Kirsi Immonen, VTT
Dr.

Tulin VTT Rajamäelle 23 vuotta sitten syntetisoimaan uusia biopohjaisia ja sähköä johtavia polymeerejä. Tämänhetkinen toimipisteeni sijaitsee VTT Tampereella tiimissä nimeltä Bioplastics, film, foams and composite applications. Aiemmin olin 10 vuotta Fortumilla/Neste Chemicalsin tutkimuskeskuksessa lähinnä lujitemuovipolyestereihin liittyvissä kehitystehtävissä.

Ydinosaamistani ovat uudet biomuovisovellukset ja kuitulujitteiset komposiittimateriaalit, joissa fokus on lähinnä erilaisissa luonnonkuitulujitteissa ja termoplastisissa materiaaleissa. Materiaalien biopohjaisuus ja kierrätettävyys ovat myös keskeisiä tutkimusalueitani.

Luontoon liittyvät asiat ovat minulle hyvin tärkeitä ja asunkin tällä hetkellä maaseudulla Jyväskylässä.

VALUEBIOMAT

www.valuebiomat.fi

@Valuebiomat

ValueBioMat

LAPIN YLIOPISTO
UNIVERSITY OF LAPLAND

VTT

Luke
LUONNONVARAKESKUS

Aalto University

Exploring drivers and barriers in circularity of biocomposites – Valuebiomat-project

Kirsi Immonen, Katri Valkokari / VTT
Esko Hakanen, Jan Holmström / Aalto

Lujitemuovipäivät, Pietarsaari 6.-7.11.2024

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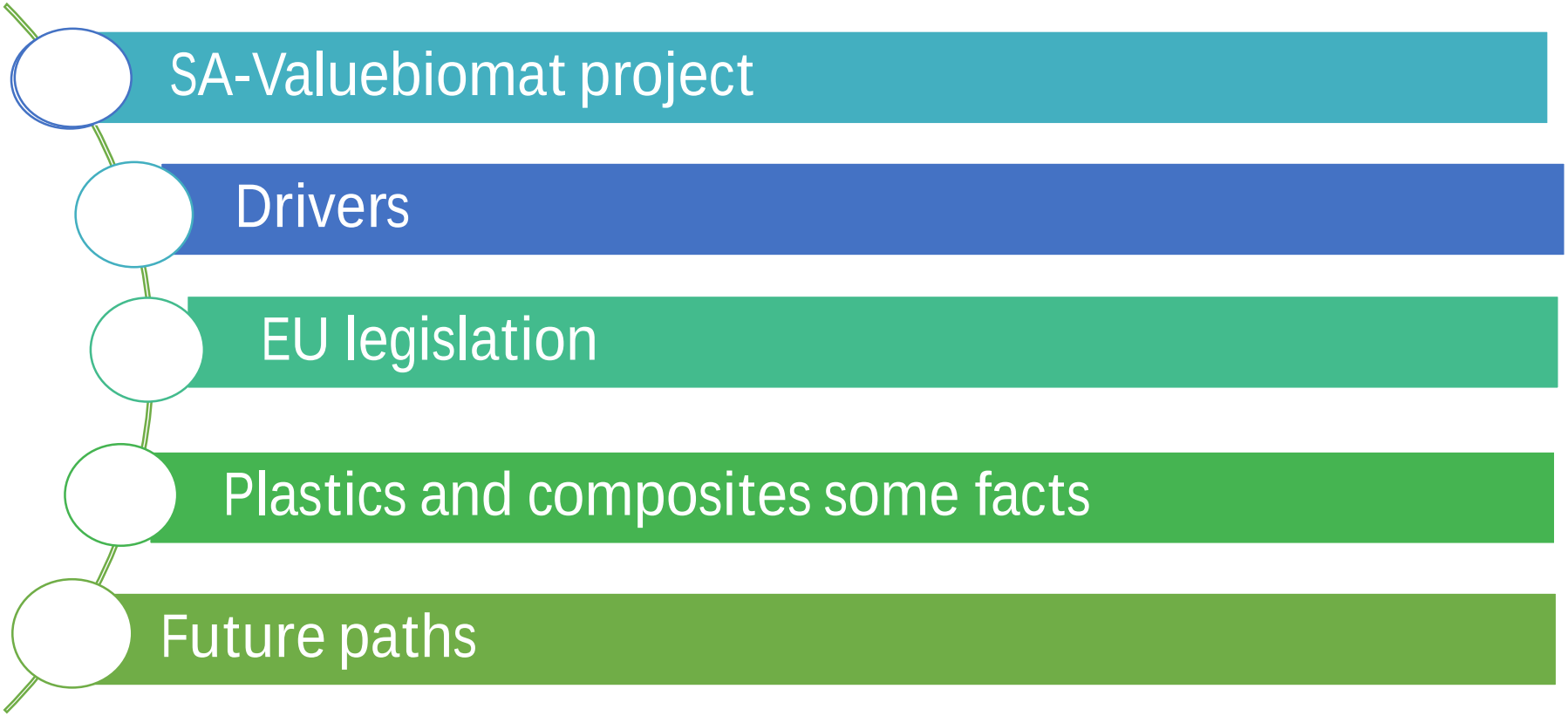
Content of presentation



VALUEBIOMAT 2019-2025

WP 1: Bio-based and CO_2 capturing polymers for AM (Jukka Seppälä)

WP 2: Optimized Digital Design and Production (Jouni Partanen)

WP 3: Business models for new bio-based products and services (Jan Holmström)

WP4: Environmental and societal impact assessment (Hannu Ilvesniemi)

WP 5: Fostering Resource Wisdom through Legislative and Policy Actions (Rosa Ballardini)

WP 6: Interaction and societal embedding (Peter Ylén)

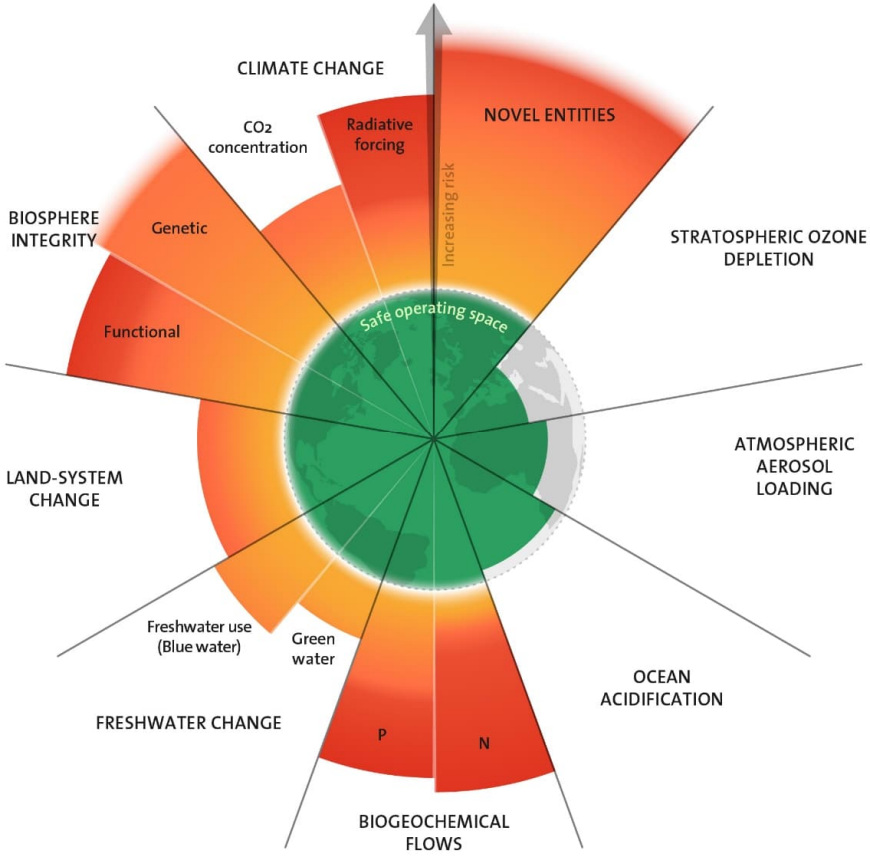
- Project goal: ”Fostering transition towards sustainable plastics value chains”
- Scenario process & group modelling for integrating the disciplinary perspectives of different research groups
- Academy of Finland funded project that part is of the Innovative Materials and Services to Promote Resource Wisdom and Sustainable Development (IMPRES) programme.

Planetary boundaries / Planeettamme rajat

- Plastics and composites made of fossil-based raw-materials have effect on:
- Novel entities through chemical pollution
- Climate change
  - Plastics were in charge of 4 % of climate change in 2015 and estimated to correspond 15 % in 2050.[1]
- UN Climate Change Conference COP28 in Dubai 2023 -> Strong recommendation to phase out fossil fuels[2]

- Bioplastics and biocomposites help to reduce above mentioned changes, but can have negative impact on Land-system change and Freshwater use

-> CIRCULAR ECONOMY IS NEEDED FOR ALL PLASTIC MATERIALS



1) www.plastics.org;
2) 2) https://valtioneuvosto.fi/en/-/1410903/dubai-climate-conference-reaches-agreement-on-phasing-out-fossil-fuels

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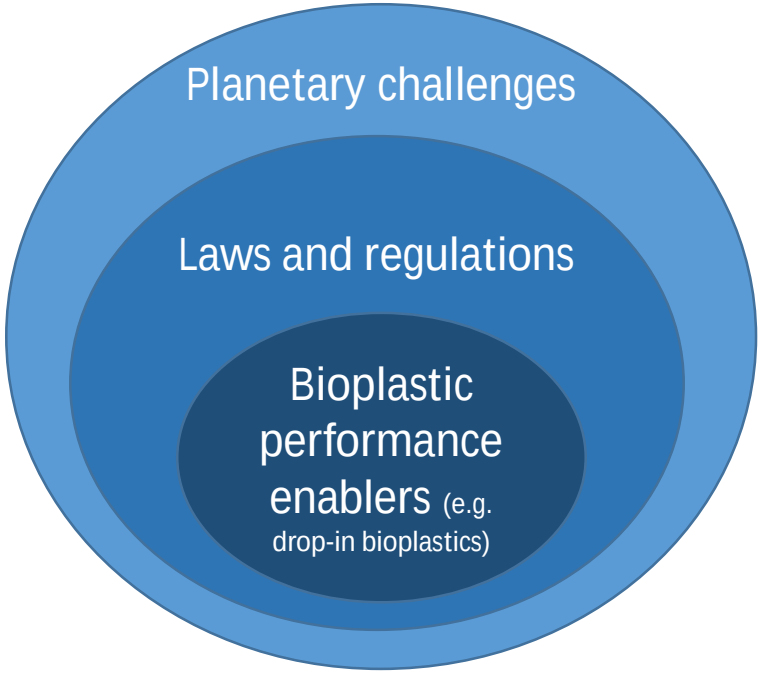
Drivers and Barriers of Biocomposite and Bioplastic Circularity

DRIVERS



BARRIERS

Logistic challenges	Societal challenges
Volumes	Technical challenges

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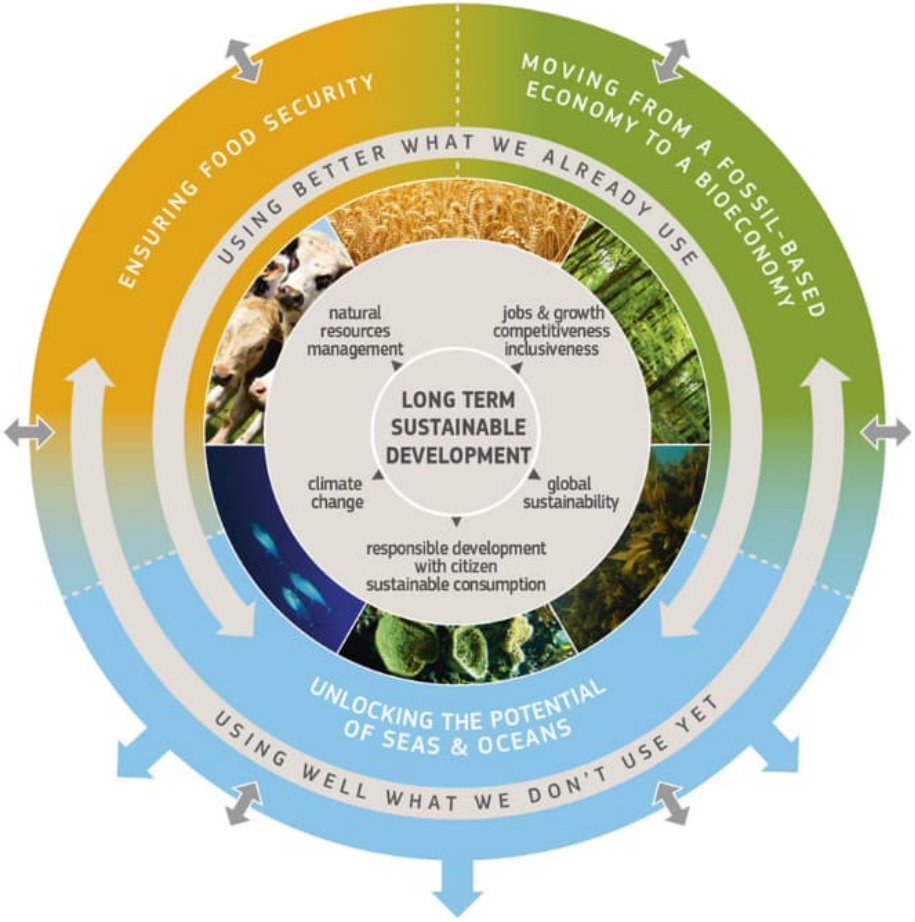
The New European Bioeconomy Strategy



The 2018 update of the Bioeconomy strategy aims to acc elerate the deployment of a sustainable European bioeconomy so as to maximise its contribution towards the UN 2030 Agenda and its Sustainable Development Goals (SDGs), as well as the Paris Agreement

• 5 aim objectives:

•Ensure food and nutrition security

•Sustainably manage natural resources

•reduce dependence on non-renewable, un-sustainable resources, whether sourced domestically or abroad

•strengthen European competitiveness and create jobs

The updated version has three new main action areas:

•Strengthening and scaling-up the bio-based sectors, unlocking investments and markets

•Rapidly deploying local bioeconomies across Europe… **Bio-based innovations like the development of new chemicals, products and processes for bio-based markets; New opportunities arising for the forestry sector in view of replacing non sustainable raw materials in e.g. construction and packaging**

•Understanding the ecological boundaries of the bioeconomy

https://www.switchtogreen.eu/a-sustainable-bioeconomy-for-europe-strengthening-the-connection-between-economy-society-and-the-environment/

EU Plastic Strategy

The Commission adopted the Plastics Strategy in January 2018, which set out its vision for a circular plastics economy, made commitments for action at EU level and recommended measures to national authorities and industry. EU Plastic Strategy is part of the EU Circular Economy Action Plan (CEAP). The Plastics Strategy includes the goal of making recycling profitable for business. It also aims to transform the way plastic products are designed, produced, used and recycled in the EU.[1]

A summary of the main actions being taken are the following[2]

- Design-oriented
  - to harmonize rules to ensure that by 2030 all plastic packaging placed on EU market can be reused or recycled in a cost-effective manner.
  - to improve the traceability and address the issue of legacy substances in recycled streams and consider requirements to support the recyclability of plastics.
  - Plastic products should be made considering their entire life span
- Boost recycled content
  - To further incentivise the use of recycled plastics, including by developing adequate verification means.
  - To develop quality standards for sorted plastics waste and recycled plastics in cooperation with the European Standardisation Committee.
- Reduce single-use plastic
  - To do the analytical work necessary to determine the scope of a legislation initiative on single-use plastic.
  - Start a process to restrict the use of oxo-plastics via REACH.
- Promote innovation and investment
  - To support the development of smarter and more recyclable plastic materials, to make recycling processes more efficient, and to trace and remove hazardous substances and contaminants from recycled plastics.

1) European Commission. Plastics strategy. Accessed November 9, 2023. https://environment.ec.europa.eu/strategy/plastics-strategy_en
https://cms.law/en/int/expert-guides/plastics-and-packaging-laws/european-union
2) https://circabc.europa.eu/ui/group/2203ac52-e11f-4a4f-82d6-a3a72eda77aa/library/915ed7a7-557e-43d1-aa5e-b050138a1de4/details?download=true

EU Policy and legislation

Classification		Most relevant EU policies impacting plastic system	Demand		Supply		
			Reduce	Reuse	Substitute[2]	Recycle	Renewable carbon feed
Policies in legislative process[1]	Policies are enacted and are legally binding	Single Use Plastic Directive[a]	■		■	■	
		Plastic Packaging Waste Levy[b]				■	
		Batteries Regulation[c]		■		■	
	Policies or part thereof are subject to revision/adaptation/ approval and are not legally binding yet	Packaging & Packaging Waste Regulation[f]	■	■	■	■	New article 8
		Waste Framework Directive[d]	■	■		■	
		End-of-life Vehicles Regulation[e]		■		■	
		Ship Recycling Regulation[k]				■	
		WEEE Directive[l]		■		■	
		Eco-design for sustainable products Directive[g]		■		■	
Strategies, communications	Positioning & guideline documents NOT legally binding	EU Strategy for Sustainable&Circular Textiles[h]		■		■	
		Sustainable Carbon Cycles Communication[i]				■	■
		Framework biobased, biodegradable & compostable Plastic Communication[j]					■

(1) Includes enacted, proposal, revisions and drafts (2) no formal mandate but include mentions and guidelines for substitution
Systemiq analysis based on (a) Directive (EU) 2019/904 of the European Parliament and of the Council of 5 June 2019 on the reduction of the impact of certain plastic products on the environment; (b) Council Decision (EU, Euratom) 2020/2053 of 14 December 2020 on the system of own resources of the European Union and repealing Decision 2014/335/EU; (c) https://environment.ec.europa.eu/topics/waste-and-recycling/batteries_en; (d) Directive 2008/98/EC of the European Parliament and of the Council of 19 November 2008 on waste; (e) Directive 2000/53/EC of the European Parliament and of the Council of 18 September 2000 on end-of life vehicles; (f) EC (2022), Proposal for a Regulation on packaging and packaging waste; (g) EC (2022) Proposal and Annexesfor a Regulation establishing a framework for setting ecodesign requirements for sustainable products and repealing Directive 2009/125/EC (h) EC (2022), Communication -EU Strategy for Sustainable and Circular Textiles (i) (EC (2021), Communication From The Commission To The European Parliament And The Council (j) EC (2022), Communication –EU policy framework on biobased, biodegradable and compostable plastics; k) https://environment.ec.europa.eu/topics/waste-and-recycling/ships_en; l) https://eur-lex.europa.eu/eli/dir/2024/884/oj

Reproduced from: Ohs, B., Herrmann, S., Carbon Stewarship: A new guiding principles for the chemical industry – Neste and SystemIQ joint presentation in Bioplastics 2023 Conference, Berlin 12.12.2023 and updated November 2024 by KI

EU-legislation – some selected points

- Communication on Sustainable Carbon Cycles (published Dec. 2021 COM(2021)800)
- States industrial sustainable carbon challenges and aspirational objectives that will be discussed between the Commission and stakeholders
  - By 2028, any ton of CO_2 captured, transported, used and stored by industries should be reported and accounted for its fossil, biogenic or atmospheric origin.
  - At least 20% of the carbon used in chemical and plastic products should be from sustainable non-fossil sources by 2030, considering EU's upcoming policies.
  - 5Mt of CO_2 should be annually removed from the atmosphere and permanently sorted through frontrunner projects by 2030.
- In addition, there is an incentive for capturing and utilizing emissions to become permanently chemically bound in a product so that they do not enter the atmosphere while in use.

- https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A52021DC0800

EU-legislation – some selected points

- Communication on Biobased, Biodegradable and Compostable Plastics (Published November 2022, COM(2022)682)

- To promote the transition to a circular plastics economy, a clear policy framework is needed on the use of biobased, biodegradable and compostable plastics. This will foster greater consistency in developing European policies, increase environmental protection, reduce consumer confusion, enhance investment certainty within the internal market, and encourage competitiveness and innovation.
- Communication is not legally binding, buy more like guideline for following points:

1) Biobased content

- There is no mandatory minimum of biobased content, biobased plastic product to be labelled as biobased. The European Technical Committee for Standarization for biobased products (CEN/TC411) set voluntary standards ideal to ensure a consistent approach. 'Biobased' or 'bioplastics' claims should only refer to the exact measurable share of biobased plastic content in the product to avoid greenwashing.

2) Feedstock sustainability

- Producers should prioritise the use of organic waste and by-products as feedstock.
- When primary biomass is used, it should be ensured that it is environmentally sustainable and does not harm biodiversity or the ecosystem health e.g. by using LCA. Biomass must meet the EU sustainability criteria for bioenergy (Renewable Energy Directive, REDIII).´Biomass should be prioritised for producing materials, and later as a source of bioenergy.
- The priority should be given to long-lived products over short-lived and single-use ones.

3) Biodegradable plastics

- Biodegradable plastics should be limited to specific applications for which reduction, reuse or recycling are not feasible. The use in open environment must be limited. Also, additives they contain must be biodegradable.
- Plastic labeled as 'biodegradable' must specify in which environments they are biodegradable and the timeframe.
- SUP plastics and litter-prone products should not have claims regarding their biodegradation.

4) Industrially compostable plastics

- Industrially compostable plastics should only be used for specific applications, such as when the environmental benefits are higher than their alternatives and when they do not have a negative impact on the quality of the compost. Only certified industrially compostable plastics should be qualified as compostable.
- Industrially compostable packaging should display, using a pictogram showing the way they should be disposed, and they should be certified according to appropriate standard.

https://environment.ec.europa.eu/publications/communication-eu-policy-framework-biobased-biodegradable-and-compostable-plastics_en

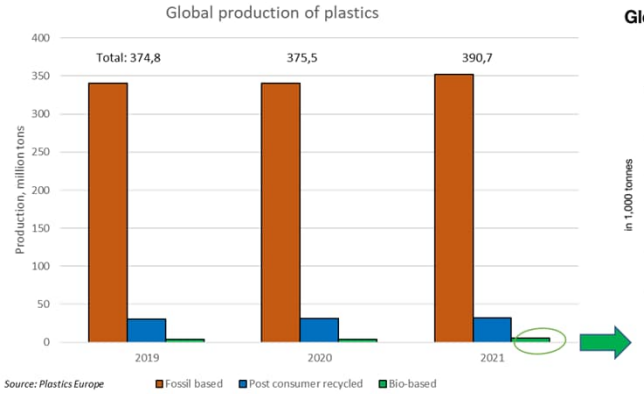
Future paths - SYSTEMIQ (2022) ReShaping Plastics – Pathways to Circular, Climate Neutral Plastic System in Europe (https://plasticseurope.org/changingplasticsforgood/

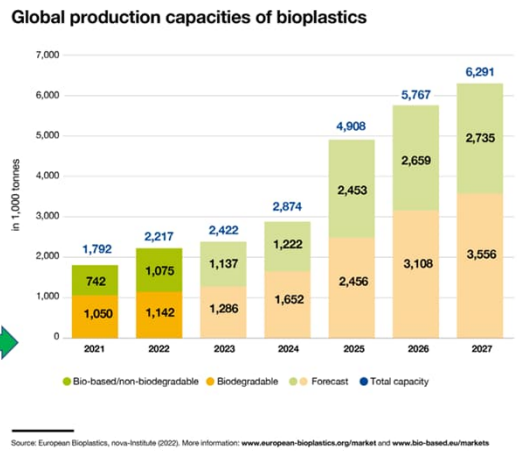
Scenario	Circularity, %	GHG Emission, $MtCO_2e$	Virgin fossil plastic use, Mt	Actions related to circular economy of plastic materials (selected from a bigger group of actions)
Base Case (current system, no change)	14	112	44	
Current Actions Scenario	33	92	37	The existing regulations (2021) are in force and executed
Reduction & Substitution Scenario	52	68	29	Cost reductions and performance improvements for compostable and other bioplastics
Recycling Scenario	69	41	24	All plastic packages are designed to be recyclable Demands for recycled material content in plastic products
Circularity Scenario	78	33	20	All previous scenarios are in use Focus on consumer education and engagement
Retrofit System Change Scenario	78	25	20	Cost effective H, CCS and CH4 to olefins technologies in use Chemical recycling of plastics in wider use.
Net-Zero System Change Scenario	78	0	11	Cost effective Carbon utilization technology in use. GHG reduction applied with plastic chemical recycling. ¼ of plastic raw materials in line with sustainable development (bio-based or captured carbon and hydrogen)

In NET ZERO SYSTEM CHANGE SCENARIO by 2050 Change the feedstock carbon source ->
to provide 1/4 (25%) of feedstock via sustainable bio-based materials or captured carbon (CCU) and hydrogen (CH4 and H to X)

https://plasticseurope.org/wp-content/uploads/2022/04/SYSTEMIQ-ReShapingPlastics-April2022.pdf

Facts about plastics





Plastics – mainly side-streams from fossil fuel production

- ❑ Produced about 8,3 billion tons since 1950's.[1,2]
- ❑ Current yearly production is about 400 million **tons**.[1,2,3]
- ❑ Yearly production is estimated to double by 2040.[4]
- ❑ Plastics were in charge of 4 % of climate change in 2015 and estimated to correspond 15 % in 2050.[4]
- ❑ Globally of all plastics ever made is circulated 9%, burned 12% and rest 79% are in landfills, nature or in use.[1]

- ❑ It is estimated than in only Europe will be generated 683000 t of composite waste in 2025[5]
- ❑ Global annual fibre reinforced composite (FRC) recycling capacity is <100000 t.[6]

- ❑ Current bioplastic production is <1% of all plastics.[7]

-> all plastic products need to be recycled!

1) Geyer, Jambeck, Law Sci. Adv. 2017;3: e1700782; 2) Rosenboom, Nature Reviews 2022, 7: https://doi.org/10.1038/ds41578-021-00407-8 ; 3) ww.iso.org ; 4) www.plastics.org ; 5) https://etipwind.eu/files/reports/ETIPWind-How-wind-is-going-circular-blade-recycling.pdf ; 6) https://www.resrecov.com/article_698007_ce9395831405b39a1c0fa8df01ed3c4c.pdf; 7) www.bioplastics.org

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European composite market

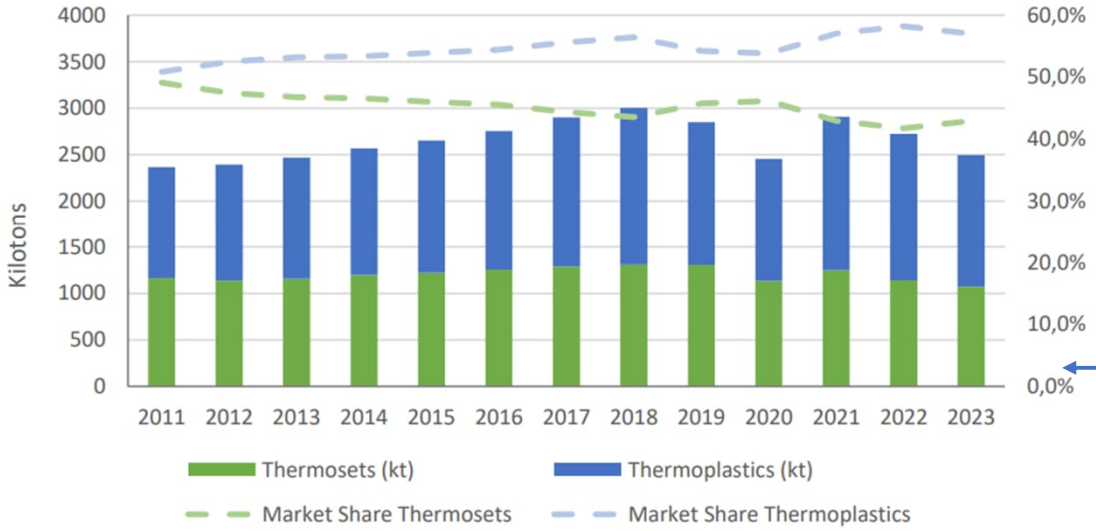


Figure 4: The European composites market by material system (in % and kilotons; excluding CRP)

AVK estimation for natural fibre reinforced plastics (NRP) market in Europe (2022) was about 90 kt (3,7%)
The main reinforcements being:

- Wood
- Flax
- Kenaf
- Hemp
- Recycled cotton and coir

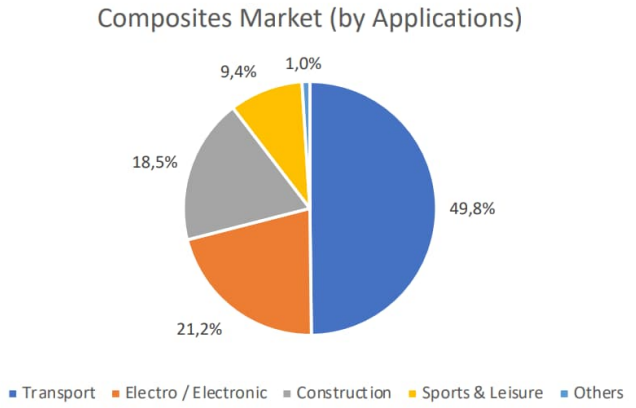


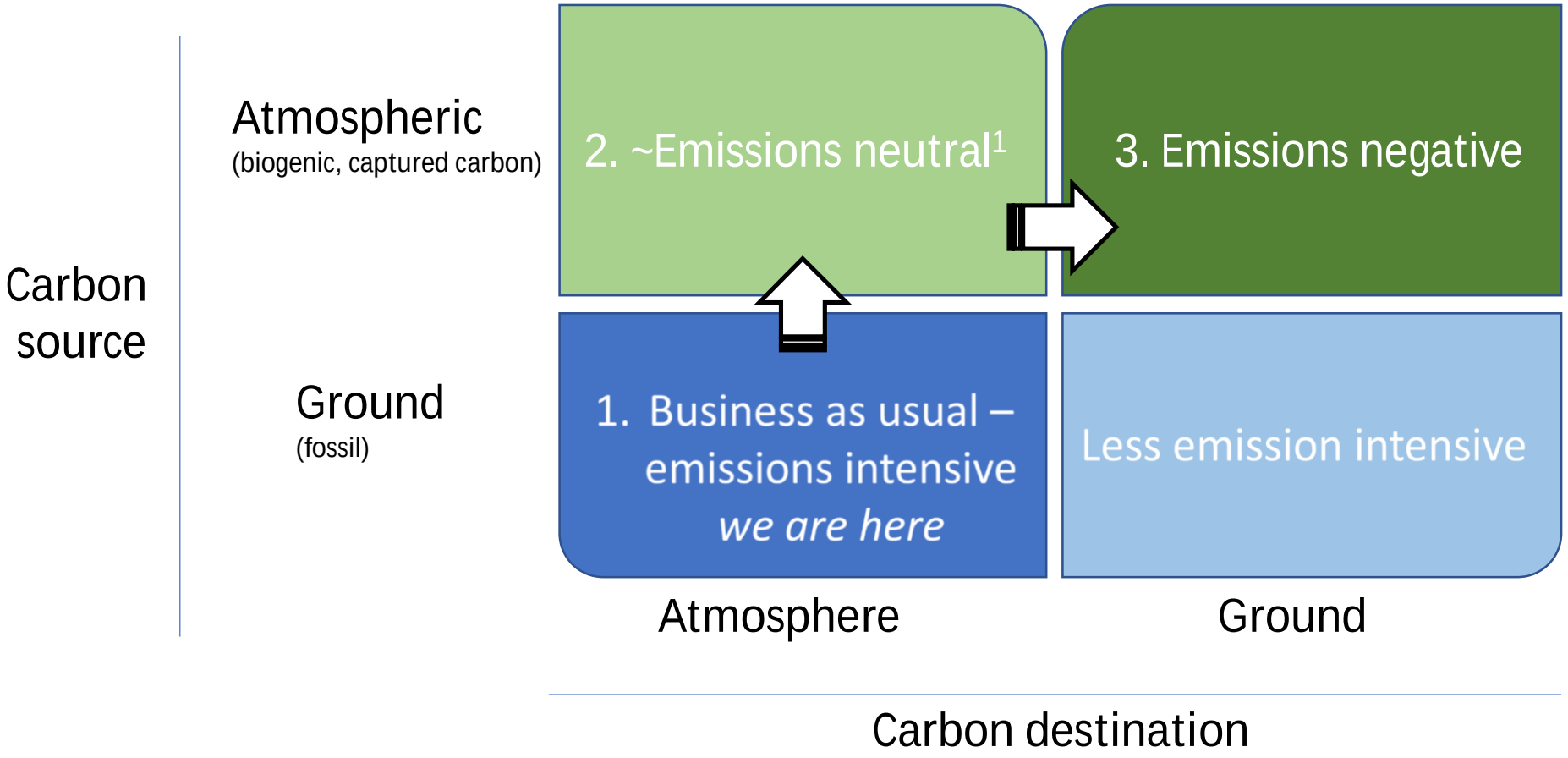
Figure 3: Total composites market by application area 2023 (in %; without CRP)

Challenges:
Increase bio-based plastics and biocomposites production volumes
Increase the amounts of recycled bioplastics and biocomposites

https://eucia.eu/wp-content/uploads/2024/05/avk_marketreport_2024_final_eng.pdf

https://www.trade.gov/sites/default/files/2024-06/2024%20Europe%20Composites%20Market%20Brief%20%281%29.pdf

The pathway towards negative emissions



Source: Adapted from Systemiq, (2022), Planet Positive Chemicals
Notes: (1) In a best-case scenario, with no associated biomass sourcing emissions and fully electrified transport and processing.
(2) Still may result in some emissions due to upstream fossil production but signicantly reduced due to end of lifesequestration.
(3) Neutrality in the context of CCS technologies should be read as 'quasi-neutral' as residual emissions will occur
Reproduced from: Ohs, B., Herrmann, S., Carbon Stewarship: A new quiding principles for the chemical industry – Neste and SystemIQ joint presentation in Bioplastics 2023 Conference, Berlin 12.12.2023

Valuebiomat – Solution Card

- Summary of the VBM project's work
- Introduces a "model of carbon-logistics" intended to capture the input/output balance of carbon at a systemic level
- A simple but powerful tool for classifying solutions that either slow down or expedite climate change

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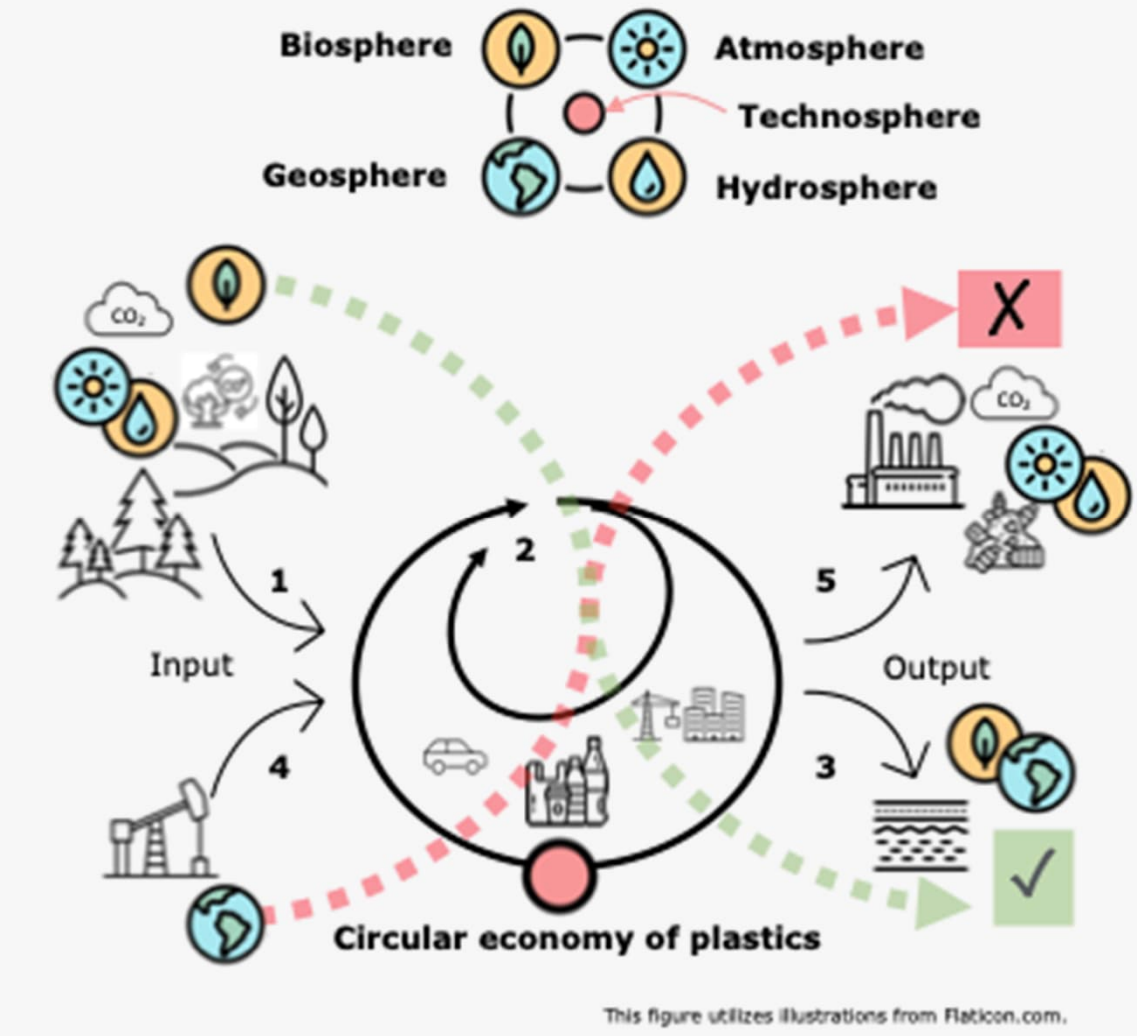
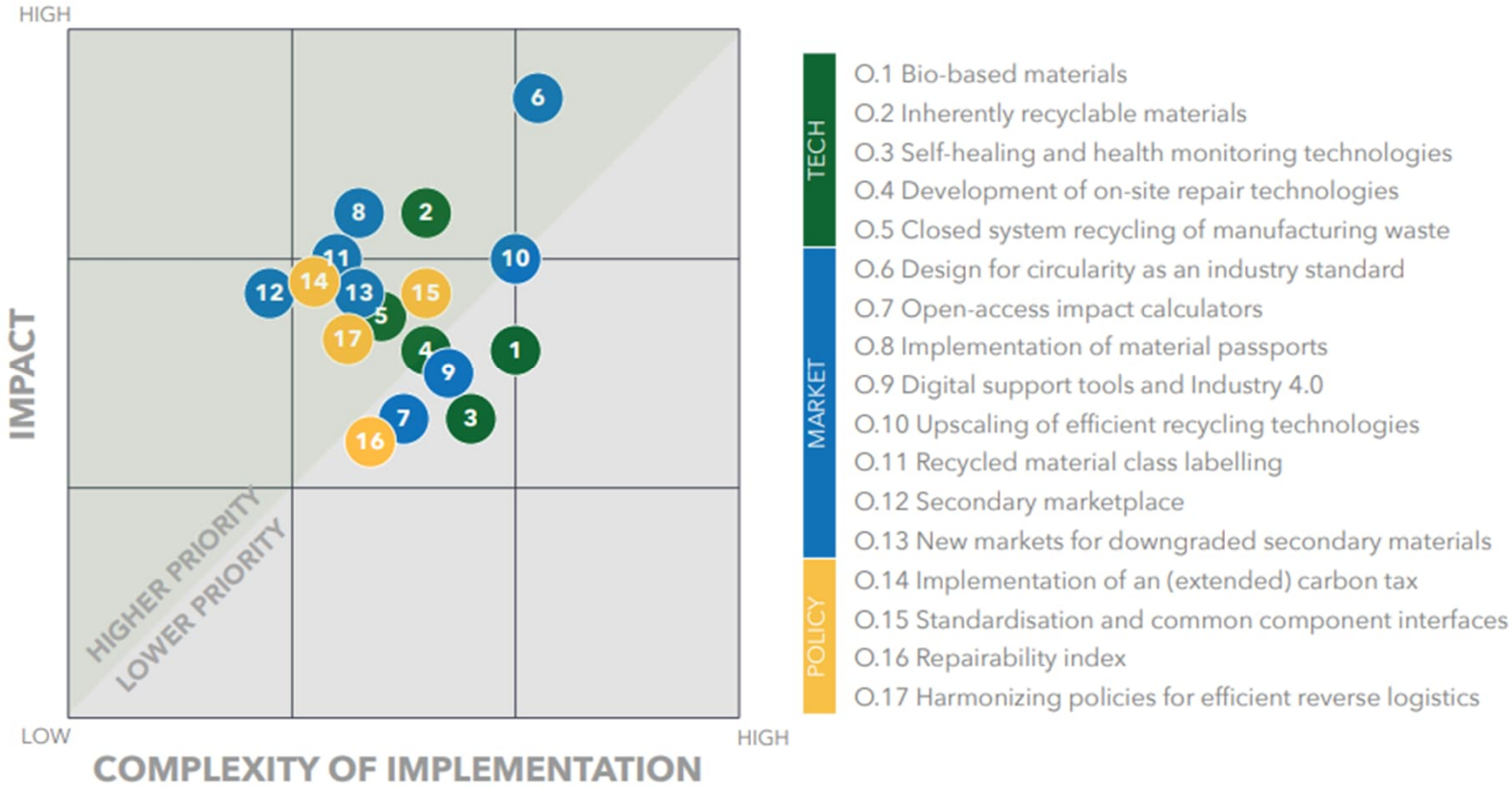


ValueBioMat – Model of carbon-logistics

- Combines the input and output at a system level
- Resembles "conventional" logistics from an operations management perspective: *sourcing*, *storage*, *transportation*, *handling*, *reuse* of items
- A simple metric for the item's impact: +/-

Future Opportunities in Recycling of Composite Materials

Prioritisation of opportunities according to impact and complexity.



Arussi et al., CSR Europe report: Composite Materials – A Hidden Opportunity for the Circular Economy

CSR Europe is European business network for Corporate Sustainability and Responsibility
About CSR Europe — CSR Europe

The New Materials and Circular Economy Accelerator believes that the current transformative efforts in the composites landscape present an opportunity to explore the set-up of a European Alliance for the Circularity of Composite Materials.
https://static1.squarespace.com/static/5df776f6866c14507f2df68a/t/6345491c24311c125f6b6def/1665485099232/CSR+Europe_Composite+Materials+FINAL.pdf

Conclusions

- Plastic composites are an essential part of our daily life enabling:
  - Long life-time, light-weight and durable product solutions for transportation (ships, boats, vehicles, aircrafts, aerospace), solar panels, windmills and construction
  - Light-weight protective casings for various electronic items
  - Indispensable in various applications for health care and sport equipment
- Thermoplastic composites are recyclable at least in theory
- Thermoset composite structures meet still challenges in recycling. Main current recycling methods being:
  - to cementitious (cement kiln) products
  - Pyrolysis, fluidized bed, microwave recycling to recover glass or carbon fibre
  - Chemical recycling -> recovery of glass fibres
  - Mechanical milling -> fillers for different purposes
- Can be combusted, but -> CO_2 challenge
- Solutions for CO_2-exhaust in systemic level exists, but they need to be implemented (e.g. carbon capture)
- Is it possible to make Plastic Industry as part of the solution - carbon sink – using carbon positive technologies?

EuCIA's European Composites Recycling Solutions database contains currently 44 Actors in Europe, 2 in Finland (Kuusakoski and Finnsementti) -> Room for new actors!

KIITOS
Thank you

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