RECYCLING

– REDUCING OR PRODUCING CONTAMINANTS

AARHUS
UNIVERSITY
DEPARTMENT OF ENVIRONMENTAL SCIENCE

CITYLEAKS MALMØ
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THE CONTENT OF MY TALK

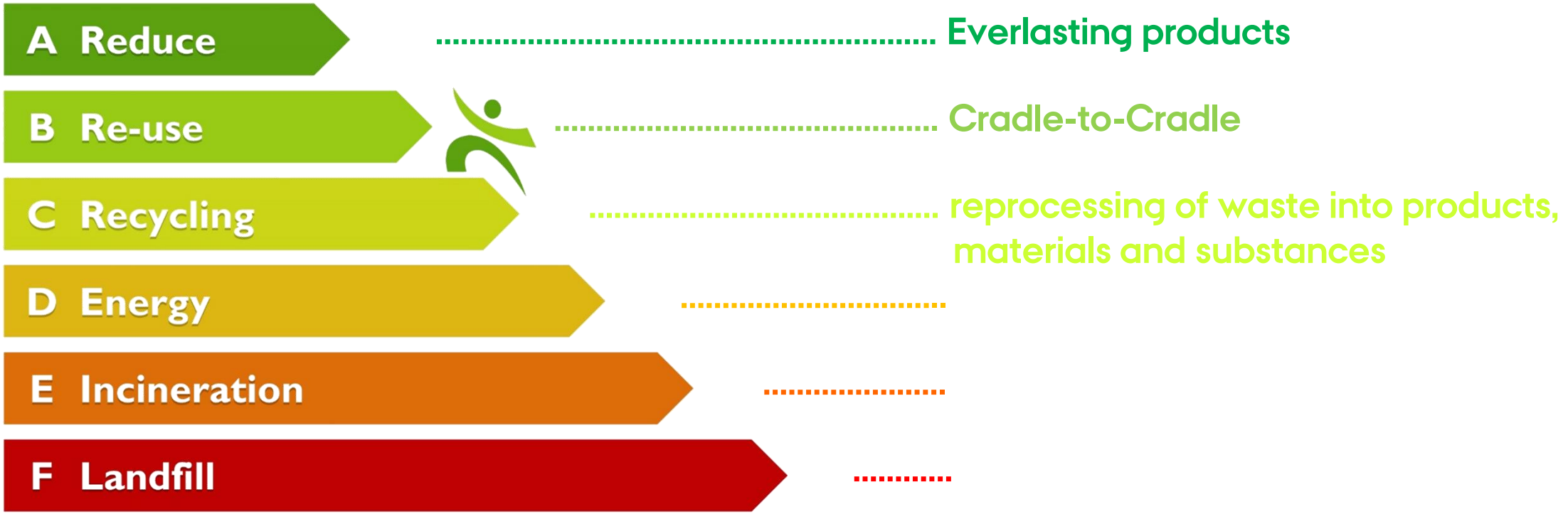
- The waste hierachy, linear to circular economy and chemicals in circulation

- A case study on phthalates
  - Multiple sources to exposure and the completeness of the REACH scenarios
  - The risk cycle of phthalates
  - Plastic recycling

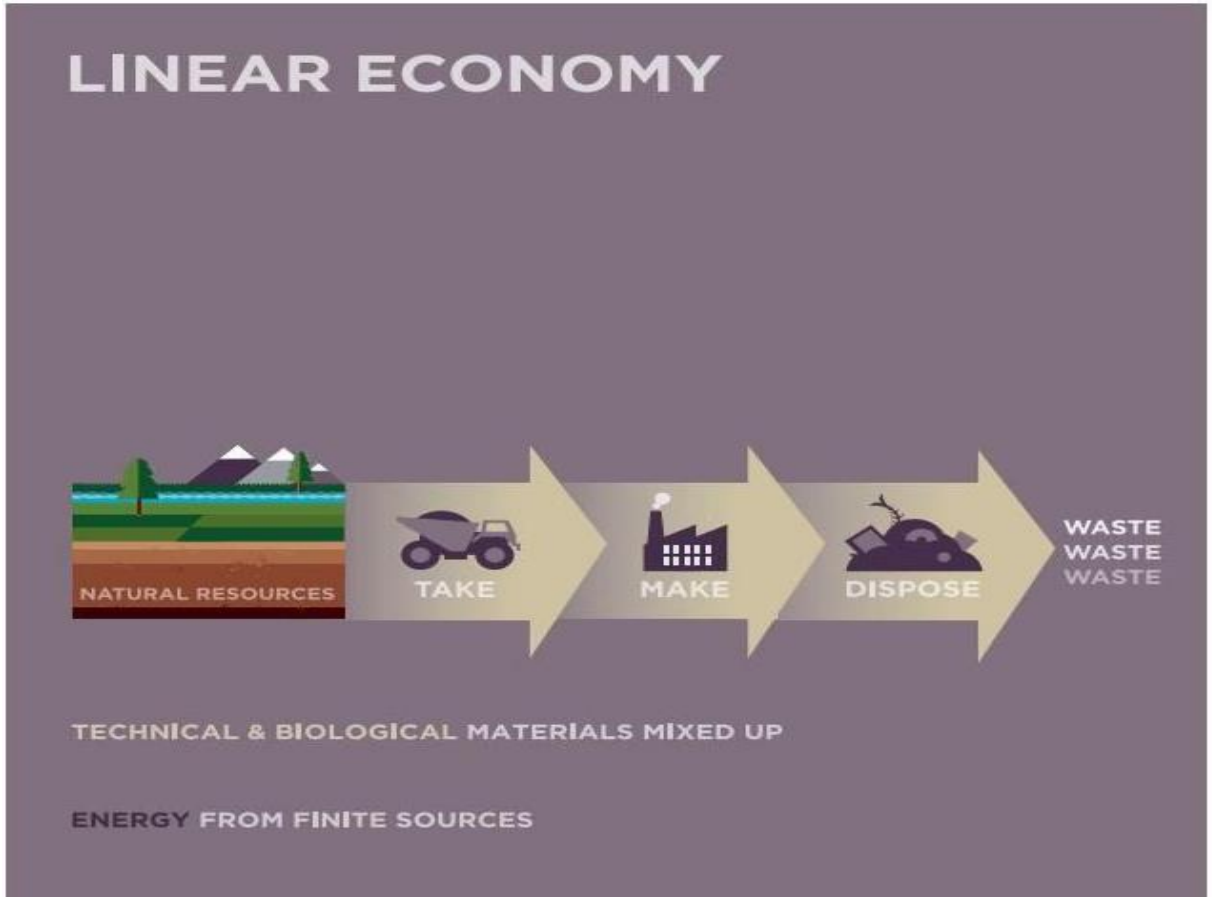
- Conclude on whether recycling is reducing or producing contamination

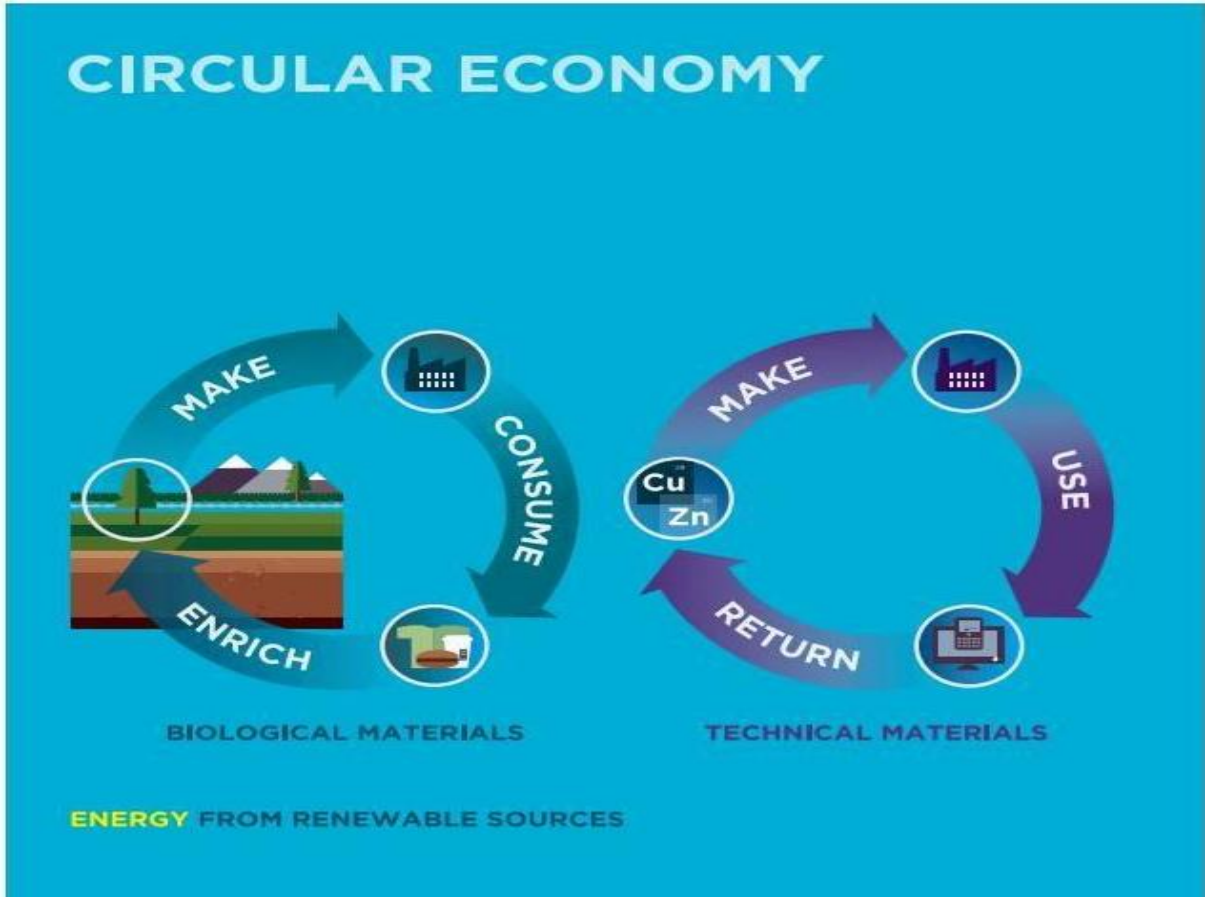
RECYCLING

Third step of the waste hierarchy – reducing or producing contaminants ?



MOTIVATION | TRANSITION | CHANGE





Difference between linear and circular economy. Source: Ellen MacArthur Foundation, 2015

CURRICULUM VITAE OF THE LINEAR ECONOMY

Emissions

Climate change

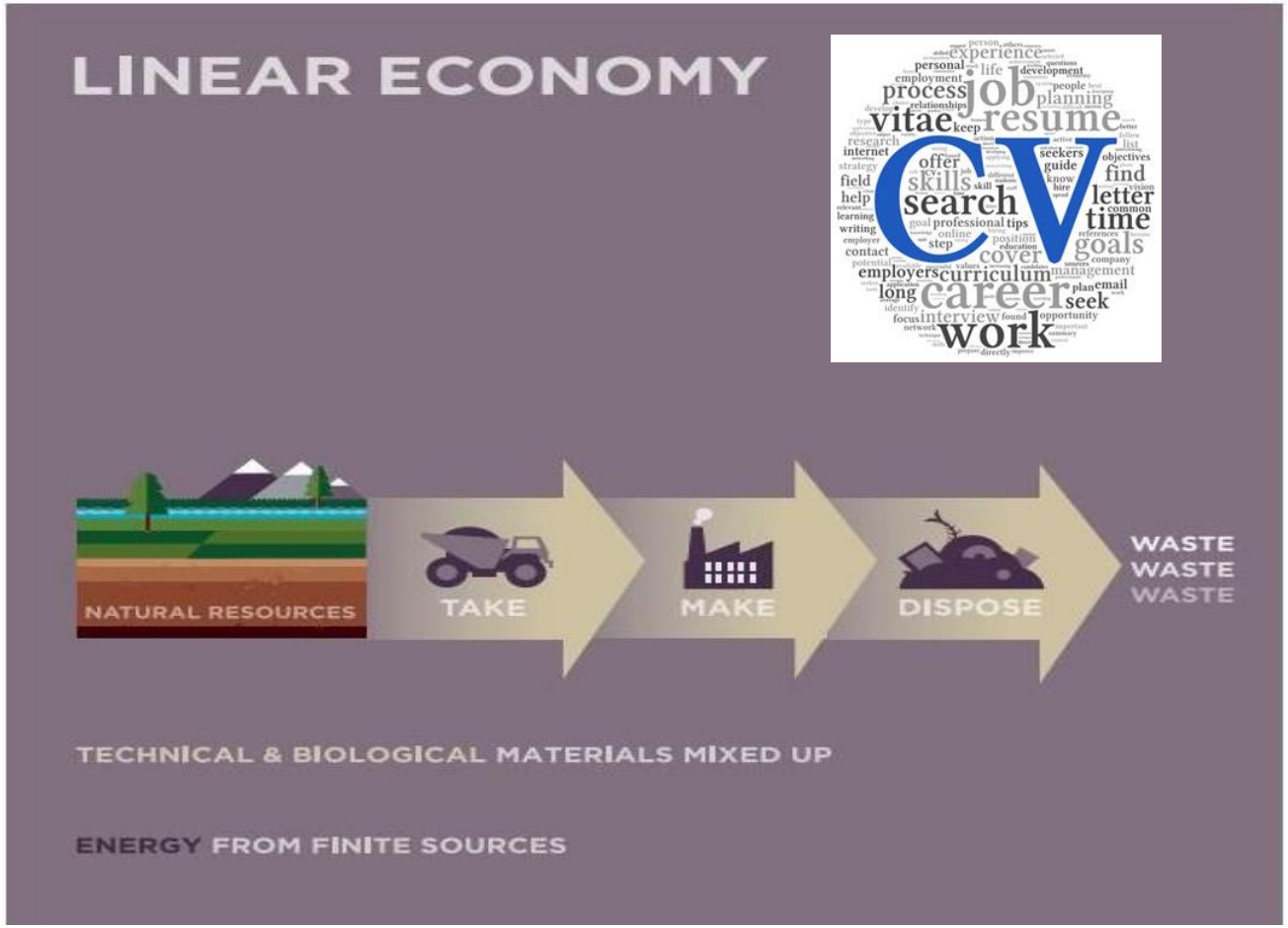
Depletion of natural resources

Pollution

Endocrine disruptors, cancer....

Loss of ecosystem services

Biodiversity



CURRICULUM VITAE OF THE CIRCULAR ECONOMY

Recycling materials and resources back into the economic system

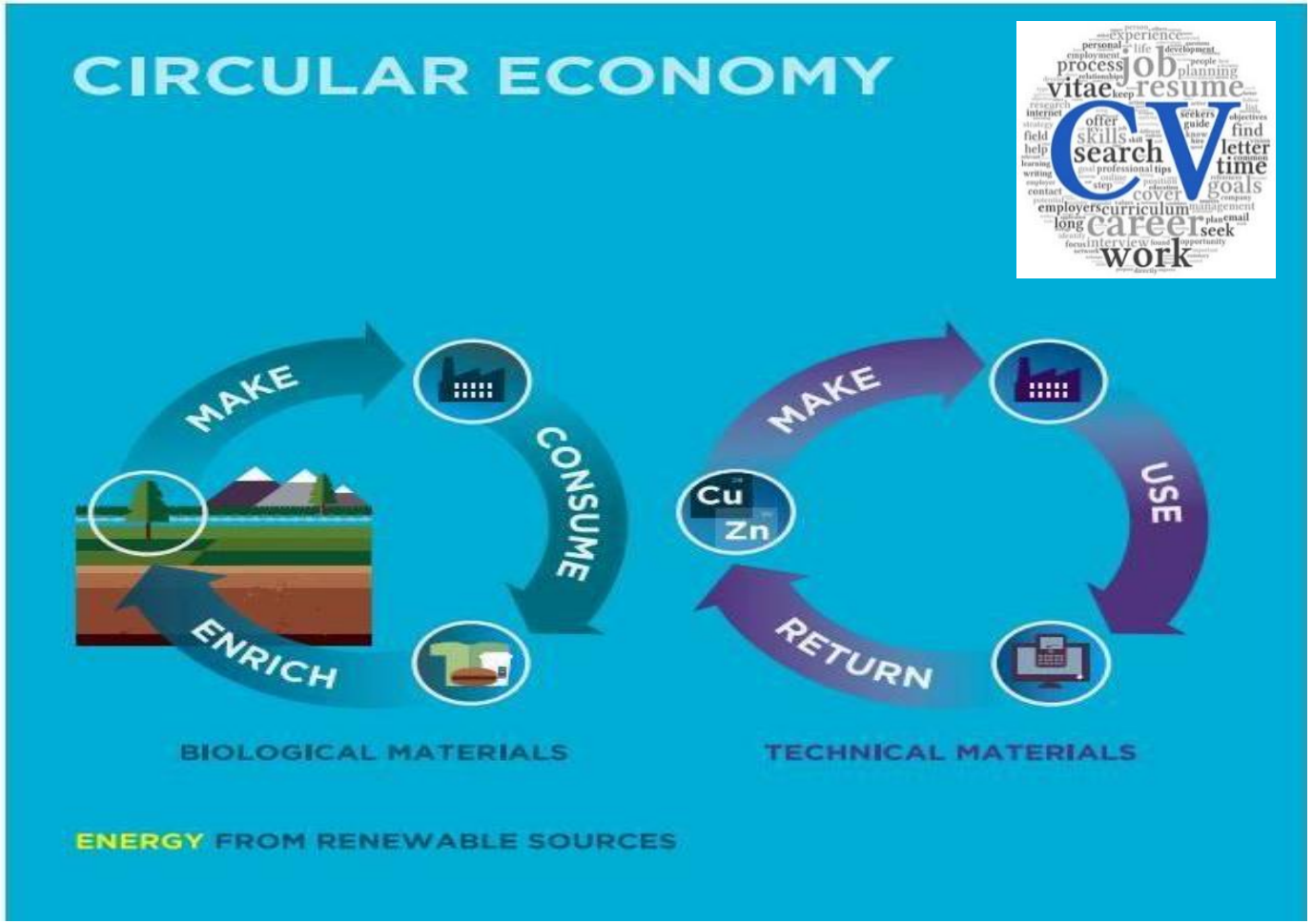
Value from waste reduction

Reducing resource consumption and process emissions

Restoring environmental quality

Saving climate balance

Closing the leakage gaps



CIRCULAR ECONOMY

A circular economy is one that is **restorative** and **regenerative** by design, and which aims to keep products, components and materials at their **highest utility** and **value** at all times, distinguishing between **technical** and **biological** cycles.

- McArthur Foundation -

UTOPIA OF THE CHEMICALS RISK CYCLE

Technical nutrients should **be recycled within the technosphere (closed loop)** and, when lost to the environment, reabsorbed in rates equal to their dispersion; **exchanged at levels below any adverse effects**

A MULTITUDE OF EUROPEAN REGULATIONS

REACH - Regulation 1907/2007

Cosmetic products - Regulation 1223/2009

Children's toys safety - Directive 48/2009

Pesticides residues in food and feedstuff - Regulation 396/2005

Food contact plastic packaging materials and articles - Regulation 10/2011

Biocide directive - Directive 8/1998

Restriction of certain hazardous substances in EEE - Directive 2011/65

Water Framework Directive 60/2000

Proposal for a Soil Framework Directive … second try 2017

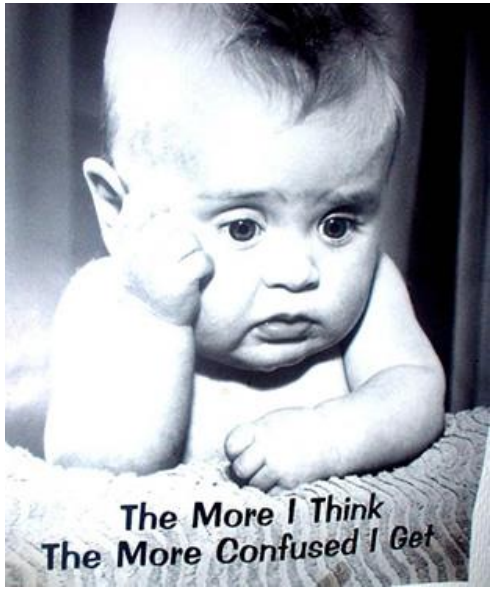
End of waste criteria … on the way ….

….. **And many more!**

CHEMICALS IN CIRCULATION

..... and the complexity of regulations

How to protect ecosystem structure and human health from toxic impacts from exposure to manmade chemicals ?

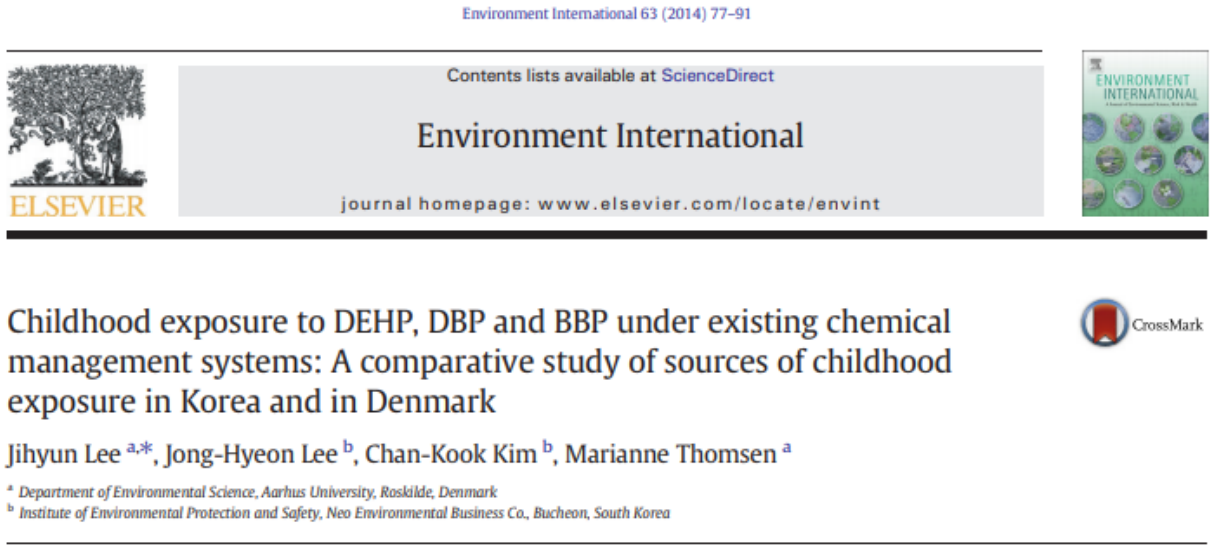


COMPLETENESS OF THE REACH SCENARIO

- Human Exposure
  - 1. Inhalation
    - 1.1 Environment
      - 1.1.1 Background quality
        - Historical (accumulated) pollutants in the air and partitioned from water, soil, etc.
        - Emitted to the air by other activities in that region
        - Transport from other region
      - 1.1.2 Added pollutants
        - Emitted by producing, using and waste stage of the substance by a registrant
    - 1.2 Product use
      - 1.2.1 Product(s) manufactured/imported by a registrant
      - 1.2.2~ Other Products manufactured/imported by other registrants or covered by other regulation
  - 2. Ingestion
    - 2.1 Environment
      - 2.1.1 Background quality
        - Accumulated pollutants in the water, soil and partitioned from other media
        - Emitted to the water and soil by other activities in that region
        - Transport from other region
      - 2.1.2 Added pollutants
        - Emitted by producing, using and waste stage of the substance by the registrant
    - 2.2 Food
      - 2.2.1 Drinking water
      - 2.2.2~ Crops, diary products, fish, meat, etc.
    - 2.3 Product use
      - 2.3.1 Product(s) manufactured/imported by a registrant
      - 2.3.2~ Other Products manufactured/imported by other registrants or covered by other regulation
  - 3. Dermal contact
    - 3.1 Environment
      - 3.1.1 Background quality
        - Pollutants in the environmental media which influence dermal exposure
      - 3.1.2 Added pollutants
        - Emitted by producing, using and waste stage of the substance by the registrant
    - 3.2 Product use
      - 3.2.1 Product(s) manufactured/imported by a registrant
      - 3.2.2~ Other Products manufactured/imported by other registrants or covered by other regulation

MULTIPLE SOURCES TO TOTAL EXPOSURE

- A review of existing regulations on phthalates in Denmark and Korea is presented
- Sources and source intensities to childhood phthalate exposure are reviewed
- Childhood exposure is estimated by exposure scenario approach and back-calculation
- Cumulative risk of childhood exposure in Korea is higher than in Denmark
- Exposure scenario estimations are lower than back-calculated exposure levels.



Environment International 63 (2014) 77–91

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Environment International

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

Childhood exposure to DEHP, DBP and BBP under existing chemical management systems: A comparative study of sources of childhood exposure in Korea and in Denmark

Jihyun Lee [a,*], Jong-Hyeon Lee [b], Chan-Kook Kim [b], Marianne Thomsen [a]

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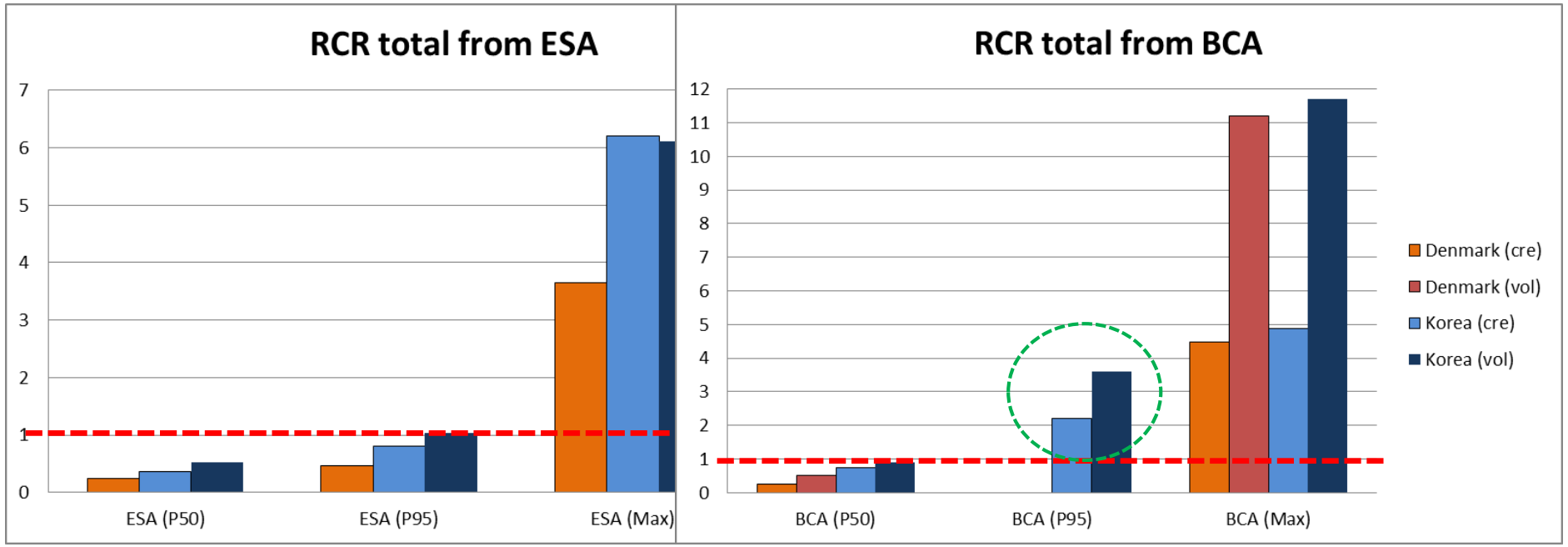
[b] Institute of Environmental Protection and Safety, Neo Environmental Business Co., Bucheon, South Korea

CHILDHOOD EXPOSURE TO PHTHALATES

Cumulative risk from combined exposure



Both ESA and BCA,

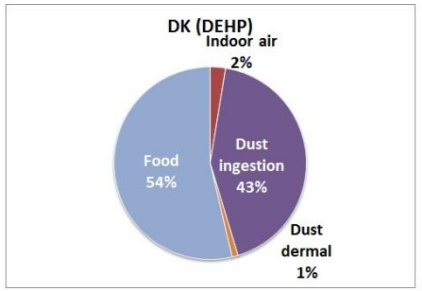
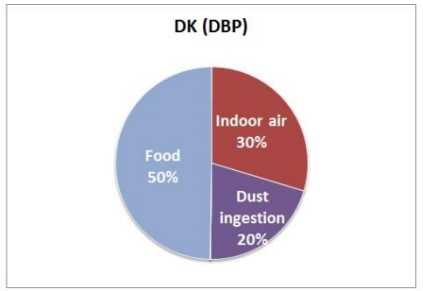
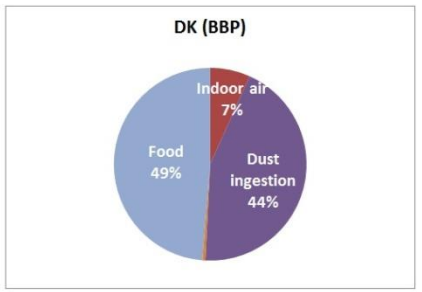
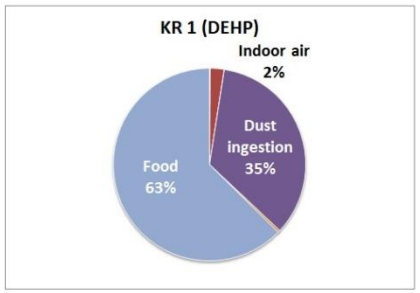
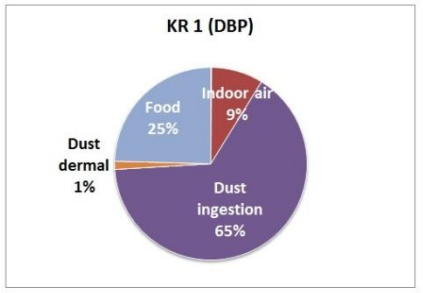
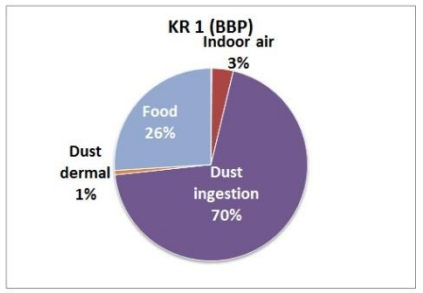
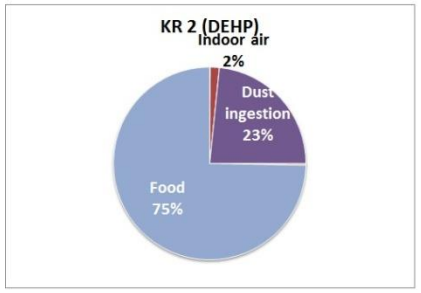
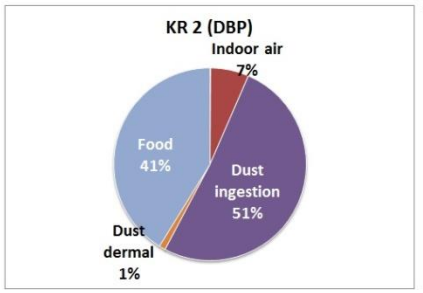
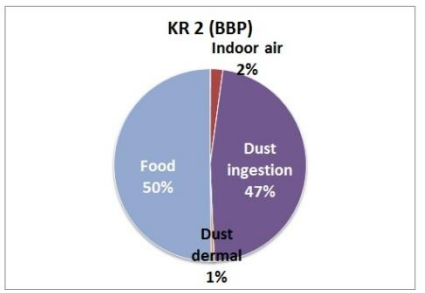
RCRtotal: DK < KR1 < KR2

RCR total: ESA < BCA

More than 5% of Korean children are exposed above safe level (1< RCR)

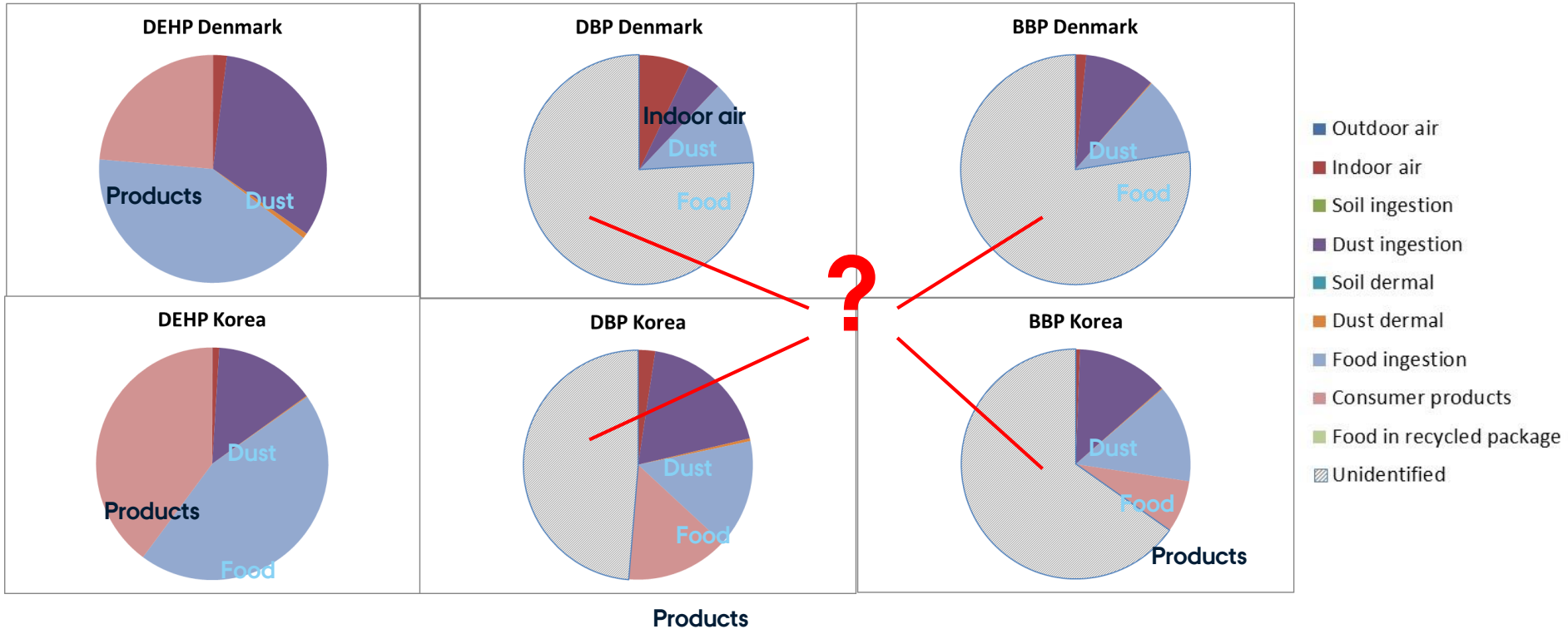
CHILDHOOD EXPOSURE TO PHTHALATES

Contributions of different sources to the mean daily intake

	DEHP	DBP	BBP
Denmark			
Korea (Scenario 1)			
Korea (Scenario 2)			

CHILDHOOD EXPOSURE TO PHTHALATES

Contributions of different sources to the mean daily intake



Still more than 50%(KR) and 70% (DK) of exposure to DBP and BBP were not explained!

PHTHALATE RISK CYCLE

Environment International 73 (2014) 312–322

Contents lists available at ScienceDirect

Environment International

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

The influence of resource strategies on childhood phthalate exposure—The role of REACH in a zero waste society

Jihyun Lee, Anders Branth Pedersen, Marianne Thomsen *

Department of Environmental Science, Faculty of Science and Technology, Aarhus University, Denmark

CHILDHOOD EXPOSURE TO PHTHALATES

Additional questions

Q1. What makes the gaps? What can be additional sources of exposure which are not included in scenario-based modelling?

- Consumer products: PVC flooring, wallpaper, plastic mats, toys, bags, textiles, footwears, swimming pools, etc. (studies financed by DEPA and KMOE**)*

* DEPA. Survey and health assessment of the exposure of 2 year-olds to chemical substances in consumer products. Survey of chemicals in consumer products, no. 102; 2009.
** KMOE. Case study on combined exposure assessments for DEHP, DBP, BBP and DINP. Sejong-City: Korean Ministry of Environment; 2009.

Q2. Does material recycling influence on the cycle of pollutants which can also contribute filling the gap between scenario estimation and back-calculation?

- How are the flows of phthalates when we recycle plastics and paper?

Q3. How the resource strategies aiming at a sustainable and circular economy can influence on the cycle of pollutants? What is the role of REACH in a zero waste society?

RISK CYCLE IN A CIRCULAR ECONOMY

Additional exposures from food in recycled packagings

Food items		Concentrations in food (ug/kg)					
		DEHP		DBP		BBP	
		Mean	SD	Mean	SD	Mean	SD
Cereals and cereal products	Reference	91.32	95.84	6.26	5.79	1.89	1.45
	In recycled paper*	46.20	27.37	48.90	36.56	1.89	1.45
Baby food (milk powder)	Reference	23.30	8.12	2.09	2.63	2.54	1.73
	In recycled paper*	62.10	25.60	23.70	12.26	2.54	1.73
Beverages	Reference	0.28	0.72	0.15	0.18	0.14	0.15
	In recycled PET**	1.47	0.95	0.31	0.19	0.05	0.02

Reference Scenario: the present situation

Scenario R30, R50, R100

: 30%, 50%, 100% of packaging material for ”Cereal, Baby food , and Beverages” is replaced by recycled plastics and paper board

* Gartner et al. (2009)

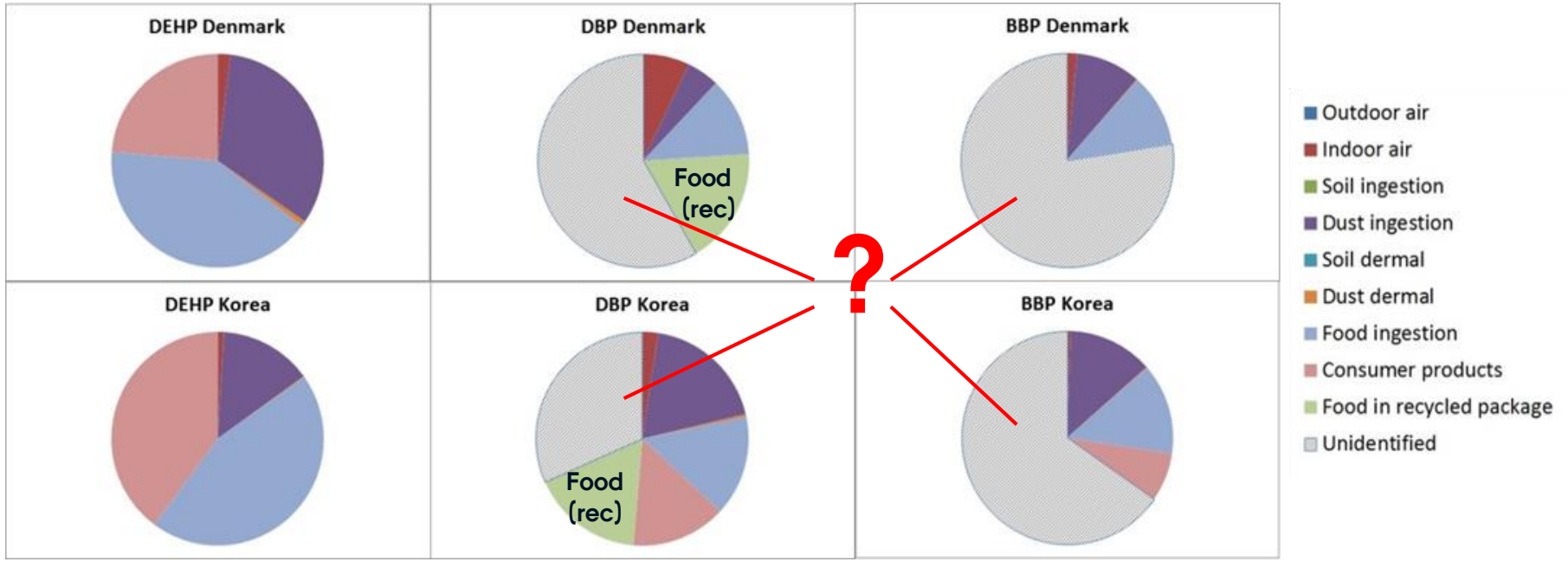
RISK CYCLE IN A CIRCULAR ECONOMY

Additional exposures from food in recycled packagings

	Scenarios	Daily exposure (µg/kg bw/day): median (95 percentile)		
		DEHP	DBP	BBP
Denmark	Reference scenario	2.712 (7.374)	0.218 (0.549)	0.075 (0.226)
	Scenario R30	2.646 (7.171)	0.334 (0.713)	0.074 (0.224)
	Scenario R50	2.601 (7.031)	0.406 (0.867)	0.072 (0.222)
	Scenario R100	2.474 (6.905)	0.573 (1.296)	0.07 (0.222)
	Gap (BCA – ESA)	-0.5	1.52	0.62
Korea	Reference scenario	3.030 (8.673)	0.235 (0.567)	0.068 (0.156)
	Scenario R30	2.939 (7.735)	0.493 (1.048)	0.068 (0.144)
	Scenario R50	2.856 (7.06)	0.642 (1.484)	0.068 (0.141)
	Scenario R100	2.555 (6.3)	1.002 (2.631)	0.064 (0.152)
	Gap (BCA – ESA)	-6.03	2.19	1.5

RISK CYCLE IN A CIRCULAR ECONOMY

Contribution of different soucres to phthalate exposure



Exposure to DBP from food in recycled packaging materials (Scenario R100) : takes 18% (DK) and 17%(KR) of the total exposure from BCA

However, 30% - 70% of DBP and BBP exposure is still not explained by ESA

PLASTIC RECYCLING

Environmental Technology & Innovation 1–2 (2014) 46–54

Contents lists available at ScienceDirect

Environmental Technology & Innovation

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

Are the resource strategies for sustainable development sustainable? Downside of a zero waste society with circular resource flows

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RISK CYCLE IN A CIRCULAR ECONOMY

Future flows of plastic and paper products in Europe

Product (Waste) categories	Reference Scenario (2012)			Future Scenario A, B (2020)			Sources for recycling rates in 2020
	Recycling	Energy	Disposal	Recycling	Energy	Disposal	
Packaging	35.0%	31.0%	34.0%	45.0%	52.4%	2.6%	PlasticsEurope et al. (2013) → applying 3.3% of annual increase rate to 2012 data
Construction & Demolition	21.8%	37.6%	40.6%	70.0%	28.6%	1.4%	Waste Framework Directive (2008)
End-of-life vehicles	11.4%	42.6%	46.0%	85.0%	14.3%	0.7%	ELV directive (2000)
WEEE	13.0%	42.0%	45.0%	75.0%	23.8%	1.2%	WEEE directive (2012)
Others	8.0%	44.0%	48.0%	50.0%	47.6%	2.4%	Waste Framework Directive (2008)
Paper	60.5%	-	-	70.0%	-	-	CEPI, 2013 → Applying 1.78% of annual increase rate to 2012 data

Reference Scenario: the year 2012

Future Scenario A: Full implementation of the EU recycing target in 2020 (with same phthalate production as 2012)

Future Scenario B: Full implementation of the EU recycing target in 2020 (with 50% reduction in phthalate use)

RISK CYCLE IN A CIRCULAR ECONOMY

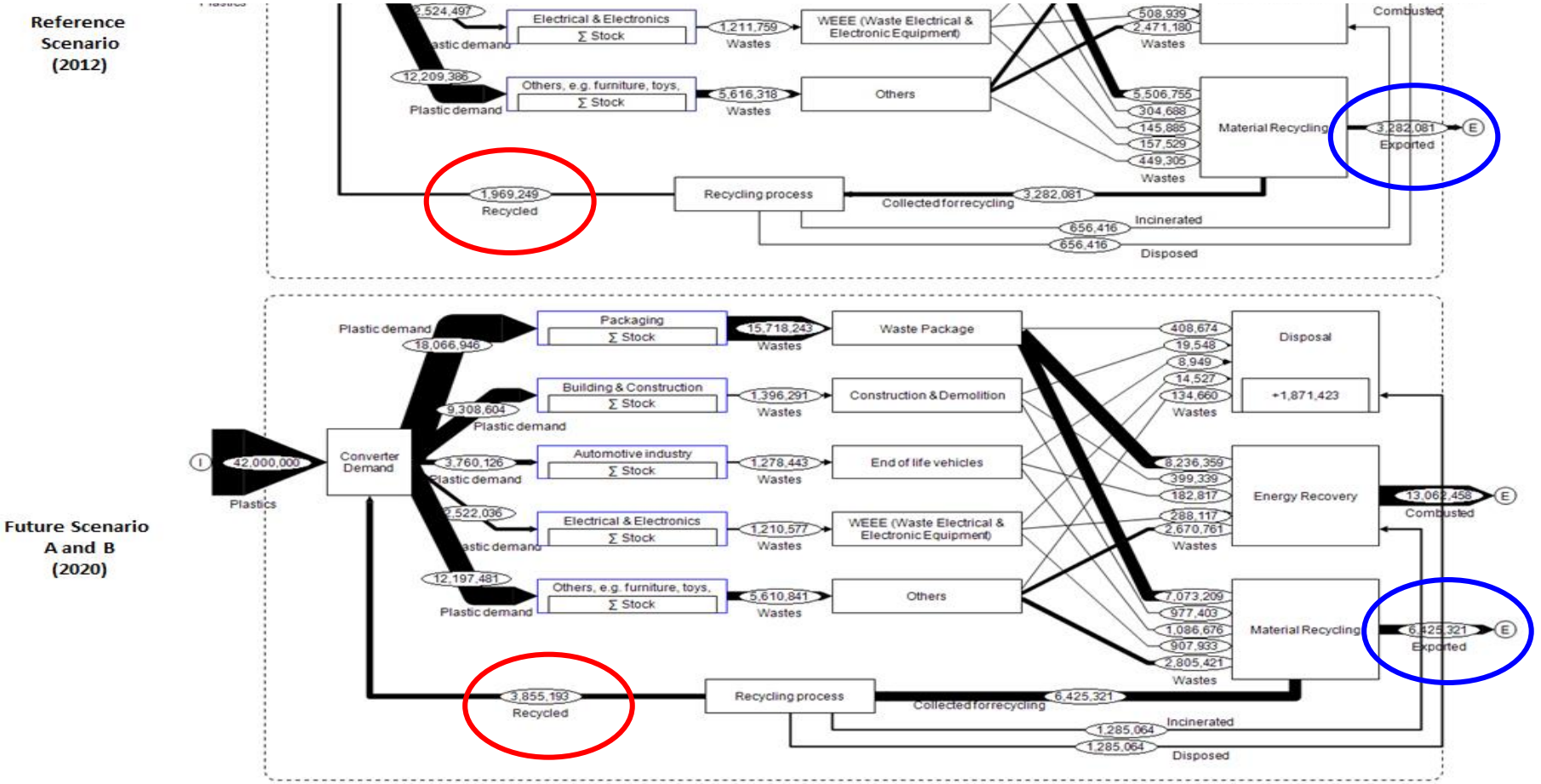
Reference Scenario vs. Future Scenarios

Collected for material recycling: 26% → 51%

(in EU 4.3%→8.4%, outside EU 7% → 14%)

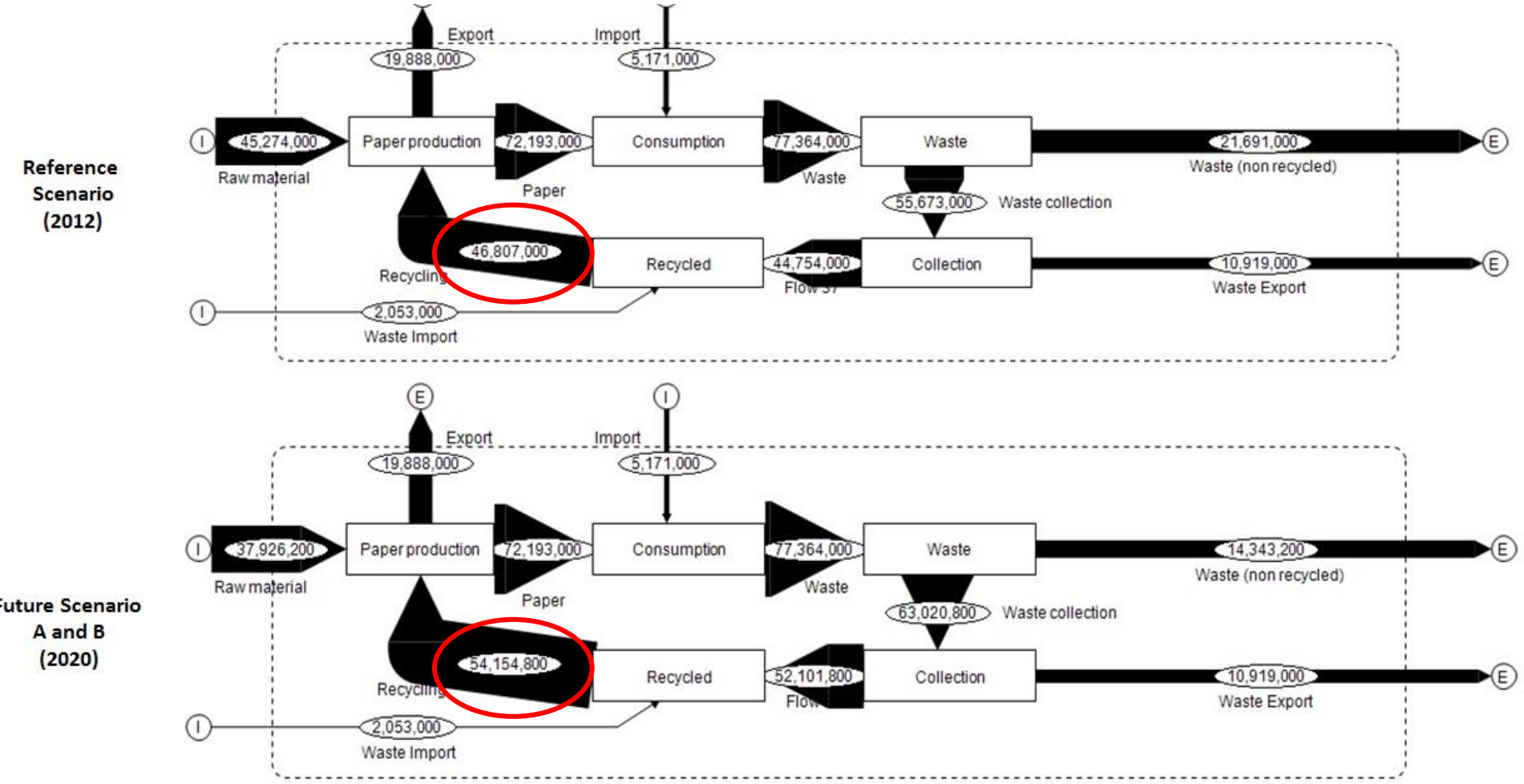
Energy recovery: 9.6 Mt → 13.1 Mt (35% ↑)

Landfilled: 10 Mt → 1.9 Mt (80%↓)



RISK CYCLE IN A CIRCULAR ECONOMY

Reference Scenario vs. Future Scenarios
Collected for material recycling: 72% → 81%
Recycled in EU: 60% → 70% (16% ↑)



RISK CYCLE IN A CIRCULAR ECONOMY

Phthalate flow analysis (

Reference Scenario vs. Future Scenario A

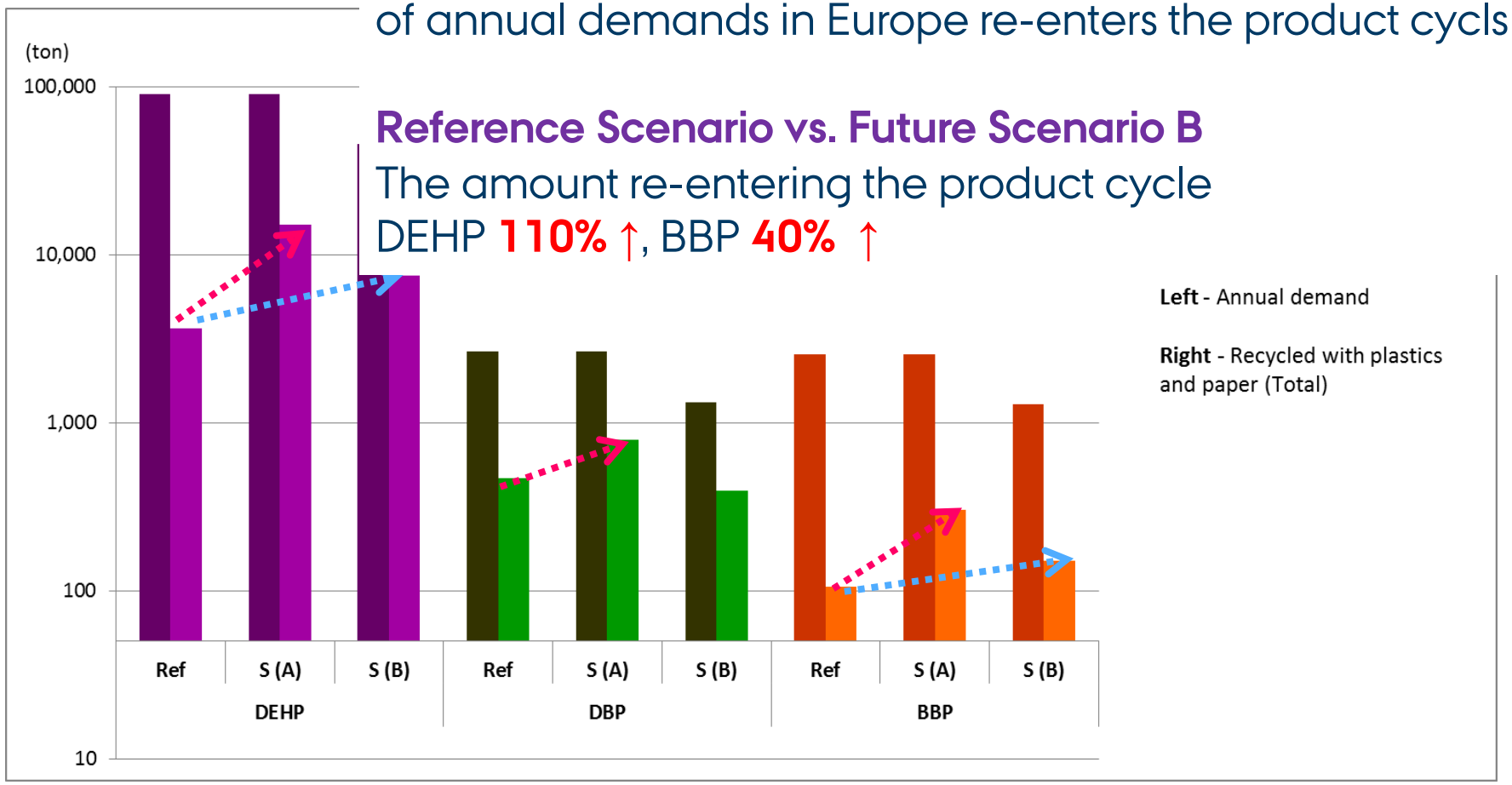
DEHP **4% → 17%,** DBP **18% → 30%,** BBP **4% → 12%**

of annual demands in Europe re-enters the product cycls

Reference Scenario vs. Future Scenario B

The amount re-entering the product cycle

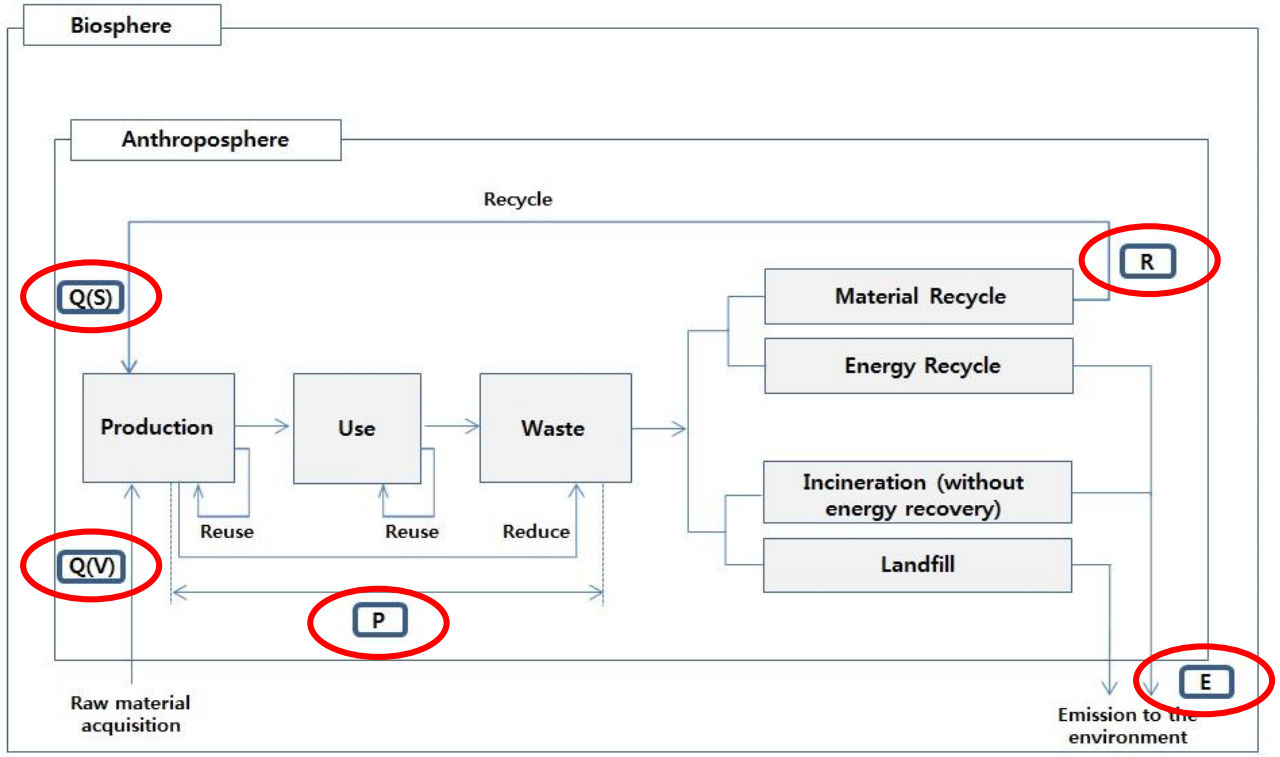
DEHP **110% ↑**, BBP **40% ↑**



Implication !

WILL RECYCLING REDUCE OR PRODUCE MORE CONTAMINANTS ?

Systemic Approach for a circular economy based on sustainable resource flows



E=Emission, R=Recycle, P=Process, Q(V/S)=Quality of virgin/secondary material

WILL RECYCLING REDUCE THE CYCLING OF CONTAMINANTS ?

NOPS !!!

BUT IF WE INSTALL UPCYCLING (DECONTAMINATION) TECHNOLOGIES PRIOR TO RECYCLING WE MIGHT HAVE A CHANCE TO CREATE A CIRCULAR ECONOMY WITH REDUCED EXTERNALITIES

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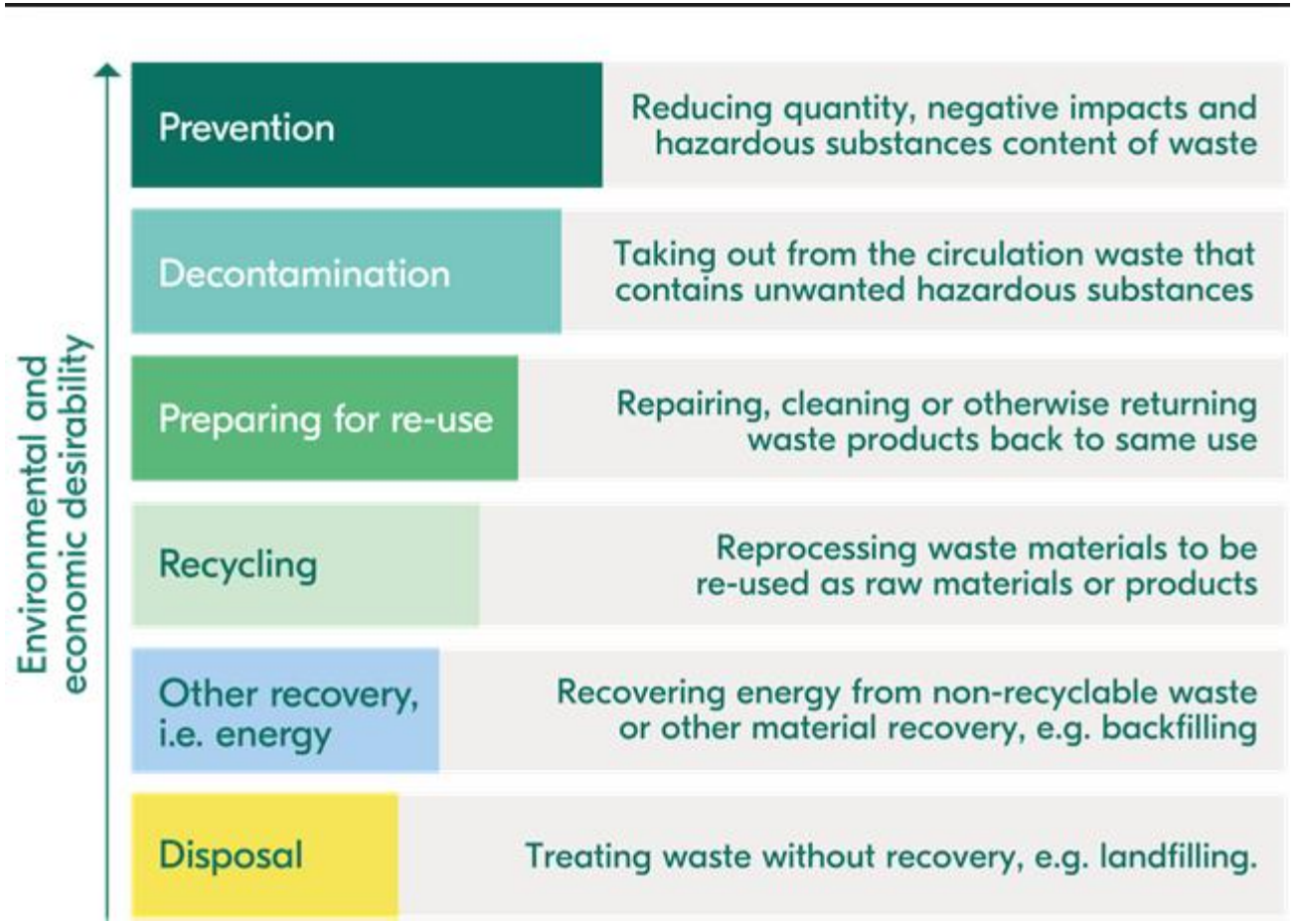
TRANSITION TO A SAFE CIRCULAR ECONOMY



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