Chemical Process and Energy Resources Institute
Centre for Research and Technology Hellas

Characterisation and classification of Solid Recovered Fuels (SRF) and development of a novel thermal utilization concept

P. Vounatsos, K. Atsonios, M. Agraniotis, K. D. Panopoulos, G. Koufodimos, P. Grammelis, E. Kakaras

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Motivation

- Present work is in the framework of LIFE09/ENV/GR000307 ENERGY WASTE
- Main objectives of the project
  - Sampling, Analysis and classification of RDF
  - Erection of CFB gasifier
    - Input RDF
    - Study various parameters on RDF gasification
    - Study syngas quality

Fuel Preparation

- The fuel includes packaging waste:
  - cardboard
  - paper
  - various plastic streams
  - Tetra pack
  - glass
  - ferrous and non-ferrous metals

- The material streams produced from the process are the following:
  1. Large materials from the reception area
  2. Unwanted materials from the pre-sorting cabin
  3. Fine fraction (<65 mm) of the trommel screen
  4. Residues from the overflow (>280 mm) of the trommel screen
  5. Residues from the rest of the process.

- The non recyclable streams 4 and 5 could be used for the production of RDF/SRF able to be utilized as fuel.

European Standard CEN/TC 343

- The European Standard CEN/TC 343 specifies all necessary standards regarding Solid Recovered Fuels (SRF).

- The work of CEN/TC 343 was organized by a Technical Committee and five Working Groups:
  - WG1 Terminology and quality management
  - WG2 Fuel specification and classes
  - WG3 Sampling, sample reduction, determination of biodegradable fraction
  - WG4 Physical parameters
  - WG5 Chemical parameters

- Latest version of Technical Specifications: 2010-2011

Sampling Procedure

- Sampling procedure designed and executed according to EN 15442:2011
- Sampling duration from
  01/06/2011 – 30/11/2011
- Sampling June 2011 – and is still ongoing:
  - Season variance
  - Weather variance
  - Customs variance

  } Seasonality

Lot definition : Storage Lot
Lot size : 1.250tonnes

↓

Sampling procedure: Sampling from a static lot

↓

Number of increments : 24

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Minimum sample size : 0.8 kg

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Minimum increment size : 430g

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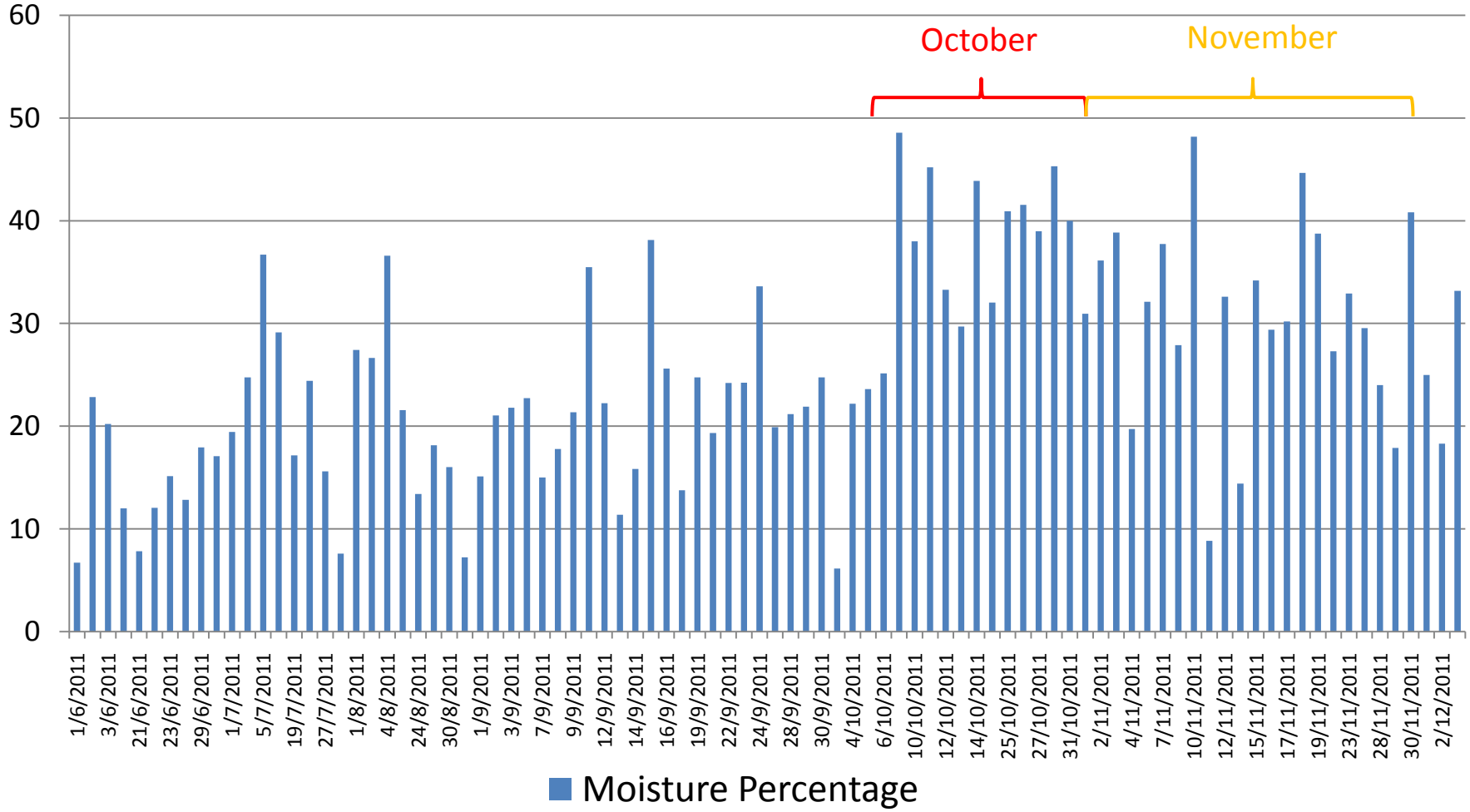
Effective increment size: 430g
Effective sample size : 10.32kg

Moisture percentage Variance



Proximate Analysis – Calorific Value

	RDF 1 – June 2011	RDF 2 – July 2011	RDF 3 – August 2011	RDF 4 – September 2011	RDF 5 – October 2011	RDF 6 – November 2011	Average
Moisture (%)	17.55	24.84	26.76	23.56	39.85	31.74	26.72
Ash (% wt. a.r.)	12.30	10.99	5.91	8.66	6.03	6.46	8.39
Volatiles (% wt. a.r.)	63.18	63.41	64.92	63.36	51.13	54.09	60.01
Char (% wt. a.r.)	6.97	0.77	2.40	4.42	3.00	7.70	4.21

	RDF 1 – June 2011	RDF 2 – July 2011	RDF 3 – August 2011	RDF 4 – September 2011	RDF 5 – October 2011	RDF 6 – November 2011	Average
HHV (MJ/kg)	19.15	24.46	19.28	20.39	21.49	23.99	20.70
LHV (MJ/kg) raw	14.39	16.40	12.47	13.97	11.17	14.61	13.43

Ultimate Analysis

		RDF 1 –June 2011	RDF 2 – July 2011	RDF 3 – August 2011	RDF 4 – September 2011	RDF 5 – October 2011	RDF 6 – November 2011	Average
C	% w.t. d.b.	40.83	57.02	46.91	50.89	46.95	50.63	48.87
H	% w.t. d.b.	5.36	8.36	6.22	6.28	6.01	6.63	6.48
N	% w.t. d.b.	1.18	1.2	1.23	0.51	1.89	1.87	1.31
S	% w.t. d.b.	0.29	0.48	0.29	0.17	0.11	0.36	0.28
O	% w.t. d.b.	37.08	17.68	36.85	30.33	34.53	30.80	31.21
Cl	% w.t. d.b.	0.34	0.64	0.43	0.49	0.49	0.24	0.44
Ash	% w.t. d.b.	14.92	14.62	8.07	11.33	10.02	9.47	11.41

Under investigation fuel samples

August 2011
high moisture content

lower moisture

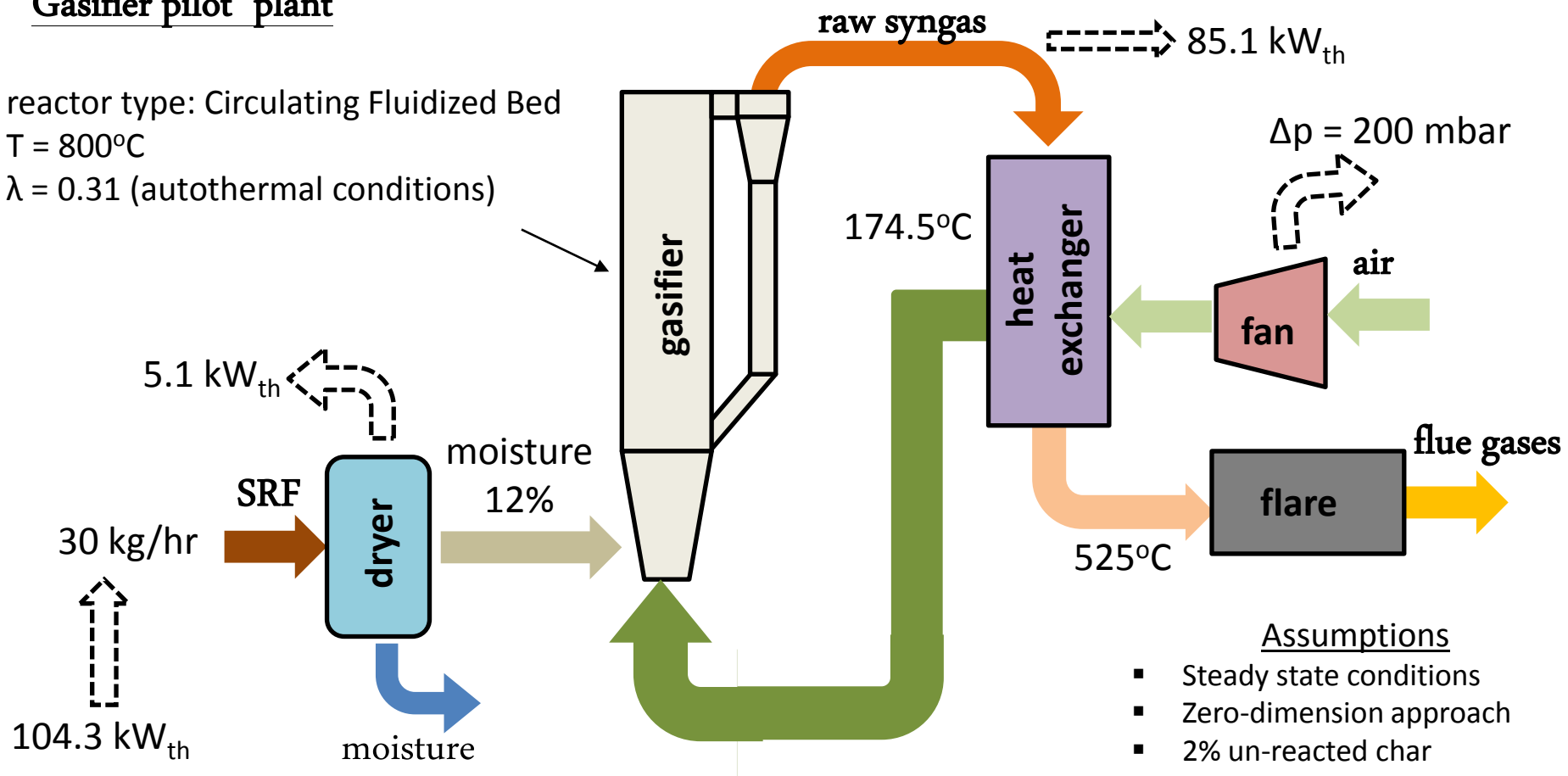
Parameters	Fuel A	Fuel B	Fuel C
Proximate analysis (wet basis)			
moisture	26.8	15.0	15.0
fixed carbon	2.4	2.8	4.7
volatiles	64.9	75.4	66.2
ash	5.9	6.9	14.1
Ultimate analysis (dry basis)			
C	45.77	45.77	43.99
H	5.96	5.96	6.36
N	1.16	1.16	1.30
O	38.56	38.56	31.09
S	0.05	0.05	0.58
Cl	0.43	0.43	0.05
calorific values			
HHV (dry) kJ/kg	19282	19282	17961
LHV (raw) kJ/kg	12515	14918	13721

high ash content

SRF energy utilization through gasification

Gasifier pilot plant

reactor type: Circulating Fluidized Bed
T = 800°C
λ = 0.31 (autothermal conditions)



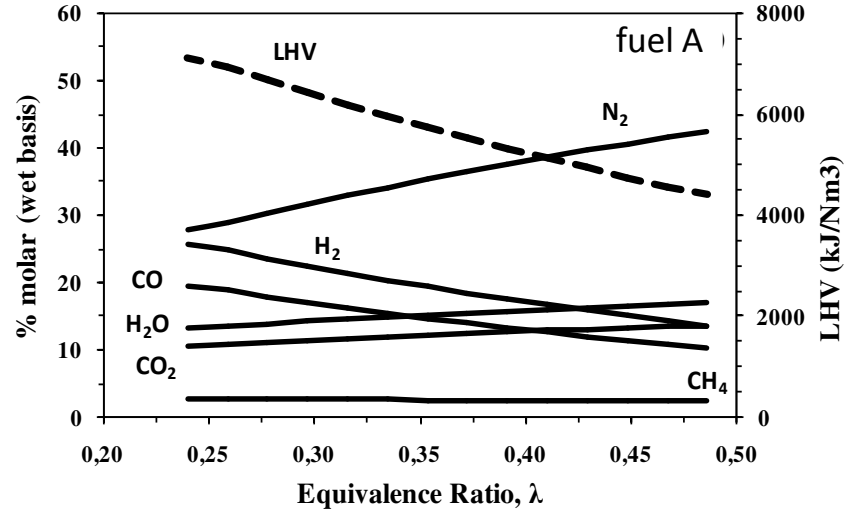
Assumptions

- Steady state conditions
- Zero-dimension approach
- 2% un-reacted char
- 3% (v/v dry basis) CH_4
- Heat losses ~3% LHV input fuel
- No NO_x formation

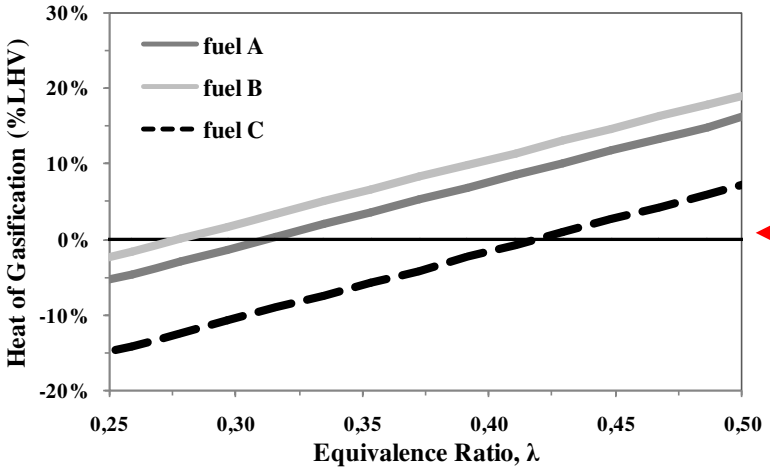
SRF gasification – main stream results

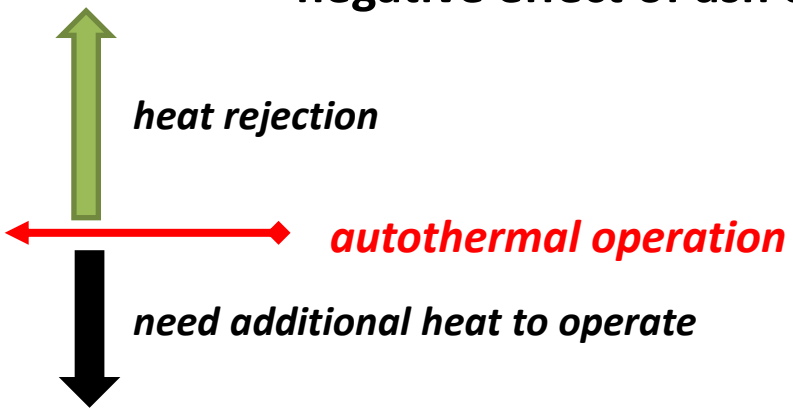
		SRF	air	hot syngas
mass flow kg/hr		30	32.04	60.07
mole flow kmol/hr		-	1.11	2.67
Temperature °C		15.0	174.5	800.0
molar composition	H_2O		0.010	0.083
	CO_2		$3.0 \cdot 10^{-3}$	0.080
	CO		0	0.211
	H_2		0	0.232
	O_2		0.207	0
	N_2		0.773	0.360
	Ar		$9.2 \cdot 10^{-3}$	$4.2 \cdot 10^{-3}$
	CH_4		0	0.027
	SO_3		0	0
	HCl		0	$1.3 \cdot 10^{-4}$
	NH_3		0	$2.8 \cdot 10^{-5}$
	COS		0	$4.5 \cdot 10^{-5}$
	H_2S		0	$1.6 \cdot 10^{-3}$

Equivalence Ratio - λ

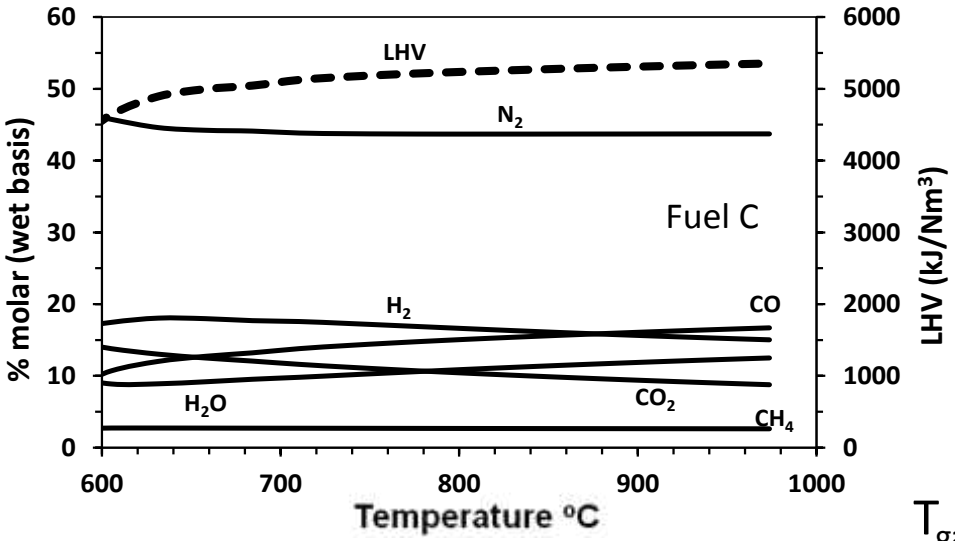


- λ↑ → CO_2, H_2O ↑
- λ↑ → CO, H_2, LHV ↓
- moisture↑ → λ ↑ for autothermal conditions
- **negative effect of ash content**





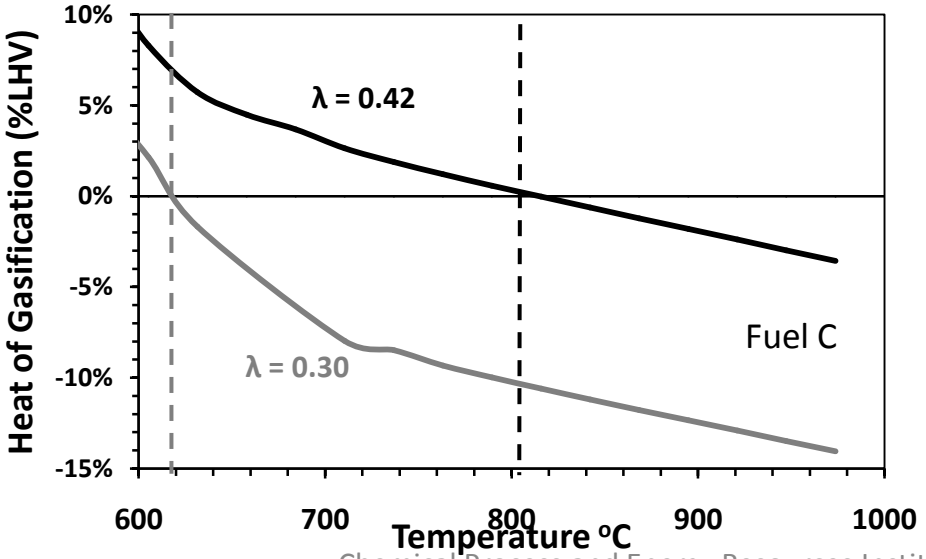
Temperature - T



- ❖ autothermal conditions
- ❖ no considerable effect on syngas composition

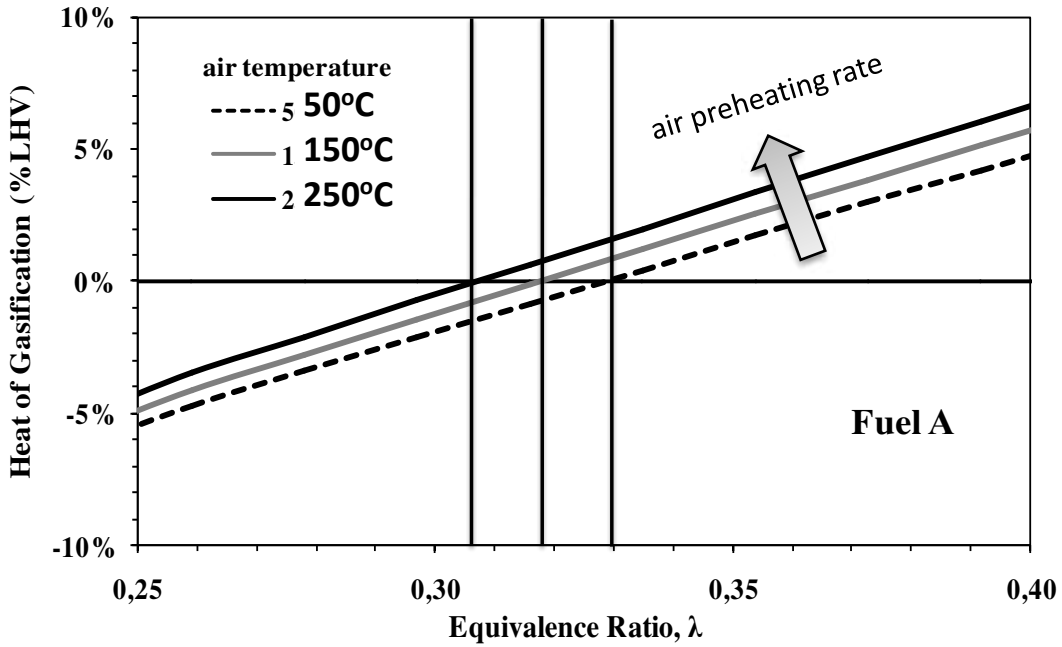
T_{gasif}=const.: **λ↓** → **LHV_{syngas} ↑**

T_{gasif}=const.: **λ** change do not affect CGE.



- **T↓** → air ↓ for autothermal conditions
- real char conversion is less that what equilibrium predicts

Air preheating



air preheating has impact on 2% air reduction

Conclusions

- the procedure of sampling classification and analysis of RDF is done according to CEN/TC 343
- samples composition vary from different time periods – great effect of other factors
- Cl content that was measured is not expected to cause technical or operational problems
- an SRF gasification process was modeled and the sensitivity analysis of some parameters were studied:
  - λ for autothermal conditions varies since fuel composition is not stable
  - Cold Gas Efficiency around 65-85%
  - positive effect of drying before gasification
  - positive effect of air preheating

Questions?

THANK YOU FOR YOUR ATTENTION!!!!