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METHANOL PRODUCTION FROM REFUSE DERIVED FUEL: A PRELIMINARY ANALYSIS ON THE INFLUENCE OF THE RDF COMPOSITION ON PROCESS YIELD

Gaetano Iaquaniello
Annarita Salladini
Processi Innovativi srl, Roma

Maria Cristina Annesini
Alessia Borgogna
Dip. Ingegneria Chimica, La Sapienza, Roma

Luca Spadacini
Antonio Pitrelli
OESA srl, Roma

Processi Innovativi

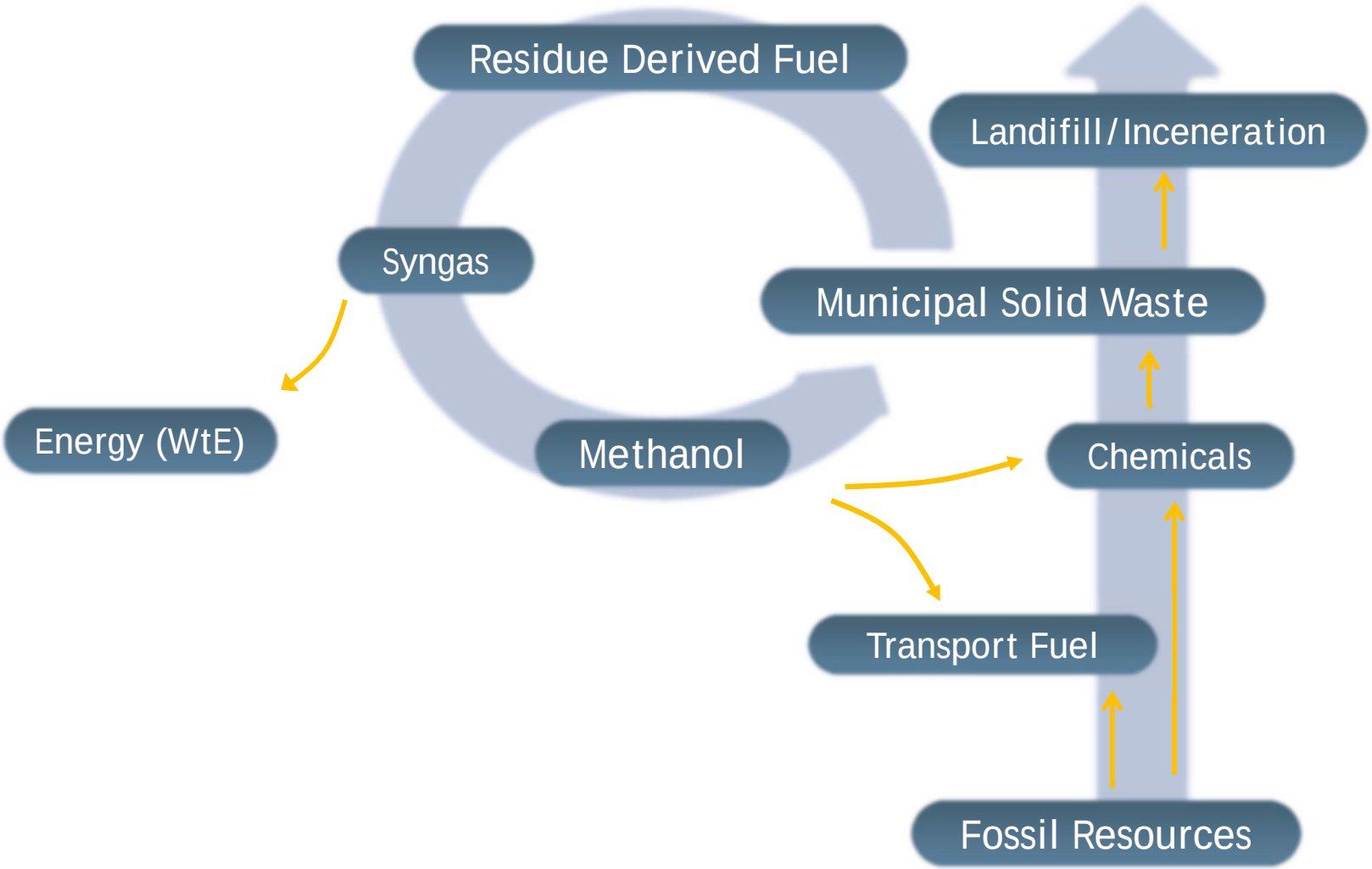
SAPIENZA

AGENDA

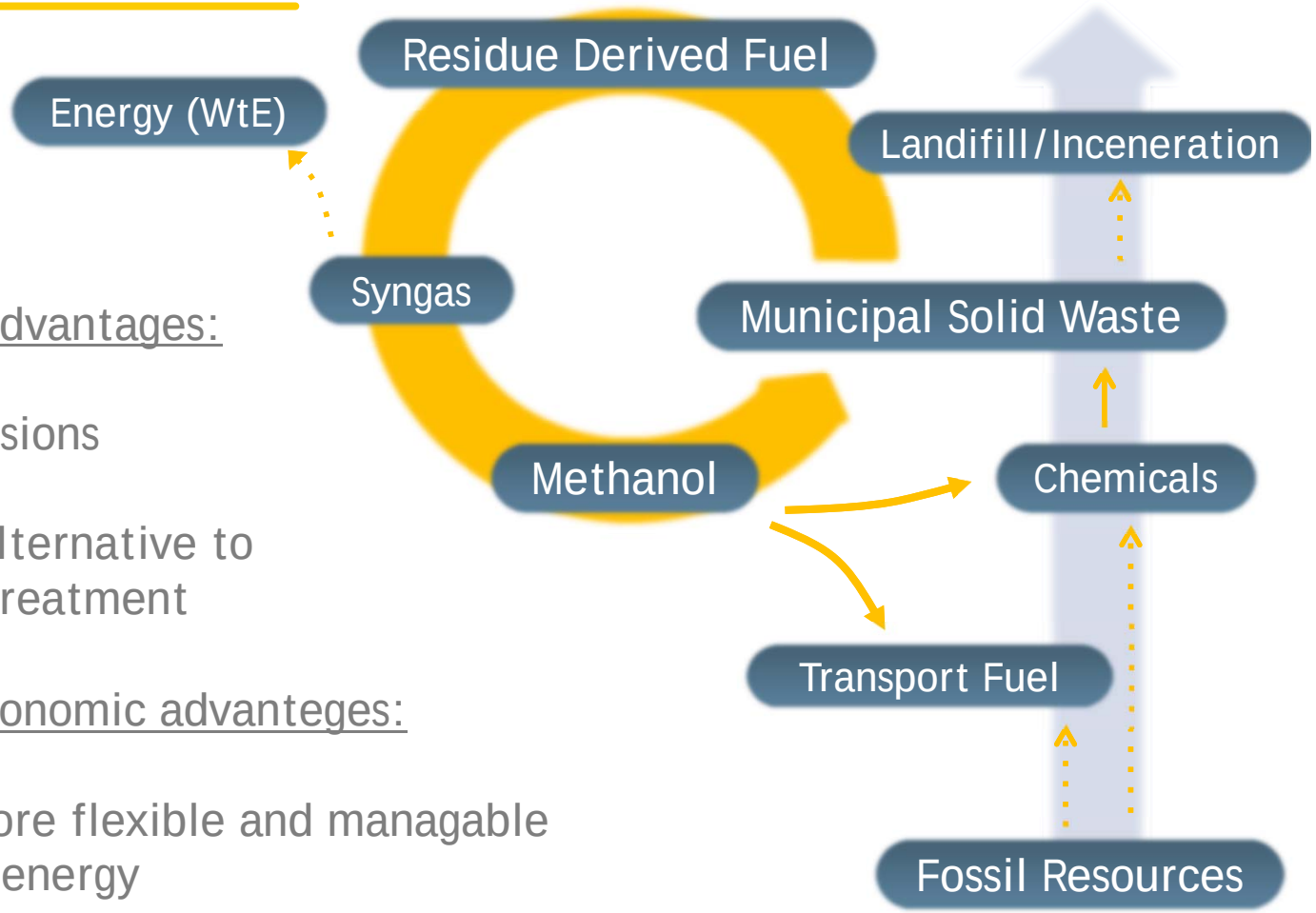
1. Introduction
2. RDF characterization
3. ASPEN Simulation Model
4. Results Discussion
5. Conclusions

CIRCULAR ECONOMY

- In recent years, efforts to replece conventional linear production of chemicals with circular one have been promoted.



THE WASTE TO METHANOL



Environmental advantages:

- ❑ Low CO_2 emissions
- ❑ Suistenable alternative to other waste treatment

Strategic and economic advanteges:

- ❑ (Bio)MeOH more flexible and managable product than energy
- ❑ Bio-fuels market growing trends
- ❑ (Bio)MeOH from Waste double counting as regards biofuel transport targert (EU Directive)

THE WASTE TO METHANOL PROCESS

High Temperature Gasification

Hot raw syngas

Cooling and Cleaning system

Clean raw syngas

Syngas conditioning unit

Suitable syngas

Methanol Synthesis

Crude Methanol

- Supplied by OESA srl
- Refence experimental data from Malagrotta (Italy) plant

Malagrotta gasification plant

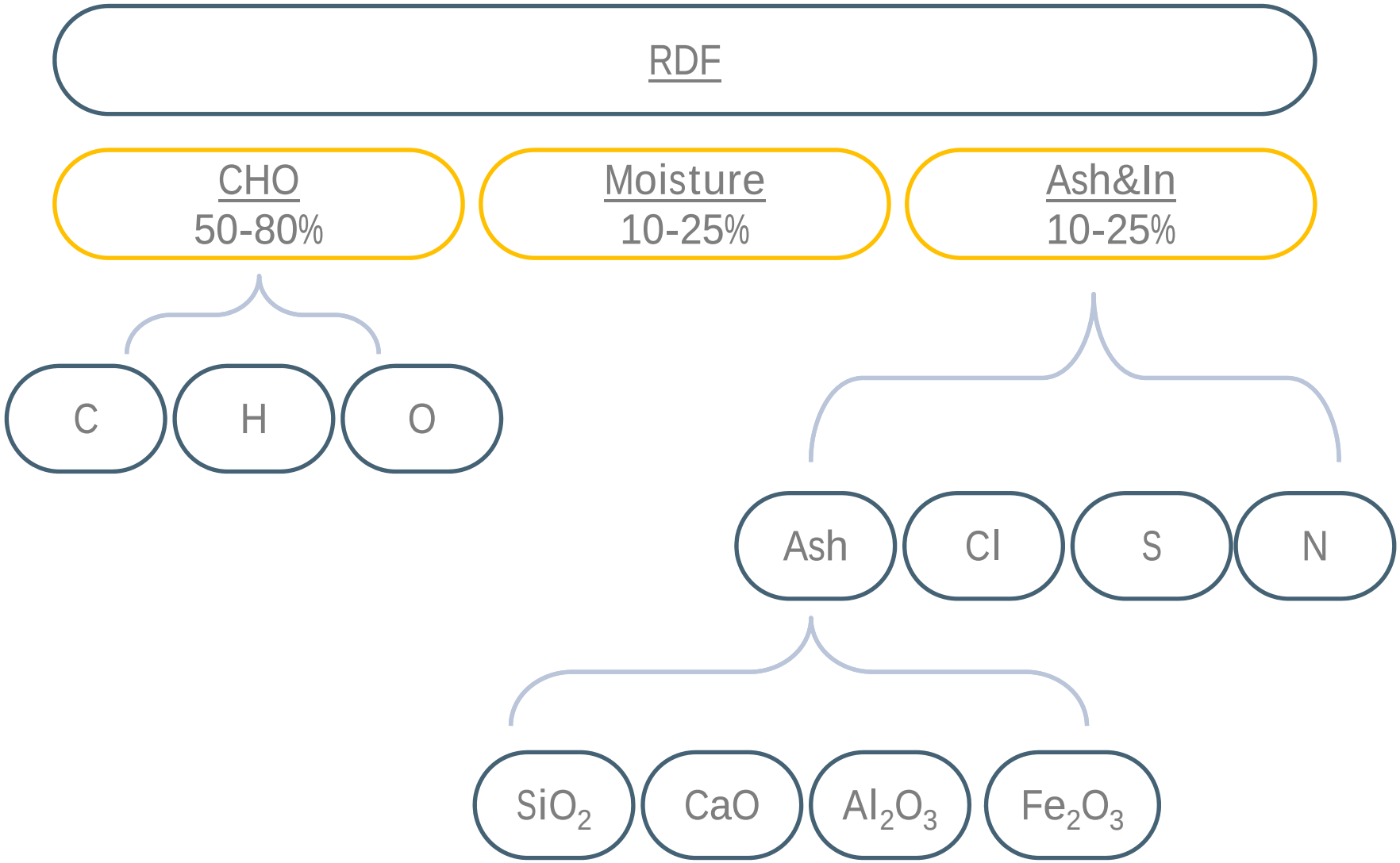
PROCESS ISSUES

- Refuse Derived Fuel marked composition variability
- Raw syngas compositon not directly suitable for methanol synthesis, thus efforts of conditiong step are required

WORK AIMS

- Obtain a spread of raw syngas composition depending on RDF variability comparable with Malagrotta experimental data, thus allowing a preliminary validation of our simulation tool
- Recognize influence of RDF characteristic on raw syngas composition and as consequence on methanol yield

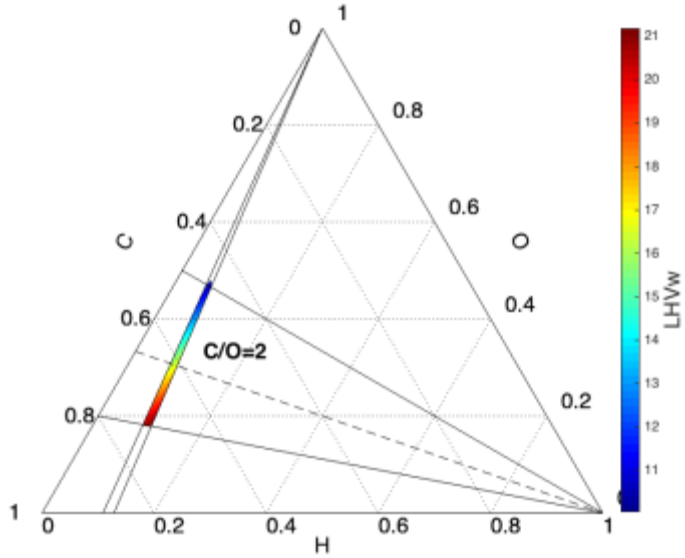
RDF COMPOSITION



COMBUSTIBLE CONTENT COMPOSITION

Material	C/H	C/O
Paper & Cardboards	7.75	1.8
Composite Material	7.5	1.5
Wood	8	1
Carpet	7.25	4
Carcass Meal	6.9	2
Mattresses	7.3	3
	7.5	1-4

Moisture=0.15 Ash&In=0.2

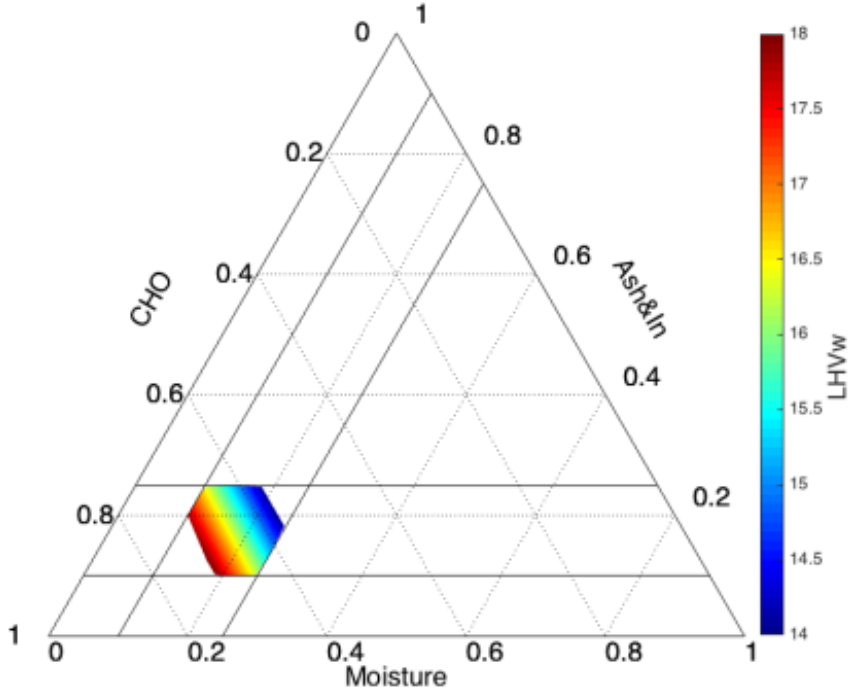


Ternary diagram of LHV in function of C, H, and O mass fraction of combustible waste content

LOWER HEATING VALUE

C/H=7.5

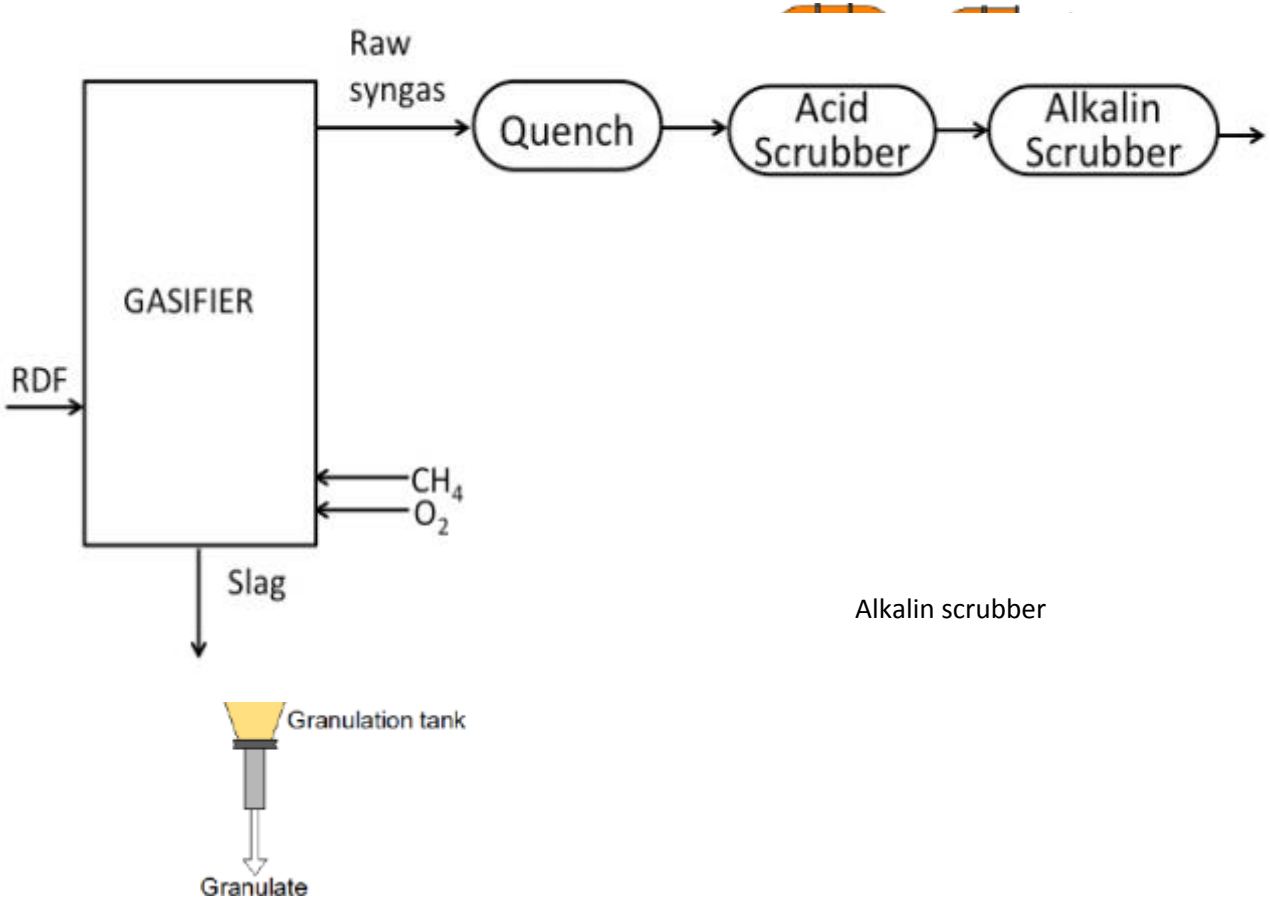
C/O=2



Ternary diagram of LHV in function of CHO, Ash&In, and Moisture waste contents

LHV from 14 to 18 MJ/kg

GASIFICATION – COOLING AND CLEANING SYNGAS UNIT



Alkalin scrubber

High Temperature Gasification

Hot raw syngas

Cooling and Cleaning system

Clean raw syngas

Syngas conditioning unit

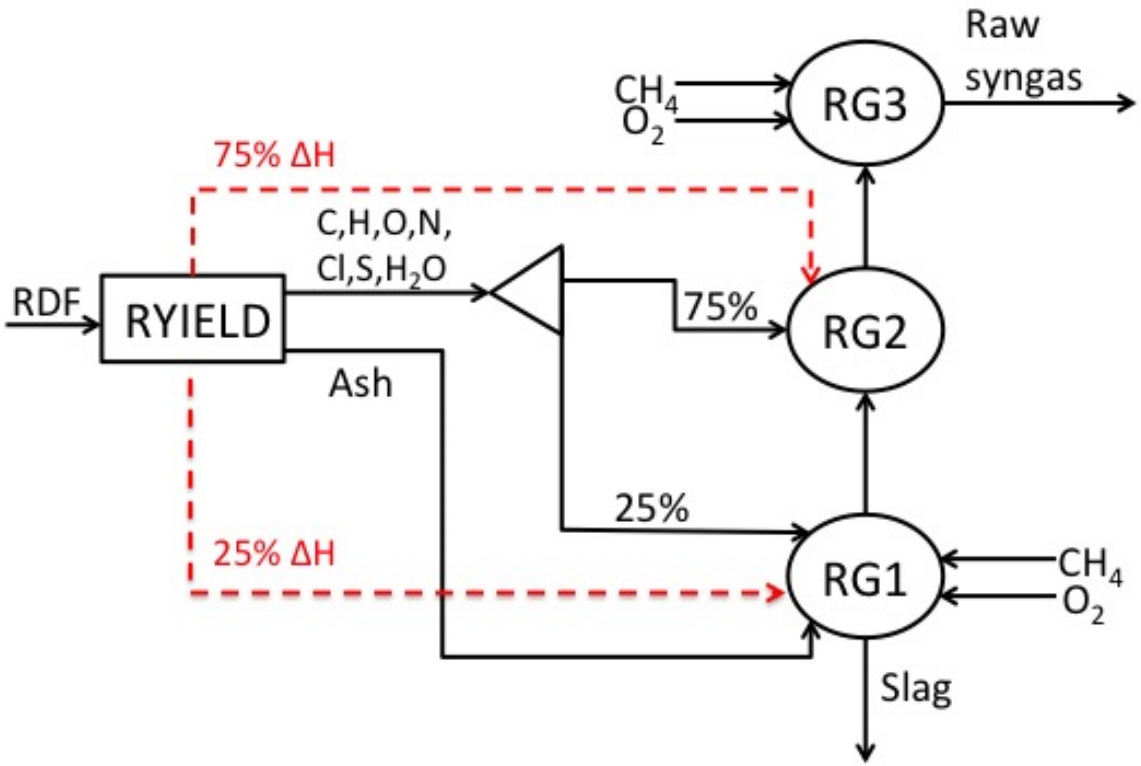
Suitable syngas

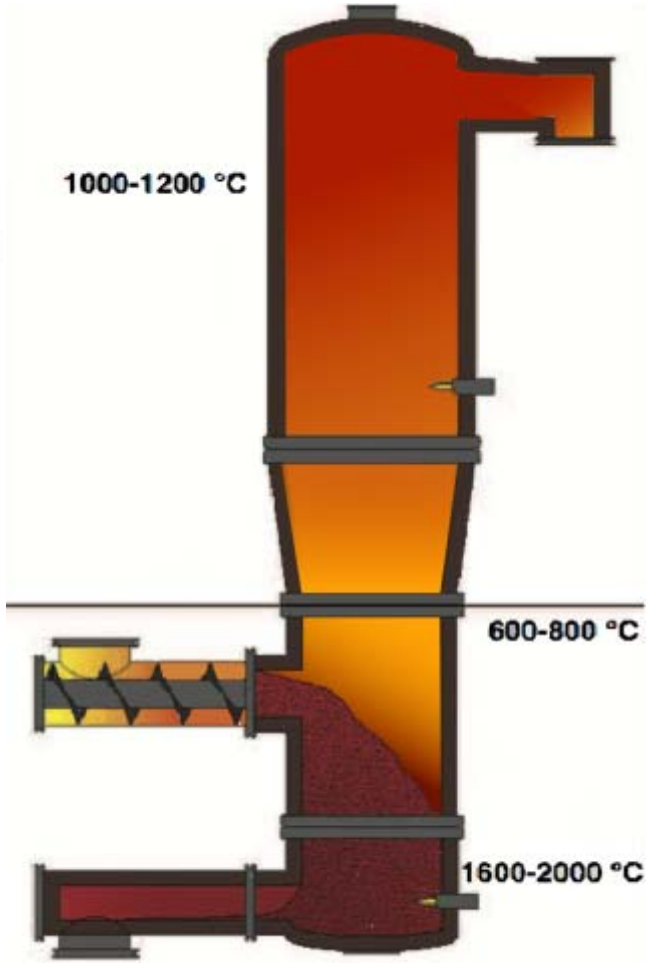
Methanol Synthesis

Methanol

ASPEN SIMULATION MODEL

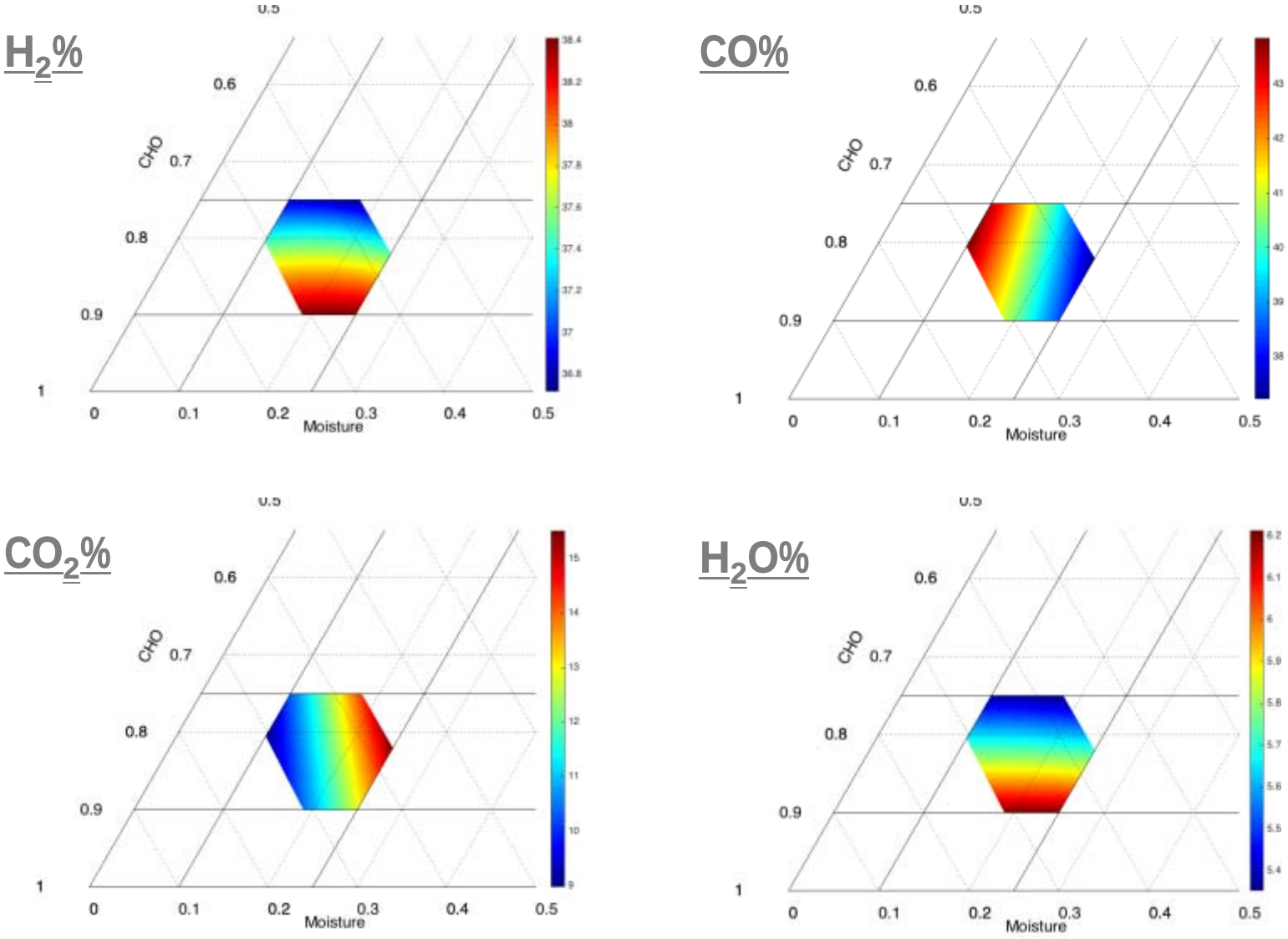
HIGH TEMPERATURE GASIFIER





ASPEN SIMULATION MODEL

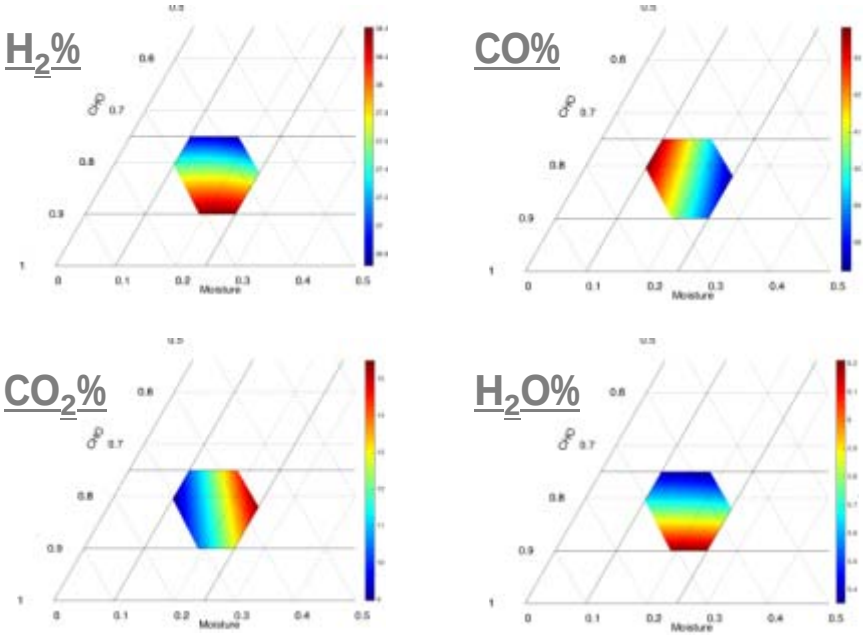
RESULT – SYNGAS COMPOSITION



Ternary diagram of syngas composition in function of CHO, Ash&In, and Moisture waste contents

RESULTS DISCUSSION

RESULT - MODEL VALIDATION



Syngas composition	Simulation	Malagrotta Experimental
H_2%	*36,8-38,4*	*36-40*
CO%	*37,2-43,9*	*37-43*
CO_2%	*9,0-15,5*	*8-16*
H_2O%	*5,4-6,2*	*5-8*

❑ Simulated range values are similar to related values of Malagrotta experimental data, which correspond to an enough long period during which RDF composition could be sensibly varied.

Slide 13

1 dividi in due e metti le formule delle yield
Alessia Borgogna; 4/6/2017

RESULT – SYNGAS YIELD, O_2 CONSUMPTION, AND EFFICIENCY

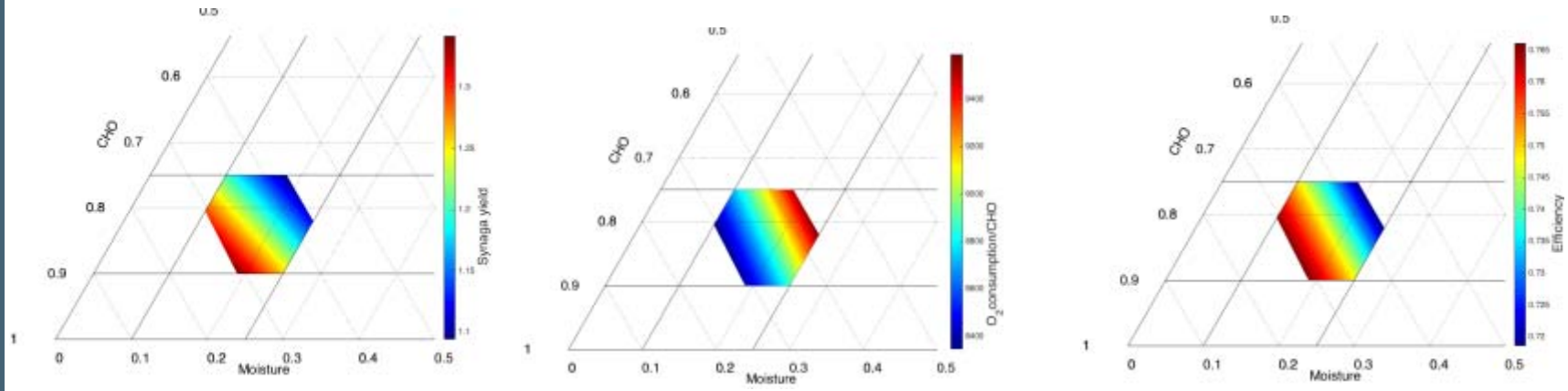
Syngas yield

$$\frac{Syngas\ [kg]}{RDF\ [kg]}$$

$$\frac{O_2\ consumption\ [kg]}{CHO}$$

Efficiency

$$\frac{LHV_{Syngas}}{LHV_{CH_4} + LHV_{RDF}}$$



Ternary diagram of syngas yield, O_2 consumption, and Efficiency in function of CHO, Ash&In, and Moisture waste contents

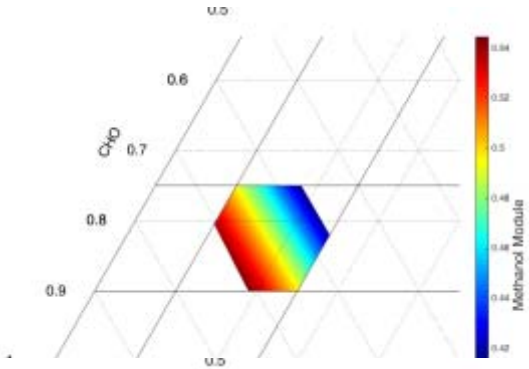
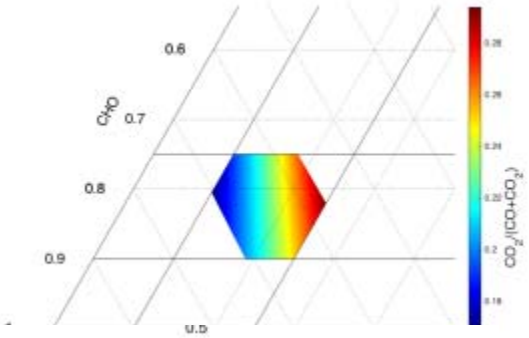
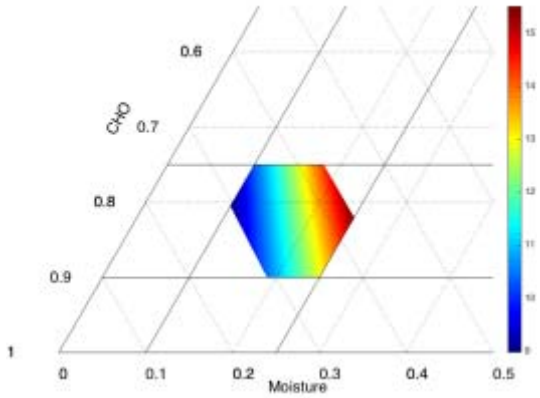
Slide 14

4 dividi in due e metti le formule delle yield

Alessia Borgogna; 4/6/2017

RESULT - EFFECT ON METHANOL PRODUCTION

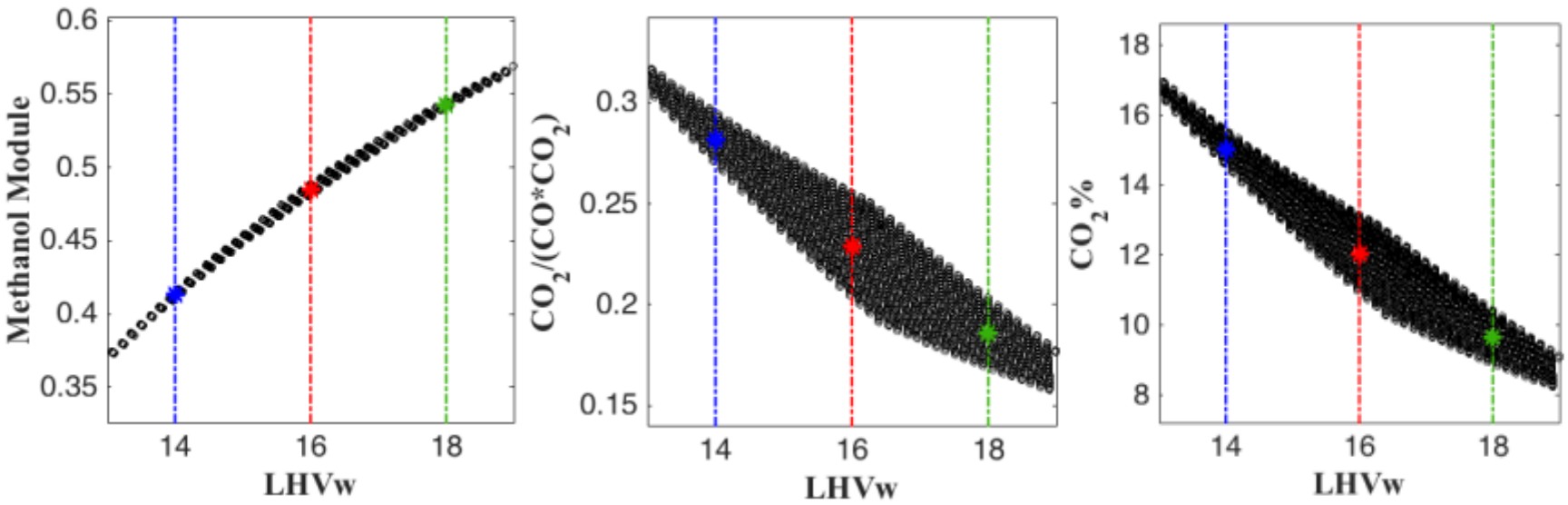
Suitable syngas composition for methanol production must present the following conditions:

REQUIRED		ACTUAL
❑ Methanol Module $\frac{H_2-CO_2}{CO_2+CO} = 2.1$		0.42-0.54
❑ $0.2 < \frac{CO_2}{CO+CO_2} < 0.5$		0.18-0.30
❑ $CO_2 < 12\ \%$		9%-15%

RESULT - LHV AS DESIGN PARAMETER

- LHV of RDF is a characteristic value for this process and it can be used as reference design parameter.

- Methanol module strictly depends on LHV of RDF
- and CO_2 are instead also affected by different waste composition at fixed LHV



- Colored points represent average values of range corresponding to LHV equals to 14-16-18 MJ/kg

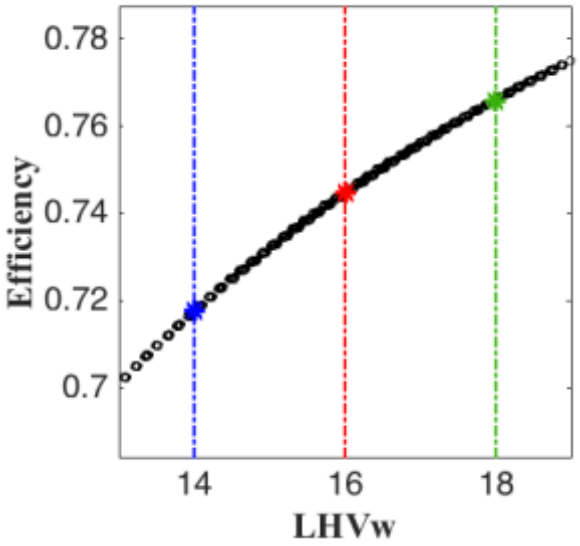
RESULT – LHV AS DESIGN PARAMETER

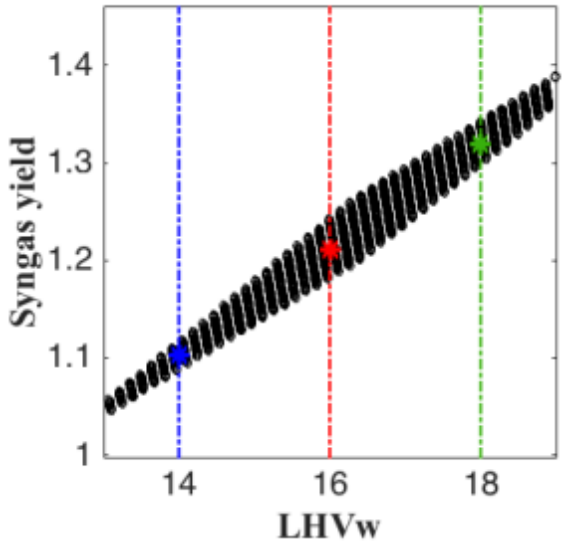
Efficiency

$$\frac{LHV \cdot Syngas}{LHV \cdot CH_4 + LHV \cdot RDF}$$

Syngas yield

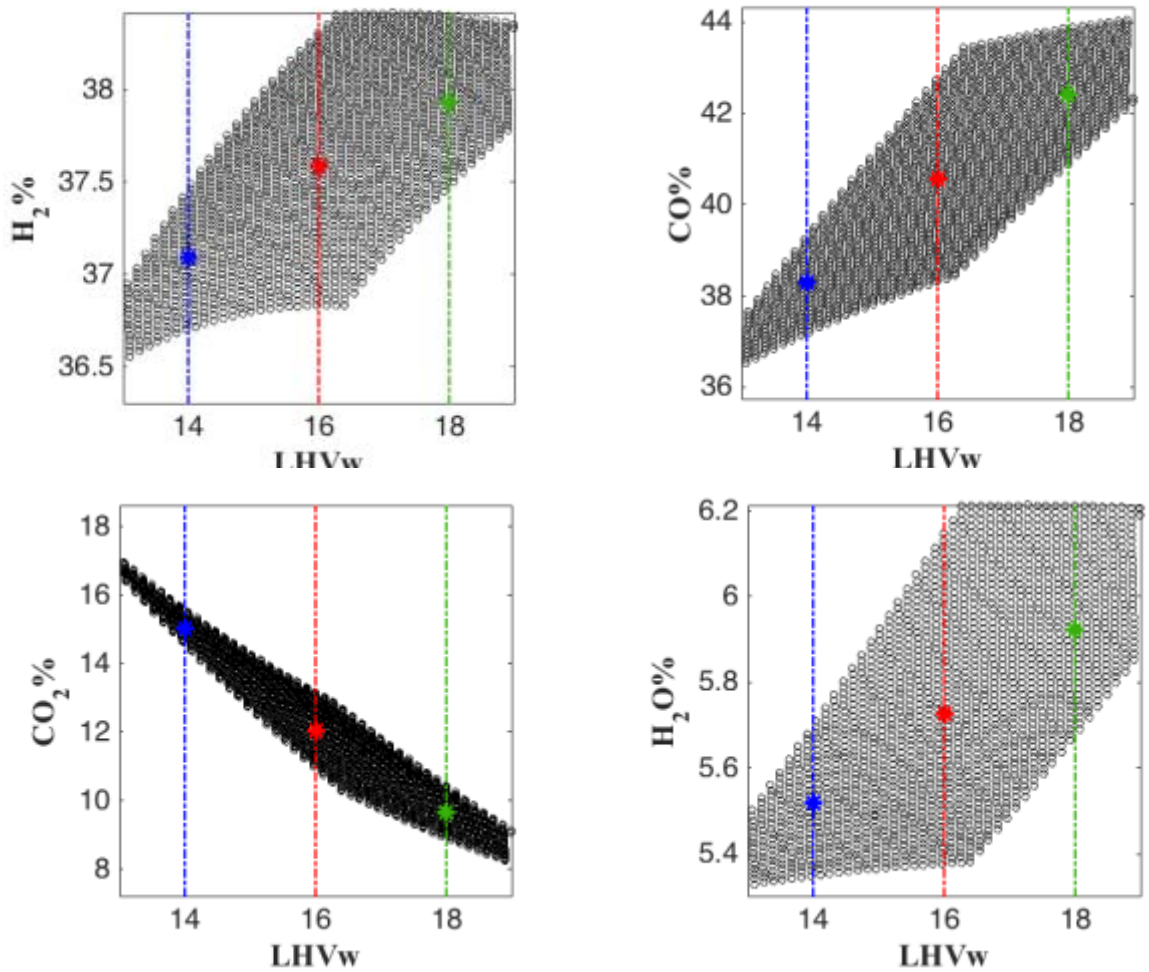
$$\frac{Syngas\ [kg]}{RDF\ [kg]}$$





- Also Efficiency is mainly correlated with LHV of RDF
- Syngas yield is instead also affected by different waste composition at fixed LHV, however the avarege values seems to present a linear trend.

RESULT – LHV AS DESIGN PARAMETER



- Syngas compositon is strongly influenced by composition of waste at fixed LHV

RESULT – LHV AS DESIGN PARAMETER

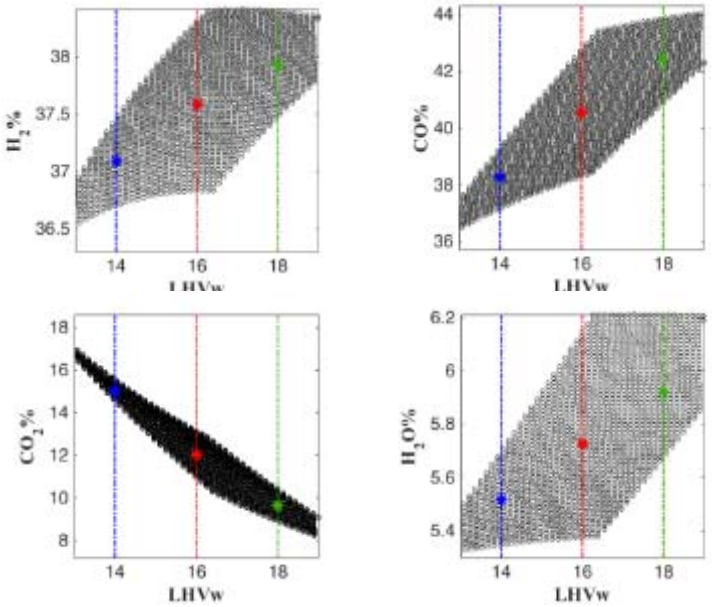
- Results confirm that LHV it could be considered a reference design parameter, indeed methanol module and efficiency stricly depende on it.

- However influnce of RDF composition observed on other important values must be also considered, in order to achieve an accurate and efficient equipment design.

- To have a suggestion of methanol yield a simplified approch has been carry out obtaing yields for different LHV values (14-16-18 MJ/kg)

RESULT - METHANOL YIELD

- To have a suggestion of methanol yield a simplified approch has been carry out obtaing yields for different LHV values (14-16-18 MJ/kg)



LHV_{RDF} [MJ/kg]	14	16	18
H_2%	37,09	37,58	37,93
CO%	38,29	40,57	42,42
CO_2%	15,04	12,06	9,67
H_2O%	5,52	5,73	5,92
MM	0,414	0,485	0,542
	0,282	0,229	0,186
Syngas Yield [kg/kg]	1,087	1,235	1,335
[kg/kg]	0,416	0,501	0,577
	54,0	0,573	0,589

CONCLUSION

- ❑ Range of syngas compositon obtained from simulation is consistent with the experimental Malagrotta data range, thus validating simulation tool BA1

- ❑ Syngas compositions from direct RDF gasifcation does not fit requirements for methanol production

- ❑ Thanks to the developed simulation tool, different operating conditions and control strategies can be approched in order to obtain a more suitable syngas composition

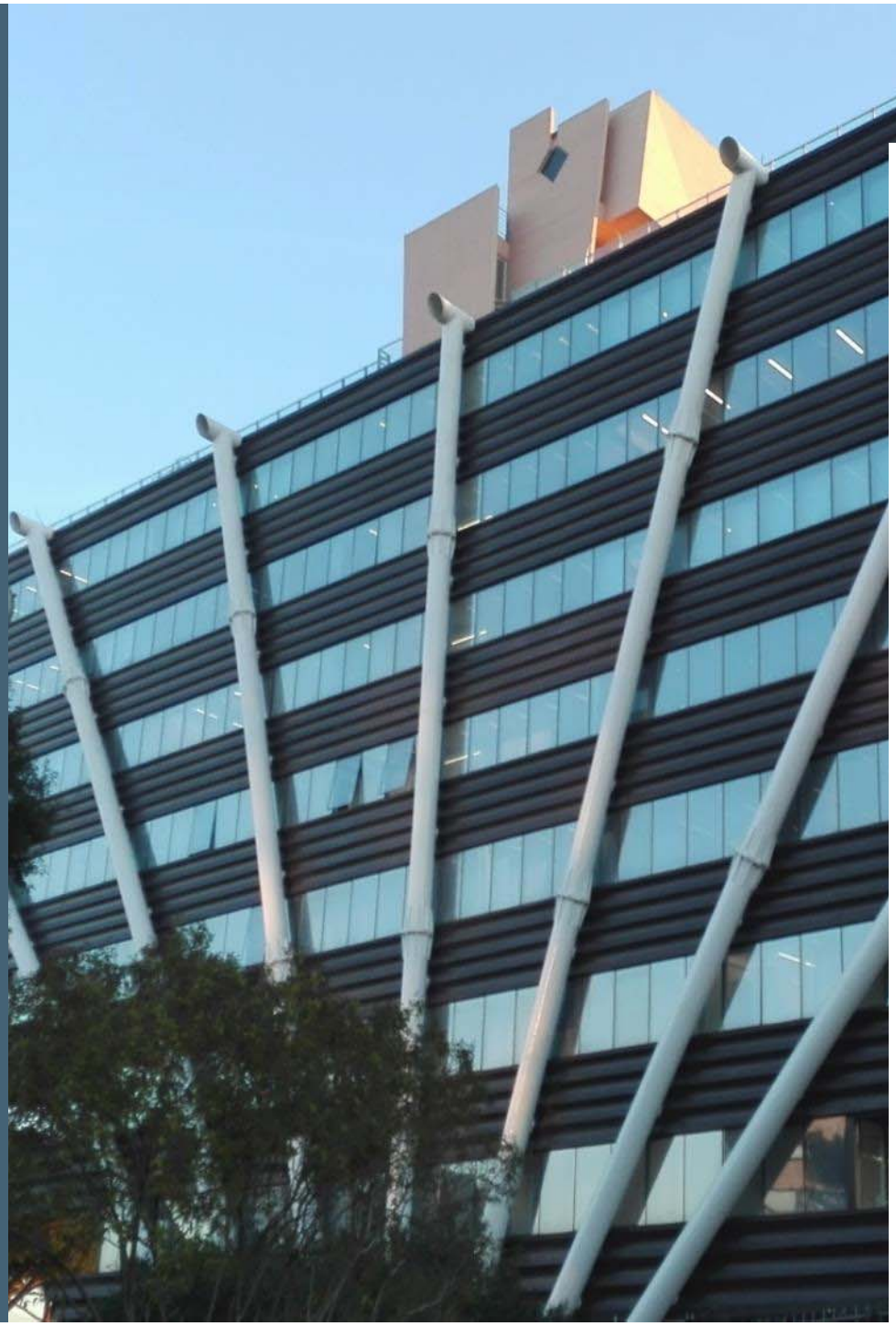
- ❑ Syngas composition and some process parameters are strongly influnced by waste composition, even at fixed LHV, while Methanol Module and efficiency depends strictly on LHV

- ❑ Lower Heating Value could be used as reference parameter for design steps keeping in mind the variability exhibited by syngas composition and other process values as consenquence of moisture and ash waste contents

Slide 21

BA1 1.. a better validation with punctual data could be approched

Borgogna Alessia; 12/6/2017



KT – Kinetics Technology's Headquarters

Viale Castello della Magliana, 27
00148 Rome
P. +39 06 60216.1
F. +39 06 6579.3002
info@kt-met.it

Processi Innovativi

Registered Office
Via Guido Polidoro, 1
67100 L'Aquila
P. +39 0862 763.411
F. +39 0862 763.547

Operative Office
Via di Vannina, 88/94
00156 Rome
P. +39 06 9356.771

www.kt-met.com

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