COST FP0901

Non-sulphur lignin studies under general biorefinery concept and evaluation of energy consumption by steam explosion

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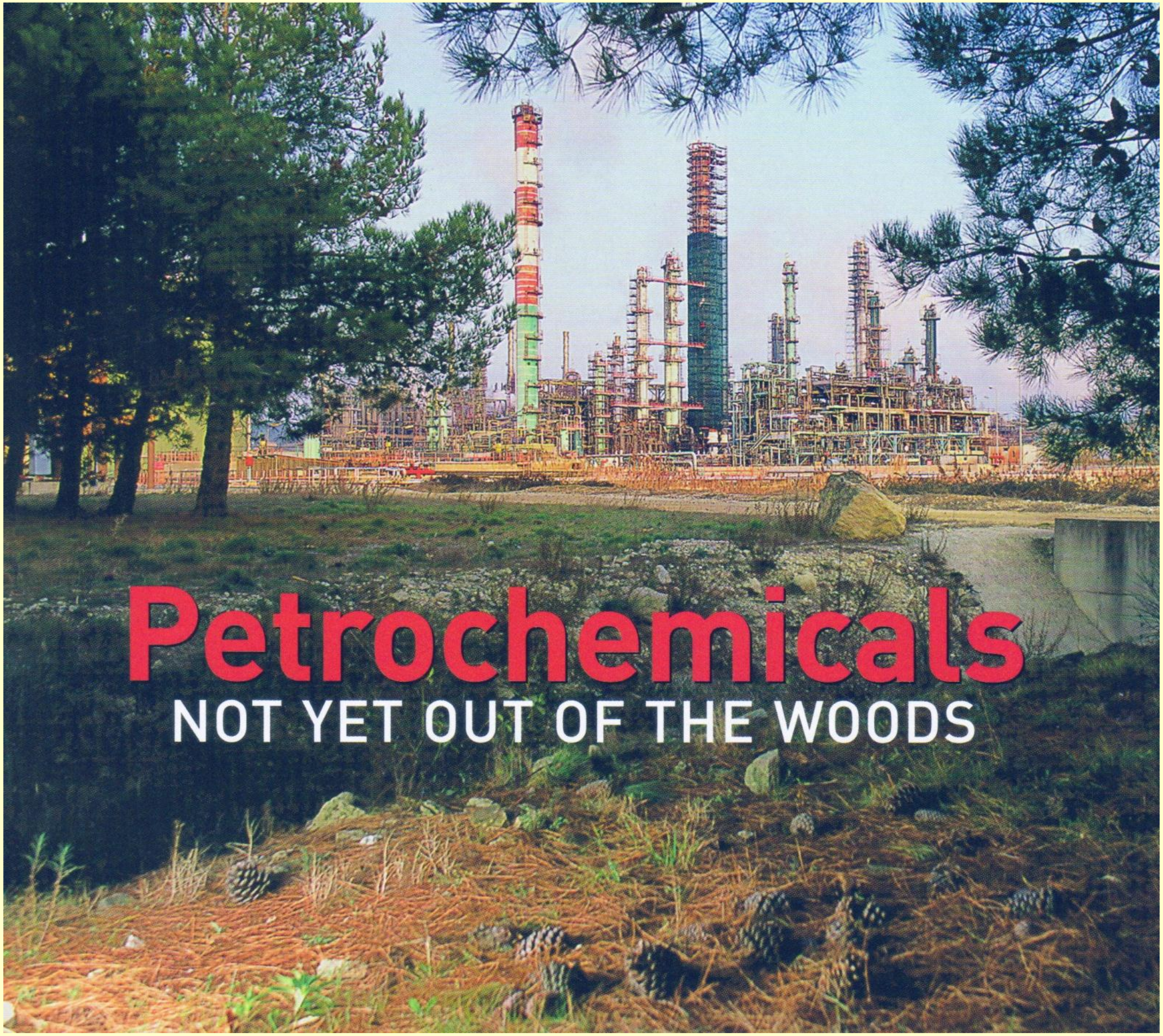
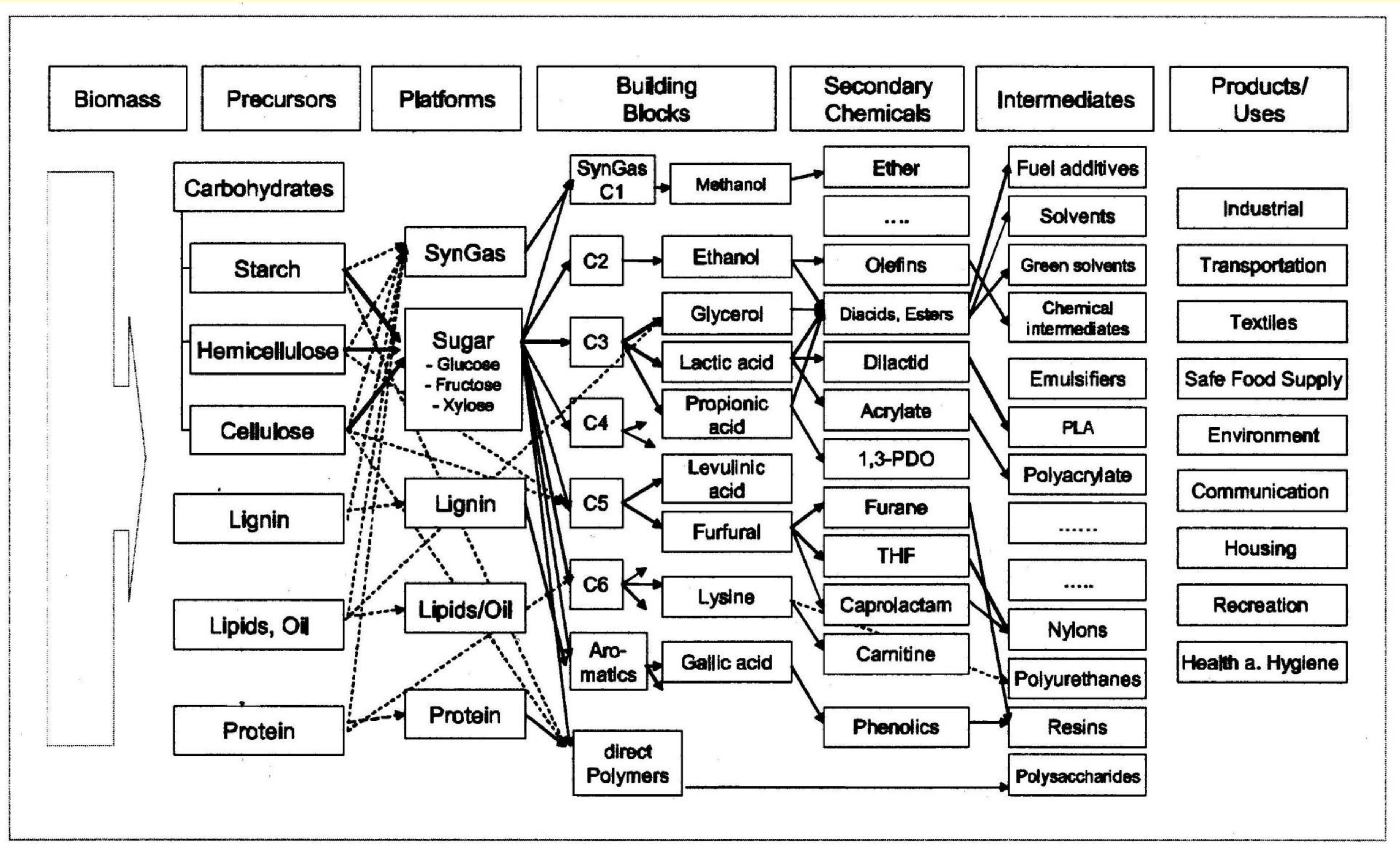

Petrochemicals
NOT YET OUT OF THE WOODS

What is biorefinery?

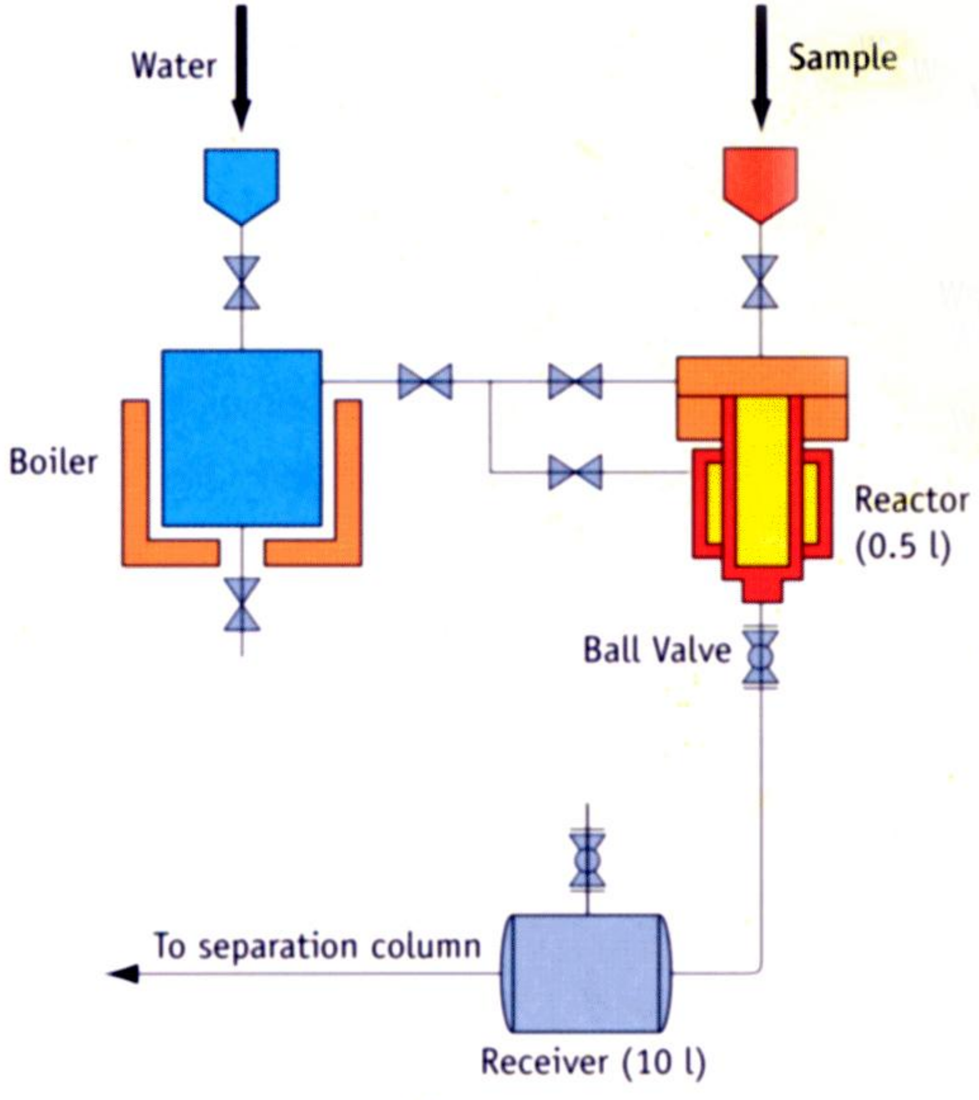
- **A biorefinery is a technologies cluster, which integrates biomass conversion into transportation fuels, power, chemicals and advanced materials within zero emissions framework. (LSIWC/LBE-EC)**

- **„Biorefineries combine the necessary technologies between biological raw materials and industrial intermediates and final products. The principal goal in the development of biorefineries is defined by the following: (biomass) feedstock-mix + process-mix → product-mix" (Kamm)**



Adapted from Kamm

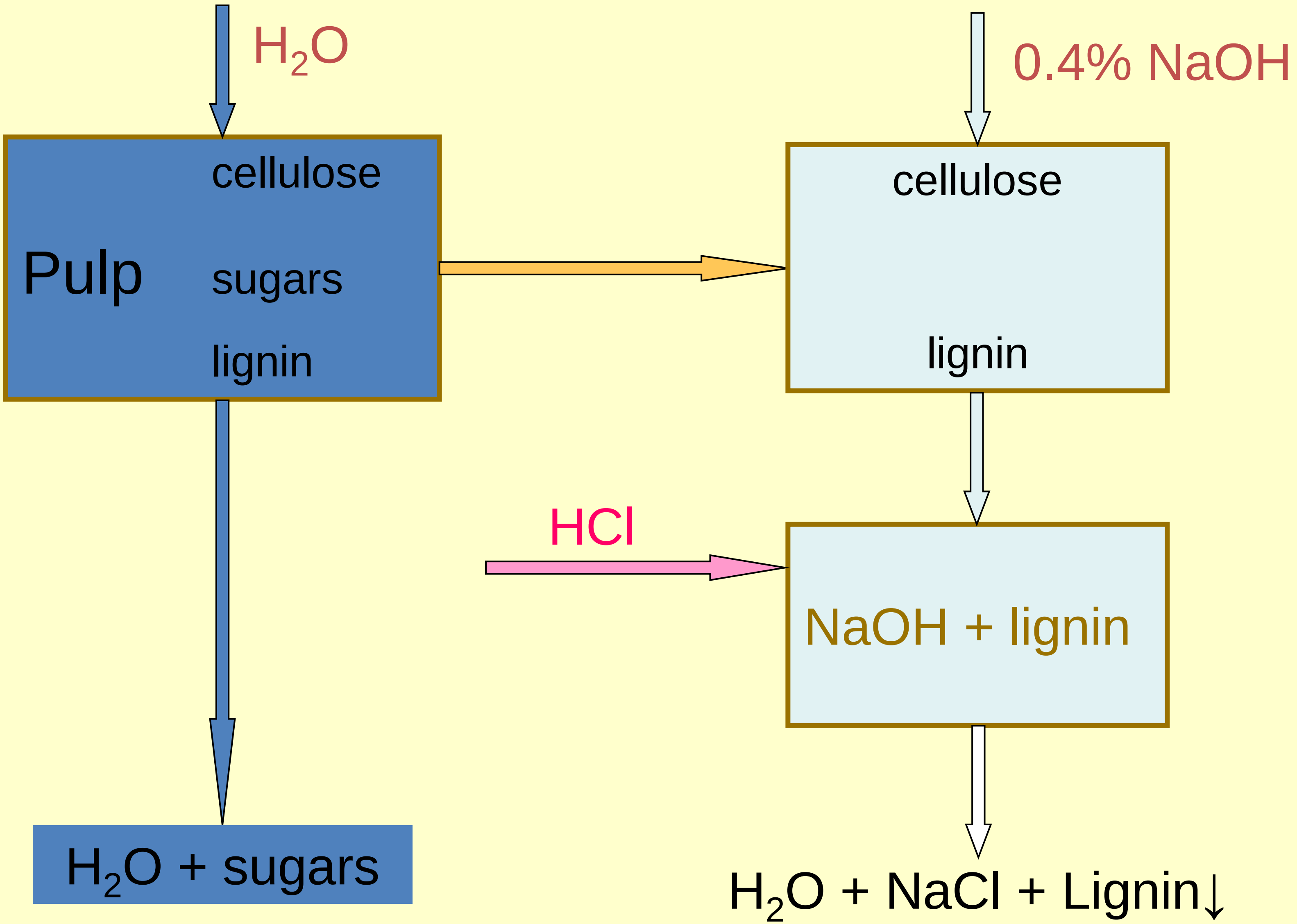
Steam Explosion Unit



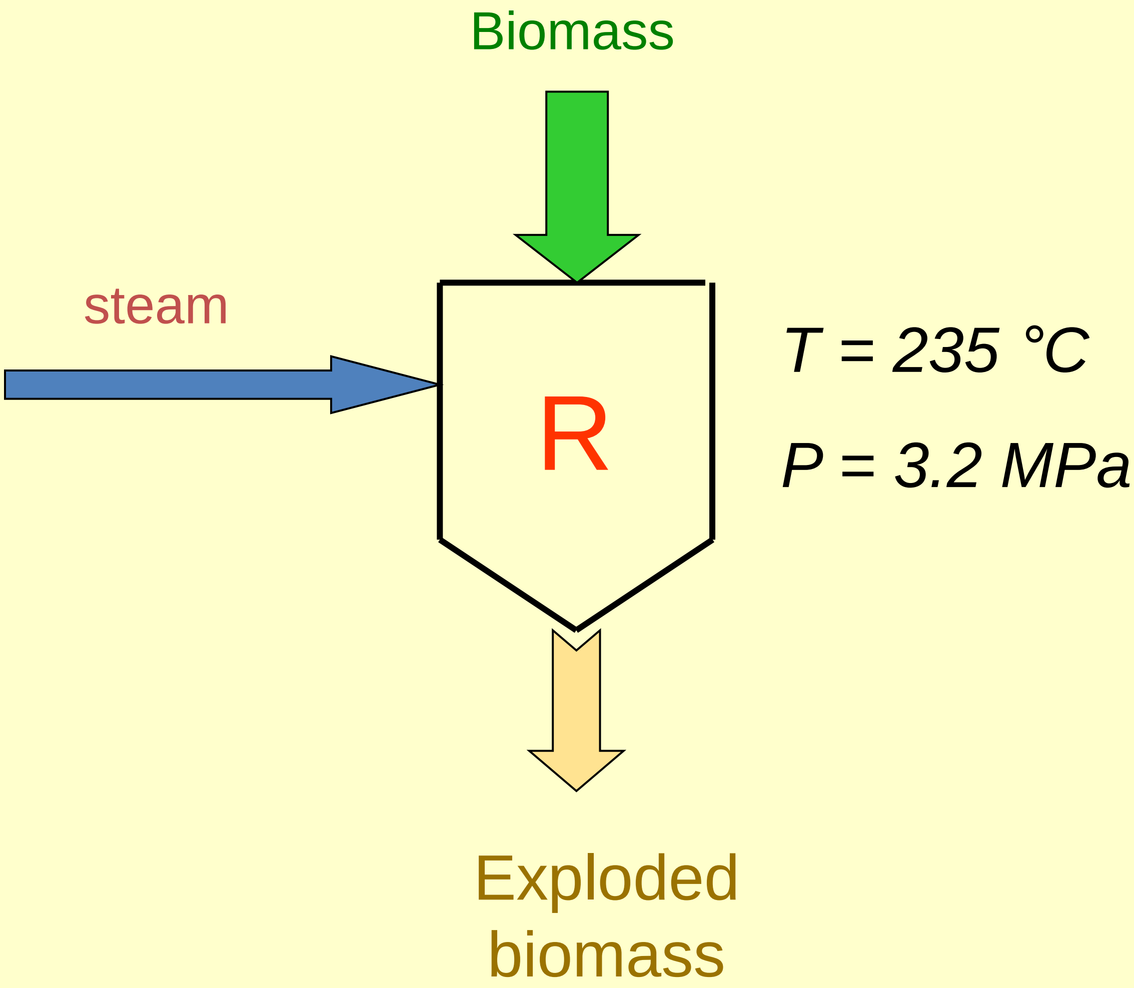
Steam Generator

Reactor

Extraction of lignin



Steam explosion auto-hydrolysis



Non-sulphur lignins

Grey Alder, SE lignin:

SE treatment conditions: N1 – 1 min; N2 – 2 min, N3 – 3 min

Birch lignin:

N4 – SE
N5 Bjorkman's lignin

N6 Wheat straw SE lignin

PY-GS/MS

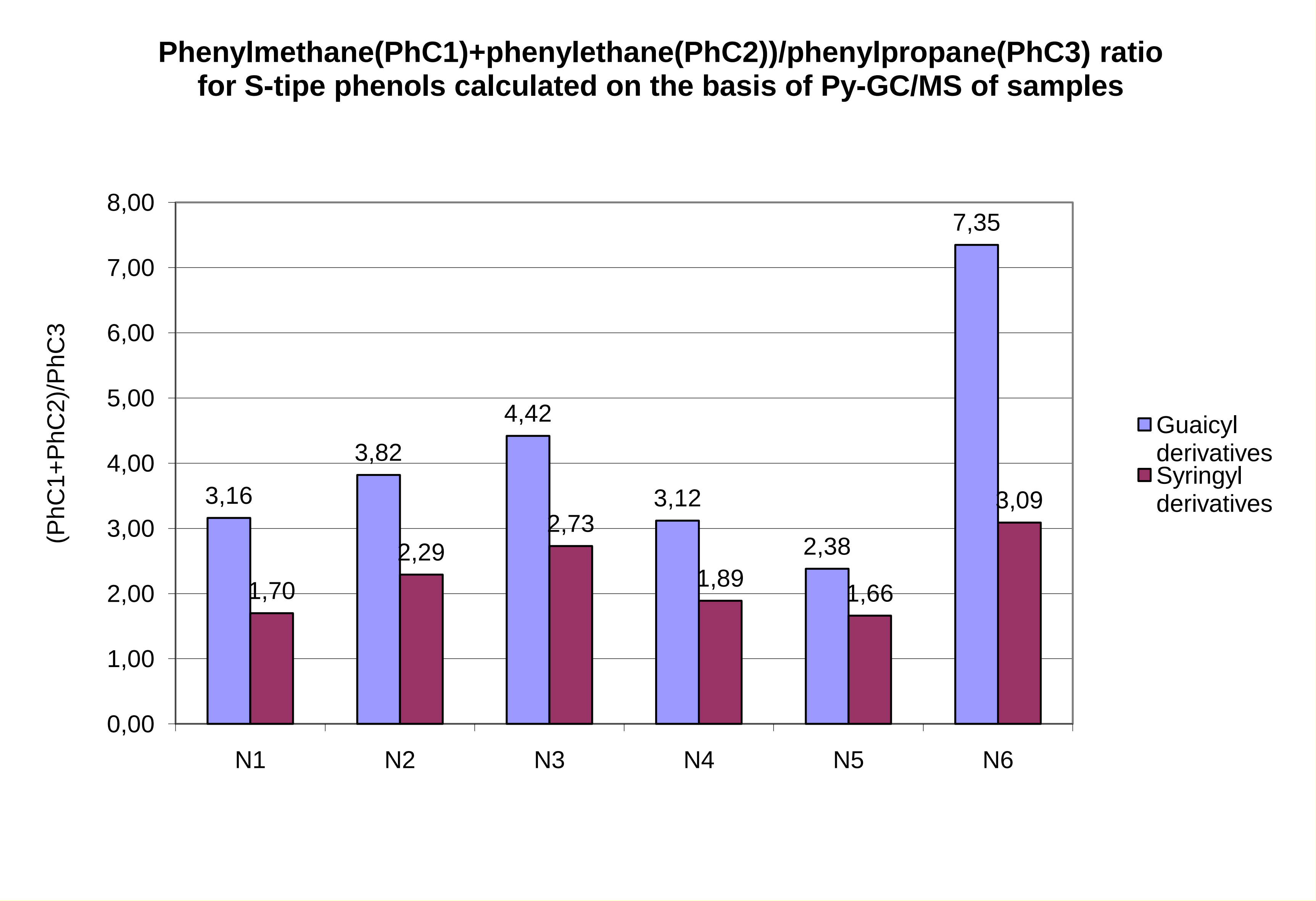
At-1701, 60m	Grey Alder, SE lignin			Birch lignin		Wheat straw lignin
MS_mod_PY sp15 . PY 500*C(1,04-1,10mg)	Different SE conditions			SE	Bjorkman's	SE
MS dati (Integration: 300/30000)						
06-07/ 07-2010	N1	N2	N3	N4	N5	N6
Carbohydrates(C)	1,92	2,07	2,29	1,33	5,67	2,27
Lignin (L)	51,42	46,86	43,57	51,29	54,39	39,92
Summa C+L=100%	53,34	48,93	45,86	52,62	60,06	42,19
Carbohydrates, % from C+L	3,6	4,23	4,99	2,53	9,44	5,38
Lignin, % from C+L	96,4	95,77	95,01	97,47	90,56	94,62
C/L	0,037	0,044	0,053	0,026	0,104	0,057

PY-GS/MS

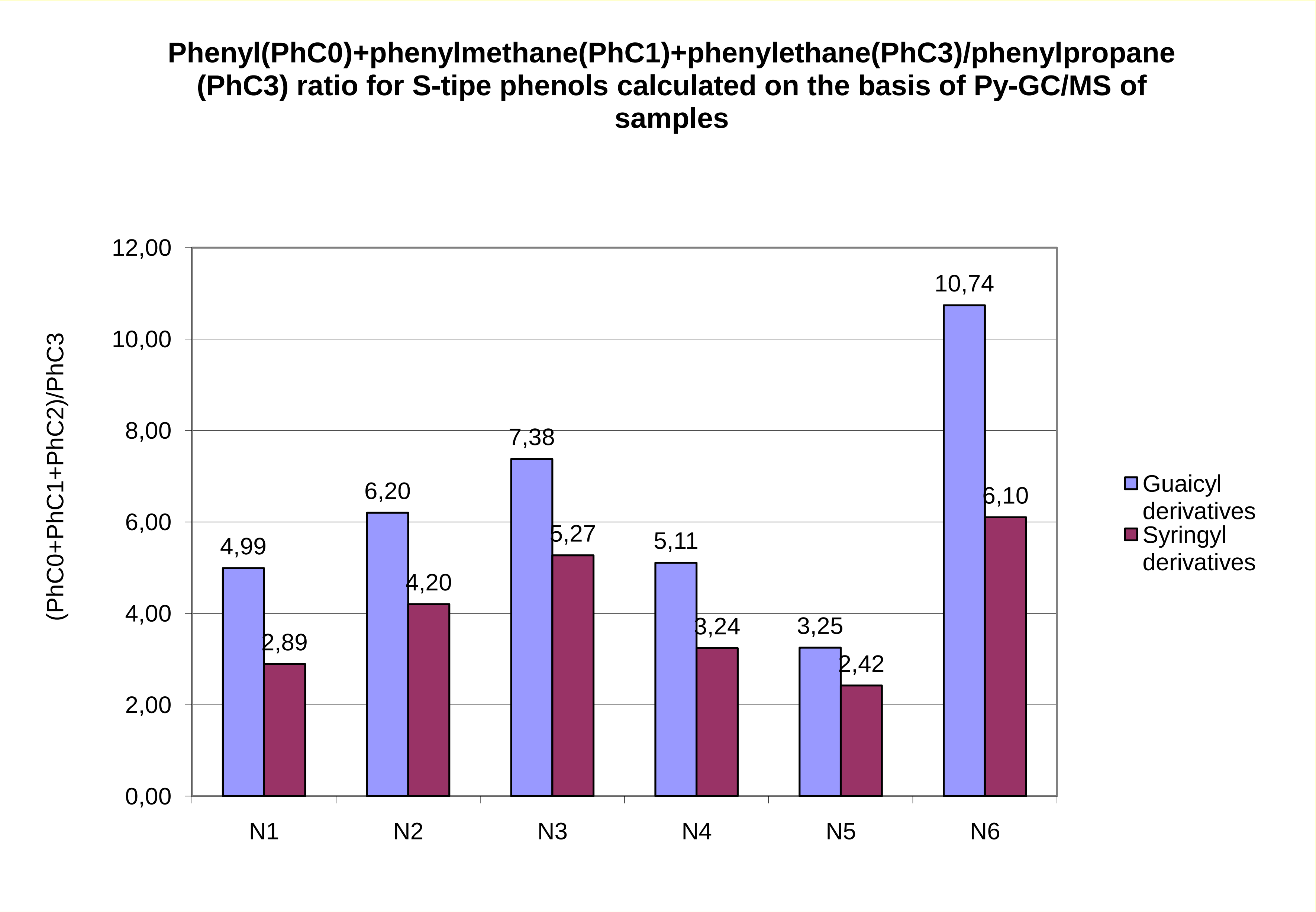
At-1701, 60m	Grey Alder, SE lignin			Birch lignin		Wheat straw lignin
MS_mod_PY sp15 . PY 500*C(1,04-1,10mg)	Different SE conditions			SE	Bjorkman's	SE
MS dati (Integration: 300/30000)						
06-07/ 07-2010	N1	N2	N3	N4	N5	N6
Carbohydrates (C), 100%	% from total C					
Acid, Ester, Ether	31,25	40,1	39,3	46,62	59,79	39,21
Aldehyde, Ketone	38,54	32,37	25,33	33,08	24,69	35,24
Alcohol					2,12	
Furan	19,27	22,22	34,06	15,04	10,05	20,7
Pyran	10,94	5,31	1,31	5,26	3,35	4,85

PY-GC/MS

At-1701, 60m	Grey Alder, SE lignin			Birch lignin		Wheat straw lignin
MS_mod_PY sp15 . PY 500*C(1,04-1,10mg)	Different SE conditions			SE	Bjorkman's	SE
MS dati (Integration: 300/30000)						
06-07/ 07-2010	N1	N2	N3	N4	N5	N6
Lignin(L), 100%	% from total L					
Phenyl and benzyl derivates,	5,74	6,34	6,72	2,87	2,61	10,28
Guaiacyl -	25,71	28,96	29,57	19,71	24,31	59,89
Syringyl -	68,55	64,7	63,71	77,42	73,08	29,83


Phenylmethane(PhC1)+phenylethane(PhC2))/phenylpropane(PhC3) ratio
for S-tipe phenols calculated on the basis of Py-GC/MS of samples
(PhC1+PhC2)/PhC3
8,00
7,00
6,00
5,00
4,00
3,00
2,00
1,00
0,00
3,16
1,70
3,82
2,29
4,42
2,73
3,12
1,89
2,38
1,66
7,35
3,09
N1
N2
N3
N4
N5
N6
Guaicyl derivatives
Syringyl derivatives

PY-GS/MS

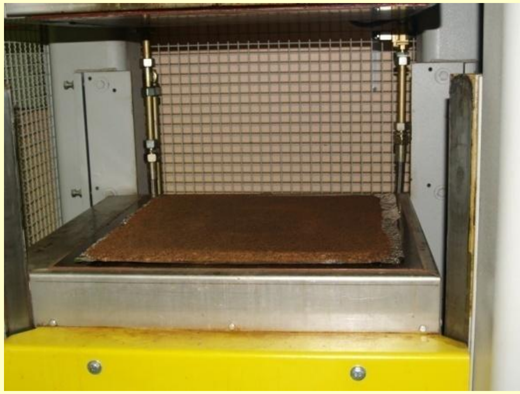


Phenyl(PhC0)+phenylmethane(PhC1)+phenylethane(PhC3)/phenylpropane (PhC3) ratio for S-tipe phenols calculated on the basis of Py-GC/MS of samples
(PhC0+PhC1+PhC2)/PhC3
12,00
10,00
8,00
6,00
4,00
2,00
0,00
4,99
2,89
6,20
4,20
7,38
5,27
5,11
3,24
3,25
2,42
10,74
6,10
N1
N2
N3
N4
N5
N6
Guaicyl derivatives
Syringyl derivatives

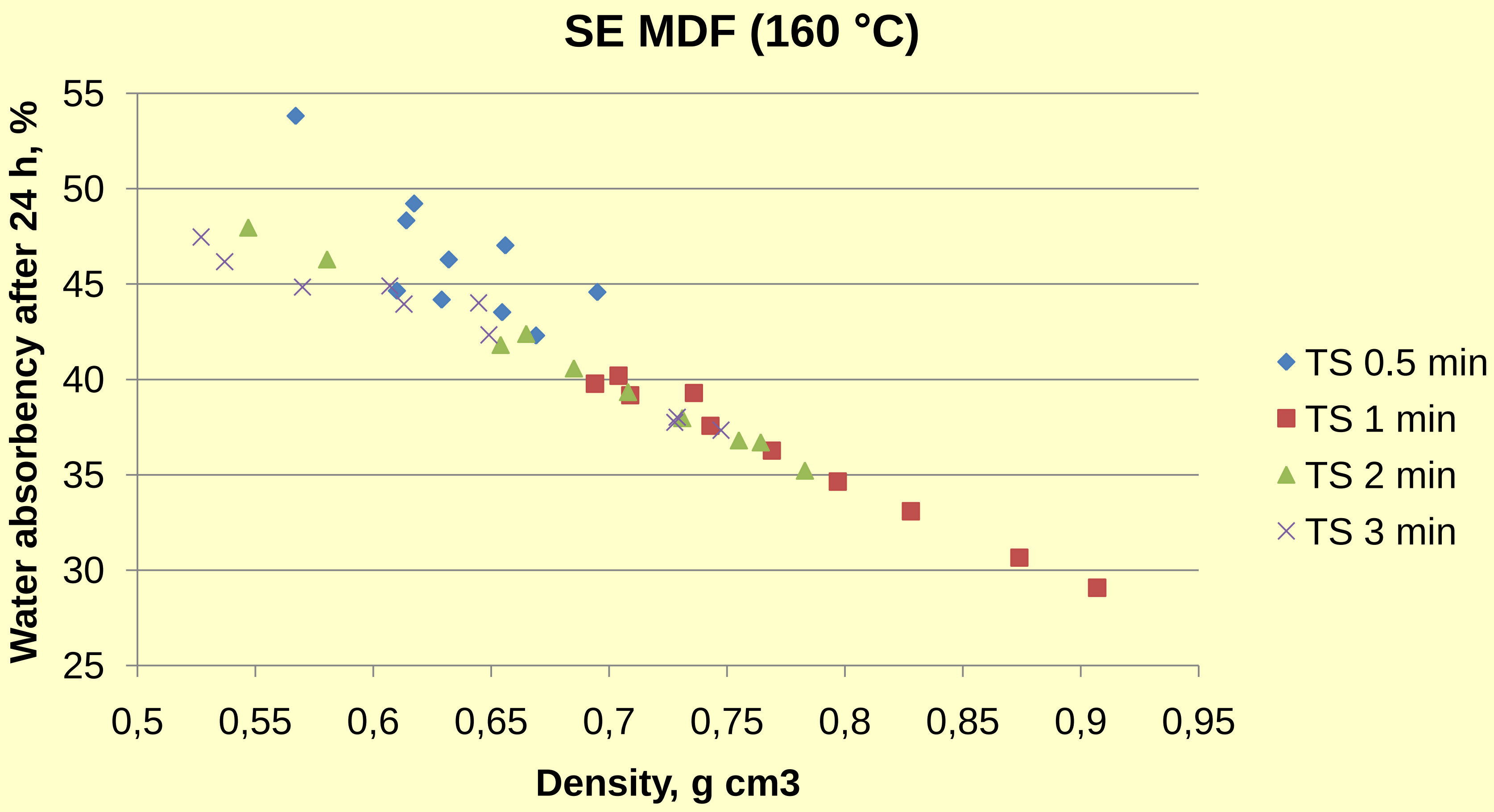
PY-GS/MS

SE self-binding MDF hot pressing

Sample	T, °C	p, Mpa max/min	Time, min (hot+cool)
SE 05	160	0.6/0.05	8 + 10
SE 1	150	0.8/0.08	8 + 15
SE 1	160	1.5/0.02	8 + 12
SE 1	170	2.1/0.02	6 + 10
SE 2	160	0.6/0.05	8 + 10
SE 3	160	0.4/0.06	8 + 10



Form Stability vs Density



Consumption of energy

Net efficiency

$$F = \frac{E_o}{E}$$

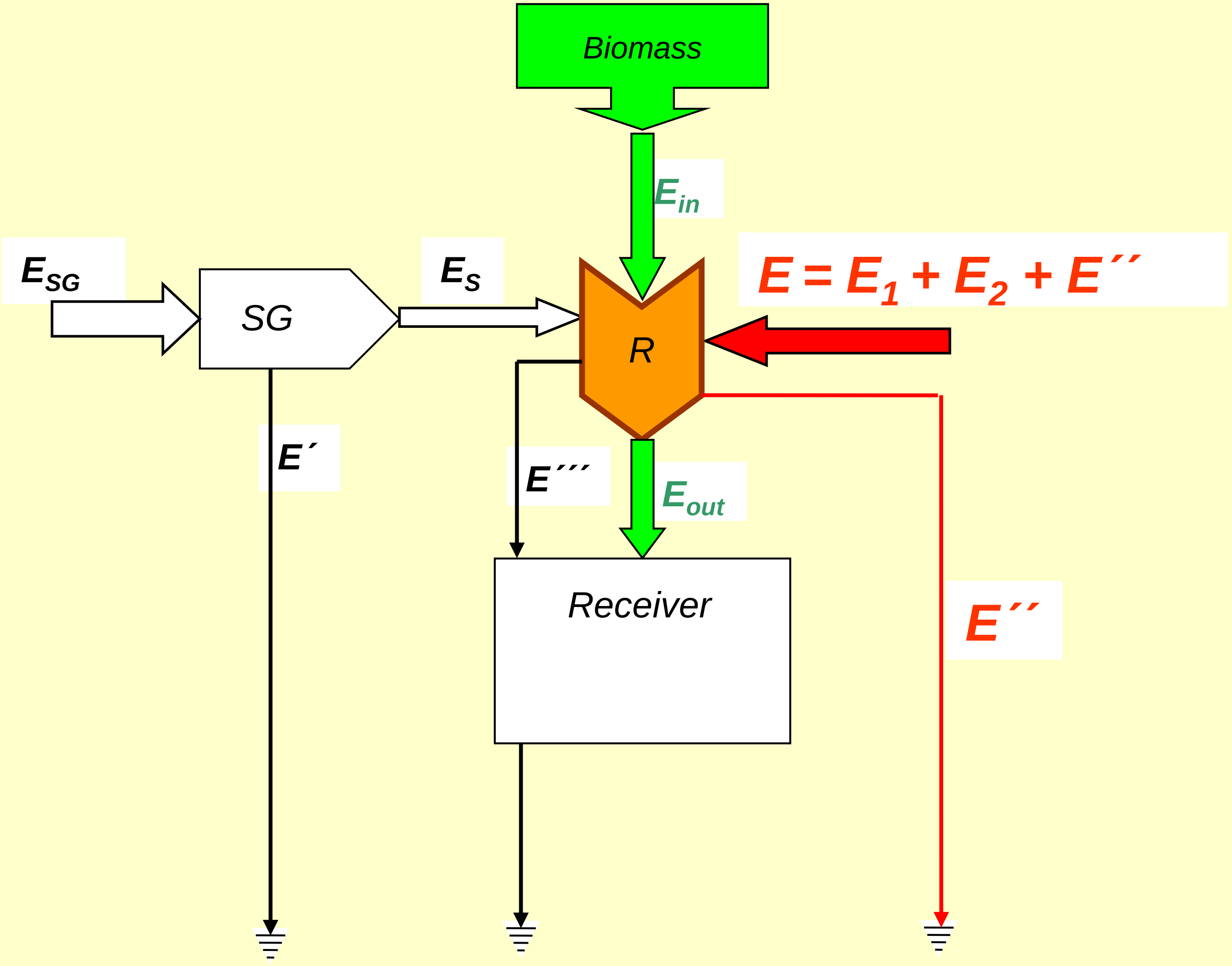
Required energy

Consumed energy

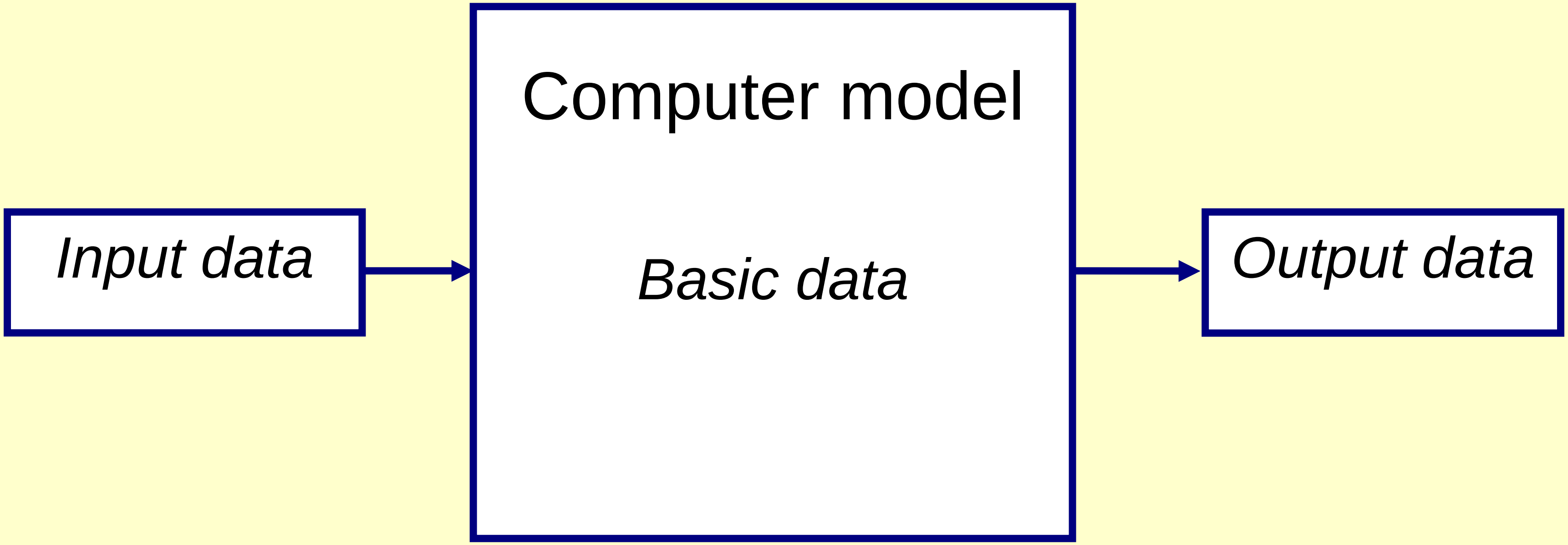
In units of biomass combustion energy E_c

$$F = \frac{E_o / E_c}{E / E_c} \quad \Longrightarrow \quad \frac{E_c}{E} = \frac{F}{\dfrac{E_o}{E_c}}$$

Energy Flows



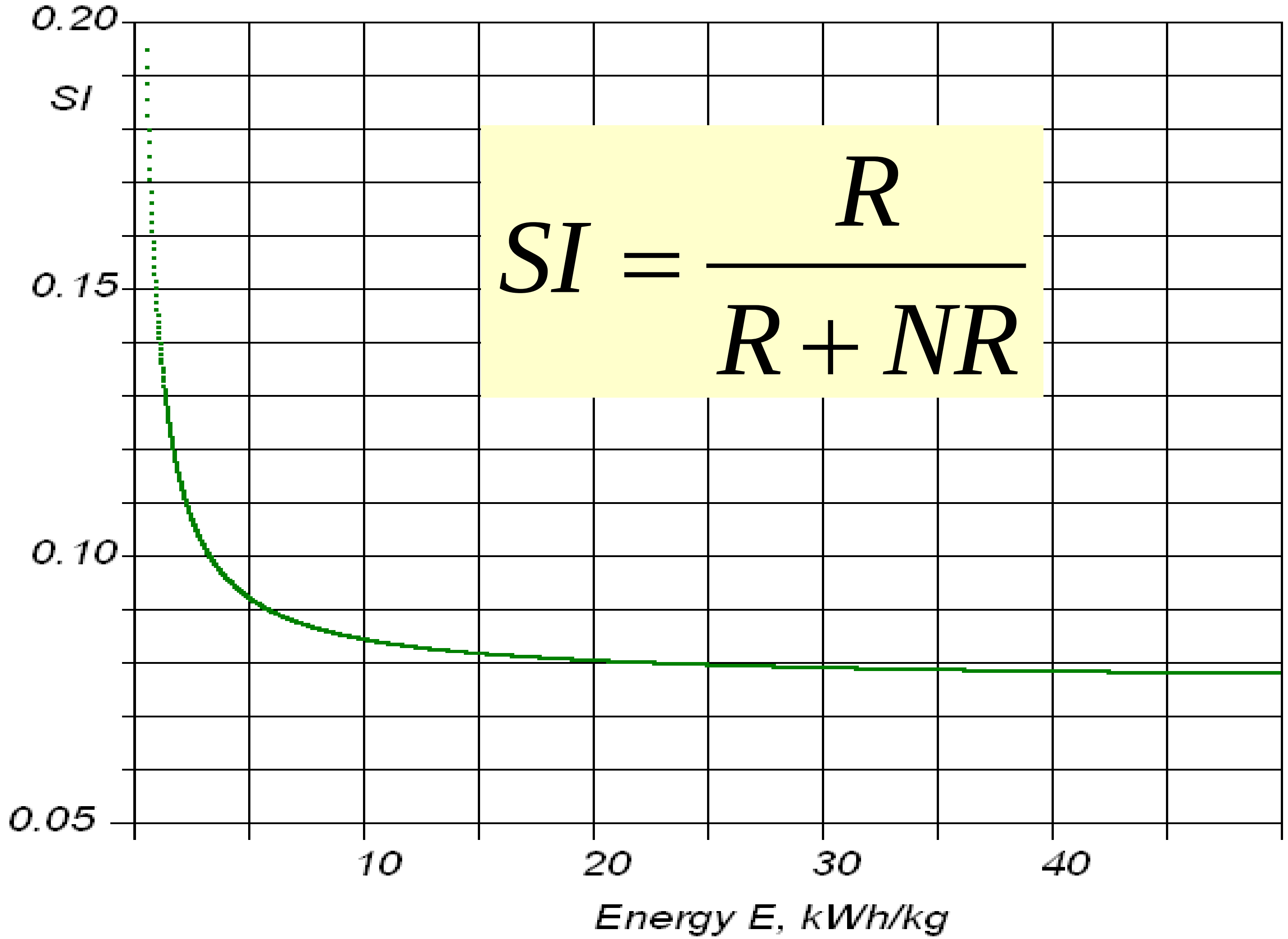
Modelling SE energy flows



Basic Data

Description	Value, kJ/kg K
Heat capacity of biomass	2.7
Heat capacity of water	4.19
Heat of water evaporation	2257
Enthalpy of steam at 60 bar, 100 ºC	423
Enthalpy of steam at 60 bar, 250 ºC	1085

Sustainability (for all biorafineries)



$$SI = \frac{R}{R + NR}$$

Emergies and indicators

Description	Value
Non-renewable emergy (NR)	1088 MWh-sol
Renewable emergy (R)	89.6 MWh-sol
Conditionally renewable emergy (SR)	26 MWh-sol
Emergy yield (EY)	1203.6 MWh-sol/kg
Added emergy ratio (AER)	45.3
Sustainability index (SI)	0.096
Environmental load (L)	0.926

When written in Chinese, the word "crises" is composed of two characters - one represents danger and one represents opportunity

危機

Questions?