SUSTAINABILITY INDICATORS FOR BIOBASED CHEMICALS: A DELPHI STUDY

Sophie Van Schoubroeck
icRS Beijing
28/06/2018

INTRODUCTION

CHEMICALS IN EUROPE

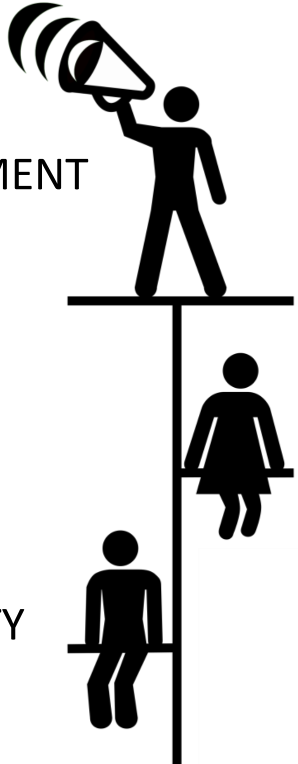
GREEN CHEMISTRY

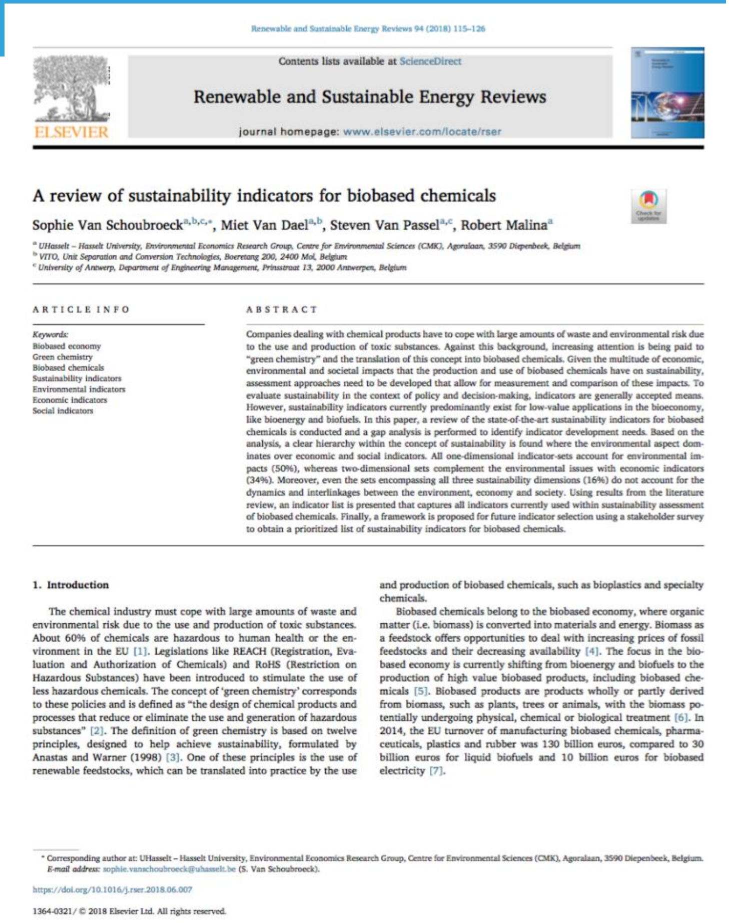
Increased sustainability?

BIOBASED CHEMICALS

→ A **systematic** and **interdisciplinary** assessment approach is needed

REVIEW STUDY





Renewable and Sustainable Energy Reviews 94 (2018) 115–126

Contents lists available at ScienceDirect

Renewable and Sustainable Energy Reviews

journal homepage: www.elsevier.com/locate/rser

A review of sustainability indicators for biobased chemicals

Sophie Van Schoubroeck[a,b,c,*], Miet Van Dael[a,b], Steven Van Passel[a,c], Robert Malina[a]

[a] UHasselt – Hasselt University, Environmental Economics Research Group, Centre for Environmental Sciences (CMK), Agoralaan, 3590 Diepenbeek, Belgium
[b] VITO, Unit Separation and Conversion Technologies, Boeretang 200, 2400 Mol, Belgium
[c] University of Antwerp, Department of Engineering Management, Prinsstraat 13, 2000 Antwerpen, Belgium

ARTICLE INFO

Keywords:
Biobased economy
Green chemistry
Biobased chemicals
Sustainability indicators
Environmental indicators
Economic indicators
Social indicators

ABSTRACT

Companies dealing with chemical products have to cope with large amounts of waste and environmental risk due to the use and production of toxic substances. Against this background, increasing attention is being paid to "green chemistry" and the translation of this concept into biobased chemicals. Given the multitude of economic, environmental and societal impacts that the production and use of biobased chemicals have on sustainability, assessment approaches need to be developed that allow for measurement and comparison of these impacts. To evaluate sustainability in the context of policy and decision-making, indicators are generally accepted means. However, sustainability indicators currently predominantly exist for low-value applications in the bioeconomy, like bioenergy and biofuels. In this paper, a review of the state-of-the-art sustainability indicators for biobased chemicals is conducted and a gap analysis is performed to identify indicator development needs. Based on the analysis, a clear hierarchy within the concept of sustainability is found where the environmental aspect dominates over economic and social indicators. All one-dimensional indicator-sets account for environmental impacts (50%), whereas two-dimensional sets complement the environmental issues with economic indicators (34%). Moreover, even the sets encompassing all three sustainability dimensions (16%) do not account for the dynamics and interlinkages between the environment, economy and society. Using results from the literature review, an indicator list is presented that captures all indicators currently used within sustainability assessment of biobased chemicals. Finally, a framework is proposed for future indicator selection using a stakeholder survey to obtain a prioritized list of sustainability indicators for biobased chemicals.

1. Introduction

The chemical industry must cope with large amounts of waste and environmental risk due to the use and production of toxic substances. About 60% of chemicals are hazardous to human health or the environment in the EU [1]. Legislations like REACH (Registration, Evaluation and Authorization of Chemicals) and RoHS (Restriction on Hazardous Substances) have been introduced to stimulate the use of less hazardous chemicals. The concept of 'green chemistry' corresponds to these policies and is defined as "the design of chemical products and processes that reduce or eliminate the use and generation of hazardous substances" [2]. The definition of green chemistry is based on twelve principles, designed to help achieve sustainability, formulated by Anastas and Warner (1998) [3]. One of these principles is the use of renewable feedstocks, which can be translated into practice by the use and production of biobased chemicals, such as bioplastics and specialty chemicals.

Biobased chemicals belong to the biobased economy, where organic matter (i.e. biomass) is converted into materials and energy. Biomass as a feedstock offers opportunities to deal with increasing prices of fossil feedstocks and their decreasing availability [4]. The focus in the biobased economy is currently shifting from bioenergy and biofuels to the production of high value biobased products, including biobased chemicals [5]. Biobased products are products wholly or partly derived from biomass, such as plants, trees or animals, with the biomass potentially undergoing physical, chemical or biological treatment [6]. In 2014, the EU turnover of manufacturing biobased chemicals, pharmaceuticals, plastics and rubber was 130 billion euros, compared to 30 billion euros for liquid biofuels and 10 billion euros for biobased electricity [7].

* Corresponding author at: UHasselt – Hasselt University, Environmental Economics Research Group, Centre for Environmental Sciences (CMK), Agoralaan, 3590 Diepenbeek, Belgium.
E-mail address: sophie.vanschoubroeck@uhasselt.be (S. Van Schoubroeck).

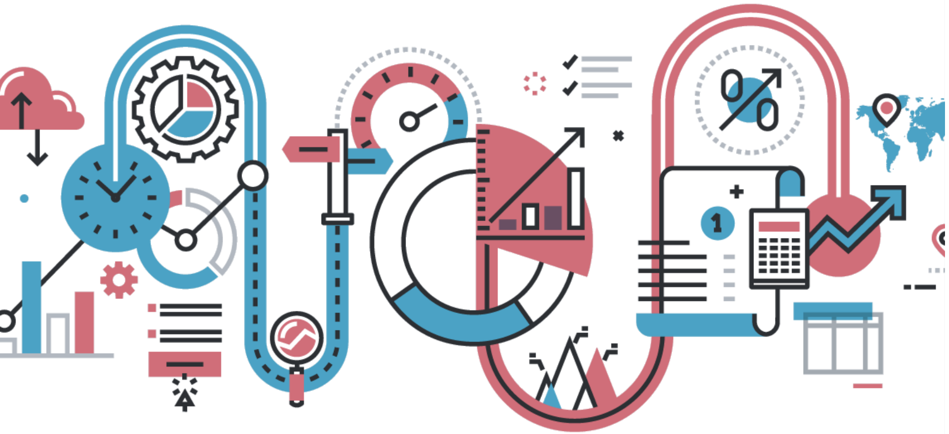
https://doi.org/10.1016/j.rser.2018.06.007

AIM OF THE STUDY

1. **Identify indicators** needed to evaluate sustainability of biobased chemicals

2. **Construct a ranking** of preferred sustainability indicators for biobased chemicals

➡ Sustainability tool



METHOD

DELPHI STUDY

Iterative feedback technique

Reach experts by e-mail

Aims for consensus

Different rounds

All over Europe

Indicators needed and preferred

DELPHI STUDY

ROUND 1

Aim: identify indicators

Open questions

71 experts

ROUND 2

Aim: rank indicators

Closed questions

46 experts

MaxDiff Exercise

MAXDIFF EXERCISE: EXAMPLE

BEST?		WORST?
☒		☐
☐		☐
☐		☒
☐		☐

MAXDIFF EXERCISE: ADVANTAGES

- ✓ Stimulate discrimination
- ✓ Easy for the respondents
- ✓ Reduce scale use bias

GOAL: to achieve preference scores for each sustainability indicator

MAXDIFF EXERCISE: ANALYSIS

Counting analysis

- ✓ Best / worst probability

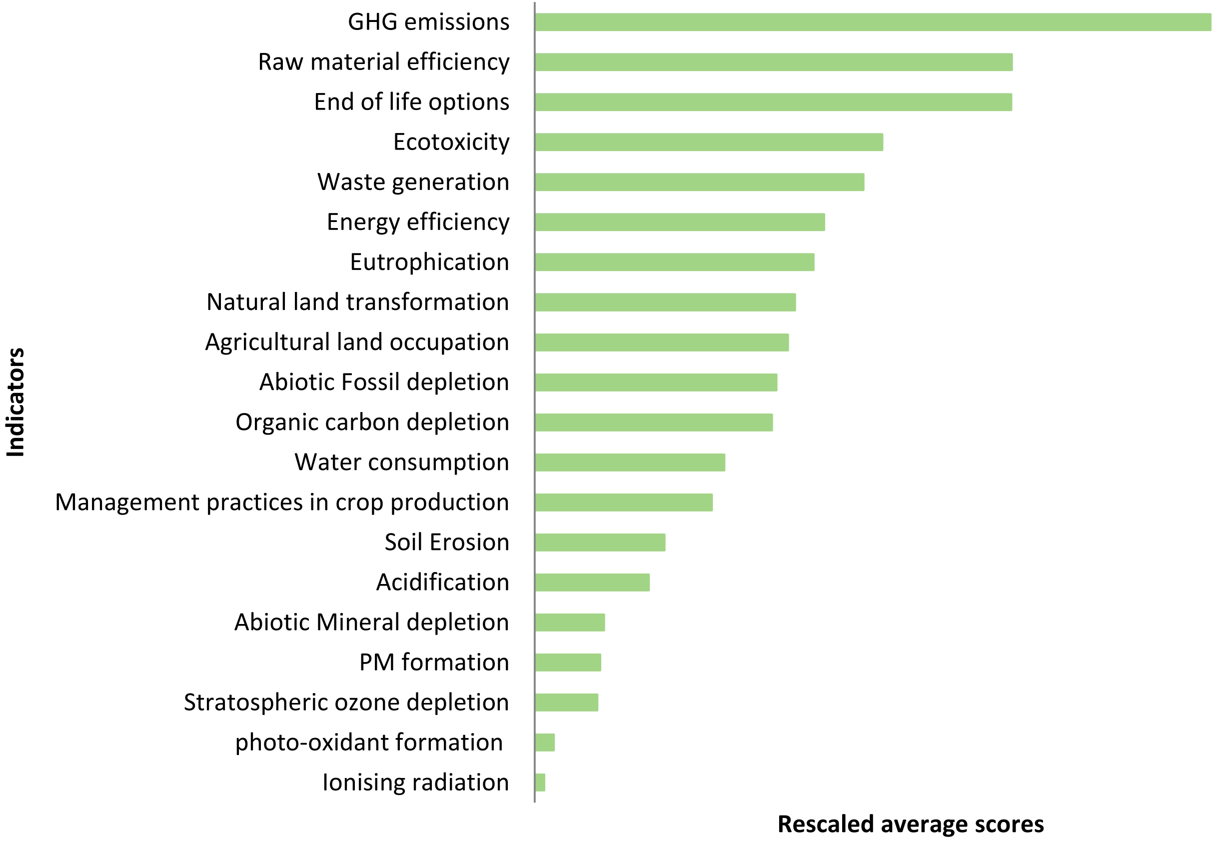
Hierarchical Bayes (HB)

- ✓ “Borrowing” information from other respondents
- ✓ Estimates a set of scores for reach respondent
- ✓ Iterative method (many iterations)

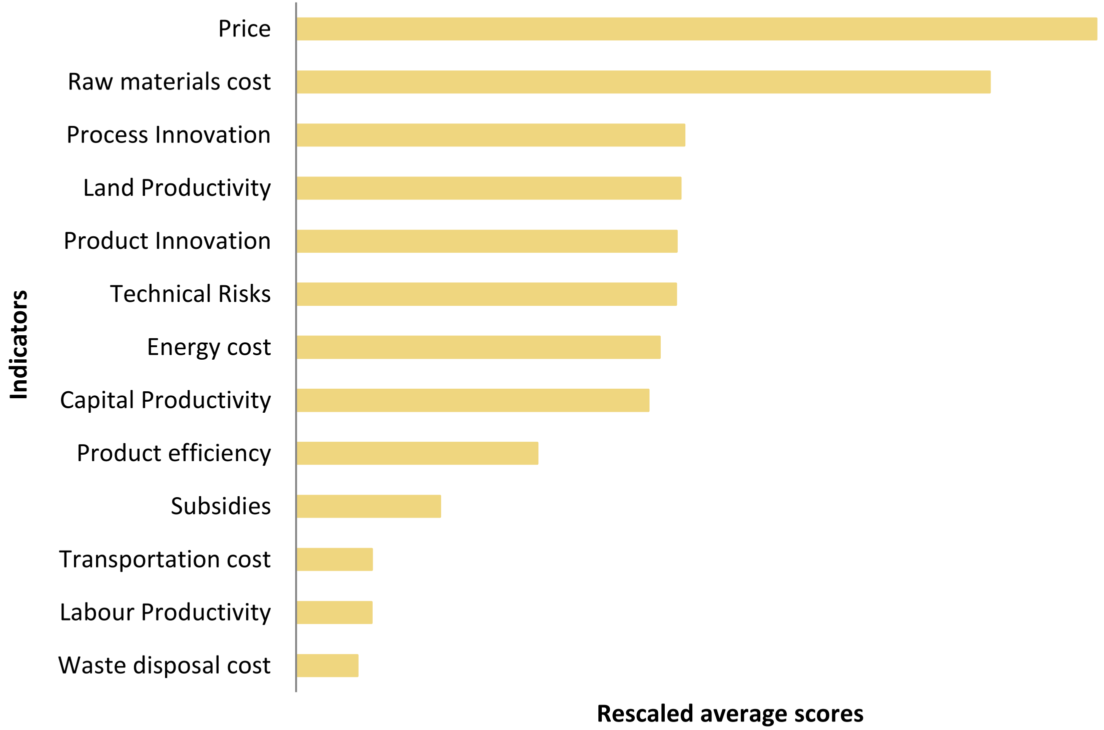
- ✓ Sawtooth software

RESULTS

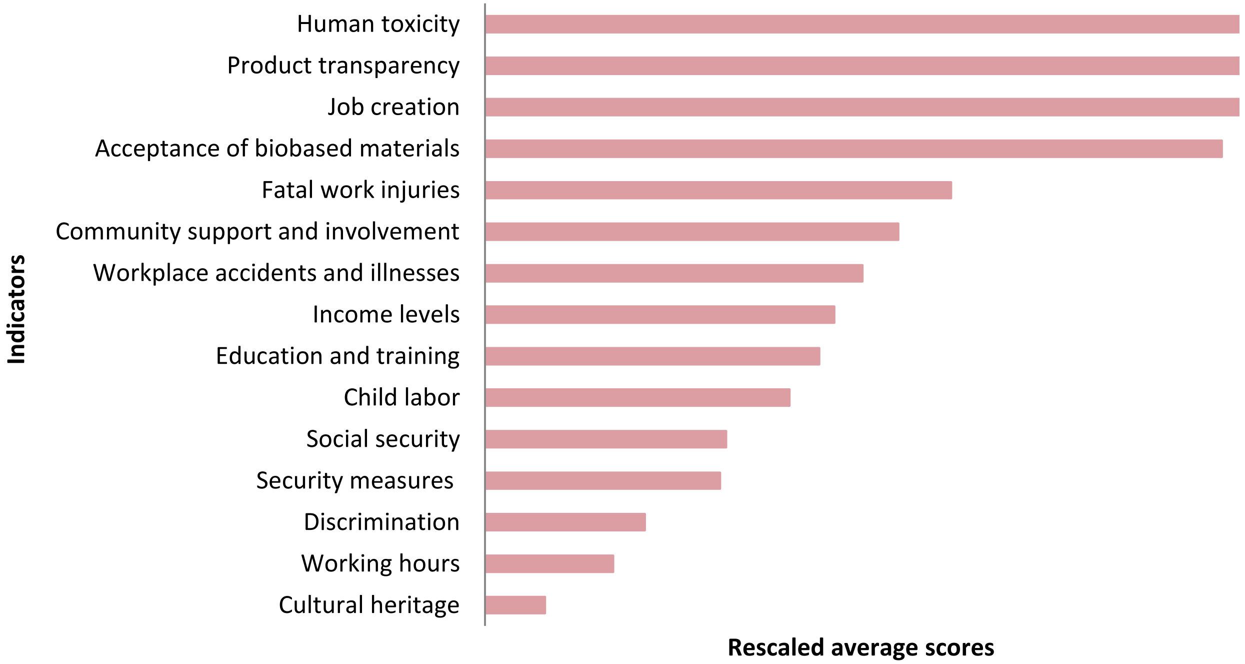
RESULTS: ENVIRONMENT

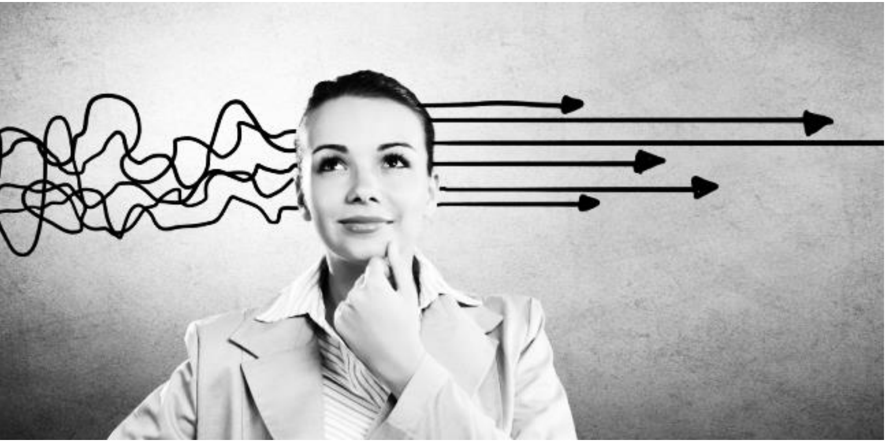


RESULTS: ECONOMY



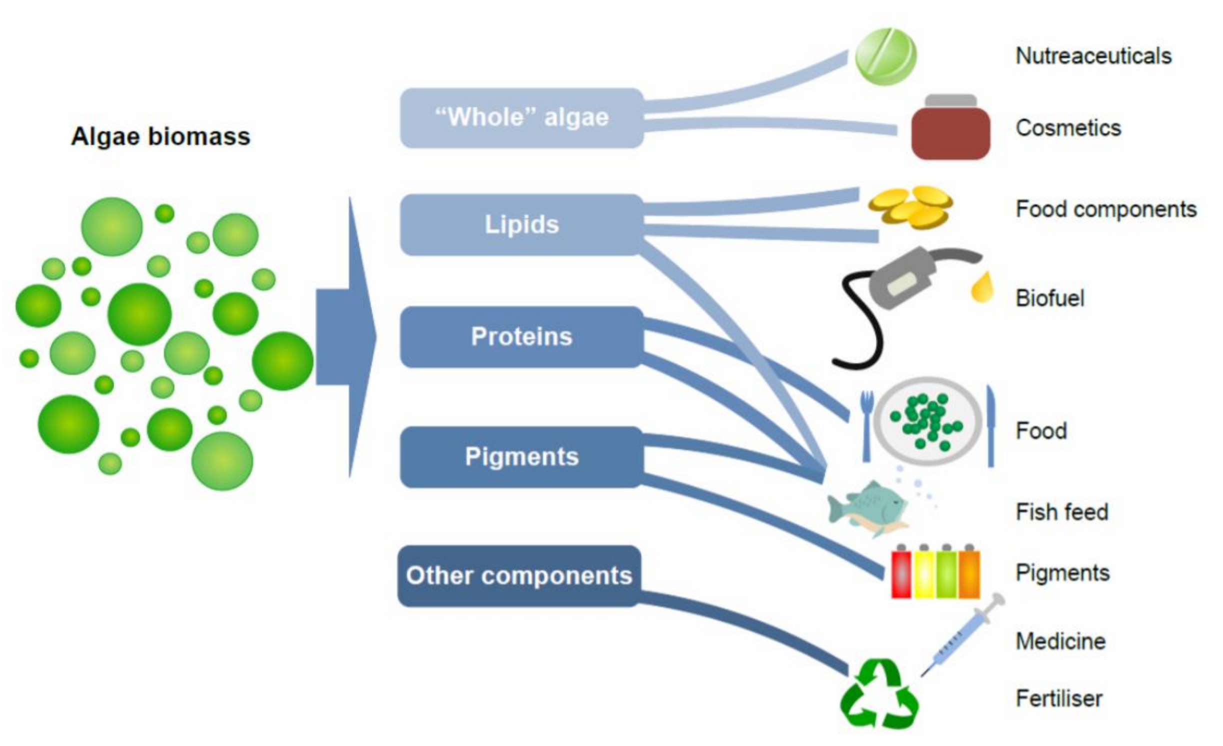
RESULTS: SOCIETY



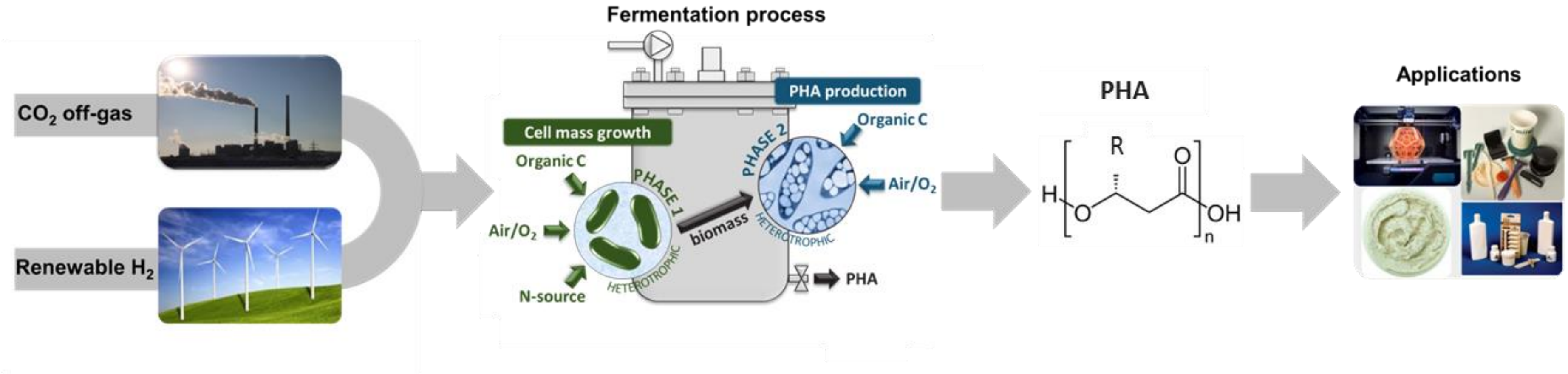


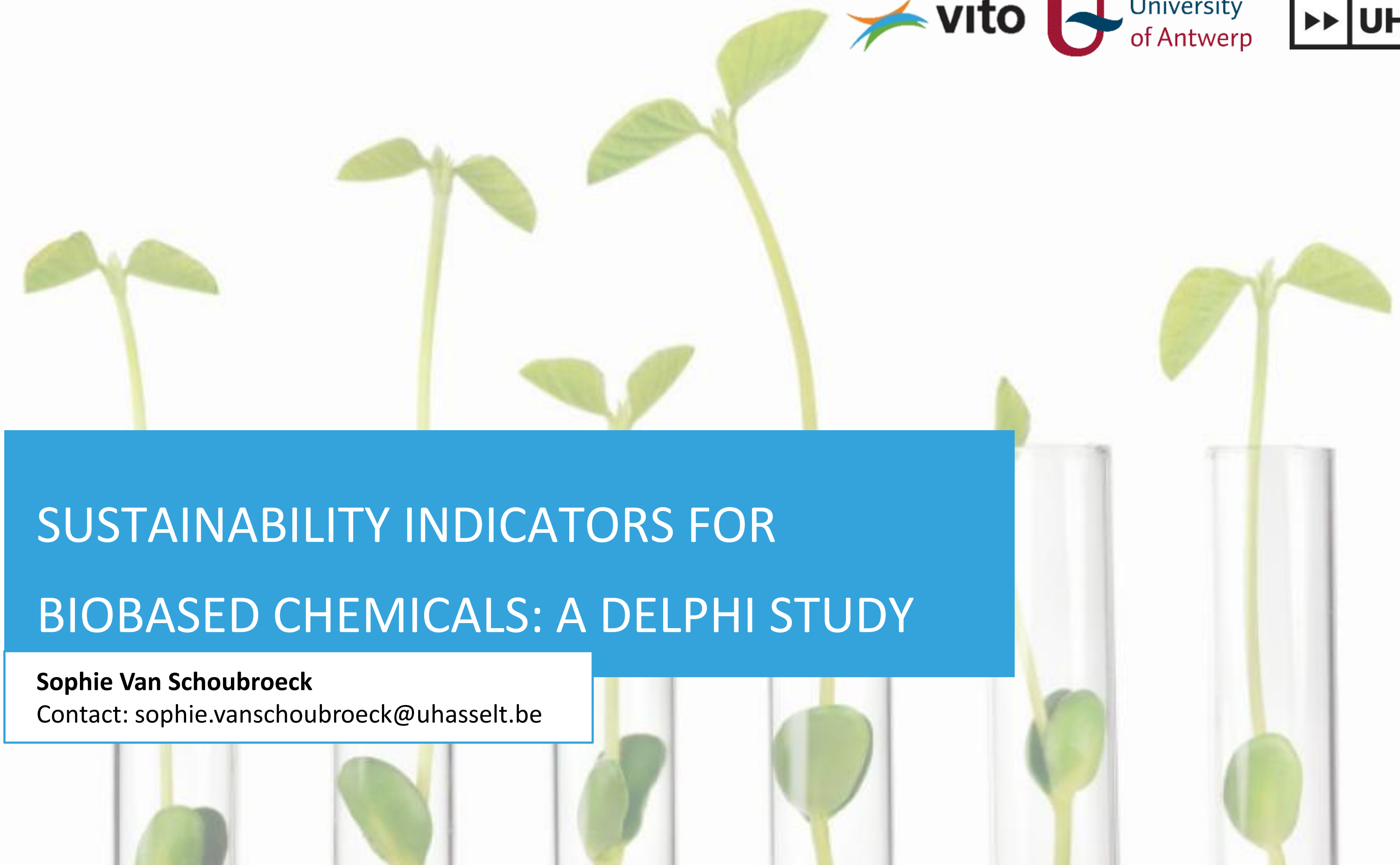
WORK IN PROGRESS

CASE 1: ALGAE BIOREFINERY



CASE 2: FROM CCU TO BIOPLASTICS





SUSTAINABILITY INDICATORS FOR BIOBASED CHEMICALS: A DELPHI STUDY

Sophie Van Schoubroeck
Contact: sophie.vanschoubroeck@uhasselt.be