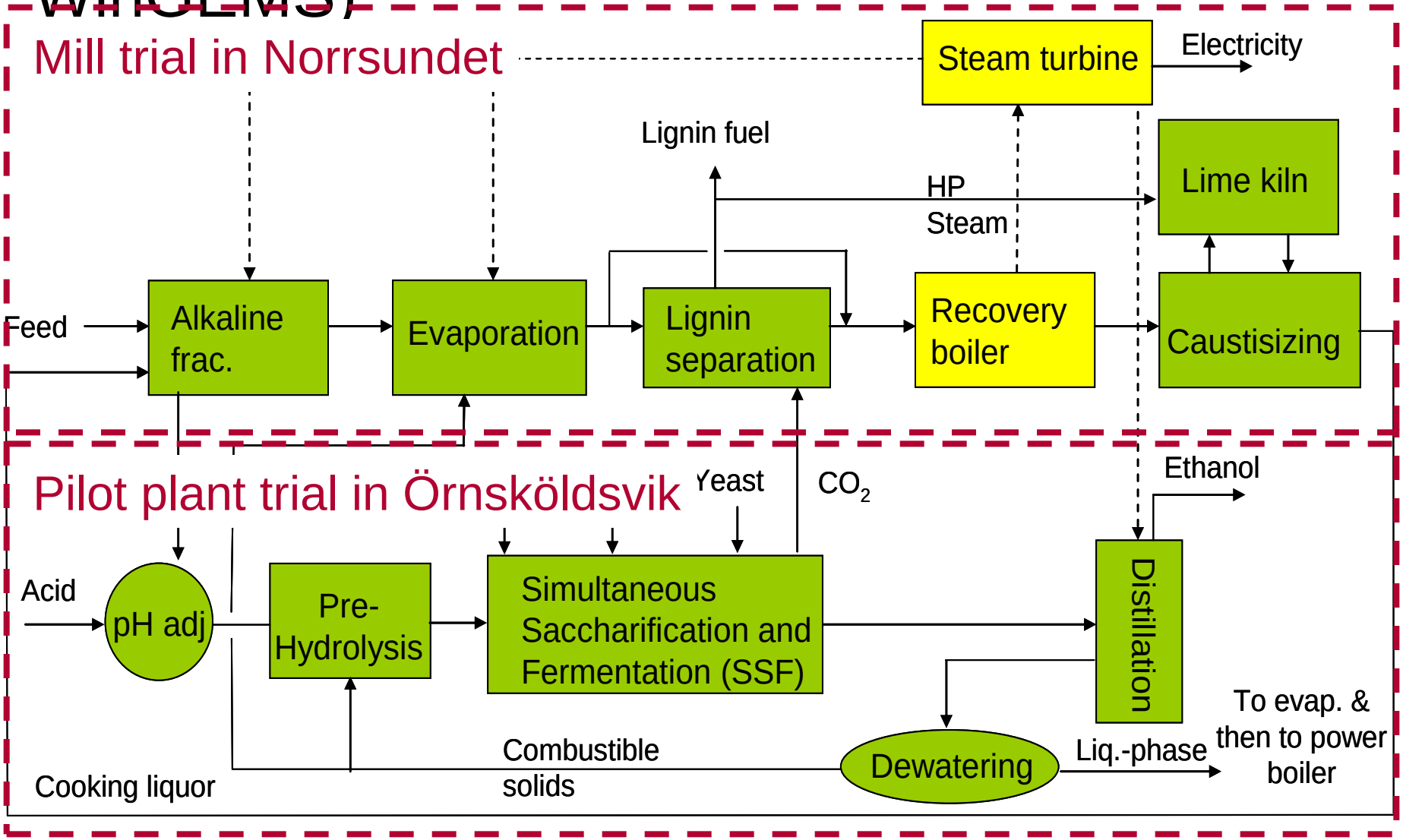
- Mostly known and well proven technology
- Possible to produce 200-250 liters of ethanol per tonne of wood
- Possible production in typical mill, ca 120 000 m^3/year
- Alternative with lignin extraction (ca 60 % of available lignin) gives steam balance and an excess of lignin and electric power
- Alternative with gasification of the spent liquor and synthesis to DME gives steam balance but a deficit of electric power
  - DME production greater than the ethanol production
- Production costs are on the order of 0.50 EUR/litre ethanol

Will it work in practice?

- Project to test the concept in mill and pilot scale trials



Simplified process layout (modelled in WinGEMS)



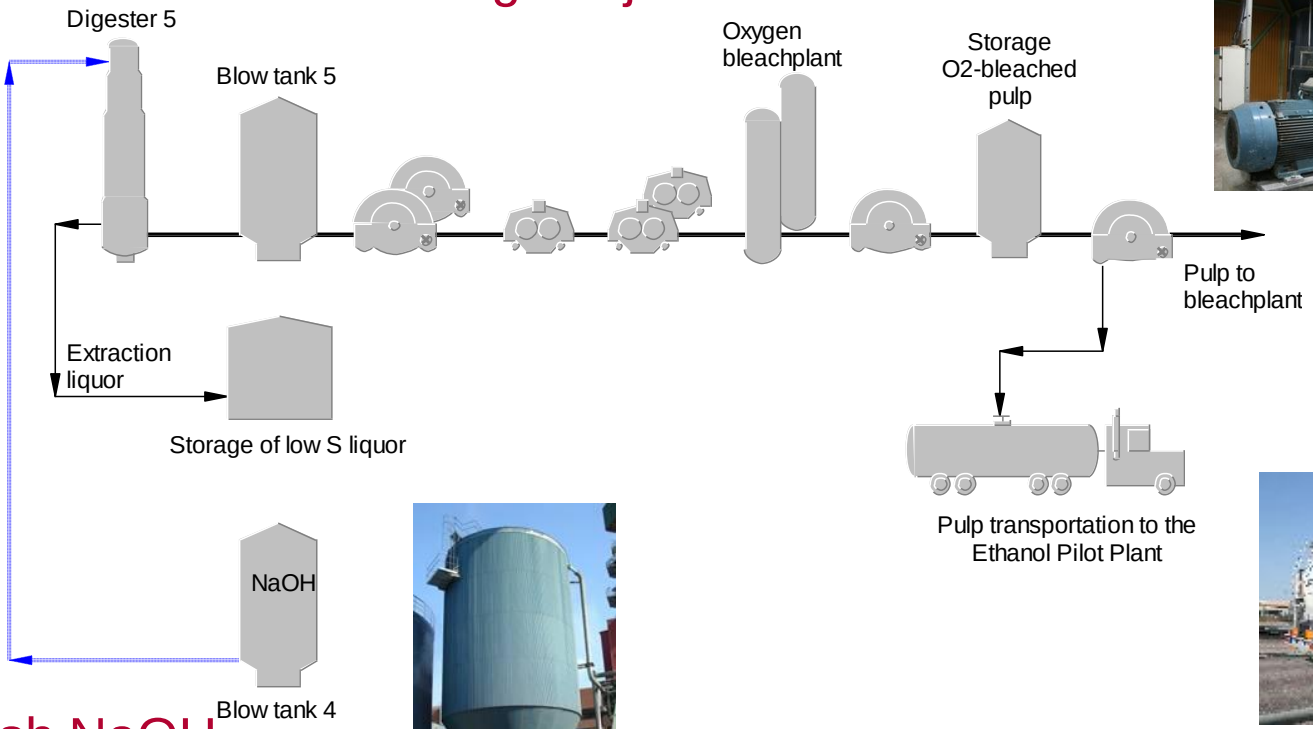
Objectives

- To show that the concept can work on full scale by producing a well delignified cellulose intermediate product and ethanol of fuel quality as the final product
  - To use a cooking liquor with no or low sulphidity to produce a well delignified cellulose in an industrial digester
  - During at least four hours produce a cellulose that can be used in the Ethanol pilot plant
  - During a 3-4 day trial hydrolyse the cellulose and ferment the sugars to ethanol in the pilot plant

Mill trial

Temperature, time and alkali charge adjusted

Cellulose removed at a consistency of 4%

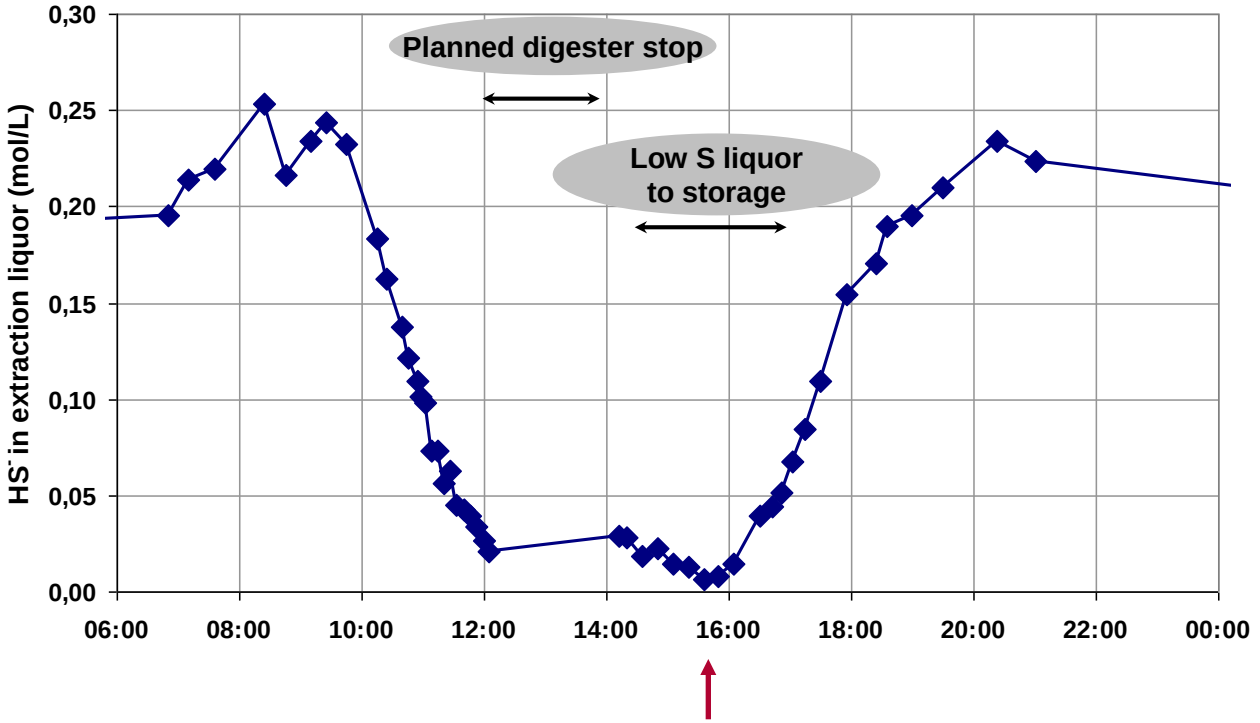


Fresh NaOH charged instead of normal white liquor

Immediately trucked to the Ethanol pilot

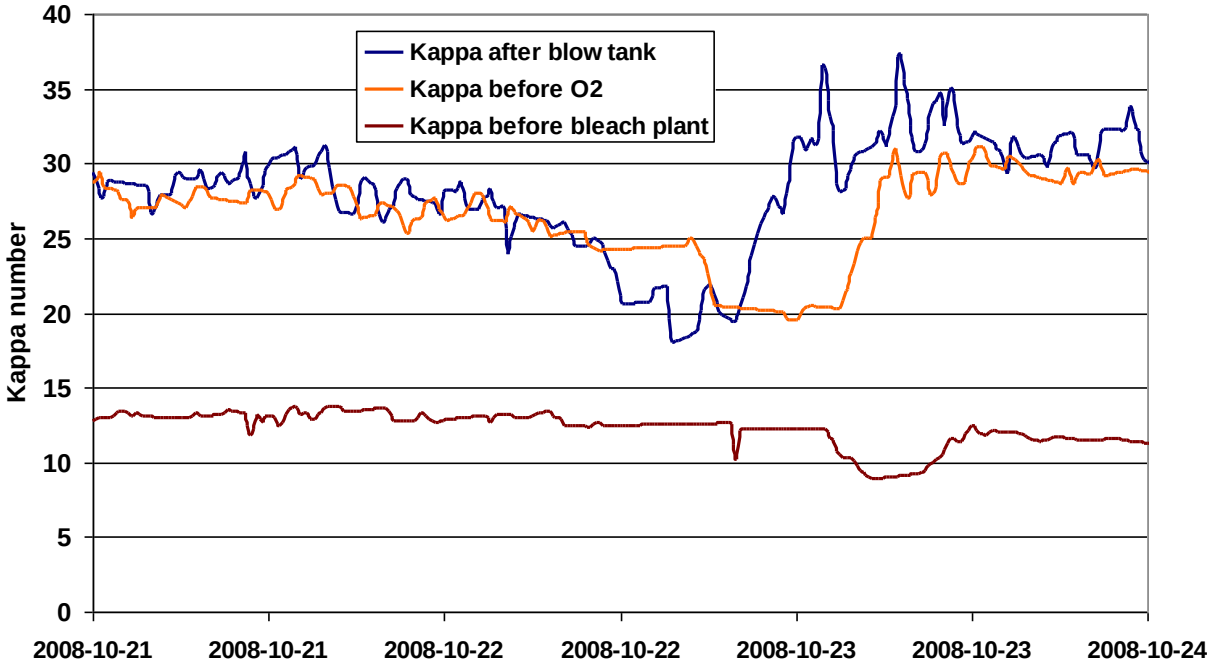
Results mill trial

70 tonnes of “soda” pulp produced



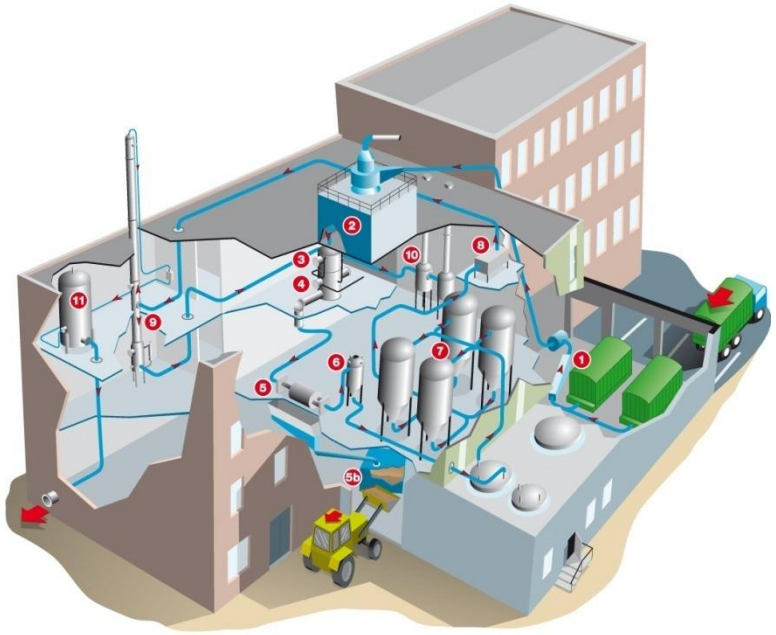
Reached a low of nearly zero sulphidity

Results mill trial



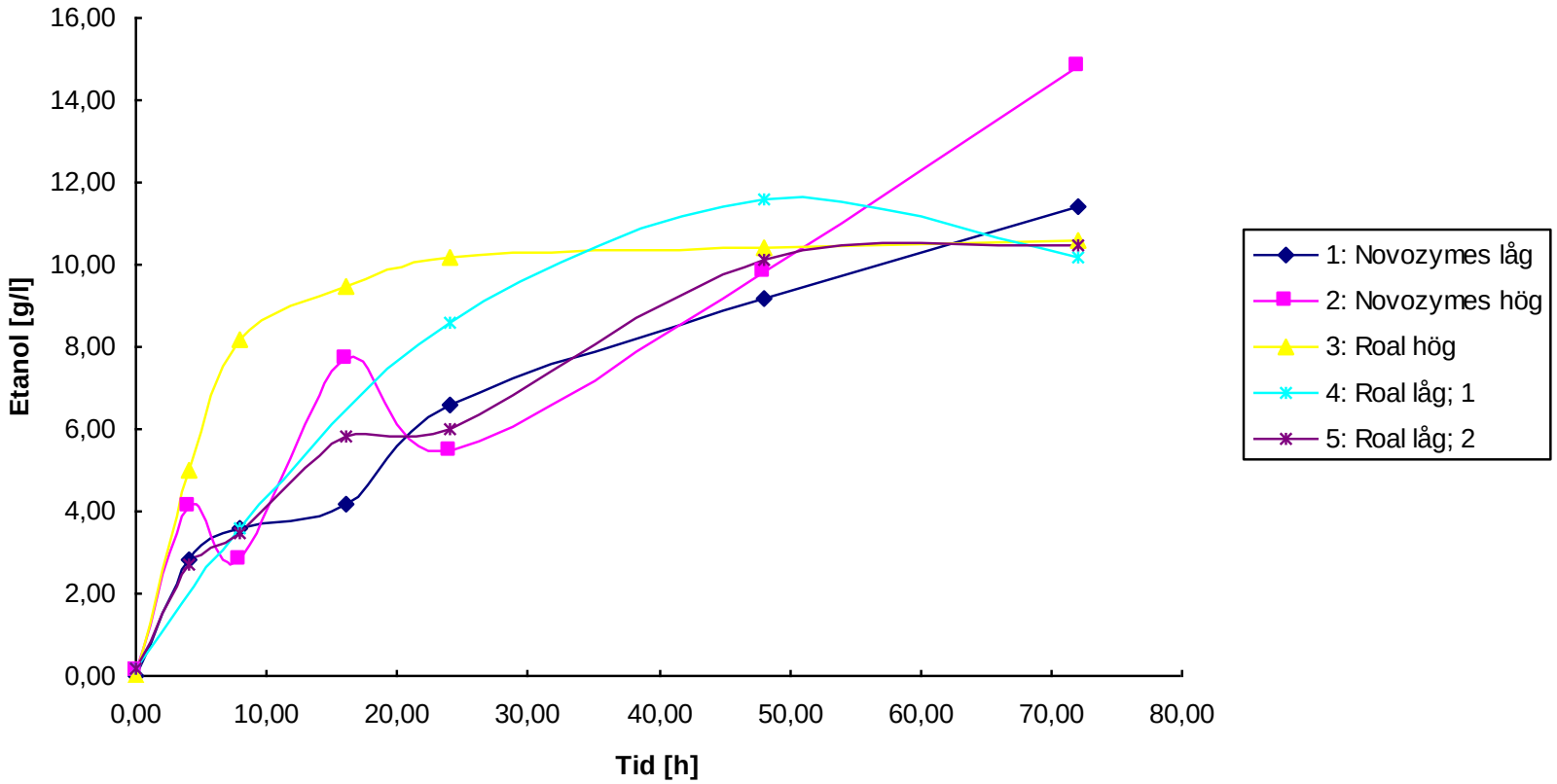
Delignification to a kappa number of < 20
(i.e. lignin content < 3 %)

Pilot plant trial



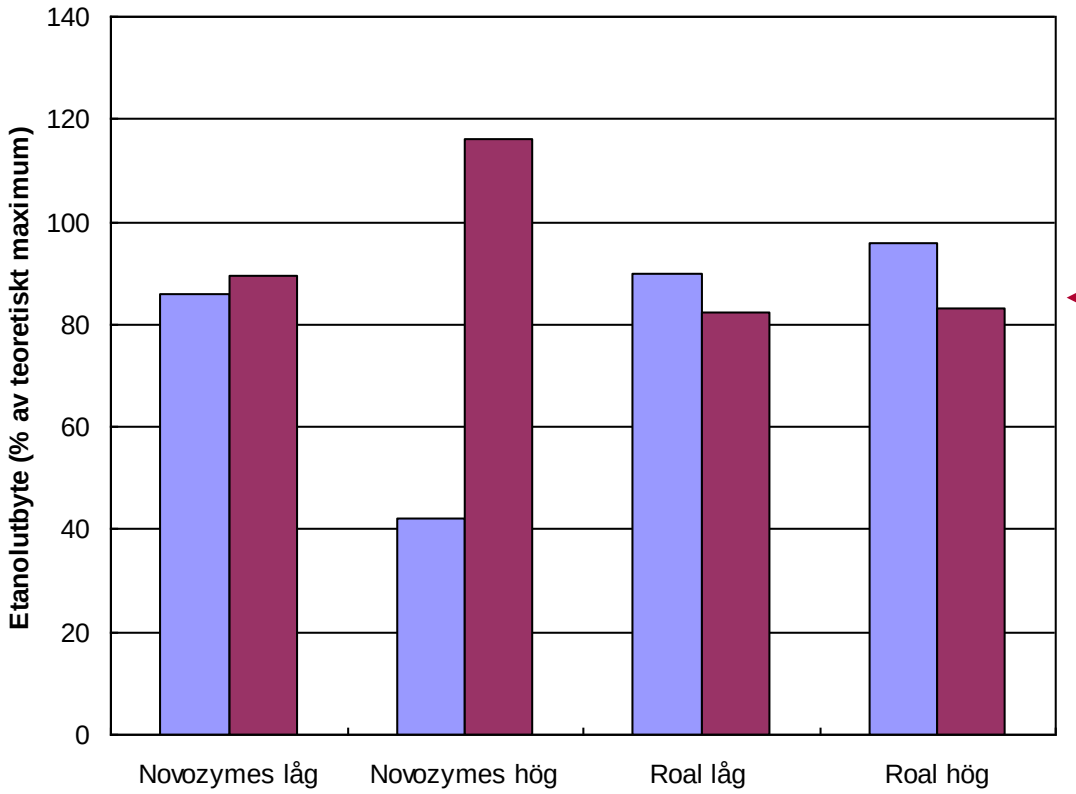
- 40 m^3 of cellulose suspension used in the trial
- Two enzyme “cocktails”
- Two levels of enzyme charge in SSF
- 700 litres of ethanol produced

Results pilot plant trial



About 48 hours to complete SSF

Results pilot plant trial



80-90 % of theoretical yield

Summary and conclusions

- Whole chain from wood to ethanol verified on large scale.
- A conventional continuous digester can be used, and necessary adjustments in temperature, alkali charge and retention time feasible without modifications.
- Sharp fractionation of the wood to an intermediate product with high cellulose content and low lignin content, and a lignin with low carbohydrate and ash content.
- The cellulose produced is well suited for enzymatic hydrolysis.
- The solid residue consists almost exclusively of yeast and it should therefore be possible to recirculate the yeast to the SSF reactor.
- The results from the large scale trial confirmed earlier lab scale results. WinGEMS simulations of the process dynamics also showed very good possibilities to predict actual concentrations and tank levels during and after the trial.

Thank you for your attention!