Congrès [avniR]
Le Management en Cycle de Vie, la solution pour l'écotransition

# Environmental assessment of woody biomass ash valorization in cement mortars

## Évaluation environnementale de la valorisation des cendres de la biomasse ligneuse dans les mortiers


Tamíris da Costa, Paula Quinteiro, Luís Tarelho, Luís Arroja, Ana Cláudia Dias

University of Aveiro - Centre for Environmental and Marine Studies (CESAM),
Department of Environment and Planning

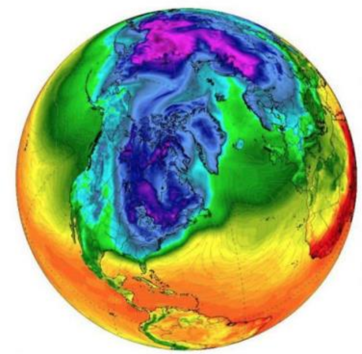

universidade de aveiro

LiSAT
Life Cycle Based Sustainability Assessment Tools Team

# Introduction

Policies promoting bioenergy production from forest residues

•Forest fire prevention



•Climate change mitigation

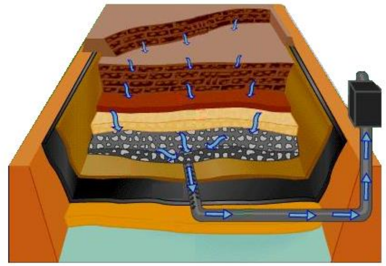
200 THOUSAND TONS OF ASH ARE PRODUCED ANNUALY IN PORTUGAL FROM POWER PLANTS FUELLED BY FOREST BIOMASS

**This amount of ashes is projected to increase**

cesam
universidade de aveiro
centro de estudos do ambiente e do mar

# Introduction

In Portugal, **less than 10 %** of the ashes are recycled



End-of-life alternatives for woody biomass ashes

glass

ceramics

construction materials

agriculture

adsorbents

**Cement mortar**

**Concrete**

**Asphalt**

# Objective

HOWEVER, environmental aspects should be assessed

Environmental sustainability

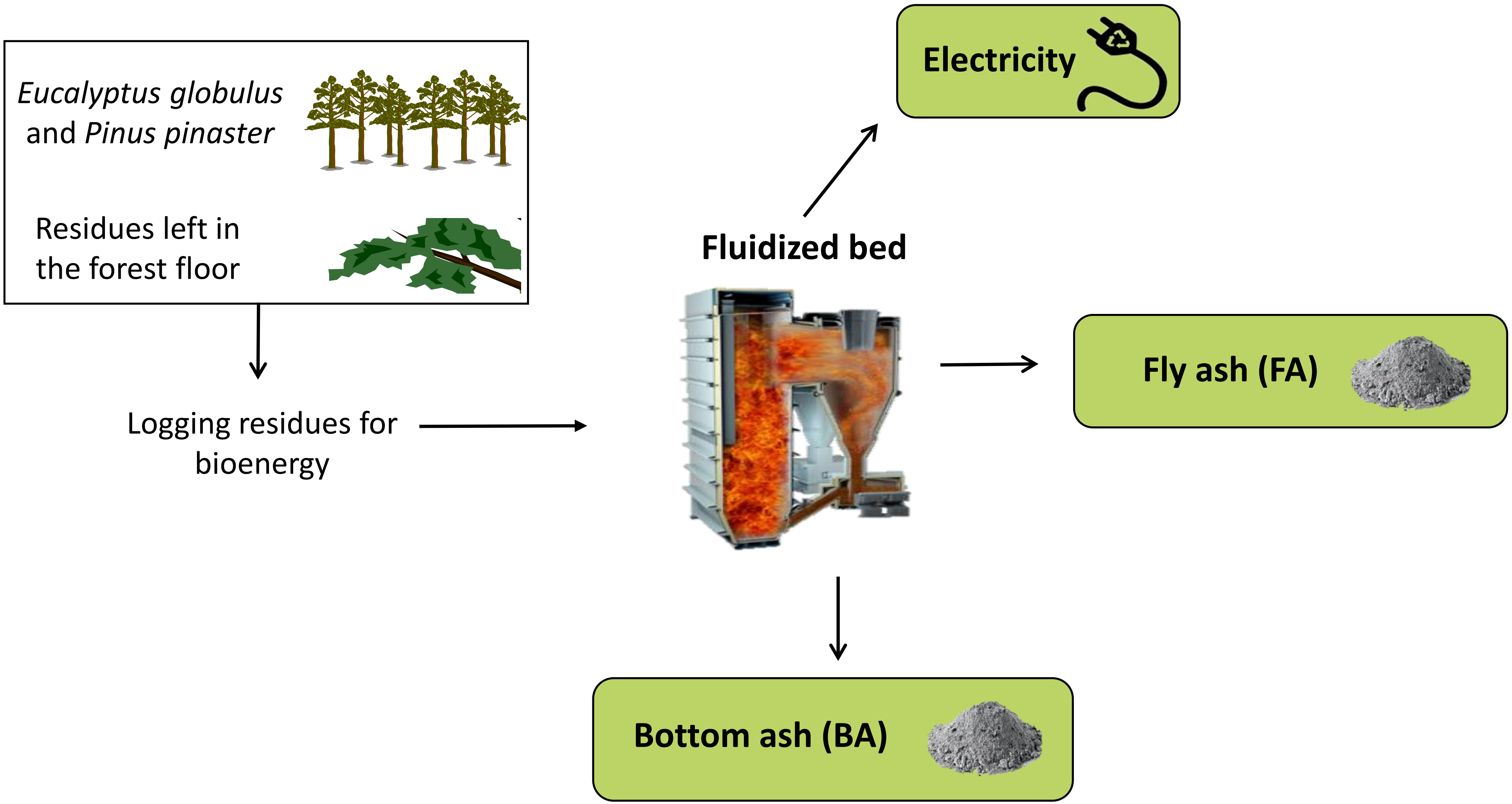

Entire life cycle

Several impacts

The objective of this work is to evaluate the environmental benefits and impacts of ash incorporation in cement mortar.

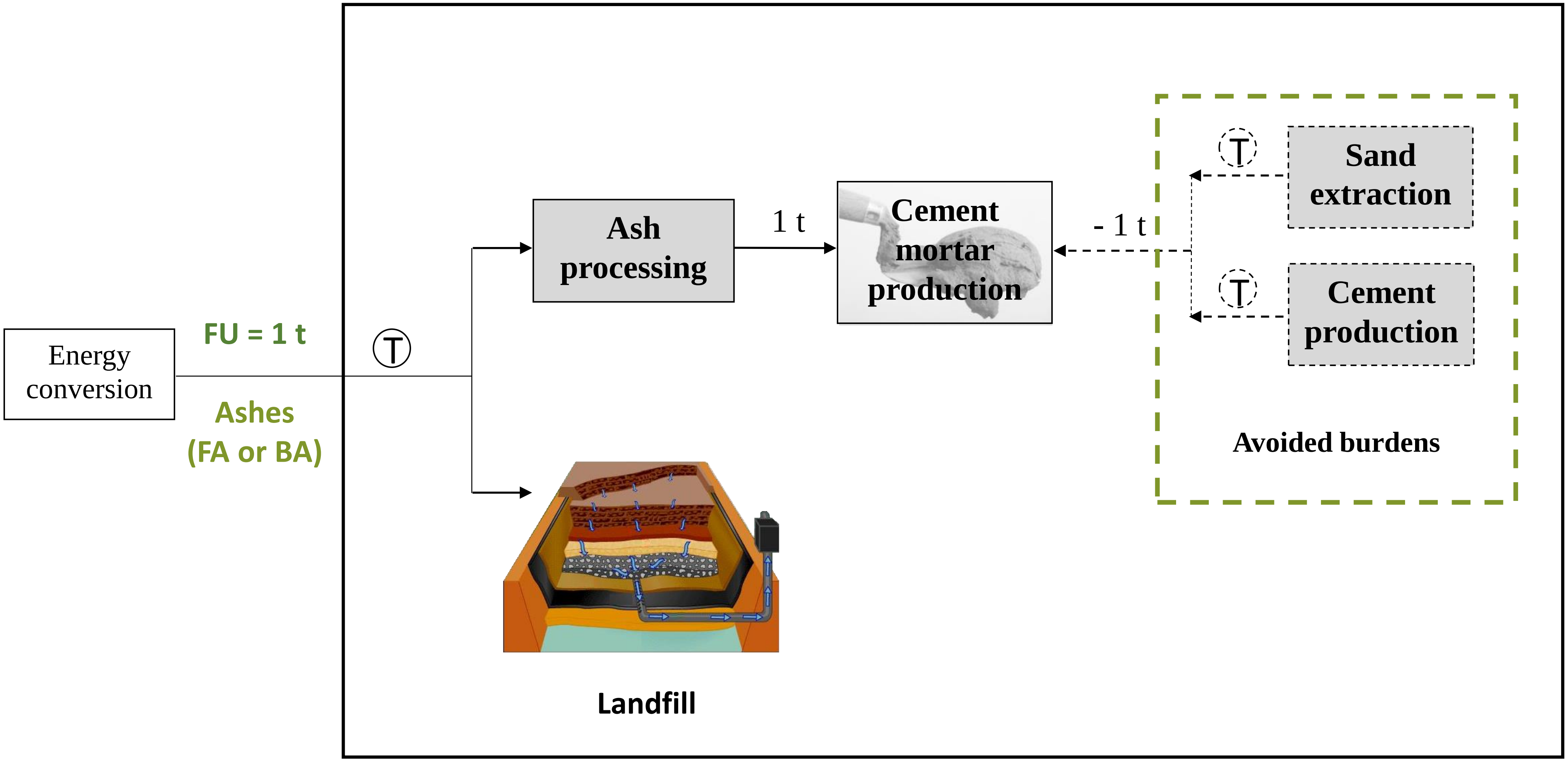
# Methodology

LiSAT




cesam
universidade de aveiro
centro de estudos do ambiente e do mar

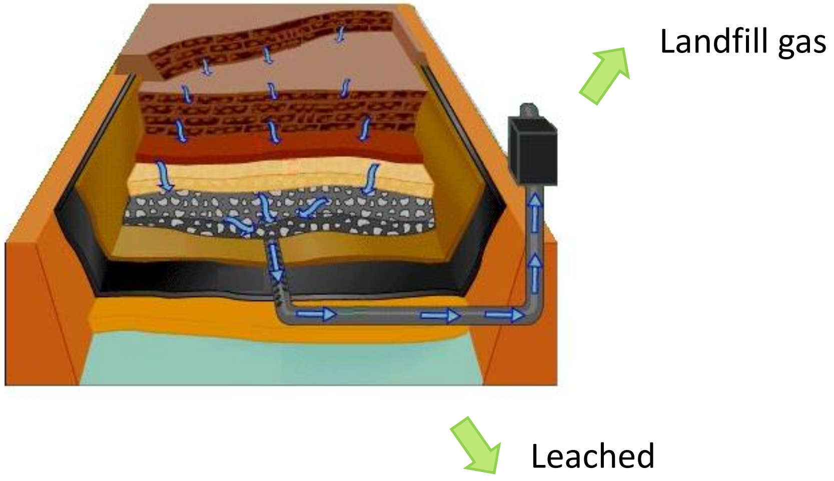
# System boundary



# Base scenario (Landfilling)

- The landfilling scenarios for woody biomass ash under study are, as follows:

- **FA landfilling.**
- **BA landfilling.**




- The landfill gas is partially captured and used to produce electricity.
- A short-term leachate treatment for leached ash was included.
- The life cycle inventory was built upon the existing models available for waste disposal in Ecoinvent (Doka, 2003; Ecoinvent, 2017), according to the ash composition.

# Valorisation scenarios


Scenario 1: cement mortar with FA (substituting cement in 10 %).

Scenario 2: cement mortar with FA (adding 20 % to the mortar).

Scenario 3: cement mortar with BA (substituting the sand in 50 %).

Scenario 4: cement mortar with BA (substituting the sand in 100 %) with ash pre-treatment (washing and drying).

- The production of sand and cement and all upstream activities were taken from Ecoinvent database.
- Both ashes are grinded and sieved to achieve the desired size.
- In scenario 4, the ash was previously washed with deionised water (liquid/solid ratio of 2 L/kg) with a running capacity equal to 10 ton/h (Modolo et al., 2013). The average weight loss of fly ash on washing is equal to 12 % (Berra et al., 2015). The ash is dried to remove excess moisture with an average energy consumption of 0.2 MJ/kg (Kasser and Pöll, 1998).

# Transportation

Table 1 presents the transport profiles in the different systems and the distances considered for woody biomass ash and the avoided materials.

| Material transport | Distance (km)[a] | Type of transport | Load (t) | Return journey |
|---|---|---|---|---|
| Power plant to landfill | | | | |
| FA and BA | 15 | Freight lorry, EURO 3 | 7.5-16 | Empty |
| Power plant to mortar facility | | | | |
| FA and BA | 35 | Freight lorry, EURO 3 | 7.5-16 | Empty |
| Avoided materials to concrete and mortar facility | | | | |
| Cement | 0 | Freight lorry, EURO 3 | 16–32 | Empty |
| Sand | 30 | Freight lorry, EURO 3 | 16–32 | Empty |

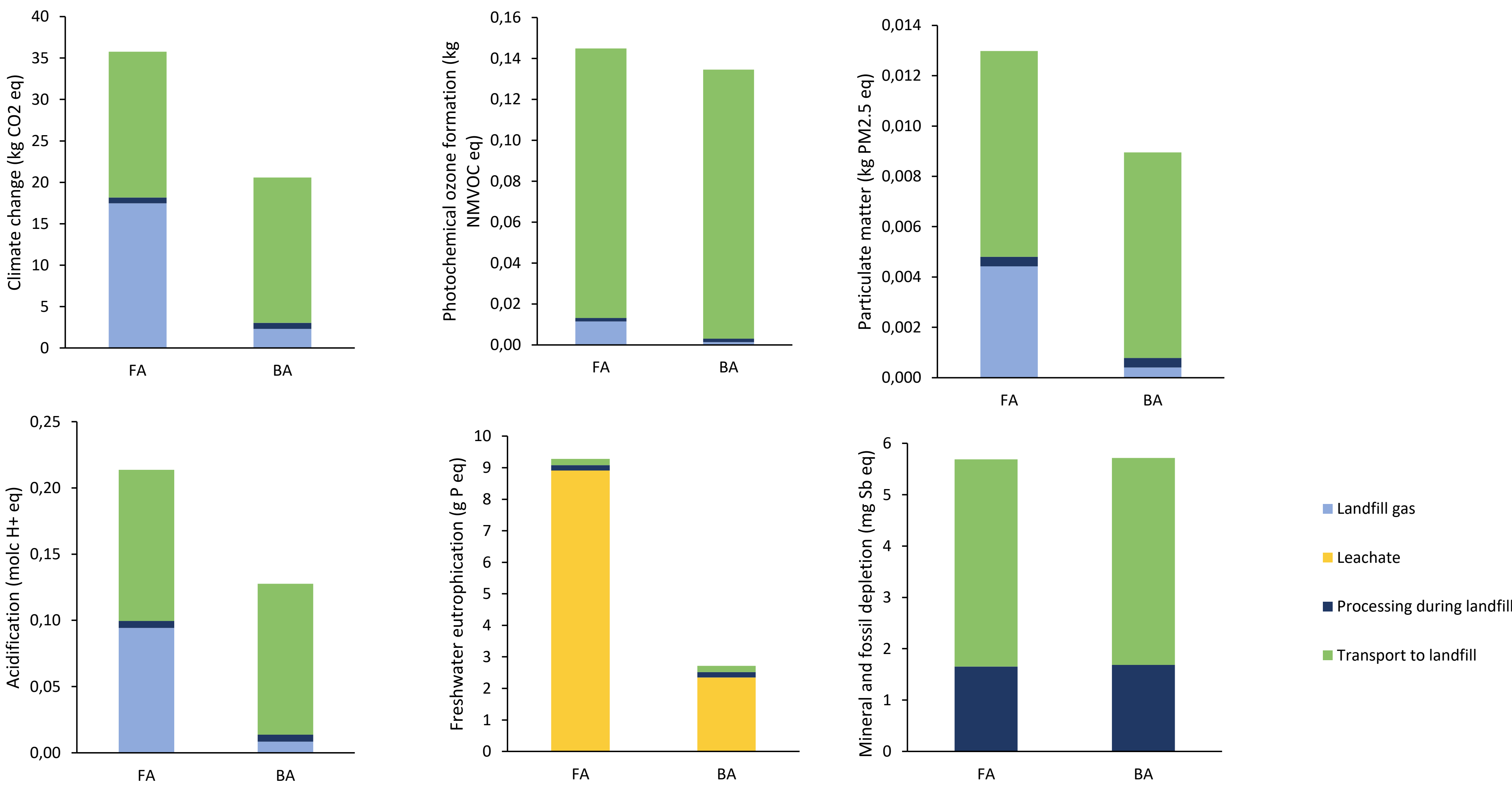
[a]This distance corresponds to an outward journey, based on distances of existing facilities in Portugal.

Inventory data for diesel consumption and air emissions were taken from the Ecoinvent database (Ecoinvent, 2017).

# Results (ILCD methodology)

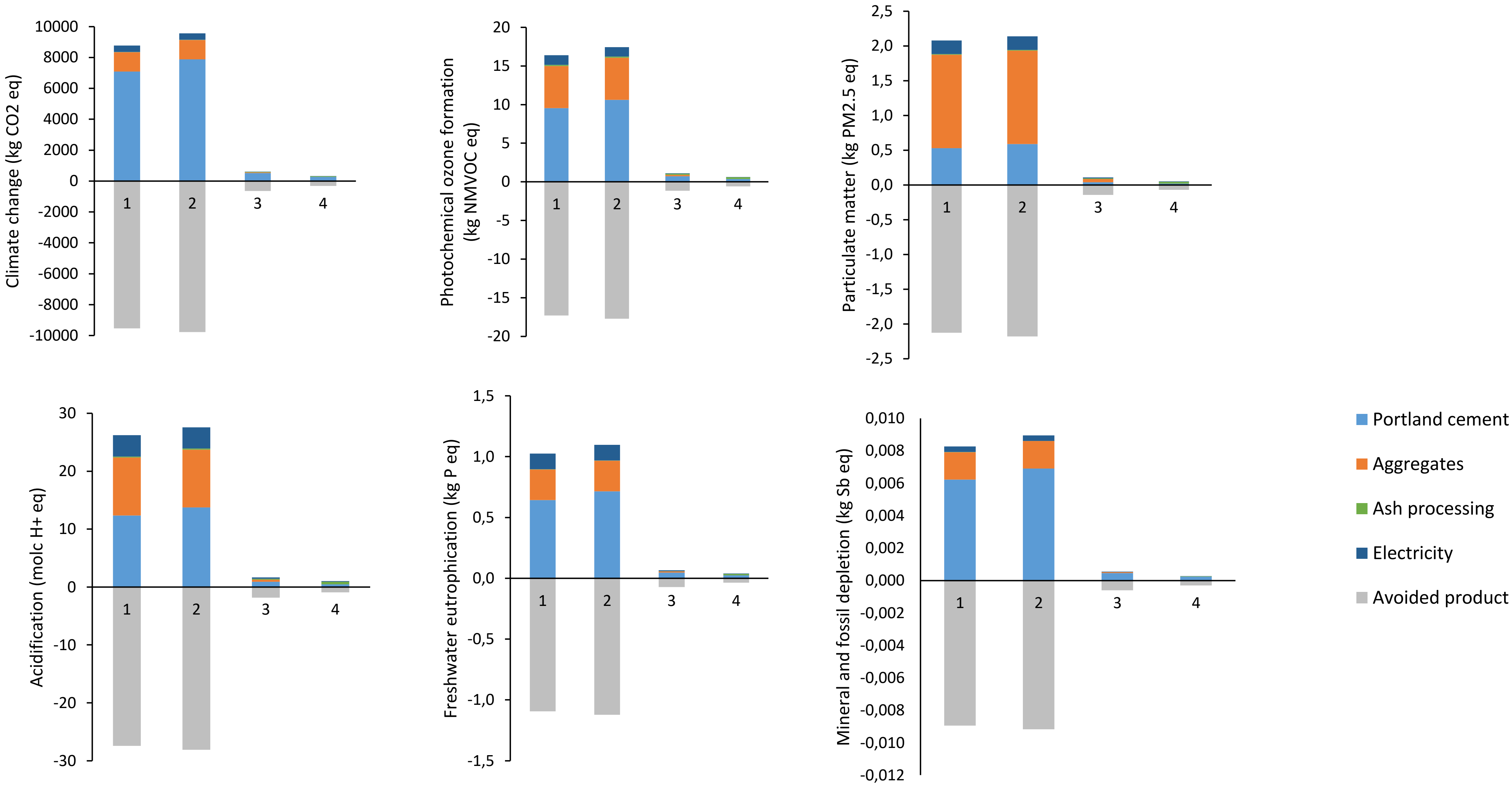
LiSAT

Figure 1 presents the environmental impact and the relative contribution of each stage, obtained for the base.



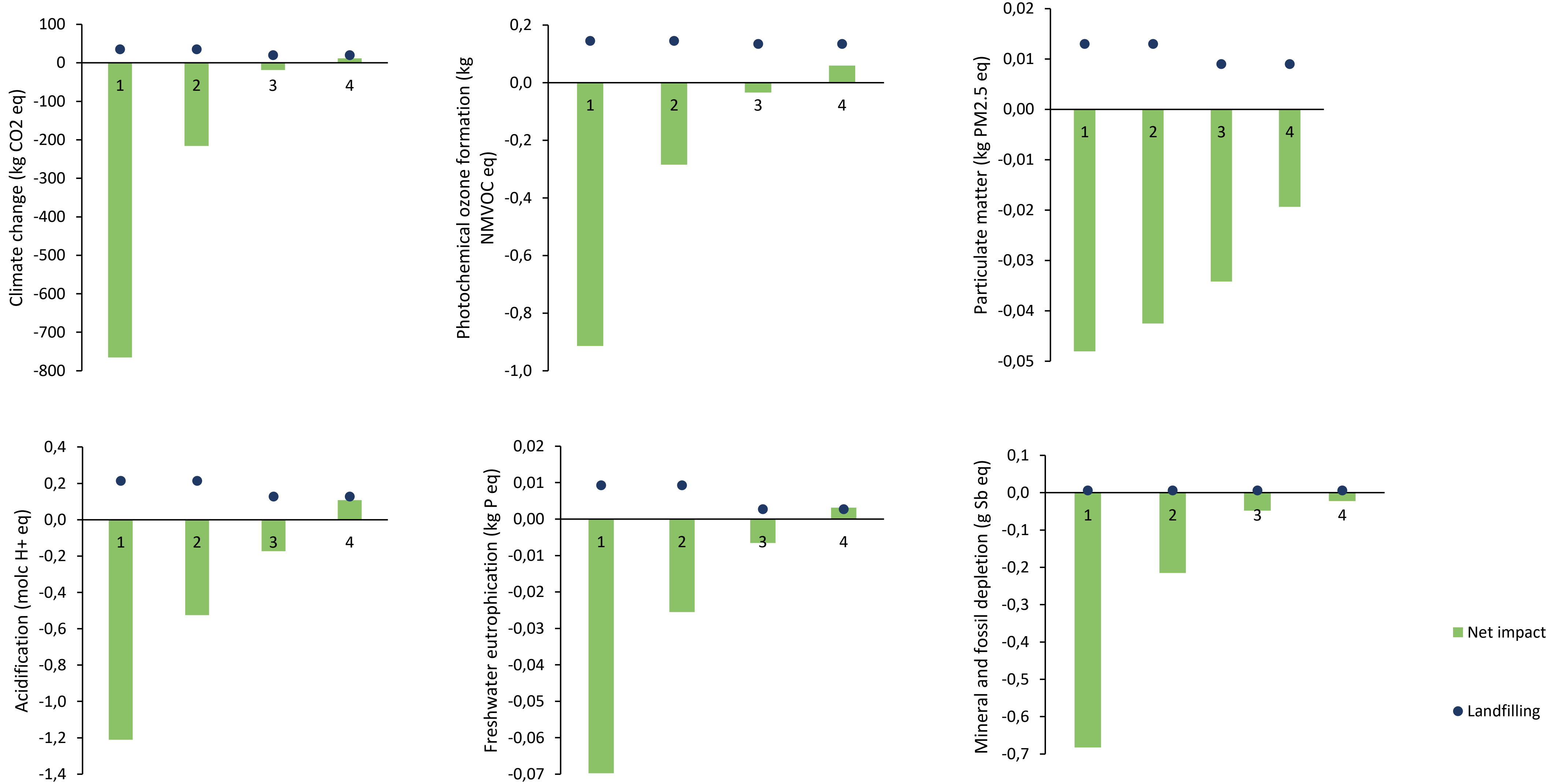
# Results (ILCD methodology)

Figure 2. Impact assessment results for valorization scenarios.



# Results (ILCD methodology)

Figure 3. Net impact results in each scenario (1 to 4) per functional unit.



# Conclusion

LiSAT

The production of cement mortar with bottom ashes avoids the extraction of sand and the production with fly ashes avoids the emissions during cement production.

The best end-of-life scenario is:

- **Fly ashes** → **Scenario 1: cement mortar with FA (substituting cement in 10 %).**

  Scenario 2: cement mortar with FA (adding 20 % to the mortar).

- **Bottom ashes** → **Scenario 3: cement mortar with BA (substituting the sand in 50 %).**

  Scenario 4: cement mortar with BA (substituting the sand in 100 %) with ash pre-treatment (washing and drying).

The environmental impact of ash valorisation in cement mortars are lower than the impacts of ash landfill.

Therefore, the production of cement mortar appears to be an end-of-life destination environmentally adequate for the woody biomass ashes.

**Acknowledgments:**

The authors would like to thank the Conselho Nacional de Desenvolvimento Científico e Tecnológico (CNPQ - Brazil) for the scholarship granted to Tamíris Pacheco da Costa (203483/2014-6). Thanks are also due to the FCT and POHP/FSE funding program for the scholarship granted to Paula Quinteiro (SFRH/BPD/114992/2016). Ana Cláudia Dias acknowledges the financial support from FCT (IF/00587/2013). The authors recognise FCT (Science and Technology Foundation - Portugal) and FEDER (European Regional Development Fund) for the financial support to CESAM (UID/AMB/50017) as well as the project SABIOS (PTDC/AAG-MAA/6234/2014) and SustainFor (PTDC/AGR-FOR/1510/2014), both funded under the project 3599-PPCDT.