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ESMIS

ENHANCE SUSTAINABLE MEASURES IN SPORTS FACILITIES

Enhance Sustainable Measures In Sports Facilities (ESMIS)

D3.4 E-BOOK

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INTRODUCTION TO THE DELIVERABLE

This E-Book (Deliverable D3.4) constitutes one of the fundamental outcomes of Work Package 3 (WP3: Testing the Methodological framework and capacity building) of the European ESMIS project. Designed to be freely available on the project website, this document was created with the central purpose of making the knowledge generated throughout the project accessible and transferable. Its importance within the ESMIS framework lies in ensuring the capitalization and long-term sustainability of the project's activities, guaranteeing that both the staff of partner organizations and the various stakeholders in the sports sector have continuous access to highly valuable educational and inspiring material

Furthermore, this E-Book represents the written consolidation of the ESMIS project's Capacity Building Programme. This programme has been dynamically articulated through a series of six webinars. These sessions were designed to cover a wide range of topics, from a general overview of the platform to the technical analysis of the four sustainability pillars defined by the project: Energy, Water, Materials, and Governance. By compiling, structuring, and presenting the core content of all these seminars, the lessons learned, successful best practices, and expert knowledge are transformed into a permanent reference tool, specifically adapted to the real needs of sports facility managers.

Finally, it must be noted that the E-Book and the Capacity Building Programme do not operate in isolation; rather, they are key components that interact with and complement the rest of the elements developed within the project. This manual is deeply integrated into the repository of the ESMIS Toolkit, creating a continuous feedback loop with practical tools such as Self-Assessment Questionnaire, the Interactive Map of best practices, White Paper and other documents. Together, all these elements form a comprehensive digital ecosystem designed to empower the sports sector, facilitate transnational learning, and provide facility managers with the necessary skills to transform their infrastructure into efficient, resilient, and environmentally responsible spaces.

WEBINAR SERIES

Below is the link to the ESMIS Capacity Building programme webinar series.

Discover the ESMIS Platform (Webinar of Chapter 1)
https://www.youtube.com/watch?v=nq5Q35h8OaE&list=PLEmGLPAy3_FxKn7tCCQ5QetTFdar373N4&index=2

Pillar 1. Energy Sustainability (Webinar of Chapter 2)
https://www.youtube.com/watch?v=Vz3dNF-s4sY&list=PLEmGLPAy3_FxKn7tCCQ5QetTFdar373N4&index=6

Pillar 2. Water Sustainability (Webinar of Chapter 3)
https://www.youtube.com/watch?v=8ve-p-ZW60c&list=PLEmGLPAy3_FxKn7tCCQ5QetTFdar373N4&index=4

Pillar 3. Materials Sustainability (Webinar of Chapter 4)
https://www.youtube.com/watch?v=TyxK9E3MBAM&list=PLEmGLPAy3_FxKn7tCCQ5QetTFdar373N4&index=5

Pillar 4. Governance Sustainability (Webinar of Chapter 5)
https://www.youtube.com/watch?v=Z97BpBbL7Ns&list=PLEmGLPAy3_FxKn7tCCQ5QetTFdar373N4&index=4

Promoting Sustainability solutions using the ESMIS platform (Webinar of Chapter 6)
https://www.youtube.com/watch?v=c0-qU1jtL0I&list=PLEmGLPAy3_FxKn7tCCQ5QetTFdar373N4&index=3

INNOVATION IN SUTAINABILITY AND EDUCATION. ESMIS CAPACITY BUILDING E-BOOK

General abstract

The objective of this document is to facilitate the transition of European sports facilities toward sustainable, resilient, and efficient management models by centralizing and disseminating practical knowledge. To achieve this, the e-book is structured into six distinct chapters, each addressing a critical dimension of the project's sustainability methodology.

Chapter 1 introduces the ESMIS framework and toolkit, presenting a transnational digital ecosystem including an interactive map and technical resources designed to overcome the sustainability practices across Europe. Chapter 2 examines energy efficiency categorizing facilities by consumption profiles. A dual approach is proposed, combining passive building interventions with active technological optimizations, which must be strictly supported by continuous monitoring and submetering. Chapter 3 is dedicated to water sustainability, exploring structural challenges and proposing both immediate low-cost measures and advanced circular-economy strategies. The transition is emphasized through the use of rainwater harvesting, greywater reuse, and advanced digitalization. Chapter 4 focuses on materials and the circular economy, establishing a theoretical five-level circularity steps. Furthermore, microplastic pollution is addressed, and industrial symbiosis and eco-design are highly recommended as strategies to close the material lifecycle. Chapter 5 highlights the essential role of governance, redefining it from a basic administrative task to a data-driven, strategic enabler. The use of Key Performance Indicators (KPIs) and transnational cooperation is established as fundamental to coordinate massive energy needs with long-term economic viability. Finally, Chapter 6 details the ESMIS Self-Assessment Questionnaire, a dual-purpose tool designed for facility self-diagnosis and large-scale data collection. The concept is introduced to highlight high-value benchmarking cases on the interactive map.

Ultimately, it is concluded throughout the document that through technological innovation, circularity, and participatory governance, outdated sports infrastructures can be effectively transformed into resilient, modern, and environmentally responsible spaces.

CHAPTER 1. INNOVATION AND SUSTAINABILITY IN SPORTS FACILITY MANAGEMENT: THE ESMIS FRAMEWORK AND TOOLKIT

Abstract

Chapter 1 introduces the ESMIS (Enhance Sustainable Measures in Sports Facilities) project within the European context. It is established that sports facilities are highly resource-intensive infrastructures that are vulnerable to climate change, yet information regarding sustainable practices remains heavily fragmented across European regions. To address this critical gap, the ESMIS framework is presented as a transnational digital ecosystem designed to centralize and disseminate practical knowledge.

The strategic objectives are defined, focusing on the mapping of best practices, the facilitation of cross-border knowledge transfer, and the democratization and empowerment of the sports sector. Key technological tools are introduced, most notably an interactive map, detailed technical data sheets, and a comprehensive resource repository containing guidelines and technical manuals. Furthermore, current trends in sports facility sustainability are identified, emphasizing energy decarbonization, water circularity, advanced eco-design, and participatory governance. Ultimately, it is concluded that through technological innovation and international cooperation, the ESMIS platform acts as a vital catalyst, empowering facility managers to transform traditional infrastructures into efficient, resilient, and environmentally responsible spaces.

1.1. INTRODUCTION TO THE ESMIS PROJECT IN THE EUROPEAN CONTEXT

Sport has become increasingly important in recent years within contemporary debates on sustainability. This interest stems largely from the environmental impact associated with sports facilities, which are resource-intensive infrastructures. These facilities require large amounts of energy for processes such as heating, cooling, lighting, and water pumping, in addition to the intensive use of water resources for maintaining surfaces like natural grass, the generation of waste from mass events or activities, and the continuous use of materials for their maintenance or renovation. In this regard, Recent systematic reviews in the field of sports facility sustainability have identified the need to move beyond traditional management models towards integrated and data-driven approaches (Gregori-Faus et al., 2025).

In this context, the European Union has promoted initiatives aimed at fostering innovation and transnational cooperation as key tools for addressing the climate crisis. The ESMIS (Enhance Sustainable Measures in Sports Facilities) project arises precisely from this need for coordinated action and the collection of information that will allow progress towards more sustainable models for the management of sports facilities. This urgency is reflected in various European strategic frameworks, which point out that the traditional model for these infrastructures is being progressively questioned due to its environmental impact and vulnerability to the effects of climate change. Although numerous facilities in Europe have implemented measures related to energy efficiency, water conservation, and the circular economy, information on these initiatives has remained largely fragmented and dispersed. As a result, many sports organizations lack access to practical examples that could be replicated in their own contexts. This isolation limits the sector's capacity to move forward in a coordinated manner and slows the widespread adoption of sustainable measures, as also indicated in recent scientific literature regarding the need to improve knowledge transfer mechanisms in the sports sector (Gregori-Faus et al., 2025).

This fragmentation of information is especially relevant in sectors such as sport, where facility characteristics, climate conditions, and governance structures vary greatly among European regions. Without platforms that centralize knowledge, successful innovations remain isolated “local solutions” instead of becoming shared European standards. This urgency is illustrated by concrete global challenges already affecting European sports facilities. In Spain, for instance, increasingly prolonged drought periods in recent years have severely constrained water availability, forcing many outdoor and aquatic facilities to review their management strategies under conditions of acute scarcity. Simultaneously, the sharp and sustained rise in energy prices triggered by the conflict in Ukraine has placed significant financial pressure on sports facility operators across the continent, making energy efficiency no longer merely a sustainability goal but an economic necessity. These real-world pressures demonstrate that the transition towards more sustainable management is both an environmental imperative and a structural response to the volatility of essential resources. Consequently, the lack of a unified knowledge base not only hampers replication but also prevents decision-makers from understanding which sustainability measures are most effective under different technical, geographic, or organizational circumstances.

ESMIS emerged as a direct response to this gap, with the mission of identifying, showcasing, and disseminating best practices already in place at sports facilities across Europe. Its digital platform allows users to compare and analyze these practices, filter by facility type or sustainability pillar (Energy, Water, Materials and Governance), and contact the responsible managers directly. In this way, ESMIS not only documents these practices but also fosters a transnational network of practical knowledge.

1.2. CONSORTIUM STRUCTURE AND PROJECT GOVERNANCE

The ESMIS project is led by a diverse consortium of organizations specializing in innovation, sport, research, and governance. This diversity is one of the project's cornerstones, as it allows for the integration of complementary perspectives and the design of a comprehensive analytical framework.

Partners include:

- EPSI (European Platform for Sport Innovation): Based in Belgium, focused on sports innovation and project dissemination.
- Cluster Sport and Technology: Coordinating entity located in the Netherlands.
- Sport Ireland: Ireland's national body, providing the public management perspective.
- Indescat: Sports industry cluster in Catalonia, Spain.
- Olympiacos SFP: Representative of the sports sector in Greece.
- University of Castilla-La Mancha (UCLM): Spanish academic institution responsible for technological development and the digital platform.
- Sport Innovator: Associate partner from the Netherlands, who played a key role as a stakeholder in the development of the Duurzame Sportsector Atlas (atlas.duurzamesportsector.nl), the Dutch sustainable sports sector mapping

initiative that served as a direct source of inspiration for the design and conception of the ESMIS platform. Their practical expertise in building knowledge-mapping tools for the sports sector has been fundamental to the methodological and technological development of ESMIS.

These institutions share the vision that sustainable sports require a systemic transition, supported by research, technological innovation, and sound governance.
The consortium has developed a governance system based on:

- Regular meetings to validate progress.
- Review of best practice selection criteria.
- Workshops to identify emerging challenges.
- Quality control processes before publishing any facility on the map.

This ensures that the platform maintains rigorous standards and that the published information is dependable, replicable, and useful in different geographical contexts. Crucially, this governance model has been complemented from the very outset by a systematic co-design process involving the platform's primary target group. Since the inception of the project, the consortium has actively consulted sports facility owners and managers, sustainability managers, and providers of sustainability solutions for the sports sector. To date, over 200 professionals from 10 different countries have contributed their expertise and feedback, ensuring that the tools, categories, and functionalities developed by ESMIS respond directly to real operational needs and challenges identified in the field. This participatory approach is not merely a methodological choice but a foundational commitment: what ESMIS builds is grounded in the voices and experiences of those who manage sports facilities every day.

1.3. STRATEGIC OBJECTIVES OF THE ESMIS PLATFORM

The ESMIS platform is not merely a static repository of information, but a digital ecosystem designed to inspire, train, and connect managers, public officials, researchers, and students. Its main objectives include:

1.3.1. Mapping Best Practices

The ESMIS interactive map presents, in a visual and intuitive way, sports facilities that already implement successful sustainable measures. Each point on the map represents a real-world example that can serve as a reference or inspiration. This feature is designed to ensure that good examples can be replicated in different European countries and foster mutual learning on an international scale. This territorial approach allows for understanding sustainability not only as a technical issue, but also as a phenomenon conditioned by climate, regulations, and local resources, thus promoting contextualized analysis.

1.3.2. Knowledge Transfer

ESMIS promotes the exchange of ideas through digital resources, workshops, and seminars. EPSI, one of the main partners, highlights that the project incorporates interactive tools designed to disseminate knowledge throughout the European sports community. Knowledge transfer is especially relevant here, as sustainability in sports facilities depends as much on the technology implemented as on the ability of managers to understand, adapt, and evaluate such practices in their own environments.

1.3.3. Identifying Replicable Models

One of the challenges of sustainability is that not all measures work equally well in all places. Aspects such as regional legislation, climate, facility type, and available resources influence viability. Therefore, the technical data sheets for each facility include indicators that help assess the degree of replicability.

1.3.4. Visibility and Empowerment of the Sports Sector

One of the platform's most notable features is that it allows any sports facility wishing to share its best practices to participate. After completing a detailed form, the practice is evaluated by the project team before being added to the map. This process democratizes participation and fosters innovative initiatives at all levels of sport, from small local centers to large complexes as it prevents only large, well-resourced facilities from gaining European visibility. It also encourages the participation of smaller facilities that, despite having fewer resources, can contribute to creative and highly replicable solutions. Furthermore, the platform is free, open, and multilingual, making it easily accessible to managers and students.

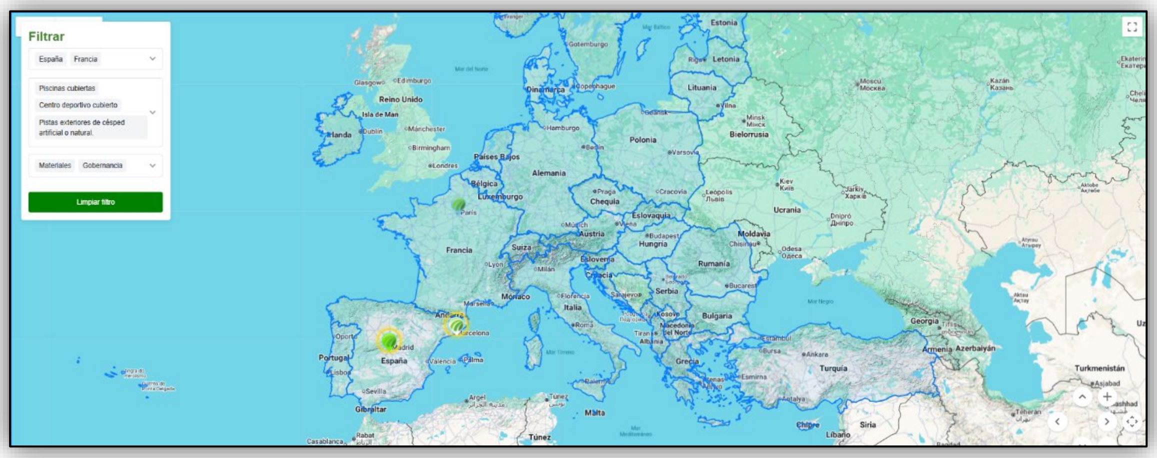
1.4. PLATFORM FUNCTIONALITIES AND TECHNICAL TOOLS

1.4.1. Interactive Map

The map is the central element of the ESMIS ecosystem. It is a visual interface that allows users to locate each registered sustainable facility. The map points are color-coded according to their category or sustainability pillar, enabling clear and intuitive navigation.

This approach is inspired by other public policy systems based on maps of exemplary practices. From this page, users can navigate through the different sections, consult the innovations included on the interactive map, access training resources, and complete the self-assessment questionnaire. The objective remains the same: to offer an accessible, visual, and practical environment that allows sports managers to learn about, compare, and implement sustainable measures in their facilities.

The map incorporates a visual distinction that helps interpret the information at a glance: the countries that are part of the Erasmus+ consortium are highlighted in blue, allowing users to quickly identify the geographical scope of the project and contextualize the innovations within the European framework.

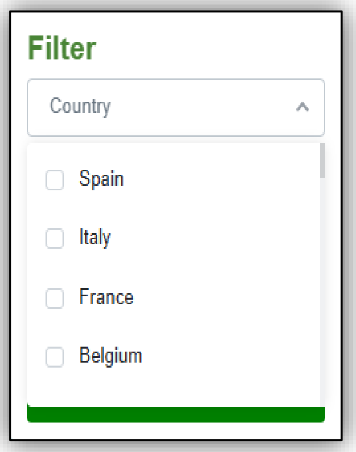


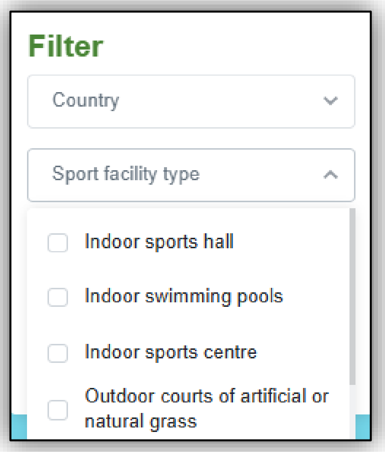
1.4.2. Filters by Facility Type and Sustainability Pillar

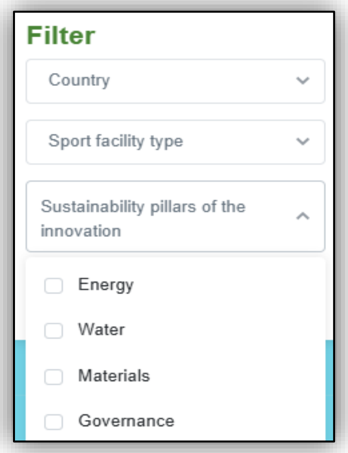
The map is the dominant element of the homepage. To optimize information searches, users have access to advanced filters that allow them to select by:

- Country: Specific geographic location.
- Facility Type: Six categories that differentiate between indoor and outdoor infrastructure.
- Sustainability Pillars: Energy, Water, Materials, and Governance.

This classification, developed by the University of Castilla-La Mancha (UCLM) and agreed upon by its partners, helps to structure information in a pedagogical way and allows managers or students to find examples aligned with their needs or training projects.



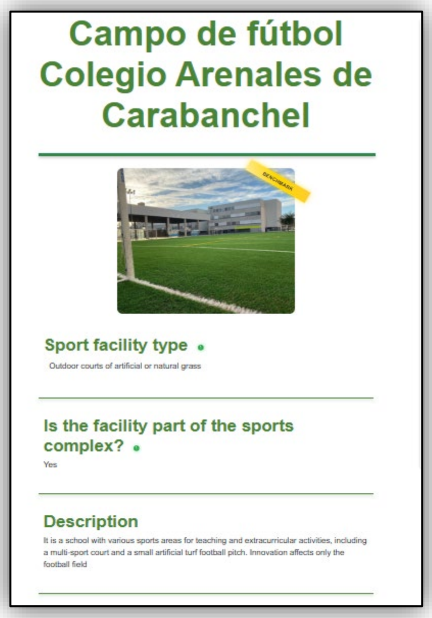




1.4.3. Detailed Technical Data Sheets

Each installation includes:

- Description of sustainable practice.
- General and specific indicators.
- Structural context (size, type).
- Difficulties encountered.
- Assessment of replicability.
- Contact information.



This practical approach aims to facilitate direct exchange between facilities, enabling managers to share lessons learned or resolve technical questions with managers in other European regions.

1.4.4. Multilingual and Accessible Platform

The platform detects the browser language and automatically translates its content. This eliminates language barriers and facilitates cooperation in a European-scale project.

1.5 LATEST TRENDS IN SUSTAINABILITY IN SPORTS FACILITIES

Analysis of the practices compiled within the ESMIS project identifies several key trends that are redefining the management of sports facilities towards more sustainable models. These trends are consistent with recent research on sports facility sustainability, which emphasizes the transition from isolated technical measures to integrated management approaches combining energy efficiency, technological innovation, and governance frameworks (Gregori-Faus et al., 2025).

1.5.1. Energy Management and Decarbonization

Energy represents one of the most critical pillars in the sustainability of sports facilities. Within the ESMIS project, partners such as EPSI and the University of Castilla-La Mancha highlight that a significant proportion of European facilities were originally designed without energy efficiency criteria, which results in structurally high levels of energy consumption. Consequently, there is a growing need to implement strategies aimed at improving energy performance and reducing operational costs. In this context, previous research has identified a set of commonly adopted measures, including the implementation of LED lighting systems, the integration of solar thermal and photovoltaic technologies, the use of centralized energy management systems, and improvements in thermal insulation, all of which contribute to enhancing energy efficiency and supporting the transition towards more sustainable facility management (Al Katsaprakakis et al., 2023).

1.5.2. Water Circularity

Water scarcity, as identified within the ESMIS project context, represents a significant challenge for sports facilities, particularly those with high water demands such as swimming pools and natural grass fields. In response, facilities are increasingly adopting water management strategies aimed at improving resource efficiency, including rainwater harvesting systems, sensor-based irrigation technologies, advanced filtration processes, and greywater reuse solutions, all of which contribute to reducing water consumption and enhancing environmental performance.

1.5.3. Ecodesign and Sustainable Materials

Renovations and new constructions tend to use low-carbon, recycled, or reusable materials, aligning with European circular economy strategies. This approach allows for a reduced environmental footprint and increased durability of the facilities.

1.5.4. Governance and Social Participation

Sustainability in sports facilities extends beyond technical and operational measures, encompassing governance as a fundamental dimension for long-term impact. In this regard, governance strategies increasingly focus on integrating sustainability into the facility's strategic mission, promoting community participation, ensuring transparency in decision-making processes, and incorporating measurable performance indicators. These elements contribute to more structured and accountable management models, enabling organizations to monitor progress and adapt their strategies over time. Within the ESMIS project, partners consistently emphasize that effective governance is essential to consolidate lasting and replicable changes across different contexts.

1.5.5.Identifying benchmarks

Benchmarking is a systematic process through which organizations compare their own practices with those of leading institutions in order to identify gaps, understand why certain approaches generate superior results, and adapt these insights to their own context. In the field of sports facility management, benchmarking allows us to differentiate between standard practices and exemplary innovations. These outstanding practices serve as sector-wide reference points, enabling managers to recognize emerging and disruptive trends that may reshape the future of European sports facilities.

1.6. RESOURCE REPOSITORY AND KNOWLEDGE PRODUCTION

In addition to the interactive map, ESMIS has developed a documentary ecosystem designed to support managers, students, and public officials. Key resources include:

- Guidelines: documents that summarize project lessons learned and explain how to implement sustainable measures in practice.
- Technical Manuals: focused on the four pillars of sustainability, with detailed explanations and recommendations.
- White Papers: strategic analyses on trends, innovation, and the green transition.
- Policy Recommendations: guidance for administrations to adapt regulations and strengthen sports sustainability.
- Webinar Series: Six webinars covering topics from a general overview of the platform to technical sessions on each pillar of sustainability.
- External Resources Library: A classified collection of documents and audiovisual materials on sports sustainability.

1.7. KEY MESSAGES FOR FUTURE PROFESSIONALS

For students of sports science, sports management, architecture, engineering, public policy, or sustainability, ESMIS is an extremely valuable resource for several reasons:

- Access to real data: Enables market research or academic studies based on already implemented technical and process innovations.
- International networking: Facilitates direct contact with managers of leading facilities throughout Europe.
- A pragmatic vision: It teaches that the goal is not "perfection," but rather impactful, understandable, and, above all, adaptable measures.

One of the project's most important messages is that the green transition of sport is inevitable. New generations of professionals will need to master digital tools, circular economy concepts, efficiency indicators, and governance models to adapt to the job market.

1.8. CONCLUSION

The ESMIS project represents a significant step forward in the sustainable transition of European sport. Its digital platform, consisting of an interactive map, a resource repository, fact sheets, and training tools, articulates practical knowledge that helps transform sports facilities into more efficient, resilient, and environmentally responsible spaces. The combination of technological innovation, international cooperation, and community participation allows progress toward more efficient, resilient, and environmentally responsible management models. In this sense, the transition to sustainable sports facilities aligns with trends identified in scientific literature, which highlight the role of energy efficiency, digitalization, and governance as key elements in this process (Al Katsaprakakis et al., 2023; Gregori-Faus et al., 2025).

Ultimately, ESMIS not only helps to showcase best practices but also acts as a catalyst for change in the sports sector, promoting an approach in which sustainability is central to the planning and management of facilities.

REFERENCES CHAPTER 1

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Gregori-Faus, C., Crespo, J., Calabuig, F., & Parra-Camacho, D. (2025). State-of-the-art of sustainability in sports facilities: a systematic review. *Environment, Development and Sustainability*, 1-22.

Useful Links

- ESMIS Official Platform - Interactive Map
    - (https://www.indescat.org/esmis/?lang=es)
    - https://mappingesmis.com/
- ESMIS Official Brochure (PDF)
    - https://www.mappingesmis.com/media/documents/Spanish_brochure.pdf
    - https://www.youtube.com/watch?v=gP5NUXNSU94

CHAPTER 2. ENERGY EFFICIENCY IN SPORTS FACILITIES: INTEGRATED MANAGEMENT, OPERATIONAL CHALLENGES, AND APPLIED BEST PRACTICES

Abstract

Chapter 2 focuses on energy efficiency and the critical water-energy nexus in sports facilities. It is established that water acts as energy in transit; therefore, every liter used entails significant energy consumption for heating, pumping, and distribution. Facilities are categorized by consumption profiles, highlighting that unique, intensive demands are faced by indoor swimming pools, stadiums, and multifunctional centers. Furthermore, structural challenges inherited from pre-ecological transition infrastructures, such as inadequate thermal insulation and obsolete, oversized water storage systems, are identified as primary sources of inefficiency. To address these challenges, a dual approach of passive and active efficiency measures is proposed. Passive interventions are focused on improving the building envelope to reduce overall resource demand, while active measures involve the technological optimization of HVAC systems, LED lighting, and domestic hot water production. Crucially, continuous monitoring and submetering are emphasized as the fundamental basis for any successful strategy, enabling the early detection of operational deviations and the accurate calculation of Return on Investment (ROI). Ultimately, it is concluded that sustainable management must be deeply integrated into organizational culture to transform sports facilities into intelligent, circular, and highly resilient systems.

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2.1. INTRODUCTION

Contemporary sports facilities present a high level of complexity from an environmental sustainability perspective, due to their intensity of use, the diversity of services they integrate, and the concentration of peak demand periods. In this context, water and the energy associated with its use have become strategic resources whose management is critical both for the economic viability and the operational resilience of these facilities. Recent studies highlight that indoor swimming pools, stadiums and leisure centres are among the public buildings with the highest combined consumption of water and energy, particularly due to water heating, continuous pumping and sanitary requirements (Gómez-Guillén et al., 2024; Gregori-Faus et al., 2025).

Water management can no longer be approached as an isolated technical supply, as it permeates all operational areas of a sports facility, including showers, pools, irrigation, cleaning, HVAC systems, catering services and safety systems. Each of these uses entails direct economic costs, operational risks and indirect emissions, largely derived from the energy required for water abstraction, treatment, heating and distribution. From a water–energy nexus perspective, the literature emphasizes that the main environmental impact of water in buildings lies not so much in the volume consumed as in the energy required throughout its entire management cycle (Wu et al., 2020).

Sports swimming pools represent a paradigmatic example of this interdependence. Evaporation, continuous reheating and permanent recirculation generate high levels of water and energy stress, especially under scenarios of climate change and rising energy prices (Gómez-Guillén et al., 2024). Similarly, large stadiums concentrate very high levels of consumption within short timeframes, associated with the intensive use of sanitary facilities, catering services and post-event cleaning, requiring resilient and properly dimensioned systems (Kesgin & Gezici, 2025).

Against this background, water sustainability must be conceived as a strategic axis of sports facility management, closely linked to energy efficiency and infrastructure planning. Scientific evidence shows that integrated water and energy management at the building level enables reductions in consumption and emissions, while also improving operational reliability and the capacity to anticipate risks such as droughts or demand peaks (Wu et al., 2020).

2.2. WATER AND ENERGY: AN INSEPARABLE STRUCTURAL RELATIONSHIP

One of the fundamental principles for understanding sustainability in sports facilities is recognizing that water acts as energy in transit. Every liter used entails energy consumption throughout its entire life cycle: abstraction, pumping, storage, distribution, heating, end use and treatment as wastewater. This approach, widely developed under the concept of the water–energy nexus, demonstrates that the environmental impact of water is intrinsically linked to the energy required to make it available and functional (Wu et al., 2020).

In sports facilities, this relationship is intensified by high frequencies of use and strict requirements related to comfort, safety and hygiene. Heated swimming pools and domestic hot water systems (DHW) account for some of the highest energy demands within these buildings. Recent studies show that water heating and thermal losses due to evaporation can represent a substantial share of total energy consumption, in many cases exceeding that associated with other building uses (Gómez-Guillén et al., 2024).

Evaporation is the primary mechanism of energy loss in swimming pools, as it extracts large amounts of latent heat that must be continuously compensated. Additional contributing factors include water renewal, chemical treatment processes and the introduction of colder make-up water, all of which increase energy demand. The literature indicates that a significant portion of these consumptions can be mitigated through improved thermal insulation, optimization of recirculation systems and more precise operational control (Wang, Wang, & Dawson, 2022).

From an integrated perspective, water management cannot be dissociated from other key building systems, such as HVAC, the building envelope, thermal generation systems and day-to-day operational practices. Approaches addressing water and energy jointly reveal clear synergies: reducing hot water consumption directly lowers energy demand, while improving building insulation reduces both space heating and water reheating requirements (Wu et al., 2020; Kesgin & Gezici, 2025).

Consequently, water sustainability in sport facilities must be understood as an integrated water–energy–building strategy, contributing simultaneously to cost reduction, resilience to resource scarcity and mitigation of climate change impacts.

2.3. TYPES OF SPORTS FACILITIES AND CONSUMPTION PROFILES

Water and energy sustainability in the sports sector cannot be addressed uniformly, as consumption patterns vary significantly depending on facility typology. Indoor swimming pools, stadiums and multifunctional sports centres exhibit distinct profiles in terms of water volumes, energy intensity and temporal distribution. Identifying these profiles is a prerequisite for designing tailored efficiency strategies, as highlighted in recent literature on sports facility sustainability (Gregori-Faus et al., 2025).

Indoor Swimming Pools and Aquatic Centres

Indoor swimming pools and heated aquatic centres systematically rank among sports facilities with the highest combined water and energy consumption. This high demand is driven by the need to maintain large volumes of water at constant temperature, comply with strict sanitary requirements and control indoor humidity levels (Gómez-Guillén et al., 2024).

Key factors shaping their consumption profile include continuous water recirculation, intensive use of showers and changing rooms, and thermal losses due to evaporation. Nevertheless, studies consistently indicate that these facilities offer substantial savings potential, even through relatively simple measures such as temperature adjustment, flow reduction and improved thermal insulation, with positive effects on both water and energy consumption (Gómez-Guillén et al., 2024).

Sports Stadiums

Sports stadiums display a distinct consumption pattern characterized by extreme demand peaks on event days. During these periods, intensive use of sanitary facilities, catering operations, cleaning processes and turf irrigation generates very high demand over short time intervals (Kesgin & Gezici, 2025).

From a sustainability perspective, this pattern requires systems capable of responding to peak demand without unnecessary oversizing during low-occupancy periods. The literature highlights the role of storage, reuse and rainwater harvesting solutions in improving operational resilience and reducing reliance on municipal supply networks (Wu et al., 2020).

Multifunctional Sports and Leisure Centres

Multifunctional sports and leisure centres combine multiple simultaneous consumption points, derived from the coexistence of wet areas, sports zones and complementary services, with high user turnover and extended operating hours. This diversity complicates efficient management in the absence of detailed usage information (Gregori-Faus et al., 2025).

In this context, consumption sectorization and advanced monitoring become essential tools for identifying inefficiencies and implementing targeted corrective measures. Scientific evidence shows that disaggregated monitoring significantly reduces the cumulative impact of small operational deviations over time (Wu et al., 2020).

2.4. STRUCTURAL CHALLENGES IN FACILITIES BUILT PRIOR TO THE ECOLOGICAL TRANSITION

A significant proportion of existing sports facilities were designed in a historical context where energy and water efficiency were not primary design criteria. Scientific literature indicates that many current inefficiencies do not stem from poor management but from structural limitations inherited from periods characterized by low energy costs and a perception of resource abundance (Wang, Wang, & Dawson, 2022; Gregori-Faus et al., 2025).

Common deficiencies include inadequate thermal insulation in roofs and building envelopes, particularly critical in large-volume facilities such as indoor pools and sports halls. These shortcomings lead to constant thermal losses, increasing energy demand for space heating and water reheating. Additional issues include outdated sanitary systems, such as uncontrolled urinals and showers, which generate unnecessary hot water consumption (Kesgin & Gezici, 2025).

Another frequent problem is the presence of oversized domestic hot water storage tanks lacking adequate sensors, resulting in overheating and inefficient boiler operation. The absence of partial metering hinders detection of these issues, while many building management systems (BMS) remain limited to basic control functions without analytical or optimization capabilities (Wu et al., 2020).

From an educational standpoint, it is essential to understand that these facilities were not designed to be inefficient, but rather to meet the requirements of a different energy context. This recognition makes it possible to steer strategies towards progressive rehabilitation, based on measurement, prioritization of actions, and the adaptation of existing infrastructures to current sustainability and resilience challenges (Gregori-Faus et al., 2025).

2.5. PASSIVE EFFICIENCY MEASURES: ACTING ON THE BUILDING

Passive efficiency measures constitute the first level of intervention for improving water and energy sustainability in sports facilities, as they reduce resource demand without relying on the continuous operation of active systems. These measures act directly on the physical characteristics of the building and determine its long-term energy performance, exerting a decisive influence on the amount of energy required to heat water and condition indoor spaces (Pérez-Lombard et al., 2008).

Among the most relevant actions is the improvement of the building's thermal envelope, particularly roofs, façades and openings. In sports facilities and especially in indoor swimming pools the roof represents one of the main sources of heat loss due to its large, exposed surface and the accumulation of warm air in upper zones. The literature indicates that a poorly insulated envelope can significantly increase a building's energy demand, particularly in contexts with high thermal and hygrothermal requirements (Gómez-Guillén et al., 2024).

The elimination of thermal bridges in windows, skylights and structural junctions is another key intervention. Although localized, these points generate continuous energy losses and promote condensation problems and structural deterioration, thereby increasing maintenance and operating costs (Pérez-Lombard et al., 2008). Likewise, solar protection adapted to building orientation allows thermal loads to be reduced in summer without compromising solar gains in winter. In facilities with extensive glazed areas, this strategy decreases cooling demand and, indirectly, the energy consumption associated with water treatment and environmental control. Finally, reconfiguring spaces according to use and orientation contributes to rationalizing energy and water demand, as demonstrated by roof retrofit projects in heated swimming pools, where sustained improvements in thermal efficiency and reductions in energy consumption have been observed (Gómez-Guillén et al., 2024; Gregori-Faus et al., 2025).

2.6. ACTIVE MEASURES: LIGHTING, WATER AND HVAC SYSTEMS

While passive measures reduce the structural demand for resources, active measures enable optimization of water and energy use through technologies, control systems and more precise operational management. In sports facilities, the appropriate combination of both strategies is essential to achieve substantial improvements in efficiency and sustainability (Pérez-Lombard et al., 2008).

Efficient Lighting

Lighting represents one of the areas with the greatest potential for improvement. Replacing conventional systems with LED technology, combined with zoning, occupancy sensors and time scheduling, has been shown to deliver very short payback periods, typically between one and three years (Pérez Lombard et al., 2008). Best-practice examples collected in international platforms such as the ESMIS mapping (Lappi Areena) initiative illustrate how these solutions are being successfully deployed in sports facilities across Europe.

Beyond the direct reduction in electricity consumption, LED lighting significantly reduces internal heat gains, thereby lowering the load on HVAC systems, particularly in enclosed and intensively used spaces. In addition, in some cities these technological upgrades are reinforced by municipal energy policies that provide access to reduced electricity tariffs or preferential rates for public and sports facilities, further improving the economic viability of such interventions. The literature agrees that these measures constitute some of the most cost-efficient interventions in the sports sector (Gregori Faus et al., 2025).

Domestic Hot Water Production and Consumption

Domestic hot water (DHW) is one of the main sources of energy consumption in sports facilities with swimming pools and changing rooms. Among the most effective measures are optimization of boilers and heat pumps, adjusting their operation to actual demand, and flow reduction through efficient showers and timers. These actions simultaneously reduce water use and the energy required for heating, resulting in substantial savings (Gómez-Guillén et al., 2024). Beyond conventional optimization strategies, innovative solutions based on waste heat recovery are also emerging as effective practices. A notable example is the Debrecen Sports Swimming Pool, where waste heat generated by a nearby university supercomputer is recovered through heat exchangers and a heat pump to supply part of the facility's heating needs, including domestic hot water. This approach demonstrates how synergies between external energy sources and sports facilities can improve energy efficiency and reduce reliance on conventional heating systems.

Heating, Ventilation and Air Conditioning (HVAC)
HVAC systems play a decisive role in the overall energy efficiency of buildings, especially in indoor swimming pools. Heat recovery and adjusting temperature setpoints and operating schedules according to occupancy help avoid unnecessary consumption. In addition, the use of CO_2 and humidity sensors allows ventilation rates to be adapted to real indoor conditions, reducing energy use without compromising indoor comfort (Wu et al., 2020). Innovative practices are also emerging in outdoor sports facilities, such as Sportpark Strijp in Eindhoven, where a collector field installed beneath an artificial turf pitch captures excess heat and transfers it to a municipal aquifer thermal energy storage system. This solution demonstrates how sports infrastructure can be integrated into local heating and cooling networks, contributing to broader district energy systems, reducing reliance on fossil fuels and expanding the role of sports facilities as active components of sustainable urban HVAC strategies.

2.7. MONITORING AND MEASUREMENT: THE BASIS OF ANY STRATEGY

The literature on building sustainability consistently highlights that measurement is the starting point of any effective water and energy efficiency strategy. In the absence of reliable data, resource management tends to rely on estimates or delayed reactions to consumption increases, significantly limiting the capacity for preventive action (Wu et al., 2020).

The installation of sub-metering and continuous monitoring systems enables consumption to be disaggregated by use and functional area, facilitating the detection of leaks, abnormal consumption and operational deviations that would go unnoticed with a single global meter. Moreover, monitoring is essential for validating real savings and assessing the impact of implemented measures (Oneda & Ghisi, 2025).

From an economic perspective, access to accurate data is crucial for calculating return on investment (ROI) and justifying refurbishment actions, as well as for accessing public funding schemes that increasingly require quantifiable evidence of impact. Furthermore, studies show that consumption visibility induces positive behavioral changes within organizations, embedding sustainability as a daily management practice rather than a purely technical intervention (Wu et al., 2020).

Case Study A: Public Swimming Pools and Operational Management

Public swimming pools provide a particularly illustrative example of how structural shortcomings combined with limited operational management can lead to high levels of water and energy consumption. Common issues in these facilities include overheated hot-water storage tanks, constant overflow from expansion vessels, and the use of hot water in processes where it is unnecessary.

In many cases, these inefficiencies stem from a lack of basic sensors and control systems capable of accurately monitoring temperatures, water volumes and flow rates. Practical experience has shown that small deviations sustained over time can result in significant increases in energy consumption.

The implementation of simple solutions such as low-cost temperature sensors and basic operational reconfiguration has been shown to generate substantial reductions in consumption and associated emissions. These interventions demonstrate that efficiency does not necessarily depend on large-scale technological investments, but rather on basic, well-applied control, grounded in measurement, adjustment and continuous follow-up.

Case Study B: Croke Park as an Advanced Model

Croke Park represents an advanced example of integrated water and energy management in a large-scale sports facility. The stadium has implemented a strategy that combines infrastructure, technology and organizational practices, incorporating rainwater harvesting systems, automated control of sanitary facilities and extensive monitoring of its resource consumption.

This approach is complemented by intelligent irrigation sensors, systematic leak detection programmes and the adoption of international environmental and energy management standards. The result is a model that integrates sustainability and operational performance without compromising facility functionality.

The case demonstrates that sustainable management not only reduces consumption and costs but also strengthens operational continuity during critical events and enhances institutional reputation. Sustainability thus becomes a strategic element that increases system resilience and adaptive capacity in the face of resource scarcity and price volatility.

2.8. WATER STEWARDSHIP PROGRAMMES AND CONTINUOUS IMPROVEMENT

Water Stewardship programmes provide a structured framework for transitioning from reactive approaches to models of continuous improvement. Through these programmes, organizations can identify water-related risks, develop consumption maps and plan phased, data-driven actions.

One of their main strengths lies in facilitating the integration of sustainability into organizational culture, moving beyond isolated projects. For managers in early stages of implementation, these programmes offer a clear roadmap that reduces uncertainty in decision-making and promotes gradual, coherent adoption of efficiency measures.

2.9. CONCLUSIONS

Water sustainability in sports facilities must be understood in an integrated manner as a tool for economic efficiency, a factor of operational resilience, and environmental and social responsibility. When properly implemented, it reduces costs, improves responsiveness to demand peaks and contributes to broader sustainability and energy transition objectives.

The key lessons of this chapter can be summarized in four core ideas: measurement is the first step towards improvement; simple solutions can generate significant impacts; building performance is as important as the sporting activity hosted; and organizational culture is decisive in consolidating technical advances.

Accordingly, future sports facilities should be conceived as intelligent, circular and resilient systems, capable of adapting to pressures arising from climate change and resource scarcity without compromising service quality or user experience.

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CHAPTER 3. WATER SUSTAINABILITY IN SPORTS AND LEISURE FACILITIES: FOUNDATIONS, CHALLENGES, BEST PRACTICES, AND EMERGING TRENDS

Abstract

Chapter 3 is dedicated to water sustainability in sports and leisure facilities. Water is established as a critical, limited resource that acts as "energy in transit"; consequently, significant energy is consumed through its continuous heating, pumping, and distribution. Specific consumption profiles are identified, with extreme demands observed in indoor swimming pools, stadiums, and leisure centers. Furthermore, structural challenges inherited from pre-ecological transition infrastructures, including inadequate thermal insulation and obsolete sanitary systems, are analyzed as primary sources of resource waste. To mitigate these issues, a dual approach is proposed. First, affordable, low-cost measures such as flow restrictors and timers are recommended for immediate impact. Second, advanced, circular-economy strategies are explored, including rainwater harvesting, greywater reuse, and the transition toward "Water Circular Ready" infrastructures. Crucially, the fundamental role of advanced digitalization, utilizing Artificial Intelligence, digital twins, and IoT sensors, is emphasized for continuous monitoring and predictive management. Ultimately, it is concluded that technological implementation must be supported by a profound shift in organizational culture, ensuring that sports facilities are transformed into intelligent, circular, and highly resilient environments.

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3.1. INTRODUCTION

Water management has become a central challenge for contemporary sports and leisure facilities. The combination of large built surfaces, high occupancy rates, extended daily operating hours, and the presence of spaces that require continuous water supply such as swimming pools, changing rooms, spas, shower areas, washrooms, and landscaped areas places these facilities among the highest consumers of this resource (Kesgin & Gezici, 2025). In recent years, regulatory pressure, environmental concerns, and the increasing cost of water and the energy required to treat it have made water sustainability a critical dimension of sports facility management (Local Government Association, 2026).

Moreover, water is a resource that directly shapes the user experience. In a heated swimming pool, its quality determines the satisfaction and safety of bathers; in a stadium, the availability of sanitary services, cleanliness, and the facility's ability to respond during high-attendance events depend on water and its efficient management (Li, Schiff & Brengman, 2010). Therefore, viewing water solely as a technical input is insufficient: it is a transversal element that conditions operations, economics, service perception, and the overall sustainability of any sports facility.

This chapter presents the foundations of sustainable water management, describes the structural problems faced by the sector, analyses practical low-cost solutions, and examines advanced strategies based on innovation, digitalization, and the circular economy. In addition, real case studies in sports environments illustrate the challenges and opportunities associated with the sustainable transformation of water.

3.2. WATER AS A LIMITED RESOURCE IN THE SPORTS CONTEXT

For a long time, water was perceived as an abundant resource, especially in regions with frequent rainfall. However, it is now recognized that every liter used in a sports facility entails significant energy, economic, and environmental costs. Heating and pumping water for showers, spas, or swimming pools requires large amounts of energy, which in some facilities particularly heated pool scan represent up to one-third of total energy consumption (Gómez-Guillén et al., 2024).

Furthermore, water carries direct economic costs since supply and sewerage tariffs include treatment processes both before and after use. Added to this is its environmental impact, as water treatment and heating generate indirect CO_2 emissions and require chemical products. Therefore, in the sports sector, every decision related to water use must be evaluated through criteria of efficiency, savings, and comprehensive sustainability (U.S. Environmental Protection Agency, 2025).

3.3. CHARACTERISTICS OF SPORTS FACILITIES WITH HIGH WATER DEMAND

Water consumption in sports facilities varies depending on their typology, although three types stand out for their particularly high demand: indoor swimming pools, stadiums and leisure centres. Heated swimming pools require large volumes of water that must undergo continuous recirculation, filtration and disinfection, in addition to replenishing losses caused by evaporation (Gómez Guillén et al., 2024). This is compounded by the intensive use of showers and changing rooms, making these facilities the most demanding in terms of both water and energy consumption.

In stadiums, water use is extremely high but concentrated at specific times. Event days generate massive use of toilets, a significant increase in catering activity and large-scale cleaning operations, in addition to irrigation of natural turf, which requires precise control to avoid wastage and agronomic damage (Kesgin & Gezici, 2025). Leisure centres such as spas, gyms or water parks combine numerous points of consumption associated with wet areas, high user turnover and recreational activities, which further increase total demand.

Understanding these differences is essential for implementing tailored saving strategies: swimming pools require interventions in climate control and water treatment systems; stadiums need systems capable of managing peak demand; and leisure centres require solutions that optimize showers, recirculation and the maintenance of wet zones.

3.4. STRUCTURAL PROBLEMS IN FACILITIES BUILT BEFORE THE ECOLOGICAL TRANSITION

Many European sports facilities were constructed in periods when water and energy efficiency were not priorities. The absence of strict regulations, the low cost of energy and the lack of control technologies led to buildings with structural deficiencies that today result in high consumption (Gregori Faus et al., 2025). Among the most common problems is the lack of thermal insulation in roofs and building envelopes, which causes major heat losses especially in heated swimming pools, where air and water temperatures must remain stable (Miletić et al., 2024). Added to this are outdated sanitary systems, such as urinals that flush continuously or showers without flow restrictors, installed under past usage standards (Gonçalves et al., 2021).

Another frequent issue is the overheating of hot-water storage tanks, caused by misadjusted valves or a lack of sensors to regulate temperature, which can lead to continuous losses for hours without detection. Finally, the lack of monitoring greatly hinders management: without sectorized meters or supervision systems, it becomes impossible to identify leaks, pinpoint abnormal consumption spikes or evaluate the real impact of efficiency measures (National Institute of Building Sciences, 2017). These limitations make many older facilities spaces where water and energy consumption are high, unpredictable and difficult to control without targeted intervention.

3.5. LOW-COST MEASURES FOR IMMEDIATE SAVINGS

Although many water-sustainability strategies require significant investment, there are affordable and rapidly deployable measures that allow for immediate savings. Among the most effective are low-flow showers and faucets, which reduce the volume of water used without diminishing user comfort, and timers or solenoid valves in urinals, which prevent continuous flushing during periods of inactivity one of the most common sources of waste in sports facilities (Massachusetts Water Resources Authority, n.d.).

Thermal insulation of pipes and hot-water storage tanks is also highly effective, as it reduces heat losses, and proper scheduling of pumps and boilers prevents them from operating unnecessarily during closing hours. Finally, replacing lighting with LED technology reduces internal heat in swimming pools and improves overall energy efficiency. These low-cost, fast-implementation actions allow any facility to make immediate progress toward more efficient water use without requiring major refurbishment projects (U.S. Environmental Protection Agency, 2025).

3.6. ENERGY MANAGEMENT LINKED TO THE WATER CYCLE

Water and energy are closely interconnected in sports facilities, especially in the case of domestic hot water (DHW), whose heating and distribution represent one of the largest energy demands in a building. Reducing hot-water use directly lowers the load on boilers, decreases fuel or electricity consumption, and reduces distribution losses an especially relevant factor in older facilities with poorly insulated pipes or continuous recirculation systems (Longarela Ares, 2019).

Likewise, lower water flow reduces the operation time of recirculation and pressurization pumps, decreasing daily electricity consumption. Improvements in thermal insulation and optimized recirculation prevent heat losses that would otherwise force the system to compensate continuously. Ultimately, lowering hot-water consumption also reduces indirect emissions, making water-efficiency measures a key tool for decarbonization and for maintaining the economic competitiveness of the sports facility (Marjoribanks et al., 2025).

3.7. CASE STUDY 1: PUBLIC SWIMMING POOLS AND THE PERSPECTIVE OF NEIL MCCABE

Neil McCabe, a sustainability specialist with extensive experience in public swimming pools, identifies recurring issues such as overheated hot-water tanks, lack of sectorized water meters, and sanitary systems that waste thousands of liters per month. These situations often arise from missing sensors, mis-calibrated valves, and outdated equipment that flushes automatically regardless of real use.

According to McCabe, very simple and inexpensive measures such as installing temperature probes, sectorizing consumption, or adding solenoid valves to urinal scan reduce total water use by 5% to 10%. His approach demonstrates that much of the potential for water savings does not require major investments, but rather operational control and well-executed basic maintenance.

3.8. CASE STUDY 2: CROKE PARK AS A REFERENCE MODEL

Croke Park, one of the largest stadiums in Europe, stands out for its rainwater harvesting system, which is capable of supplying irrigation, cleaning operations and soon, sanitary flushing. The facility includes more than 500 urinals controlled by a BMS, soil-moisture sensors for automated irrigation, and a water-monitoring system that covers over 90% of the venue allowing leaks to be detected and consumption to be adjusted in real time.

Additionally, its catering equipment is highly efficient, and all processes are optimized for large events. The stadium demonstrates that water sustainability can be fully integrated even in environments of significant operational complexity, reducing costs and enhancing resilience without compromising service quality.

3.9. ADVANCED STRATEGIES: REUSE, HARVESTING AND AUTOMATION

The most advanced sports facilities are adopting water-management strategies that combine circular-economy principles and digitalization to reduce consumption, improve water quality and increase resilience to climate change. One of the main lines of action is greywater reuse, using water from showers or washbasins after basic treatment through UV filtration or membranes for non-potable purposes such as irrigation, cleaning or toilet flushing, thereby reducing dependence on potable water. Rainwater harvesting has also become a key strategy: by storing and treating water collected from roofs and outdoor surfaces, facilities can meet daily needs without overloading the municipal network and can maintain a useful reserve during drought or heavy rainfall periods (Kesgin & Gezici, 2025).

Advanced filtration systems, such as ozonation or ultrafiltration, improve water quality and clarity, reduce the use of chemical products and increase reuse potential, particularly in swimming pools where sanitary standards are stringent. Added to this is the growing role of artificial intelligence, which helps anticipate consumption, detect anomalies and adjust systems based on occupancy patterns or historical data. Algorithms can predict peak demand during major events and optimize pump and boiler scheduling. Finally, digital twins make it possible to simulate the water-management behavior of an entire facility, assessing the impact of operational changes before implementing them in the physical building. This tool transforms water management into a predictive process, reducing errors, optimizing resources and avoiding unnecessary costs (Gandola et al., 2025).

A representative example of these advanced strategies is the Sport Ireland National Aquatic Centre, one of the largest indoor aquatic facilities in Europe. The centre has implemented an alternative water sourcing system by connecting the facility to on-site boreholes, which are capable of supplying more than 85% of its total water demand. Through the installation of a dedicated treatment plant, groundwater is treated to a quality suitable for use in swimming pools, showers, sanitary facilities and operational cleaning processes, significantly reducing dependence on the municipal water network. This technical innovation illustrates how large-scale aquatic facilities can combine water self-sufficiency, advanced treatment systems and circular resource management to achieve substantial water savings estimated at over 70%with a relatively short return on investment.

3.10. WATER SUSTAINABILITY AS A PROFESSIONAL COMPETENCE

Water sustainability is now an essential competency for sports managers, maintenance technicians and facility operators. Beyond understanding basic principles, professionals must be capable of conducting water audits, identifying consumption patterns, detecting leaks and prioritizing interventions according to their economic and environmental impact.

It is equally important to be able to diagnose and plan improvements, assessing which measures offer a rapid return and which require medium- or long-term investment. The ability to develop efficiency plans with measurable objectives, monitoring indicators and realistic proposals is a key skill in the sector.

Environmental communication is another crucial pillar: managers must effectively convey to staff, authorities and users the importance of specific practices, ensuring that technical improvements are integrated into daily operations and supported by the entire team.

Finally, water sustainability must be understood in direct relation to the economic viability of the facility. Reducing consumption saves money, extends equipment lifespan and improves service reliability. Thus, sustainability is not only an environmental commitment but also a strategic management tool for the professional sports sector.

3.11. LATEST TRENDS IN WATER SUSTAINABILITY (2025–2026): INNOVATIONS AND BEST PRACTICES

These trends reflect not only technical innovations but also a cultural shift in how the sports sector understands its environmental responsibility.

Advanced Water Digitalization: AI, IoT Sensors and Digital Twins

Digitalization has become the principal driver of innovation in water management. Technologies such as artificial intelligence (AI), IoT sensors, and predictive models make it possible to monitor water use in real time, detect invisible leaks, anticipate consumption peaks and optimize overall operations (UNESCO, 2025). Thanks to continuous data capture from showers, storage tanks, reservoirs and internal networks it is possible to adjust pressures, schedule pump operations efficiently and significantly improve decision-making accuracy (Mandal et al., 2025).

In Europe, these solutions are aligned with new guidelines promoting interoperability between water and energy systems, as well as the use of big data to create more efficient facilities. A notable application is the growing use of digital twins in large stadiums, allowing operators to simulate consumption according to event type or weather conditions, anticipate needs, and prevent overload or unnecessary waste (AVEVA, 2025).

Rainwater Harvesting and Water Reuse: "Water Circular Ready" Facilities

The transition toward circular water-economy models is a strong and growing trend. *Water circular ready* facilities incorporate rainwater harvesting systems, greywater reuse, and on-site treatment processes to reduce dependence on potable water and optimize its use.

Rainwater harvesting can supply irrigation, cleaning and toilet flushing, while greywater after treatment with UV filtration or membrane scan significantly reduces total water consumption. Advanced filtration systems also improve water quality in swimming pools, reduce the need for chemical products and facilitate reuse. In addition, the use of green roofs and nature-based solutions is expanding; these reduce building temperatures and prevent evaporation losses (Rodrigues et al., 2023). In Scandinavian countries, the regeneration of canals and harbour areas through natural filtration has enabled new recreational water spaces for swimming and kayaking in urban environments.

European Regulatory Momentum and the Water Resilience Strategy (2025–2026)

The European regulatory framework is driving a transition toward a Water-Smart Economy, in which water is managed as a strategic resource. The Water Resilience Strategy promotes efficiency, water-energy integration, clean technologies, and multisectoral water governance (European Commission, 2026). Events such as *Water Innovation Europe 2025* reinforce the importance of professionalizing the sector, accelerating digitalization and attracting specialized talent to ensure that sports facilities are prepared for the future.

3.12. CONCLUSIONS

Water sustainability has become an essential component for ensuring the operational, economic and environmental viability of sports and leisure facilities. The high consumption associated with heated swimming pools, changing rooms, green areas and food services combined with rising energy costs and regulatory demands requires facilities to abandon reactive approaches and adopt strategic management rooted in efficiency and environmental responsibility.

A key message is that water sustainability does not depend solely on large investments. Many significant improvements stem from simple, low-cost actions, such as installing sensors, detecting leaks early, correctly calibrating hot-water tanks or replacing obsolete equipment. When combined with continuous monitoring, these measures generate immediate savings and lay the groundwork for more ambitious interventions.

The centrality of data is another fundamental element. Modern facilities rely on systems integrating IoT sensors, predictive analytics and sectorized metering, allowing precise understanding of consumption patterns and inefficiencies. Without data, management becomes intuitive and ineffective; with data, resource optimization, problem anticipation and evidence-based decision-making become possible.
However, technology is only effective when accompanied by a sustainability-oriented organizational culture. Staff training, user awareness and periodic maintenance protocols are essential to ensure long-term adoption of technical solutions. Water sustainability must be seen as a continuous process rather than a one-off intervention.

Likewise, adopting circular-economy water principles enhances facility resilience. Rainwater harvesting, greywater reuse, advanced filtration and integrated landscaping reduce dependence on potable water and mitigate scarcity risks. These approaches broaden the environmental dimension of water management and strengthen operational independence.

The case studies presented from Neil McCabe's practical insights into public swimming pools to Croke Park's advanced management model demonstrate that a well-designed water strategy not only reduces consumption but also improves service continuity, prevents system overload during critical periods and increases user satisfaction.
Ultimately, water sustainability emerges as a cross-cutting axis that influences economic efficiency, service quality and environmental reputation. Its potential is maximized when integrated into professional management that combines technology, data, organizational culture and strategic vision. The sports facilities of the future must operate as intelligent, circular and resilient systems, capable of adapting to climate challenges and ensuring sustainable, high-quality service for all users.

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CHAPTER 4. SUSTAINABILITY IN MATERIALS AND THE CIRCULAR ECONOMY

Abstract

Chapter 4 focuses on the Sustainability in Materials pillar and the principles of the circular economy within sports facilities. A theoretical five-level "Innovation Staircase" for material treatment is established, ranging from authorized landfill disposal to the ultimate goal of material reduction, with eco-design acting as a transversal requirement. The severe crisis of microplastic pollution is addressed, highlighting artificial turf pitches with polymeric infills as a primary source of environmental contamination. To combat this, alignment with the European Union's scientific advice framework is proposed, emphasizing the restriction of intentional microplastics and the promotion of advanced recycling. Furthermore, industrial symbiosis is highly recommended, transforming sports facilities into innovation hubs where waste from other sectors is imported, or sports waste is exported for new manufacturing processes. These concepts are practically demonstrated through the Green Compounding and Escuela Ideo case study. In this project, agricultural plastics were successfully transformed into a safe, microplastic-free turf system, definitively concluding that the material lifecycle can be effectively closed while protecting human health and natural ecosystems.

4.1. INTRODUCTION

The transition toward sustainable management in sports facilities requires a comprehensive approach that addresses multiple environmental and structural dimensions. Within the context of the ESMIS (Enhance Sustainable Measures In Sports Facilities) project, which is co-funded by the European Union through the Erasmus+ program, the primary objective is established as the development of tools to promote and improve sustainability in sports facilities. This is achieved through the identification of best practices and the generation of specialized materials designed to foster innovation across different sustainability dimensions.

This specific chapter is resolute exclusively to the "Materials Sustainability Pillar," focusing heavily on the principles of the circular economy. Furthermore, a specific and highly critical challenge is addressed: the severe issue of plastic and microplastic pollution generated by European sports facilities. The theoretical foundations of material lifecycle management are explored, followed by an analysis of European regulatory frameworks and a detailed best-practice case study, demonstrating how theoretical concepts can be successfully translated into practical, sustainable realities.

4.2. THE HIERARCHY OF CIRCULAR ECONOMY INNOVATIONS

Before any circular economy initiative is incorporated into a sports facility, a theoretical hierarchy of material treatment must be thoroughly understood and considered. This hierarchy, often conceptualized as an "Innovation Staircase," categorizes material management strategies into five distinct levels, ordered from the least to the most sustainable (ESTC, 2021).

Level 1: Landfill and Authorized Disposal. The lowest level of the hierarchy is represented by the disposal of materials in authorized landfills. It is assumed as a fundamental baseline that the proper treatment of waste such as debris generated from the demolition or renovation of a sports facility must be conducted in legally authorized facilities. However, while this ensures basic environmental compliance, it is explicitly noted that this level lacks any true circularity. The lifecycle of the material is definitively terminated, and no further value is extracted from the resources.

Level 2: Energy Recovery. The second level involves energy recovery, a method frequently observed in the management of waste. While a second life is technically provided to the material through its conversion into energy, a significant problem is identified: future lifecycles are permanently prevented. The material is not returned to a state where it can be manufactured into a new physical product, meaning the loop is not closed. Consequently, the continuous extraction and production of virgin plastics and materials are not avoided, making this approach significantly less optimal than true recycling.

Level 3: Recycling. (The Core of Innovation) Recycling is highlighted as the level with the highest potential for innovation and practical applicability within the realm of sports facilities. At this stage, residue generated by the sports facility itself, or waste sourced from entirely different industrial sectors, are processed and transformed into new materials. By applying these recycled materials to the construction or maintenance of a sports facility, the manufacturing of virgin materials is actively avoided. Therefore, a genuine contribution to the circular economy is achieved, allowing materials to re-enter the production cycle.

Level 4: Reuse. The fourth level is the direct reuse of materials. Theoretically, this is considered a highly sustainable level because an entire industrial manufacturing process can be skipped. If material can be extracted and immediately utilized for another purpose without undergoing extensive transformation, massive amounts of energy and resources are saved. However, it must be carefully noted that this concept is often misapplied in practice, and its feasibility in technical sports infrastructure is sometimes limited by safety and performance standards.

Level 5: Reduction. The highest and ultimate goal of the circular economy hierarchy is reduction. The absolute maximum priority must be placed on the reduction of materials that have low recirculation possibilities or those that are highly polluting. If the generation of waste is avoided at the source, the need for complex recycling or disposal processes is entirely eliminated.

The Transversal Role of Ecodesign and digitalization

It must be emphasized that the concept of "Ecodesign" cuts across all the aforementioned levels. The design of any sports facility, from its inception, must include a comprehensive plan for the preliminary use of materials. Crucially, this plan must also detail the subsequent applications and destinations of those materials once the useful life of the facility eventually ends. Ecodesign ensures that end-of-life recirculation is not an afterthought, but a foundational characteristic of the infrastructure.

Furthermore, digitalization also plays a key role in addressing the challenges of the circular economy in the sports sector by acting as a catalyst for more sustainable, efficient, and resilient models (Kaur et al., 2025). Digital technologies enable a rethink of the entire life cycle of sports equipment and infrastructure, from design and manufacturing to use and end-of-life. Tools such as the Internet of Things, artificial intelligence, data analytics, and blockchain support real-time monitoring, predictive maintenance, material reuse, and waste reduction. In addition, digitalization facilitates the development of new circular business models, including equipment rental, repair, refurbishment, and sharing platforms. In the area of sports infrastructure, “smart stadiums” leverage digital systems to optimize energy use, water consumption, and operational efficiency. Overall, digital transformation is presented as a fundamental enabler for integrating sustainability, innovation, and competitiveness, helping the sports industry move towards a truly circular and environmentally responsible ecosystem.

4.3. THE MICROPLASTICS CRISIS IN SPORTS FACILITIES: A MODERN POLLUTION CHALLENGE

When discussing the sustainability of materials, the principal pollution problem that must be addressed is the generation and release of microplastics. Based on a highly referenced 2018 editorial published in *Science* magazine, microplastic pollution is definitively categorized as "modern pollution". The inherent danger of this phenomenon lies in the degradation process; plastics break down into increasingly smaller, virtually imperceptible chemical particles. These micro-particles subsequently infiltrate natural ecosystems, water sources, and ultimately, the global food chain.

Therefore, true innovation in circular economy cannot be limited to merely reusing plastic; it must ensure that the manufacturing, use, and characterization of these plastics actively prevent the release of microplastics into the environment.

To tackle this widespread issue, a scientific advice document issued by the European Union must be considered as the primary guiding framework (European Union, 2019). This framework proposes five concrete measures, which act as sub-themes for the materials pillar in the context of sustainable sports facilities:

1. **Reduction of plastic use:** Aligning with the highest level of the innovation staircase, the overall reliance on plastic materials must be minimized.

2. **Restriction and elimination of intentional microplastics:** The use of materials that are already defined as microplastics (particles smaller than 5mm) at their point of origin must be eliminated from the market. This measure is directly linked to recent and highly impactful European regulations concerning microplastic control.
3. **Reduction of microplastic formation from wear and tear:** It is acknowledged that plastics currently in use will inevitably suffer degradation. Therefore, strategies must be implemented to minimize the fragmentation of these materials caused by daily friction and use.
4. **Control of the release path:** The trajectory of the microplastics, from their source of generation to their potential release into the environment, must be mapped and controlled.
5. **Recovery and proper disposal/recirculation:** Systems must be designed to capture these particles at the point of release, ensuring they are properly disposed of or safely reintegrated into a controlled circular economy loop.

The Specific Impact of Artificial Turf

Within the European framework regarding microplastics, the sports sector is explicitly identified as a major contributor (European Commission, 2023). Specifically, artificial turf fields are classified as the primary source of intentionally released microplastics. This alarming statistic is driven predominantly by the use of polymeric infills, such as SBR rubber, which is traditionally derived from end-of-life vehicle tires. While the repurposing of tires is technically a form of circular economy, its application as loose infill creates a severe environmental risk due to the massive dispersion of micro-rubber particles into surrounding soils and waterways. Consequently, an urgent need for sustainable innovations in artificial turf systems has been established.

4.4. INDUSTRIAL SYMBIOSIS AND PRACTICAL APPLICATIONS IN THE SPORTS SECTOR

When a sports facility undergoes renovation such as the replacement of an artificial football pitch, the process must be evaluated to ensure a genuinely sustainable outcome. It is explicitly stated that simply paying a fee for the removal and basic disposal of the waste is entirely insufficient. Instead, sports facilities must be empowered to act as active promoters of their own circular economy projects.

A highly effective strategy for achieving this is the implementation of Industrial Symbiosis. Under this concept, sports facilities are transformed into testing laboratories and hubs of innovation whereby-products and waste generated by entirely different industrial sectors are beneficially reused. This symbiotic relationship can be established bidirectionally:

- **Importing Waste into Sports:** Materials that would otherwise be discarded by external industries are repurposed for sports infrastructure. A notable example is the manufacturing of multi-game areas or outdoor sports furniture utilizing plastic waste that has been successfully recovered from the sea.
- **Exporting Waste from Sports:** Conversely, the massive volume of waste generated by the decommissioning of sports facilities can be exported to other manufacturing processes. For instance, the biomass and synthetic plastic extracted from a retired artificial football pitch can be processed and utilized as the raw material for manufacturing stadium seating.

Through industrial symbiosis, the sports sector not only minimizes its own environmental footprint but actively contributes to the decarbonization and waste-reduction efforts of the broader industrial ecosystem.

4.5. EUROPEAN FUNDING OPPORTUNITIES FOR CIRCULAR ECONOMY PROJECTS

The transition toward circular economy models and the implementation of advanced eco-design require financial investment. However, numerous European funding opportunities are made available to support these sustainable transformations.

Facility managers and policymakers must be made aware of key funding instruments, which include:

- **The Erasmus+ Program:** This program, which co-founds the ESMIS project itself, provides significant support for collaborative partnerships, knowledge transfer, and capacity-building initiatives aimed at improving sustainability in sports.
- **Horizon Europe (Cluster 4):** Specifically within the "Digital, Industry, and Space" cluster, multiple funding lines are available that are clearly linked to the promotion of the circular economy, advanced materials, and industrial symbiosis.
- **The LIFE Program:** This program is highly dedicated to environmental initiatives, offering targeted funding for projects focused on the circular economy, quality of life enhancements, and climate change mitigation and adaptation.

The existence of these diverse programs proves that projects of all sizes ranging from small-scale local initiatives to large-caliber, transnational infrastructure development scan be successfully financed if they align with European sustainability goals.

4.6. BEST PRACTICE CASE STUDIES

4.6.1. CASE STUDY. GREEN COMPOUNDING & ESCUELA IDEO

To ensure that the theoretical frameworks and European regulations previously discussed are firmly grounded in reality, a practical case study is presented. This case study details an innovation developed by Green Compounding (GWC), a company specializing in the recycling of agricultural plastics.

GWC operates by collecting polyolefins (plastic residues) generated by the agricultural sector. These materials are meticulously classified, shredded, washed, dried, and extruded to create a high-value recycled pellet. Through a symbiotic relationship between the agricultural and sports sectors, a specific product named *Ecolastene* was developed to serve as an elastic infill for artificial turf pitches.
Ecolastene was engineered specifically to address the microplastic crisis and comply with stringent EU regulations. The key characteristics of this material are defined as follows:

- **Size Compliance:** The particles are manufactured to be larger than 5mm, ensuring strict compliance with European restrictions regarding the intentional release of microplastics.
- **High Durability:** The product is highly durable and does not fragment under mechanical stress, thereby preventing the secondary generation of microplastics over time.
- **Low Environmental and Human Impact:** The manufacturing process results in a very low carbon footprint, and crucially, the material does not emit any toxic or harmful substances that could negatively impact the health of the athletes utilizing the facility.

Practical Implementation

The *Ecolastene* innovation was successfully implemented as part of a broader project titled "Circular and Safe Solution for Synthetic Turf Pitches". The first successful installation of this comprehensive system was executed at the *Escuela Ideo* in Madrid.

In this installation, the *Ecolastene* product was reformatted to serve not only as the infill but also as the elastic base layer of the pitch. Furthermore, the turf backing itself was constructed from biobased materials (polyolefins). Because the entire system utilizes compatible polyolefin materials, the entire pitch can be easily recovered, recycled, and reintegrated into the same lifecycle or utilized in another industrial sector once its operational lifespan concludes.

Measured Impact and Metrics

The sustainable impacts achieved by the *Escuela Ideo* installation are highly significant and strictly measurable:

- A **70% reduction in the total weight of plastic** used in the system was achieved, leading to a massive decrease in resource consumption and waste generation.
- **Zero microplastics are emitted** into the surrounding environment, successfully mitigating the primary environmental hazard associated with artificial turf.
- An innovative **retention system** was included in the facility's design. This system guarantees that any fragments that might degrade over years of intense use are safely captured and accumulated, preventing any environmental leakage and allowing for their eventual recovery and proper valorization.

4.6.2. CASE STUDY. PREZERO ARENA (TSG HOFFENHEIM, GERMANY)

The principles of industrial symbiosis, material circularity, and waste reduction are not limited to the management of synthetic turf systems. At the level of full stadium operations, the PreZero Arena in Sinsheim, Germany, home to Bundesliga club TSG Hoffenheim, stands as one of the most advanced documented examples of circular economy implementation in European sports infrastructure, and is registered as a best practice on the ESMIS platform.

Since 2019, TSG Hoffenheim and its sustainability partner PreZero have systematically redesigned the material flows of the entire facility. Their approach is structured around three core principles reduce, reuse, and recycle applied consistently across all stadium operations. Among the most notable innovations implemented is a reusable cup system that replaced the previously non-recyclable single-use cups, with each cup now capable of being reused up to 400 times. Additionally, the approximately two tonnes of grass clippings generated monthly from maintaining the stadium pitch are collected, dried on-site, and sent to a paper factory to produce grass paper, which is subsequently used to manufacture players' autograph cards and fan merchandise. This represents a textbook case of industrial symbiosis, where a residual material from sports maintenance re-enters a productive industrial cycle.

In 2023, the PreZero Arena became the first football stadium in Europe to be independently certified as a Zero Waste facility by TÜV Süd, in accordance with the DIN Spec 91436 standard. The facility achieved a recycling rate of 87%, exceeding the minimum threshold of 85% required for certification. This milestone demonstrates that the circular economy principles described in this chapter including waste reduction at source, material reuse, and the systematic closure of material loops are not merely theoretical constructs, but fully achievable operational realities in large-scale sports facilities.

4.7. CONCLUSION

The challenges posed by material waste and microplastic pollution in sports facilities are undeniably severe, yet they present a unique opportunity for transformative innovation. As demonstrated throughout this chapter, reliance on traditional, linear disposal methods must be abandoned. Instead, the principles of the circular economy must be deeply integrated into the management and construction of sports infrastructure.

Through the rigorous application of eco-design, the fostering of industrial symbiosis across diverse sectors, and the utilization of innovative materials like agricultural polyolefins, the lifecycle of materials can be successfully closed. It is definitively concluded that highly functional, safe, and economically viable sports facilities can be developed while simultaneously ensuring the absolute protection of human health and the natural environment.

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CHAPTER 5. GOVERNANCE SUSTAINABILITY IN SPORTS FACILITIES: THE ESMIS PROJECT MODEL

Abstract

Chapter 5 explores the critical role of governance in the sustainable management of sports facilities. Governance is redefined from a basic administrative task into a central element of ESG standards, essential for coordinating massive energy needs with economic viability. The sector is currently challenged by skyrocketing energy costs, climate-driven operational demands (such as increased cooling needs), and a structurally aging European facility stock built predominantly between 1960 and 1980.

To overcome these challenges, a data-driven governance framework is proposed by the ESMIS project, emphasizing standardized data collection and Key Performance Indicators (KPIs) to measure economic and environmental returns. Strategic tools, including an interactive innovation map and a comprehensive toolkit, are established to facilitate evidence-based decision-making. The importance of participatory governance and transnational cooperation is highlighted, particularly the valorization of "negative feedback" to prevent the replication of failures across borders. Además, la aplicación práctica de estos principios de gobernanza a nivel de instalación se demuestra a través del caso del Estadio de la Paz y la Amistad, que ilustra cómo los grandes complejos polivalentes pueden alinear las decisiones operativas en todos sus subsistemas hacia una estrategia de sostenibilidad unificada. Ultimately, governance is positioned as the essential enabler required to transform outdated infrastructures into resilient, modern, and environmentally responsible spaces.

5.1. INTRODUCTION

The European **ESMIS** project emerged at a critical moment for infrastructure management on the continent. Its main goal is to build a network where managers can share knowledge and practical examples that help them improve their facilities. Within this program, various entities act as "pillars of best practices," contributing innovative solutions that are currently scattered and not always visible to those who must implement them. The project is in an active development phase, aiming to bring these innovations together in a single digital platform that makes sustainable improvements easier to implement.

- Key Concept: In this chapter, governance will be understood as the set of decisions, processes, and organizational tools that guide facility management toward objectives of sustainability, economic viability, and quality of sports service.

5.1.1. Importance of Governance in Sports Facility Management

Governance has moved from being a basic administrative task to becoming a central element in the management of sports facilities. It has become a core component of ESG (Environmental, Social & Governance) standards, which are now systematically applied in European sports infrastructure. In the sports sector, literature shows a growing interest in integrating sustainable strategies into organizational structures (Trendafilova & McCullough, 2018). Furthermore, sustainable development in sports facilities requires a comprehensive approach that combines environmental, social, and economic dimensions (Gregori-Faus et al., 2025). In the sports sector, governance dictates the sustainability of facilities, as it allows for the coordination of enormous energy needs with financial viability. Poor governance today not only affects the environment but also jeopardizes the economic survival of venues due to the volatility of energy prices and the effects of climate change.

5.1.2. Chapter Objective

This chapter aims to analyze, from an academic and technical perspective, the governance model proposed by the ESMIS project. It will examine how data collection, transnational cooperation, and the use of key performance indicators (KPIs) enable future sports managers to transform outdated infrastructure into modern, resilient, and efficient facilities.

5.2. THE CONTEXT OF THE CRISIS: FINANCIAL, CLIMATE, AND INFRASTRUCTURAL CHALLENGES

A major challenge for today's facility managers is the sharp rise in operating costs. According to data presented in the webinar, large-scale facilities have seen their annual electricity bills rise from €350,000 in 2019/2020 to nearly €900,000 today. The increase in energy costs has reinforced the need to apply sustainable practices in sports facilities, where managers play a key role in decision-making (Talay et al., 2025). These increases highlight the sector's vulnerability to energy fluctuations and underscore the urgent need to adopt more efficient technologies. Furthermore, they underscore the importance of assessing economic returns before investing in improvements, reinforcing the role of technical and financial governance.

5.2.1. The Impact of Climate Change on Operational Management

Climate change is directly affecting the management of sports facilities, forcing the adaptation of energy and operational systems (Cayolla et al., 2025). For example, in Greece, and specifically in Athens, it has been observed that even at the end of November, temperatures range between **15 and 25 degrees Celsius.** This unusual warmth forces managers to maintain constant use of cooling units, resulting in massive energy consumption and a continuous loss of efficiency (Santamouris, 2016). Governance must therefore integrate climate adaptation as a priority in daily planning.

5.2.2. The European Stock of Sports Facilities

Europe faces a structural problem: there are approximately 1.5 million sports facilities, the vast majority of which were built between 1960 and 1980. These aging infrastructures exhibit low energy efficiency, and, most worryingly, the annual renovation rate is less than 2%, compounded by structural limitations due to their age and lack of modernization (Gregori-Faus et al., 2025). This means that facilities are not being modernized at the pace demanded by current needs, forcing a shift from "basic renovations" to comprehensive "energy upgrades".

The combination of financial pressures, climate-driven operational challenges, and an ageing European facility stock reveals that traditional management approaches are no longer sufficient. These structural issues demand governance models capable of integrating data, long-term planning, and cross-country collaboration. In this context, the ESMIS project positions governance not as a static administrative function, but as the strategic core that enables managers to transform fragmented innovations into cohesive and effective sustainability solutions. This shift marks the starting point for understanding the governance framework developed through ESMIS.

5.3. THE ESMIS GOVERNANCE FRAMEWORK: DEFINITION AND KEY ELEMENTS

In the ESMIS model, governance is not a static manual, but rather the core of a broader support ecosystem. Its logic is based on mapping practices to facilitate the flow of knowledge among managers in different countries. It is not just about informing, but about providing tools that help with the practical implementation of sustainability solutions. This ecosystemic approach recognizes that sustainability does not depend solely on isolated technologies, but on the ability to connect experiences, standardize criteria, and facilitate evidence-based decision-making.

5.3.1. Uniform and Standardized Data Collection

For governance to be realistic and dependable, it must be data-driven. The ESMIS project uses a standardized data collection tool that allows for systematic documentation of innovations in participating countries. This tool not only records basic information about each facility but also gathers data on the implementation methods adopted, as well as the positive outcomes and challenges encountered during the process, thus providing a more comprehensive and transferable knowledge base.

5.3.2. Key Performance Indicators (KPIs) and Economic Return

Modern governance requires tangible results. ESMIS places special emphasis on key performance indicators, such as the economic return on interventions. This allows managers to present measurable figures on how much the electricity bill has decreased and how much carbon savings have been achieved through the use of renewable energy. Without this measurable data, it is difficult to justify the necessary investments to boards of directors or public entities (Gregori-Faus et al., 2025).

5.4. STRATEGIC TOOLS FOR DECISION-MAKING

The core component of this governance model is an interactive innovation map designed to support decision-making processes. This tool allows facility managers and development directors to identify relevant solutions by applying dynamic filters based on geographical location, type of sports facility, and specific sustainability dimensions such as energy, water, or materials, thereby facilitating the transfer of knowledge between comparable contexts.

5.4.1. The User-Linked Self-Assessment Tool

A key future feature is the self-assessment tool. This will allow each facility to evaluate its own level of sustainability and receive specific, tailored proposals based on its identified needs, moving from general information to a practical and personalized application.

5.4.2. The Toolkit and the Educational Component

Governance within the ESMIS framework is further strengthened through training and knowledge transfer mechanisms. In this regard, the project incorporates a dedicated toolkit that combines educational modules, webinars, and practical implementation guides. This resource plays a crucial role in translating theoretical knowledge into actionable strategies, ensuring that sustainability measures can be effectively implemented and maintained over time, particularly by future generations of facility managers.

5.5 CASE STUDY: THE PEACE AND FRIENDSHIP STADIUM (SEF)

The Peace and Friendship Stadium acts as a leading partner in innovation. One of its most ambitious projects is the use of all the stadium's parking areas for the installation of photovoltaic canopies. The strategic objective of this governance measure is to achieve 100% energy coverage of the facility by harnessing solar energy, transforming a passive space (the parking lot) into an active source of resources.

5.5.1. The Dilemma of Mass Events and Efficient Lighting

Sports facilities face a unique challenge: the need to save energy clashes with the requirements of live events, national championships, or concerts, where intensive lighting use is unavoidable. The solution adopted by the SEF has been the massive replacement of traditional lamps with energy-saving systems in the central arena, allowing the quality of the show to be maintained while reducing base consumption.

5.5.2. Integrated Management: Indoor vs. Outdoor Areas

A common governance mistake is to focus solely on the main building. However, in cases like SEF, the outdoor areas (5x5 courts, Karaiskakis Stadium, beach volleyball areas, marina, and canal) are four times larger than the indoor venue. All these areas consume energy and require coordinated management and similar energy upgrades for the complex to be truly sustainable as a whole.

- Key Lesson: Sustainability in large complexes depends on aligning interventions across all subsystems (indoor and outdoor) with unified governance.

5.6. PARTICIPATORY GOVERNANCE AND TRANSNATIONAL COOPERATION

The success of ESMIS lies in fostering an honest “dialogue” among European partners. This includes the ability to critically evaluate the practices of other countries. For example, a solution successfully implemented in the Netherlands might not be directly applicable in Greece due to climatic or technical differences. Participatory governance allows for explaining obstacles and proposing modifications to adapt innovations to the local context.

5.6.1. The Importance of “Negative Feedback”

In an innovative shift towards transparency, the program values negative feedback. Documenting why a measure did not work or what difficulties arose is crucial for the rest of the European Union, as it prevents other managers from making the same mistakes and allows for refining solutions before widespread implementation.

5.6.2. Participation in European Decision-Making Centers

The ultimate goal of this network is for sports facility managers to be active participants in European Union decision-making centers, rather than passive recipients of input. Only through this active presence can the necessary investments be attracted to renovate the aging facility stock and bring it up to the required standards by 2025.

5.7 LATEST TRENDS IN SUSTAINABILITY AND GOVERNANCE

Various trends can be applied to improve sustainability through governance, starting with highly efficient and easy-to-implement initiatives.

5.7.1. Digitization through QR Codes

Governance is becoming more accessible through mobile technology. The use of QR codes, enabling technicians and managers to instantly access data collection tools, evaluate the map, and monitor project progress, is a growing trend that facilitates real-time participation.

5.7.2. Focus on Cooling Efficiency

Given the aforementioned climate trend, sustainability is shifting its primary focus from heating to cooling efficiency. Designing systems that minimize air conditioning use in climates that remain warm for most of the year is an emerging priority in facility governance in Southern Europe.

5.7.3. The Transition from Information to Practical Application

A key emerging trend in sports facility governance is the transition from purely informational approaches towards implementation-oriented frameworks. Rather than focusing solely on knowledge dissemination, current models emphasize the integration of data driven tools, practical guidelines, and performance indicators, enabling facility managers to translate sustainability concepts into concrete operational improvements (McCullough, 2014).

The ESMIS program aims to transform accumulated knowledge into a guide for real-world implementation. Future sports managers must not only understand what sustainability is but also be able to navigate an ecosystem of tools (maps, toolkits, indicators) to implement tangible changes in their infrastructure.

5.8. CONCLUSIONS

The governance of sports facilities in Europe is at a turning point. The combination of outdated infrastructure (1960-1980), tripled energy costs, and the impact of climate change demands a management model based on cooperation and scientific evidence. Students and future sports professionals must be trained in the use of tools such as those proposed by ESMIS. The ability to use interactive maps, interpret economic return KPIs, and participate in European exchange networks will define a successful manager in the next decade.

The success of programs like ESMIS depends on the active and honest participation of all stakeholders. Only through transparent governance that learns from mistakes and leverages innovations such as large-scale photovoltaics and digitalization will it be possible to deliver modern, sustainable, and resilient facilities to society by 2025 and beyond.

Ultimately, the experience shared in the Greek webinar demonstrates that successful sustainability in sports facilities relies on governance systems capable of unifying stakeholders, managing uncertainty, and transforming data into actionable strategies. Projects such as ESMIS show that the future of European sports infrastructure will depend not only on innovative technologies such as photovoltaic systems, cooling optimization, or digital tools but on managers who can interpret indicators, participate in transnational decision-making arenas, and adapt best practices to their local context. Governance, therefore, emerges as the essential enabler that bridges vision and execution, ensuring that sports facilities evolve into resilient, modern, and environmentally responsible spaces for the decades ahead.

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CHAPTER 6. FROM DATA TO ACTION: THE ESMIS SELF-ASSESSMENT TOOL AND INTERACTIVE MAP

Abstract

Chapter 6 introduces the ESMIS Self-Assessment Questionnaire. Hosted on the toolkit, this tool serves a twofold objective: it acts as a self-diagnosis instrument for sports facility managers to identify sustainability needs, and it collects data for the ESMIS Interactive Map to foster cross-border learning. The questionnaire takes about 15 minutes and categorizes data into three main parts.

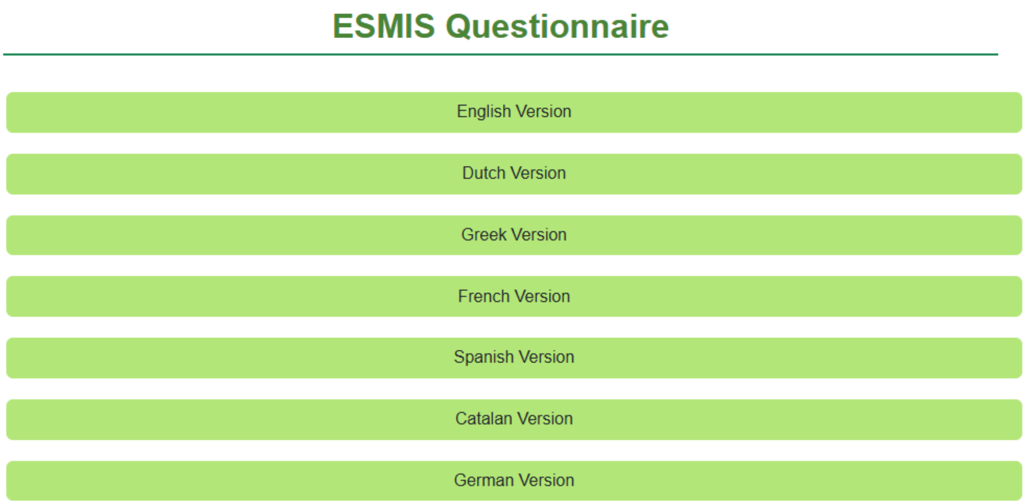
- Part 1 establishes a baseline by collecting general facility details and classifying them into distinct typologies.
- Part 2 evaluates innovations across four sustainability pillars (Energy, Water, Materials, and Governance), requiring managers to transparently share both positive impacts and implementation barriers.
- Part 3 focuses on hard data, such as annual consumption, visitor numbers, and Return on Investment.

Crucially, estimated data is perfectly acceptable to avoid barriers to information sharing. Cases providing comprehensive hard metrics are awarded the "Golden Circle," highlighting them as high-value benchmarking models on the interactive map. Ultimately, this tool facilitates strategic matchmaking and empowers a transnational movement toward a greener, healthier, and more sustainable European sports sector

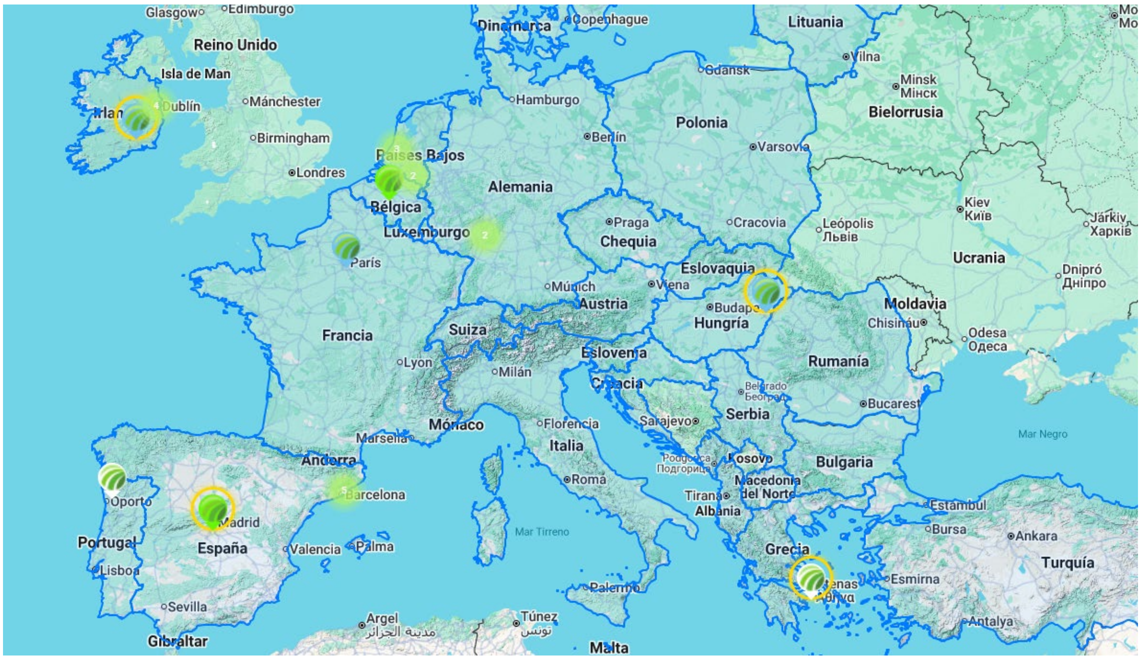
6.1. INTRODUCTION

The traditional model of sports facilities has been the subject of profound discussion over the last few years. The need to advance toward the sustainable management of sports facilities has become a crucial objective, especially in light of recent global circumstances, such as the climate crisis and the energy price surge, which have negatively impacted the sports sector across Europe. In this context, the ESMIS (Enhance Sustainable Measures In Sports Facilities) project aims to facilitate a positive European ecosystem to advance toward more efficient and sustainable sports facilities by identifying and sharing concrete solutions.

At the heart of this initiative is the ESMIS Self-Assessment Questionnaire, hosted via Microsoft Forms. This tool is a core component of the project's Toolkit and serves a fundamental twofold objective. First, it acts as a self-diagnosis instrument, helping sports facility managers identify specific needs, challenges, and areas for improvement to advance toward sustainability. Second, it functions as the primary data collection mechanism for the ESMIS Interactive Map, gathering relevant information about innovative measures to foster a European ecosystem of shared knowledge and cross-border learning.



The platform is designed to connect those in need of sustainability innovations with the providers of such solutions, showcasing real data and practical cases that actually work. To distinguish the depth of information provided, the interactive map utilizes the "Golden Circle" concept. When an uploaded case contains comprehensive hard data such as exact investment costs, energy or water savings, and consumption metrics it receives a golden circle around its map pin, indicating a high-value benchmarking case. Conversely, cases that lack hard data serve as inspirational or descriptive best practices, offering valuable ideas without detailed metrics. The ultimate goal is to encourage all facilities to aim for the golden circle, transforming the sports sector from a casualty of global warming into a key driver of sustainability.



6.2. PREPARATION BEFORE STARTING

The completion of the Microsoft Forms questionnaire is a straightforward process that takes approximately 15 minutes. However, the key to a smooth and efficient submission lies in the preliminary gathering of all necessary information. Before the link to the questionnaire is opened, the following checklist of items must be prepared:

- General Facility Details: Basic information about the facility must be collected, including its exact name, year of construction, and ownership details.
- High-Quality Picture: A clear, high-resolution photo of the facility or the specific innovation is required. It is critical that copyright ownership is held by the submitter or that explicit permission to use and share this photo on a public platform has been granted.
- Geographic Coordinates: Precise Google Maps coordinates must be extracted to accurately place the facility on the Interactive Map. This action requires just two

clicks on Google Maps (right-clicking the location and copying the numerical coordinates).

- Hard Data and Metrics: To achieve the "Golden Circle" benchmark status, estimates regarding annual energy and water consumption, the number of visitors per year, specific investment costs for the innovation, and estimated savings must be prepared.

By ensuring this data is readily available, the questionnaire can be seamlessly navigated, avoiding the frustration of pausing the process to search for technical specifications or financial records.

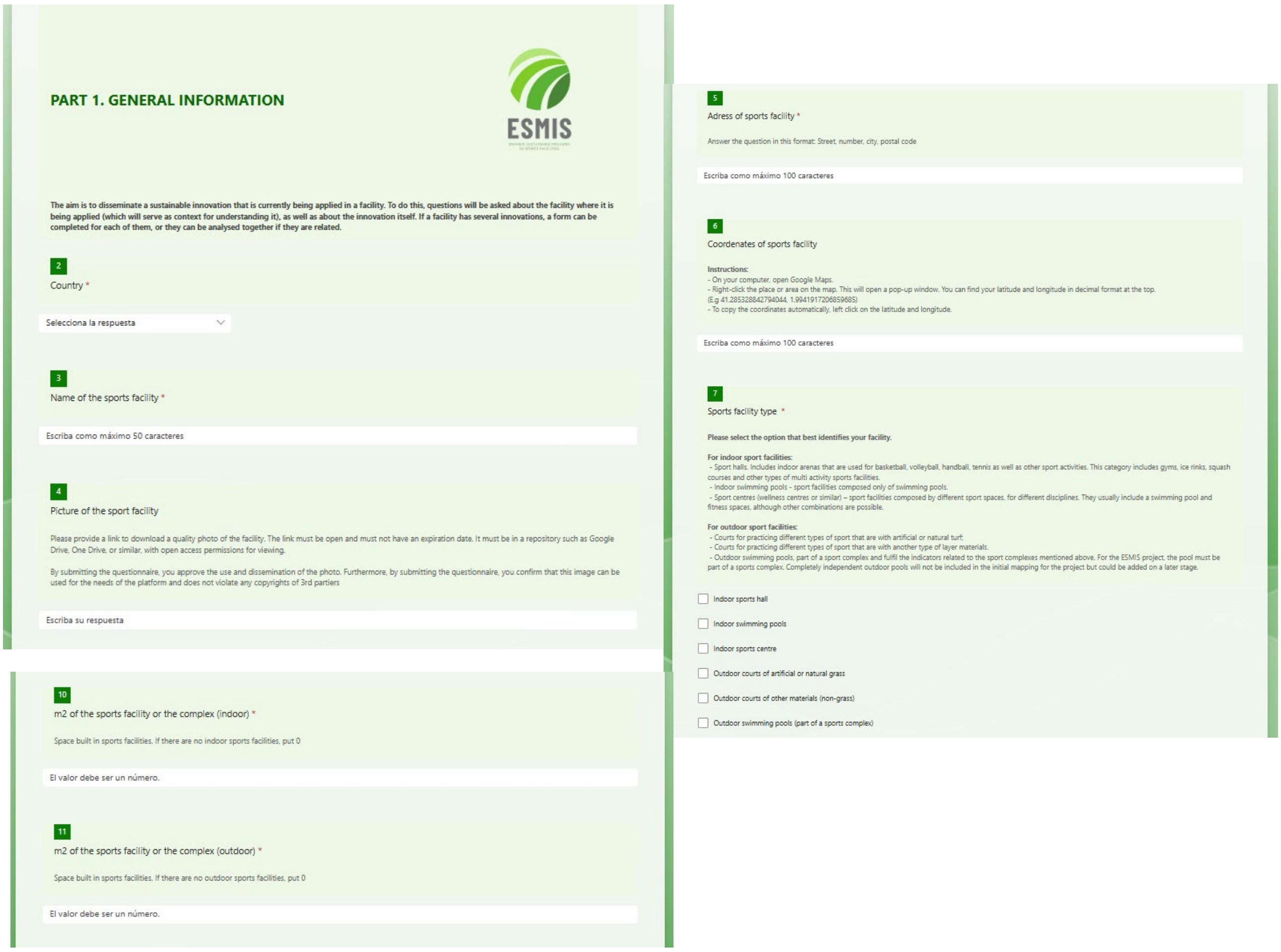
6.3. STEP-BY-STEP WALKTHROUGH OF THE QUESTIONNAIRE

To illustrate the theoretical and practical application of the questionnaire, a real-world example discussed during the ESMIS webinar will be used: the Sportpark Strijp in Eindhoven, Netherlands. This facility successfully implemented a sustainable collector field system and provides an excellent blueprint for how the assessment should be completed.

Part 1: General Information

The first section of the questionnaire focuses on contextualizing the facility. Theoretical background suggests that benchmarking is only effective when similar environments are compared; therefore, establishing a clear baseline is essential.

- Facility Identification: The process begins by selecting the respective country and inputting the facility's name (e.g., Sportpark Strijp), the picture link, and the precise address and coordinates. The year the facility was built (e.g., 2012) and the owner (e.g., the Municipality of Eindhoven) are also requested.
- Typology Selection: The ESMIS methodology classifies sports facilities into six distinct categories, such as indoor swimming pools, indoor sports halls, or outdoor courts of artificial or natural grass. In Eindhoven example, the facility falls under "outdoor courts of artificial or natural grass". It is possible to select more than one category if the facility is part of a larger, multi-sport complex.
- Size of the Facility: The size of the facility must be inputted in square meters. This metric is theoretically crucial for data normalization. It allows the platform to calculate energy or water consumption per square meter, ensuring that a small local gym can be fairly compared against a massive Olympic stadium. The system only accepts numerical values for indoor or outdoor sizes to maintain data consistency.


PART 1. GENERAL INFORMATION

The aim is to disseminate a sustainable innovation that is currently being applied in a facility. To do this, questions will be asked about the facility where it is being applied (which will serve as context for understanding it), as well as about the innovation itself. If a facility has several innovations, a form can be completed for each of them, or they can be analysed together if they are related.

2
Country *
Selecciona la respuesta

3
Name of the sports facility *
Escriba como máximo 50 caracteres

4
Picture of the sport facility
Please provide a link to download a quality photo of the facility. The link must be open and must not have an expiration date. It must be in a repository such as Google Drive, One Drive, or similar, with open access permissions for viewing.
By submitting the questionnaire, you approve the use and dissemination of the photo. Furthermore, by submitting the questionnaire, you confirm that this image can be used for the needs of the platform and does not violate any copyrights of 3rd partiers
Escriba su respuesta

10
m2 of the sports facility or the complex (indoor) *
Space built in sports facilities. If there are no indoor sports facilities, put 0
El valor debe ser un número.

11
m2 of the sports facility or the complex (outdoor) *
Space built in sports facilities. If there are no outdoor sports facilities, put 0
El valor debe ser un número.

5
Adress of sports facility *
Answer the question in this format: Street, number, city, postal code
Escriba como máximo 100 caracteres

6
Coordenates of sports facility
Instructions:
- On your computer, open Google Maps.
- Right-click the place or area on the map. This will open a pop-up window. You can find your latitude and longitude in decimal format at the top.
(E.g 41.285328842794044, 1.9941917206859685)
- To copy the coordinates automatically, left click on the latitude and longitude.
Escriba como máximo 100 caracteres

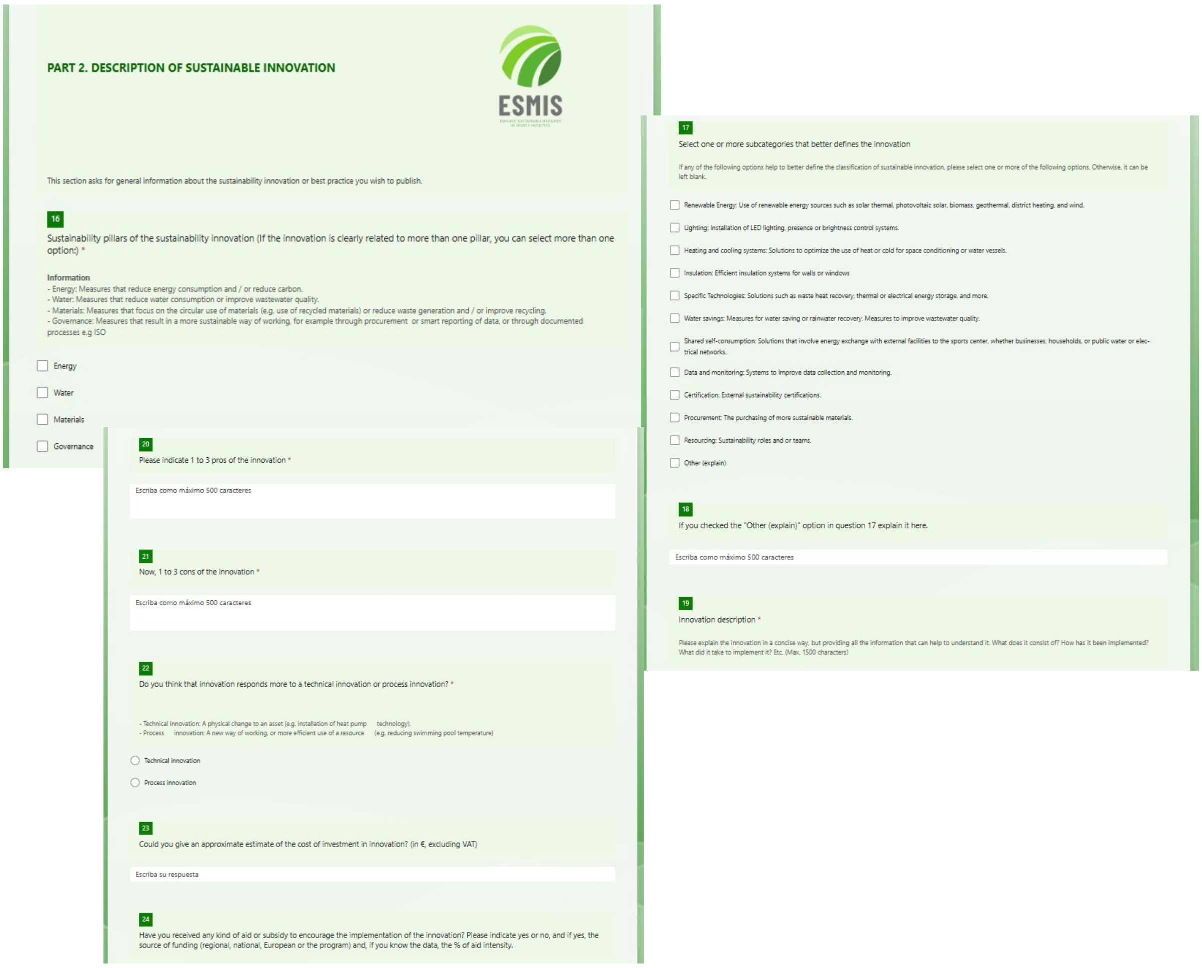
7
Sports facility type *
Please select the option that best identifies your facility.
For indoor sport facilities:
- Sport halls. Includes indoor arenas that are used for basketball, volleyball, handball, tennis as well as other sport activities. This category includes gyms, ice rinks, squash courses and other types of multi activity sports facilities.
- Indoor swimming pools - sport facilities composed only of swimming pools.
- Sport centres (wellness centres or similar) – sport facilities composed by different sport spaces, for different disciplines. They usually include a swimming pool and fitness spaces, although other combinations are possible.
For outdoor sport facilities:
- Courts for practicing different types of sport that are with artificial or natural turf;
- Courts for practicing different types of sport that are with another type of layer materials.
- Outdoor swimming pools, part of a sport complex and fulfil the indicators related to the sport complexes mentioned above. For the ESMIS project, the pool must be part of a sports complex. Completely independent outdoor pools will not be included in the initial mapping for the project but could be added on a later stage.

☐ Indoor sports hall
☐ Indoor swimming pools
☐ Indoor sports centre
☐ Outdoor courts of artificial or natural grass
☐ Outdoor courts of other materials (non-grass)
☐ Outdoor swimming pools (part of a sports complex)

Part 2: Sustainability Pillars and Innovation Description

This section delves into the core of the sustainable measure. The ESMIS framework evaluates sustainability across four main pillars: Energy, Water, Materials, and Governance.

- Categorizing the Innovation: The specific pillar addressed by the innovation must be selected. In the case of Sportpark Strijp, the best practice is related to Energy, and it is specifically categorized under "heating and cooling installations" and "specific technology". If the innovation spans multiple pillars, multiple options can be selected.
- Describing the Innovation: A concise description of the measure is required. The platform distinguishes between technical innovations (e.g., solar panels, LED lighting, a new collector field) and process innovations (e.g., new waste management protocols or staff training). The goal is not to produce an exhaustive essay, but to provide a clear, practical summary that can be easily understood and replicated by other facility managers.
- Pros, Cons, and Investment: A unique and highly valuable aspect of this questionnaire is the request for up to three positive sides and three negative sides (cons) of the innovation. Theoretically, sharing limitations, implementation barriers, or "bad practices/failures" is vital for realistic cross-border learning. It provides a transparent view of what to expect, avoiding the trap of "greenwashing". Finally, the specific investment required for the innovation must be detailed (e.g., the cost of the collector field system alone), along with any potential funding sources that were utilized.



PART 2. DESCRIPTION OF SUSTAINABLE INNOVATION

ESMIS

This section asks for general information about the sustainability innovation or best practice you wish to publish.

16
Sustainability pillars of the sustainability innovation (If the innovation is clearly related to more than one pillar, you can select more than one option:) *

Information
- Energy: Measures that reduce energy consumption and / or reduce carbon.
- Water: Measures that reduce water consumption or improve wastewater quality.
- Materials: Measures that focus on the circular use of materials (e.g. use of recycled materials) or reduce waste generation and / or improve recycling.
- Governance: Measures that result in a more sustainable way of working, for example through procurement or smart reporting of data, or through documented processes e.g ISO

☐ Energy
☐ Water
☐ Materials
☐ Governance

17
Select one or more subcategories that better defines the innovation

If any of the following options help to better define the classification of sustainable innovation, please select one or more of the following options. Otherwise, it can be left blank.

☐ Renewable Energy: Use of renewable energy sources such as solar thermal, photovoltaic solar, biomass, geothermal, district heating, and wind.
☐ Lighting: Installation of LED lighting, presence or brightness control systems.
☐ Heating and cooling systems: Solutions to optimize the use of heat or cold for space conditioning or water vessels.
☐ Insulation: Efficient insulation systems for walls or windows
☐ Specific Technologies: Solutions such as waste heat recovery, thermal or electrical energy storage, and more.
☐ Water savings: Measures for water saving or rainwater recovery. Measures to improve wastewater quality.
☐ Shared self-consumption: Solutions that involve energy exchange with external facilities to the sports center, whether businesses, households, or public water or electrical networks.
☐ Data and monitoring: Systems to improve data collection and monitoring.
☐ Certification: External sustainability certifications.
☐ Procurement: The purchasing of more sustainable materials.
☐ Resourcing: Sustainability roles and or teams.
☐ Other (explain)

18
If you checked the "Other (explain)" option in question 17 explain it here.

Escriba como máximo 500 caracteres

19
Innovation description *

Please explain the innovation in a concise way, but providing all the information that can help to understand it. What does it consist of? How has it been implemented? What did it take to implement it? Etc. (Max. 1500 characters)

20
Please indicate 1 to 3 pros of the innovation *

Escriba como máximo 500 caracteres

21
Now, 1 to 3 cons of the innovation *

Escriba como máximo 500 caracteres

22
Do you think that innovation responds more to a technical innovation or process innovation? *

- Technical innovation: A physical change to an asset (e.g. installation of heat pump technology).
- Process innovation: A new way of working, or more efficient use of a resource (e.g. reducing swimming pool temperature)

○ Technical innovation
○ Process innovation

23
Could you give an approximate estimate of the cost of investment in innovation? (in €, excluding VAT)

Escriba su respuesta

24
Have you received any kind of aid or subsidy to encourage the implementation of the innovation? Please indicate yes or no, and if yes, the source of funding (regional, national, European or the program) and, if you know the data, the % of aid intensity.

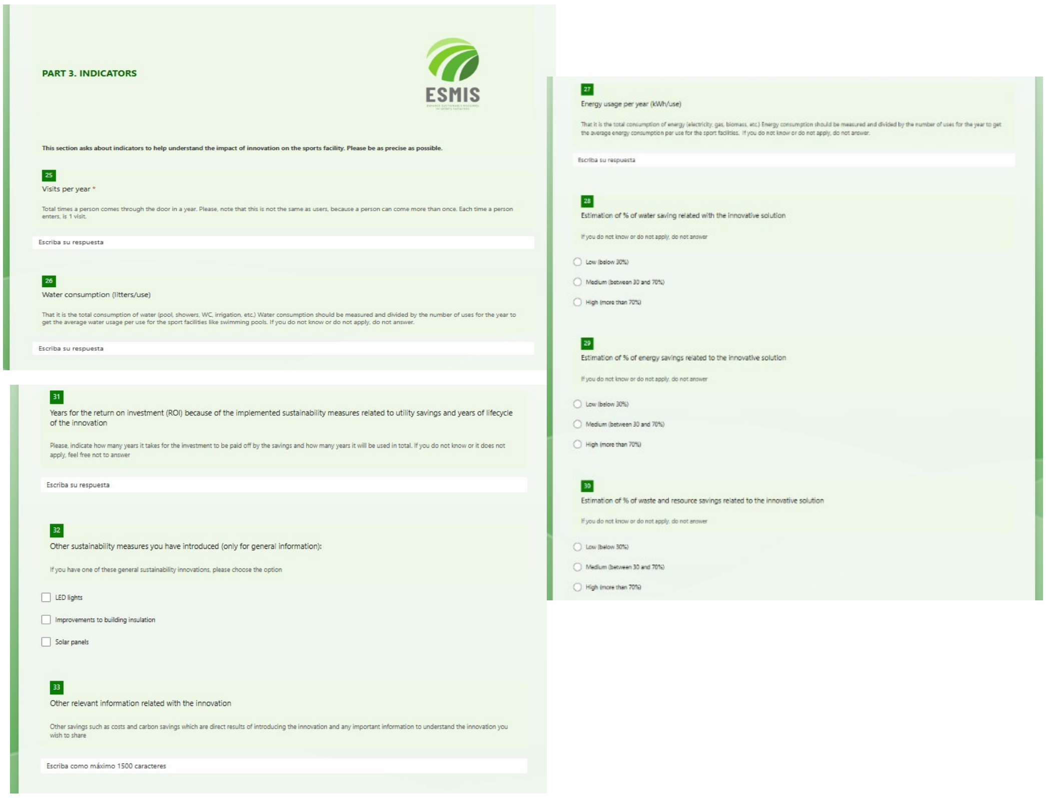
Part 3: Facility Indicators and Impact (The Hard Data)

This is the most critical section for sports facilities, as it determines whether the submitted case receives the highly coveted "Golden Circle". It translates sustainable intentions into measurable impacts.

- Calculating Impact: The annual consumption of the facility and the number of visitors per year must be provided. For Sportpark Strijp, a broad range of visitors was initially considered, but for the sake of accurate metrics, a specific number of 100,000 visitors was established. By combining consumption with visitor numbers, highly relevant metrics, such as energy usage per user, can be calculated by the platform.
- Savings and ROI: Estimated energy or water savings resulting from the innovation are requested. In the Eindhoven case, the estimated energy savings were

exceptionally high, exceeding 70%. Questions regarding waste and resource saving can be skipped if they are not relevant to the specific pillar being addressed. Furthermore, detailing the Return on Investment (ROI) helps build a business case for local authorities or investors.

- Addressing Data Gaps (Theoretical Advice): Hesitation often arises regarding the sharing of data when numbers are imperfect or lack rigorous scientific documentation. It must be emphasized that estimated data is perfectly acceptable. The platform is designed to accommodate human error, and no penalties will be applied if a rough estimate is provided. The creation of barriers to information sharing must be avoided. If only estimates for savings or ROI are available, they should be submitted confidently.

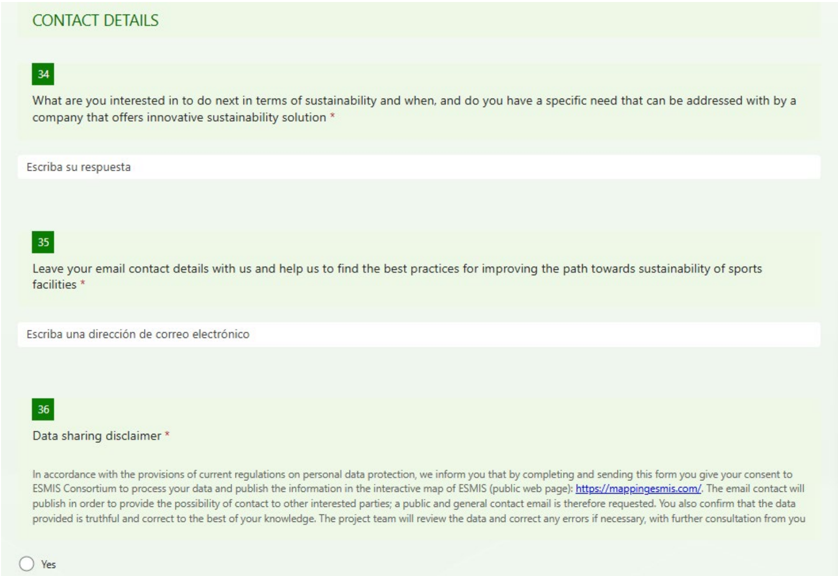


6.4. NEXT STEPS AND DISCLAIMER

The final phase of the questionnaire sets the stage for future collaboration and ensures legal compliance.

- Interested Next Steps: A section is included to inquire about the facility's future goals and intended next steps. This is a strategic feature designed to foster future matchmaking. By understanding future objectives, the ESMIS platform can connect facilities with specialized sustainability solution providers or other entities embarking on similar projects.

- Contact Details and Data Sharing Disclaimer: A contact email must be provided (e.g., Eva from the Municipality of Eindhoven) to allow interested parties or the project team to reach out. Crucially, before the submission is finalized, the data-sharing disclaimer must be accepted. This disclaimer clarifies that full responsibility is taken by the submitter regarding the truthfulness and accuracy of the provided information. The ESMIS platform acts solely as a secure dissemination channel to share this knowledge across Europe.


CONTACT DETAILS

34

What are you interested in to do next in terms of sustainability and when, and do you have a specific need that can be addressed with by a company that offers innovative sustainability solution *

Escriba su respuesta

35

Leave your email contact details with us and help us to find the best practices for improving the path towards sustainability of sports facilities *

Escriba una dirección de correo electrónico

36

Data sharing disclaimer *

In accordance with the provisions of current regulations on personal data protection, we inform you that by completing and sending this form you give your consent to ESMIS Consortium to process your data and publish the information in the interactive map of ESMIS (public web page): https://mappingesmis.com/. The email contact will publish in order to provide the possibility of contact to other interested parties; a public and general contact email is therefore requested. You also confirm that the data provided is truthful and correct to the best of your knowledge. The project team will review the data and correct any errors if necessary, with further consultation from you

○ Yes

6.5. THE VALIDATION PROCESS AND PLATFORM INTEGRATION

A specific workflow is triggered "behind the scenes" after the "Submit" button is clicked.

- Review and Verification: Upon submission, a notification is automatically sent to the project staff, and the data is carefully reviewed. If any figures appear unrealistic, incomplete, or if there are doubts about the provided measurements, the facility manager will be proactively contacted via the provided email. Follow-up questions will be asked to refine the data before it is published.
- Publication on the Interactive Map: Once the data is verified and approved, the best practice is translated into a live entry on the ESMIS Interactive Map. Stakeholders across Europe can navigate the map, click on specific geographic locations, read innovation descriptions, view hard metrics, and access contact details for direct knowledge transfer.

- The Ultimate Goal: If the submitted case successfully included the hard data metrics required in Part 3, the Golden Circle will be proudly displayed. This visual indicator serves as a beacon of inspiration and a benchmark of excellence for sustainable sports facilities worldwide.

6.6. CONCLUSION

The ESMIS Self-Assessment Questionnaire is more than a simple form; it is a catalyst for change. The sharing of data even if it consists only of estimates is strongly encouraged among sports facility managers, owners, and sustainability providers. Contribution to this collective European map not only provides access to a tailored toolkit for facility improvement, but also empowers a transnational movement toward a greener, healthier, and more sustainable sports sector.