# Work Package 5

*Sustainability assessment*

*Eliza Nika, Brunel University London (BUL)*

*Ana Arias Calvo, University of Santiago de Compostela (USC)*

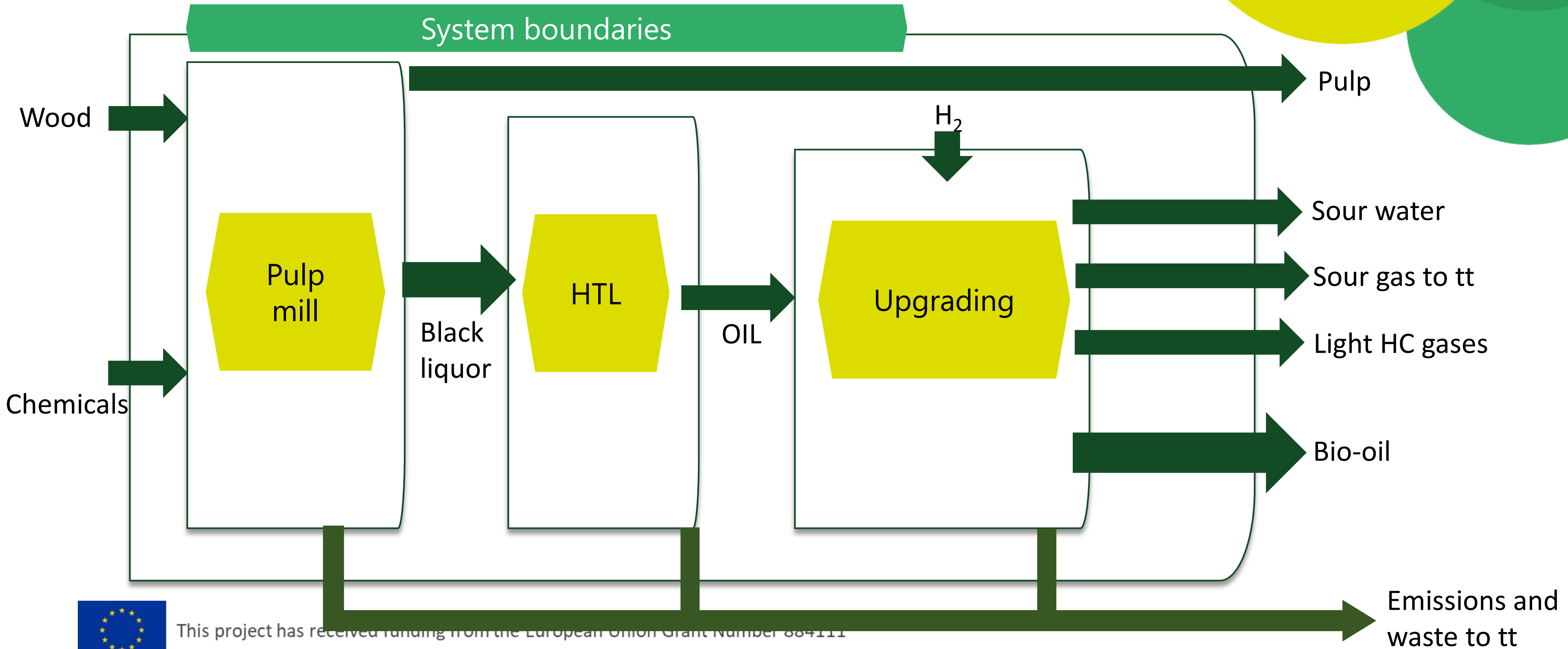
*Evina Katsou, Brunel University London (BUL)*

BL2F

Transforming Black Liquor to Biofuel

This project has received funding from the European Union Grant Number 884111

# Process under assessment

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# Task 5.1: Environmental Assessment

## FU, system boundaries and LCI

**FU: 1 kg of biocrude**

Cradle-to-gate approach

Attributional assessment

### MidPoint impact categories

| | |
|---|---|
| CC | Climate change |
| POF | Ozone formation |
| EF | Eutrophication, fresh |
| ET | Ecotoxicity, fresh |
| HT-NC | Human tox. n-cancer |
| RF | Fossil resources |
| OD | Ozone depletion |
| AC | Acidification |
| EM | Eutrophication, marine |
| HT-C | Human tox. cancer |
| RM | Mineral resources |
| WU | Water use |

### EndPoint impact categories

| | |
|---|---|
| HH | Human health |
| RS | Resources |
| EC | Ecosystem |

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# **Task 5.1:** Environmental Assessment

Consideration of various percentages of the BL going for the HTL unit

Consideration of 3 process schemes for biocrude production: Case 1, Case 2 and Case 3

Comparison with the conventional fuels

| Scenario | Description & goal | |
|---|---|---|
| **5% of BL for HTL unit** | Traditional pulp mill with one variation: a 5% of the BL is not used for energy production for process self-consumption but for be valorized in the HTL unit. The goal is to analyze the effect over the pulp-mill process sustainability. | |
| **10% of BL for HTL unit** | Traditional pulp mill with one variation: a 10% of the BL is not used for energy production for process self-consumption but for be valorized in the HTL unit. The goal is to analyze the effect over the pulp-mill process sustainability. | |
| **15% of BL for HTL unit** | Traditional pulp mill with one variation: a 15% of the BL is not used for energy production for process self-consumption but for be valorized in the HTL unit. The goal is to analyze the effect over the pulp-mill process sustainability. | |
| **Integrated biorefinery with a production capacity of 100 ton/h of BL** | Considering Case 1 technology from D4.1. | Assessment of the environmental profile of the integrated biorefinery assuming a input of BL that amounts to 100 ton/h. |
| | Considering Case 2 technology from D4.1. | |
| | Considering Case 3 technology from D4.1. | |
| **Integrated biorefinery with a production capacity of 300 ton/h of BL** | Considering Case 1 technology from D4.1. | Assessment of the environmental profile of the integrated biorefinery assuming a input of BL that amounts to 300 ton/h. |
| | Considering Case 2 technology from D4.1. | |
| | Considering Case 3 technology from D4.1. | |
| **Integrated biorefinery with a production capacity of 600 ton/h of BL** | Considering Case 1 technology from D4.1. | Assessment of the environmental profile of the integrated biorefinery assuming a input of BL that amounts to 600 ton/h. |
| | Considering Case 2 technology from D4.1. | |
| | Considering Case 3 technology from D4.1. | |

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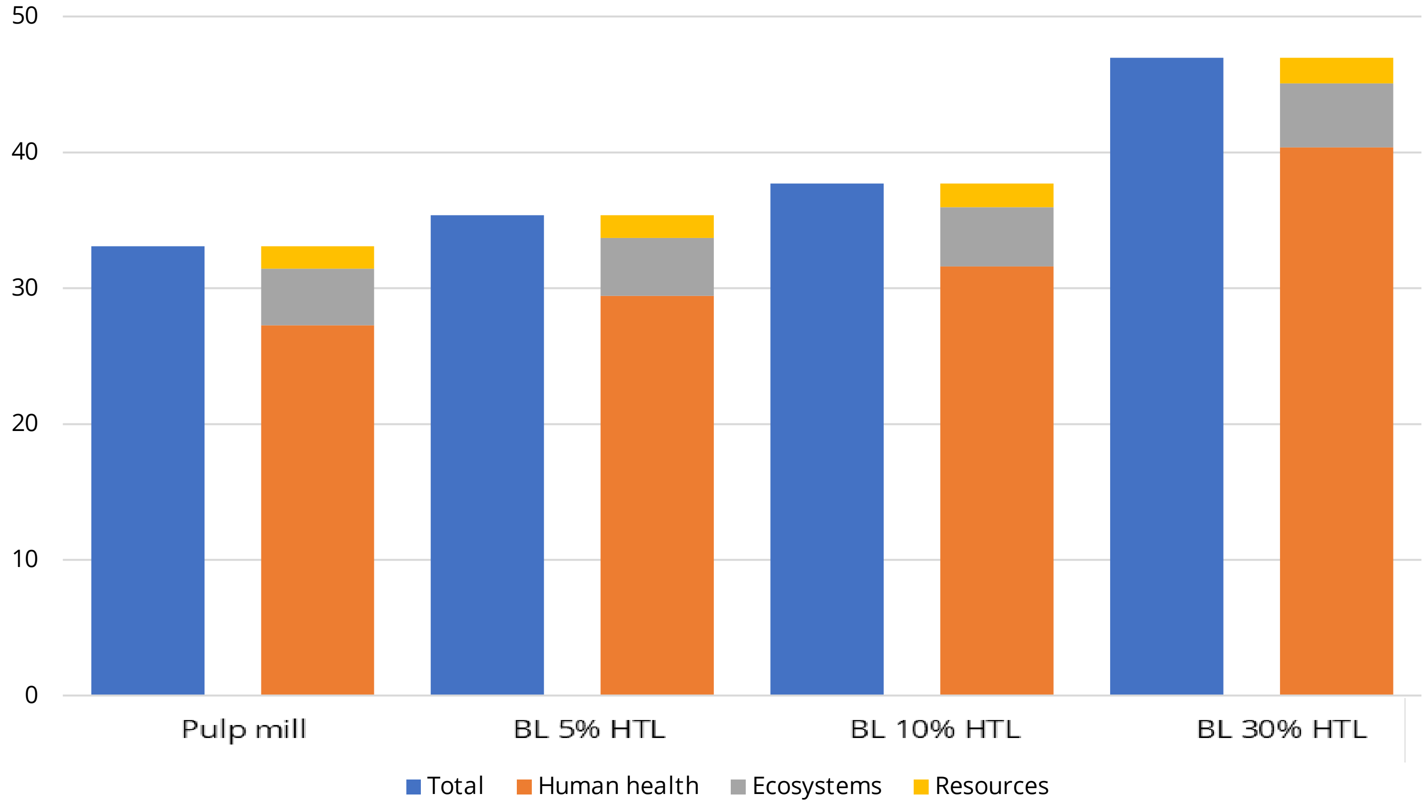
# **Task 5.1:** Environmental Assessment




Consideration of various percentages of the BL going for the HTL unit

The use of BL for biocrude production entails not much difference when around 10% of it is used for this alternative valorization, above 30% it could have a negative effect over the sustainable potential of the conventional pulp mill

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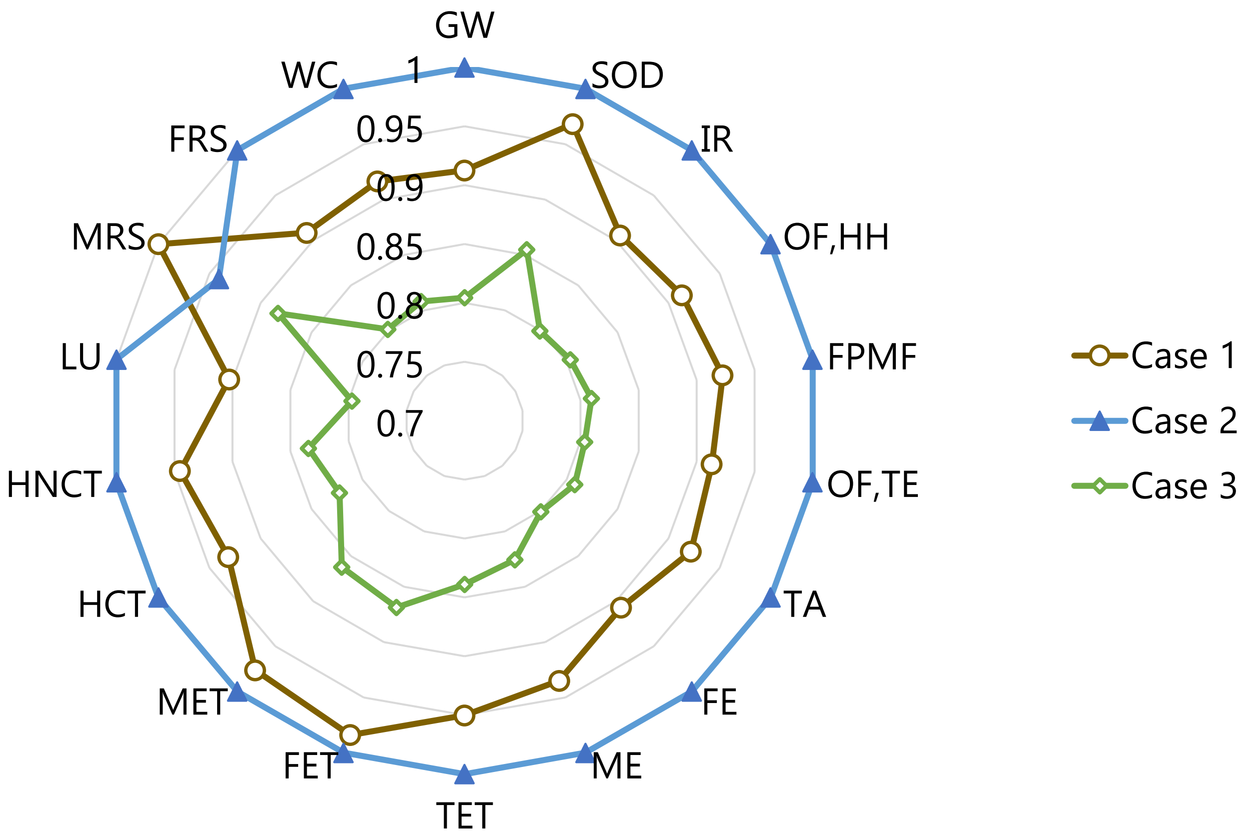
# **Task 5.1:** Environmental Assessment




Consideration of 3 process schemes for biocrude production: Case 1, Case 2 and Case 3

BIOCRUDE produced using BL and HTL technology following Case 3 implies **lower environmental loads** compared to the other Cases

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# **Task 5.2:** LCC considerations

## LCC indicators considered for analysis and comparison

- CAPEX AND OPEX
- OPEX/CAPEX
- OPEX/(CAPEX + OPEX)
- Net Present Value (NPV)
- Annualized NPV
- Internal Rate of Return (IRR)
- Modified IRR
- Investment efficiency
- Payback
- Range minimum selling price

**Minimum selling price considered for the biocrude**

**1 $/L – 6.5 $/L**

3 CASE STUDIES AND 3 CAPACITIES

| **Low** | **Medium** | **High** |
|---|---|---|
| 100 ton/day | 300 ton/day | 600 ton/day |

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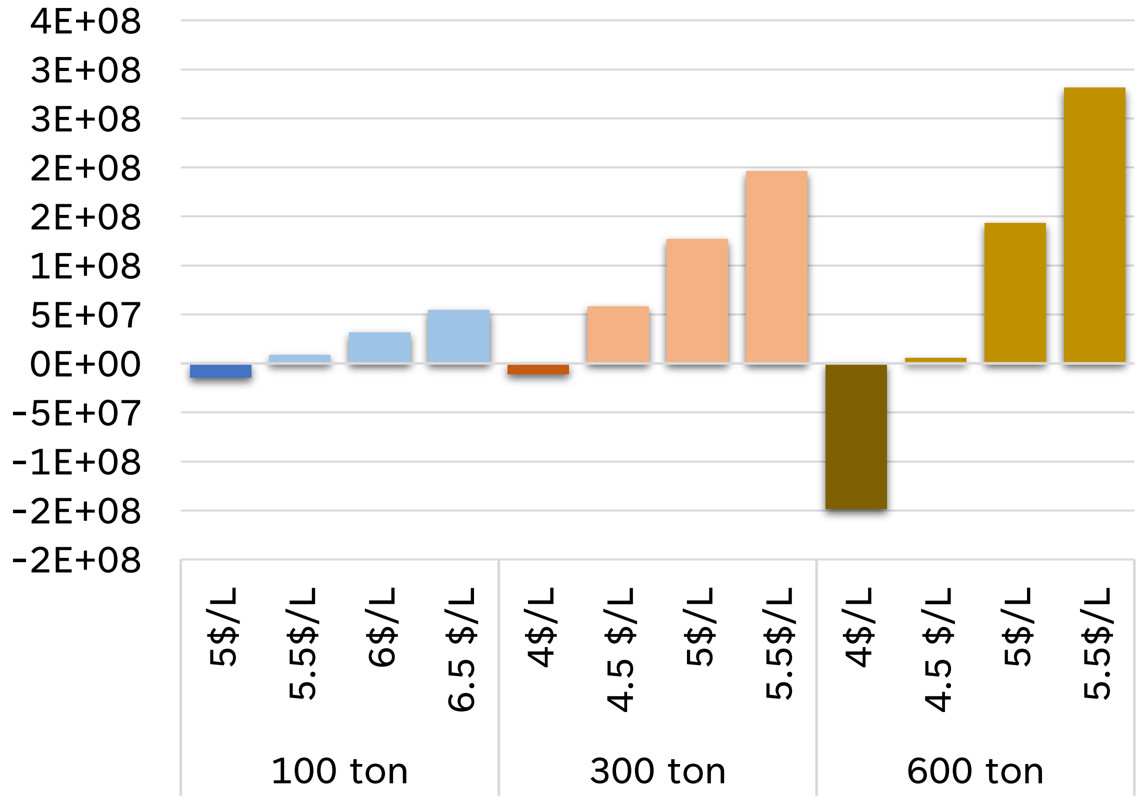
# Task 5.2: LCC results

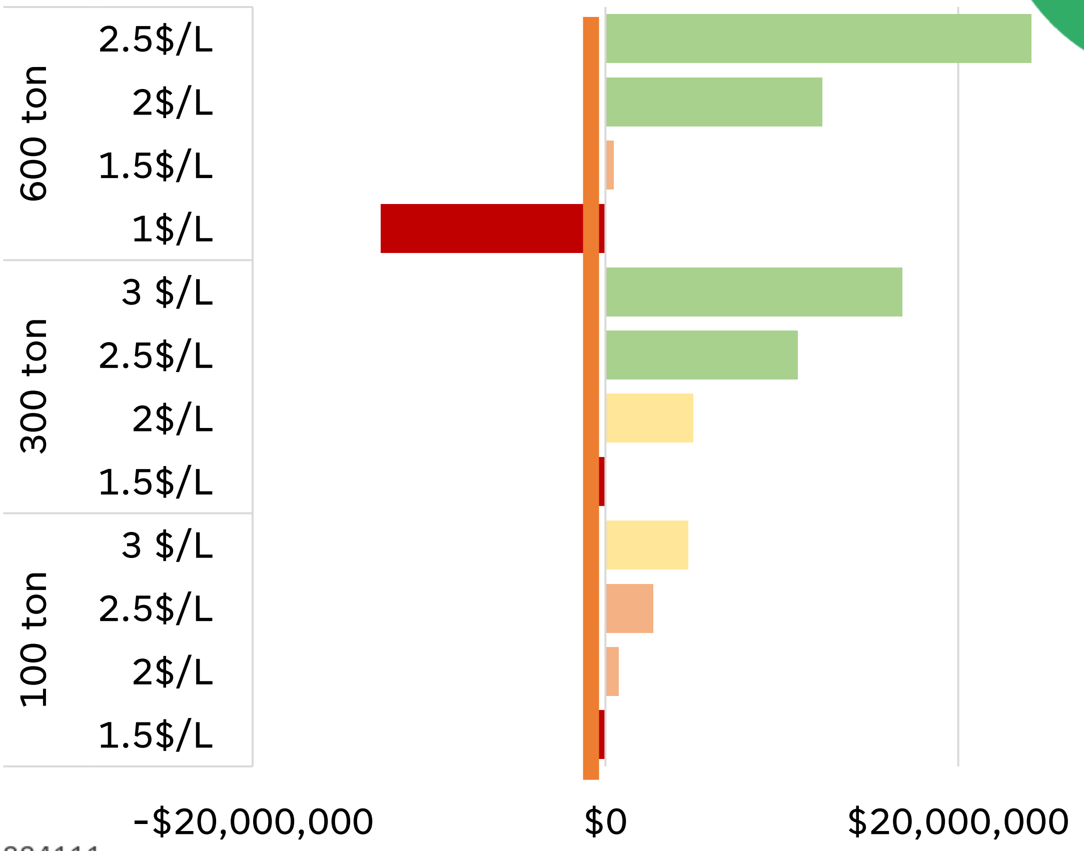
**CASE 3**

| Low | Medium | High |
|---|---|---|
| 100 ton/day | 300 ton/day | 600 ton/day |

## Net Present Value (NPV)




## Annualized NPV

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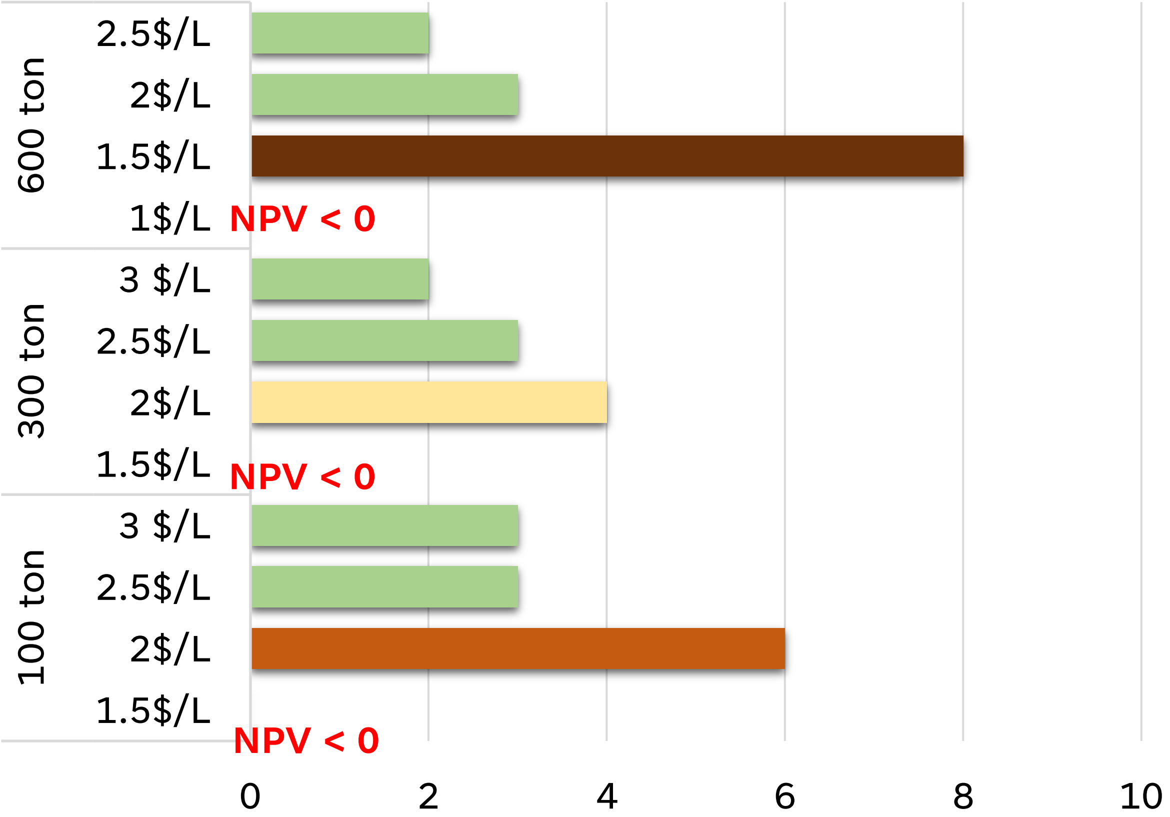
# Task 5.2: LCC results

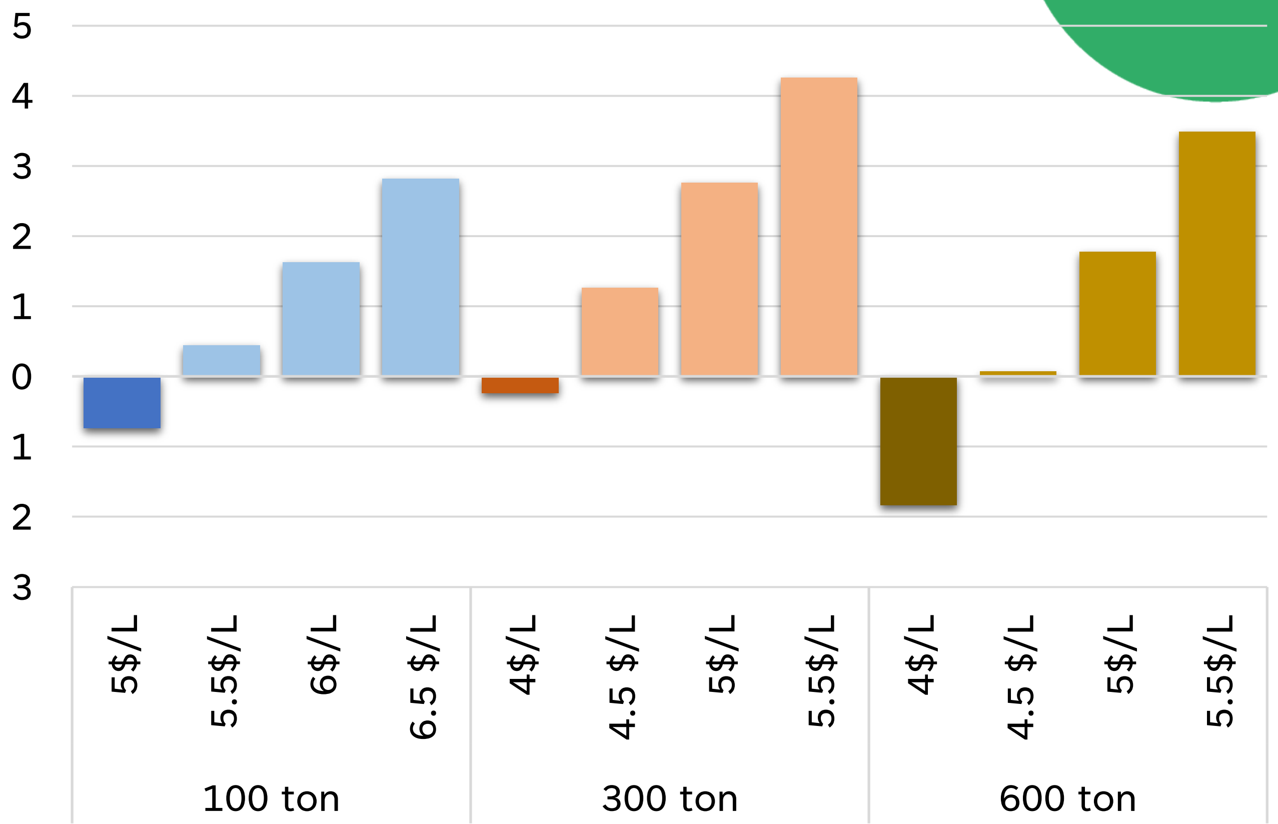
**CASE 3**

| **Low** | **Medium** | **High** |
|---|---|---|
| 100 ton/day | 300 ton/day | 600 ton/day |

Payback




Investment efficiency

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# **Task 5.2:** LCC results

## Net Present Value (NPV)

**High**

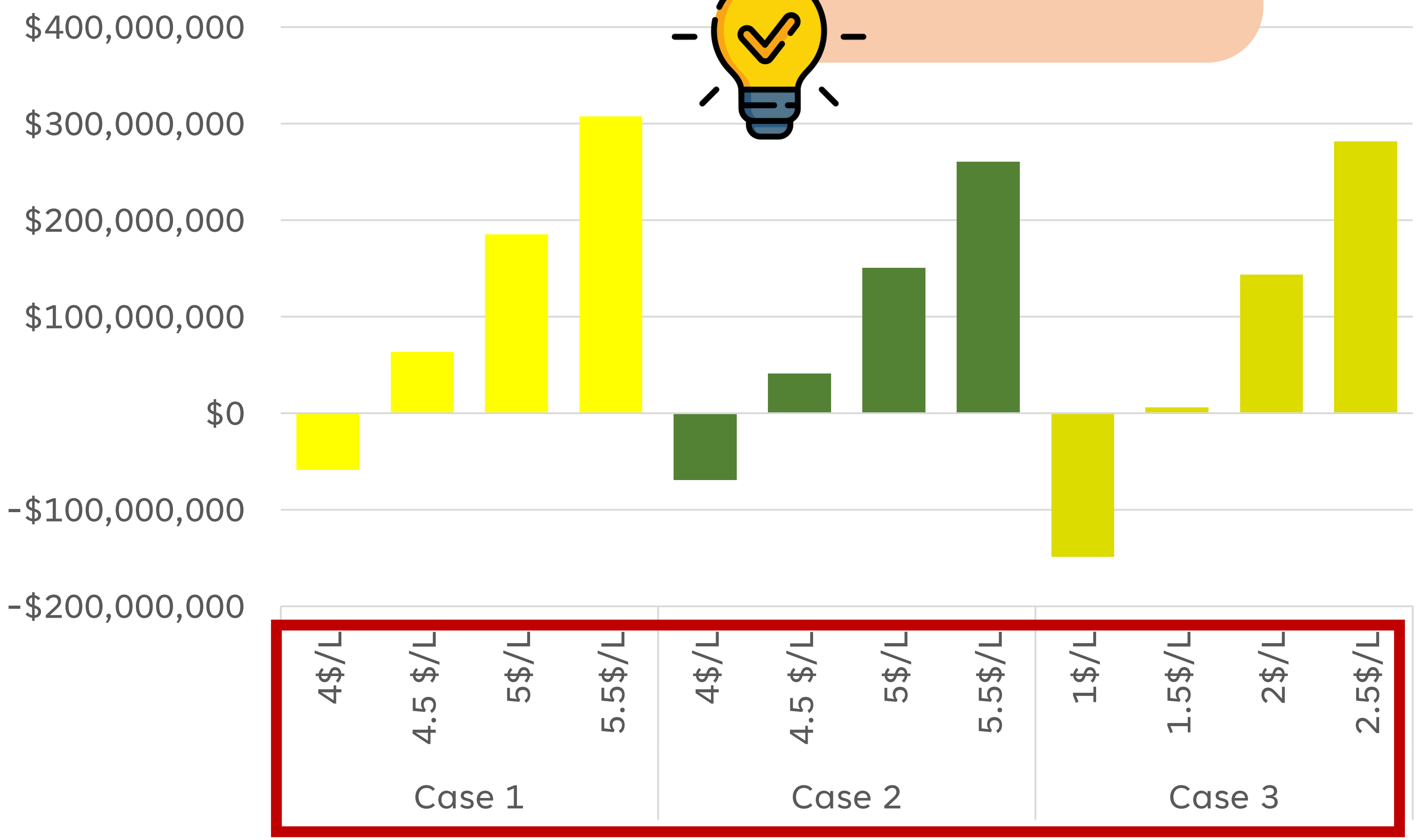
**600 ton/day**

**CASE 1**

**CASE 2**

**CASE 3**

Comparing **Case 1** and **Case 2, Case 1** provides higher benefits, it is more profitable




**Case 3** is the most profitable as it provides benefits from a biofuel selling price around 1.5$/L

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# **Task 5.3:** Circularity evaluation

**Analysis of various circularity indicators to assess the circular potential of the biocrude production**

| | CASE 1 | CASE 2 | CASE 3 |
|---|---|---|---|
| Circular process feedstock intensity | 9,41 | 8,27 | 7,11 |
| Mass of Raw materials | 0,20 | 0,16 | 0,17 |
| Mass of products+coproducts+recovered | 0,02 | 0,02 | 0,02 |
| Energy return on investment | 0,29 | 0,27 | 0,33 |
| Gross energy produced (30.5 MJ/kg), MJ) | 644 | 580 | 729 |
| Local energy inputs + upstream energy inputs (kW) | 2239 | 2154 | 2239 |
| Climate change impact of bio-oil | 1,66 | 1,84 | 1,47 |
| Gllobal warming potential (kg CO2 eq.) | 35,09 | 35,01 | 35,03 |
| kg of produced bio-oil | 21,10 | 19,00 | 23,90 |
| Critical raw materials of bio-oil | 0,55 | 0,60 | 0,43 |
| kg of CRM used | 11,58 | 11,47 | 10,22 |
| kf of procuded bio-oil | 21,10 | 19,00 | 23,90 |

**Case 3 is the one providing the best results**, as higher energy is produced, lower feedstock intensity is achieved, lower amount of Critical raw materials are required, and higher kg of bio-oil are produced

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# Thank you!

- WP Leader: Prof. Evina Katsou, Brunel University London (BUL)
- email: evina.katsou@brunel.ac.uk

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