

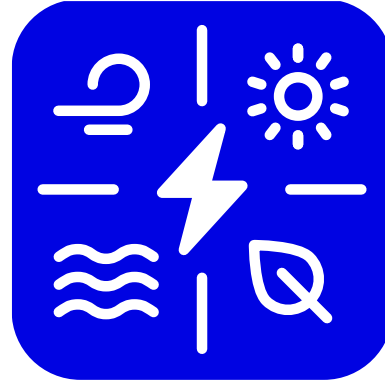


KWVB

Resilient water management strategies for Kalundborg

Anne Kleyböcker, Malte Zamzow, Ulf Miehe

Research and Consulting since 2001



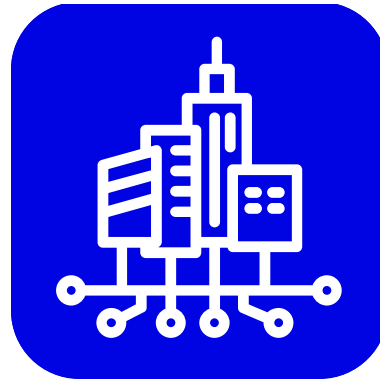
Energy & Resources



Water Treatment &
Reuse



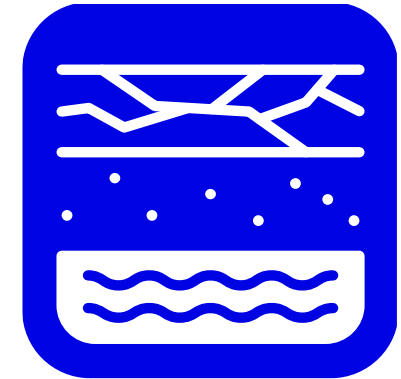
Water & Risk



Stormwater &
Surface Waters



Smart City &
Infrastructure



Groundwater



Cooperation with Kalundborg

- **2017-2022**  **CWPharma**
- **2020-2024**  **ULTIMATE**
- **2024-2027**  **REACREATE**

Cooperation with Kalundborg

Alternative water resources for a resilient water management strategy

• 2020-2024 **ULTIMATE** 

• 2024-2027 **REACREATE** 



WATER SMART INDUSTRIAL SYMBIOSIS

Industry water utility symbiosis for a smarter water society

Kleyböcker, A., Jählig, J., Schütz, J., Kraus, F., Rodenkam Melchiorson, L., Bendix Larsen, S., Kristensen, M., Milter, H., Thisgaard, P., Vredenbregt, L., Miehe, U.



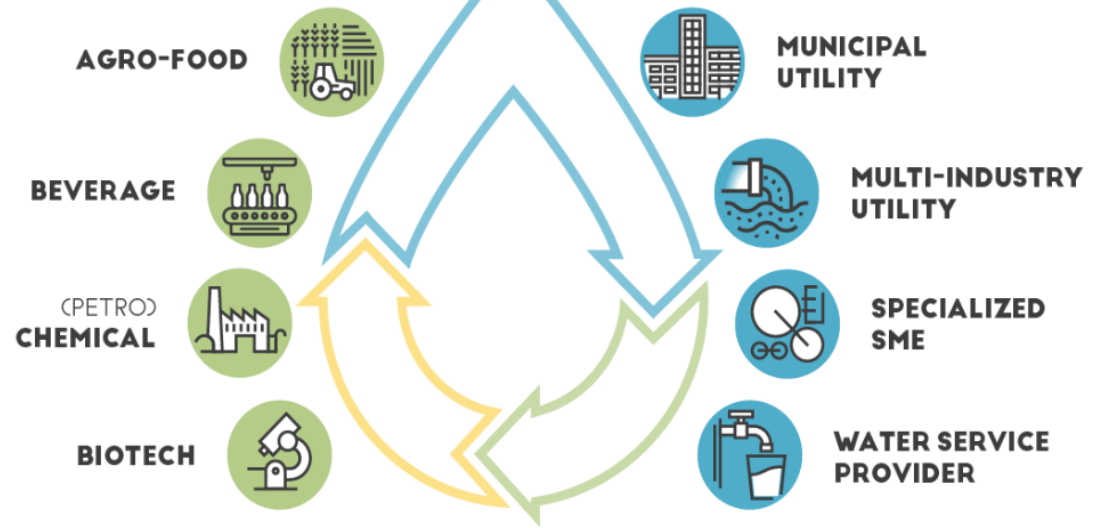


ULTIMATE solutions involve circular economy technologies

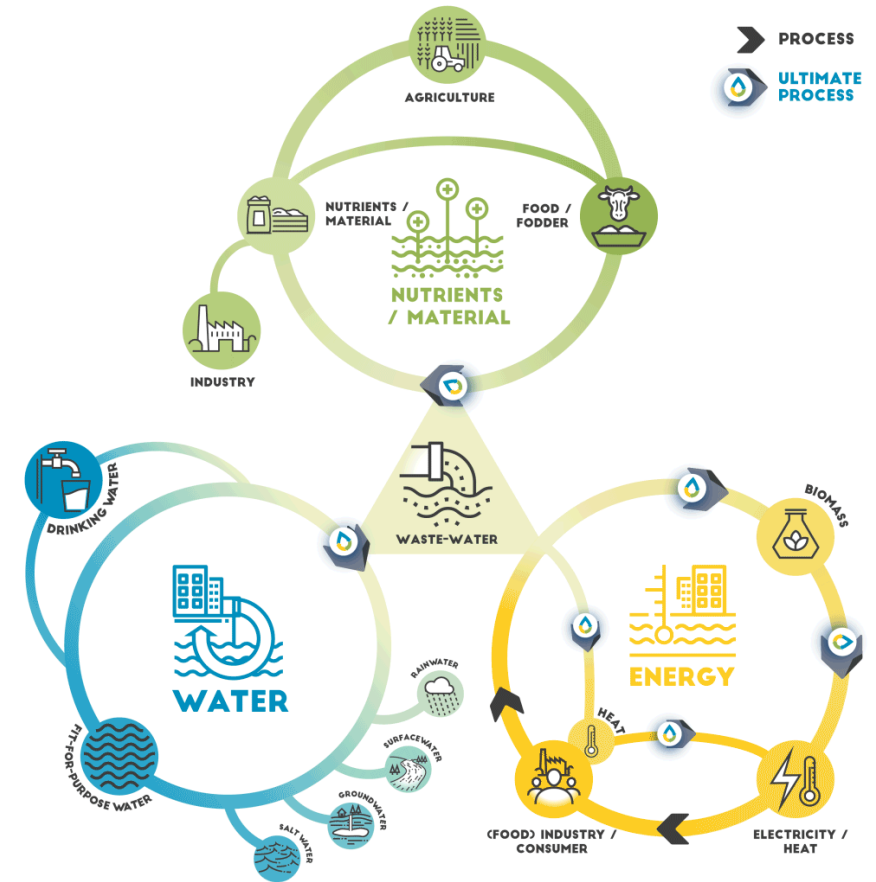
SYMBIOSES BETWEEN:

INDUSTRIAL SECTORS

SERVICE PROVIDERS



ULTIMATE



➔ PROCESS
ULTIMATE PROCESS





ULTIMATE

- 9 Case studies
- 24 Pilot plants
- 28 Partners

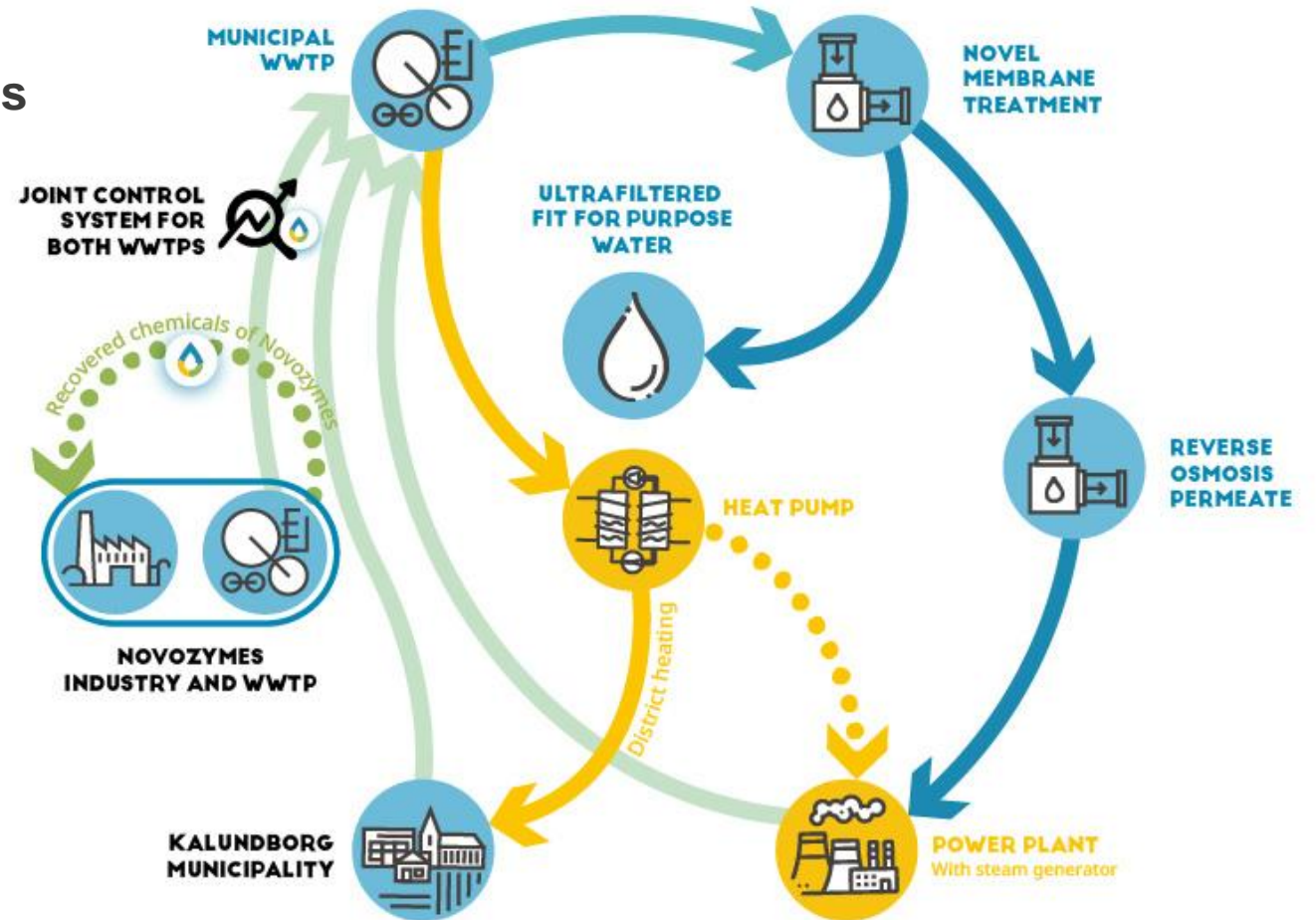


The project leading to this application has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 869318



CS9 Kalundborg (DK)

- Biotech & pharmaceutical industry
- Production of cooling water
- Joint control system for two WWTPs





Water reclamation → industrial cooling

- 2 years of pilot plant operation
- Best performance: dual media filter + cUF + RO
- **Cooling water quality** achieved

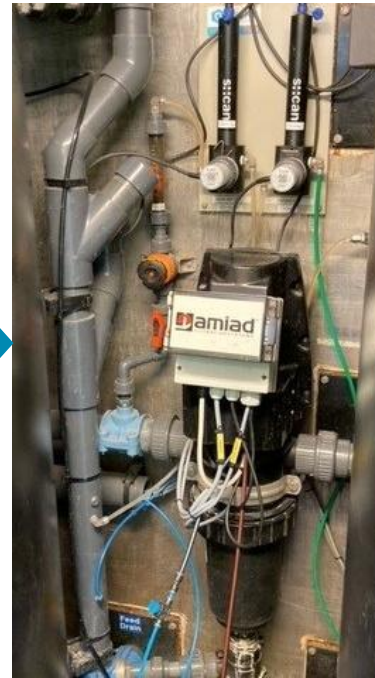
→ Jährig et al. 2025 Wat. Sci. Tech.



Dual media filter



Pre-filter



Ultrafiltration/
Nanofiltration
cUF/tUF/NF



Reverse Osmosis
RO



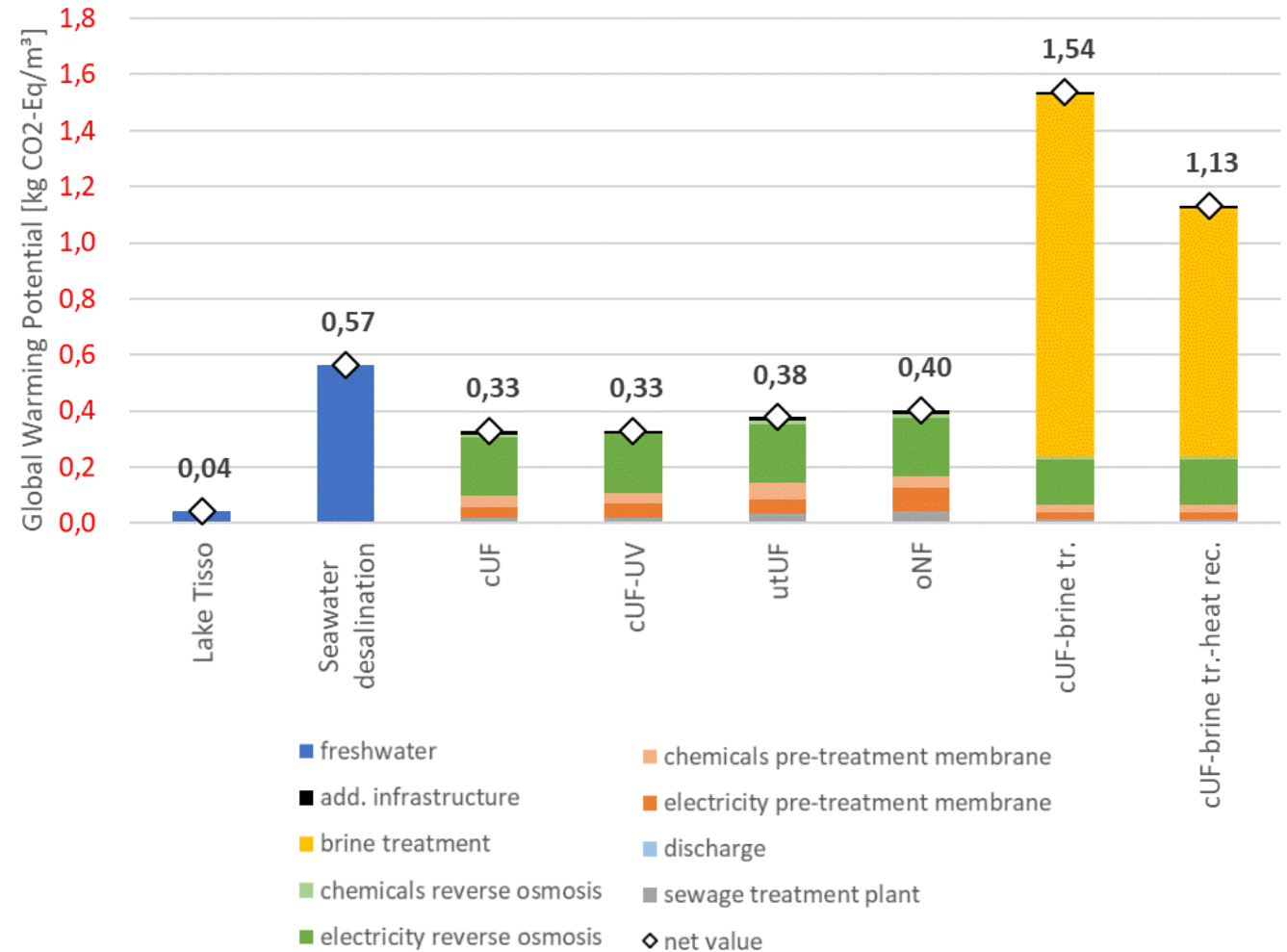
Cooling
water



Water reclamation: CO₂-footprint is lower compared to seawater desalination

Learnings from LCA:

- Reclaimed water has lower GHG footprint than desalinated seawater
- Brine treatment is crucial → more R&D needed!
- Heat reuse decreases GHG footprint

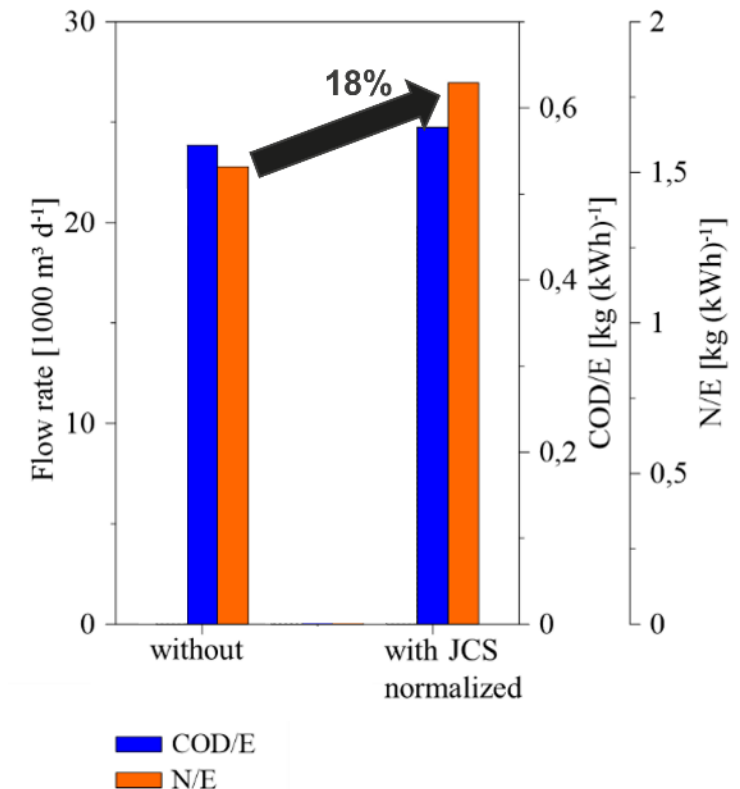
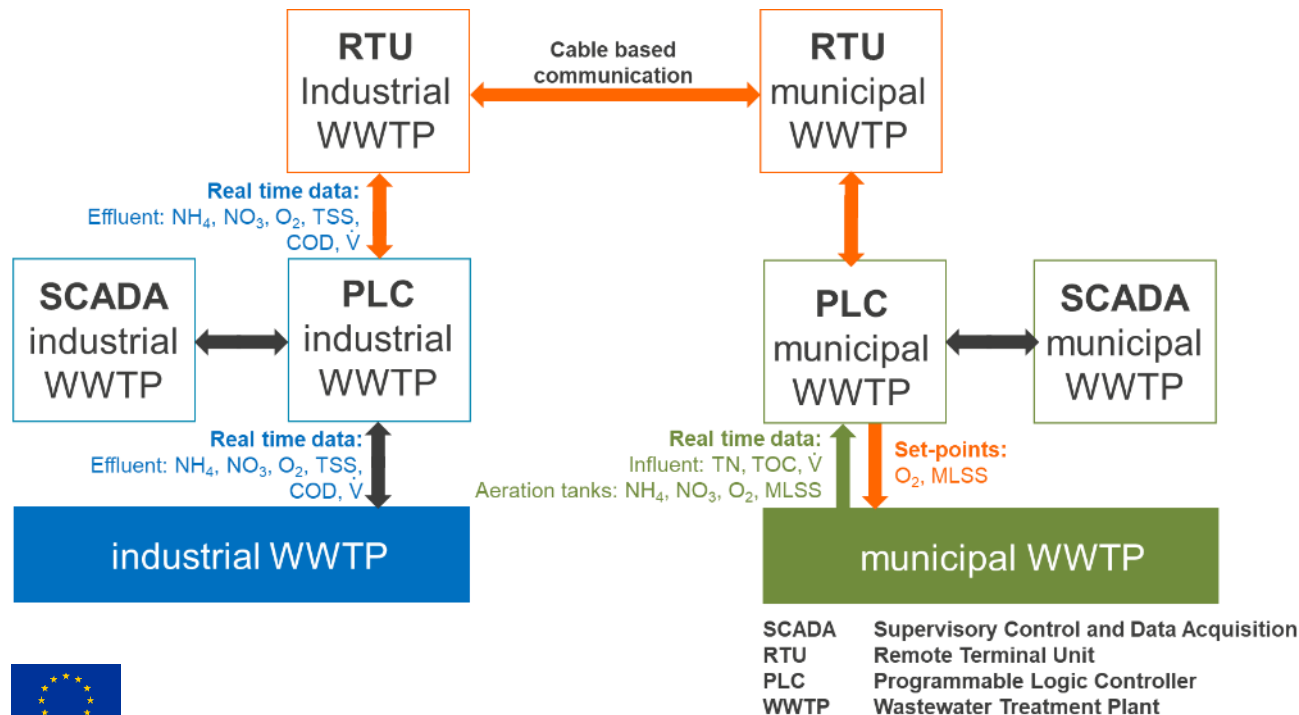




Joint control system implemented in real environment

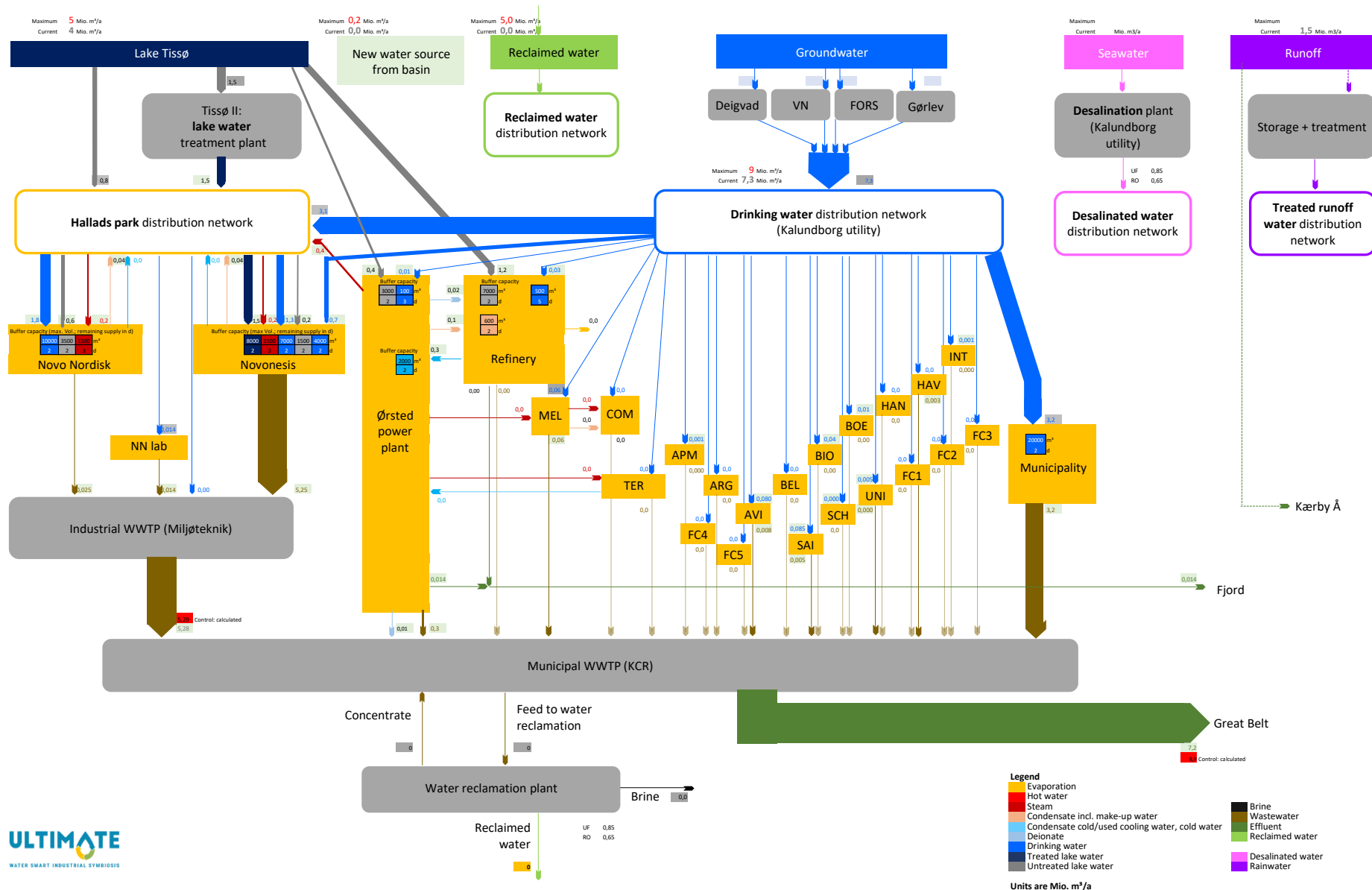
- Predicts increasing nitrogen loads from iWWTP → mWWTP
 - Enables demand-driven aeration in mWWTP
- Increase in energy efficiency: **18% (N/E)**

→ Schütz et al. 2024 Wat. Sci. Tech.





Dynamic tool to visualize water types and flow rates



Reliability and effectiveness of integrated **alternative water resources (AWR)** management for regional climate change adaptation

Kleyböcker, A., Thisgaard, P., Zamzow, M., Mieke, U.

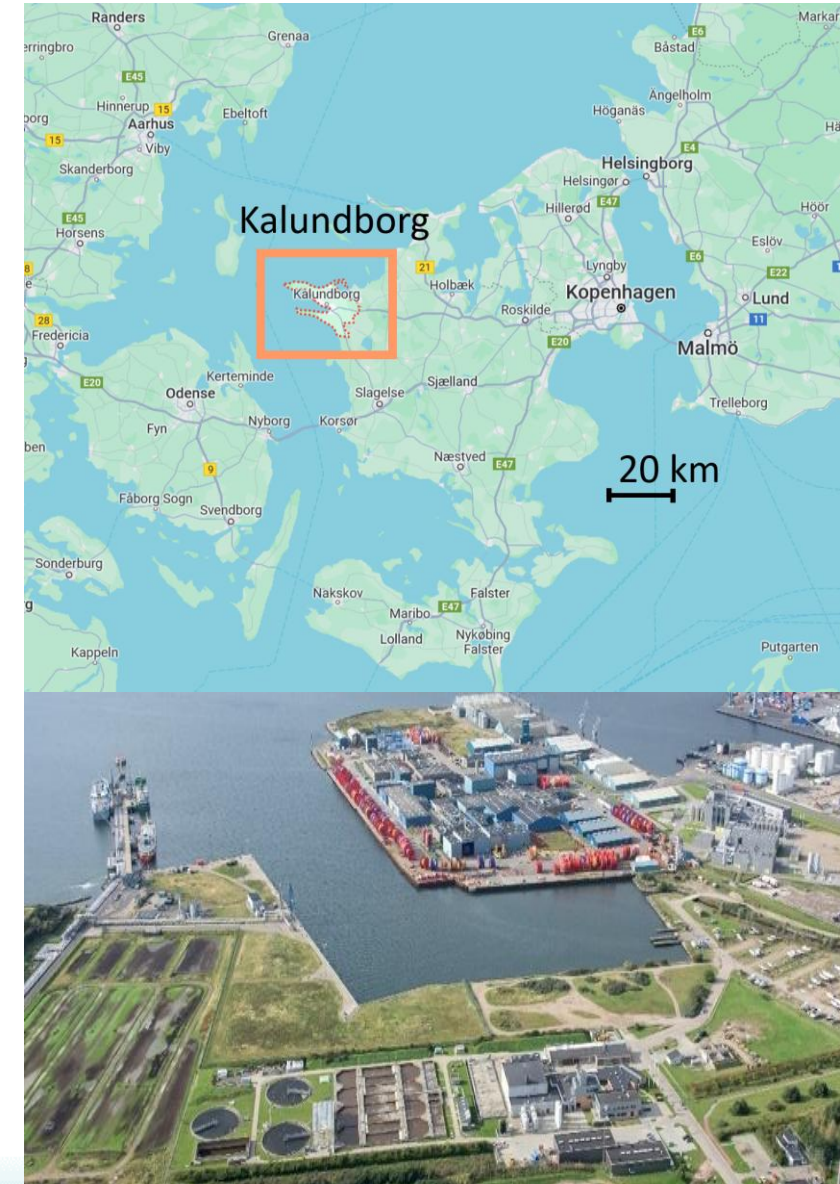




CS2 – Kalundborg

- Expansion of Industrial Symbiosis
- Lake Tissø: uncertainty about future water extraction
- Longer drought periods (summer)
- More precipitation (winter)
- Groundwater availability: limited
- Uncertainty about the price of fit-for-purpose water and how to finance new distribution systems
- EU 2020/741: not yet applied in Denmark

→ **New executive orders and laws supporting AWR in preparation!**



Governance structure is changing → enabling water reuse and the use of AWR

New executive order and law in preparation supporting the use of AWR e.g.:



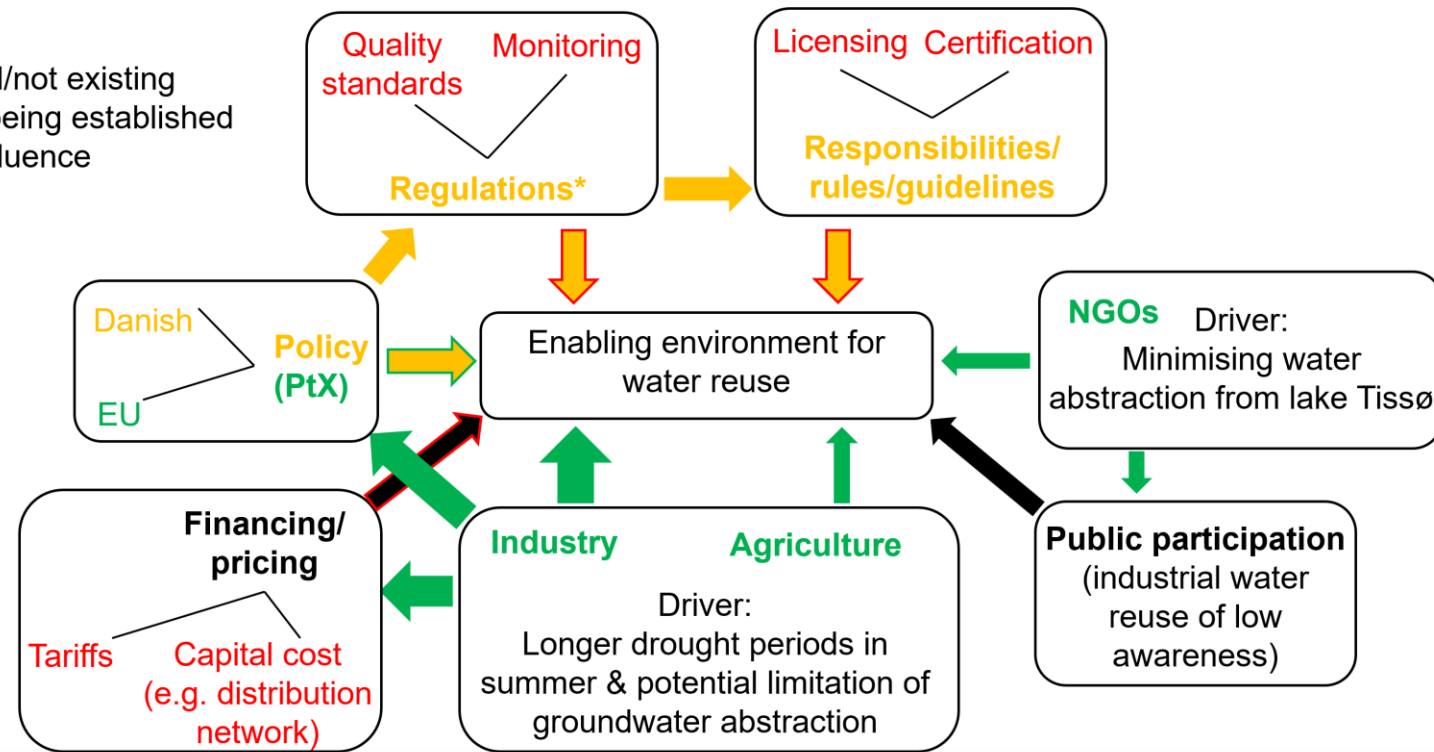
→ Allowing to use desalinated seawater for drinking water production



→ Source for technical water (no drinking water) can be: e.g. treated wastewater

Legend:

- not defined/not existing
- changing/being established
- positive influence
- neutral



Climate change impact modelling



→ Future scenarios



UWOT modelling



→ Capacity design and upgrade of new and existing infrastructure



Water Management Strategy (WMS)



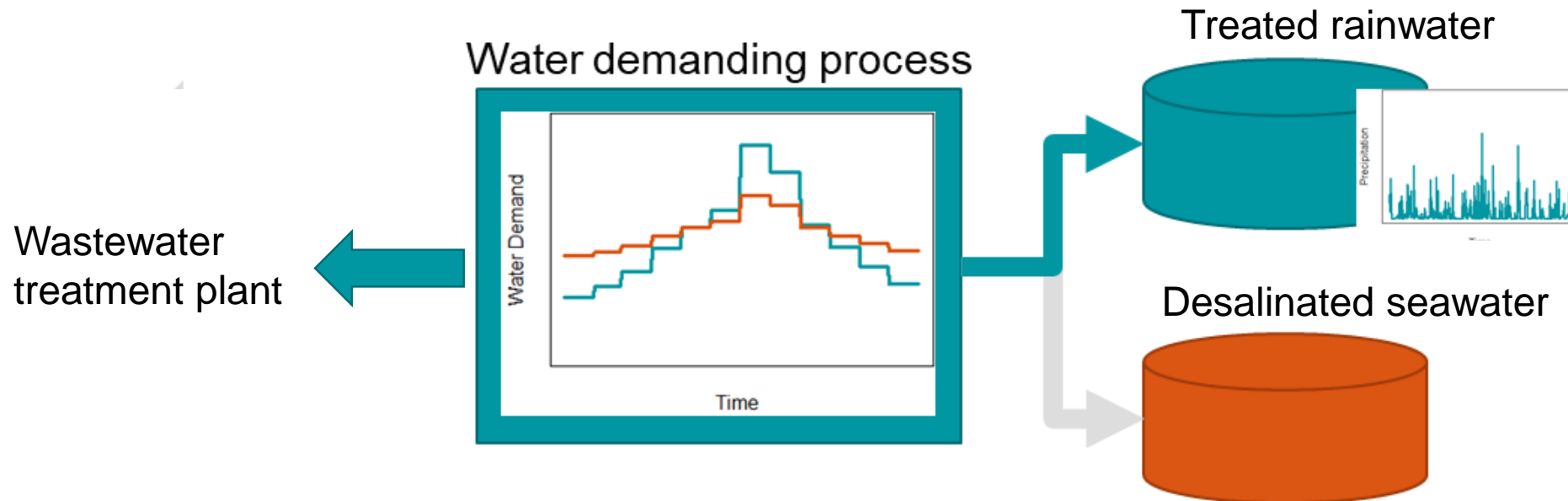
LCA, cost efficiency, microbial and chemical risk assessments → Optimisation of WMS



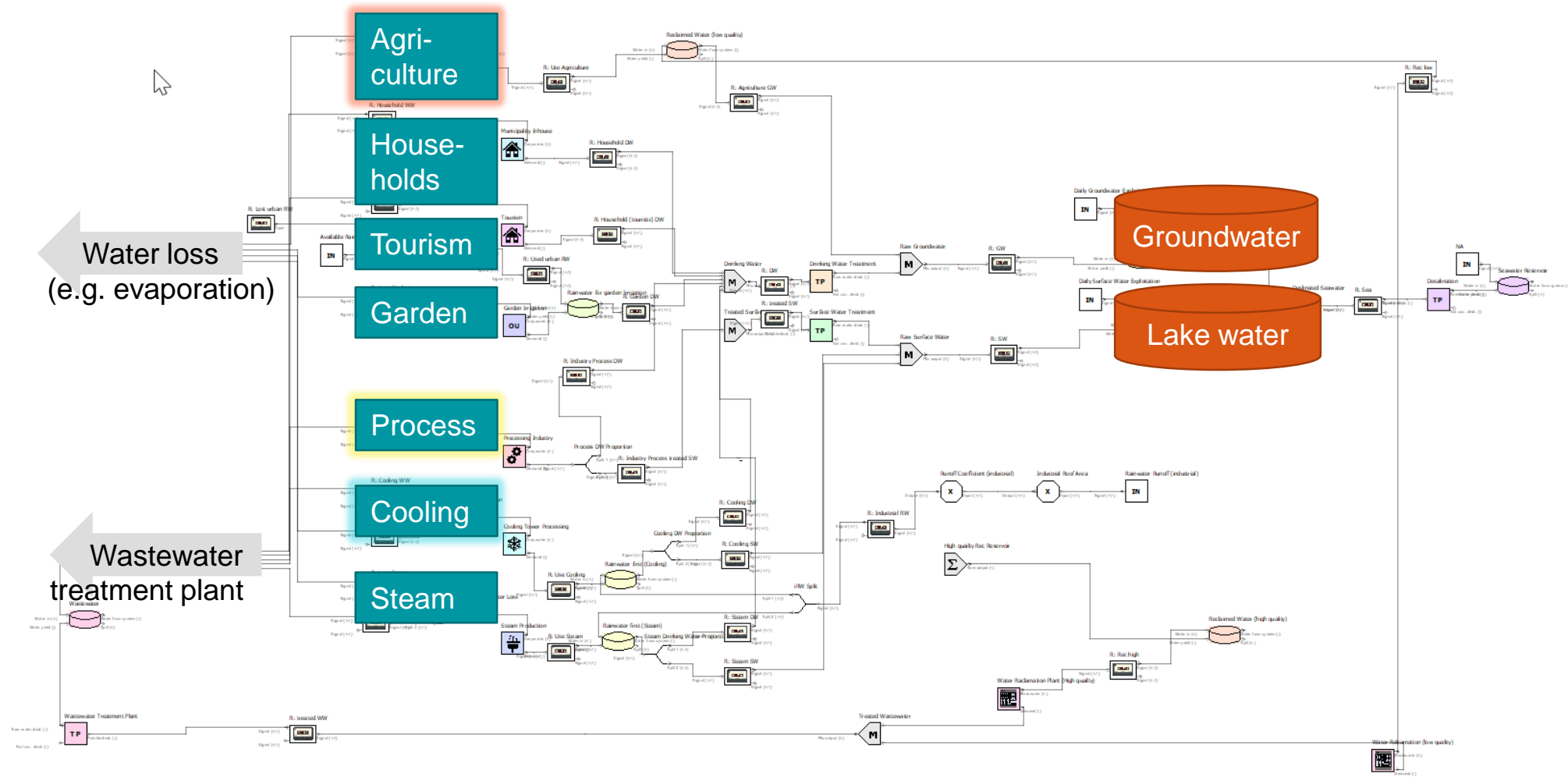
Input: Risk Management Plan

Urban Water Optioneering Tool (UWOT)

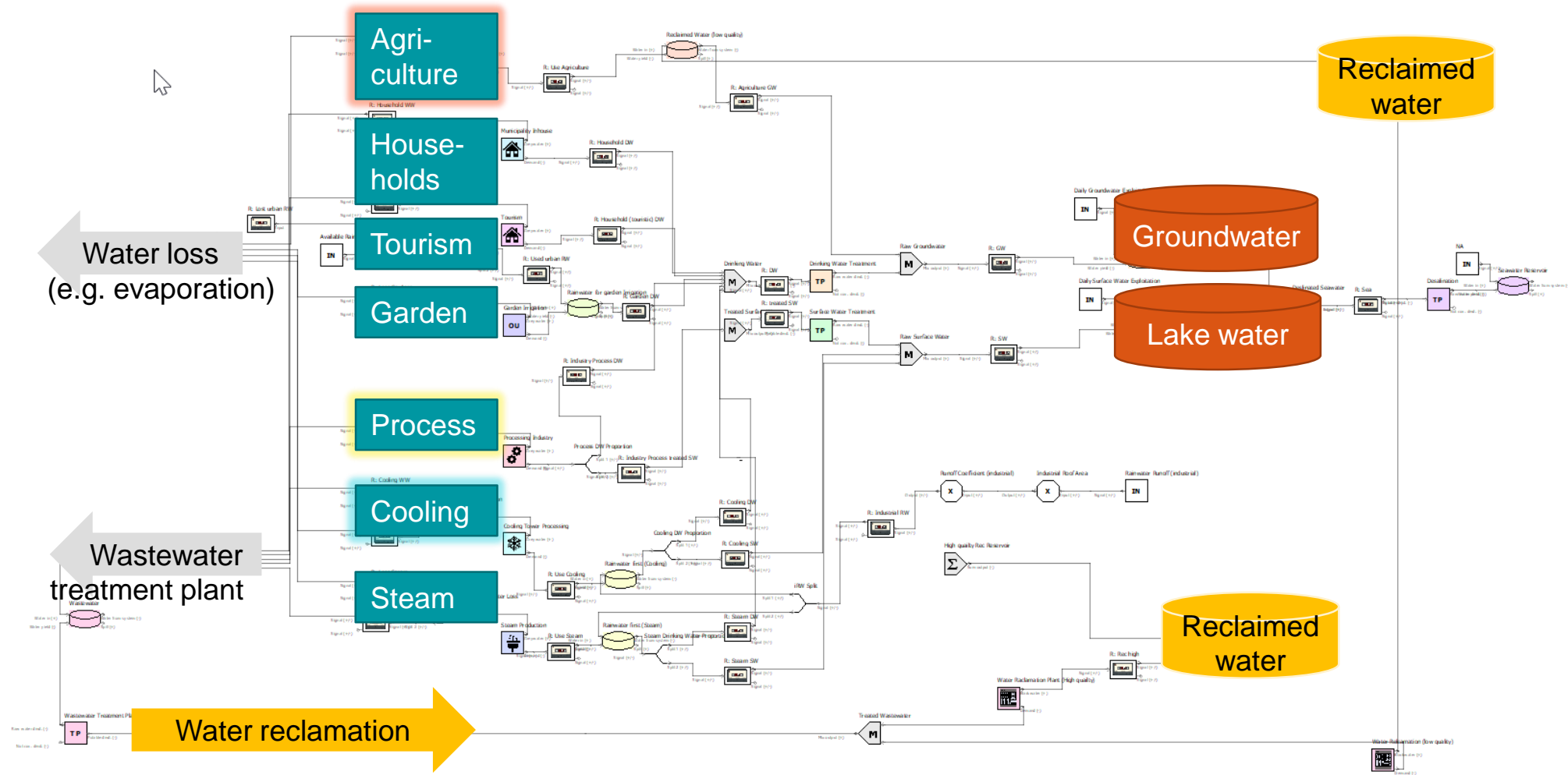
- Simulation of different scenarios
- Considering climatic conditions and seasonal effects
- Dynamic simulation with adjustable timesteps
- Possibility of water source prioritisation
- Capacity design and upgrade of new and existing infrastructure



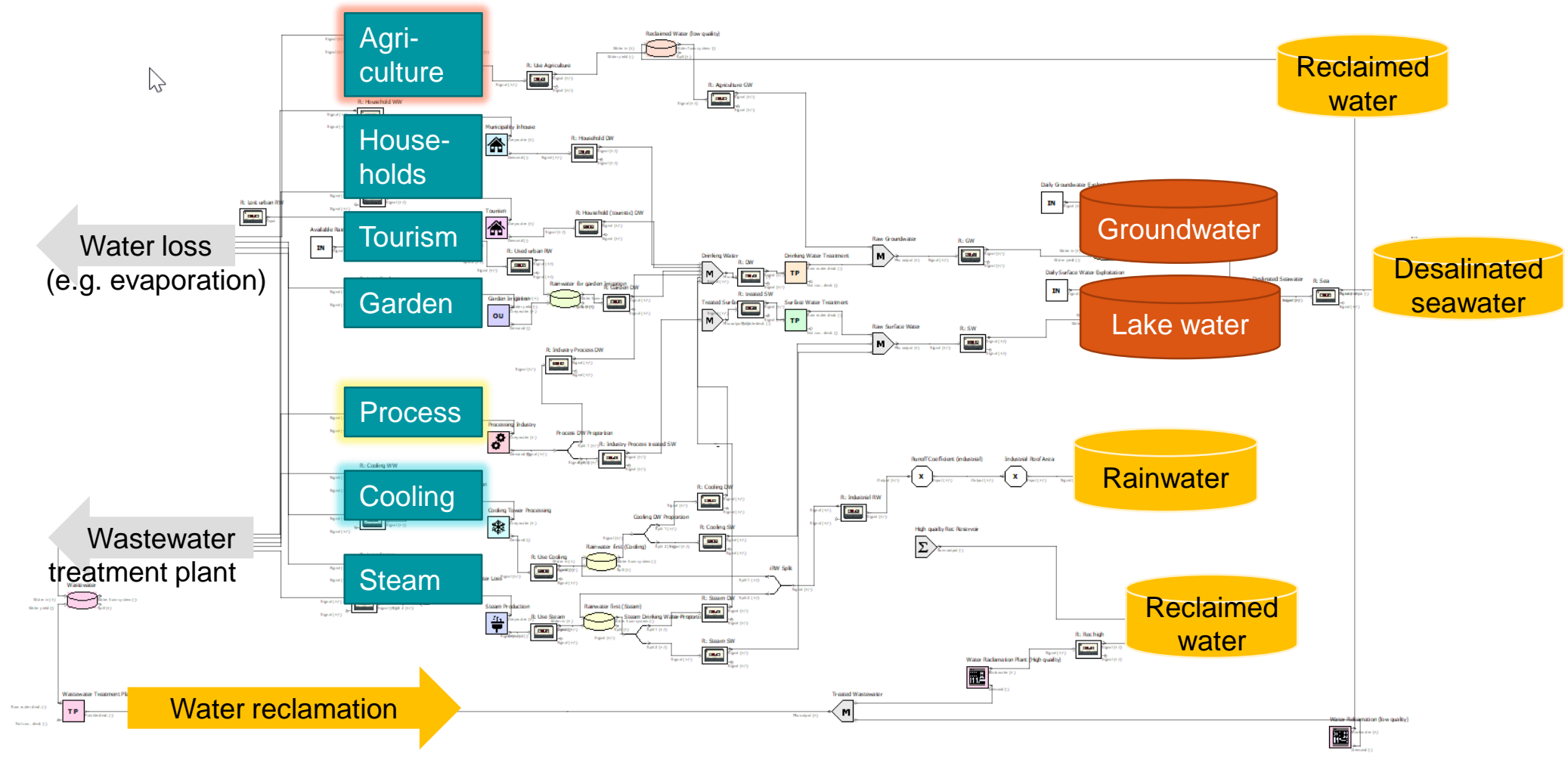
RECREATE Example: UWOT model



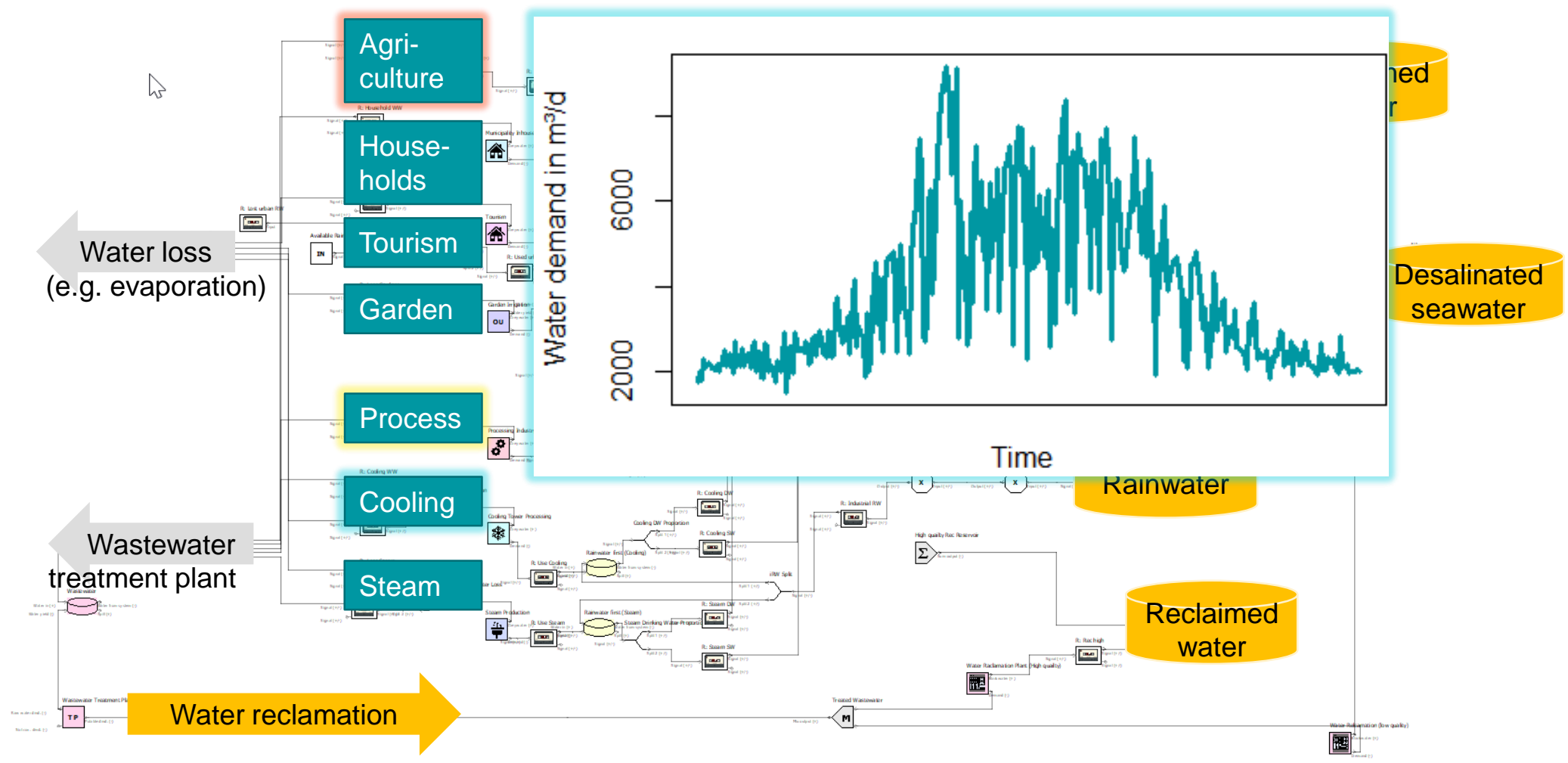
REACREATE Example: UWOT model



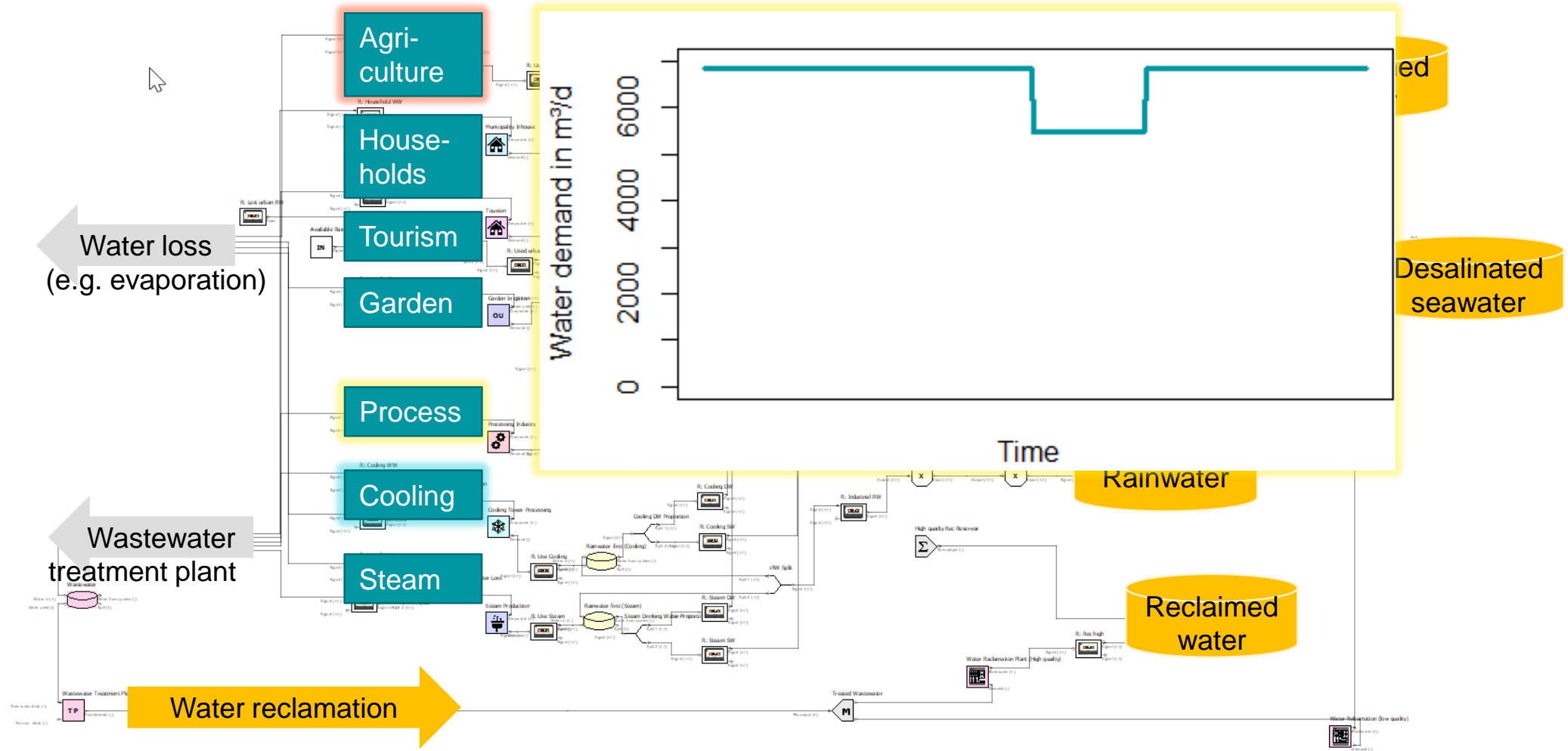
RECREATE Example: UWOT model



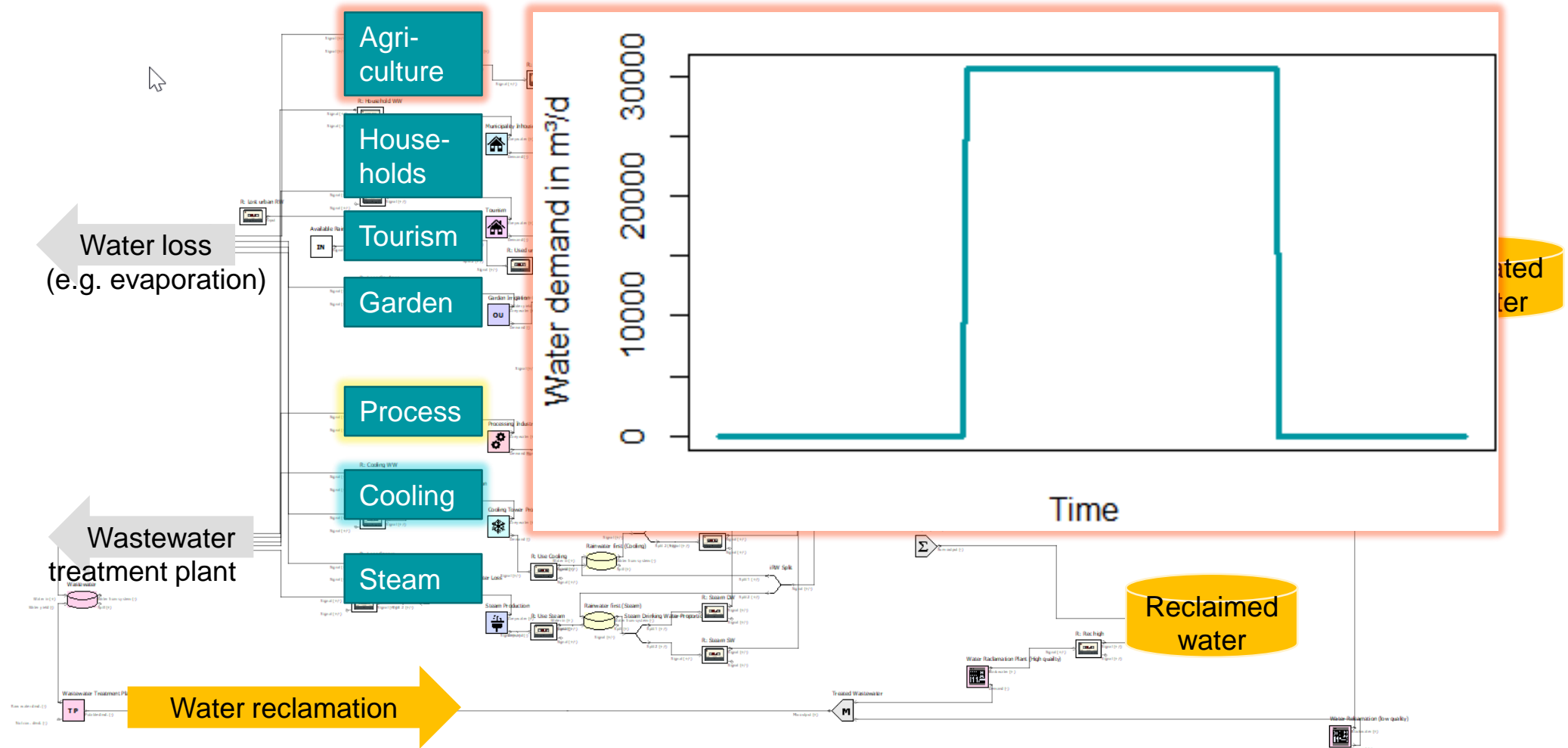
RECREATE Example: UWOT model



RECREATE Example: UWOT model



RECREATE Example: UWOT model



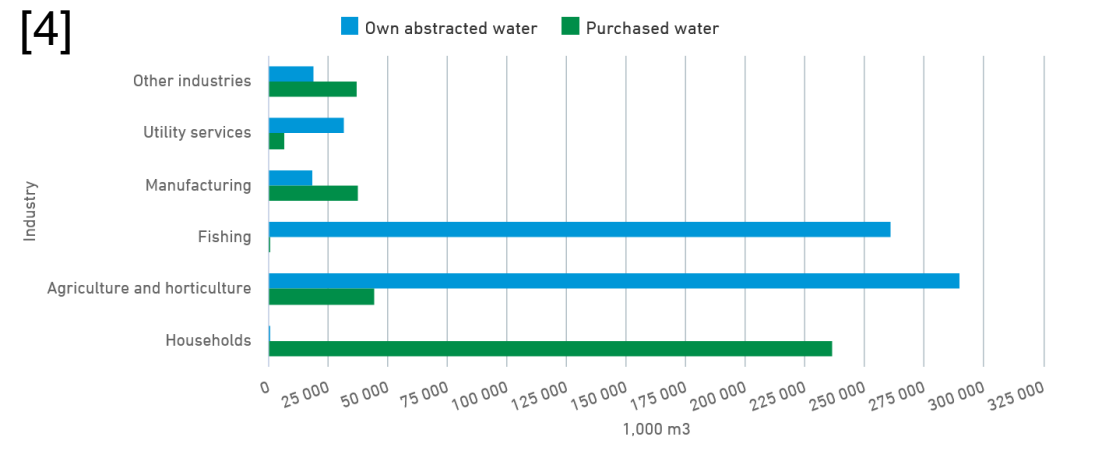
Estimation: water consumption for agricultural irrigation

Area of Kalundborg Municipality (KAL):	604 km ² [1]
Agricultural area of KAL:	60-70% (estimated using googlemaps)
Area DK	42434 km ² [2]
Agricultural area in DK:	65% [3]
Agricultural irrigation in DK (2023):	330 M m ³ /a [4]
Agricultural irrigation in KAL:	4.7 M m³/a

Water consumption in industries and households, 1,000 m³

Time: 2023 | Water type:

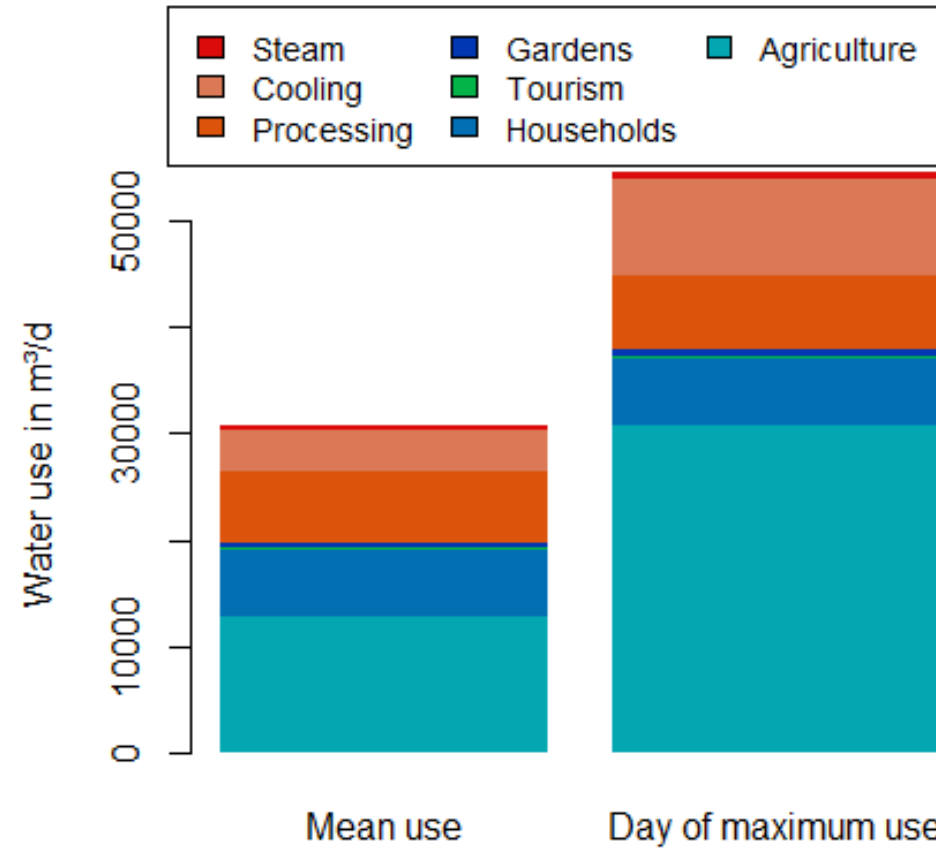
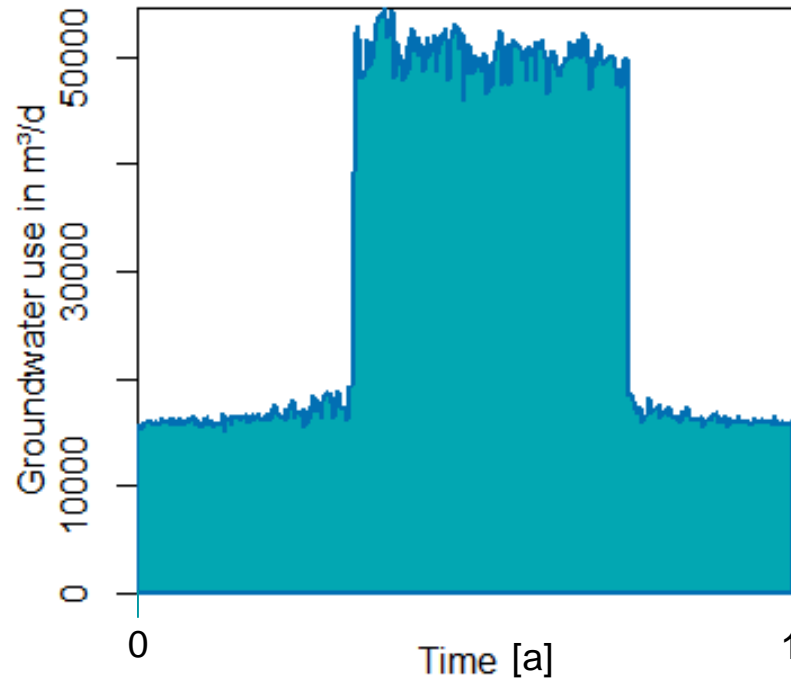
[4]



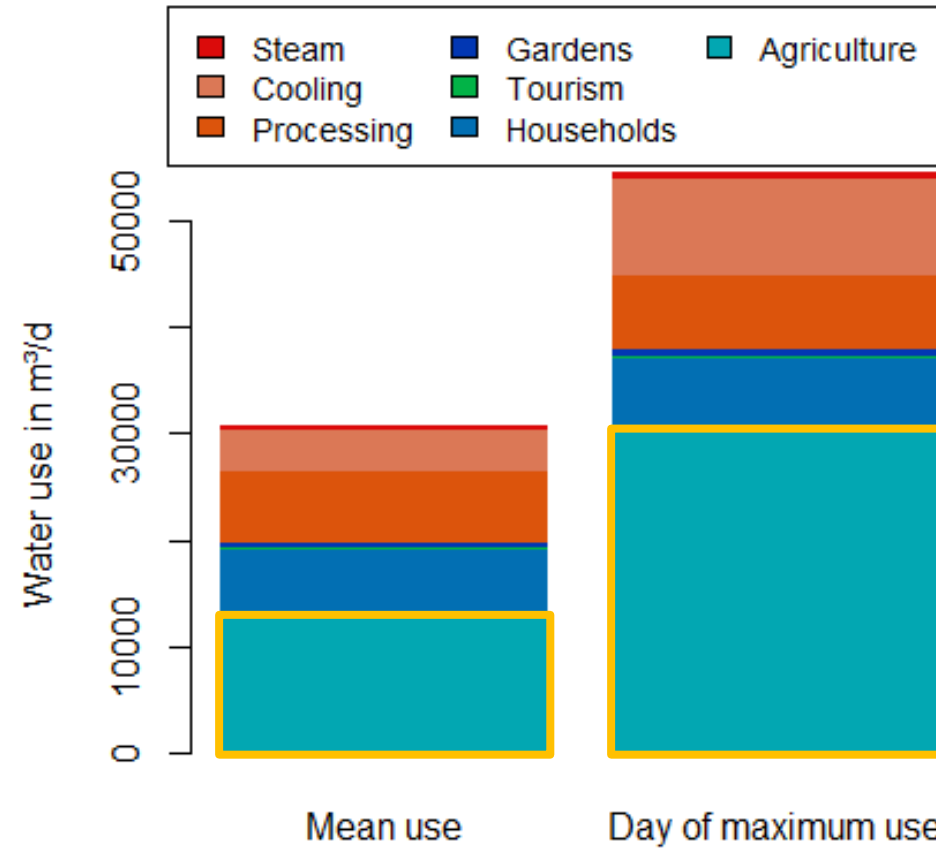
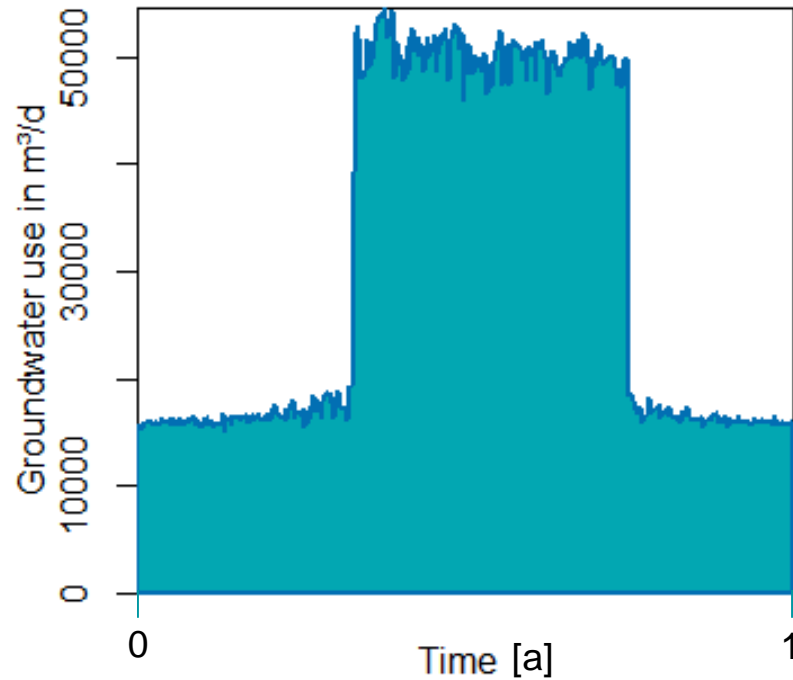
References:

- [1] https://en.wikipedia.org/wiki/Kalundborg_Municipality
- [2] <https://www.cia.gov/the-world-factbook/countries/denmark/#geography>
- [3] <https://tradingeconomics.com/denmark/agricultural-land-percent-of-land-area-wb-data.html>
- [4] <https://www.dst.dk/en/Statistik/emner/miljoe-og-energi/groent-nationalregnskab/vand-og-spildevand>

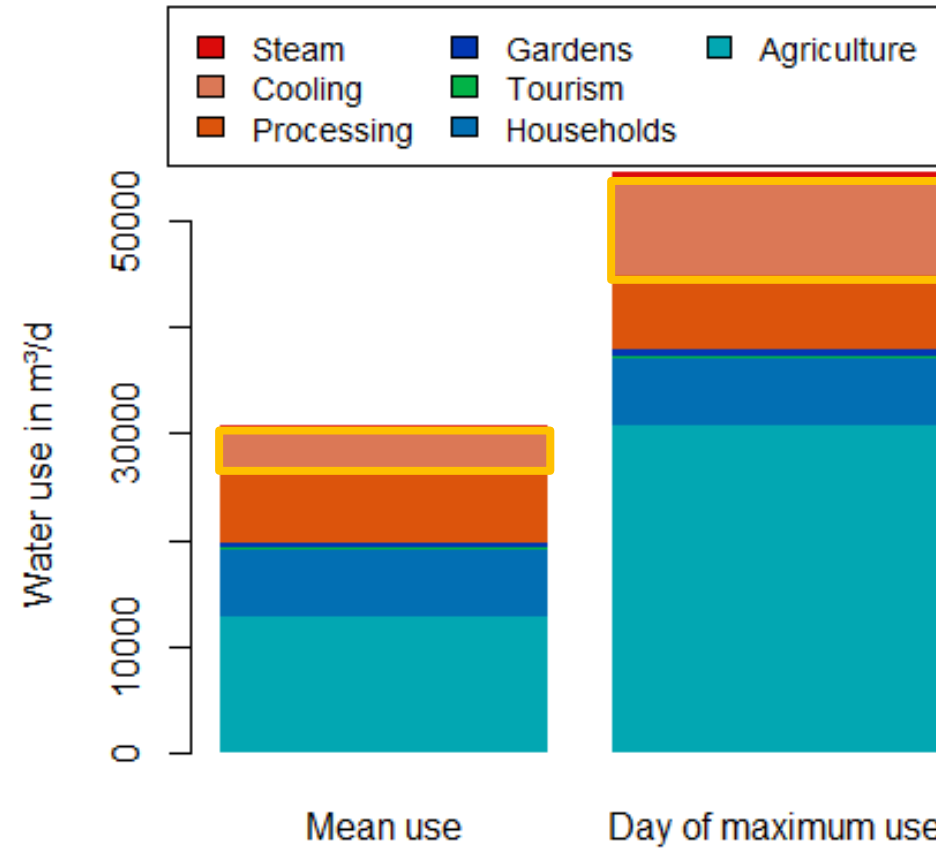
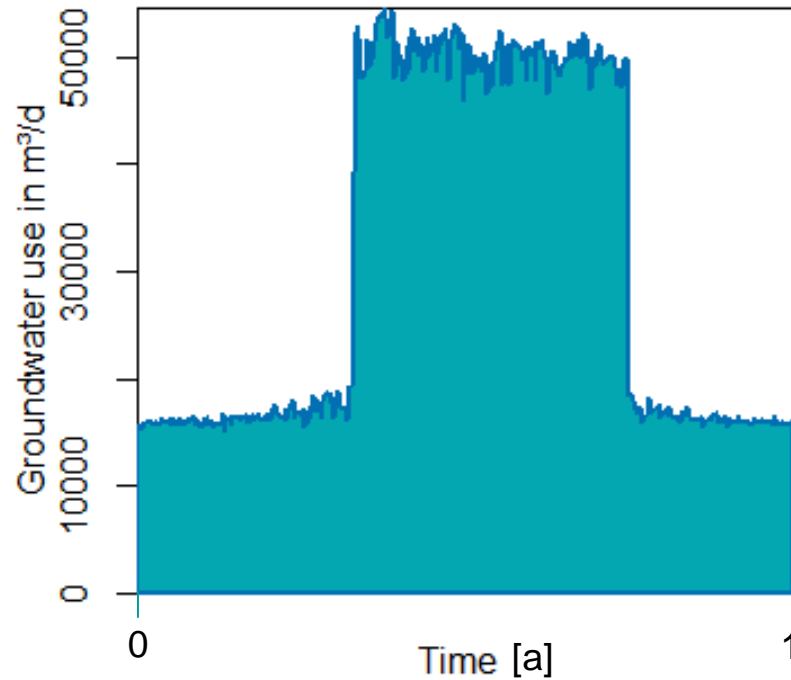
Example of seasonal variation → peak events are crucial



Example of seasonal variation → peak events are crucial



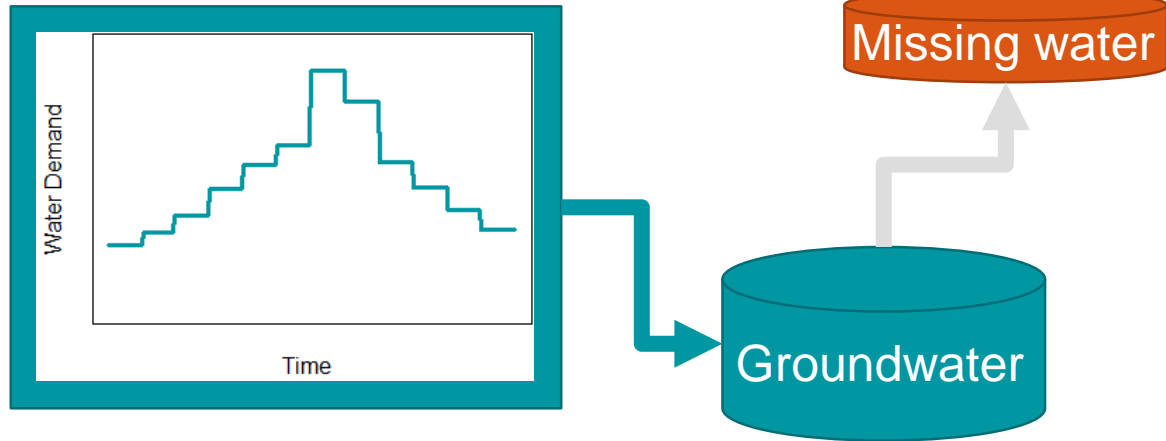
Example of seasonal variation → peak events are crucial



Types of water resource hierarchy for future scenarios

Step 1: How much water is missing when?

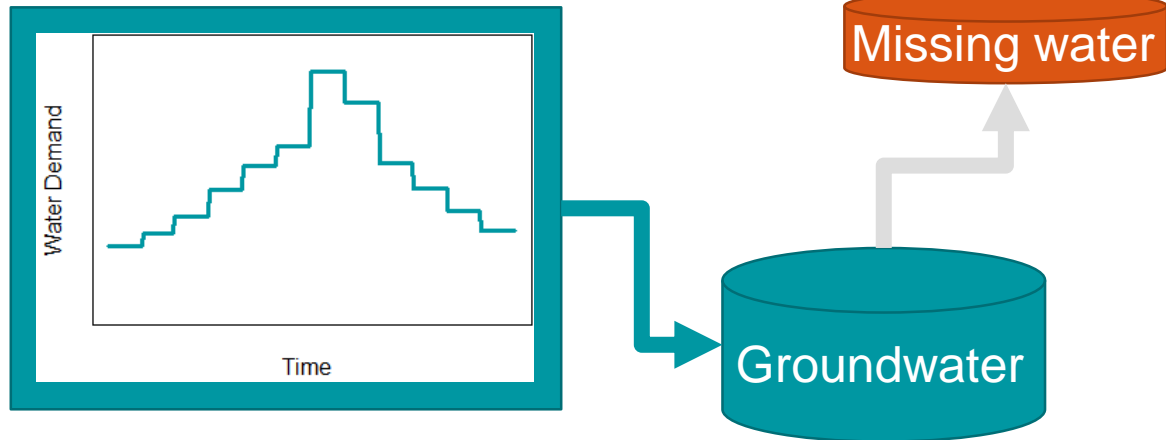
Water demanding process



Types of water resource hierarchy for future scenarios

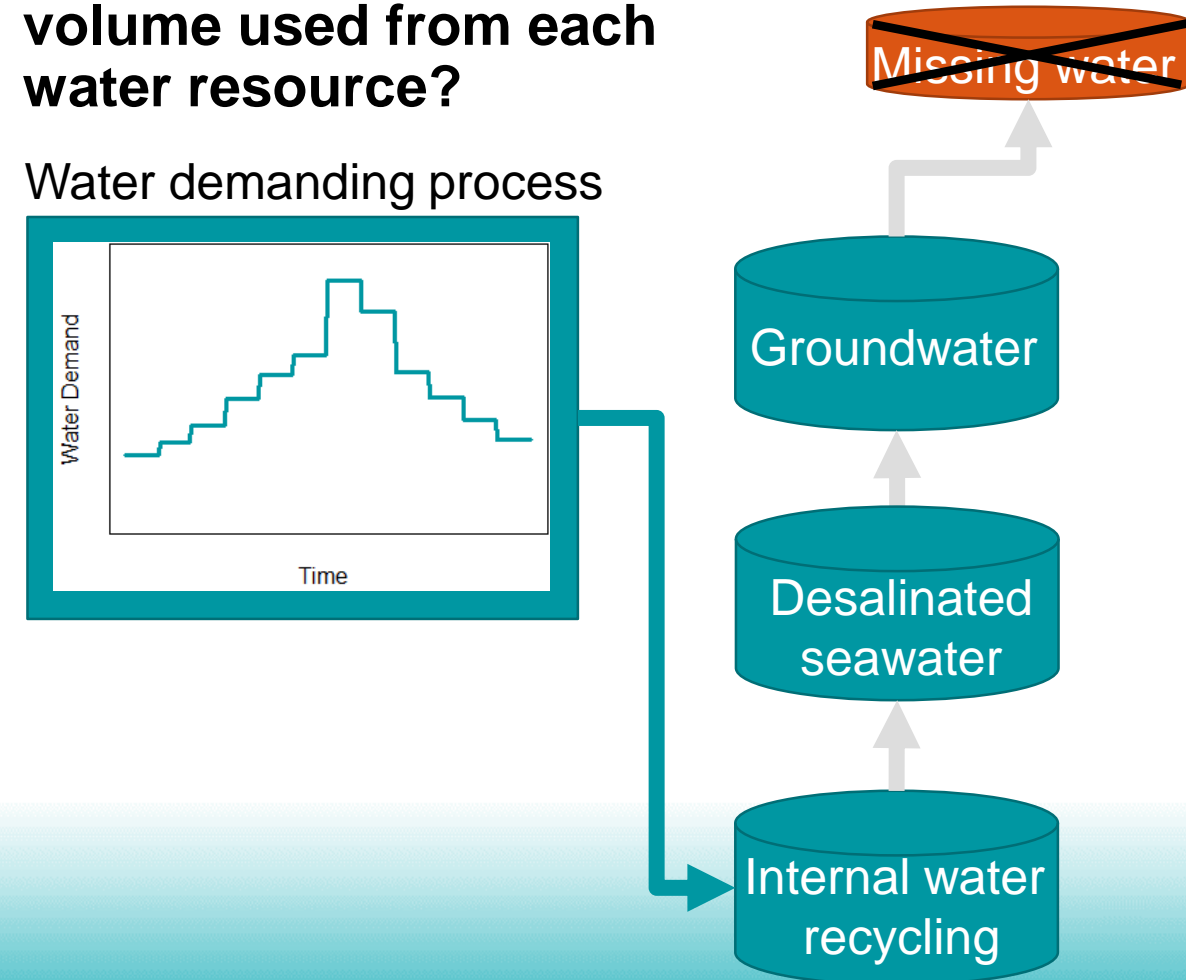
Step 1: How much water is missing when?

Water demanding process



Step 2: What is the water volume used from each water resource?

Water demanding process



UWOT input:

Basic future scenario assumption:

Groundwater abstraction and available lake water are limited

Alternative water resources:

Desalinated seawater, rainwater, reclaimed water in different qualities

Output of UWOT:

What is a realistic water source hierarchy per water use?

Which production and storage capacities are needed?

RECREATE

Thank you!



anne.kleyboecker@kompetenz-wasser.de



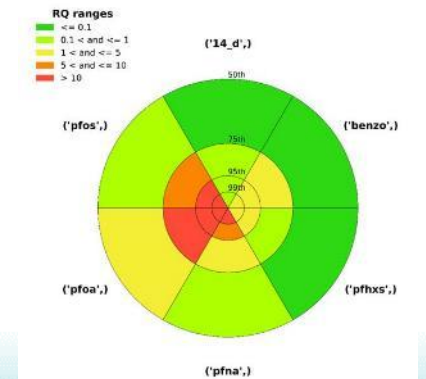
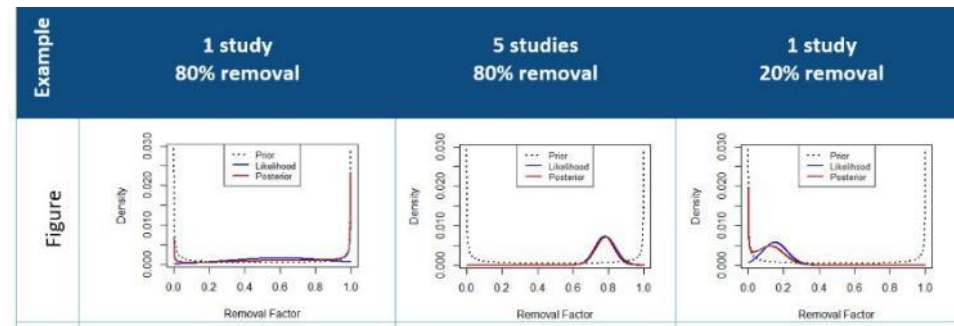
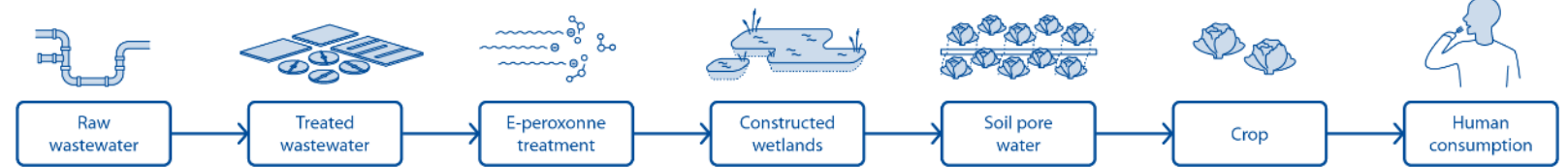
This project has received funding from the European Union's Horizon Europe research and innovation programme under grant agreement No. 101136598. This document reflects only the views of RECREATE consortium, neither the European Commission nor any associated parties are responsible for any use that may be made of the information it contains.

Quantitative microbial and chemical risk assessments (QMRA & QCRA) to protect public health

QMRA
TOOL BY KWB

<https://qmra.org>

QCRA tool developed by KWB



<https://zenodo.org/records/15308552>