

PSYCHE Project

Prof. Kevin Van Geem, 08/12/2022



Certech
R&D partner in chemistry



Chimie Lille
ÉCOLE NATIONALE SUPÉRIEURE DE CHIMIE

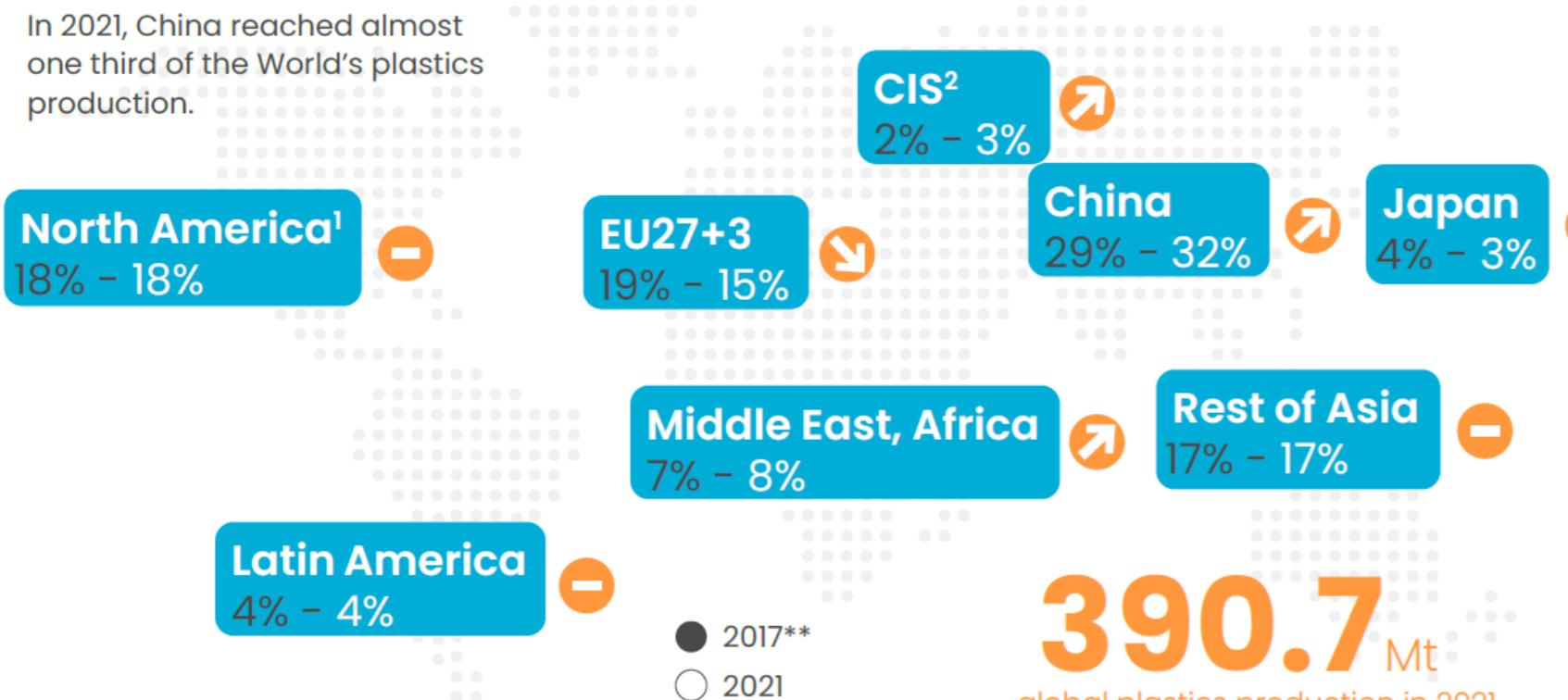


Interreg
France-Wallonie-Vlaanderen
UNION EUROPÉENNE
EUROPESE UNIE
PSYCHE



Plastics production

- World Plastics Production (MT) in 2020 → 2021: 375.5 → 390.7
- EU Plastics Production (MT) in 2020 → 2021: 53.9 → 57.2



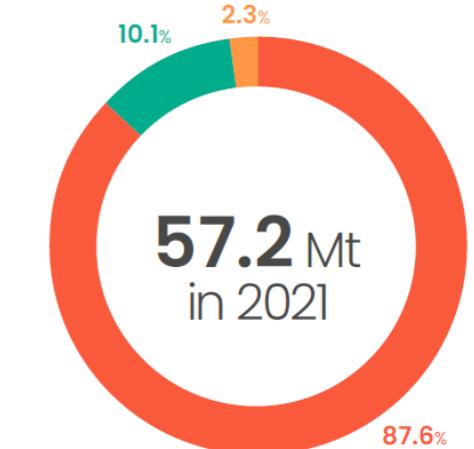
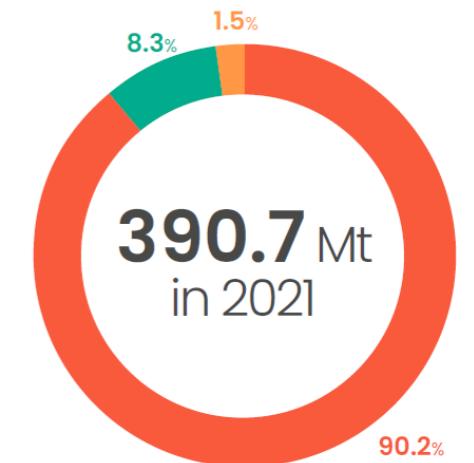
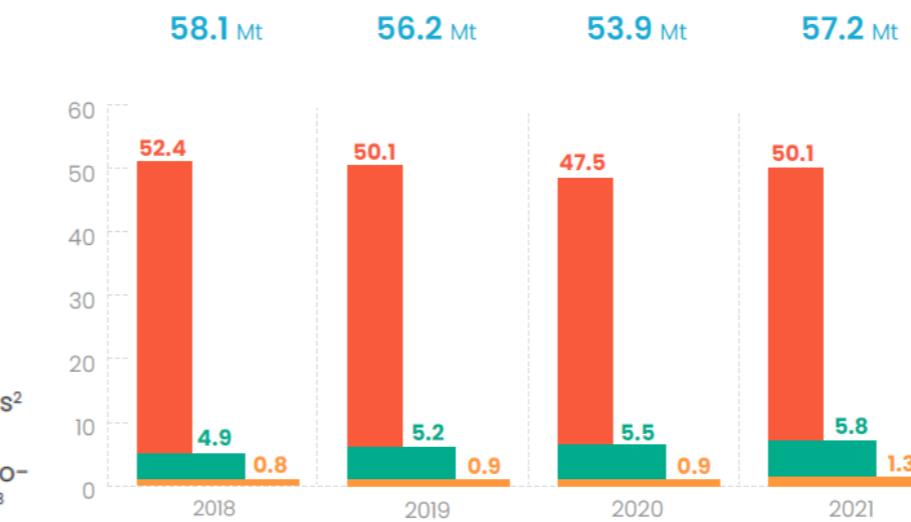
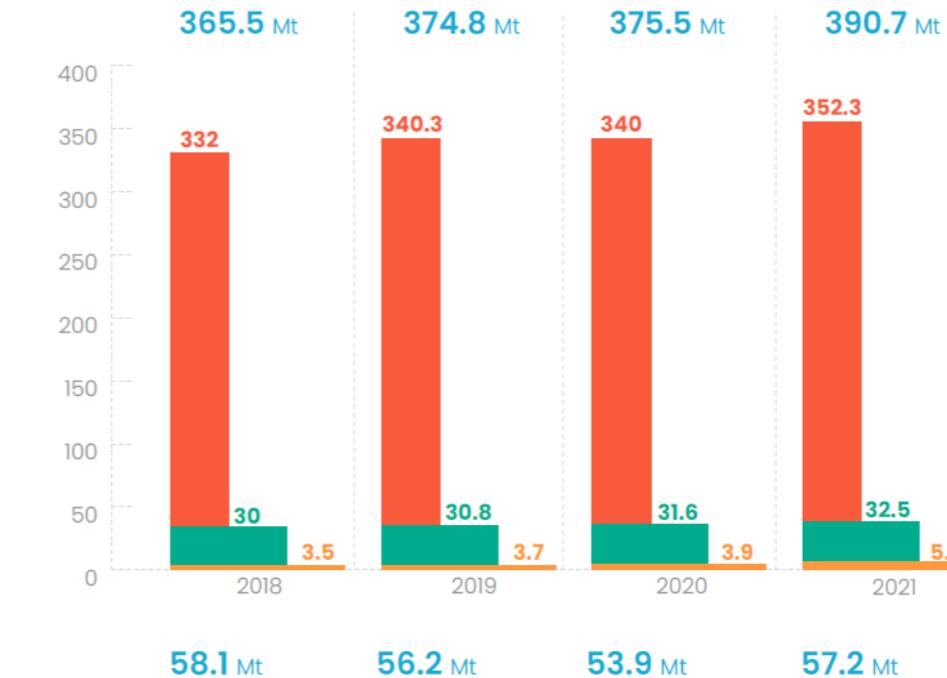
390.7 Mt
global plastics production in 2021

in million tonnes

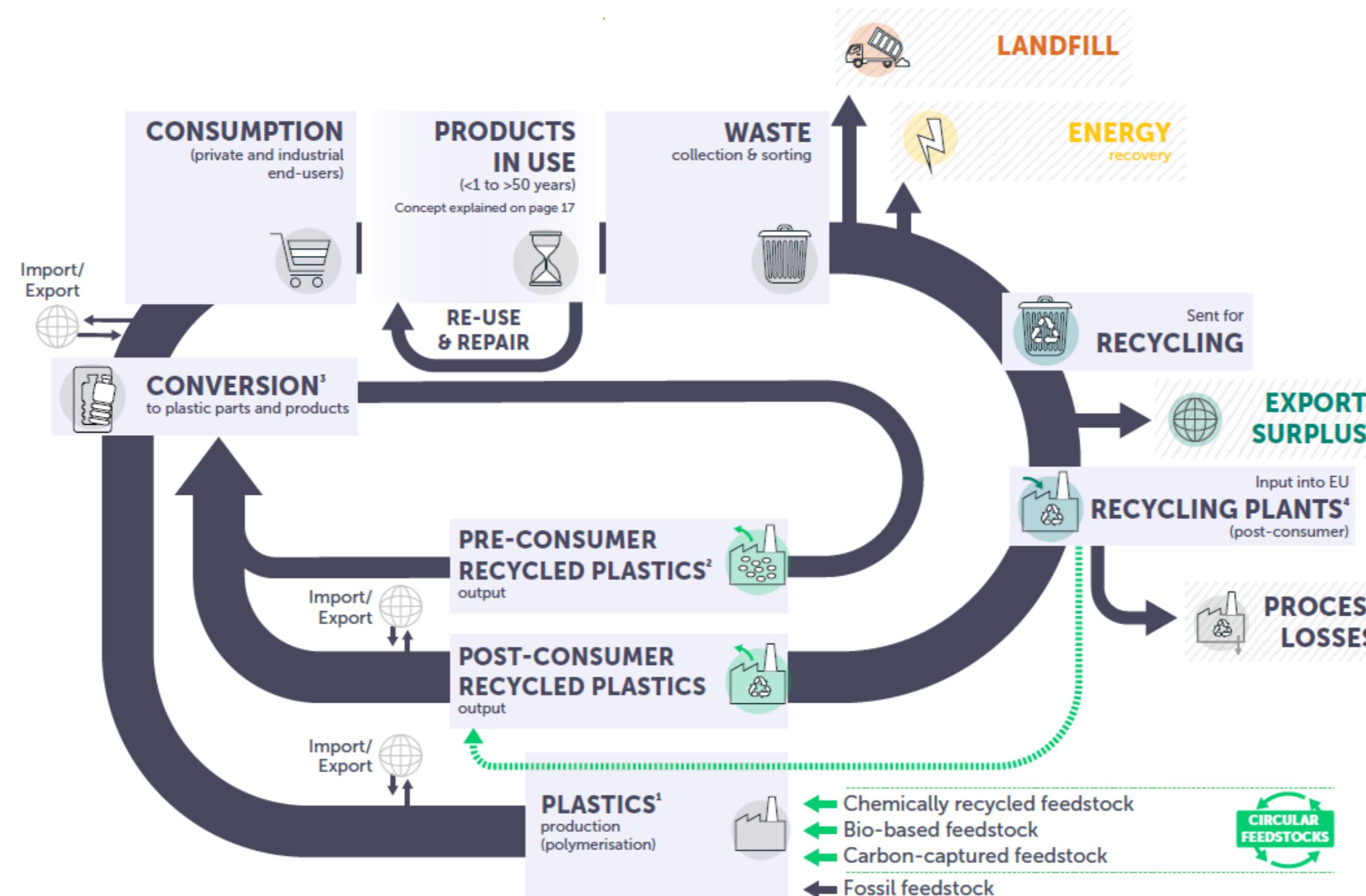
Fossil-based plastics¹

Post-consumer recycled plastics²

Bio-based plastics (including bio-attributed plastics in 2021 data)³



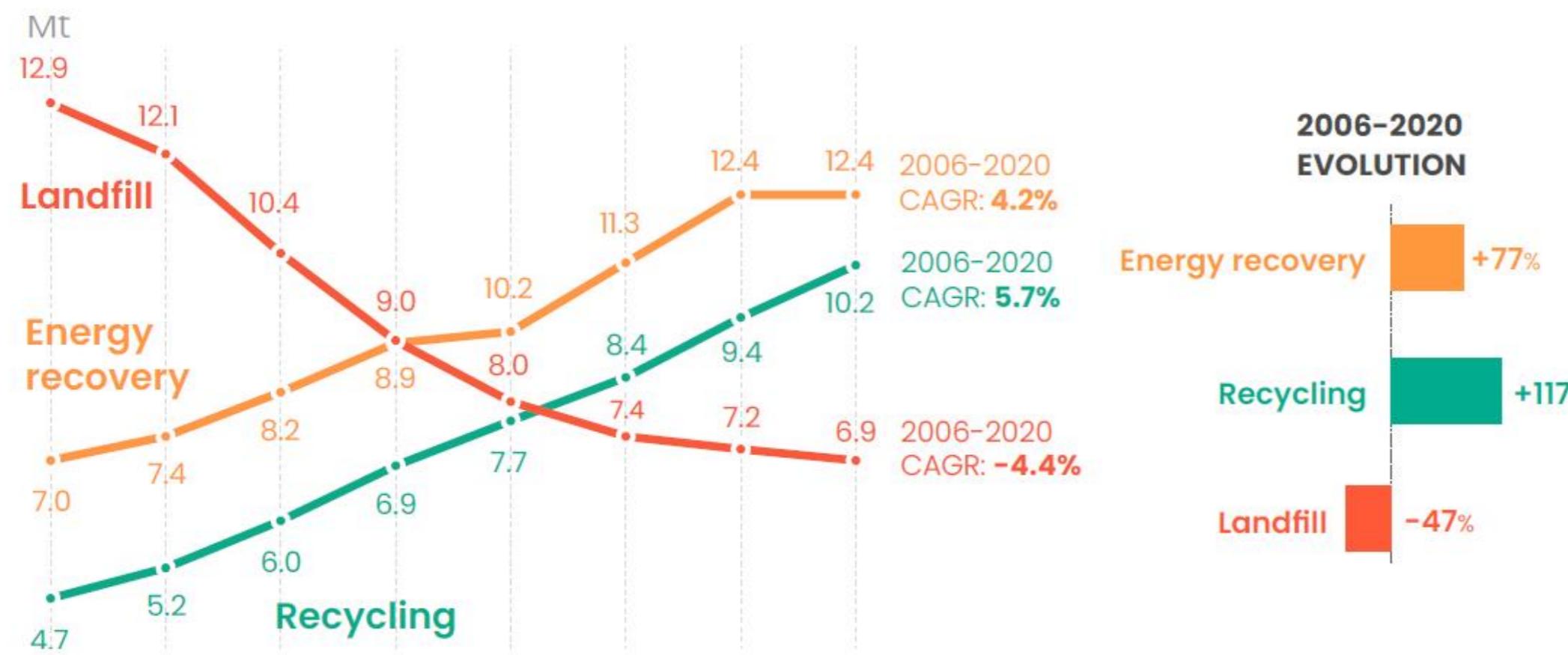
Circular Economy



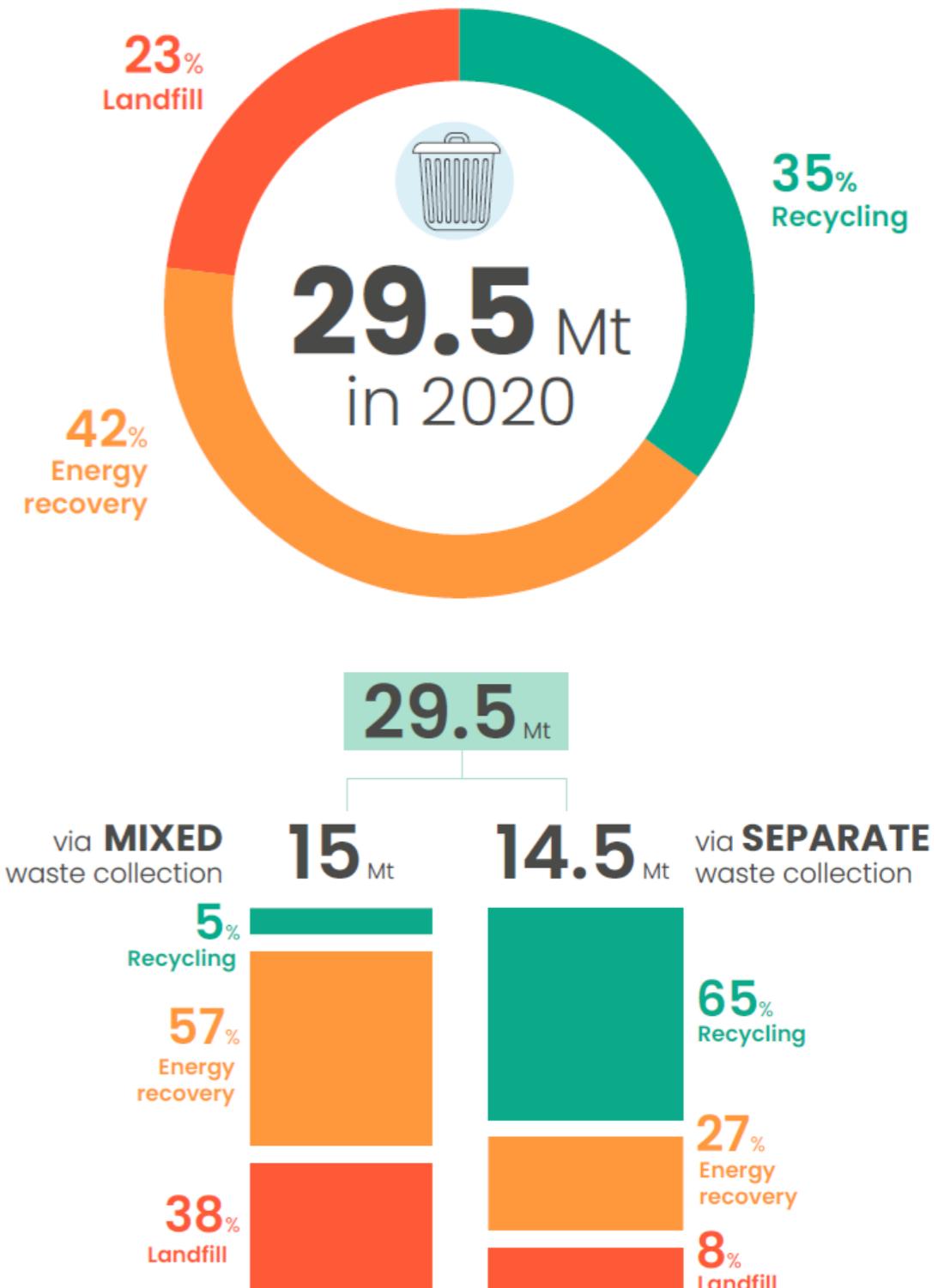
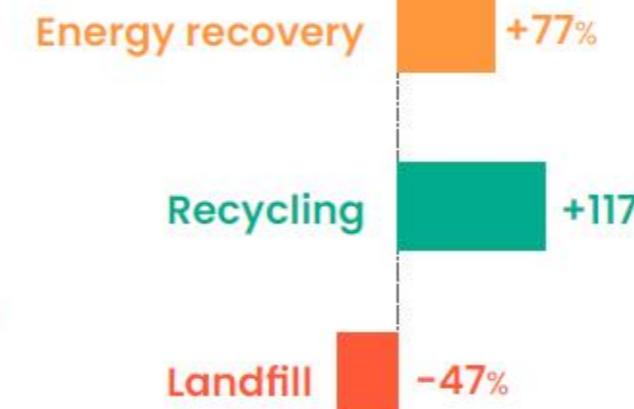
PlasticsEurope, 2020. Plastics – the Facts 2020: An analysis of European plastics production, demand and waste data, PlasticsEurope Brussels, Belgium.

Increased plastic waste recycling

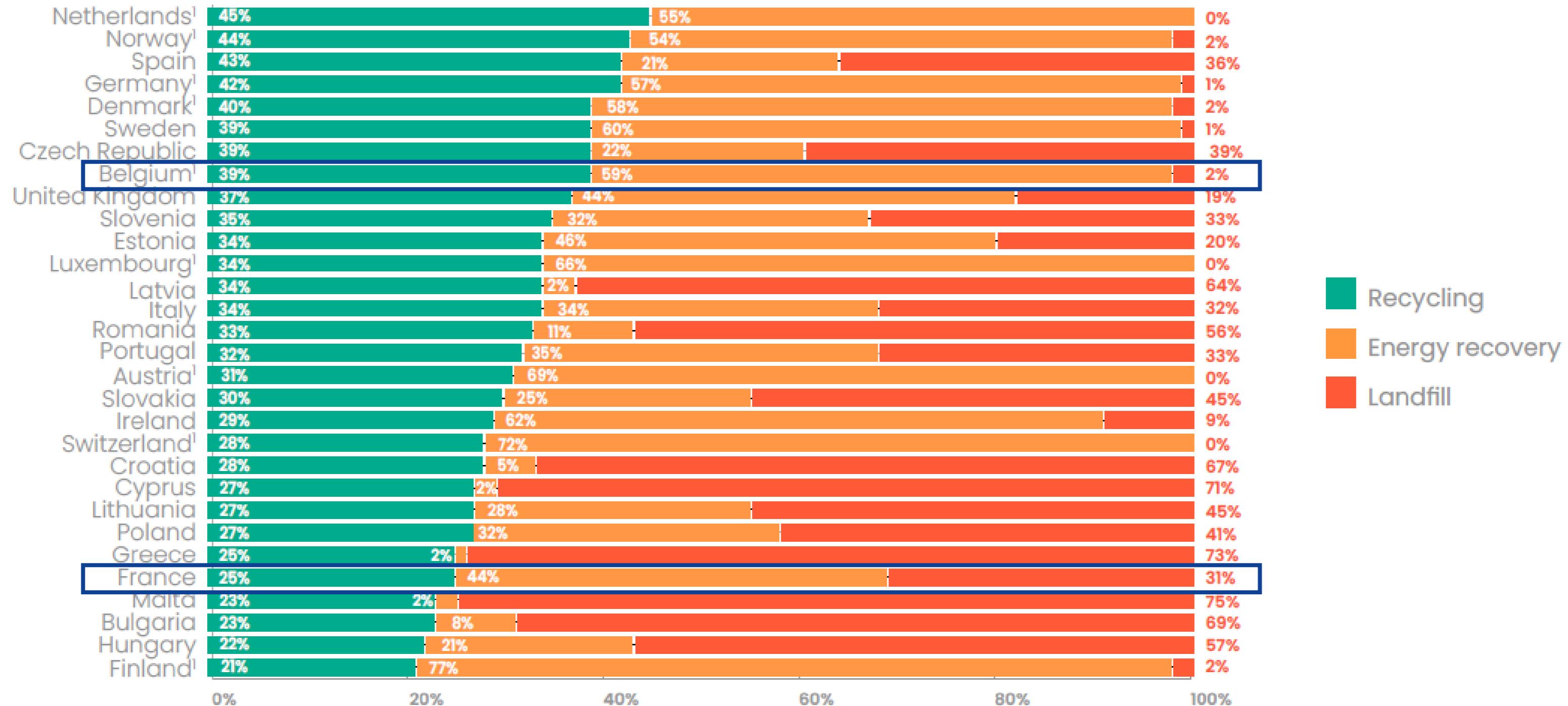
- EU plastic waste treatment from 2006 to 2020
- In 2016, landfill became lower than recycling



2006-2020
EVOLUTION



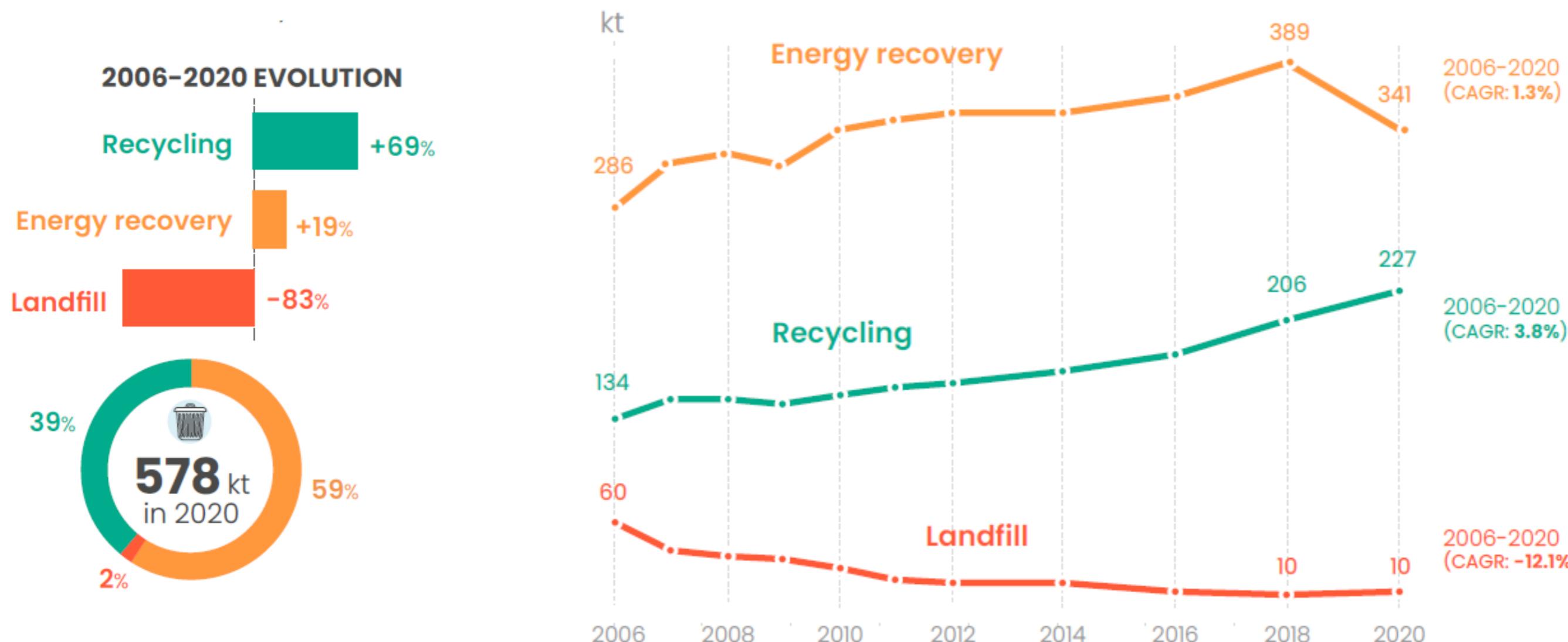
Plastic waste treatment per country in 2020



█ Recycling
█ Energy recovery
█ Landfill

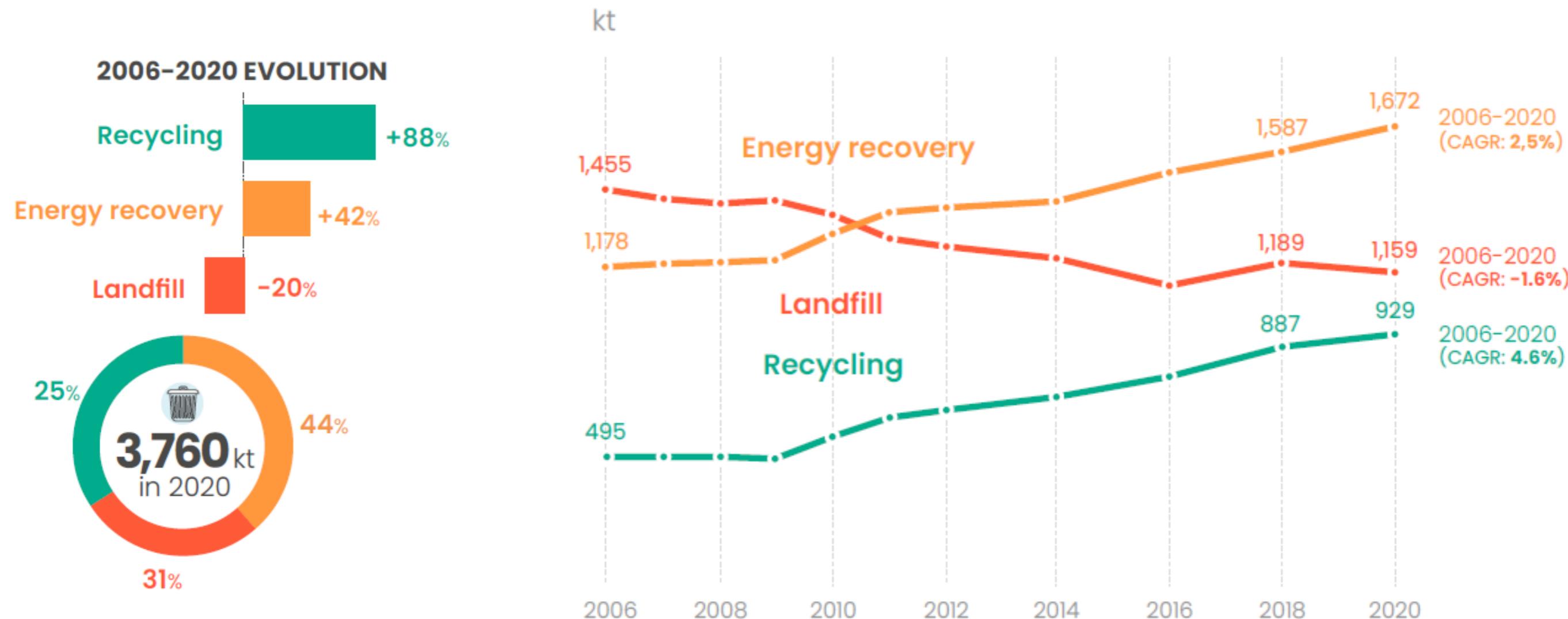
Plastic waste treatment in Belgium

- Post-consumer plastics waste treatment evolution 2006-2020 (kt)



Plastic waste treatment in France

- Post-consumer plastics waste treatment evolution 2006-2020 (kt)



PSYCHE Project

Conversion of plastic waste to base chemicals via gasification and subsequent Fischer-Tropsch synthesis for reuse in the chemical industry

Funding:



Avec le soutien du Fonds européen de développement régional
Met steun van het Europees Fonds voor Regionale Ontwikkeling

€ 2.6 Million



Wallonie

Competitiveness pools:



Partners



Guy Marin
Kevin Van Geem
Joris Thybaut
Steven De Meester



Benoit Kartheuser



Juray De Wilde



Andrei Khodakov
Robert Wojcieszak



Mirella Virginie

PSYCHE Objective



Project duration: 01/07/2018 – 31/12/2022

Work Packages

WP1 Project management

WP2 Communication

Experimental

WP3 Pretreatment and
gasification of plastic waste

WP4 Syngas purification and
Fischer Tropsch production of
olefins

WP5 Education

Education

Four **workshops** and four sets of **guest lectures** were organized during the project:

- Pretreatment May 8th 2019, coupled to Greenwin event
- Gasification & vortex May 14th 2020, online event via Teams
- Purification of syngas May 10th 2021, online event via Teams
- Fischer Tropsch Synthesis June 2nd 2022, hybrid event online / ULille

Four sets of **guest lectures** were organized during the project:

- Fischer-Tropsch synthesis (Andrei Khodakov, UCCS) & Gasification (Juray De Wilde, UCL)
- Syngas purification (Lilia Ben Mustapha, Certech) & Vortex reactor technology (Kevin Van Geem, UGent)
- Fischer-Tropsch synthesis (Mirella Virginie, UCCS) & Gasification (Juray De Wilde, UCL)
- Syngas purification (Benoit Kartheuser, Certech) & Fischer-Tropsch modelling (Joris Thybaut, UGent)

Youtube videos available on PSYCHE website: www.psycheplastics.eu

Advisory Board



Project realisations

- 5 proof of concepts
 - ✓ Deinking method for the plastic waste pretreatment
 - ✓ Use of virtual catalyst screening method in SEMK modelling
 - ✓ New type of bimetallic promotors for iron catalysts in Fischer-Tropsch synthesis
 - ✓ Pyrolysis of polystyrene in vortex reactor, yielding mainly styrene
 - ✓ Regenerable dry process for Sulphur removal from syngas
- 3 patents on deinking methods
- 4 PhDs (3 joint PhDs and 1 with co-promoter from partner institution)

Dissemination

Public press

- Recyclage et valorization des déchets plastiques: comment ça marche? (The Conversation)
- Déchets plastiques: les recycler, c'est bien, mais les valoriser c'est mieux (20 minutes)
- Une solution pour valoriser des déchets plastiques en olefins légères (L'Actualité Chimique)
- Gents centrum coördineert ambitieus Europees project rond kunststofafval (Bijlage Duurzame Chemie, De Morgen)



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Dissemination

Conferences



Television reports (Plastic recycleren, vrt)



Dissemination

Scientific communication (1)

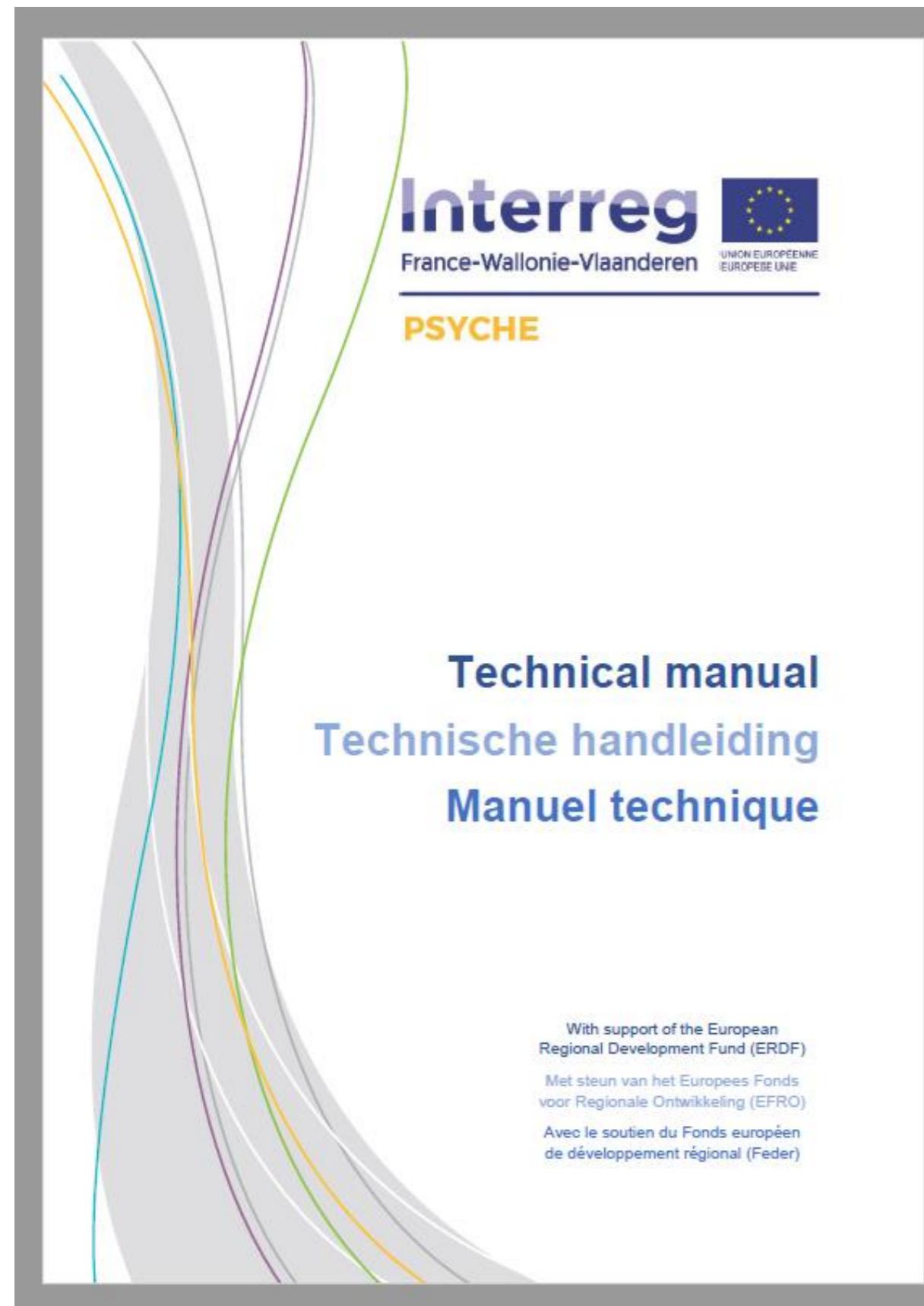
- Challenges and opportunities of solvent based additive extraction methods (*S. Ügdüler et al., Waste Manag., 2020, 104, 148-182*)
- Identification of efficient promoters and selectivity trends in high temperature Fischer-Tropsch synthesis (*A.J. Barrios et al., Appl. Catal. B, 2020, 273, 119028*)
- Mobility and versatility of the liquid bismuth promoter in the working iron catalysts for light olefin synthesis from syngas (*B. Gu et al., Chem. Sci., 2020, 11, 6167-6182*)
- Towards closed-loop recycling of multilayer and coloured PET plastic waste by alkaline hydrolysis (*S. Ügdüler et al., Green Chem., 2020, 22, 5376-5394*)
- Towards a better understanding of delamination of multilayer flexible packaging films by carboxylic acids (*S. Ügdüler et al., ChemSusChem, 2021, 14, 1-17*)
- Unravelling the influence of catalyst properties on light olefin production via Fischer-Tropsch synthesis: A descriptor space investigation using Single-Event Microkinetics (*A. Chakkingal, Chem. Eng. J., 2021, 419, 129633*)
- Active phases for high temperature Fischer-Tropsch synthesis in the silica supported iron catalysts promoted with antimony and tin (*D.V. Peron et al., Appl. Catal. B., 2021, 292, 120141*)
- Biomass fast pyrolysis in an innovative gas-solid vortex reactor: Experimental proof of concept (*M. Nunez Manzano et al., J. An. Appl. Pyrolysis, 2021, 156, 105165*)
- Carbon-based catalysts for Fischer-Tropsch synthesis (*Y. Chen et al., Chem. Soc. Rev., 2021, 50, 2337-2366*)
- Machine learning based interpretation of microkinetic data: A Fischer-Tropsch synthesis case study (*A. Chakkingal et al., React. Chem. Eng., 2021, 7, 101-110*)

Dissemination

Scientific communication (2)

- Efficient promoters and reaction paths in the CO₂ hydrogenation to light olefins over zirconia supported iron catalysts (*A.J. Barrios et al., Appl. Catal. B, 2021, submitted*)
- Bismuth mobile promoter and cobalt-bismuth nanoparticle in carbon nanotubes supported Fischer-Tropsch catalysts with enhanced stability (*B. Gu et al., J. Catal., 2021, 401, 102-114*)
- Experimental study on the temperature distribution in fluidized beds (*E. Milacic et al., 2022, 248 part A, 117062*)
- Liquid injection in fluidized bed: Temperature uniformity (*E. Milacic, M. Nunez Manzano, S. Madanikashani, G.J. Heynderickx, K.M. Van Geem, M. Baltussen, J.A.M. Kuipers, Chem. Eng. Sci.*)
- Analysis of the kinetics, energy balance and carbon footprint of the delamination of multilayer flexible packaging films via carboxylic acids (*S. Ügdüler, T. De Somer, K. Van Geem, J. De Wilde, M. Roosen, B. Deprez, S. De Meester, Resour. Conserv. Recycl., 2022, 191, 106256*)
- Multi-output machine learning models for kinetic data evaluation: A Fischer-Tropsch synthesis case study (*A. Chakkingal, P. Janssens, J. Poissonnier, M. Virginie, A.Y. Khodakov, J.W. Thybaut, Chem. Eng. J., 2022, 137186*)
- Gas-solid hydrodynamics in a stator-rotor vortex chamber reactor (*X. Lang, Y. Ouyang, L.A. Vandewalle, B. Goshayeshi, S. Chen, S. Madanikashani, P. Perreault, K.M. Van Geem, Chem. Eng. J., 2022, 137323*)
- Multi-scale modeling of plastic waste gasification: Opportunities and challenges (*S. Madanikashani, L. Vandewalle, S. De Meester, J. De Wilde, K.M. Van Geem, Materials, Accepted*)

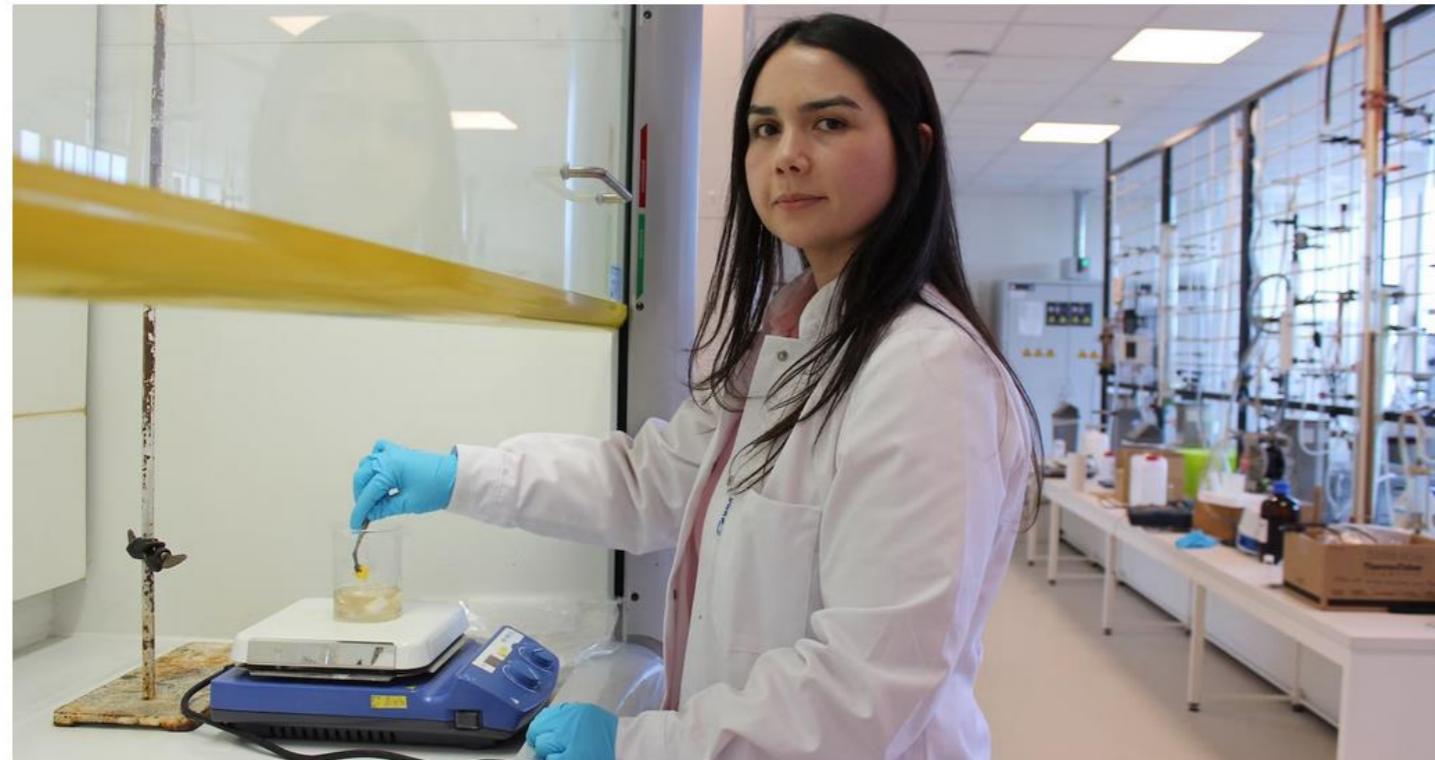
PSYCHE manual



- Overview of best-practices and how the processes are operated for each project part, based on the results obtained within the project:
 - Pretreatment
 - Gasification & vortex reactor technology
 - Purification of syngas
 - Fischer-Tropsch synthesis

EOS Pipet Prize 2022

Sibel Ügdüler (PSYCHE PhD student) has won the EOS Pipet 2022 for her work on the pretreatment of plastic waste.



Acknowledgements



PSYCHE



Avec le soutien du Fonds européen de développement régional
Met steun van het Europees Fonds voor Regionale Ontwikkeling



Prof. Dr. Ir. Kevin Van Geem

Full Professor

LABORATORY FOR CHEMICAL TECHNOLOGY

E kevin.vangeem@ugent.be
T +32 9 264 55 97
M +32 9 264 58 30

www.ugent.be

 Ghent University

 @ugent

 Ghent University

