

Global Sensitivity Analysis for Robust Decision-Making

A Consequential LCA Case Study on Chestnut
Biochar Valorisation

LCA Webinar

Polimi LCA Network – Junior Researchers Group

15.01.2026 | Nicolas Bertoldo , Marianna Guagliano & Giovanni Dotelli

Contents

01

Introduction

Problem definition

02

Methodology

LCA case study
GSA procedure

03

Results

LCA results
GSA results

04

Conclusions

Remarks and
recommendations

Introduction – Problem definition

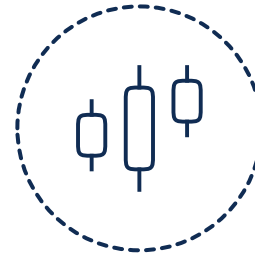


LCA is becoming more and more **recognized** as a tool to **support** decision-making

Introduction – Problem definition



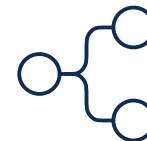
LCA is becoming more and more **recognized** as a tool to **support** decision-making



Emerging technology and future implementations are associated with **high uncertainty**



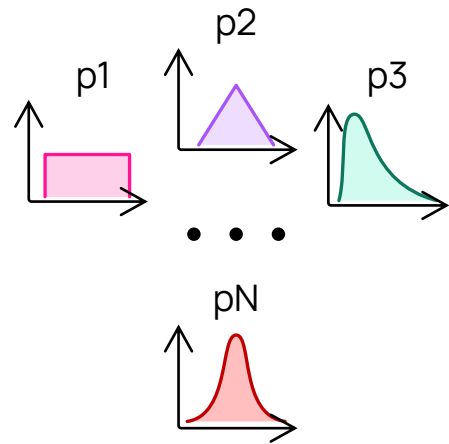
Related to data collection



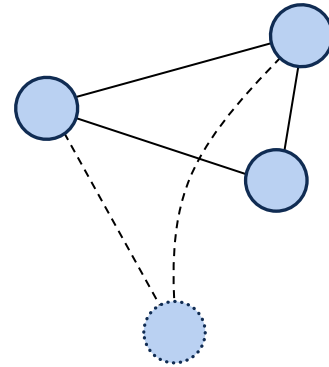
Related to the modeling of the system

Global Sensitivity Analysis (GSA)

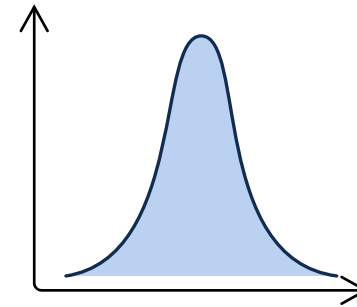
GSA quantifies the **influence** of input parameters on model outputs to identify the most significant drivers.



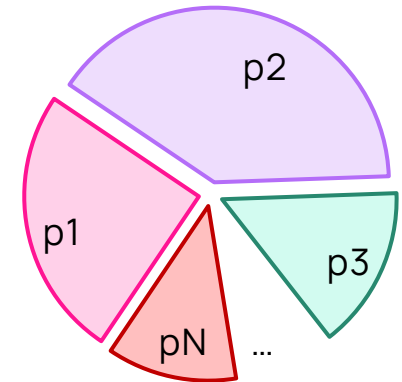
Input parameters
distribution



Model

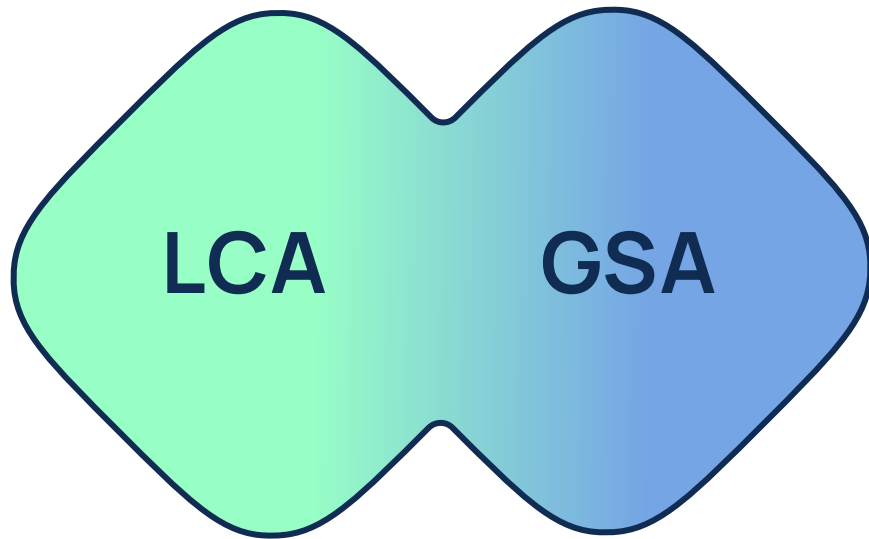


Distribution of
model results



Influence of input
parameters
(e.g., Sobol indices)

Goal of the study



To apply GSA to an LCA model for assessing the uncertainty of the impact of a future implementation and supporting decision-making

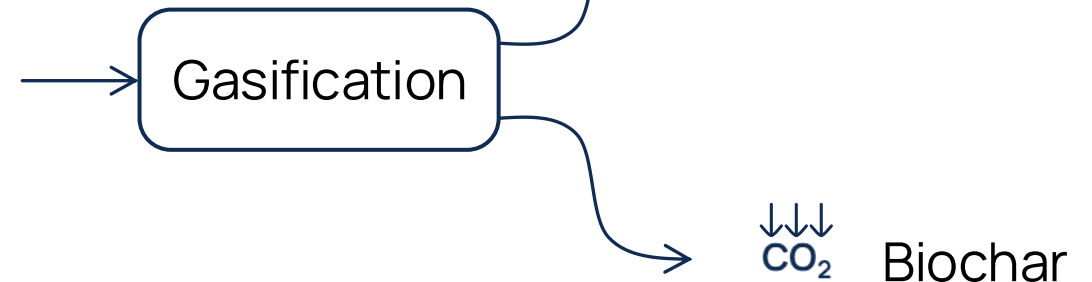
LCA case study

 Frozen chestnut factory, located in Portugal



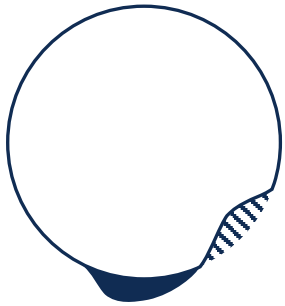
 Plan to install a **gasification plant** for the treatment of the chestnut shell waste

 Chestnut shell

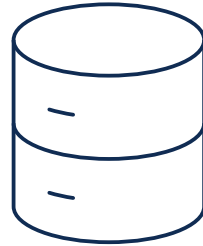


LCA case study

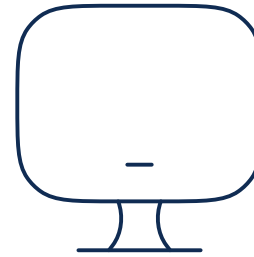
Functional unit: management of 1 ton of **chestnut shells**



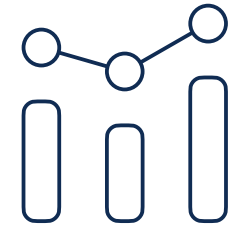
Consequential
approach



Primary data
+
ecoinvent
v 3.11, consequential
system model

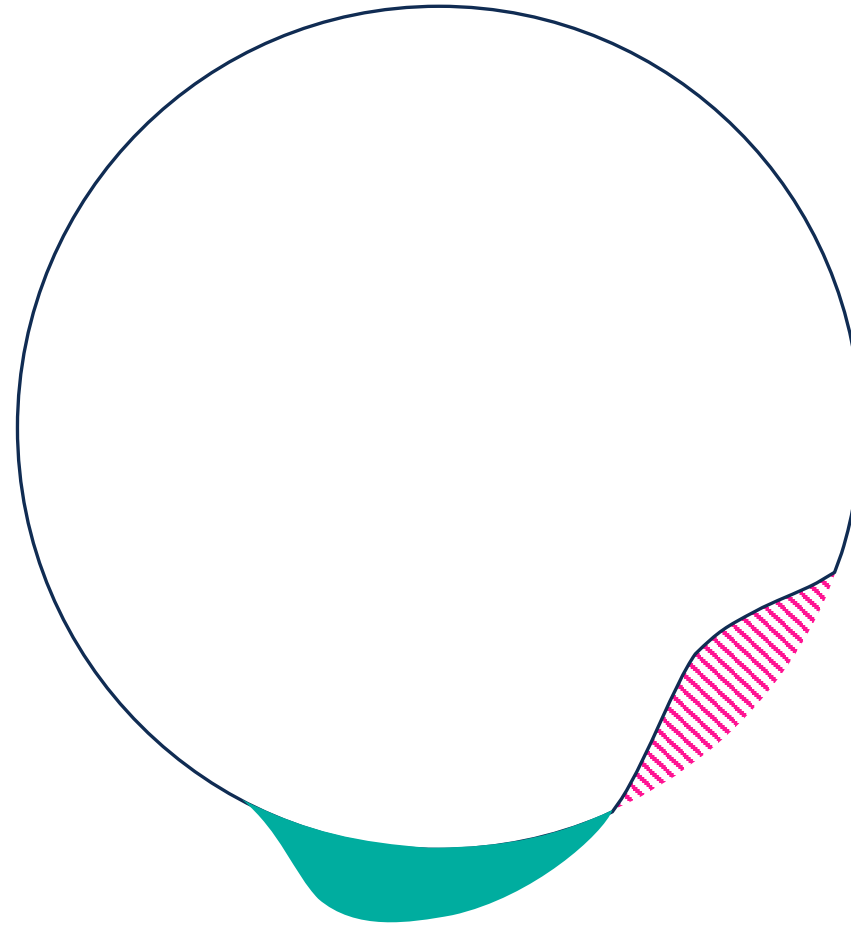


Brightway 2.5

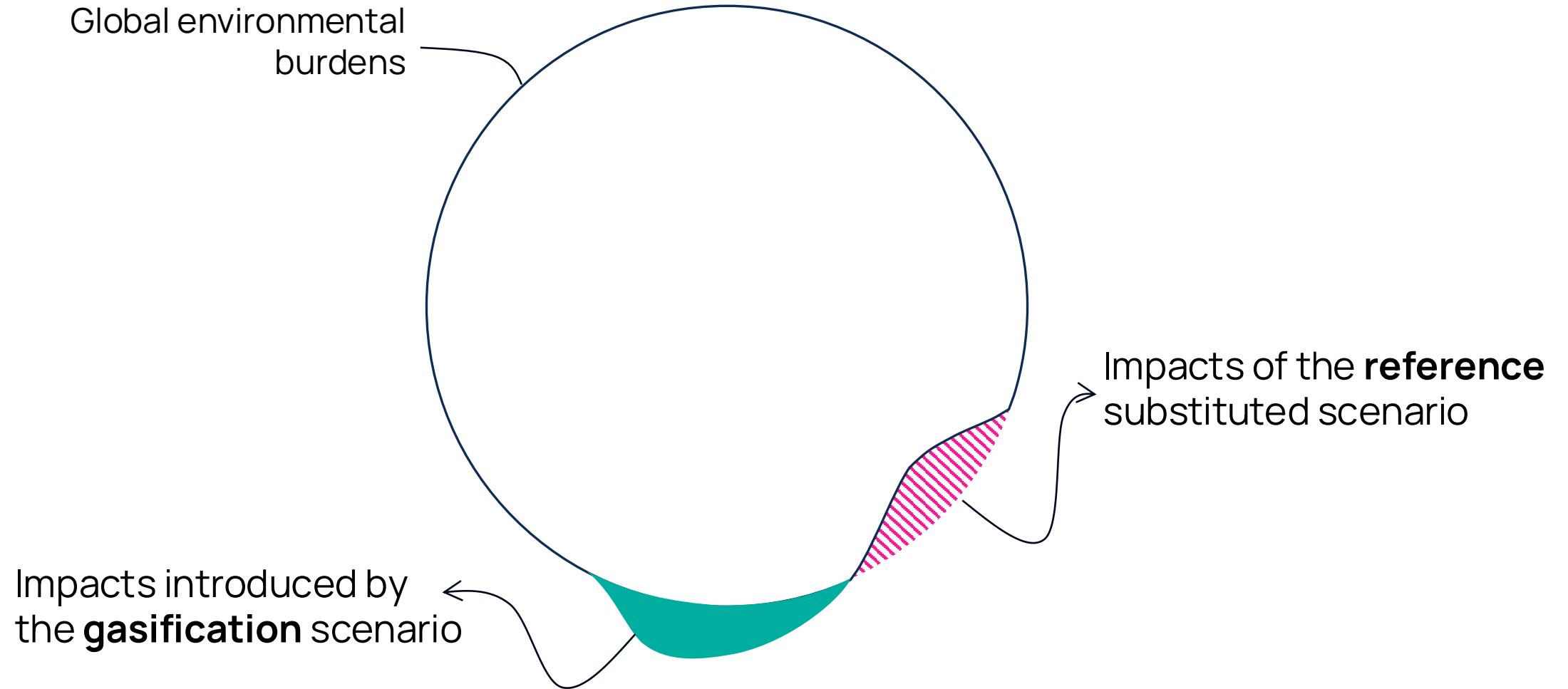


IPCC 2021
(incl. biogenic CO₂)
-1/+1 approach

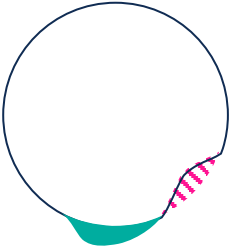
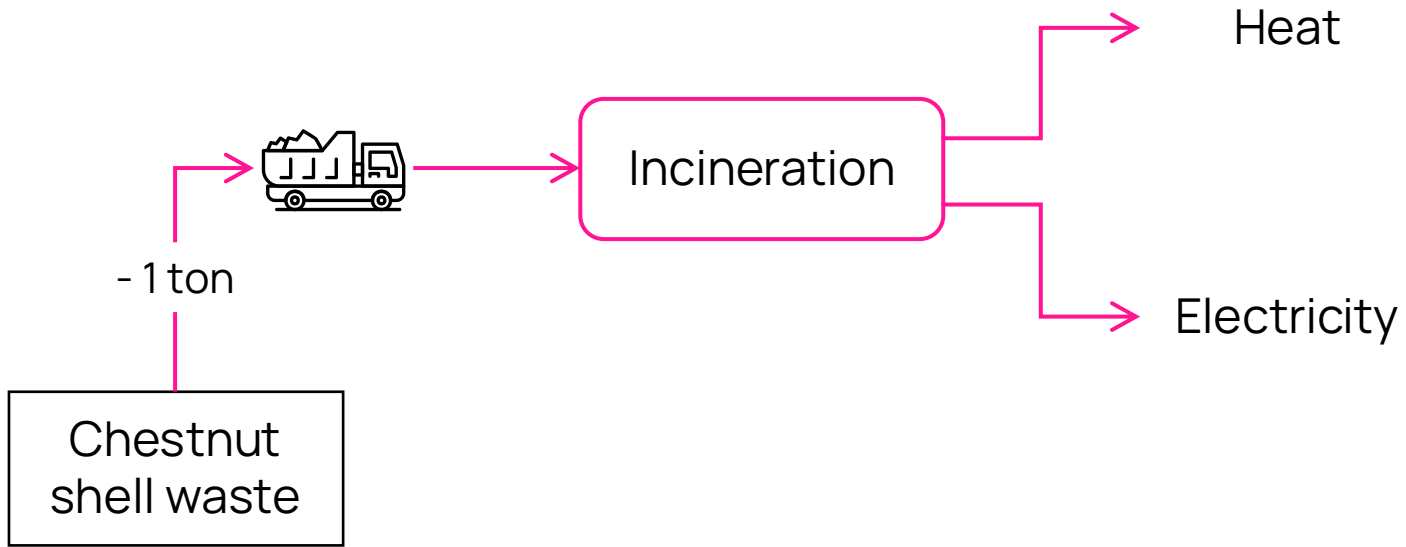
LCA case study



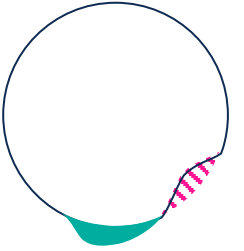
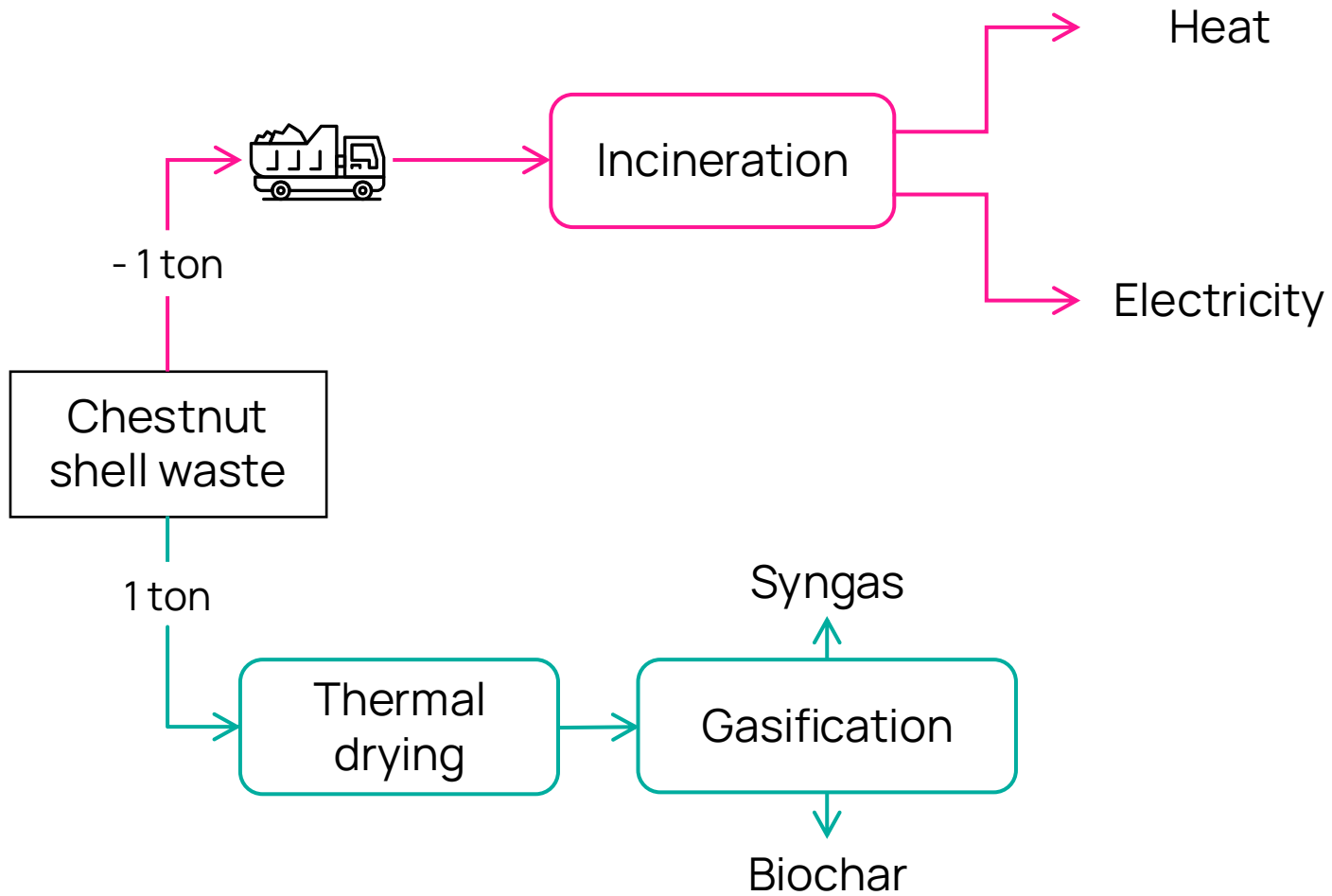
LCA case study



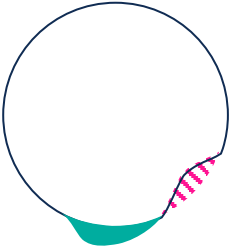
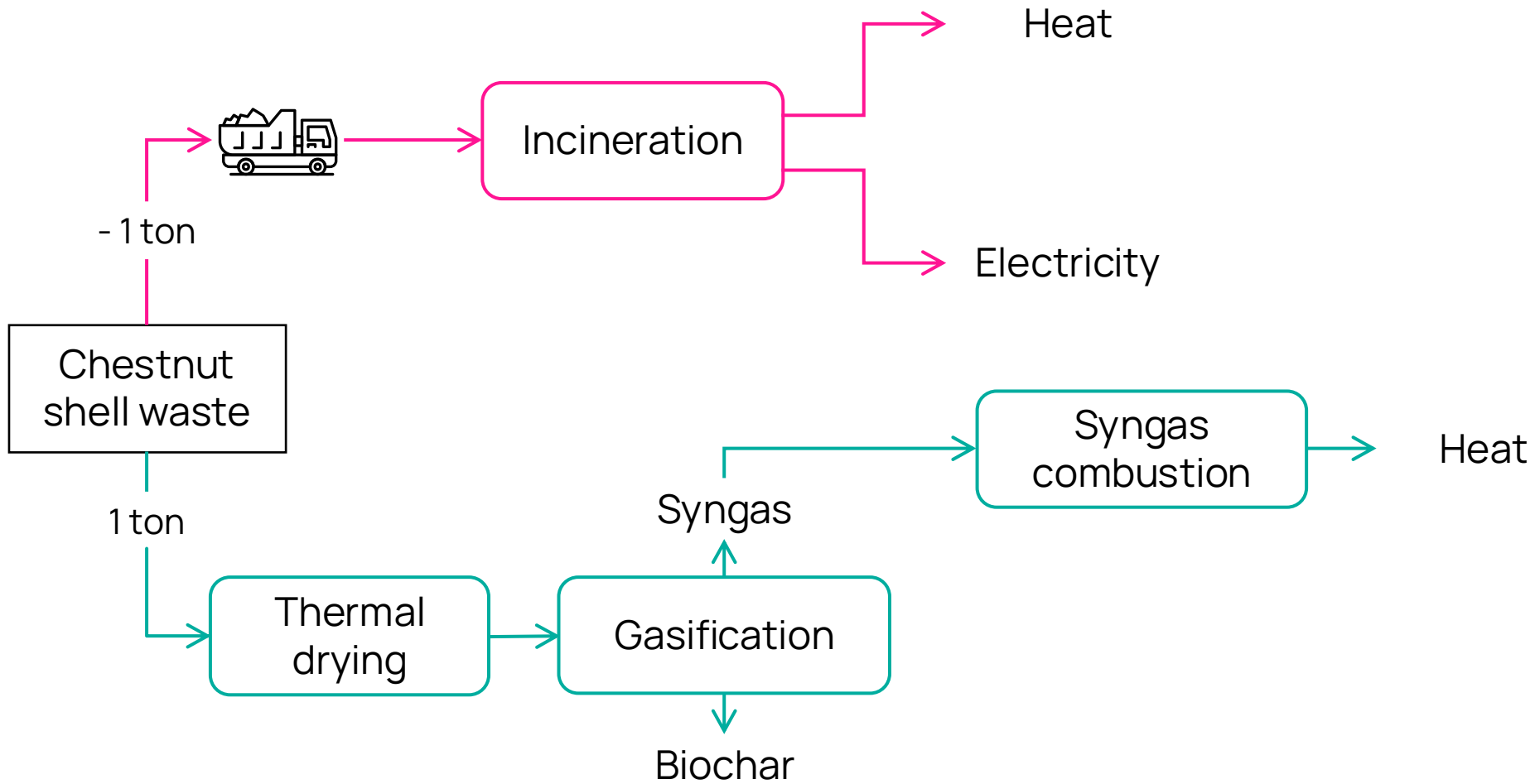
System boundary



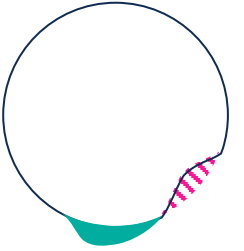
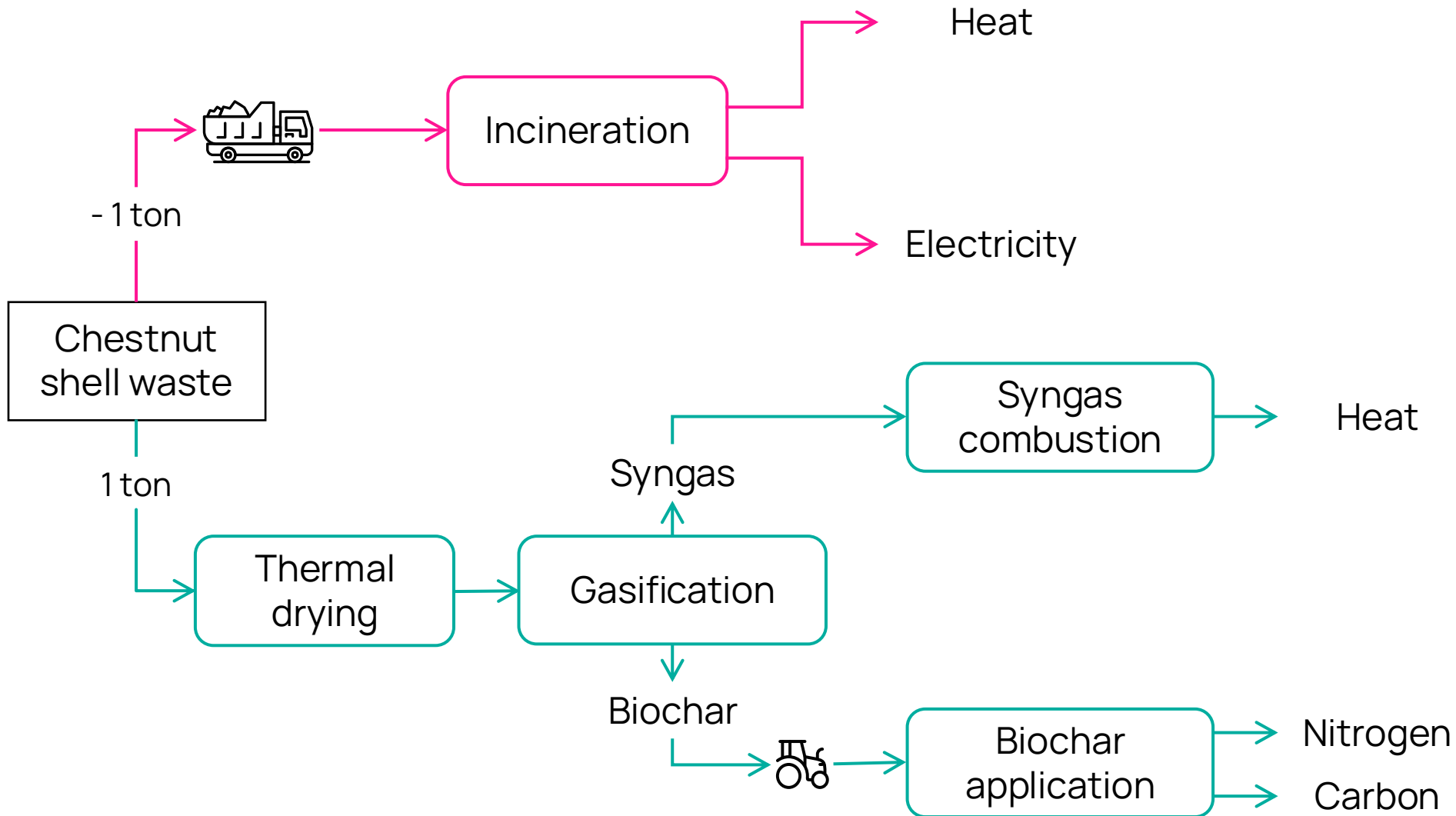
System boundary



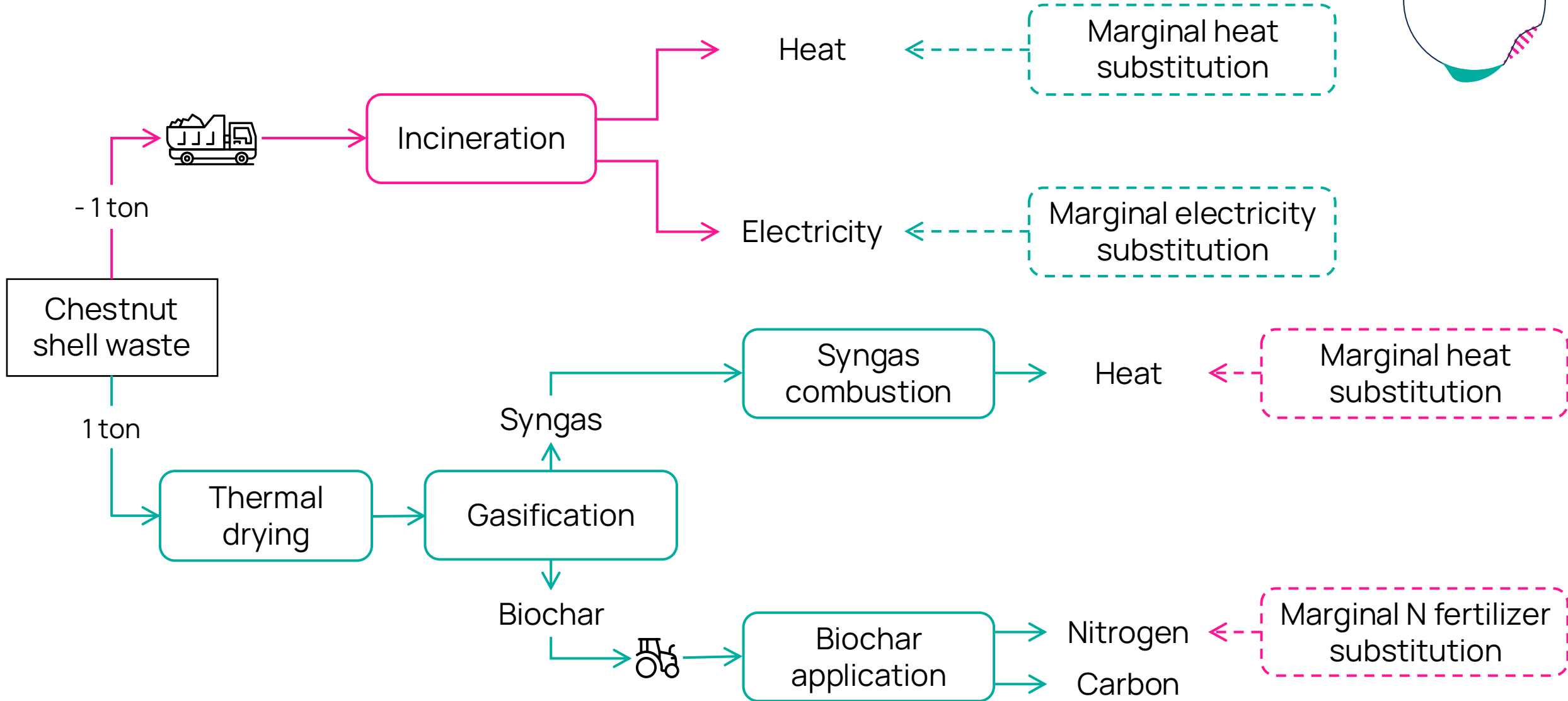
System boundary



System boundary



System boundary

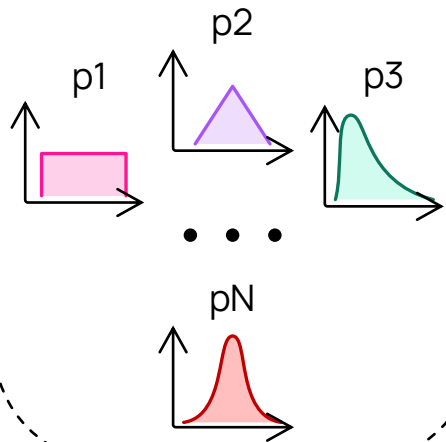




GSA procedure

1. Define the problem

13 input parameters

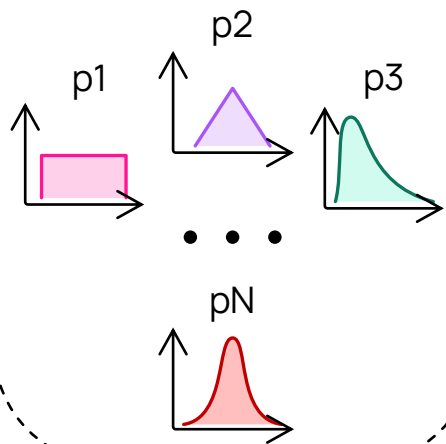




GSA procedure

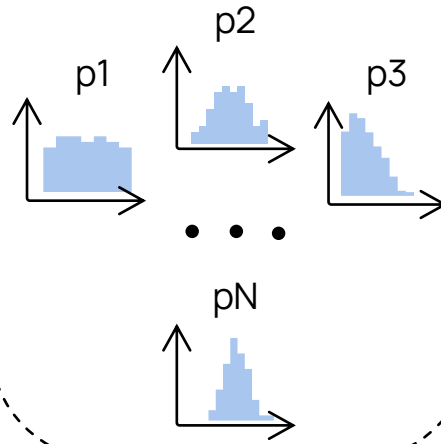
1. Define the problem

13 input parameters



2. Generate the Monte Carlo samples

2^{10} samples

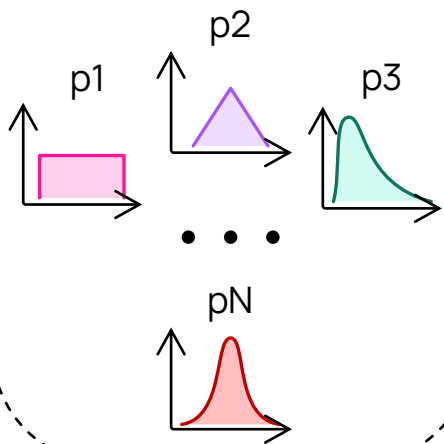




GSA procedure

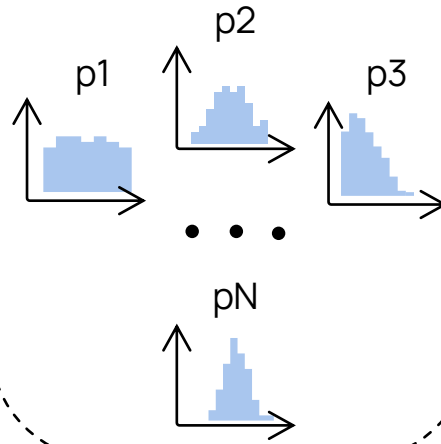
1. Define the problem

13 input parameters



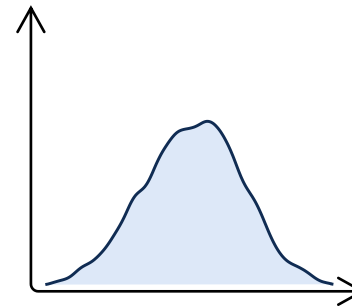
2. Generate the Monte Carlo samples

2^{10} samples



3. Run the LCA model

GWP =
 $f(p_1, p_2, \dots, p_N)$

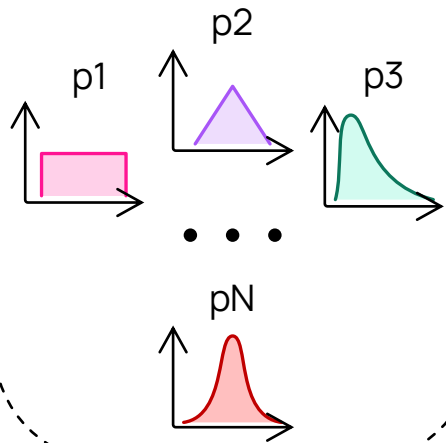




GSA procedure

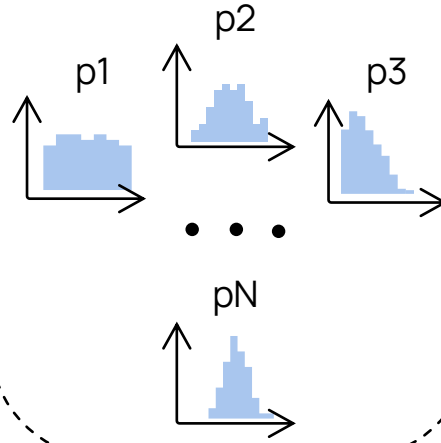
1. Define the problem

13 input parameters



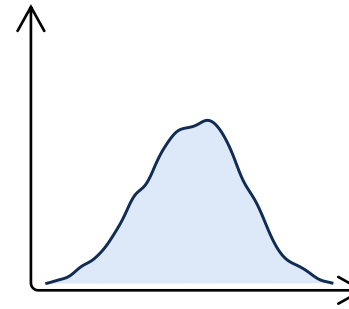
2. Generate the Monte Carlo samples

2^{10} samples

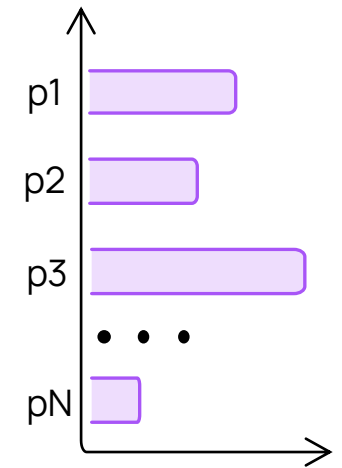


3. Run the LCA model

GWP =
 $f(p_1, p_2, \dots, p_N)$



4. Compute Sobol indices



GSA procedure – Sobol Indices

First-order indices:

They represent the fraction of total variance that is explained by the parameter

$$SI_i = \frac{V[E[GWP|p_i]]}{V[GWP]}$$

GSA procedure – Sobol Indices

First-order indices:

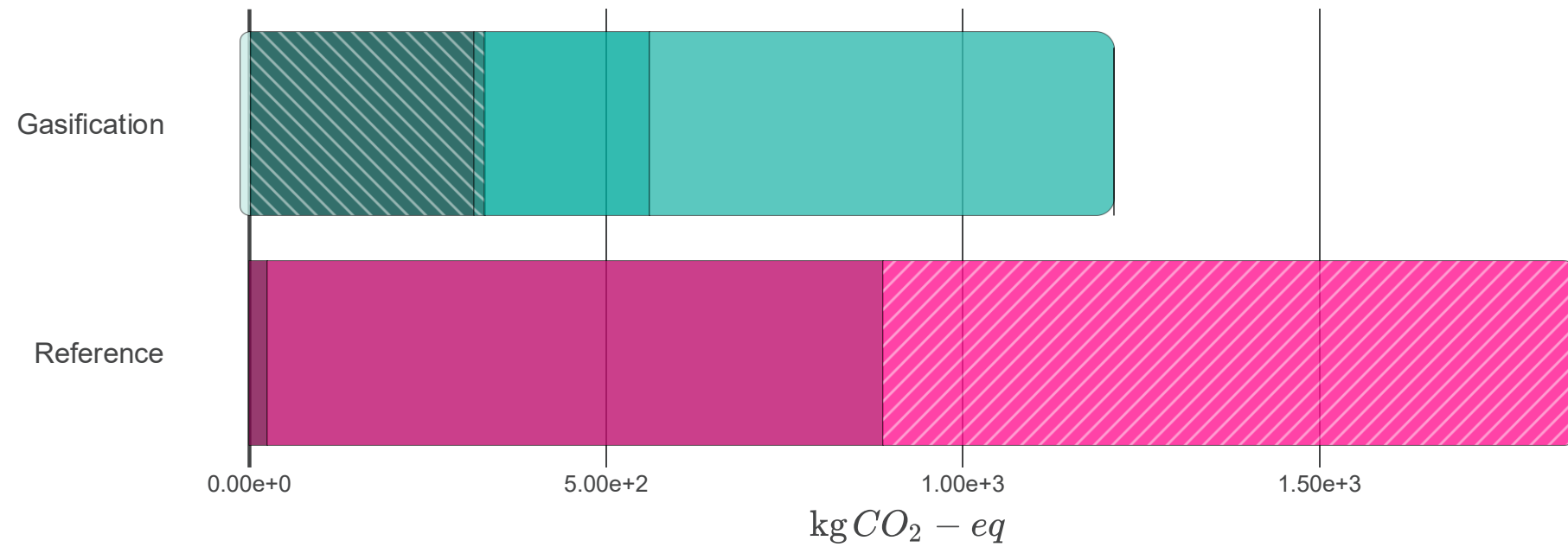
They represent the fraction of total variance that is explained by the parameter

Variance of the expected value of GWP given p_i

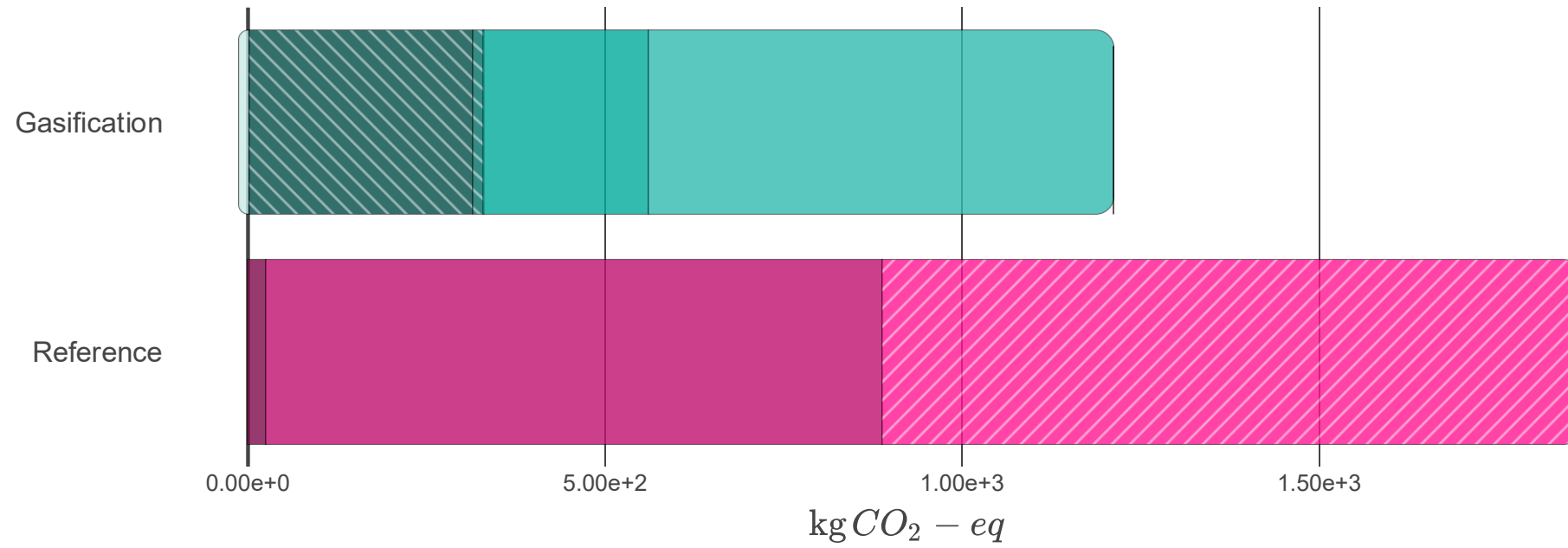
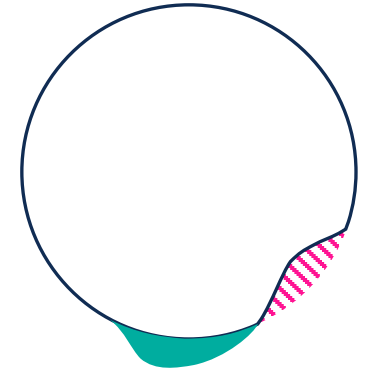
$$SI_i = \frac{V[E[GWP|p_i]]}{V[GWP]}$$

Total variance of the model

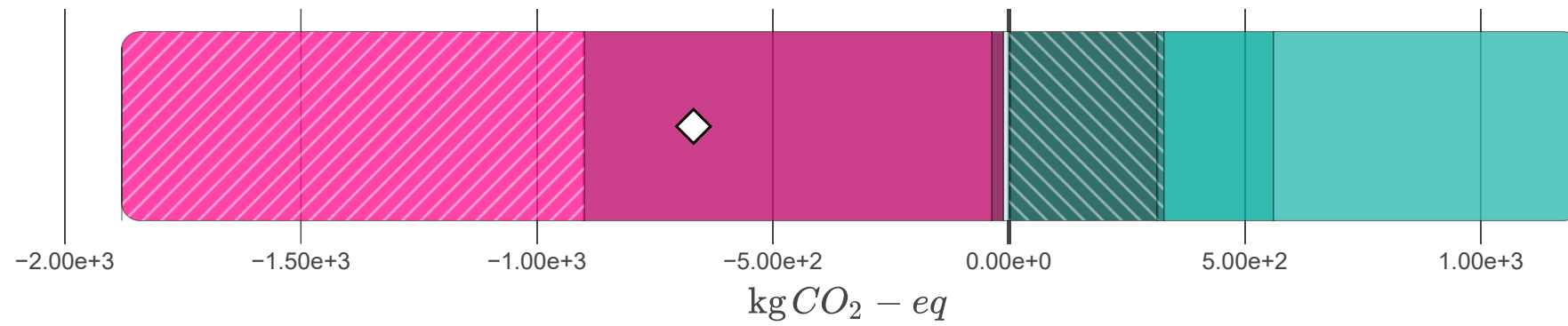
LCA results – Climate Change



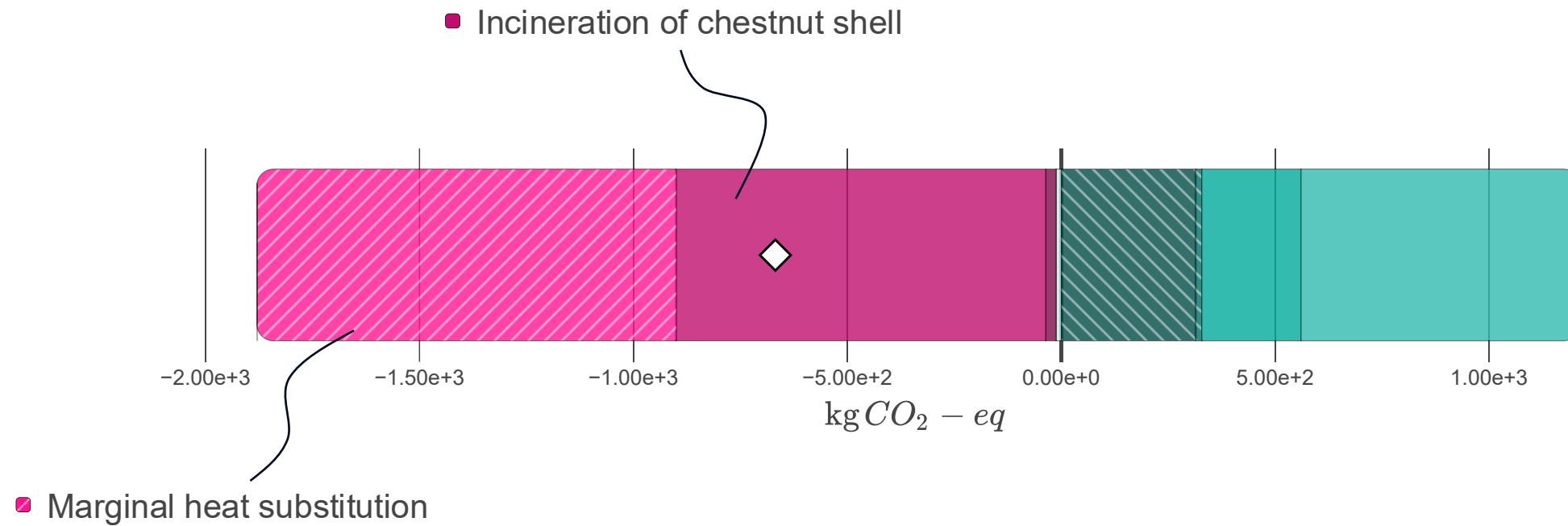
LCA results – Climate Change



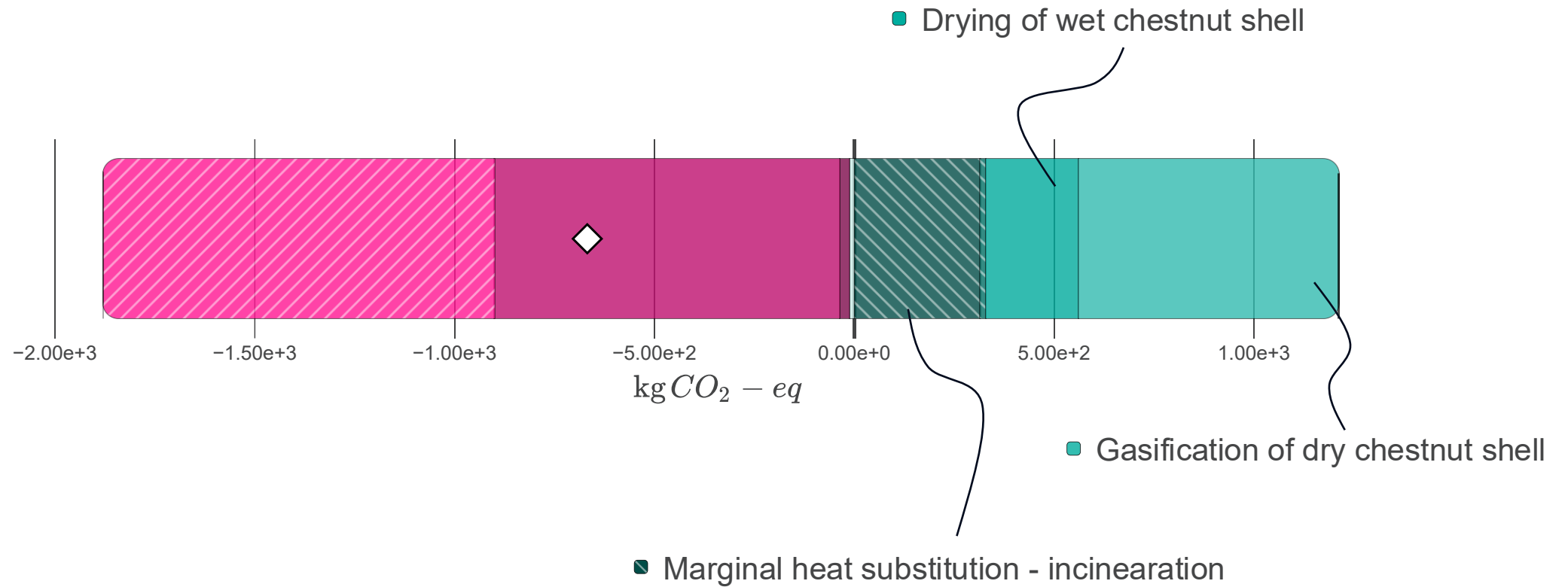
LCA results – Climate Change



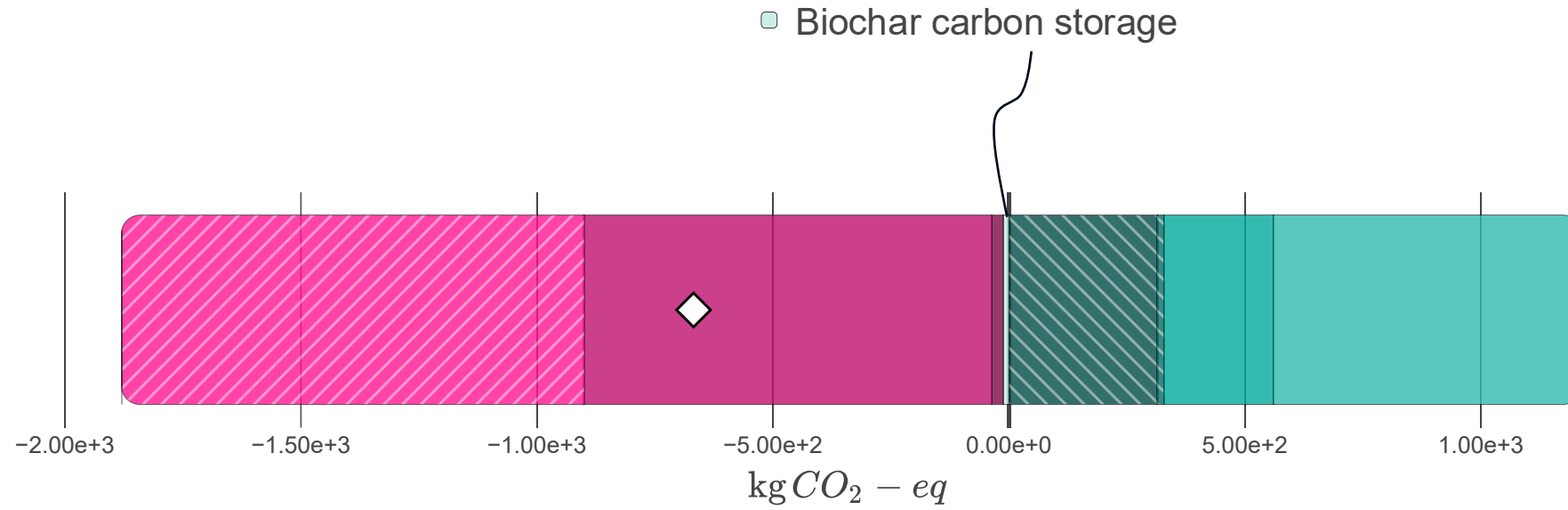
LCA results – Climate Change



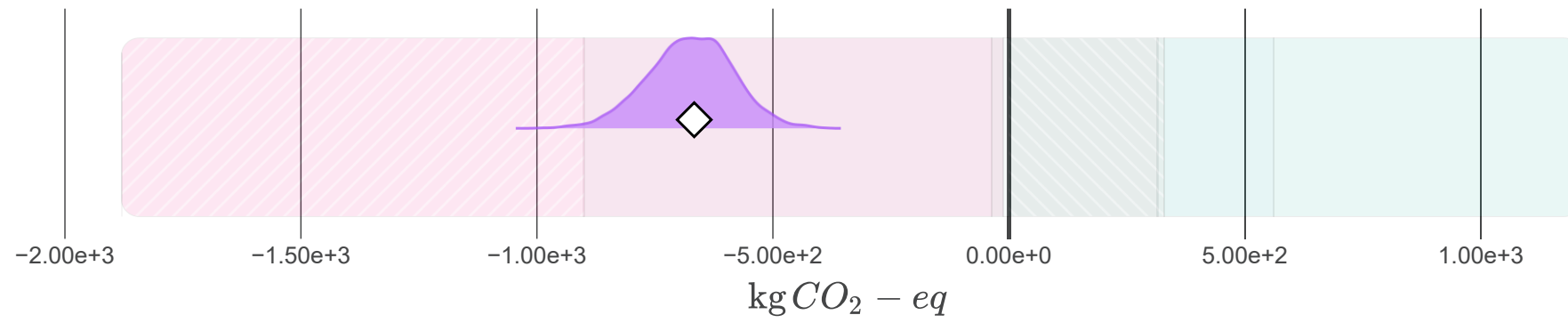
LCA results – Climate Change



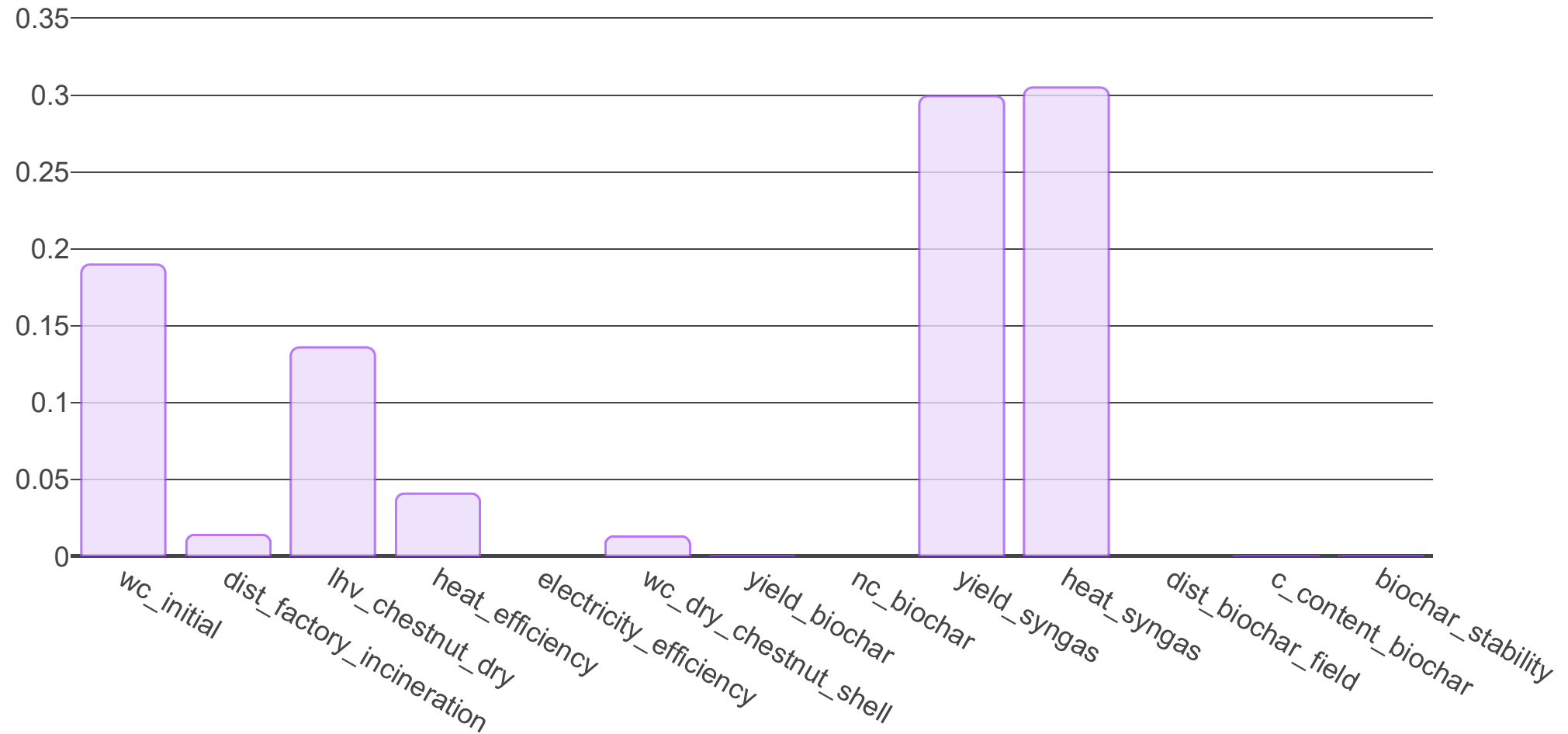
LCA results – Climate Change



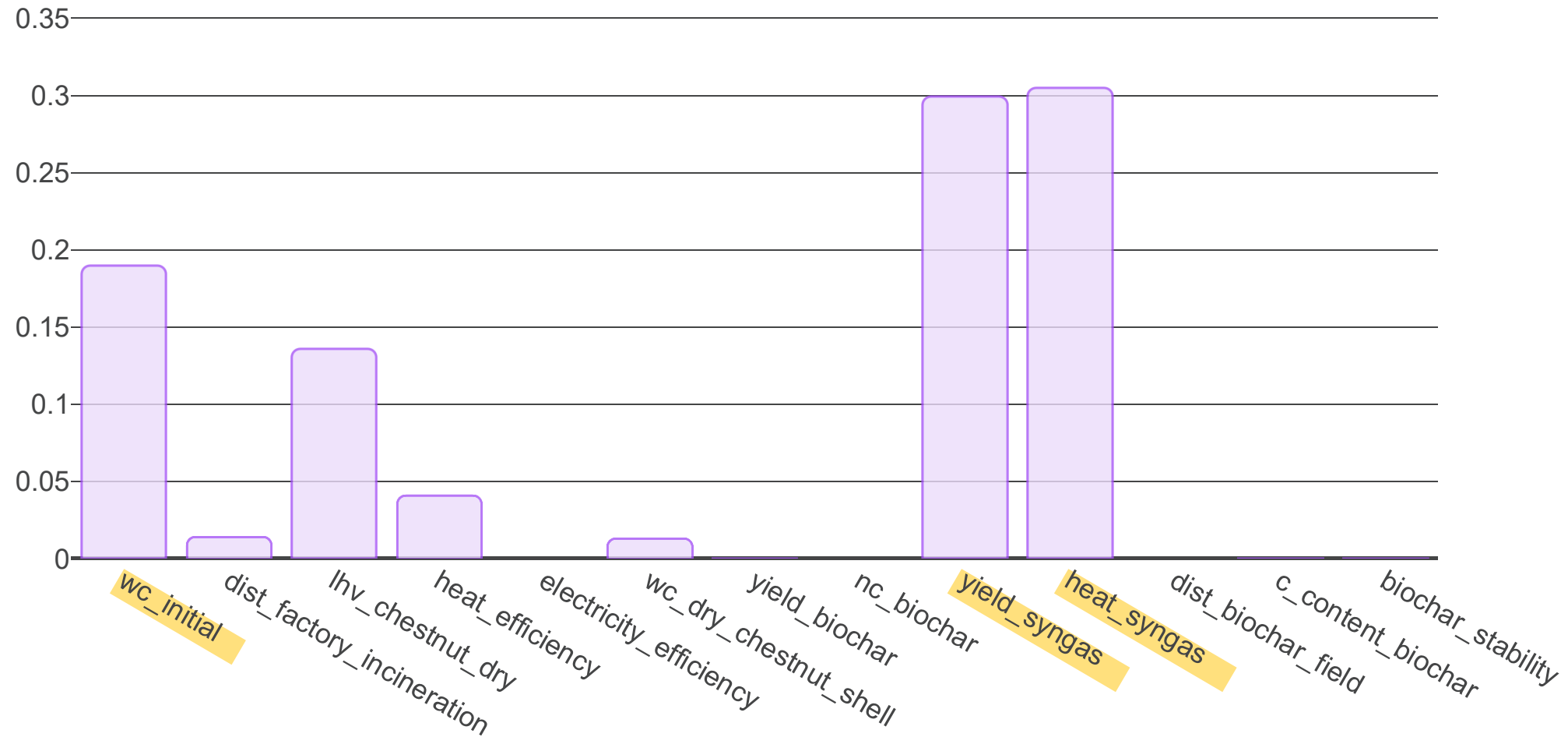
GSA results



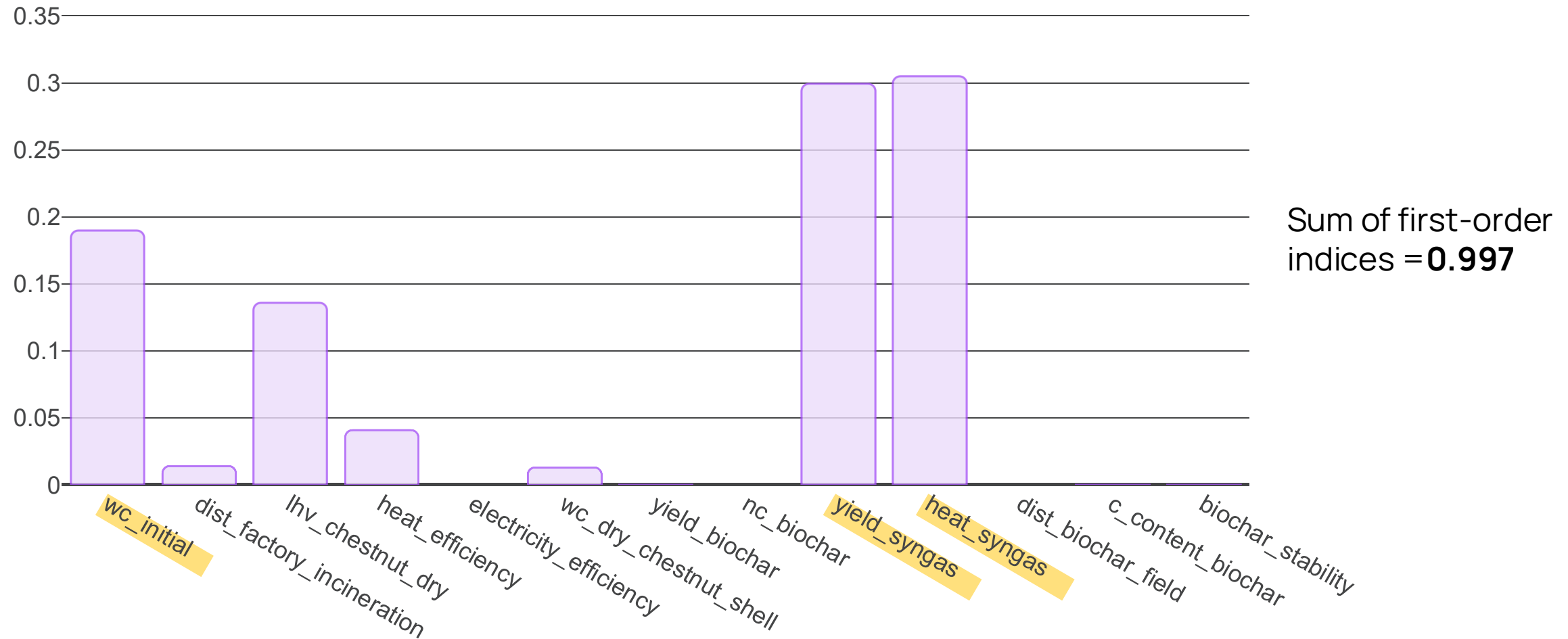
GSA results – First-order Sobol indices



GSA results – First-order Sobol indices



GSA results – First-order Sobol indices



Conclusions



- Implementing a gasification plant can lead to a **reduction** of the GWP
- Most of the benefit is given by the production of **heat from syngas combustion**

Conclusions



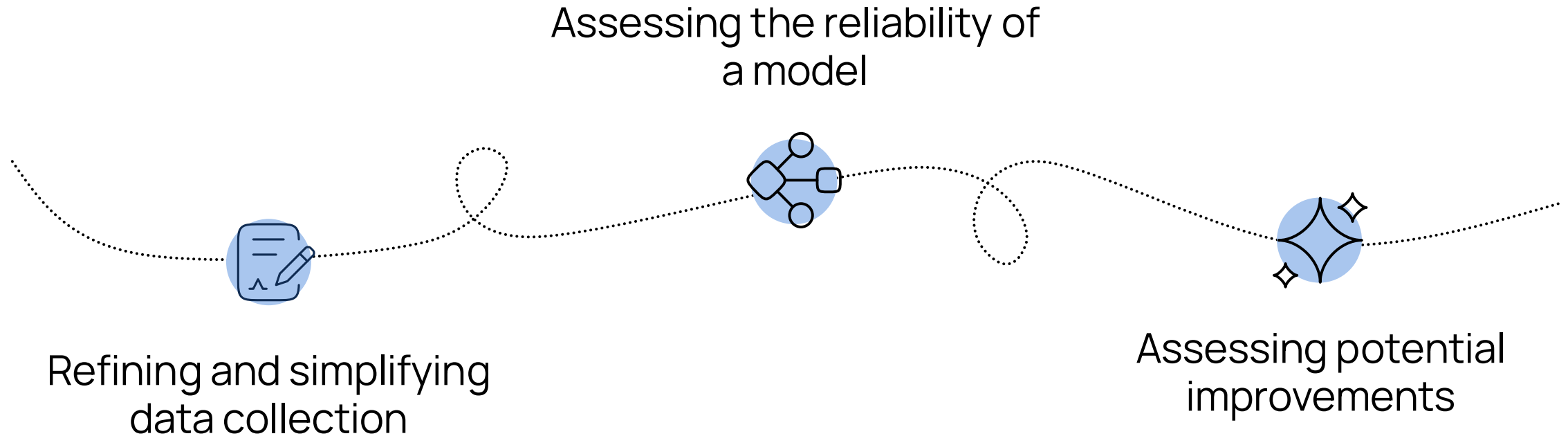
- Implementing a gasification plant can lead to a **reduction** of the GWP
- Most of the benefit is given by the production of **heat from syngas combustion**



The most relevant parameters are:

- The **water content** in the shells.
- The **syngas yield**.
- The **heat produced** from syngas.

GSA remarks





POLITECNICO
MILANO 1863



Global Sensitivity Analysis for Robust Decision-Making

A Consequential LCA Case Study on Chestnut Biochar Valorisation

15 – 01 – 2026 | Nicolas Bertoldo , Marianna Guagliano & Giovanni Dotelli

Contact details

Piazza Leonardo da Vinci, 32 – 20133 Milano

nicolas.bertoldo@polimi.it

www.polimi.it

