Residue 2 Heat

Renewable Residential Heating
with Fast Pyrolysis Bio-oil

Project Overview and Status

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Residue2Heat Objective

A long-term objective of *Residue2Heat* is to use agricultural or forest residue streams that are unsuitable for food or feed production and have low ILUC values for residential heating

<u>Challenges</u> on residential heating systems

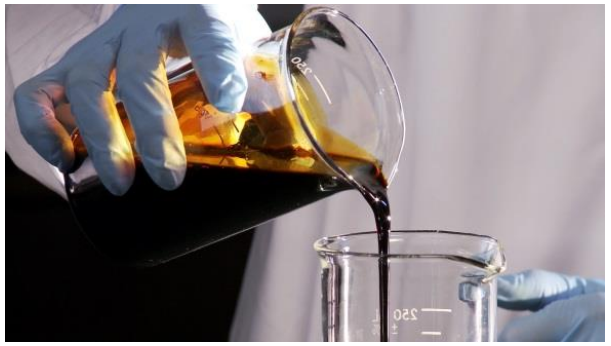
- **High ash contents**

One aim of *Residue2Heat* is to idenfify potential bottlenecks for future implementation of new fuels.

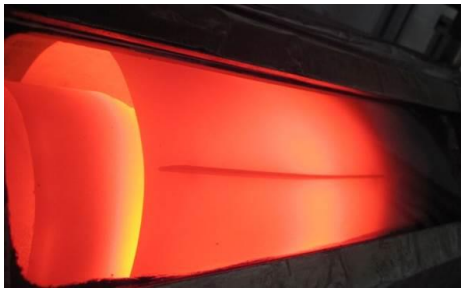
<u>Solution</u> Pyrolysis-oil (FPBO) ?

ILUC = Indirect Land Use Change
FPBO = Fast Pyrolysis Bio-Oil

Overview Residue2Heat

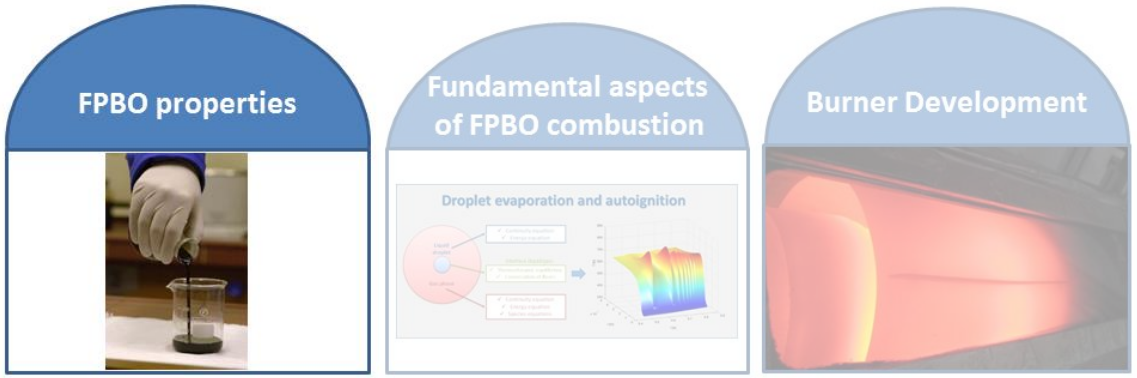


Within *Residue2Heat* a burner is modified to build up a reliable combustion system in which FPBO can be used as single fuel. Up till now the utilization of FPBO in residential-scale systems has never been done.



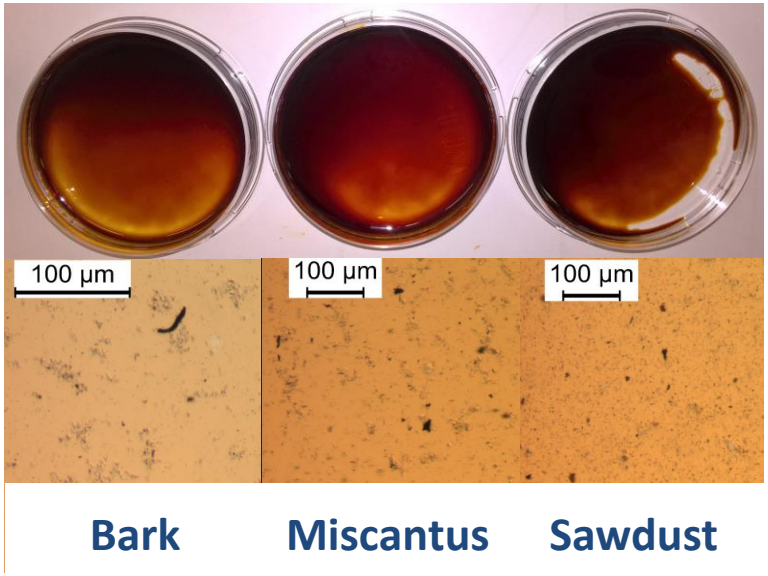
http://www.residue2heat.eu

Main topics – FPBO Properties



FPBO Properties

- Homogeneous FPBO using different feedstock
- Allowed as fuel in residential heating systems?
  - Currently no norm available
  - Standardisation activities, CEN TC19.
- Handling: Production, transport, storage, handling
- Properties differ completely from Heating Oil

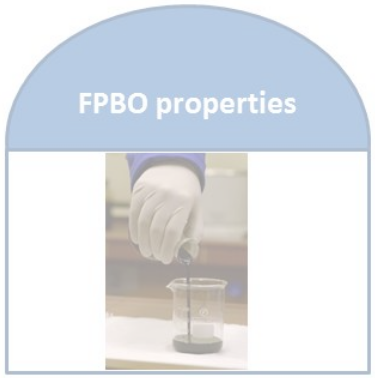


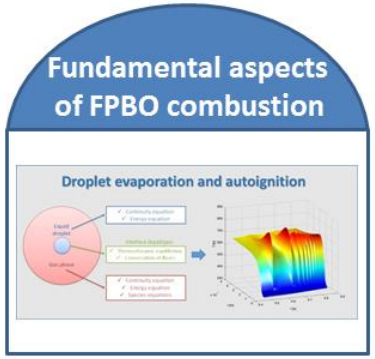
FPBO Properties

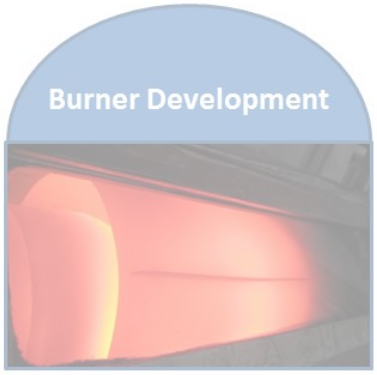
- FPBO production from ash-rich biomass successful.
- FPBO produced from different feedstock
  - Clean wood (reference FPBO);
  - Forest residue;
  - Wheat straw;
  - Bark;
  - Miscanthus;
  - Sawdust

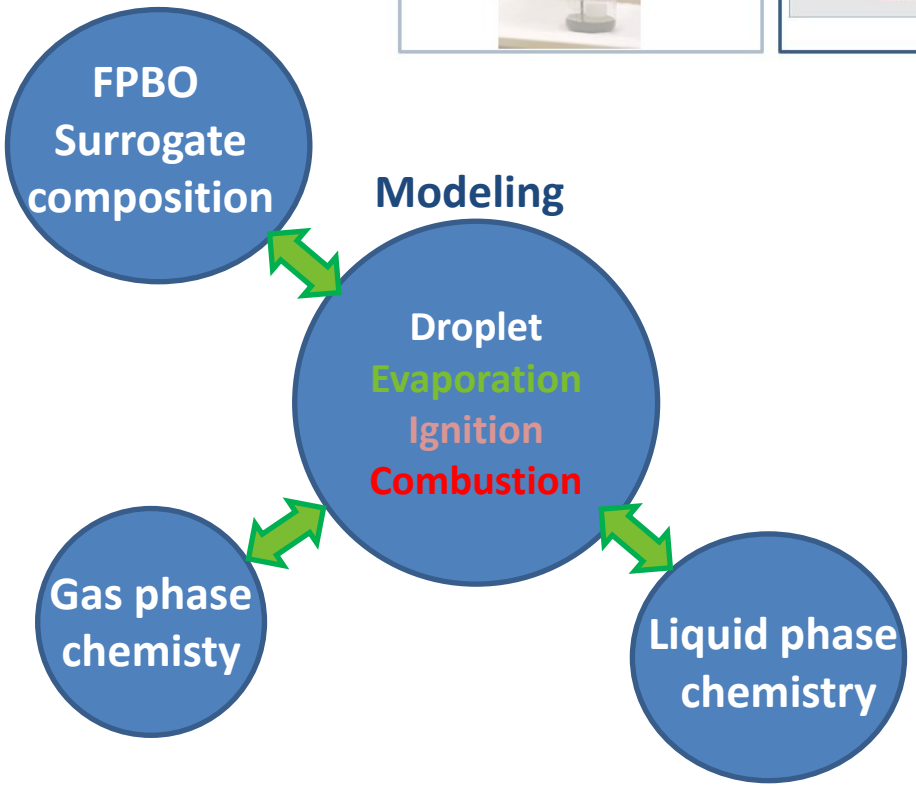
- FPBO quality can be improved by conditioning
- Data produced for standardization efforts.

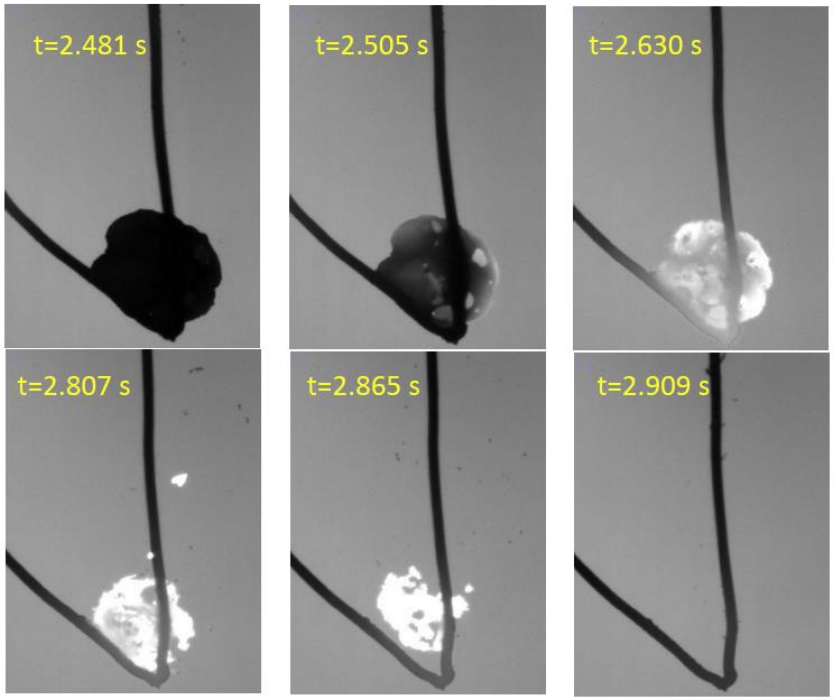
Main topic – FPBO Fundamentals

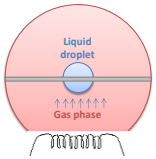




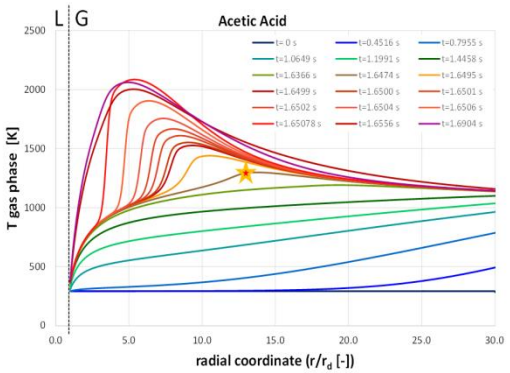








1D transient model



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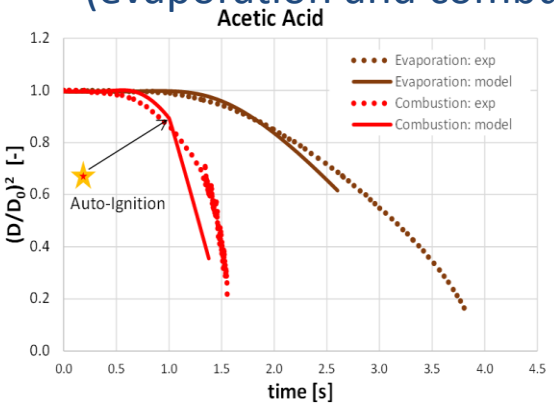
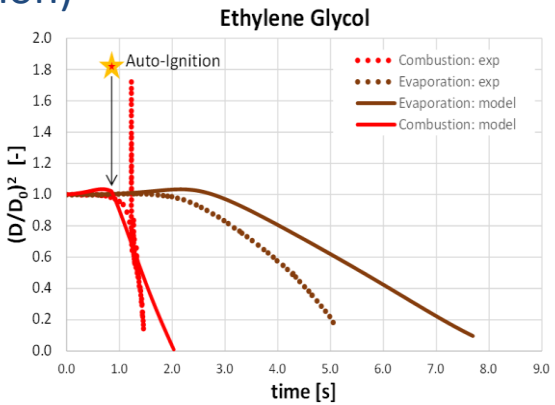
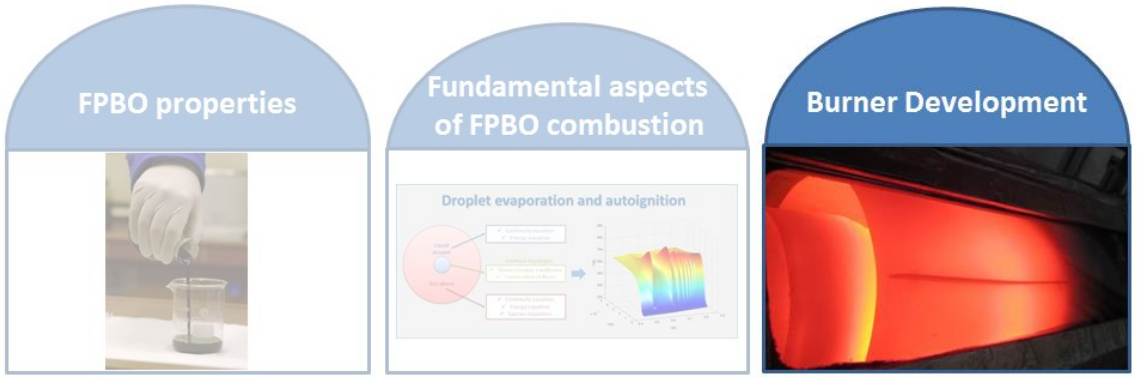
Comparison with experimental data (evaporation and combustion)



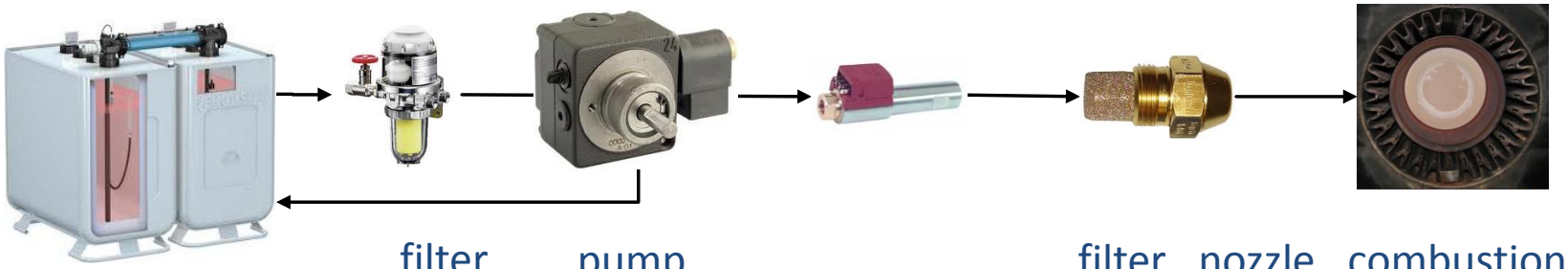


- Updated kinetic mechanism and droplet 1D model. (First results of a 2D model).
- Thermo-physical characterization of the FPBOs and surrogate composition. This surrogate contains 9 components including the heavy lignin component to represent the Heavy Molecular Mass (HMM) fraction of the FPBO. This component plays a relevant role in the formation of carbonaceous solid residue.
- Validation of the approach using experimental results from ***Residue2Heat*** project (WP3, WP4).

Main topic – FPBO Burner



Fuel - Component interaction



Burner Component Tests

FPBO 20% Ethanol 80%	FPBO 80% Ethanol 20%	FPBO 100% Ethanol 0%
		
		

Standard components:

- Without any modifications no stable operation with pure FPBO
- Good results with admixture of ethanol
- Corrosion and deposit formation noticeable

❑ More detailed investigations needed

Burner development

Main focus

- ❑ Stable combustion
- ❑ Emission control

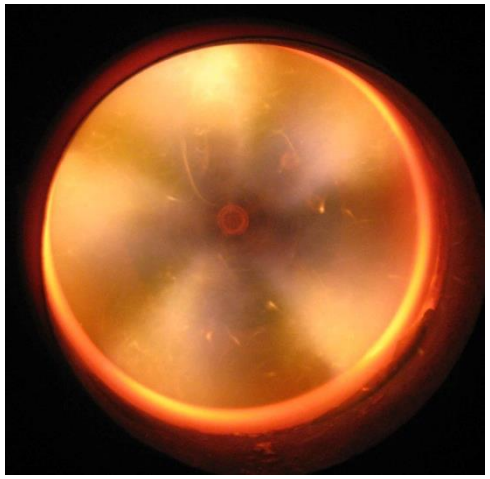
Steps taken recently

- ❑ Redesign burner
- ❑ Different type of injectors

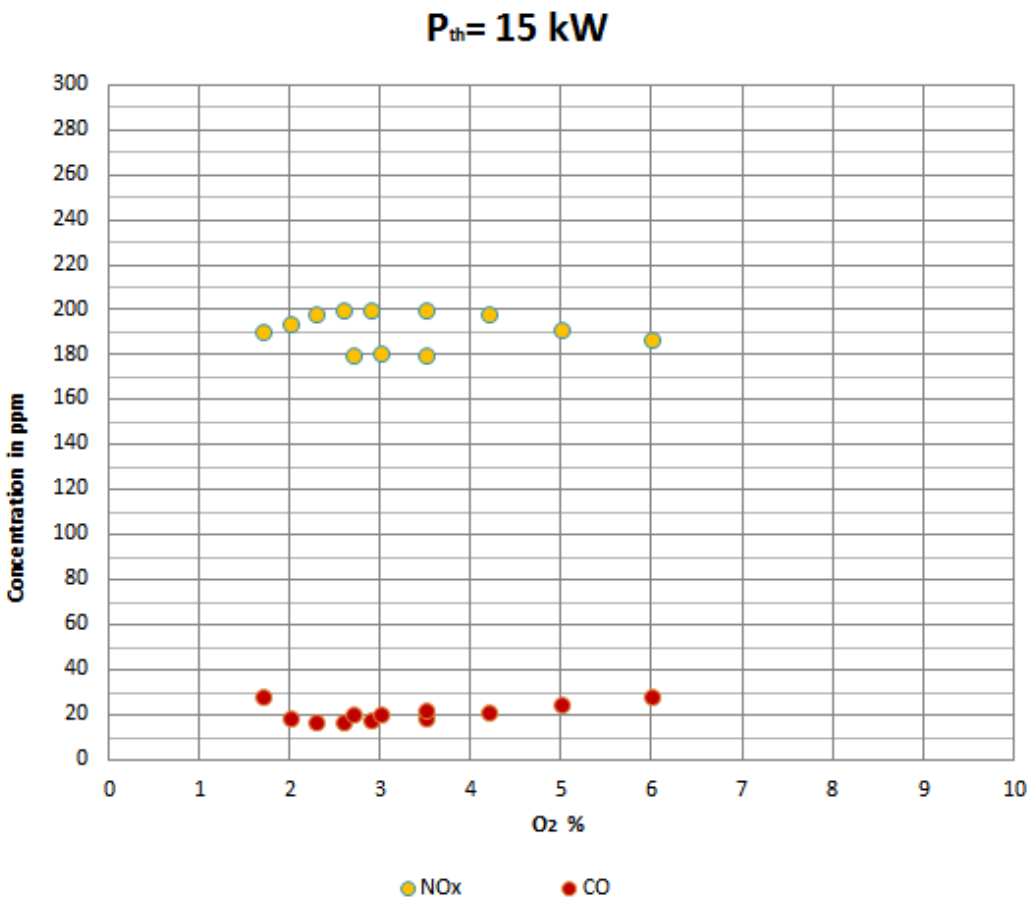
Development of a lab scale demonstrator

FPBO 100%

Concept



- FPBO Preheating
- No air preheating
- No pilot flame
- Stable combustion: 100% FPBO!
- NOx Emissions too high, mainly fuel NO



Limit values for heating oil @ 3% O_2:
CO 46 (ppm)
NOx 56 (ppm)

Sustainability chain evaluation

- Selection of feedstocks & regions
- Analysis according to RED I & RED II proposal COM(2016)767
- Sustainability risk analysis

FPBO feedstock:	Straw	Miscanthus	Forest residues	Bark
GHG emission saving according to RED and RED2	90% Accepted according to RED and RED2	79% Accepted according to RED and RED2	85% Accepted according to RED and RED2	95% Accepted according to RED and RED2
Carbon stocks	Possible impacts related to soil organic carbon balances due to straw harvest.		Possible impacts on soil carbon balances in forest due to residue harvest.	
Indirect land use change		Potential ILUC risk if miscanthus cultivation replaces food production.		
Biodiversity	Extensive extraction of straw may impact on nutrients and soil quality, and thus have a negative impact on biodiversity.		Collection of forest residues from forest impacts the availability of deadwood and can thus have a negative impact on biodiversity.	
Cascading use of biomass	If cascading principle was strictly applied concerning biomass, the biomass feedstocks should be first used as products (e.g. biomaterials) before their use for energy. However, it is not always possible to use (residual) biomass for products, and the direct energy use can be an optimal solution.			

Legal and pre-normative issues

- A draft overview of legal and pre-normative has been made at EU level and partially at the level of the focus countries.
- No binding European emission limits are in place for pyrolysis oil combustion in small units.
  - ❑ Formally pyrolysis oil combustion in heating systems of 20-200 kW does not fall under the Ecodesign Directive and its regulations
  - ❑ Pyrolysis oil might not fall under the definition of biomass as found in European emission regulations.
- In several countries (AT, DE, IT) pyrolysis oil has not the fuel-status, and thus cannot be used as a fuel.
- In other countries (like NL), a special fuel status is not need to allow combustion of pyrolysis oil.

During the project, a pathway to obtain the needed fuel status and further clarity on emission limits will be developed.

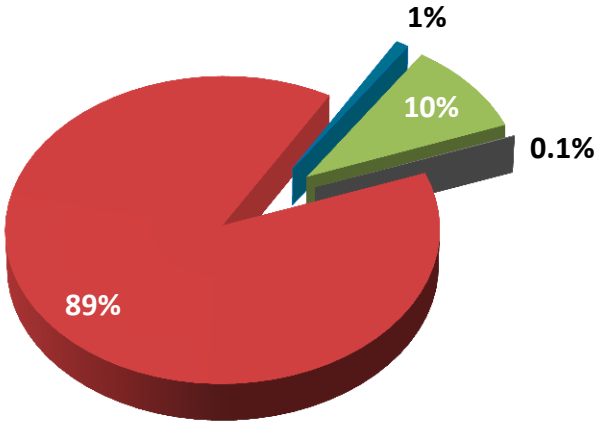
Legal and pre-normative issues

	Germany	Austria	Italy	France	United Kingdom
Classification as fuel relevant to bring FPBO on the market	yes (<100 kW)	yes	yes	no	no
Does FPBO already classify as fuel	no	no	no	n.a.	n.a.
Procedure available to classify FPBO available (without the need to change the law)	yes	yes	no (!)	n.a.	n.a.
Environmental permit needed	< 100 kW: no 100 - 200 kW: yes	no (only if boiler is as part of commercial activity	no	no: if FPBO regarded biomass yes: if FPBO not regarded biomass	no, but notification is needed
Requirements to installation and operation	< 100 kW: type test from manufacturer available	Yes: found in Art 15 a B VG	Those relevant according to EU law	Yes: details in order of 24/06/13 on class 2910-B	In Building regulations 2000

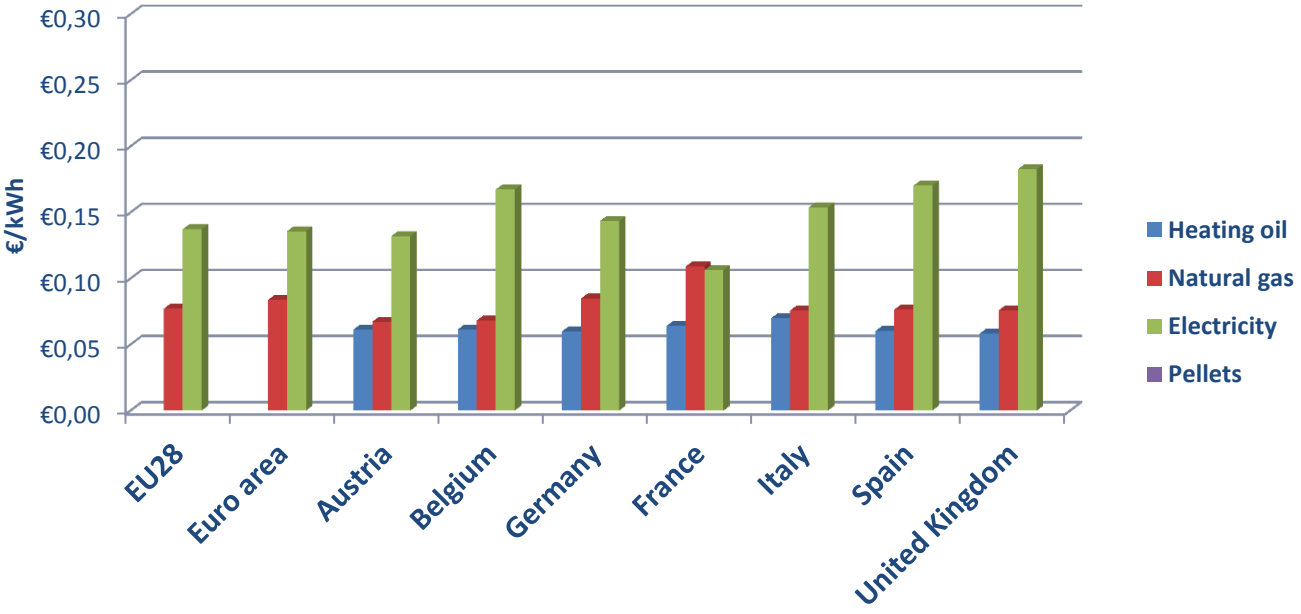
Market and Business Assessment

The market share of units installed in Europe with their typical energy labelling classification.

89% are outdated!

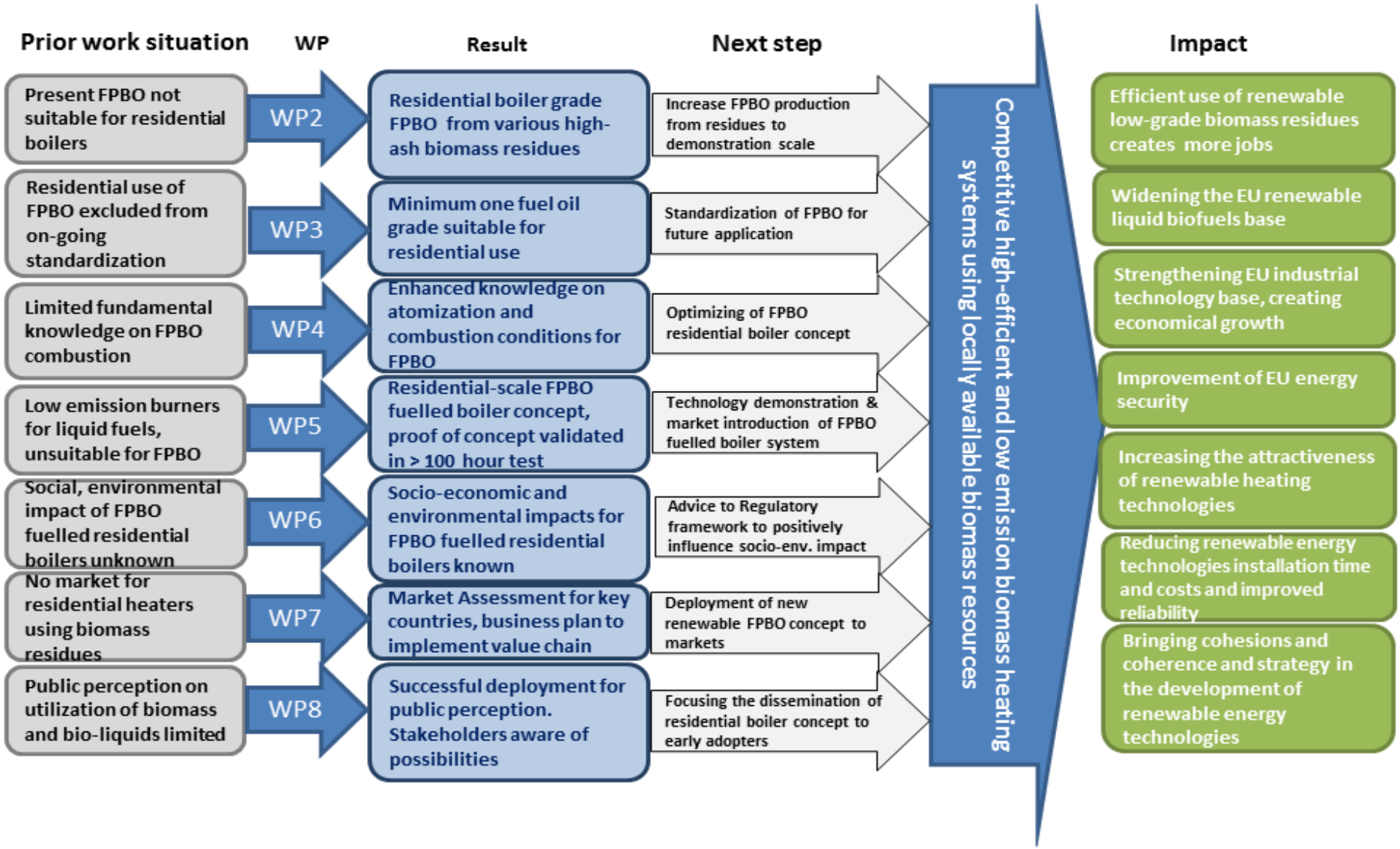


	Label
Heat pumps	A++
Gas and Oil condensing boilers	A
micro-CHP	A++
Gas and Oil low-temperature boilers	C



A competing price for FPBO would be between pellet prices and domestic heating oil prices, roughly between €0.05 and €0.07 per kWh (without taxes).

Expected Impact



Contact / Acknowledgement

Thank you for Attention!

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