Review

Relevance of Industrial Symbiosis in the Tourism Sector

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ABSTRACT

The global sustainability challenges are constantly growing, to which the tourism sector also strongly contributes. After the COVID-19 pandemic, the sector has shown signs of recovery, so the sustainability challenges could also increase more. The negative environmental effects of overtourism must be mitigated.

According to experts, circular economy and its sub-fields could solve the problem. This article examines industrial symbiosis, a sub-field of circular economy. Originally in symbiotic relationships, the stakeholders come mainly from companies, but as the concept has evolved, the importance of other stakeholders has also been highlighted. The research describes and categorizes existing connections between these stakeholders in the tourism sector.

The authors combine a systematic literature review with a comprehensive search for existing good practices and their categorized presentation with the introduction of a leading example in the field.

The results highlight that the connection between industrial symbiosis and the tourism sector is present and could offer a possible solution to the sector's problems by promoting collaboration, waste regeneration and resource efficiency. These activities could be especially vital in easing the environmental consequences of overtourism.

This article extends the available literature on the topic, draws stakeholders' attention to the potential of the concept, and encourages the international academic community to expand related research.

KEYWORDS: industrial symbiosis; tourism; sustainable tourism

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INTRODUCTION

The 21st century presents humanity with significant challenges. We all can experience the adverse effects of globalization, the decline in biodiversity, the amount of waste generated, and the destruction of the natural environment [1–4]. These critical problems need to be addressed. Humanity, sensing the need for action, has set out for change. Kjaer [5]

believes society increasingly prioritizes sustainability, informed consumption, and the community's interests instead of individualism.

Sustainable transformation is essential in tourism, the sector contributes significantly to worldwide waste generation, especially in significant, prominent destinations [6–9].

These factors challenge decision-makers, cities, municipalities, regional and national governments [10]. The circular economy and its sub-areas are being proposed at an increasing rate as a solution.

The Ellen MacArthur Foundation defines circular economy as an economic model built to reuse and restore resources rather than throw them away, focusing on using renewable energy, avoiding harmful chemicals, and designing better products and systems so that waste is reduced or eliminated altogether [11].

As its scientific popularity grew, circular economy has become an umbrella concept. The blue economy, which is related to the seas and oceans; biomimicry, where technological innovations are inspired by nature; cradle-to-cradle, which promotes sustainable product design and industrial ecology; and the framework of economic interactions based on the model of natural ecosystems also fall under the circular economy concept [12–15]. The search for loopholes has also begun. Greenwashing has now become a widespread concept, and the fight against this phenomenon is of high importance [16].

The goal of this paper is to examine a part of industrial ecology, namely industrial symbiosis [17], and to introduce its existing connections with the tourism sector. To achieve this, a three-step process has been followed during the research. With a systematic literature review, the authors gather scientific articles published on the topic and summarize their findings. Secondly, the authors present and categorize already existing collaborations. Thirdly, a complex collaboration as a best practice is introduced.

The logical framework of the article is the following: The first section defines the core features of industrial symbiosis, providing a foundation for understanding its principles and establishment methods. Building on this, the Potential of industrial symbiosis in tourism section explores how these practices can support more sustainable and efficient tourism systems. In the Results section, good practices, impactful and innovative initiatives will be introduced, where stakeholder involvement is a key feature. This definition of good practices guided the research by shaping the criteria for case selection and analysis, ensuring that only practices with demonstrable results and a clear element of innovation were examined, thereby aligning with the study's aim to identify scalable models for sustainable tourism development. These good practices are categorized by several criteria, together with a deeper introduction to a leading example in the tourism sector. Finally, the authors summarize the main insights and highlight the possible implications.

CHARACTERISTICS OF INDUSTRIAL SYMBIOSIS COLLABORATIONS AND THEIR INTERPRETATION IN THE TOURISM SECTOR

In order to gain a deeper understanding of industrial symbiosis and its potential, one needs to define the term and see how such collaborations can be established. In the early 2000s, scholarly attention largely centered on applications within heavy industry, where empirical studies demonstrated the effectiveness of industrial symbiosis in mitigating environmental pollution and improving resource efficiency [18–20]. Chertow's foundational work on industrial ecology and industrial symbiosis defined the latter as a collaborative network in which at least three firms exchange a minimum of two different material or energy flows [17,21]. Over time, however, the conceptual boundaries of industrial symbiosis have been progressively expanded. This conceptual evolution is exemplified by the UK's National Industrial Symbiosis Programme (NISP, 2005–2009), a government-supported initiative that facilitated cross-sectoral resource sharing. Although some collaborations documented in NISP did not align strictly with Chertow's original criteria, they were nonetheless framed as valid instances of industrial symbiosis [22]. A more recent contribution by Fraccascia and Giannoccaro underscore the fact that economic feasibility and systemic integration are central considerations, and spatial proximity is not a prerequisite for effective symbiotic relationships [23]. The scalability of such networks, both in terms of geographic reach and the diversity of participating actors and resource flows, further illustrates the dynamic and adaptive nature of the industrial symbiosis framework [22,24–26]. As the conceptual framework has been expanded, researchers have started to view industrial symbiosis as a process and stated that industrial symbiosis is not a fixed concept, rather a model that is constantly evolving around different settings [27].

Overall industrial symbiosis collaborations can bring economic, environmental, and social benefits, thus achieving the goals of sustainable development [28]. While ensuring profitability, companies can decrease their environmental footprint, can help and elevate each other, and often reuse old industrial land, thus creating new job opportunities [29].

The relevancy of this study comes from the fact that the tourism sector, especially in the 21st century has its serious challenge: overtourism [30,31]. The term refers to an excessive growth of tourists in numbers, which have negative implications on the environment, local communities and overall affects visitor experience [32]. The high demand for natural, material, and energy resources associated with tourism-related activities (e.g., food consumption) is a problem that needs special attention [33].

The authors of this article argue that industrial symbiosis solutions can mitigate the negative environmental consequences of tourism by reducing waste generation, sharing resource flows and infrastructure and fostering cooperation between companies.

In the next section, the implementation methods of industrial symbiosis solutions are presented. The scientific literature examines

industrial symbiosis from two directions: by level of cooperation and by direction of implementation. In the next section, these will be introduced in order to emphasize the potential of the concept.

Industrial Symbiosis Solutions by Scale of Cooperation

The micro level cooperation category refers to small, localized cooperations. At this level, companies are closely linked. A well-known example is the Kalundborg symbiosis, which is one of the first collaborations that created symbiotic relationships next to Lake Tissø. The complex, territorially growing cooperation, encompassing many companies, is still flourishing today [20]. China's industrial parks should also be mentioned when examining micro level industrial symbiosis solutions. The country became familiar with the concept of industrial symbiosis in the late 1990's and, in the following years, continuously transformed its existing facilities while founding new industrial parks in the spirit of the concept [18,34,35].

When the relationship goes beyond the boundaries set by the industrial park or the small-scale synergies, meso level collaborations can be examined. In such cases, complex cooperation is established, for example, with the settlement where the park is located. In this case, we can talk about urban-industrial symbiosis. Good practices are typically found in urban waste management.

Urban waste management can be a point of connection with the tourism sector. If the system is consciously built, waste and other pollutants generated by tourists could be reused [36–38].

Macro-level cooperation can also be established and planned. In this case, macro level means that relationships extend across multiple settlements, a given region, or even national borders. This is made possible by the scalability of industrial symbiosis [22,24–26].

Industrial Symbiosis Solutions by the Direction of Implementation

In the bottom-up implementation [39], the participants decide to join the cooperation independently, without any external influence. International literature discusses many such examples. The aforementioned Kalundborg symbiosis also belongs to this category [20]. The famous The Plant complex in Chicago used to operate as a meat processing plant. Bubbly Dynamics purchased the vacant building in 2010, modernized it in the following years and now they work together with several enterprises. Connection to the tourism sector can also be observed as the complex welcomes visitor groups and has many services designed for the visitors, such as a farmers' market [40,41].

The concept of facilitated industrial symbiosis was developed by Paquin and Howard-Grenville [42] during the analysis of the NISP implemented in the United Kingdom. In this model, a facilitator or a mediator is needed to connect companies that are open to cooperation but do not know each other. Local governments can play a key role in this case,

as they can also be these actors. The effectiveness of the facilitated implementation method has also been recognized by the European Union, so it may receive special attention in the future [43].

In top-down implementation the industrial symbiosis collaborations are planned and managed by authorities, e.g., the government. A typical example of a country with top-down collaborations is China. The majority of collaborating companies are located in eco-industrial parks. The country receives special attention for the many good practices that have been developed [18,44,45].

POTENTIAL FOR INCORPORATING INDUSTRIAL SYMBIOSIS INTO THE ACTIVITIES OF THE TOURISM SECTOR

The authors argue that the concept of industrial symbiosis is just as relevant in the tourism sector as in the heavy industry. The waste generated can be recycled by transporting and processing instead of dumping. This activity can work either at the micro level, knowing the activities of The Plant [38,39], at the meso level in the framework of urban-industrial symbiosis, or even at the macro level, regionally.

Possible practical solutions for circular hotels have been categorized [46]. These cover most of a hotel's daily processes and include several solutions, such as using recycled paper in offices, using environmentally friendly cleaning products, and raw materials obtained from sustainable farming.

However, continuous cooperation between several actors is necessary to create industrial symbiosis. Mortensen and Kørnøv [47] emphasize the importance of continuous contact and long-term cooperation between actors in their research examining the implementation of industrial symbiosis. Based on the characteristics of the sector, self-organized and facilitated symbiotic relationships are the most likely to succeed, but top-down cooperations cannot be ruled out either. Their research summarizes the development of symbiotic relationships and creates a three-step method:

- The first step is the stage for creating stable foundations.
- Second step: involving additional actors.
- Third step: it is about deeper integration, continuous self-organization and further development.

Geospatial industrial diversity within industrial ecosystems facilitates resource reuse, thereby supporting complex sustainability efforts; places with lots of different types of businesses tend to have more types of resource-sharing partnerships [48]. However, according to the European Commission's technical document on the subject, tools that would allow the identification of potential connections between multiple sectors and industries are currently lacking [49].

In their research, Patricio et al. [50] are working on introducing a method that facilitates establishing these connections by developing a

basic database and creating a digital platform. The technique consists of the following three steps:

- Identification of material and energy *outputs* by each activity/industry,
- Identification of material and energy *inputs* by each activity/industry,
- Matching outputs and inputs of each activity/industry.

Voluntary cooperation and mutual trust of the participating partners are essential. Without these elements, no collaboration can be successful in the long term.

In the next section, the authors examine the international scientific databases and describe the existing symbioses in the tourism sector.

MATERIALS AND METHODS

In this research, the authors examine the topic in several steps. After discussing the theoretical framework, a systematic literature review was conducted using the Web of Science and Scopus databases. This aimed to examine the extent to which the concept is present in international scientific discourse. The search was carried out in the Topic field, using the keywords “industrial symbiosis” AND “tourism” among English-language scientific articles in December 2024. The systematic literature review was conducted utilizing the PRISMA (Preferred Reporting Items for Systematic reviews and Meta-Analyses) method [51]. Originating from healthcare, systematic literature reviews were utilized to minimize selection bias and to maximize the inclusion of all studies written in a research field. Consequently, the PRISMA method was also developed to produce reliable, transparent and well-considered systematic literature reviews [51,52]. Next, the authors assigned good practices to the establishment categories—by the scale of cooperation and by the direction of implementation—highlighted in the previous section. It is important to note here that there may be an overlap between good practices classified into specific categories (e.g., categories according to the nature of key activities and implementation methods). Finally, the authors present a leading example, a complex initiative and its elements. For the sake of clarity, Table 1 shows the summarized materials and methods of this research.

Table 1. Objectives, materials and methods of the comprehensive research.

Research Phase	Research Goal	Research Question	Research Method	Geographical Area
I.	A systematic review of scientific works and research on industrial symbiosis, in relation to the tourism sector.	Examining the extent to which the concept is present in the international scientific discourse.	A systematic literature review was conducted using the Web of Science and Scopus systems.	Comprehensive
II.	Examining the possibilities adaptation using the principles of industrial symbiosis, focusing on categorization and the possible relations to tourism activities.	How can the principles and approaches of industrial symbiosis-type cooperations be applied specifically to tourism activities?	Categorizing individual industrial symbiosis activities and assigning good practices specifically from the tourism sector.	Comprehensive International examples, good practices: Austria, Denmark, Monaco, Black Sea region, Japan, China, Spain, Sweden, Hungary United Arab Emirates
III.	Presenting a leading example that can serve as a "flagship" in the research of industrial symbiosis in the tourism sector	What practical solutions support the justification for initiating industrial symbiosis-type cooperations in the tourism sector?	An evaluative analysis of complex symbiotic collaboration through the case study of Kawasaki King Skyfront Tokyu REI Hotel.	Kawasaki City, Japan—an area designated as a special zone in the country's development strategy—is an open innovation center.

The study of industrial symbiosis from a tourism perspective was carried out following the steps above in order to obtain a comprehensive picture of the subject under study.

As a result of the keyword search in the Web of Science and Scopus databases, it can be stated that the topic appears in international scientific discourse but needs to be studied in greater detail. Keyword search in Scopus and Web of Science together provide more than 500 results for the search criteria "circular economy" AND "tourism" and more than 25,000 results for the search criteria "sustainability" AND "tourism." The connection between sustainability, circularity and the tourism sector is established, but further research could be needed to examine the possibilities offered by deeper than circular integrations.

Figure 1 shows the PRISMA diagram of the literature review. By entering the search criteria "industrial symbiosis" AND "tourism" in the Topic field and searching for scientific articles in English, the authors got 16 search results. One article was duplicated, and one was retracted so that the authors could identify 14 scientific articles. In the final step, eight articles were excluded, because they were not relevant to this research. These articles did not focus on the relationship between industrial symbiosis and its connection with the tourism sector. As a result, six research articles were deemed relevant and included in the review.

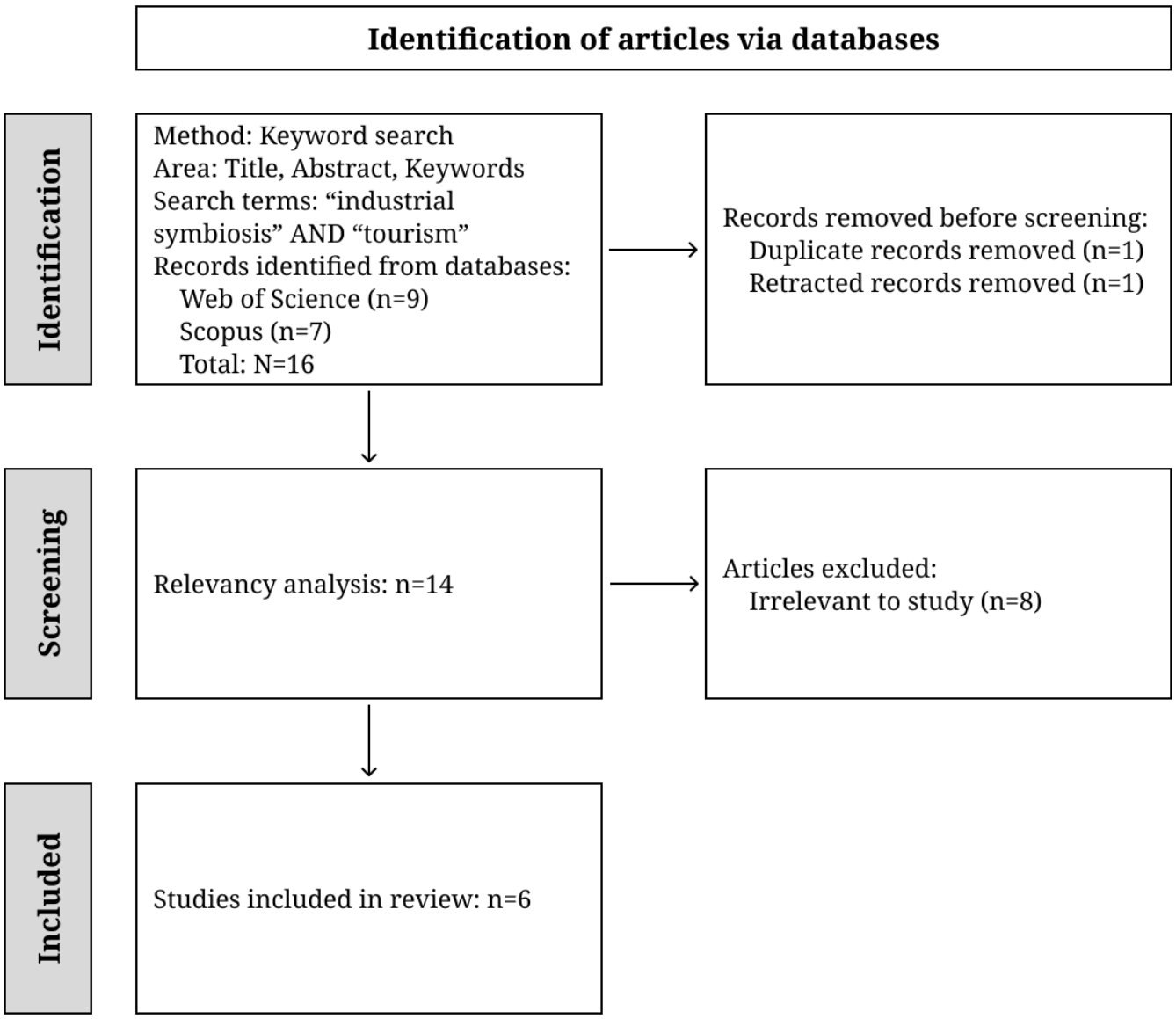

Figure 1. PRISMA diagram of the research of the authors.

RESULTS

Results of the Systematic Literature Review

Viken [53] drew attention to the possible connections between industrial symbiosis and the tourism sector as early as 2010. In his opinion, this requires cooperation between decision-makers, researchers, and companies, as these are complex collaborations. Kaszás et al. [54] also highlight that deeper than circular economic integrations are relevant in the tourism sector, which also means implementing industrial symbiosis processes. Nie and Tang [55] argue that not only industrial symbiosis but also resource symbiosis, management symbiosis, and environmental symbiosis, as parts of the Symbiosis Theory, are relevant in the tourism sector. Zhao et al. [56], when examining the Chinese city of Jiaozuo, explain that long-term planning and the design of urban and industrial symbiosis

solutions are needed to achieve sustainable development. De Almeida et al. [57] examines the corporate sustainability in the tourism sector, with a focus on helping the companies measuring their sustainability level and highlight on strengthening the companies' performance measurement routines. At the same time, Wu et al. [58] point out that in the tourism sector, for businesses, eco-efficiency performance is pushed into the background alongside socioeconomics, thus slowing down the progress towards sustainability.

The results of the systematic literature review highlight the relevancy and potential of the possible connection between industrial symbiosis and the tourism sector. The following patterns were identified:

- Deeper integration than typical circular activities offer is needed [54].
- Industrial and other types of symbiosis are applicable in the tourism sector [55].
- Cross-sectoral collaboration is needed for successful establishment [53]
- Planning is a crucial factor in ensuring long-term success [56].

In the next section the authors introduce already established good practices.

Established Good Practices of Industrial Symbiosis Cooperations in the Tourism Sector

This article steps beyond the traditional sectoral boundaries [59] assumed in the mainstream literature by systematically identifying and categorizing industrial symbiosis practices within tourism-linked establishments (e.g., hotels, attractions, and other services). This reframing suggests that industrial symbiosis solutions are relevant in tourism and are underexplored, especially in service-based economies.

The section aims to shed light on industrial symbiosis from multiple perspectives, which provides additional opportunities for those interested in obtaining information. In the first two parts of the section, the authors present examples of industrial symbiosis solutions according to their implementation direction and level.

The following categorized good practices (Tables 2 and 3) resulted from an extensive search for existing collaborations and the vast majority of which have not yet been processed in international literature.

The novel perspective of this research did not result in finding good practices in scientific databases, so the authors utilized search engines to find news articles, professional journals, blogs, and industry websites with evidence of industrial symbiosis activities in the tourism sector. The authors started by looking for evidence in Asia, Europe and the USA. This was based on the findings of Neves et al. [60], who showed that the most industrial symbiosis case studies come from these regions, in this order.

In Table 2, the authors categorize existing good practices by the scale of cooperation, highlighting micro, meso and macro level collaborations. To determine the scale on which these good practices work, the authors first

identified the initiator of the collaborations, then examined the participating companies and the extent of their cooperation.

Table 2. Categorizing good practices in the tourism sector by the scale of cooperation.

Scale of the Cooperation	Good Practice in the Tourism Sector	Initiator(s)	Key Areas of the Cooperation and Their Connection to Tourism
Micro level—inter-company collaborations	Regional Operative Program (ROP) (Spain) [61]	Government	Improving collaboration between SMEs in agriculture, fishing and tourism sectors.
	Lake Hévíz (Hungary) [62]	Municipality	Energy supply of spa and hospital buildings through a joint investment.
Meso level—municipal collaborations	Hartberg Ökopark (Austria) [63]	Companies	Supporting applied research in industrial symbiosis while acting as tourist attraction with visitor center.
	Sotenäs (Sweden) [64]	Municipality	Establishing industrial symbiosis related to fisheries while incorporating tourism.
Macro level—regional/country level collaborations	Hainan Port (China) [65]	Municipality	Fostering innovation in tourism and service sector, in high-tech industry and tropical agriculture.
	Black Sea Industrial Symbiosis Platform [66]	Government	Enabling communication and cooperation by providing a platform for manufacturing, logistics, tourism and the energy industry.

On micro level, the ROP in Valencia, Spain was implemented within the framework of the Interreg Europe program. This program includes innovative production and business cooperation in the agriculture, fisheries, and tourism sectors [61].

In Hévíz, Hungary, the city initiated the utilization of the wastewater of the local thermal lake in 2017 in partnership with the Hévíz Thermal Spa and the St. Andrew's Rheumatology Hospital. Through the joint investment, energy is fed back from the wastewater of the thermal lake to heat the hospital and spa buildings using a heat pump. With the transformation, the heating of the Thermal Spa and the mud plant building belonging to the hospital can be solved entirely; by replacing two gas boilers and using natural gas, the cooperation achieved its goals [62].

On the meso level, in the Hartberg Ökopark in the Austrian region of Styria, more than 51 companies operate with 350 employees. The park combines sustainability, the principles of the circular economy, the use of renewable energies, and the environmentally friendly disposal and recycling of waste. The eco-park also promotes applied research on industrial symbiosis by operating a permanent public exhibition and visitor center on environmental technologies and industrial symbiosis type collaborations between companies. The park now also functions as a tourist attraction for professionals interested in the topic and students who want to learn [63].

Sotenäs municipality in Sweden has established a local industrial symbiosis network that connects fish processing plants, a biogas facility, a marine recycling center, and other local industries to exchange resources and minimize waste. Fish waste and wastewater are converted into biogas and biofertilizer, which are reused within the local economy, closing material loops. The Sotenäs Symbiosis Center coordinates these efforts and serves as a hub for innovation, education, and collaboration. Tourism is

integrated into this system through guided study visits, workshops, and tours that allow visitors to learn about circular economy practices firsthand. This fusion of industrial symbiosis and sustainable tourism enhances regional identity while promoting environmental awareness and economic resilience [64].

At the macro level, the southern Chinese province of Hainan initiated the construction of a free trade port, focusing on four leading industries: tourism, the service sector, the high-tech industry, and tropical agriculture, which account for about 70 percent of the economy. Hainan's coordinated regional development is based on increasing the activity of economic stakeholders in industrial symbiosis [65].

Also on macro level, the Black Sea Industrial Symbiosis Platform aimed to map and support networking and cooperation opportunities for companies in the Black Sea Basin in manufacturing, logistics, tourism, and energy [66].

The good practices presented in Table 2 show that industrial symbiosis solutions can operate at various levels and scales in the tourism sector. In Table 3, the authors categorized good practices according to the previously established implementation directions (bottom-up, facilitated, top-down). The categorization was made by checking the initiator first, and the way the cooperation is handled, so the implementation direction could be determined.

The Austrian HySnow Project is a self-organizing initiative. The four-year project aims to reform the winter industry. This project, funded by the Austrian Research Promotion Agency and the Climate and Energy Fund, designed and converted snowmobiles powered by renewable energy and green hydrogen. The snowmobiles were presented to the public during the FIS World Cup Ski Event [67].

Table 3. Categorizing good practices in the tourism sector by the direction of establishment and cooperation.

Direction of the Cooperation	Good Practice in the Tourism Sector	Initiator (s)	Key Areas of the Cooperation and Their Connection to Tourism
Bottom-up establishment	HySnow Projekt (Austria) [67]	Consortium of companies	Decarbonizing snowmobiles in winter tourism
	Abu Dhabi Premier Inn (Abu-Dhabi) [68]	Company	Development of a greywater recycling system in the hotel.
Facilitated establishment	Hydrogen Round Table and Energy Boat Challenge (Monaco) [69]	Foundation, Ministry	Hydrogen innovation in the sea industry
	Green Hysland Project (Mallorca, Spain) [70]	Companies and Municipality	Establishment of hydrogen ecosystem, municipal fuel and heat available for the public.
Top-down establishment	Kawasaki King Skyfront Tokyu REI (Japan) [71]	Municipality	Operating a carbon-neutral hotel with several additional sustainability interventions in collaboration with partner organizations.
	Bornholm (Denmark) [72,73]	Municipality	Complex collaborations in order to become a zero waste island by 2032.

Another self-organizing example is built around water. The 300-room Abu Dhabi Premier Inn hotel at Abu Dhabi International Airport was

among the first to develop a greywater recycling system in the region in cooperation with the water treatment company Waterscan. The hotel saves an average of 735,000 L/month of water, about a quarter of its monthly water use. In the 300 hotel rooms, the wastewater from bathing and showering is filtered with an ultrafiltration membrane and then returned to the hotel for irrigation and toilet flushing. As a result, recycled water is used in the hotel's washrooms, reducing overall water consumption by an average of 60 liters per guest [68].

Among the facilitated initiatives are the Hydrogen Roundtable and Energy Boat Challenge, organized annually by the Yacht Club de Monaco, the Prince Albert II of Monaco Foundation, and the Monaco Energy Transition. The critical goal of the event is to shape attitudes, involve interested parties, and familiarize them with the topic. The transition to sustainable hydrogen energy in the maritime industry is vital for the country, the naval industry, and, thus, the tourism sector [69].

In Mallorca, the Green Hysland project, partly funded by the European Commission, aims to facilitate the creation of a hydrogen ecosystem by producing green hydrogen from solar energy and delivering it to end users through hydrogen fuel for public transport, as well as in hotels and municipal combined heat and power systems, powering a ferry terminal and feeding it into the local gas network. The project also develops a roadmap up to 2050, outlining a vision for expanding the hydrogen economy in Mallorca and the wider Balearic Islands [70].

A top-down initiative, the Kawasaki King Skyfront Tokyu REI Hotel, in collaboration with the Ministry of the Environment's Regional Cooperation and Low-carbon Hydrogen Technology Demonstration Project, has created a carbon-neutral hotel powered entirely by sustainable resources [71].

Bornholm is an example of how industrial symbiosis and tourism can be integrated to establish a more sustainable and circular economy. The island reuses organic waste, wastewater, and energy byproducts across sectors like food production, energy, and agriculture. Businesses from the tourism sector participate through initiatives which help hotels and restaurants adopt circular practices. Visitors are directly involved in waste separation and sustainability efforts as part of Bornholm's "Bright Green Island" strategy. This makes tourism both a contributor to and beneficiary of the island's industrial symbiosis network [72,73].

The short introduction of good practices shows the wide range of examples already established. In the next section, a leading example of industrial symbiosis solutions in the tourism sector will be introduced in detail.

Case Study of the Kawasaki King Skyfront Tokyu REI Hotel

An excellent example of the practical implementation of complex collaborations is the Kawasaki King Skyfront Tokyu Rei Hotel. The Hotel is located in Kawasaki City, Kanagawa Prefecture. This example's uniqueness comes from the fact that not just the hotel but the whole city aims to become sustainable through green innovation [74,75]. The facility, which has been in operation since 2018 as the world's first Hotel to use hydrogen energy and other innovative solutions, is a part of the city's sustainability goals.

The project was implemented as part of a complex urban development plan—also focusing on tourism aspects—in an industrial area bordered by petrochemical complexes. The city has recently made serious efforts to exploit its industrial heritage and technological strengths to increase tourism and boost regional revitalization.

The Hotel is established in a 45-hectare area (King Skyfront), which has been designated as a special zone in the country's new growth strategy. The development zone invites domestic and international research institutes, businesses, and other organizations to establish research and development bases. One of the flagship and demonstration projects of the concept is a complex, novel approach to the design and operation of the Hotel itself [76,77]. Table 4 summarizes the organizations cooperating in the project, activities, and roles in the extremely consciously organized industrial symbiosis cooperation.

Table 4. Partner organizations involved in the implementation and operation of the Hotel and their role based on [76–80].

Partners	Activities	Role in the Symbiosis	Results of the Activities
The Kawasaki King Skyfront Tokyu REI Hotel (Tokyu Hotels Co. Ltd (Tokyo, Japan). and W's Company Co., Ltd. (Nagoya, Japan)	Hotel operation	Concentrated energy use, provision of infrastructure. (Energy supply "demand side".)	Disposal of hotel plastic and food waste, energy recovery.
Showa Denko K.K. (Tokyo, Japan)	chemical company, hydrogen production	Processing hotel plastic waste and household plastic waste, extracting hydrogen gas from it. (Energy supply "supply side".)	The Hotel provides ~30% of its total energy needs from hydrogen energy.
Toshiba Energy Systems & Solutions Corporation (Kawasaki, Japan), and Meiji Electric Industry Co., Ltd. (Nagoya, Japan)	design and operation of energy systems	Providing a clean hydrogen fuel cell system, using plastic to extract hydrogen gas. (Connecting the "supply side" and "demand side" of energy supply.)	Generating and utilizing energy from hydrogen from processed plastic.
J Bio Food Recycle Co. Ltd. (Yokohama, Japan)	biological waste management and recycling	Disposal of the Hotel's food waste and production of biogas from it. (Energy supply "supply side".)	The Hotel provides ~70% of its total energy needs from biogas with a high methane content.
Kawasaki City, Japan	municipal government, city administration	National Strategic Special Zone: encouraging the creation of an R&D base for international research institutes, businesses and other organizations.	Transforming a former industrial area into a green, open innovation center. Generating collaborations.
Resonac Inc./(Tokyo, Japan) Japan Ministry of the Environment	chemical industry, electronics industry/ government organization	Cooperation/support in the low-carbon hydrogen technology demonstration project.	Strengthening the demonstration nature of the project and putting hydrogen strategic ideas into practice.

The demonstration project, also known as the “World’s First Hydrogen Hotel,” aims to produce and utilize hydrogen locally from plastic waste. The project fits Kawasaki City’s Hydrogen and Japan’s plastic recycling strategies.

Thanks to the extensive partnership and industrial symbiosis approaches, several additional elements appear in the operation that can serve as models for tourism actors in similar fields. The hotel publishes them [78] on the basis of data from other organizations [79,80], but these are not exhaustive.

- The glasses and cups used in the rooms are made with environmentally friendly ingredients, using 55% cellulose fiber.
- Instead of bottled mineral water provided in the guest rooms, water dispensers have been installed on each floor. This process reduces the amount of plastic bottle waste by approximately 20,000 bottles per year.
- The use of electricity from secondary raw materials allows the hotel to operate perfectly and grow plants. Lettuce is grown in the hotel under LED lighting in an environment with a temperature of 22–26 degrees and a humidity of 60–80%. It is harvested in several batches in 30–40-day cycles, with approximately 40 heads per week, and served in the hotel restaurant.
- Used toothbrush handles and hairbrushes made of biodegradable material are collected separately and recycled into placemats placed in the hotel's guest rooms and café.

In addition, the city intends to increase and expand the number of sightseeing tours to emphasize sustainability and circular economy aspects and to connect with the many unique museums and their programs around the city. It wants to encourage more companies to participate in a unique program.

The city places great emphasis on environmental education but figuring out what to do to arouse children’s interest has been challenging. According to experience, the hydrogen bus and hydrogen hotel operated by Tokyu Bus are popular among the younger generations. The information materials of Toshiba Energy Systems & Solutions Corporation registered in the city are the driving force behind the investment, highlighted that the project was generated by various organizations that would not usually come into contact with each other, such as the national government and local government offices, partner companies, professional organizations, and other interested parties [81]. The partner organizations involved in the presented demonstration project cooperate closely to achieve the shared sustainability goals. The case study can serve as a good example of cooperation that focuses on the tourism sector and reflects the principles of industrial symbiosis.

DISCUSSION

The approach of industrial symbiosis from a tourism perspective can be interpreted as mutually desirable cooperation arising from the voluntary will of all involved actors. In each destination—considering its unique characteristics and characteristic activities—it can harmonize the sector's efforts to preserve the sustainability and natural environment with the goals of increasing efficiency and economy.

During the study, the authors' highlighted the constant development of the industrial symbiosis concept, and examined the relationship between industrial symbiosis and the tourism sector from several aspects. As a result, good practices were presented.

The steps taken during the research can be evaluated as follows:

The systematic literature review in the first step highlighted that the topic has been present in recent years. However, the number of scientific articles discussing the field has been relatively low so far.

The grouping and categorization of good practices carried out in the second step of the research proves that many good practices in the tourism sector have not been or only partly examined scientifically. These examples can be found in Tables 2 and 3.

In the third step, a leading example was examined by presenting and analyzing the Kawasaki King Skyfront Tokyu REI Hotel (Table 4). Such and similar future collaborations may further strengthen the topic's role in international scientific and non-scientific public discourse. Just as Kalundborg became the flagship project of the classic industrial symbiosis [20], such good practices are also needed in the tourism sector. The example the authors present may be one of them.

The authors' complex research can open new dimensions in examining the relationship between industrial symbiosis and the tourism sector since no one has presented such comprehensive categorization of previously scientifically unexplained good practices yet. The research outlines several future tasks (for example, expanding the definition that take tourism aspects into account even more, determining success factors, etc.) for which our current research can provide a sound basis.

CONCLUSIONS

In this research, the authors argued that the connection between industrial symbiosis and tourism is present and offers opportunities for mitigating the negative effects of the tourism sector. The good practices described show the complexity of the concept and show that cooperation can offer an advantage.

Industrial symbiosis solutions can play a significant role in achieving the sustainability goals of the tourism sector. Consciously organized collaborations can occur with any number of actors and include any material flow. All decision-makers, facilitators, and businesses should become familiar with industrial symbiosis solutions that can be

implemented at multiple levels in the future. Climate change, biodiversity loss, environmental pollution and overtourism are all problems that must be solved sooner rather than later. Businesses must consciously cooperate and work for success. Local governments and national leadership must acknowledge the topic and act. Capital can even be raised through European Union Funds to solve financing problems.

The tourism sector is characterized by complexity and the interdependence of different activities, making it suitable for developing symbiotic relationships. In addition to operating catering establishments and accommodation facilities, the cooperation of many actors of different sizes and scopes of activities is the key to exploiting the topic's potential.

A more sustainable tourism sector is in our common interest, and we all must work for it. The authors hope this study will contribute to making the topic more widely known and to attitude shaping, which is the basis of all successful cooperation. While the determination of a single actor may be sufficient to implement the elements of the circular economy, long-term, conscious collaboration is essential for creating industrial symbiosis solutions. This research illustrates the opportunities offered by industrial symbiosis for the tourism sector and the world.

THEORETICAL CONTRIBUTION AND PRACTICAL IMPLEMENTATIONS

By naming and framing these practices as industrial symbiosis, the authors help bridge the gap between sustainability efforts in tourism and industrial symbiosis, thereby supporting calls in the literature for a broader understanding of concept. The connection between the circular economy and the tourism sector has already been scrutinized by the international scientific community. However, the relevance of subcategories such as industrial symbiosis has been rarely touched on. This article aims to bridge this gap and link industrial symbiosis and the tourism sector together while highlighting existing examples and leading good practices. The benefits of this are twofold. First, it helps to raise attention to this critical matter, and second, the article aims to spread the knowledge to reach the companies, to give them more information to facilitate change and a shift towards a more sustainable future. The key contribution of the research is the categorized introduction of industrial symbiosis solutions in the tourism sector.

LIMITATIONS OF THE RESEARCH

This research uses research methods that work with secondary resources which are available online. The authors' goal was to use the most recent findings; however, it is possible that some information is outdated. Complex empirical research involving site visits and stakeholder interviews is needed to fully understand the potential of symbiotic collaborations, and to examine active, working good practices.

DATA AVAILABILITY

All data generated from the study are available in the manuscript.

AUTHOR CONTRIBUTIONS

Conceptualization: KN, PB, EP; methodology: KN, EP; collection of good practices: KN, PB, EP; original draft preparations: PB; review and editing: KN, PB, EP; supervision: KN, EP. Final manuscript: KN, PB, EP.

CONFLICTS OF INTEREST

The authors declare that they have no conflicts of interest.

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