A systematic identification of relevant processes and upscaling approaches for biobased technologies.

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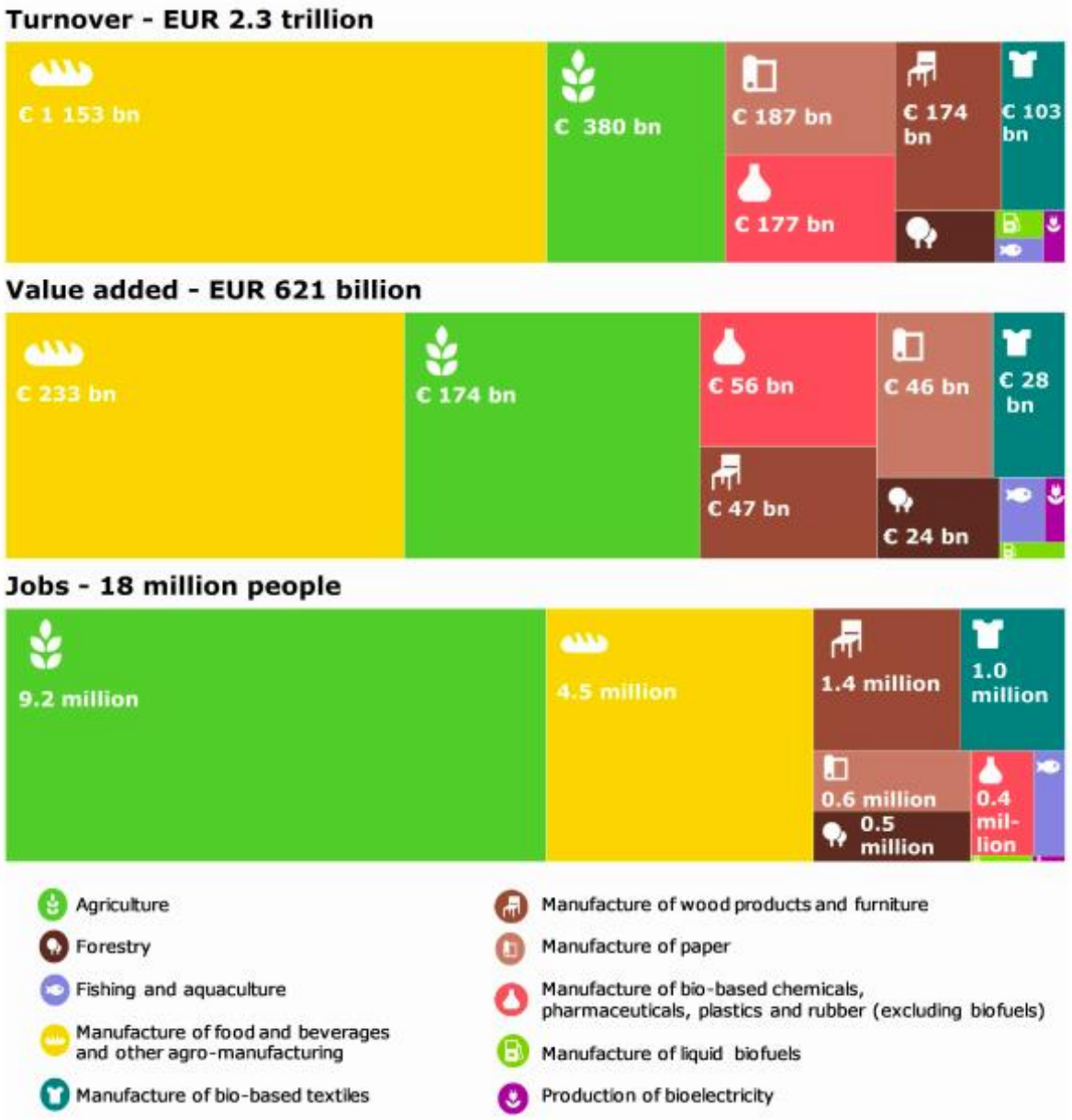
Previous Research

- In 2018, the European Commission (EC) released their updated Bioeconomy Strategy
  - Consider the bioeconomy to be a necessity if Europe is to develop a carbon neutral society
  - Economic potential - growing ~5% yearly

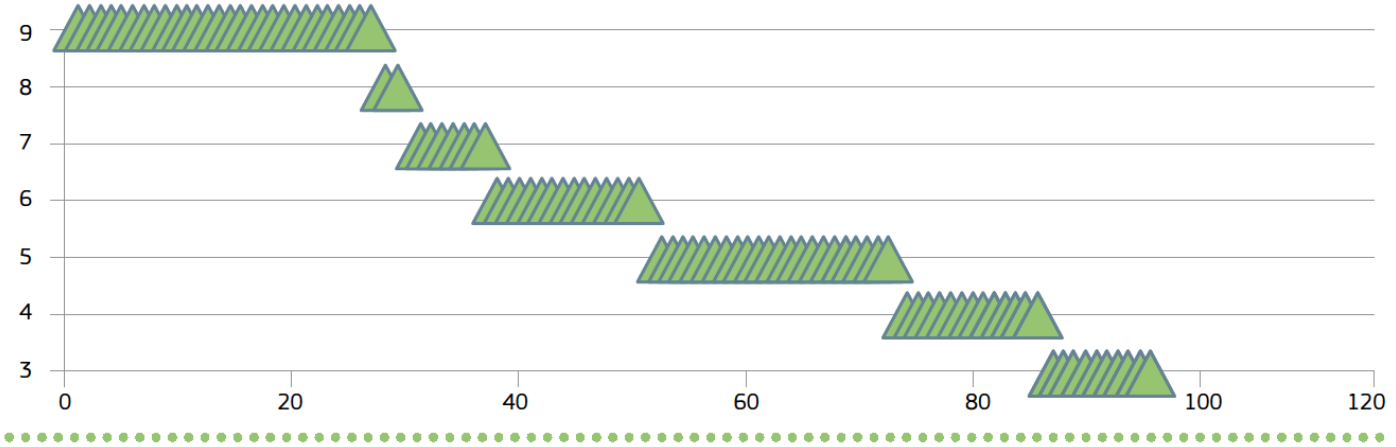


Turnover, value added, and jobs provided metrics for bioeconomy sectors in 2015. From European Commission, 2018

Previous Research

- In the same year, the EC identified their top emerging bio-based products (BbP).
  - Natural rubber, vegetable fibres, renewable oils and fats, lignin, terpenes, polyelectrolytes, urban biowastes

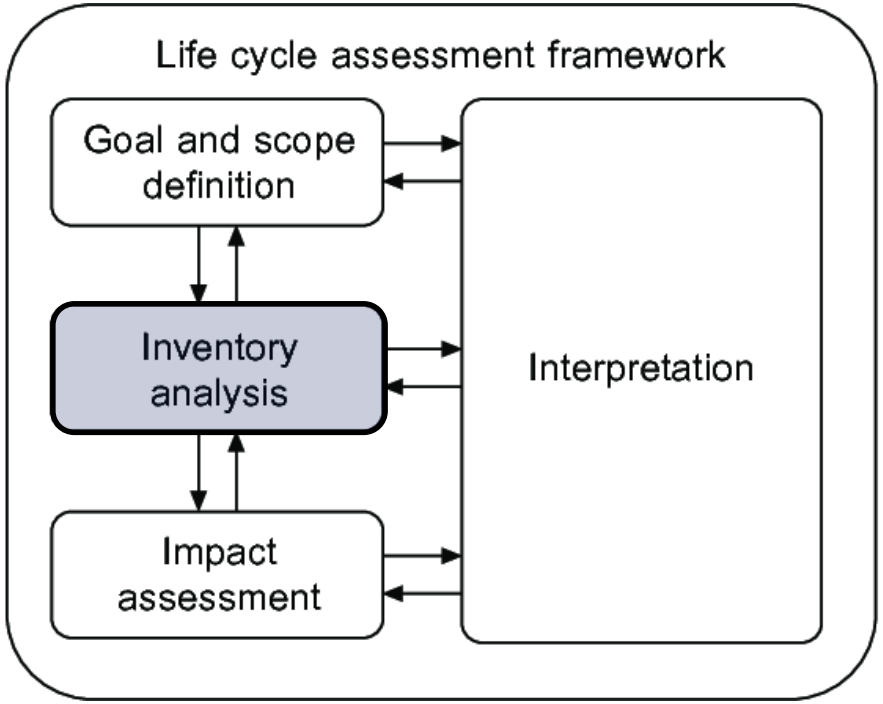
- Primary feedstocks used:
  - Food processing waste
  - Agri-based feedstock
  - Urban biowaste



TRL distribution of emerging technologies reviewed. From European Commission, 2018

Our Research

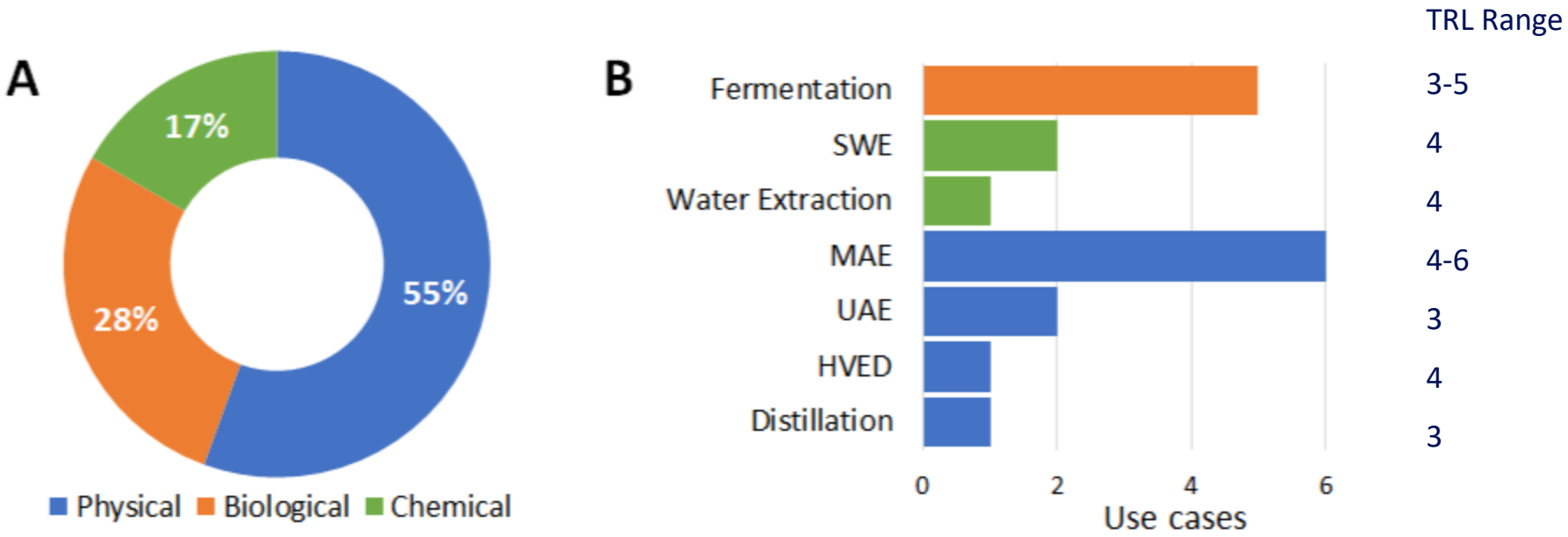
- Does a growing bioeconomy guarantee environmental benefits?
  - Need for systematic environmental assessment to further understand the impacts of emerging technologies in the bioeconomy.
- Approach from an prospective LCA perspective
  - Focus on Inventory Analysis
  - Food processing waste from the EC top emerging BbP report used as a case study
- Objective: Develop a methodological framework to standardize inventory modelling in prospective LCA of biobased systems.



LCA framework diagram

Inventory Analysis

- Reviewed the technologies used to produce BbP from food processing waste.

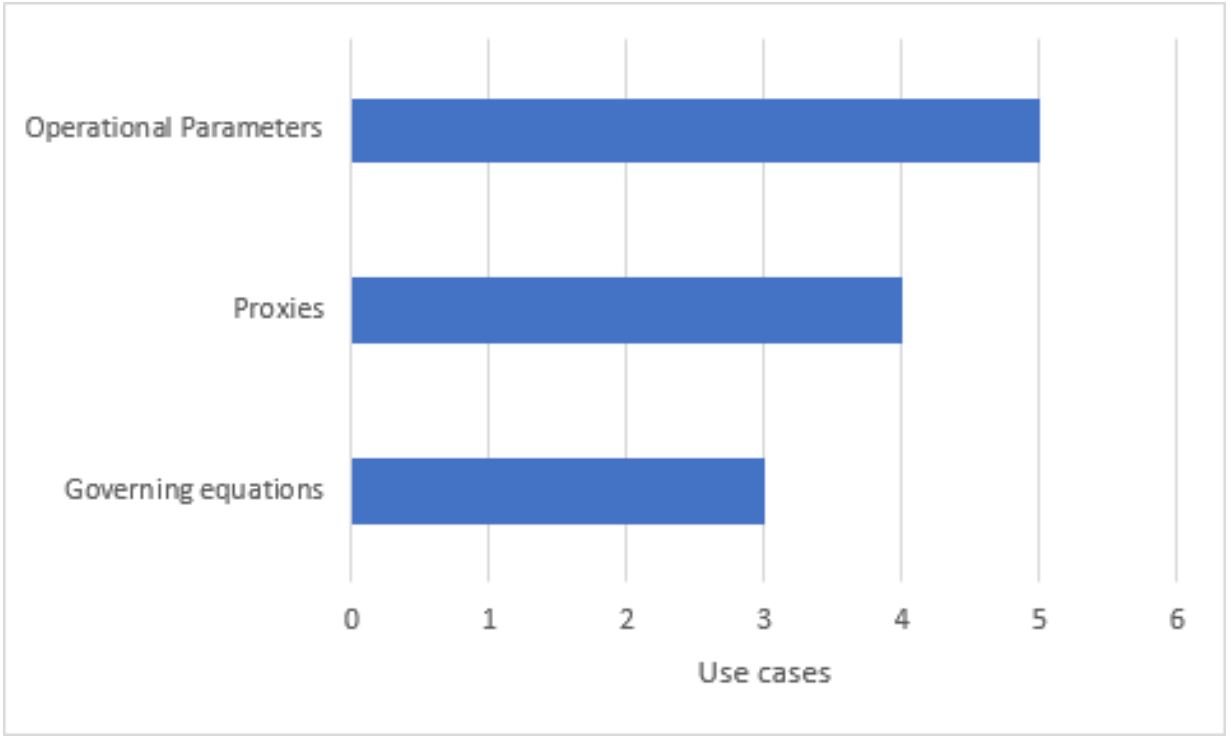


Distribution of technologies utilized by main processes A. distributed by pathway and B. distributed by type. MAE: Microwave Assisted Extraction, UAE: Ultrasound Assisted Extraction, HVED: High Voltage Electrical Discharges, SWE: Subcritical Water Extraction.

Inventory Analysis

- No technologies found in LCI databases (LCA commons, eco-invent 3.7)
- Identify upscaling strategies for each technology based on available data

- Operational Parameters at different scales:
  - Including: temperature, pressure, yield, energy input, etc.…
- Proxies:
  - Identified based on function, reaction parameters, kinetics, and product quality
- Governing equations:
  - Engineering based approach



Upscaling strategies identified for technology

Inventory Analysis

Ultrasound Assisted Extraction governing equations. From Boukroufa et al., 2015

Description	Formula	Variable Identification
Power, P (W)	$P = m\ C_p\ dT/dt$	(m) mass of solvent, (C_p) heat capacity of solvent, (dT/dt) temperature variation over time
Ultrasonic Power, UI (Wcm^{-2})	$UI = 4P / \pi D^2$	(D) internal diameter of ultrasound reactor

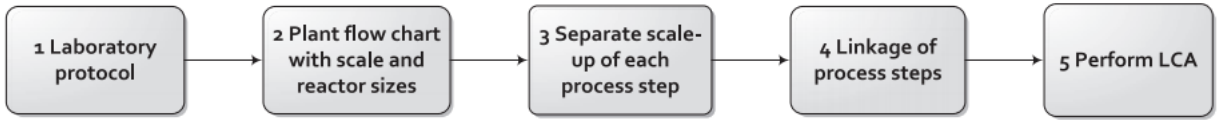
Identification of potential proxies

Process	Proxy Description	Databases
Ethanol production from pomegranate peels fermentation	Ethanol production from grass fermentation	Ecoinvent
Ethanol production from wheat bran	Ethanol production from rye	Ecoinvent, LCA Commons

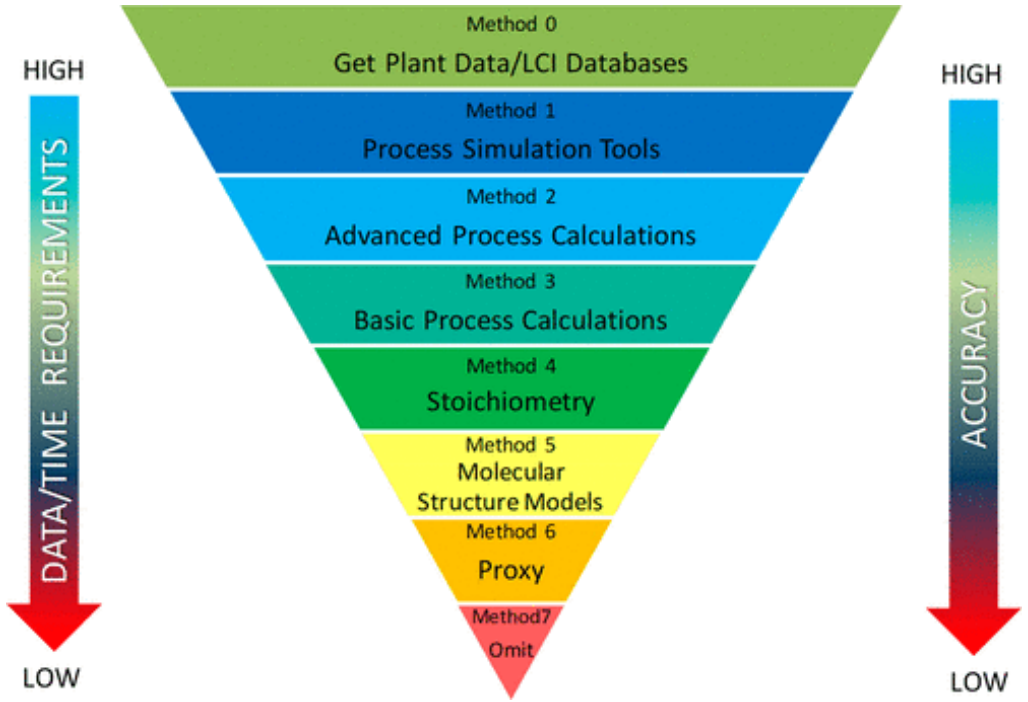
Operational parameters of sub-critical water extraction of flavonoids from mandarin peel. From Ko et al., 2016

System Scale	Temperature (°C)	Extraction Time (min)	Pressure (MPa)	Solute/Solvent ratio	Yield (mg/g_{peel})	Input Biomass (kg_{DW})	Input Solvent (L)
Laboratory	170	1	3	1:34	118	0.001	0.0022
Pilot	130	15-20	3	1:22	113	0.1	2.2

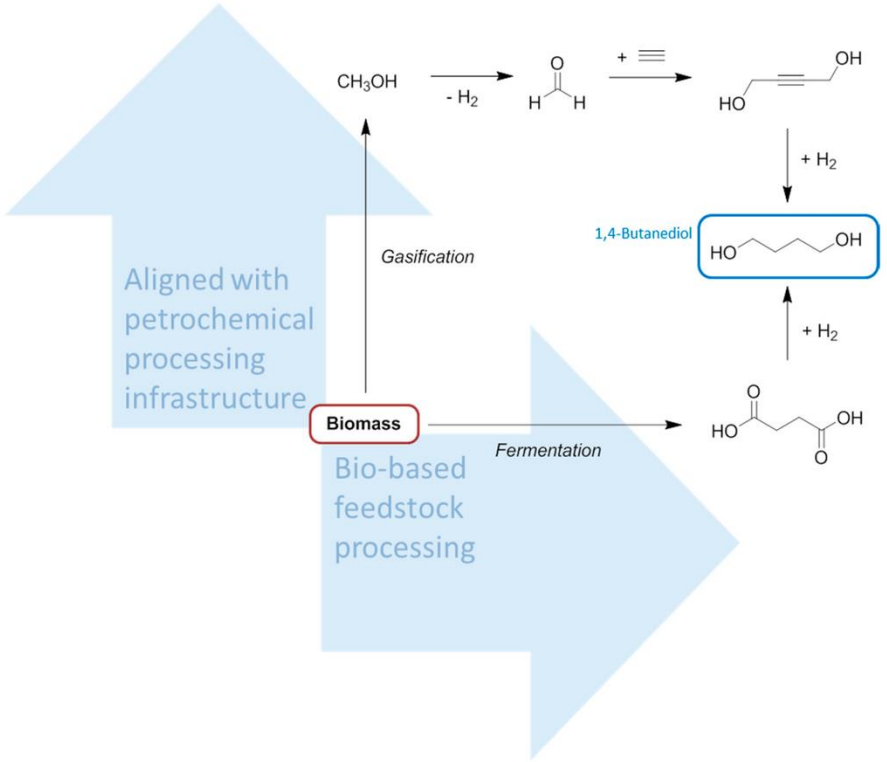
Upscaling Strategies – Process vs System Scaling



Overview of scale-up procedure. From Piccinno et al., 2016



Upscaling strategies. From Parvatker and Eckelman, 2018



Manufacturing processes of 1,4-butanediol from biomass. From Clark et al., 2015

Future Work

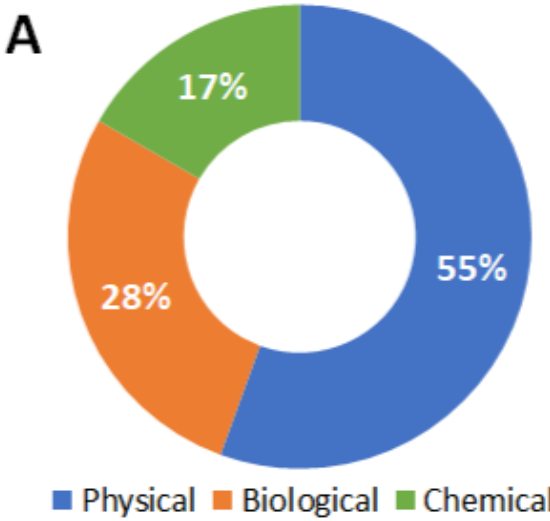
- Standardise our foreground system approach and expand to background systems

- Identifying alternative functions of the technology
  - MAE* can be used to produce pectin, essential oils, or polyphenols
  - Function may change over time based on policy maker expectations, hierarchy of value, feedstock availability, etc…

- Identify key background system hotspots
  - Electricity production
  - Water production
  - Feedstock production

- How to estimate emissions?

*Microwave Assisted Extraction



Distribution of technologies by pathway

Thank you!

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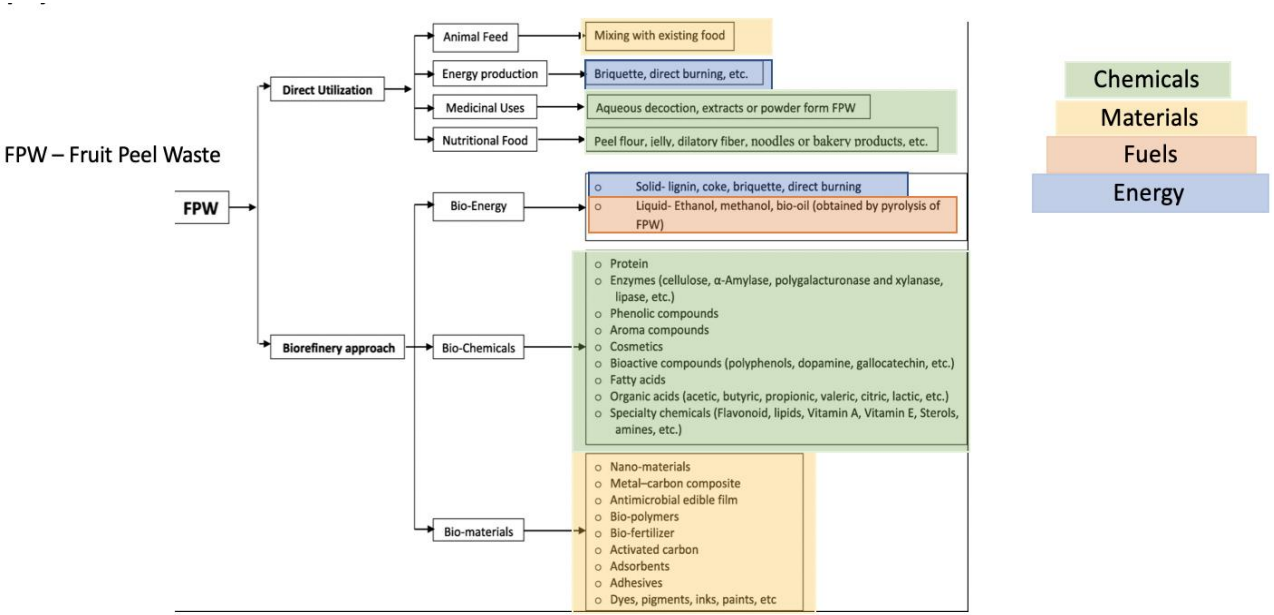
Inventory Analysis

- Proxy by function:
  - Grass fermentation to produce ethanol
  - Pomegranate peel fermentation to produce ethanol

- Proxy by parameters:
  - Chemical / Enzymatic Hydrolysis
  - Water extraction
  - Key parameters: heating energy, stirring energy

Biorefinery possibilities



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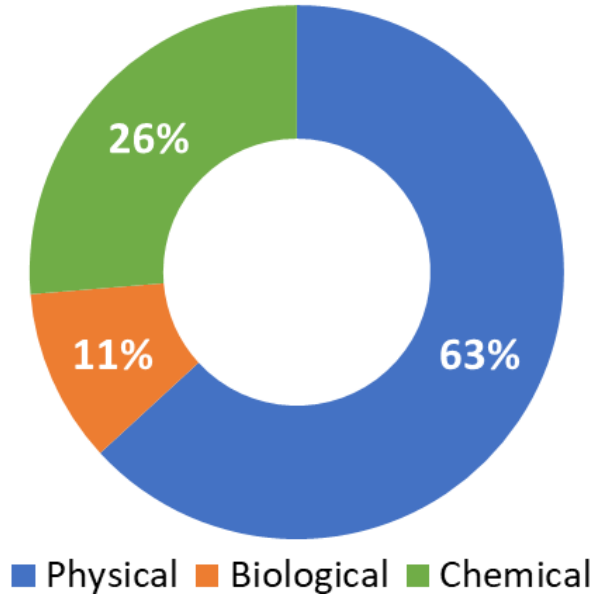

Figure 8. Distribution of technologies utilized by upstream and downstream processes distributed by pathway