ULTIMATE

WATER SMART INDUSTRIAL SYMBIOSIS

REACREATE

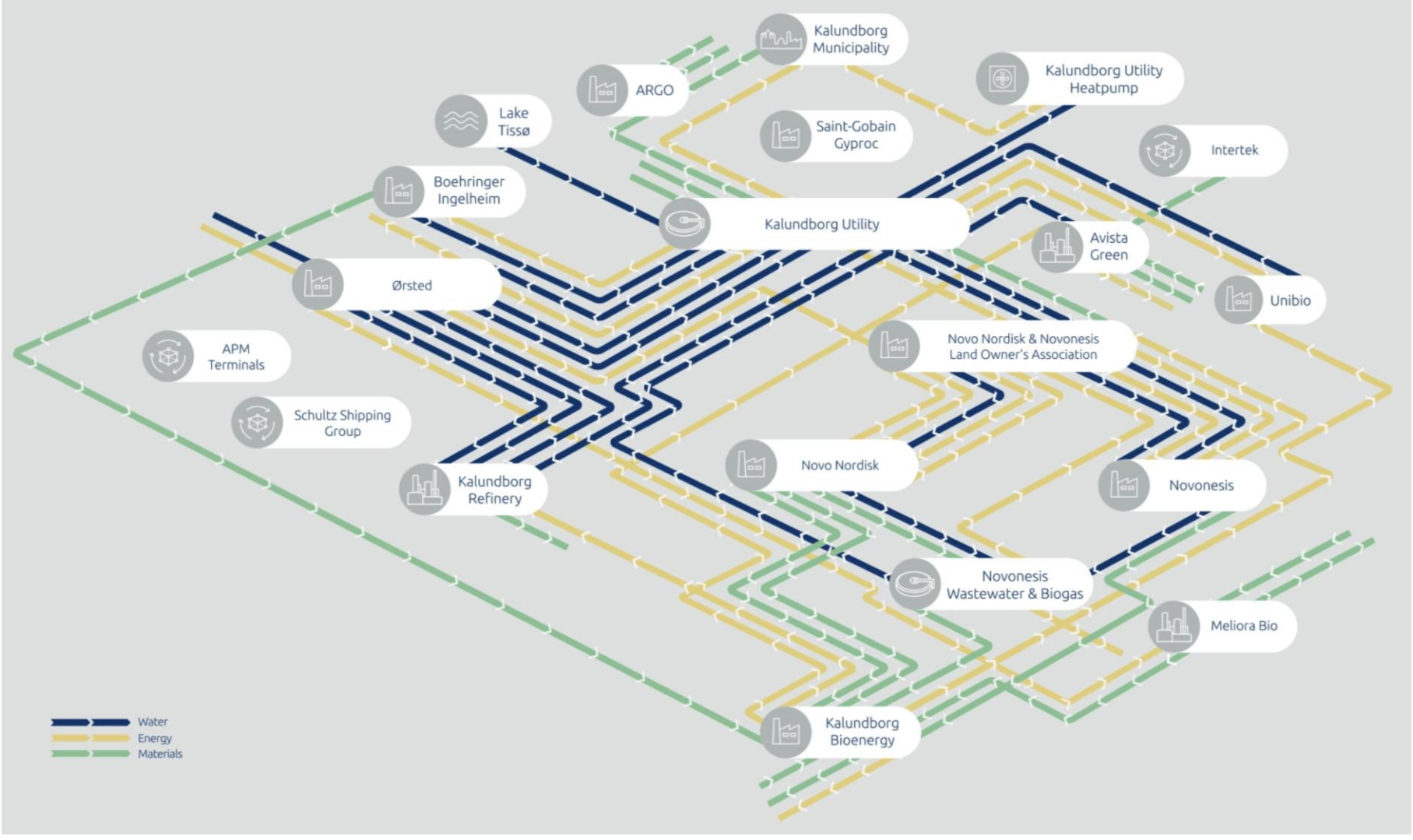
Resilient water management strategies for the Industrial Symbiosis Kalundborg

A. Kleyböcker, H. Milter,
J. Jährig, U. Miehe



Industrial Symbiosis Kalundborg (since 1972)

- 17 private und public companies
- Recycling: Water, Materials and Energy



New industrial area



Kalundborg - Challenges

- Fast expansion of Industrial Symbiosis
- Water demand is expected to double within 2 years
- Lake Tissø: uncertainty about future water extraction
- Longer drought periods (summer)
- More precipitation (winter)
- Groundwater availability: limited





Dynamic tool: simplified version with fictional values

Max. production rate under sustainable management

Maximum

Current

Lake Tissø

Water resources

Max. production rate under sustainable management

Maximum

Current

Groundwater

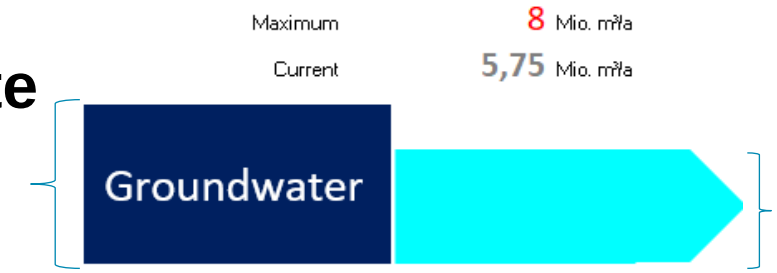
Dynamic tool: simplified version with fictional values

Max. production rate under sustainable management



current production rate

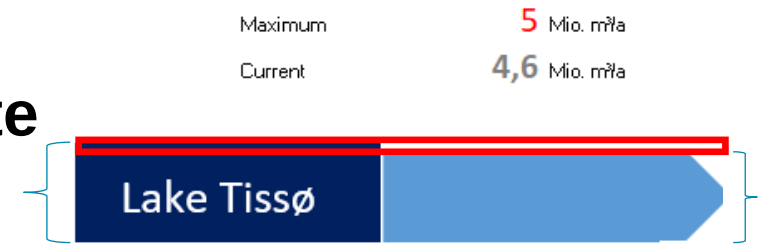
Max. production rate under sustainable management



current production rate

Dynamic tool: simplified version with fictional values

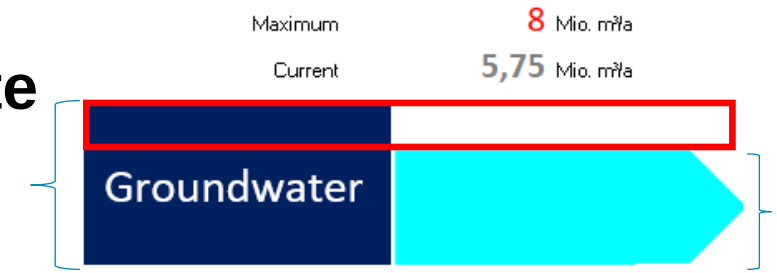
Max. production rate under sustainable management



Buffer

current production rate

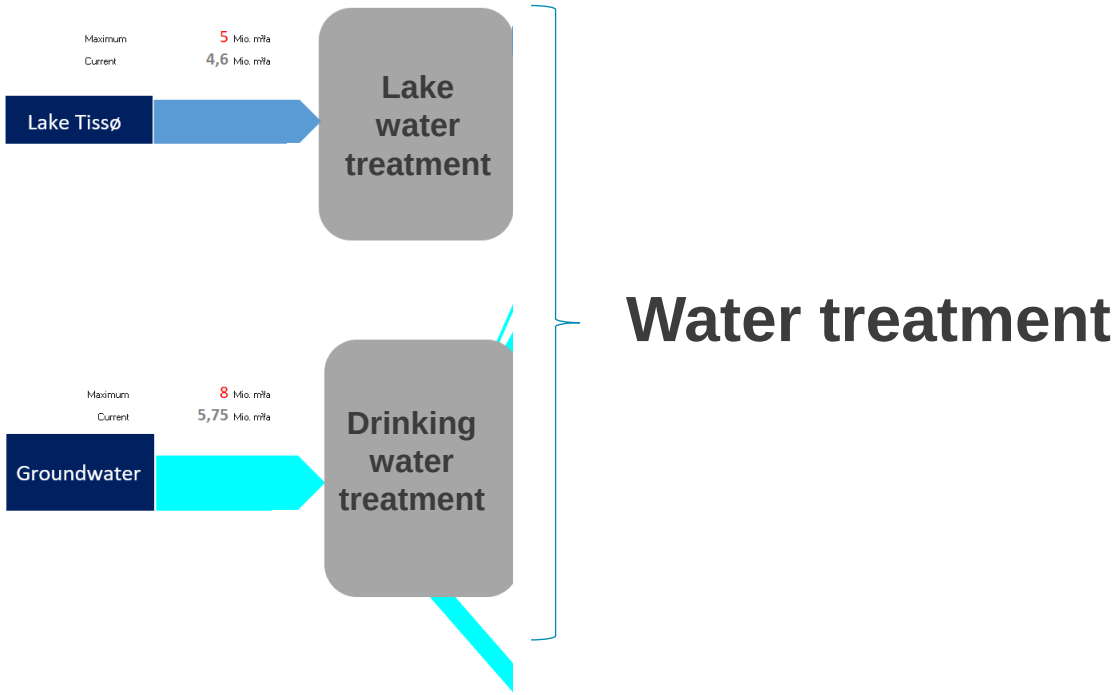
Max. production rate under sustainable management



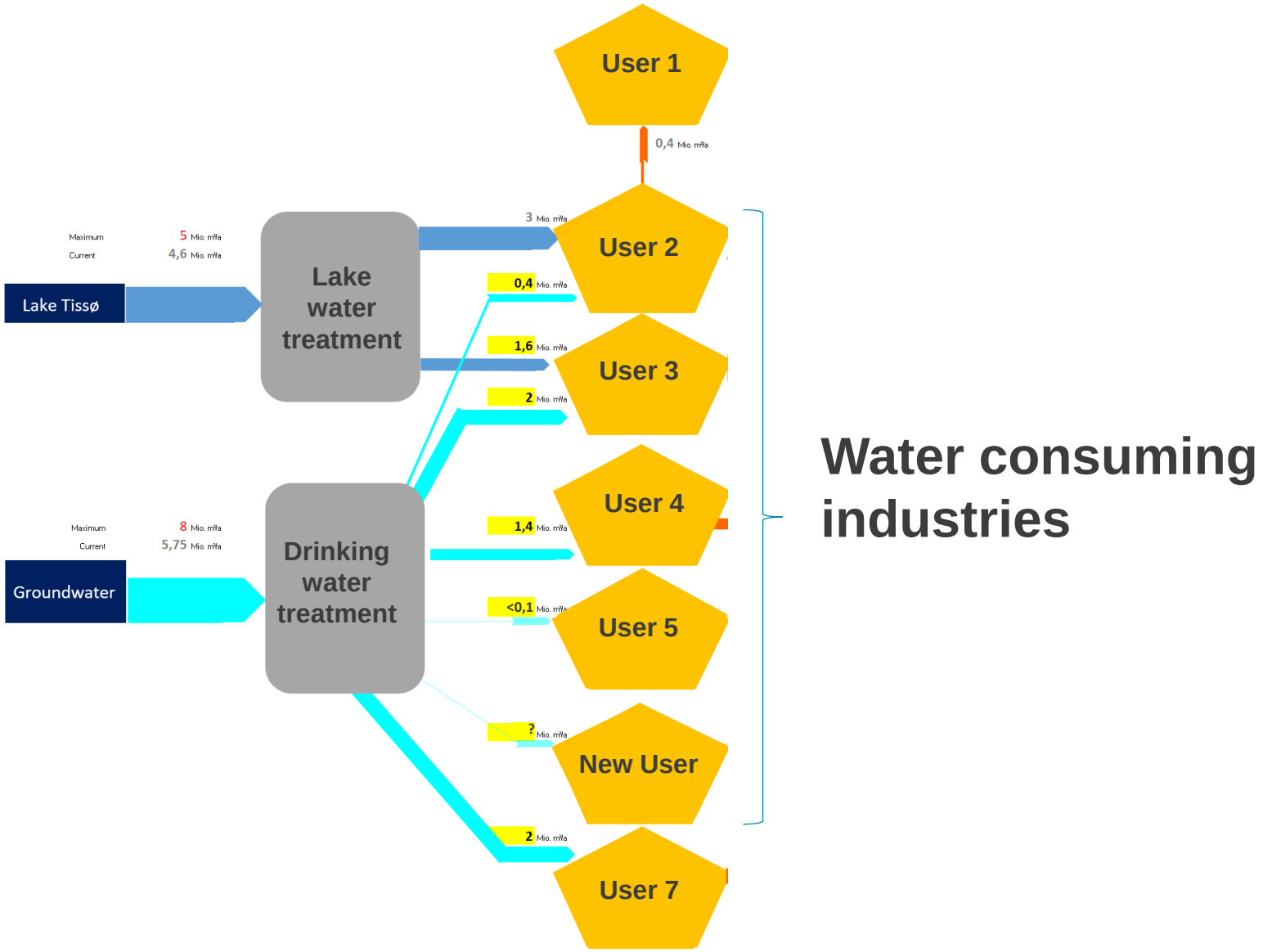
Buffer

current production rate

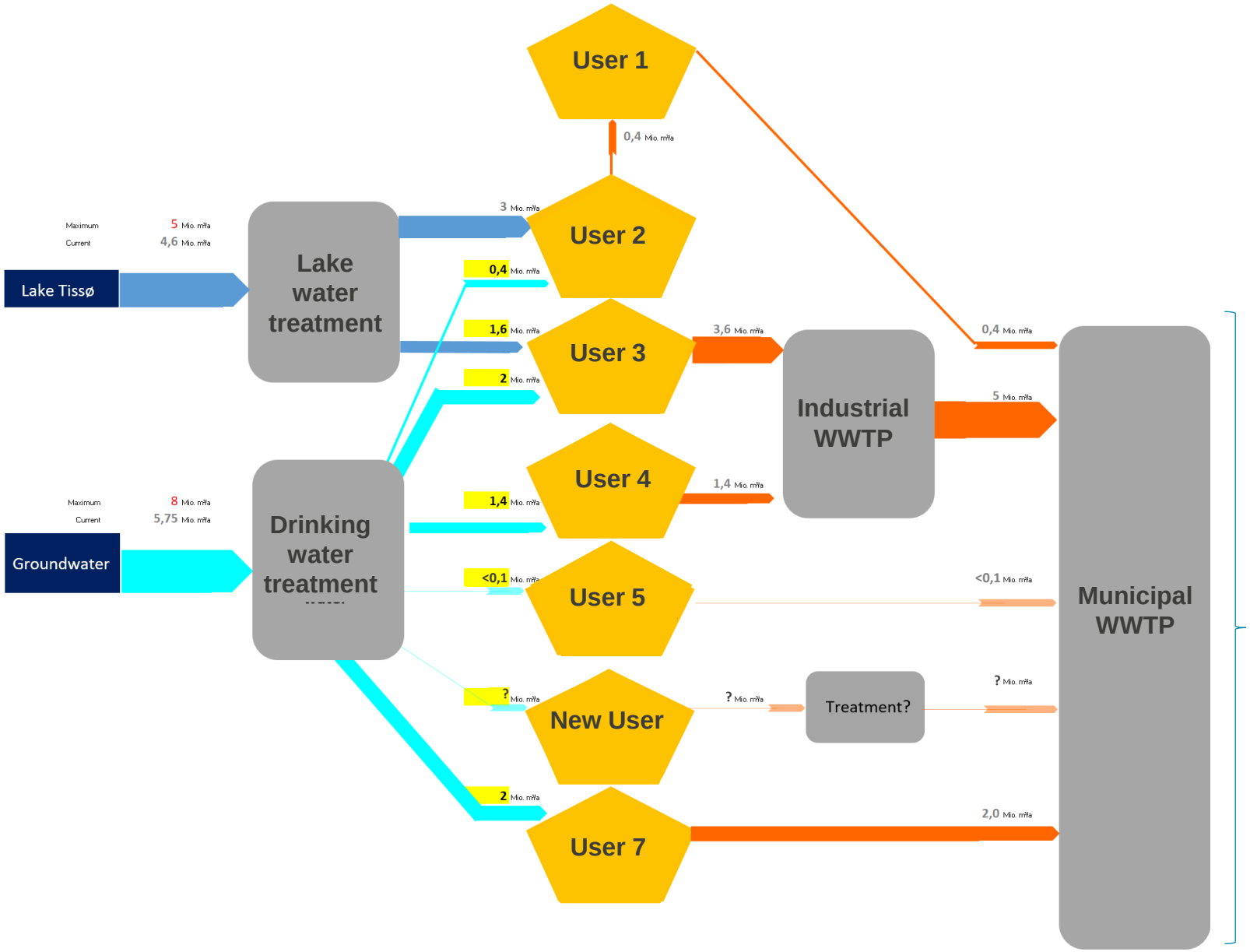
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Dynamic tool: simplified version with fictional values

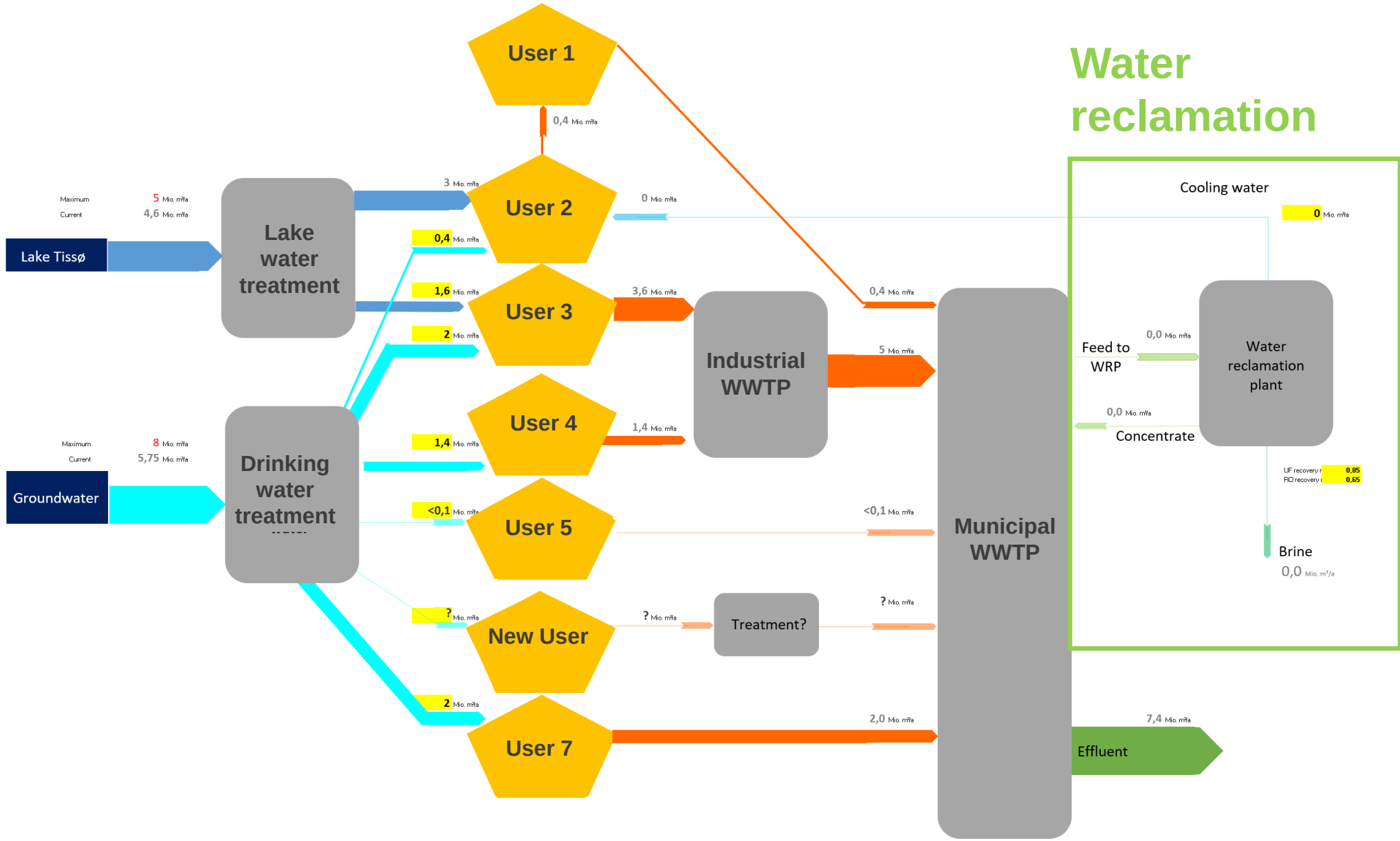


Dynamic tool: simplified version with fictional values



Wastewater treatment

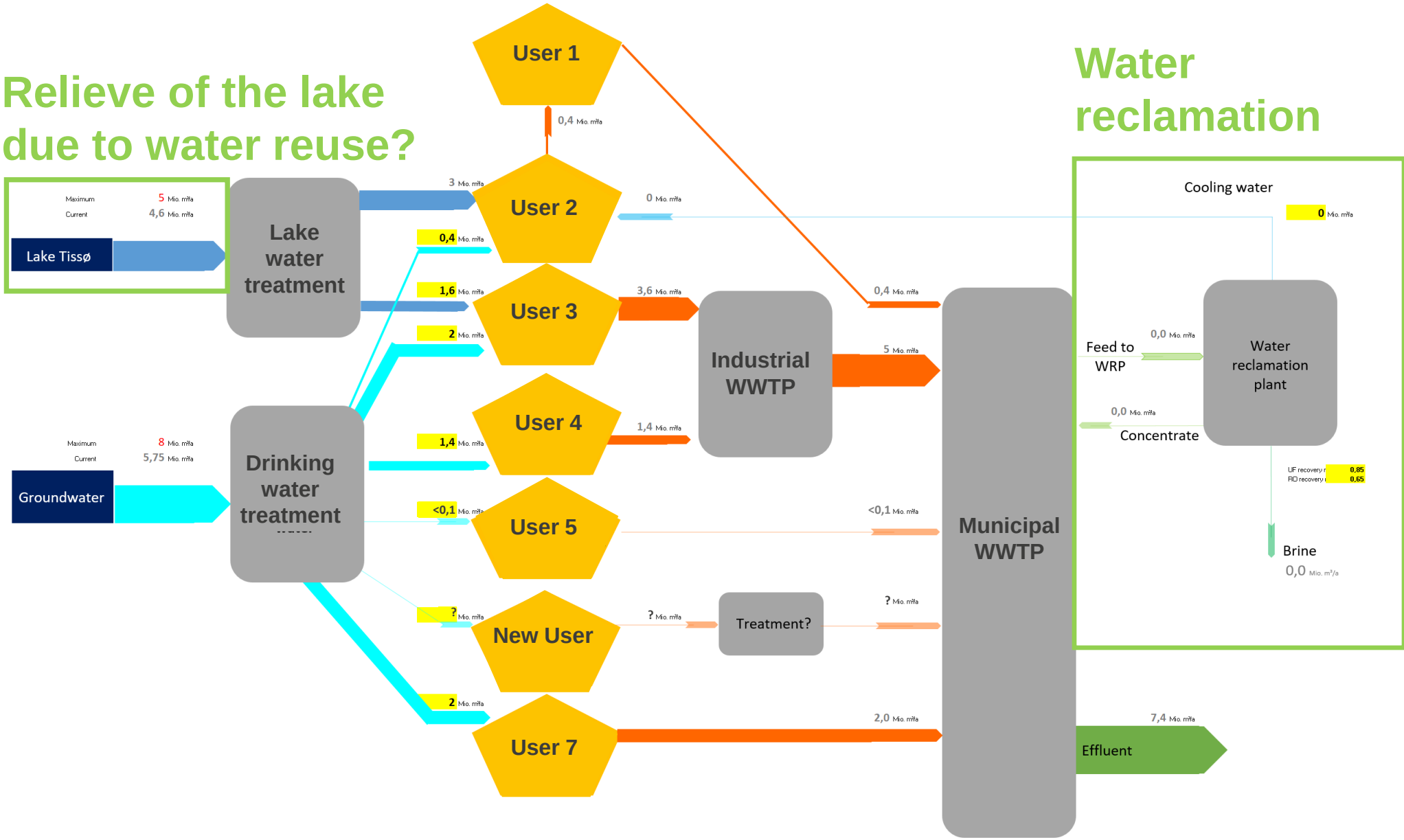
Dynamic tool: simplified version with fictional values



Dynamic tool: simplified version with fictional values

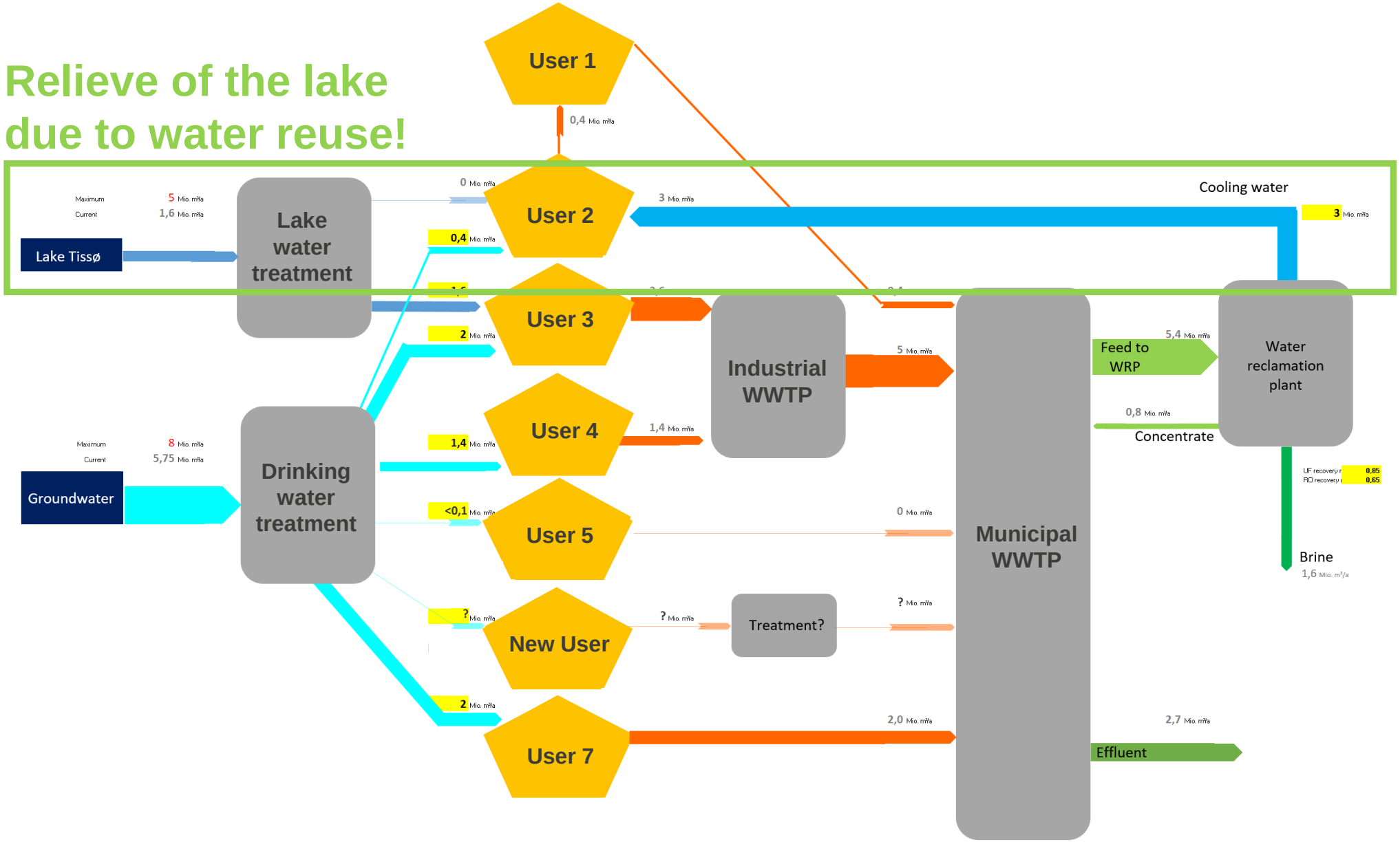
Relieve of the lake due to water reuse?

Water reclamation



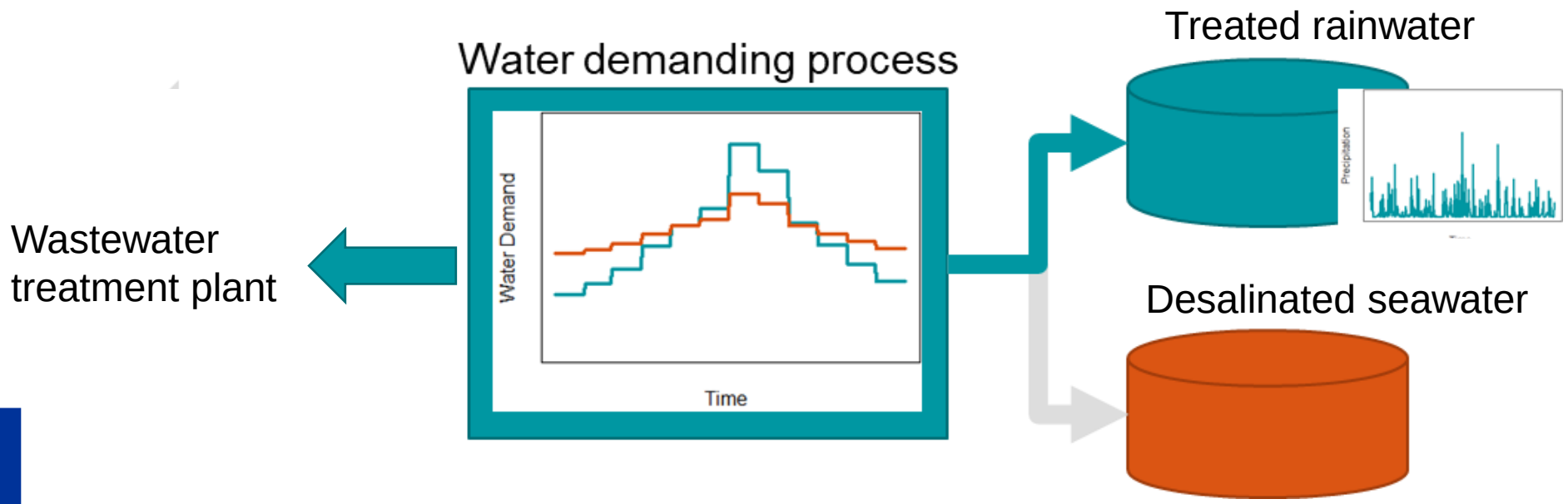
Dynamic tool: simplified version with fictional values

Relieve of the lake due to water reuse!

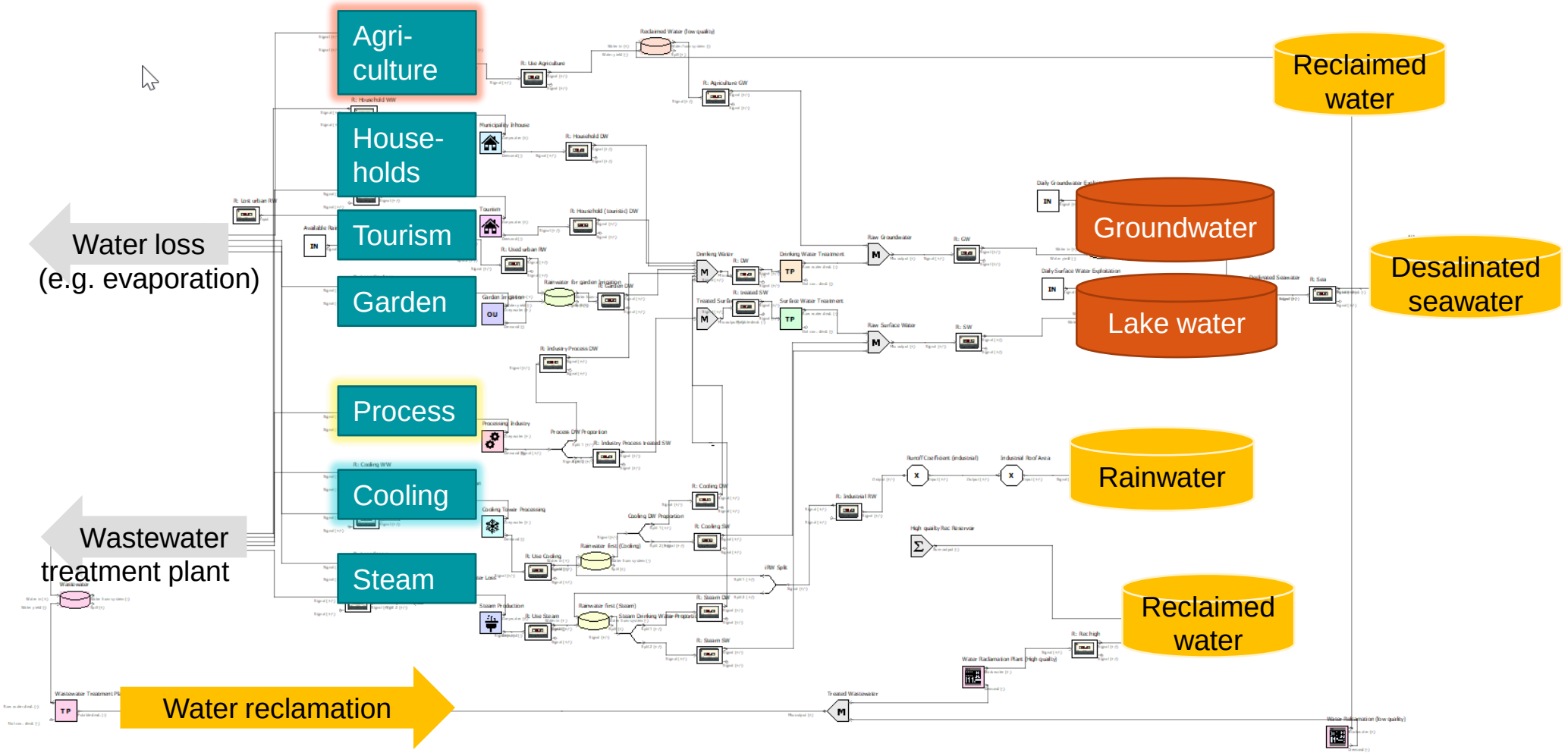


Urban Water Optioneering Tool (UWOT)

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

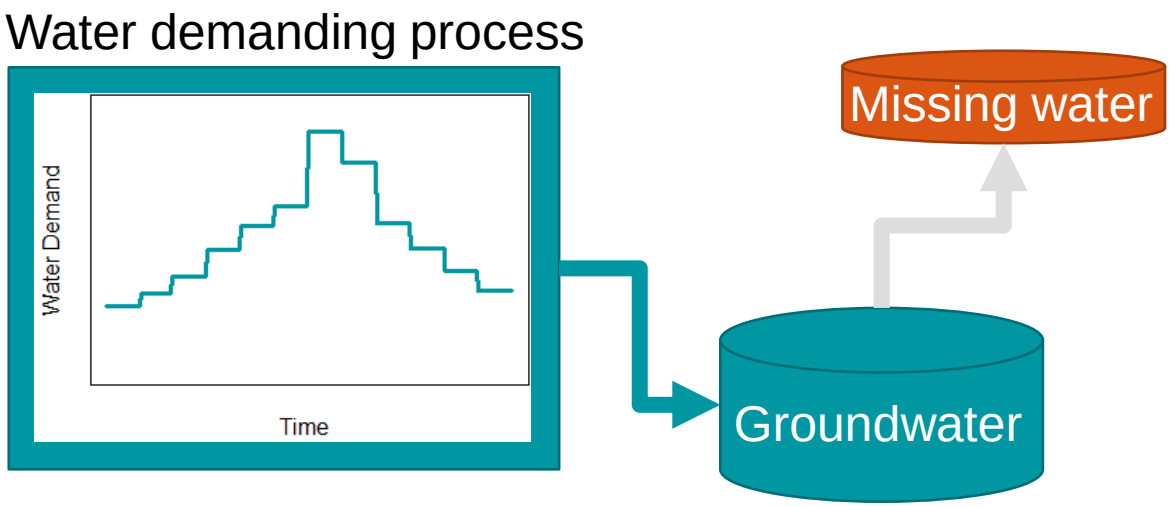


Example: UWOT model

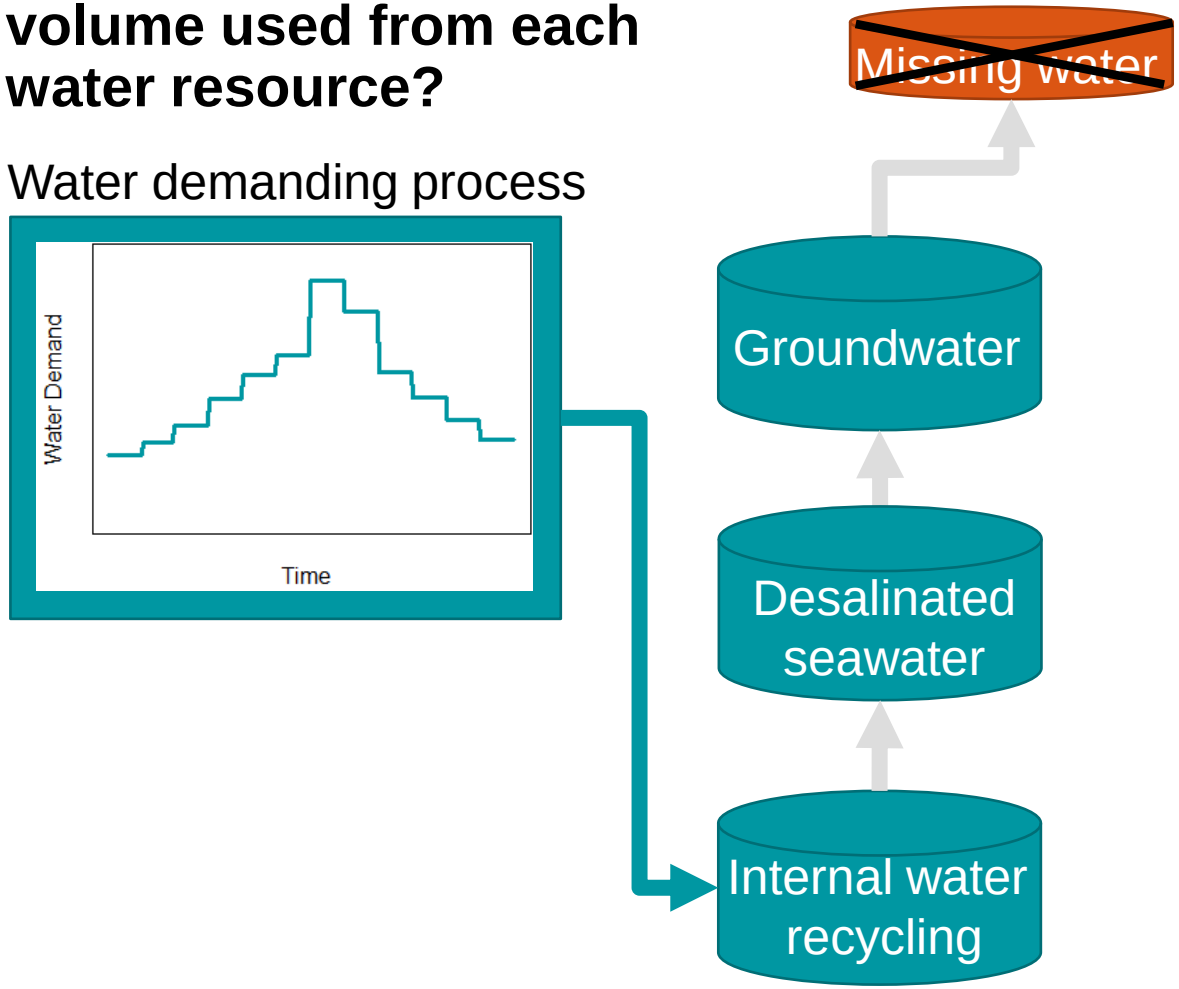


Types of water resource hierarchy for future scenarios

Step 1: How much water is missing when?



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



Water reclamation?

Is it technically feasible?

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

Challenges

55% industrial wastewater and 45% municipal wastewater

→ Challenging wastewater composition (high fraction of non-degradable organic matter)

Research questions

1. Which treatment train can produce a sufficient **water quality** for industrial cooling?
2. Which pre-treatment UF/dUF/NF does a reverse osmosis membrane protect best against process failure (**fouling)**?



Water reclamation → industrial cooling

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

Dual media filter



Pre-filter



Ultrafiltration/
Nanofiltration
cUF/tUF/NF



Reverse Osmosis
RO



Cooling water



Water reclamation → industrial cooling

- 2 years of pilot plant operation
- Best performance: dual media filter + cUF + RO

Check for updates

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Innovative pre-treatments for reverse osmosis to reclaim water from biotech and municipal wastewater for the industrial symbiosis in Kalundborg

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Alternative water resources?
How are they perceived and are they accepted by stakeholders?

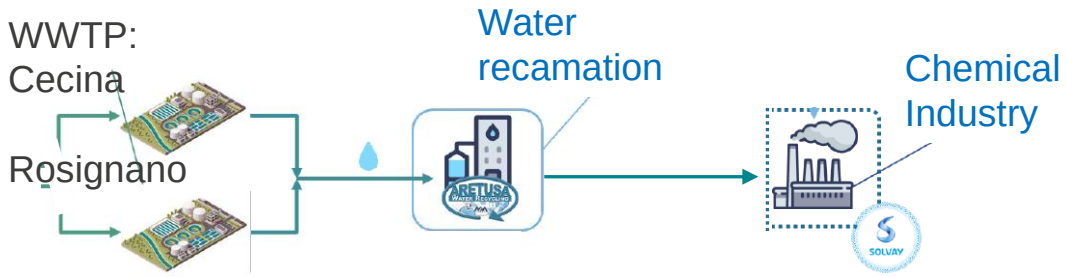
Workshops with stakeholders:

Learning from existing full-scale installations

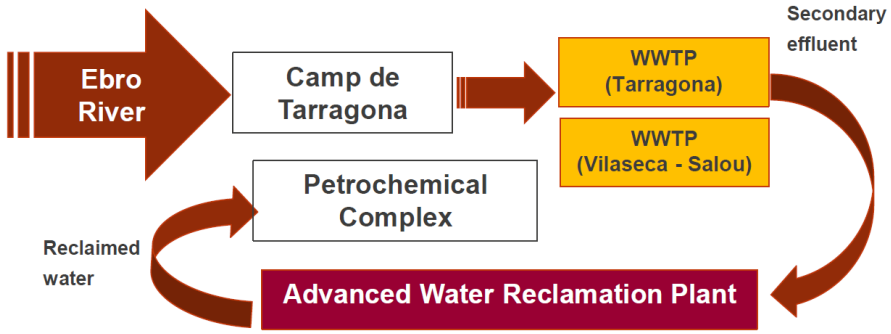
Torrelle (BE): Infiltration of reclaimed water



Rosignano (IT): industrial water reuse



Tarragona (ES): industrial water reuse



Koyambedu: largest water reclamation plant in India



Escape-Room Game:
How do I achieve a resilient water management strategy?





How have the legal framework conditions changed, and what was the key to success?

New solutions calls for new legislation

- Legislation often looks backwards
- Regulation, in general, are not prepared for new water structures



- Identification of regulatory barriers
- Collaboration with authorities on technical understanding and acceptance

Legislation change

Drinking water

Before:

- Only groundwater

Now:

- Groundwater
- Surface water
- Desalinated seawater

Technical water

Before:

- No national definition
- No national regulation

Now:

- Simple definitions
- Guidance for company structure
- No quality criterias

Other surface water

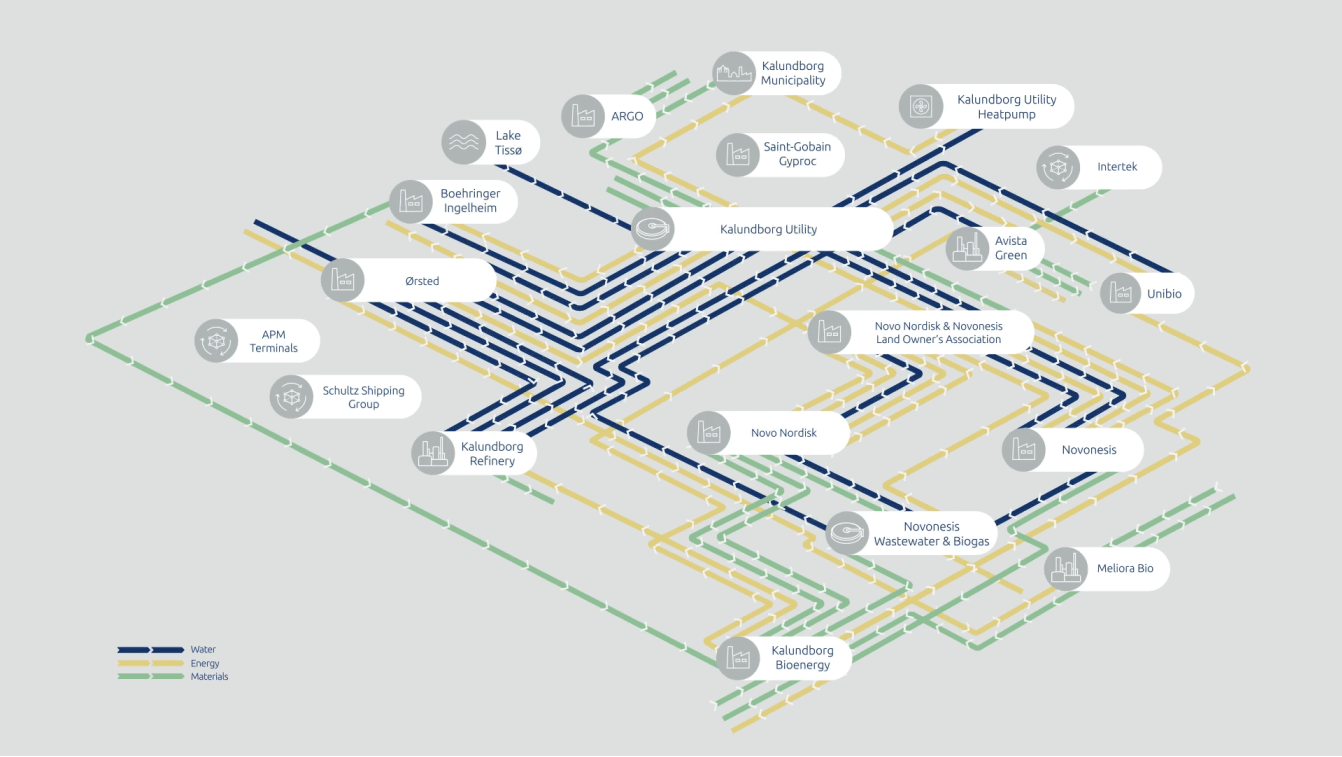
Now:

- Not allowed as source process or drinking water for industrial use

Needs:

- Allowed as source for process or drinking water for industrial use

Cooperation



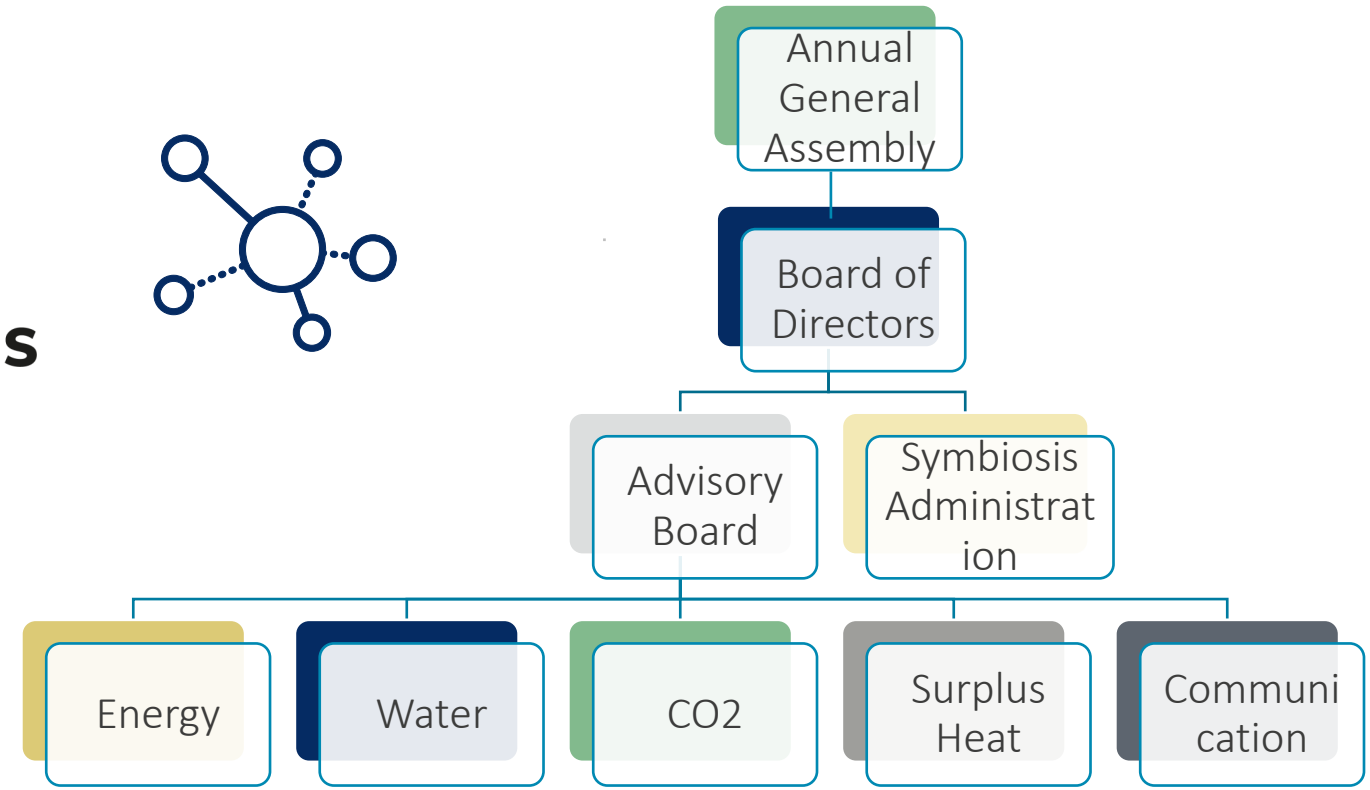
Cooperation between companies

Kalundborg
SYMBIOSIS

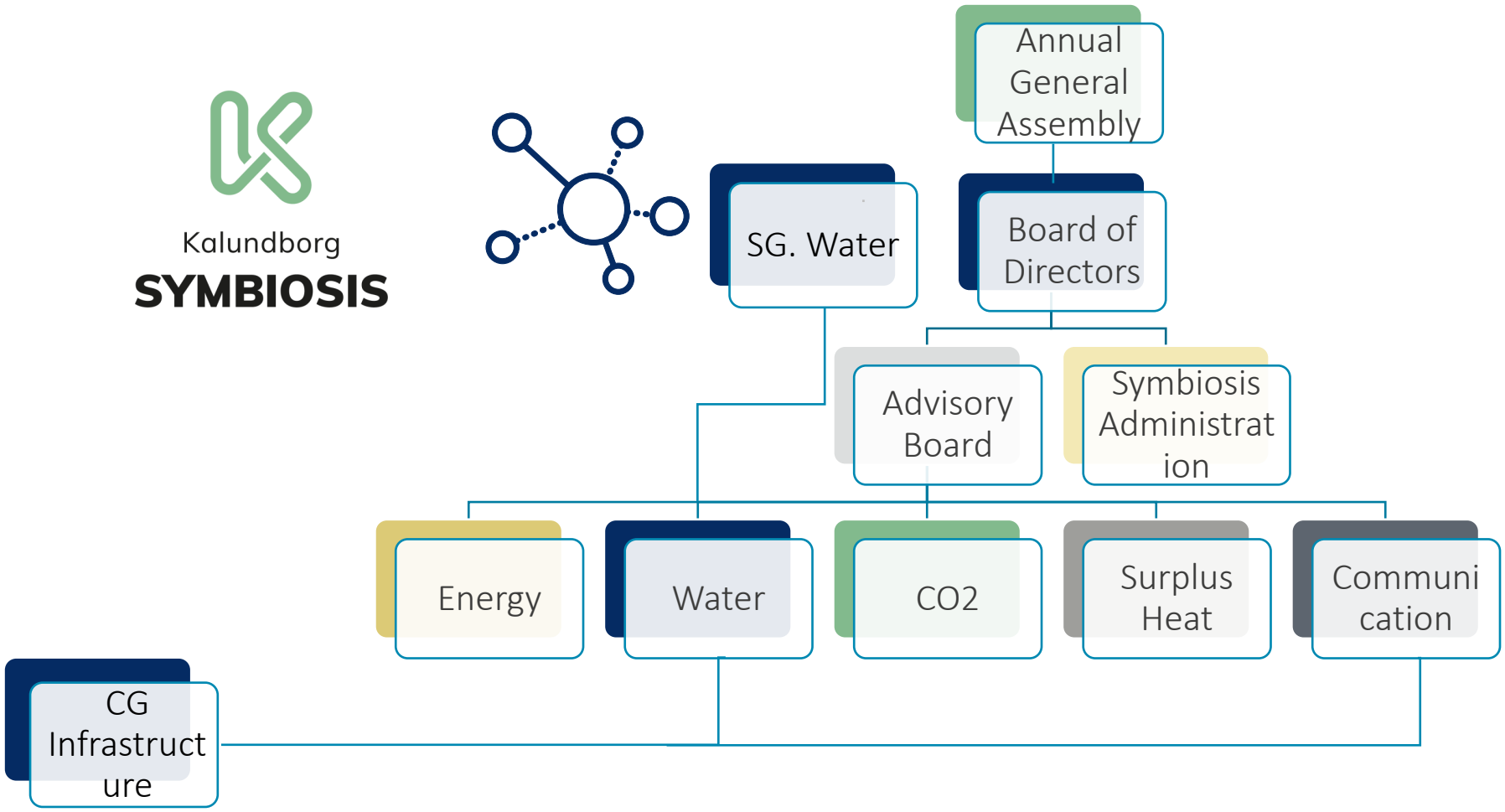
- Dynamic update on projects
- Joint identification of risks and needs
- **Problems are OURS** not THEIRS
- Solutions are individual or joint
- Influence legislation as one group

Governance structure – Kalundborg Symbiosis

Kalundborg SYMBIOSIS

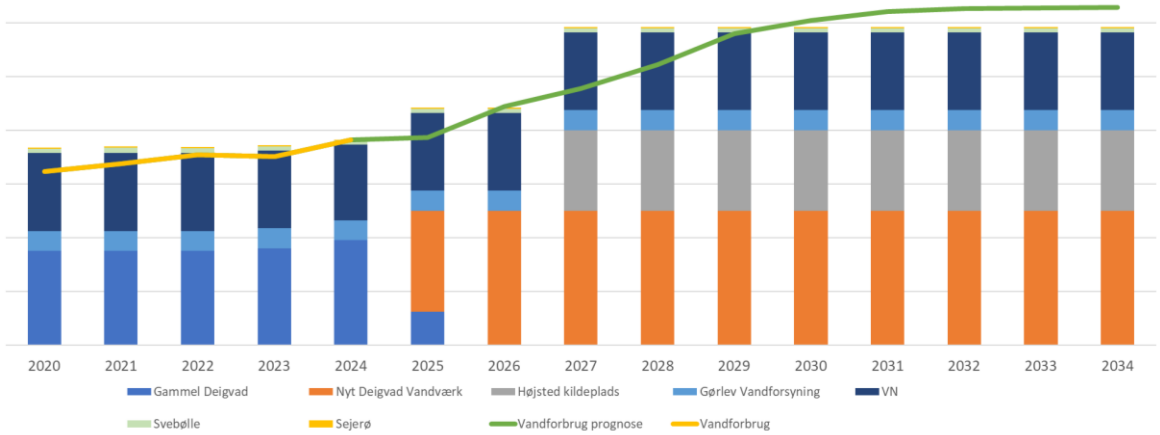


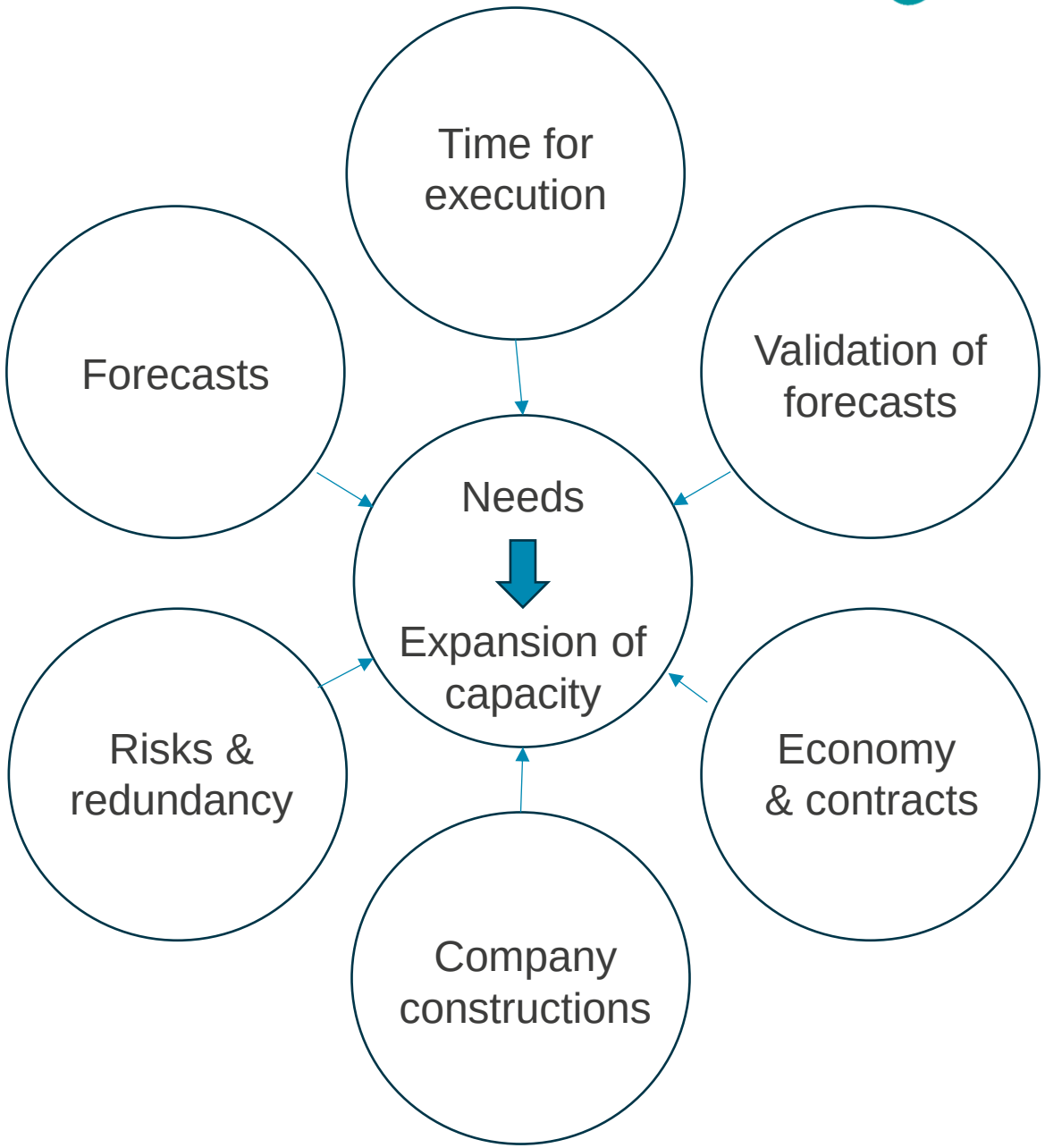
Governance structure - water



Full-scale implementation

When?

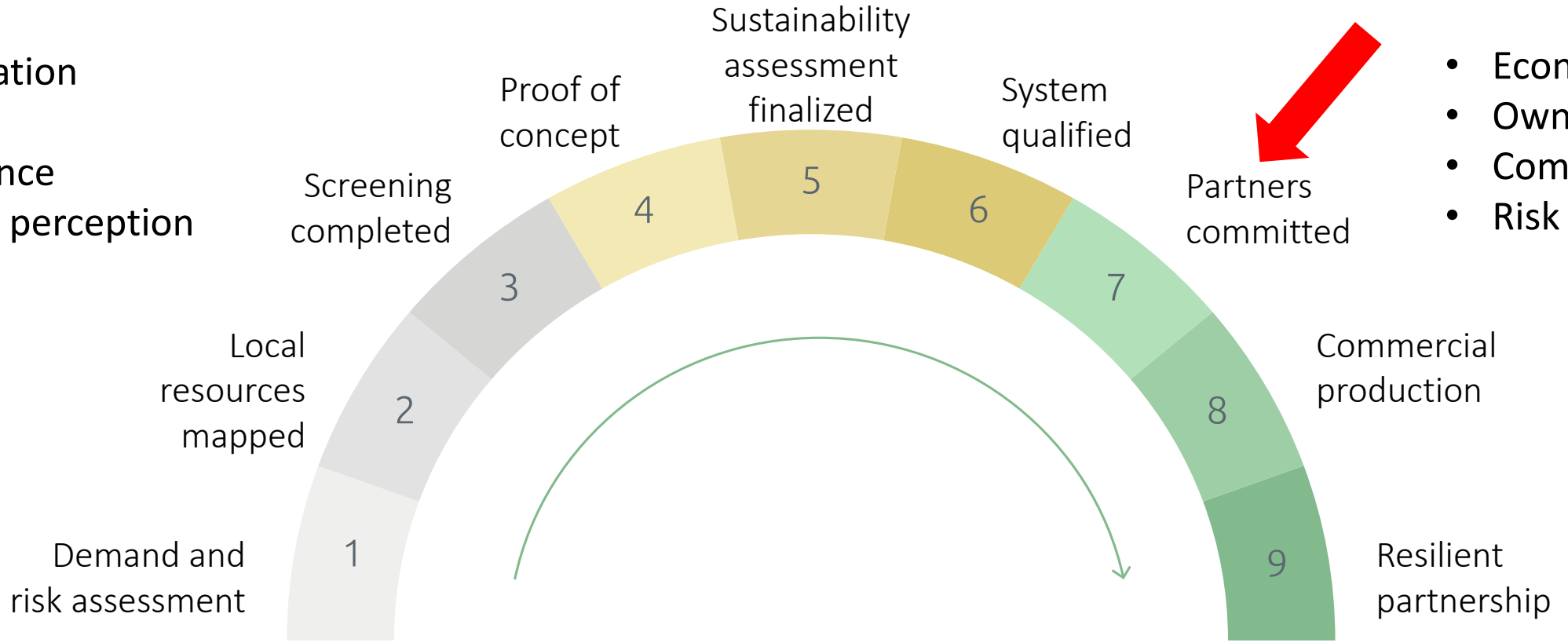

2020
2021
2022
2023
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2028
2029
2030
2031
2032
2033
2034
Gammel Deigvad
Nyt Deigvad Vandværk
Højsted kildeplads
Gørlev Vandforsyning
VN
Svebølle
Sejerø
Vandforbrug prognose
Vandforbrug


Time for execution
Forecasts
Validation of forecasts
Needs
Expansion of capacity
Risks & redundancy
Economy & contracts
Company constructions

Bringing technology to execution

Boundary Conditions

- Legislation
- Policy
- Influence
- Public perception



Commitment

- Economy
- Ownership
- Company agenda
- Risk assessment

Desalination

Legislation



Energy





Feasibility

Large-scale pilot



Picture from Danfoss

Full-scale desalination plant


Picture from Danfoss

Brine management

- Danish legislation (WWTP discharge – brine discharge)
- Environmental risk assessment?
- Symbiosis?

Water reclamation → industrial cooling

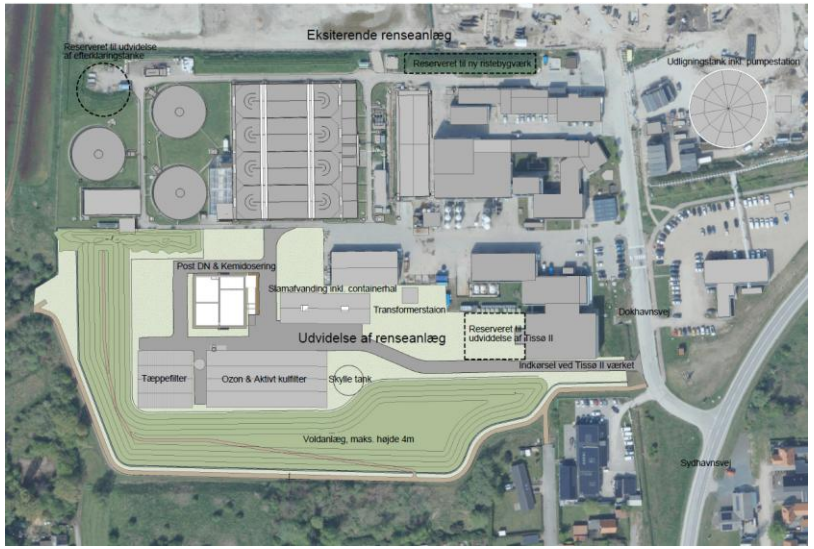
Feasibility

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WATER SMART INDUSTRIAL SYMBIOSIS



Pilot

New WWTP → effluent



Full-scale reclamation plant


Water reclamation plant in Tarragona (ES)

? Brine management

- Accumulation in WWTP?
- Resource mining?
- Symbiosis?

Lessons learned

Strong collaboration between stakeholders

- Agree on what is important
- Allocate the right ressources
- Get decision makers involved

Kalundborg SYMBIOSIS

- Gain high level of confidence
- Clear mandate
- Identify gaps and bottlenecks

- Speak with one voice

Cooperation with the authorities

Miljøministeriet
Miljøstyrelsen

Klima-, Energi- og Forsyningsministeriet

KALUNDBORG KOMMUNE

- Comment on draft legislation
- Discuss the focus of environmental impact assessments
- Elaborate effects of ”new” technologies together
- Identify challenges through pilots

In three lines

- Strong collaboration between stakeholders
- Do pilots
- When is the right time to build full-scale

→ **Let's work together also internationally to give ourselves a joint voice at a European level and promote the implementation of alternative water resources!**

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WATER SMART INDUSTRIAL SYMBIOSIS

RECREATE



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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

KALUNDBORG FORSYNING KWB novonesis PENTAIR X-FLOW