

# CONVERSION OF LIGNOCELLULOSICS TO BIOFUELS

Bioenergy - I:  
*From Concept to Commercial Processes*  
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Maria Costa-Ferreira  
João Matos de Sousa

INETI  
National Institute for Engineering,  
Technology and Innovation  
Portugal

# OUTLINE

**Policy**

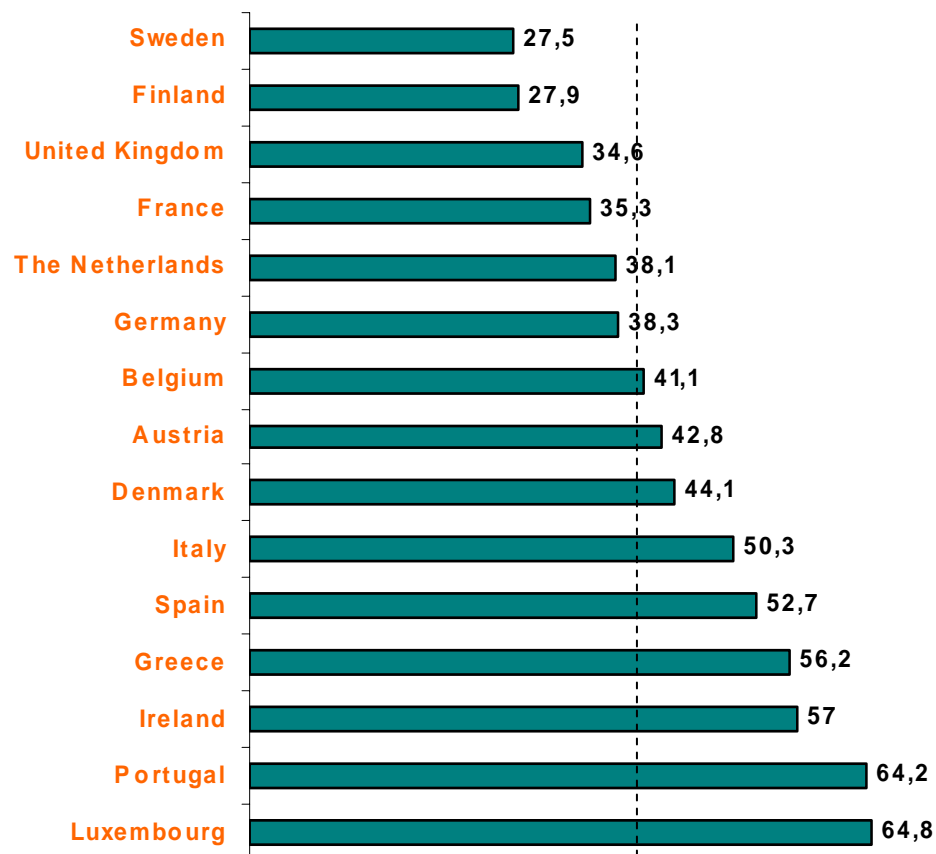
**The lignin factor in bioconversion  
of lignocellulosics**

**Portuguese pulp and paper industry**

**Scenarios for Fischer Tropsch diesel  
conversion**

**Overall considerations**

# EXTERNAL DEPENDENCE ON PRIMARY ENERGY SOURCE



40.5

# CONTEXT

In the resolution of the Council of Ministers nº 63/2003, the Portuguese Government lists its objectives for Portuguese energy policy. Its implementation follows three strategic axes:

- 1 - Maintain security of national energy supply
- 2 - Promote sustainable development
- 3 - Promote national competitiveness

# NATIONAL STRATEGY FOR THE ENERGY SECTOR

## Promotion of Technologies for the Development of Renewables

- New objectives for energy from renewable sources
- Flexible administrative processes
- Introduction of biofuels (Directive EU/2003/30/EC)
- Valorization of forest biomass
- Program for solar-heated water

**Wind energy  
(2 - 3 000 MW)**

**Solar-heated water**

**Biofuels**

**Biomass**

## Implementation of a Plan for increasing Energy efficiency

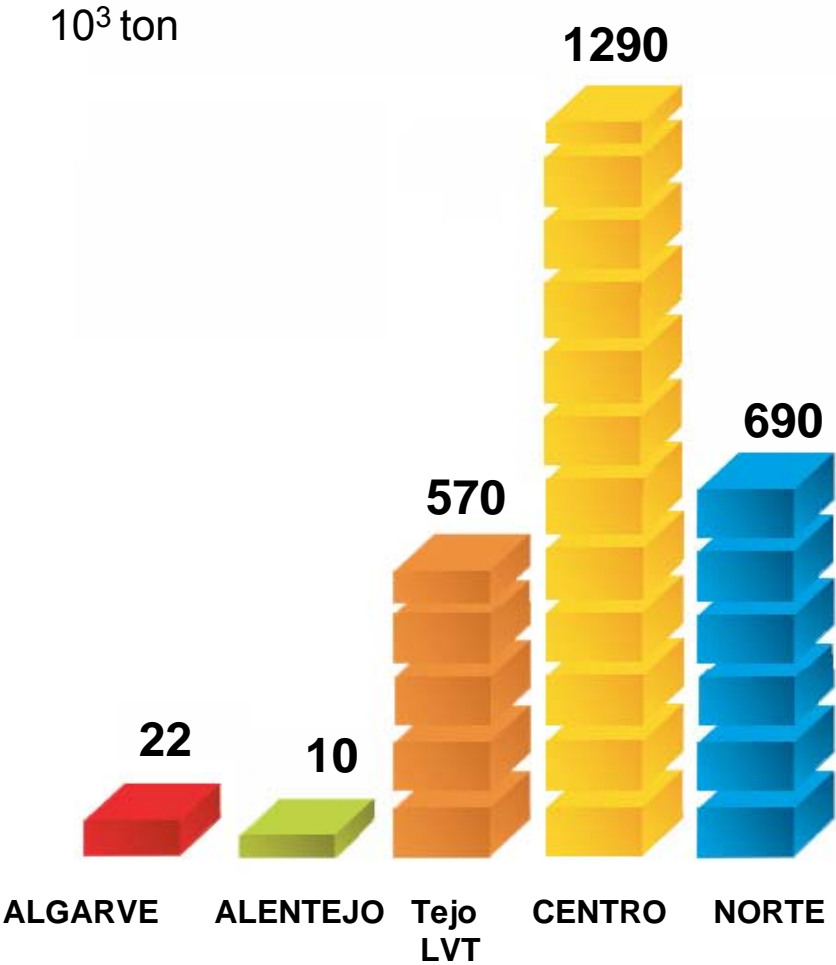
- Creation of a carbon tax
- Legislation on efficient energy use in buildings
- Application of the Directive on cogeneration
- Introduction of alternative fuels

**Increase in  
Energy efficiency**

# RESIDUES FROM MAIN INDUSTRIAL ACTIVITIES

<b>ACTIVITY</b>	<b>Non-toxic residues</b>	<b>Toxic residues</b>	<b>nd</b>	<b>Total (ton)</b>
Production of textiles	1 471 782	15 008	10	1 486 801
Clothing industry, dyeing	374 598	116	70	374 784
Leather tanning and finishing	1 377 012	279	47	1 377 338
Cork and wood industry	2 205 155	12 404	605	2 218 164
Pulp and paper industry	582 272	2 078	0	584 350

# RESIDUES FROM WOOD PROCESSING INDUSTRIES



# TYPICAL % COMPOSITION OF DIFFERENT LIGNOCELLULOSICS

	Lignin	Ash	Cellulose	Hemicellulose
Softwood	27 - 30	2	35 - 40	25 - 30
Hardwood	20 - 25	2	45 - 50	20 - 25
Wheat straw	15	8	33	25
Waste newspaper	16	trace	61	20

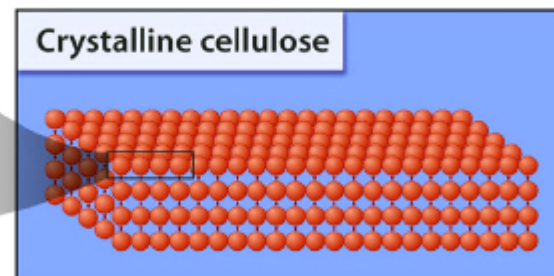
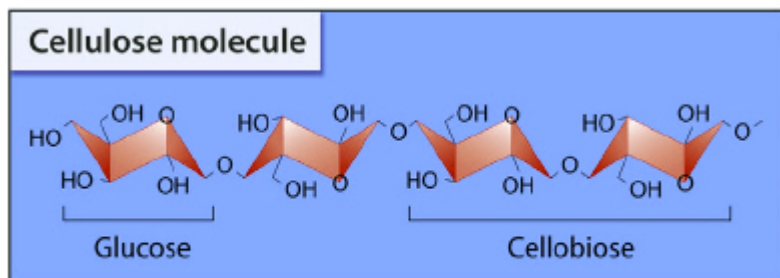
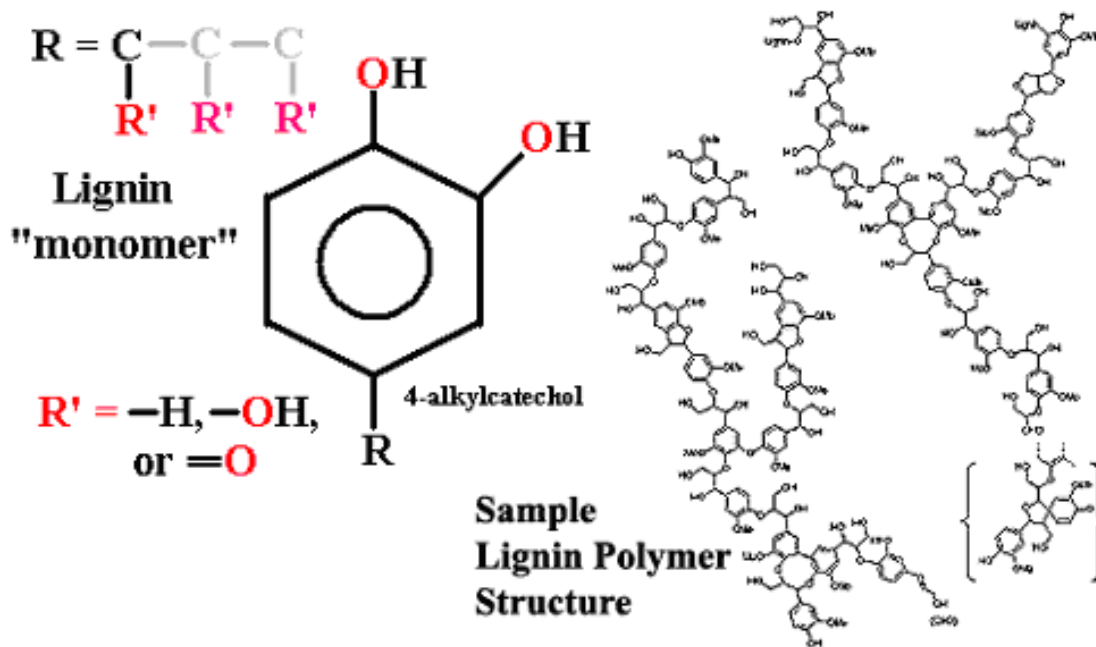




From enzymes ....



# LIGNIN AND CELLULOSE STRUCTURE



# TOOLS FOR STUDYING LIGNIN BIOTRANSFORMATION

*In vivo* labelled pine by growth on [ $^{14}\text{C}$ ] -ferulic acid  
(different positions)

Synthetic lignins (DHPs) coniferyl alcohol labelled

$^{14}\text{C}$ - kraft pulp (CLKP)

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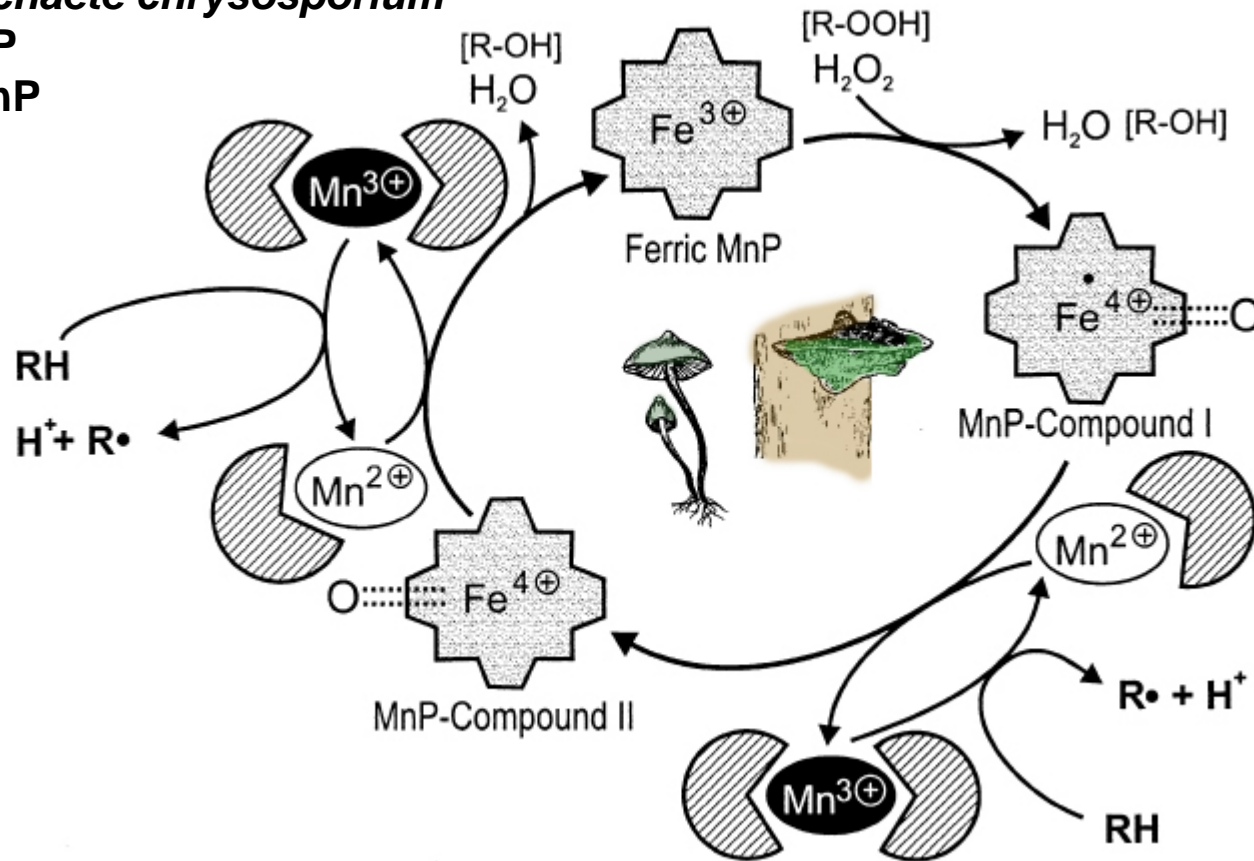
Mineralization can be followed by the release of  $^{14}\text{CO}_2$

# LIGNIN AND MANGANESE PEROXIDASE

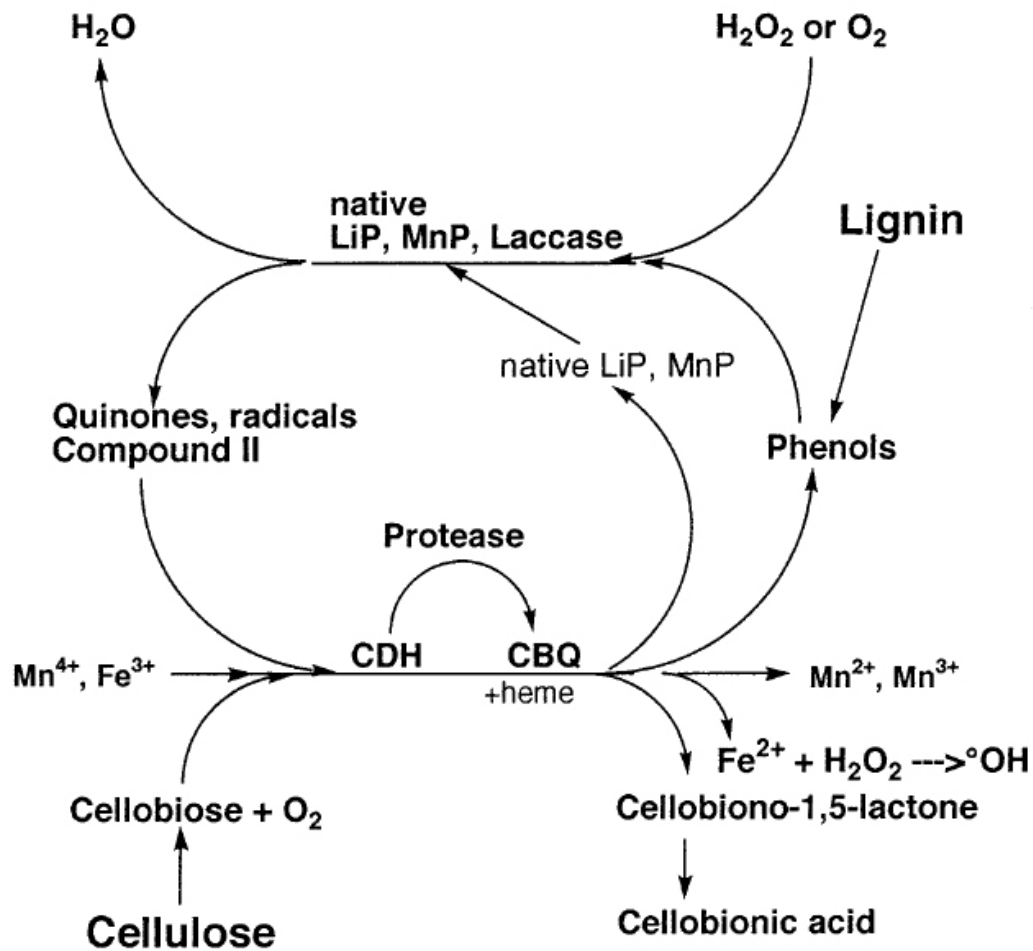
*Phanerochaete chrysosporium*

1983 - LiP

1984 - MnP



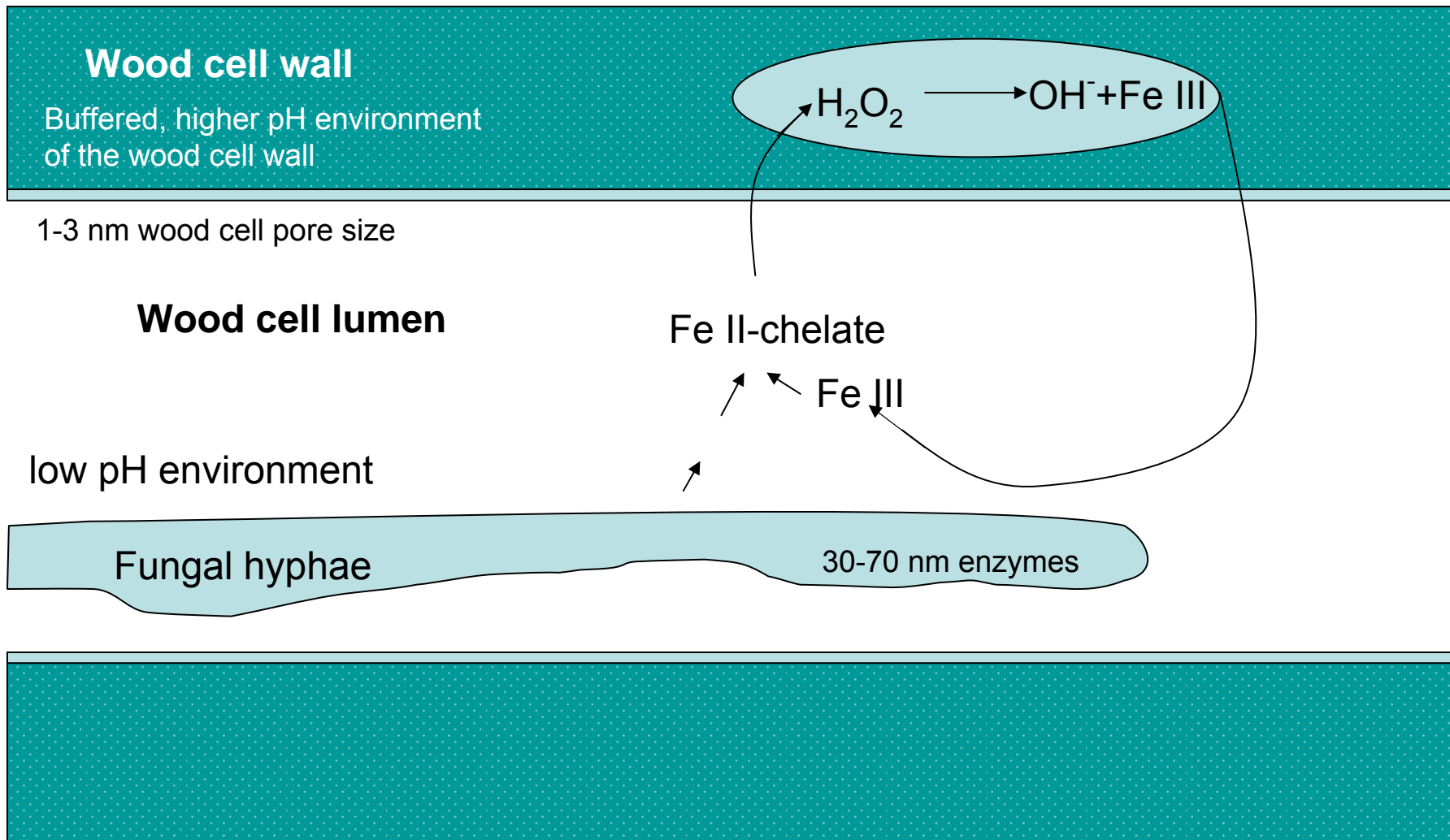
# POSSIBLE COUPLING OF LIGNIN AND CELLULOSE BIOTRANSFORMATION



*Phanerochaete chrysosporium*

CDH = cellobiose dehydrogenase  
 CBQ = cellobiose:quinone oxidoreductase

# LOW MOLECULAR WEIGHT REDOX MEDIATORS



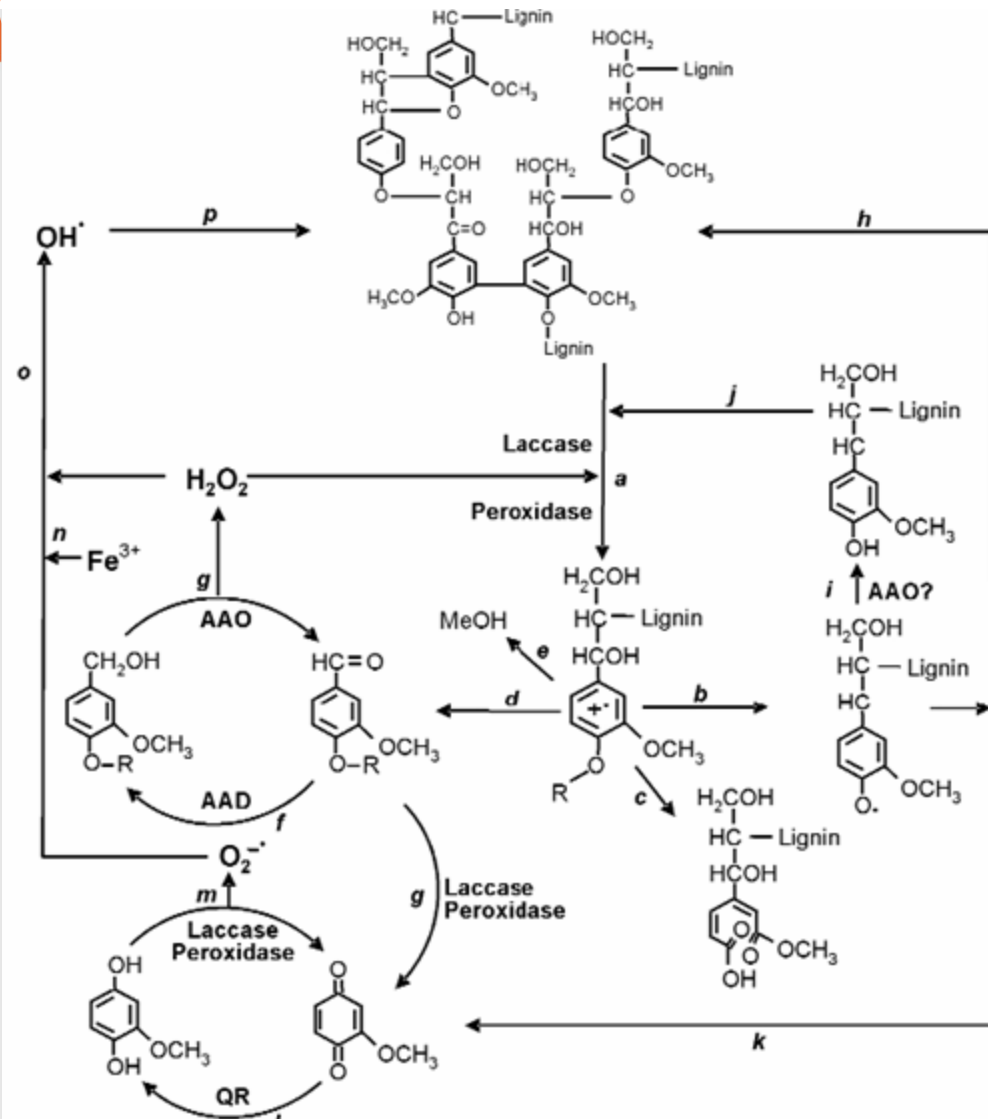
# IN VITRO LIGNIN BIODEGRADATION

*Pleurotus sp.*

Versatile peroxidase/laccase

- a. ether linkage
- b. C4 ether breakdown
- c. aromatic ring cleavage
- d. C $\alpha$ -C $\beta$  breakdown
- e. demethoxylation
- j. re-oxidation
- h. repolymerization

AAD = aryl alcohol dehydrogenase  
AAO = aryl alcohol oxidase



# CHALLENGE

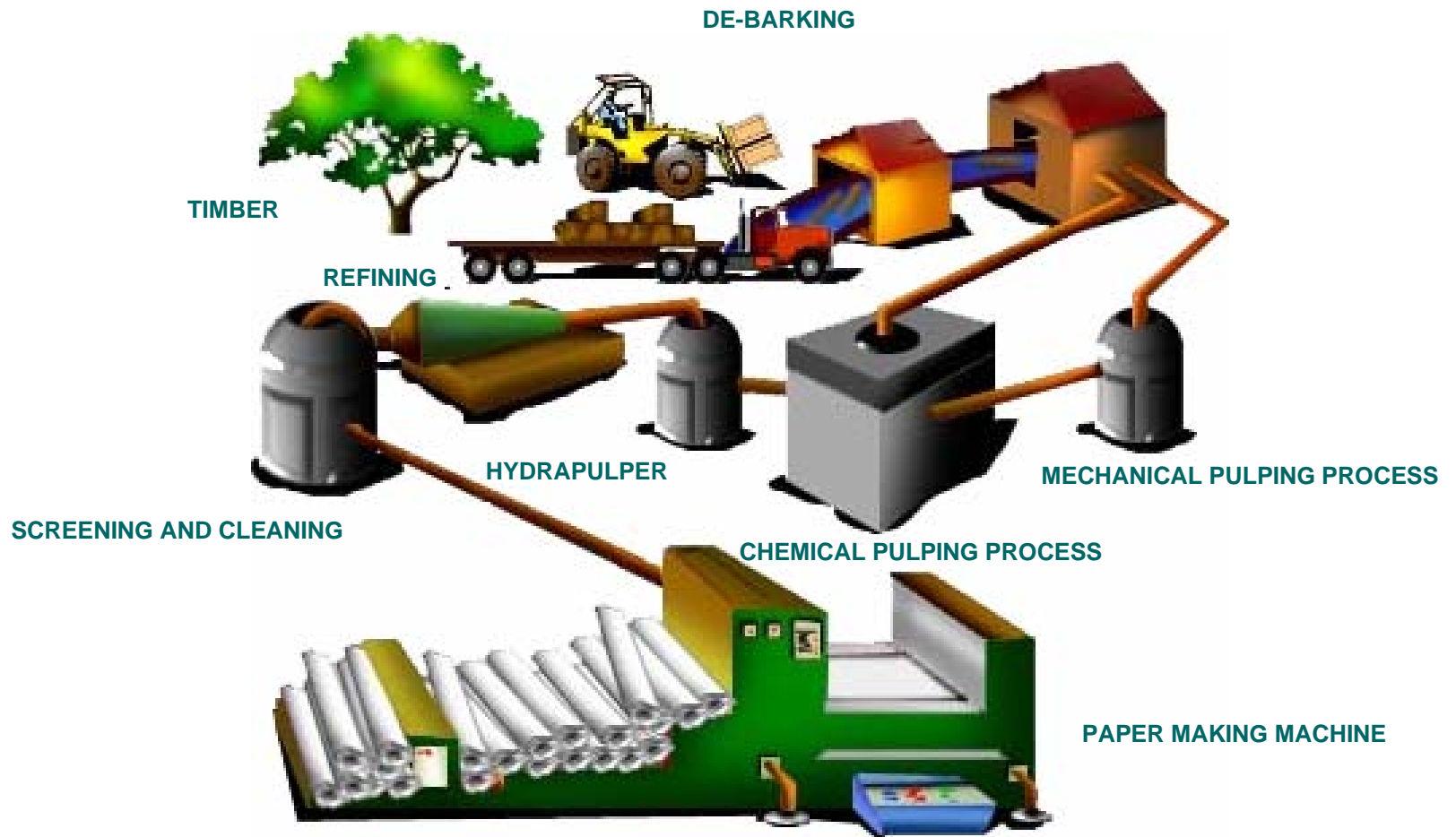
Given our incomplete understanding of how lignin is biotransformed,  
need to invest more in R & D.

Many potential benefits/applications in developing a simple & cost-  
effective biosystem  
eg. for pretreatment of biomass for bioenergy

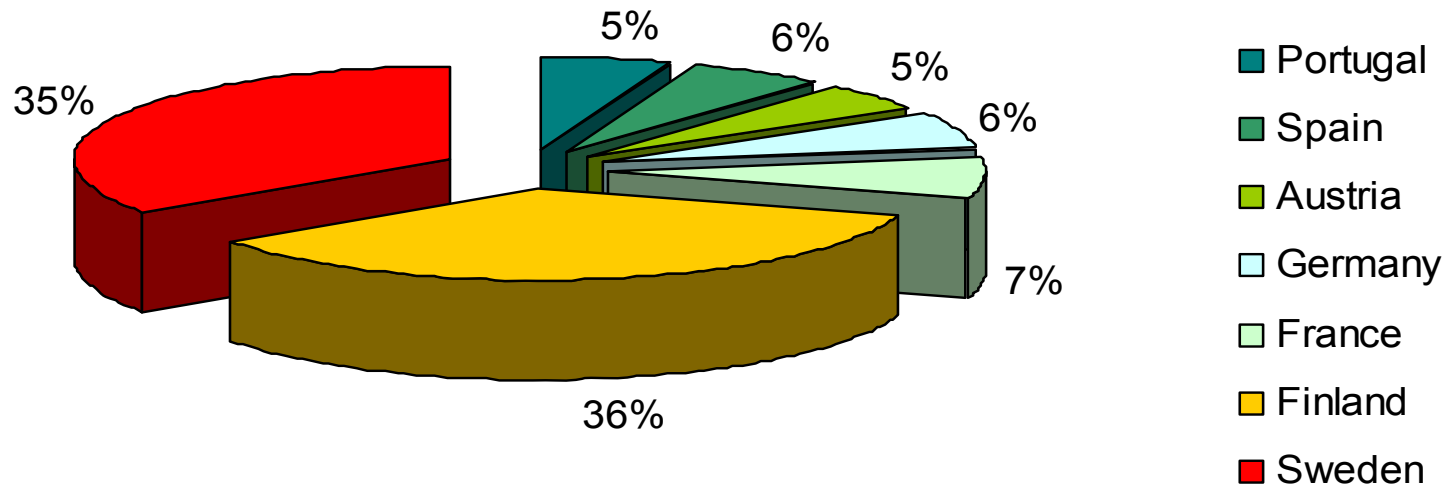
.....or for application in  
the pulp and paper industry



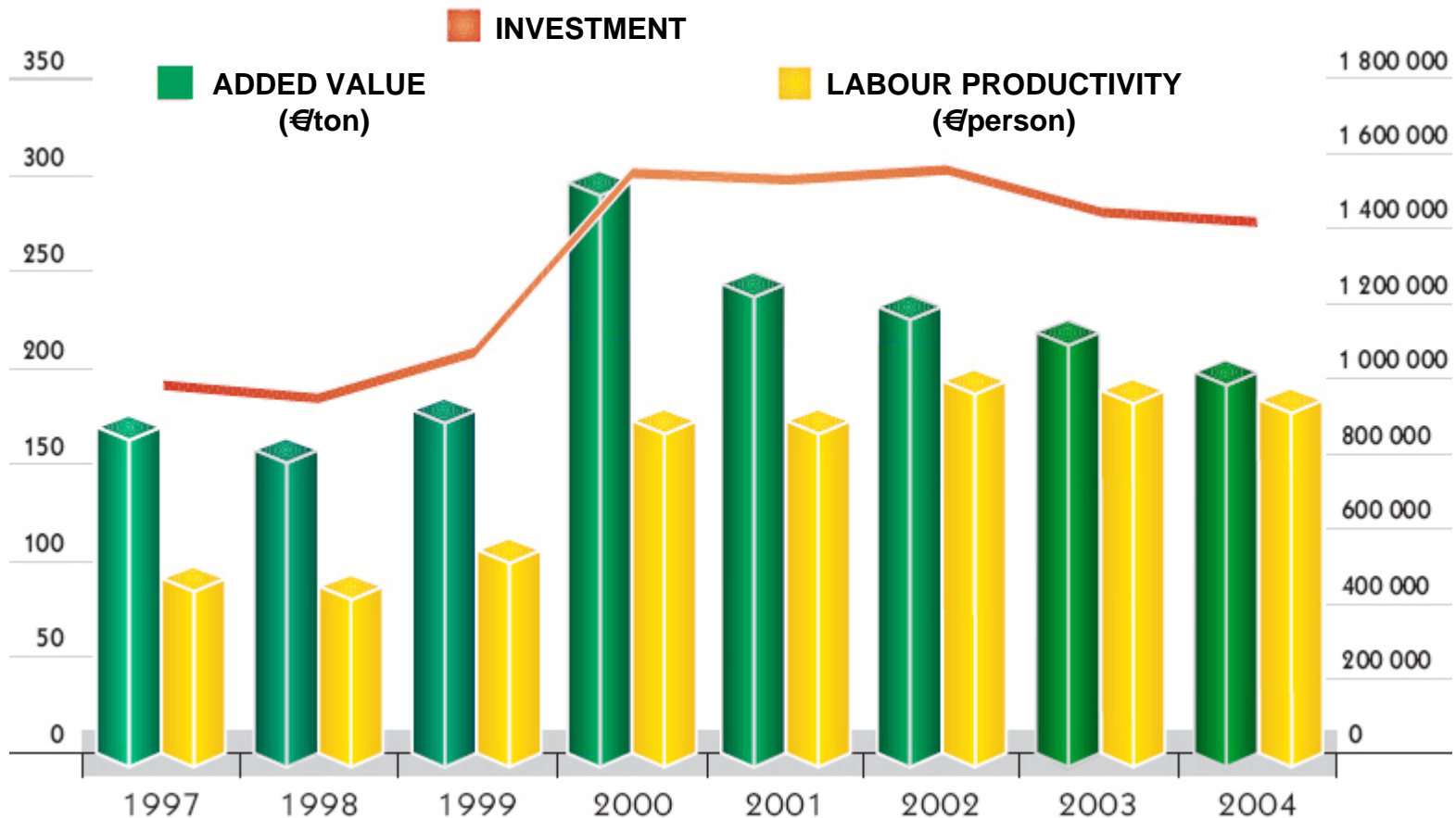
# PAPER MAKING DIAGRAM



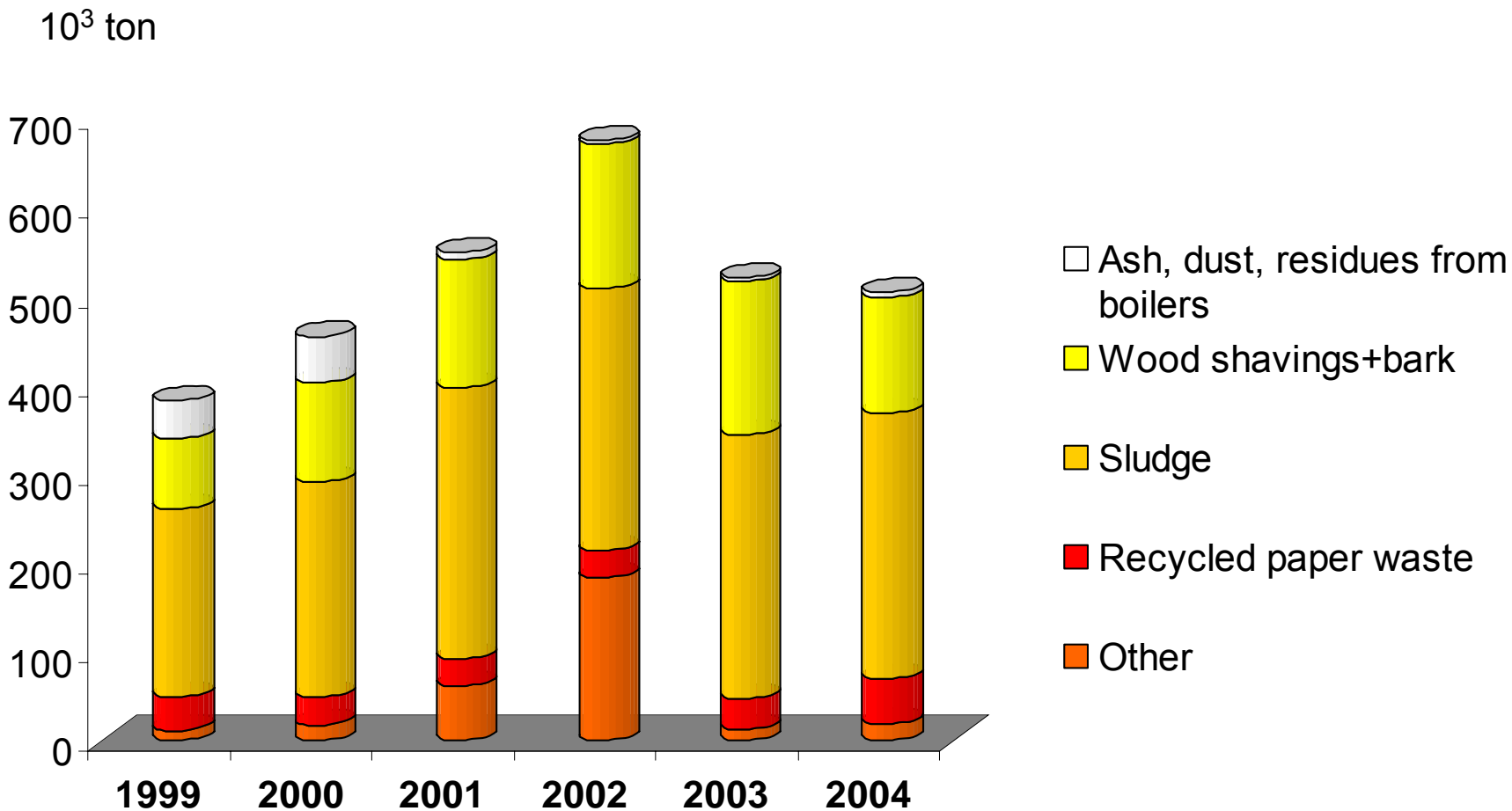
# EU PULP PRODUCERS



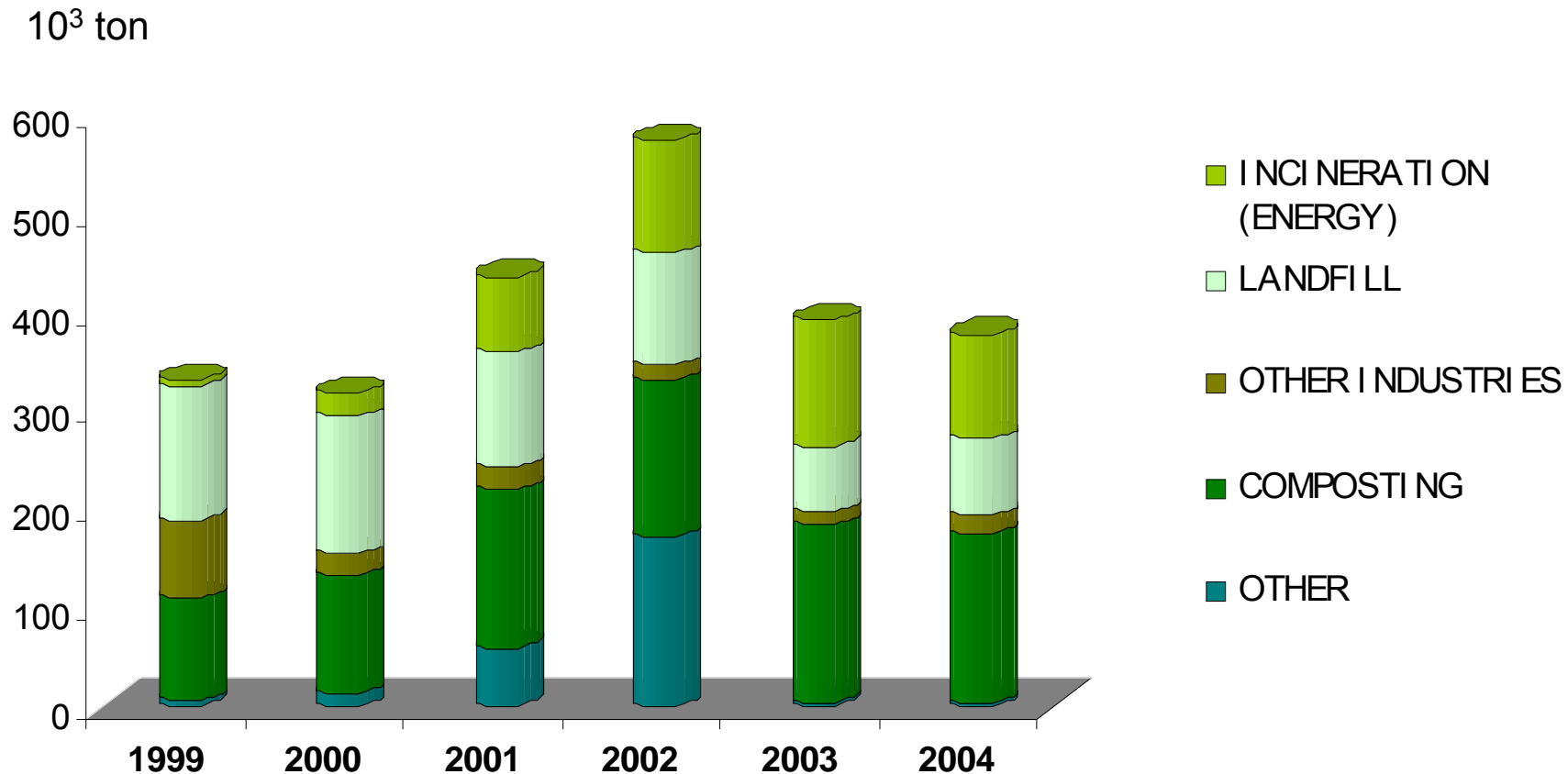
# INVESTMENT, LABOUR PRODUCTIVITY AND ADDED VALUE IN P&P INDUSTRY



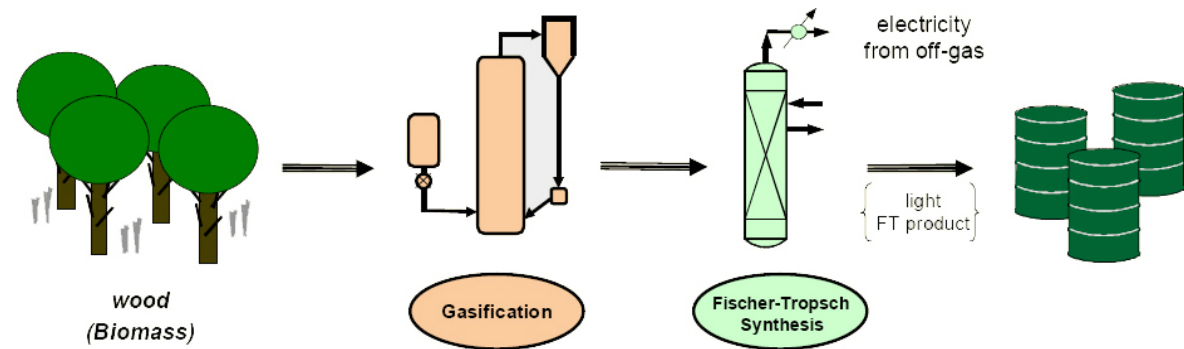
# SOURCE OF SOLID RESIDUES WITHIN PULP AND PAPER PROCESSING INDUSTRY



# FATE OF RESIDUES FROM PULP AND PAPER PROCESSING INDUSTRY



# FROM LIGNOCELLULOSICS TO FT-DIESEL



## SCENARIO I

Biomass is used for generating energy

Hydrogen via the homogeneous water gas reaction

Oxygen and nitrogen via air separation

Biomass to diesel conversion ratio (w/w) 9.3 : 1 (35% water)

## SCENARIO II (future )

Energy, hydrogen and oxygen produced from renewables

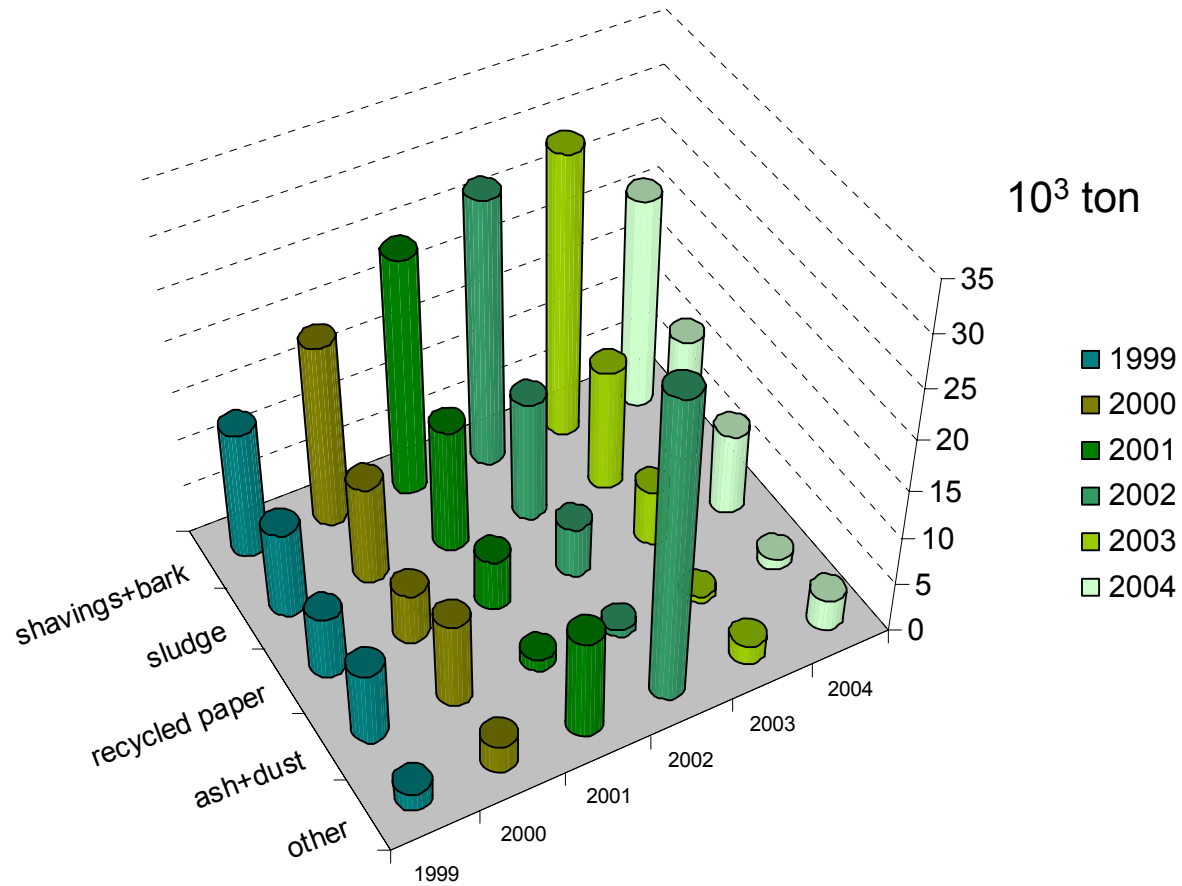
Biomass to diesel conversion ratio 3.4 : 1 (35% water)

## ASSUMPTIONS

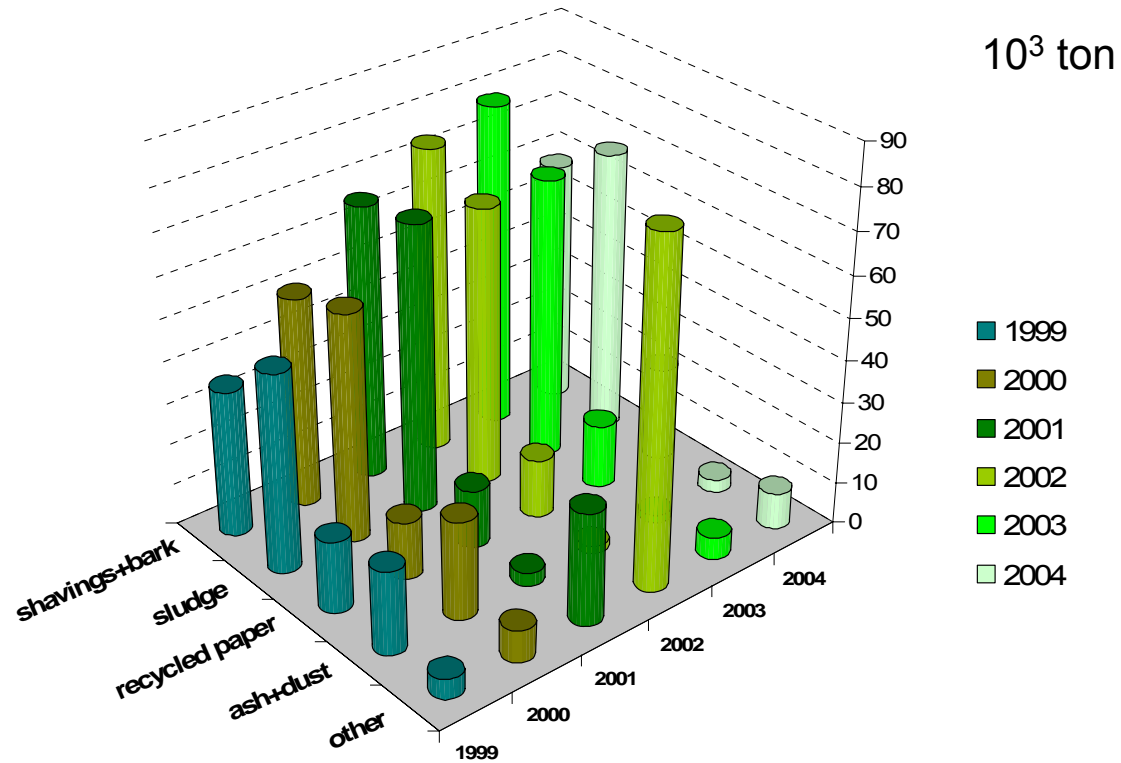
Equivalent conversion for different residues

Transportation of biomass about 100 Km

# RESIDUE DIESEL EQUIVALENT SCENARIO I



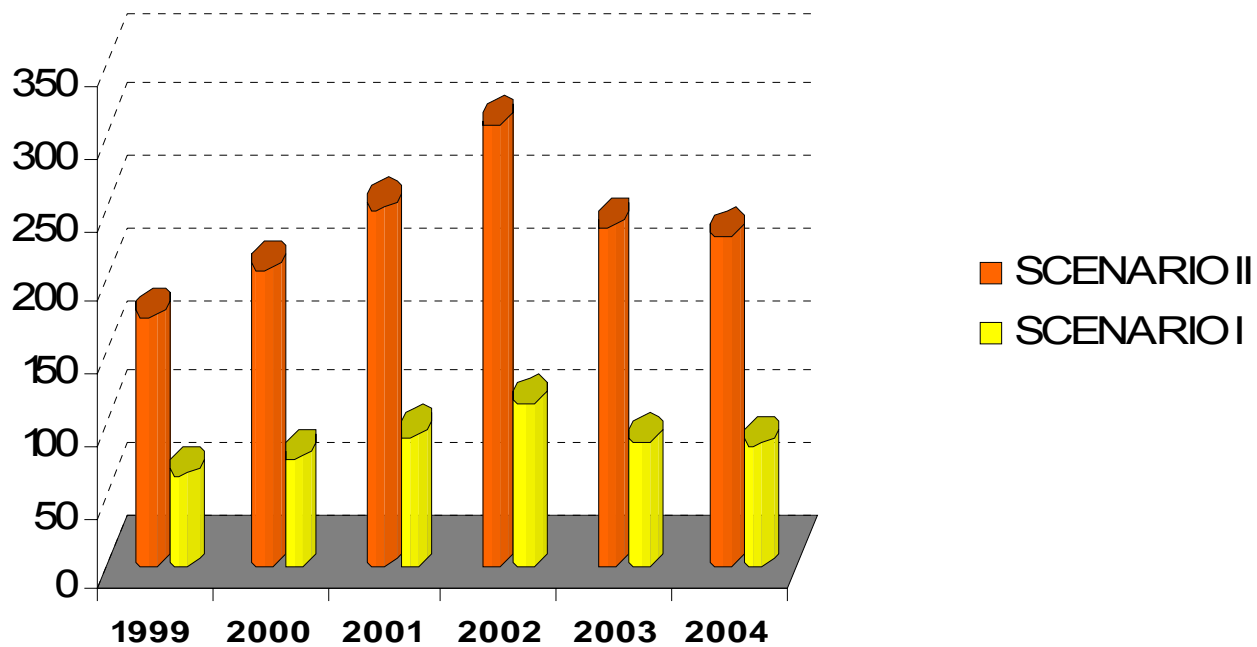
# RESIDUE DIESEL EQUIVALENT SCENARIO II





# TOTAL RESIDUE DIESEL EQUIVALENT

10<sup>3</sup>ton diesel



# OVERALL CONSIDERATIONS I

## Technological Challenges

### Biomass

- Process is versatile; feedstock; wet feedstocks do not need to be dried
- Feedstock cost is important (at 4 €/GJ accounts of about half of overall cost)
- Biomass supply chain needs to be established
- Transportation costs need to be considered (vs pyrolysis oil option)
- Biomass pre-treatment variable ?

### Gasification

- Gas clean-up

### Economy of scale

FT diesel can be “designed” to meet developments in engine design

# OVERALL CONSIDERATIONS II

## Portugal

- FT diesel production is in tune with the activity of major Portuguese energy suppliers
  - Greater market penetration in Europe
- Sustainable development of deserted rural areas (eg. Alentejo) by energy crops
- Forest fires
  - Since 1980 30% of Portugal burnt out by fires
  - (2001-2004) 450 000 ha of plantations plus 335 000 ha of forest (wild)
    - 17.7% of pine
    - 13.2% of Eucalyptus
- Net energy needs of the pulp and paper industry can be met

# ACKNOWLEDGMENTS





**Thank You !**