



POLITECNICO
MILANO 1863



Valutazione della sostenibilità ambientale del fine vita delle materie plastiche

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Recupero e riciclo delle materie plastiche 8 settembre 2021

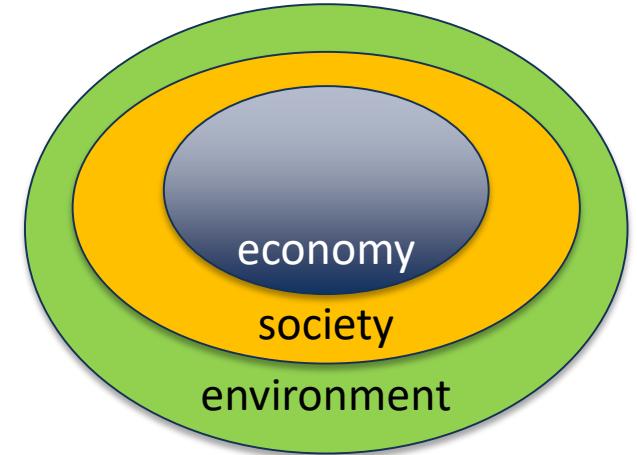
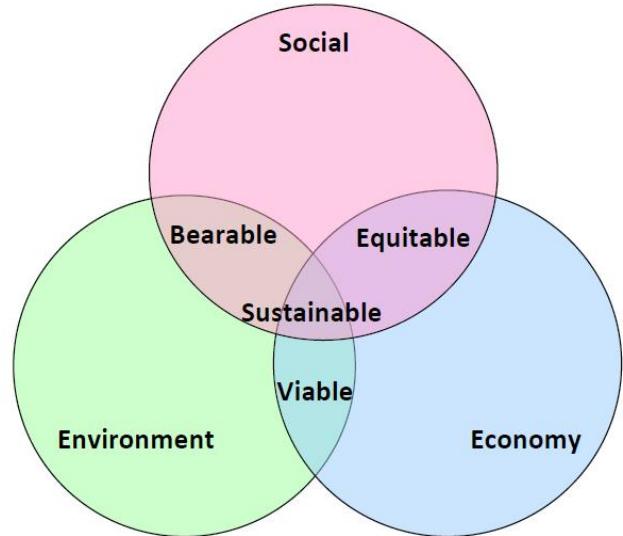
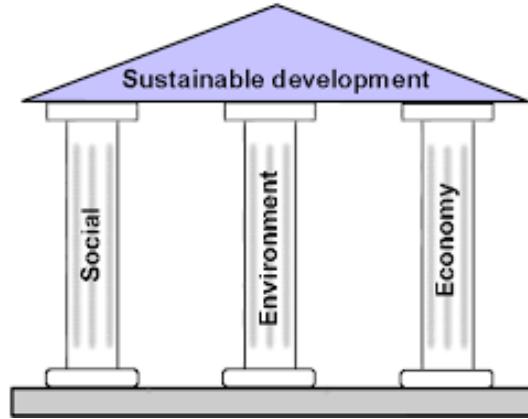
SOSTENIBILITÀ – UN CONCETTO COMPLESSO

Sostenibilità

- “sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs.” (Brundtland report, 1987)
- “the integration of environmental health, social equity and economic vitality in order to create thriving, healthy, diverse and resilient communities for this generation and generations to come. The practice of sustainability recognizes how these issues are interconnected and requires a systems approach and an acknowledgement of complexity.” <https://www.sustain.ucla.edu/what-is-sustainability/>
- “Sustainability is based on a simple principle: Everything that we need for our survival and well-being depends, either directly or indirectly, on our natural environment. To pursue sustainability is to create and maintain the conditions under which humans and nature can exist in productive harmony to support present and future generations.” <https://www.epa.gov/sustainability/learn-about-sustainability#what>



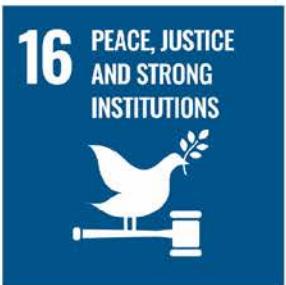
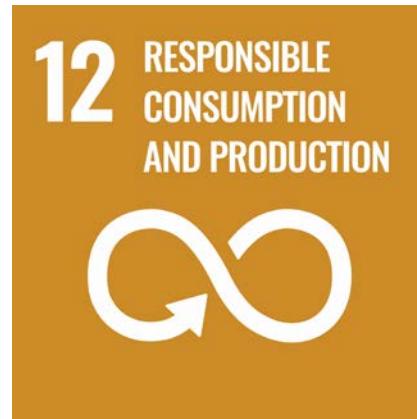
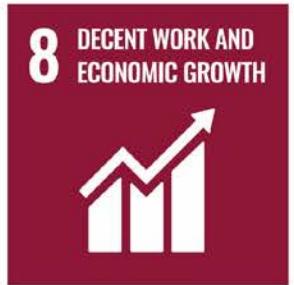
I tre pilastri della sostenibilità



"One particularly prevalent description of 'sustainability' employs three interconnected 'pillars'... encompassing economic, social, and environmental (or ecological) factors or 'goals'."*

* Purvis, B., Mao, Y. & Robinson, D. Three pillars of sustainability: in search of conceptual origins. *Sustain Sci* **14**, 681–695 (2019). <https://doi.org/10.1007/s11625-018-0627-5>

Sustainable Development Goal (SDG)



QUALE ROADMAP?

Roadmap verso un uso intelligente dei rifiuti

■ I rifiuti plastici sono inaccettabili in qualunque ambiente vengano rilasciati

Plastic waste is unacceptable in any habitat and this is PlasticsEurope's and the plastics industry's top priority at all times. Global issues demand global approaches and global solutions. Strong partnerships between an interconnected plastics value chain and all stakeholders, be they local, national or global, are needed to solve this problem and to develop innovative, sustainable solutions. By working hand in hand with all relevant parties, we can create a framework to boost the circular economy for plastics and develop a collective blueprint to accelerate our transformation to a more sustainable future.

Our commitment as an industry is to relentlessly focus on ensuring that plastics continue to deliver societal benefits while having a positive impact on the environment.

<https://www.plasticseurope.org/it/resources/publications/4312-plastics-facts-2020>



Roadmap verso un uso intelligente dei rifiuti

- **Riciclare i materiali plastici implica uno spostamento verso l'economia circolare**

*"A **circular economy** aims to maintain the value of products, materials and resources for as long as possible by returning them into the product cycle at the end of their use, while minimising the generation of waste. The fewer products we discard, the less materials we extract, the better for our environment.*

This process starts at the very beginning of a product's lifecycle: smart product design and production processes can help save resources, avoid inefficient waste management and create new business opportunities." [<https://ec.europa.eu/eurostat/web/circular-economy>]



- [Circular Economy Package \(2015\)](#)
- [report on the implementation of the Circular Economy Action Plan \(2019\)](#)
- [Circular Economy Action Plan \(2020\)](#)

- [European Green Deal](#)
- [climate and energy](#)
- [Clean Energy for all Europeans](#)
- [Next steps for a sustainable European future](#)
- [Sustainable Development Goal 12 'Responsible consumption and production'](#).



Roadmap verso un uso intelligente dei rifiuti

- **L'adozione di nuove strategie richiede una analisi quantitative seria che adotti una prospettiva di ciclo di vita (Life Cycle Thinking)**

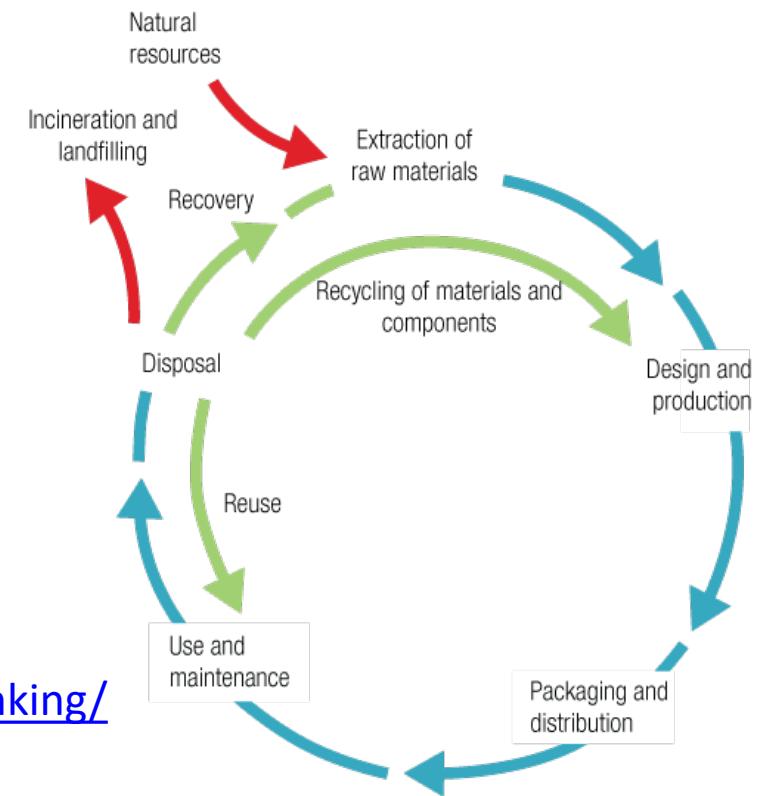
Life Cycle Thinking (LCT) is about going beyond the traditional focus on production site and manufacturing processes to include environmental, social and economic impacts of a product over its entire life cycle.

[<https://www.lifecycleinitiative.org/starting-life-cycle-thinking/what-is-life-cycle-thinking/>]

UNA NUOVA PROSPETTIVA

Life Cycle Thinking (LCT)

“Life Cycle Thinking (LCT) is about going beyond the traditional focus on production site and manufacturing processes to include environmental, social and economic impacts of a product over its entire life cycle.”



<https://www.lifecycleinitiative.org/starting-life-cycle-thinking/what-is-life-cycle-thinking/>

Life Cycle Management (LCM)

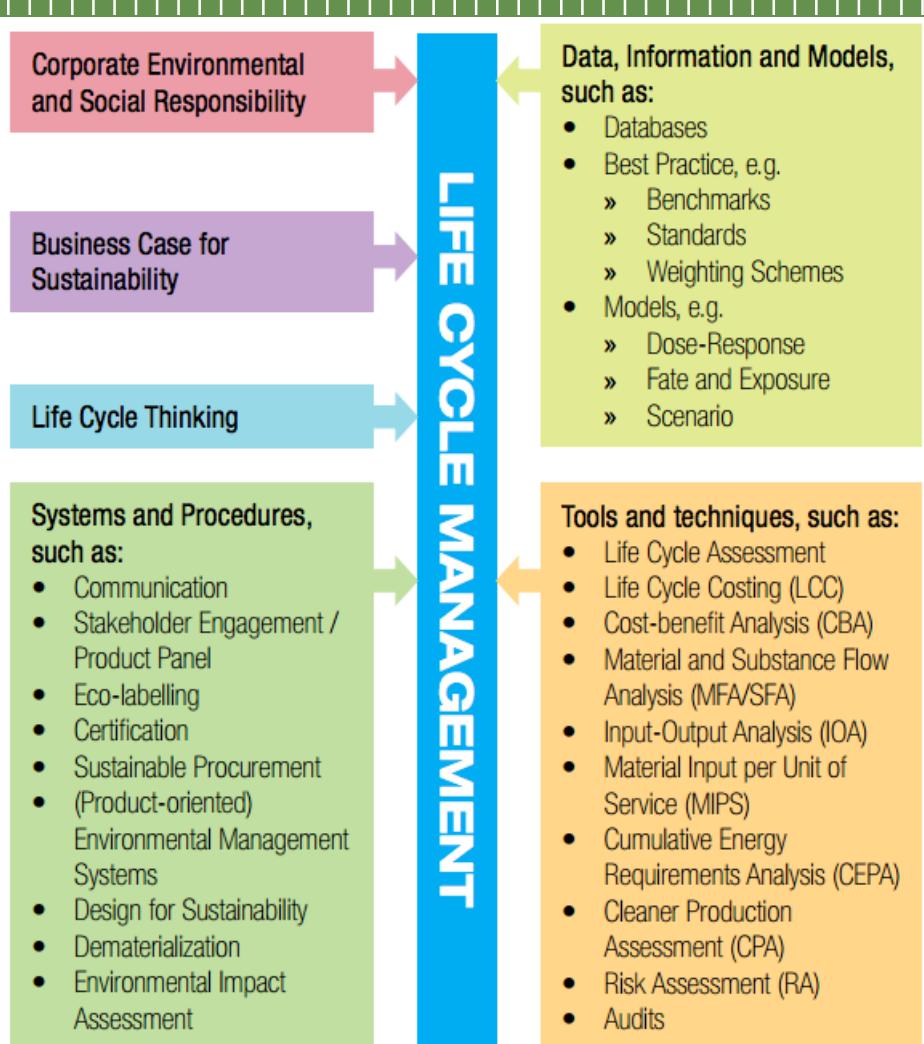
“Life Cycle Management (LCM) is an integrated concept for managing the total life cycle of goods and services toward a more sustainable production and consumption.

.... LCM uses various procedural and analytical tools for different applications and integrates economic, social, and environmental aspects into an institutional context.”*

Life Cycle Management is the way to make operational LCT.

* G. Itskos, N. Nikolopoulos, D.-S. Kourkoumpas, A. Koutsianos, I. Violidakis, P. Drosatos, P. Grammelis, Chapter 6 - Energy and the Environment, Editor(s): Stavros G. Poulopoulos, Vassilis J. Inglezakis, Environment and Development, 2016, Pages 363-452, <https://doi.org/10.1016/B978-0-444-62733-9.00006-X>.

<https://www.lifecycleinitiative.org/startng-life-cycle-thinking/life-cycle-approaches/>



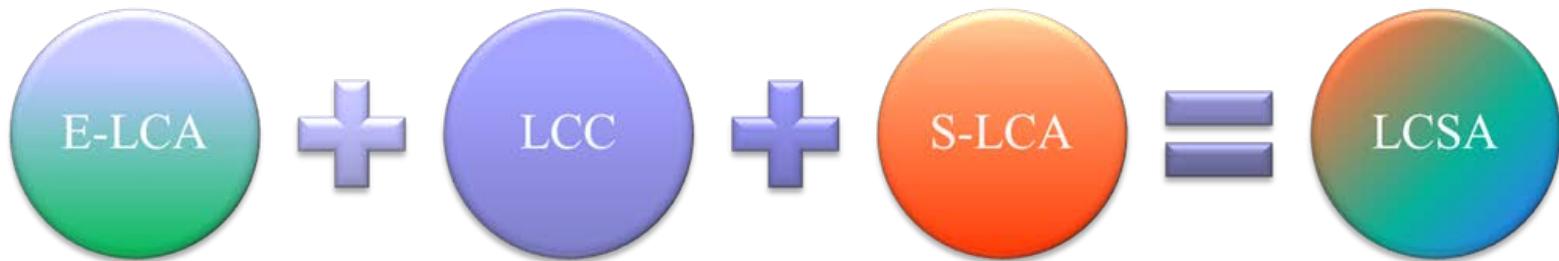
Source: UNEP/SETAC. Life Cycle Management: A Business Guide to Sustainability. Paris, 2007.



Life Cycle Sustainability Assessment (LCSA)

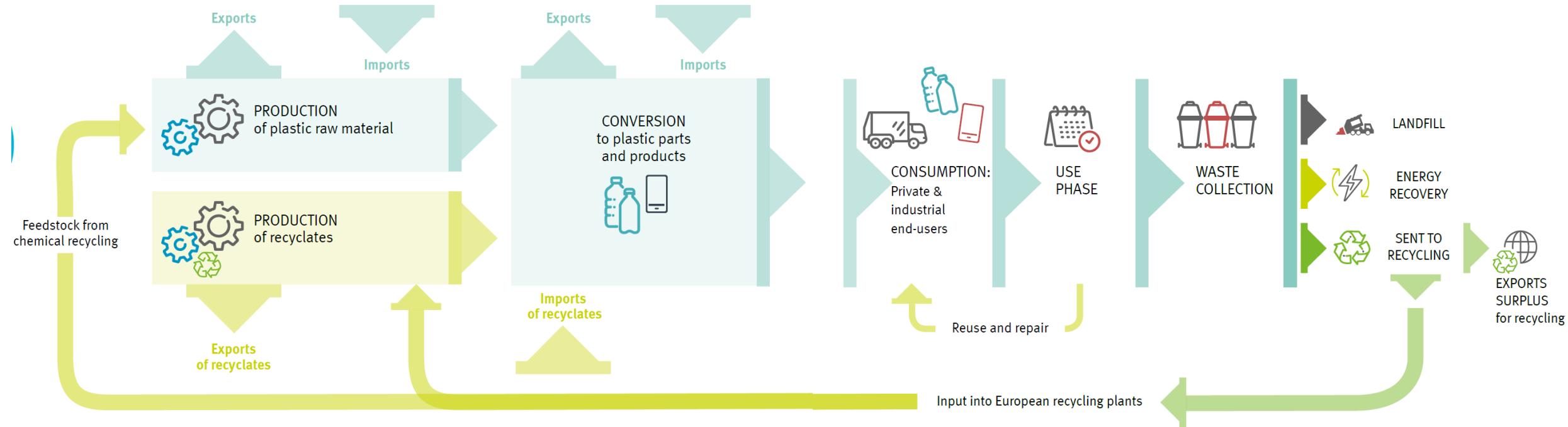
Life Cycle Sustainability Assessment (LCSA) è una metodologia che comprende la valutazione di tutti gli impatti e i benefici ambientali, economici e sociali.

- Environmental Life Cycle Assessment (E-LCA)
- Life Cycle Cost Assessment (LCCA) or Life Cycle Costing (LCC)
- Social Life Cycle Assessment (S-LCA)



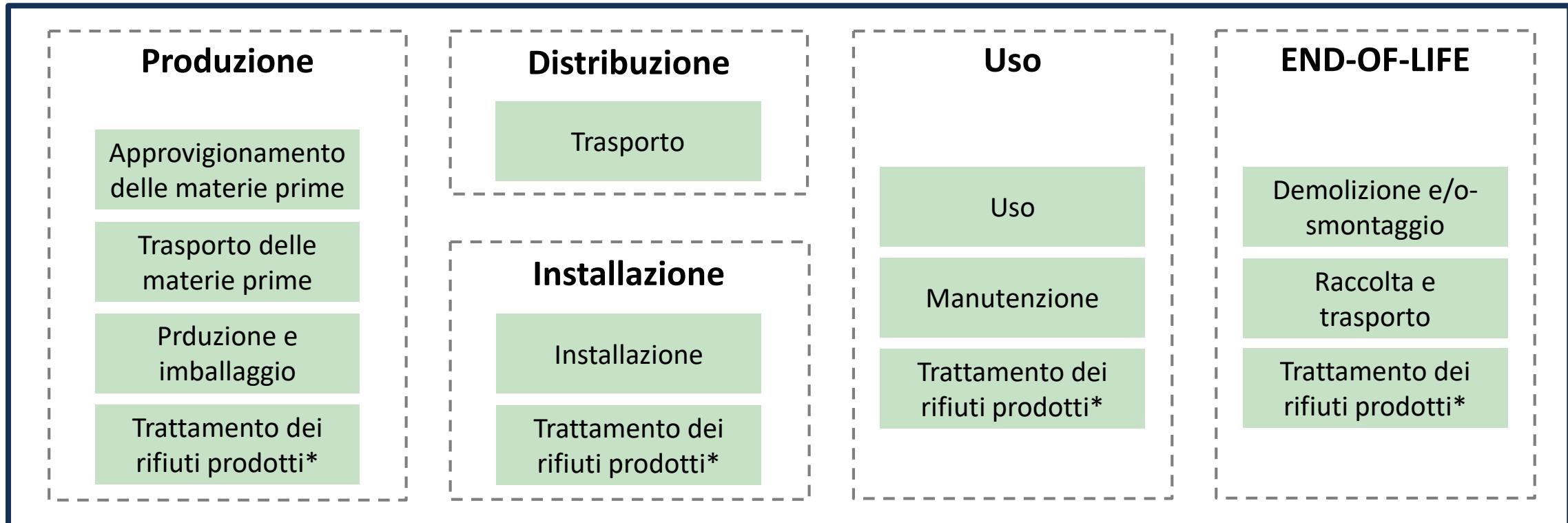
<https://www.lifecycleinitiative.org/starting-life-cycle-thinking/life-cycle-approaches/life-cycle-sustainability-assessment/>

Ciclo di vita delle plastiche per Plasticseurope



<https://www.plasticseurope.org/it/resources/publications/4312-plastics-facts-2020>

Fasi di vita di un prodotto secondo le direttive europee



*polluter pays principle



I NUMERI



PRODUZIONE DI MATERIE PLASTICHE



World

2018
359
million tonnes → 2019
368
million tonnes

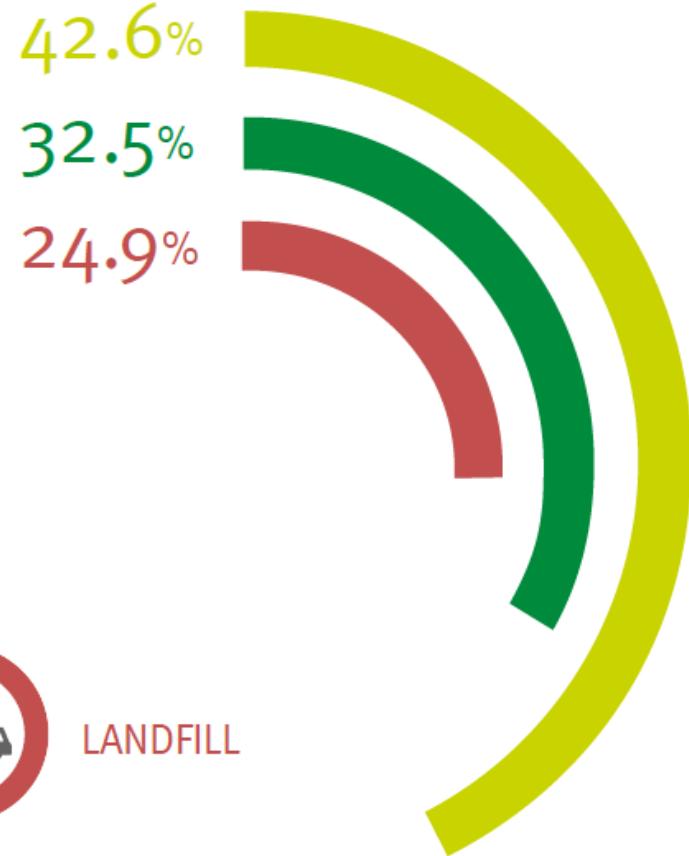


Europe
(EU28+NO/CH)

2018
61.8
million tonnes → 2019
57.9
million tonnes

<https://www.plasticseurope.org/it/resources/publications/4312-plastics-facts-2020>

TRATTAMENTO DEI RIFIUTI DI PLASTICHE POST-CONSUMO NEL 2018



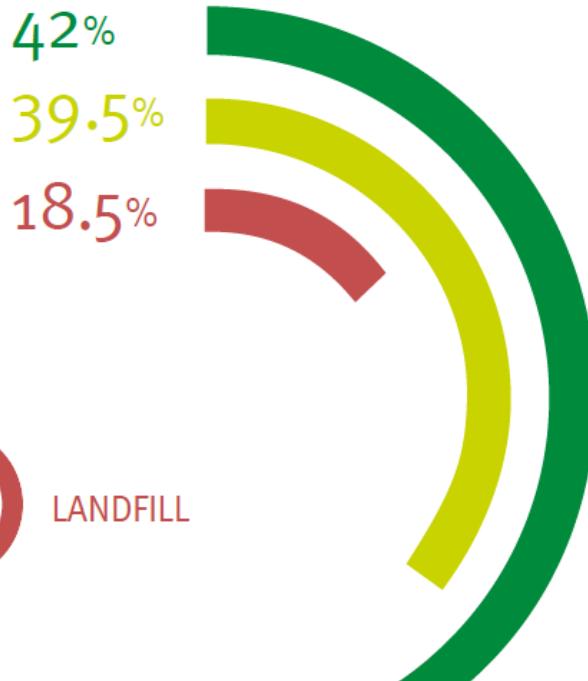
<https://www.plasticseurope.org/it/resources/publications/4312-plastics-facts-2020>

TRATTAMENTO DEI RIFIUTI DA IMBALLAGGI IN PLASTICA NEL 2018

Plastic **PACKAGING*** waste treatment in 2018 (EU28+NO/CH)

17.8 Mt

Collected plastic post-consumer
packaging waste



7.5 Mt di inviato a
riciclo



RECYCLING



ENERGY
RECOVERY



LANDFILL



<https://www.plasticseurope.org/it/resources/publications/4312-plastics-facts-2020>

RICICLO MECCANICO (circa 5 Mt nel 2018)

RICICLO CHIMICO

ALTRO (RIUSO, BIOCOMBUSTIBILI, ...)?

LCA E SOSTENIBILITA' AMBIENTALE

ETICHETTE AMBIENTALI

Environmental label or declaration is a claim which indicates the environmental aspects of a product or service (ISO 14020:2000 SECOND EDITION)



456 ecolabels in 199 paesi e 25 settori industriali

ECOLABEL
INDEX

<http://www.ecolabelindex.com/>

<http://www.greenmarketing.com/blog/comments/how-to-choose-the-right-eco-label-for-your-brand/>

Perché l'analisi di ciclo di vita (Life Cycle Assessment LCA)?

- compilation and evaluation of the inputs, outputs and the potential environmental impacts of a product system throughout its life cycle (ISO 14040:2006)*
- Metodologia quantitativa per il calcolo degli impatti ambientali potenzialmente connessi ad un prodotto, processo o servizio
- Considera tutte le fasi della vita di un prodotto
- Non permette «burden shift»
- Esistono degli standard internazionali riconosciuti che regolano la metodologia (ISO 14040:2006 e ISO 14044:2006+A1:2018)
- E' alla base delle certificazioni ambientali note come etichette di tipo III (ISO 14025:2006)

Ecolabels

- Type I environmental labelling programme is voluntary, multiple-criteria-based third party programme that awards a license which authorizes the use of environmental labels on products indicating overall environmental preferability of a product within a particular product category based on life cycle considerations (ISO 14024:2018)*
- Ecolabels adottano una prospettiva di ciclo di vita, ma non richiedono una LCA



- EU Ecolabel
- Nordic Swan Ecolable
- Blue Angel

DICHIARAZIONI AMBIENTALI DI PRODOTTO (EPD)

- Type III environmental declaration is an environmental declaration providing quantified environmental data using predetermined parameters and, where relevant, additional environmental information (ISO 14025:2006)**
- Si basano su una analisi di ciclo di vita
- Sono necessarie delle regole di categoria di prodotto (PCR)
- E' previsto un operatore di programma indipendente che organizza e gestisce un sistema di EPD
- Gli operatori di programma nel mondo sono parecchie decine



<https://aclca.org/pcr/program-operators/>

UN CASO DI STUDIO

www.environdec.com
AQUAFIL 
synthetic fibres and polymers

ENVIRONMENTAL PRODUCT DECLARATION for ECONYL® NYLON TEXTILE FILAMENT YARNS



EPD[®]

CPC263&264-TEXTILE YARN AND THREAD OF NATURAL FIBRES, MAN-MADE FILAMENTS OR
STAPLE FIBRES
PCR2013:12 VERS. 1.01



IL PRODOTTO

TECHNICAL SPECIFICATION	TEST METHOD	TEST METHOD
Commercial article description	ECONYL® FDY yarn on beams	-
Basic polymer; % of basic polymer / Generic name of synthetic fibre; % of synthetic fibre	100 % Polyamide 6	EN ISO 1043-1:2011 / ISO 2076 : 2010
Type of yarn or fibre	Filament yarn	ISO 8159:1987
Type of processing	Fully Drawn Yarn	BISFA
Intended use	See section 2.1	-
Resulting linear density	17 dtex-78 dtex	ISO 2060-1994
Filament number	various	-

A) ECONYL® FDY YARNS ON BEAM

TYPE OF PRODUCT/SERVICE	% OF MATERIAL BY WEIGHT	OF WHICH % RECYCLED
Polyamide 6	93-96	100 %
Pigments	0-1,6	
Spin Finish	1,0-1,5	
Water	3-4	
Percent of which main materials, pigments and dye stuff, and other materials is bio-based	100 %	
Of which post-consumer waste		50 %
Of which pre-consumer waste		50 %

GLI IMPATTI AMBIENTALI

>TABLE 6.A. TOTAL ENVIRONMENTAL IMPACT FOR PRODUCTION OF 1 kg OF ECONYL®FDY YARN ON BEAMS

Units	UPSTREAM	CORE	DOWNTREAM	TOTAL
Global Warming Potential (GWP) from fossil fuels g CO ₂ eq	2875	374	19	3268
Acidification Potentials g SO ₂ eq	12	1	<0,2	13
Photochemical Ozone Creation P. g C ₂ H ₄	<1	<0,1	<0,02	<1
Eutrophication Potentials g PO ₄ --- eq	3	<0,5	<0,03	4

totals may not match, because of rounded data.

>TABLE 6.B. TOTAL ENVIRONMENTAL IMPACT FOR PRODUCTION OF 1 kg OF ECONYL®TEXTURIZED YARN ON CONES

Units	UPSTREAM	CORE	DOWNTREAM	TOTAL
Global Warming Potential (GWP) from fossil fuels g CO ₂ eq	3020	330	19	3369
Acidification Potentials g SO ₂ eq	12	1	<0,2	14
Photochemical Ozone Creation P. g C ₂ H ₄	1	<0,09	<0,02	1
Eutrophication Potentials g PO ₄ --- eq	3	<0,5	<0,03	4

totals may not match, because of rounded data.

GWP PA66 8.6 kg CO2e

GWP PA6 9.8 kg CO2e



LA RICERCA

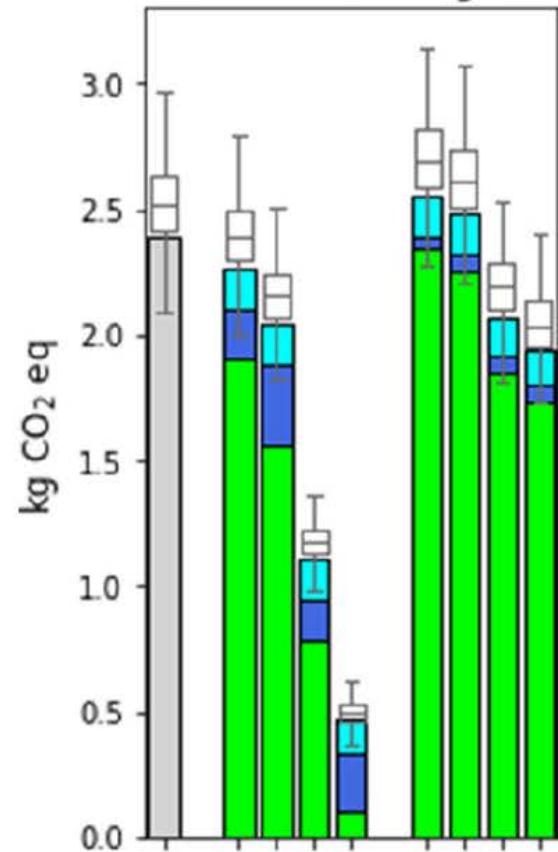
LCA di 1 kg polyethylene (PE) pipe grade resin from recycled high-density polyethylene (HDPE) blended with virgin HDPE.

Istrate, I.-R., Juan, R., Martin-Gamboa, M., Domínguez, C., García-Muñoz, R.A., Dufour, J.
Environmental life cycle assessment of the incorporation of recycled high-density polyethylene to
polyethylene pipe grade resins (2021) Journal of Cleaner Production, 319, art. no. 128580, DOI:
[10.1016/j.jclepro.2021.128580](https://doi.org/10.1016/j.jclepro.2021.128580)

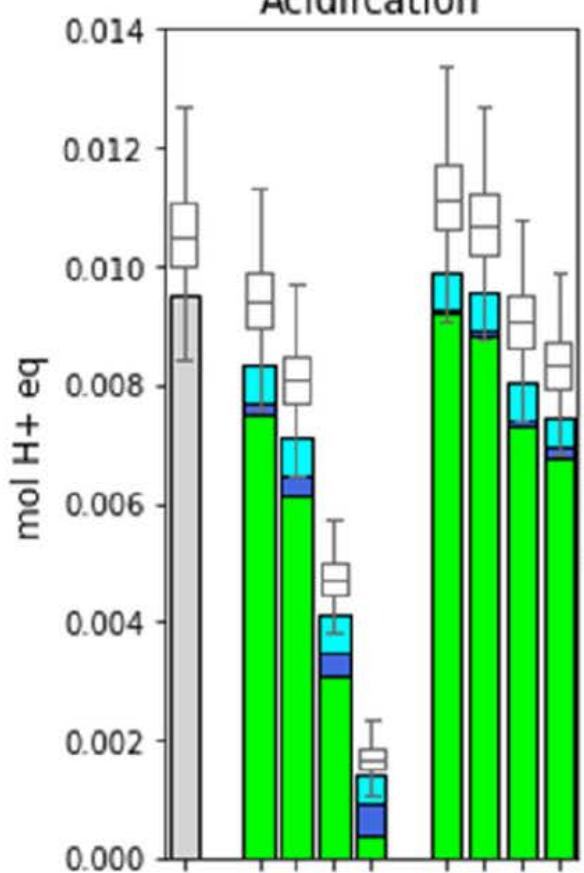
GLI IMPATTI

■ Virgin content ■ Recycled content ■ Extrusion

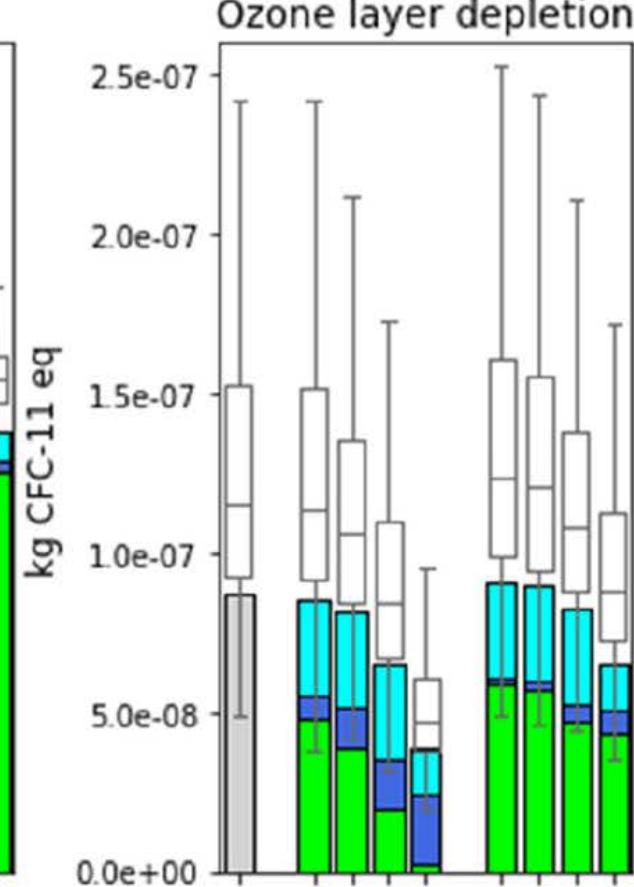
Climate change



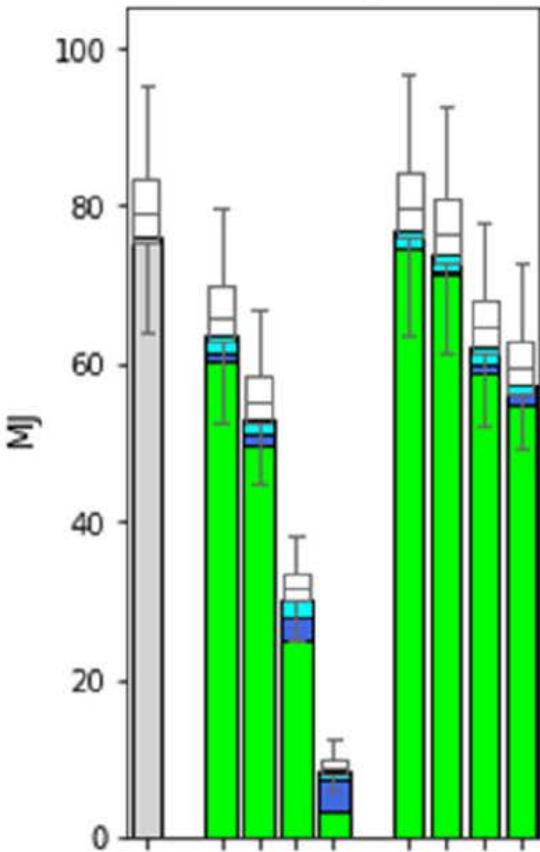
Acidification



Ozone layer depletion



Resources, fossil



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-  Mat4En2 Lab Polimi
-  mat4en2.cmic.polimi.it