Energias Renováveis (Biomassa)

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O Laboratório Associado

LAETA - Laboratório Associado de Energia, Transportes e Aeronáutica

Research units:
- IDMEC/IST
- INEGI/UP
- ADAI/UC
- AEROG/UBI

In 2013
- 253 PhD researchers
- 284 PhD students
- 25 projects (FP7)
- 1.1 MEuro/year
- 320 papers ISI/year

Thematic research lines:
- Energy
- Transports technology
- Aeronautics and space
- Advanced manufacturing
- Advanced materials
- Biomechanics
- Engineering design
- Engineering systems
- Forest fires

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Current areas of research on biomass

- **Co-combustion of coal with biomass, with emphasis on difficult biomass fuels**
  (3 PhDs: Rita Silva, Pedro Ferreira, Miriam Rabaçal)
- **Formation of fine particulate matter in biomass combustion**
  (1 PhD: Ulisses Fernandes)
- **Torrefaction of biomass (particle fragmentation)**
  (1 PhD: Francisco Costa)
- **Polygeneration district heating and cooling systems based on renewable resources, including RDF from MSW**
  (1 PhD: Natalia Kabalina)
- **Destruction of the tar present in syngas by combustion in porous media**
  (1 Pos-Doc: Cláudia Casaca; 1 MSc: Tiago Brito)
- **Biomass gasification and pyrolysis**
  (1 Pos-Doc: Ana Filipa Ferreira; 1 PhD: Ricardo Gouveia; 1 MSc: Ana Ferreiro)
- **Energy valorization of crude glycerin (combustion, co-combustion, steam reforming,…)**
  (2 MScs: Pedro Queirós, Pedro Barata)

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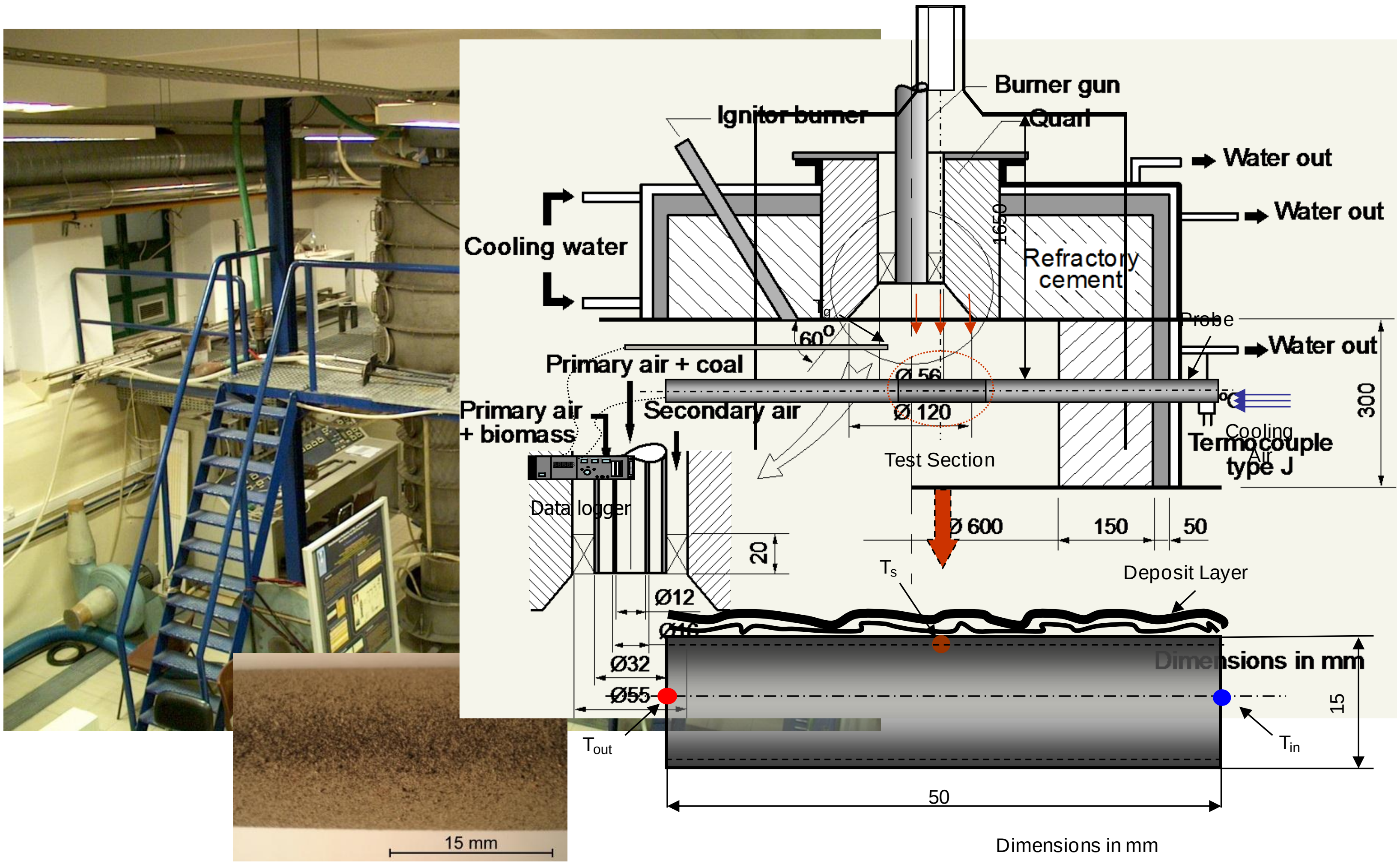
Experimental facilities and instrumentation

Co-combustion of coal with biomass (1)

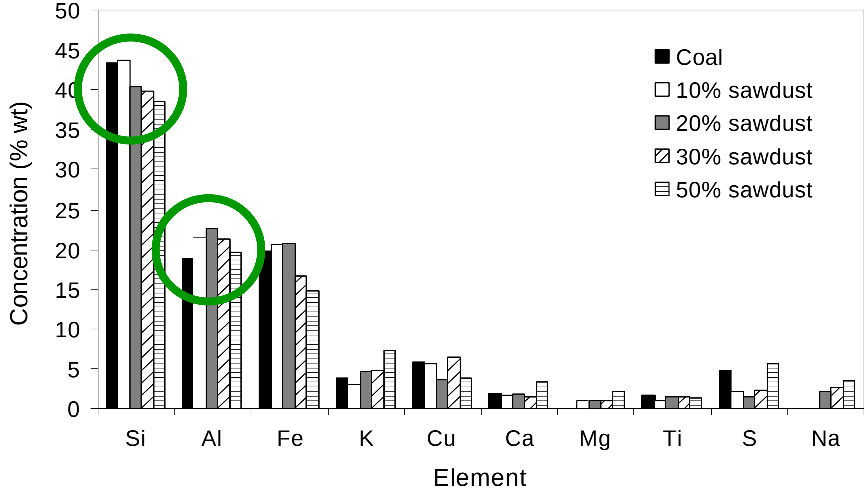
Slagging and fouling can reduce the heat transfer in heat exchangers

Co-combustion: biomass fuels present high percentages of inorganic matter; high levels of alkali metals can produce sulphates and chlorides (KCl, NaCl, Na_2SO_4, K_2SO_4); ashes with low melting point; high levels of Cl (corrosion)

Co-combustion of coal with biomass (2)

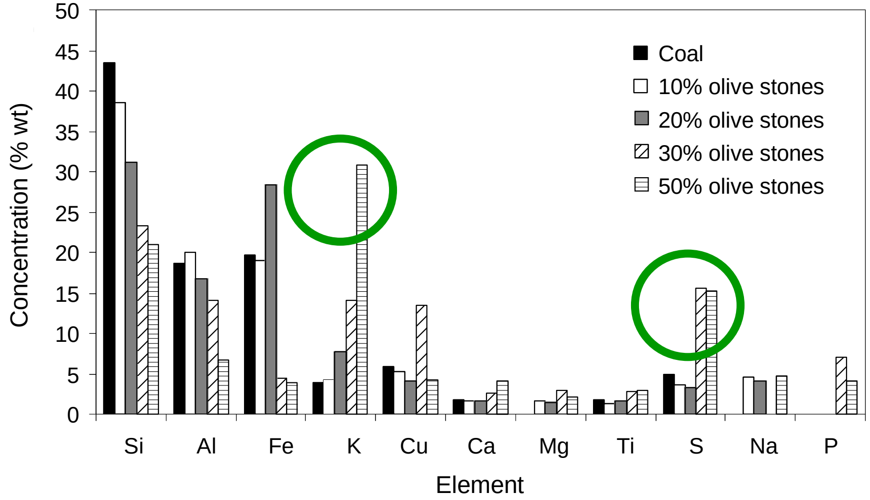


Co-combustion of coal with biomass (3)



- Coal + sawdust co-firing
- High content of Si and Al

  SiO_2 e Al_2O_3 high melting temperatures



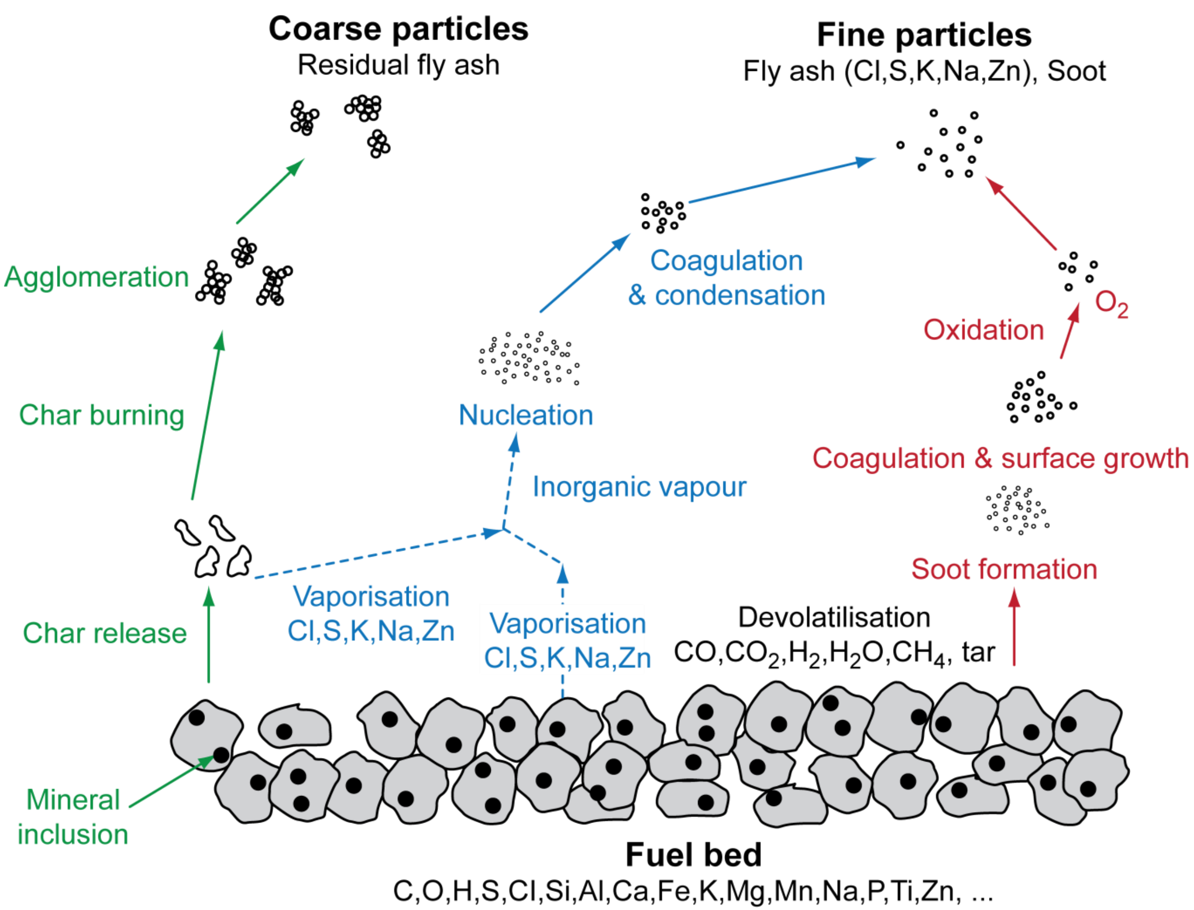
- Coal + olive stones co-firing
- High content of K

  K_2O and K_2SO_4 have low melting temperatures
- High content of S

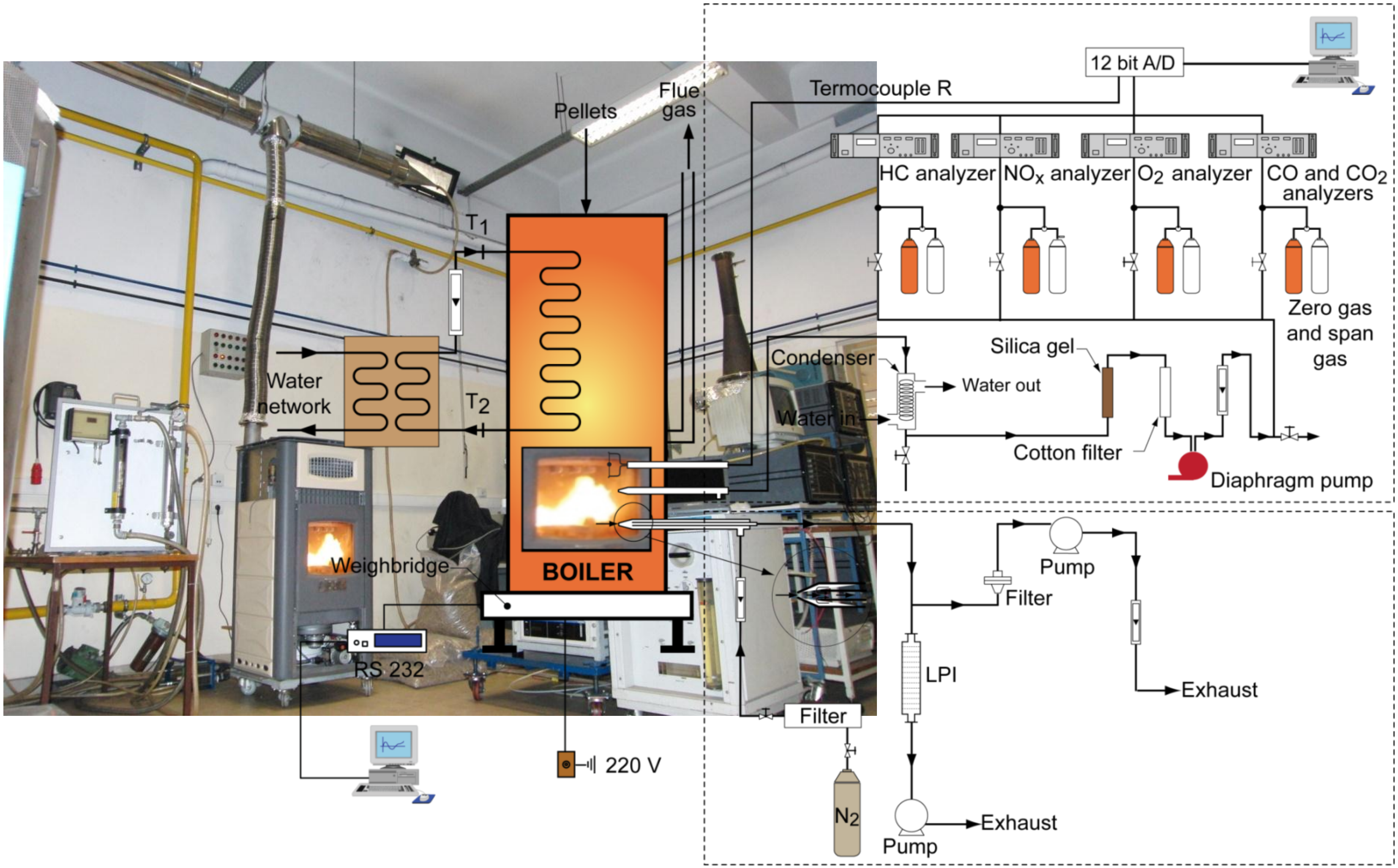
  Formation of sulfates

Formation of fine particulate matter in biomass combustion (1)

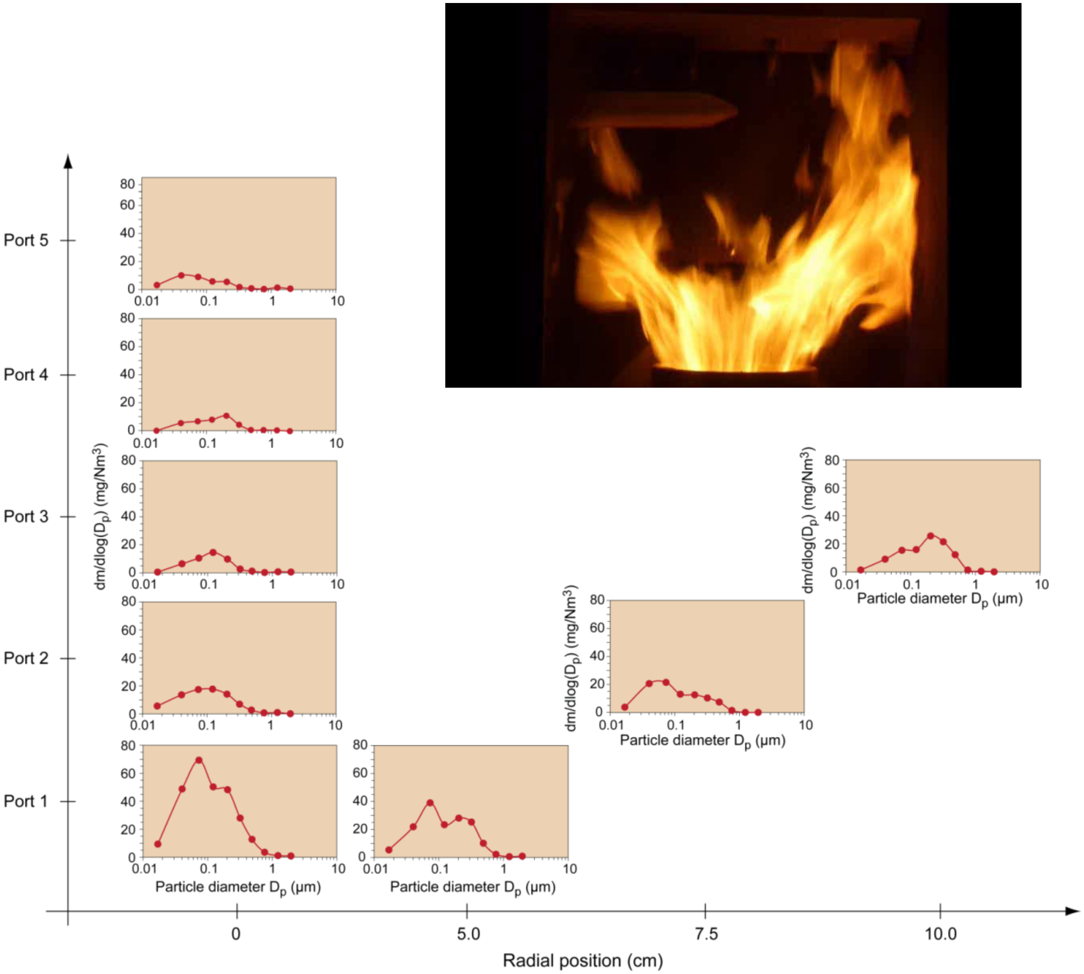
Simplified illustration of the particulate formation mechanisms during fixed-bed combustion of a solid biomass

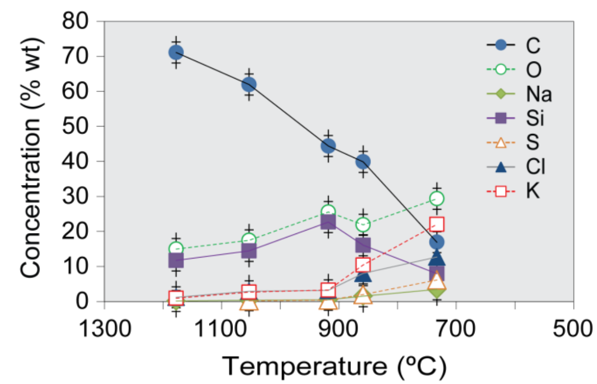


Formation of fine particulate matter in biomass combustion (2)

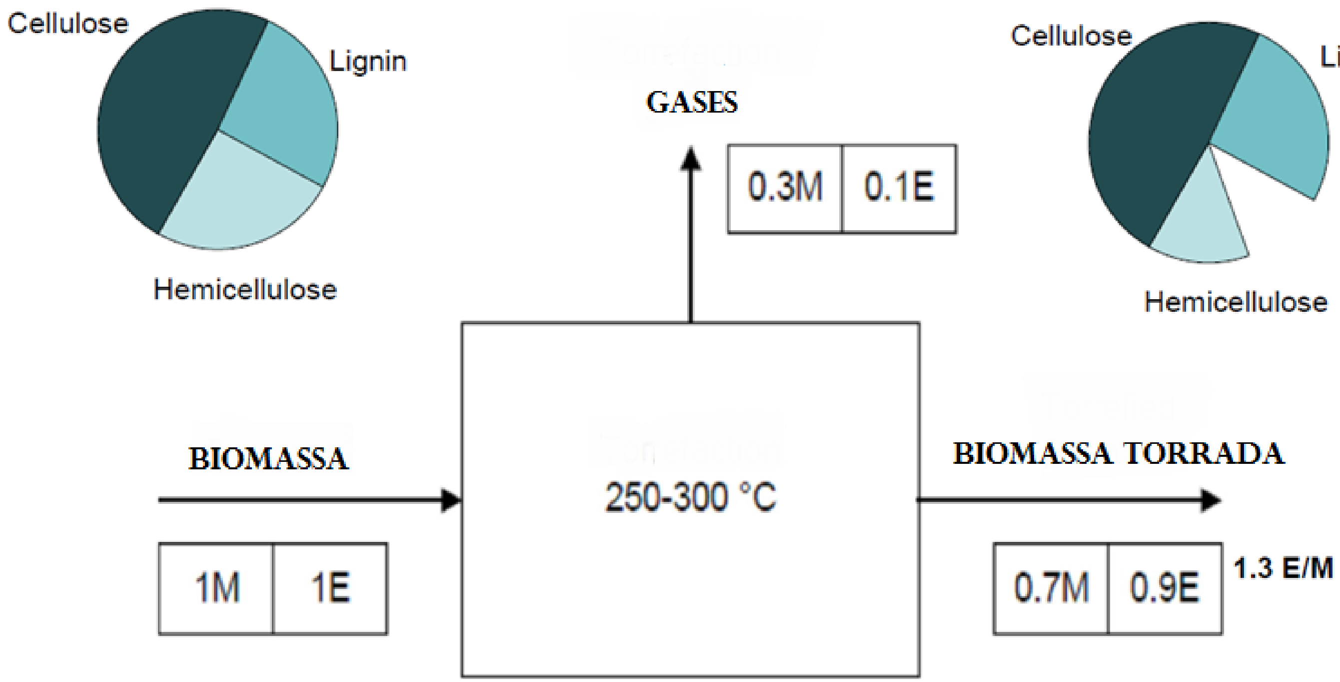


Formation of fine particulate matter in biomass combustion (3)



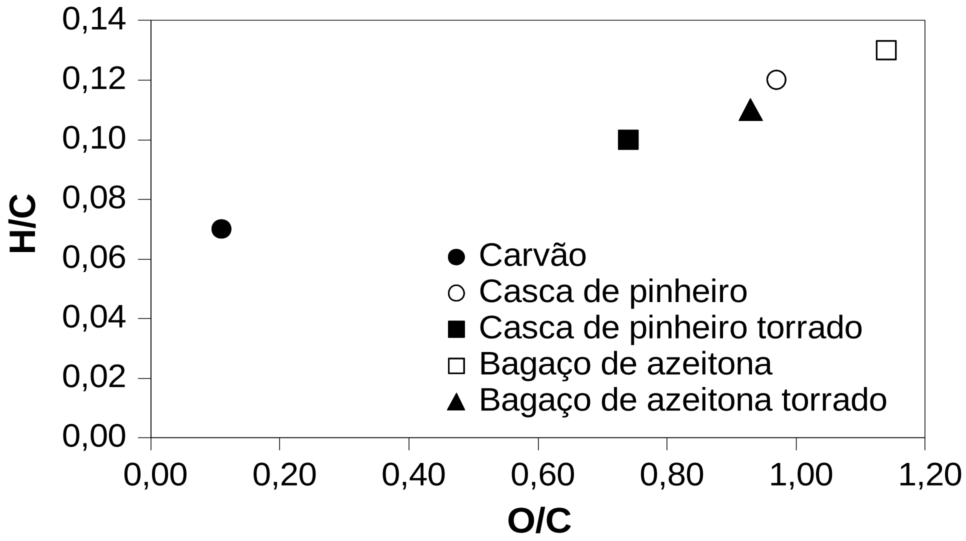


Torrefaction of biomass (1)

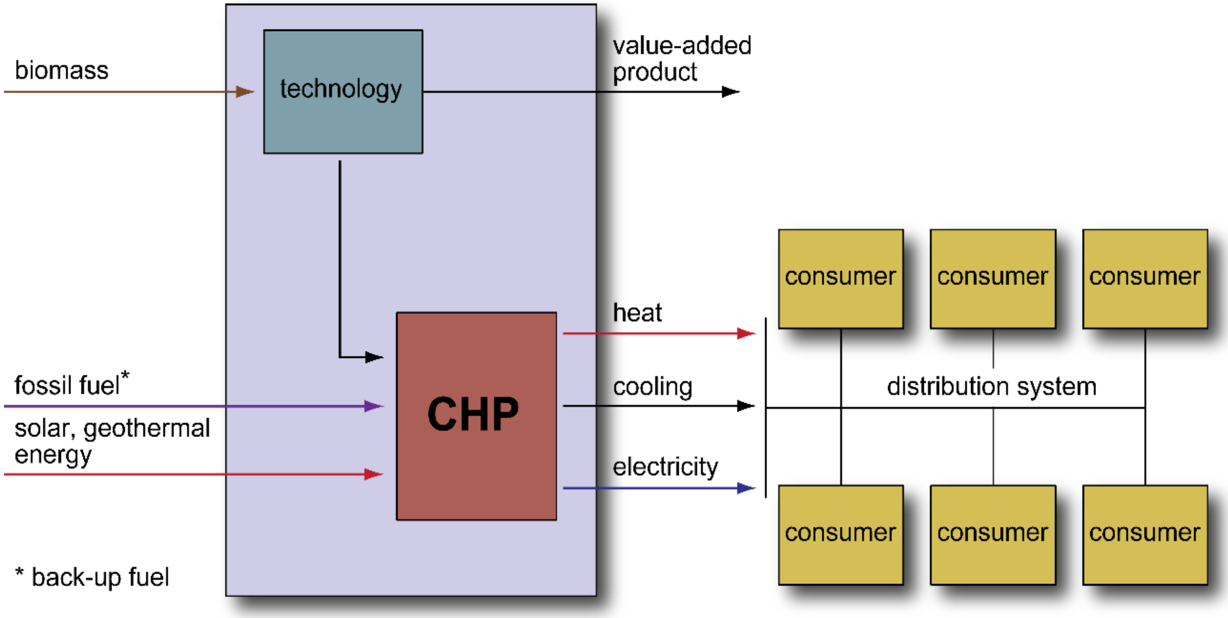


Torrefaction of biomass (2)

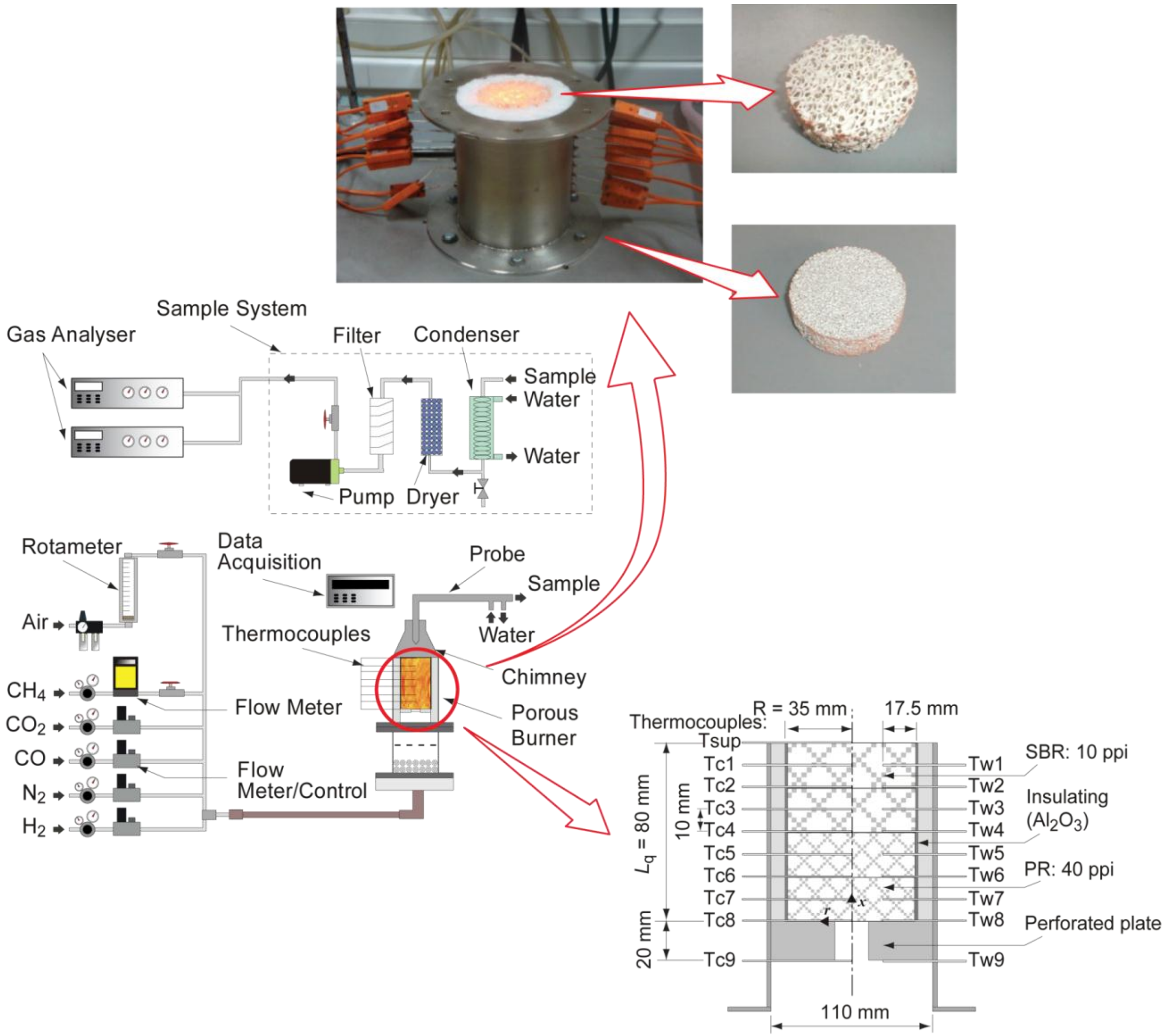
Parâmetro	Casca de pinheiro		Bagaço de azeitona		Carvão
	Original	Torrado	Original	Torrado	
Análise imediata (*wt%, as received*)					
Matéria volátil	58,9	69,4	57,8	60,6	44,6
Carbono fixo	25,9	27,6	19,7	23,1	51,4
Humidade	13,9	1,0	9,4	0,3	1,7
Cinzas	1,3	2,0	13,1	16,0	2,3
Análise elementar (*wt%, daf*)					
Carbono	47,8	54,4	43,2	47,8	79,3
Hidrogénio	5,6	5,5	5,6	5,1	5,9
Azoto	0,3	0,4	1,9	2,3	1,9
Enxofre	0,0	0,0	0,0	0,0	0,5
Oxigénio	46,3	39,7	49,3	44,8	12,4
Poder calorífico superior (MJ/kg)	18,82	23,52	17,54	20,67	35,04



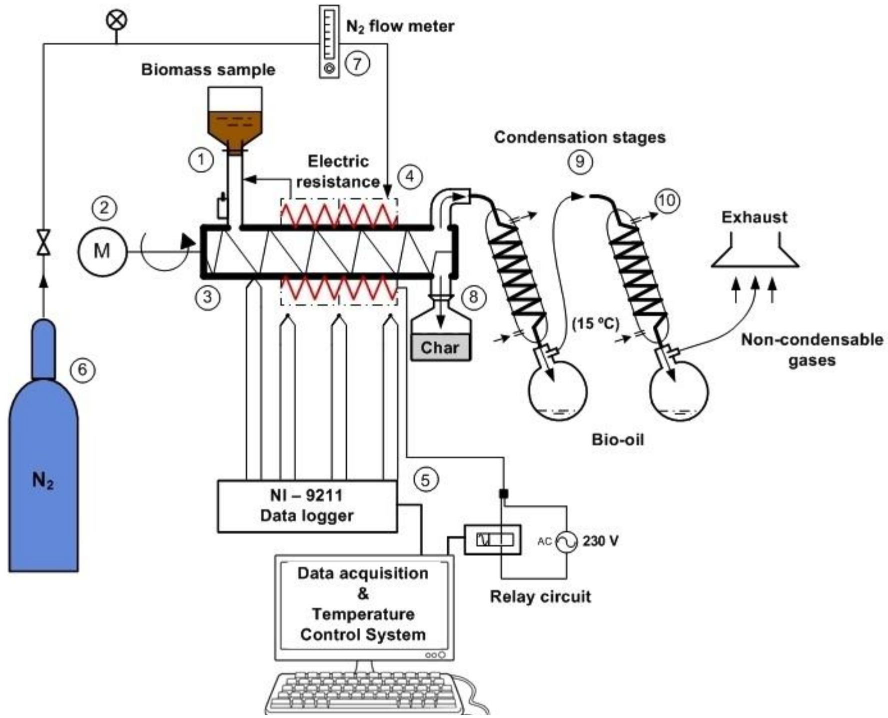
Polygeneration district heating and cooling systems based on renewable resources

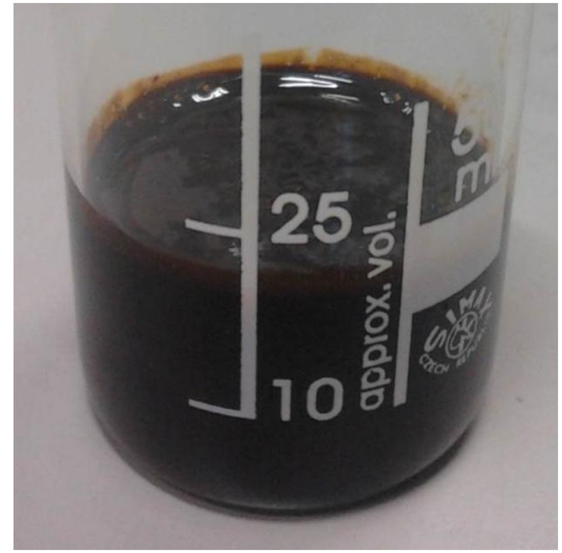


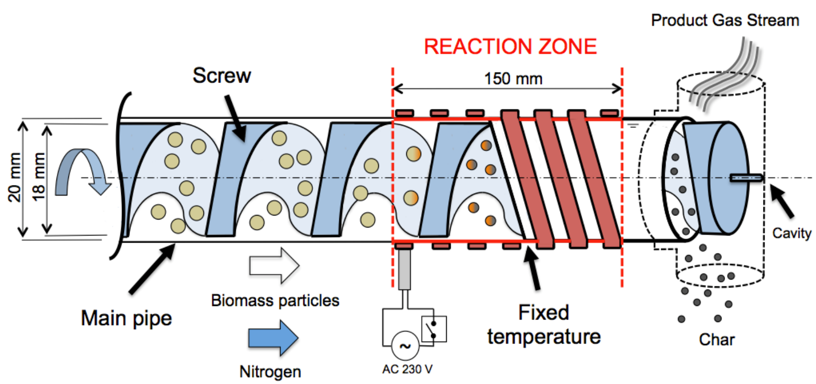
Destruction of the tar present in syngas by combustion in porous media



Biomass pyrolysis

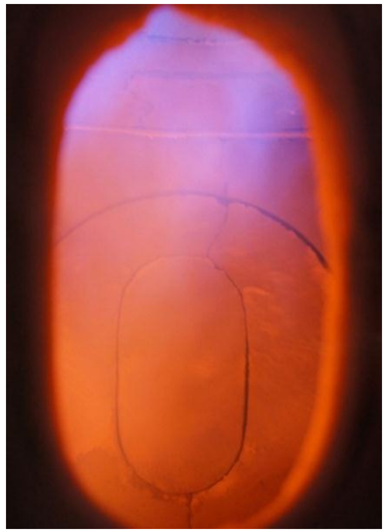






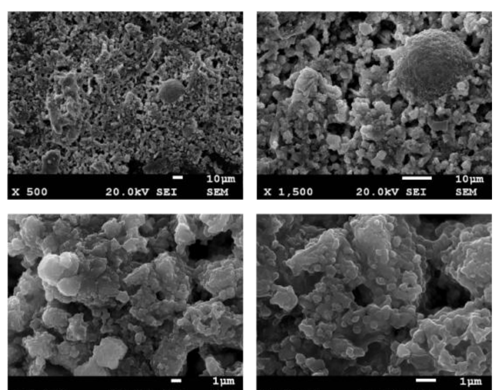
Energy valorization of crude glycerin

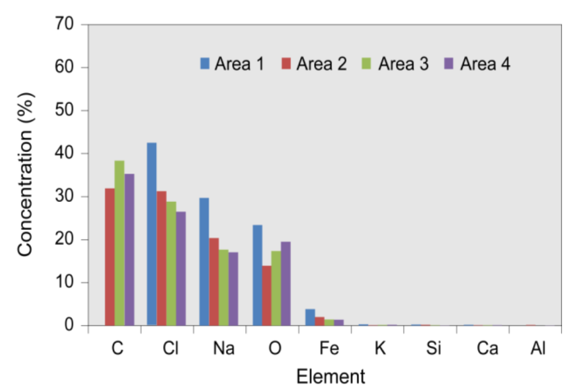
Co-combustion of crude glycerin



NG + H_2

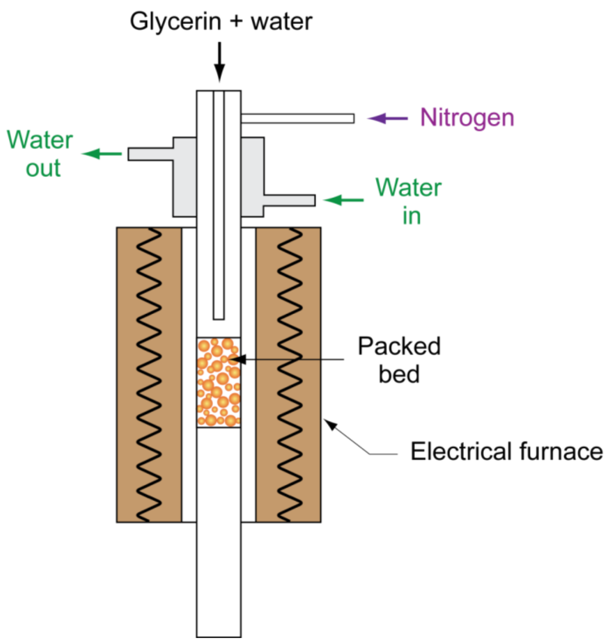
NG + H_2 + glycerin

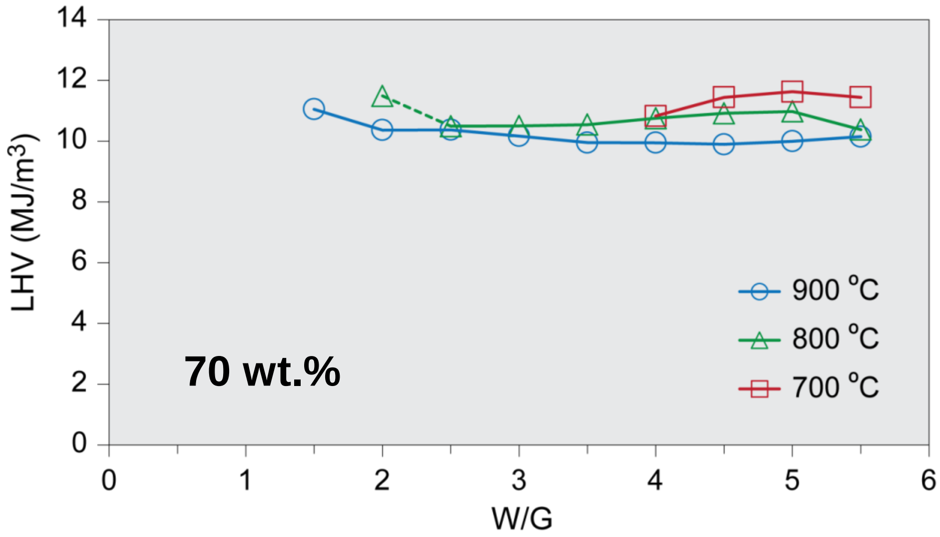


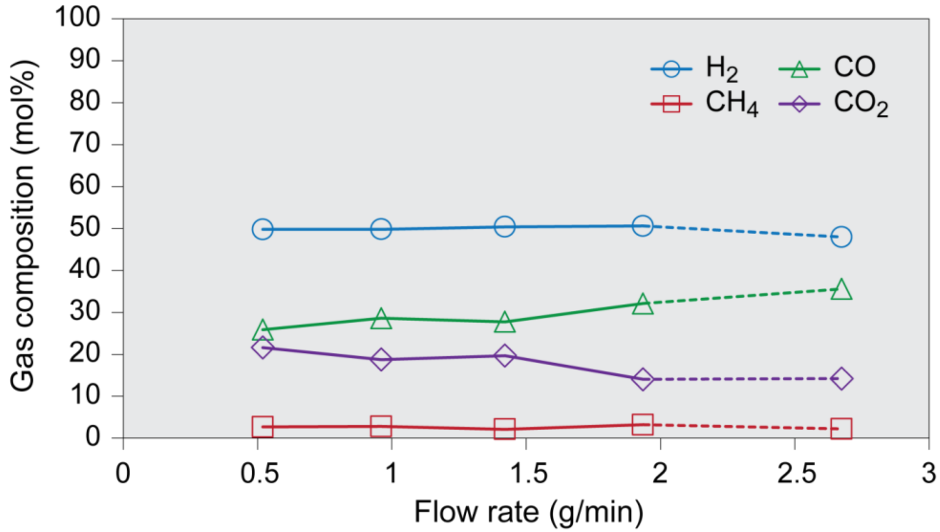


Energy valorization of crude glycerin

Steam gasification of crude glycerin in a packed bed reactor







Some challenges

- **Co-combustion of coal with biomass, with emphasis on difficult biomass fuels**
- **Formation of fine particulate matter in biomass combustion**
- **Torrefaction of biomass (particle fragmentation)**
- **Gasification of RDF from MSW**
- **Integrated Energy Systems (biomass, solar, …)**

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International collaboration

- Imperial College London (Londres)
- Universidade Federal de Santa Catarina (Brasil)
- Universidade de Lund (Suécia)
- Universidade de Haifa (Israel)
- Universidade Zaragoza (Espanha)
- Universidade de Granada (Espanha)
- Universidade de Aachen (Alemanha)
- Universidade de Duisburg-Essen (Alemanha)
- Kungliga Tekniska Högskolan (Suécia)

Recent publications on biomass (ISI)

1. CASACA, C. and COSTA, M. (2009). NO_x control through reburning using biomass in a laboratory furnace: effect of particle size. Proceedings of the Combustion Institute, **32**, 2641-2648.
2. VASCO, H. and COSTA, M. (2009). Quantification and use of forest biomass residues in Maputo province, Mozambique. Biomass and Bioenergy, **33**, 1221-1228.
3. Francisco Jr., R. W., Rua, F., Costa, M., Catapan, R. C. and Oliveira, A. A. M. (2010). On the combustion of hydrogen rich gaseous fuels with low calorific value in a porous burner. Energy & Fuels, **24**, 880-887.
4. FERNANDES, U. and COSTA, M. (2010). Potential of biomass residues for energy production and utilization in a region of Portugal. Biomass and Bioenergy, **34**, 661-666.
5. Abreu, P., CASACA, C. and COSTA, M. (2010). Ash deposition during the co-firing of bituminous coal with pine sawdust and olive stones in a laboratory furnace. Fuel, **89**, 4040-4048.
6. CASACA, C. and COSTA, M. (2011). Detailed measurements in a laboratory furnace with reburning. Fuel, **90**, 1090-1100.
7. FERNANDES, U. and COSTA, M. (2012). Particle emissions from a domestic pellets-fired boiler. Fuel Processing Technology, **103**, 51-56.
8. QUEIRÓS, P., CARVALHO, R. H. and COSTA, M. (2013). Co-combustion of crude glycerin with natural gas and hydrogen. Proceedings of the Combustion Institute, **34**, 2759-2767.
9. Rabaçal, M., Fernandes, U. and Costa, M. (2013). Combustion and emission characteristics of a domestic boiler fired with pellets of pine, industrial wood wastes and peach stones. Renewable Energy, **51**, 220-226.
10. Francisco Jr., R. W., Costa, M., Catapan, R. C. and Oliveira, A. A. M. (2013). Combustion of hydrogen rich gaseous fuels with low calorific value in a porous burner placed in a confined heated environment. Experimental Thermal and Fluid Science, **45**, 102-109.
11. FERNANDES, U. and COSTA, M. (2013). Formation of fine particulate matter in a domestic pellet-fired boiler. Energy & Fuels, **27**, 1081-1092.
12. Fernandes, U., Guerrero, M., Millera, A., Bilbao, R., Alzueta, M. U. and Costa, M. (2013). Oxidation behavior of particulate matter sampled from the combustion zone of a domestic pellet-fired boiler. Fuel Processing Technology, **116**, 201-208.
13. CARPIO, M., ZAMORANO, M. and COSTA, M. (2013). Impact of using biomass boilers on the energy rating and CO_2 emissions of Iberian Peninsula residential buildings. Energy and Buildings, **66**, 732-744.
14. Pottmaier, D., Costa, M., Farrow, T., Oliveira, A. A. M., ALARCON, O. and Snape, C. (2013). Comparison of rice husk and wheat straw: from slow and fast pyrolysis to char combustion. Energy & Fuels, **27**, 7115-7125.
15. WANG, G., PINTO, T. and COSTA, M. (2014). Investigation on ash deposit formation during the co-firing of coal with agricultural residues in a large-scale laboratory furnace. Fuel, **117**, 269-277.
16. WANG, G., SILVA, R. B., AZEVEDO, J. L T., MARTINS-DIAS, S. and COSTA, M. (2014). Evaluation of the combustion behaviour and ash characteristics of biomass waste derived fuels, pine and coal in a drop tube furnace. Fuel, **117**, 809-824.
17. Garcia-Maraver, A., Zamorano, M., Fernandes, U., Rabaçal, M. and Costa, M. (2014). Relationship between fuel quality and gaseous and particulate matter emissions in a domestic pellet-fired boiler. Fuel, **119**, 141-152.
18. SILVA, R. B., FRAGOSO, R., SANCHES, C., COSTA, M. and MARTINS-DIAS, S. (2013). Which chlorine ions are currently being quantified as total chlorine on solid alternative fuels?. Fuel Processing Technology, submetido para publicação.
19. pereira, C., wang, G. and Costa, M. (2013). Combustion of biodiesel in a large-scale laboratory furnace. Energy, submetido para publicação.
20. RABAÇAL, M., Franchetti, B. M., Marincola, F. C., PRONCH, F., COSTA, M., HASSE, C. and KEMPF, A. M. Large eddy simulation of coal combustion in a large-scale laboratory furnace. Proceedings of the Combustion Institute, submetido para publicação.
21. COSTA, F. F., WANG, G. and COSTA, M. Combustion kinetics and particle fragmentation of raw and torrified biomass in a drop tube furnace. Proceedings of the Combustion Institute, submetido para publicação.
22. Pottmaier, D., Costa, M., Farrow, T., Oliveira, A. A. M., ALARCON, O. and Snape, C. (2014). Super-reactivity of coffee: impact of the pyrolysis conditions on char combustion. Energy & Fuels, submetido para publicação..