The potential net value creation of recycling non-household end-use plastics waste: Case study from the City of Ghent

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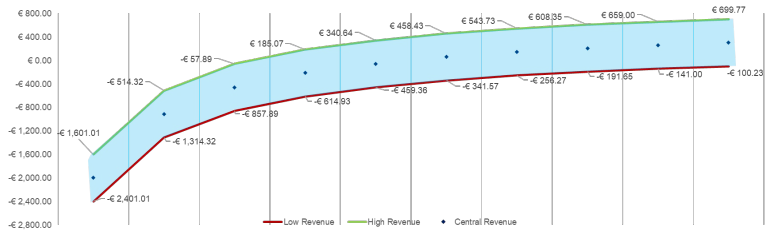

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Interreg 2 Seas Mers Zeeën PlastiCity European Regional Development Fund

Acknowledgement

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Non-household end-use plastic waste

Status Quo

… lack of data on industrial and commercial waste ***quantity*** *and* ***composition***
e.g. waste from restaurant, wholesale retails, manufacture sectors, etc

… **High potential for recycling** with low contamination and homogeneous stream

Research questions

- Which sectors generate most of the plastic waste?
- What is the quantity and composition of non-household end-use plastic?
- What is the net economic balance of recycling non-household end-use plastic?

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Research Methodology

Building and applying techno-economic assessment model

- Investigate the potential **waste quantity** through top-down and bottom-up approach
- Investigate the non-household end-use plastic **composition**
- Predict the **material flows** through plastic recycling process and its associated **cost** and **revenue**
- Investigate the **potential business case** for '*PE Films Recycling*'

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Techno-economic assessment

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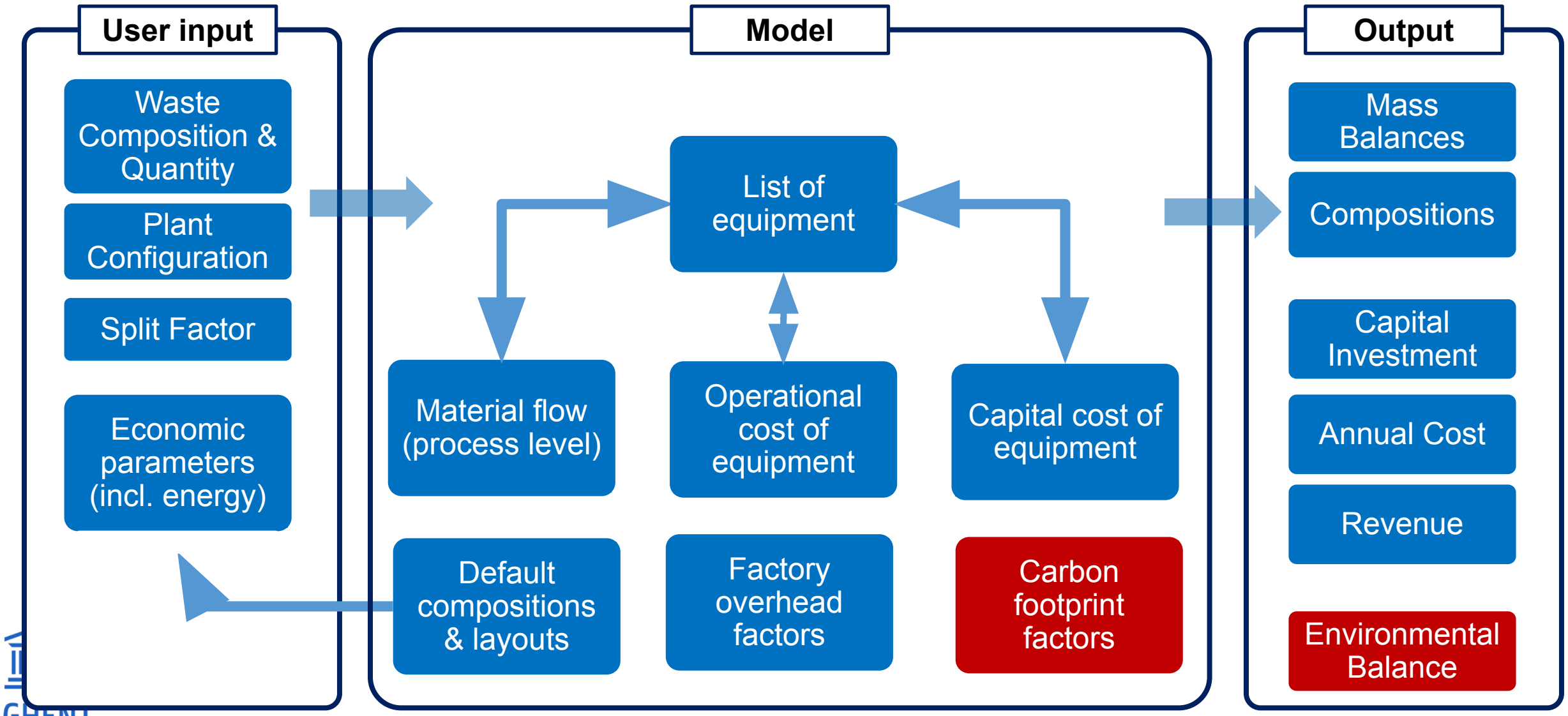
Techno-economic assessment model



Model inputs, processes and outputs considered in this research

The modeling process and output that are excluded from this research

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Estimation of waste quantity

Bottom-up approach

- ✔ **Quantity** of collected non-household plastics **films**
- ✔ Number of **collection points**, listed per *NACE code*
- ✔ **Total companies** operating in Flanders and Ghent, listed per *NACE code*

Top-down approach

- ✔ The quantity of **total plastics waste** generated from 7 *NACE code (A-G)* in Belgium

Literature review:

- ✔ Share of non-household **rigid vs. films** plastics; on avg. 42% vs. 58%
- ✔ Share of plastics waste generated **in Flanders**; ± 60% of total plastics waste in Belgium
- ✔ Share of plastics waste generated **in Ghent**; estimated to be 5% of total plastics waste in Flanders

Estimating total non-household plastics film

- ✔ **Extrapolate** the quantity data (Valipac to Orbis database)
- ✔ Compare the result to the top-down approach

Estimating total non-household plastics film

- ✔ **Scale down** the quantity in Belgium to Ghent level (using the ratio that is obtained from literature review)
- ✔ Compare the result to the bottom-up approach

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Estimation of waste composition

Composition
- Estimated from Hestin et al (2018) – Deloitte Report
- Estimated from sampling campaigns performed by PlastiCity project

Input composition to the model from two sources (in %)

Polymer	Characteristics	Hestin et al. 2018*	Survey	
PE	Transparent	*79%	46 – 50%	
	Colored		2 – 3%	48 – 53% PE films
PP	Transparent	*15%	36 – 42%	
	Colored		2 – 3%	38 – 45% PE films
Other films	PVC, etc	1%	3 – 4%	
Residue		5%	5%	
Total		**100%**	**100%**	

***Remarks**
- Data from Hestin et al. 2018 does not distinguish the films characteristics
- 5% Residue from literature (Thoden van Velzen et al. 2016 ; Horodytska et al. 2020 ; Roosen et al. 2021)

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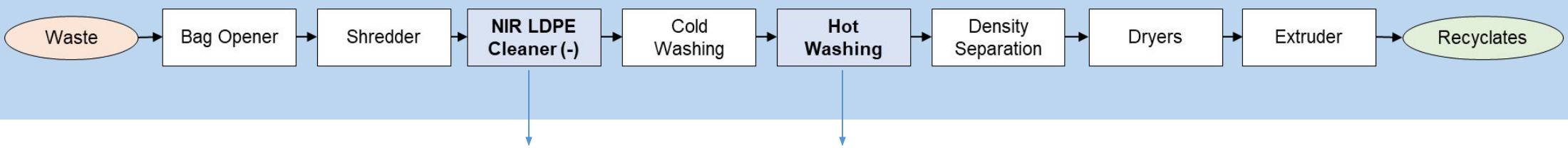
Plant Configuration

Modeling of '*basic*' and '*advanced*' recycling of non-household end-use plastics

- Scenario 1: basic recycling process
- Scenario 2: advanced recycling process

Recycling process flow



NIR and Hot Washing are* ***excluded in Scenario 1: basic recycling process*

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Economic Modeling Parameters

Library of data points for each sorting and recycling equipment

E.g. NIR machine – 2.8 meter width, incl. air compressor

Investment	
Total investment cost, including:	€ 265,000
Installation Cost	€ 90,000
Project Management Cost	€ 24,000

Usages	
Electricity for NIR machine (incl. converyor belt)	5 kWh
Electricity for air jet	8 kWh/tph
Depreciation	15 %
Repair and maintenance	4 %
Insurance	0.7 %

Cost modeling parameters

Source: Literature review, stakeholders consultation, Eurostat

Investment, including:

- Price of equipment
- Installation cost
- Project management cost
- Plant building and construction (accounts for 25% of the total investment)

Operational cost

- Hours of Operation : 8,000 hours/year
- Electricity price : 0.074 €/kWh
- Natural Gas : 0.070 €/kWh
- Water(and waste treatment) : 1.1 €/m^3
- Disposal fee : 132.5 €/ton residue
- Depreciation : 10% - 15 %
- Maintenance : 4 %
- Insurance : 0.7 %
- Labour : Avg. € 64,200/person
- General expenses : 10 %

Regranulate Price		
Scenario 1: Basic recycling process		
PE film regranulate	High value	€ 800/tonne
	Central value	€ 600/tonne
	Low value	€ 400/tonne
Scenario 2: Advanced recycling process		
PE film regranulate	High value	€ 1200/tonne
	Central value	€ 800/tonne
	Low value	€ 400/tonne

**Source:*
Price for *'Basic'* recycling process is estimated from Tier 1 – rPE Flex of CEFLEX QRP chain

Price for *'Advanced'* recycling process is estimated from Tier 1 – rPE Film Natural of CEFLEX QRP chain

Database with split factors and OPEX/CAPEX factors, with excel based model

Source: Cimpan et al. 2016 ; Larrain et al. 2021 ; WRAP 2009 ; EEA, 2021 ; Lase et al. 2022 ; Bashirgonbadi et al. 2022

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Summary of the scenarios

Two input composition:

- A higher input quality from Hestin et al. 2018
- A lower input quality from GRCT sorting and compositional analysis

Two recycling plant configuration:

- Basic recycling plant: *without* NIR LDPE Cleaner (-) and Hot Washing
- Advanced recycling plant: *with* NIR LDPE Cleaner (-) and Hot Washing

Total four scenarios

- Basic recycling plant with higher input quality
- Basic recycling plant with lower input quality
- Advanced recycling plant with higher input quality
- Advanced recycling plant with lower input quality

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Modelling Results

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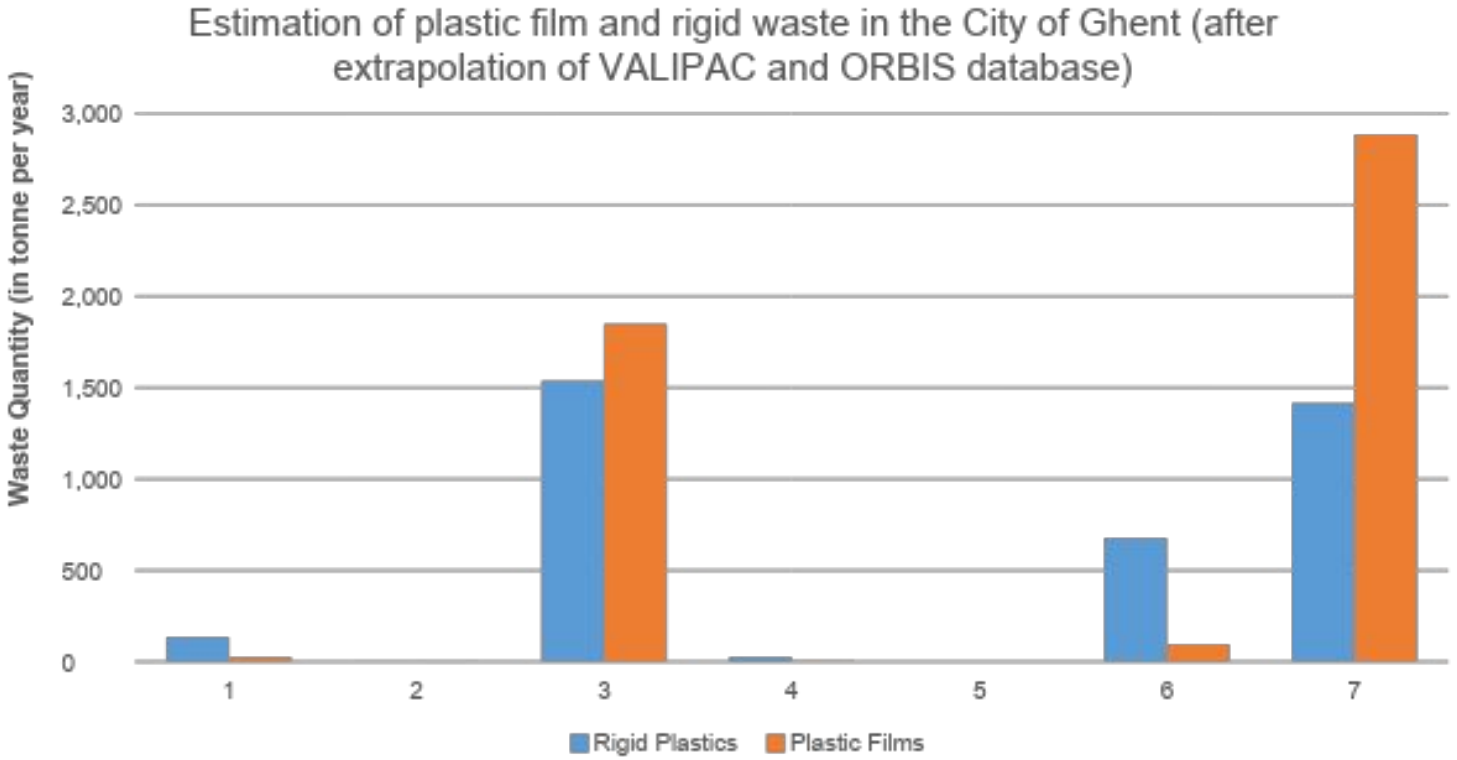
Estimated quantity of non-household end use plastics in Ghent



Estimated non-household plastics waste quantity in Ghent (in tonne)

NACE code	*Rigid*	*Film*
A	134	24
B	1	1
C	1,536	1,848
D	25	3
E	0	0
F	678	95
G	1,416	2,887
Total	**3,791**	**4,882**
Total film & rigid	**8,673**	
Mass Ratio	**44%**	**56%**

Data comparison from literature

- Waste quantity estimated from Eurostat
- Estimated mass ratio by Hestin et al. 2018
  - Rigid : 42%
  - Film : 58%

Estimated quantity (in tonne)
NACE Code A – G from Eurostat

Total	Rigid	Total
8,649	3,633	5,016

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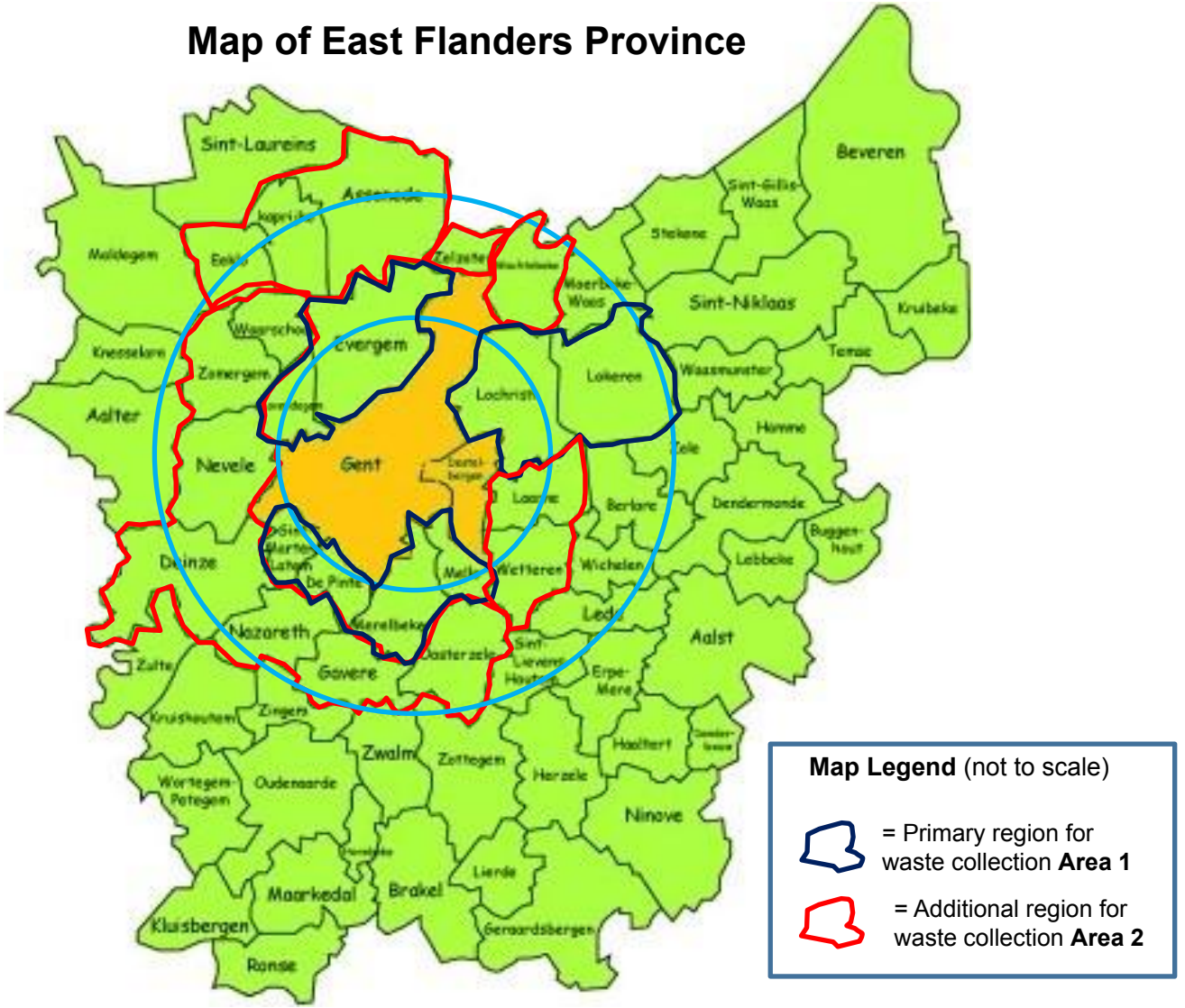
Potential additional waste quantity from nearby municipalities

Expanding the collection area from the City of Ghent:

- ✔ Optimize the recycling plant processing capacity (i.e., ± 10,500 tonne per annum)
- ✔ Benefit from the economic of scales of non-household end use plastics recycling
- ✔ Improve the circular economy of plastics of nearby municipalities

Map of East Flanders Province



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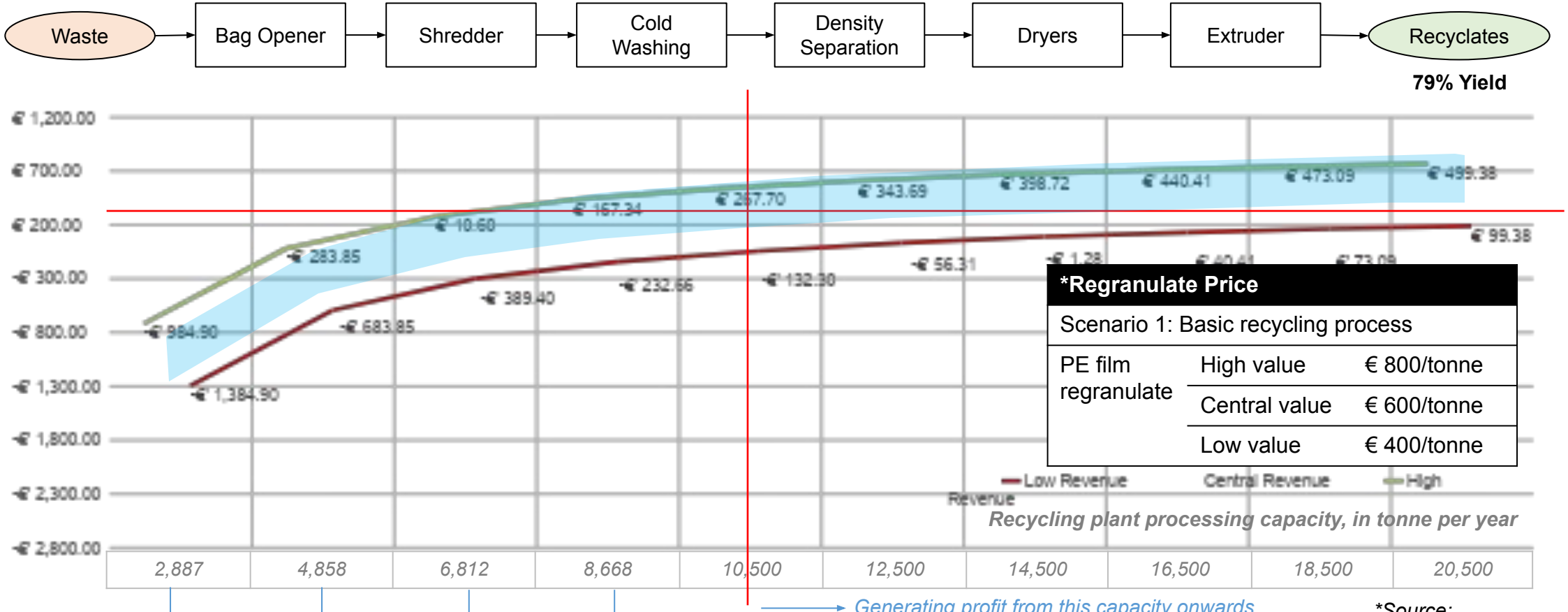
Net Loss/Profit: Basic Recycling Plant w/ higher input quality



*Regranulate Price		
Scenario 1: Basic recycling process		
PE film regranulate	High value	€ 800/tonne
	Central value	€ 600/tonne
	Low value	€ 400/tonne

Recycling plastic film waste from NACE A to G from all listed municipalities

Recycling plastic film waste from NACE A to G from City of Ghent and 7 nearby municipalities (selection based on density of economic activity)

Recycling plastic film waste from NACE A to G from City of Ghent

Recycling plastic film waste from NACE G – Wholesale retail (biggest source of plastic film waste) in Ghent

Source:
Price for *'Basic'* recycling process is estimated from Tier 1 – rPE Flex of CEFLEX QRP chain

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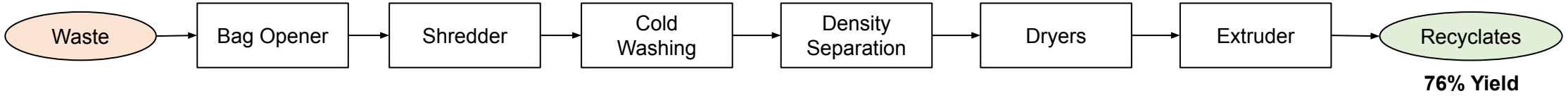
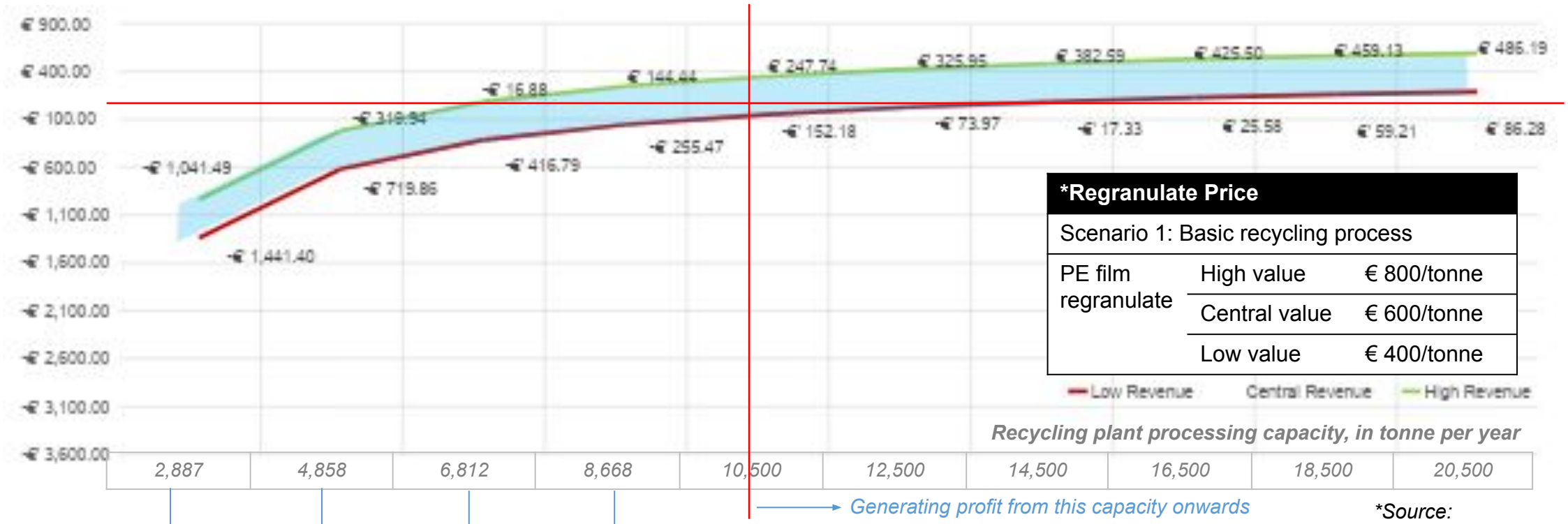
Net Loss/Profit: Basic Recycling Plant w/ lower input quality



76% Yield



*Regranulate Price		
Scenario 1: Basic recycling process		
PE film regranulate	High value	€ 800/tonne
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	Low value	€ 400/tonne

Recycling plastic film waste from NACE A to G from all listed municipalities

Recycling plastic film waste from NACE A to G from City of Ghent and 7 nearby municipalities (selection based on density of economic activity)

Recycling plastic film waste from NACE A to G from City of Ghent

Recycling plastic film waste from NACE G – Wholesale retail (biggest source of plastic film waste) from City of Ghent

Source:
Price for *'Basic'* recycling process is estimated from Tier 1 – rPE Flex of CEFLEX QRP chain

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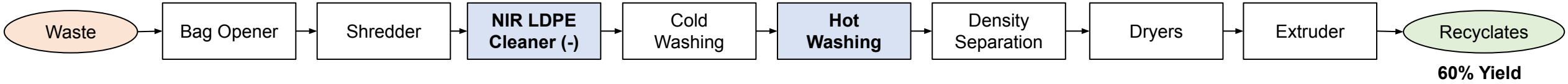
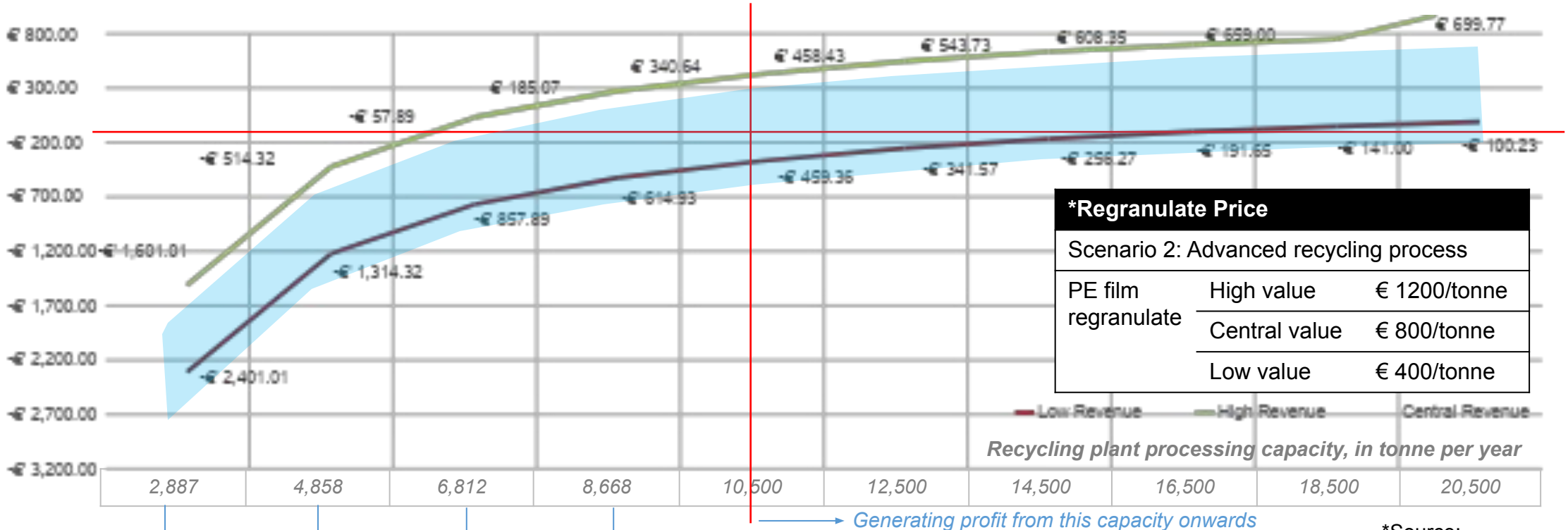
Net Loss/Profit: Advanced recycling plant w/ higher input quality



60% Yield



*Regranulate Price		
Scenario 2: Advanced recycling process		
PE film regranulate	High value	€ 1200/tonne
	Central value	€ 800/tonne
	Low value	€ 400/tonne

Recycling plastic film waste from NACE A to G from all listed municipalities

Recycling plastic film waste from NACE A to G from City of Ghent and 7 nearby municipalities (selection based on density of economic activity)

Recycling plastic film waste from NACE A to G from City of Ghent

Recycling plastic film waste from NACE G – Wholesale retail (biggest source of plastic film waste) from City of Ghent

*Source:
Price for *'Advanced'* recycling process is estimated from Tier 1 – rPE Film Natural of CEFLEX QRP chain

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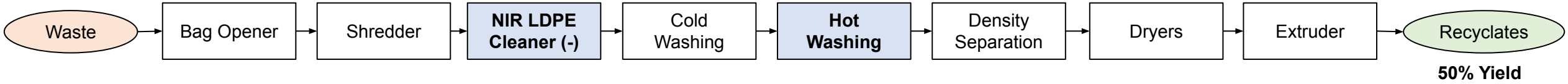
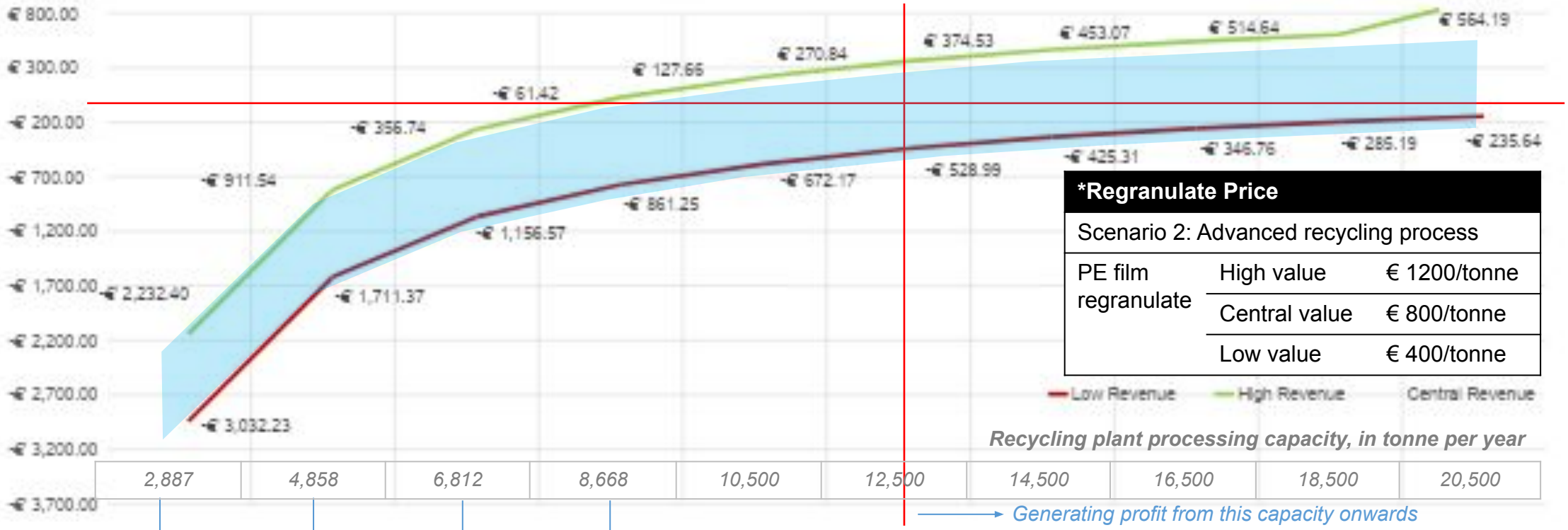
Net Loss/Profit: Advanced recycling plant w/ lower input quality



50% Yield



*Regranulate Price		
Scenario 2: Advanced recycling process		
PE film regranulate	High value	€ 1200/tonne
	Central value	€ 800/tonne
	Low value	€ 400/tonne

Recycling plastic film waste from NACE A to G from all listed municipalities

Recycling plastic film waste from NACE A to G from City of Ghent and 7 nearby municipalities (selection based on density of economic activity)

Recycling plastic film waste from NACE A to G from City of Ghent

Recycling plastic film waste from NACE G – Wholesale retail (biggest source of plastic film waste) from City of Ghent

*Source:
Price for *'Advanced'* recycling process is estimated from Tier 1 – rPE Film Natural of CEFLEX QRP chain

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Modelling and Business Case Conclusion

Business case development:

- Developed through material flow and cost modelling
- Granular data points at process level
- The output gives indication of the potential net economic balance

Non-household end-use plastics film recycling:

- Recycling and valorization of non-household end use plastics films can be economically attractive
- Cost of improved recycling process (e.g., with hot washing) can be compensated by higher selling price of a higher recyclate's quality
- The net economic balance is linked to the amount of feedstocks (input quantity)

Thank you!

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Backup Slides

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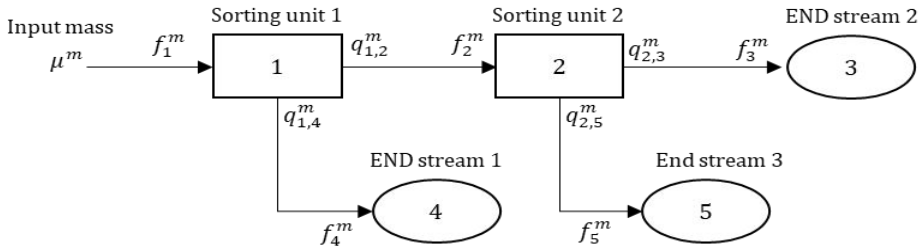
Split factors

Model predicts behavior based on input composition and plant configuration of recycling plant:

- Efficiencies specific to processes and representative products, based on:
  - ✔ Machine design specifications
  - ✔ Experimental data
  - ✔ Expert judgment

- Matrix calculations allow internal loops



$$\begin{bmatrix} f_1^m \\ f_2^m \\ f_N^m \end{bmatrix} = \begin{bmatrix} q_{1,1}^m & q_{2,1}^m & \cdots & q_{N,1}^m \\ q_{1,2}^m & q_{2,2}^m & \cdots & q_{N,2}^m \\ q_{1,N}^m & q_{2,N}^m & \cdots & q_{N,N}^m \end{bmatrix} \begin{bmatrix} f_1^m \\ f_2^m \\ f_N^m \end{bmatrix} + \begin{bmatrix} \mu^m \\ 0 \\ 0 \end{bmatrix}$$

$$f^m = (Q^m)^T f^m + \mu^m$$

$q_{i,j}^m$: ***Split factors*** *of the fraction of waste item m that is sent from process i to process j [%]*

Waste Management 120 (2021) 290–302

Contents lists available at ScienceDirect

Waste Management

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

Development and application of a predictive modelling approach for household packaging waste flows in sorting facilities

Kerstin Kleinhans [a,b,c], Michelle Hallemans [b], Sophie Huysveld [b], Gwenny Thomassen [b,e], Kim Ragaert [c], Kevin M. Van Geem [d], Martijn Roosen [a], Nicolas Mys [a,c], Jo Dewulf [b], Steven De Meester [a,*]

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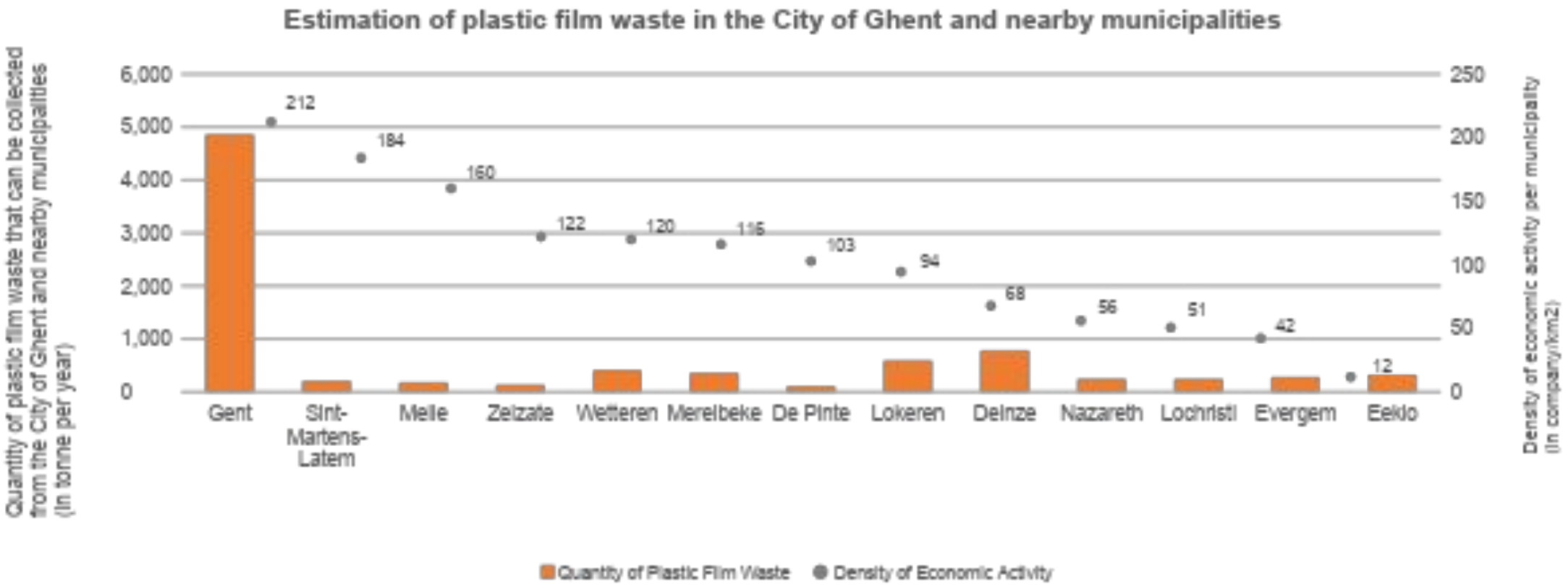
Estimated quantity of plastic films in Ghent and nearby municipalities



Quantity of plastic film waste per municipality, in tonne per year

Gent	Sint-Martens-Latem	Melle	Zelzate	Wetteren	Merelbeke	De Pinte	Lokeren	Deinze	Nazareth	Lochristi	Evergem	Eeklo
4,858	202	175	129	405	353	100	589	780	241	239	275	321

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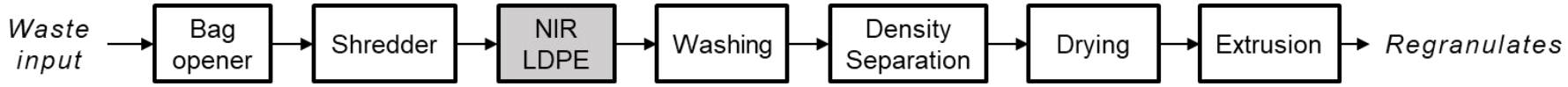
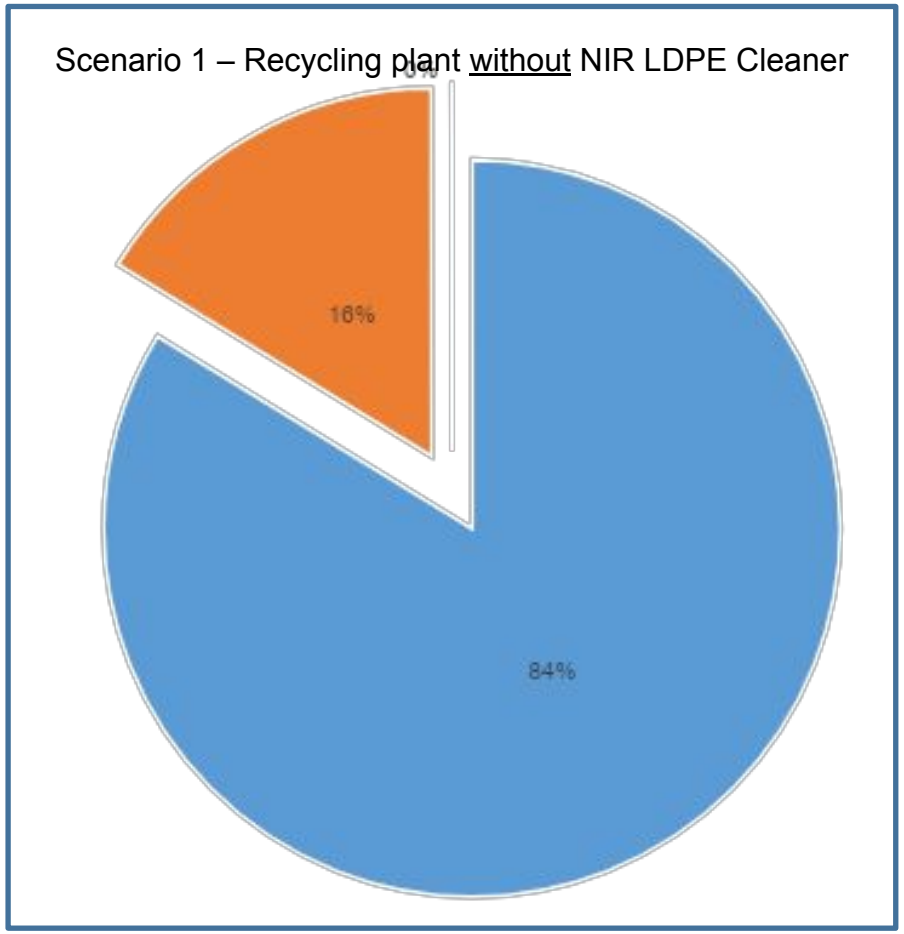
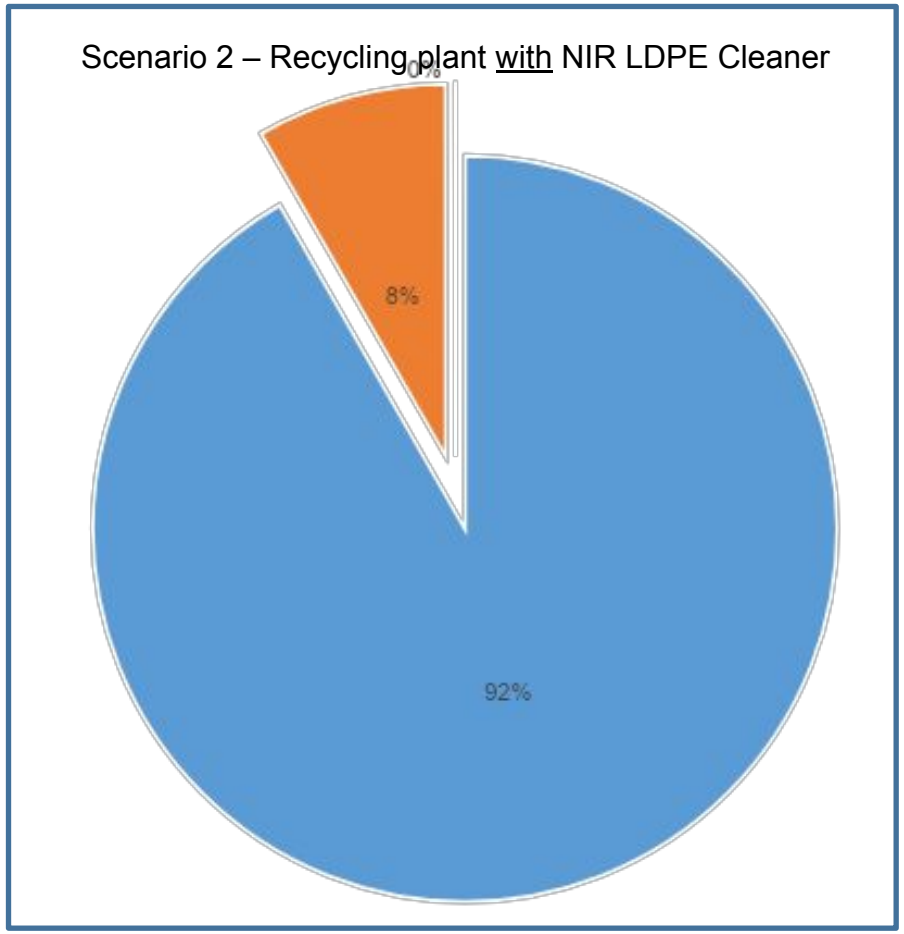
Results – Modeled waste composition (higher input quality)







PE Film PP Film

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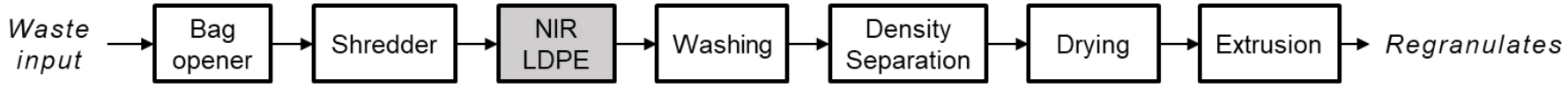
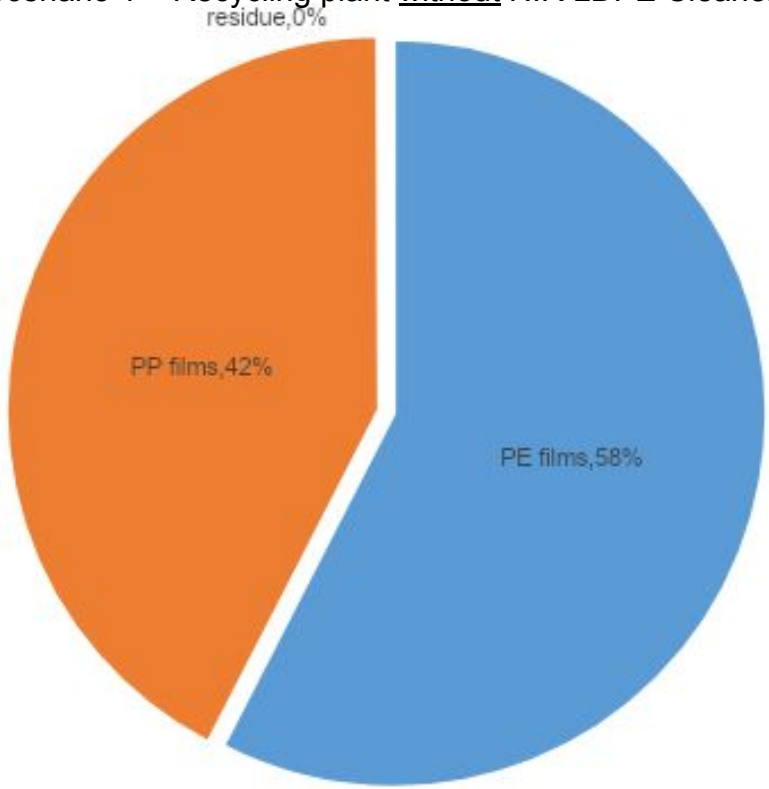
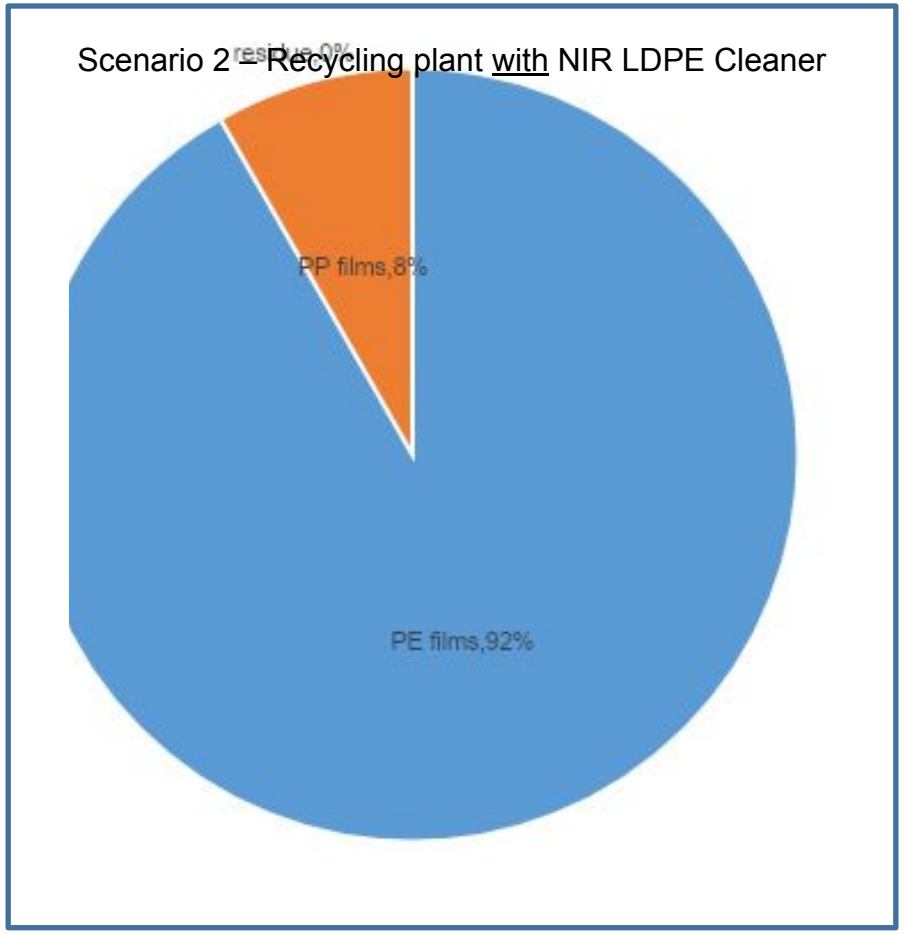
Results – Modeled waste composition (lower quality input)



Scenario 1 – Recycling plant <u>without</u> NIR LDPE Cleaner



Scenario 2 – Recycling plant <u>with</u> NIR LDPE Cleaner



PE Film PP Film

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