nextGen
Circular Water Solutions

Technology Evidence Base final version

Accompanying document to Deliverable D1.7

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Technical References

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[1] PU = Public
PP = Restricted to other programme participants (including the Commission Services)
RE = Restricted to a group specified by the consortium (including the Commission Services)
CO = Confidential, only for members of the consortium (including the Commission Services)

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Document history

V	Date	Beneficiary/Author	Action
1	24.10.2022	KWB et al., Kleyböcker et al.	Send to internal reviewer Sandra Casas
2	25.10.2022	EUT, Sandra Casas	Feedback of internal reviewer → Kleyböcker et al.
3	27.10.2022	KWB, Kleyböcker	Send to external reviewer Andrea Rubini
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6	23.11.2022	QA	Feedback of QA → Kleyböcker et al.
7	18.11.2022	KWB et al., Kleyböcker et al.	Final version → EC
8	02.01.2023	KWB et al., Kleyböcker et al.	Revised version according to the comments of the reviewer

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Update of previous version

Review of NextGen D1.7

The deliverable presents the structure of the TEB consisting of sub-domains linked to the nexus components. It is linked to the Water Europe Market Place (D5.5) and includes factsheets on the various technologies and case studies. It aims to unify the results to allow future end-users easy access to relevant information. This can be seen in the report and on the dedicated website. It is good that after the finalisation of the project, 2 other projects will take over the responsibility for the maintenance of the TEB, its further update and integration of new technologies. However, the methodology for the selection of technologies included in the TEB is not fully clear and should be better explained. Recommendations of the second project review have not been fully taken up regarding the inclusion of economic data and the unclear definition of the specific purpose and target group of the TEB as well as the sustainability of solutions regarding the overall nexus. Furthermore, it was recommended that quantitative microbiological (QMRA) and chemical risk assessment (QCRA) data (see T2.2) should have been clearly defined (e.g. which pollutants) and embedded in the TEB in order to make it available to the policy level (e.g. also in policy briefs).

Reviewer's comment	Revision	Explanation
Methodology for the selection of technologies included in the TEB is not fully clear and should be better explained	Done	The chapter was restructured and more details were provided.
Inclusion of economic data	Done	The results of the cost analyses have been inserted in the case study factsheets and are now, better described in the accompanying document.
Definition of the specific purpose and target group of the TEB is unclear	Done	An additional chapter was added explaining the specific purpose and target group of the TEB (chapter 2).
the sustainability of solutions regarding the overall nexus	Done	The results of the life cycle assessments showing the sustainability of the solutions regarding the overall nexus have been added in the case study factsheets and are now, better described in the accompanying document.
Quantitative microbial risk assessments (QMRA) should have been clearly defined (e.g. which pollutants) and embedded in the TEB	Done	The results of the QMRA have been added to the TEB on the case study factsheets and are now, better described in the accompanying document.
Quantitative chemical risk assessment (QCRA) data should have been clearly defined (e.g. which pollutants) and embedded in the TEB	Done	The results of the QCRA have been added to the TEB on the case study factsheets and are now, better described in the accompanying document.

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Summary

In the European Union (EU) Horizon 2020 (H2020) project NextGen, 24 technologies related to circular economy in the water sector were investigated at 10 case studies distributed across Europe. The technologies are involved in water management and recovery, material recovery and energy recovery (Figure 1). In this context, a database containing information and data referring to those technologies was developed. The database is called technology evidence base (TEB), is open access and hosted by Water Europe as part of the Marketplace (https://mp.watereurope.eu/).

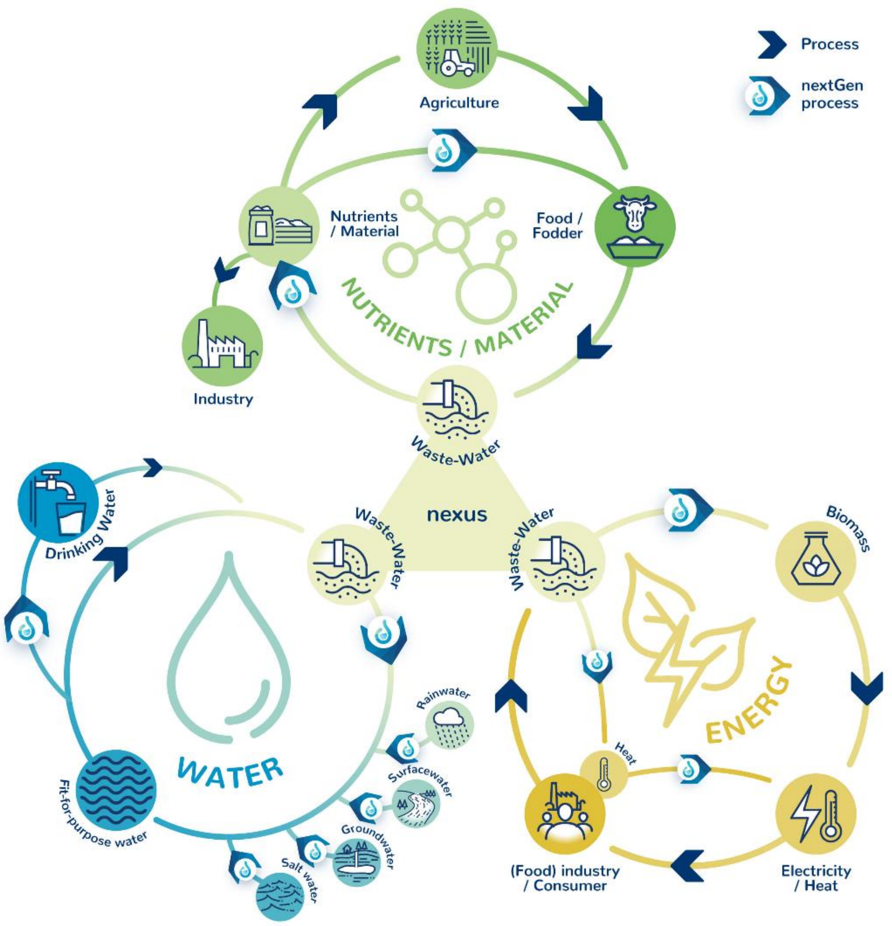

Figure 1 Circular economy: wastewater is a valuable resource for water, material and energy recovery. It is the nexus between the three cycles, in which the NextGen technologies are involved.

For each technology, a factsheet was elaborated containing the explanation, how this technology works, its unique selling points, requirements to implement the technology, flow schemes, pictures and a link to the case study, in which the technology has been build and applied. For each case study, also a factsheet was elaborated containing the main results such as the performance of the technology, lesson learned from its operation and best practice guidelines as well as the outcome of the assessments such as the life-cycle assessment, life cycle costing and/or risk assessments for human health from recovered water (QMRA) and for the environment form recovered fertilisers (QCRA). In addition, the related legislation is listed which is crucial e.g. to establish the fertiliser on the market. Also contact data of the entities and companies operating those technologies are provided in order to enable consultation

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and/or discussion between problem owners and solution providers. The NextGen consortium developed and uploaded 24 technology factsheets (https://mp.watereurope.eu/teb/) and 10 case studies factsheets (https://mp.watereurope.eu/l/CaseStudy/) including their NextGen results.

After the finalisation of NextGen, the EU H2020 projects ULTIMATE (grant agreement number: 869318) and B-WaterSmart (grant agreement number: 869171) will take over the responsibility for the TEB. They will also collect data and integrate their technologies in the TEB. ULTIMATE plans to add 21 new technologies and will extend the factsheet of 4 already existing technologies. B-WaterSmart is currently preparing a list with technologies they want to add. They will mainly focus on membrane technologies applied for fit-for-purpose water recovery. On the long-term, it is recommended to involve more research and innovation projects to maintain the TEB, because it is time-intensive and needs an expertise to assess the application of new factsheets. Also, via the involvement of those projects, the TEB might remain open access, what is considered as crucial, if a broader spectrum of user types is desired.

The TEB will promote circular economy technologies in the water sector and enable decision makers, engineers, investors and interested persons to gain a fast overview of the innovative technologies available. Hence, the TEB can contribute highly to reach the ambitions of the European Green Deal its Action Plan for Circular Economy to reduce strongly the EU greenhouse gas emissions, to provide clean water, maintain healthy soil, make industry resilient and produce cleaner energy.

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Disclaimer

Any dissemination of results must indicate that it reflects only the author's view and that the Agency and the European Commission are not responsible for any use that may be made of the information it contains.

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Abbreviations

AAT	Advanced anaerobic technology
AOP	Advanced oxidation processes
AnMBR	Anaerobic membrane bioreactor
ASR	Aquifer storage recovery
CAPEX	Capital expenditures
CEA	Cost-effectiveness analysis
D	Deliverable
ELSAR	Electrostimulated anaerobic reactor
EU	European Union
GA	Grant Agreement
GAC	Granular activated carbon
H2020	Horizon 2020
HFMC	Hollow fibre membrane contactor
KPI	Key performance indicator
LCA	Life cycle assessment
LCC	Life cycle costing
MBR	Membrane bioreactor
MELiSSA	Micro-ecological life support system alternative
MNR	Metabolic network reactor
OPEX	Operational expenditures
QCRA	Quantitative chemical risk assessment
QMRA	Quantitative microbial risk assessment
RO	Reverse osmosis
SOFC	Solid oxide fuel cell
TEB	Technology evidence base
UF	Ultrafiltration
WP	Work Package
WWTP	Wastewater treatment plant

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1. Introduction

The Horizon 2020 project NextGen promotes circular economy technologies based on water recovery, material recovery and energy recovery. At ten case studies distributed across Europe the technologies were conceptualized, designed, constructed and showcased specifically, in Braunschweig (DE), Costa Brava (ES), Westland (NL), Altenrhein (CH), Spernal (UK), La Trappe (NL), Gotland (SE), Athens (EL) and Timișoara (RO) and Filton (UK).

In this frame, a so called Technology Evidence Base (TEB) was established. The TEB is a database that contains and presents generic information on the demonstrated circular economy technologies of NextGen and of two other Horizon 2020 projects, ULTIMATE (GA N° 869318) and B-WaterSmart (GA N° 869474). In addition, the TEB disseminates the case study specific results of each project. The TEB aims to unify the results and to allow for an easy access to relevant information needed for setting up new circular economy schemes in the water sector. The TEB is accessible via the Water Europe Marketplace (*D5.5 The NextGen Online Marketplace*, https://mp.watereurope.eu/). For the TEB, the NextGen consortium developed and uploaded 24 technology factsheets (https://mp.watereurope.eu/teb/) and 10 case studies factsheets (https://mp.watereurope.eu/l/CaseStudy/) including their NextGen results.

While in NextGen the circular economy technologies are mainly applied in the frame municipal wastewater treatment, ULTIMATE focuses on water smart industrial symbioses and demonstrates circular economy based technologies applied in the frame of industrial wastewater treatment. Therefore, ULTIMATE supplements very well the industrial aspect in the TEB and provides new information on symbiotic cooperation opportunities between the industry and the water sector at nine case studies. Furthermore, B-WaterSmart focuses on water smart solutions and management solutions for six coastal cities and regions.

This document accompanies *D1.7 Technology Evidence Base final version* (https://mp.watereurope.eu/teb/) and explains the structure and organization of the TEB, it provides information on the content and structure of the technological factsheets, the presentation of the results from NextGen on case study level (https://mp.watereurope.eu/l/CaseStudy/) including results from technology performance and lessons learned (WP1, Plana Puig et al. 2022, Kim et al. 2022 and Kleyböcker et al. 2022), results from the assessments (WP2, D2.1 Remy et al. 2022, D.2.2 Misev et al. 2022), legal and regulatory information (WP4) and the link to the Marketplace for business opportunities (WP5, D5.5). This document also outlines the maintenance procedure of the TEB and the future plans for it including aspects regarding the assurance of a good data quality and an extension of the TEB by other projects and solution providers.

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2. Purpose of the TEB and target groups

The TEB consists of a catalogue of circular economy related technologies and refers to its demonstration cases, where the technologies have been applied, tested and important data have been collected in a scientific way.
The TEB presents generic information on the demonstrated technologies and case study specific results of three projects aiming at including more innovation and research projects in the future. The results comprise the lessons learned from the technology implementation and operation, the technology performance, the CO_2 foot print of the system, cost assessments, risk assessments and policy briefs.
The idea behind the TEB is to establish a "Wikipedia"-like database for circular economy technologies and their application. Especially the synergies originating from the nexus between water, material and energy recovery are shown for every relevant technology via links and showcased in detail on case study level as well as emphasised e.g. in the sustainability assessments (life cycle assessment).

The TEB aims to unify the results and to allow for an easy access to relevant information needed for setting up new circular economy schemes in the water sector. It starts with easy to understand information and provides links to detailed reports and data for persons that have a deeper interest in the technologies. Thus, it is suitable for users, that need a short overview on circular economy technologies and their concepts, but it is also valuable for problem owners and solutions providers which want to promote and implement circular economy concepts and are interested in already tested and demonstrated technologies. Via the provided contact data of the operators and evaluators of the technologies, the origin of the results is transparent. The involvement of the innovation and research projects allows scientists who are independent from the technology manufacturer to conduct assessments. Hence, it is an interesting data base for investors in those technologies such as utilities, municipalities, industries in order to gain an impression of a technology that has been tested in a real environment.
Moreover, a match between solution providers and problem owners can be enabled due to the availability of the contact data to the operators of such technologies. Because this database also includes scientific data from innovative technologies, this platform is also interesting for technology developers and manufactures, for planners and engineers and persons involved in education.
In the section "Legislation and policy recommendation" on case study level, also policy makers will find valuable hints and ideas for further action to enable and promote circular economy concepts in Europe.
The TEB is hosted and promoted by Water Europe in order reach the broad water sector in Europe comprising utilities, private companies, policy makers, scientists and other interested parties.

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3. Structure and organisation of the TEB

The final version of the NextGen parts in the TEB is open accessible via the Water Europe Marketplace at https://mp.watereurope.eu/ by clicking on the button "Technologies" (Figure 2). Figure 3 illustrates the entrance of the TEB with the three cycles concerning the recovery and reuse of water, material and energy. The nexus between the three cycles shows the potential for synergies of the circular economy technologies and the figure explains the circular economy character of the technologies supporting the TEB users to easily discover new opportunities for creating their own circular economy concepts.

After clicking on one of the cycles, the next webpage provides an overview of the technology domains that are relevant for the selected cycle.

For the water cycle, the subdomains are:

- Wastewater treatment for water reuse
- Rainwater harvesting systems
- Surface water and infiltration systems
- Groundwater systems
- Desalination technologies

For the nutrient and material cycle, the subdomains are:

- Nutrient recovery technologies
- Material recovery technologies
- Food/fodder production technologies

For the energy cycle, the subdomains are:

- Biomass production technologies
- Heat recovery & storage systems

Each technology domain contains subdomains and factsheets as exemplarily shown for the material cycle in Figure 4. By clicking on one of the subdomains, the corresponding factsheets belonging to the certain subdomain are displayed and can be accessed via clicking on them. Furthermore, related case studies are also shown and can be accessed via this pathway.

However, the case study specific factsheet, can also directly be visited by clicking on "case studies" in the left menu on the starting page of the TEB, by clicking on the "Case studies" button on the starting page of the Marketplace or by directly visiting this webpage https://mp.watereurope.eu/l/CaseStudy/.

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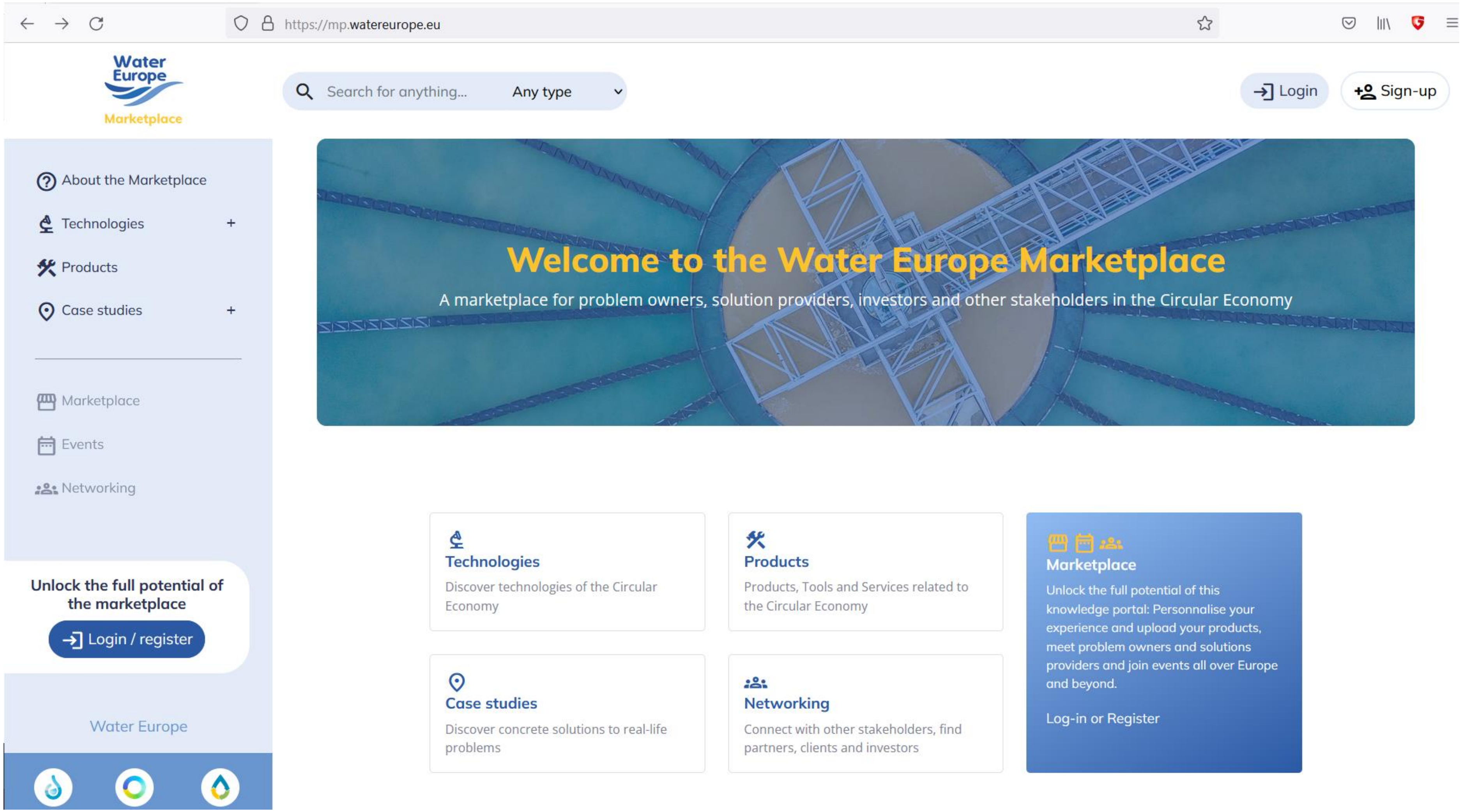

Figure 2 Starting page of the Water Europe Marketplace (D5.5 The NextGen online Marketplace)

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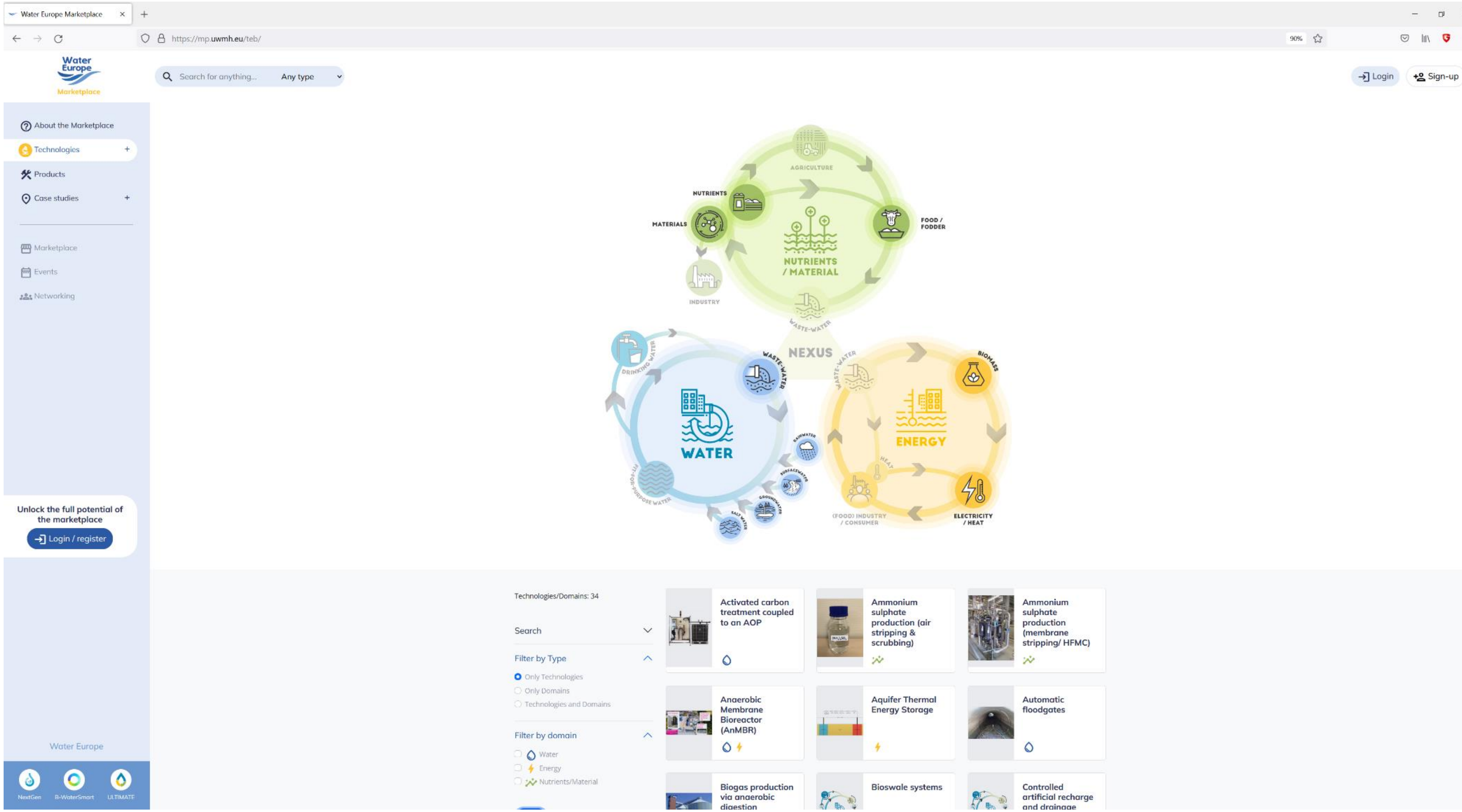

Figure 3 Entrance to the TEB via the Water Europe Marketplace: showing the three cycles of water, material and energy and corresponding factsheets referring to each domain

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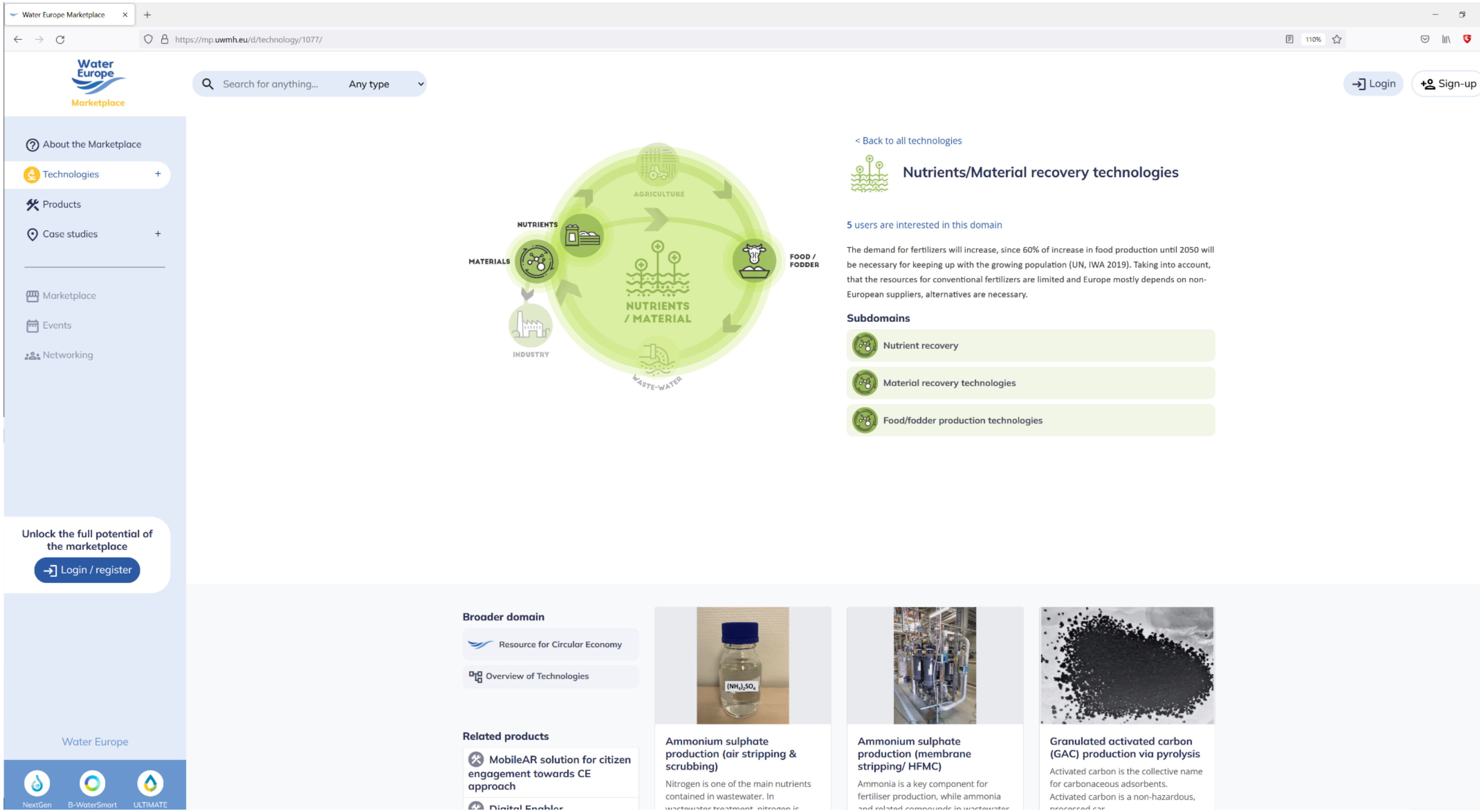

Figure 4 Example for the technology domain of material recovery technologies displaying its subdomains and providing links to its corresponding factsheets

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The “Overview of Technologies” can be illustrated by clicking on the corresponding button (Figure 4). Thereby, all factsheets assigned to their subdomains and broader domains can be accessed as shown in Figure 5. This structure is also called *taxonomy of the technologies*.

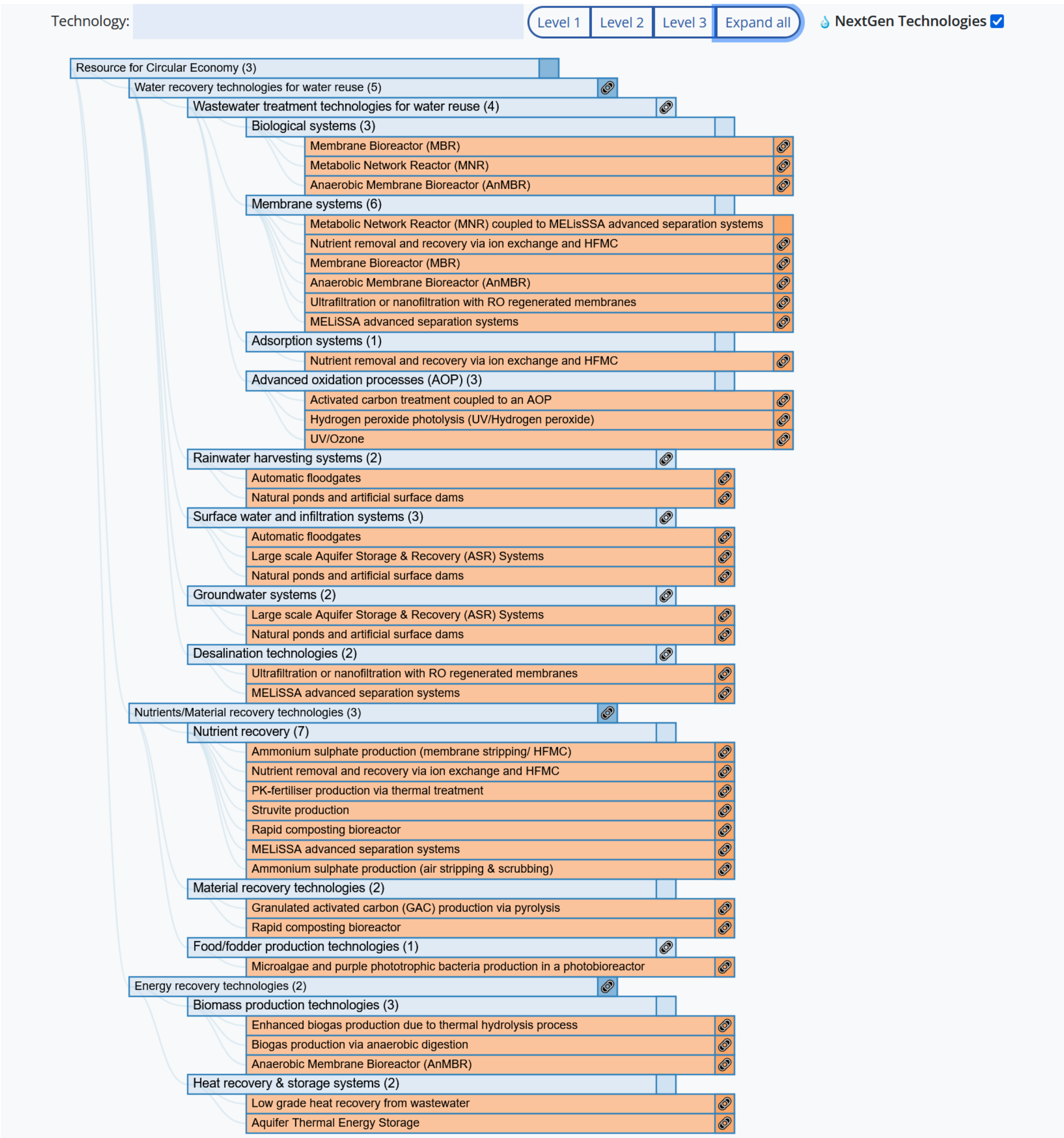

Figure 5 Overview about the taxonomy of the NextGen technologies: technology domains and subdomains are illustrated in blue and the technology factsheets are coloured in orange

Via the search function in the upper left part of each webpage (Figure 2, Figure 3, Figure 4 and red circle in Figure 6), the user can search directly for a technology or product to be recovered such as biogas, heat, phosphorus, etc.

Below the search function on the right side of the webpage, the green circled “Back to all technologies” button allows to navigate back to the starting page of the TEB.

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Figure 6 Technology domain: Energy recovery technologies: red circle shows the "search function" and the green circle indicates the button to navigate back to the starting page of the TEB

Figure 7 shows the technology factsheet. In the upper part (red circle) the pathway of the factsheet is presented. Also, by clicking on the domain or subdomain, the user can navigate back to the overview pages. The same navigation can be done by clicking on the blue button of the broader domain and the orange buttons of the subdomains as shown in Figure 5. Between the different factsheets, links are provided in order to easily switch between pages and to find information (Figure 7, green circle). Those links are further explained in the next paragraph "Content of the factsheets".

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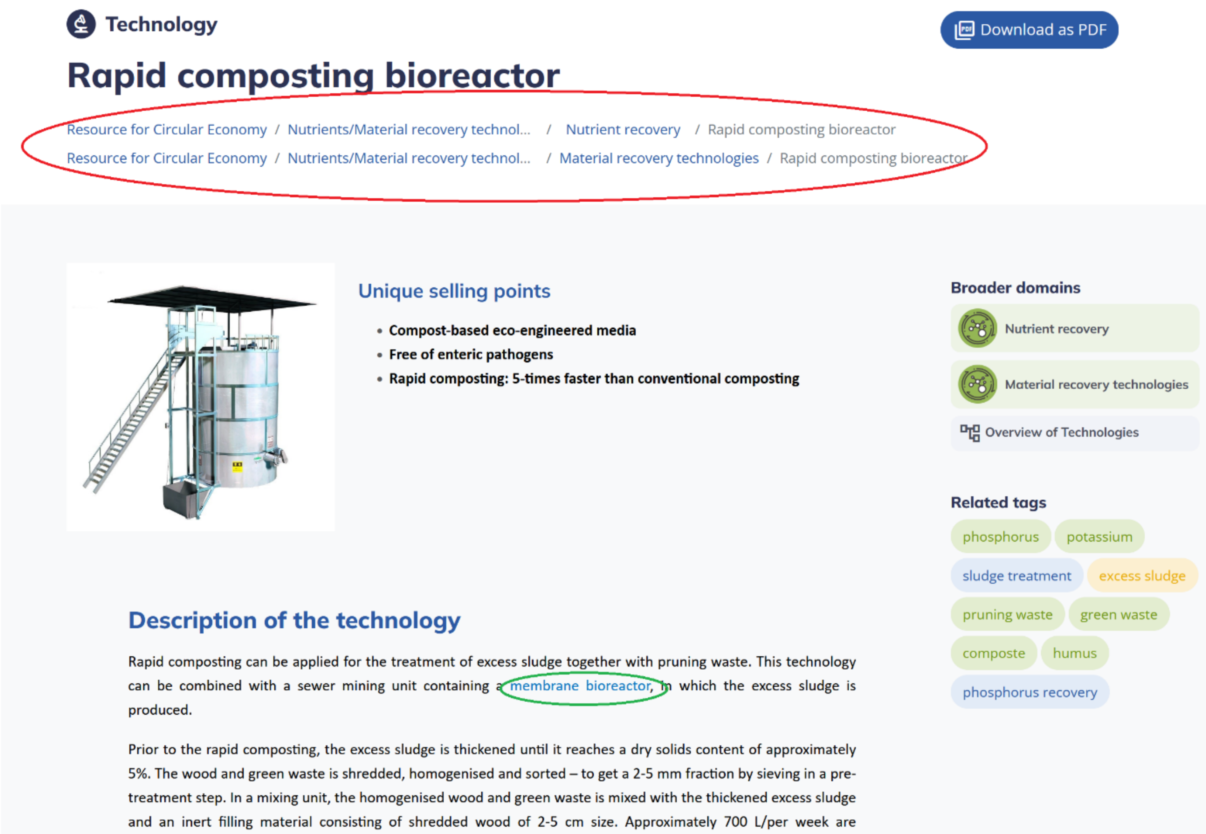

Figure 7 First part of the technology factsheet for the rapid composting bioreactor

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4. Content of the factsheets

All technology factsheets have the same structure following the layout in Figure 7 and containing information about the listed categories (see bullet points below). The NextGen consortium discussed and agreed on the structure of the factsheets and Water Europe reviewed and also agreed the concept of the TEB. The basic information is generic and for each category, easy-to-understand with summarised information content is presented together with a link to more detailed information such as literature references. For the cited literature, open access publications shall be the first choice.

Each factsheet contains the following elements:

Technology factsheet with generic information:

- Name of the technology
- Unique selling points
- Description of the technology (point of application, capacity, explanation of the process with literature references, type of product produced by the technology)
- Flow scheme of the technology
- Pictures of the technology and if available short videos
- Synergetic effects and motivation to implement this technology
- Key performance indicators (KPIs) & technical parameters: data for the performance of the technology (e.g. nutrient recovery rate, biogas yield, log removal rate of pathogenic organisms),
- Requirements for the implementation of the technology and operating conditions
- Link to the case study where the technology is applied (here the case study specific information will be presented, see also Figure 8)
- Links to similar related technologies or other technologies producing the same product
- Literature references

The results of the NextGen related technologies are presented as case study specific information in a case study factsheet. This part is accessible via a link at the end of the related technology factsheet, directly via the button "Case studies" on the Marketplace (Figure 2) or on the left hand menu that is always visible when navigating through the Marketplace and TEB.

Case study factsheet with case study specific information (Figure 8):

- Description of the case study
- Applied technologies
- Applied tools
- Abstract of key lessons from WP1 and link to the corresponding deliverables D1.3, D1.4, D1.5 (New approaches and best practices for the optimal operation of the technologies and explaining the success of the symbioses)
- Abstract of the outcomes of the assessments from WP2 in D2.1 (e.g. LCA (CO_2 footprint, energy consumption/production), QMRA, QCRA) and in D2.2 (LCC incl. CAPEX, OPEX, return rate, distribution costs, etc. and CEA),
- Legal and regulatory information regarding the value chain concerning the technology (→link to the corresponding case study results in WP4)

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- Contact data of companies/entities operating and assessing the technologies for business opportunities and link to the Marketplace

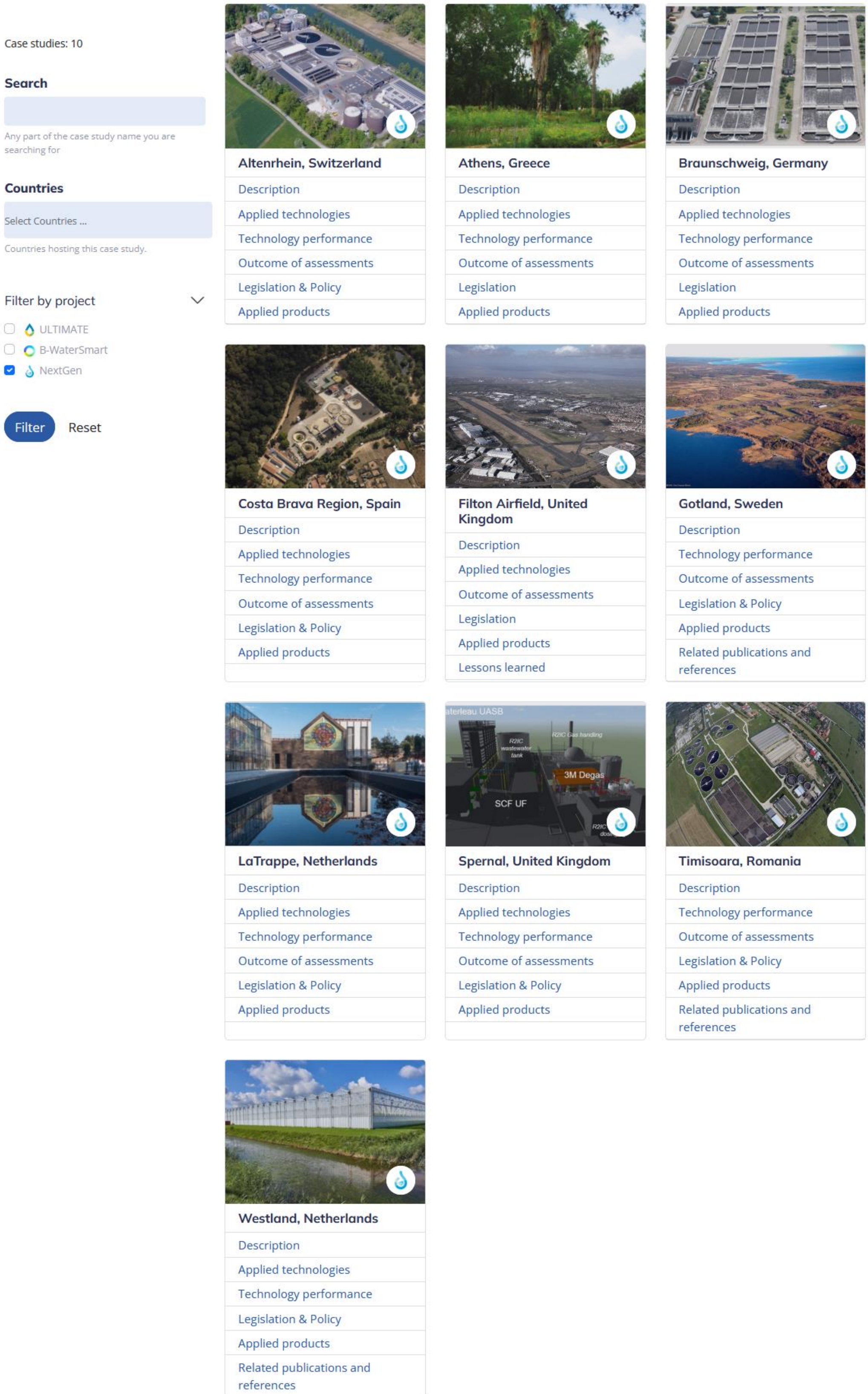

Figure 8 NextGen case studies in the TEB: showing links to the NextGen results such as "Technology performance", "Outcome of assessments"; "Legislation & Policy"; also the factsheets of the technologies in the TEB can be accessed via the shown links

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Clicking on the links shown in Figure 8, results in accessing the case study factsheet. Figure 9 shows the first and upper part of the factsheet. It starts with a picture of the case study, followed by a short description of the case study and the links to the applied technologies, where general information is available as explained earlier.

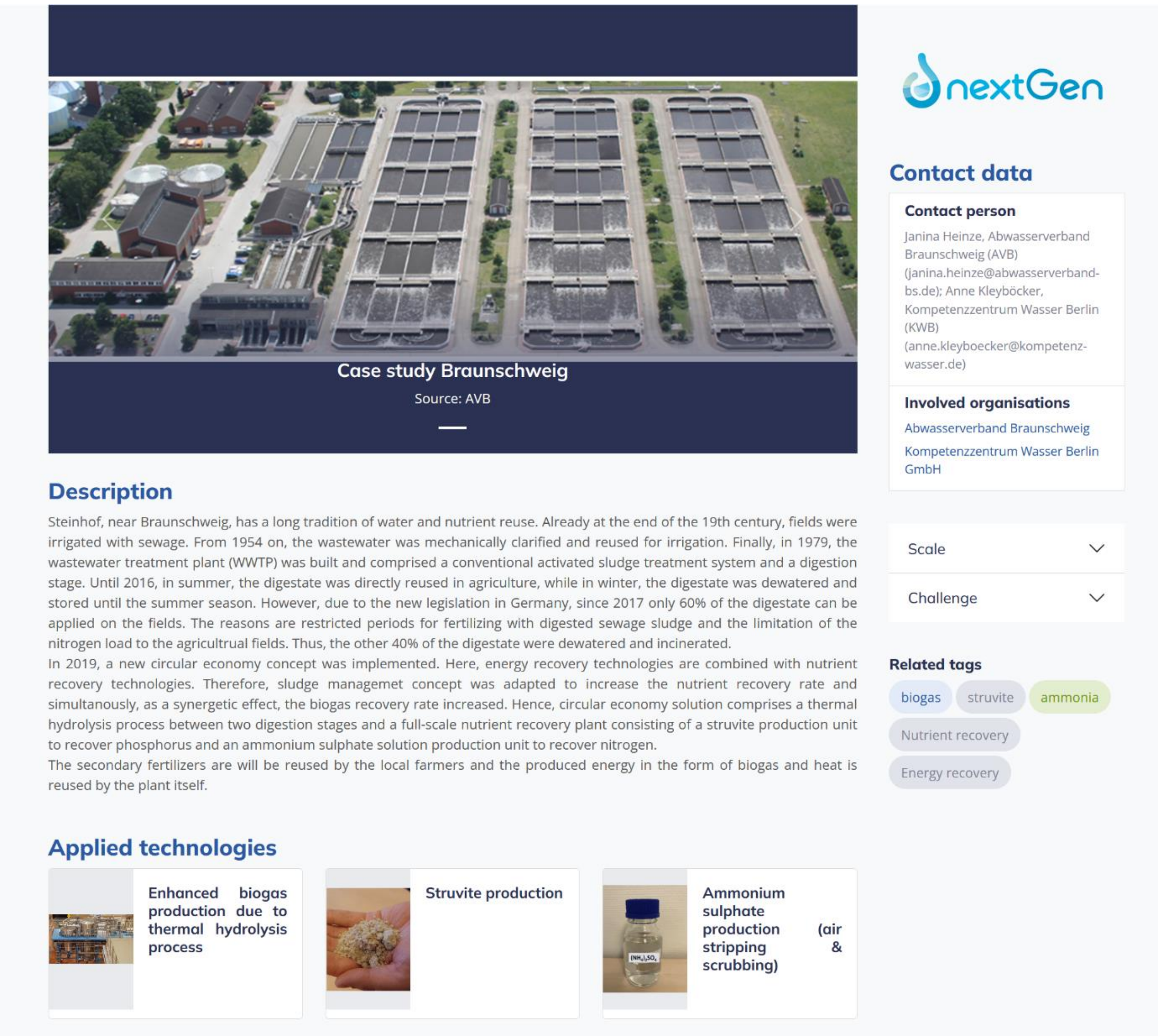

Figure 9 First part of the Braunschweig case study factsheet: description of the case study and applied technologies, which provide the link to their factsheets

In Figure 10, the second part of the case study factsheet is shown. Here, the NextGen results of WP1 are presented named “Technology performance and best practices” for each technology in the form of a short abstract including a link to the detailed project report indicated by the red circle.

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Technology performance and best practices

Enhancing biogas formation via thermal pressure hydrolysis

The goal of the Braunschweig (DE) case was to enhance biogas production via thermal pressure hydrolysis at the municipal WWTP. Thermal pressure hydrolysis (TRL 9) was performed as a pre-treatment of digestion, resulting in higher biodegradation during digestion. The results showed that the biogas production increased by 20% and the dewatering efficiency of the digestate increased by 10% due to the higher biodegradation of the thermally hydrolysed sludge. Although high attention to operating and maintenance of the system is mandatory, the technical feasibility of the thermal pressure hydrolysis has been successfully demonstrated. The better biodegradation contributed also to an increase in phosphate and ammonium concentrations in the liquor, which are crucial for the subsequent nutrient recovery. Detailed results can be found in D1.4.

Nutrient recovery (struvite, ammonium sulphate)

Nutrient recovery at TRL 9 was successfully demonstrated. To remove and recovery phosphorus, the struvite production unit used the liquor of dewatered digestate in a side stream and reached recovery rates between 80%-97%. The recovery rate depended highly on the chemical composition of the liquor, the mixing conditions in the precipitation reactor and the dosing rates of $MgCl_2$. The potential for struvite production is 300 t struvite/a. This corresponds to 16% of the phosphorus influent load and to 1% of the nitrogen influent load to the WWTP. Detailed results can be found in D1.5.

For nitrogen removal and recovery, an air stripping and scrubbing unit was implemented to produce ammonium sulphate solution. The recovery rates were easy to control and could be operated between 80% and 97% as required. The potential for the production of $(NH_4)_2SO_4$ solution is 2000 t/a corresponding to 175 t N/a, which is 12% of the inflow nitrogen load to the WWTP. Detailed results can be found in D1.5.

Contact data

Contact person

Janina Heinze, Abwasserverband Braunschweig (AVB) (janina.heinze@abwasserverband-bs.de); Anne Kleyböcker, Kompetenzzentrum Wasser Berlin (KWB) (anne.kleyboecker@kompetenz-wasser.de)

Involved organisations

Abwasserverband Braunschweig

Kompetenzzentrum Wasser Berlin GmbH

Scale

Challenge

Figure 10 Second part of the Braunschweig case study factsheet presenting the project results from WP1

Figure 11 shows the third part of the case study factsheet and presents the "Outcome of the assessments" such as the life cycle assessment showing the sustainability of the NextGen solutions and hereby focusing on their nexus and the resulting synergies. In addition, the results from the life cycle costing and cost effectiveness analysis are outlined. Furthermore, the outcomes from the quantitative microbial risk assessments and/or the quantitative chemical risk assessments are presented together with links to more detailed information in the project reports. Hereby, it should be noted, that the presented case study focused only material and energy recovery and hence, a microbial risk assessment was not relevant. This is different to the case study in Athens, where both assessments were done as shown in Figure 12.

Outcome of assessments

Life Cycle Assessment

The combined sludge and sludge water treatment scheme with thermal pressure hydrolysis, struvite recovery and ammonium sulphate solution recovery is able to recover nutrients with a net-zero CO_2 footprint. Direct N_2O emissions and emissions of reactive nitrogen species are reduced. A further reduction of the CO_2 footprint could be achieved by utilisation of excess heat in summer for the stripper to reduce caustic soda consumption. Further LCA results can be found in D2.1.

Life cycle costing & cost effectiveness analysis

The implementation of a combined sludge and sludge water treatment scheme with thermal pressure hydrolysis, struvite recovery and ammonium sulfate solution recovery in the WWTP Braunschweig–Steinhof has an additional cost as the fertilisers revenues are much lower than the additional annual infrastructure related costs, personnel and chemical costs. However, the nutrient recovery schemes are required to ensure that the discharge limits for nitrogen and phosphorus are met. Further LCC and CEA results can be found in D2.2.

Chemical risk assessment for the application of renewable fertilisers

In Braunschweig, phosphorus and nitrogen are recovered as struvite and ammonium sulphate solution for agricultural use. The risk was assessed for several inorganic substances (As, Cd, Cr, Cu, Pb, Hg, Ni, Zn), Benzo(a)pyrene and PCDD/F + dl-PCB. No high risk was characterised for any of the secondary fertilizers with respect to the soil or groundwater ecosystem after long-term fertiliser application. Detailed results can be found in D2.1.

Contact data

Contact person

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Involved organisations

Abwasserverband Braunschweig

Kompetenzzentrum Wasser Berlin GmbH

Scale

Figure 11 Third part of the Braunschweig case study factsheet presenting the project results from WP2

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Outcome of assessments

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Life cycle assessment

Sewer mining can substitute drinking water for irrigation at the tree nursery and helps to decrease the local water footprint. However, the membrane bioreactor needs more energy and related CO_2e emissions than the central water supply in Athens. With composting of sewage sludge and green waste, a surplus of nutrient-rich compost can be exported. Heat recovered from the wastewater can be used to meet local demand, but should use green electricity to decrease the CO_2e footprint of the entire system. Further LCA results can be found in D2.1.

Life cycle costing & cost effectiveness analysis

Local water reuse by sewer mining to substitute potable water for urban tree nursery irrigation is profitable. CAPEX and energy input are the main costs of this circular solution. Heat recovery from wastewater with heat exchangers has a positive annual cost balance, with the potential cost savings of recovered energy more than offsetting the CAPEX and energy input costs. The rapid composting should be further optimised as the potential annual cost savings related to the substitution of market fertiliser and the reduction of pruning waste disposal cannot yet offset the additional CAPEX and OPEX (mainly energy input). Further LCC and CEA results can be found in D2.2.

Quantitative microbial risk assessment (QMRA)

At the case study in Athens, an innovative approach to water reuse was applied by extracting urban wastewater with a sewer mining (SM) unit to produce safe urban green irrigation water at the point of demand. The QMRA was used to address and quantify potential health risks resulting from the exposure of people to irrigation water produced by the SM unit. More details are presented in D2.1.

Chemical risk assessment for the application of compost

The compost produced in Athens is used for horticultural purposes next to the sewer mining unit. Due to the limited spatial application, the soil ecosystem was assumed to be the only relevant endpoint within the risk assessment. Heavy metals were considered a potential hazard to the ecosystem, since they are not removed during treatment. For mercury and cadmium, a high risk was characterised after a long-term application of the compost. In order to manage the risk, more information on background concentration in soil and the atmospheric deposition is recommended. A monitoring of heavy metals during the early years of application can contribute to the risk management and eventually help determine a tolerable yearly fertiliser amount. Detailed results can be found in D2.1.

Contact data

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Involved organisation
National Technical University of Athens (NTUA)

URL
https://nextgenwater.eu/demonstration-cases/athens/

Scales

Challenges

Download

- Sewer mining unit (in Greek) (source: Klio Monokrousou)

Related tags

sewer mining sewer

Figure 12 Third part of the Athens case study factsheet presenting the project results from WP2 incl. QMRA results

Figure 13 shows the fourth part of the case study factsheet of Braunschweig. This is mainly related to the outcomes of WP4. However, in the case of Braunschweig also the the compliance of the fertilizer quality referring to the German legislation was evaluated in the frame of WP1, what is also indicated here. Since the utilisation of such small amounts is usually limited to a nearby region and to avoid long distance transportation, the main focus was set on the German legislation. Nevertheless, the European legislation was also discussed.

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Legislation and policy recommendations

In NextGen, we analysed the policy and regulatory landscape to identify relevant opportunities for and barriers to upscaling circular economy in the water sector. Our recommendations, targeted at the revised Urban Wastewater Treatment Directive, are summarised in our policy brief. These recommendations focus on creating meaningful incentives and policy drivers towards circular systems (e.g., through energy and carbon neutrality targets, and additional guidance on water recycling) and simplifying the route to market for recovered products (e.g., fertilisers and other materials). More details can be found in our policy brief.

Important regulations for the Braunschweig case study are listed below. In addition, D1.5 provides an overview, how good the struvite and ammonium sulphate comply with the legal requirements.

- **DüMV (2012)** Verordnung über das Inverkehrbringen von Düngemitteln, Bodenhilfsstoffen, Kultursubstraten und Pflanzenhilfsmitteln (Düngemittelver-ordnung – DüMV vom 5. Dezember 2012, BGBl. I S. 2482), Bundesministerium der Justiz und Bundesamt für Justiz
- **AbwV (2022)** Verordnung über Anforderungen an das Einleiten von Abwasser in Gewässer (Abwasserverordnung – AbwV vom 17. Juni 2004 BGBl. I S.1108, 2625 und vom 20. Januar 2022 BGBl. I S. 87, Bundesministerium der Justiz und Bundesamt für Justiz
- **EU (2019/1009)** Regulation of the European Parliament and of the Council of 5 June 2019 laying down rules on the making available on the market of EU fertilising products and amending Regulations (EC) No 1069/2009 and (EC) No 1107/2009 and repealing Regulation (EC) No 20
- **EU (2021/2086)** Commission Delegated Regulation of 5 July 2021 amending Annexes II and IV to Regulation (EU) 2019/1009 of the European Parliament and of the Council for the purpose of adding precipitated phosphate salts and derivates as a component material category in E

Contact data

Contact person
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Involved organisations
Abwasserverband Braunschweig
Kompetenzzentrum Wasser Berlin GmbH

Scale

Challenge

Figure 13 Fourth part of the Braunschweig case study factsheet presenting the project results from WP4 and WP1

Figure 14 shows the last part of the Braunschweig case study factsheet, where the applied products are shown and the project report and/or publications referring to this case study are listed and links are provided to the corresponding documents.

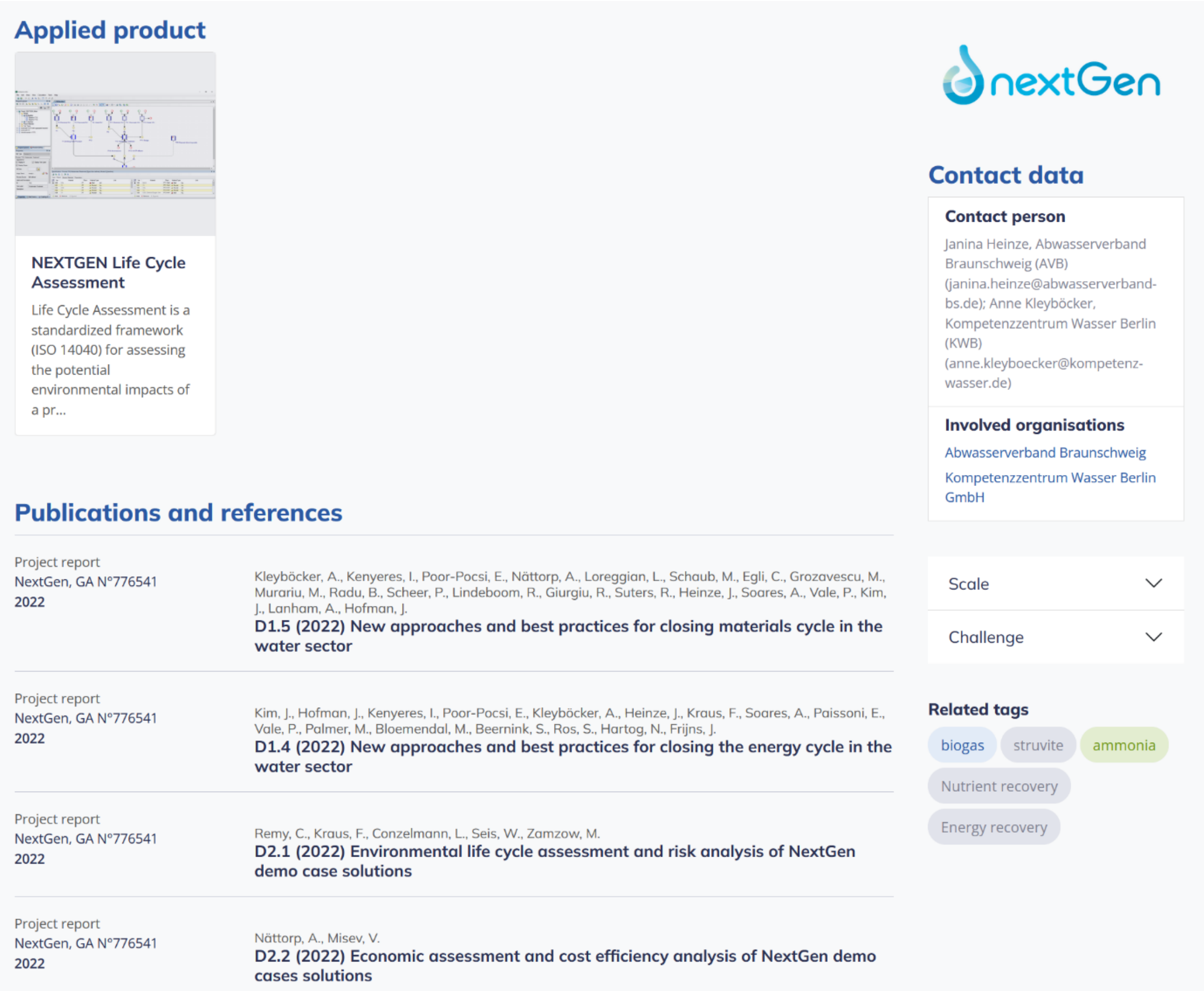

Figure 14 Last part of the Braunschweig case study factsheets linking to the applied product at the certain case study and to the project reports/publications

Because the TEB is part of the Marketplace, the problem owner can be easily use the Marketplace to find a solution provider. In addition, contact persons are assigned to each technology. They can also support and consult problem owners and provide further contact data to their solution providers.

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5. Future of the TEB

The EU H2020 projects ULTIMATE and B-WaterSmart will take over the responsibility for the TEB after the finalisation of NextGen. Hence, they will extend the TEB with their own technologies, they will maintain the TEB and find a solution together with Water Europe, how to proceed, once they will be finalised, too.

4.1 Integration of other technologies from ULTIMATE and B-WaterSmart

The TEB has been developed as a flexible database and can be extended with additional technologies. Hereby, the domains of the taxonomy (water reuse technologies, material recovery technologies and energy recovery technologies) will remain. However, the subdomains can be adapted, supplemented in the case of new technologies and/or deleted in the case of irrelevant technologies. Hence, the database can be used even beyond the project.

During the lifetime of NextGen, already two other projects started to add their factsheets to the TEB. ULTIMATE is an EU Horizon 2020 funded project (Grant Agreement No. 869318) and started in June 2020. It will last until May 2024. In nine case studies, circular economy concepts for water, material and energy recovery are showcased in the context of water smart industrial symbiosis. ULTIMATE will add 17 additional technologies and contribute to 4 existing technology factsheets. ULTIMATE will take over the responsibility to maintain the TEB after NextGen.

New technologies to be added by ULTIMATE are:

- Electrostimulated anaerobic reactor (ELSAR)
- Immobilised anaerobic high rate anaerobic system (AAT)
- Small bioreactor platform
- Early warning system for membrane fouling (AnMBR)
- Electrodialysis
- Membrane distillation
- Novel tight ultrafiltration (UF) membrane
- Reverse osmosis (RO)
- Adsorption using renewable granular active carbon
- Hydrochar production
- Ammonium adsorption with zeolites
- Coagulation and adsorption with bentonite
- High added value products adsorption and subcritical water extraction
- Monitoring system for high chloride concentrations
- Joint control system for an industrial and a municipal wastewater treatment plant (WWTP)
- Sulphur recovery
- Solid oxide fuel cell (SOFC)

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B-WaterSmart is another EU Horizon 2020 project (Grant Agreement No. 869171) and already added six additional case studies to the database. B-WaterSmart deals mainly with water recovery and will mainly contribute the membrane technologies. A list of technologies to be added will be elaborated in the coming weeks.
Furthermore, to gain more scientifically validated data for the TEB, the consortium members of ULTIMATE will promote the TEB and present it to other research projects.

4.2 Maintenance of the TEB

The TEB is and will be hosted by Water Europe. Until now, the projects NextGen and ULTIMATE mainly maintained the TEB. So called data managers were assigned from each project for the domains water recovery, material recovery and energy recovery. Those data managers were responsible to collect the data for the technology factsheets and to upload the project results to the TEB via the case study factsheets.
For the technology factsheets, a review procedure was established, before they were uploaded to the TEB. First the factsheets were prepared by the case study partners who investigated the certain technology and then, reviewed by the corresponding data manager and one scientist of the corresponding project, who had not been involved in the elaboration of the factsheets.

This method will be maintained in the future according to Figure 15. First, the data manager assesses, if the mandatory information and data are provided for a new factsheet or for its update/extension.

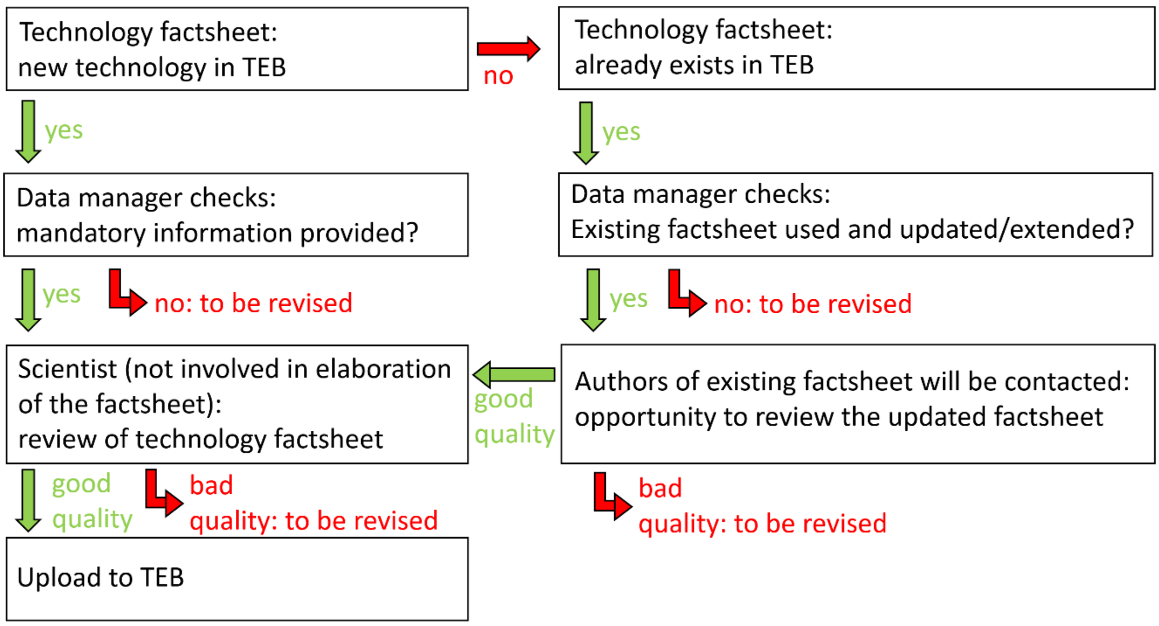

Figure 15 Decision tree for accepting a contribution to the TEB

Hereby, mandatory information and data are:
- Classification of the technology group indicating the position of the technology in the infographic and taxonomy
- 3 tags (keywords)

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- Unique selling points
- Description of the technology (incl. capacity and level of competence for its operation)
- Flow scheme
- Pictures and (if available) videos
- Synergetic effects and motivation to implement the technology
- Requirements of the technology and operating conditions
- Key performance indicators
- References to case studies or similar projects
- Literature references (including links to publications with DOI, ISBN etc.)

In the case the factsheet exists already (Figure 15), the new contributor uses the already existing factsheet and updates it with his/her own data. The updated factsheet will be shared with the authors of the original factsheet and reviewed by them (in the pdf-version of each factsheet, the authors are indicated). The original authors will have the opportunity to update their contributions in this frame, too. So, they can make sure, that their old data are up to date in the case the technology has been further optimised.
In the case the original authors are not available anymore, a scientist from ULTIMATE or B-WaterSmart will be requested to review the new contribution.
In the case, somebody wants to submit a factsheet who is not a partner of one of the projects, either the data managers suggest a reviewer or another solution has to be found. For those applicants, an online form will be available to submit their contribution.
In the case the authors of the original technology factsheet consider the update to be of a poor quality, the applicant has to revise the factsheet. The same procedure applies, if the scientist, who was not involved in the elaboration of the factsheet, considers the factsheet to be of a poor quality. If the quality is considered as good, the factsheet will be accepted and uploaded.

The case study factsheet is optional and can also be delivered at a later stage. It shall contain specific information on:

- Description of the case study and pictures
- Lessons learned from the first implementation and operation of the technology presented as technology performance and best practices
- Outcome of assessments such as life cycle assessment, cost assessment and risk assessments
- Legal and regulatory information concerning the technology and its products
- Contact data for business opportunities
- References and links to detailed reports explaining the results

As an orientation, the following questions can support the data manager and reviewers to evaluate, if the technology factsheet and the case study related data are of a good quality:

a. Data cited in scientific publications?

Important facts and data must be cited. If the used literature comprises mainly peer reviewed scientific publications, the contribution to the TEB can be accepted, because this indicates good data quality. In this case, the links to the publications and the DOIs or ISBN must be provided in the literature reference section. Therefore, if available, open access publications shall be preferred to cite the facts.

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b. Facts and data cited in non-reviewed literature or not cited at all?

If no peer-reviewed publications were used to cite facts and data, a peer-review process is required to decide, if the contribution can be accepted for publication in the TEB.
In the case, the contribution contains no citation at all, but provides valuable data, a peer review process will help to better assess the quality of the contribution and the suitability for the TEB. The quality of the factsheet depends highly on the reliability of the shown data.
The choice of the reviewers is still under discussion among the core team of the TEB task. In this case, the cooperation with a certain organisation such as the Biorefine Cluster Europe might also be a good option.

In addition, the TEB might also be interesting for technology providers who want to present their technology in the context of the marketplace, but have not done an independent evaluation or assessment of their technologies by scientific parties. If there is no evidence that the provided data and facts were produced in a reliable way, the contribution can be rejected in order to be revised. However, if the reviewer considers a factsheet as highly valuable, but he or she is not fully convinced by its quality, the contribution might be uploaded with the statement "data quality is uncertain".

To keep the TEB up to date, the expiration of a factsheet might be considered. In this case, if not a new update of a certain factsheet will be provided within three years, all authors of this factsheet shall be automatically asked to update their factsheet otherwise the factsheet will be expire and removed from the TEB.
In the case, the authors won't be available anymore after the project lifetimes, an alternative is needed. Different options for the alternative will be discussed in the coming months in the core team of ULTIMATE.

4.3 Potential fate of the TEB after finalisation of ULTIMATE and B-WaterSmart

Currently, different options are being investigated and discussed among the core team of the TEB task. For example, one option might be to involve other organisations such as the Biorefine Cluster Europe. ULTIMATE recently joined the cluster (https://www.biorefine.eu/), which aims to interconnect bio-based research and innovation projects dealing with circular economy and to disseminate and promote their results.
This will be further discussed with the final version of the TEB in order to show to potential candidates a first complete version of the TEB and not only a concept.

After the project lifetimes, the next data managers will be appointed. They can be members of collaborating research projects or refer to connected organisations such as the Biorefine Cluster Europe. This has to be elaborated and discussed in detail in the coming weeks in ULTIMATE.

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6. Conclusion

The TEB is a valuable database for interested persons, engineers, decision makers and investors, for gaining a fast overview on circular economy related technologies in the water sector. It provides easy to understand information on the functionality of the technologies, but also in-depth data on the performance of the technologies, their CO_2-footprint, their costs and legislative framework.

The TEB can highly contribute to the transition from a linear to a circular economy in Europe and via its close connection to the Marketplace, it might even serve as an initial spark for problem owners to find the right solution provider and to initiate first contacts to entities or institutions that can provide valuable experience reports and lessons learned for certain technologies.

Its maintenance is important and time-intensive. Also, expert knowledge is beneficial to update the TEB and take care of a good data quality. Therefore, it is recommended to further cooperate with research projects to integrate further innovative technologies and update the already existing concepts with potential future improvements. In this way, the open access to the TEB might also be maintained, which is an important aspect to address a wider spectrum of users.

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7. Literature references

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