AGENZIA NAZIONALE
PER LE NUOVE TECNOLOGIE, L'ENERGIA
E LO SVILUPPO ECONOMICO SOSTENIBILE

TyGRe Project

Waste tyre gasification

Pierpaolo Iovane, Sabrina Portofino

C.R. ENEA Trisaia- UTTRI-RIF; C.R. ENEA Portici - UTTP-NANO

Ecomondo – Rimini, 10 November 2011

Summary

I. INTRODUCTION

II. THERMAL PROCESS

III. EXPERIMENTAL DATA

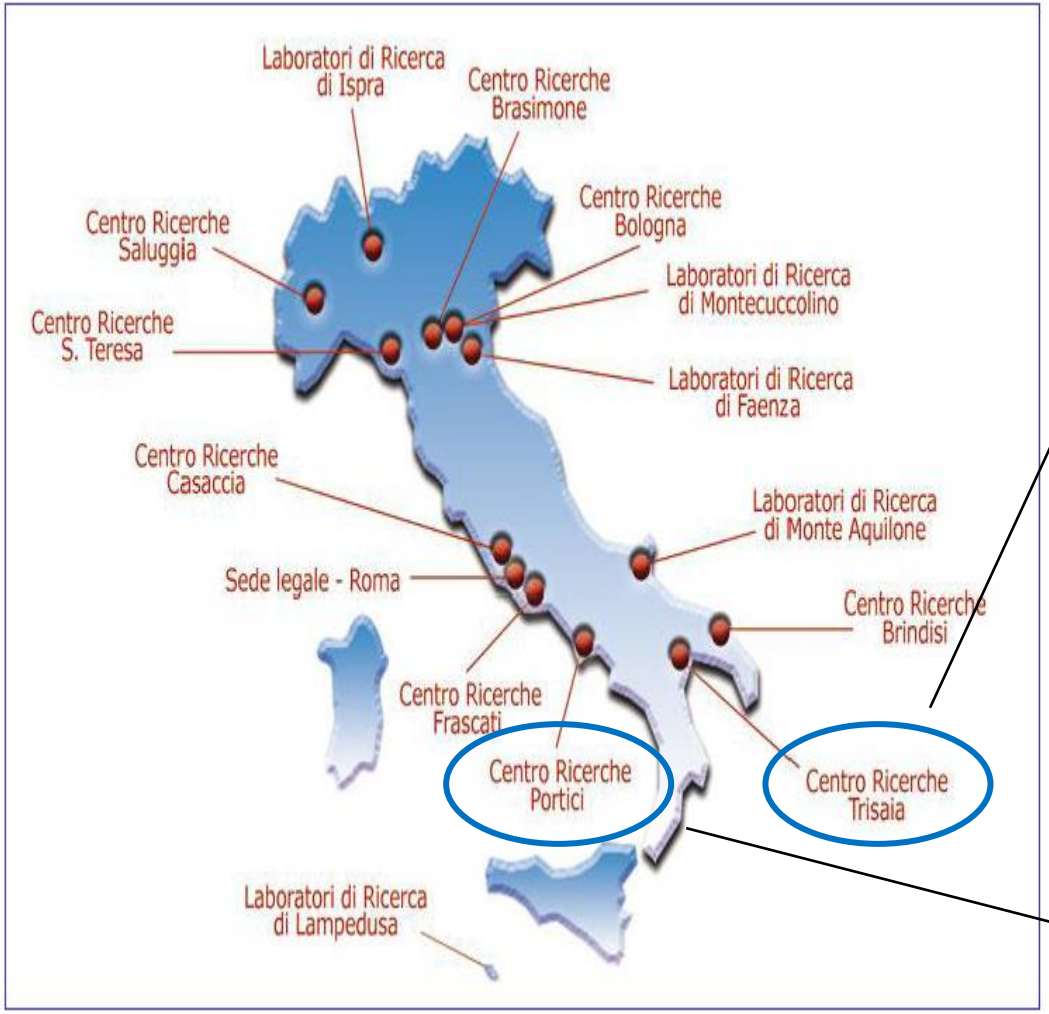
Introduction

Environmental Technologies

- Research and Development of processes for matter and/or energy recovery from waste.

- Development of technologies and design of pilot plants for waste treatment .

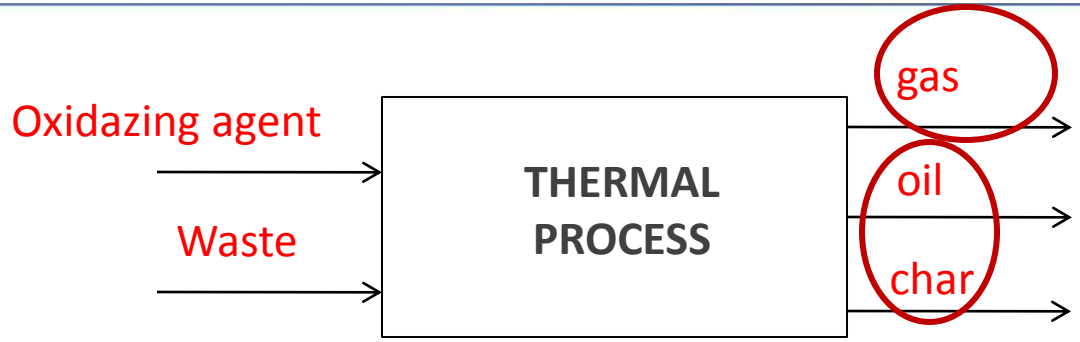
Introduction

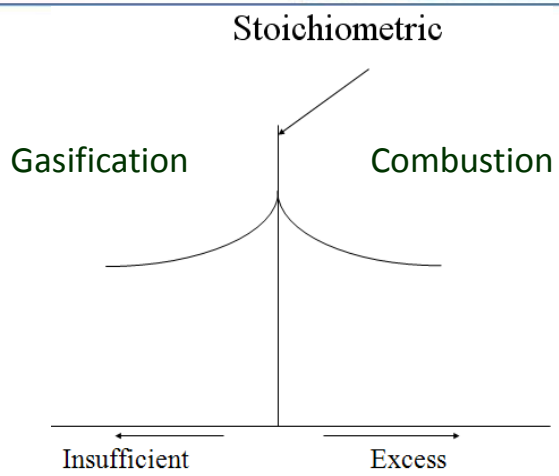


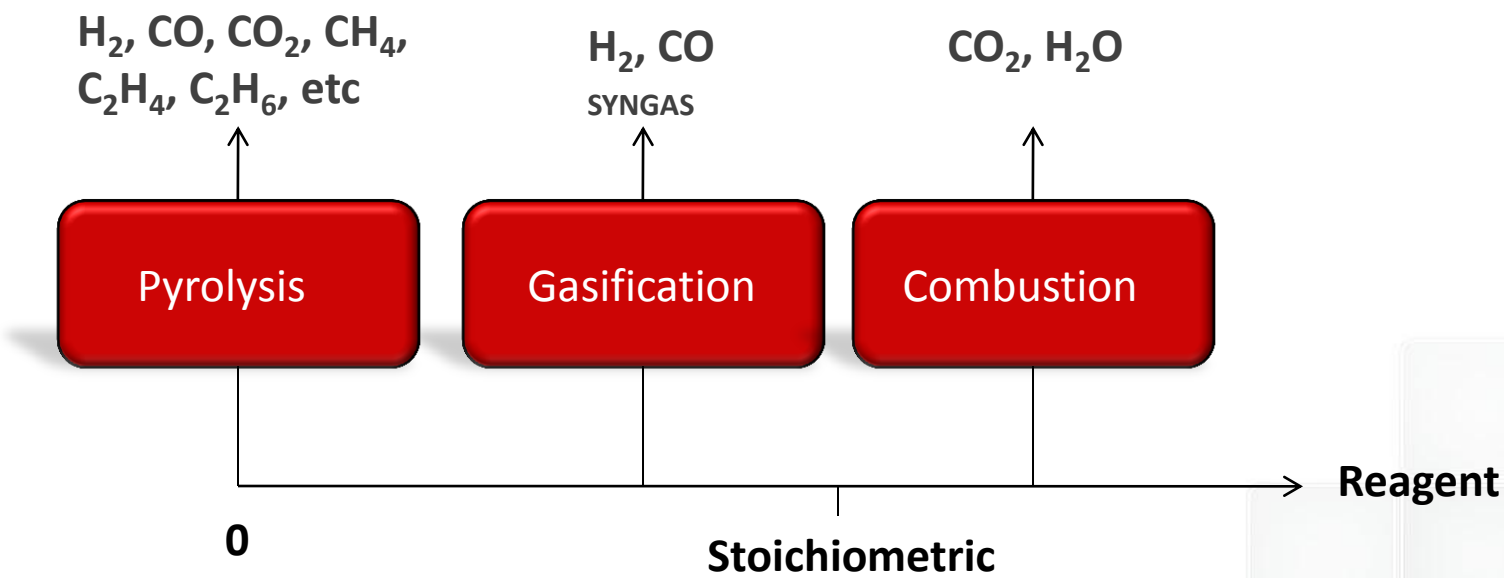
Solid and liquid waste treatment Laboratory **(UTTRI-RIF)**

Eco-sunstainable materials Laboratory **(UTTP-NANO)**

Thermal process of waste



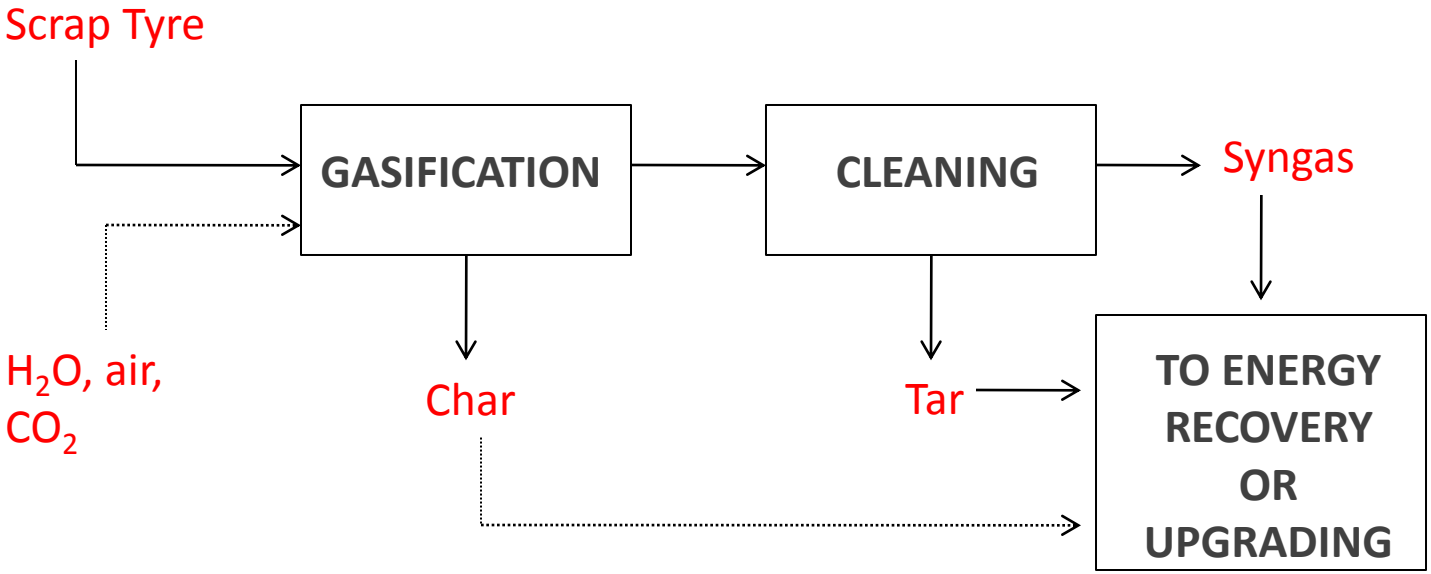




Gasification

- Partial oxidation process using air, pure oxygen, oxygen enriched air, carbon dioxide or steam;
- Temperature > 750°C;
- Main product is syngas.

Thermal process on Waste tyres

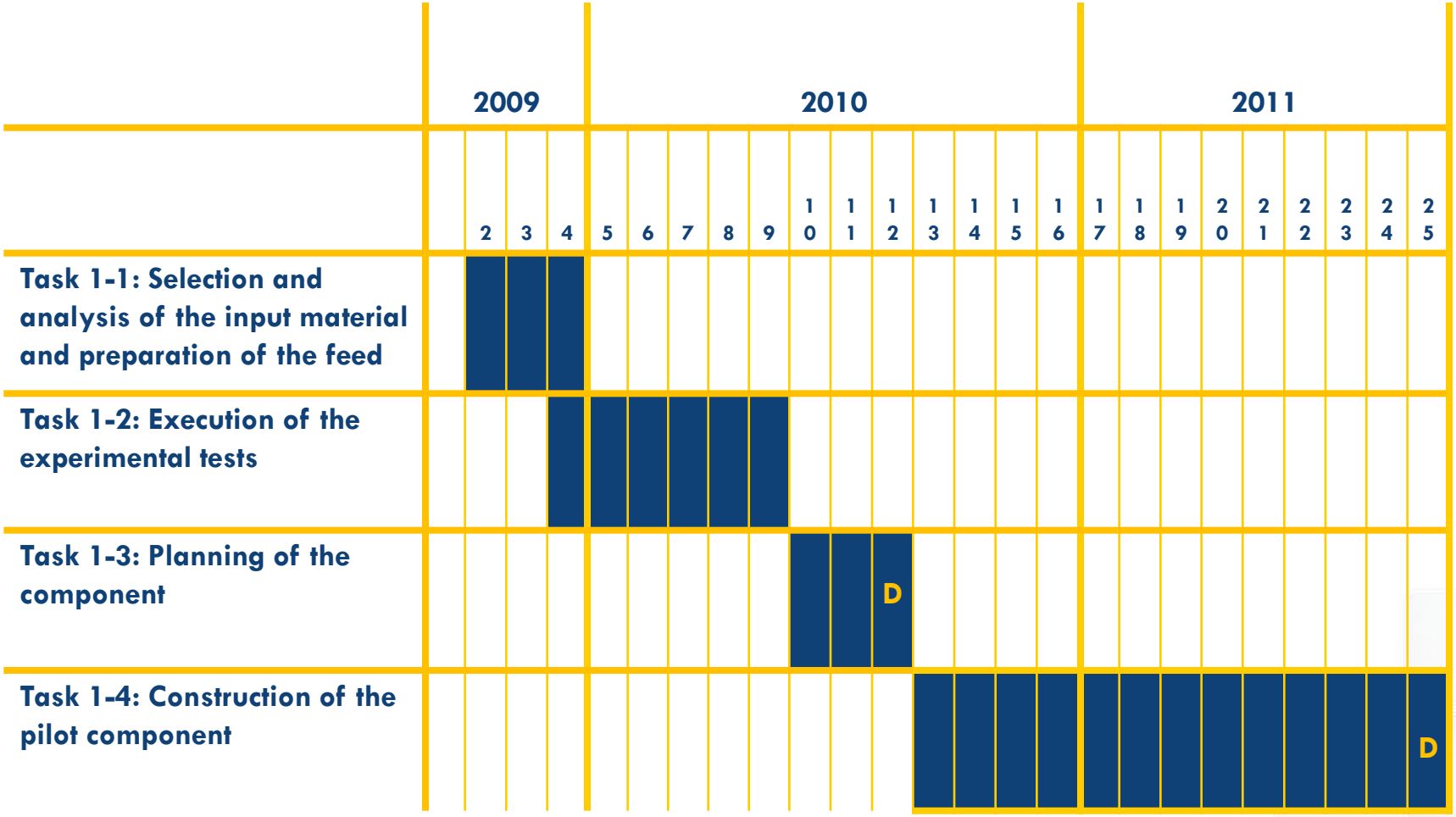


Primary Products	Main Composition	Upgrade
Syngas	H_2, CO, CH_4, C_2H_4, C_2H_6, CO_2	Production of chemicals, Energy, etc
Char	Carbon, Sulphur and metal oxide (ZnO)	Activation, Production high added value materials, etc
Tar	Aromatics, Ketones, Aldehydes, Alkanes, Alkenes	Liquid fuels, chemicals, adhesives and other products

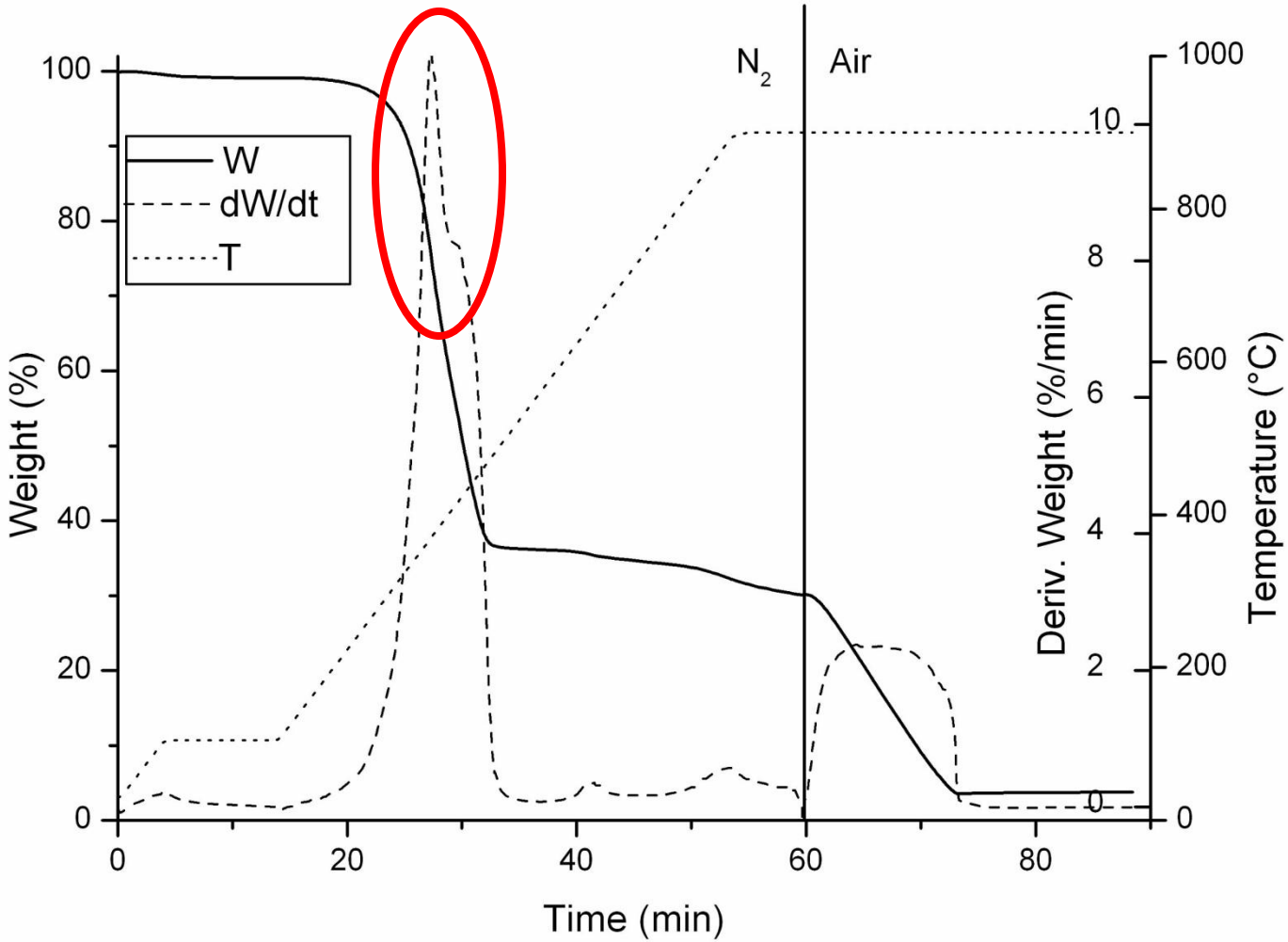
Work package

Work package No.	Work package title	Type of activity	Lead beneficiary No.
WP0	Project management	MGT	ENEA
WP1	Gasification	RTD	ENEA
WP2	Gas Separation	RTD	RWTH
WP3	Energy Production	RTD	TUBITAK MAM
WP4	Carbothermal Reduction	RTD	IMEC
WP5	Ceramic Product Tests	RTD	COMETAS
WP6	Set-up and operational tests on pilot scale plant	RTD	ENEA
WP7	Sustainability assessment	RTD	ENEA
WP8	Market analysis and Exploitation of results	RTD	ETRA
WP9	Dissemination	OTHER	ETRA

Workplan


2009
2010
2011
2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25
Task 1-1: Selection and analysis of the input material and preparation of the feed
Task 1-2: Execution of the experimental tests
Task 1-3: Planning of the component
D
Task 1-4: Construction of the pilot component
D

Material characterization



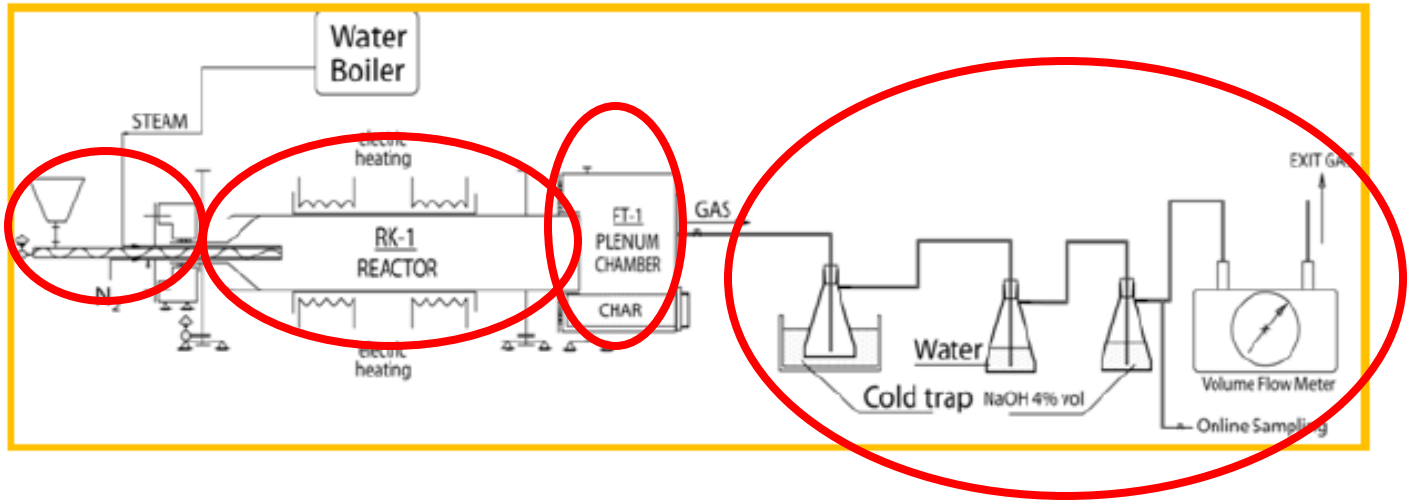
Material characterization

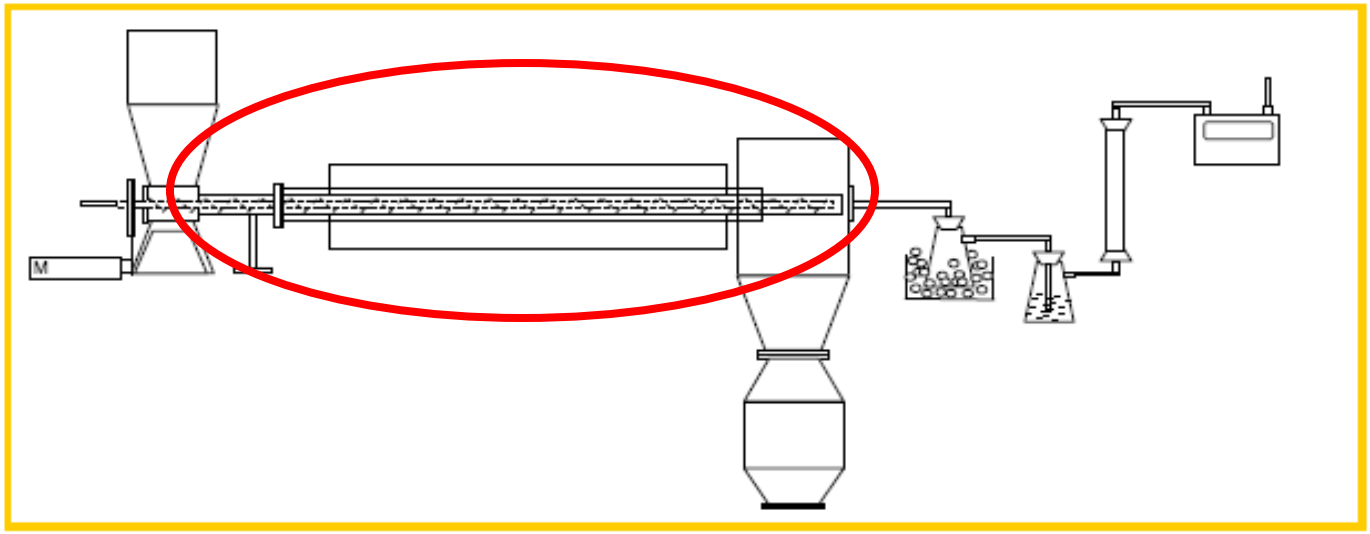
Ultimate Analysis	
	(%)
C	77,3
H	6,2
N	0,6
S	1,8
O	7,1

Proximate analysis	
	(%)
Volatile	67.7
Fixed Carbon	25.5
Ash	6.8

density (kg/m^3)	0,8

Schematic diagrams of ENEA equiptments

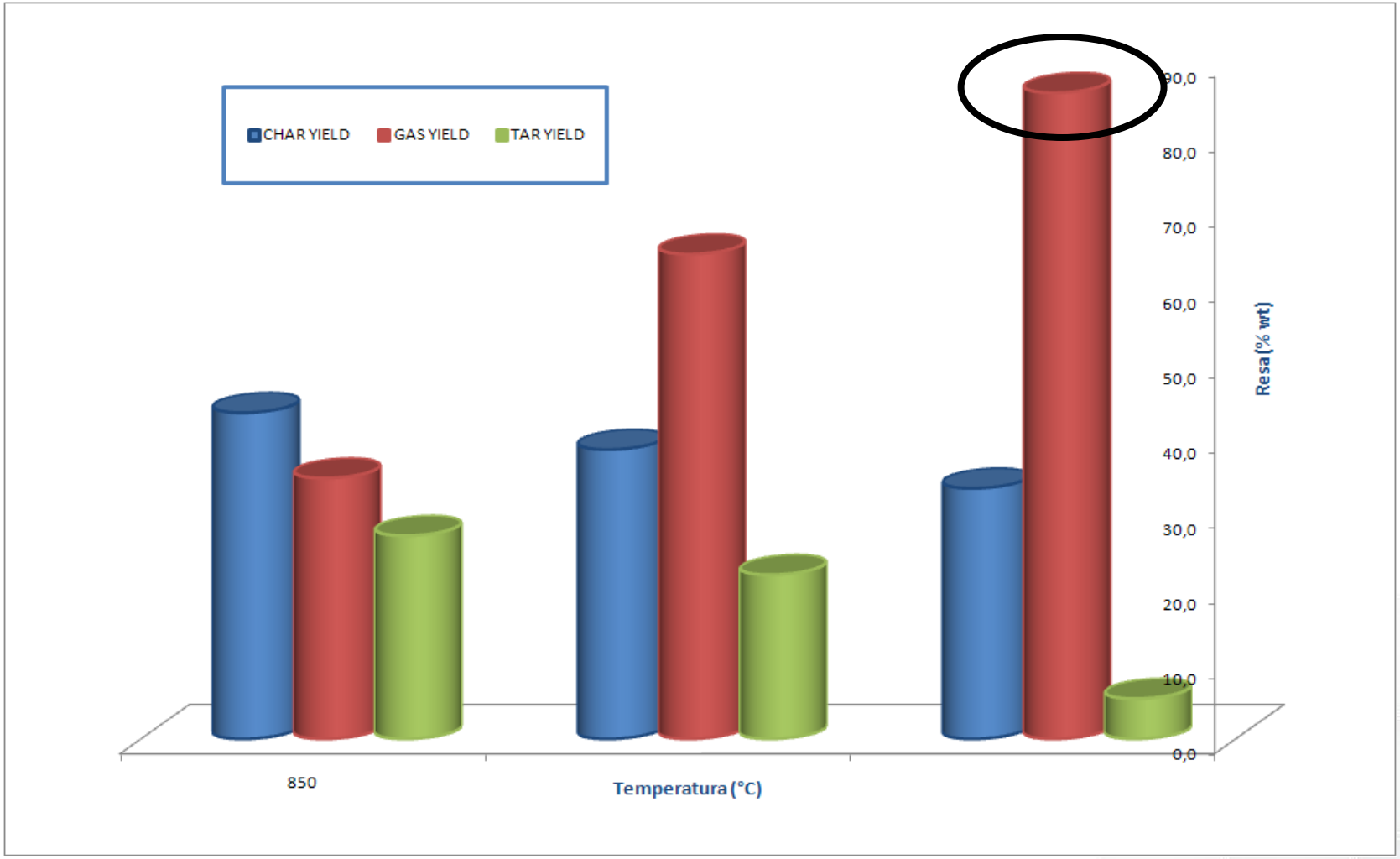




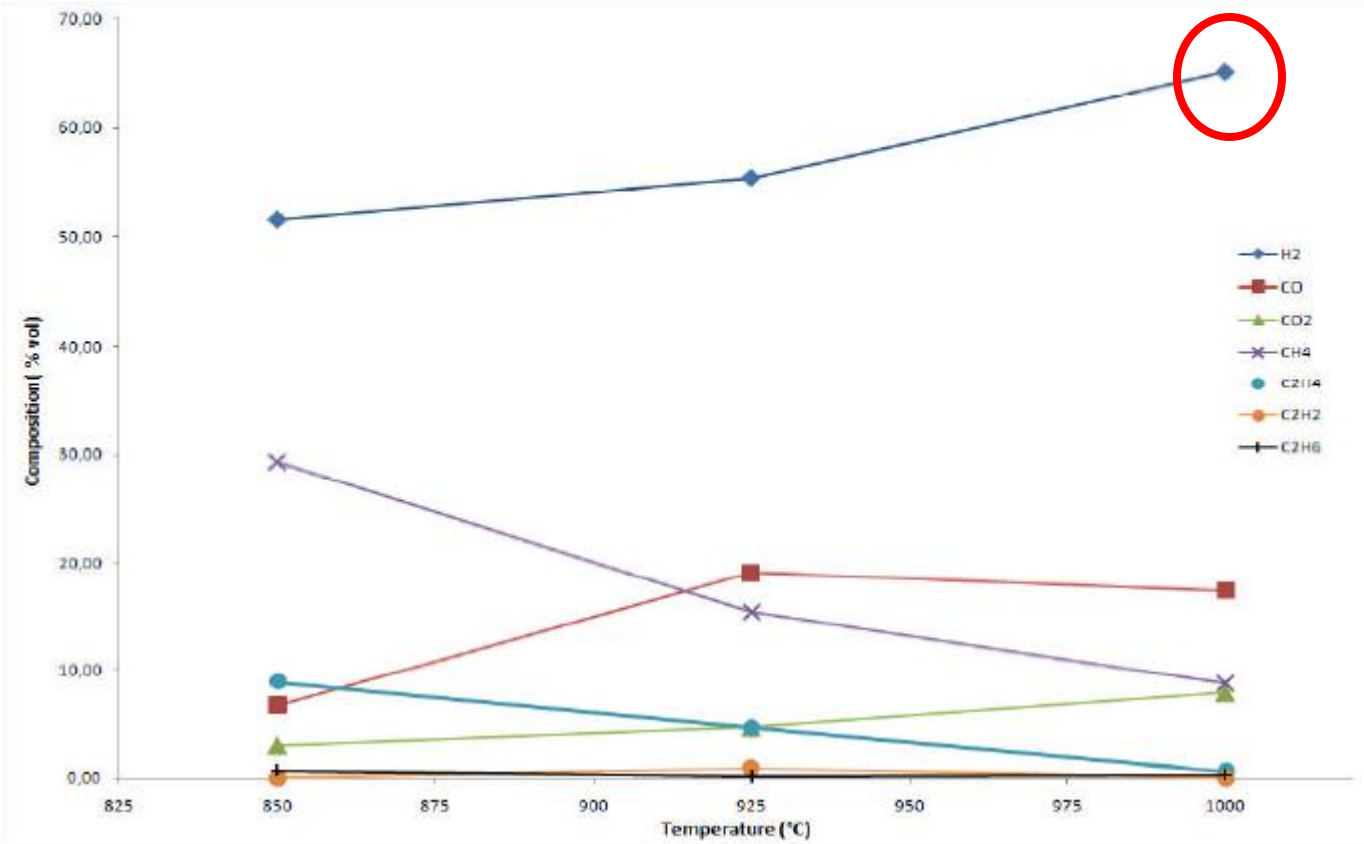
Process parameters

Test Code	Temperature	Flow (N_2)	Steam / Tyre ratio	Solid residence time	Gas residence time
	(°C)	(l/min)		(min)	(s)
T1SGTy	850	1.0	2	>100	6.2
T2SGTy	925	1.0	2	>100	5.7
T3SGTy	1000	1.0	2	>100	5.3

Main fractions yields



Gas composition vs Temperature



Main gasification reactions

Water gas shift reaction

$CO + H_2O \rightarrow CO_2 + H_2$ $\Delta H_{298K} = -41.2$ kJ/mol

Boudouard's reaction

$C + CO_2 \rightarrow 2CO$ $\Delta H_{298K} = 172.5$ kJ/mol

Gasification reactions

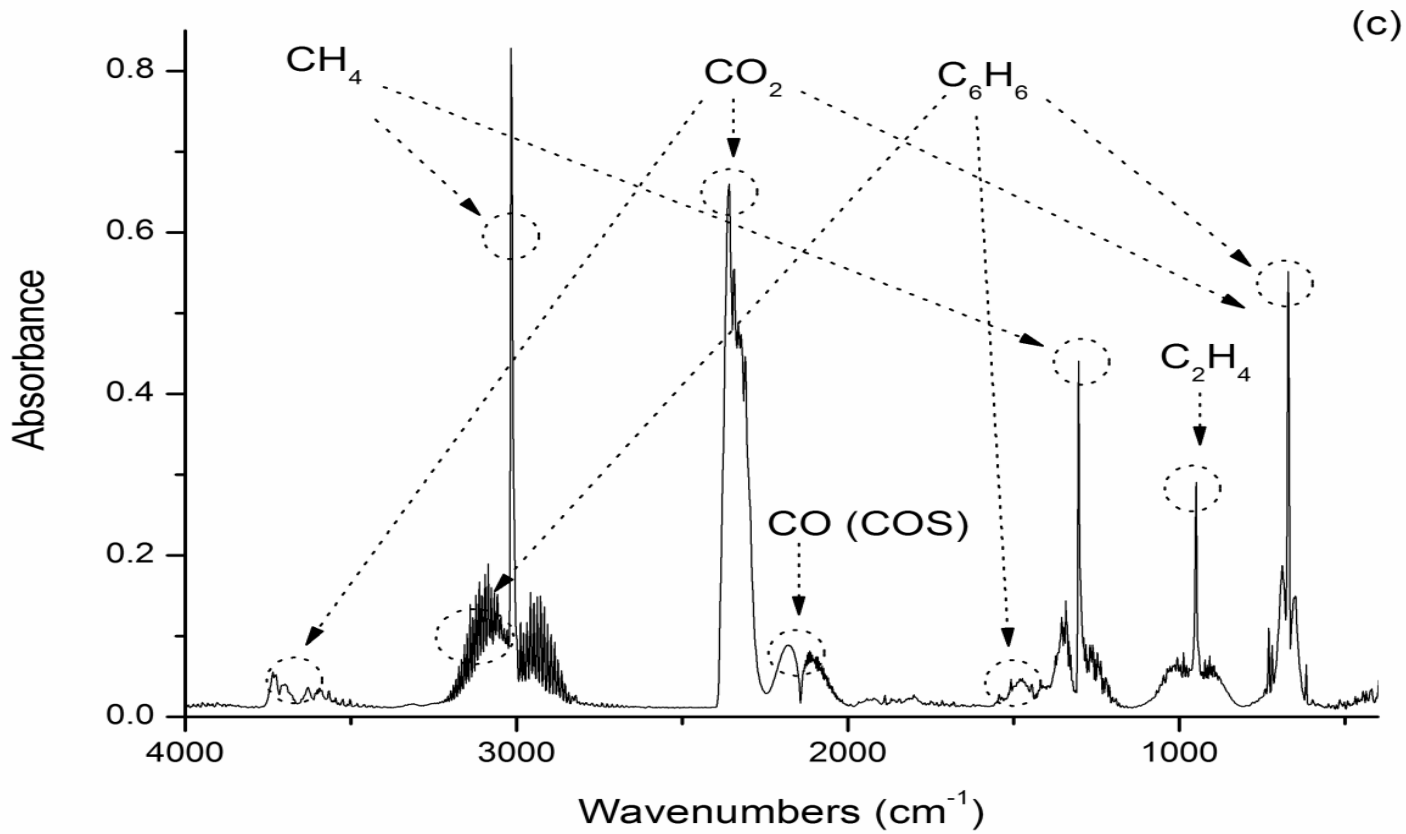
$C + H_2O \rightarrow CO + H_2$ $\Delta H_{298K} = 131.3$ kJ/mol

$CH_4 + H_2O \rightarrow CO + 3H_2$ $\Delta H_{298K} = 206.1$ kJ/mol

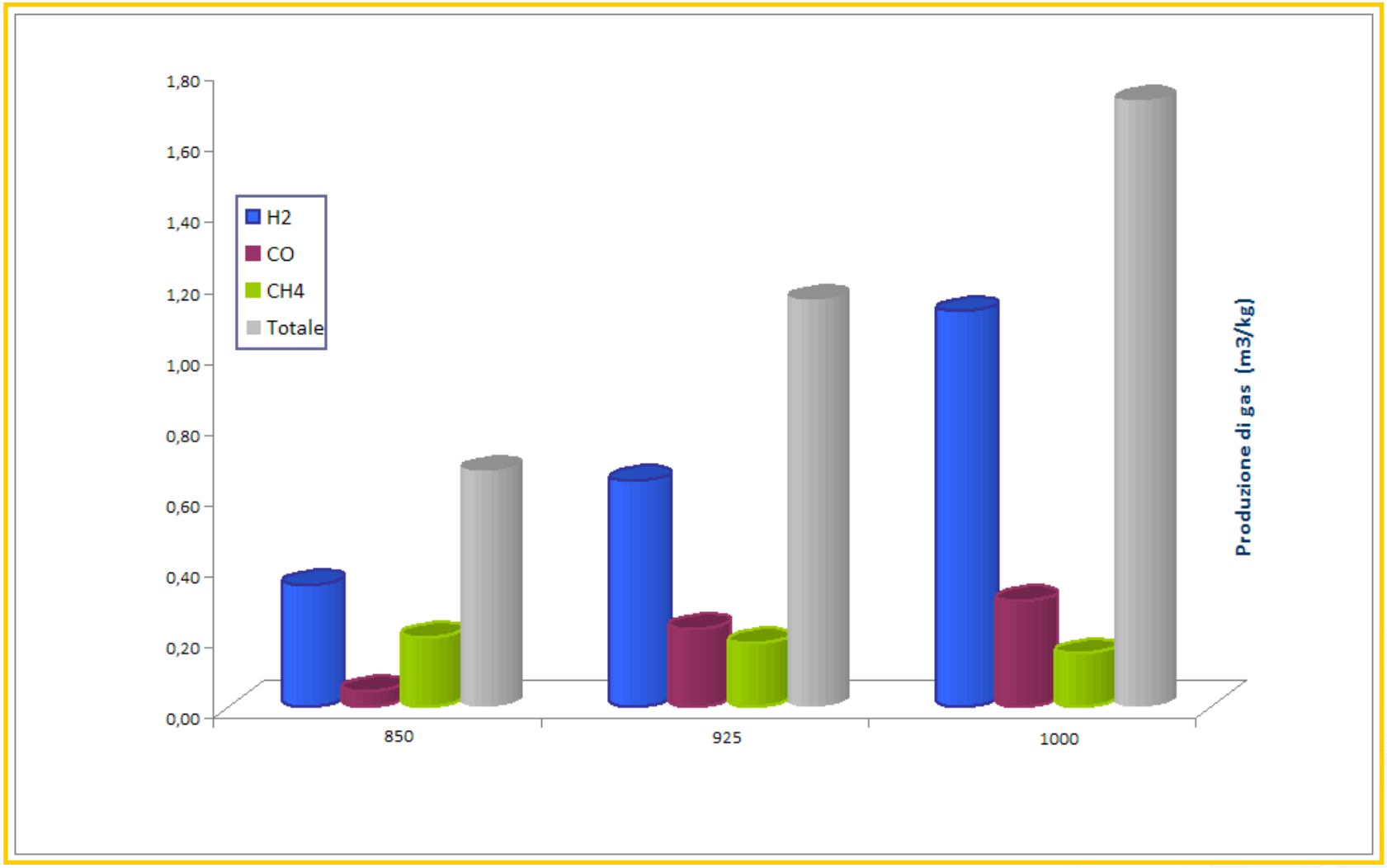
$CH_4 + 2H_2O \rightarrow CO_2 + 4H_2$ $\Delta H_{298K} = 164.6$ kJ/mol

$C_nH_m + 2nH_20 \rightarrow (2n + m/2)H_2 + nCO_2$ $\Delta H_{298K} > 0$

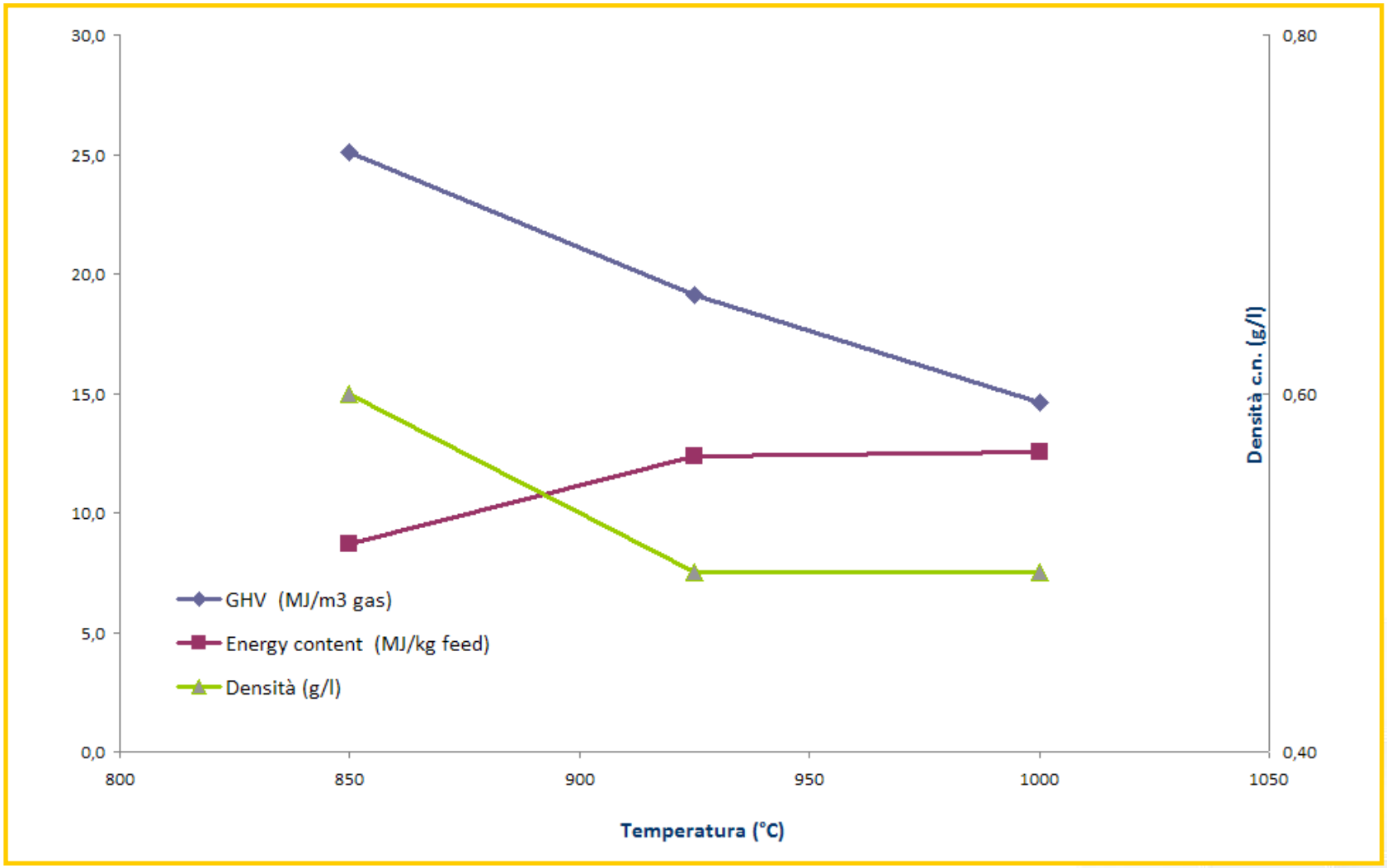
Off-line FTIR Analysis



Gas production



Gas Characterization



Char Characterization

	WASTE TYRE	T1SGTy	T2SGTy	T3SGTy
Proximate analysis	(% wt)	(% wt)	(% wt)	(% wt)
Volatile matter	67,7	3,1	4,4	5,5
Fixed Carbon	25,5	78,9	77,5	71,4
Ash	6,8	18,0	18,1	23,1
Conversion		0,61	0,67	0,73

Conclusions

- Different trials of the steam gasification of scrap tyre was performed, varying the process temperature within the range of 850-1000 °C
- Running the process, a large amount of soot is detected that require a severe cleaning system (filtration) to avoid plugs in the plant
- Data show that a higher temperature results in:
  - a higher syngas production (86 %wt)
  - a growth of the syngas yield mainly against the condensable fraction, indicating an increase of secondary cracking reactions in vapour phase

Conclusions

- a decrease of the char yield in the same way, showing an enhancement of solid-gas phase reaction with temperature
- a higher hydrogen production at higher temperature (up to 65% vol) with respect to the hydrocarbon abundance

- The adopted operating conditions allow to obtain an appreciable amount of char, whose high carbon content suggest its exploitation both as activated carbon (after activation process) and as carbon source for synthesis reactions.

Thank you for your attention

For other information: www.tygre.eu