

**Session: 10th November 2020
Sustainable Chemistry in Society (Economy and Education)**

Chemistry, sustainability and textiles in a post-trash society

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Chemists for Sustainability



IOCD

**International Organization for
Chemical Sciences in Development**

**Imperial College
London**

Institute of Global Health Innovation

**Robert Bosch Research Group
Processes of Sustainability Transformation**

**Institute of Sustainable and
Environmental Chemistry (ISEC)**



LEUPHANA
UNIVERSITY LÜNEBURG

“The away myth”
There is no such thing as ‘away’. When we throw anything away *it must go somewhere.*

Leonard & Conrad. The Story of Stuff, 2010
<https://epdf.pub/the-story-of-stuff.html>

Waste does not exist: there is only post-trash.

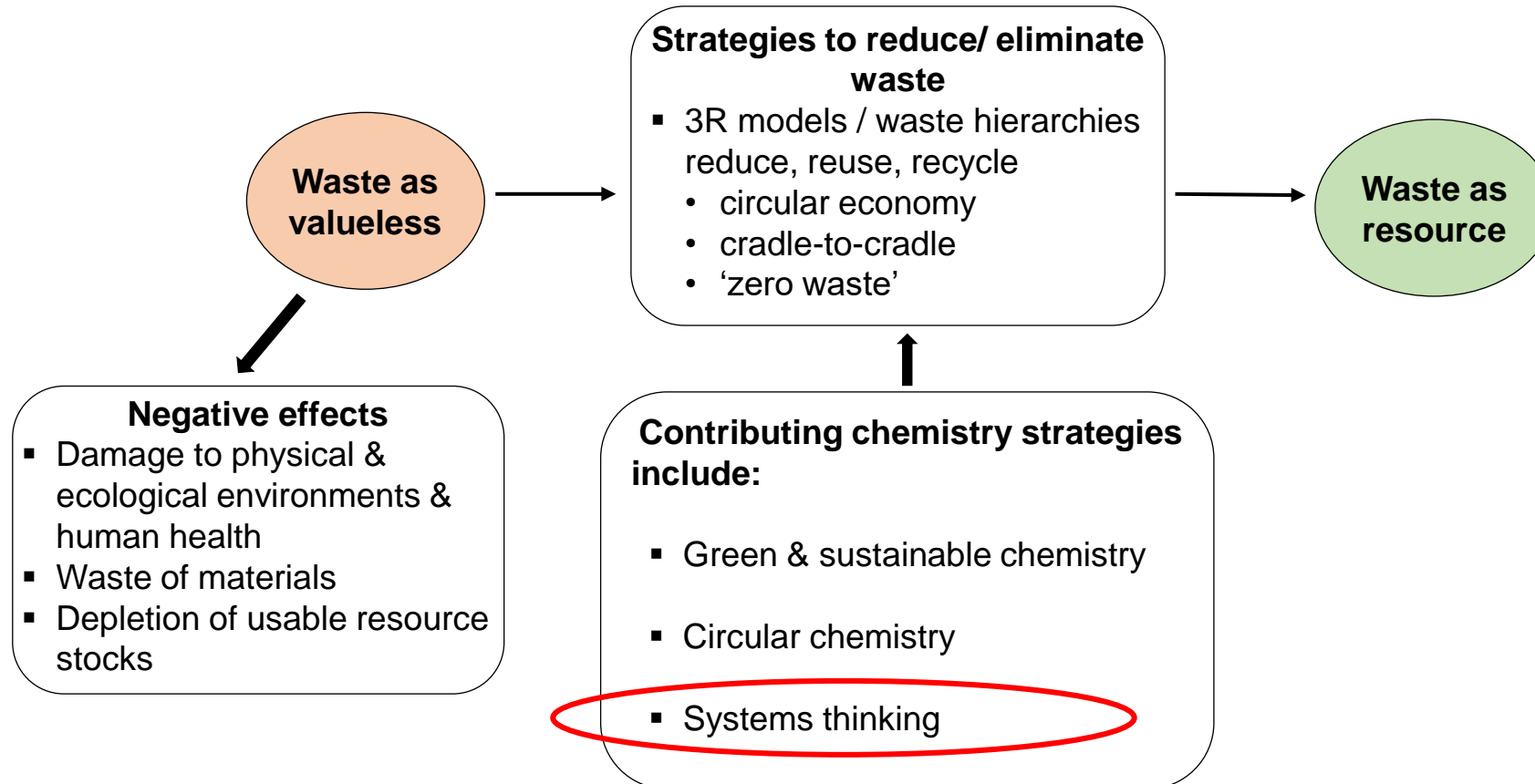
Hopf et al. SciDev.Net, 22 April 2019

<https://www.scidev.net/global/environment/opinion/waste-does-not-exist-there-is-only-post-trash.html>

Ending the time of waste: Clean up, catch up, smarten up.

Matlin et al. Angle Journal, 1 November 2019

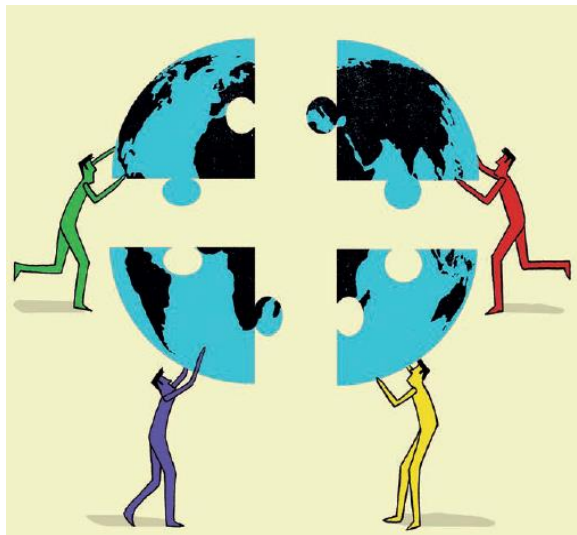
<http://anglejournal.com/article/2019-11-ending-the-time-of-waste-clean-up-catch-up-smarten-up/>



The chemical sciences have been central to global progress and **will be essential to meeting oncoming global challenges** – especially sustainable development – **with ‘one-world’ chemistry**

Matlin, Mehta, Hopf, Krief. ‘One-world’ chemistry and systems thinking. *Nature Chemistry* 2016, 8, 393-6
<https://doi.org/10.1038/nchem.2498>

‘One-world’ chemistry



www.iocd.org/OWC/intro.shtml



Chemists for Sustainability

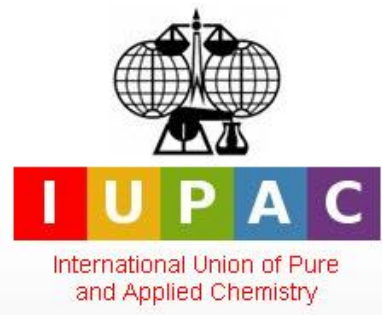
Requires:

- Cross-disciplinary approaches
- Systems thinking (ST) – “*one of five key competencies for a sustainable future*”

Wiek, Withycombe, Redman. *Sustain Sci* 2011, 6, 203–218
<https://doi.org/10.1007/s11625-011-0132-6>

- **ability to understand and interpret complex systems**
 - interconnections
 - dynamic behaviour
 - **systems-level properties emerge** from interactions between the system’s parts – the whole is greater than the sum of the parts
- **Sustainability emerges as a system property and is not merely a property of individual elements of systems**

Ceschin & Gaziulusoy. *Design Studies* 2016, 47, 118-163
<https://doi.org/10.1016/j.destud.2016.09.002>



Infusing **S**ystems **T**hinking into (Post)-Secondary General **C**hemistry **E**ducation **STICE**

Supported by



IUPAC Project # 2017-010-1-050

Co-chairs: Peter Mahaffy, Stephen Matlin

STICE outputs

- **Journal of Chemical Education 2019, vol 96: Special Themed Issue**
Reimagining Chemistry Education: Systems Thinking and Green and Sustainable Chemistry

<https://pubs.acs.org/toc/jceda8/96/12>

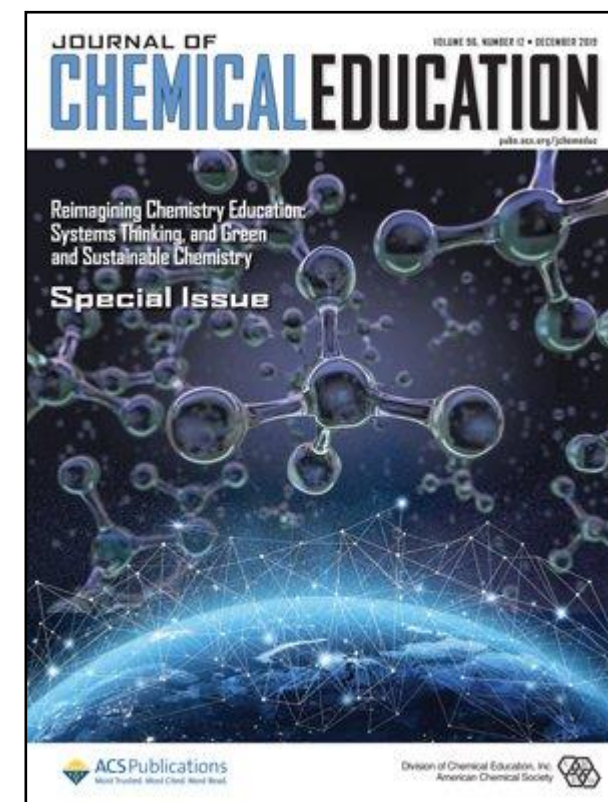
- **Development of a new visualization tool** to assist in teaching, learning and practicing ST in chemistry
Systems-Oriented Concept Map Extension *SOCME*

Mahaffy, Matlin, Holme, MacKellar. *Nature Sustainability* 2019, 2, 362-370

<https://rdcu.be/bBCMs>

Aubrecht, Dori, Holme, Lavi, Matlin, Orgill, Skaza-Acosta. *J Chem Educ* 2019, 96, 2888-2900

<https://pubs.acs.org/doi/10.1021/acs.jchemed.9b00314>



Material Circularity and the Role of the Chemical Sciences as an Enabler of a Sustainable Post-Trash Age

Stephen A. Matlin, Goverdhan Mehta, Henning Hopf, Alain Krief, Lisa Keßler, Klaus Kümmerer
Sustainable Chemistry and Pharmacy 2020, 17, 100312, <https://doi.org/10.1016/j.scp.2020.100312>

Case studies

1. Aluminium

- One of the most extensively recycled manufactured materials in the world: c. **75%** of all aluminium ever produced is currently in use

2. Plastics

- Complex materials: synthetic polymers, often with additives
- Only c. **12%** of plastic manufactured are recycled

3. Textiles

- Very complex materials: combination of natural fibres and synthetic polymers, often with many additives
- Account for 10% of global carbon emissions
- **Low levels** of recycling: most ends up in landfill

PLASTICS

Systems
Oriented
Concept
Map
Extension

SOCME

Nature Sustainability

2019, 2, 362-370

J Chemical Education

2019, 96, 2888-2900

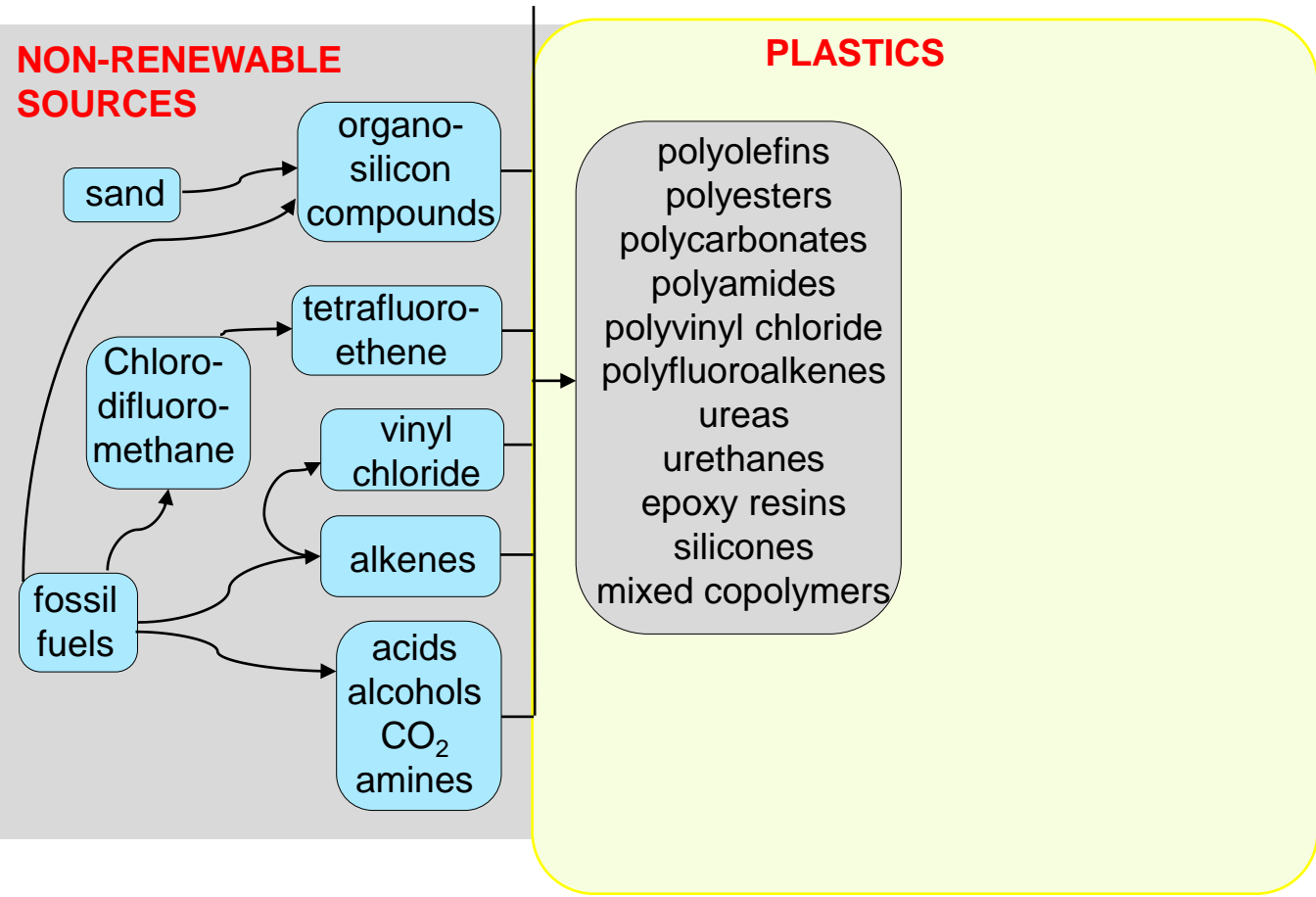
Sustainable Chemistry and Pharmacy

2020, 17, 100312

PLASTICS

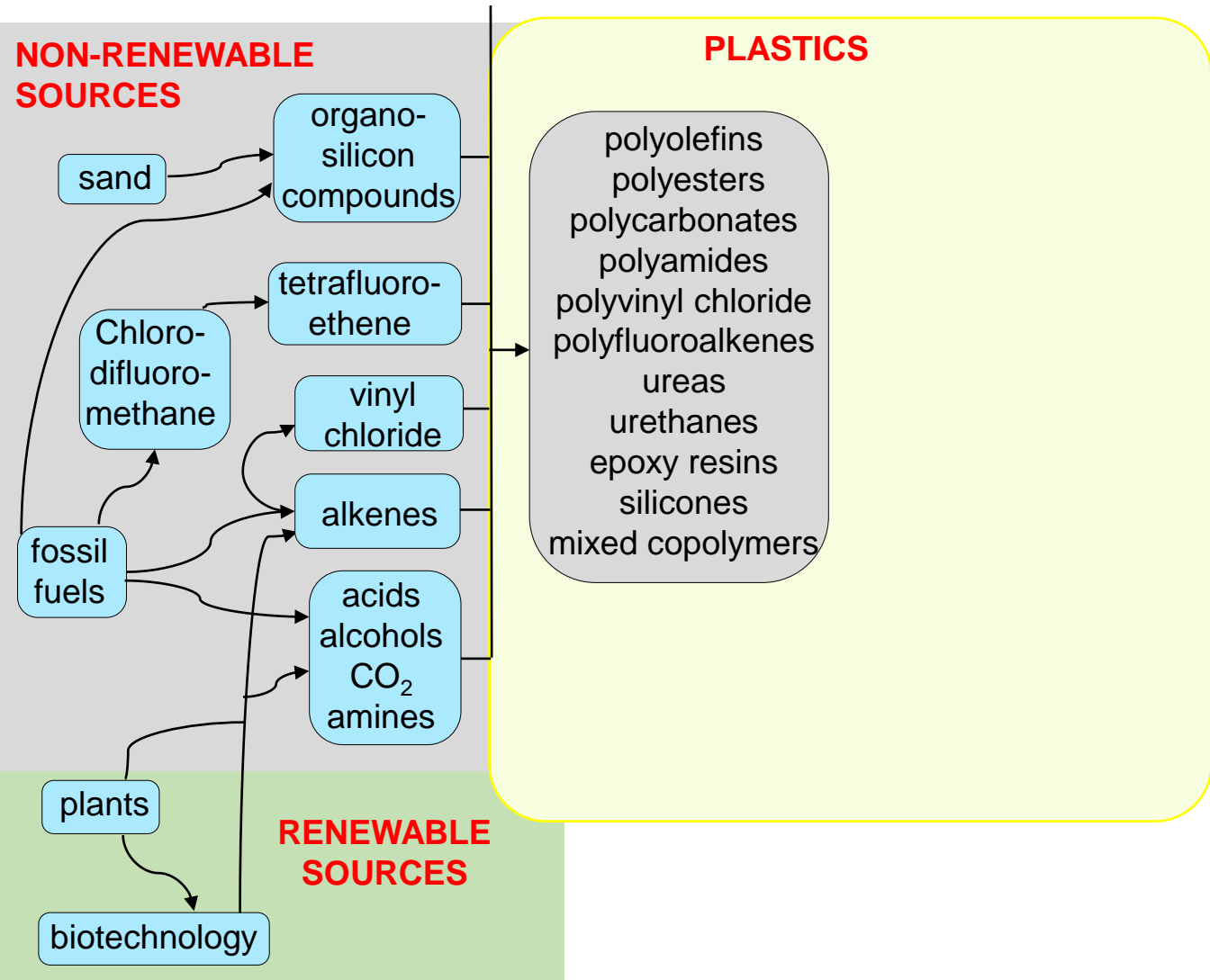
polyolefins
polyesters
polycarbonates
polyamides
polyvinyl chloride
polyfluoroalkenes
ureas
urethanes
epoxy resins
silicones
mixed copolymers

NON-RENEWABLE SOURCES



PLASTICS

- polyolefins
- polyesters
- polycarbonates
- polyamides
- polyvinyl chloride
- polyfluoroalkenes
- ureas
- urethanes
- epoxy resins
- silicones
- mixed copolymers



ENERGY INPUT SYSTEM

renewable energy

fossil fuels

heat & electricity

for processes

NON-RENEWABLE SOURCES

sand

organo-silicon compounds

Chloro-difluoro-methane

tetrafluoro-ethene

vinyl chloride

alkenes

acids
alcohols
CO₂
amines

fossil fuels

plants

RENEWABLE SOURCES

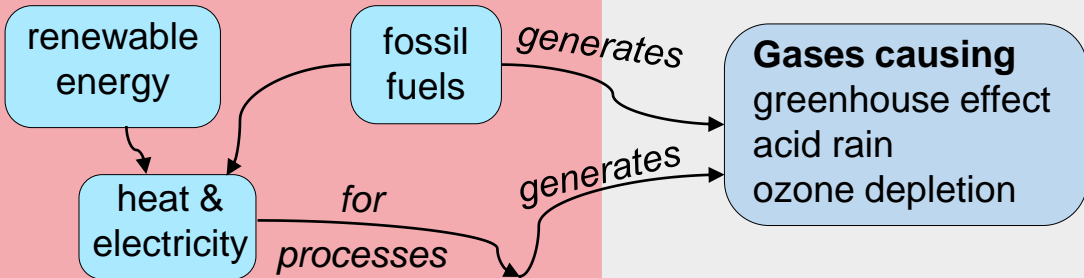
biotechnology

PLASTICS

polyolefins
polyesters
polycarbonates
polyamides
polyvinyl chloride
polyfluoroalkenes
ureas
urethanes
epoxy resins
silicones
mixed copolymers

ENERGY INPUT SYSTEM

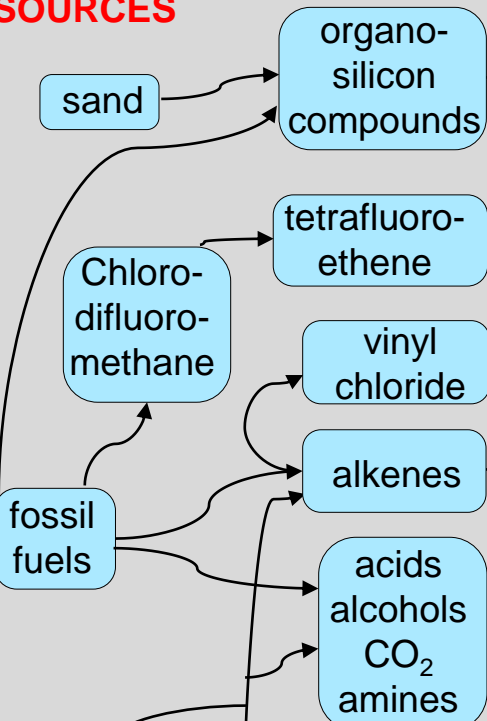
ATMOSPHERIC SYSTEM



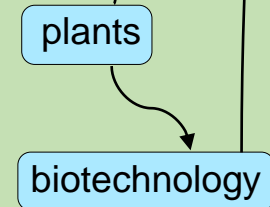
NON-RENEWABLE SOURCES

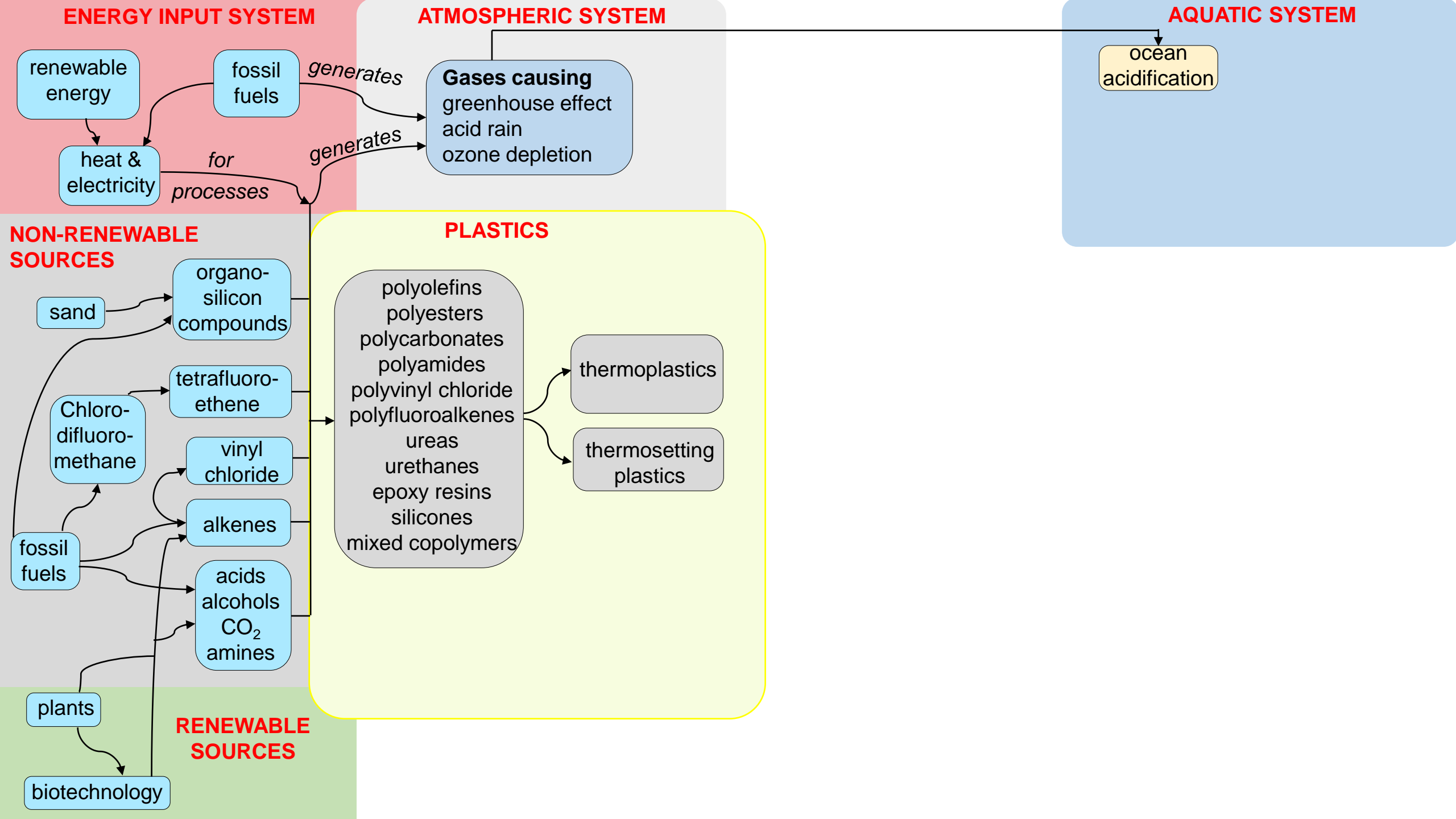
PLASTICS

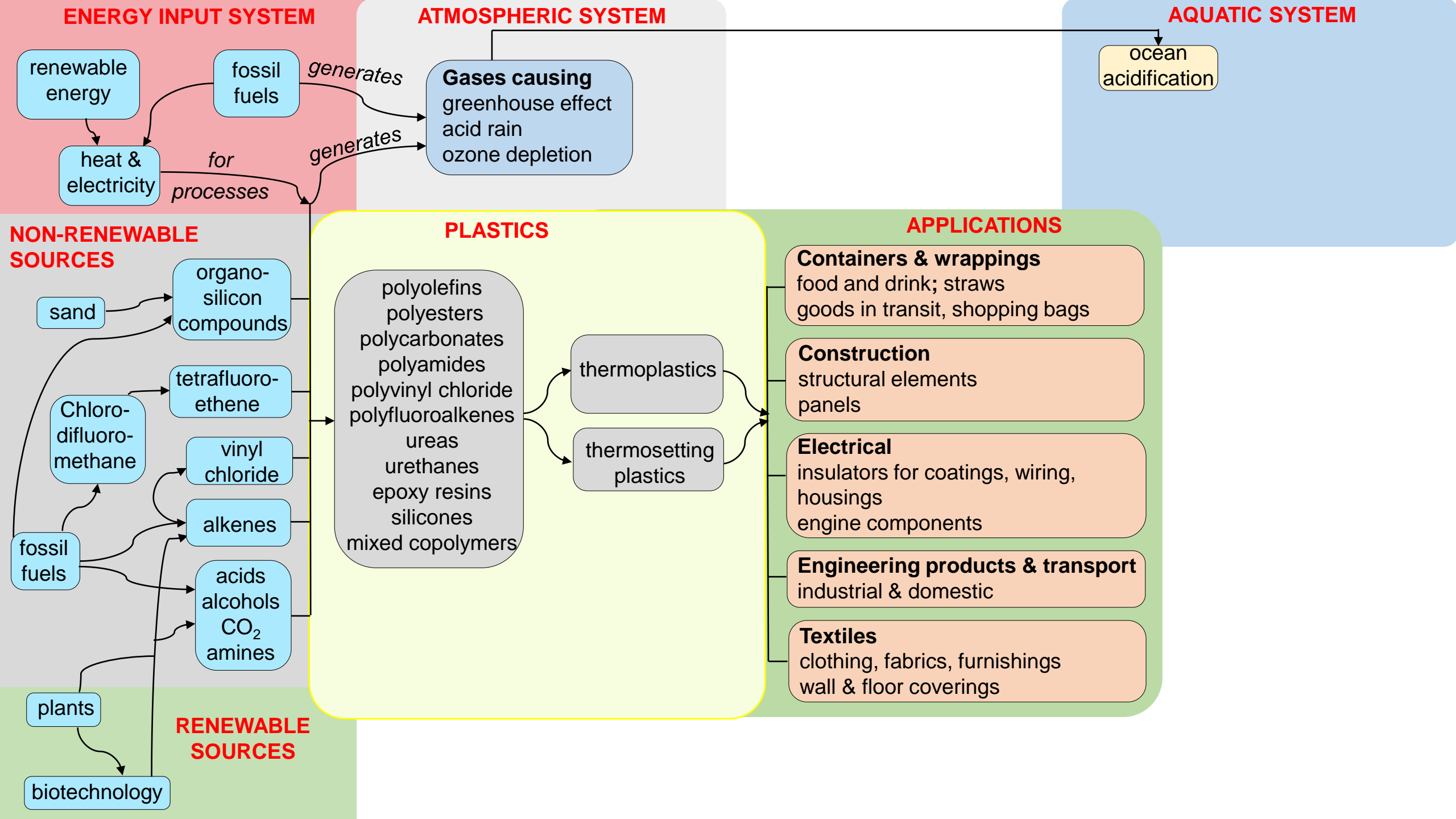
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epoxy resins
silicones
mixed copolymers

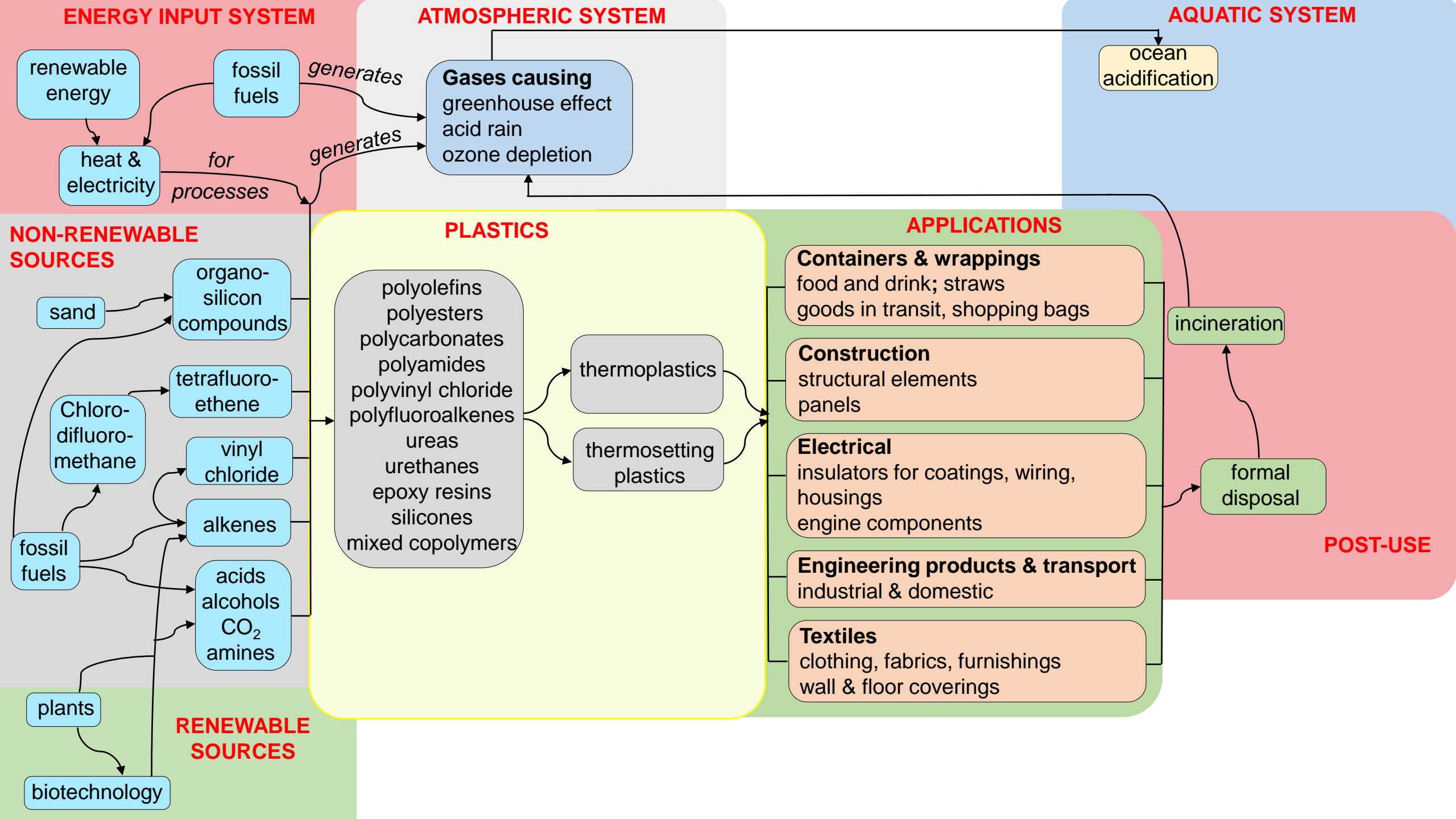


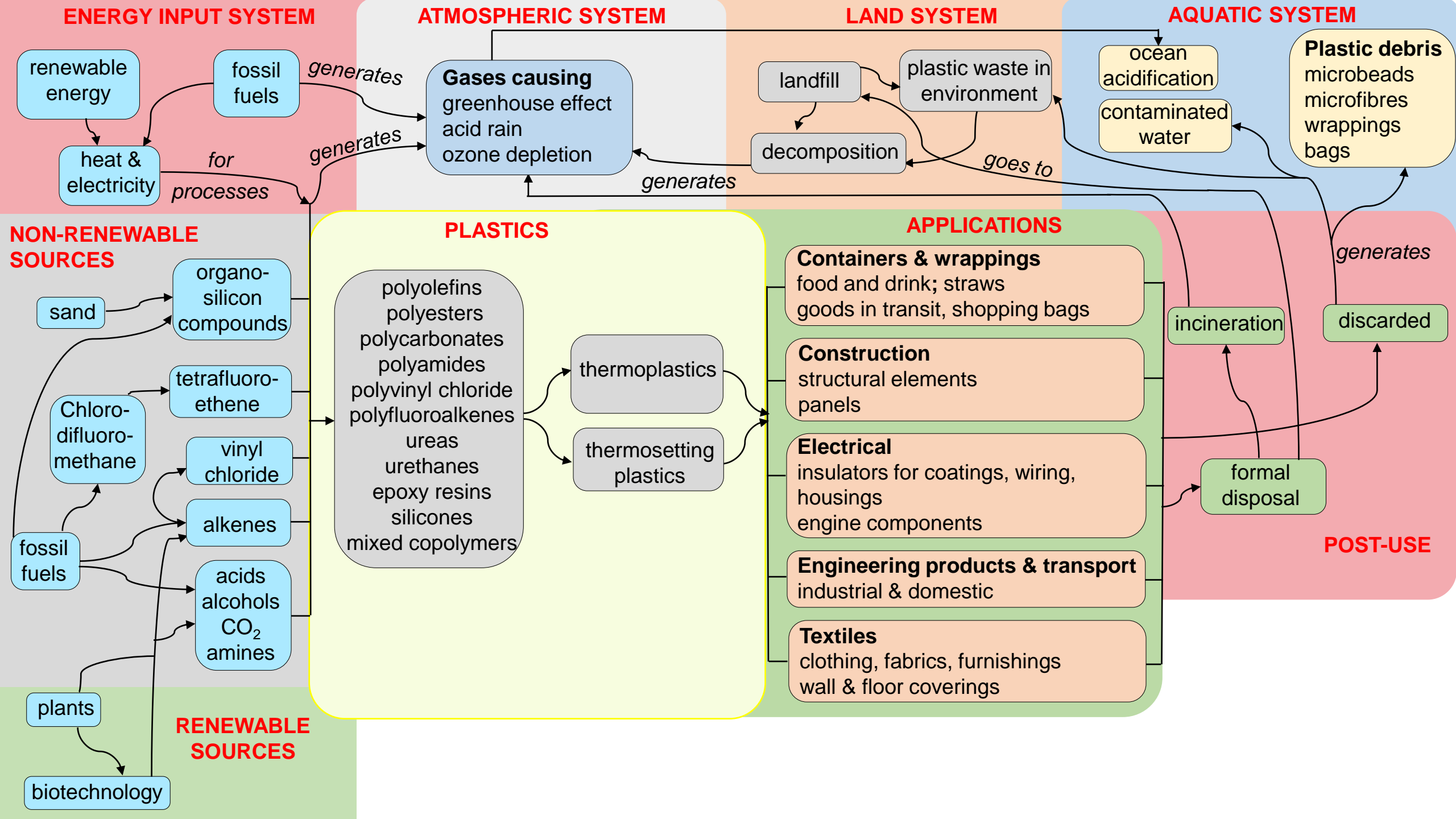
RENEWABLE SOURCES

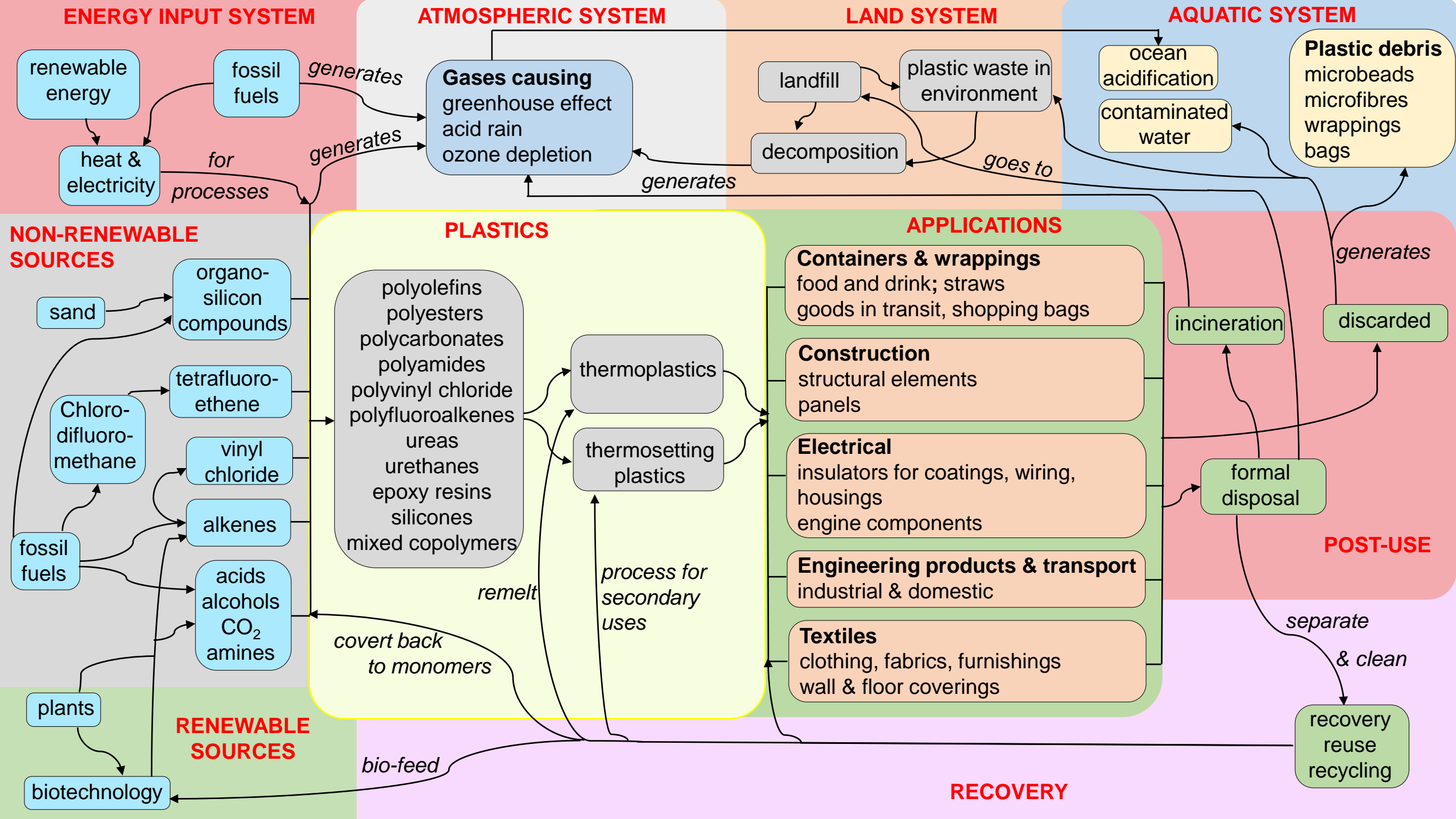


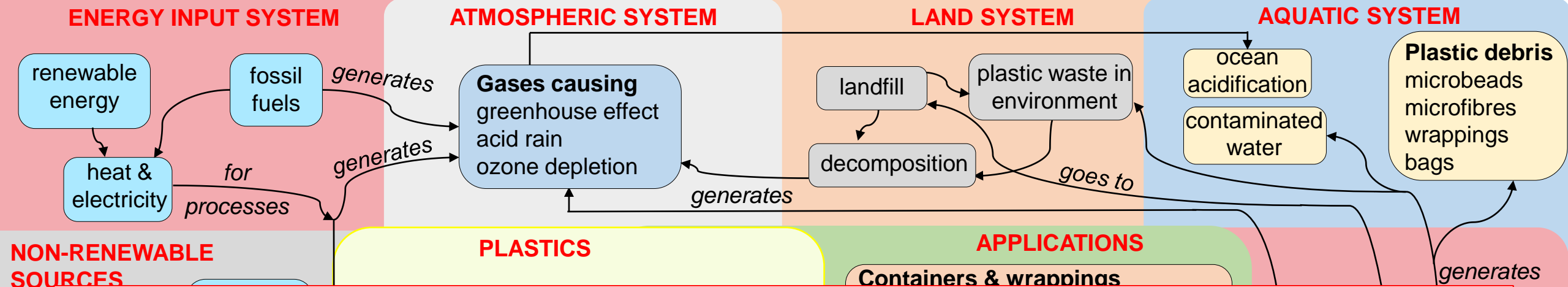




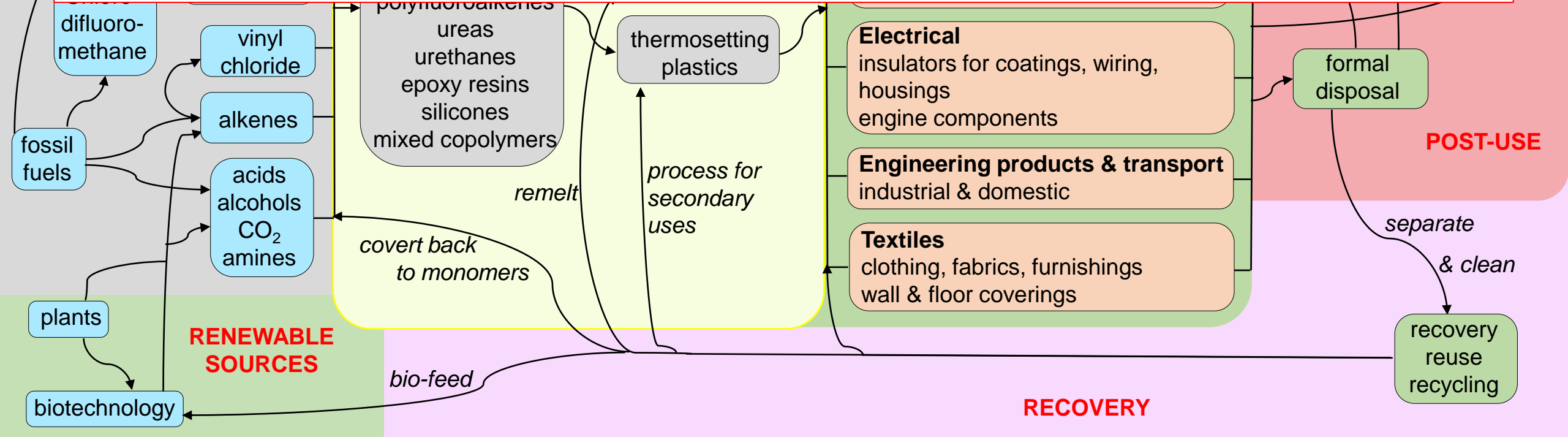








Sustainability is a property of the whole system
 – it is not simply a property of individual elements of the system



Key Facts - Textile Industry

- Global fibre production in 2018 totalled 111 million tonnes

63% of fibres derived from petrochemicals (e.g. polyester, polyamide)

37% natural fibres

26% cotton

11% other e.g. silk, wool, flax

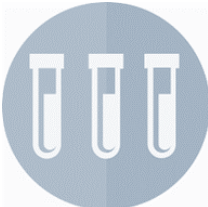
- cotton production provides income for more than 250 million people worldwide and employs almost 7% of all labor in developing countries

Sustainability Challenges in the Textile Sector

I
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Resource challenges



TAKE



MAKE



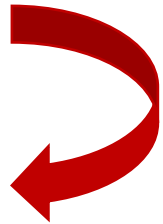
USE



WASTE

Environmental challenges

Social challenges



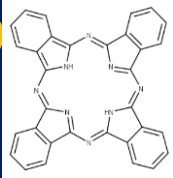
O
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Resource challenges

5 billion



kg of dyes, pigments and finishing chemicals currently used

high volumes/diversity of chemicals



2000



liters water needed to produce one kilogram of cotton

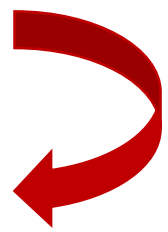


fossil fuel input

90%

of initially introduced chemicals are still present in post-consumer textiles
Individual chemical fingerprint of post-consumer textiles

Environmental challenges



generation of wastewater



1.1 billion

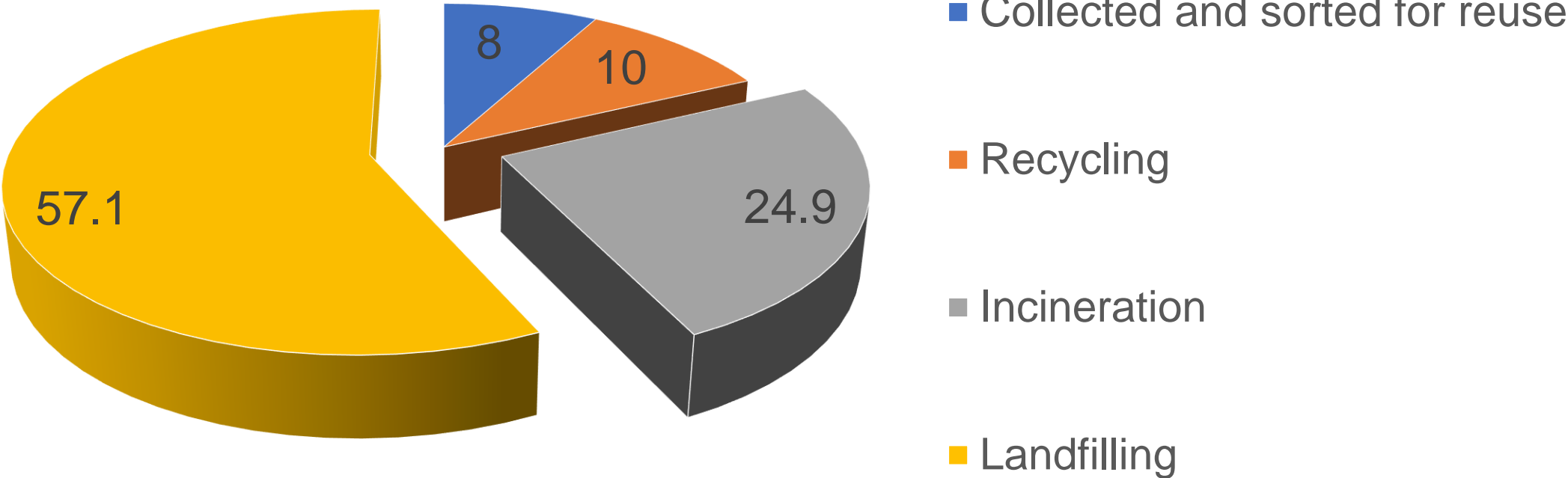
tonnes of CO₂ equivalent by textile production
GHG emissions

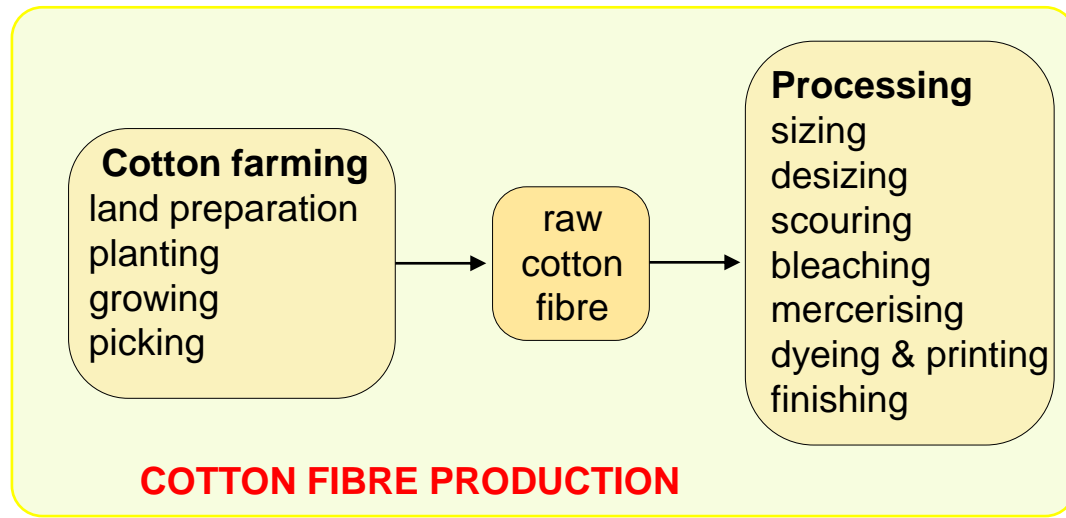
2.2 million

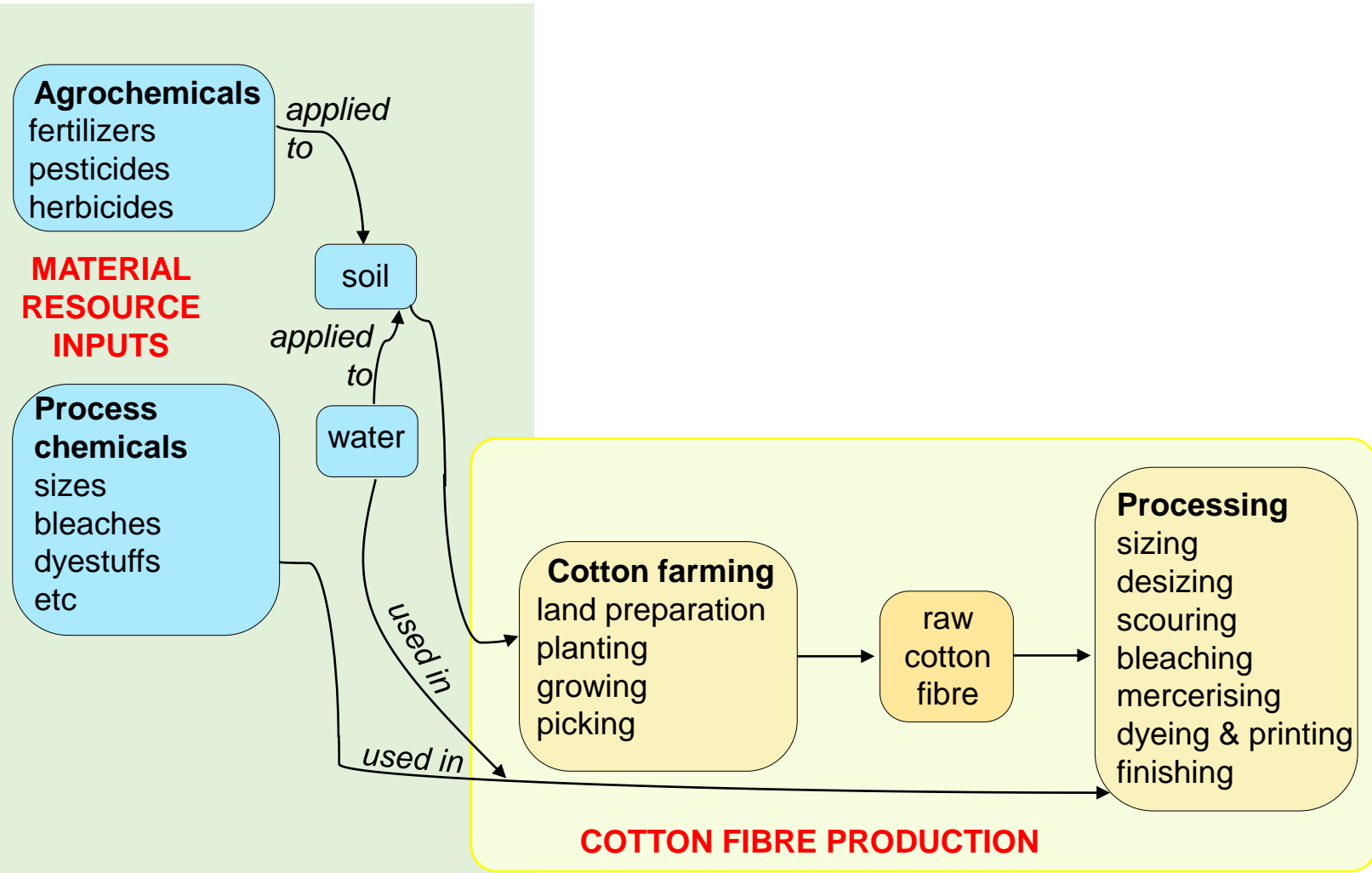
tonnes of textile waste generated as solid wastes produced in 2016 within the EU

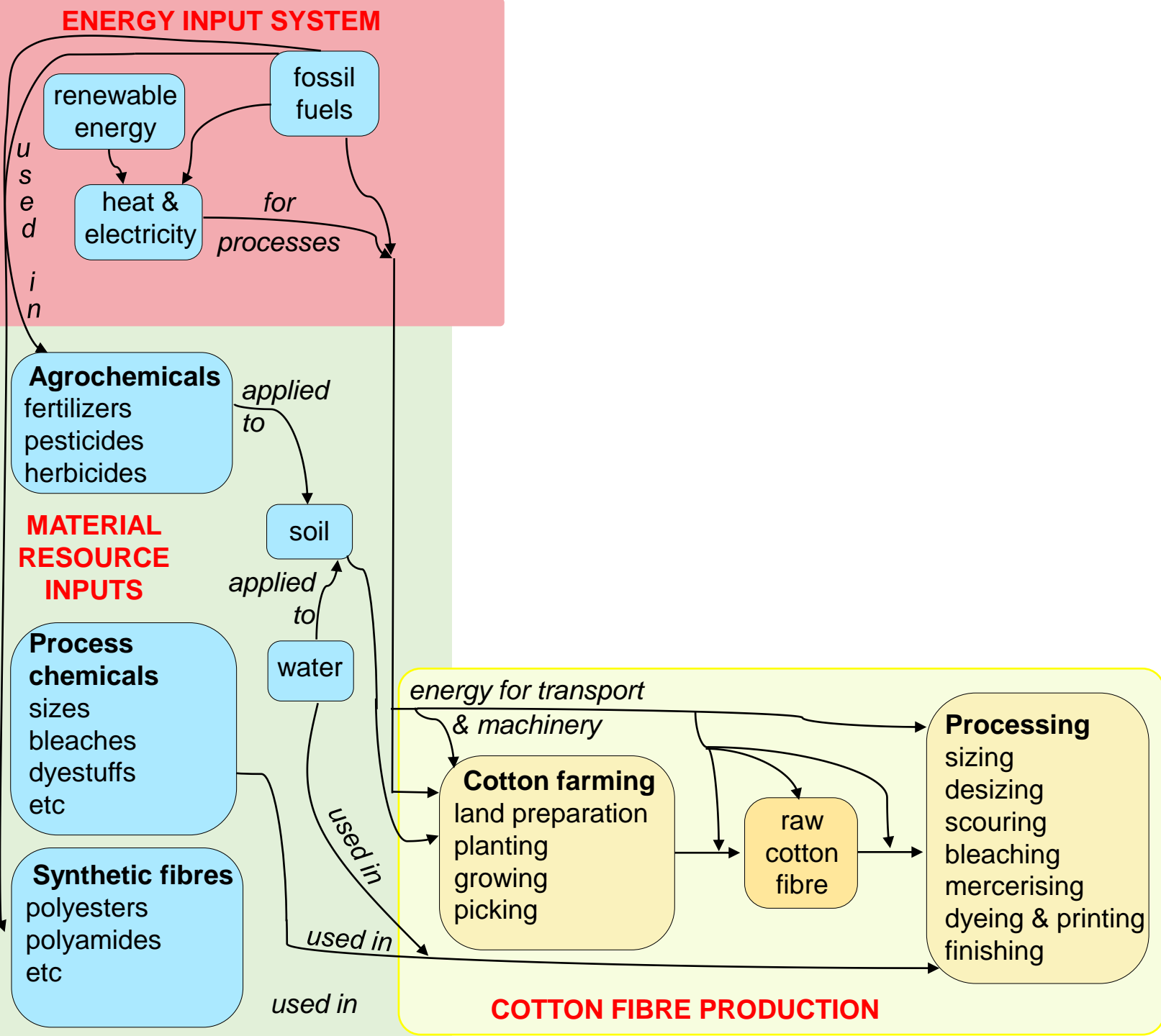
Post-consumer textiles: A resource and environmental burden

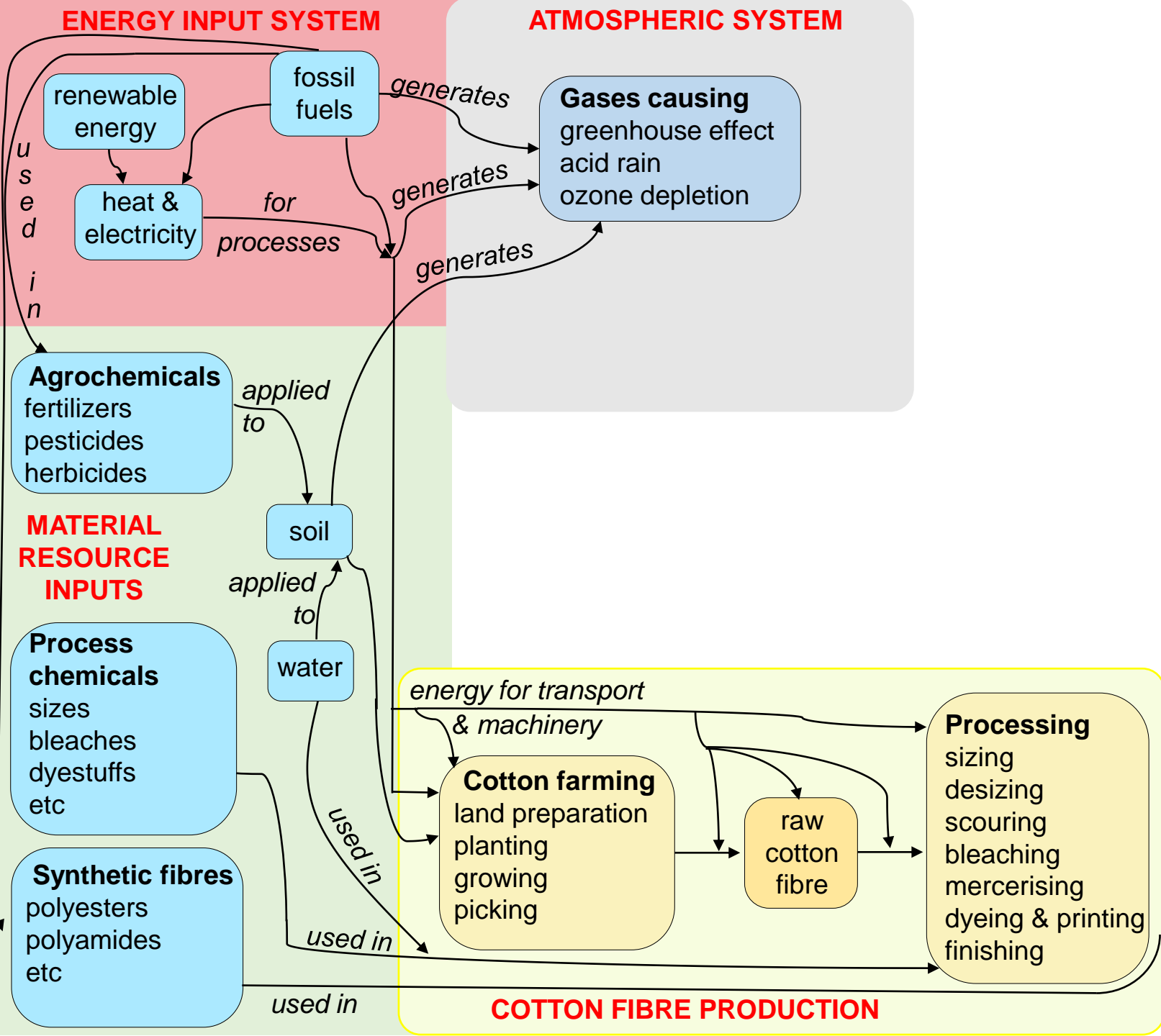
Textile Waste within the EU [in %]

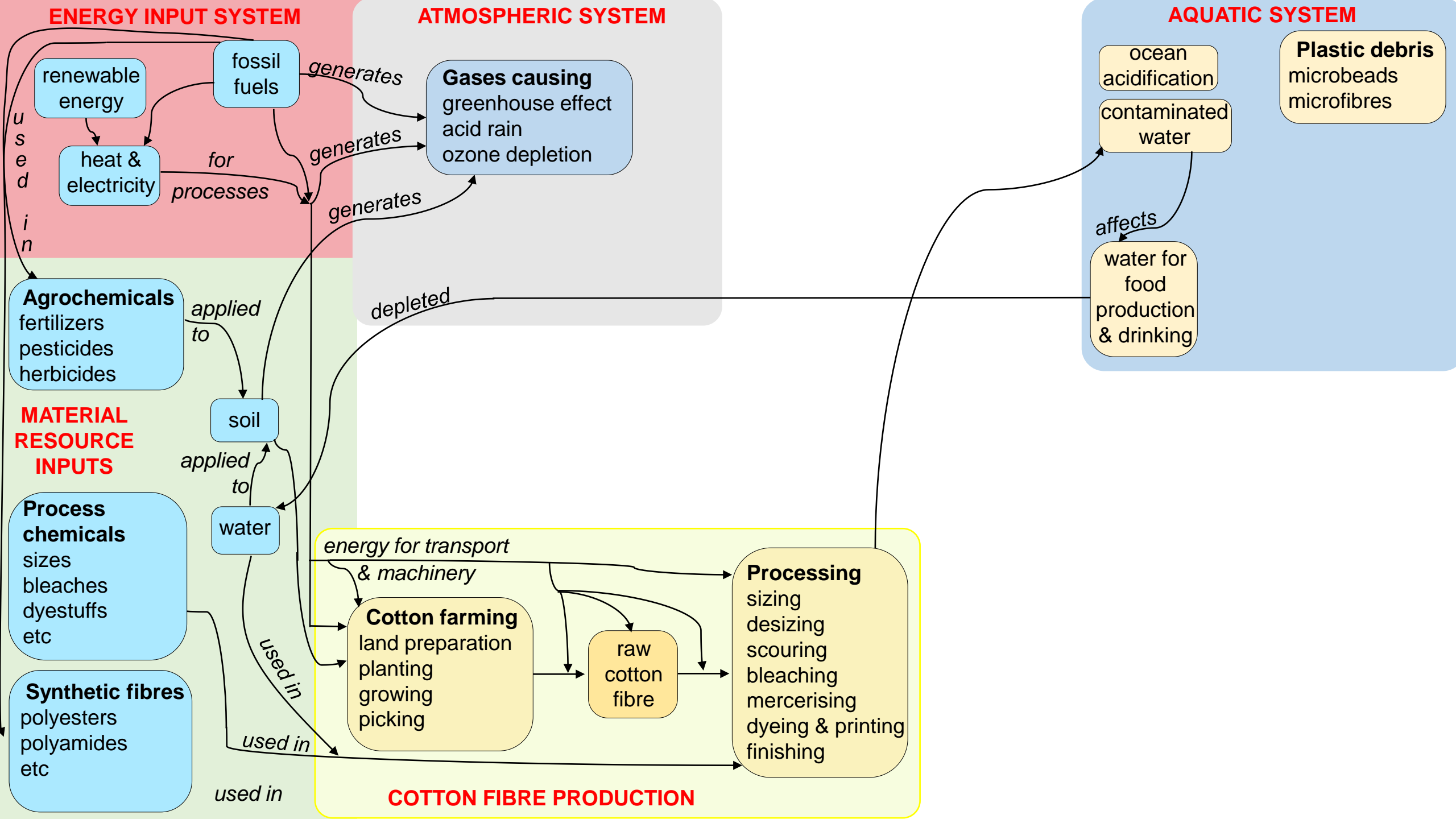


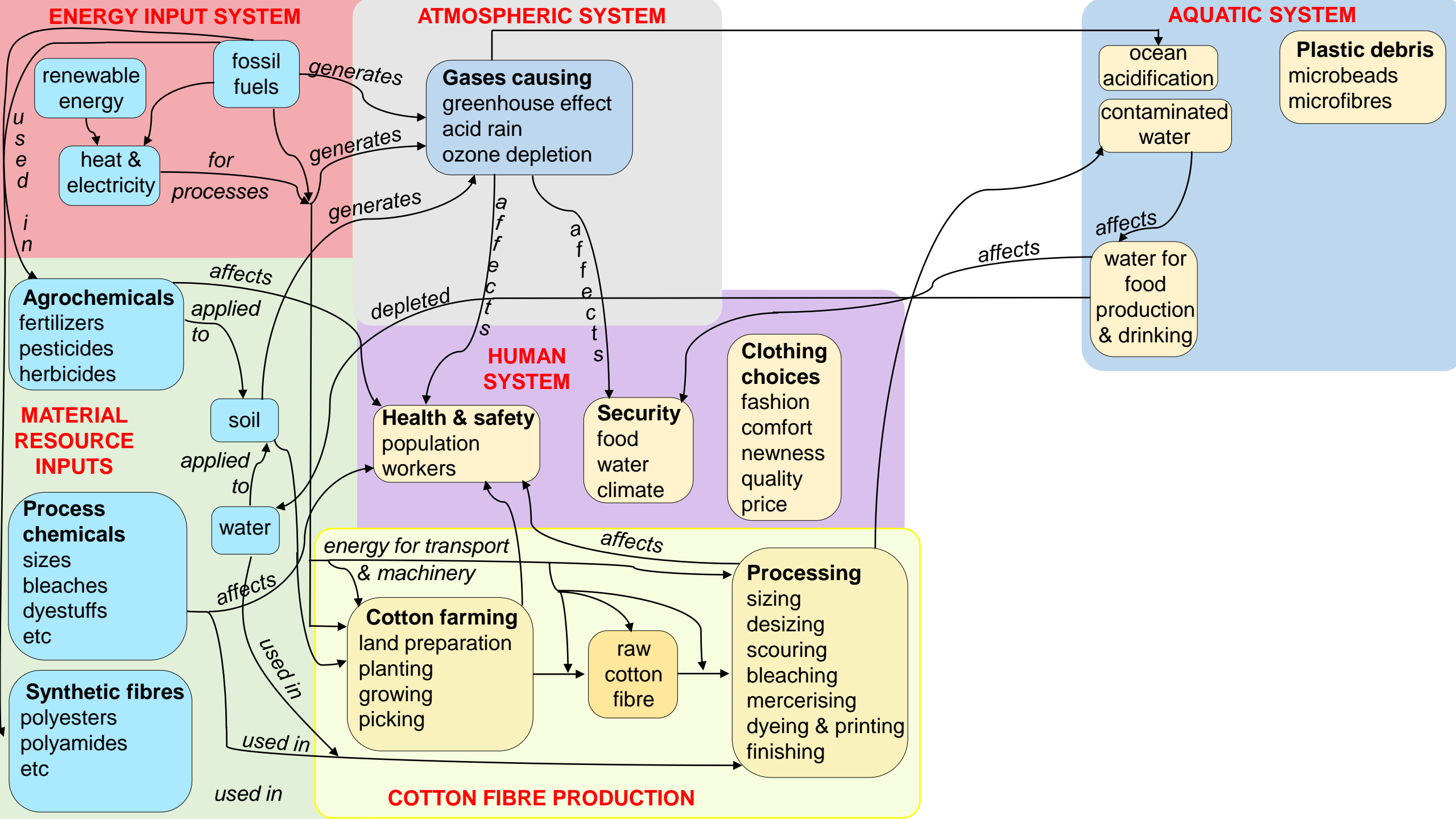


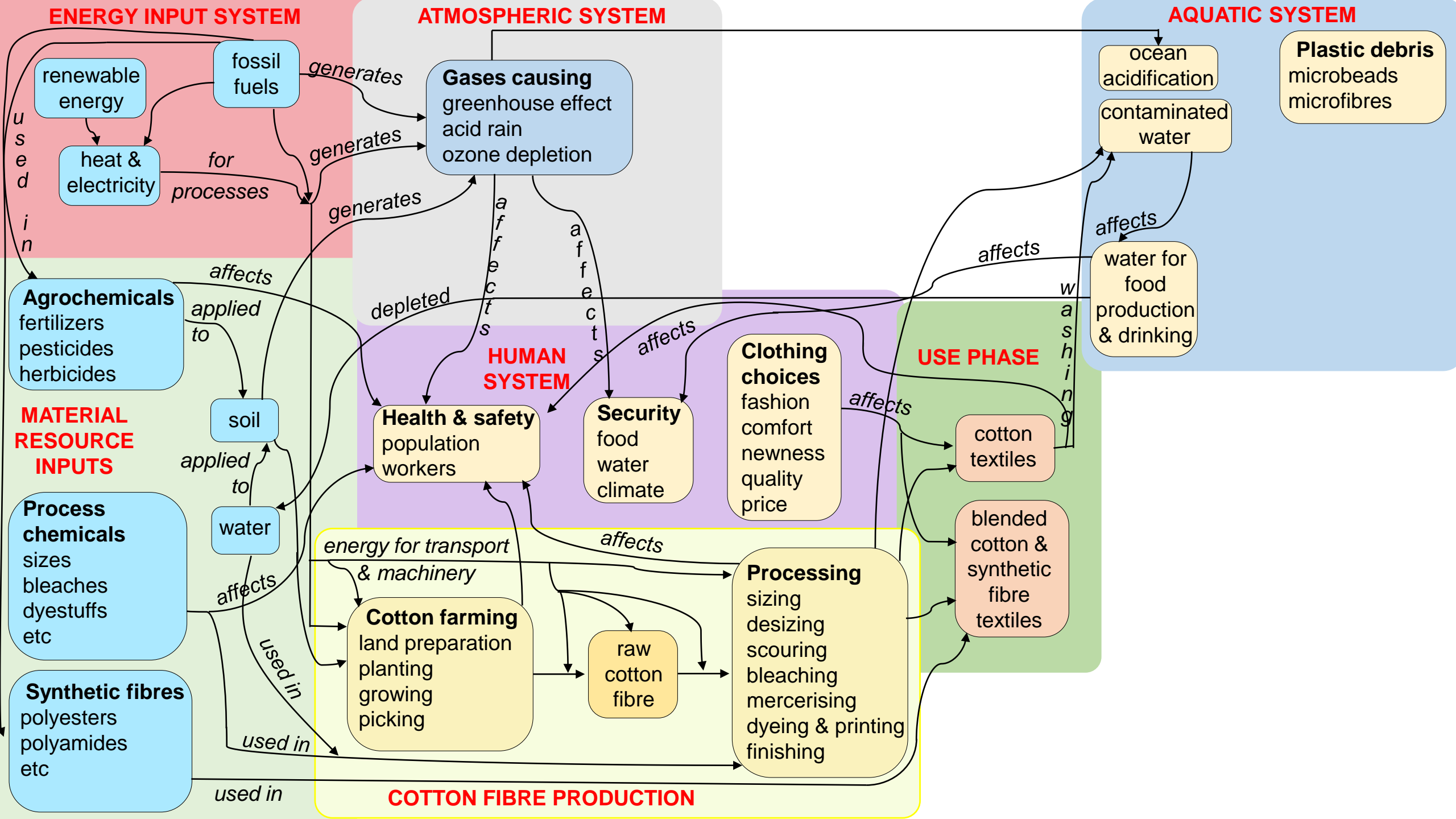


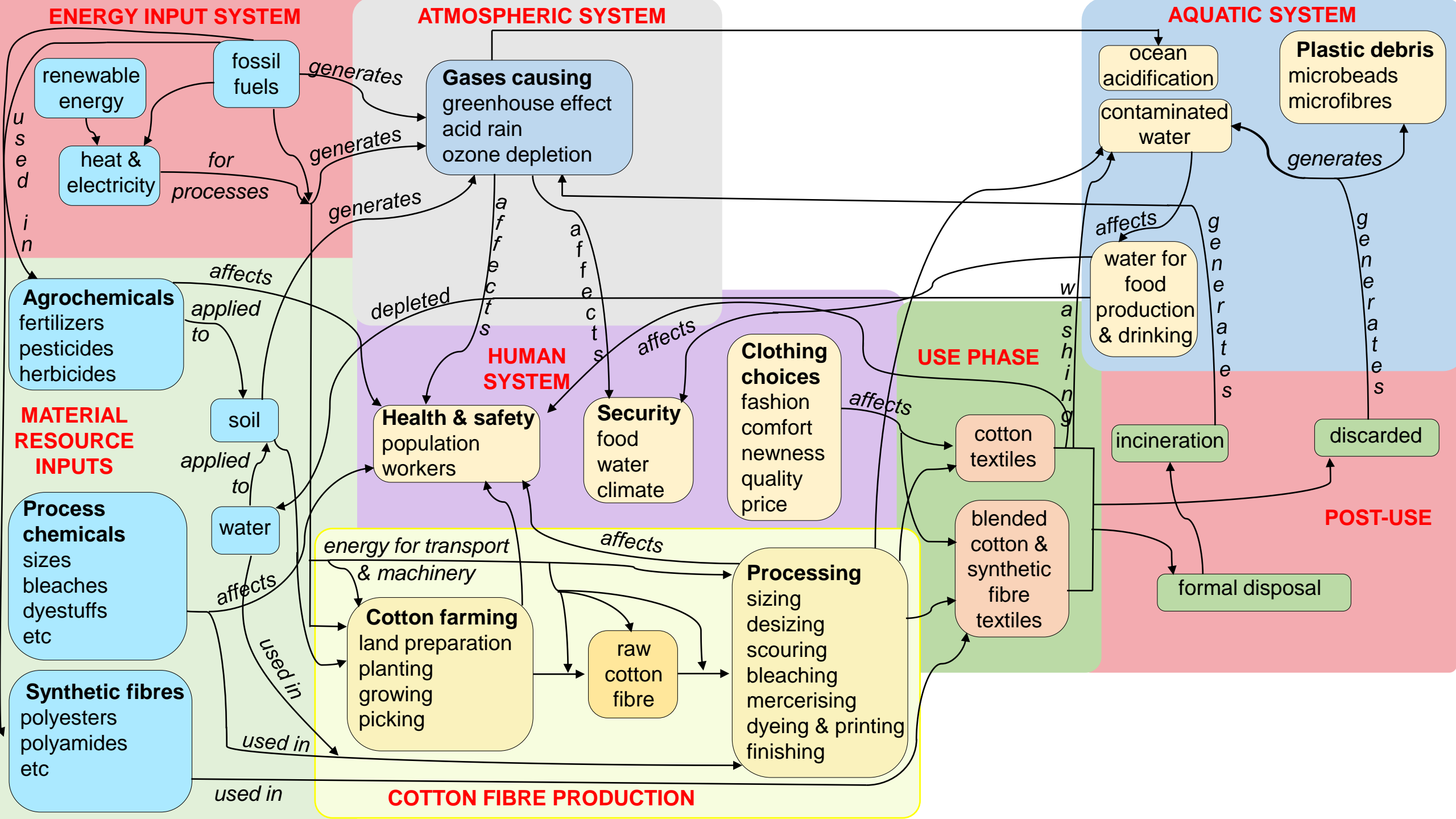


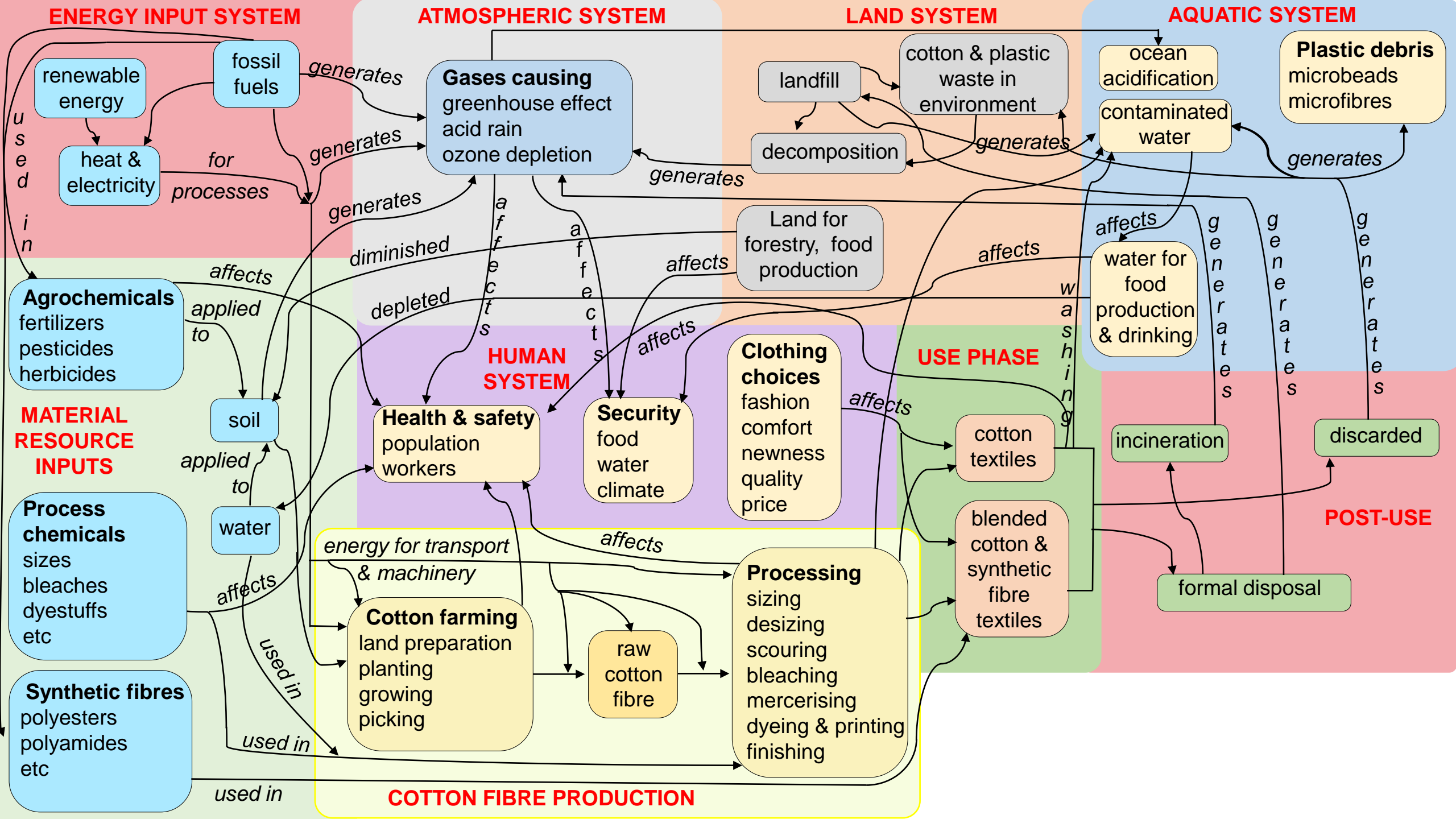


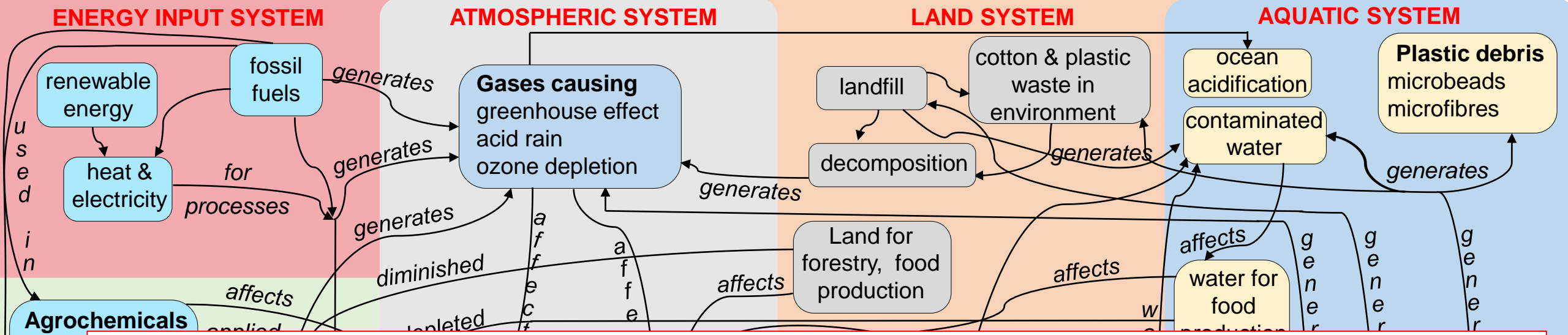




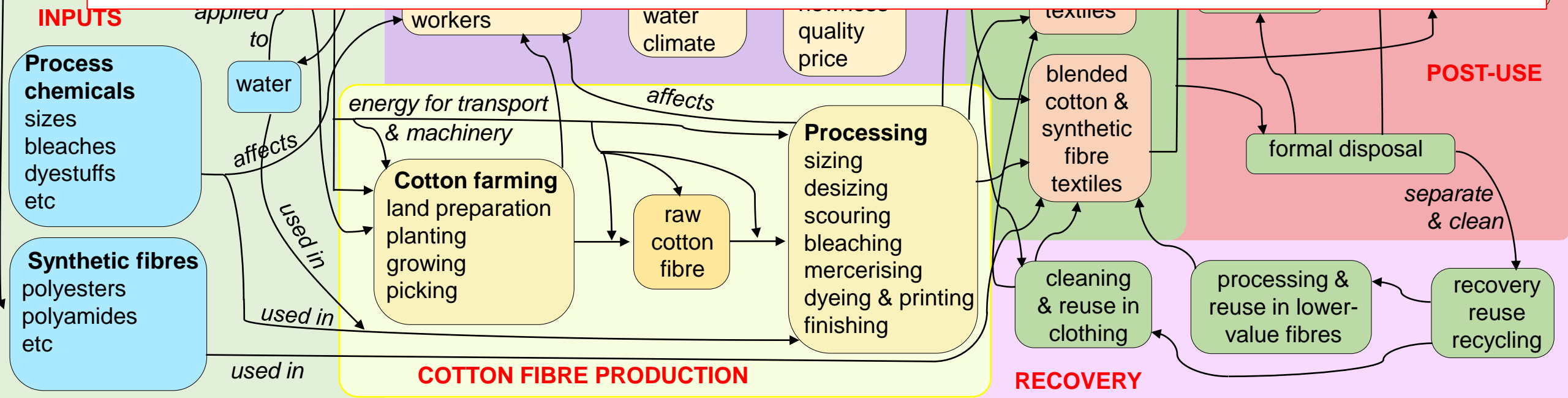








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Acknowledgments

- IUPAC Project No 2017-010-1-050 on Systems Thinking In Chemistry Education (STICE), 2017-2019, was supported by IUPAC and IOCD
- L.K. gratefully acknowledges the financial support from the Robert Bosch Foundation (12.5.F082.0021.0).

SAM thanks:

- IOCD *Chemists for Sustainability* group for contributing to 'one-world' chemistry
Henning Hopf, Alain Krief, Goverdhan Mehta
- Peter Mahaffy, Tom Holme and members of the IUPAC Task Group for contributing to the STICE project and development of the SOCME tool

LK thanks:

- Klaus Kümmerer and Henrik von Wehrden for PhD supervision

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