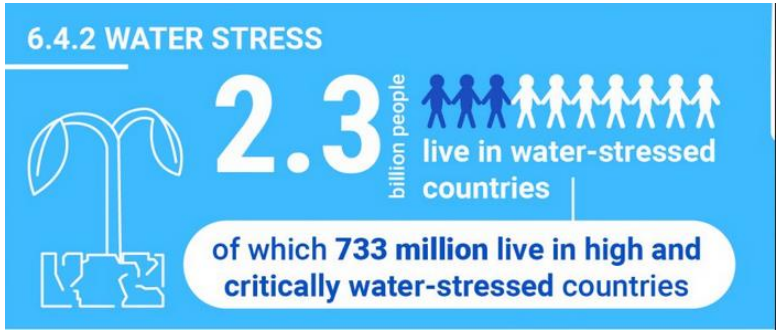
ULTIMATE

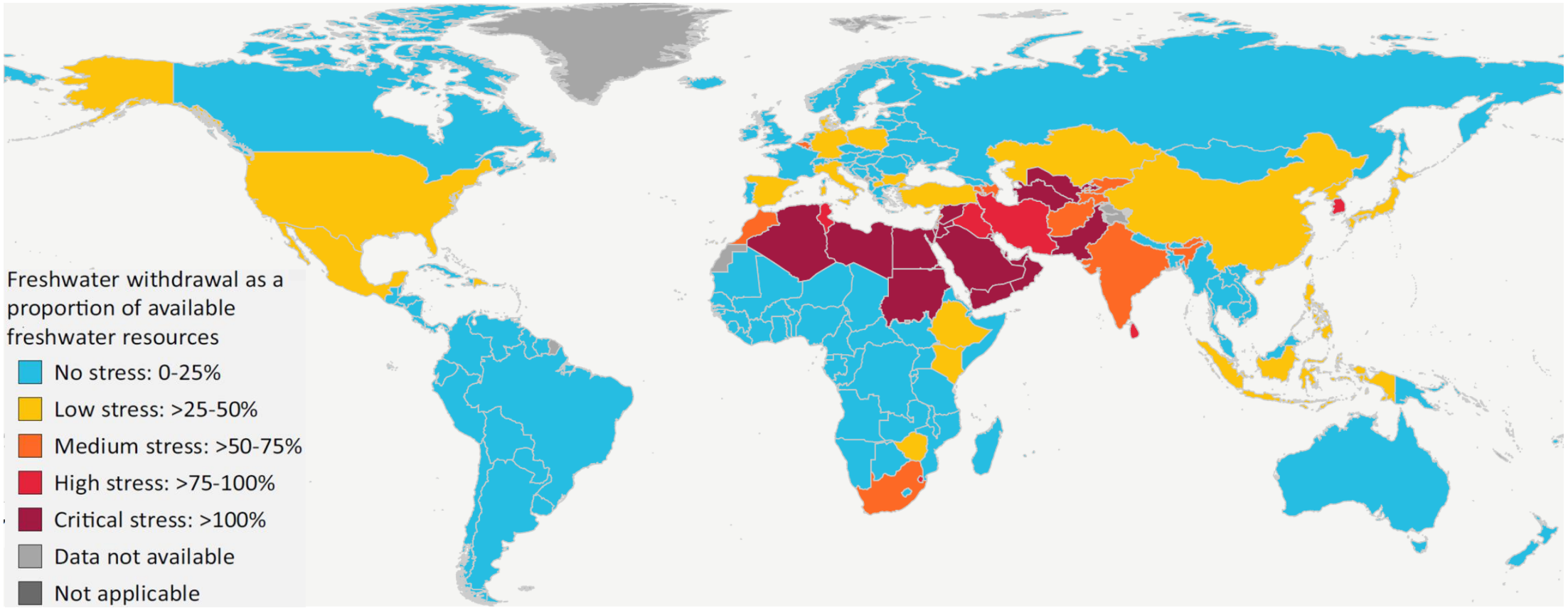
WATER SMART INDUSTRIAL SYMBIOSIS

Water smart industrial symbioses:
recovering and reusing resources from industrial wastewater

A. Kleyböcker and C. Remy

Do we need circular economy?





United Nations: https://sdg6data.org/en/maps accessed on Oct. 24th 2023: based on data from 2020

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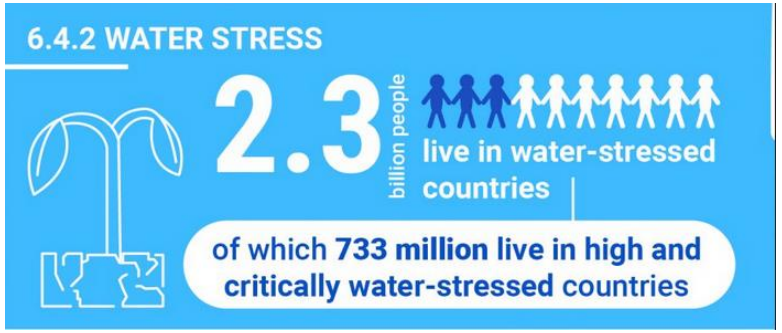
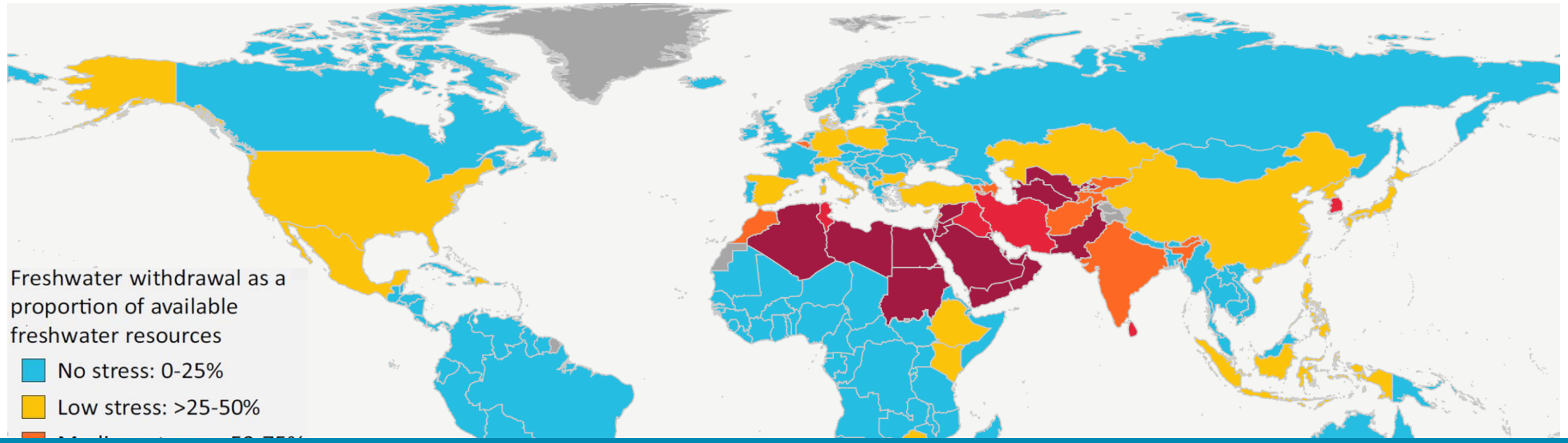


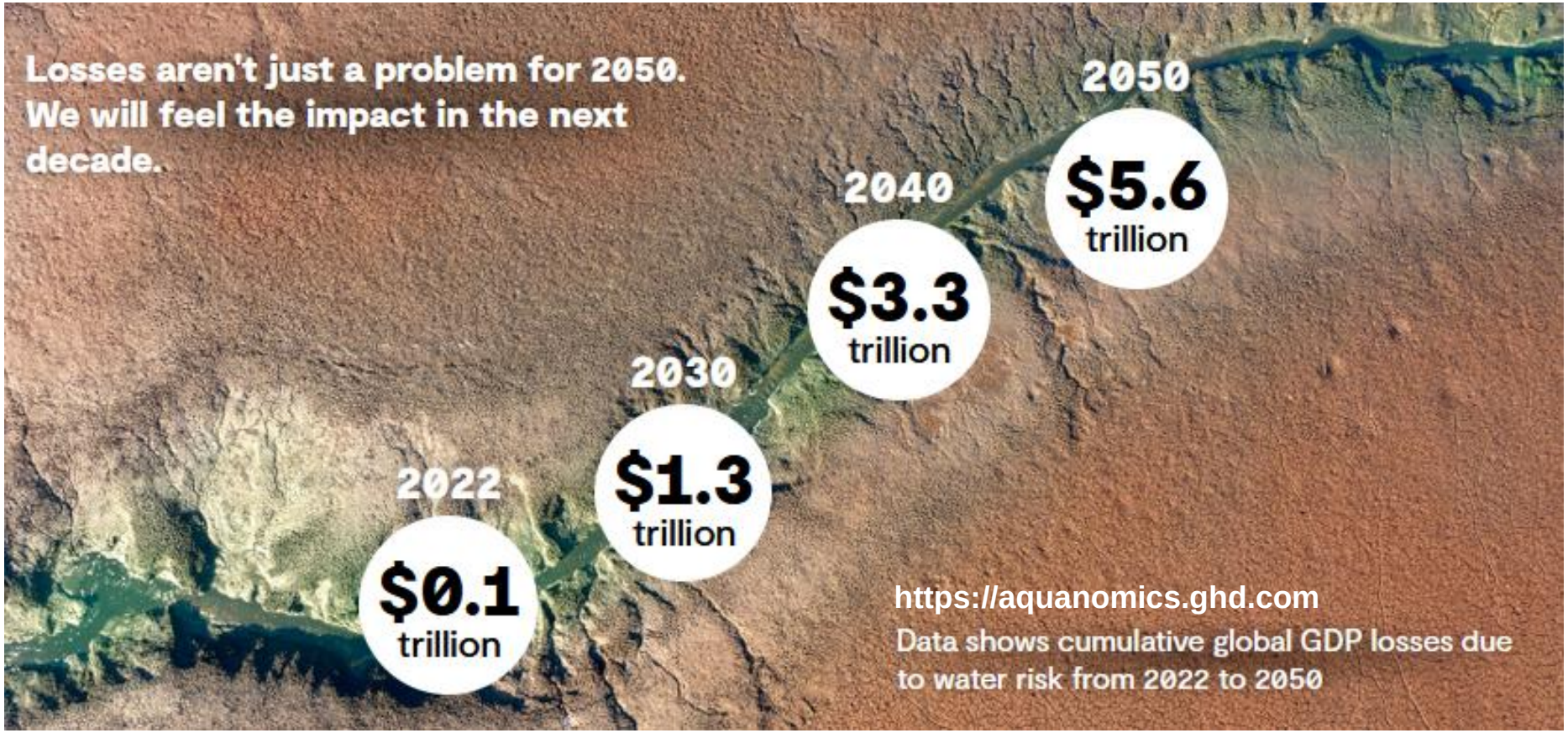


Droughts and water scarcity in EU (EEA 2021):

- **20% of territory**
- **30% of total population**

Climate change will increase global water stress

Gap between water supply and demand by 2030: 56%
(Strong et al. 2020, World Resource Institute)



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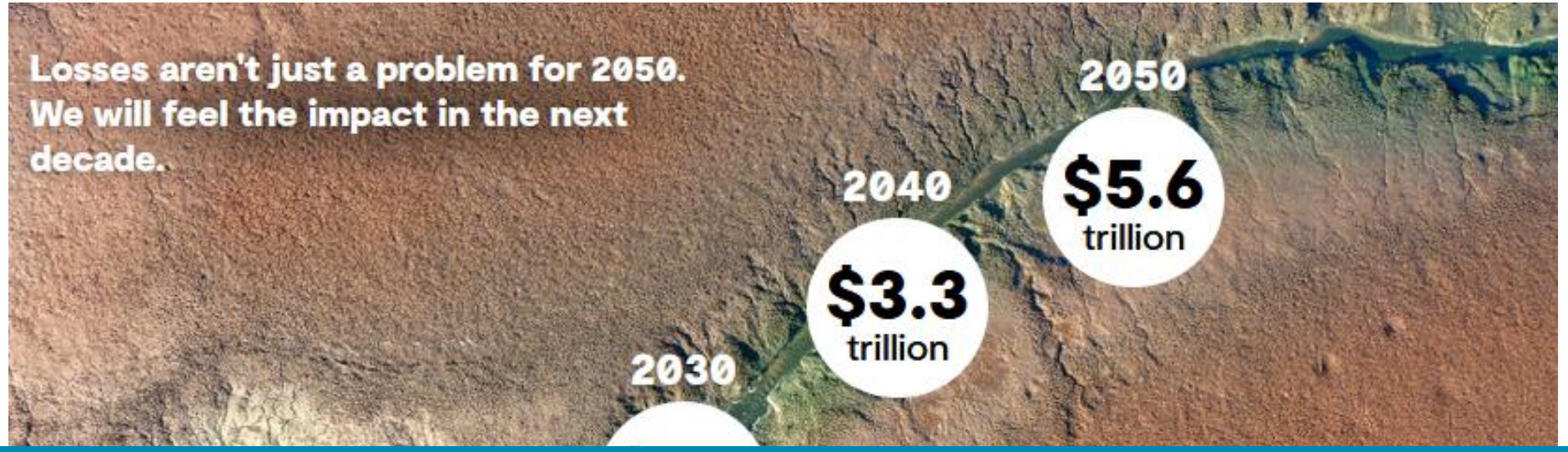
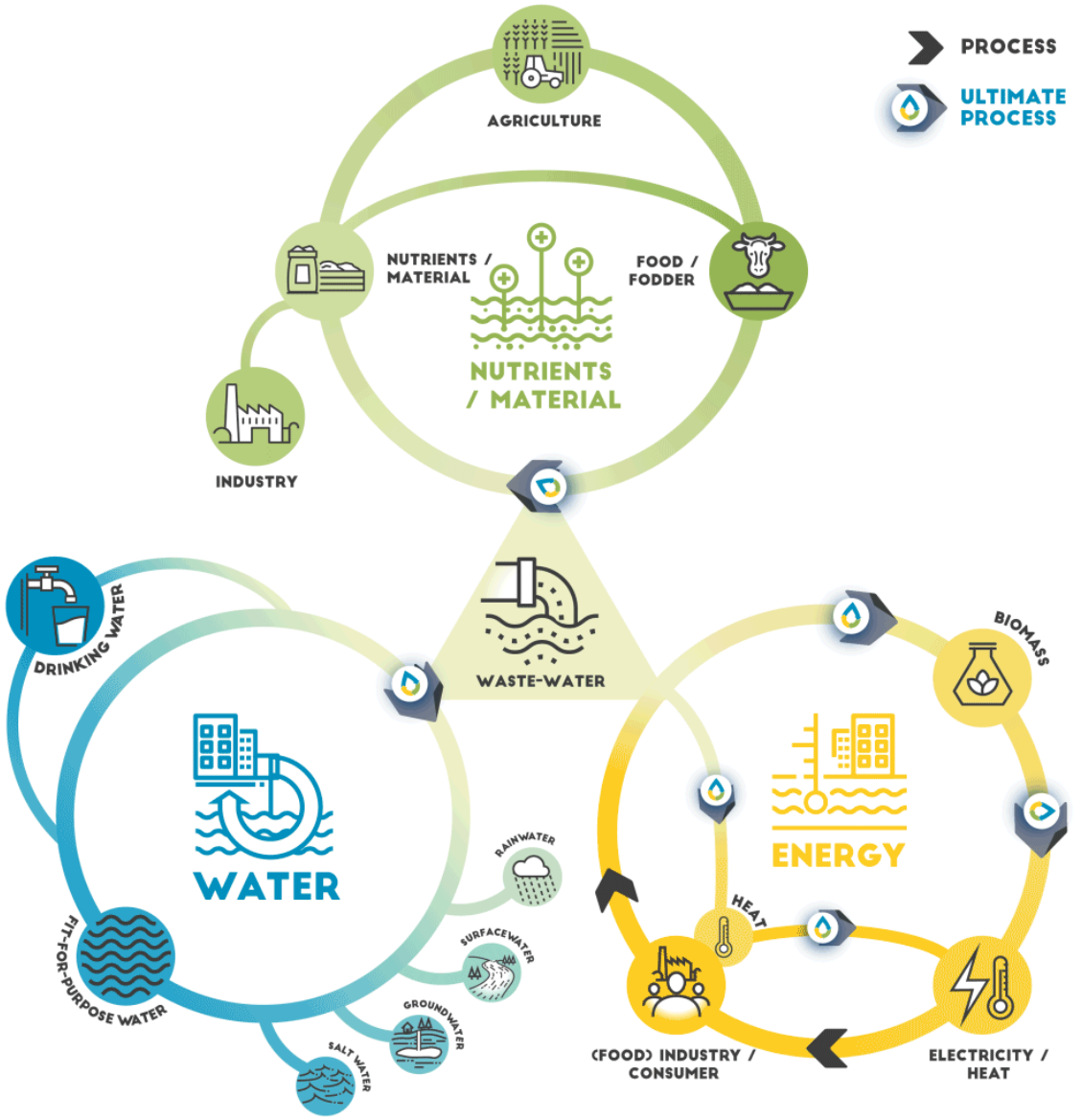


EU: Droughts and water scarcity will increase:
→ especially in western and southern Europe!

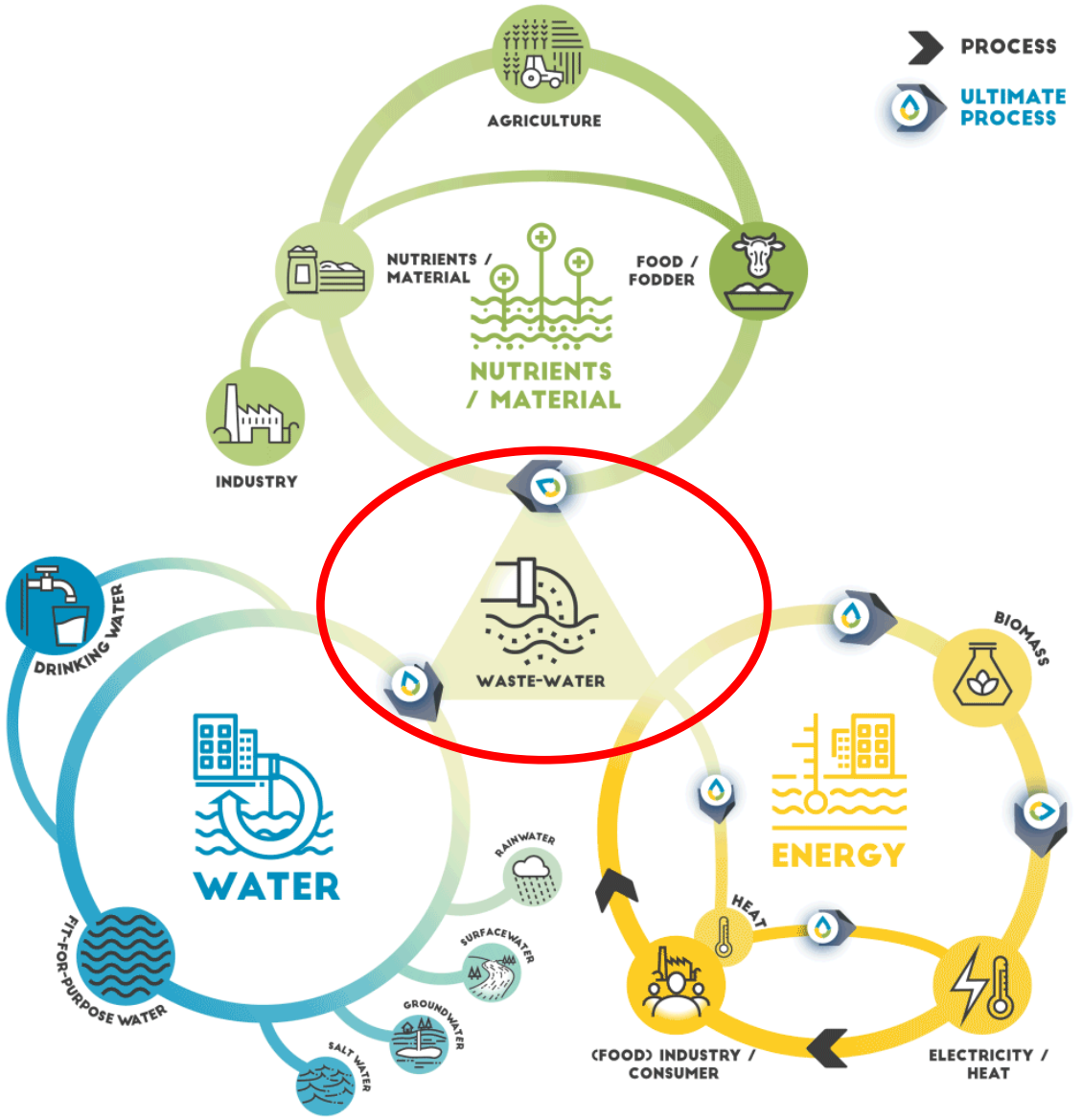
How does circular economy work?



Wastewater is a valuable resource

Wastewater from

- municipalities
- industries (pulp and paper, steel, food, beverage, chemical, biotech, etc.)

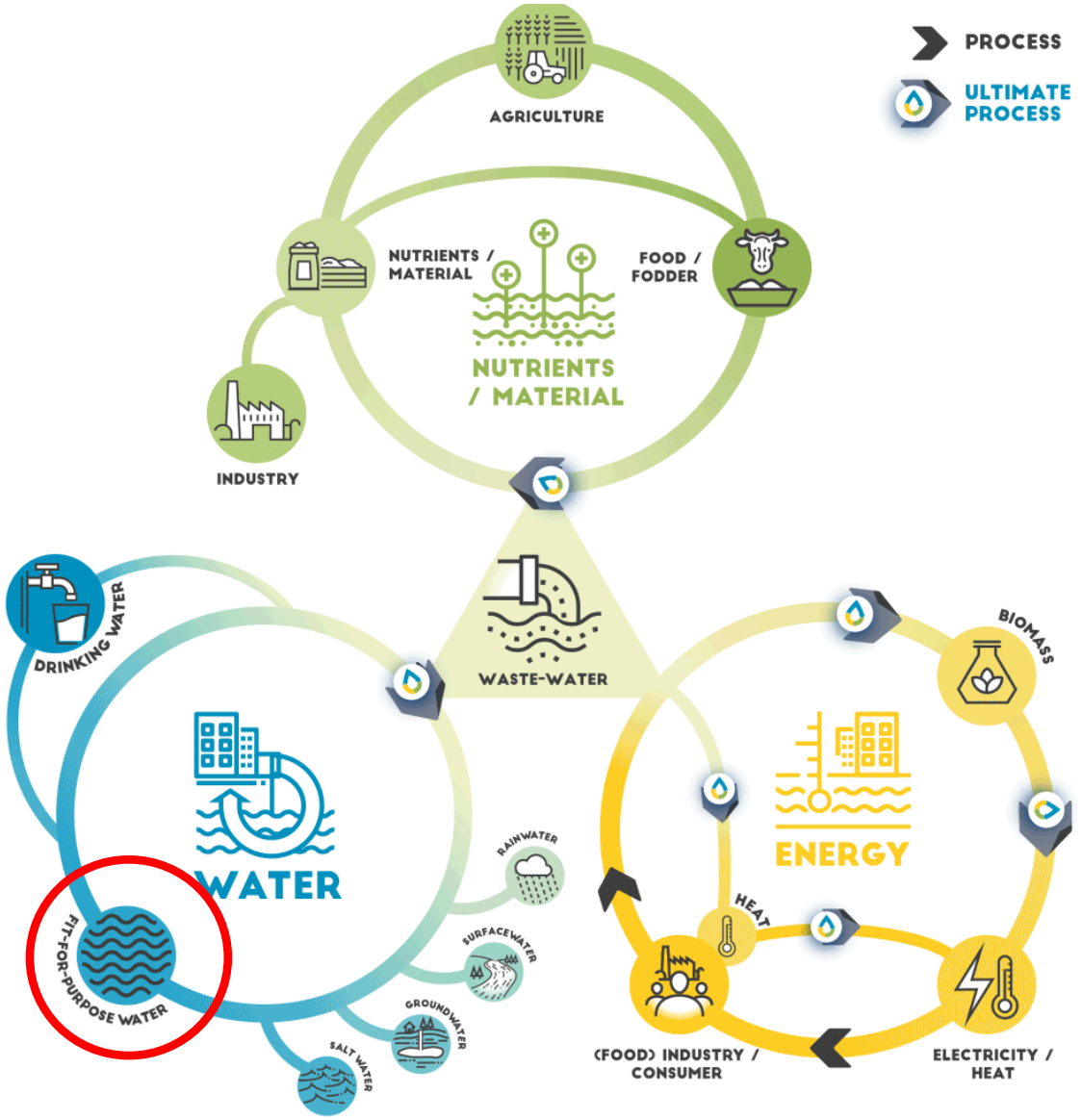


Wastewater is a valuable resource:

➡ fit-for-purpose water

Reuse purposes:

- **Irrigation**
- **Cooling processes**
- **Steam production**
- **Cleaning**



Wastewater is a valuable resource:

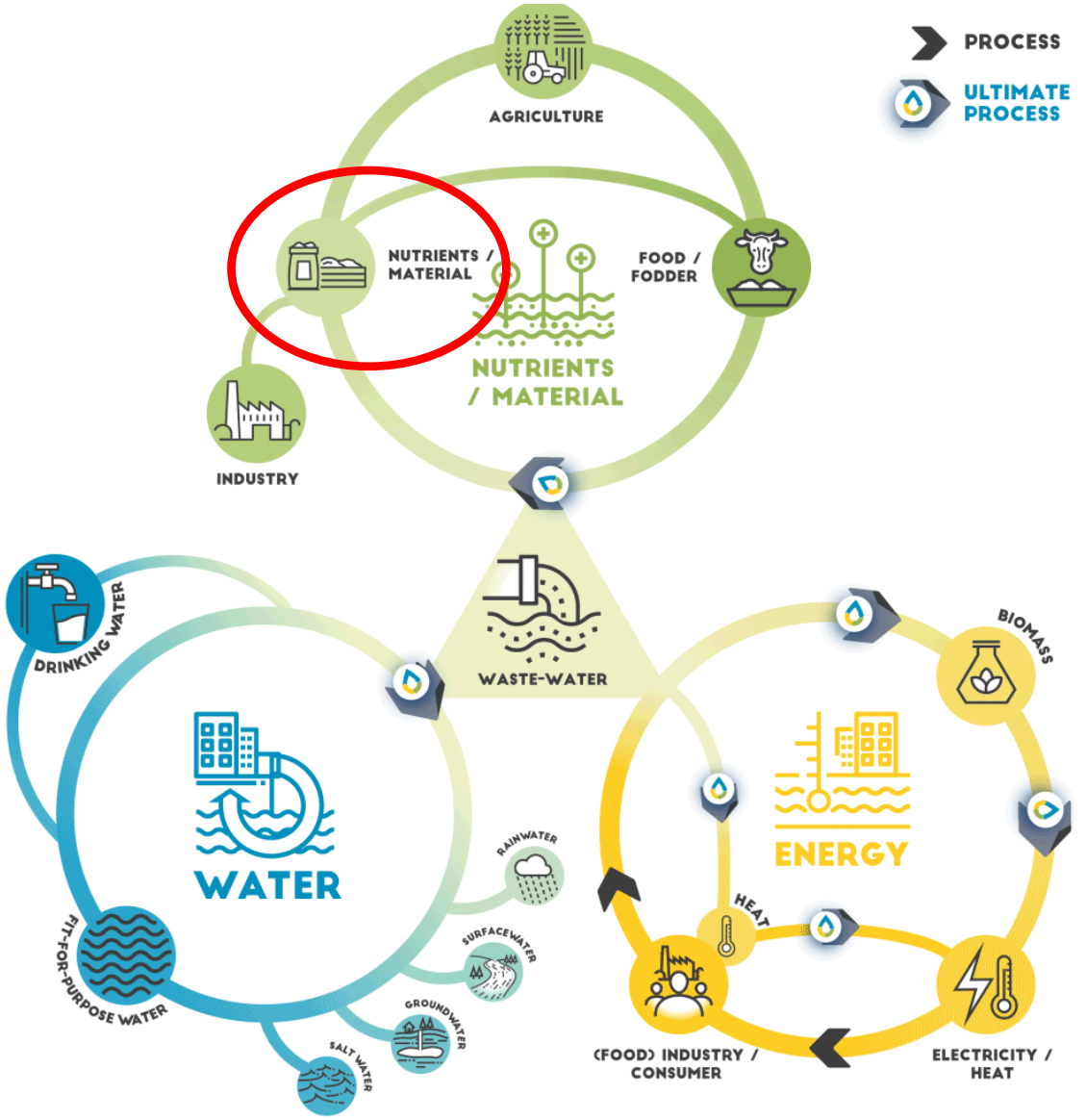
➡ material recovery

Materials to be recovered:

- nutrients (N, P, K, S)
- biomass for compost production
- high added value compounds

Basis for microalgae production as fodder additive

Reuse of industrial byproducts in wastewater treatment



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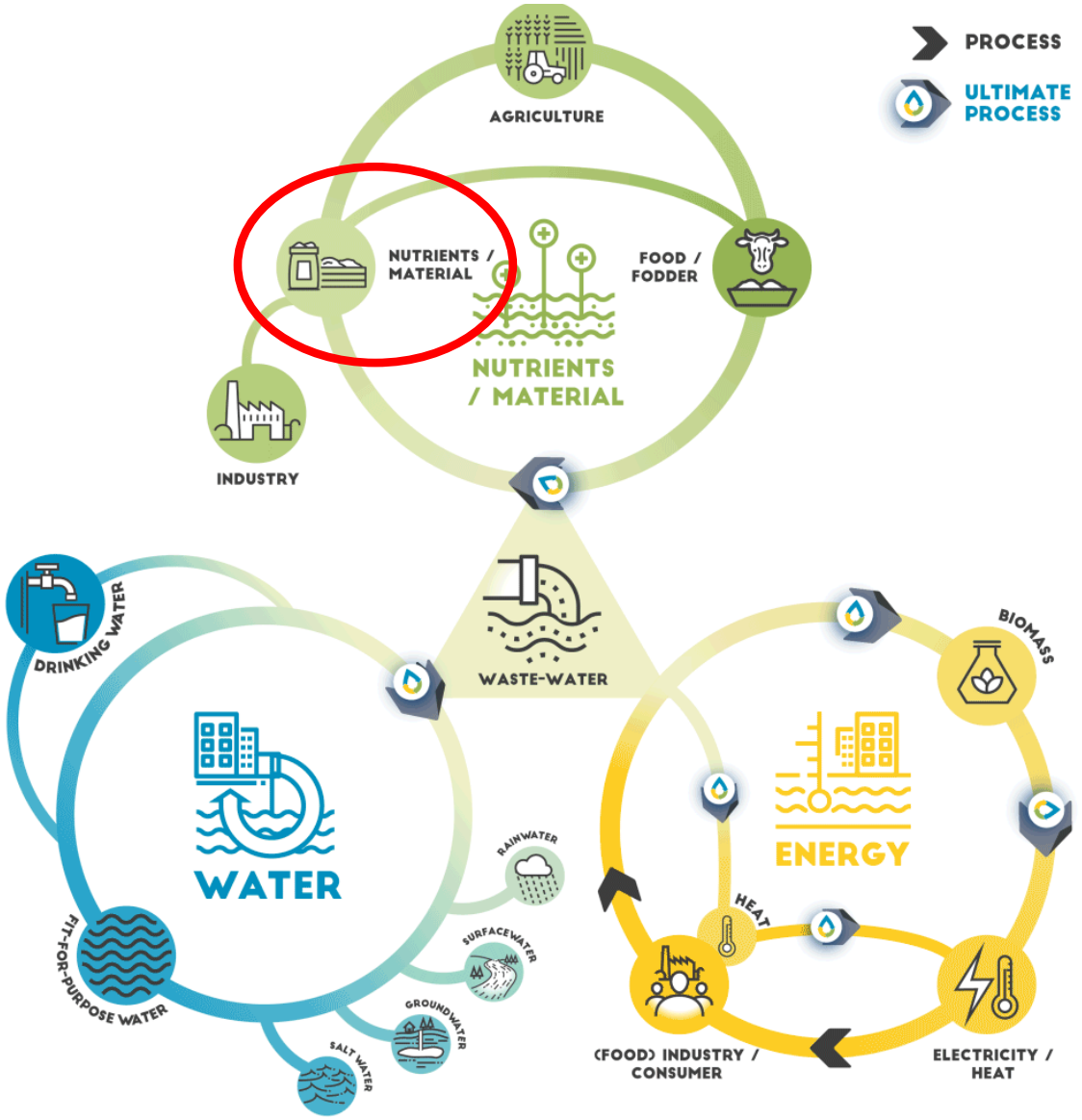

High added value compounds ➡ treasure in wastewater

Value-Added Compounds

Fruit	Compound	Class	Properties & Uses	Price/g*
Orange	Hesperetin	Flavonone	Lowers cholesterols, Anticancer, Favourably favours lipids	€13
	Naringenin	Flavonone	Antioxidant	€1
	Kaempferol	Lignan	Reducing the risk of chronic diseases, especially cancer.	€5.900
Redcurrant	Cyanidin 3-O-glucoside	Anthocyanin	Food colourant	€29
Beetroot	Luteolin	Flavone	Potentials for cancer prevention and therapy	€18.100
			Used in green tea extracts	€22.499
Black Chokeberries	Cyanidin 3-O-arabinoside	Anthocyanin	Used as natural colorant	€84.000
Pomegranate	(+)-Catechin	Flavonol	Used in green tea extracts	€22.499
	(+)-Gallocatechin	Flavonol	Antibacterial, Antifungal, Antimalarial, Diuretic, Antiulcer, Xanthine oxidase inhibitor, Antiplasmodic…	€150.000
Carot	3,4-Dicaffeoylquinic acid	Phenolic acid	Antioxidative, DNA protective, Neuroprotective, Hepatoprotective, Anti-influenza viral activity	€374.000

*Price of analytics standards normalised to 1g

Iossifidis, D. (2020): CS4 in Greece and CS6 in Israel. Ultimate project

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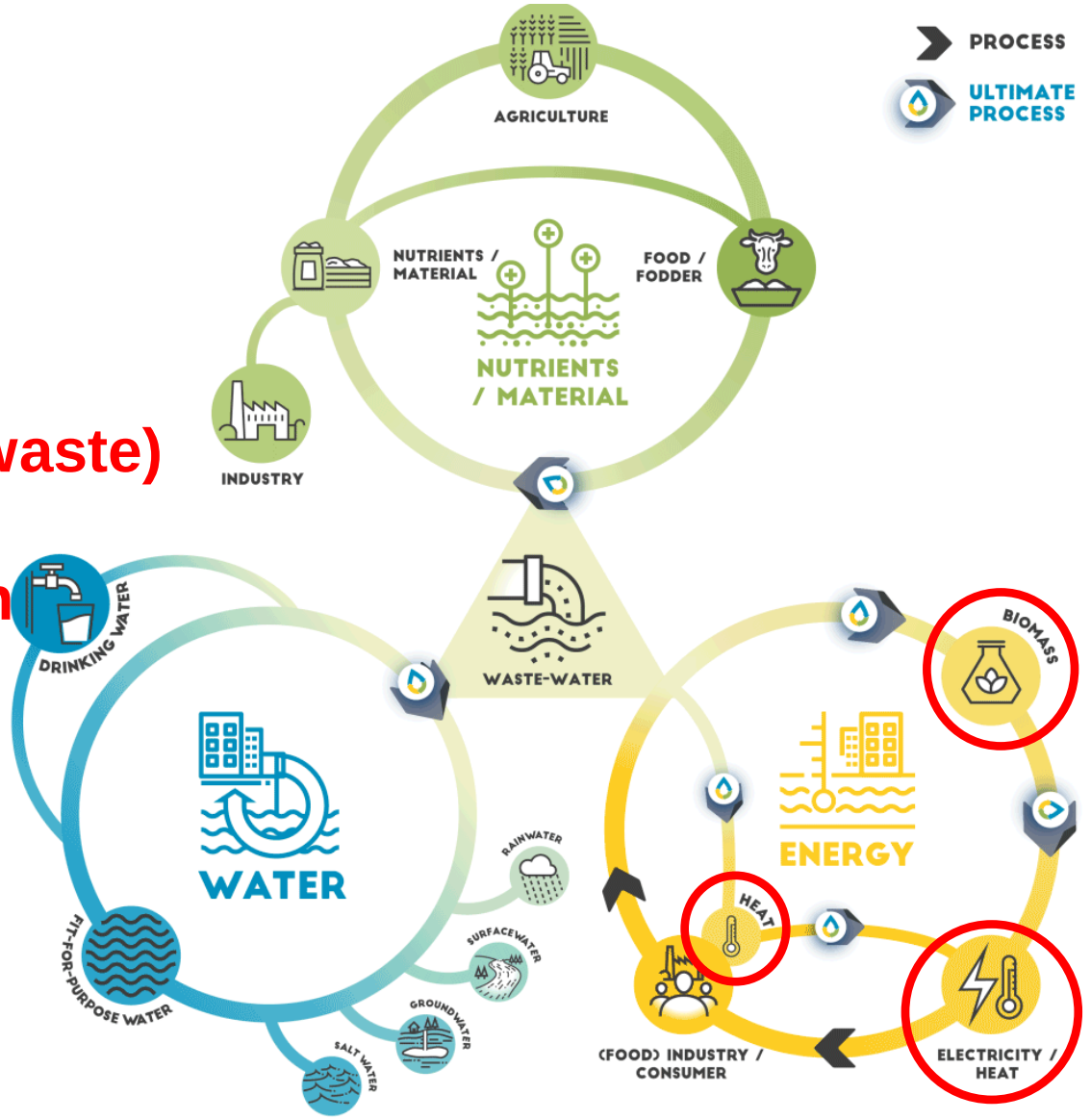
Wastewater is a valuable resource:

➡ energy recovery

- Heat recovery
- Biogas production
  (→ combination with organic waste)
- Electricity and heat production from biogas



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Nice concept, but how will it become a success?

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Find cooperation partners to create win-win situations:

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→ Who produces wastewater?

→ Who needs the recovered products (water, material, energy)?

→ Who is capable to operate the technologies?

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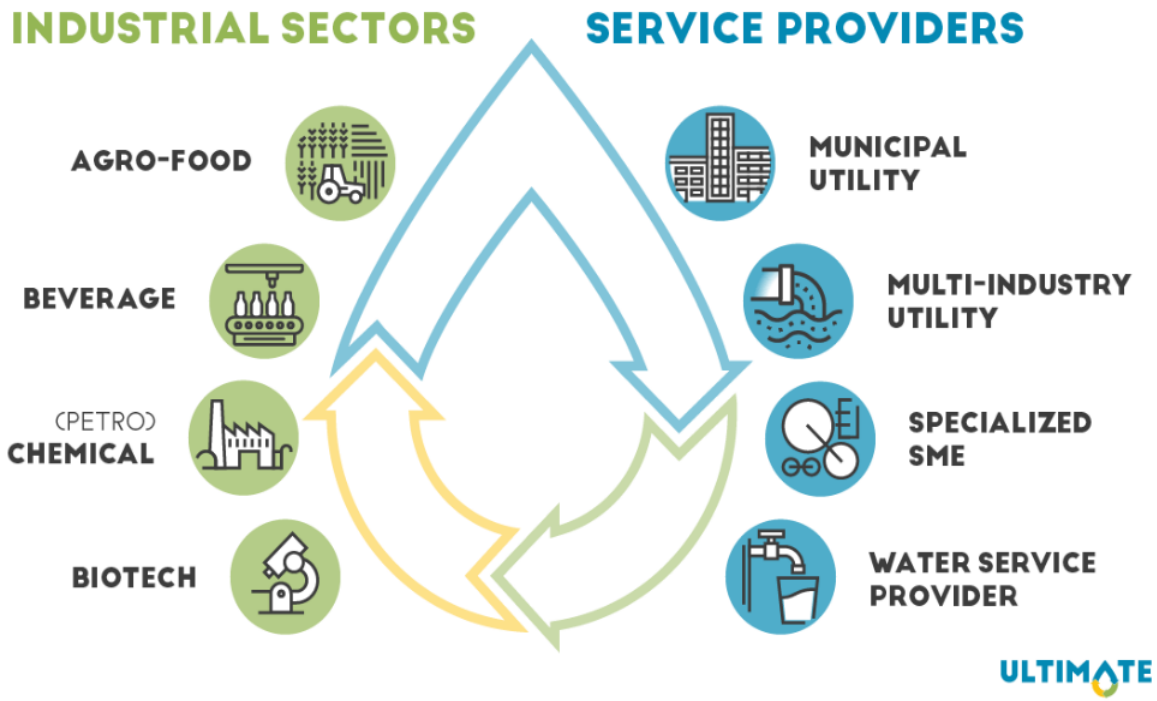
Water Smart Industrial Symbioses:



ULTIMATE (Jun. 2020 – Oct. 2024)

- 9 Case studies
- 24 Technologies
- 28 Partners

The project leading to this application has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 869318

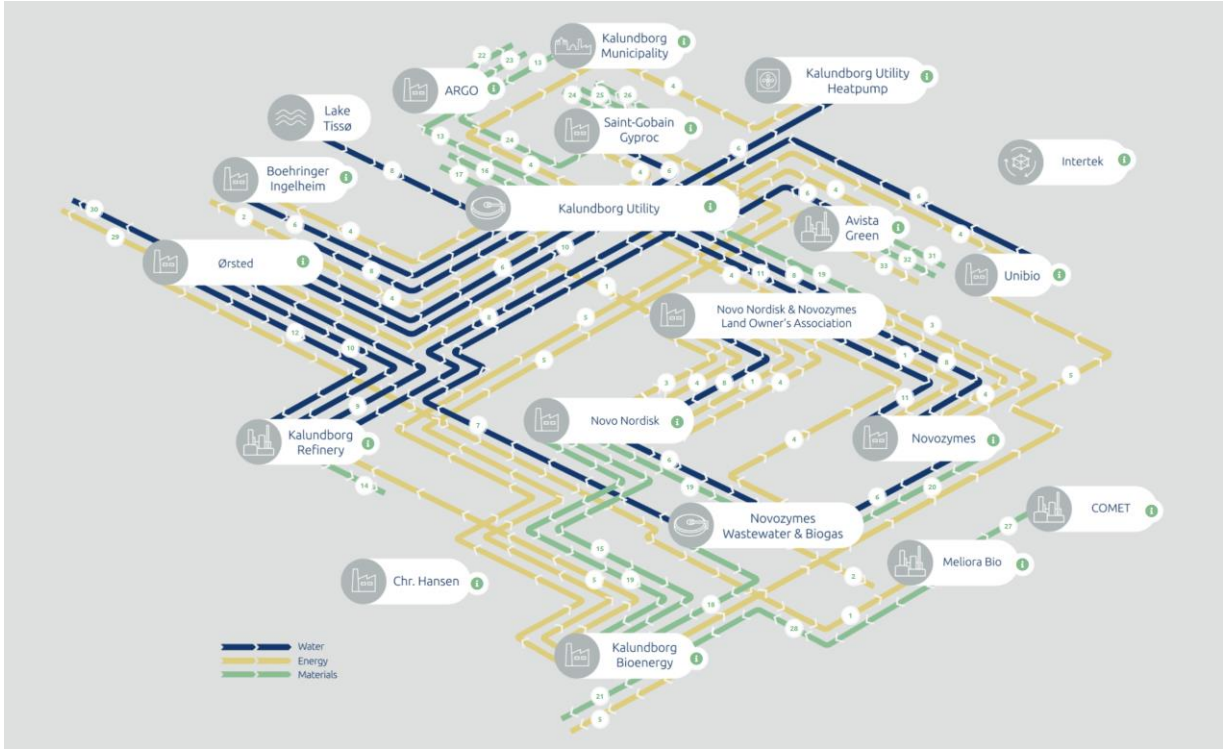
Example: Kalundborg Symbiosis since 1972

- **17 companies**
- **Reuse and recycling of water, energy and materials**

Success until now:

- **CO_2: 586,000 t/a** saved
- **CO_2 emissions: 80%** reduced since 2015
- **CO_2 neutral:** local energy supply
- **Materials: 62,000 t/a** recycled
- **Groundwater: 4 Mio. m^3/a** saved by using surface water

→ **ULTIMATE: further extension!**



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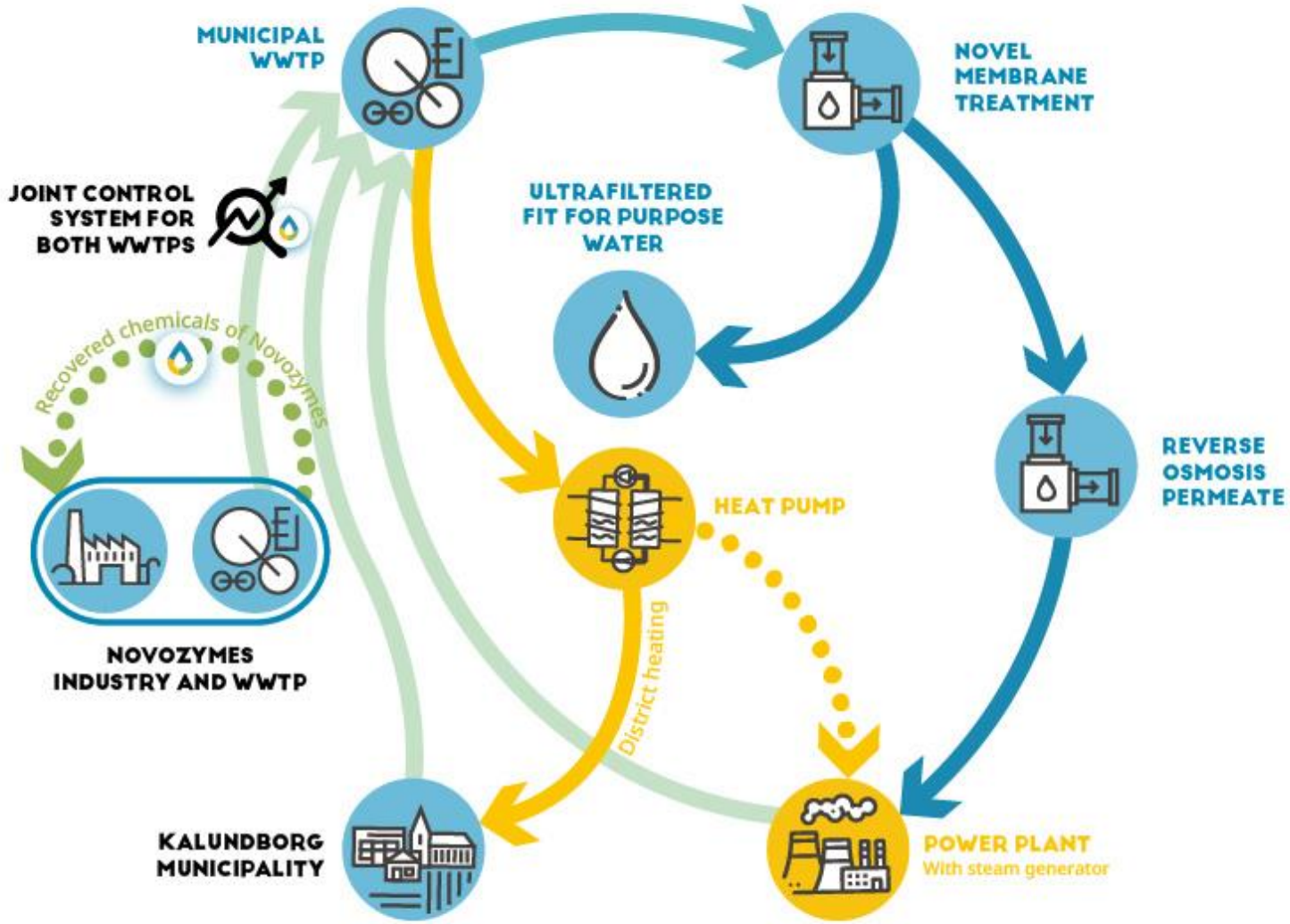
https://www.symbiosis.dk/en/partnerne-bag/

Kalundborg (DK)

- Biotech & pharmaceutical industry, etc.
- Joint control system for two WWTPs
- Fit-for-purpose water for industrial reuse (cooling tower)



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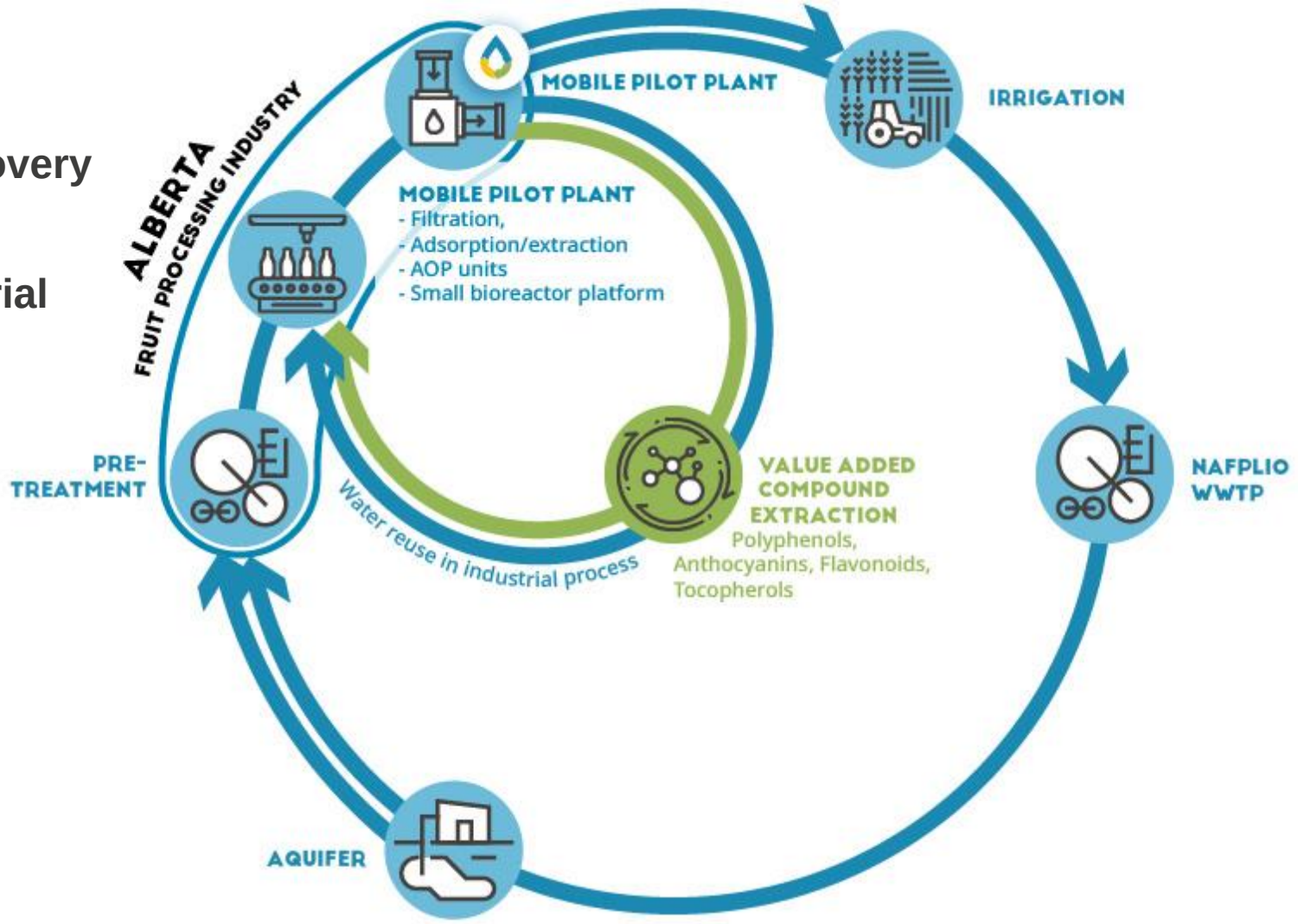
Nafplio (EL)

- Fruit processing industry
- Polyphenol and antioxidant recovery as high added value products
- Fit-for-purpose water for industrial reuse & irrigation



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Lleida (ES)

- Brewery
- Biogas production
- Heat & electricity production
- Fit-for-purpose water for industrial reuse and irrigation

Nice, but in my case….

Which technologies can be applied?

What does it cost?

Are they environmentally friendly?

Which legislative framework is necessary for the implementation of such a concept?

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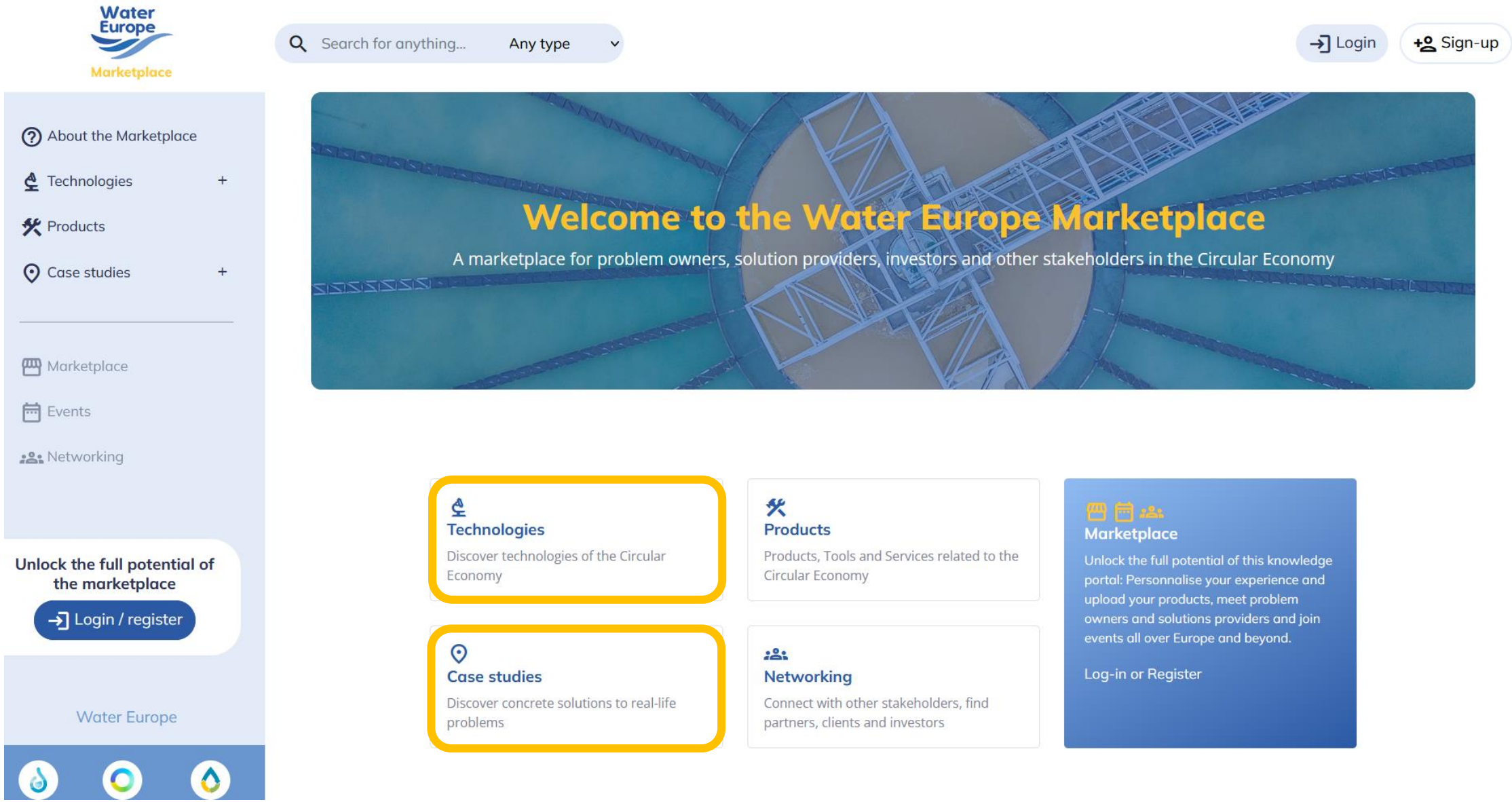
Water Europe Marketplace: Technology Evidence Base

https://mp.watereurope.eu/



Technology factsheets

→ 50 factsheets

Adsorption with sludge-based renewable adsorbents

Ammonium sulphate production (air stripping & scrubbing)

Anaerobic Membrane Bioreactor (AnMBR) with degassing unit

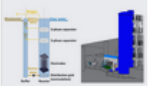
Immobilised high rate anaerobic reactor

Aquifer Thermal Energy Storage

Electrodialysis

Sulphur Recovery

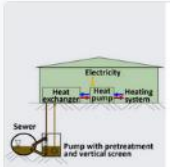
Joint control system for two wastewater treatment plants



Electrostimulated anaerobic reactor

Membrane distillation

Softening, coagulation and flocculation with alternative by-products



Low grade heat recovery from wastewater

Solid oxide fuel cell using biogas

Ultrafiltration & nanofiltration membranes as pre-treatment for reverse osmosis

Case study factsheets

→ 28 factsheets

→ Deliverables/results

→ Contact data of case study leaders

Camp de Tarragona, Spain

- Description
- Applied technologies
- Applied products
- Related publications and references

Chemcial Platform of Roussillon

- Description
- Applied technologies
- Related publications and references

Kalundborg, Denmark

- Description
- Applied technologies
- Applied products
- Related publications and references

Karmiel and Shafdan, Israel

- Description
- Applied technologies
- Related publications and references

Lleida, Spain

- Description
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- Related publications and references

Nafplio, Greece

- Description
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- Related publications and references

Nieuw Prinsenland, Netherlands

- Description
- Applied technologies
- Outcome of assessments
- Applied products
- Related publications and references

Rosignano, Italy

- Description
- Applied technologies
- Related publications and references

Tain, United Kingdom

- Description
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Contact

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Thanks for your attention!

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