



Advancing Sustainability of Process Industries through Digital and Circular Water Use Innovations

A Framework for Industrial Water Efficiency Assessment and its application in AquaSPICE case studies

AquaSPICE final conference

Shaping the Future of Sustainable Water Management in Process Industries

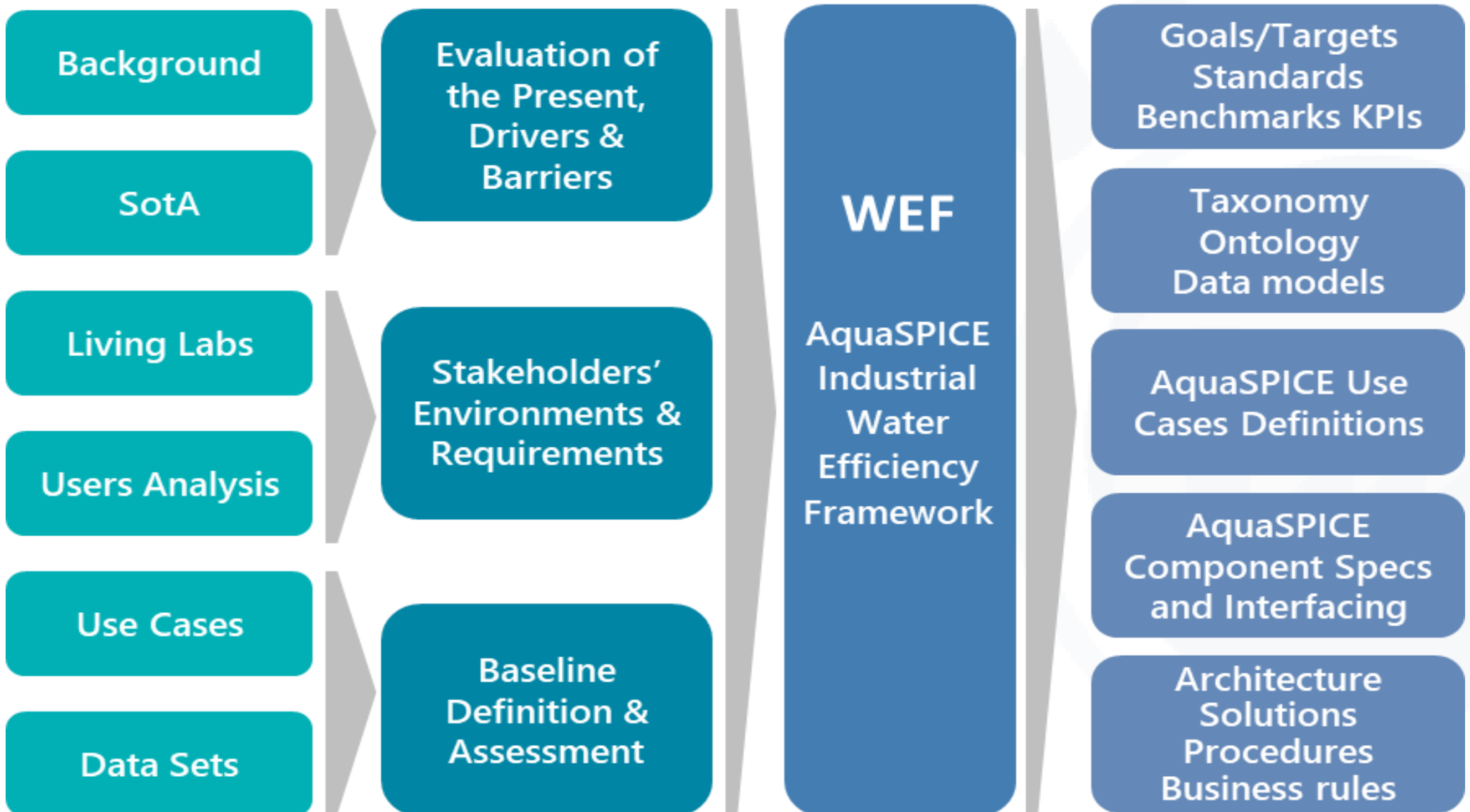
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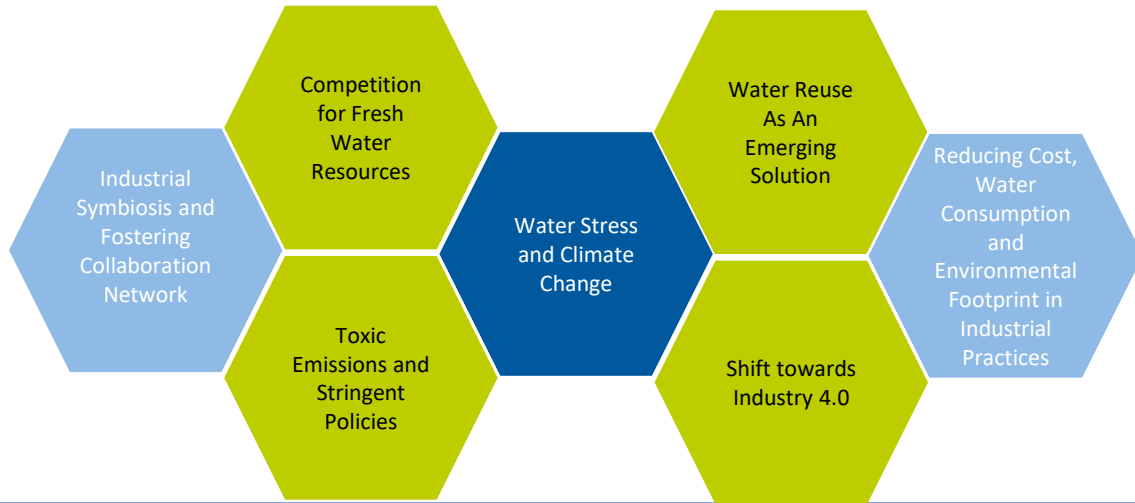
12 December 2024



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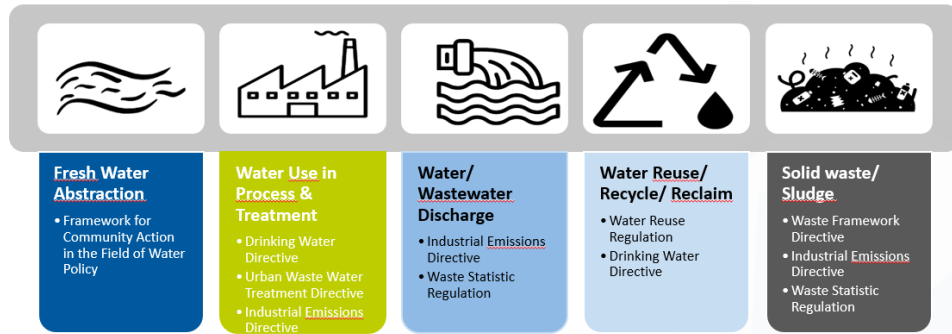
Drivers and Opportunities



Gaps and Barriers



Relevant EU Directives and Regulations

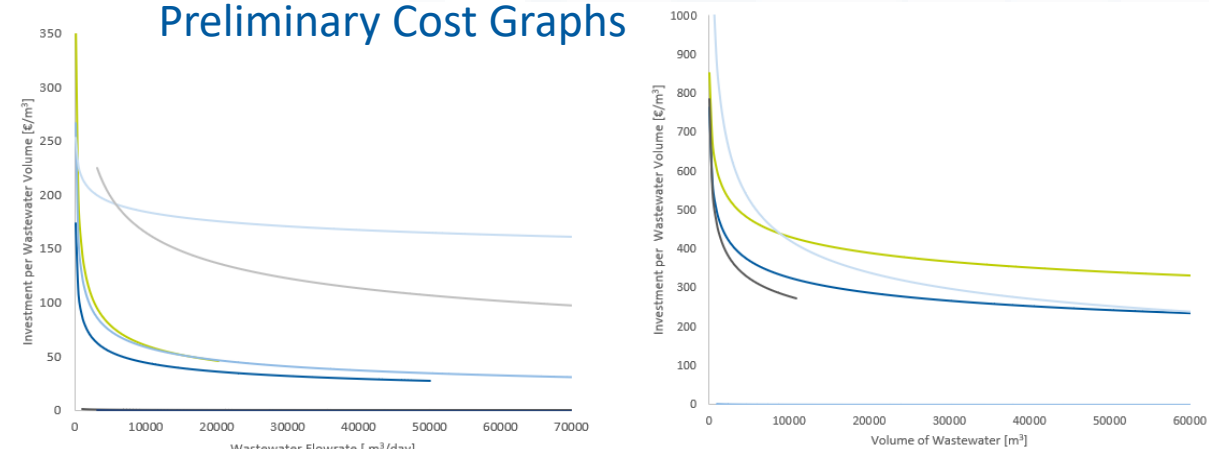


Water Framework Directive (WFD)

A Blueprint to Safeguard Europe's Water Resources

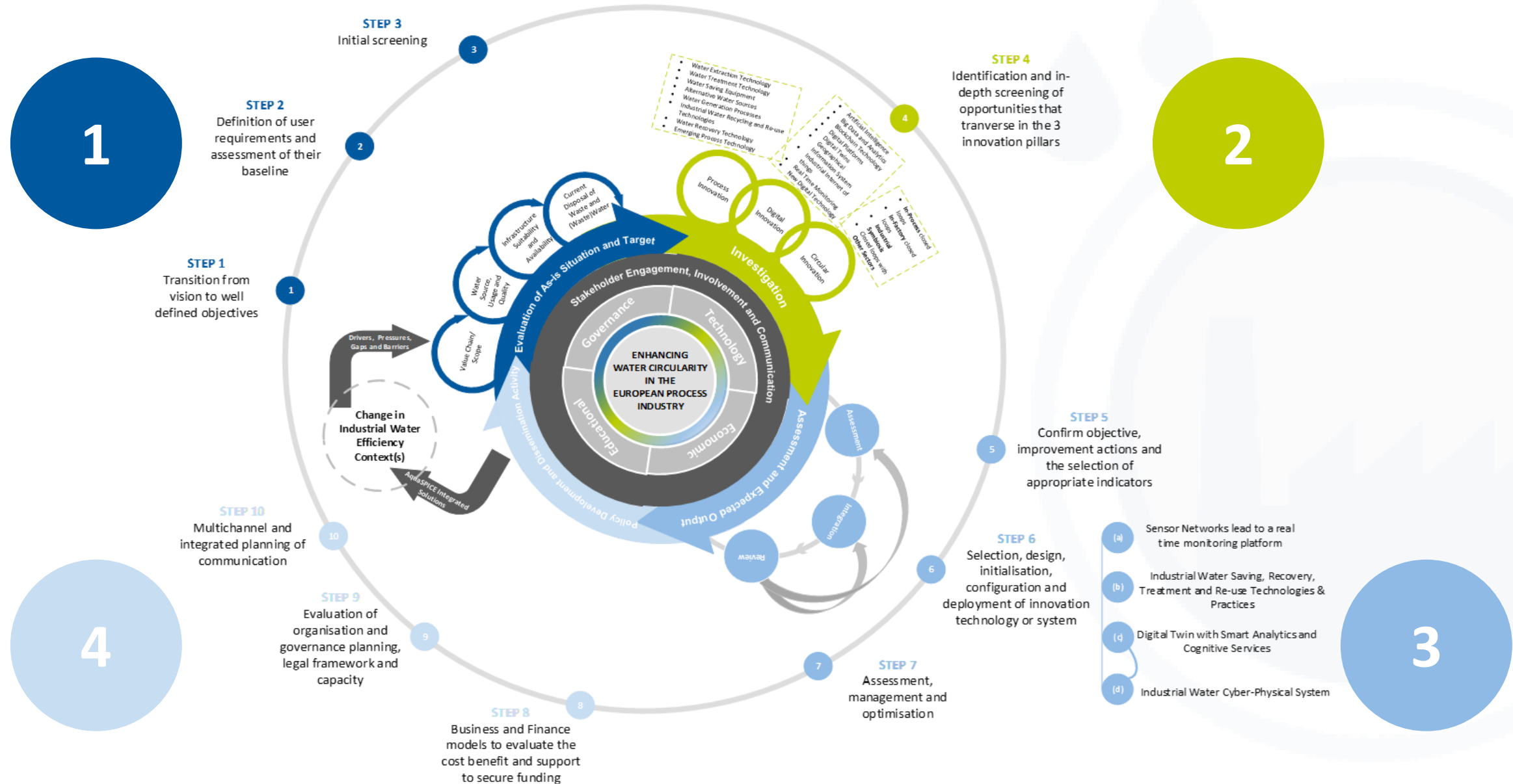
A new Circular Economy Action Plan For a cleaner and more competitive Europe

Preliminary Cost Graphs



J. Hilbig, B. Boysen, P. Wolfsdorf, and K. U. Rudolph, "Economic evaluation of different treatment options for water reuse in industrial parks using modular cost functions," *J. Water Reuse Desalin.*, vol. 10, no. 4, pp. 419–430, Dec. 2020, doi: 10.2166/wrd.2020.032.

Water Efficiency Framework



1



Phase 1 – Evaluation of as-is situation and target

Technology configuration and basic design for each case study

STEP 3
Initial screening

3

User Analysis, Use Cases Requirements and Quality Criteria
Use Cases Definition with Baseline Assessment

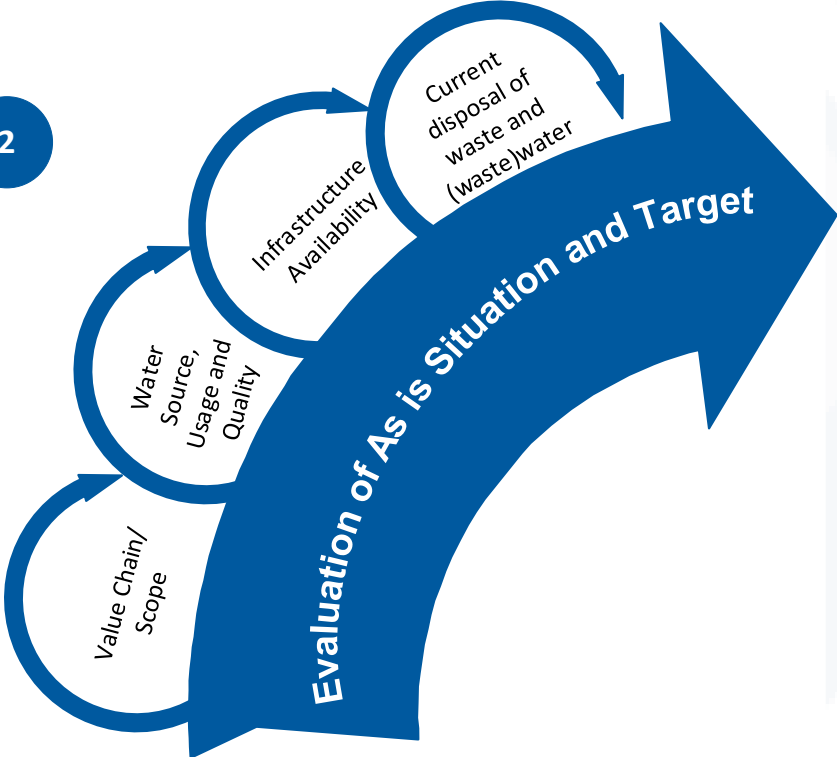
STEP 2
Definition of user requirements and assessment of their baseline

2

User Analysis, Use Cases Requirements and Quality Criteria

STEP 1
Transition from vision to well defined objectives

1



2



Phase 2 – Inventorisation



STEP 4
Identification and in depth screening of opportunities that tranverse in the 3 innovation pillars

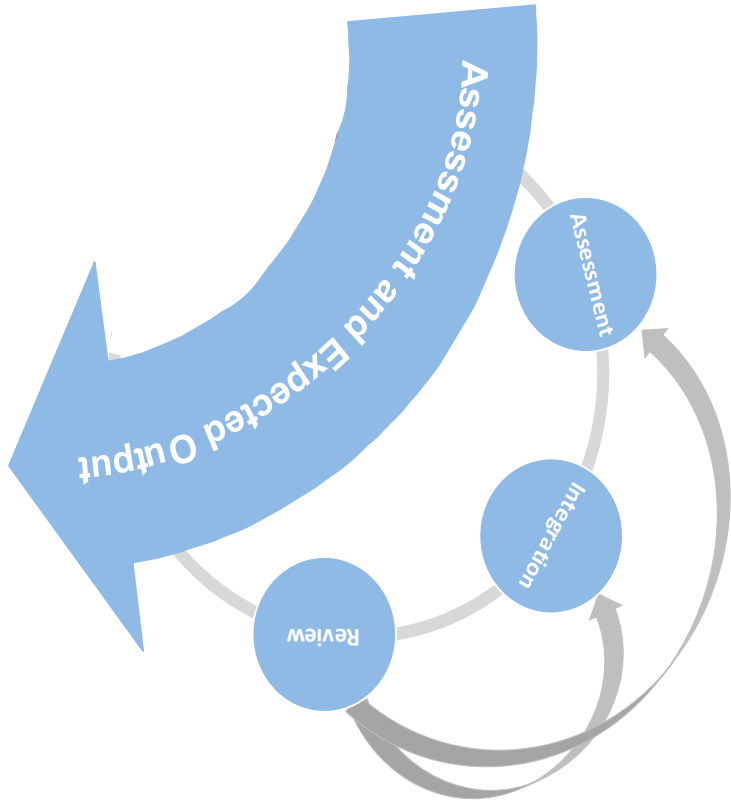
Outcomes:

- Technologies and Practices Evaluation Framework
- Smart Sensors and RTM Platform Deployed in Case Studies
- Production System and Value Chain Dynamic Process Modelling

3



Phase 3 – Assessment and Expected Output



STEP 5
 5 Redefine objective, improvement actions and the selection of appropriate indicators

Technologies and Practices Evaluation Framework

STEP 6
 6 Selection, design, initialisation, configuration and deployment of innovation technology or system

- (a) Sensor Networks leads to a real time monitoring platform
- (b) Industrial Water Saving, Recovery, Treatment and Re-use Technologies & Practices
- (c) Digital Twin with Smart Analytics and Cognitive Services
- (d) Industrial Water Cyber Physical System

RTM Specification and System Architecture
 Smart Sensors and RTM Platform Deployed in Case Studies
 Data Management and Harmonization Plan
 Real-time or near-real-time visualization of time series for the different sensors and associated analytics

Technologies and Practices Evaluation Framework
 Deployment report of pilot installations in each case study
 Technologies and Practices Evidence Base

Cognitive Model and Simulation of Water-Related Processes

STEP 7
 7 Assessment, management and optimisation

Water Dynamic Life-Cycle Assessment
 Water Efficiency Optimisation Services
 Case Studies Cross-Evaluation, Lessons Learnt, Recommendations & Best Practices

4



Phase 4 – Business model, policy development and dissemination activity

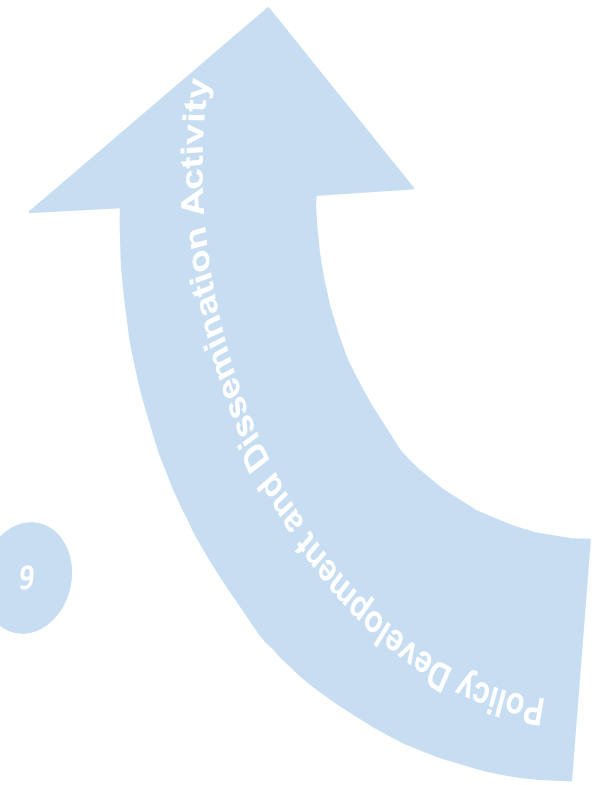
STEP 10
Multichannel and integrated
planning of communication



STEP 9
Evaluation of organisation and
governance planning, legal
framework and capacity



STEP 8
Business and Finance model to
evaluate the cost benefit and
support to secure funding

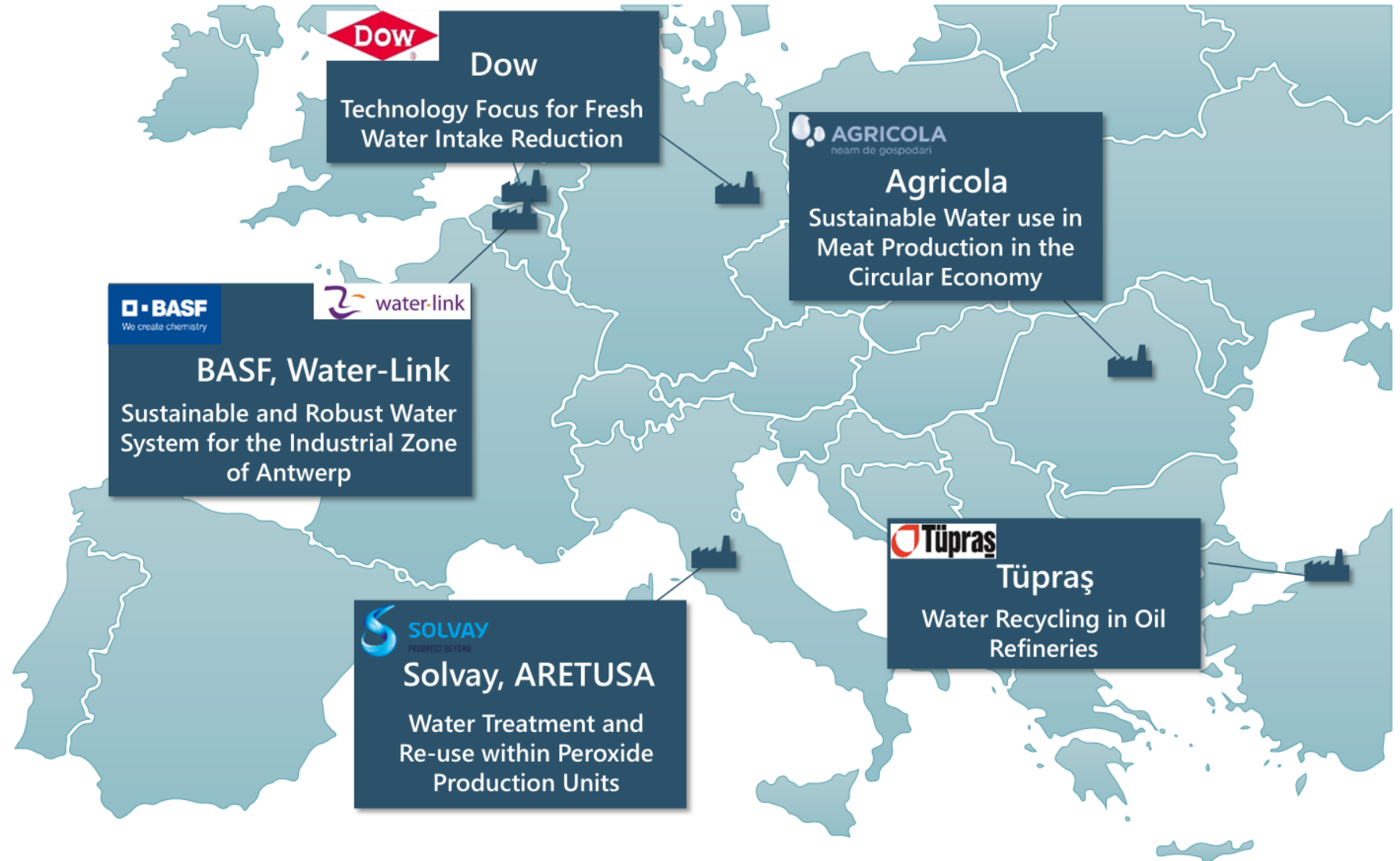


Guide for Organising Deployment and Governance of AquaSPICE Solutions
Final Report on European Policies and Industry Recommendation

Market Analysis and Strategic Plan for Uptake, Replication & Upscale
Business and Financial Models Adapted AquaSPICE Solutions
Exploitation Plan for AquaSPICE results

Application of the WEF to AquaSPICE Case Studies

- Application
- Validation
- Insights
- Learning



Phase 1 – Evaluation of as-is situation and target

Case Study	Transition from Vision to Objectives	Definition of User Requirements & Baseline	Initial Screening of Approaches & Technologies
CS #1 Dow	Set objective to reduce freshwater intake by reusing process streams (CTBD, DSBD). Focused on long-term sustainability in water-scarce areas like Boehlen and Terneuzen.	KPIs were defined through collaboration with SMEs, focusing on technology efficiency and operational needs.	Conducted laboratory trials to screen reuse technologies and identified optimal configurations for water reuse.
CS #2 Solvay	Clear objective to reuse wastewater from hydrogen peroxide production, aligning with Solvay’s sustainability program (Solvay One Planet).	Baseline established by analysing wastewater composition from peroxide production, identifying critical contaminants and treatment requirements.	Initial screening identified treatment options for peroxide wastewater based on analytical measurements and operational needs.
CS #3 BASF	Focused on maintaining water quality in cooling systems while reducing freshwater intake, targeting long-term water management strategies in the Antwerp industrial zone.	Developed baseline data by establishing a real-time monitoring system to identify water quality impacts from increased salinity and water scarcity.	Conducted initial assessment of cooling water recirculation and options for reuse of process water.
CS #5 Agricola	Aimed to be a leader in circular water use in Romania's poultry industry, focusing on reducing water consumption in agriculture and meat production.	Developed baseline by mapping current water usage and reuse opportunities, adhering to EU regulations for water reuse in the food industry.	Screened effluent for bacteria and other contaminants, identified suitable treatment options for water reuse.
CS #6 Tupras	Set goals to reduce the water footprint at the refinery, focusing on improving water quality and increasing water reuse.	Established baseline with existing data. Tackle challenges in real-time monitoring due to the variability in water quality.	Conducted initial screening to assess blending options for treated and untreated water streams.

Phase 2 – Inventorisation

Case Study	In-Depth Screening of Opportunities	Focus on Process Innovation	Circular Water Reuse Opportunities	Digital Innovations Focus
CS #1 Dow	Identified opportunities to reduce freshwater intake by reusing streams like CTBD and DSBD, focusing on both internal recycling and water-saving strategies.	Focused on the optimisation of water treatment processes using GAC-UF-RO (Granular Activated Carbon, Ultrafiltration, Reverse Osmosis) technology to improve reuse efficiency.	Reuse of CTBD (Cooling Tower Blowdown) emerged as a key solution for reducing freshwater intake at Böhlen and Terneuzen.	Deployed additional meters and analysers to optimise water treatment processes and monitor water reuse in real time.
CS #2 Solvay	Screening focused on optimising wastewater reuse by installing compact, efficient treatment plants for peroxide production.	Process innovation focused on advanced filtration techniques to maximise reuse within the plant's boundaries and reduce water discharge.	Strategic circular water solutions were established through collaboration with public and private stakeholders to promote water reuse.	Automated process control using real-time data from digital sensors to optimise treatment efficiency and reduce costs.
CS #3 BASF	Identified options for reusing process and cooling water within the Antwerp industrial zone to address salinity issues and water scarcity.	Focused on enhancing the recirculation of cooling water and reusing reverse osmosis (RO) concentrate from the demineralised water treatment process.	Explored reuse of highly concentrated RO brine for industrial processes, reducing reliance on external freshwater sources.	Deployed a real-time smart monitoring and management system to track water quality and usage and adapt strategies during droughts.
CS #5 Agricola	Focused on real-time monitoring of water quality across poultry farms and meat processing plants, to reduce water consumption and improve reuse.	Introduced bacterial sensors to control water quality in real time, facilitating safer and more efficient water reuse.	Explored new circular strategies for reusing water in agricultural processes, though initially no reuse was implemented.	Implemented smart monitoring systems to track water use across the supply chain, from field to wastewater treatment.
CS #6 Tupras	Explored opportunities to increase sustainability by maximising wastewater reuse and reducing discharge volumes.	Process innovation focused on increasing water reuse while addressing quality issues caused by contaminants.	Targeted circular opportunities to recover up to 50% of contaminated water for reuse within refinery operations.	Used digital tools to improve real-time decision-making and water management through advanced data analytics.

Phase 3 – Assessment and Expected Output

Case Study	Confirm Objectives & Select KPIs	Innovative Technology/System Deployment	Ongoing Management & Optimisation
CS #1 Dow	Confirmed objectives of reducing freshwater intake, focusing on key performance indicators such as water quality and treatment efficiency.	Deployed GAC-UF-RO systems at both Dow sites, which delivered stable performance and significant water savings.	Adjustments were made during trials to improve technology performance and reduce water consumption further.
CS #2 Solvay	Met reuse objectives by aligning wastewater reuse goals with Solvay One Planet’s sustainability program. KPIs focused on water reuse volume and contaminant reduction.	Deployed a demo plant using innovative filtration systems and online sensors to continuously monitor and optimise wastewater treatment.	Managed the demo plant to maintain consistent performance, using sensor data to validate and optimise system reliability.
CS #3 BASF	Confirmed objectives to reduce freshwater intake and manage salinity in cooling systems, setting KPIs around water quality and system efficiency.	Deployed a real-time monitoring system to track cooling water quality and manage salinity impacts, adapting operations based on data.	Regular adjustments to cooling water recirculation systems were made based on real-time monitoring data to ensure optimal performance.
CS #5 Agricola	Confirmed objectives for reducing water consumption and improving reuse, focusing on water quality and bacterial load reduction.	Installed real-time bacteria sensors to improve water quality control and facilitate safer water reuse in poultry processing.	Continued to optimise treatment processes based on sensor data, focusing on integrating digital tools into water management.
CS #6 Tupras	Identified challenges in maintaining water quality and implementing real-time monitoring systems. KPIs focused on water recovery and quality standards.	Pilot plant faced cybersecurity issues that delayed critical water quality tests and sensor deployment, slowing system optimisation.	Ongoing optimisation efforts aimed to resolve technical issues and increase the pilot plant’s water reuse potential.

Case Study	Business & Finance Model Development	Governance & Legal Framework	Multichannel Communication Planning
CS #1 Dow	Developing a business case to secure funding for further implementation of water-saving technologies, including the installation of a UF unit.	Ongoing discussions with authorities to align water reuse strategies with local discharge permits and regulatory frameworks.	Shared project results at conferences and workshops to increase awareness of water reuse technologies in the chemical sector.
CS #2 Solvay	Exploring scalability of pilot wastewater treatment plant across other Solvay sites, with potential for widespread implementation.	Supported by agreements between public and private partners to promote industrial water reuse and establish new regulatory frameworks.	Actively engaged with stakeholders through conferences and Living Lab events, sharing results to drive further adoption of water reuse technologies.
CS #3 BASF	Developing a collaborative business model to expand water reuse efforts, particularly focusing on long-term sustainability of water systems in Antwerp.	Engaged with stakeholders to develop governance structures for maintaining the real-time monitoring network and scaling water reuse efforts.	Presented findings at international conferences and published research to promote water reuse strategies, involving multiple stakeholders across sectors.
CS #5 Agricola	Initial efforts focused on developing a finance model for scaling up water reuse efforts, though no immediate large-scale investment planned.	Adhering to strict EU regulations for water reuse in the food industry, particularly for poultry and meat processing.	Engaged stakeholders through workshops and public events, promoting the benefits of water reuse and discussing potential applications in agriculture.
CS #6 Tupras	Evaluating the potential for expanding water reuse technologies at the refinery, dependent on further pilot plant results.	Focused on aligning water treatment strategies with local discharge permits and environmental regulations, ensuring compliance.	Continuously disseminating project results through publications, exhibitions, and workshops to inform stakeholders about water reuse opportunities.

Key Exploitable Results	Description summary
Real-Time Monitoring Platform	VITO will use the <i>real time monitoring network for water quality parameters</i> and the <i>operational model</i> in their future contracts (individual exploitation, added to current commercial portfolio)
Water Cyber-Physical System	MAG will exploit and commercialise it for industrial sites.
Process Suite Modelling	TUC and UOH - new service/product added to existing commercial portfolio.
NEWASYS	STRANE: market test was successful, 19 offers won out of 42 submitted. Legal creation of a spinoff planned in the next months. 6 jobs and > 2M€ of value created in the next 3 years.
Industrial synergies	STRANE already created a spinoff (SEITISS), AquaSPICE contributed to identification of new synergies and development of the activity

Integrated Approach:

- Developed a comprehensive Water Efficiency framework combining technical, organisational, and regulatory components.

System-wide Applicability:

- The framework addresses the entire industry value chain and targets for water efficiency.

Pilot Feedback Utilised:

- Framework designed using inputs from pilots and cross-work package collaboration, ensuring real-world applicability.

Strategic Outcome:

- Established roadmap for enhanced water efficiency monitoring, assessment, optimisation, and management.



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Thank you!