NAMOR

Advancing Decentralized Water and Wastewater Systems

POLICY BRIEF #1

Water Resilience at the Right Scale: Integrating Decentralised Treatment into Europe's Water Systems

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1. EXECUTIVE POLICY MESSAGE

Europe needs water infrastructure that is resilient, adaptable and appropriate to local conditions. Decentralised and hybrid treatment systems should be considered as part of the solution not as a universal substitute for centralised wastewater treatment, but as complementary options where they can deliver clear environmental, operational and economic value.

Water stress, changing climate conditions, uneven settlement patterns and the need to improve resource efficiency are increasing the importance of flexible approaches to water and wastewater management. In some settings, extending or upgrading conventional networks may remain the most appropriate option. In others, treating water closer to where it is generated may offer advantages, particularly where flows are variable, connection costs are high, local reuse is feasible, or existing treatment infrastructure needs additional flexibility. NAMOR is developing and demonstrating a modular microalga-membrane photobioreactor (MPBR) that combines microalgae-bacteria treatment with membrane filtration. Its three demonstration cases in Slovenia, Finland and Greece examine different operational and climatic conditions. The project is also developing digital tools to support monitoring and optimisation, assessing sustainability and business-model options, and engaging stakeholders in the design and governance of decentralised solutions.

The central policy message is that technology readiness must be matched by regulatory, operational, financial and societal readiness. Wider deployment requires clear responsibilities, proportionate permitting, reliable performance evidence, appropriate safeguards for water reuse and recovered resources, capable operators, and financing models that account for whole-life costs and benefits.

This first policy brief translates NAMOR's concept and early groundwork - developed under Work Package 6 (Citizens Participatory Actions and Business Models) and disseminated through Work Package 7 (Task 7.3) - into EU-level recommendations. This policy brief is mainly based on the information from the activities around deliverables 2.1, 3.1 and 6.1 (issued in 2026). While the number of deliverables remains limited from NAMOR, there is a policy opportunity for the project to issue a policy brief and contribute to several EU initiatives linked to the implementation of the EU Water Resilience Strategy:

- The EU Algae Initiative launched in 2022.
- The implementation of the Zero Pollution Action Plan.
- Implementation of the recast Urban Wastewater Treatment Directive (Directive (EU) 2024/3019), including its provisions on individual systems, integrated urban wastewater management, water reuse and resource recovery.
- The Circular Economy Act and the implementation of the EU Circular Economy Action Plan.

- Discussions around the Reuse Regulation and its potential revision.
- Discussion on water governance in connection with the political decision to revise the Water Framework Directive.

This policy brief sets out seven recommendations for pioneering a next-generation water treatment solution at EU level in line with the policy dossiers in correlation with the first outcomes of the project:

1. Integrate decentralised and hybrid systems into water infrastructure planning
2. Establish clearer, proportionate and evidence-based permitting pathways
3. Strengthen interoperable monitoring, digital twins and decision-support tools
4. Establish safe and predictable pathways for resource recovery and reuse
5. Make stakeholder participation and inclusive governance an implementation requirement for decentralised water projects
6. Make whole-life performance and affordability visible in investment and procurement decisions
7. Support the transition from demonstration to replication and market uptake

These priorities are directed primarily at EU institutions, Member State authorities, regulators, water utilities, municipalities, funding bodies and technology providers. They aim to create conditions that enable the selection, authorisation and operation of decentralised and hybrid systems where these offer demonstrable value, while ensuring appropriate protection for human health and the environment.

The NAMOR project is ongoing; therefore, the recommendations stem from validated project results and focus on policy actions that can be implemented immediately. The project's demonstration cases and associated technical, digital, environmental, economic and social assessments will strengthen the evidence base for future recommendations.

The policy brief will be designed for dissemination in line with NAMOR communication (this version has been developed for reporting purposes). We foresee two main actions:

- General dissemination of the policy briefs with NAMOR communication channels, and partners' communication channels such as Water Europe (e.g., newsletter, website). EU-level projects will be used for communication, such as Water Innovation Europe.
- Specific communication to EU policymakers in the EU Parliament or key stakeholders that express interest in water-related and algae policy. Water Europe will also inform the EU policymakers (e.g., EU Commission and relevant Member States).

This approach also helps exploit opportunities in the EU agenda to contribute to key policy dossiers and EU Commission public consultations. Attention will be given to consultations that connect with the aforementioned dossiers. INTRODUCTION

Why decentralised and hybrid water treatment matters

Centralised sewer networks and wastewater treatment plants remain essential components of public health protection and environmental management. They provide economies of scale and are indispensable in many urban and densely populated areas. However, a single infrastructure model cannot be assumed to be the most suitable option for every location, wastewater stream or operational requirement. Rural and peri-urban communities, remote settlements, industrial and agricultural sites, and facilities experiencing variable or seasonal flows may face high connection costs, long infrastructure lead times or treatment needs that differ from those of conventional municipal systems.

In such circumstances, decentralised or semi-decentralised treatment and hybrid configurations that complement existing networks and plants may offer additional flexibility. Their suitability must be assessed case by case, taking account of local conditions, treatment performance, costs, environmental impacts, operational capacity and opportunities for safe water reuse. DWWTS can bring treatment closer to the point of generation, potentially reducing the need for some conveyance infrastructure and creating opportunities for fit-for-purpose water reuse and resource recovery. Their value, however, cannot be judged by the treatment unit alone. Decisions must consider the complete system, including collection and conveyance, energy and chemical requirements, residuals management, maintenance, monitoring, operator skills, public acceptance and the long-term costs and benefits of the selected configuration.

A policy opportunity and an implementation challenge

The EU Water Resilience Strategy[1], published in June 2025, calls for Europe to anticipate, withstand and recover from water stress while enabling a water-smart economy, and explicitly points to digitalisation, smart metering and the better integration of water uses as levers for that goal. The Reuse Regulation[2], the Zero Pollution Action Plan[3], the Circular Economy Action Plan[4] and the Commission's 2022 initiative on the EU algae sector[5] all point in a complementary direction: water, nutrients and biomass should be reused and valorised as close as possible to where they arise.

[1] European Commission, EU Water Resilience Strategy, COM(2025) 280 final, June 2025.
[2] EUR-LEX, Regulation (EU) 2020/741 of the European Parliament and of the Council of 25 May 2020 on minimum requirements for water reuse, 2020
3 EUR-LEX, Pathway to a Healthy Planet for All EU Action Plan: 'Towards Zero Pollution for Air, Water and Soil', COM/2021/400 final, 2021
4 EUR-LEX, A new Circular Economy Action Plan For a cleaner and more competitive Europe, COM/2020/98 final, 2020
[5] European Commission, Towards a Strong and Sustainable EU Algae Sector, COM(2022) 592 final, 15 November 2022.

The next step is to connect these agendas: decentralisation should be assessed as one infrastructure option within integrated planning, without lowering health or environmental safeguards. The recast Urban Wastewater Treatment Directive (UWWTD)[6] provides a particularly relevant implementation framework for NAMOR. These policy frameworks point to a shared implementation challenge: innovative treatment solutions need clear conditions under which they can be considered, assessed, permitted, monitored and maintained. Policy should enable innovation without weakening safeguards. It should also avoid assuming that decentralised systems are inherently more sustainable or less costly than centralised alternatives. Their comparative value depends on local circumstances and evidence across the relevant life cycle.

Four enabling conditions are especially important:

1. Infrastructure planning and permitting must recognise decentralised and hybrid configurations where appropriate.
2. Monitoring and performance assessment must provide credible evidence of treatment reliability, environmental protection and operational resilience.
3. Resource recovery and water reuse must be supported by clear requirements for quality, risk management and intended use.
4. Deployment models must address investment, maintenance, operator capacity and stakeholder confidence, not only the installation of the technology.

How NAMOR contributes

NAMOR is developing a modular microalga–membrane photobioreactor (MPBR) that combines microalgae–bacteria cultivation with membrane filtration. The system is designed to be adaptable to different operating contexts and to be capable, where appropriate, of integration with existing centralised infrastructure or autonomous on-site operations. The project also develops a Digital Twin and a Decision Support System (DSS), examines environmental, economic and social performance, and explores stakeholder-led governance and viable business models.

The project's three demonstration cases in Slovenia, Finland and Greece provide a basis for examining how system configuration and operating conditions respond to different climates, wastewater characteristics and flow conditions. This diversity is valuable because it highlights the need for context-specific design rather than a one-size-fits-all approach.

At this mid-term stage, the policy value of NAMOR lies in its combination of technical demonstration, digital optimisation, sustainability assessment and stakeholder engagement. Its findings help identify the evidence and enabling conditions required for

[6] EUR-LEX, Directive (EU) 2024/3019 of the European Parliament and of the Council of 27 November 2024 concerning urban wastewater treatment (recast),2024.

deployment and replication decisions. The recommendations that follow focus on the conditions needed to move towards technology implementation: integrated planning, clear permitting, trustworthy data, safe resource recovery, participatory governance, whole-life affordability and a credible route from demonstration to replication.

RECOMMENDATIONS
1. Integrate decentralised and hybrid systems into water infrastructure planning
2. Establish clearer, proportionate and evidence-based permitting pathways
3. Strengthen interoperable monitoring, digital twins and decision-support tools
4. Establish safe and predictable pathways for resource recovery and reuse
5. Make stakeholder participation and inclusive governance an implementation requirement for decentralised water projects
6. Make whole-life performance and affordability visible in investment and procurement decisions
7. Support the transition from demonstration to replication and market uptake

1. NAMOR IN PRACTICE

1.1 A Modular Treatment Concept Designed for Different Operating Contexts

NAMOR is testing in three demo cases (in Slovenia, Finland and Greece) the concept across different climates, wastewater strengths and flow conditions, demonstrating the importance to consider local conditions. The project is developing a microalgae-membrane photobioreactor (MPBR), a modular unit in which microalgae and bacteria are co-cultivated to treat water, while membrane filtration delivers a high-quality, fit-for-purpose effluent. The modular system is designed for retrofit; it can plug into an existing centralised network to absorb peak or high-strength flows, or run autonomously to treat and reuse water on-site, and it targets more than 80% recovery of the nitrogen and phosphorus in the water it treats, with over 25% lower energy use than conventional decentralised alternatives.

Demo cases	Concept	What it tests
Slovenia[7]	Expandable, containerised algae-bacteria system (33 m^2 for the mobile unit and a 100 m^2 raceway pond) at a municipal WWTP	Handling high and peak flow rates, including stormwater, at full municipal scale

[7] NAMOR, Demo Case 1 Slovenia, 2025

Finland[8]	Mixed microalgae-bacteria culture selected for cold-climate performance	Year-round operation, including low-temperature, low-light winter conditions
Greece[9]	Immobilised-culture unit with downstream membrane filtration	Delivering high water quality from high-strength effluent

NAMOR will examine whether recovered biomass can be co-digested, composted or otherwise valorised with existing sludge and municipal bio-waste infrastructure. This could connect local treatment to nutrient and energy recovery rather than treating residual biomass only as waste. Policy pathways must nevertheless be based on demonstrated quality, contaminant control, traceability and end-use safety. Equivalent treatment does not automatically mean equivalent feedstock status; criteria should reflect risk and intended use.

1.2 Digital Optimisation and Evidence-Based Infrastructure Decisions

Sensors, predictive analytics and a digital twin will support real-time monitoring and performance prediction while strengthening confidence for replication. The DSS is intended to compare configurations and operating conditions against environmental, economic and social indicators, helping users decide when a decentralised, centralised or hybrid pathway is preferable. The policy value lies not only in automation, but in making infrastructure choices more transparent and evidence based. Replication will require interoperable data, cybersecurity, clear data governance and sufficient capacity among smaller operators and public authorities.

1.3 Co-designing Systems and Governance with Stakeholders

None of this works without the people who will host, regulate and use these systems, demonstrating the importance of the Living Labs approach. NAMOR establishes a stakeholder group at each demo site, covering researchers, technology providers, utilities, businesses, regulators and citizens, and uses a Living Lab, back-casting approach to co-design the systems, their governance and their business models with those groups from the outset. Citizen acceptance and co-designed governance are treated as a precondition for DWWTS to scale, on the same footing as their technical performance.

Taken together, local treatment, digital optimisation, resource recovery and citizen participation are the practical building blocks of a water-smart economy, in line with the

[8] NAMOR, Demo Case 2 Finland, 2025
[9] NAMOR, Demo Case 3 Greece, 2025

Water Resilience Strategy, in which water systems are managed as adaptively and locally as the conditions they serve, without losing the coordination that EU-level policymaking can provide.

1.4 Learning beyond the EU: India and the Republic of Korea

NAMOR's links with associated partners in India and the Republic of Korea provide an opportunity to explore whether the project's technical, regulatory and business-model lessons may be relevant beyond the EU. This international dimension should be approached as a process of comparison and mutual learning, rather than as an assumption that European arrangements can be transferred directly to other jurisdictions.

India. The National Framework for Safe Reuse of Treated Water provides a reference point for examining how reuse policies, implementation responsibilities and economic models interact across different levels of governance. NAMOR's engagement can help identify questions relevant to decentralised treatment, including how treatment quality is demonstrated, how responsibilities are allocated, and how potential users and off-takers can be connected to viable reuse arrangements. The applicable national, state and local requirements should be verified with the relevant Indian partners before concluding specific permitting or market-access pathways. This makes India a relevant case for examining how decentralised systems can demonstrate treatment quality, clarify responsibilities and connect reuse or recovered products to viable off-takers[10].

Republic of Korea. The Water Reuse Promotion and Support Act provides a starting point for examining the Korean approach to water-reuse planning and infrastructure, offering a useful comparison with the EU's more sector-specific rules. Further partner validation is needed to identify the current implementing standards relevant to decentralised treatment, including water-quality requirements, facility approval, monitoring and permitted end uses[11].For both countries, the policy value of NAMOR's international cooperation will depend on structured exchange with local partners and relevant authorities. Comparative work should identify both transferable principles - such as reliable performance evidence, clear responsibilities, safe reuse and viable operating models - and the legal, institutional and market conditions that require locally tailored solutions. Any recommendations for implementation should be based on verified country-specific evidence and engagement with the competent stakeholders.

10 Government of India, Ministry of Jal Shakti, *National Framework for Safe Reuse of Treated Water*, 2022
11 Republic of Korea, *Water Reuse Promotion and Support Act*, Act No. 14532, Jan. 17, 2017

2. POLICY RECOMMENDATIONS

2.1 Integrate decentralised and hybrid systems into water infrastructure planning

Expected policy benefit: More consistent consideration of decentralised and hybrid options in infrastructure decisions, better alignment between local treatment needs and catchment-level objectives, and a clearer basis for choosing appropriate configurations.

River basin, drought-management and integrated urban wastewater management plans should explicitly plan for decentralised and semi-decentralised systems as a legitimate long-term option, not a temporary solution for when centralised connection is unavailable or delayed. Under the recast UWWTD, Member States should use integrated urban wastewater management plans and the rules for individual systems to define when decentralised solutions are appropriate, what equivalent protection means in practice, and how these assets connect to catchment-level objectives.

NAMOR's demonstration cases can contribute evidence on how different configurations respond to different climates, wastewater characteristics and operating conditions. They inform context-specific assessment rather than establishing a universal solution.

2.2 Establish clearer, proportionate and evidence-based permitting pathways

Expected policy benefit: More predictable authorisation pathways, stronger cooperation between innovators and regulators, and improved opportunities to turn demonstration experience into operational guidance

The Commission and Member States should enable controlled regulatory experimentation for DWWTS, allowing regulators, utilities and technology providers to test innovative solutions under real operating conditions and use the resulting evidence to develop clearer, more predictable permitting pathways.

2.3 Strengthen interoperable monitoring, digital twins and decision-support tools

Expected policy benefit: Improved evidence for regulatory decisions, more transparent comparisons between treatment configurations, and better-informed operational and investment choices.

NAMOR's digital twin and decision-support tool are intended to support monitoring, performance prediction and comparison of configurations.

The upcoming EU-wide Action Plan on digitalisation in the water should support interoperable monitoring, digital twins and decision-support systems that help decentralised assets adapt to changing operating conditions and connect with wider water-management systems, underpinned by common approaches to data quality, security and exchange.

2.4 Establish safe and predictable pathways for resource recovery and reuse

Expected policy benefit: More predictable pathways for responsible reuse and valorisation, stronger links between treatment operators and potential users, and better integration of water management with circular-economy objectives.

As identified in the CINEA study[12], EU and national circular-economy frameworks should clarify pathways for nutrients, energy and biomass recovered from decentralised wastewater treatment based on MPBR, to enter circular value chains, with requirements based on demonstrated quality, contaminant control, traceability and intended end use.

NAMOR's work on resource recovery and sustainability assessment can help identify promising options and the evidence needed to evaluate them.

2.5 Make stakeholder participation and inclusive governance an implementation requirement for decentralised water projects

Expected policy benefit: Better-informed design choices, clearer local governance arrangements, stronger stakeholder confidence and earlier identification of implementation risks.

EU and national programmes should embed stakeholder mapping, Living Labs, social-impact assessment and co-design as substantive project tasks with measurable outputs, recognising social acceptance as much a determinant of success as technical performance.

NAMOR's Living Lab activities provide a framework for exploring how stakeholder engagement can inform system design, governance and business-model development.

[12] European Commission: European Climate, Infrastructure and Environment Executive Agency, Trinomics, sPro, Ghent University, Latvian Institute of Aquatic Ecology, Technopolis, Roheline Vihmavari, Møreforsking and Noord University, [European Climate, Infrastructure and Environment Executive Agency, Trinomics, sPro, Ghent University, Latvian Institute of Aquatic Ecology, Technopolis, Roheline Vihmavari, Møreforsking, Noord University], *Study to support a sustainable EU algae industry – Final report*, Publications Office of the European Union, 2025, https://data.europa.eu/doi/10.2926/3023544

2.6 Make whole-life performance and affordability visible in investment and procurement decisions

Expected policy benefit: More transparent and defensible investment decisions, stronger understanding of affordability and operational requirements, and a better basis for comparing infrastructure options over time.

NAMOR's planned techno-economic, environmental, circularity and social assessments can contribute to this evidence base. Their results should be used to identify where decentralised or hybrid systems offer demonstrable value and where alternative configurations may be more appropriate.

2.7 Support the transition from demonstration to replication and market uptake

Expected policy benefit: A more credible route from project demonstration to sustained operation, stronger links between research, public authorities and the market, and replication that is adapted to local conditions rather than based on a one-size-fits-all model.

Horizon Europe follow-on actions, cohesion policy and blended-finance instruments should support public-private partnerships that bring decentralised treatment to market, including through the international cooperation routes NAMOR is testing with partners in India and the Republic of Korea.

NAMOR's monitoring, sustainability assessments, stakeholder activities and business-model work can help identify the evidence and enabling conditions required for replication.

3. CONCLUSION: FROM INNOVATION TO IMPLEMENTATION

Decentralised and hybrid water treatment can contribute to a more resilient and circular European water system, provided that solutions are selected according to local needs and supported by appropriate safeguards, reliable evidence and sustainable operating arrangements.

NAMOR brings together several elements needed to explore this potential: modular microalgae - membrane treatment, demonstration under different operating conditions, digital monitoring and optimisation, sustainability assessment, stakeholder participation and business-model development. The value of this integrated approach lies in examining not only whether a technology can work, but also under what conditions it can be operated responsibly, compared with alternatives and considered for replication.

The immediate policy task is to create an enabling environment that combines innovation with accountability. Public authorities need clear permitting pathways and credible performance evidence; utilities and operators need practical guidance, appropriate skills and viable operating models; and funding bodies need transparent criteria for assessing long-term costs, benefits and risks.

As NAMOR progresses, its demonstration results and associated assessments should be used to refine these recommendations and identify the conditions under which decentralised and hybrid configurations provide demonstrable value. The objective is not to favour one infrastructure model in all circumstances, but to ensure that decision-makers can choose the most appropriate solution for each context.

Europe's water resilience will depend on making the right infrastructure choices in the right places, supported by evidence, sound governance and long-term responsibility.

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