Muovien kiertotalous

Uudet Vähähiiliset Ratkaisut Kiertotaloudessa Seminaari
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VTT – beyond the obvious

VTT is one of the leading research, development and innovation organizations in Europe. We help our customers and society to grow and renew through applied research. The business sector and the entire society get the best benefit from VTT when we solve challenges that require world-class know-how together and translate them into business opportunities.

Our vision
A brighter future is created through science-based innovations.

Our mission
Customers and society grow and renew through applied research.

Strategy
Impact through scientific and technological excellence.

Established in
1942

268 M€
Net turnover and other operating income (VTT Group 2018)

2,049
Total of personnel (VTT Group 31.12.2018)

Owned by

Ministry of Economic Affairs and Employment

44%
From the net turnover abroad (VTT Group 2018)

31%
Doctorates and Licentiates (VTT Group 2018)

Yhteenveto VTT:n R&D&I aktiviteeteista muovien kiertotalouteen liittyen

ALTERNATIVES TO VIRGIN FOSSIL PLASTICS: From bio, CO2 & recyclates

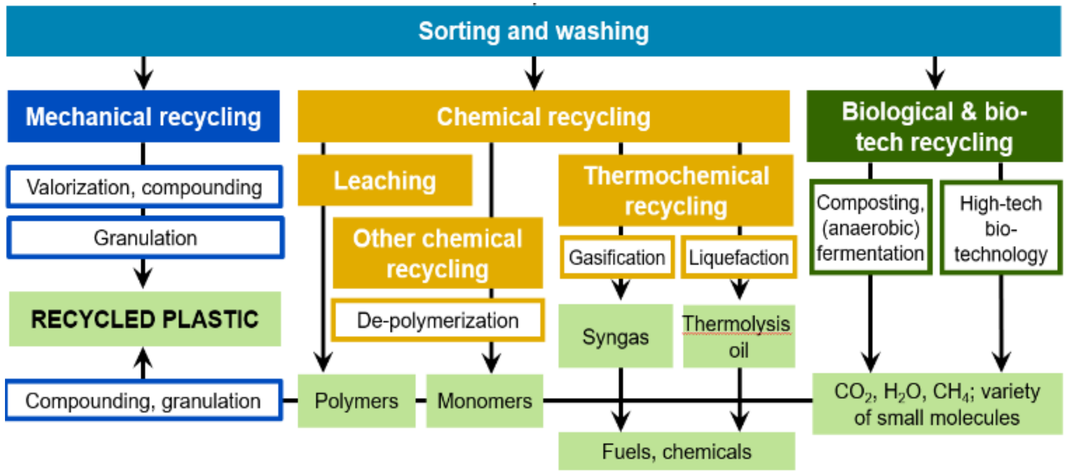
- **Valorization of side and waste streams**
- **CO2 as feedstock**
- **Recycled polymers and monomers**
- **Biobased monomers**: Biotechnical production (GA, HA)
- **Biobased polymers and plastics**: High performance bioplastics like polyglycolacid PGA, PEF
- **Cellulose-based materials:** Thermoplastic cellulose, for example the biobased packaging solution awarded by the Ellen MacArthur Foundation.

REDUCE AND AVOID

- **Efficient and smart use of plastics:** packages, composites, structural materials.
- **Product design:** Modelling tools such as Propertune for use and end-of-life
- **Business models:** reuse business models

RECYCLE AND REUSE

- **Recycling of plastics**: Mechanical, chemical, biological and biotechnical recycling,
- **Material detection and separation, feedstock management and logistics**: remote identification with spectral cameras and AI robotics for waste streams,
- **Plastic repurposing**: compounding of plastic mixtures, foaming, textile recycling, plastic gasification and pyrolysis,
- **Capturing the energy value of plastics**: CO2 capture, storage and utilization
- **Operational environment**: regulations, directives, standards, policy recommendations
- **Safety and analyses:** safe processing, innovations to support safe handling of waste streams
- **LCA, TEA**



Muovien kiertotalous

Miksi?
Mitä?
Miten?

Muovit – loistava materiaali

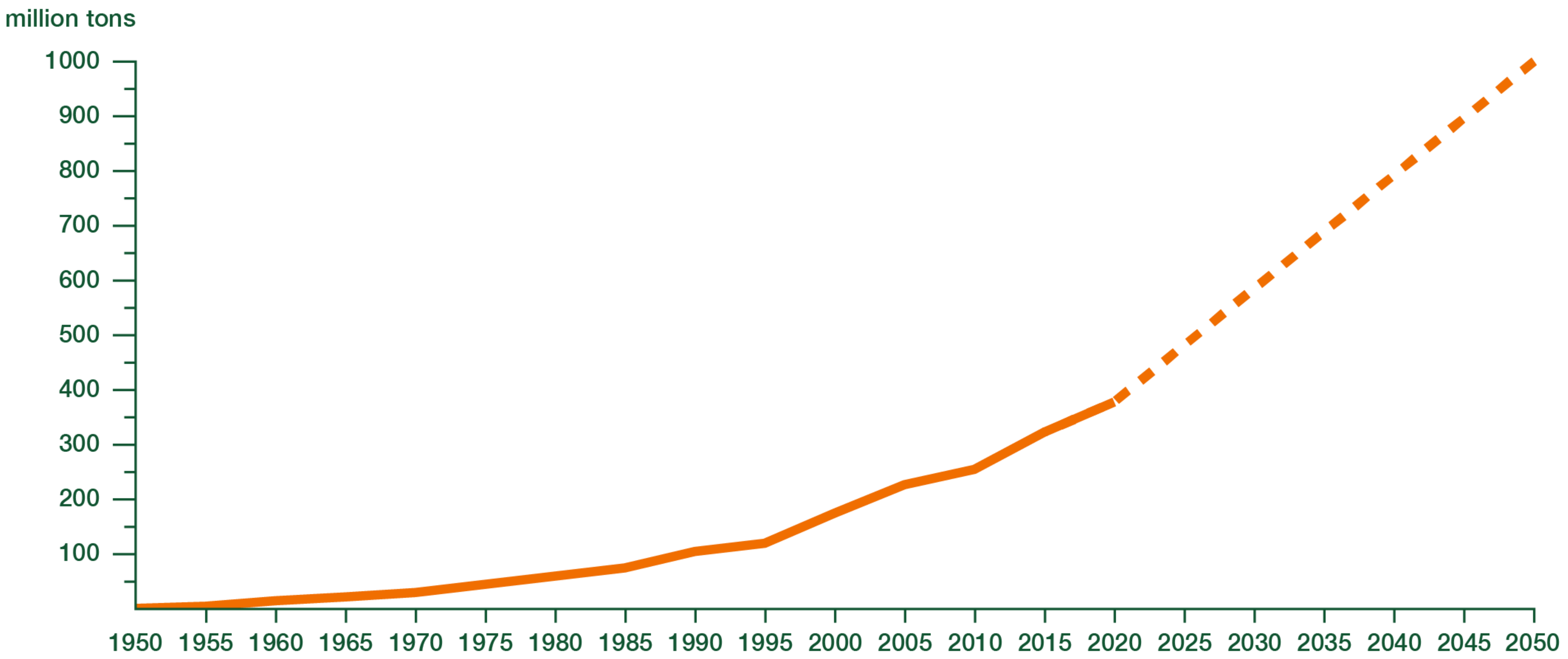
Muovit ovat helposti prosessoitavissa ja muokattavissa, kevyitä ja kustannustehokkaita

- Suojaavat meitä onnettomuuksissa liikenteessä tai urheillessa
- Lääketieteen applikaatiot parantavat elämänlaatua
- Ruoan turvallinen säilöminen

Produce	Cucumber	Zucchini slices	Banana (distribution)	Cherries	Pear	Fish	Cheese	(Whole) Chicken
Shelf life: no packaging with plastic packaging	3 days 14 days	1–2 days 4–5 days	15 days 36 days	14 days 28 days	7–10 22–25	7 days 12 days	190 days 280 days	7 days 20 days
Difference	11 days	2–4 days	21 days	14 days	15 days	5 days	90 days	13 days

Globaali muovin kulutus 1950-2050

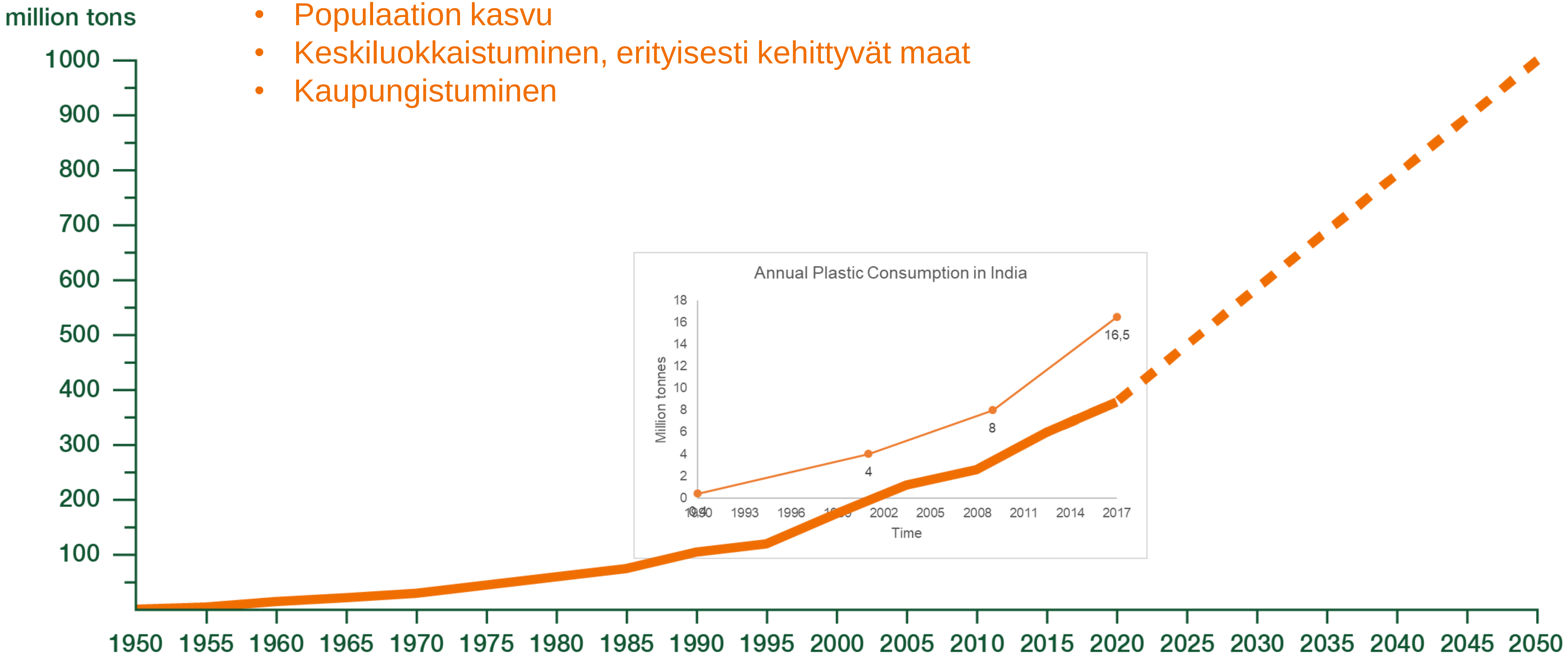
Ajurit kasvun takana?



Globaali muovin kulutus 1950-2050

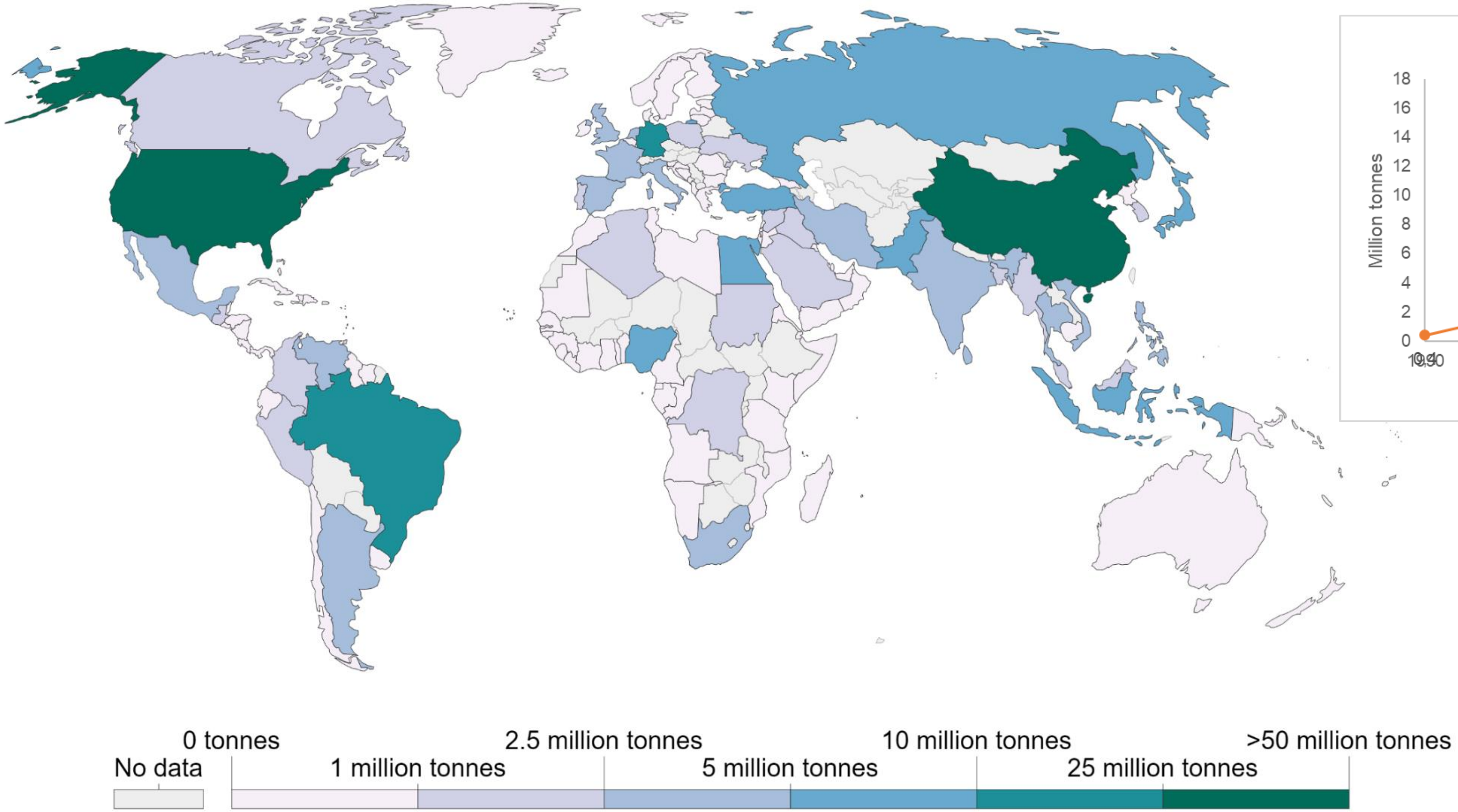
Ajurit kasvun takana?

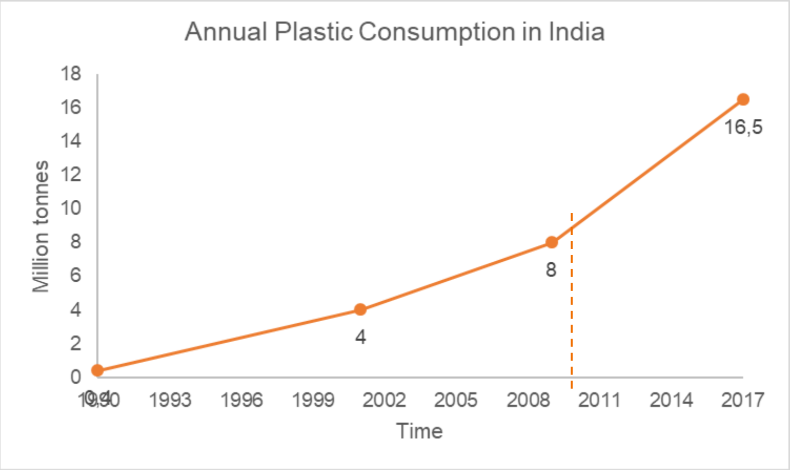
- Populaation kasvu
- Keskiluokkaistuminen, erityisesti kehittyvät maat
- Kaupungistuminen



Plastic waste generation, 2010

Total plastic waste generation by country, measured in tonnes per year. This measures total plastic waste generation prior to management and therefore does not represent the quantity of plastic at risk of polluting waterways, rivers and the ocean environment. High-income countries typically have well-managed waste streams and therefore low levels of plastic pollution to external environments.

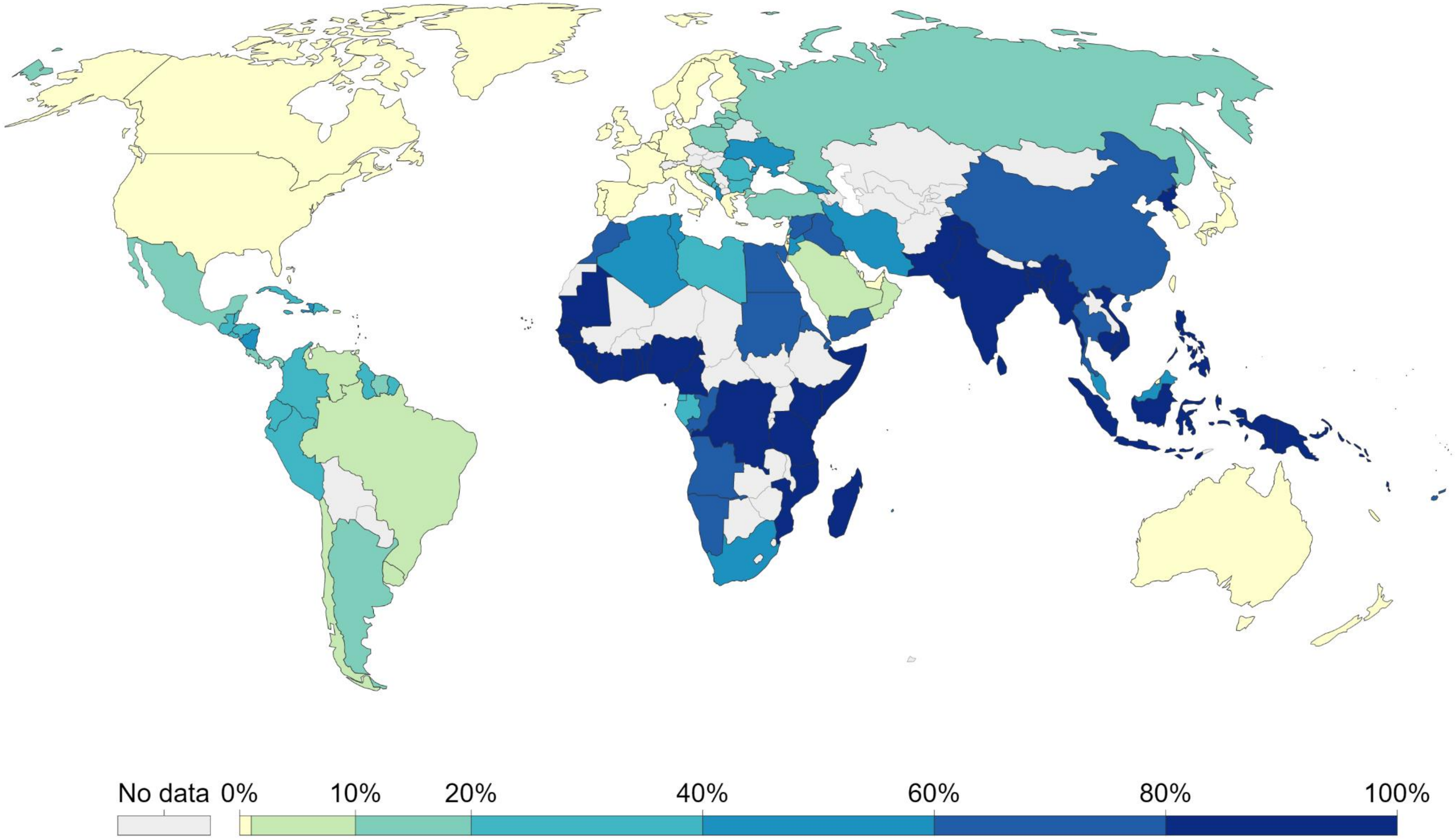




Source: OWID based on Jambeck et al. (2015) & World Bank

Share of plastic waste that is inadequately managed, 2010

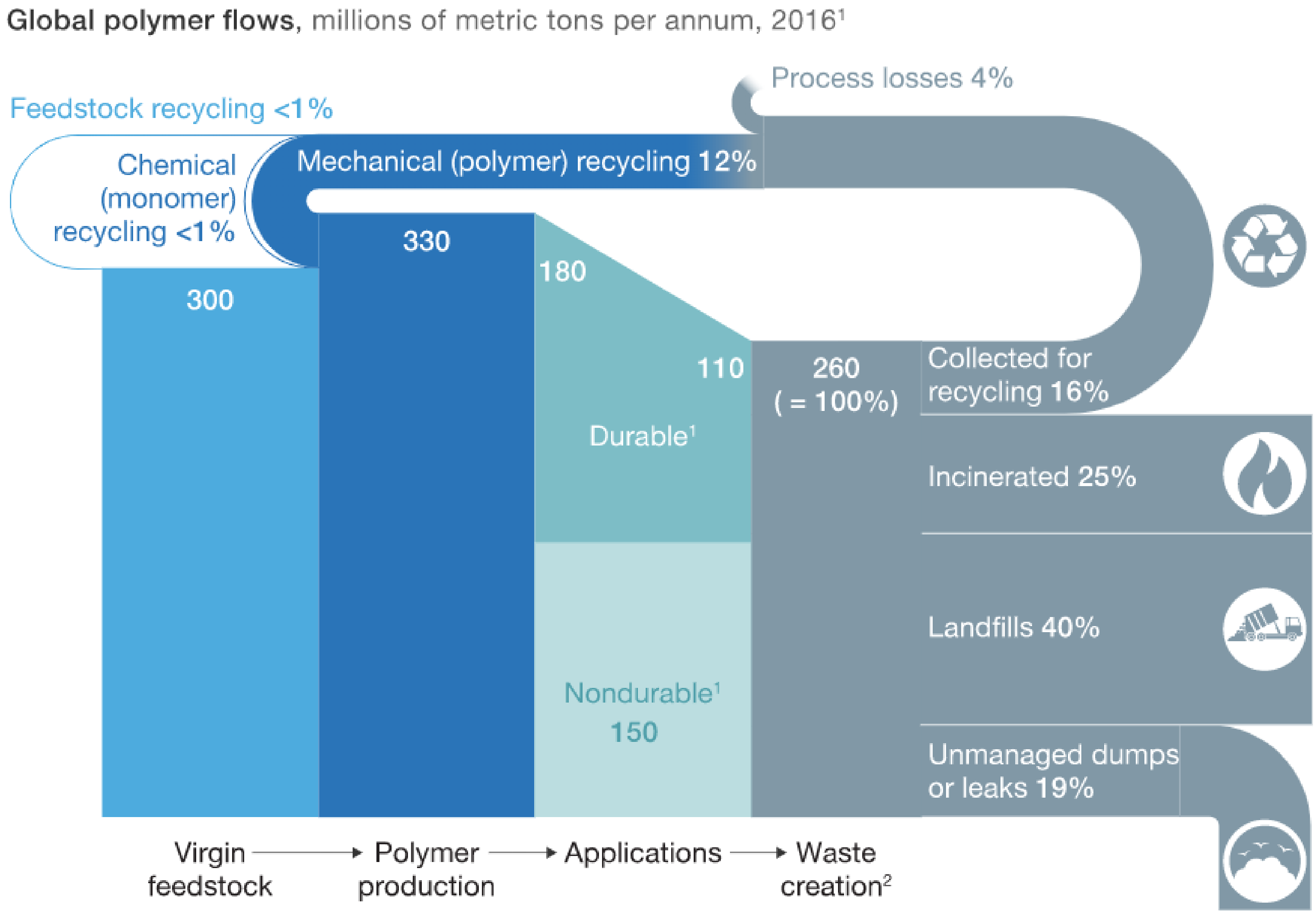
Inadequately disposed waste is not formally managed and includes disposal in dumps or open, uncontrolled landfills, where it is not fully contained. Inadequately managed waste has high risk of polluting rivers and oceans.



Source: Jambeck et al. (2015)

Note: This does not include 'littered' plastic waste, which is approximately 2% of total waste.

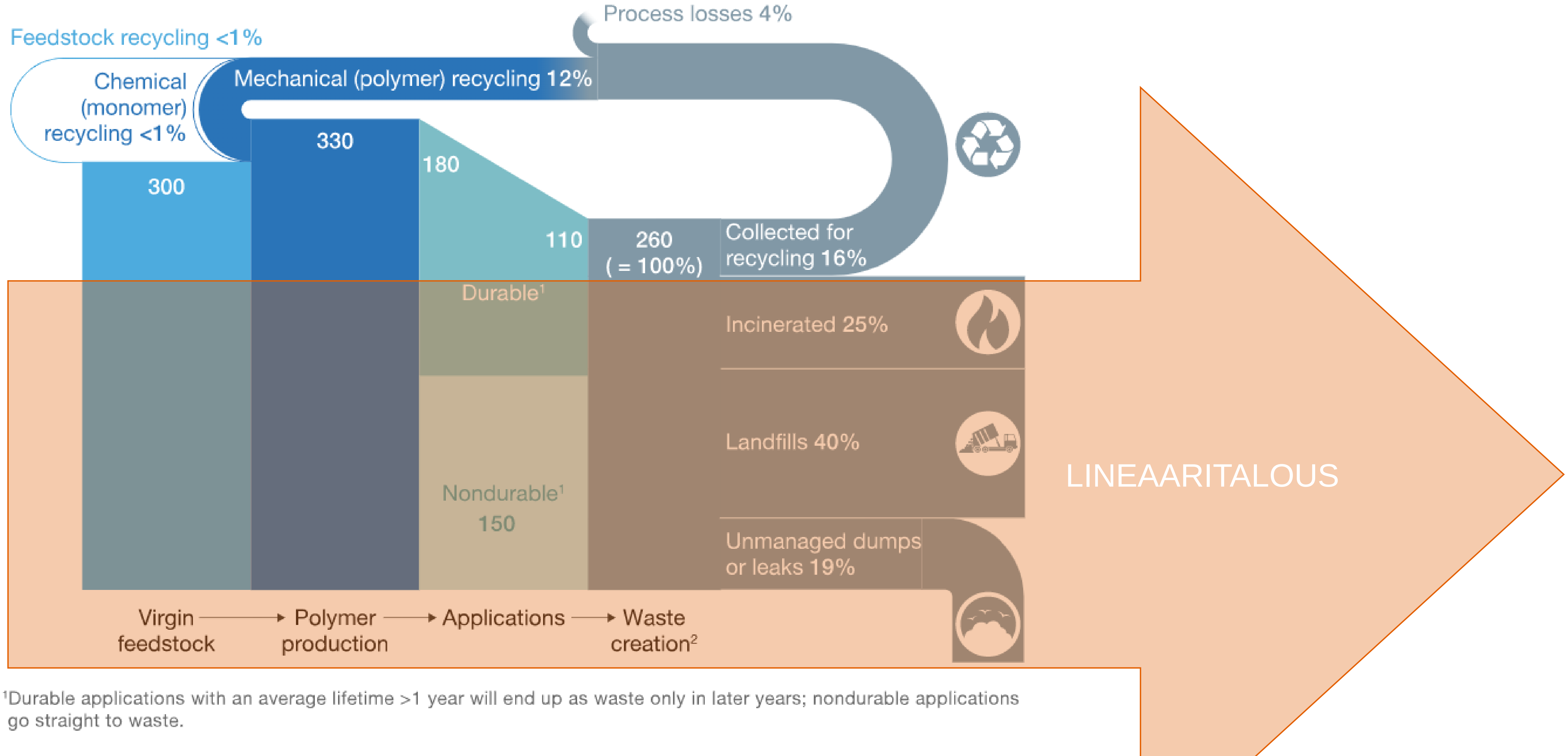
Vain noin 12 % muoveista kierrätetään globaalisti



[1]Durable applications with an average lifetime >1 year will end up as waste only in later years; nondurable applications go straight to waste.

Vain noin 12 % muoveista kierrätetään globaalisti

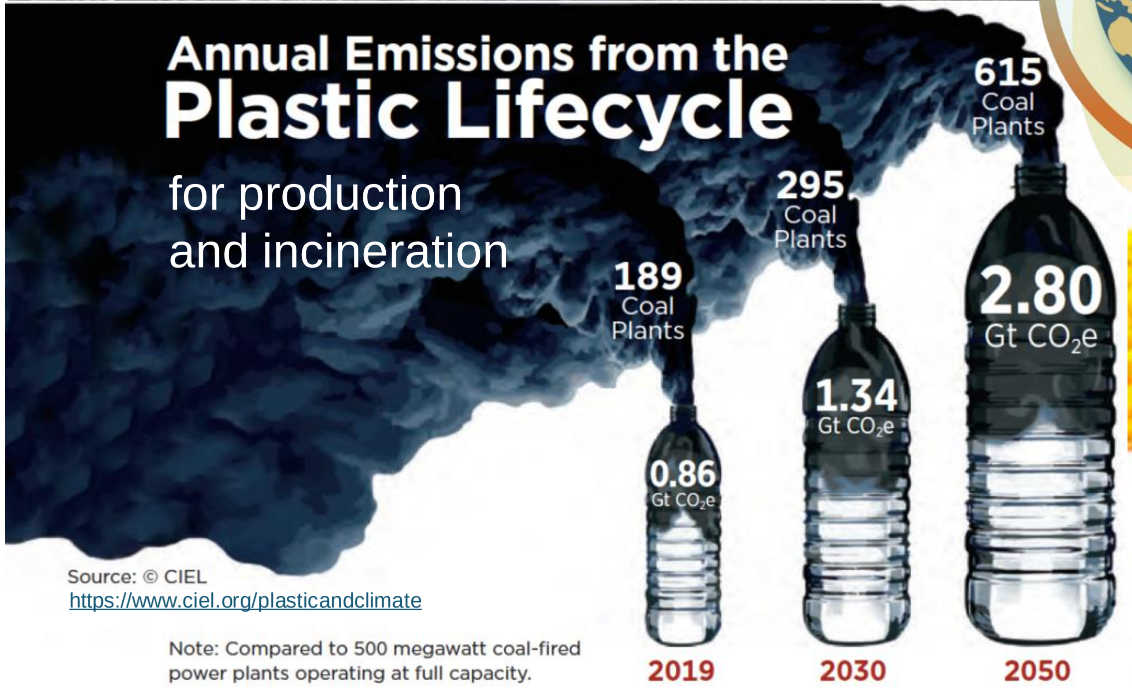
Global polymer flows, millions of metric tons per annum, 2016[1]

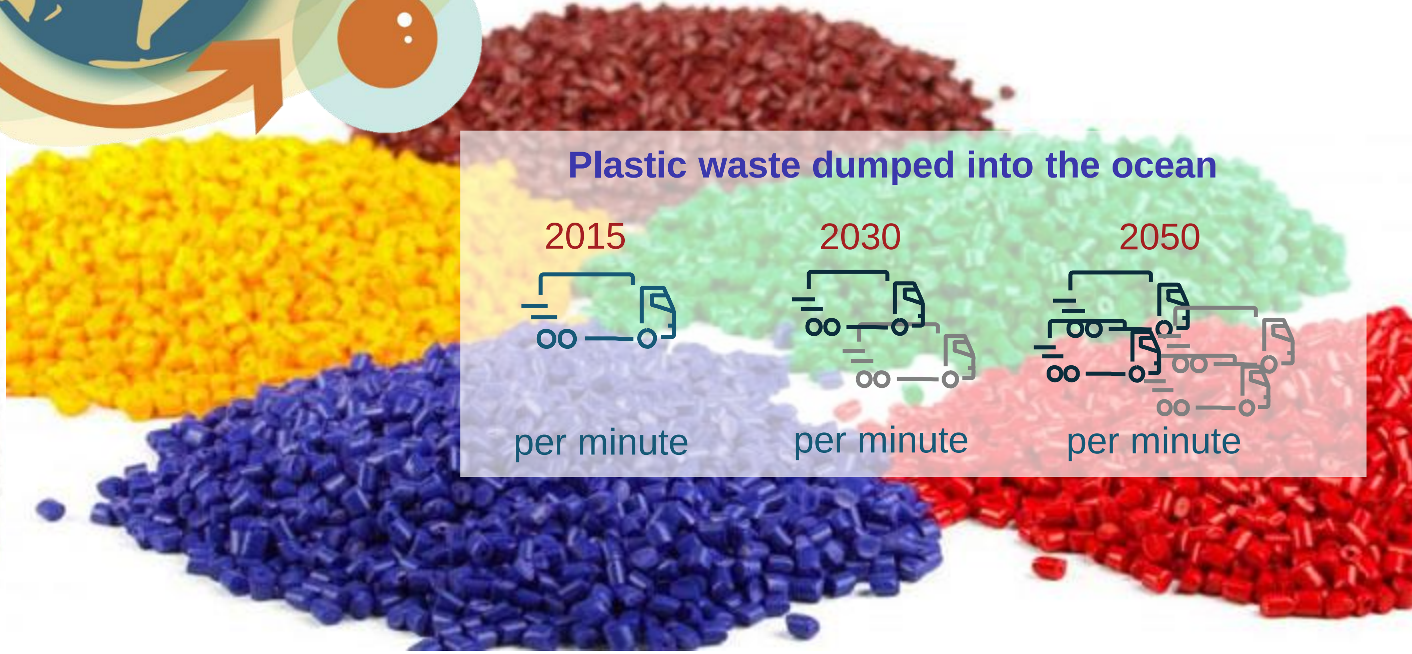


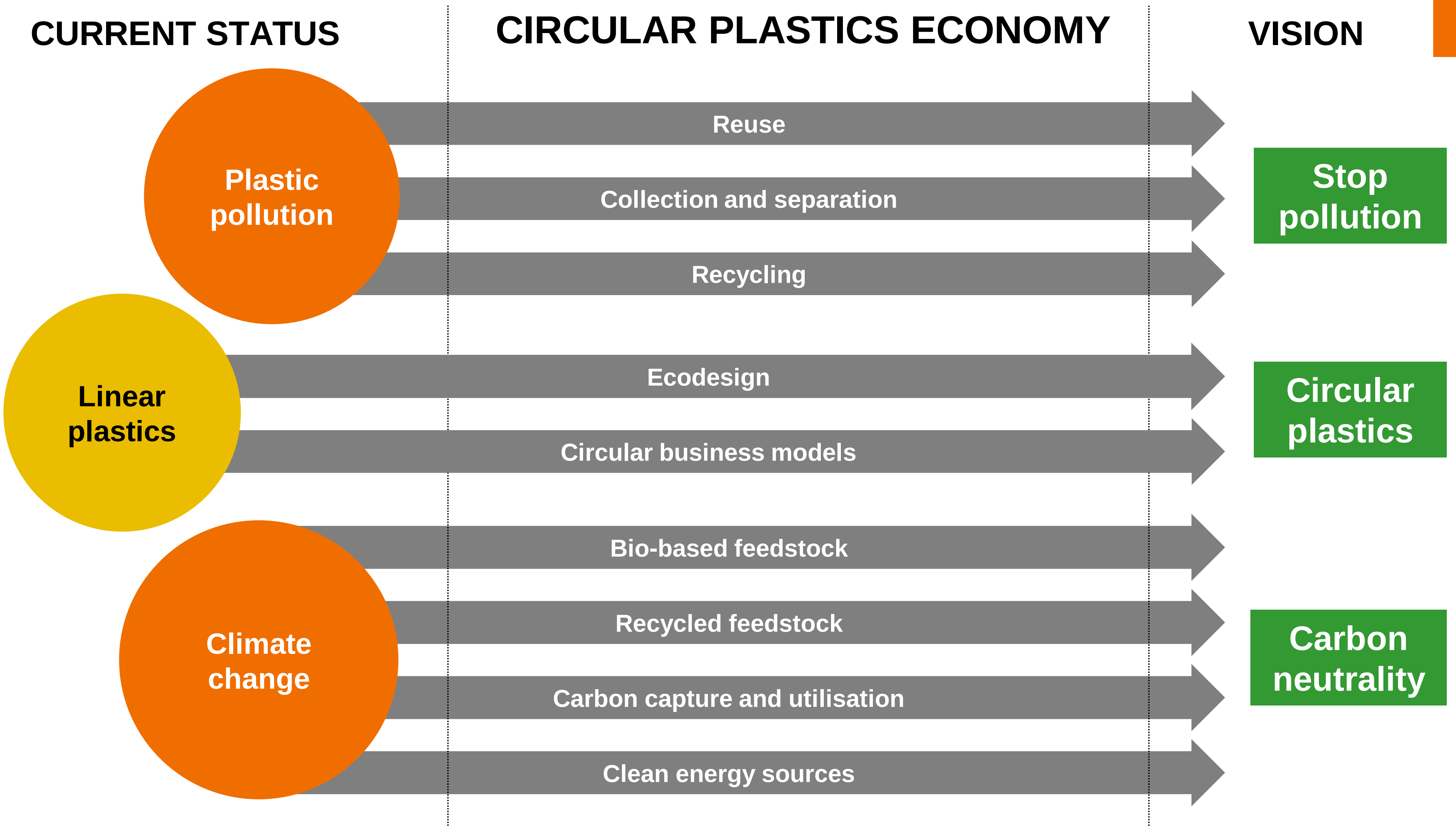
[1]Durable applications with an average lifetime >1 year will end up as waste only in later years; nondurable applications go straight to waste.

Lineaaritalouden sekä muovien kasvavan käytön tuomat globaalit haasteet

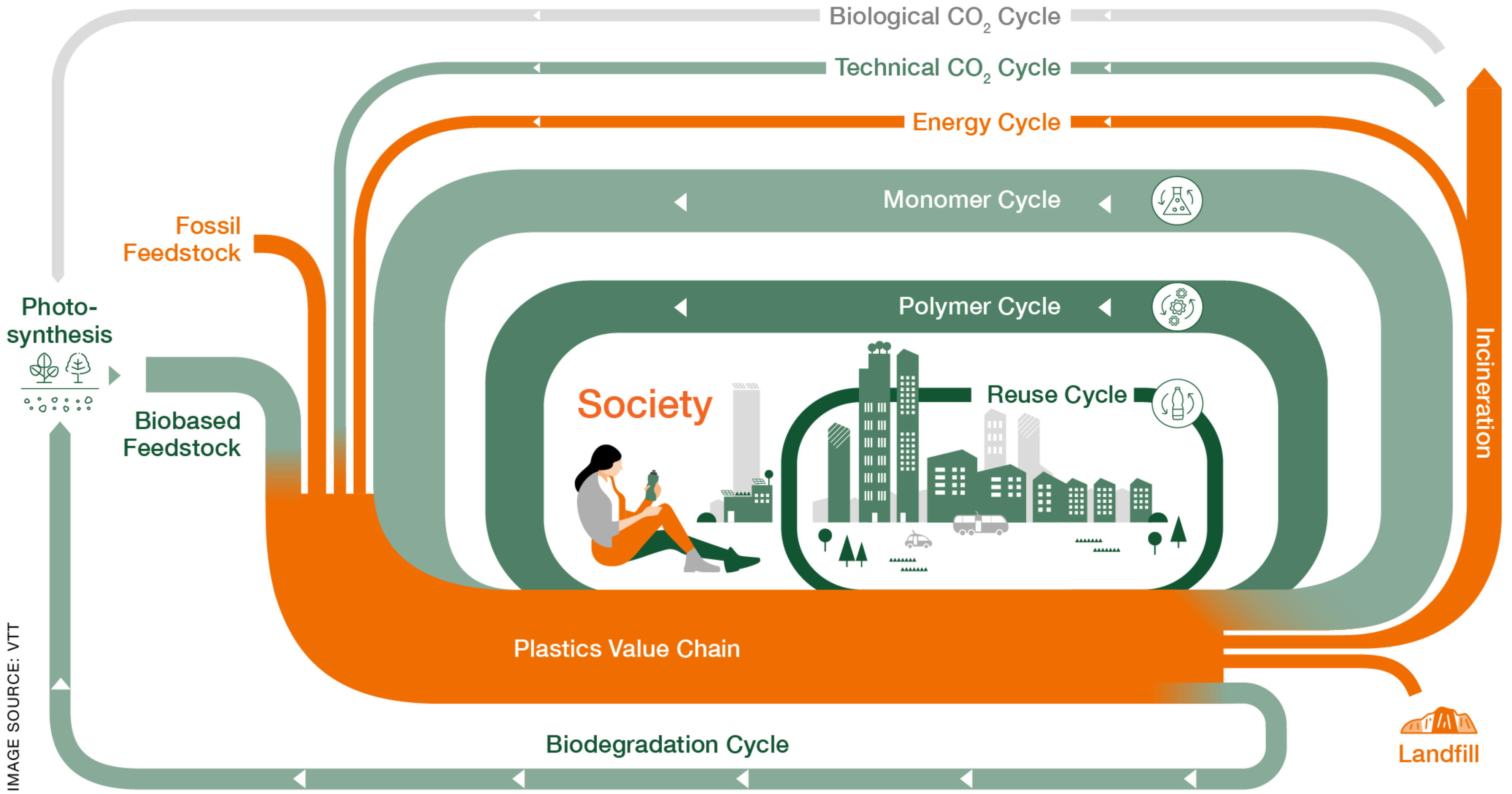
ILMASTONMUUTOS
MUOVISAASTE






CURRENT STATUS
CIRCULAR PLASTICS ECONOMY
VISION
Plastic pollution
Linear plastics
Climate change
Reuse
Collection and separation
Recycling
Ecodesign
Circular business models
Bio-based feedstock
Recycled feedstock
Carbon capture and utilisation
Clean energy sources
Stop pollution
Circular plastics
Carbon neutrality

VTT Circular Plastics Vision



https://cris.vtt.fi/en/publications/a-circular-economy-of-plastics-a-vision-of-redesigning-plastics-v

Muovien laaja kirjo: polymeerit ja lisäaineistukset

The two categories of plastics

Thermoplastics

are a family of plastics that can be melted when heated and hardened when cooled. These characteristics, which lend the material its name, are revesible. That is, it can be reheated, reshaped and frozen repeatedly.

- Polyethylene (PE)
- Polypropylene (PP)
- Polyvinyl-chloride (PVC)
- Polyethylene Terephthalate (PET)
- Polystyrene (PS)
- Expanded polystyrene (EPS)
- ABS
- SAN
- Polyamides (PA)
- Polycarbonate (PC)
- Poly methyl methacrylate (PMMA)
- Thermoplastic elastomers (TPE)
- Polyarysulfone (PSU)
- PEEK
- POM
- PBT
- Etc.

Thermosets

are a family of plastics that undergo a chemical change when heated, creating a three dimensional network. After they are heated and formed these plastics cannot be re-melted and reformed.

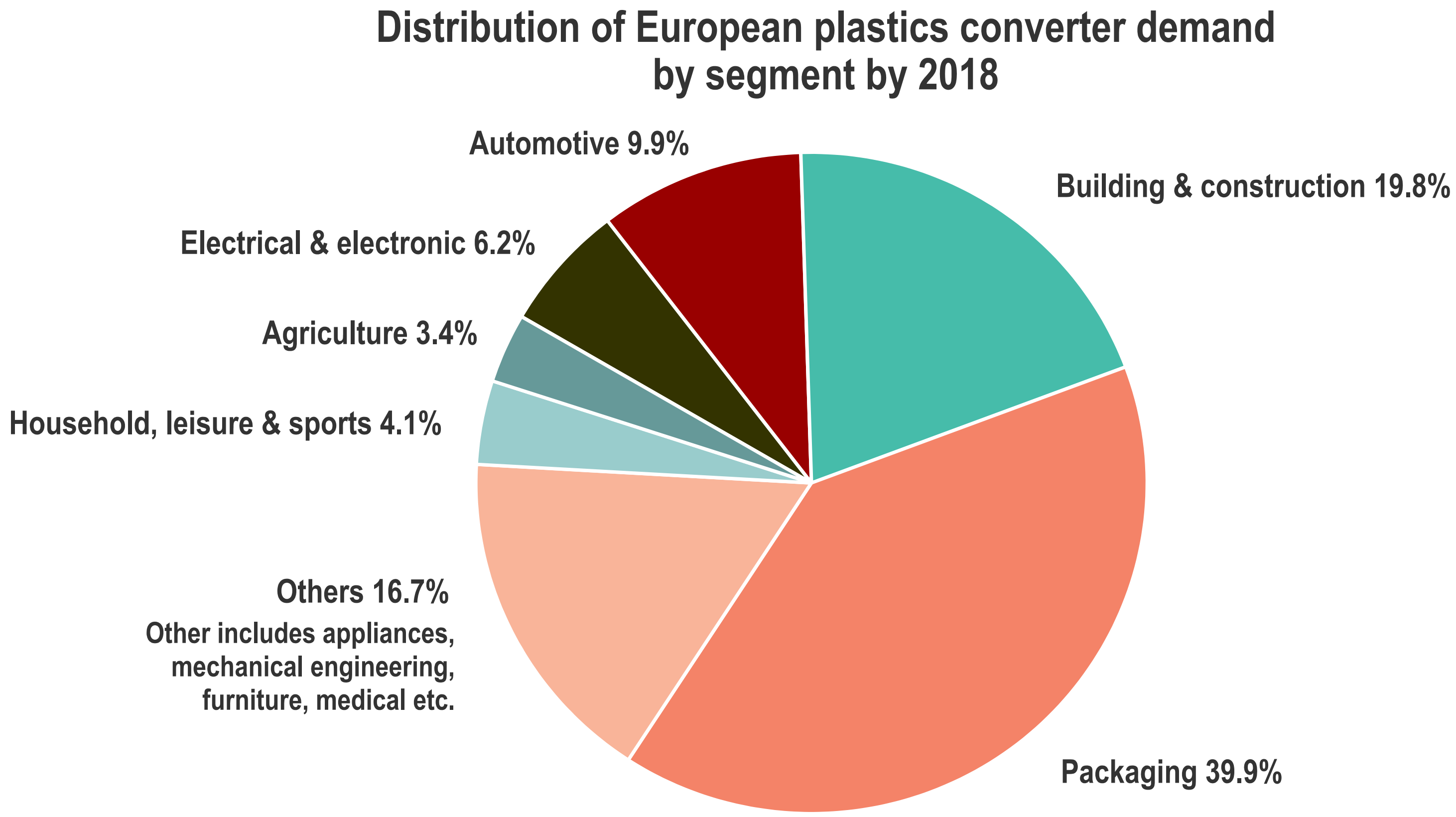
- Polyurethane (PUR)
- Unsaturated polyester
- Epoxy resins
- Melamine resin
- Vinyl ester
- Silicone
- Phenol – formaldeyhde
- Urea – formaldeyhde
- Phenolic resins
- Acrylic resins
- Etc.

Category/Type of additive	**Typical amount range (% w/w)**
Functional additives	
Plasticisers	10–70
Flame retardants	3–25 (for brominated)
	0.7–3
Stabilisers, Antioxidants and UV stabilizers	0.05–3
Heat stabilisers	0.5–3
Slip agents	0.1–3
Lubricants (internal and external)	0.1–3
Anti-statics	0.1–1
Curing agents	0.1–2
Blowing agents	Depends on the density of the foam and the potential gas
Biocides	0.001–1
Colorants	
Soluble (eg. azocolorants)	0.25–5
Organic pigments	0.001–2.5
Inorganic pigments	0.01–10
Fillers	
Calcium carbonate, talc, clay, zinc oxide, glibber, metal powder, wood powder, asbest, barium sulphate, glass microspheres, silicious earth	Up to 50
Reinforcements	
Glass fibers, carbon fibers, aramide fibers	15–30

Muovit: n. 380 Mt/vuosi (globaali, 2020)

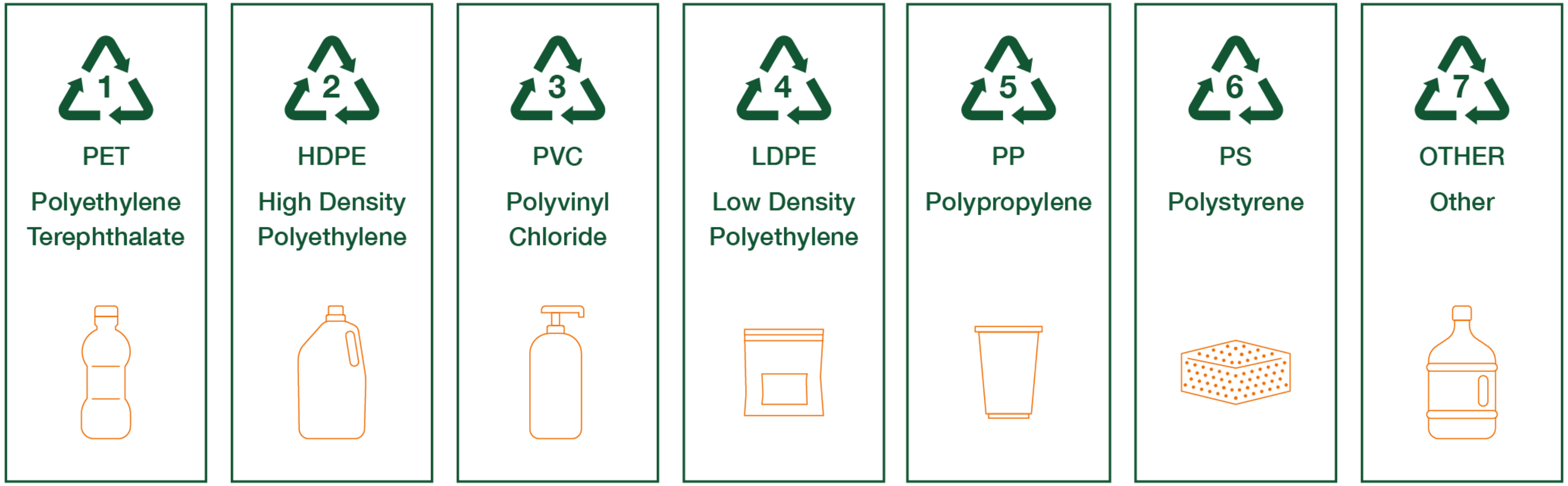
Lisäaineet: 17 Mt/vuosi (globaali, 2020)

Muovit EU:ssa

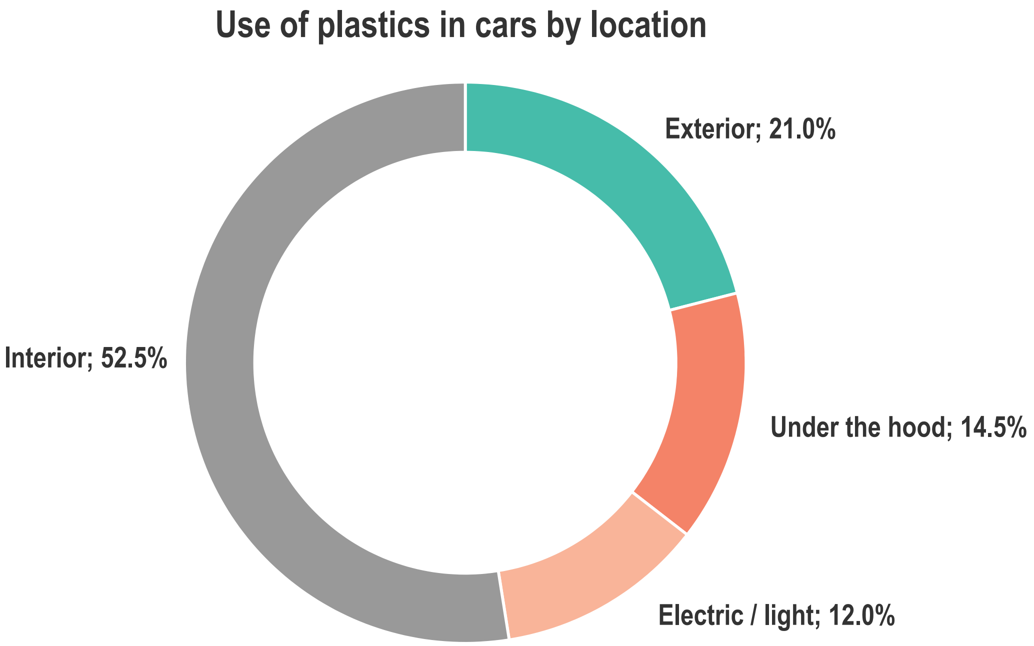


Muovit pakkauksissa

Esimerkki pakkausten muovien kategorioinnista kierrätystä varten

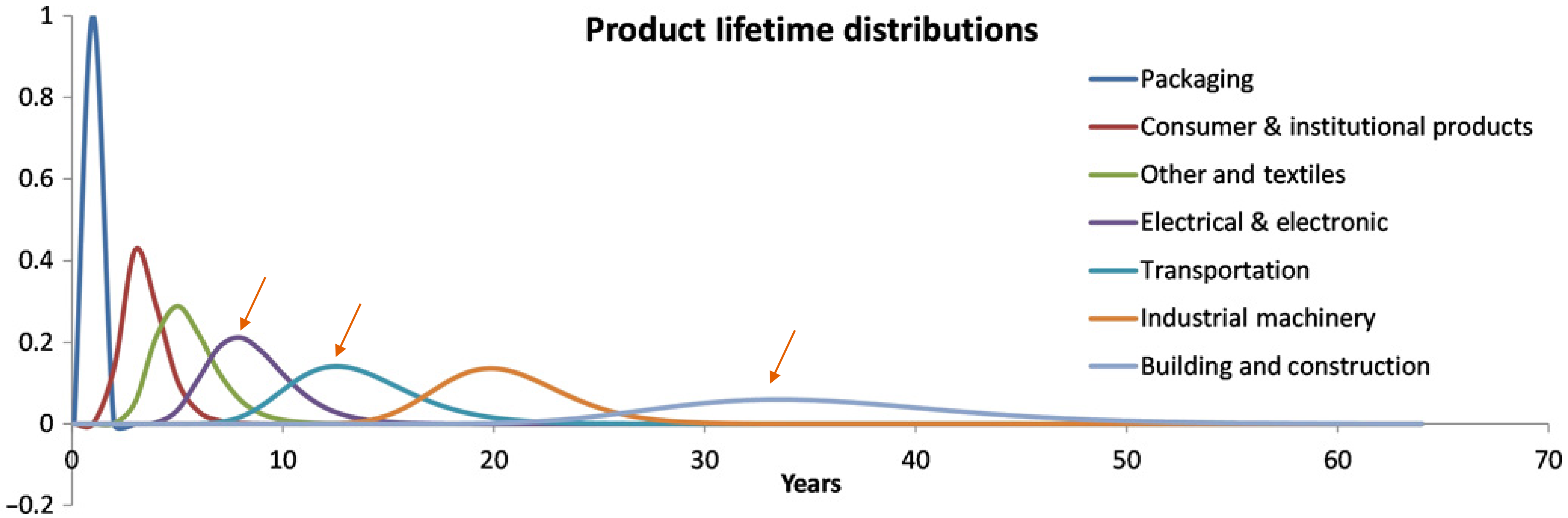


Muovit autoissa

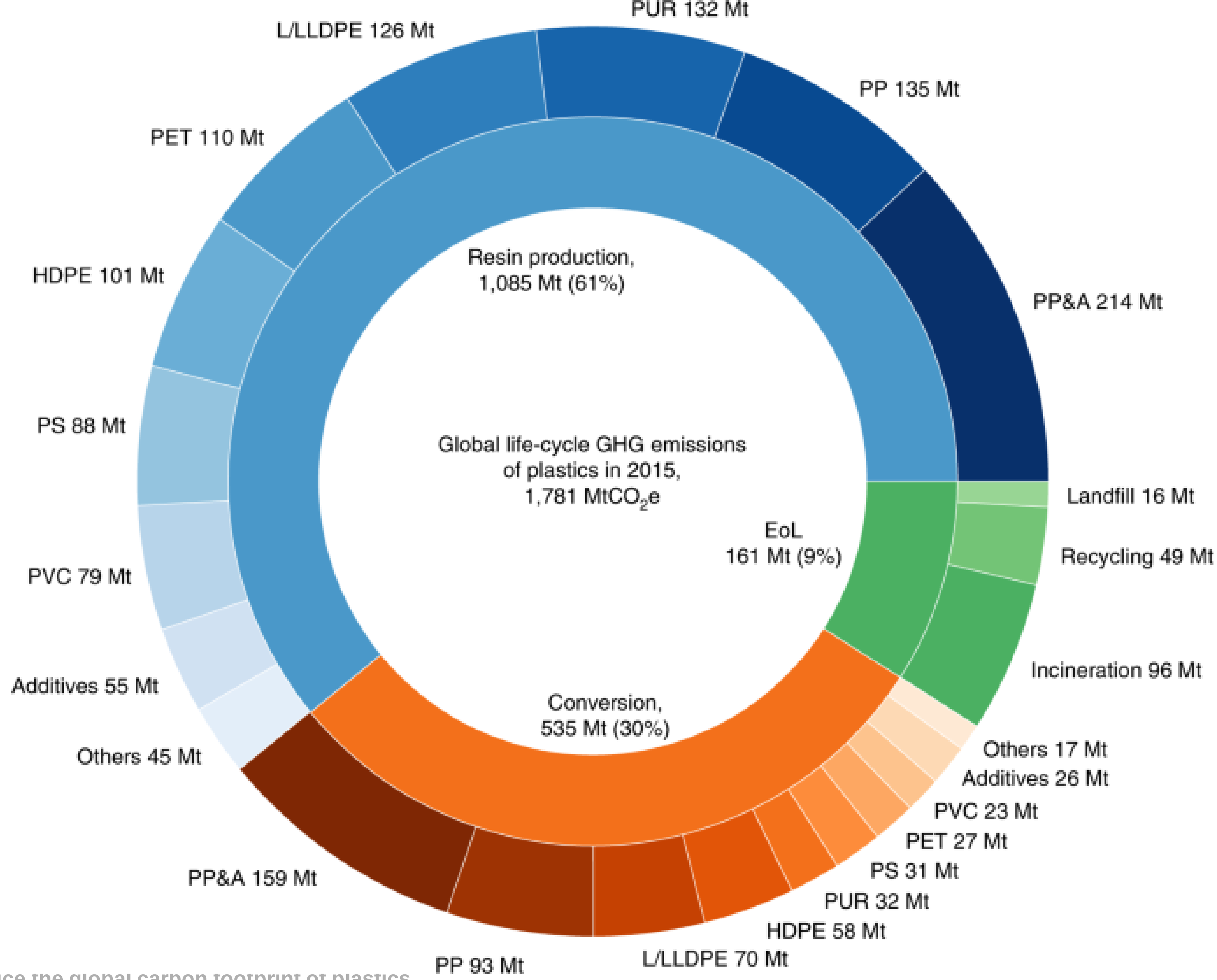


Component	Main types of plastics	Weight in average car (kg)
Interior trim	PP, ABS, PET, POM, PVC	20
Seating	PUR, PP, PVC, ABS, PA	13
Bumpers	PP, ABS, PC/PBT	10
Under-bonnet components	PA, PP, PBT	9
Upholstery	PVC, PUR, PP, PE	8
Dashboard	PP, ABS, SMA, PPE, PC	7
Electrical components	PP, PE, PBT, PA, PVC	7
Fuel systems	HDPE, POM, PA, PP, PBT	6
Body (including panels)	PP, PPE, UP	6
Lighting	PC, PBT, ABS, PMMA, UP	5
Exterior trim	ABS, PA, PBT, POM, ASA, PP	4
Liquid reservoirs	PP, PE, PA	1
Total		105

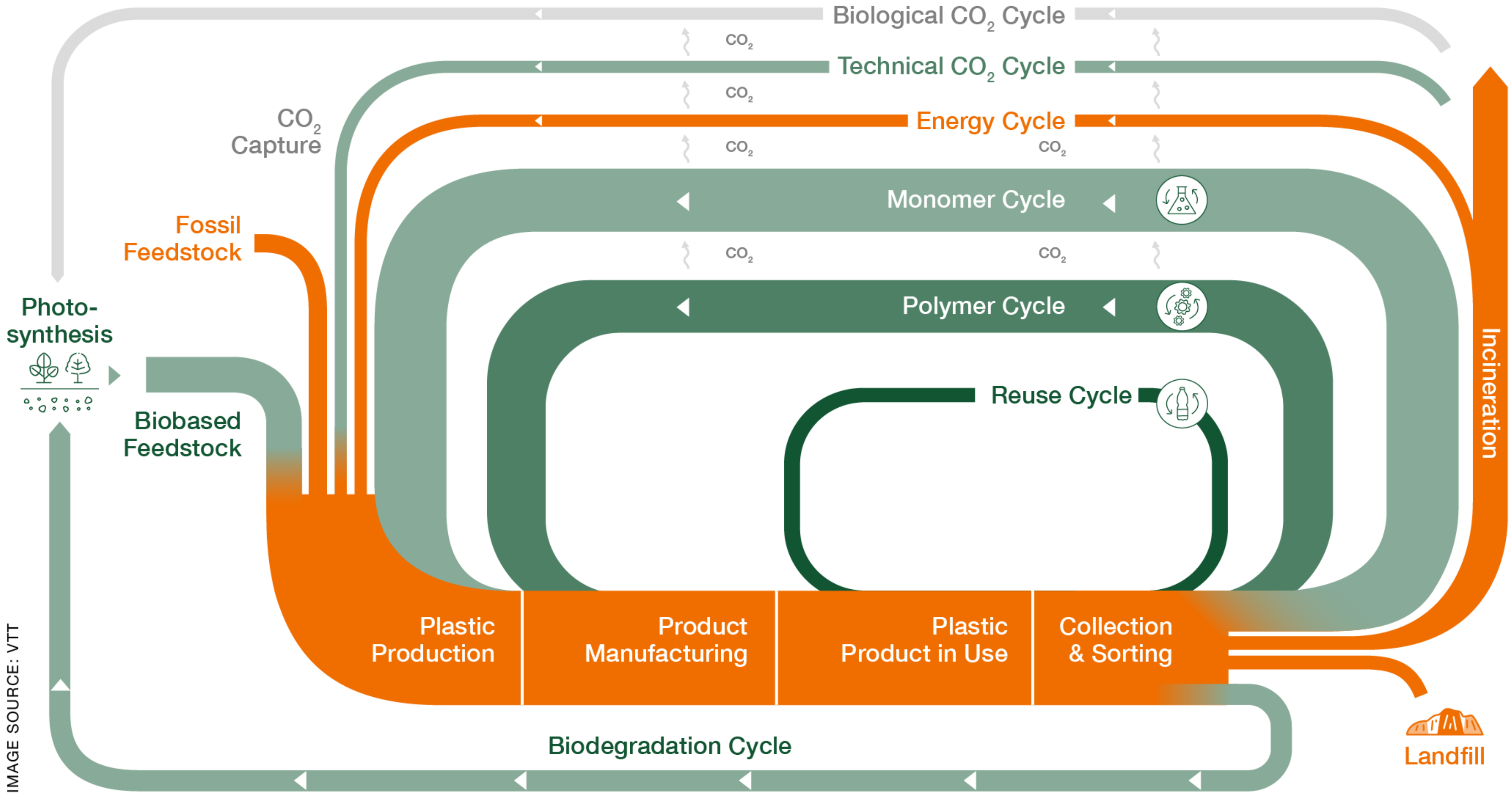
Tuotteiden keskimääräiset elinkaaret



Muovien arvoketjun eri vaiheiden ja polymeeri-kohtaiset GHG päästöt



Source: Zheng, J. & Suh, S., 2019, Strategies to reduce the global carbon footprint of plastics



Biological CO_2 Cycle
Technical CO_2 Cycle
Energy Cycle
Monomer Cycle
Polymer Cycle
Reuse Cycle
CO_2
CO_2 Capture
Fossil Feedstock
Photo-synthesis
Biobased Feedstock
Plastic Production
Product Manufacturing
Plastic Product in Use
Collection & Sorting
Incineration
Landfill
Biodegradation Cycle
IMAGE SOURCE: VTT

REUSE: Muovimateriaalien ja –tuotteiden hyödyllisen elämänkaaren pidentäminen

CHALLENGE

- Wear and tear of products in use phase make reuse business models less attractive
- Surfaces become scratched
- Degradation makes articles brittle

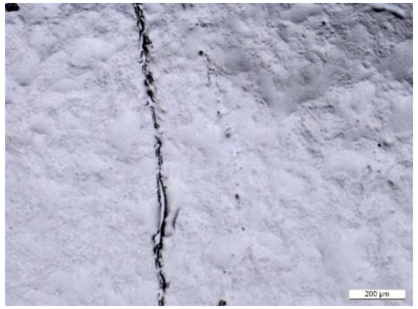
VTT ratkaisu: self-healing materiaalit

TRL 2-4

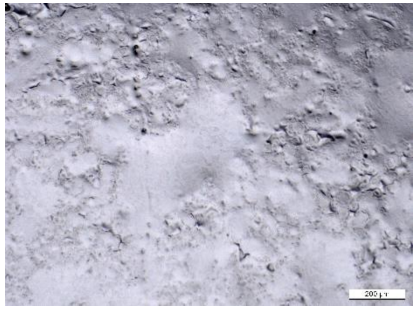
Molecular repair triggered through UV or heat treatment

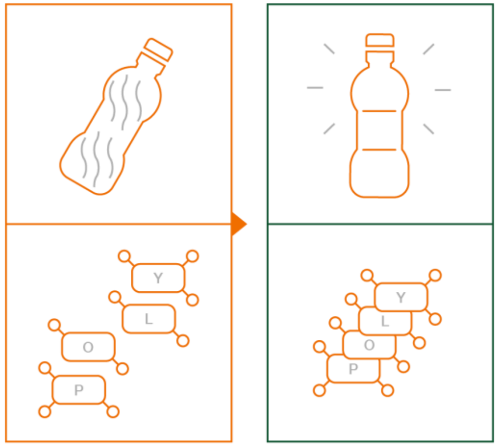
- Proof of concept existing for dispersion coatings on various surfaces
- Shows significant decrease in scratch depth

A "fresh" scratch on the coating surface



After UV and heat treatment





Market: Improving plastics deposit schemes / food packaging / surface coatings

ECODESIGN: Kiertotalouden materiaalien digitaalinen suunnittelu

CHALLENGE

- New materials better suited for circularity are needed
- Material design by experimentation is slow and expensive

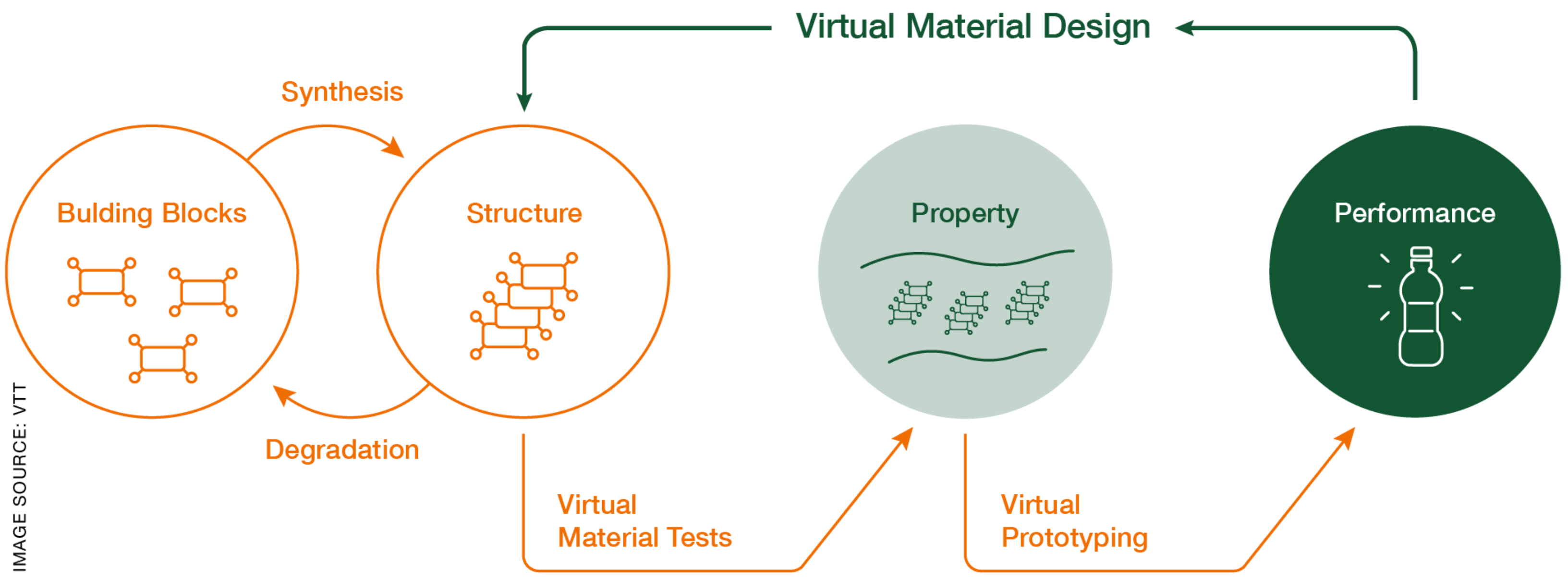


IMAGE SOURCE: VTT

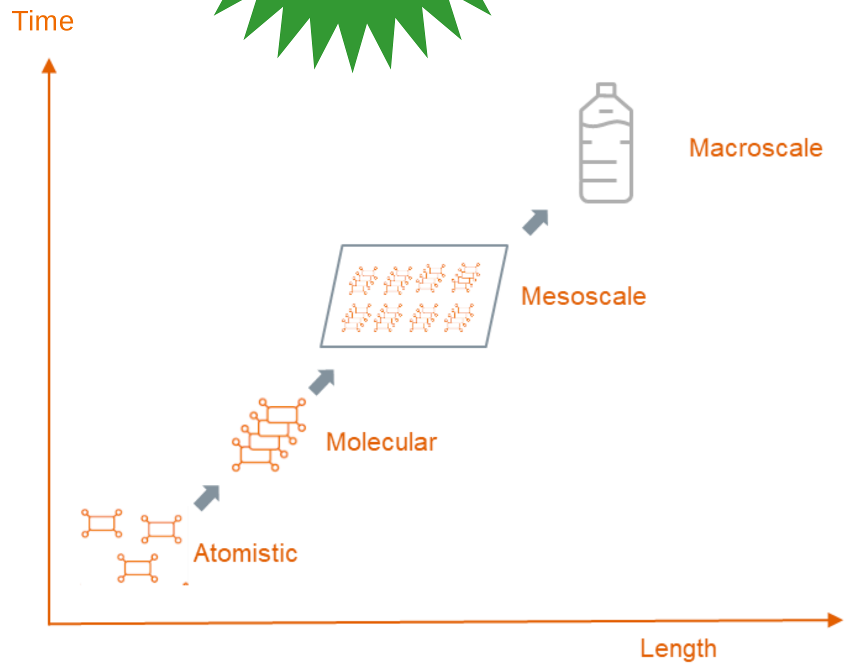
VTT ratkaisu: Propertune-suunnittelutyökalu muoveille ja muovimateriaaleille

TRL 2-6*

* Depending on the application

- **VTT ProperTune®** is VTT's Integrated Computational Material Engineering (ICME) platform and uses multi-scale modeling for materials design

- Design of high performance materials
  - Reduces product development time by an average of 50%
  - Systematic optimisation of e.g. wear, fatigue and fracture resistance
  - Deeper understanding of material degradation mechanisms



RECYCLING: Toimet materiaalivirtojen laadullista vaihtelua vastaan

CHALLENGE

- Degradation and/or mixed feedstock reduce recyclate quality

VTT:n ratkaisu: innovatiivinen viskositeettiin perustuva mekaaninen kierrätyslinjasto

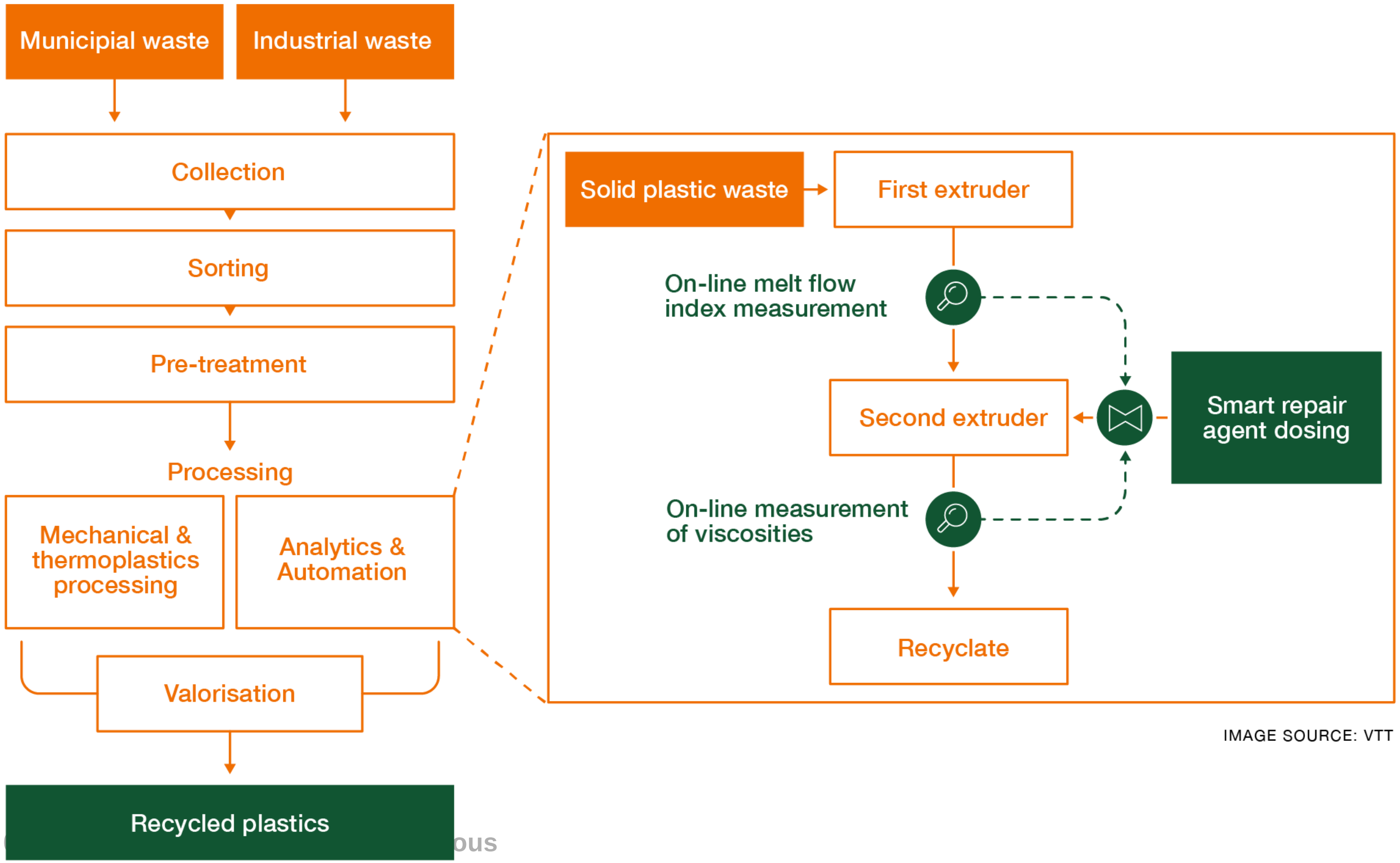
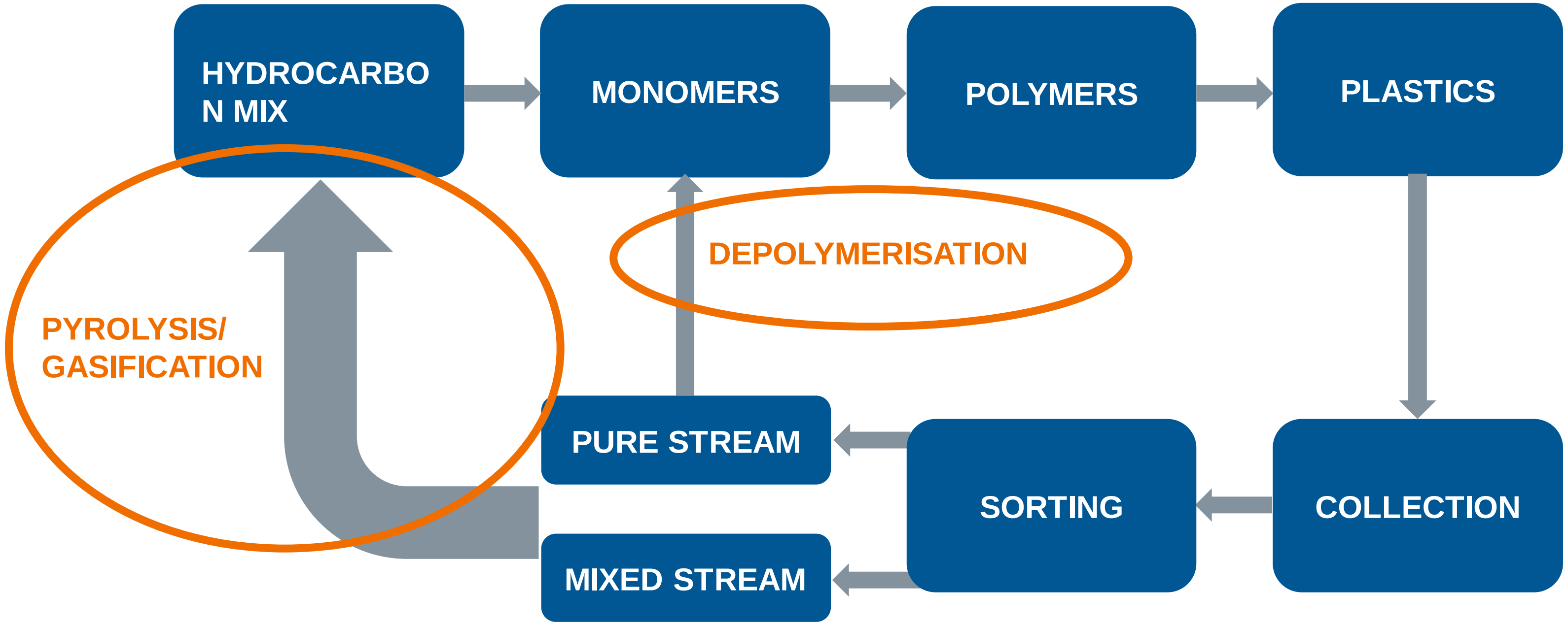


IMAGE SOURCE: VTT

RECYCLING: Heterogeeniset ja kompleksiset raaka-ainevirrat

CHALLENGE

- To find an outlet for plastic waste not suitable for mechanical recycling



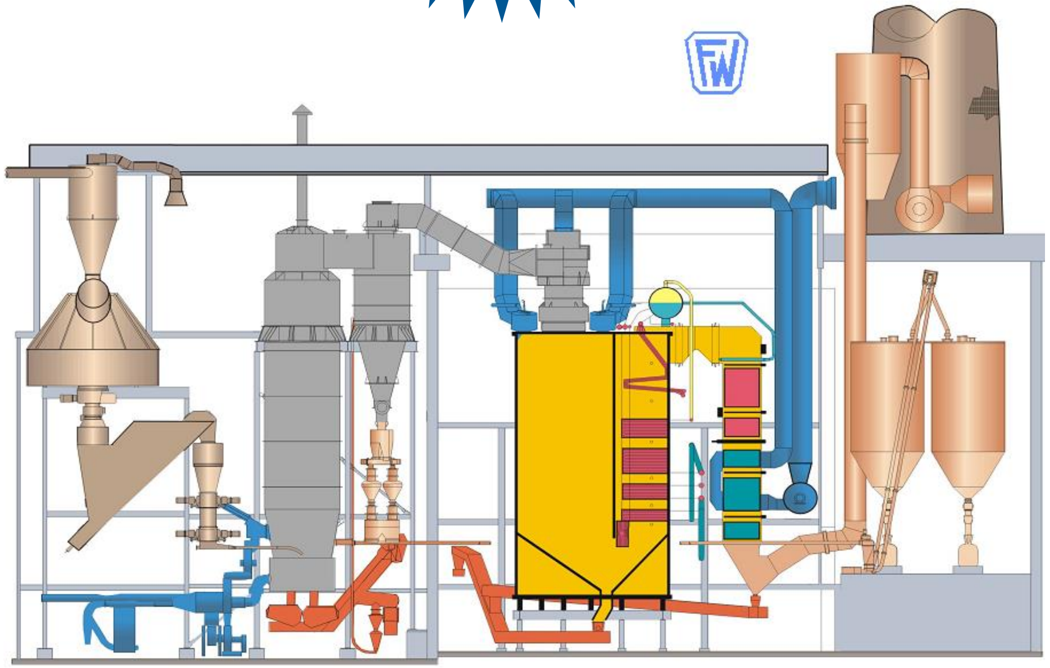
VTT:n ratkaisu: pyrolyysi

- Develop thermo-chemical recycling of plastic waste towards monomers and refinery feedstock

VTT:n ratkaisu: kaasutus

TRL 9

- Gasification enables recycling of mixed plastic waste containing organic or inorganic contaminants
- Syngas (H2, CO) can be used as a feed of Fischer-Tropsch or MeOH synthesis for olefins, chemicals, liquid fuels or energy
- Direct conversion to olefins and other recyclable hydrocarbons is possible



Plastic waste gasification plant (50 MW_{fuel}) at StoraEnso in Varkaus (developed by VTT, constructed by Sumitomo Foster Wheeler).

Raaka-ainevirta: Uusiutuvat raaka-aineet

CHALLENGE

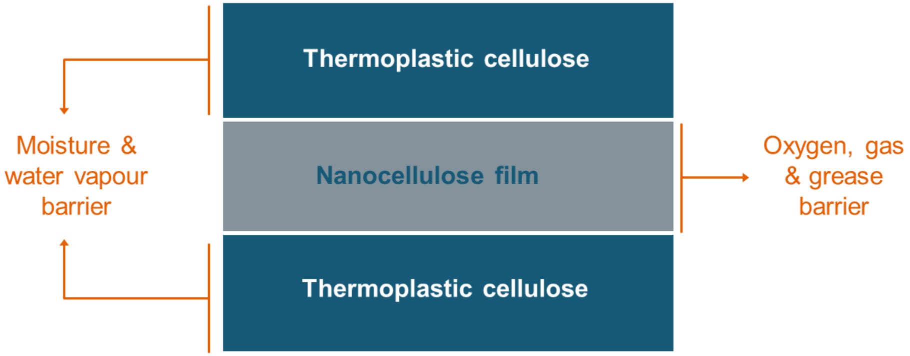
- Create high-performing plastics from biobased feedstock

VTT'S VISION

- Utilising forest and food waste streams as feedstock

Awarded VTT's biobased packaging material solution

3 layer barrier film structure



- **100 % BIOBASED**
- **RECYCLABLE in extrusion**
- **HEAT SEALABLE**
- Accepts **MULTIPLE BIOBASED RAW MATERIALS** – use of local resources that don't compete with food production
- Processable with **EXISTING MACHINERY**

ELLEN MACARTHUR FOUNDATION

WINNER
Circular Materials Challenge 2018
Ellen MacArthur Foundation

SUSTAINABILITY AWARDS 2018

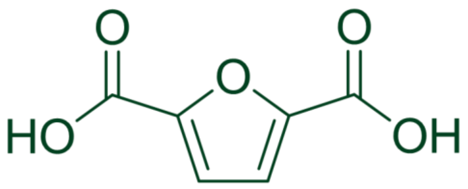
WINNER
Sustainability Awards 2018
Biobased Packaging category Packaging Europe

PI PACKAGING INNOVATIONS 2018

WINNER
Ecopack Challenge 2018
Packaging Innovations in assoc. with Marks&Spencer

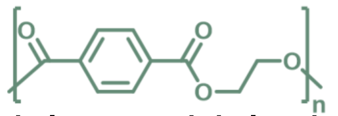
Monomers from food waste to food packaging material based on PEF

- **Targeted applications**
  - Select replacement for fossil-based PET
- PET market volume >60 million tonnes/a
- 40−55 % lower carbon footprint*

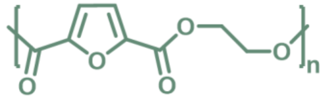


Better barrier properties than PET**

- O_2 BARRIER = **10 times** better
- CO_2 BARRIER = **4 times** better
- H_2O BARRIER = **2 times** better



Polyethylene terephthalate (PET)



Polyethylene furanoate (PEF)

* Energy Environ. Sci., 2012,5, 6407-6422
** Avantium's research

Single-use plastics	Molecular repair Refurbishment	Reusable plastics
Non-recyclable multi-materials	Polymer design	Recyclable mono-materials
Low quality recyclate	Novel material identification and sorting Counteracting feedstock variations and degradation	High quality recyclate
Mechanical recycling rejects	Chemical and thermochemical recycling	Recycled chemical building blocks
Virgin fossil-based plastics	Renewable feedstocks CO_2 from CCU	Plastics made from renewables
Plastics not currently recycled	Polymer development and biodegradability and recyclability assessment	Bio-degradable or recyclable plastics

VTT:n visio muovien kiertotalouden toteuttamiseksi ja globaalien haasteiden ratkaisemiseksi

Current status		VTT's vision
Plastics are beneficial, versatile and affordable materials mostly used in a make-use-dispose economy	• Ecodesign • Circular business models	Establish material circularity while maintaining performance and economic feasibility of plastics
Plastic waste ending up in the environment harms natural and economical ecosystems	• Collection & separation • Reuse • Recycling	Stopping plastics pollution
The plastics value chain is based on virgin fossil feedstock and contributes strongly to climate change	• Bio-based feedstock • Recycled feedstock • Carbon capture and utilization • Renewable energy sources	Stopping the plastics value chain contributing to climate change

Kiitos!

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