APPLICATION OF BIO-OIL OTHER THAN FUEL WITH FOCUS ON CONTAMINATED FEEDSTOCK

Naples, Nov '23

RUI GALHANO DOS SANTOS

WIRE

Waste biorefinery technologies for accelerating sustainable energy processes

CERENA
Centro de Recursos Naturais e Ambiente
DEQ
DEPARTMENT OF CHEMICAL ENGINEERING
TÉCNICO LISBOA

HIDDEN CLIMATE SCIENCE PIONEER

"An atmosphere of that gas would give to our earth a high temperature"

August 1856

On the Heat in the Sun's Rays.

ART. XXXI.—*Circumstances affecting the Heat of the Sun's Rays*; by EUNICE FOOTE.

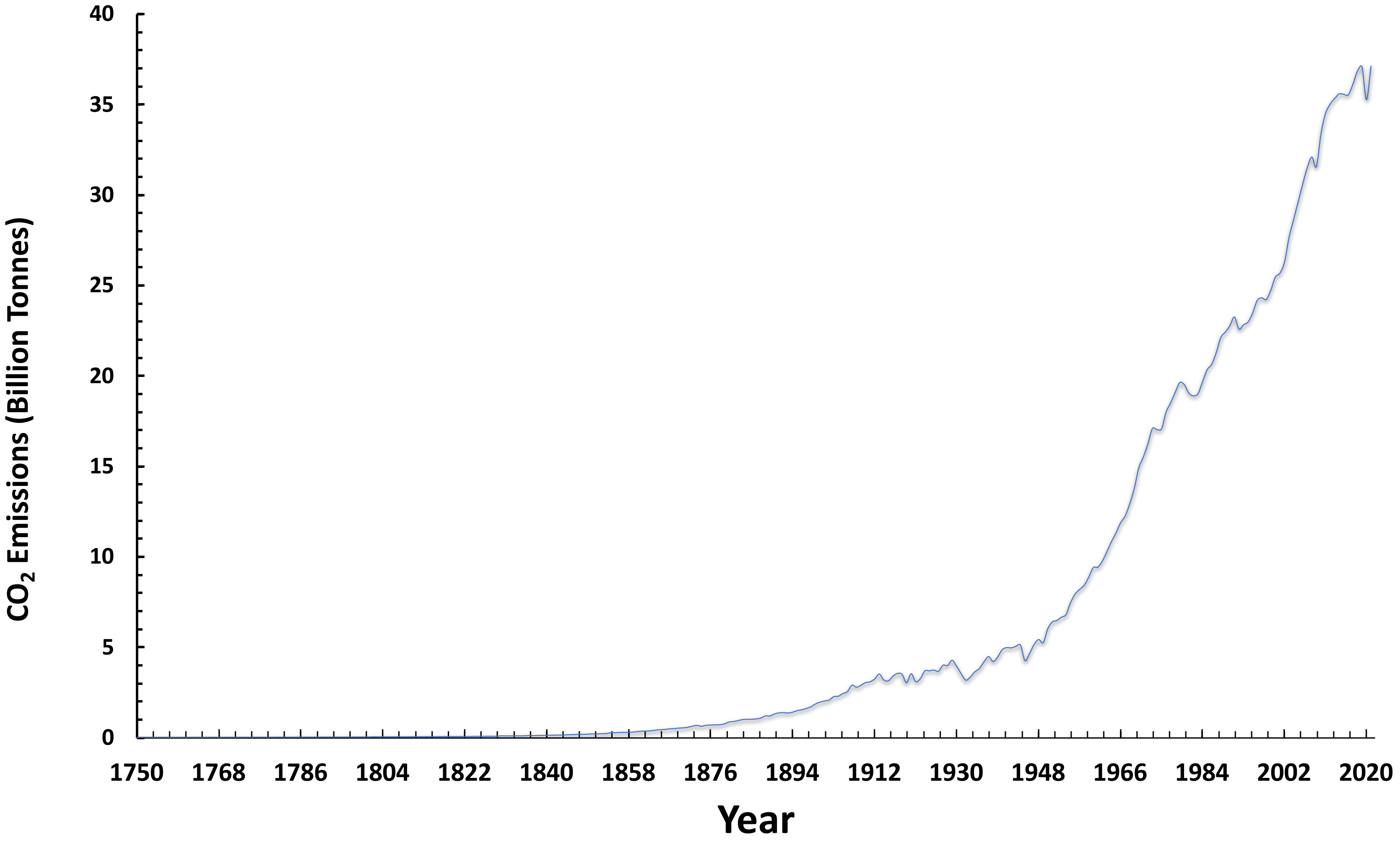
(Read before the American Association, August 23d, 1856.)

MY investigations have had for their object to determine the different circumstances that affect the thermal action of the rays of light that proceed from the sun.

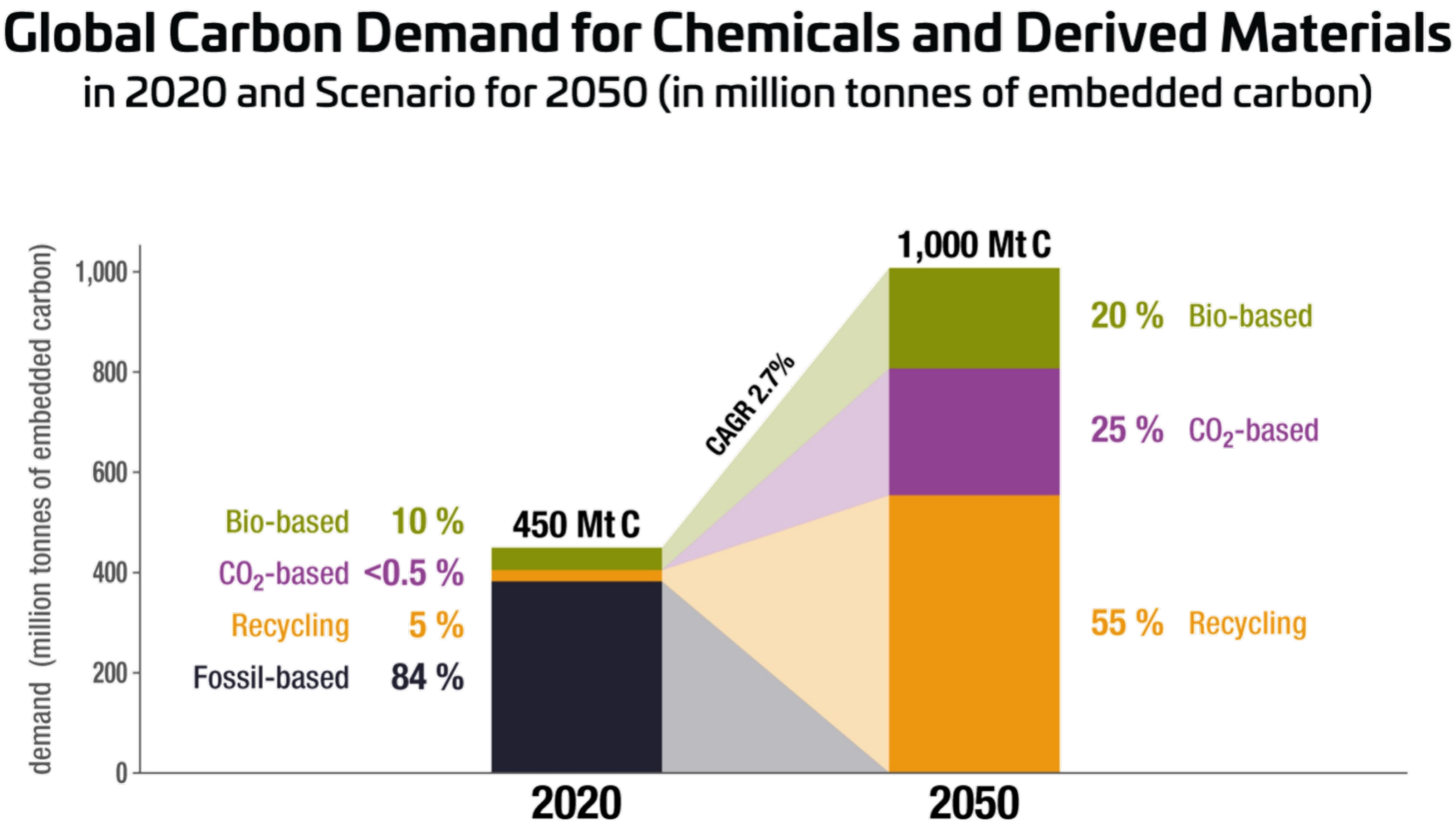
Several results have been obtained.

Eunice Foote

EVOLUTION OF CO_2 EMISSIONS

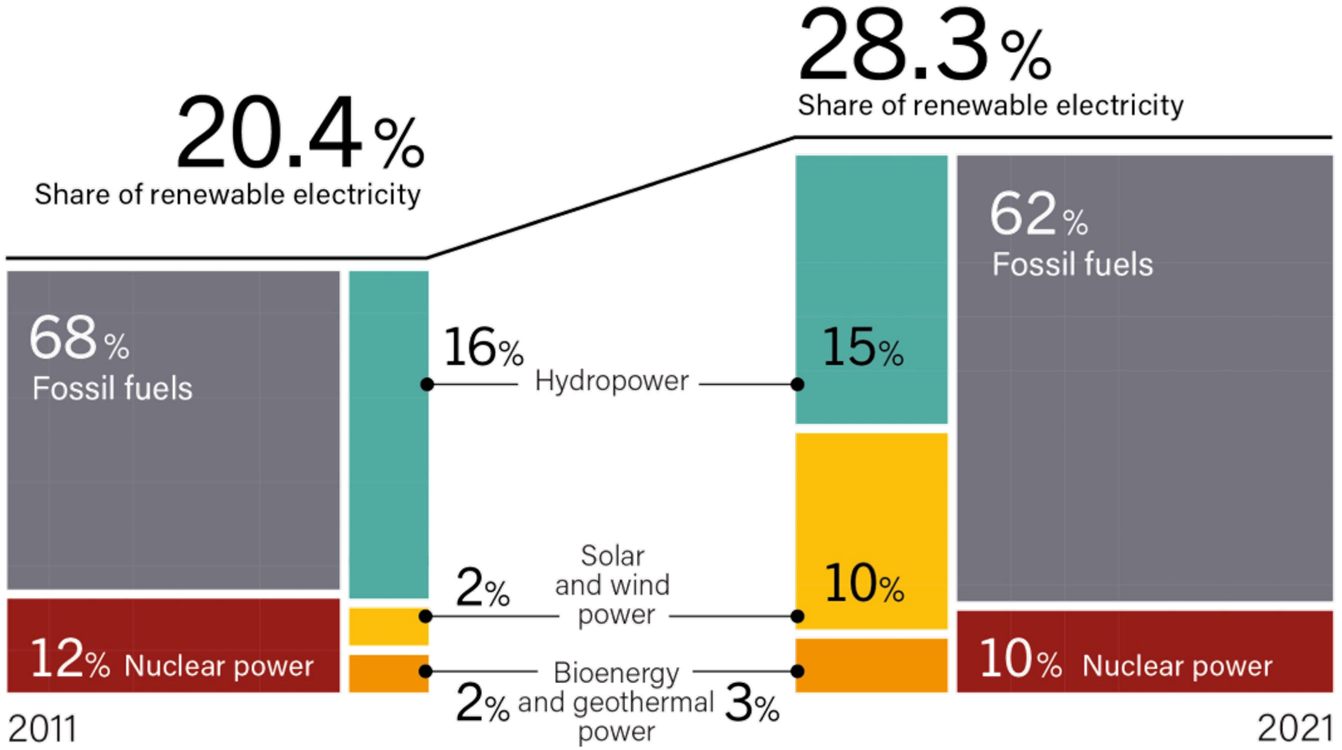


CARBON DEPENDENCY ON THE CHEMICAL INDUSTRY



available at www.renewable-carbon.eu/graphics

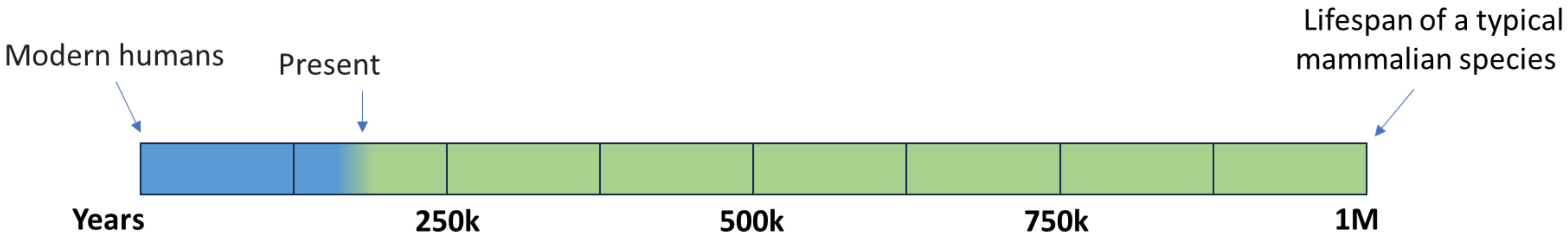
Share of Renewable Energy in Power, 2011 and 2021

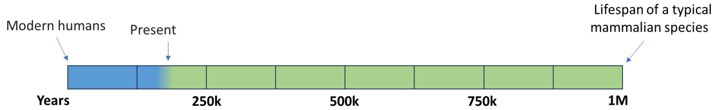


Renewable power share increased by almost 8 percentage points in the past decade.

Source: Based on IEA data.

THE GENERATIONS TO COME





Our World in Data

Humanity’s past

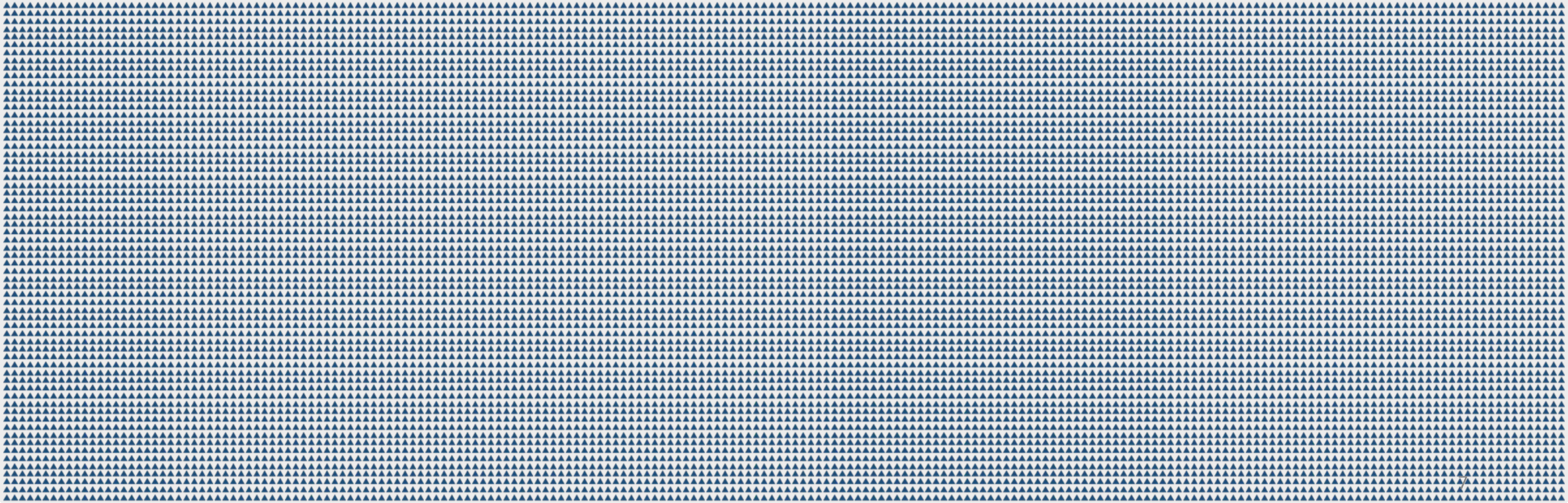
All the people who ever lived, ~117 billion, ratio of 14:1 compared to the current population

Humanity’s present

All the people who are alive today, ~8 billion, about 6.8% of all people who ever lived

Humanity’s future

All the people who could ever live, about 100 trillion, assuming the Earth remains habitable



WHAT CAN WE DO?

KEY POINTS WHEN DEVELOPING NEW PROCESSES

- ***Holistic vision of the processes***
- ***Prioritize energy efficiency, recyclability, durability, social responsibility***
- ***Promote environmentally friendly and socially responsible systems***
- ***Promote a more sustainable and circular economy***

WHY BIOMASS AND ITS DERIVATIVES?

VERSATILITY FOR BIOPRODUCTS AND BIOREFINERIES

Can be used to produce a wide range of bioproducts, including biofuels, bioplastics, and biochemicals

RENEWABLE, SUSTAINABLE AND ABUNDANT

Renewable and abundant resource, providing a sustainable alternative for energy and various industrial applications (e.g., >**82% of the world's biomass is plant-based matter**)

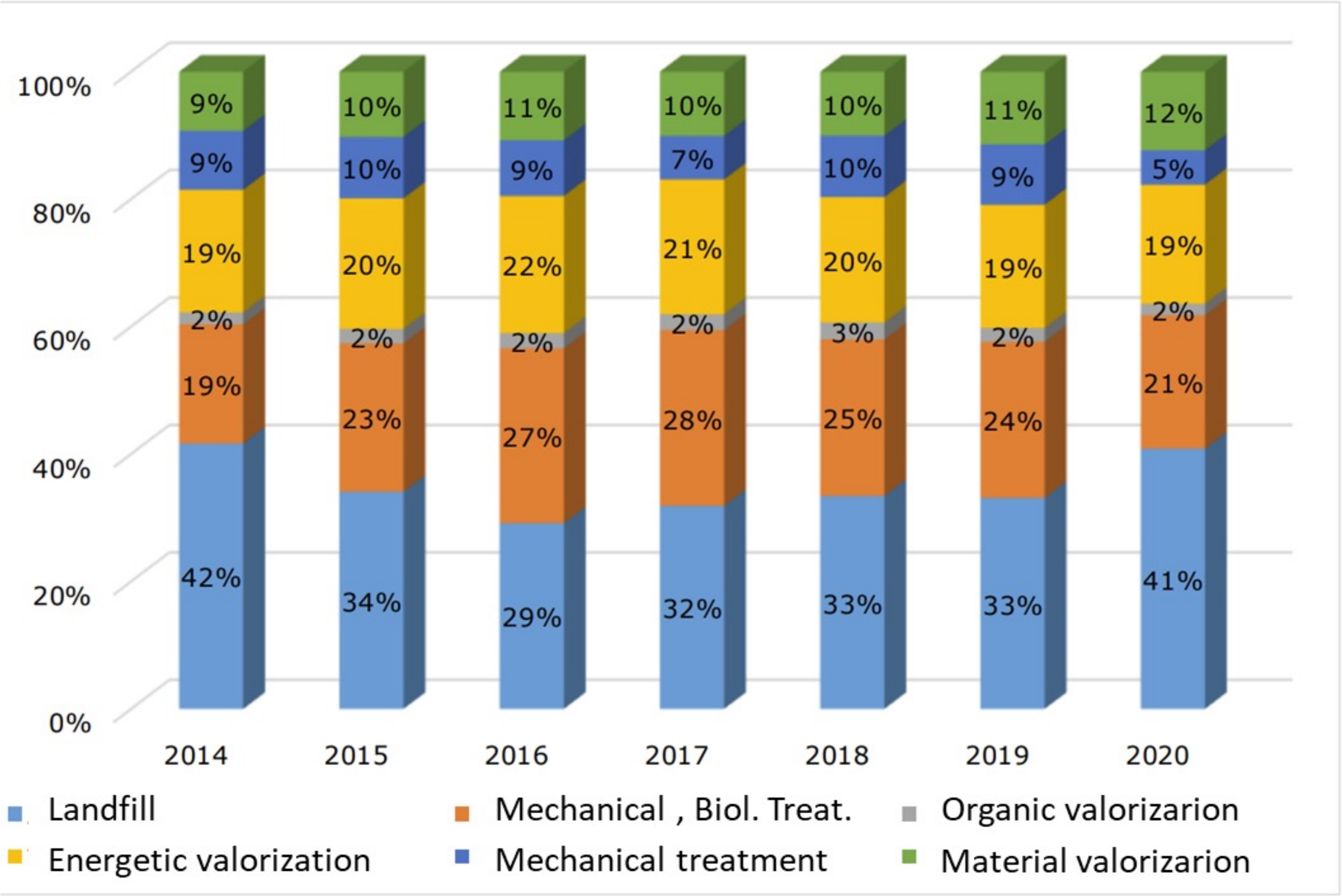
ENERGY DIVERSITY AND SECURITY

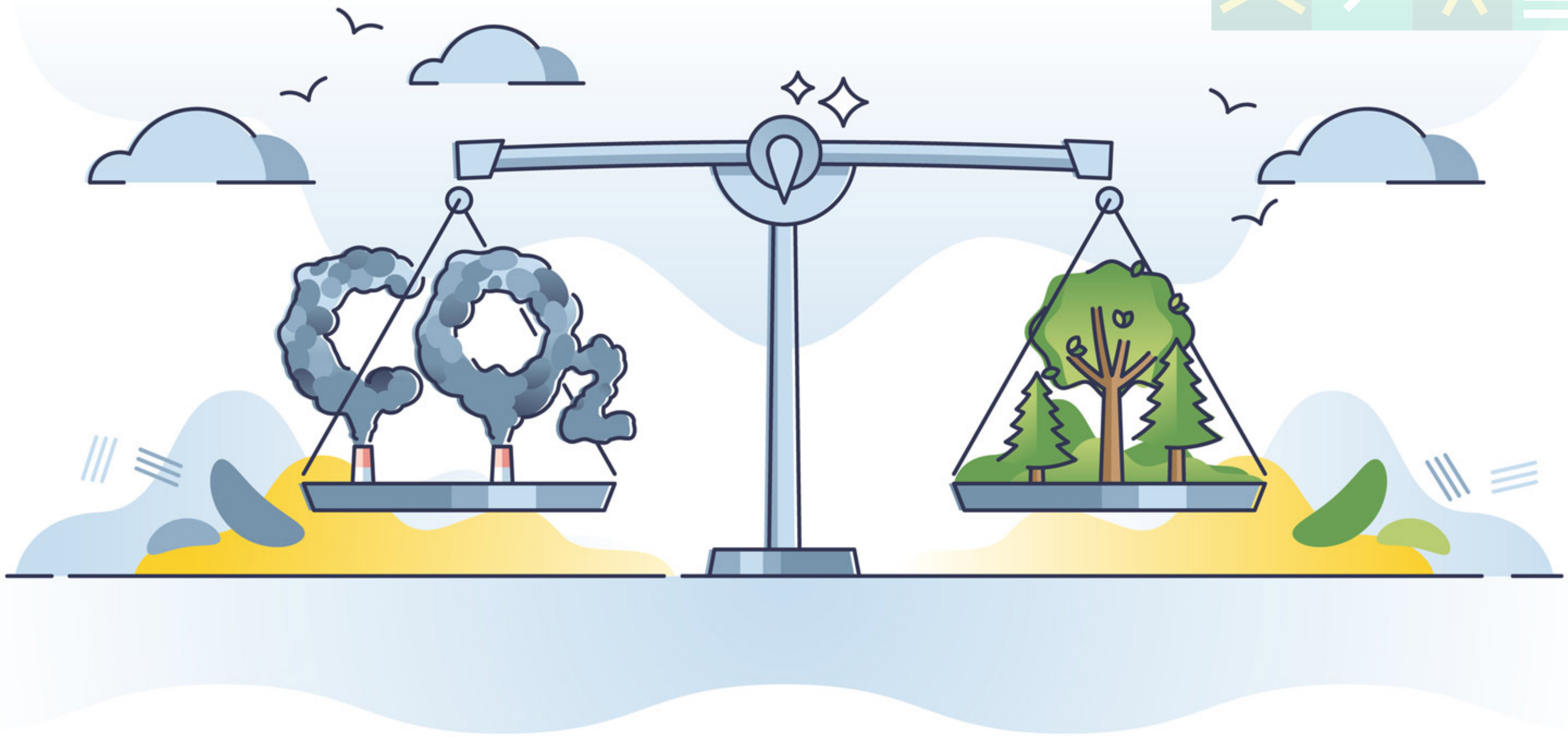
Contributes to diversifying the energy mix, reducing dependence on a single energy source

REDUCED GREENHOUSE GAS EMISSIONS

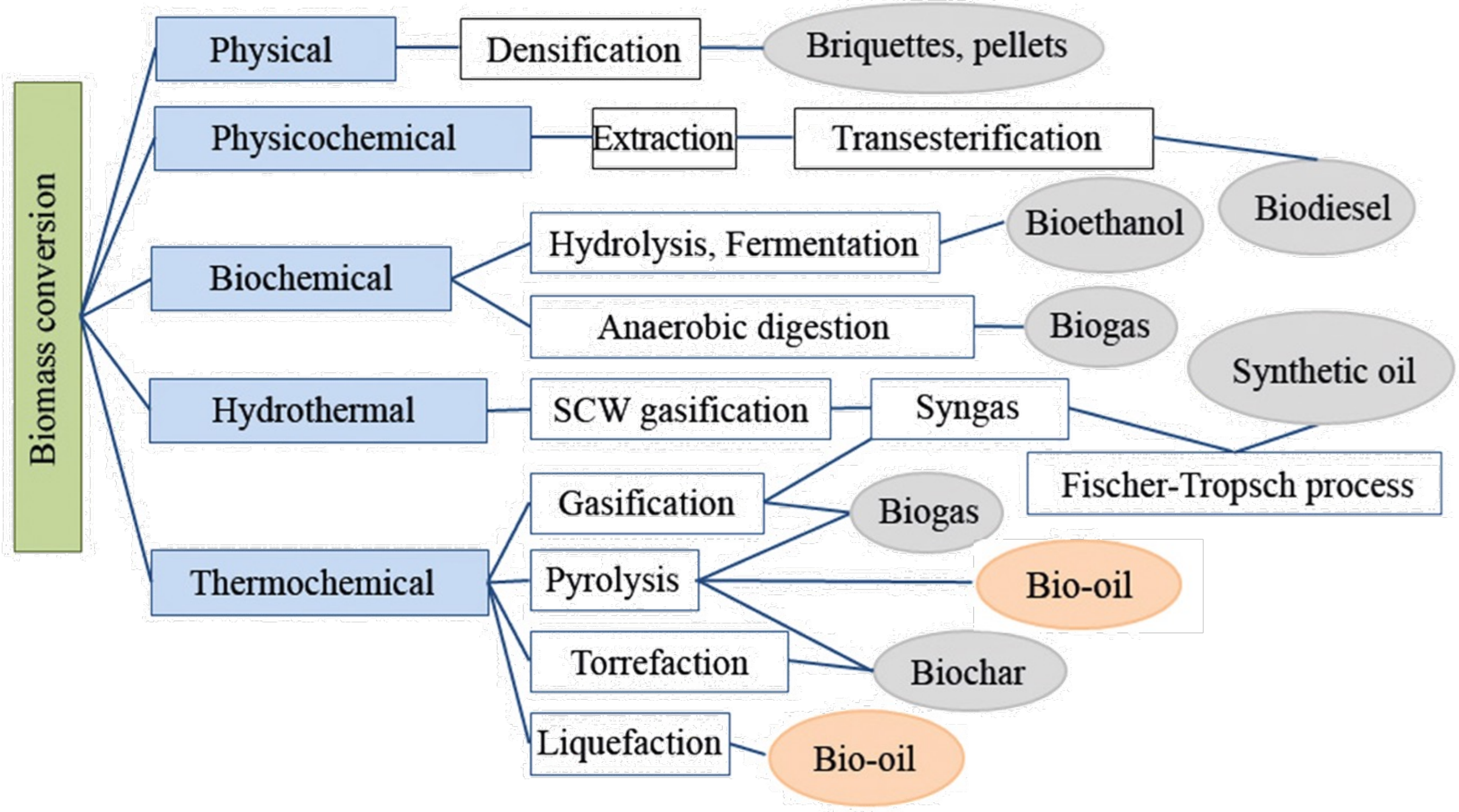
Offers the potential to be a carbon-neutral or even carbon-negative energy source

URBAN WASTES – AN OPPORTUNITY?



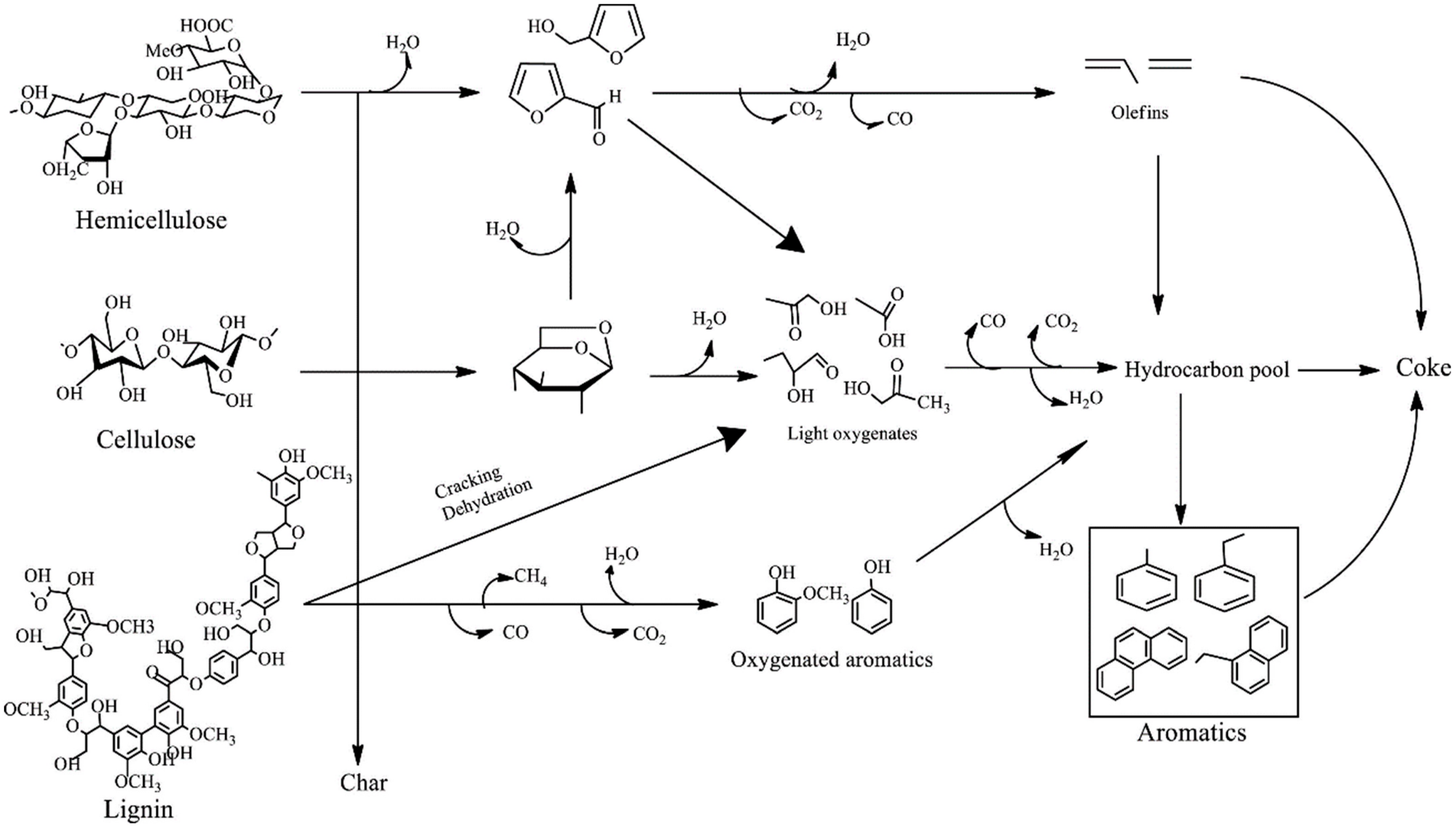

CO2

BIOMASS CONVERSION TECHNOLOGIES/PROCESSES

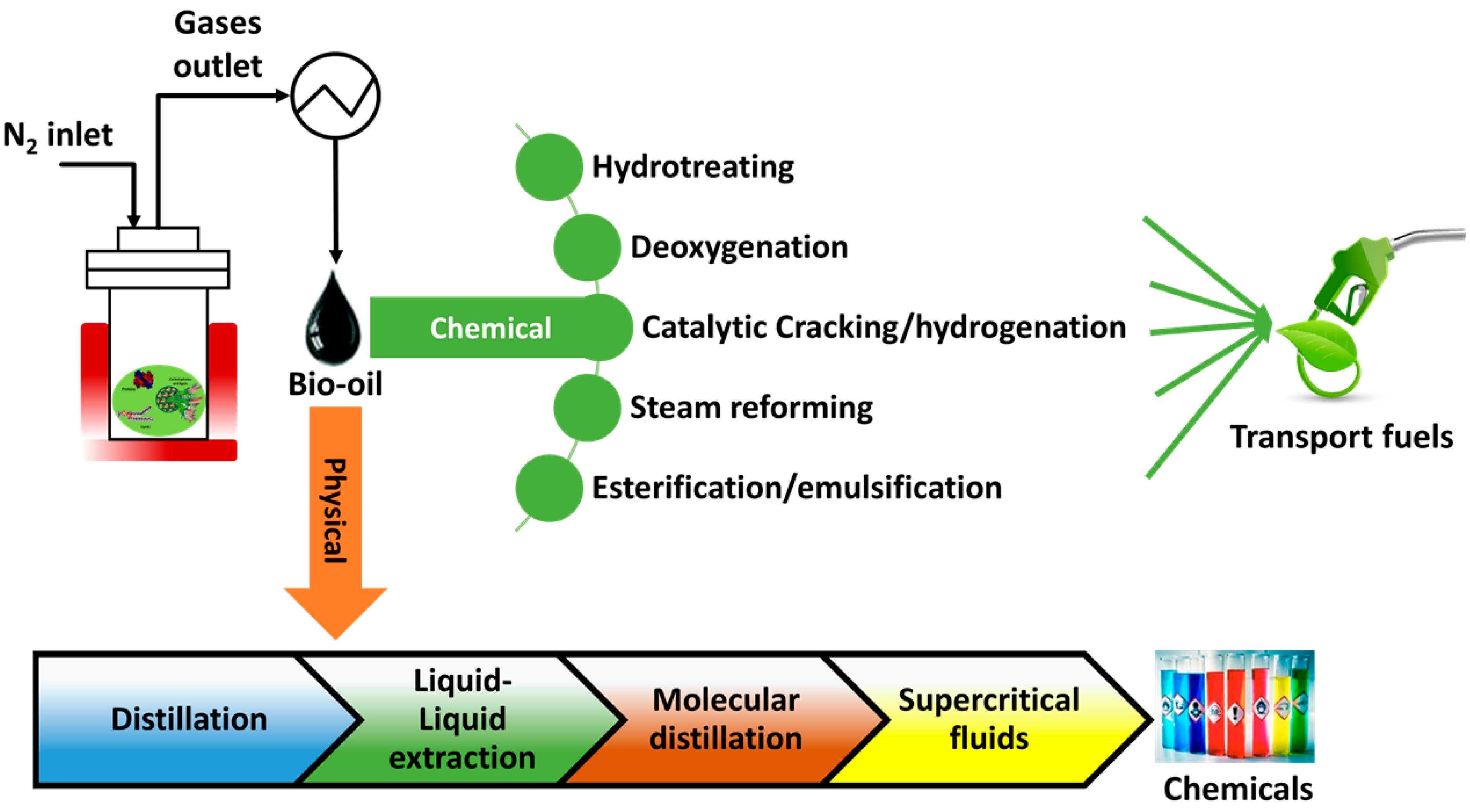


https://doi.org/10.1007/s10553-022-01348-w

BIOMASS PYROLYSIS – MECHANISMS



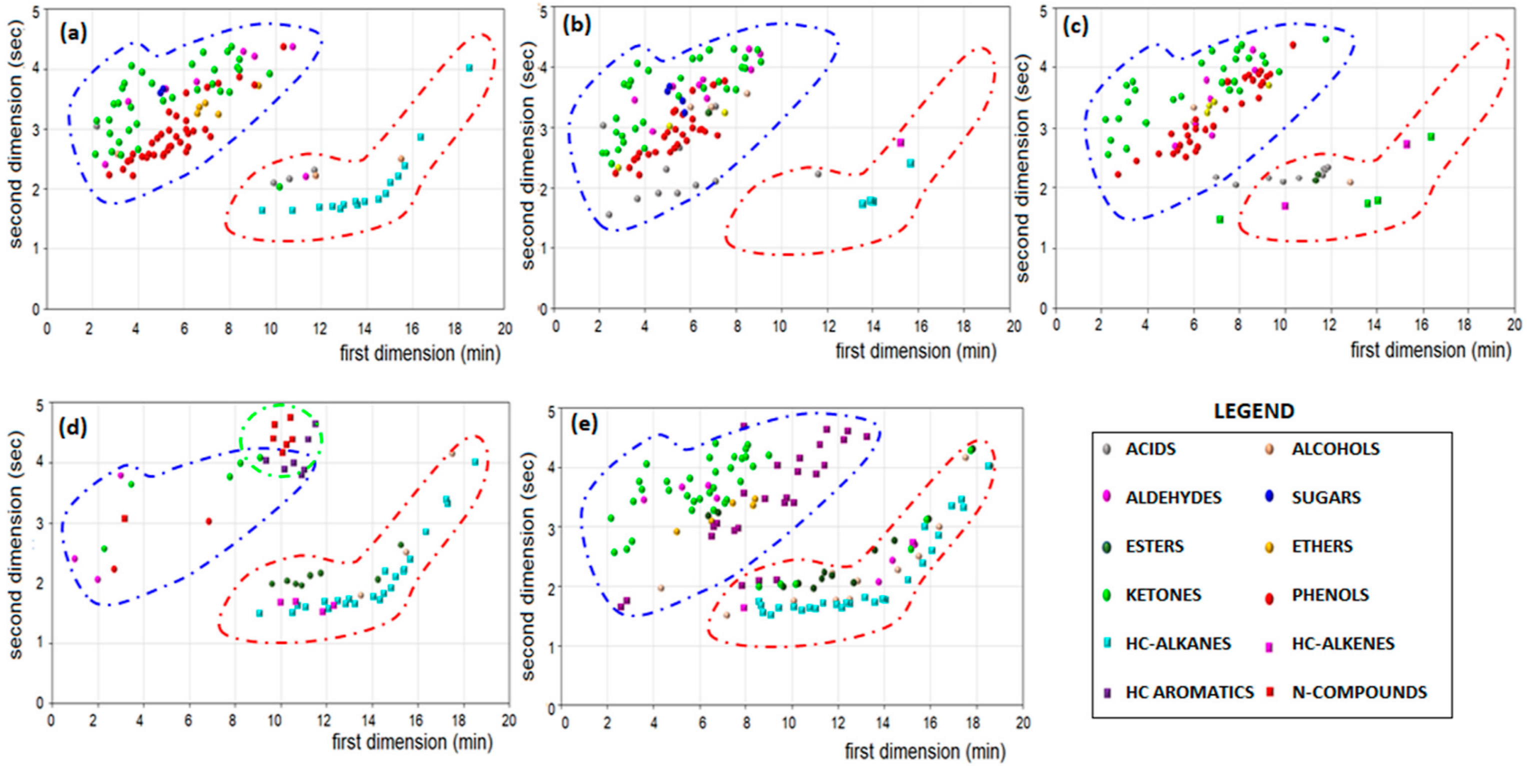
BIO-OILS – POTENTIAL REFINING TECHNIQUES



BIOMASS CONVERSION TECHNOLOGIES/PROCESSES

Techniques	Operating Conditions	Reaction	Technique Feasibility	
			Advantages	**Challenges**
Physical processes to chemical productions				
Distillation	(Atmospheric) 80–250 °C	No reaction	Production of alcohols, aldehydes, and acids	Avoid the polymerization reactions
	(Vacuum) Low temperatures		Avoid polymerization reaction and degradation of thermally sensitive compounds	More expensive, energy intensive, and hard operation
	(Molecular) High vacuum (<10^{-6} atmospheric pressure)		Low distillation temperature and heating rates and high efficiency of fractionation	
Supercritical fluids	Mild conditions (T > 32 °C P > 100 bar)		Clean solvents and bio-oil with low viscosity and oxygen content	Energy intensive and hard operation system
Liquid–liquid extraction	(Water extraction) Normal conditions (T and P)		Simple technique, increases the heating value and stability of bio-oil, and decreases the viscosity	Increases water/solvent content and decreases pH
Emulsification	Warn conditions, surfactant, and co-surfactants	Emulsified with petroleum-based fuels	Classic and cost-effective route	High energy for production is the most important challenge of these processes

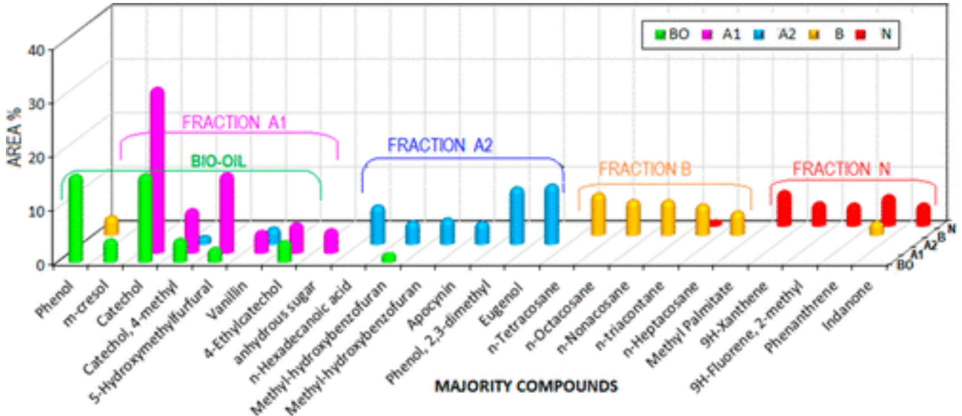
GCxGC-TOFMS



Hydrocarbons & Non-Polar Compounds

Polar Oxygenated Compounds

N-Compounds



Ind. Eng. Chem. Res. 2022, 61, 27, 9567-9574

PHYTOREMEDIATION - BIO-OIL PRODUCTION USING LEAD CONTAMINATED SWITCHGRASS FEEDSTOCK

According to US Agency for Toxic Substances and Disease Registry (ATSDR) superfund sites can have lead concentrations of above 10,000 mg/kg .

Commonly used methods for the cleaning of lands

- on-site stabilization
- ex-situ washing.

Lengthy
Expensive
modifies soil’s nutritional and microbial balance

Waste Biomass Valor **7**, 1091–1104 (2016). https://doi.org/10.1007/s12649-016-9508-2

PHYTOREMEDIATION - BIO-OIL PRODUCTION USING LEAD CONTAMINATED SWITCHGRASS FEEDSTOCK

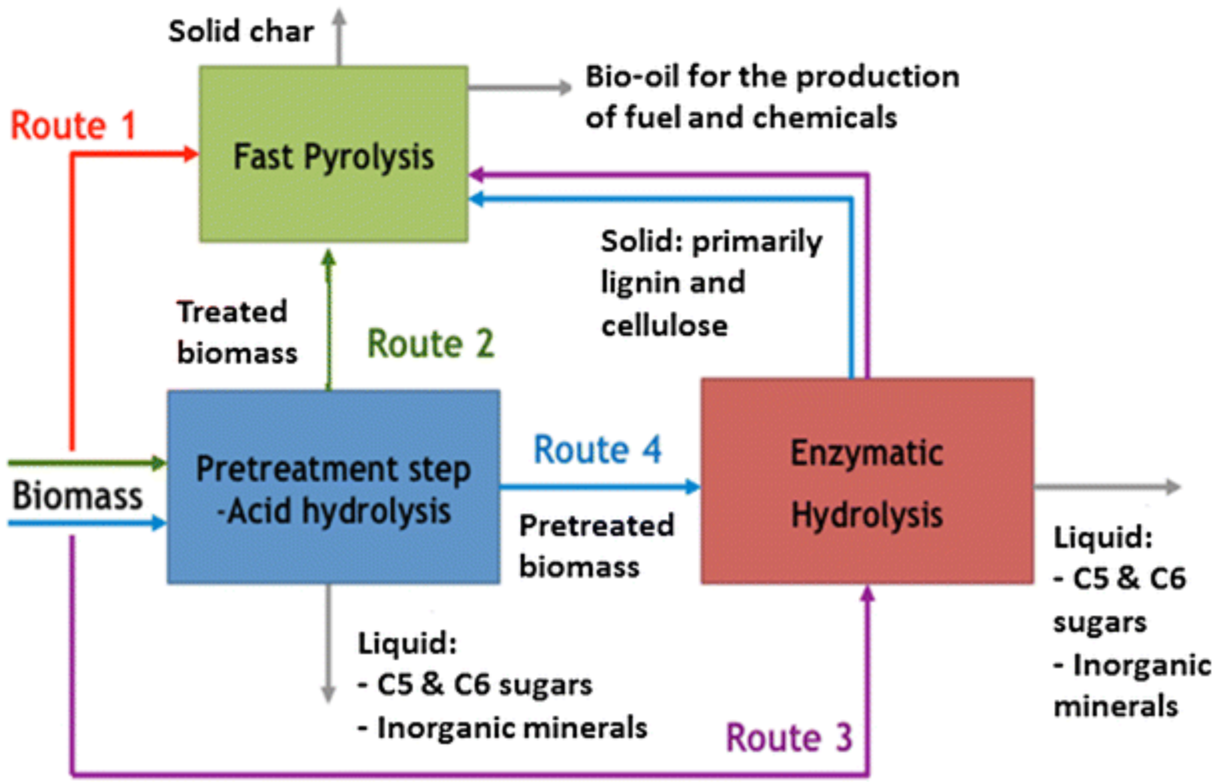
Phytoextraction
absorb the metal contaminants in the soil by drawing the soluble metal ions into the shoots or aerial parts of the plant in the top 1–2 m of soil.

- more cost-effective method for metal extraction,
- environmental friendly because
- avoids the loss of topsoil experienced in excavation processes

The phytoremediation effectiveness depends on the site as well as the plant used, but most phytoremediation plants have shown a potential to reduce the organic pollutants by more than 50 %

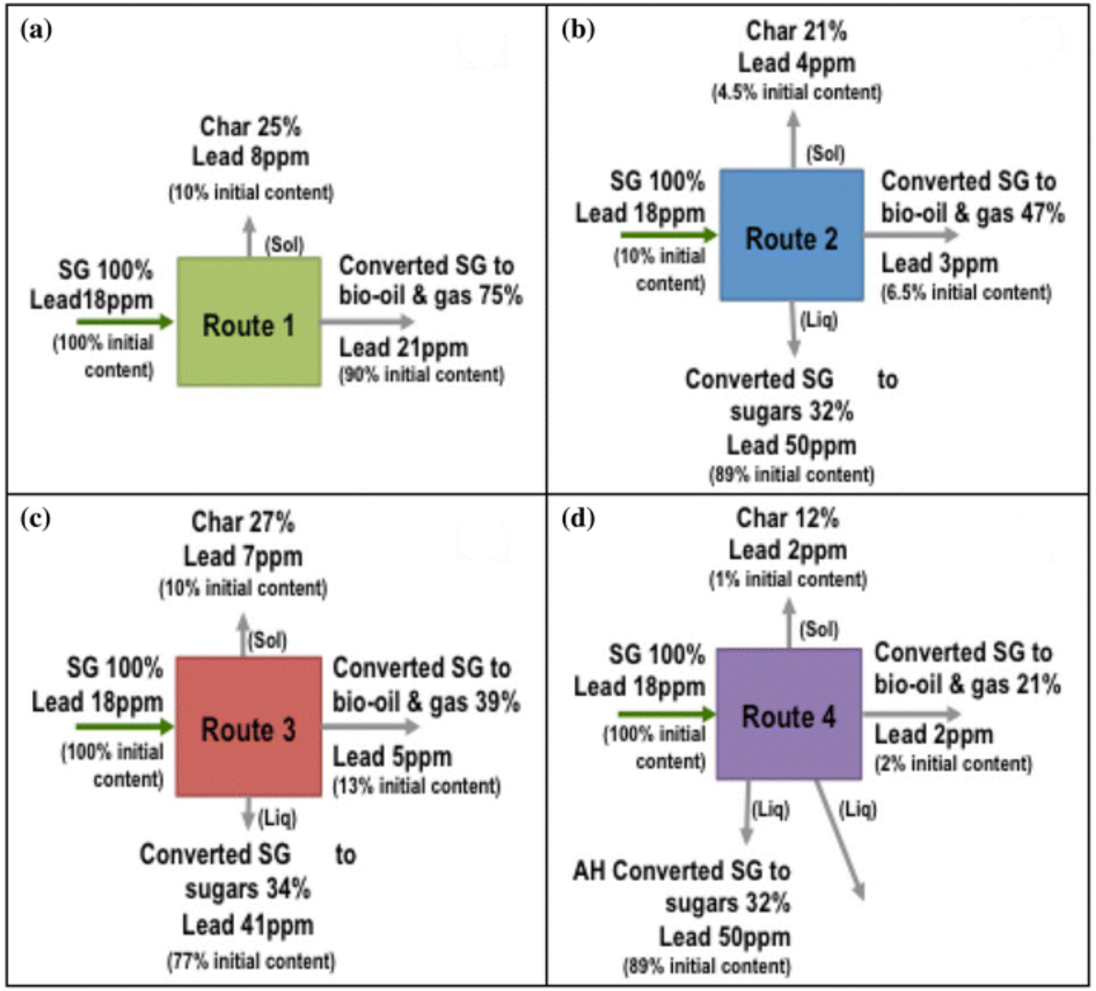
Waste Biomass Valor **7**, 1091–1104 (2016). https://doi.org/10.1007/s12649-016-9508-2

PHYTOREMEDIATION – BIO-OIL PRODUCTION USING LEAD CONTAMINATED SWITCHGRASS FEEDSTOCK



PHYTOREMEDIATION – BIO-OIL PRODUCTION USING LEAD CONTAMINATED SWITCHGRASS FEEDSTOCK

Mass balance for the four process routes. a Route 1, fast pyrolysis at 500 °C. b Route 2, acid hydrolysis with 4 % H3PO4 and fast pyrolysis at 500 °C. c Route 3, enzymatic hydrolysis with a combination of A. Niger, T. Reesei and H. Grisea and fast pyrolysis at 500 °C. d Route 4, acid hydrolysis with 4 % H3PO4, enzymatic hydrolysis with a combination of the three enzymes and fast pyrolysis at 500 °C



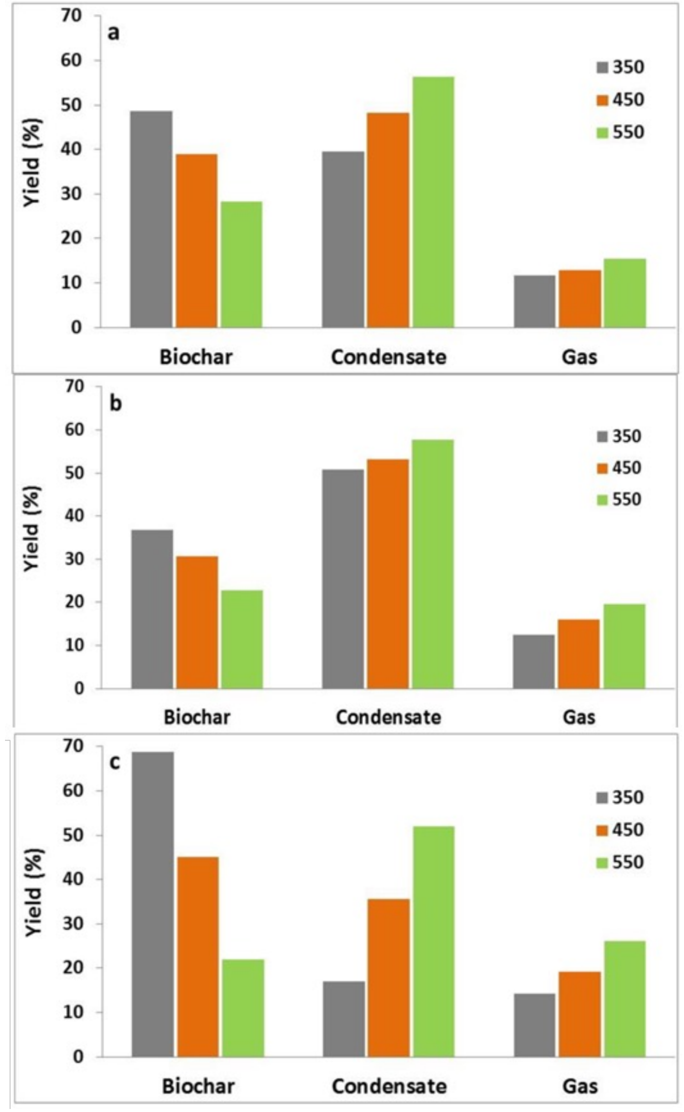
Waste Biomass Valor **7**, 1091–1104 (2016). https://doi.org/10.1007/s12649-016-9508-2

Compositions	Torrefied MFW at 275 °C	
	Organic compounds in the aqueous phase	Organic phase
Maltol	4.7	**19.94**
2-Furanmethanol	5.09	**17.55**
2-Hydroxy-3-ethyl-2-cyclopenten-1-one	3.41	**11.68**
Acetic acid	9.54	**10.29**
1-(2-Furanyl)-Ethanone		4.09
2-Hydroxy-3-methyl-2-cyclopenten-1-one		3.45
Phenol		3.35
1,5-Dimethyl piperidine-3-ol		3.26
4(2-Propenyl)- phenol	2.1	2.99
2-Methoxy phenol		2.83
Propanoic acid		2.65
Trimethyl pyrazine		2.3
Methyl pyridine		1.81
Methyl-2-hydroxy propanoate	4.3	1.69
3-Ethyl-2,5-dimethyl pyrazine		1.59
2-Furanmethanol acetate		1.48
Pyridine		
1-Hydroxy-2-pentanone	1.24	
4-Hydroxy-4-methyl-2-pentanone	2.06	
2,6-Dimethyl pyrazine	1	
D-Manitol	1.76	
Dianhydromanitol	**26.05**	
Methyl tetradecanoate	2.6	
Methyl hexadecanoate	**26.61**	
Methyl 9-Octadecanoate	3.91	

BIO-OIL FROM FOOD WASTE PYROLYSIS AFTER TORREFACTION

https://www.sciencedirect.com/science/article/abs/pii/S0956053X22000149?via%3Dihub

REFUSED DERIVED FUELS – PYROLYSIS



Sample	PCO	FOR	RDF
Density (g/cm^3)	0.94	0.93	1.30
Dynamic viscosity (cP)	7.0	1.5	110.6
pH	3.0	2.1	3.1
C (%)	59.0	52.4	43.5
H (%)	8.9	7.9	5.0
N (%)	1.2	0.1	3.9
S (%)	-	-	-
O (%)	30.9	39.6	47.6
HHV (MJ/kg)	27.1	21.9	13.4

FOR – Forest residues
PCO – Pine Cones
RDF – Refuse derived fuels

Appl. Sci. **2023**, *13*, 1482. https://doi.org/10.3390/app13031482

REFUSED DERIVED FUELS - SOLVOLYSIS

Run	Reaction Time	Temperature	Catalyst concentration	Yield
1	90 min	160°C	3%	11,66 %
2	205 min	160°C	3%	7,60 %
3	90 min	175°C	3%	7,29 %
4	90 min	160°C	10%	27,44 %
5	205 min	175°C	10%	33,28 %
6*	205 min	175°C	10%	33,0 %

*dried

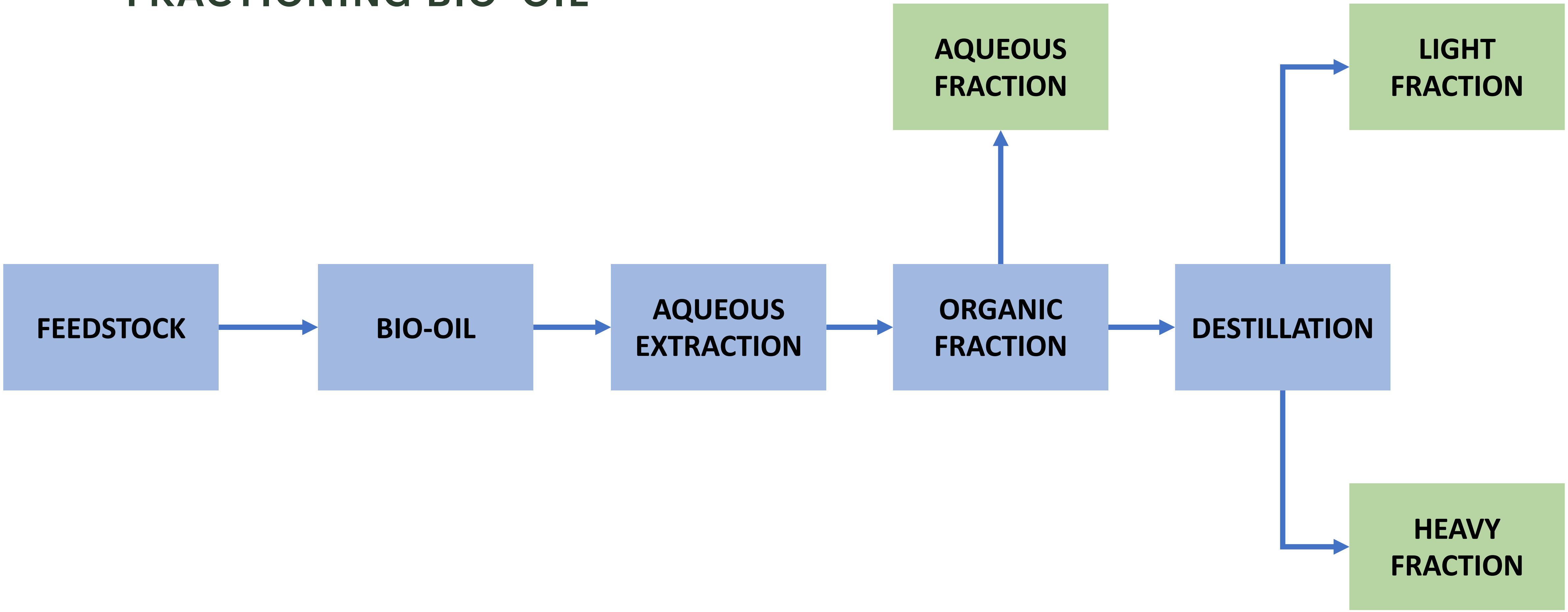
BIO-OIL FROM ALTERNATIVE CONTAMINATED FEEDSTOCKS

Entry	Sample	Chemical analysis (%)						HHV (MJ/kg)
		Moisture	C	H	O	N	S	
1	Pinewood	14.9	50.90	6.22	41.48	1.13	0.27	20.10
2	***LPW***	1.00	69.80	12.65	15.49	1.58	0.48	37.41
3	Paper sludge	76.1	33.90	4.93	58.64	2.00	0.53	nd
4	***LPS***	0.4	74.86	14.30	10.64	0.00	0.20	40.26
5	Swine manure	75	38.30	6.13	52.63	1.95	0.99	15.90
6	***LSM***	1.5	63.20	11.70	22.89	1.51	0.70	33.38

AQUEOUS EXTRACTION OF BIO-OILS

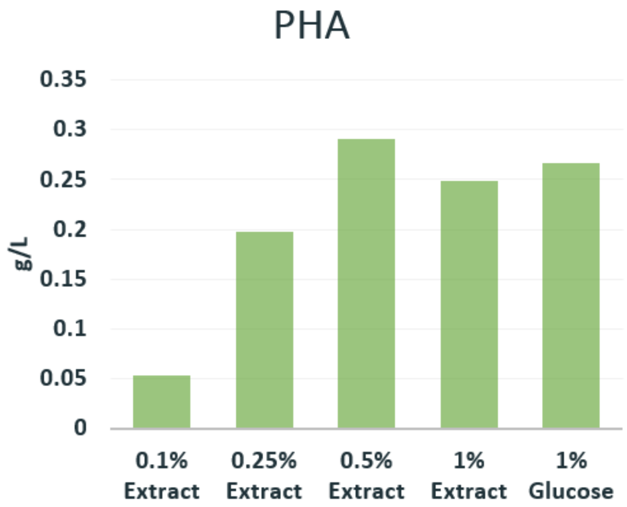
Entry	Sample	Moisture (%)	HHV (MJ/kg)
1	**Cork wastes**	20	21.6
2	**Liquefied cork**	0.7	34.14
3	**Aqueous extract**	9.7	20.29
4	**Organic Extract**	1.0	37.91

FRACTIONING BIO-OIL



BIO-PLASTICS – POLYHYDROXYALKANOATES

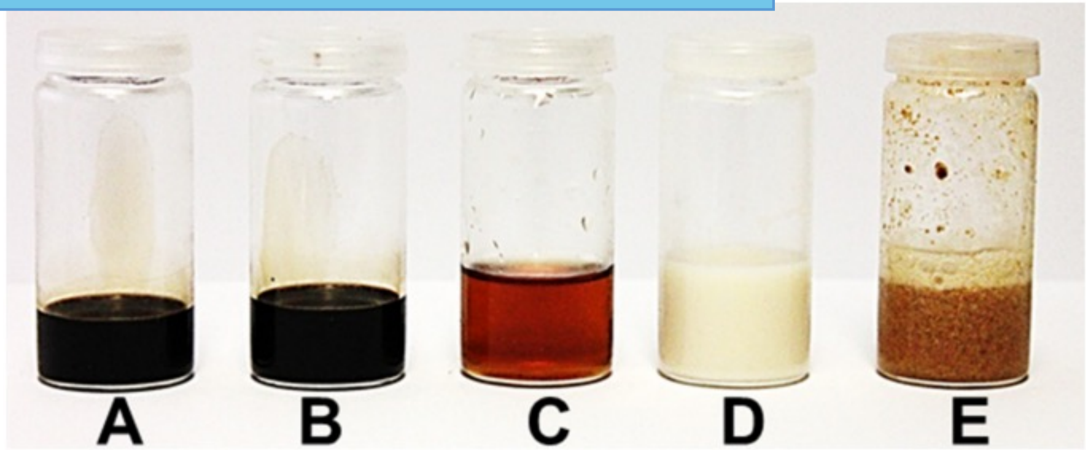
"Polyhydroxyalkanoates (PHA**) are polyesters produced by several groups of bacteria as a carbon and energy reserve**"



Paracoccus sp.

PRODUCTION OF SUSTAINABLE ADHESIVES FOR BIO-OIL DERIVATIVES

>96% BIO-BASED COMPONENTS




The United States of America

The Director of the United States Patent and Trademark Office

Has received an application for a patent for a new and useful invention. The title and description of the invention are enclosed. The requirements of law have been complied with, and it has been determined that a patent on the invention shall be granted under the law.

Therefore, this

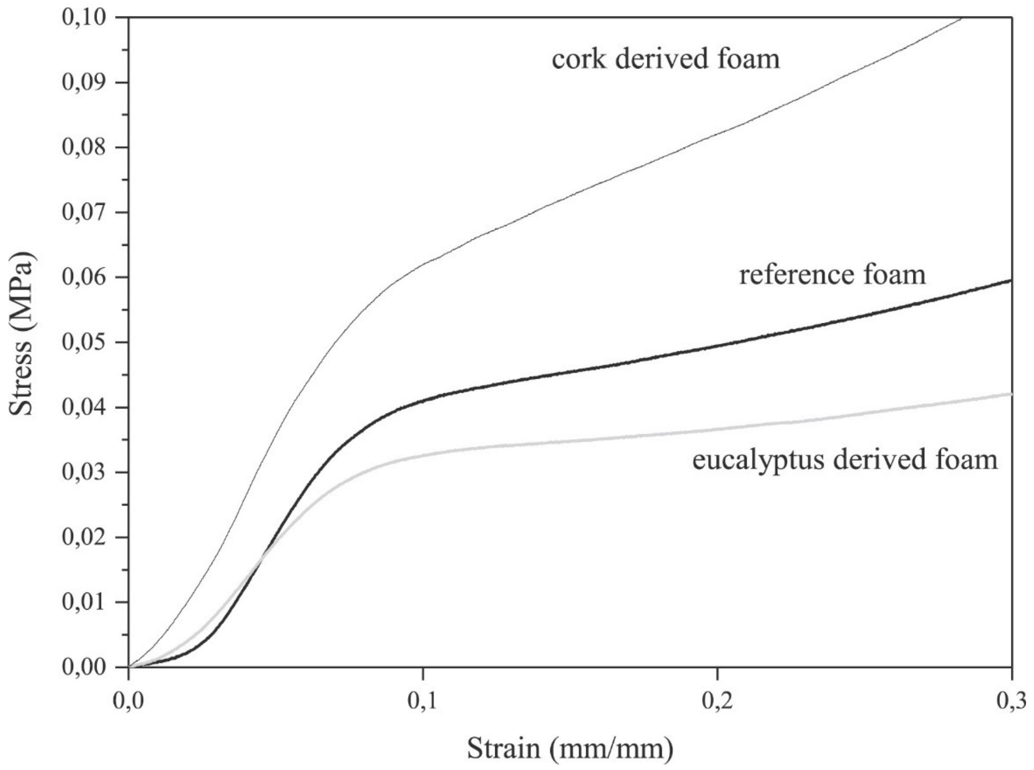
United States Patent

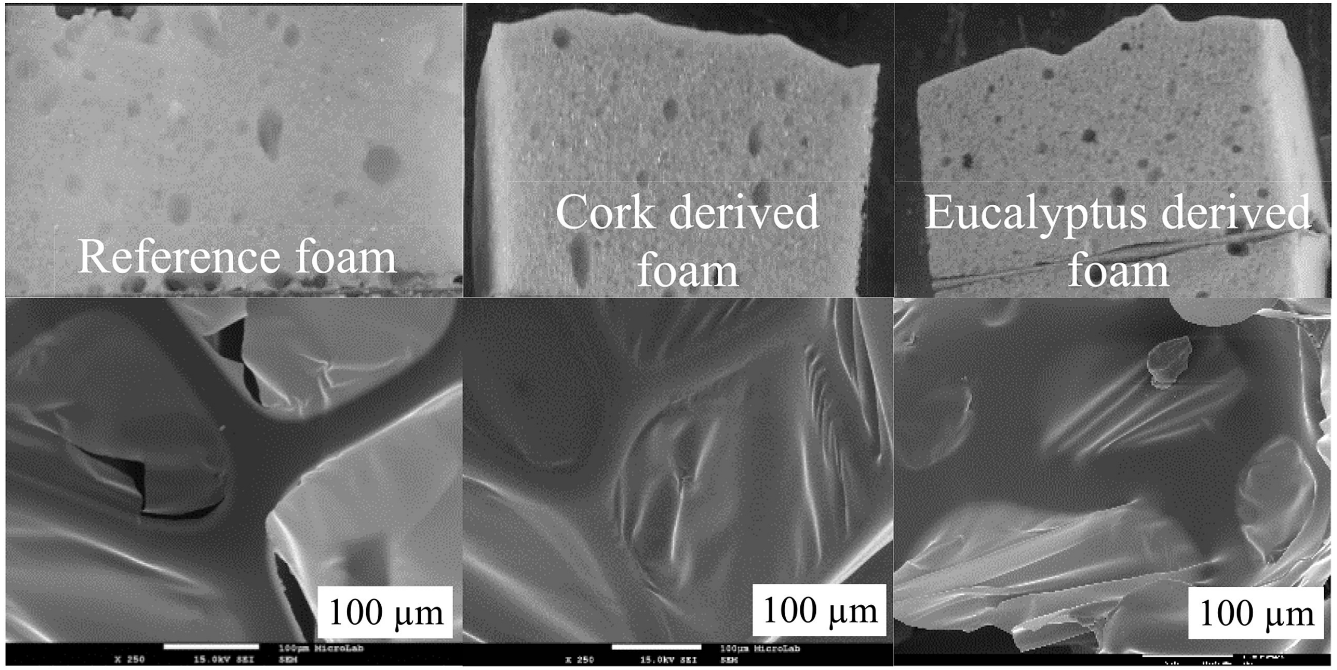
Grants to the person(s) having title to this patent the right to exclude others from making, using, offering for sale, or selling the invention throughout the United States of America or importing the invention into the United States of America, and if the invention is a process, of the right to exclude others from using, offering for sale or selling throughout the United States of America, or importing into the United States of America, products made by that process, for the term set forth in 35 U.S.C. 154(a)(2) or (c)(1), subject to the payment of maintenance fees as provided by 35 U.S.C. 41(b). See the Maintenance Fee Notice on the inside of the cover.

Joseph Matal

- PT107143
- PCT/PT2014/000058
- WO/2015/034383
- CN 105745256 A
- EP3041886 A1
- US9688806 B2

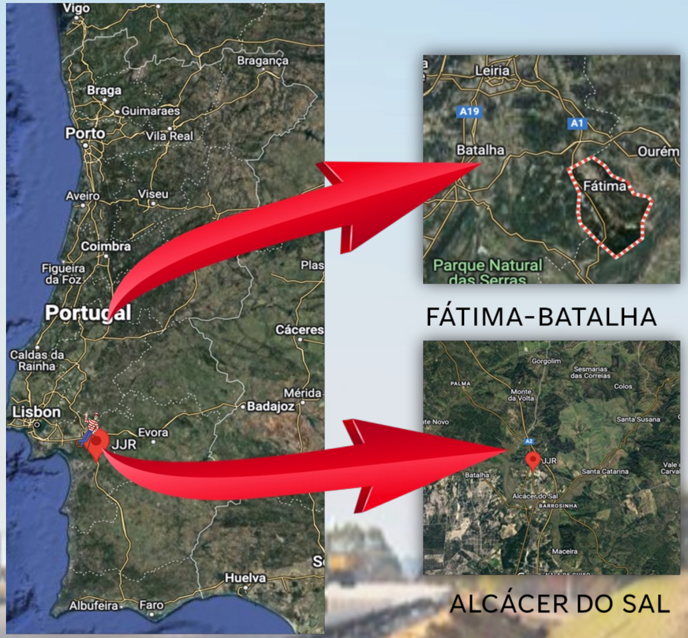
PU FOAMS FROM LIQUIFIED BIOMASS





SUSTAINABLE BIO-BINDER FOR ROAD PAVEMENT
PRODUCTION OF BITUMEN FROM BIO-OILS

EXPERIMENTAL SECTION – **June '23**



FÁTIMA-BATALHA

ALCÁCER DO SAL

Bio-oil bitumen with properties similar to those of 35/50 bitumen


VOLVO
PT240R

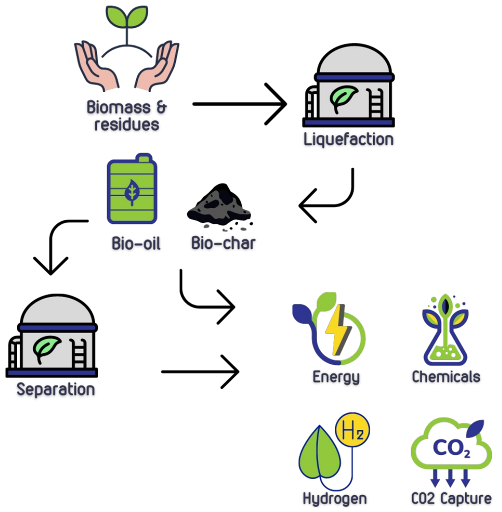

JJR

BIO2VALUE

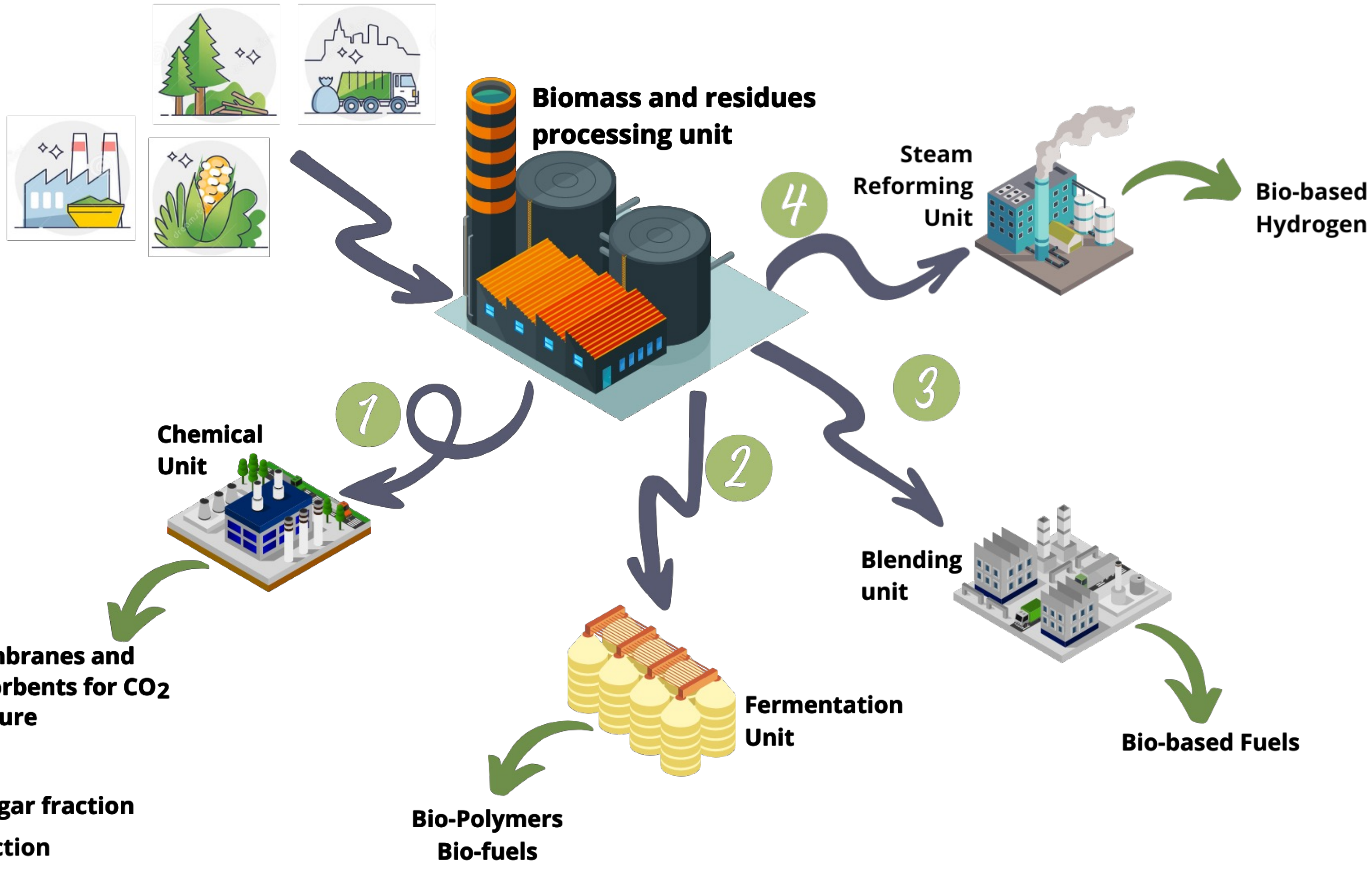
CREATING VALUE

RESEARCH

Bring together the valorization of biomass and the concept of biorefinery in an integrated platform for the upcycling of biomass, but above all of waste



BIO2VALUE – AN INTEGRATED PLATFORM FOR THE RECOVERY OF BIOMASS AND WASTE



1. Biochar
2. Enriched-sugar fraction
3. Organic fraction
4. Bio-oil and fractions

BIO2VALUE
CREATING VALUE

ZERO WASTES | CO_2 NEUTRAL | CIRCULAR

CAN BIO-OILS BE A SOLUTION IN THE TRANSITION TO A MORE SUSTAINABLE ECONOMY?

DEQ
DEPARTAMENTO
DE ENGENHARIA QUÍMICA
TÉCNICO LISBOA

CHEMICAL ENGINEERING DEPARTMENT

Come to visit us at our beautiful Lisbon

The gastronomy is great as well!!!

THANK YOU!