

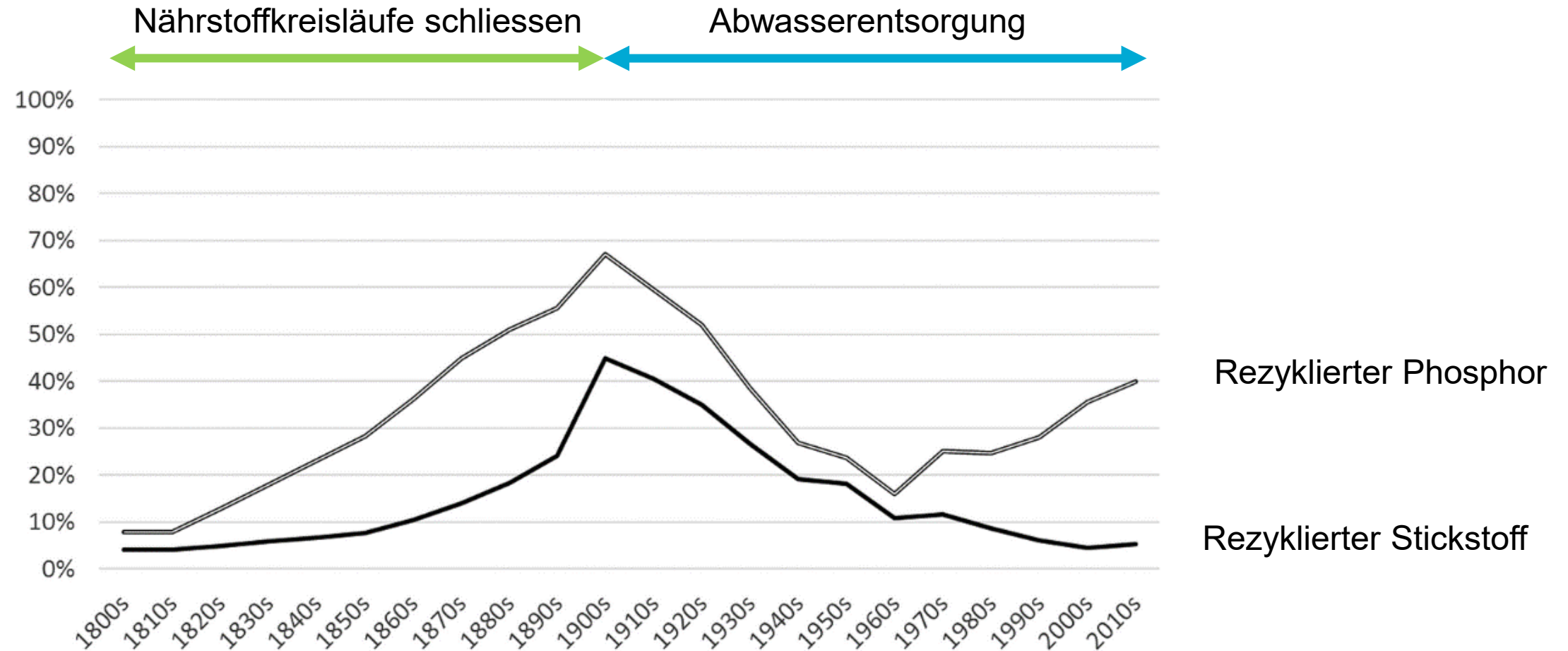


Kreislaufwirtschaft beginnt in der Toilette

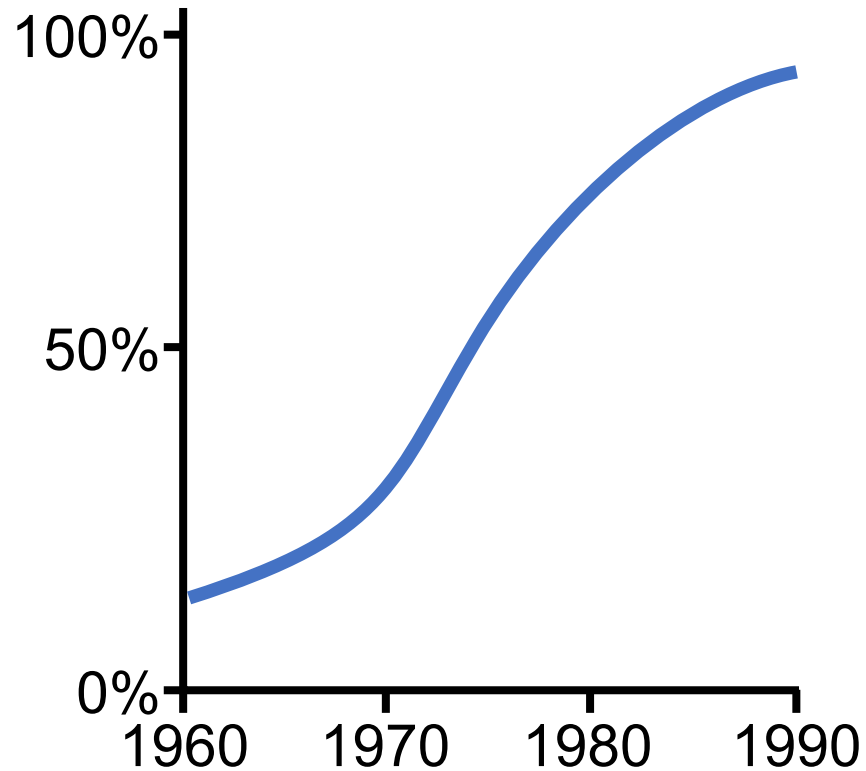
Neue Ansätze für die Abwasserreinigung

Prof. Dr. Kai M. Udert
Eawag und ETH Zürich

Strategie für Abwassermanagement in Paris



Immense Infrastruktur für Abwasser



Schweizer Bevölkerung mit
Anschluss an Kläranlage

gemäss Bacchini und Bader (1996)

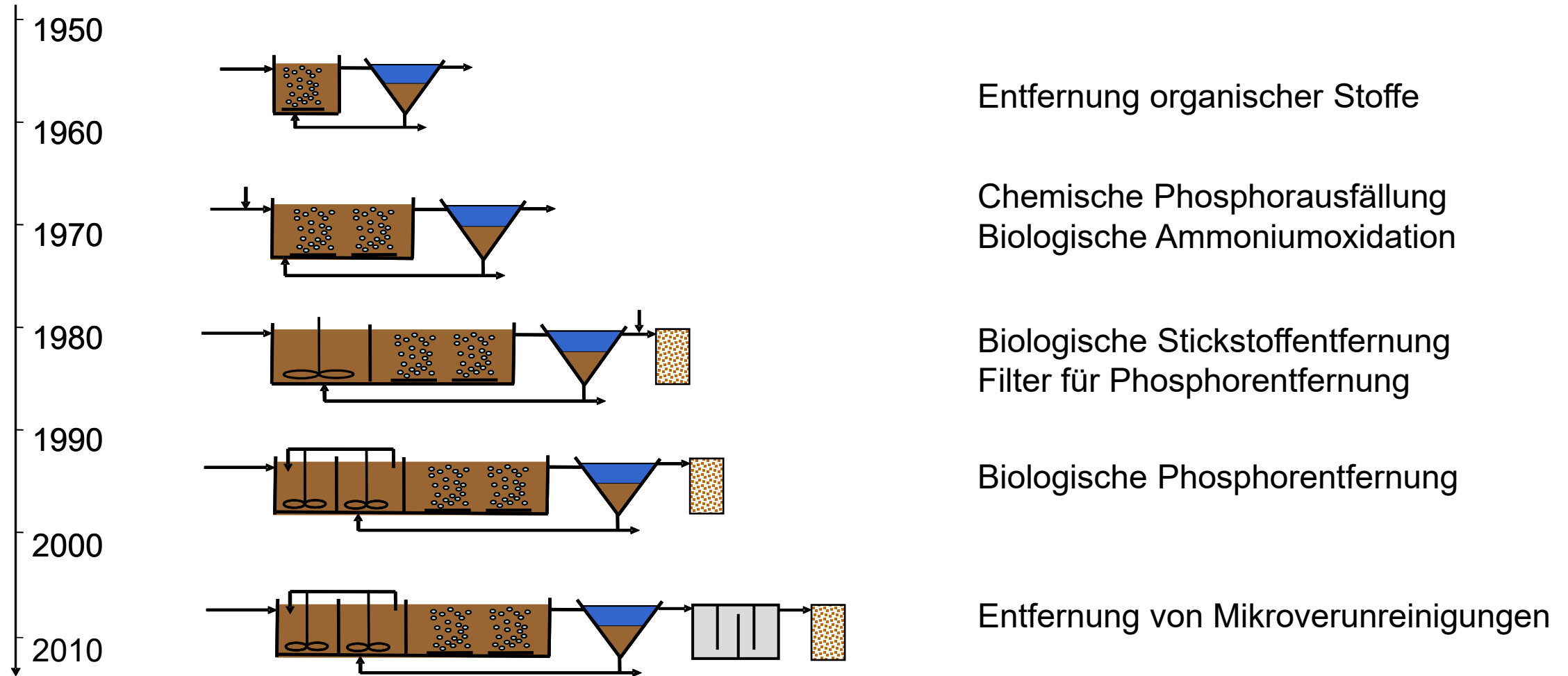


Schweizer Abwasserinfrastruktur:
120 Mia CHF Wiederbeschaffungswert

Hofmann et al. (2014)

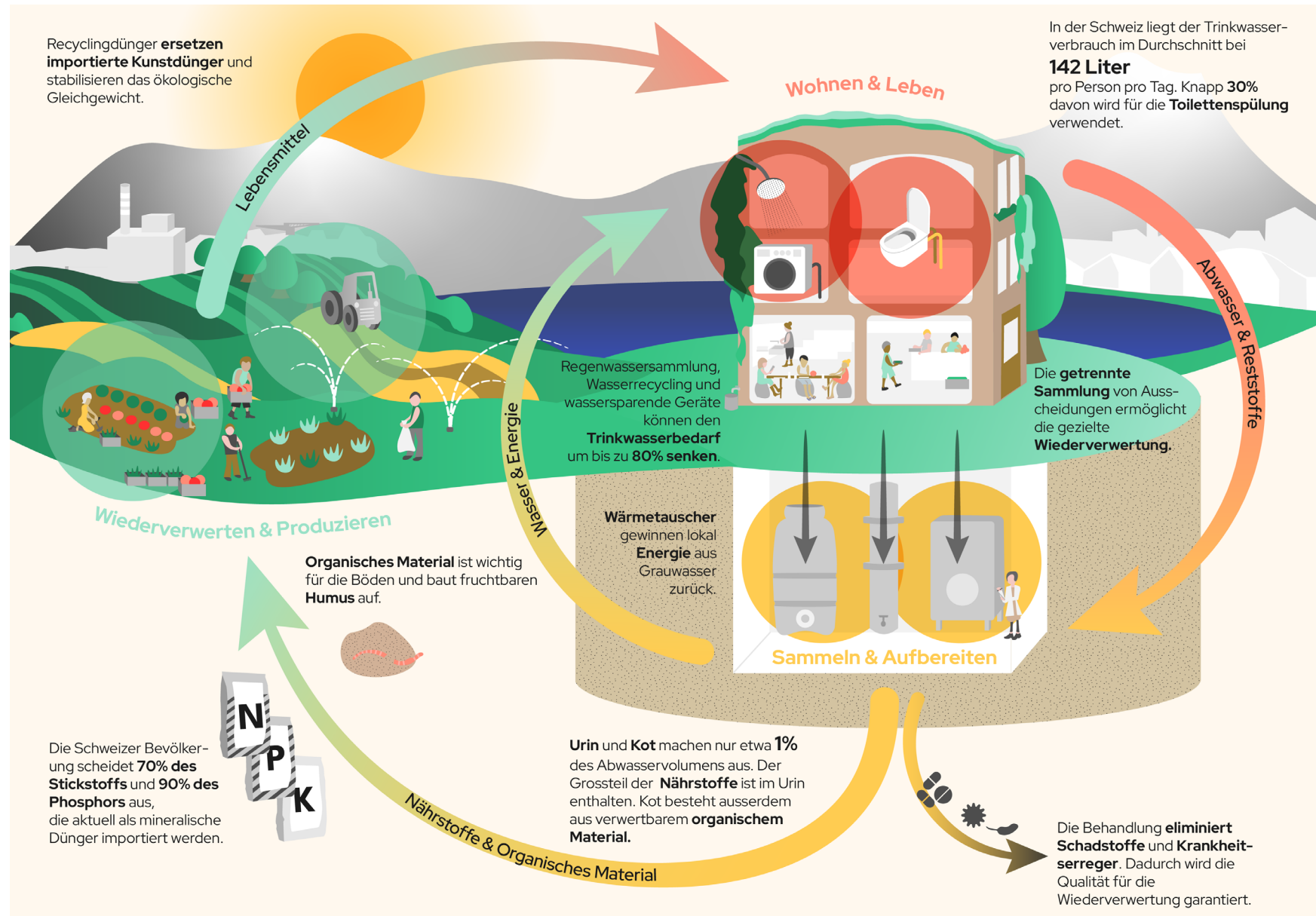
Eawag

Entwicklung der Abwasserbehandlung in der Schweiz

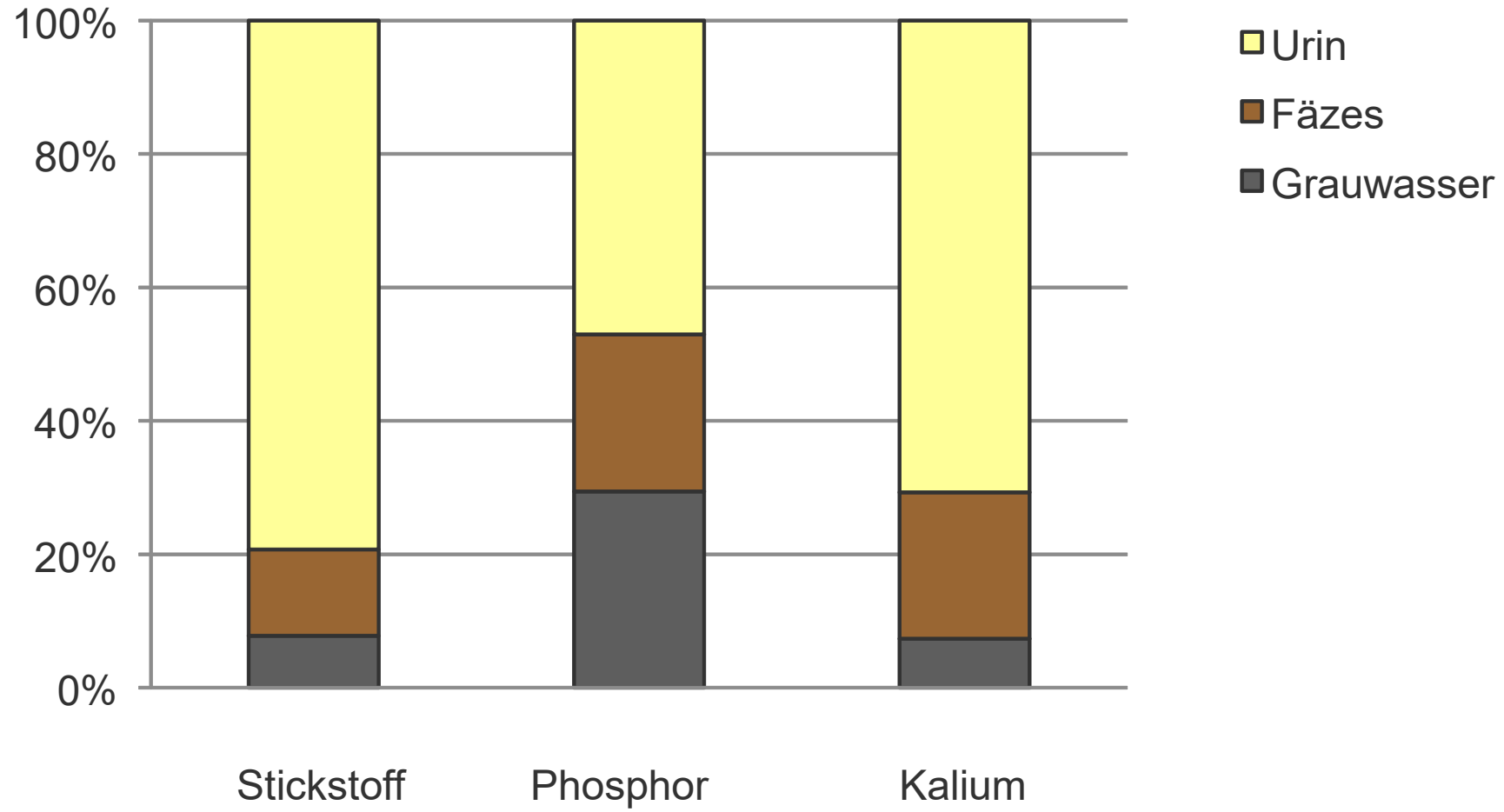


**Demnächst: Phosphorrückgewinnung !
Stickstoffrückgewinnung ?**

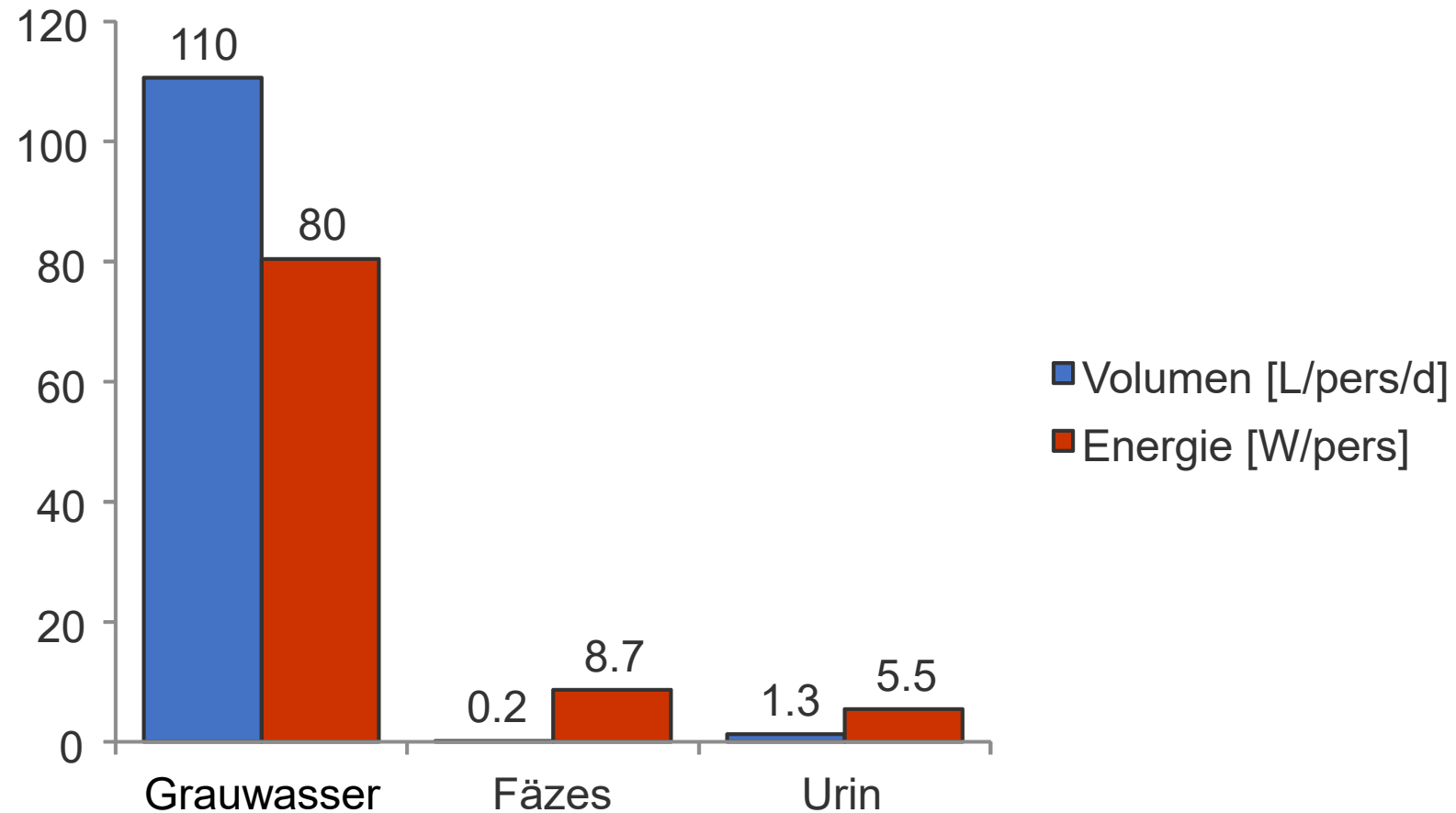
Kreisläufe schliessen



Nährstoffe im Abwasser



Wasser und Energie

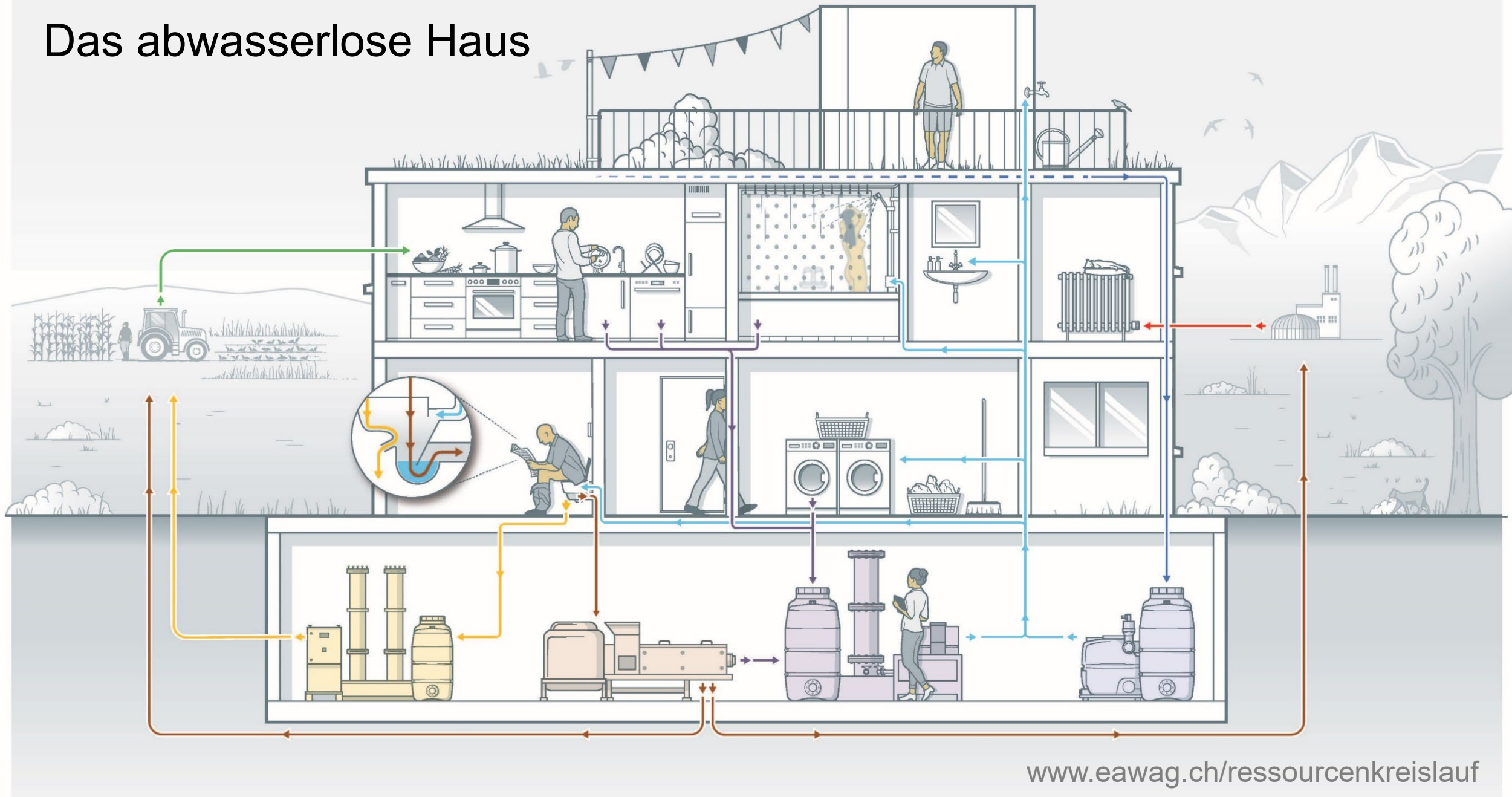


Friedler et al. (2013) in Larsen et al. Source separation and decentralization for wastewater management

Larsen and Maurer (2011) in Wilderer Treatise on Water Science

eigene Berechnungen

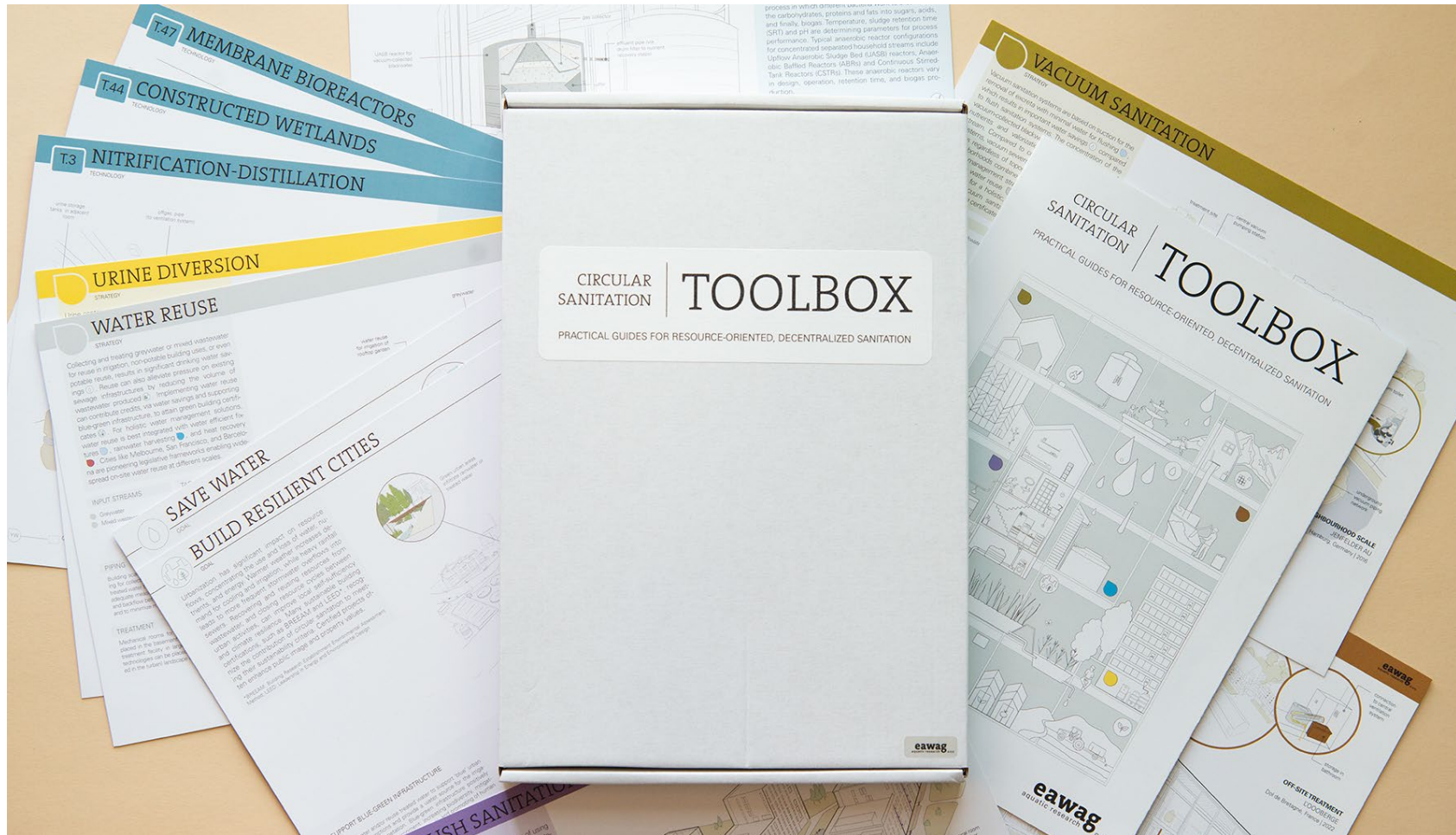
Das abwasserlose Haus



Circular Sanitation Toolbox

Leitfaden zu ressourcen-orientierten Sanitärtechnologien

<https://www.eawag.ch/waterhub>

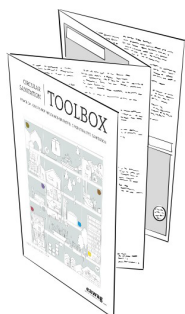


CIRCULAR SANITATION

TOOLBOX

PRACTICAL GUIDES FOR SOURCE-SEPARATED AND DECENTRALIZED SANITATION

BROSCHÜRE

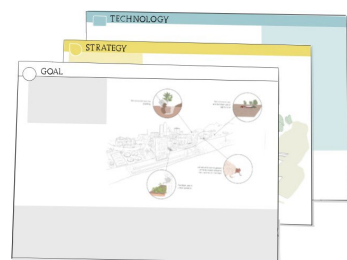


Hintergrund und
Anwendungsbereich
der Toolbox

Einführung zu
Dezentralisierung und
Trennung an der Quelle

Erläuterung der
Toolbox-Teile

LEITFADEN



Zusammenfassung
der Ziele, Strategien
und Technologien

Jeder Leitfaden (Guide)
ist ein eigenständiges
Dokument

In Kombination ergibt
es ein kreislauffähiges
Sanitärsystem



ZIELE

-  WASSER SPAREN
-  NÄHRSTOFFE ZURÜCKGEWINNEN
-  ENERGIE ZURÜCKGEWINNEN
-  RESILIENTE STÄDTE BAUEN
-  NETZUNABHÄNGIGKEIT ERMÖGLICHEN



STRATEGIEN

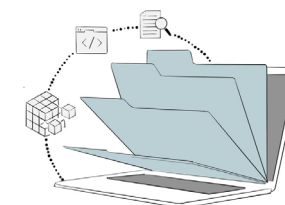
-  URINTRENNUNG
-  TROCKENSYSTEME
-  VAKUUMSYSTEME
-  WASSERGESPÜLTE SYSTEME
-  WASSER-WIEDERVERWENDUNG
-  WASSERSPARENDE INSTALLATIONEN
-  REGENWASSER-NUTZUNG
-  WÄRME-RÜCKGEWINNUNG



TECHNOLOGIEN

-  T.1 URINLAGERUNG & PASTEURISIERUNG
-  T.2 NITRIFIKATION AUF PFLANZENKOHLE
-  T.3 NITRIFIKATION & DESTILLATION
-  T.4 STRUVIT-AUSFÄLLUNG
-  T.5 AMMONIAKSTRIPPUNG
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-  T.50 UV & CHLOR-DESINFEKTION
-  T.51 OZONIERUNG & ADVANCED OXIDATION
-  T.61 WÄRMETAUSCHER | WÄRMEPUMPEN

WEITERE DOKUMENTE



Datenbank mit
Fallstudien

Technologie- und
Dienstleistungsanbieter
der Fallstudien

Weiterführende
Dokumente (Faktenblätter,
Leitfäden, Werkzeuge)

TOOLBOX

WIESO MÖCHTEN SIE
EIN KREISLAUFFÄHIGES
SANITÄRSYSTEM UMSETZEN?

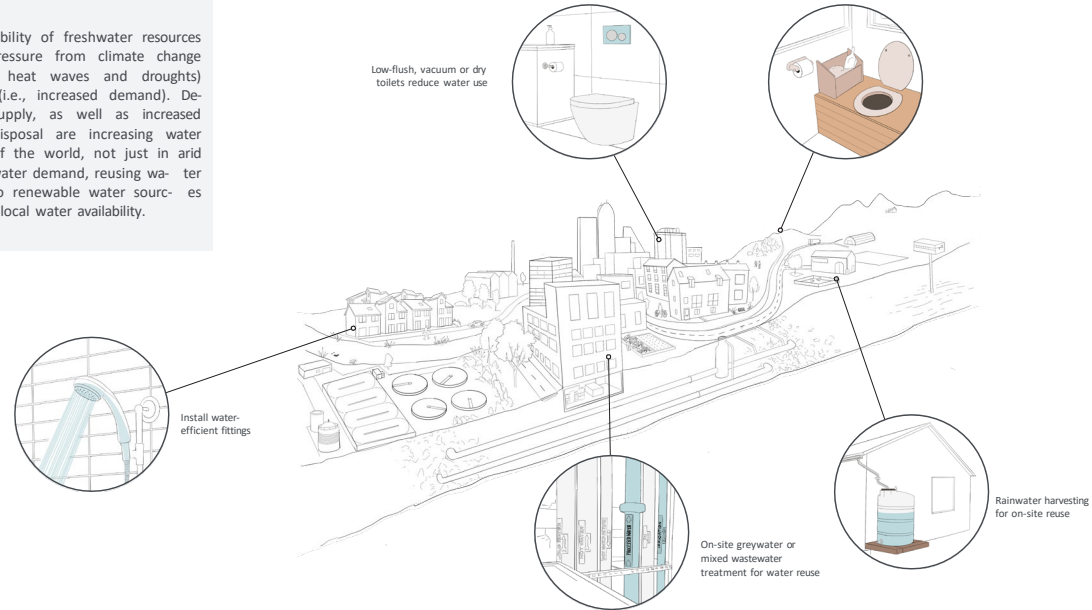
Ziele bestimmen



SAVE WATER

GOAL

The availability and reliability of freshwater resources are under increasing pressure from climate change (e.g., warmer weather, heat waves and droughts) and rapid urbanization (i.e., increased demand). Decreased and variable supply, as well as increased abstraction, use, and disposal are increasing water scarcity in many parts of the world, not just in arid environments. Reducing water demand, reusing water on site, and tapping into renewable water sources (e.g., rainwater) increases local water availability.



REDUCE WATER USE

Swap out water-intensive appliances and toilets, with waterless and water-efficient alternatives. Appliances can be anything from faucet fittings to water recirculating showers to dry or vacuum toilets. Such fixtures minimize water demand, and some also reduce the energy demand needed to heat the water.



REUSE WATER

Treat used water (e.g. greywater, blackwater, mixed water) streams to provide an alternative water supply for non-potable and potable reuse. Depending on the desired end use, water is treated to match end use demand for quality and quantity, to provide reliable and safe water supply. Reusing water minimizes demand for drinking water supply and diverts hydraulic flow to existing sewer infrastructure.



CAPTURE RAINWATER

Harvest rainwater for fit-for-purpose reuse. Depending on the desired end-use, these water sources can be treated to match end-use demand for quality and quantity, including irrigation, non-potable reuse and potable reuse. Using captured water minimizes demand for drinking water supply and diverts hydraulic flow to existing sewer infrastructure.



Circular Sanitation TOOLBOX | 2025 | © Eawag
References and further information available at www.eawag.ch/en/vsh/toolbox

**WASSER SPAREN****NÄHRSTOFFE ZURÜCKGEWINNEN****ENERGIE ZURÜCKGEWINNEN****RESILIENTE STÄDTE BAUEN****NETZUNABHÄNGKEIT ERMÖGLICHEN**

TOOLBOX

WIESO MÖCHTEN SIE
EIN KREISLAUFFÄHIGES
SANITÄRSYSTEM UMSETZEN?



WASSER SPAREN



NÄHRSTOFFE ZURÜCKGEWINNEN



ENERGIE ZURÜCKGEWINNEN



RESILIENTE STÄDTE BAUEN



NETZUNABHÄNGKEIT ERMÖGLICHEN

Ziele bestimmen



SAVE WATER

GOAL

The availability and reliability of freshwater resources are under increasing pressure from climate change (e.g., warmer weather, heat waves and droughts) and rapid urbanization (i.e., increased demand). Decreased and variable supply, as well as increased abstraction, use, and disposal are increasing water scarcity in many parts of the world, not just in arid environments. Reducing water demand, reusing water on site, and tapping into renewable water sources (e.g., rainwater) increases local water availability.



Install water-efficient fittings

REDUCE WATER USE

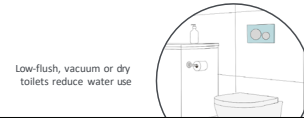
Swap out water-intensive appliances and toilets, with waterless and water-efficient alternatives. Appliances can be anything from faucet fittings to water recirculating showers to dry or vacuum toilets. Such fixtures minimize water demand, and some also reduce the energy demand needed to heat the water.

REUSE

Treat used streams and pota is treated provide demand f existing s



Circular Sanitation TOOLBOX | 2025 | © Eawag
References and further information available at www.eawag.ch/en/vth/toolbox



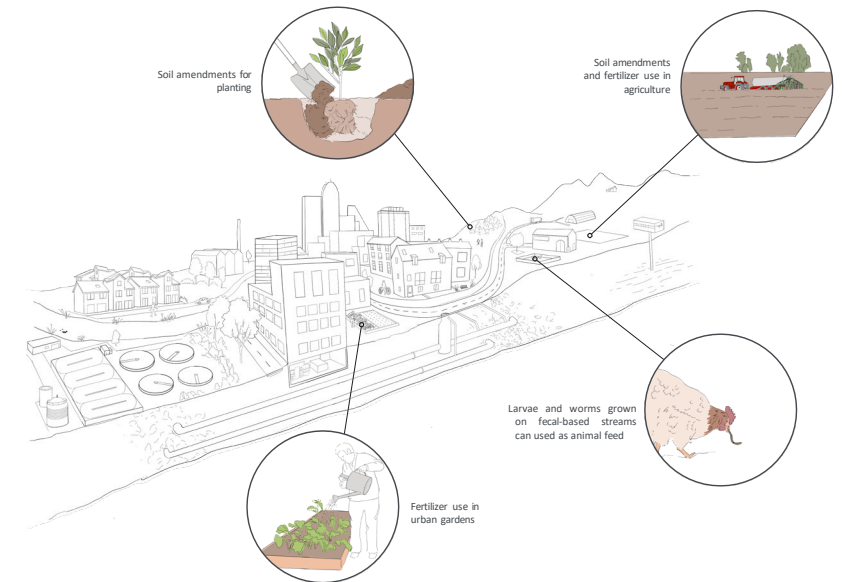
Low-flush, vacuum or dry toilets reduce water use

eawag
aquatic research

RECOVER NUTRIENTS & ORGANIC MATTER

GOAL

Current linear nutrient flows are characterized by: 1) cheap and resource-intensive fertilizer production that relies on fossil fuels, and finite, spatially-concentrated ore reserves, 2) food and farming systems that contribute to soil nutrient imbalances and soil organic matter depletion, and 3) human excreta management practices that result in irretrievable losses of nutrients and organic matter to air, water, and landfills. Nutrients discharged to surface waters can cause eutrophication (algal blooms, dead zones, and fish kills). Recovering nutrients and organic matter from streams containing human excreta diverts nutrients from existing infrastructure, reduces losses, and allows for the production of renewable fertilizers and soil amendments.



PRODUCE FERTILIZER

Separate wastewater streams containing urine and/or feces at the source to facilitate the treatment and targeted extraction of nutrients as fertilizers, minimizing pollution and losses. Recovery can target specific nutrients (often one macronutrient) or several nutrients (macro- and micronutrients). The recovered products can be reused as fertilizer in agriculture, horticulture, plant nurseries, and on sport fields.



Circular Sanitation TOOLBOX | 2025 | © Eawag
References and further information available at www.eawag.ch/en/vth/toolbox

PRODUCE SOIL AMENDMENT

Separate fecal streams at the source, or after solid-liquid separation of mixed wastewater, to aid nutrient and organic matter recovery. Treatment and recovery processes of the fecal streams, potentially combined with kitchen and/or garden waste, produce soil amendments that increase soil health and supply nutrients. Source separation also lowers pollutants, like heavy metals, compared to sludge from centralized treatment plants.



PRODUCE BIOMASS

Use streams containing urine and/or feces to grow or produce algal biomass, worms or insects (e.g., black soldier fly larvae). While algae is often grown on nutrient-rich liquids, such as urine, larvae and worms can be grown on fecal biomass and/or kitchen waste. The products can be used as, or in, animal feed, or used as soil amendments/fertilizer (e.g., algae).



TOOLBOX

WELCHE STRATEGIE KÖNNEN SIE
UMSETZEN, UM IHR ZIEL ZU ERREICHEN?

URINTRENNUNG

TROCKENSYSTEME

VAKUUMSYSTEME

WASSERGESPÜLTE SYSTEME

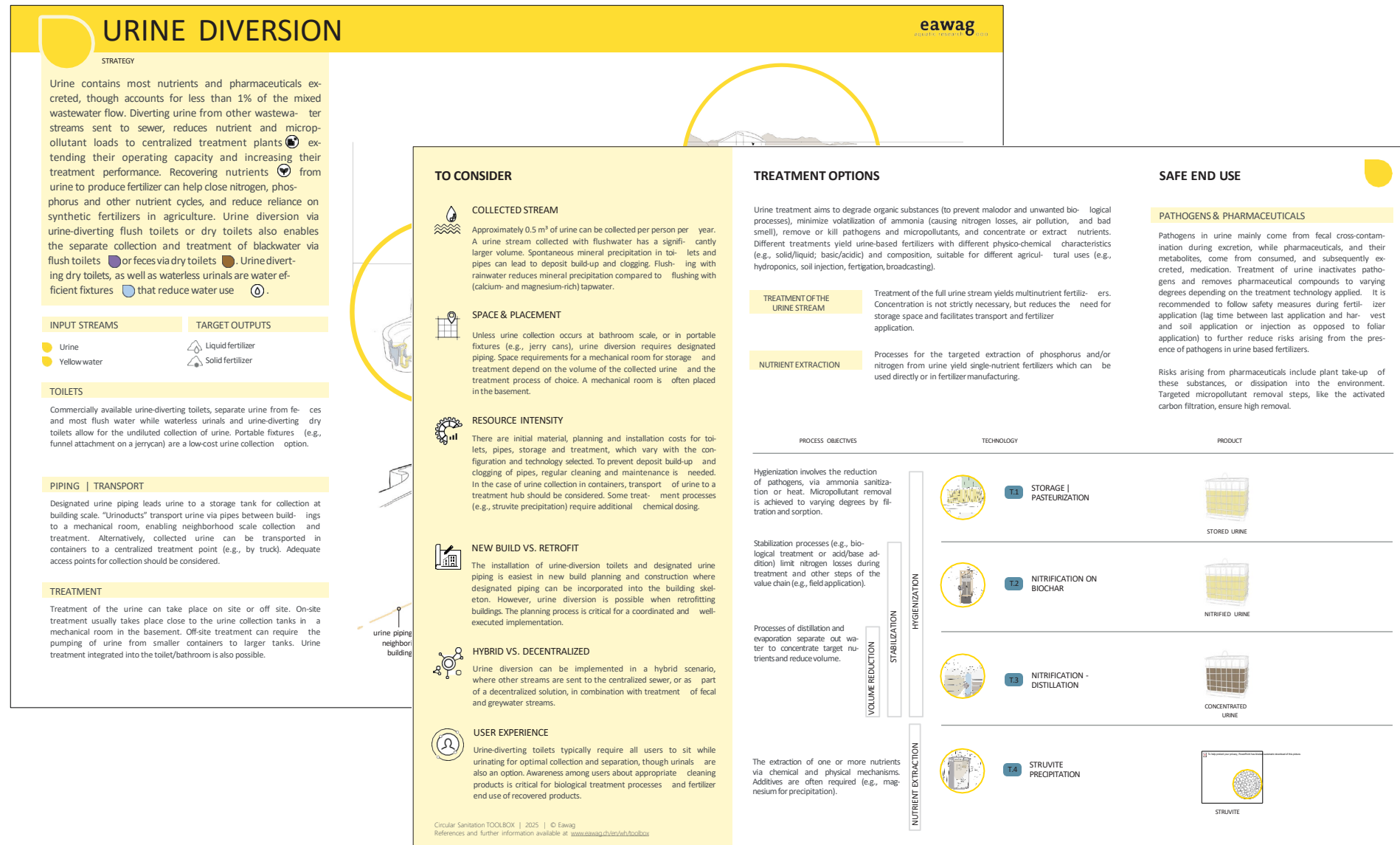
WASSER-WIEDERVERWENDUNG

WASSERSPARENDE INSTALLATIONEN

REGENWASSER-NUTZUNG

WÄRME-RÜCKGEWINNUNG

Strategien erkunden

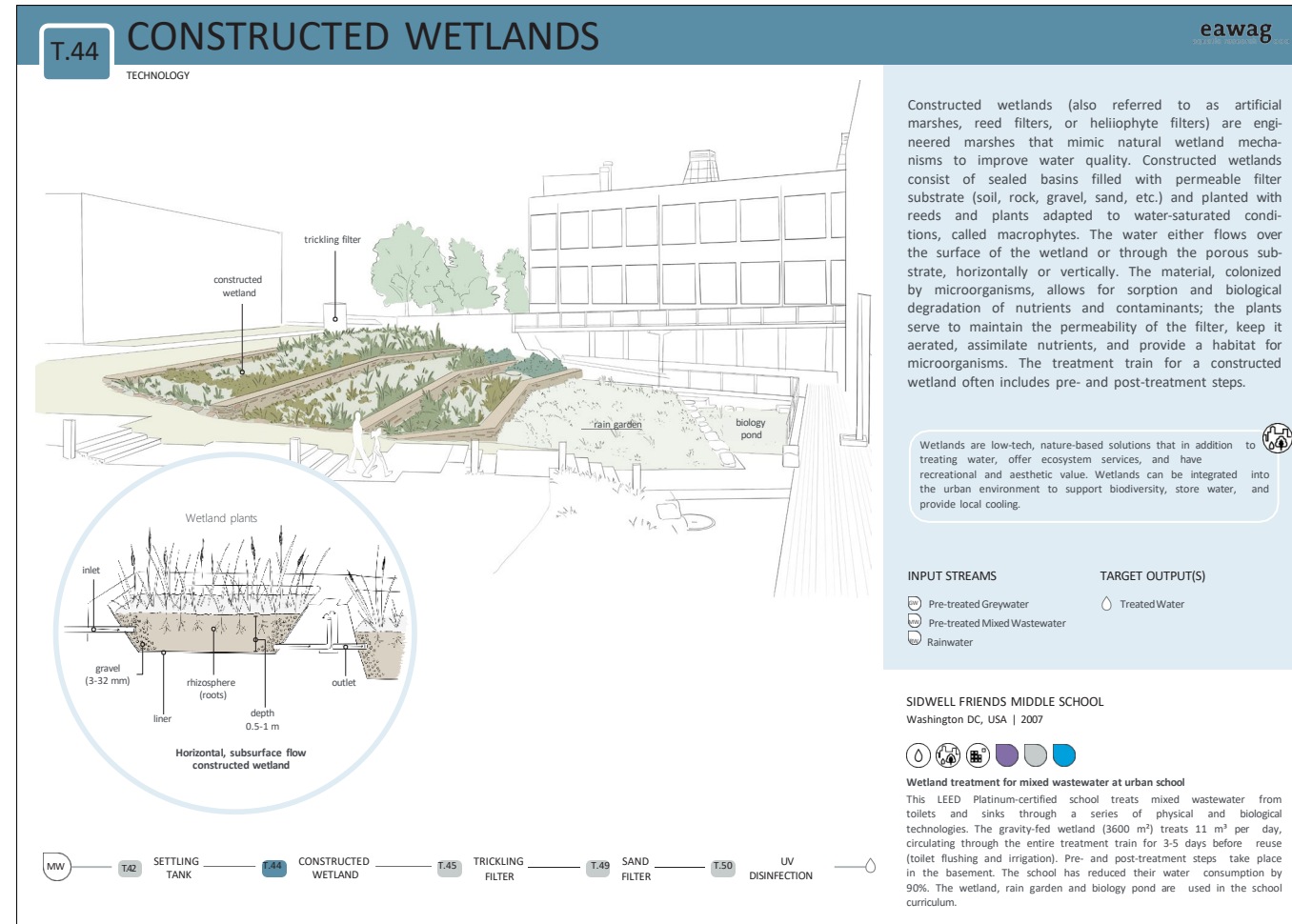


Technologien auswählen

TOOLBOX

WELCHE TECHNOLOGIEN PASSEN ZU
IHREM ZIEL UND IHRER STRATEGIE?

- T1 URINLAGERUNG & PASTEURISIERUNG
- T2 NITRIFIKATION AUF PFLANZENKOHLE
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- T61 WÄRMETAUSCHER | WÄRMEPUMPEN

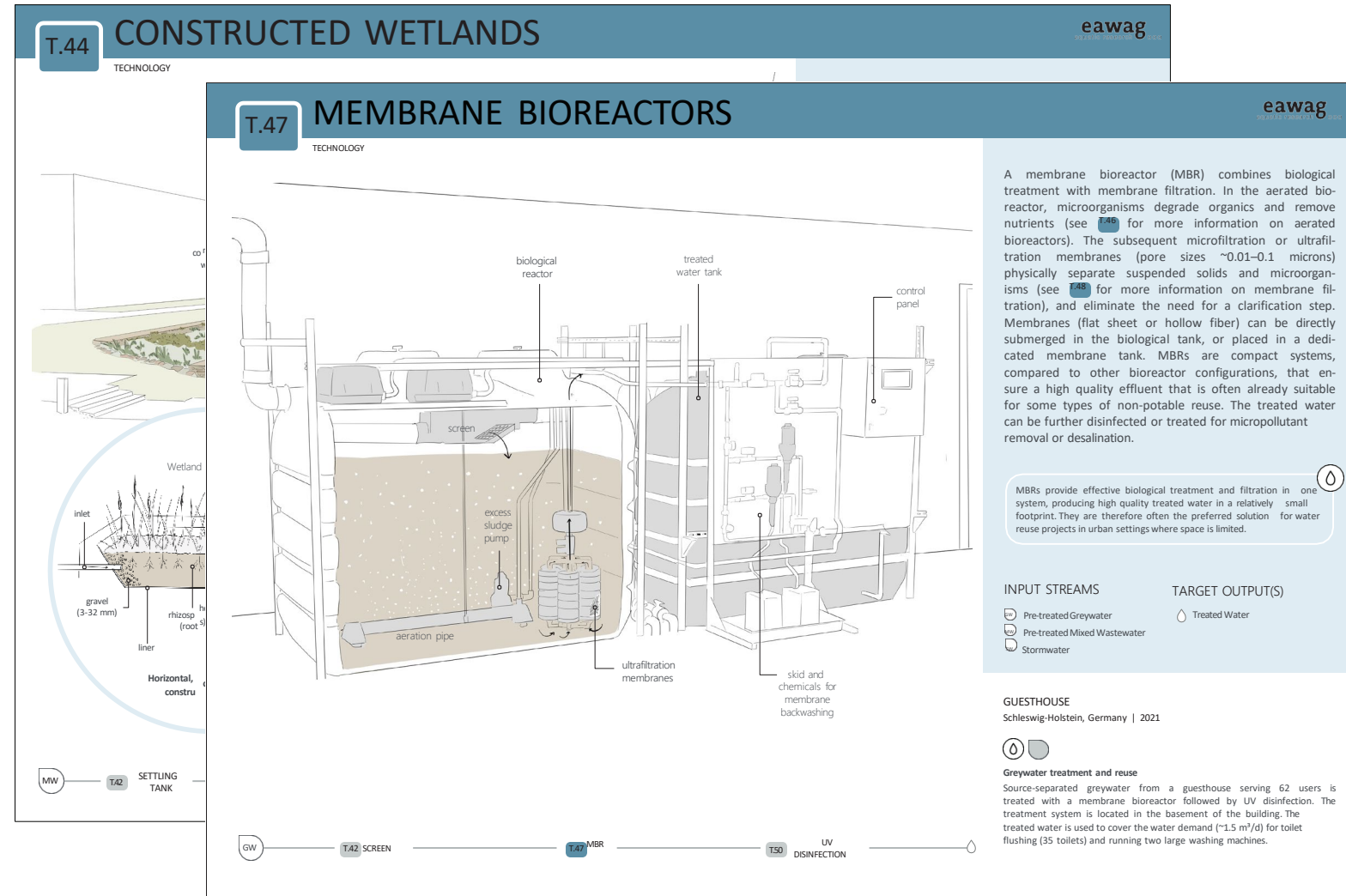


Technologien auswählen

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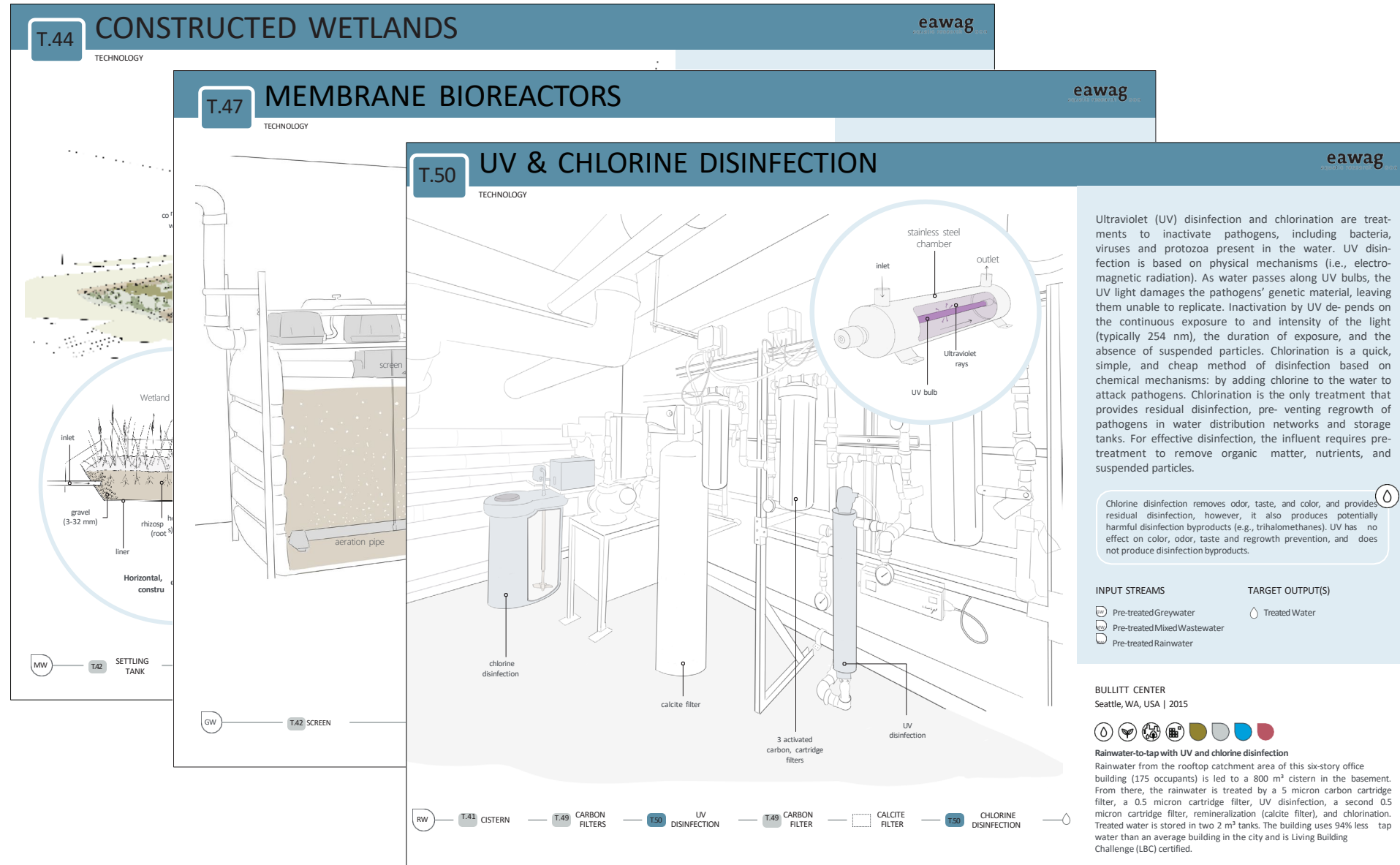


Technologien auswählen

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Das Vuna-Verfahren

Sammeln



Stabilisieren



Reinigen



Eindampfen



Düngen



Frischer Urin

Aurin-Dünger

Wasser

✗ Schwermetalle – keine im Urin

Geruch, flüchtiges Ammoniak

Arzneimittel & Hormone

Krankheitserreger

Hauptnährstoffe Stickstoff, Phosphor, Kalium

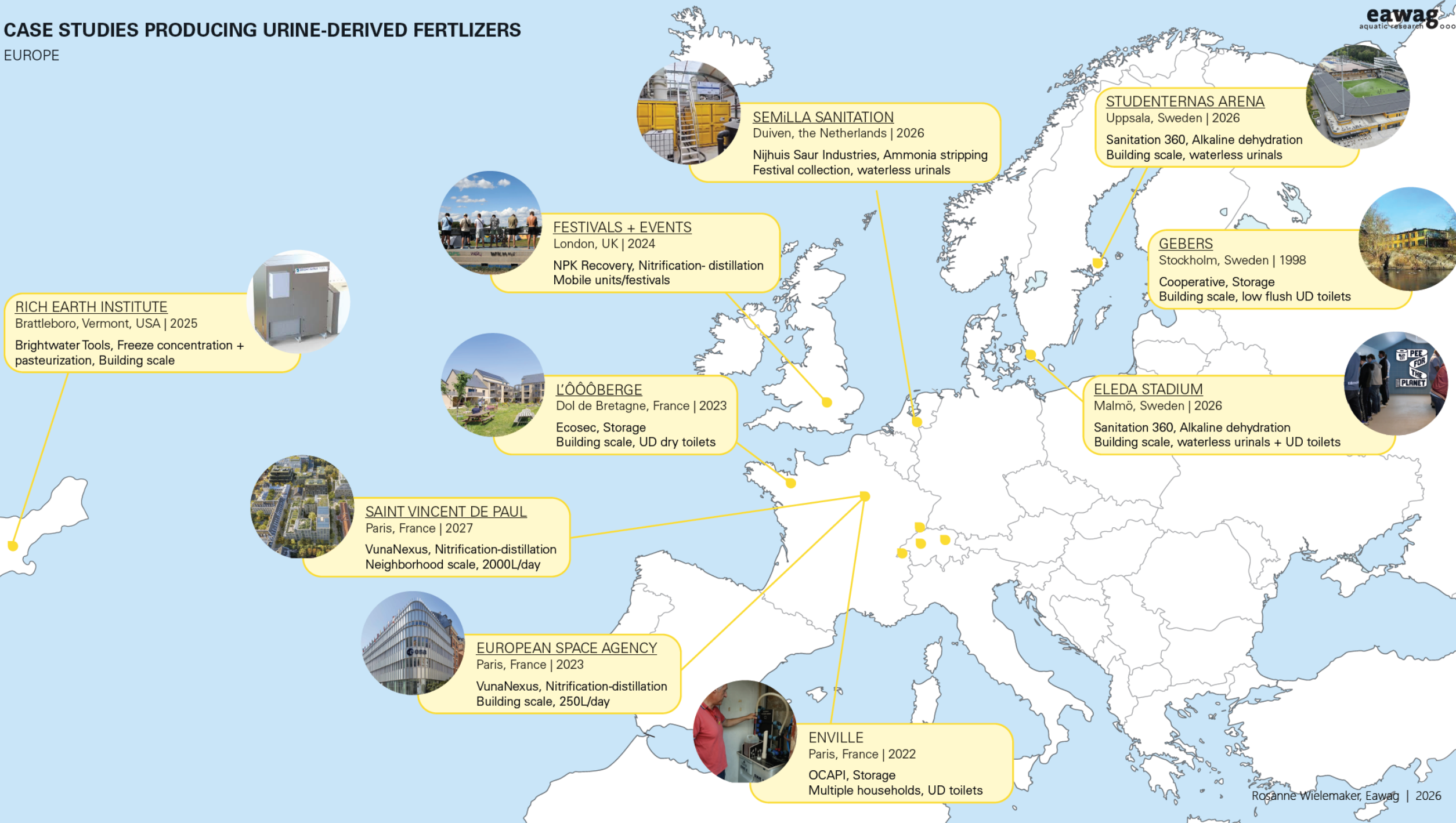
Spurennährstoffe z.B. Bor, Eisen, Zink

Düngerbewilligungen
in der Schweiz, in
Liechtenstein,
Österreich und
Frankreich.



CASE STUDIES PRODUCING URINE-DERIVED FERTLIZERS

EUROPE



RICH EARTH INSTITUTE
Brattleboro, Vermont, USA | 2025

Brightwater Tools, Freeze concentration +
pasteurization, Building scale



FESTIVALS + EVENTS
London, UK | 2024

NPK Recovery, Nitrification- distillation
Mobile units/festivals



L'ÔÔÔBERGE
Dol de Bretagne, France | 2023

Ecosec, Storage
Building scale, UD dry toilets



SAINT VINCENT DE PAUL
Paris, France | 2027

VunaNexus, Nitrification-distillation
Neighborhood scale, 2000L/day



EUROPEAN SPACE AGENCY
Paris, France | 2023

VunaNexus, Nitrification-distillation
Building scale, 250L/day



ENVILLE
Paris, France | 2022

OCAPI, Storage
Multiple households, UD toilets



SEMILLA SANITATION

Duiven, the Netherlands | 2026

Nijhuis Saur Industries, Ammonia stripping
Festival collection, waterless urinals

STUDENTERNAS ARENA

Uppsala, Sweden | 2026

Sanitation 360, Alkaline dehydration
Building scale, waterless urinals



GEBERS

Stockholm, Sweden | 1998

Cooperative, Storage
Building scale, low flush UD toilets



ELEDA STADIUM

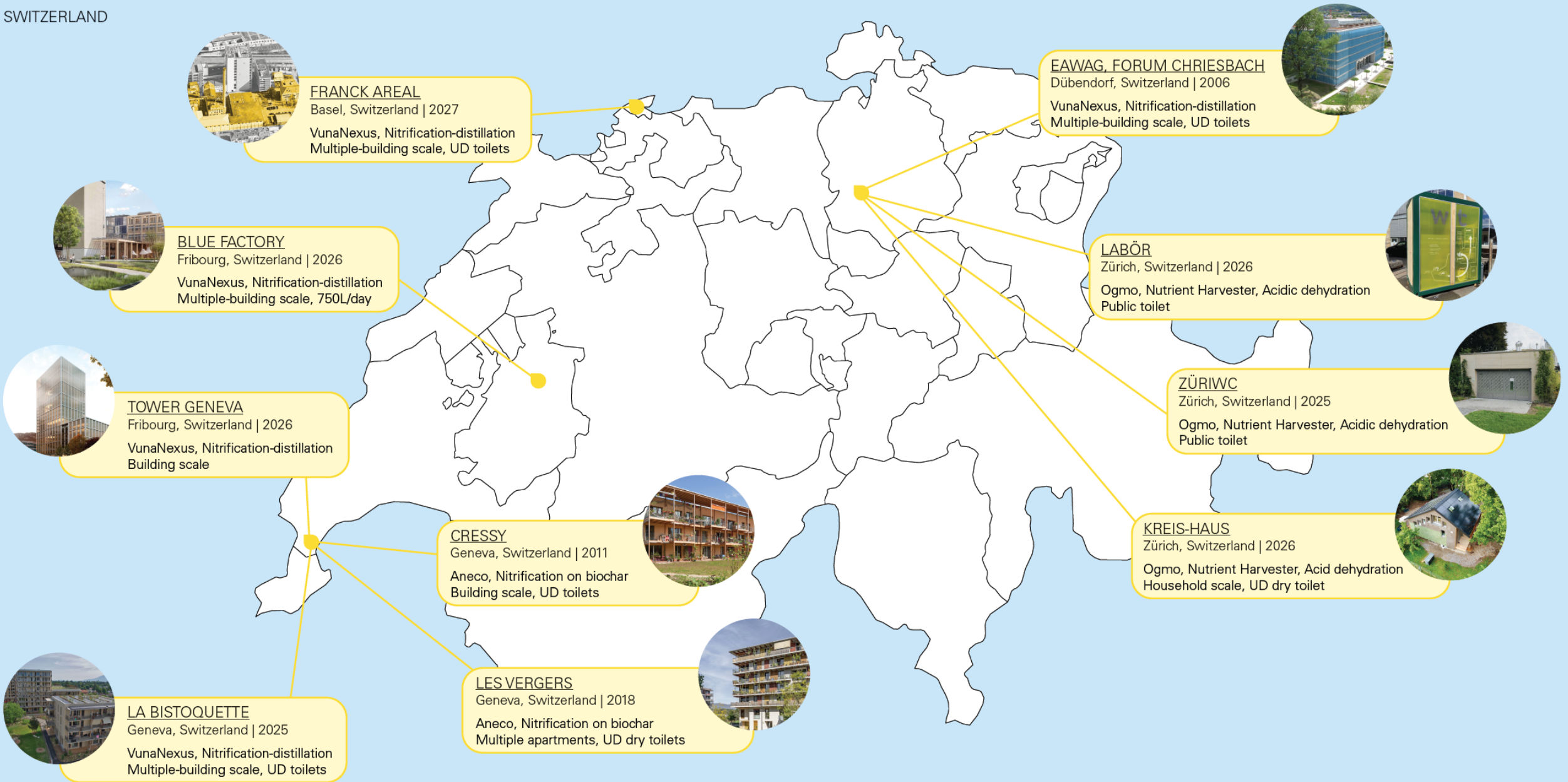
Malmö, Sweden | 2026

Sanitation 360, Alkaline dehydration
Building scale, waterless urinals + UD toilets



CASE STUDIES PRODUCING URINE-DERIVED FERTILIZERS

SWITZERLAND





Vielen Dank für Ihre
Aufmerksamkeit !