High efficiency pellet boilers characterized by low PM emissions compared to traditional ones through LCA

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Introduction

This research has been carried on in the framework of the EU FP7 Research Project "BioMaxEff "(Cost efficient biomass boiler systems with maximum annual efficiency and lowest emissions, Period: 2011-2014) aiming at the demonstration of ultra-low emissions and high efficiency small scale pellet boilers.The work focuses on the environmental impact assessment (through LCA analyis) of both Austrian high efficiency pellet boilers and traditional boilers (fuelled with oil and natural gas) using data coming from experimental tests and from the most updated Ecoinvent database (v. 3).

Objectives

- Real innovative pellet boiler emission factors calculation (different models manufactured by Windhager);
- Pellet boiler environmental impact assessment evaluation;;
- Comparison between new pellet boilers and standard ones;
- Comparison of pellet and fossil fuelled boilers LCA analysis results.

LCA Method

The SimaPro software (v.8.1) has been used to perform the LCA analysis. The Recipe Endpoint Impact Assessment method (Egalitarian version) has been chosen to evaluate the environmental impact assessment[1]. Human healh, Ecosystems, and Resources depletion are the considered damage categories. 1MJ of energy production has been considered as functional unit for the final LCA analysis results and comparisons. LCA system boundaries include fuel production, boilers construction, boilers operational phase, boilers and fuel disposal and boilers transports. It is supposed a 20 years average boiler lifetime.

Boiler's type	VW120P	BW100E	VW060S	BW102E	S. pellet b	JWP155	NG boiler
Fuel type	Pellet	Pellet	Pellet	Pellet	Pellet	Light fuel oil	Natural gas
Nominal Output (kW)	12	10	6	10	15	15,5	15
Thermal Efficiency (%)	85	87	75	90	75	89,5	99

***Table 1**: Boilers technical features.*

Real emission factors for pellets boilers are measured according to the Load Cycle method as defined in [2]; oil and gas boilers emission factors come from literature [3]. Data on pellets and oil boilers construction and disposal are provided by the boiler manufacturer, while gas boilers data are taken from the most updated Ecoinvent database (v.3). Pellet boilers BW102E is a new technology aiming at reducing TSP emission factor and with a higher efficiency with respect to other models. Data on pellet production process comes from the Ecoinvent database (v. 3) and are representative of an European average plant (about 50.000 tons/year output).

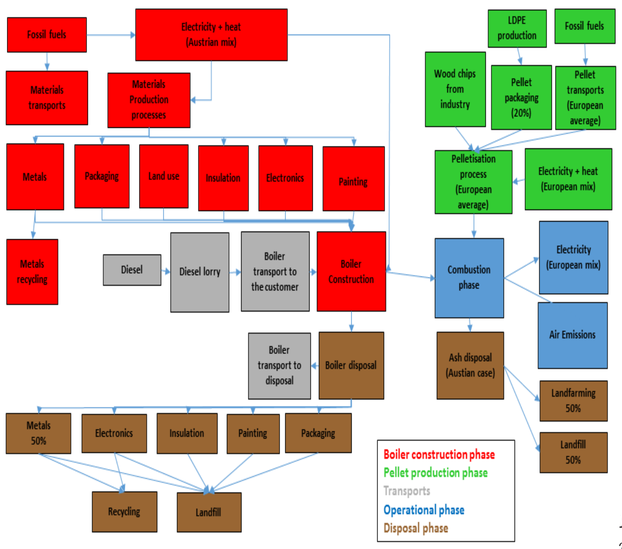

***Fig.1**: System boundaries for LCA analysis.*

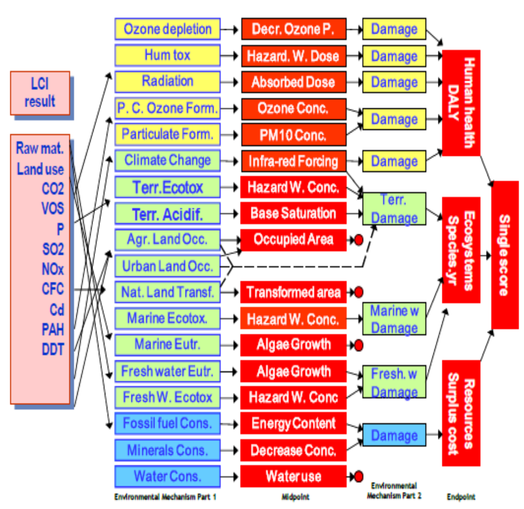

***Fig.2**:Description of the Recipe Endpoint method:it is based on a selection of environmental mechanisms starting from man made interventions in different areas (Part 1) till their final impact on damage categories (endpoint).*

Results

According to the Recipe Endpoint LCIA method, emissions of hazardous substances and extractions of natural resources are converted into impact category indicators at the midpoint level (such as acidification, climate change and ecotoxicity), while others employ impact category indicators at the endpoint level (such as damage to human health, ecosystems quality and resources).Results have to be analysed depending on the damage macrocategory that interests most.

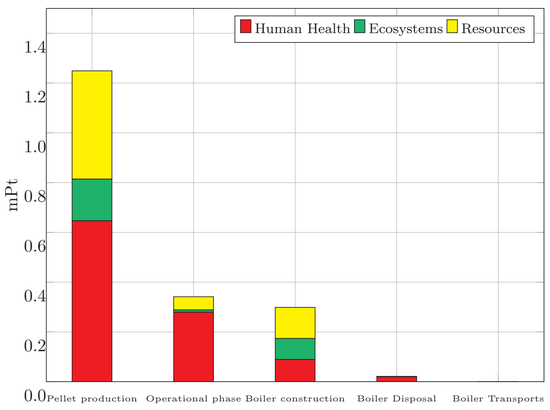

***Fig.3**: BioWin 102 E impact assessment according to the Recipe method: weigthed processes contributions over the three damage categories.*

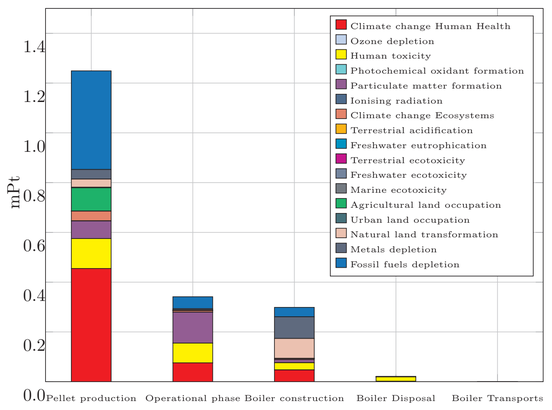

***Fig.4**: BioWin 102 E impact assessment according to the Recipe Endpoint method: weigthed processes contributions over specific damage subcategories.*

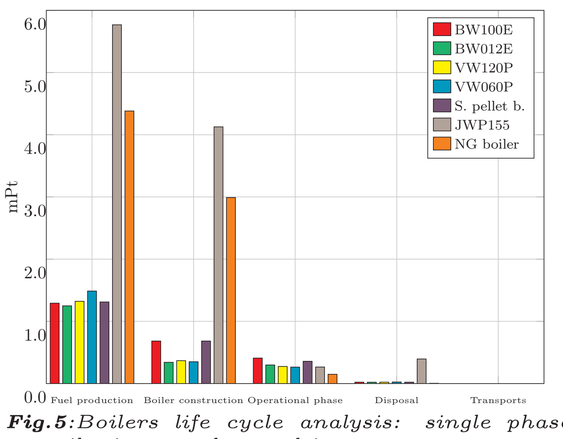

***Fig.5**:Boilers life cycle analysis: single phases contributions to the total impact.*

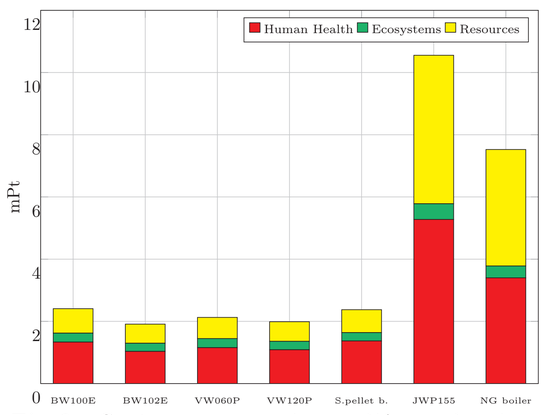

***Fig.6**: Systems comparison: life cycles impacts over the 3 damage macrocategories according to the Recipe Endpoint method.*

References

1. M. Goedkoop et al, Recipe 2008, a life cycle impact assessment method which comprises harmonised category indicators at the midpoint and the endpoint level, first edition (v. 1.08), 2008, Dutch Ministry for the Environment.
2. M. Schwarz et al, Determination of annual efficiency and emission factors of small scale biomass boiler. Proceedings of Central European Biomass Conference, 2011.
3. EMEP, EEA. Air pollutant emission inventory guidebook 2013.

Acknowledgements

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Conclusions

- WH boilers life cycle phases present, on average, the following contributions: pelletisation (64%), operational phase (20%), construction phase (15%), disposal phase (1%);
- With respect to standard pellet boiler WH boilers have presented a lower environmental impact (till 20% in the case of BW102E);
- With respect to fossil fuelled boilers, all pellet boilers have presented much lower impacts (on average 80% and 70% reduction of impact of oil and NG boilers respectively);
- The impact distribution among the 3 damage macrocategories (HH, EQ and R) is though different: all pellet boilers impact most on Human Health (average contributions of about 55%) and present lower impacts on Ecosystems (13%) and Resources Depletion (32%)
- The pellet boiler that shows the lowest environmental impact (less than 2 mPt) is the innovative BW102E model, whose first prototypes have been developed during the project time by WH and has just entered the pellet boilers market.