LCA of Burning Different Solid Biomass Substrates

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Introduction

- LCI's for direct combustion of biomass substrates
- Environmental impacts of direct combustion
- Quantify emissions and impacts
- Comparison biomass substrates to wooden and fossil fuels
- Influence of the substrates and combustion technology

Preliminary Study

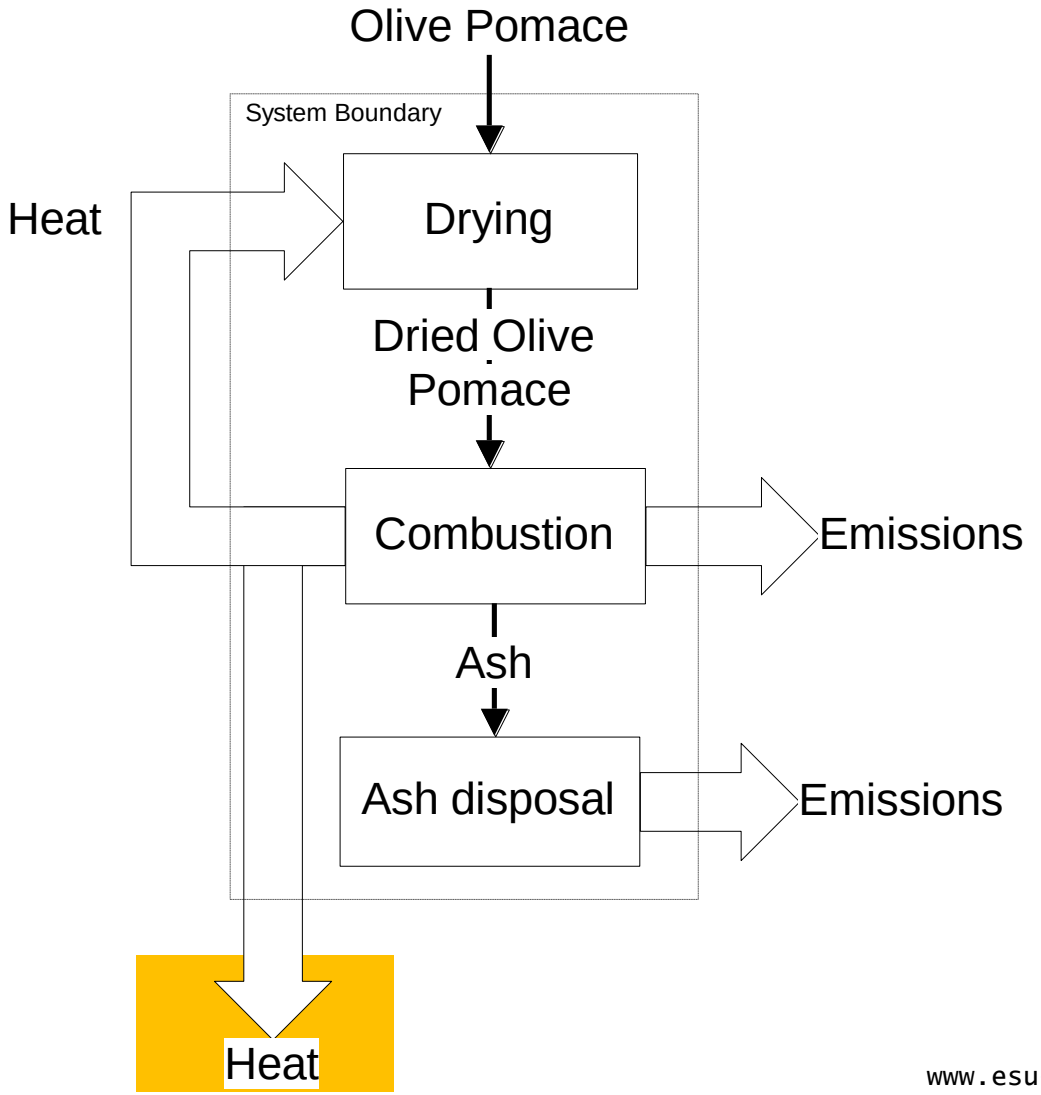
- Potential Substrates:
  - About 40 substrates
  - Kernels, Shells, Pomaces and other wastes
  - Mainly by-products and wastes
- Selected: Olive pomace, coffee grounds, poultry litter, horse dung and pig slurry
- Based on data availability

Life cycle inventory analysis

- New LCI for combustion of different solid biomass substrates
- Processes included:
  - substrate preparation
  - biomass combustion
  - ash disposal
- Cut-Off approach for substrates

System overview olive pomace

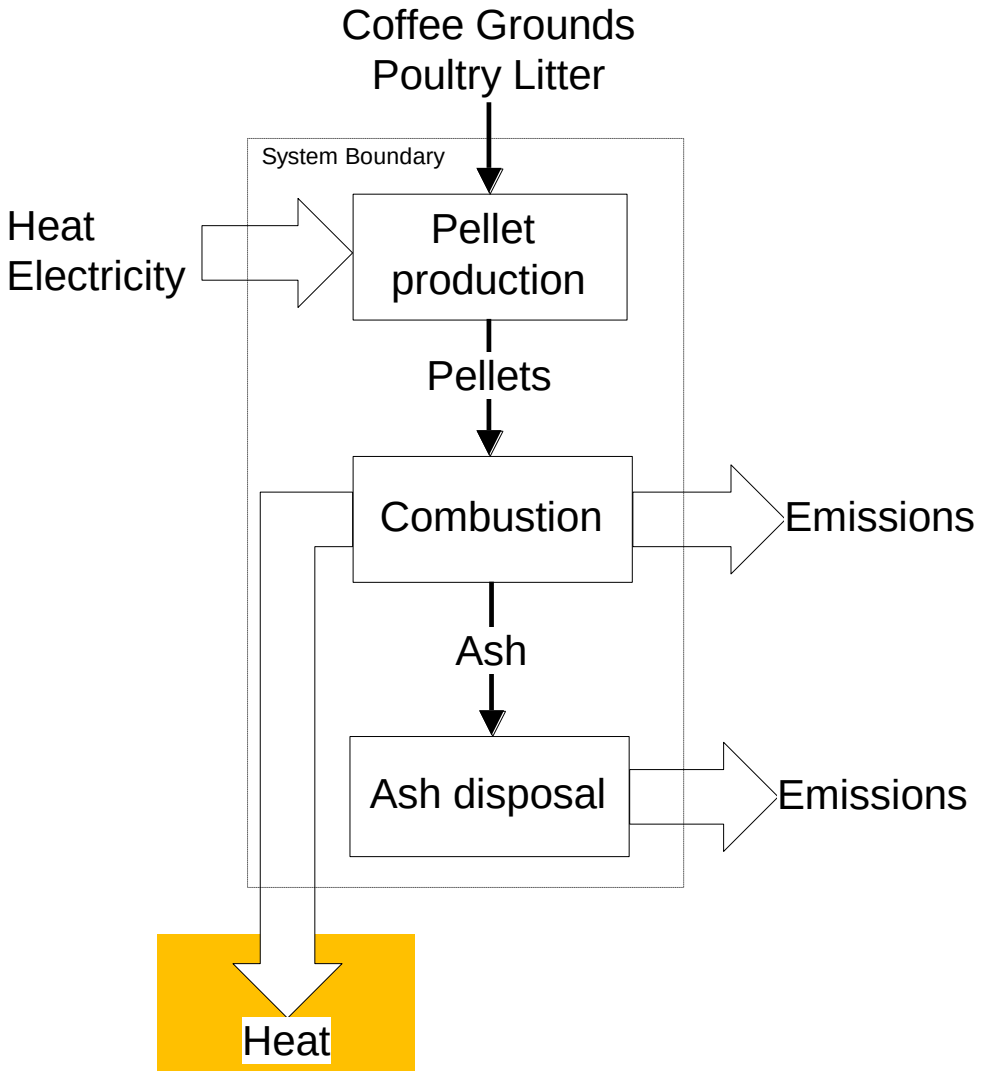
Olive pomace



System overview pellets

Coffee grounds

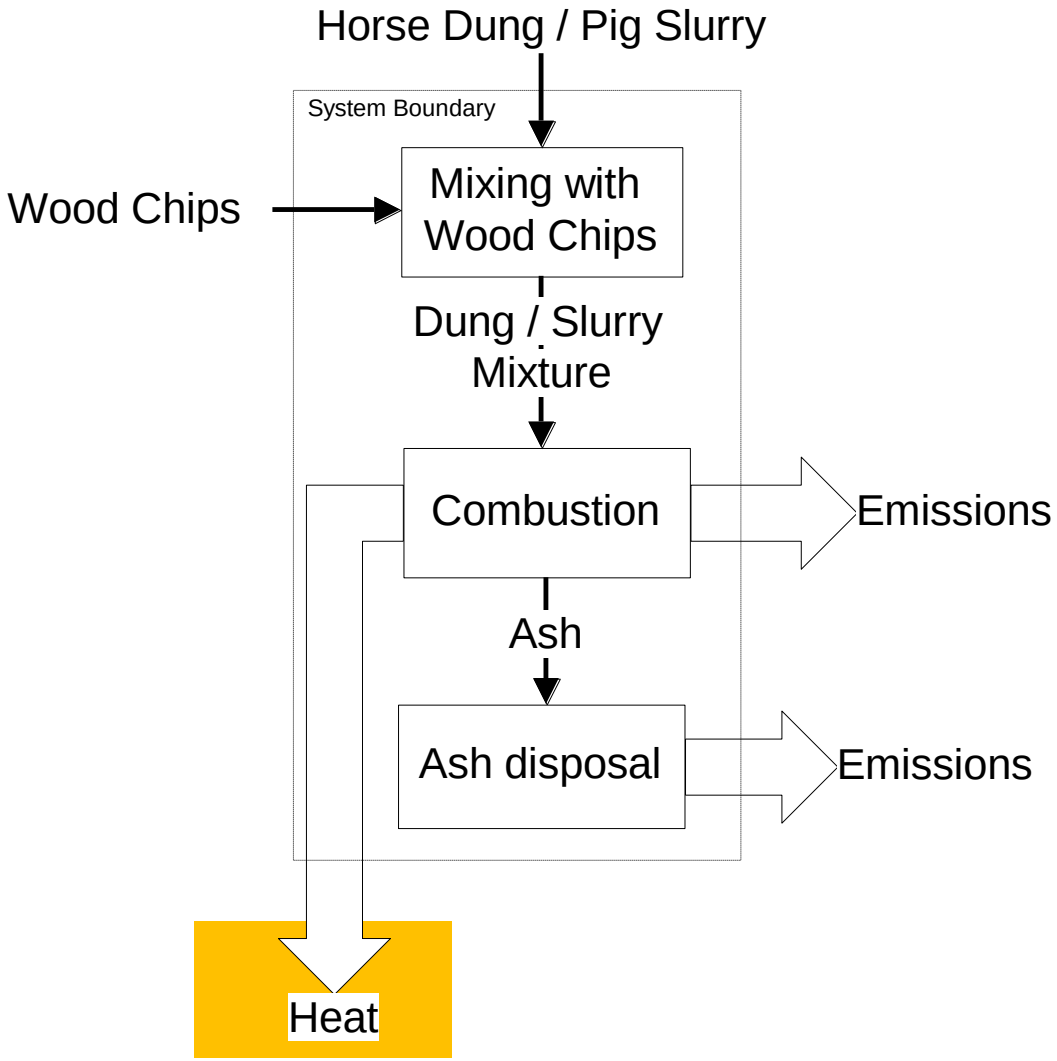
Poultry litter



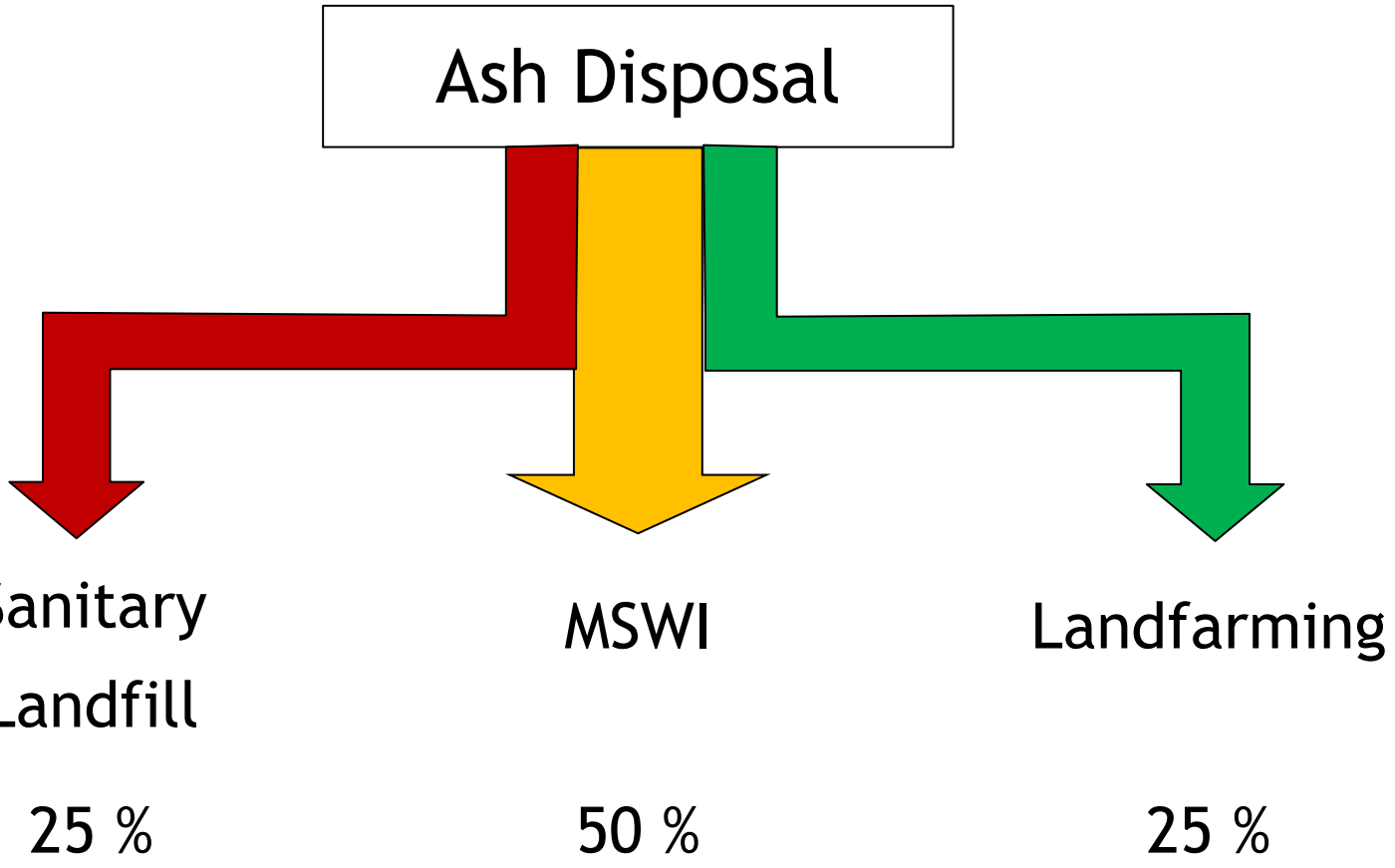
System overview dung and slurry

Horse dung

Pig slurry



Disposal routes for the ash



- Ash disposal for biomass substrates modeled like for wood according to ecoinvent

Flue gas treatment

Cyclone

Electrostatic filter

Combustion technology

General description	Device	Cyclone	Electro-static filter	Comment
Olive pomace	tubular reactor	no	no	experiment in lab
Coffee ground pellets	automatic furnace	no	no	wood combustion
Poultry litter pellets	grate furnace	yes	no	pilot plant
Horse dung and wood chips	grate furnace	yes	yes	wood combustion, filters did not work
Slurry solids and bark chips	boiler furnace	no	no	wood combustion

- combustion technology and flue gas treatment with improvement potentials

Elemental composition

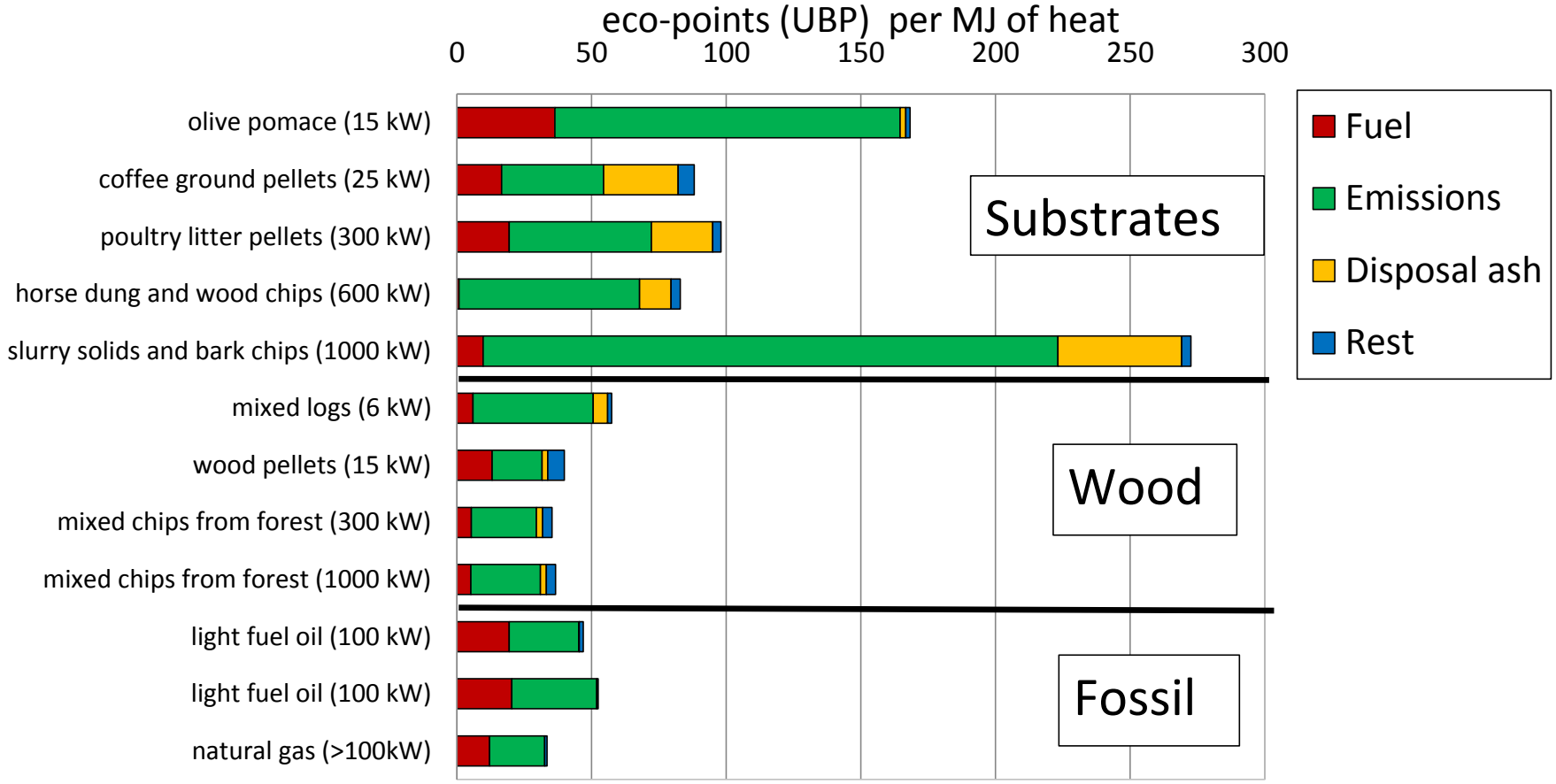
Elemental composition	Olive pomace	Coffee ground pellets	Poultry litter pellets	Horse dung & wood chips	Pig slurry solids & bark chips	Wood, Logs
Unit	kg/kg fuel, dry	kg/kg fuel, dry	kg/kg fuel, dry	kg/kg fuel, dry	kg/kg fuel, dry	kg/kg fuel, dry
Carbon C	47.00%	51.20%	40.00%	48.00%	46.50%	49.80%
Hydrogen H	5.70%	5.50%	6.50%	5.50%	5.50%	6.00%
Oxygen O	38.40%	40.40%	35.50%	37.30%	35.00%	44.00%
Nitrogen N	1.10%	0.00%	3.83%	0.18%	2.20%	0.08%
Sulphur S	0.10%	0.00%	0.00%	0.03%	0.43%	0.01%
Ash content	7.70%	2.90%	14.20%	9.00%	10.40%	0.10%
Total dry mass	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
Moisture content	14.00%	14.60%	15.00%	45.00%	61.00%	14.00%

- Biomass substrates have a higher nitrogen, sulphur and ash content
- Manure mixtures are extremely wet fuels

Life cycle impact assessment

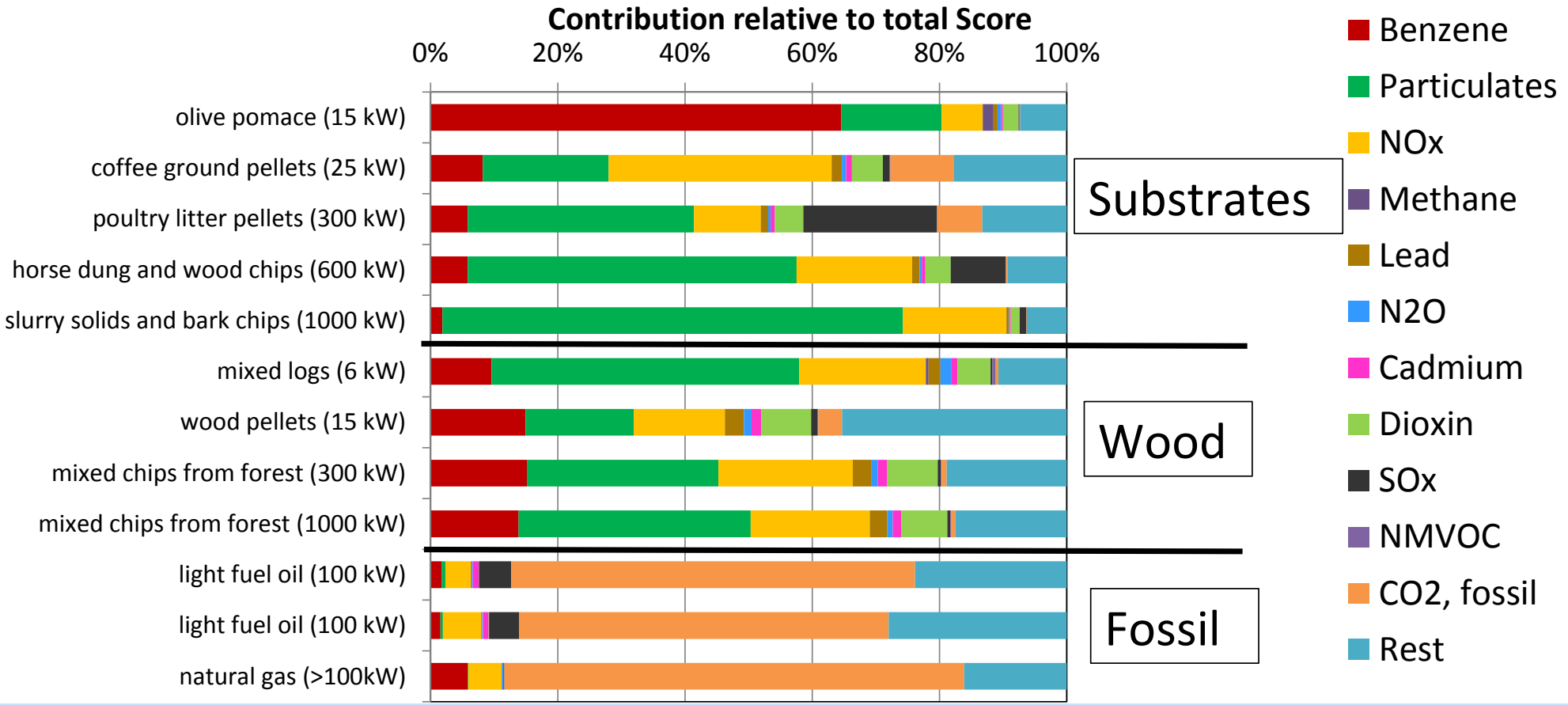
- Functional unit: Provision of 1 MJ of useful heat
- Indicators: Ecological Scarcity 2006 and IPCC GWP
- Main contributors ecological scarcity and GWP
- Heavy metal emissions into soil

Ecological Scarcity 2006



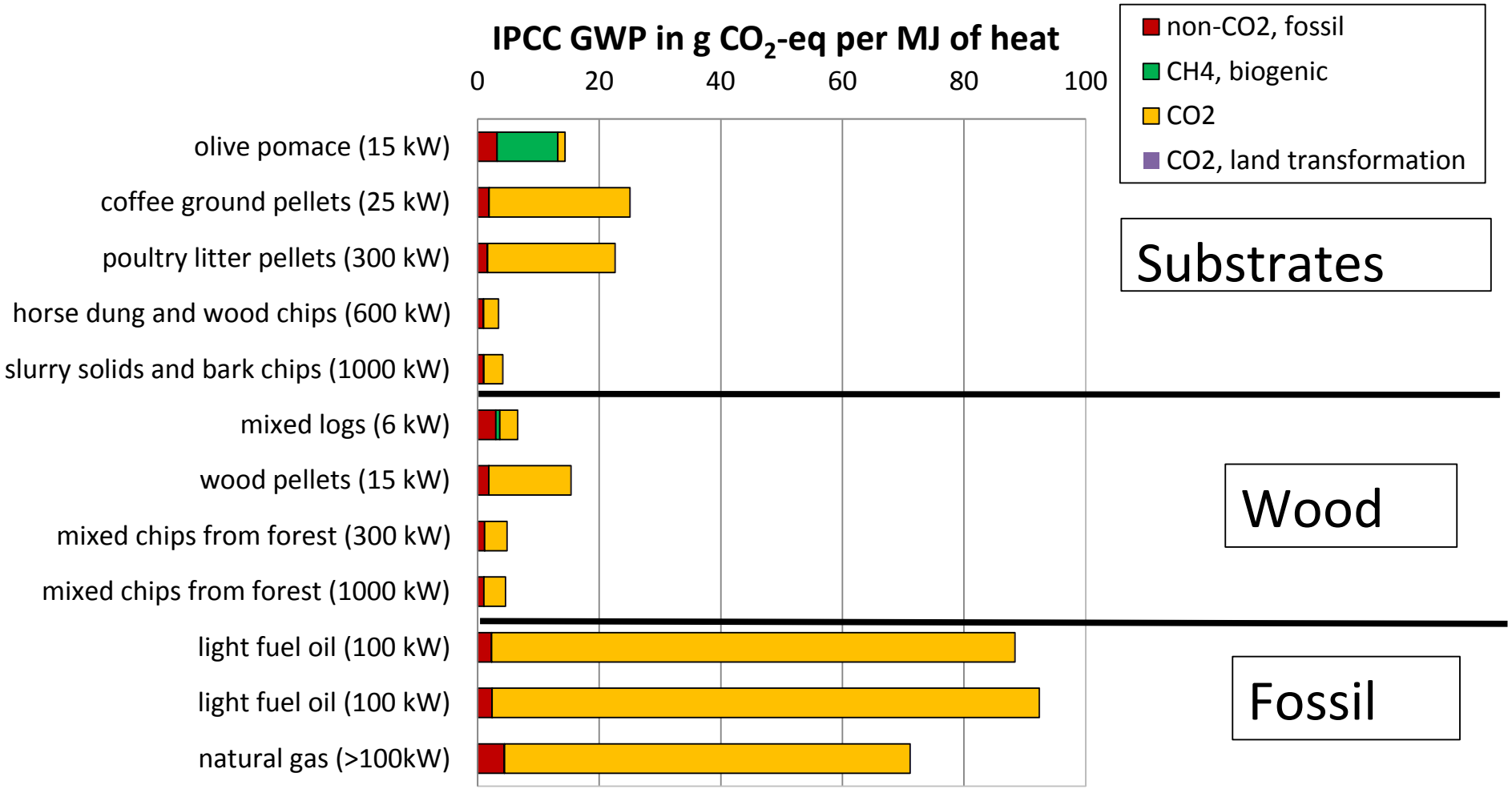
- High emission during combustion lead to higher total impacts than for conventional fuels

Ecological Scarcity 2006 Air Emissions



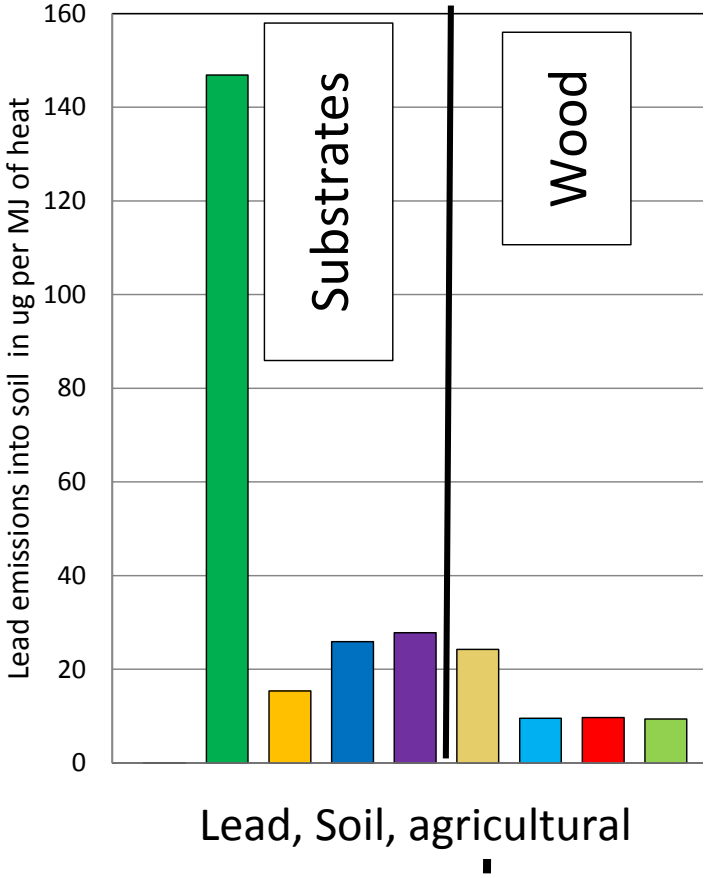
- Particle, NO_X and Benzene emissions cause more than 50% of the environmental impacts in case of the biomass substrates

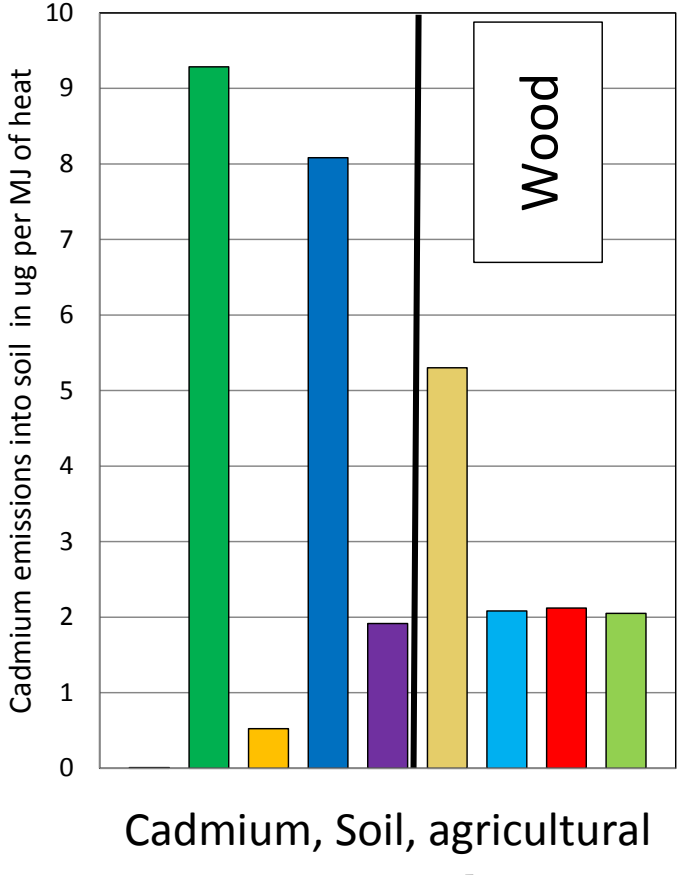
IPCC Global Warming Potential



- Fossil fuels cause higher GWP than wood and biomass

Results: Soil emissions





- olive pomace (15 kW)
- coffee ground pellets (25 kW)
- poultry litter pellets (300 kW)
- horse dung and wood chips (600 kW)
- slurry solids and bark chips (1000 kW)
- mixed logs (6 kW)
- wood pellets (15 kW)
- mixed chips from forest (300 kW)
- mixed chips from forest (1000 kW)

- Biomass substrates tend cause higher heavy metal emissions than wood but the emissions are still comparable

Conclusions 1

- Biomass substrates cause higher impacts compared to wooden and fossil fuels according to ecological scarcity 2006
- Biomass substrates cause lower greenhouse gas emission compared to fossil fuels according to IPCC GWP
- Trade-off between GWP and overall environmental impacts

Conclusions 2

- Particulate matter emissions cause the highest share of the impacts according to ecological scarcity
- High uncertainty because lacking data regarding particle distribution for biomass substrates
- Some of the biomass substrates cause higher heavy metal emissions than wooden fuels but for most of the substrates the heavy metal emissions are equal or lower compared to wooden fuels

Conclusions 3

- No recommendation can be made regarding the furnace type
- Data mainly for pilot plants without flue gas treatment
- High potential to reduce particle emissions with basic flue gas treatment

Conclusions

Flue gas treatment is essential to minimize particle emissions during biomass combustion.

The use of biomass substrates can reduce greenhouse gas emissions, at the cost of increased particulate matter emissions.

Thanks for your attention!

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Download the study and electronic data: http://www.lc-inventories.ch/

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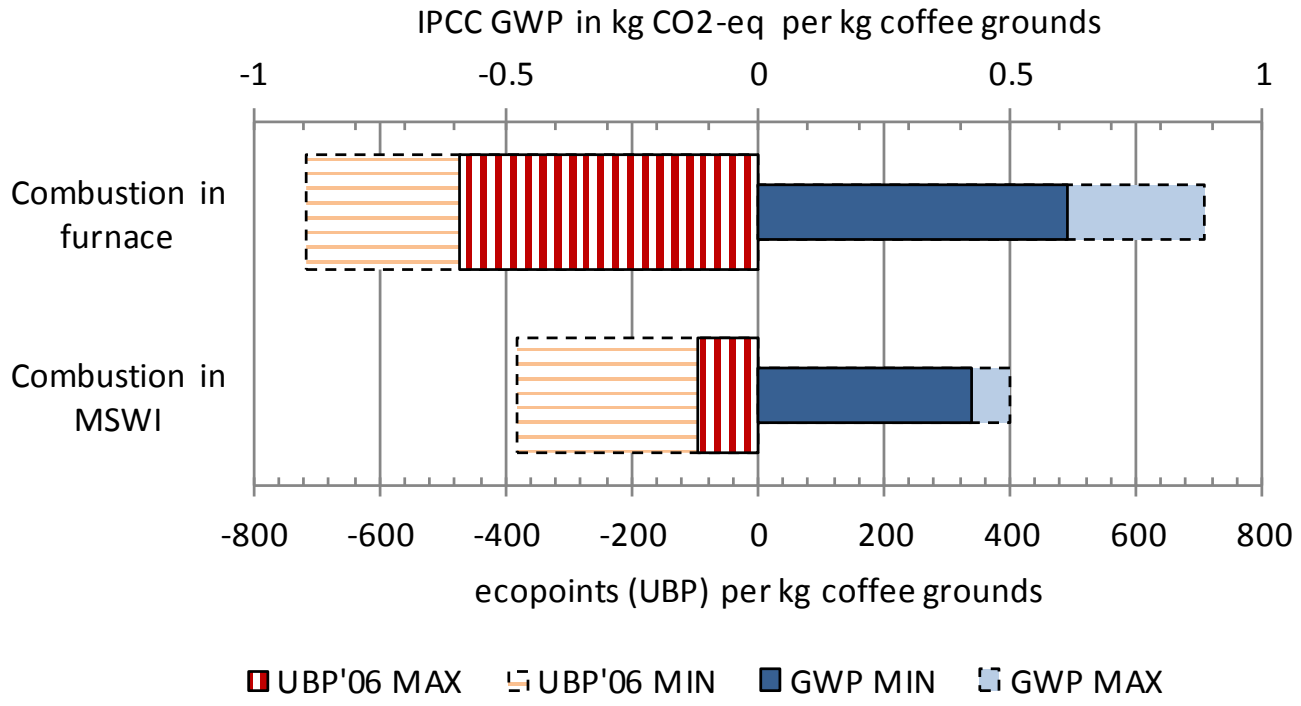
Additional Slides

Results: Coffee grounds

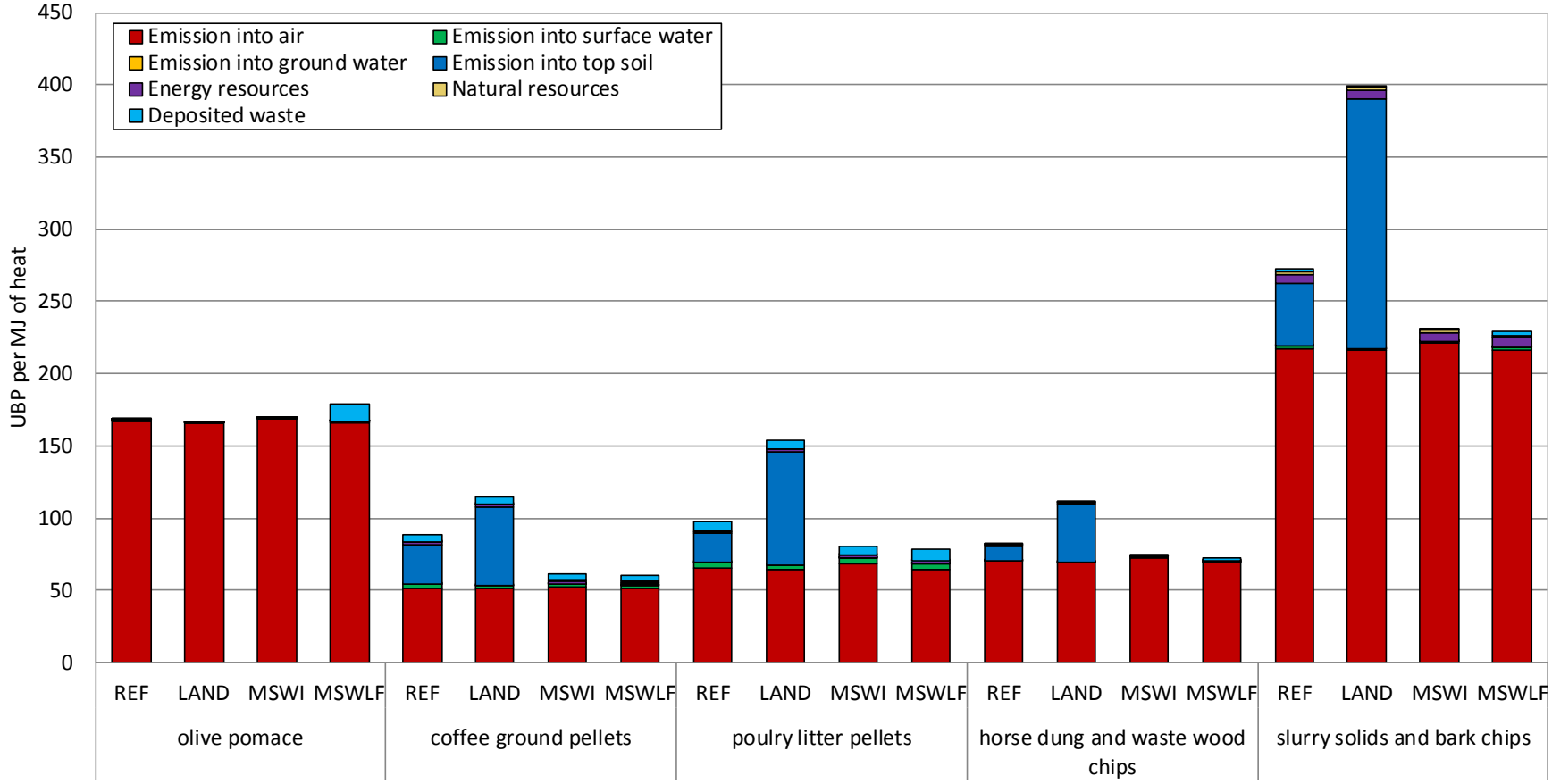
Direct combustion vs MSWI



- Combustion of coffee grounds in MSWI causes lower impacts

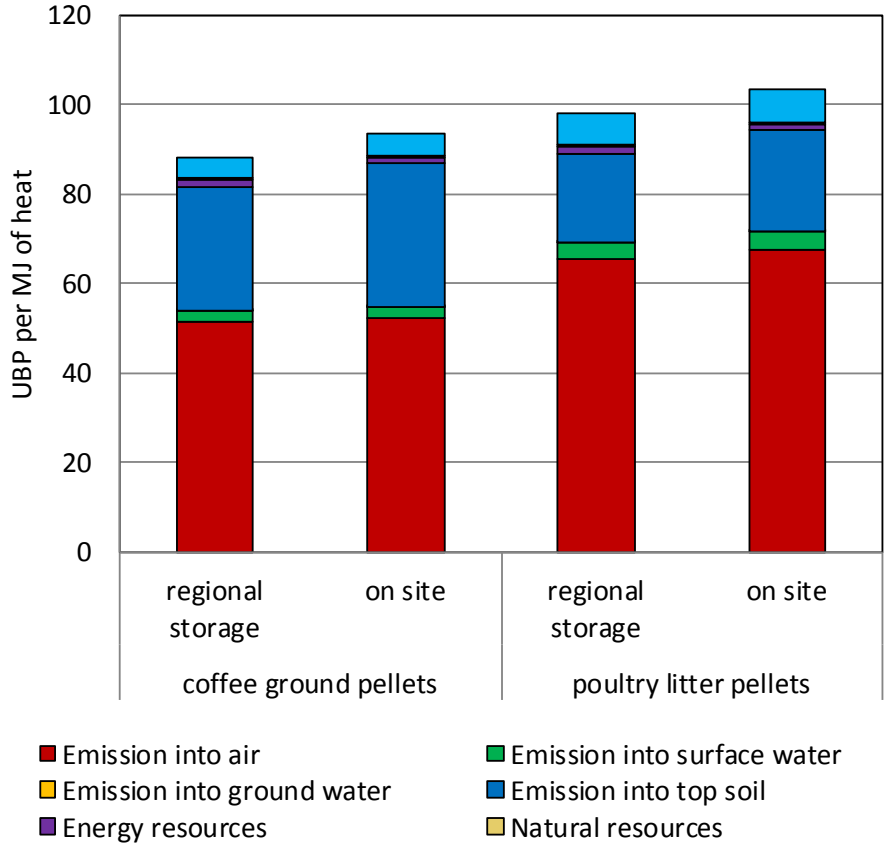
Results: Scenarios for Ash Disposal

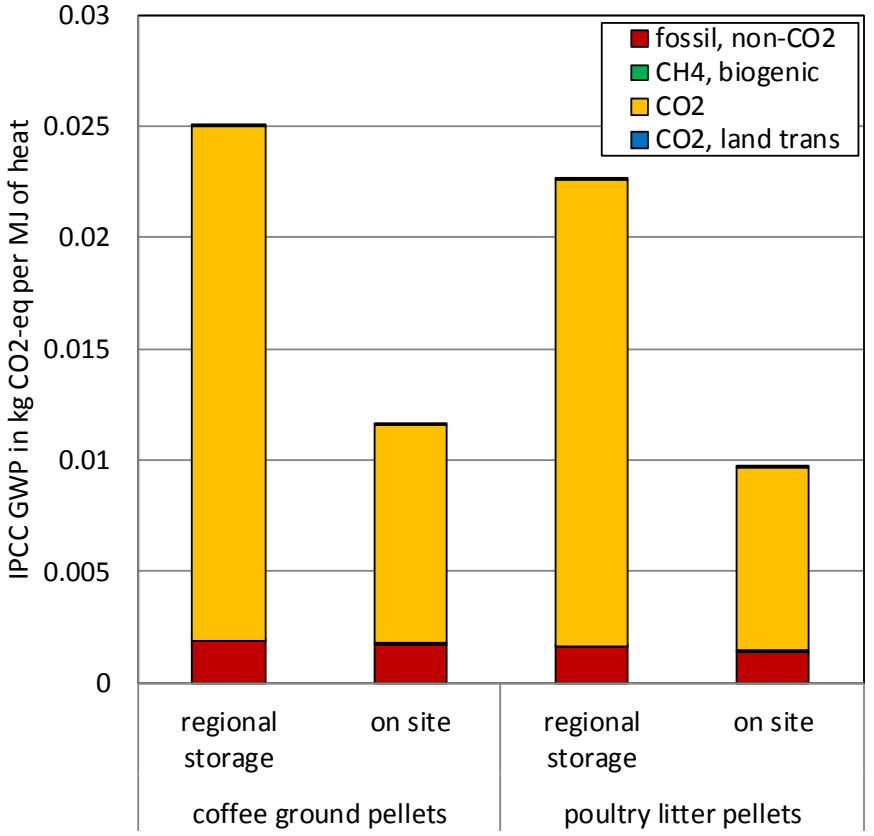
Ecological Scarcity 2006



Results: Scenarios fuel preparation

Ecological Scarcity 2006 and IPCC GWP





Substrates considered in this study (1)

Olive pomace

Coffee grounds

Poultry Litter pellets

Substrates considered in this study (2)

Horse dung and wood chips

Slurry solids and wood chips