# INDUSTRIAL SYMBIOSIS

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**URBAN METABOLISM COURSE – ACE155**

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# Learning outcomes

## ILO 1

explain critical aspects of sustainability for urban areas with focus on environmental impacts and resource constraints

## ILO 2

study urban socio-economic and technical systems in order to assess cities performance in relation to sustainable development

## ILO 3

make models of urban socio-economic and technical systems

## ILO 4

**suggest alterations to technical systems, technology, resource management and lifestyle that may promote an attractive livable city and enable efficient resource use**

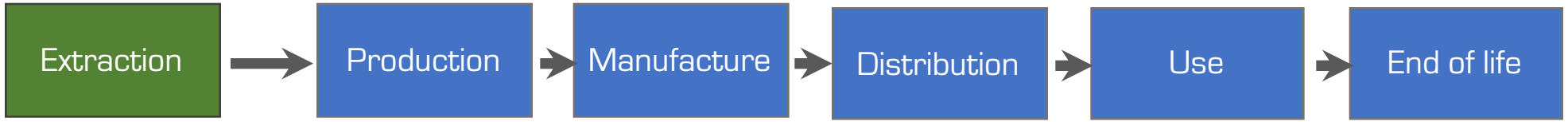
## ILO 5

simulate, estimate and evaluate the effect of suggested alterations on resource flows and environmental impact

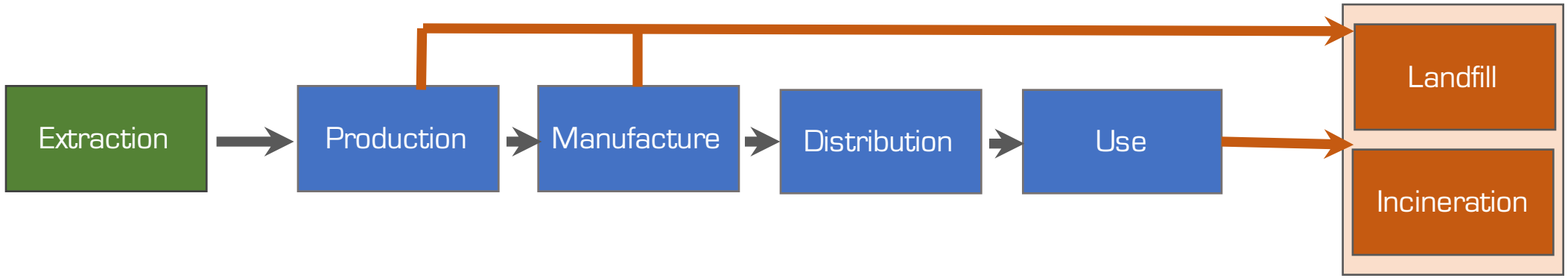
# OBJECTIVES

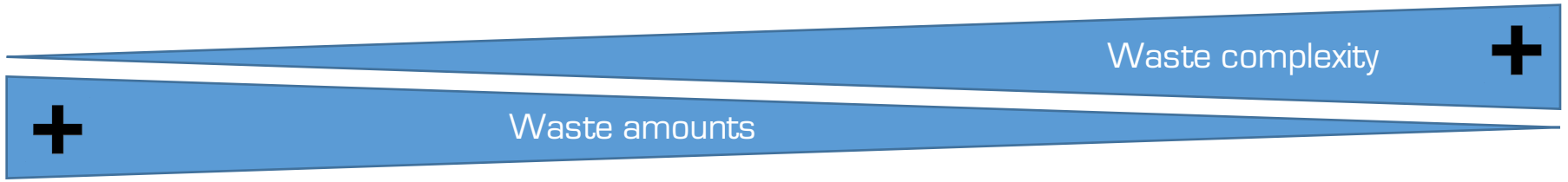
- Introduce the industrial symbiosis concept;
- Show examples of industrial symbiosis;
- Identify important factors for initiating an industrial symbiosis at regional level;
- Identify the steps for implementing an industrial symbiosis.

# SUPPLY CHAIN



# LINEAR ECONOMY



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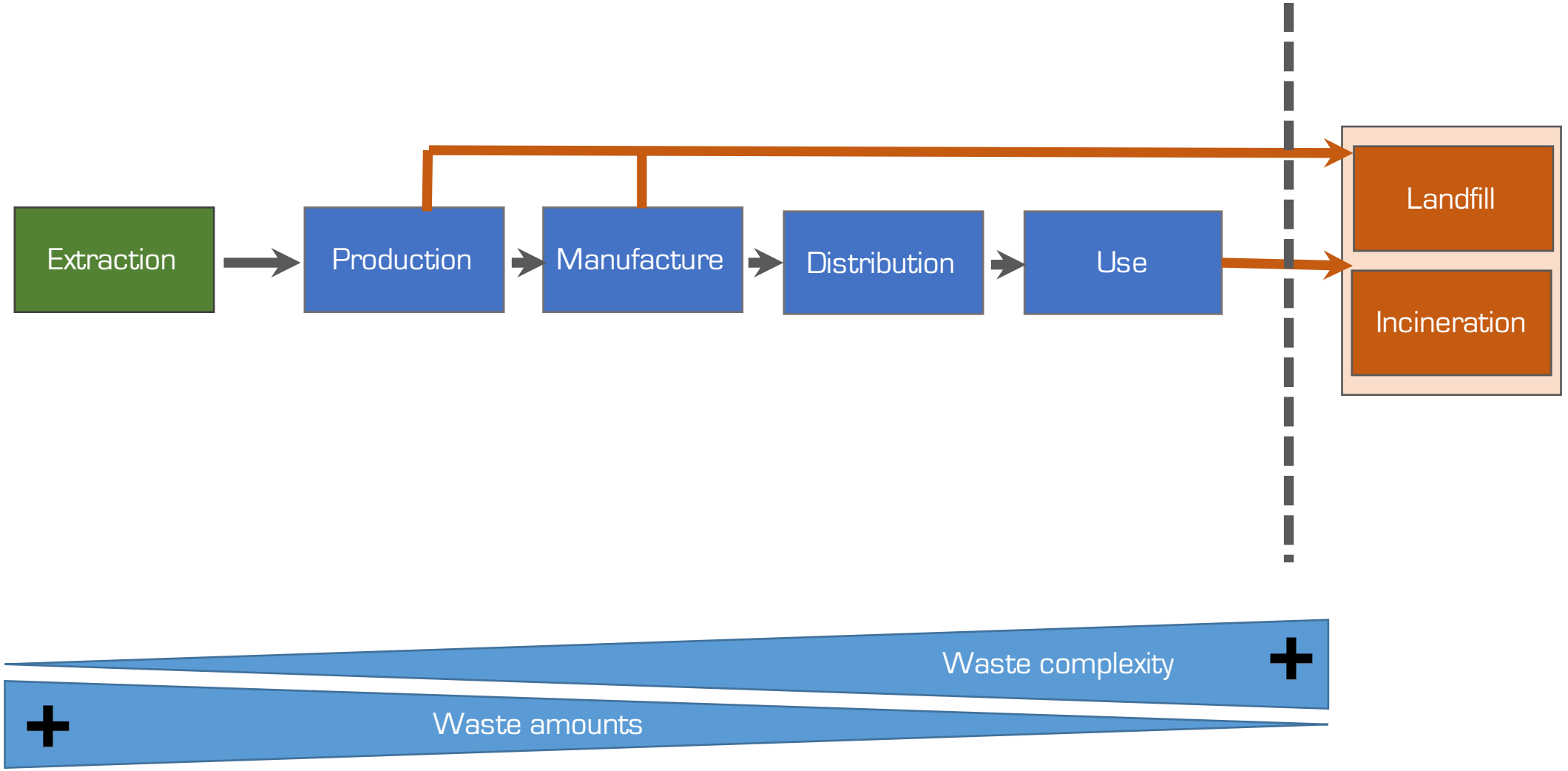
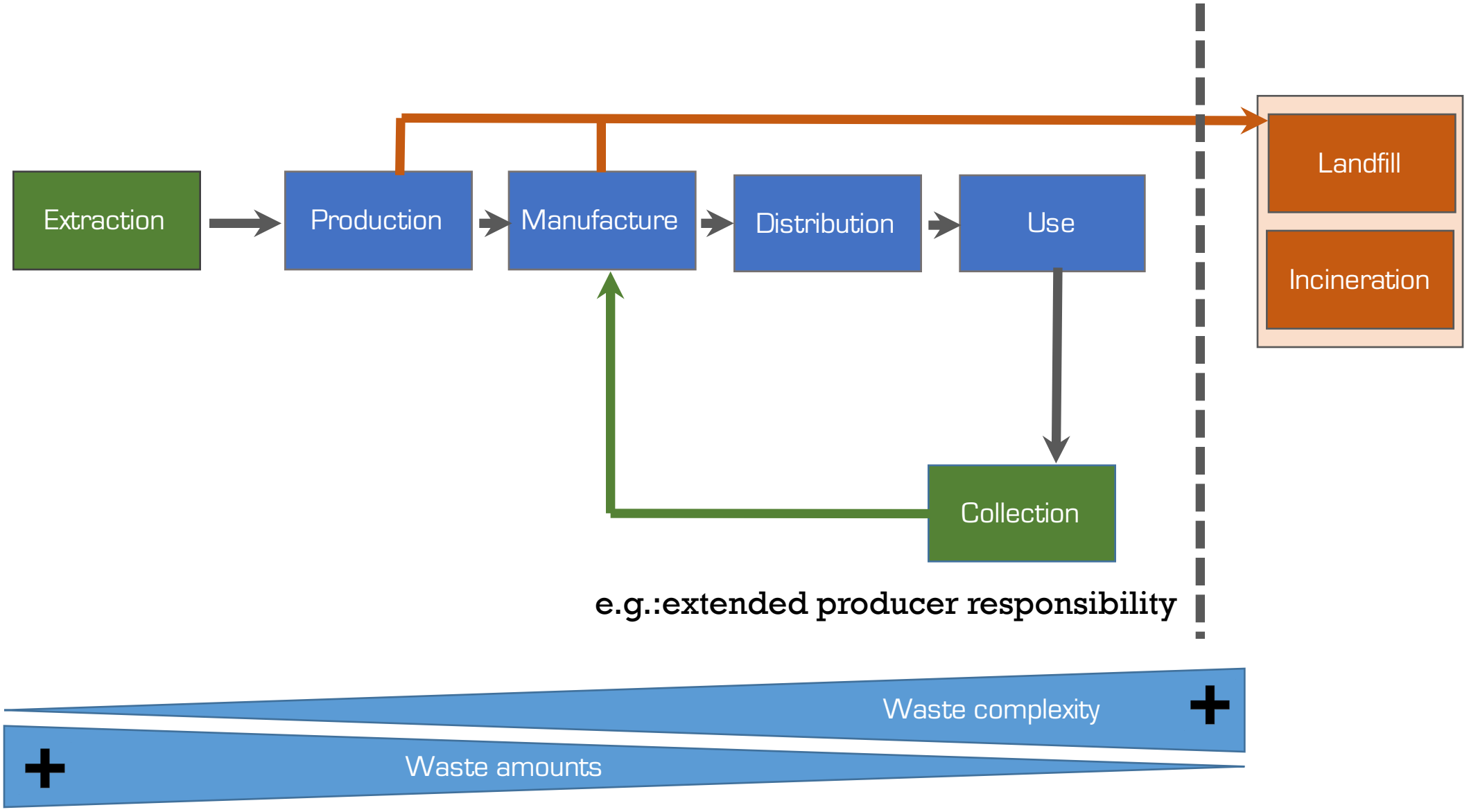


# CIRCULAR ECONOMY



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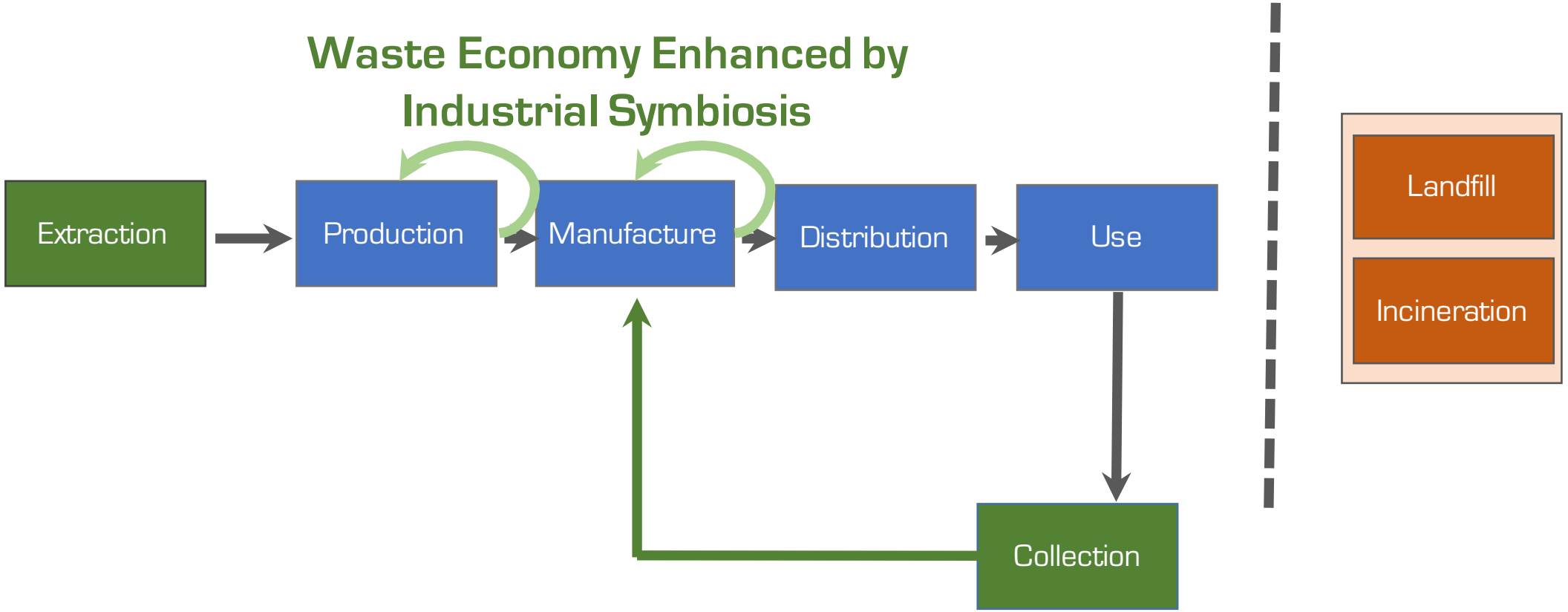
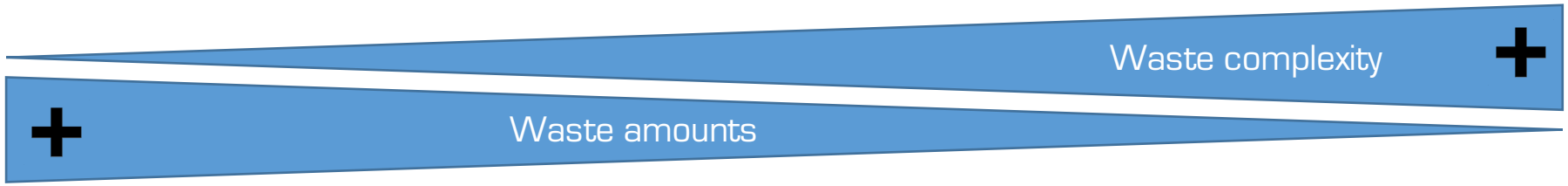


# COFFEE EXAMPLE

Second largest trade commodity in the world after petroleum.

Harvesting → Drying → Milling → Roasting → Grinding

100% — IN MASS TERMS — 0.2%

## Examples of solutions for the waste:

- Converting pulp into nutrient-rich compost
- Convert agriculture pulp into biogas
- Making tea from dried coffee (innovative process)
- Convert coffee pulp into Coffee Flour (innovative process)

Source: https://sustainableamerica.org

# SYMBIOSIS

Interaction between two different biological species.

# INDUSTRIAL SYMBIOSIS

Numerous academic definitions…

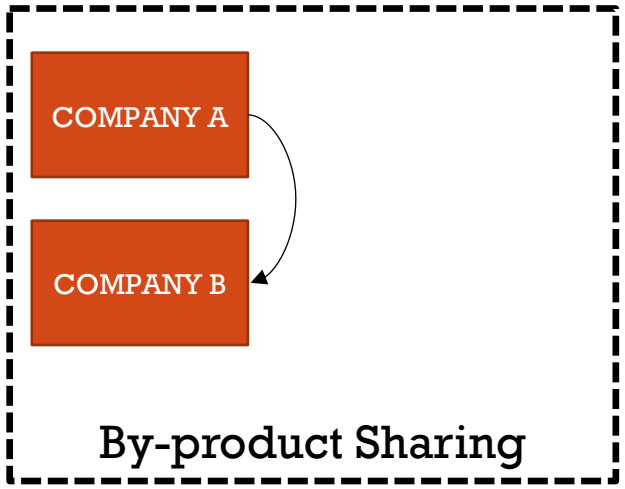
**In essence:**

"**inter-firm sharing**, which include physical exchanges of wastes, energy, water and by-products, or infrastructure and services sharing."

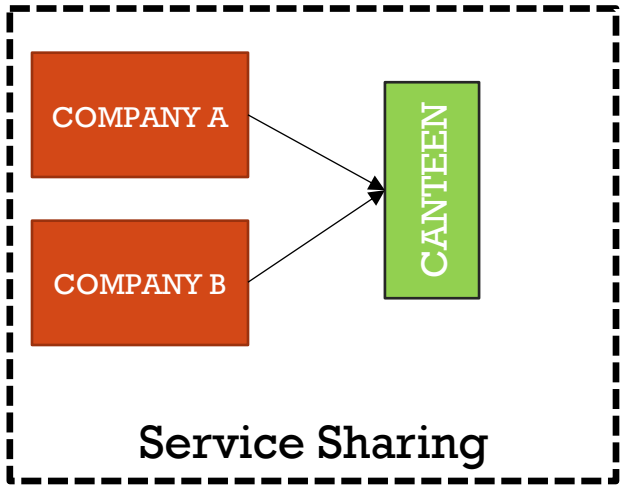
Source: "Uncovering" Industrial Symbiosis, Chertow 2007

# INDUSTRIAL SYMBIOSIS

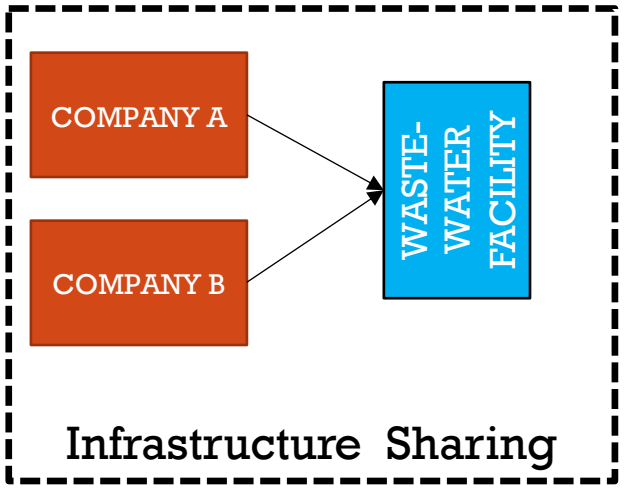
**TYPE 1**




**TYPE 2**




**TYPE 3**



# INDUSTRIAL SYMBIOSIS IN THE EUROPEAN UNION

Industrial symbiosis has gradually been recognized by the European Union as a **tool to promote sustainable growth and resource efficiency**

In 2012, industrial symbiosis was defined as one of the **seven top priority areas** by the European Resource Efficiency Platform (Johnsen et al., 2015).

**"Improve resource efficiency in business–to-business relations "**

Full report:
http://ec.europa.eu/environment/resource_efficiency/documents/erep_manifesto_and_policy_recommendations_31-03-2014.pdf

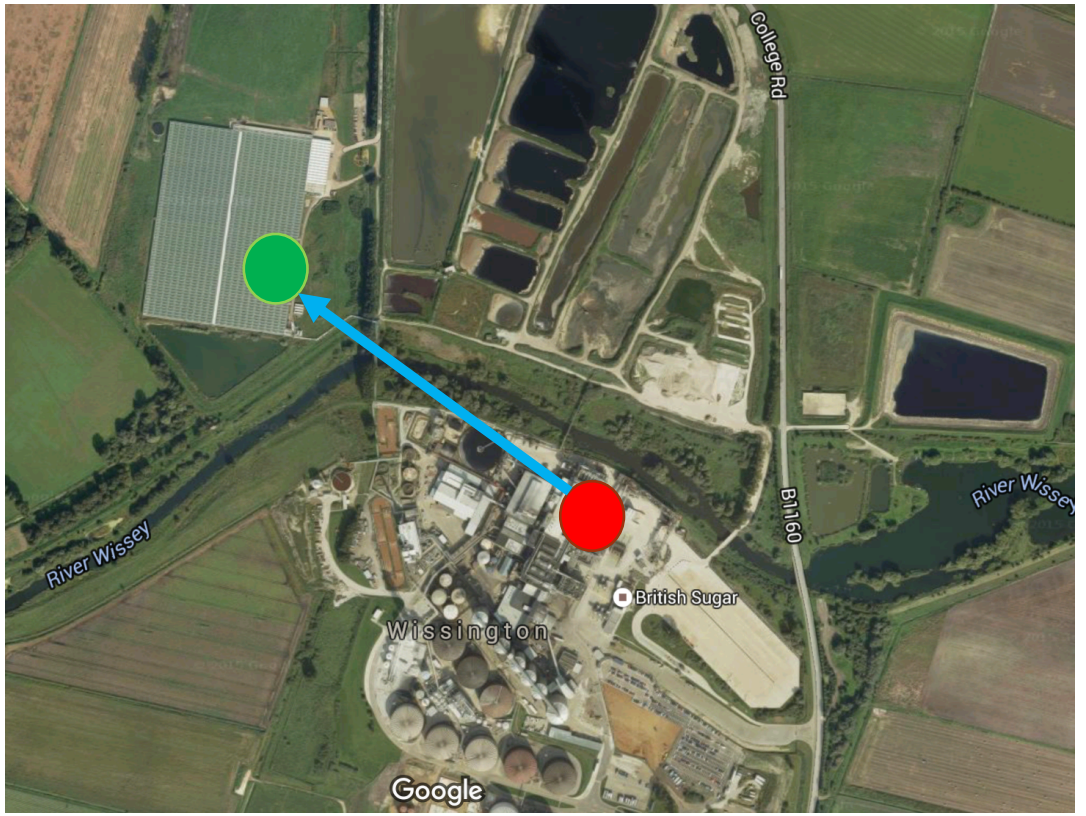
# INDUSTRIAL SYMBIOSIS EXAMPLES

# INDUSTRIAL SYMBIOSIS – EXAMPLE 1

## Sugar factory and a Greenhouse
## Location: Norfolk  in the United Kingdom

- **Waste heat** and **carbon dioxide** are transported to a greenhouse (18 hectares).

- Natural agents are used to **pollinate the crop - over 8,500 bees.**
- More than **115 million litters of rainwater** is annually collected on the roof.



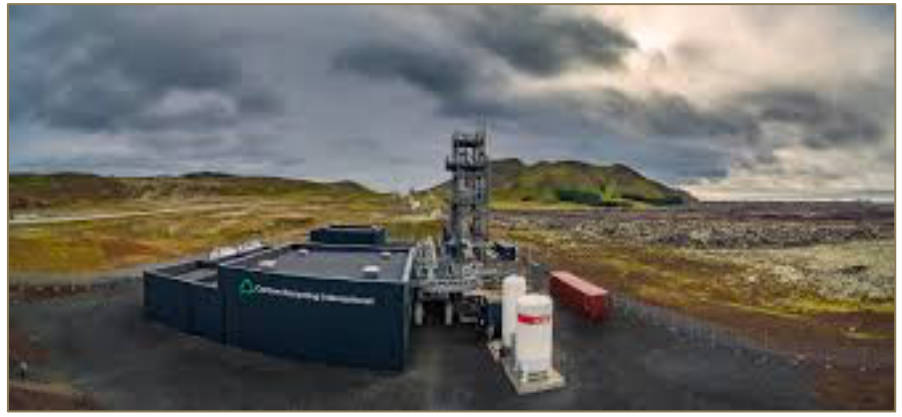

Source: https://core.ac.uk/download/pdf/42339002.pdf

# INDUSTRIAL SYMBIOSIS – EXAMPLE 2

Source: Carbon Recycling International (CRI)


Geothermal Plant

Carbon Dioxide



Methanol Plant

**Methanol production:** 5 million liters a year
**Carbon dioxide utilization:** 5.5 thousand tones per a year
**Energy Sources:** hydro and geothermal sources

# INDUSTRIAL SYMBIOSIS – EXAMPLE 3

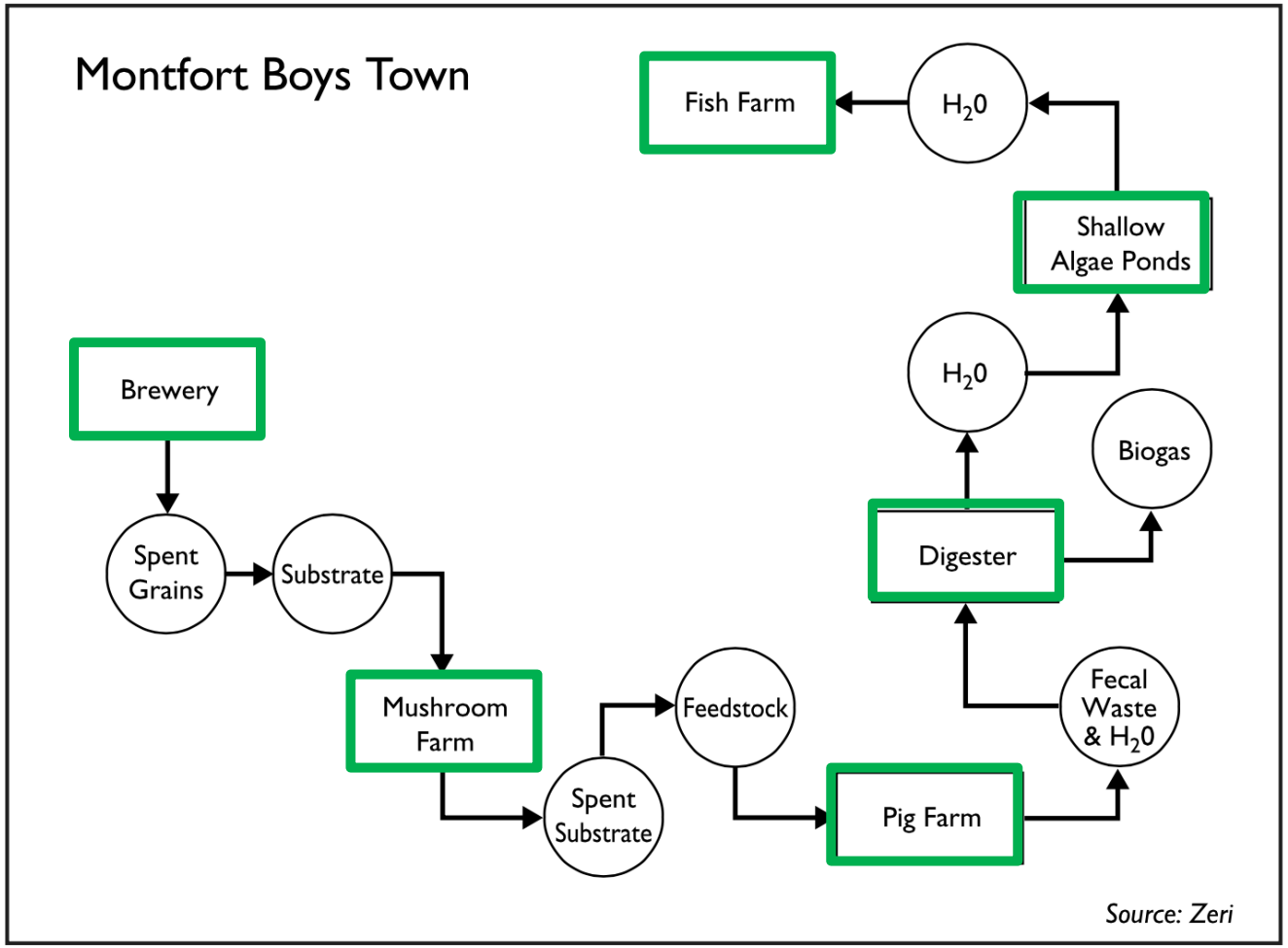
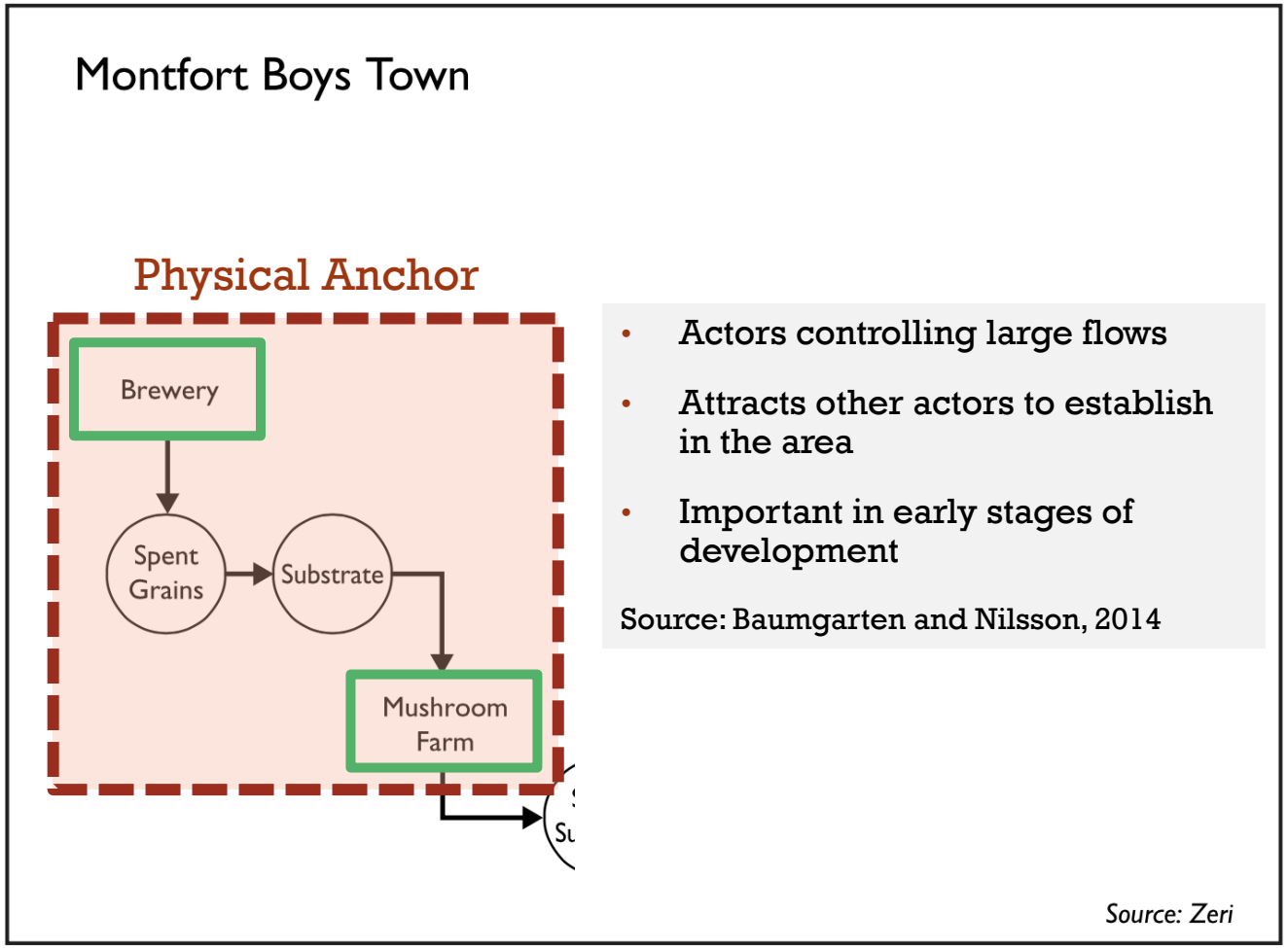



Figure 2 A Model IBS (Montfort Boys' Town, Suva, Fiji)

Source: Hardy, 2000 – Integrated Bio-Systems: Mushrooming Possibilities 2000

# INDUSTRIAL SYMBIOSIS – EXAMPLE 3

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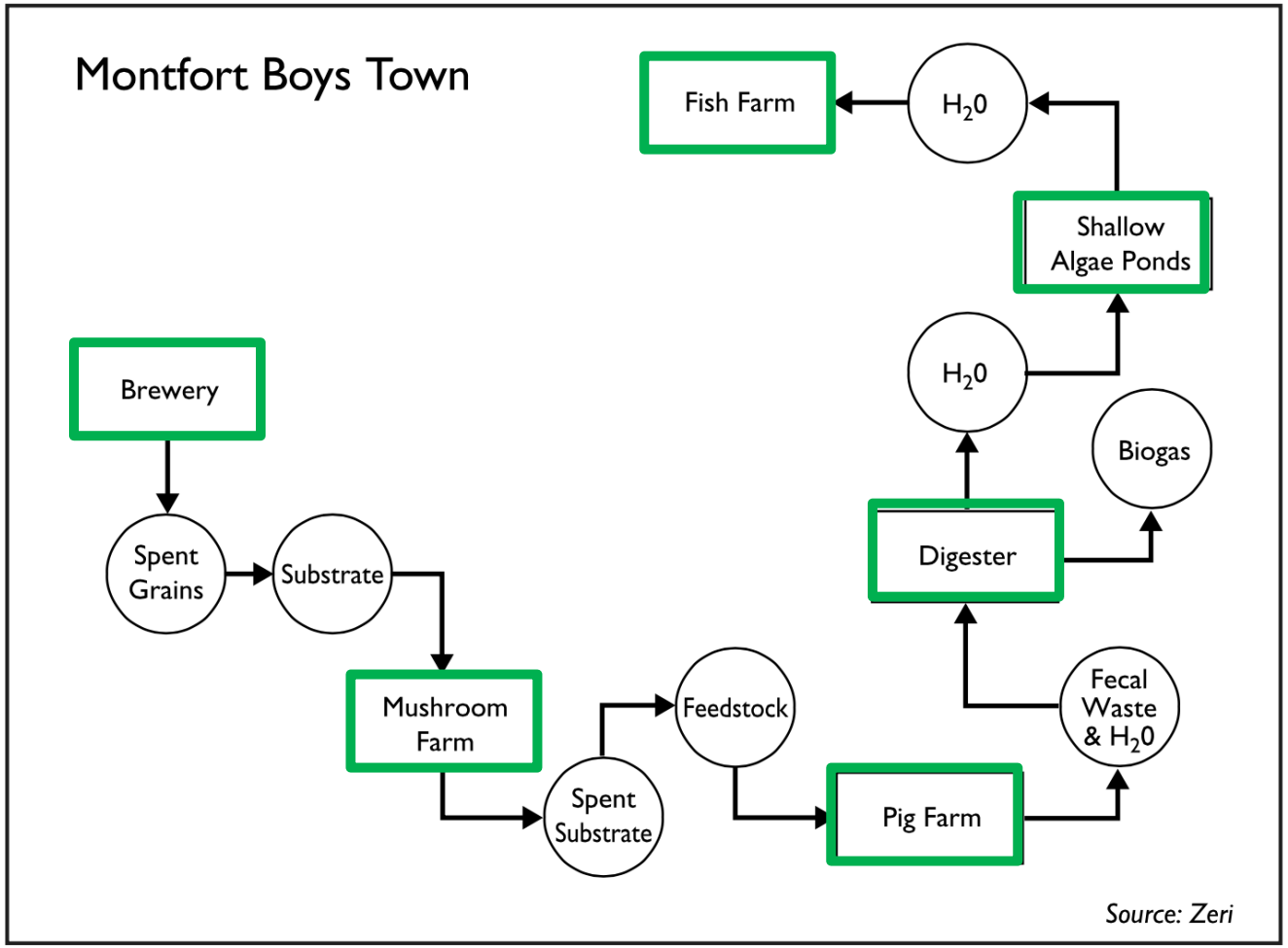
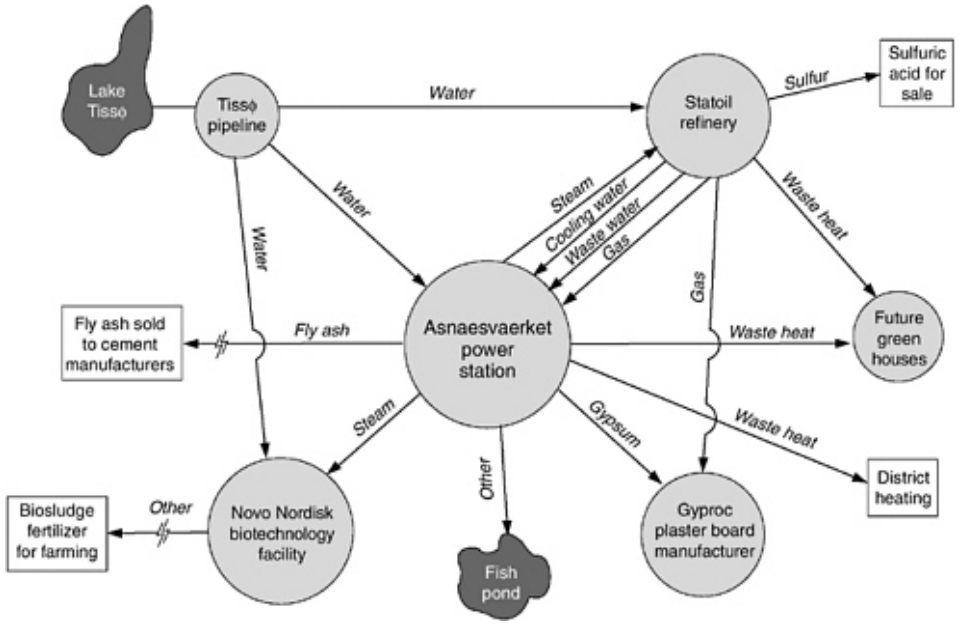



Figure 2 A Model IBS (Montfort Boys' Town, Suva, Fiji)

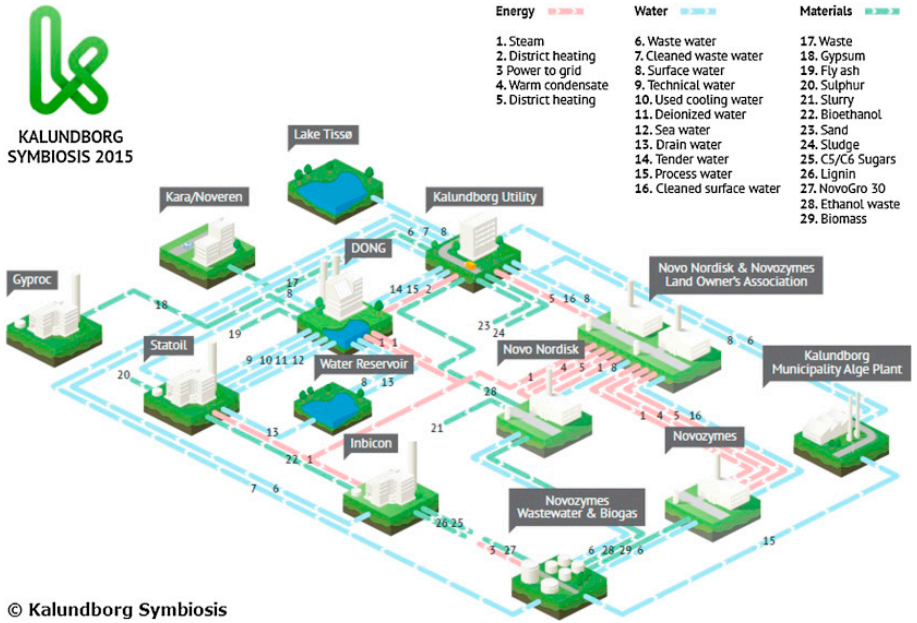
Source: Hardy, 2000 – Integrated Bio-Systems: Mushrooming Possibilities 2000

# INDUSTRIAL SYMBIOSIS – EXAMPLE 4




1993

Source: https://www.nap.edu



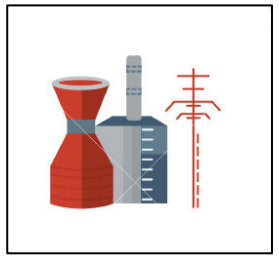

2019

Source:http://www.symbiosis.dk/en/

# Exercise

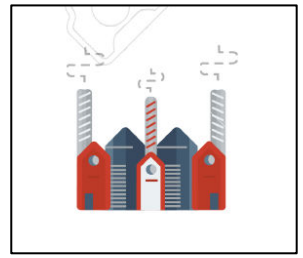
With your neighbor, come up with one separate example of industrial symbiosis that includes at least a company from the following industrial sectors:

- 1. Agriculture sector
- 2. Food processing sector
- 3. Wood Industry sector



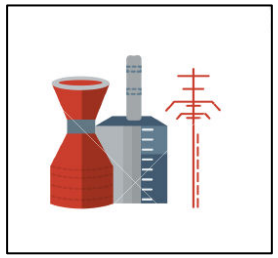
Donor

SHARING?



Receiver

# AGRICULTURE



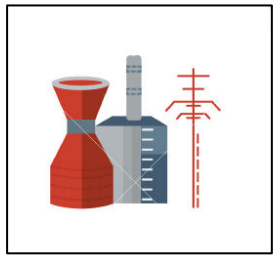
Farm

Mushrooms
Leftovers

Pig raising


Mushrooms sauce

# WOOD INDUSTRY

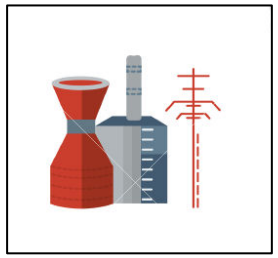


Sawmill

Sawdust

Plywood

# FOOD PROCESSING



Cheese industry

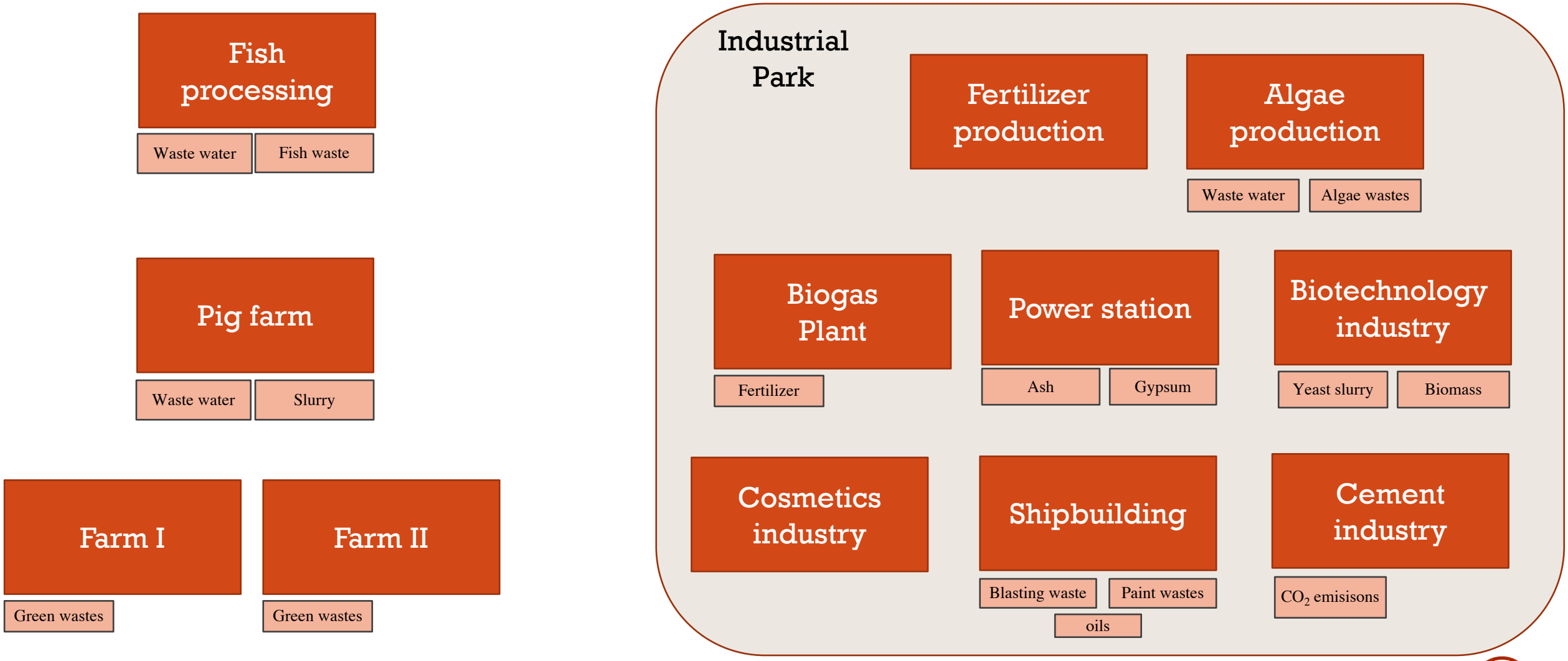

Whey


Protein shakes

# Exercise

In groups of three, suggest industrial symbiosis partnerships that could be implemented in the following system:

# INDUSTRIAL SYMBIOSIS EXERCISE

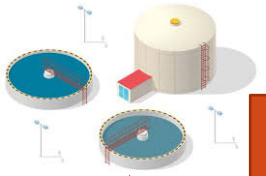


# INDUSTRIAL SYMBIOSIS EXERCISE

Fish processing

Waste water

Fish waste



Pig farm

Waste water

Slurry

Farm I

Farm II

Green wastes

Green wastes

Industrial Park

Fertilizer production

Algae production

Waste water

Algae wastes

Biogas Plant

Fertilizer

Power station

Gypsum

Ash

Biotechnology industry

Yeast slurry

Biomass

Cosmetics industry

Shipbuilding

Paint wastes

Blasting waste

oils

Cement industry

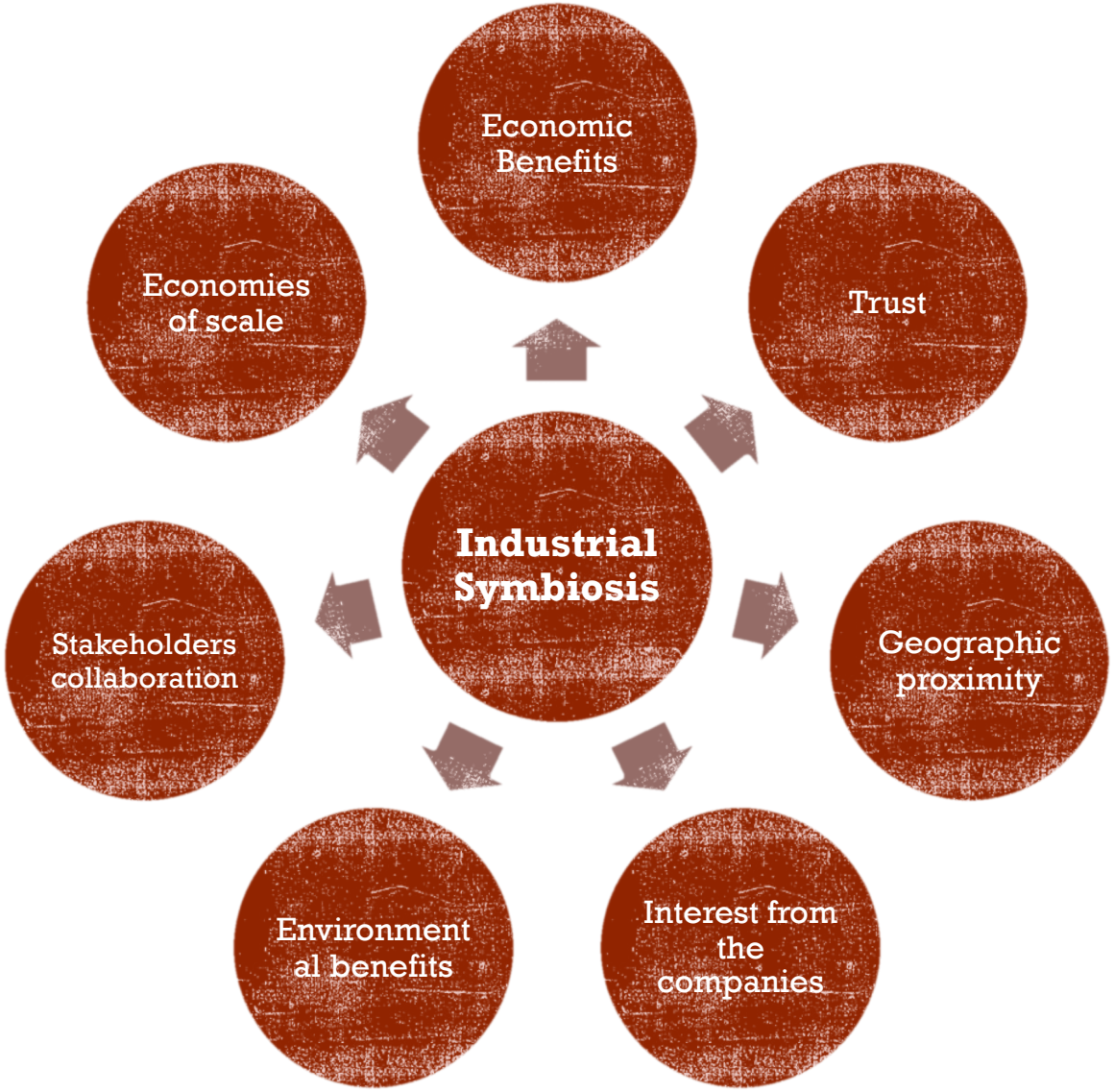
$CO_2$ emisisons

# Discussion

Discuss factors that may be important to make possible industrial symbiosis partnerships.

Use the previous linkages to give examples, if necessary.

# IMPORTANT FACTORS FOR INITIATING INDUSTRIAL SYMBIOSES



# INDUSTRIAL SYMBIOSIS IMPLEMENTATION

# IS IMPLEMENTATION STEPS


Source: FISSAC, 2016

# IS IMPLEMENTATION STEPS


SWOT analysis
Cost Benefit Analysis
LCA
Barrier Assessment
Network Strength Analysis
…

Source: FISSAC, 2016

# INDUSTRIAL SYMBIOSIS ASSESSMENT

# Discussion

Identify the main benefits of implementing an industrial symbiosis partnership.

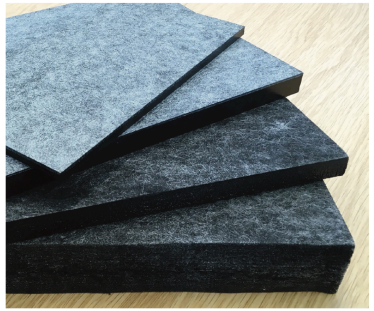
# INDUSTRIAL SYMBIOSIS BENEFITS

- **Economical**
  - New business opportunity
  - Reduce waste management costs
  - Green marketing
- **Environmental**
  - Less waste disposed
  - Less virgin material used
  - Less air emissions
- **Social benefits**
  - Jobs creation
  - Trust among companies

294,000 tonnes of textile → 44,100 tonnes of post-production textile waste

Reading suggestion: TransTextile, an interdisciplinary innovation project that addresses the textile waste issues in Sri Lanka

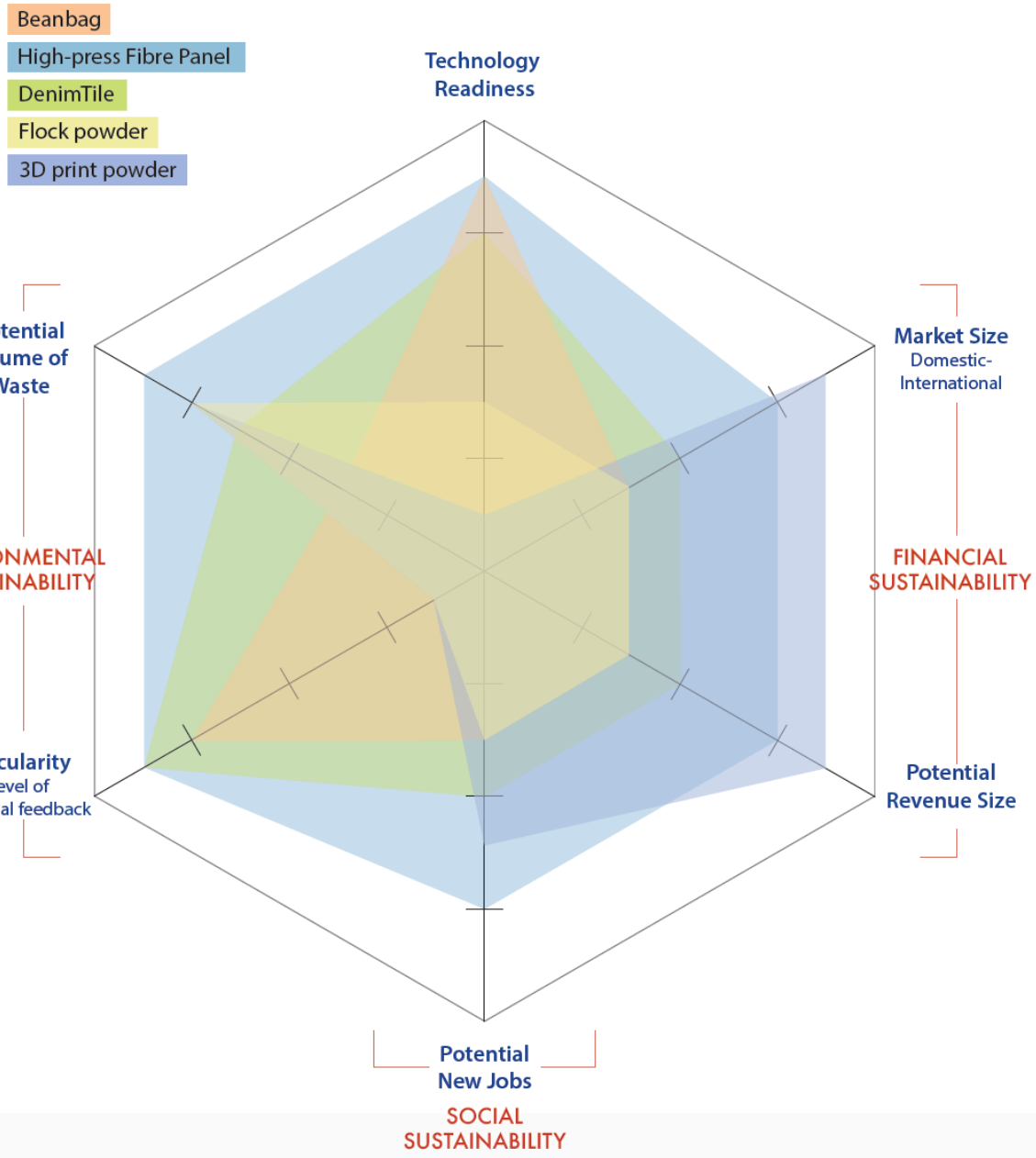
Beanbag



High-press fibre panel

DenimTile

Flock powder

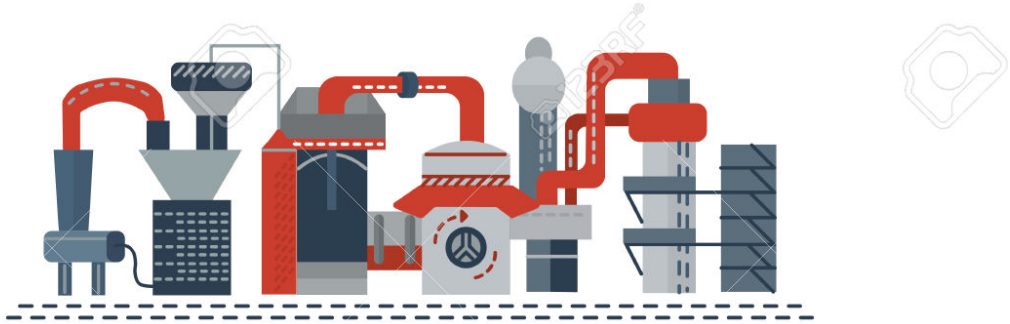



Source: TransTextile

3D print powder

# IDENTIFYING INDUSTRIAL SYMBIOSIS USING TOP DOWN APPROACHS

# PREDICTING INDUSTRIAL WASTE

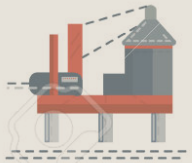
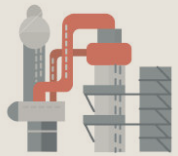
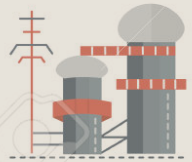


Industry Sectors Waste Profiles

***Common wastes that industry produce***

# PREDICTING INDUSTRIAL WASTE

## Industry Sectors Waste Profiles

| |  sawmilling |  bread/fresh pastry goods |  metals industry |  communication equipment |
|---|---|---|---|---|
| Food waste | | ■ ■ ■ | | ■ |
| Metals waste | ■ | | ■ ■ ■ | ■ |
| Wood waste | ■ ■ | | | ■ |
| Paper waste | ■ | ■ | ■ | ■ |

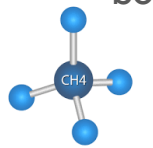
# PREDICTING INDUSTRIAL WASTE

BIOGAS

Source: 123rf.com

## Industry Sectors Waste Profiles

| | sawmilling | bread/fresh pastry goods | metals industry | communication equipment |
|---|---|---|---|---|
| Food waste | | ■ ■ ■ | | ■ |
| Metals waste | ■ | | ■ ■ ■ | ■ |
| Wood waste | ■ ■ | | | ■ |
| Paper waste | ■ | ■ | ■ | ■ |




Methane Yield

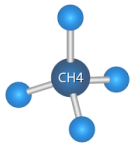
**(mL/g wet basis)**

824

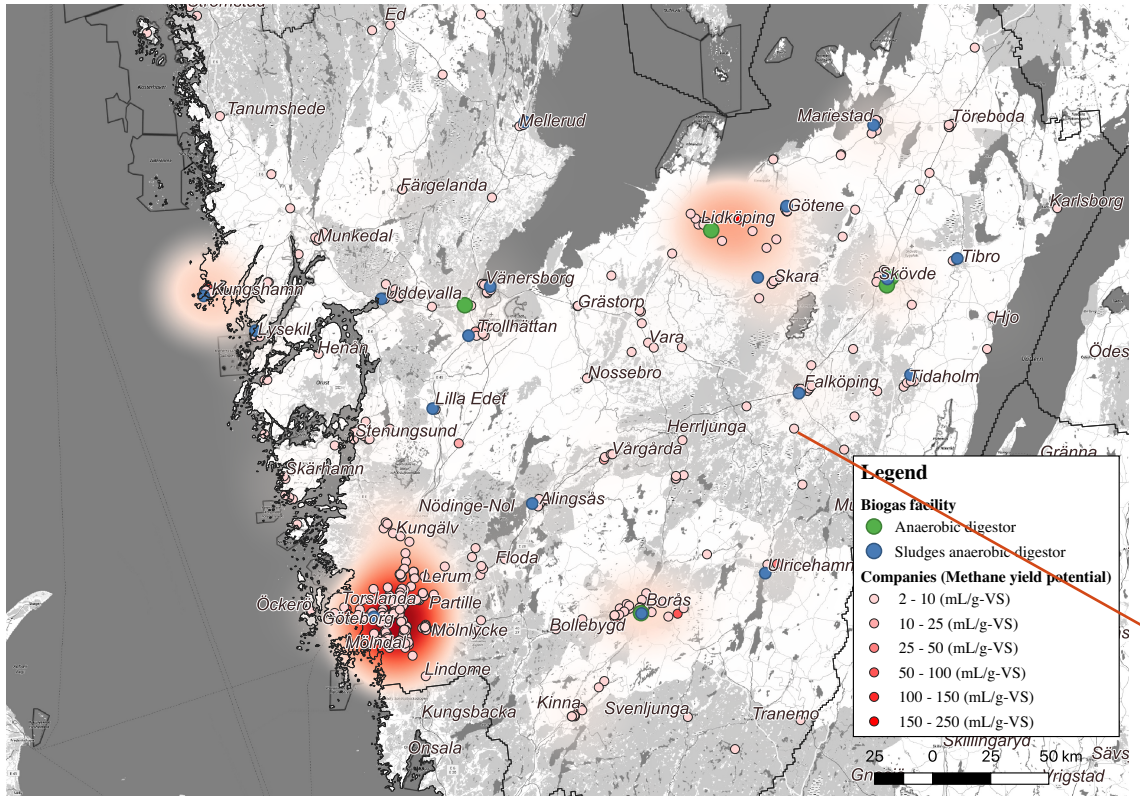
251

# PREDICTING INDUSTRIAL WASTE

## PRIORITIZING COMPANIES THAT PRODUCE WASTE THAT CAN BE USED TO PRODUCE BIOGAS




Methane yield




For each company:

***Raw Data:***
Company name
Industrial Activity
Company Size

***Estimated:***
Amounts of waste
Types of waste

***Plugins:***
Methane Yield

***Company: A***
*NACE 1071 – bread production*
*11 tons of animal and food waste*
*1 ton of paper waste*

***Methane yield potential: 2.2mL/g-VS***

# CONCLUSIONS

- Industrial Symbiosis can be considered as an important tool to foster circular economy;
- It is already recognized by the European Union as an efficient tool to help the promotion of circular economy;
- May help not only reducing the amount of waste produced, but also reduce the dependence on raw materials extraction and material imports;
- It is a complex system, not easy to implement, involving different factors as well as different stakeholders.