LODZ UNIVERSITY OF TECHNOLOGY
FACULTY OF MECHANICAL ENGINEERING
INSTITUTE OF TURBOMACHINERY

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PhD Title : "Biomass torrefaction and co-firing. Processes modeling."

Key words: biomass, torrefaction, co-firing

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PhD Title : „Heat pipes in heating and ventilaion systems."

Key words: heat pipes, ventilation

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PhD Title : „Biomass gasification."

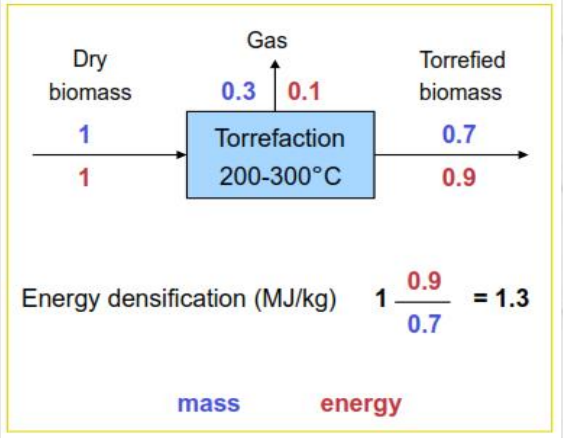
Key words: biomass, gasification

Scope of work:

- PhD Thesis
- Work Packages
- Summerise and conclusions
- Further improvments and future plans

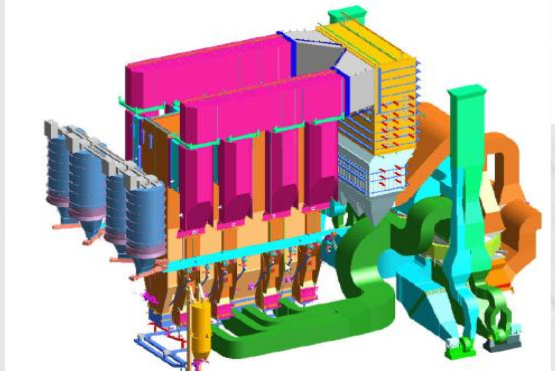
What is torrefaction?

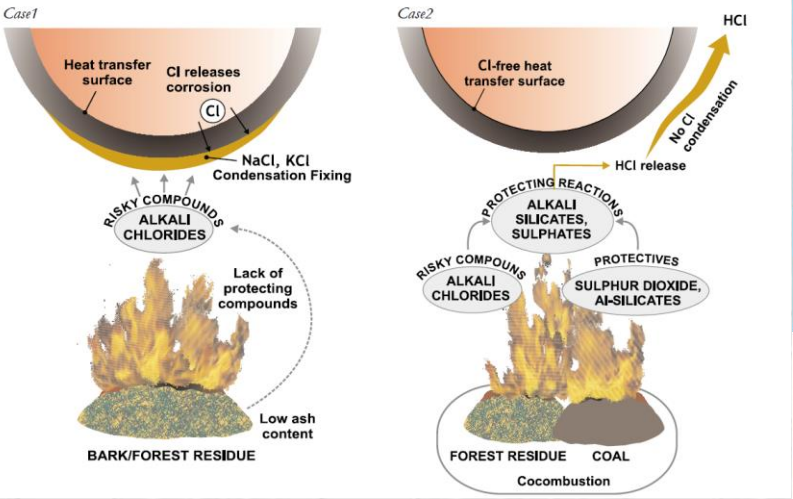
Torrefaction (carbonization) - is thermo-chemical degradation process of biomass particules under atmospheric pressure, in inert atmosphere (nitrogen, argon) in temperature range from 200 to 300 ºC.



What is biomass co-firing ?

Co-firing is the process of replacing part of the fossil fuel supplied to a power station or boiler with a 'carbon lean', renewable alternative. Usually it is used to refer to the use of solid biomass within coal fired power stations.





Work Packages

WP	WP Description	WP period
1.	**Pre-selection of the most promising and efficient from thermodynamic point of view method from all possible biomass pre-treatment techniques.**	4 months
2.	**Fuel characteristics of selected types of biomass and their classification using technical analysis methods (moisture content, volatile matter content, ash content, low heating value, high heating value) and elemental analysis (using elemental analyser to specify percentage amount of hydrogen, sulfur, nitrogen and oxygen content).**	8 months
3.	**Biomass pre-treatment process using the most optimal methods like for example biomass high temperature drying process - torrefaction using thermogravimetric methods.**	8 months
4.	**Analysis of the biomass carbonization (torrefaction process) to find out the most fundamental kinethics elements of biomass using self-design and self-build installation for biomass torrefaction with special reactor.**	8 months
5.	**Using data from the critical conversion of biomass and elemental analysis, technical analysis to build up the nummerical model of biomass co-firing process with selected types of coal.**	12 months
6.	**Validation of experimental results made in special reactor for biomass torrefaction, boiler,thermogravimetric analyser and FTiR anlyser with computer simulations.**	8 months

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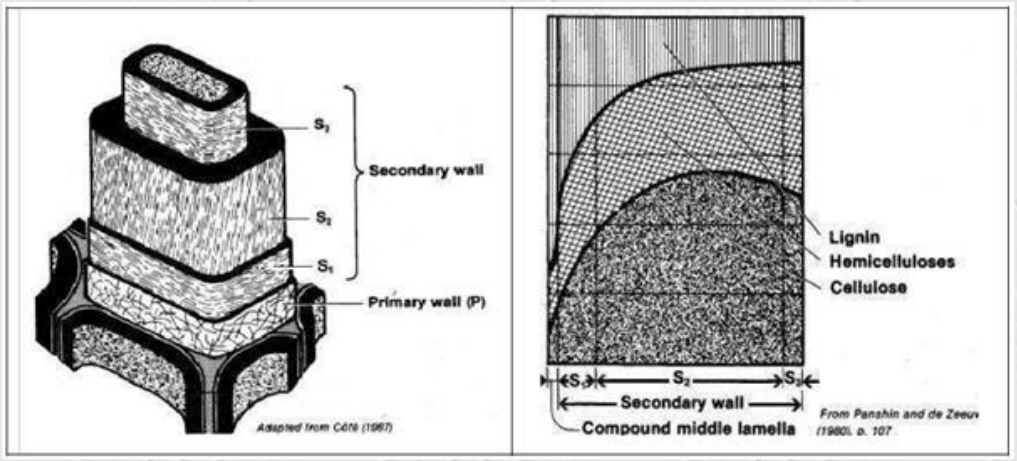
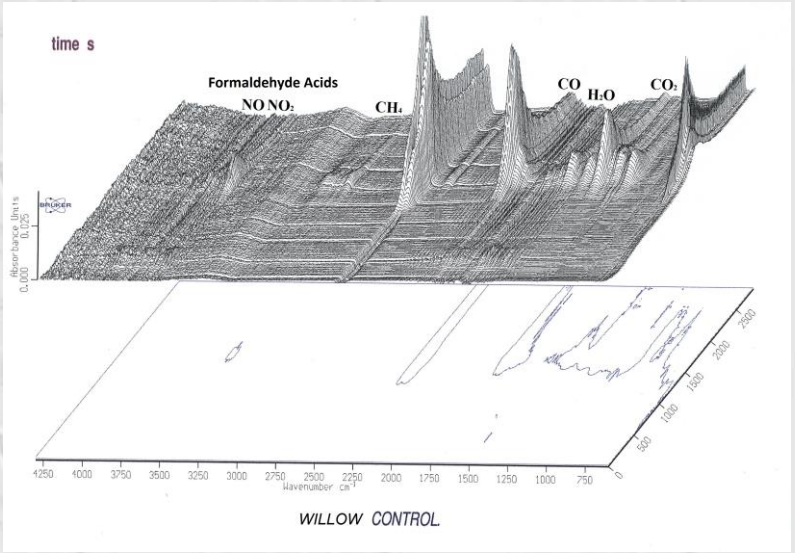
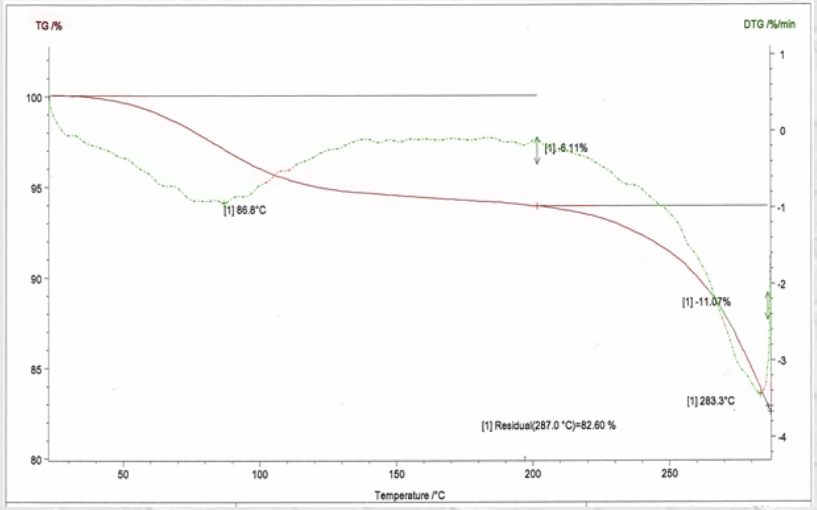
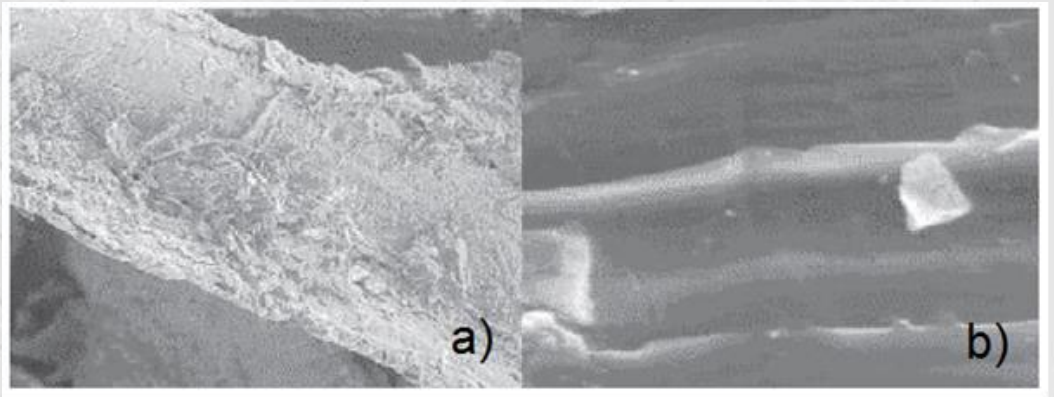
TG and FTiR Analysis of biomass torrefaction

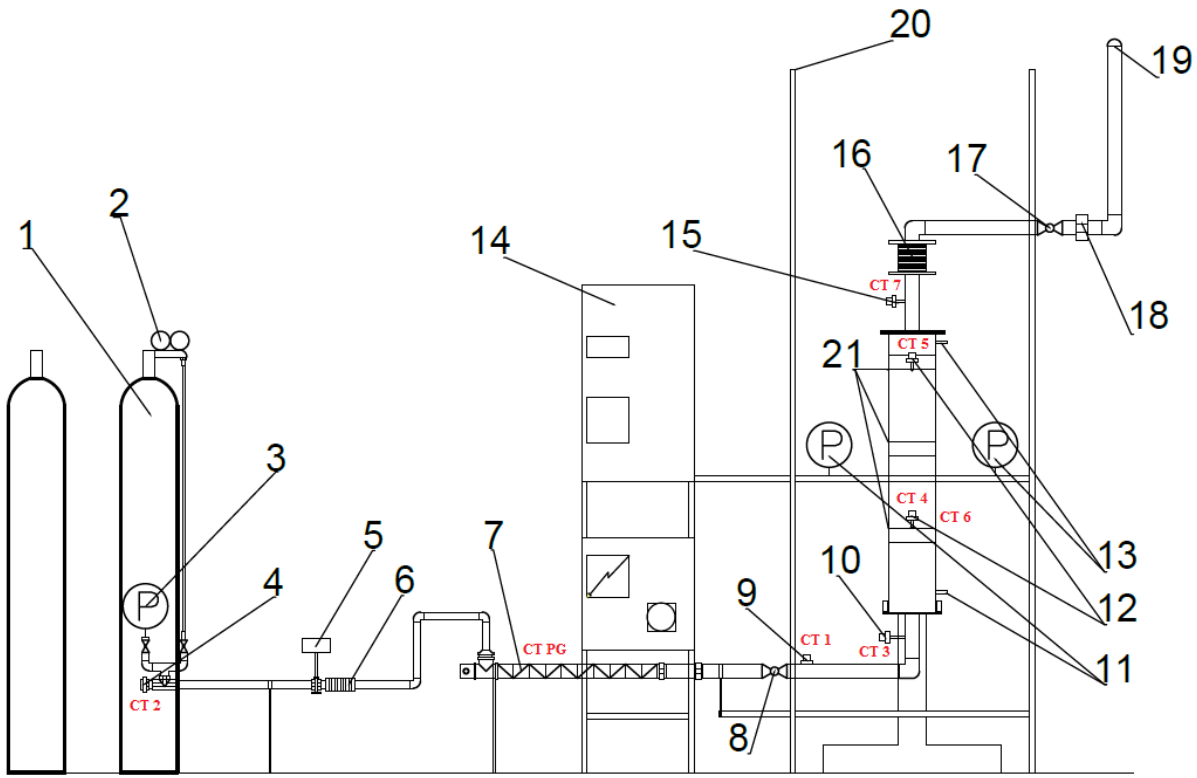






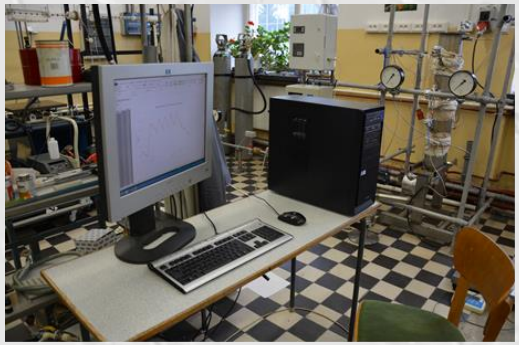


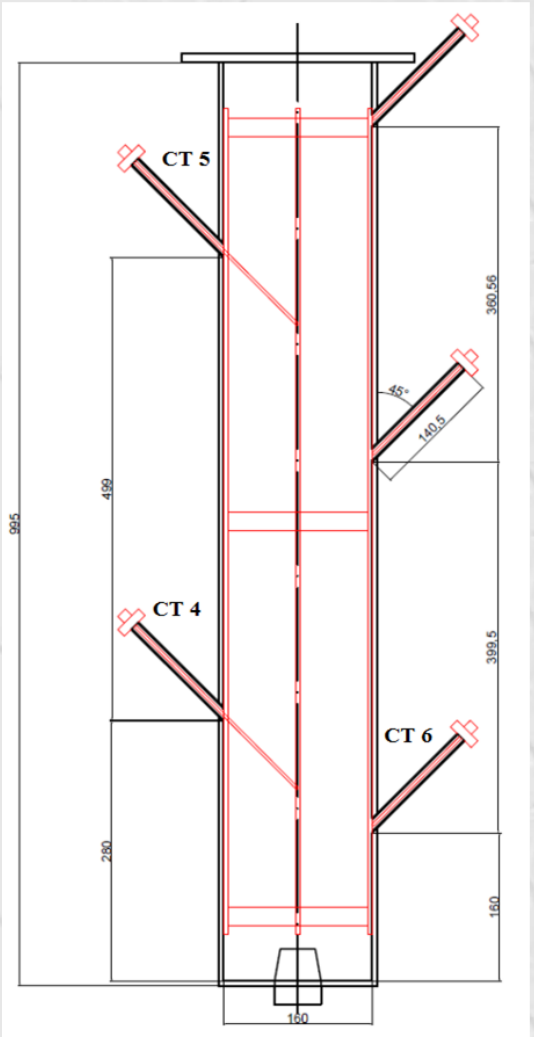
Installation for biomass torrefaction



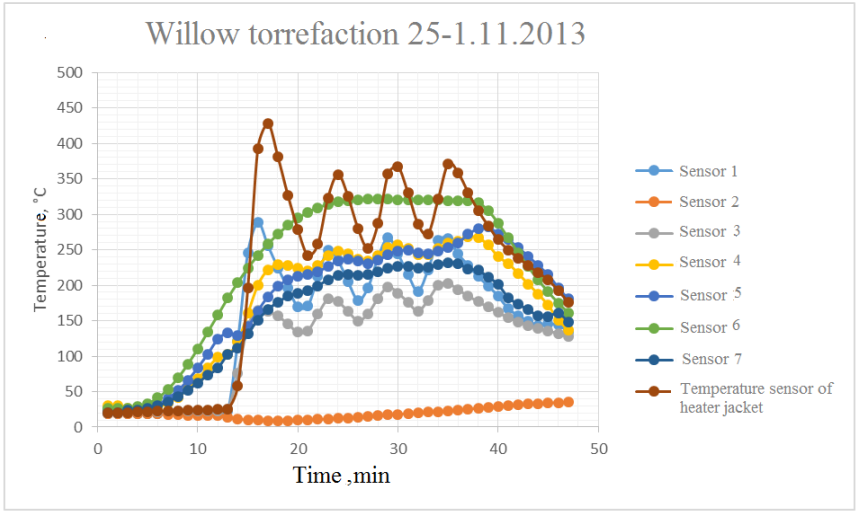
1 - Bottle with technical nitrogen
2 - Reducer to nitrogen
3 - Manometer
4 - Temperature sensor
5 - Calorimetric mass flowmeter
6 - Insulating element from overheating flowmeter
7 - Instantaneous electric heater nitrogen
8 - Pressure reducing valve
9 - A temperature sensor controling nitrogen temperature
10 - Temperature sensor
11 - Pressure sensor
12 - The sensor assembly for batch reactor temperature control
13 - Pressure sensor
14 - The control cabinet with the recorder and controller
15 - Temperature sensor
16 - Check valve
17 - Controle valve
18 - Flare connecting the lid of the reactor
19 - The exhaust outlet for chimney
20 - The support structure
21 - Heaters girdling 3x2kW
CT - Temperature sensor
CT PG - The heater jacket sensor

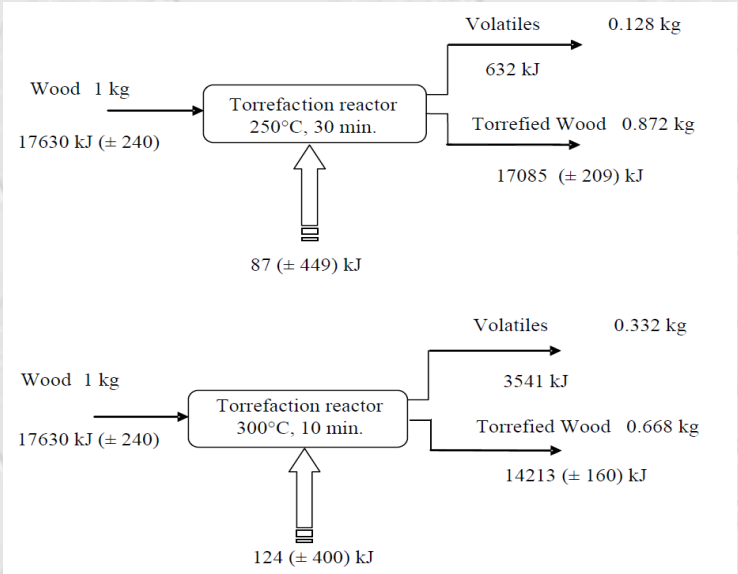
Installation for biomass torrefaction

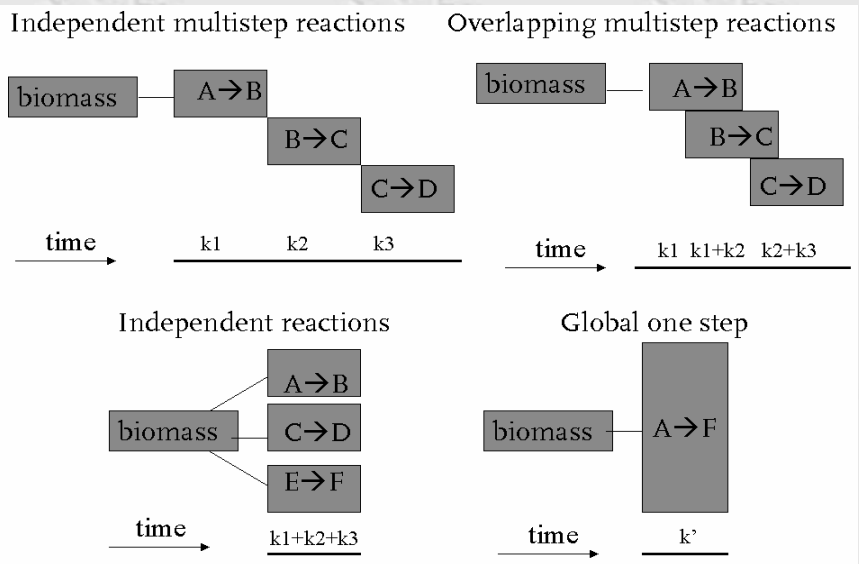


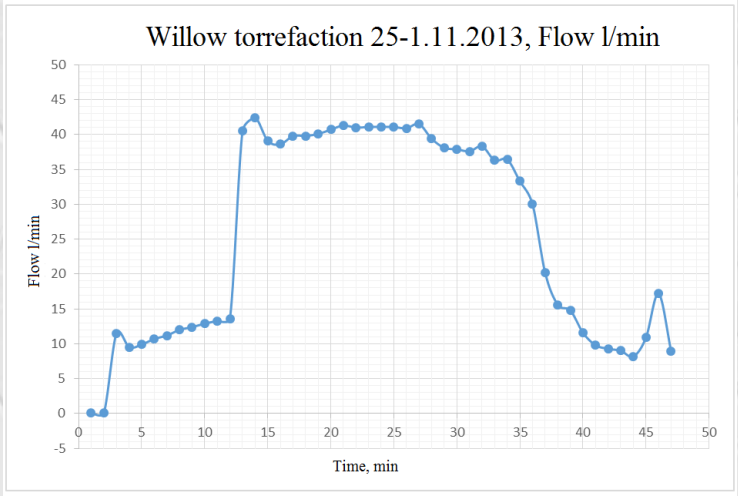


Installation for biomass torrefaction – results and problems which occur





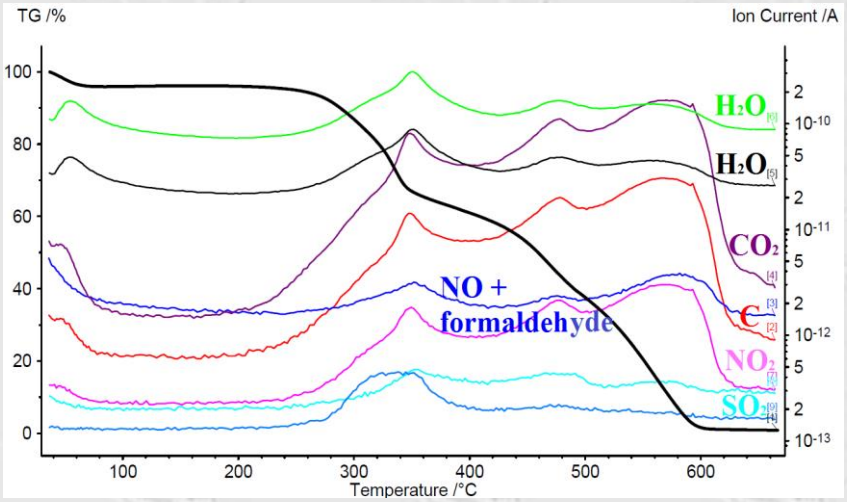


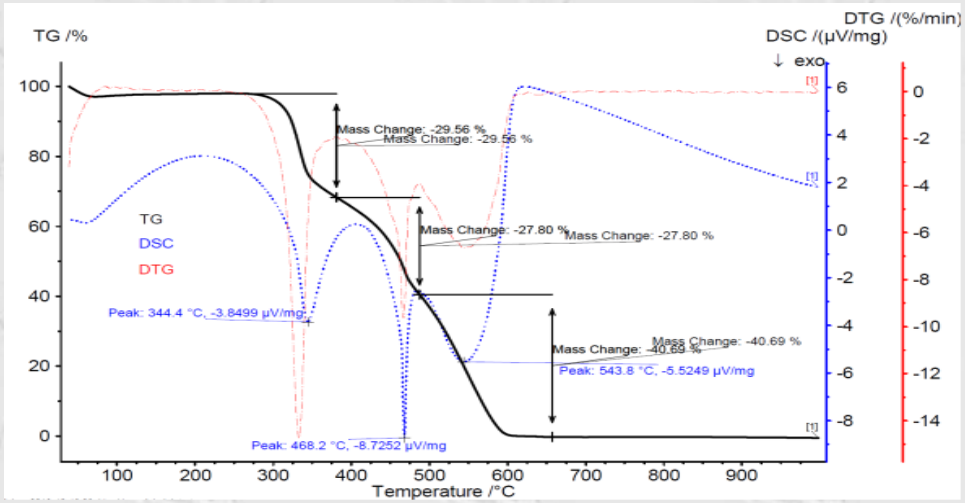


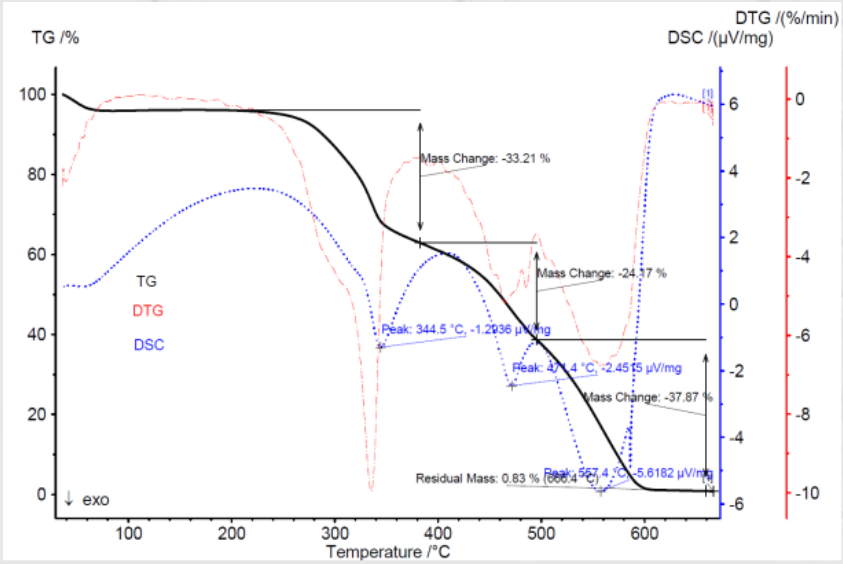
Installation for biomass torrefaction – results and problems which occur

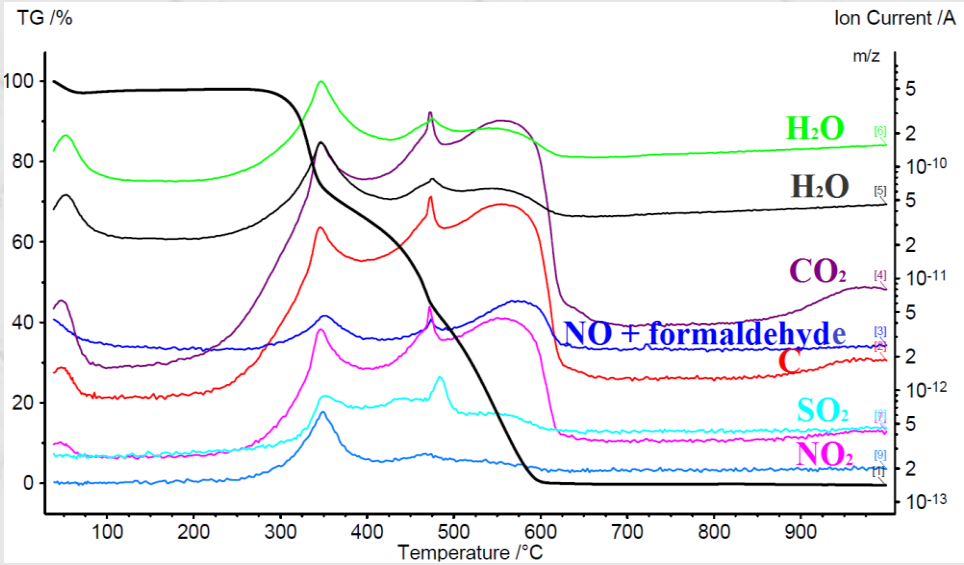
Biomass type	C	H	C/H	Moisture content (%)	Ash (%)	HHV(MJ/kg)	LHV (MJ/kg)
Sida	%	%		Analytical	Dry matter	Average	Average (3 samples)
(2) 3_1.12.2013	55,9	5,38	10,39	4,42	4,2	22,47	20,06
(2) 3_2.12.2013	51,81	5,62	9,22	6,31	2,74	19,40	17,32
(2) 4_1.12.2013	53,3	5,57	9,57	5,41	3,17	20,41	18,22
(2) k 5_1.12.13	54,16	5,42	9,99	4,98	3,65	21,88	19,54
(1) 4_1.12.13	52,5	5,67	9,26	6,11	2,82	19,88	17,75
(1) 5_1.12.13	53,09	5,62	9,45	5,89	2,97	20,19	18,03
Jerusalem artichoke							
(2) 30_1.11.2013	56,4	5,21	10,83	5,93	6,12	24,35	21,74
(1) 30_2.11.2013	53,86	5,31	10,14	6,44	5,82	22,42	20,02
(1) 30_2.11.2013	54,6	5,35	10,21	6,15	6,02	22,68	20,25
(2) 2_2.12.2013	52	5,54	9,39	7, 72	5,11	21,26	18,98
(1) 2_2.12.2013	53,31	5,46	9,76	7,14	5,46	21,92	19,57
Willow							
(1) 26_1.11.2013	49,21	5,67	8,68	4,12	2,92	22,31	19,92
(2) 26_2.11.2013	52,51	5,85	8,98	4,05	3,01	23,48	20,96
(1) 26_2.11.2013	53,2	5,85	9,09	3,93	3,2	24,02	21,45
(1) 22.11.2013	54,53	5,72	9,53	3,78	3,46	25,10	22,41
Coal (Katowice)	79,91	5,16	15,49	2,21	9,78	32,31	28,85

Co-firing - TG and DSC, FTiR results – Torrefaction of willow

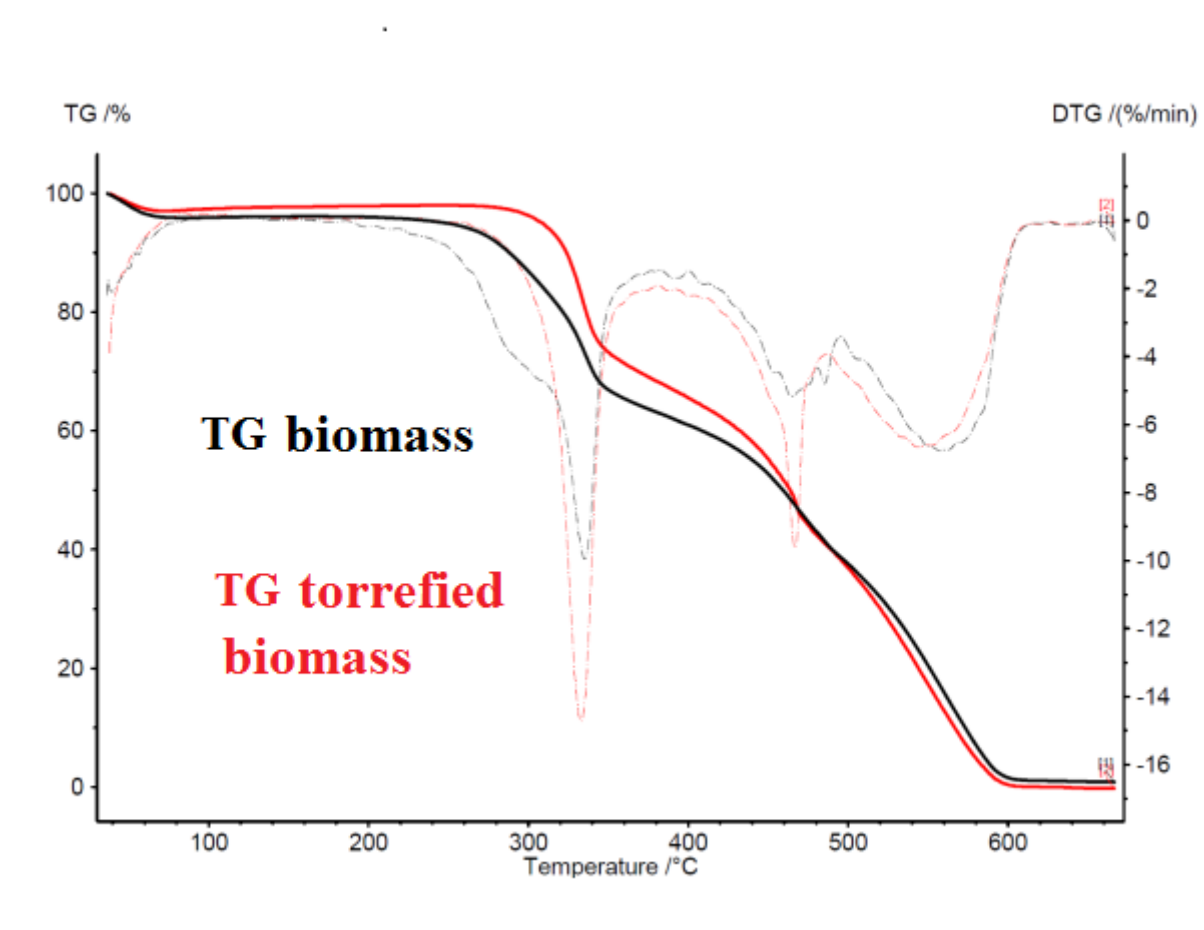




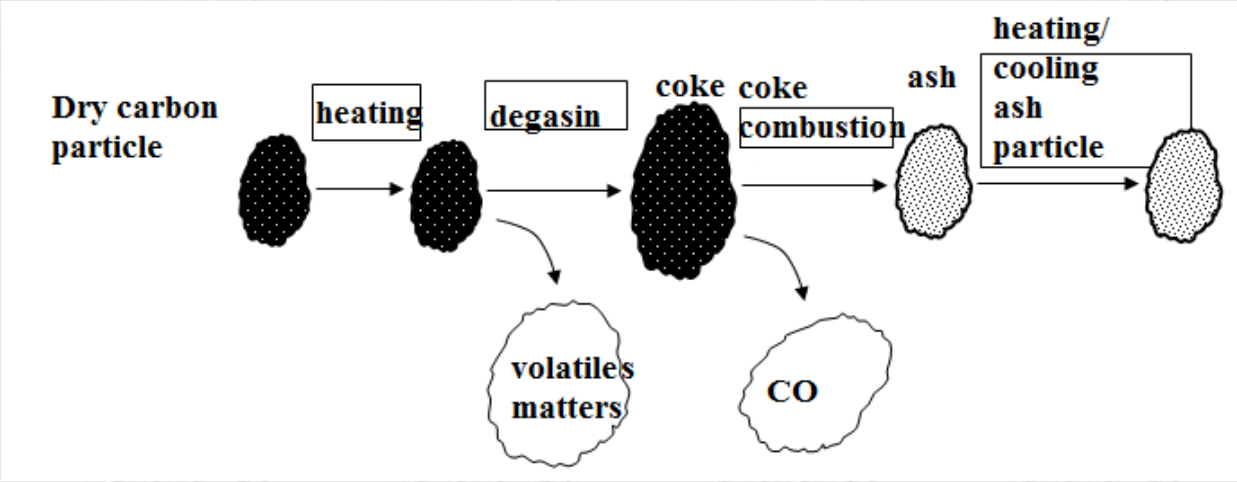


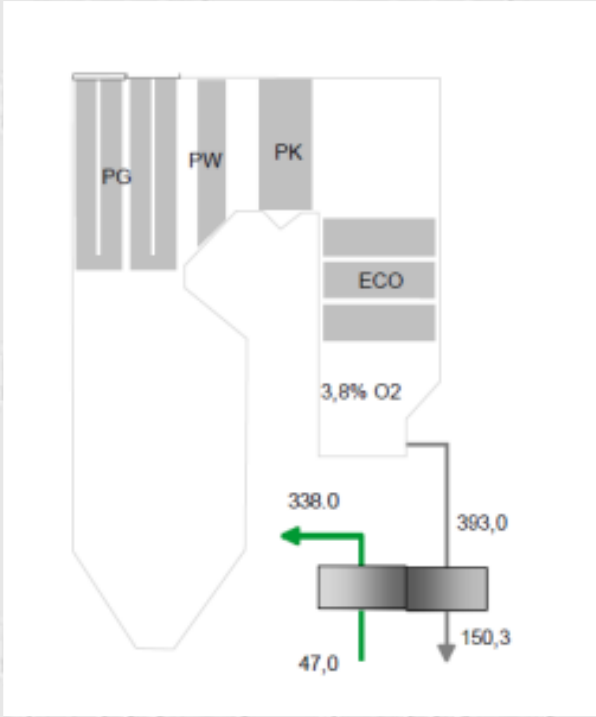


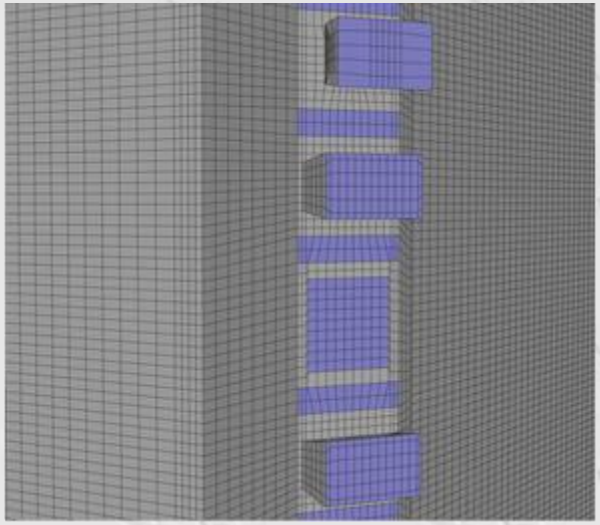
Co-firing - TG and DSC, FTiR results and problems which occurs

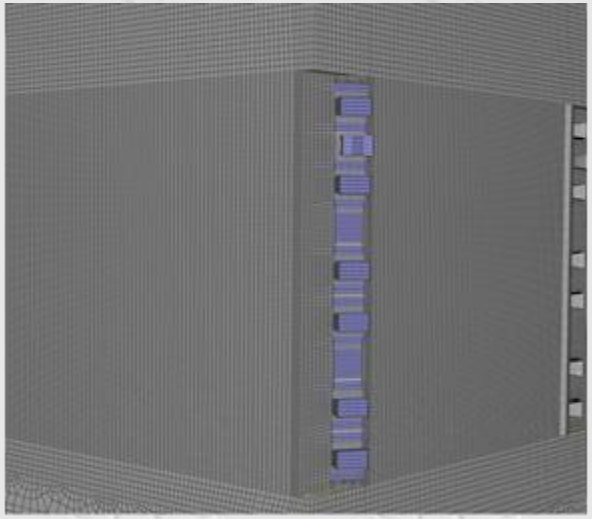


Biomass Co-firing Nummerical Simulation – Pulverised Boiler OP-250



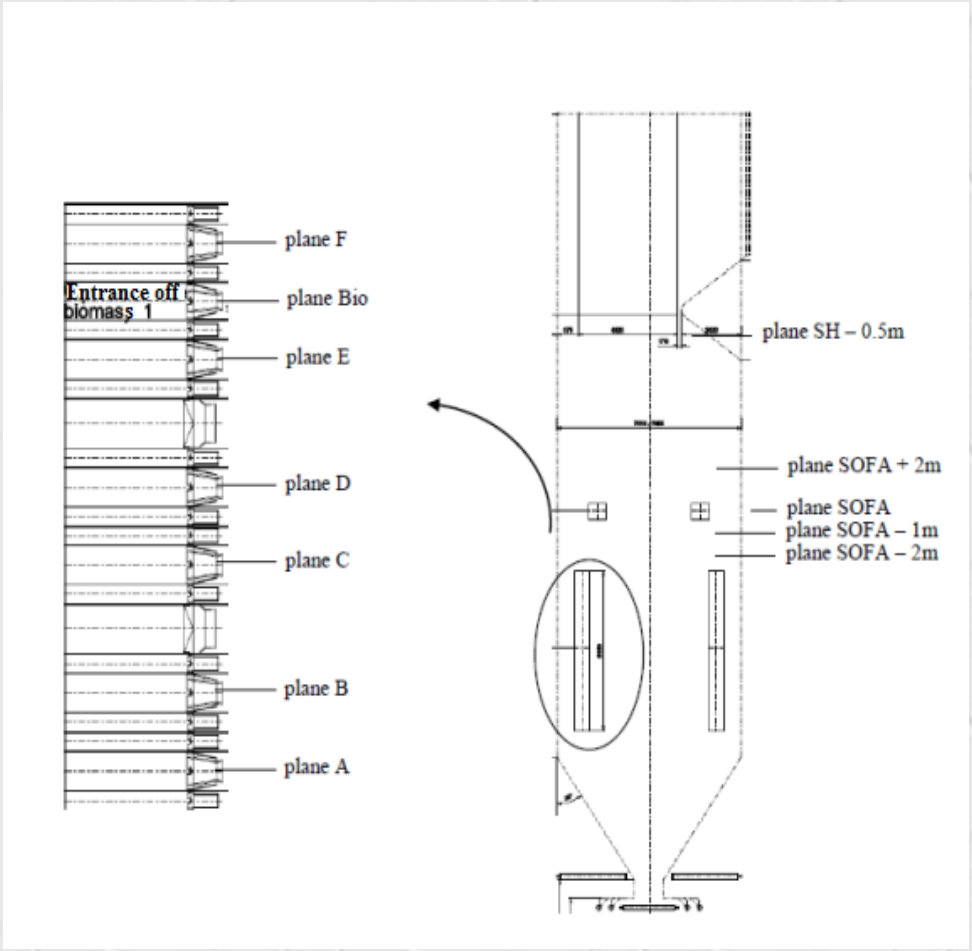


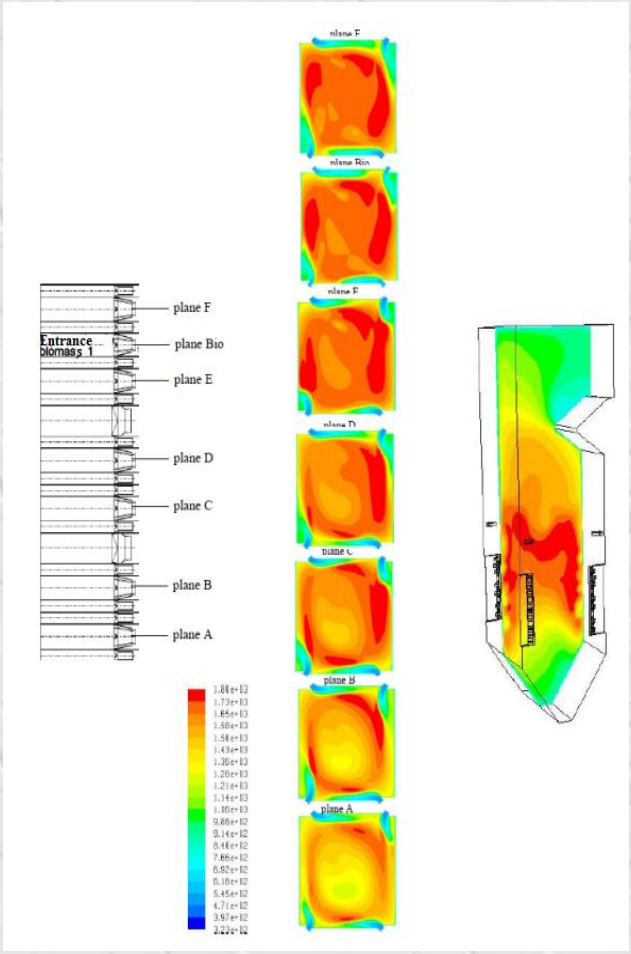




The grid made of two million volume control

Co-firing Nummerical Simulation – Pulverised Boiler OP-250





Section along the boiler burner zone and the temperaturę distribution [K]

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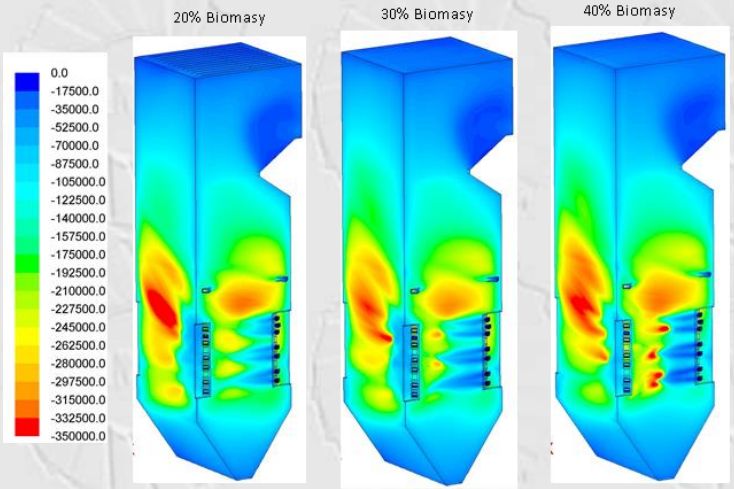
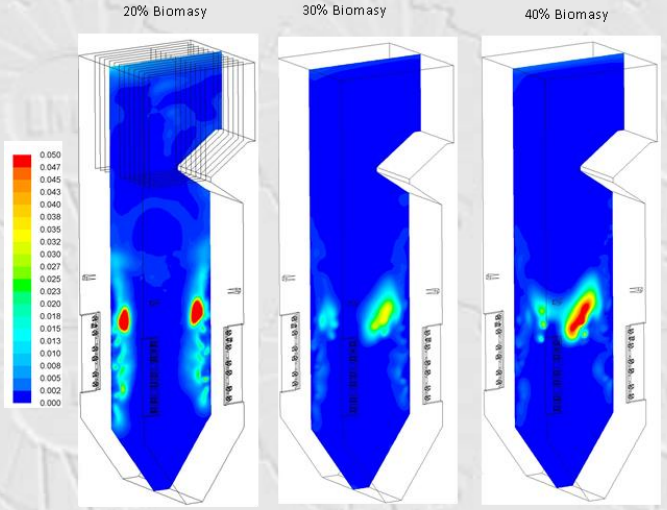
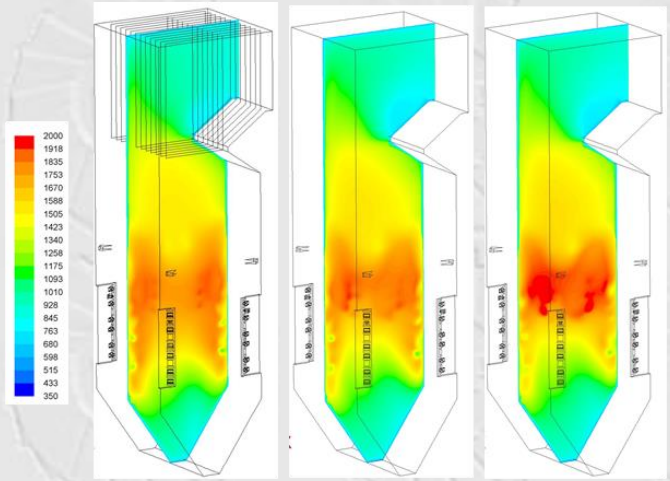
Co-firing Nummerical Simulation – Pulverised Boiler OP-250



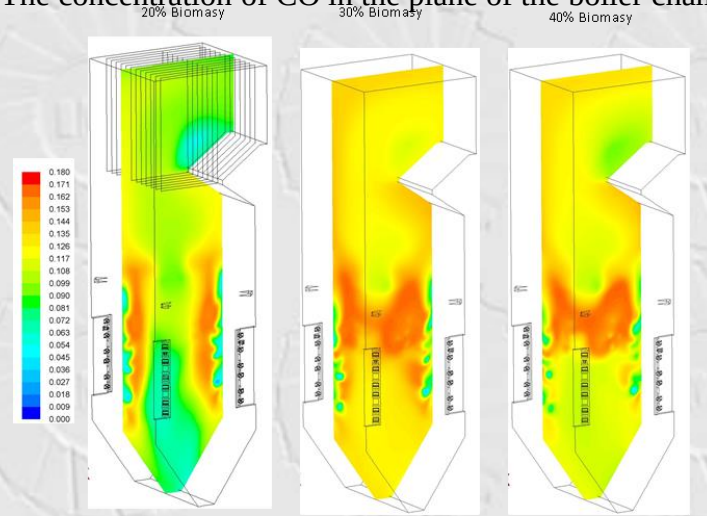
Thermal load [W/m2]



The concentration of CO in the plane of the boiler chamber



The temperature [K] distribution in the plane of the chamber of the boiler



The concentration of CO2 in the plane of the boiler chamber

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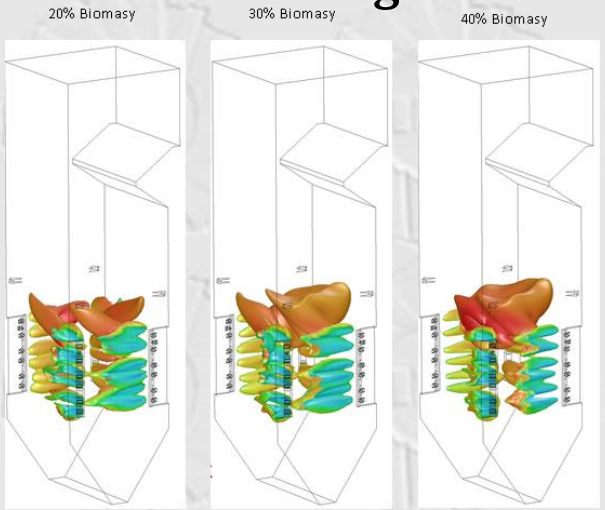
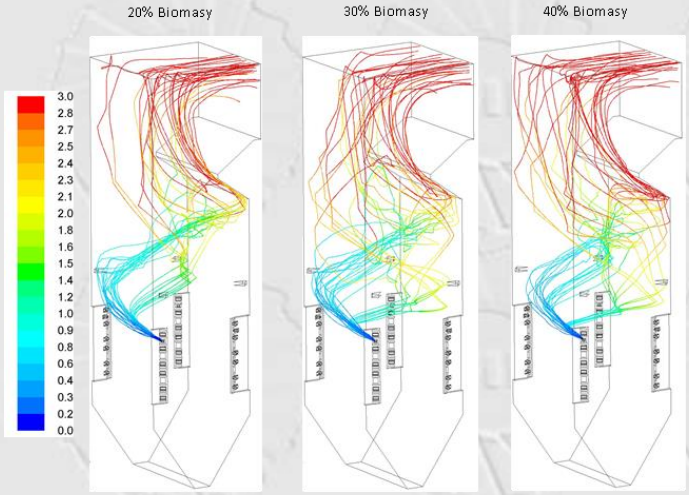
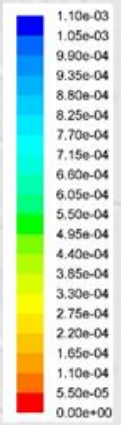
Co-firing Nummerical Simulation – Pulverised Boiler OP-250

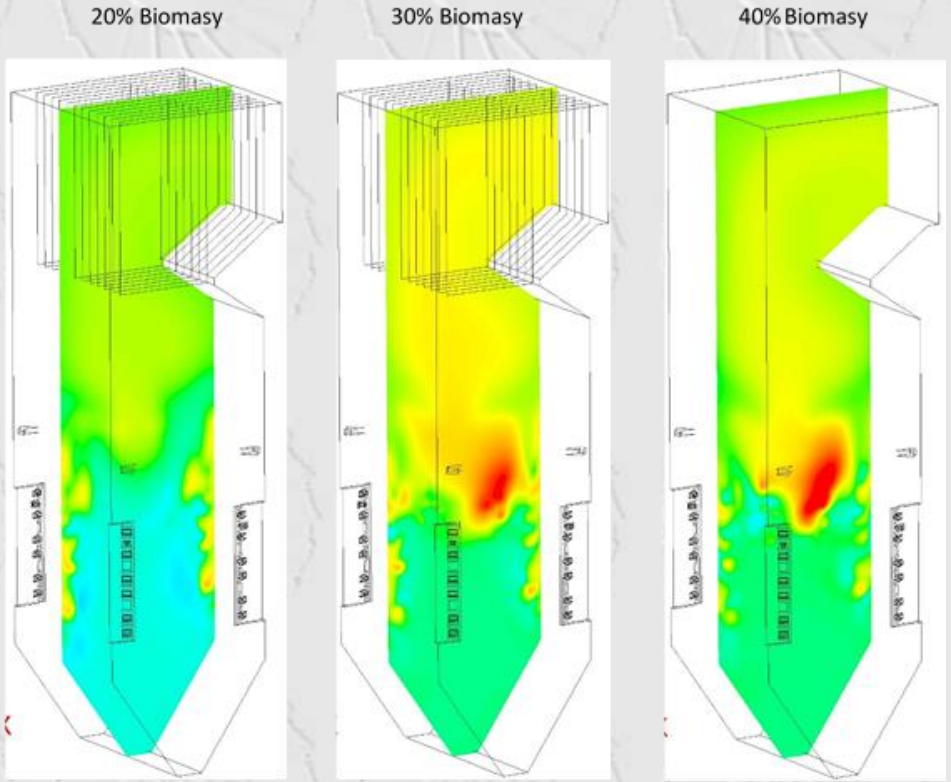


The concentration of CO in the plane of the boiler chamber



The residence time of biomass particles [s]





The concentration of NO in the plane of the boiler chamber

- Summerise and Conclusions: **Torrefaction is improving co-firing procces but starts to be not resonable technology from eoconomical point of view in Poland due to unstable system of subsidies of green certificates for biomass co-firing !**

- Further improvments and future plans -→ **Biomass Gasification**