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Lessons Learned from the Application of the UNIDO Eco-Industrial Park Toolbox in Viet Nam and Other Countries

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Abstract: The transformation of conventional industrial parks into eco-industrial parks (EIPs) presents an effective opportunity to attain inclusive and sustainable industrial development. UNIDO has acquired broad experience of EIPs by implementing a number of EIP projects in developing countries. To support these, a UNIDO EIP Toolbox was developed in order to (a) provide a practical set of customized and flexible tools to assist practitioners with the development and implementation of EIPs and related initiatives, and (b) to support EIP implementation and decision-making processes in relation to existing and new industrial parks. The EIP Toolbox currently covers tools on selecting industrial parks for EIP projects, stakeholder mapping, policy support, assessing industrial parks against the International EIP Framework, industrial symbiosis identification, monitoring impacts from company-level Resource Efficiency and Cleaner Production (RECP) assessments and park-level EIP opportunities. The focus of this paper is the application of the developed EIP tools in Viet Nam, supported by learnings from their application in other countries (e.g., China, Colombia, India, Morocco and Peru). The application of the EIP tools to date has demonstrated their value in contributing to the development and implementation of EIP practices. The added value of the tools is to support decision-making and stakeholder consultation processes on specific EIP topics of interest. An overall lesson learned from the tools' applications is that they are useful in identifying and prioritizing "tip of the iceberg" symbiosis and RECP options as well as park-level EIP opportunities through interactive stakeholder consultations or workshops, possibly led by park management, and in guiding the discussion through a step-by-step structured approach. As such, rather than a stand-alone solution, the tools are best placed to be used as a supplementary instrument, in conjunction with other pragmatic and detailed implementation approaches. The current version of the UNIDO EIP Toolbox represents version 1.0. It is envisaged that the set of tools will be updated and expanded to reflect insights from their application in EIP projects. It is hoped that this paper will create further interest among EIP stakeholders and the academic community in applying the UNIDO EIP Toolbox as well as feedback from users in developing, transition and developed countries to further strengthen and expand the tools.

Keywords: eco-industrial parks; EIPs; inclusive and sustainable industrial development; toolbox; industrial park management; cleaner production; resource efficiency; industrial symbiosis; monitoring impacts

1. Introduction

As emerging economies seek to increase industrial output, there is also a pressing need to decouple economic growth from resource consumption in order to meet wider social objectives. In this

regard, strategically planning and effectively managing industrial parks is essential to achieve the desired economic, social and environmental targets. Therefore, the transformation of conventional industrial parks into EIPs presents an effective opportunity to attain inclusive and sustainable industrial development and to meet the Sustainable Development Goals (SDGs) and the objectives of the 2030 Agenda.

A number of definitions are used in relation to EIPs (e.g., sustainable industrial parks, low-carbon zones, green industrial areas) [1–4]. Each definition alludes to a dedicated area for industrial development supported with park-level infrastructure and utility services that enhance business performance, while at the same time addressing technical, infrastructural, managerial, environmental, social, economic and monitoring aspects in order to make the area more sustainable.

The types of benefits (economic, environmental and social) deriving from EIPs differ greatly and often go beyond conventional business case benefits [4–6]. The benefits are also strategic, leading to reduced risks, improved competitiveness and productivity and an improved stakeholder reputation. EIPs enable companies to transform environmental problems into business opportunities through improved resource efficiency, utilization and recycling, as well as collaborations on shared infrastructure.

UNIDO has been working on the development of EIP pilot projects in different countries (including China, Colombia, India, Morocco, Peru, South Africa and Viet Nam), together with national governments and local stakeholders [7]. For instance, in Viet Nam, UNIDO has been collaborating with national stakeholders (e.g., the Ministry of Planning and Investment (MPI), provincial authorities, park management and tenant companies), with the objective of introducing and implementing EIP concepts in three existing industrial parks in Ninh Binh province, Da Nang city and Can Tho city. The work focuses on developing policies and guidelines to facilitate the transformation of industrial zones into EIPs, capacity-building on EIP strategies and measures, implementing RECP and industrial synergies and information dissemination. The work to date in Viet Nam contributed to the approval of a national decree (Decree no. 82/2018/ND-CP dated 22 May 2018) regulating EIPs in the country, among other successes of the EIP activities in Viet Nam [8–10].

One key focus area of UNIDO's work on EIPs at international level is to support the creation of a common understanding and awareness relating to EIPs and to provide practical guidance to practitioners on how to implement the EIP concept. Practical handbooks, tools and capacity-building materials have been developed to support the implementation of EIP through bottom-up approaches (industrial parks as entry points) and top-down approaches (national governments as entry points).

The objectives of this research paper are: (a) to introduce the set of customized EIP Tools developed by UNIDO (including rationale, targeted users, their methodologies); (b) to discuss the results and added value from their application in Viet Nam; and (c) to share the lessons learned from the tools' application in other countries in which UNIDO has been working on the topic of EIPs (e.g., China, Colombia, India, Morocco and Peru).

2. Materials

This section presents a summary review of existing tools to set the context and rationale for the development of UNIDO's EIP toolbox. Following this review, the overall objective and structure of UNIDO's EIP toolbox is presented as an introduction to the subsequent sections on specific EIP tools.

2.1. Review of Existing Tools

EIP is a multidisciplinary concept covering technical assessments, park management and governance, policy and regulations, integration with local communities and protection of the natural environment. The EIP concept is used to optimize and upgrade existing industrial parks as well as to plan and develop new ones.

An overview of existing tools related to EIPs is provided in Table 1. The review focused on the tools freely available in the public domain, as this is important in enabling their wider application,

in particular by stakeholders, in developing and transition economies. The list of tools does not claim to be all-inclusive—other tools may exist [11].

The review of existing tools shows that a limited number of practical tools customized to the development and implementation of EIPs are freely available. It was found that existing tools do not yet fully meet the specific needs of UNIDO's EIP activities in the project countries. The approach taken by UNIDO was to develop a customized set of EIP tools and to incorporate and reference specific components of existing tools on a case-by-case basis.

Table 1. Review of existing EIP-related tools freely available in the public domain Not all-inclusive (adapted from [12]).

Topic	Existing Tools	Reference	Scope of Tools
EIP—overall	Sustainable Industrial Area (SIA) Toolbox	[13]	(1) Introduction (analysis, standards, sensitization); (2) designing SIA (technical infrastructure, master planning, retrofitting); (3) operating SIA (management, resource efficiency, social aspects, climate change).
Selecting industrial parks for EIP projects	CII-Sohrabji Godrej Green Business Centre Methodology for pre-assessment of industrial parks	[14]	Evaluation methodology including checklist to rate parks on diverse parameters and thus compare parks.
Stakeholder mapping	Public-Private Dialogue (PPD) Stakeholder Mapping Toolkit	[15]	Guide stakeholder analysis in PPD using the net-map method.
Policy support	Practitioner's guide to strategic green industrial policy	[16]	Support decision-makers on the transition towards a Strategic Green Industrial Policy (SGIP) that reflects their country's context and aspirations.
	Sustainable consumption and production: A Handbook for policymakers—Global edition	[17]	Assist policy-makers in developing, implementing, monitoring and evaluating policies that support the transition towards sustainable consumption and production.
Park management	Business planning tools	Example: [18]	Assist in the development of business plan to set out systematically how business opportunities will be implemented, what resources will be required and what results can be expected by when.
	Project management and programme management	[19]	Present a number of concepts and instruments for project/business management that are applicable to EIP management.
Industrial symbiosis	Stan2web	[20]	Software to map resource flows/stocks (material flow analysis).
	Umberto®	[21]	Software to analyze resource and material flows/stocks. Different packages exist, including carbon footprint, life-cycle assessment and efficiency software.
Monitoring impacts from RECP and industrial synergies	Enterprise-level indicators for resource productivity and pollution intensity: A primer for small and medium-sized enterprises (SMEs)	[22]	Provide a framework for documenting enterprise-level RECP results that is widely applicable to SMEs in developing and transition countries. The primer provides a core set of indicators for enterprise-level resource productivity and pollution intensity.
	RECP indicator calculation tool	[22]	Enable companies to track their performance, calculate results and present their RECP profiles.
	Cleaner production toolkit	[23]	Train the trainer toolkit to support trainers in the field of cleaner production.

2.2. UNIDO EIP Toolbox

A number of publications have been produced to bring together the technical experience of UNIDO in developing and implementing EIP projects [4,12,24,25]. To support these guidelines and handbooks, a UNIDO's EIP Toolbox was developed to (a) provide a practical set of customized and flexible tools to assist practitioners with the development and implementation of EIPs and related initiatives, and (b) to support EIP implementation and decision-making processes in relation to existing and new industrial parks.

The targeted users of the EIP tools are national and international development agencies and supporting service providers working on EIP projects. The toolbox is designed to be applicable to industrial parks in a range of international contexts and with different characteristics (e.g., types of industry sectors in park, park size, level of technology development, park management model).

In order to have a focused and effective approach, priority topics to be covered by UNIDO's EIP Toolbox were selected, based on the specific needs of UNIDO's work in the project countries and a review of existing tools already available in the public domain. The prioritized functions for the EIP tools were determined to be as follows: (i) selecting industrial parks for EIP projects; (ii) stakeholder mapping; (iii) policy support; (iv) park management; (v) industrial symbiosis identification; and (vi) monitoring impacts from company-level RECP assessments and park-level EIP opportunities.

An overview of UNIDO's EIP tools developed to date is presented in Table 2, including their scope (e.g., focus on existing versus new industrial parks, technical versus organization/political assessments) and their objectives. As discussed in the previous section of this paper, the toolbox is organized according to the prioritized needs in UNIDO's project countries. The EIP tools are freely available and can be downloaded from the following address: <https://open.unido.org/projects/C6/projects/170222>.

The tools have been applied in China, Colombia, India, Indonesia, Morocco, Peru, South Africa and Viet Nam, and will continue to be applied and expanded as part of the Global EIP Programme (2019–2023). The following sections of this paper discuss the application of the tools and their lessons learned, using the Vietnamese case as an example.

3. EIP Assessment Tool: Assessing Parks against the International EIP Framework

This section discusses the rationale, objective and methodology of the EIP Assessment Tool, followed by the results from the application of this tool in Viet Nam and learnings from other countries.

3.1. Rationale and Objective

The International Framework for Eco-Industrial Parks [24] guides policy-makers and practitioners on the critical elements that will help both governments and the private sector to work together in establishing economically, socially and environmentally sustainable EIPs. The overall framework is presented in Figure 1.

Table 2. Overview of UNIDO's EIP Tools (adapted from [26]).

EIP Tools	Scope of the Tools		Tool Objectives
	Existing Industrial Parks	New Industrial Parks	
EIP Assessment Tool	√		Assess an industrial park against an International Framework for Eco-Industrial Parks [24] and subsequently prioritize, plan, manage and monitor their EIP initiatives.
EIP Selection Tool	√	√	Support the selection of industrial parks with high potential for EIP development and creating successful EIP projects.
Stakeholder Mapping Tool	√	√	Help to identify missed or hidden opportunities related to different kinds of scenarios to design win-win solutions for stakeholders.
EIP Policy Support Tool	√	√	Support policy development and implementation processes and government decision-making with regard to EIPs
Industrial Symbiosis Identification Tool	√	√	Support the identification of by-product synergies and waste exchanges (industrial symbiosis).
RECP Monitoring Tool	√		Monitor and report the resource savings and results of RECP assessments accomplished in industrial parks.
EIP Opportunities Monitoring Tool	√		Monitor and report resource savings, improvements and impacts from EIP opportunities identified and implemented in industrial parks with the support of (inter)national development projects.

The International EIP Framework describes the performance requirements for EIPs grounded in four key categories: park management performance, environmental performance, social performance and economic performance. The framework provides the basis for defining and setting prerequisites and performance requirements for EIPs, based on 51 criteria (benchmarks). These criteria are inclusive in scope and are aimed at all types of industrial parks (e.g., Special Economic Zones, Industrial Estates, and Manufacturing Zones) in different contexts. The criteria relate to stakeholders in the private and public sectors (e.g., park management, tenant companies, local/regional/national government agencies) wherever these industrial parks are located. While adherence to all of these criteria is recommended, it is understood that some countries may wish to adjust the criteria to their local specificities. Compliance with national and local regulations is a requirement for all industrial parks, regardless of their specific geographic location and characteristics. The focus of the framework is to encourage industrial parks to exceed compliance with local and national regulations with respect to environmental and social issues.

The objective of the EIP Assessment Tool is to assess an industrial park against the International EIP Framework and subsequently prioritize, plan, manage and monitor their EIP initiatives. It can be used and adapted to all types of existing industrial parks and management structures (e.g., private company, public authority, public-private set-up, real estate). The following paragraphs summarize the key steps of the EIP Assessment Tool.

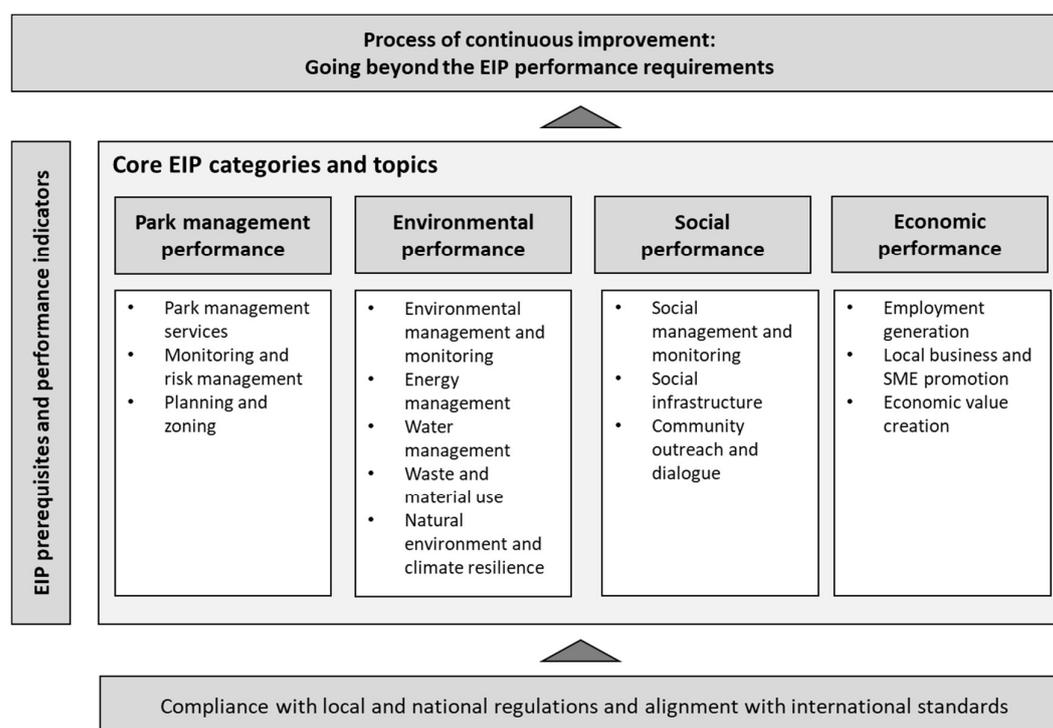


Figure 1. Overall framework for describing eco-industrial parks (Extracted from [24]).

3.2. Methodology

3.2.1. Step 1: Assess Industrial Park Performance against the International EIP Framework

Together with the park management team, the user goes through the benchmarks of the International EIP Framework and assesses to what extent the park meets each benchmark. This assessment is conducted for the park's current performance, but can also be carried out for its intended performance (e.g., two-three years). If a benchmark is not met, the team brainstorms about a specific opportunity that could be undertaken by park management and/or companies in order to meet the benchmark.

3.2.2. Step 2: Select EIP Opportunities Which Are Most Achievable and Beneficial

For each of the EIP opportunities identified, the team selects a qualitative rating (e.g., Low, Medium, High) of the likely achievability, anticipated benefits and interest from park management and companies in working on the opportunity. On this basis, the team reaches a consolidated decision for each EIP opportunity on whether or not to select it for short-term action and monitoring. This selection process needs to be undertaken with the park management team and, where needed, with the relevant tenant companies.

3.2.3. Step 3: Plan, Manage and Monitor Progress on Prioritized EIP Opportunities

The next step is to formulate the EIP opportunities (as selected in step 2) into concrete initiatives. For each initiative, the team: (a) estimates the capital expenses, operating expenses and cost recovery model; (b) defines activities to deliver the initiative, including time period, responsible person, progress note and, if needed, corrective actions; and (c) sets Specific, Measurable, Attainable, Relevant and Timely (SMART) targets and notes the actual performance levels over time. Recognizing that park management may already have systems in place to monitor and manage their activities, it is envisaged that the planning and monitoring framework is adapted to suit the specific requirements of park management and the existing systems in place.

3.3. Results from Tool Application in Viet Nam

The EIP Assessment Tool was applied, for instance, to the Khanh Phu Industrial Zone (Ninh Binh), one of the industrial parks participating in a current UNIDO, Global Environment Facility (GEF) and State Secretariat for Economic Affairs of Switzerland (SECO)-funded project (full project title: “Eco-Industrial Park Initiative for Sustainable Industrial Zones in Viet Nam”. Global Environment Facility (GEF). Available online at: www.thegef.org/project/implementation-eco-industrial-park-initiative-sustainable-industrial-zones-vietnam). The tool was used to assess the current performance of the industrial park in relation to the International EIP Framework (see Figure 2) and, subsequently, to identify gaps and scope interventions for the park to transform into an EIP.

The assessment was undertaken by the UNIDO team in close collaboration with the provincial authorities, the management of the industrial zone and resident companies, which also provided the data to support the assessment. Where no data was available for specific benchmarks, “To be confirmed” was used instead (Figure 2).

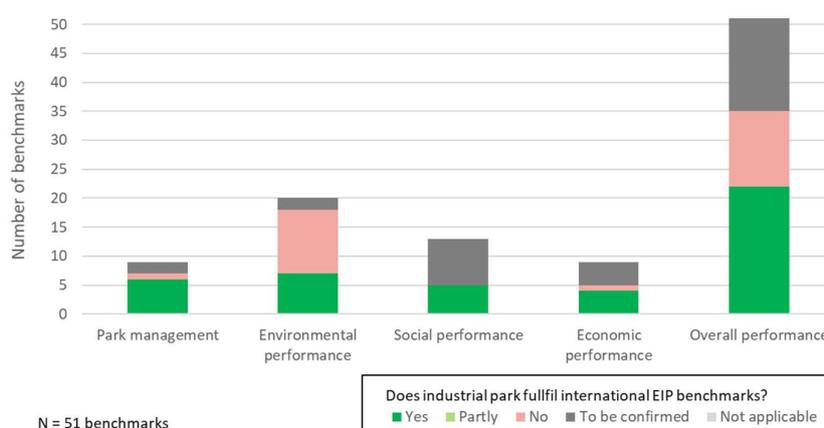


Figure 2. Example: Assessment of Khanh Phu (Ninh Binh) against the International EIP Framework.

It is noted that the objective of the tool application was not to serve as a statistical analysis, but rather as a pragmatic and qualitative approach to understand the current performance of the targeted industrial zone in relation to the International EIP Framework and to identify concrete EIP opportunities. A detailed description and justification of the EIP benchmarks of the International EIP

Framework is provided in [24]. It is beyond the scope of this paper to cover a detailed discussion on the EIP benchmarks.

The assessment demonstrated that Khanh Phu currently meets 22 (six park management, seven environmental, five social and four economic benchmarks) out of the 51 benchmarks, equivalent to 43 percent of the applicable international benchmarks, while 13 benchmarks (one park management, one economic and 11 environmental benchmarks) are currently not met. The actual performance of Khanh Phu is expected to be higher, as the performance against 16 benchmarks needs to be confirmed through further data validation.

Based on the application of the EIP Assessment Tool, a set of EIP opportunities was identified for consideration by Khanh Phu management, covering park management as well as the park's environmental, social and economic performance. In collaboration with Khanh Phu management, the EIP opportunities were prioritized based on their likely achievability, potential benefits (economic, environmental and social) and interest from park management and companies. Such EIP opportunities may be selected for follow-up by Khanh Phu management directly or, alternatively, through international support. After this assessment has been carried out, a key next step would be to assist in the implementation of promising EIP opportunities through an action and monitoring plan, including key actions, responsibilities and timelines. This plan should then be regularly reviewed to reflect the progress made, as well as to address potential changes in priorities and external circumstances.

3.4. Learnings from Tool Application

Beyond its utilization in Viet Nam, the EIP Assessment Tool was applied in Colombia (with Parque Industrial Malambo (PIMSA)), Morocco (with Berrechid Industrial Eco-Park) and South Africa (with East London Industrial Development Zone (ELIDZ)) [7,26]. The tool utilization in these countries revealed that some criteria are not applicable in many industrial parks and should be adapted. For instance, five criteria (one environmental and four social) specifically address firms with more than 250 employees, the upper limit of SMEs in Europe. These criteria are not relevant in a number of industrial parks in developing countries, where companies with more than 250 employees are difficult to find.

In Morocco, the tool was applied to assess a new industrial park. For most of the criteria, it was possible to obtain information by consulting the master plan. Only six criteria could not be confirmed due to a lack of available data, which demonstrates that the tool can be used effectively at the planning stage of an industrial park. This new industrial park was planned as an EIP by an experienced park designer/manager, who helped to find the relevant missing information for input in the tool.

The application of the EIP Assessment Tool to date in Viet Nam and other project countries by UNIDO demonstrates that the International EIP Framework [24] provides a comprehensive and practical basis from which to assess industrial parks against international benchmarks [7,26]. It has created learnings to update some of the criteria in a subsequent version of the International EIP Framework, as some criteria were found not very practical (difficult to obtain the underlying data), not very relevant (too simplistic, too vague), or very difficult to comply with (almost never fulfilled).

UNIDO's experiences to date in the project countries confirmed that the utilization of the tool was helpful in revealing innovative EIP opportunities in the industrial parks through interactive workshop sessions (e.g., opportunities such as establishing joint-industry committees on waste management and recycling, creating a business unit for the management of wastewater and its reuse, updating the Master Plan to incorporate industry clustering and joint industry facilities). Therefore, it is advised that the assessment be carried out in close collaboration with park management staff (including the park director, operations and infrastructure manager and environmental coordinator).

The use of the EIP Assessment Tool served as a basis for park management to support engagement with its external stakeholders on its strategic position, current performance and future plans for transformation into an EIP.

The action plan to address gaps in the performance against the International EIP Framework needs to apply a step-by-step approach to enable industrial parks to work towards an EIP through a process of continuous improvement. Such an approach is important to ensure that the industrial park's management, monitoring and reporting structures are being developed in a self-sustainable manner. An action plan that is too ambitious and not aligned with the priorities of park management and tenant companies will result in ineffective implementation and disappointment.

4. EIP Selection Tool: Prioritization of Parks for EIP Interventions

This section discusses the rationale, objective and methodology of the EIP Selection Tool, followed by the results from the tool application in Viet Nam and learnings from the tool application in other countries.

4.1. Rationale and Objective

Before implementing EIP projects, it is important to understand the baseline and potential of existing industrial parks to be transformed into EIPs (i.e., their current performance). This potential depends on a number of factors, such as the commitment of park management, the diversity of industries located in the park, as well as visibility and the potential for replicability. Selecting industrial parks through a structured and comprehensive process is critical to avoiding the selection of industrial parks that do not match the project's scope and objectives with regard to park management, environmental/social/economic aspects, replication and visibility. Working with the most appropriate pilot parks (in terms of potential for improvement and features for project implementation) is important in allowing efficient use of human and financial resources.

The objective of the EIP Selection Tool is therefore to support the selection of (existing) industrial parks with high potential for EIP development and to identify successful, visible and replicable EIP projects. The key steps of the tool are introduced in the following paragraphs.

4.2. Methodology

4.2.1. Step 1: Shortlisting Industrial Parks for Consideration in the Selection Process

The full list of industrial parks within a defined geographical boundary (e.g., country, province) needs to be screened in order to obtain a shortlist of industrial parks. Screening criteria are unique for each country and project, but might include: operating park; available contact information; accessible location; built area (more than 50 percent developed). It is envisaged that up to 10 to 15 industrial parks can be shortlisted for consideration in the selection process (this number can vary depending on the resources available).

4.2.2. Step 2: Pre-Selecting Industrial Parks that Meet Minimum Selection Criteria

This step involves the pre-selection of industrial parks based on minimum selection criteria (e.g., management, size, industrial activities, law and regulation, confidentiality, risk, location, commitment). The pre-selection criteria are binary criteria that can be answered with "Yes" or "No". A "No" answer to one or more criteria could disqualify an industrial park from being part of the EIP project, or at least trigger a discussion within the project team on the suitability of the industrial park in question.

4.2.3. Step 3: Prioritization of Pre-Selected Industrial Parks

The prioritization of pre-selected industrial parks is based on a set of 19 qualitative criteria formulated as statements. Each statement needs to be answered for the pre-selected parks, by giving scores from 1 (totally incorrect) to 6 (totally true). The weight of each prioritization statement can be changed to reflect specific country priorities. Answering each statement will generate a graph with the average prioritization score for each industrial park, as well as a graph with a prioritization score on each criterion (e.g., park management, environmental/social/economic interventions, replicability,

visibility). An industrial park is considered high priority (i.e., high potential to be transformed into an EIP and features for successful EIP project implementation) if all criteria are fulfilled.

4.2.4. Step 4: Review of Prioritized Industrial Parks against International EIP Framework

The prioritized industrial parks are reviewed against the International Framework for Eco-Industrial Parks [24]. This review indicates the current performance of the parks based on the criteria provided in the international framework and the score (in terms of the percentage of criteria fulfilled) envisaged at the end of the EIP project (based on ex ante expert opinion). A review against the International EIP Framework is advised only for parks which were given an overall high prioritization score (in step 3) and not for parks which were allocated an overall low prioritization score. A prioritization score is considered high if the total average score of all prioritization criteria is higher than a given threshold, for instance 4.5. The review is not intended to be as detailed as for the EIP Assessment Tool.

4.2.5. Step 5: Final Selection of Industrial Parks

The prioritization (Step 3), together with the review against the international framework (Step 4), supports the selection of suitable and most suited industrial parks for an EIP project. The number and types of industrial parks to be selected will depend on the scope and available resources (financial and human), as well as the national context and the priorities of government agencies and donors.

A number of options are available for the types of industrial parks to be selected for an EIP project. One approach is to select a “model” industrial park, in combination with one or more lower-performing parks with significant potential for improvement. The model park has a high current performance with regard to the International EIP Framework and could serve as a leading example in the country to encourage other parks to transform into an EIP.

4.3. Results from Tool Application in Viet Nam

The EIP Selection Tool was applied to support the selection of industrial parks in Viet Nam for UNIDO’s Global EIP Programme. The application of the tool was undertaken through a multistakeholder consultation process, including the MPI, provincial authorities, industrial park/zone developers (“park management”), the donor agency (SECO) and UNIDO.

The data to support the application of the tool in Viet Nam was provided by the relevant national stakeholders (as listed in the previous paragraph), as well as data collected through the GEF and SECO-funded project. As with the other EIP tools presented in this paper, the objective of the EIP Selection Tool was not to serve as a full statistical analysis, but rather as a pragmatic approach to guide decision-making and support stakeholder consultations for UNIDO’s EIP programme.

Four provinces (Dong Nai, Hai Phong, Thanh Pho and Ho Chi Minh) account for a significant proportion of industrial activity in Viet Nam and the authorities in these four provinces demonstrate a high level of commitment to transforming existing parks into EIPs. As a result, these four provinces have been prioritized by the MPI for further pilot EIP work in the country. In consultation with the provincial authorities, ten industrial parks were shortlisted to be considered for participation in the Global Eco-Industrial Parks Programme (GEIPP), based on initial screening criteria (e.g., size of the industrial park, interest and commitment of park management, diversity of industrial activities).

Nine of the ten shortlisted industrial parks met all of the pre-selection criteria. One of the parks is located in a flood-prone area, but the park management and the city have taken a series of preventive measures to minimize the risks of flooding in the future. It was therefore decided to keep the industrial park in the pre-selection for the GEIPP.

The total scores from the prioritization of the pre-selected industrial parks are presented in Figure 3. The y-axis in the figure is the average score of the 19 weighted prioritization criteria. Each of the prioritization criteria were rated from 1 (totally incorrect) to 6 (totally true) (see Step 3 in Section 4.2.3). Parks are grouped according to their geographical location (North, Centre and South Viet Nam), as the

intention is to take into account the geographical balance for the GEIPP. In Figure 3, a higher score means that the park has greater potential to transform into an EIP and the park embeds more favorable features for the successful implementation of the GEIPP.

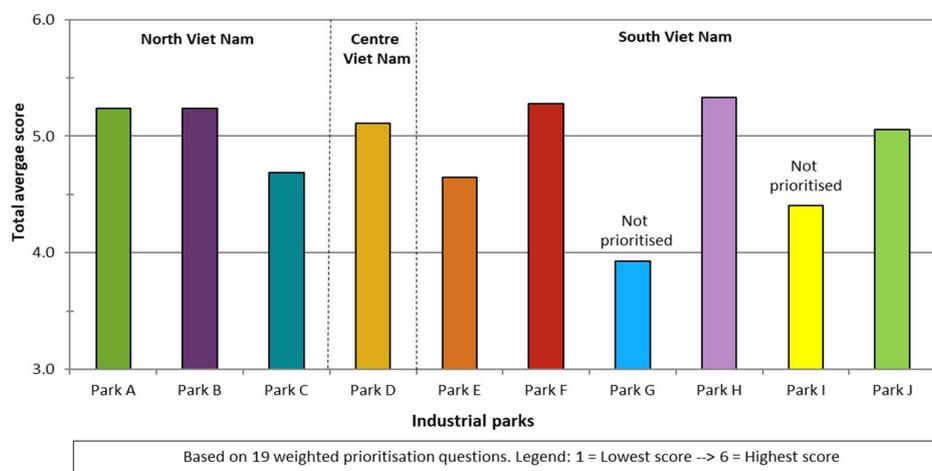


Figure 3. Prioritization of industrial parks for GEIPP Viet Nam—Total scores.

In the north of Viet Nam, both Park A and Park B showed an equally high potential for transformation into an EIP, as well as favorable features for successful GEIPP implementation. In the south of Viet Nam, three parks have a total average prioritization score of over 5, and therefore show great potential for the successful implementation of the GEIPP. Based on the prioritization, Parks G and I were excluded from the selection process as they have a lower average score in comparison with the other industrial parks. A lower score indicates that a park has a lower potential to transform into an EIP and embeds fewer features for successful EIP project implementation.

A review of the current and intended performance (at the end of the EIP programme) of the prioritized industrial parks against the International EIP Framework was undertaken. The results (shown in Figure 4) demonstrate that Park J has the highest score on its current performance against the International Framework, as well as its intended performance at end of the GEIPP. Park B and Park E are the two parks with the largest difference between current and intended performance. The International EIP Framework publication [24] provides a description and justification of all EIP benchmarks. A detailed discussion on the EIP benchmarks is beyond the scope of this paper.

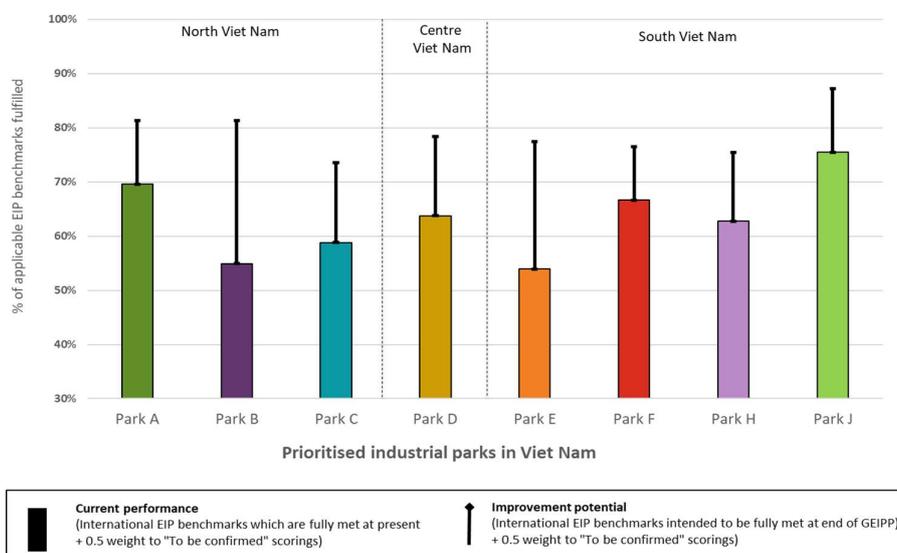


Figure 4. Review of prioritized parks against International EIP Framework.

In principle, all prioritized industrial parks are suitable candidates to receive capacity-building and advisory services on specific topics of interest. For the GEIPP in Viet Nam, this analysis made it possible to respond to a request from the recipient country to include among the beneficiaries one leading “model” industrial park in Viet Nam, which has a high score with regard to International EIP Framework, and one industrial park representative of the national context, with a high improvement potential.

4.4. Learnings from Tool Application

The tool provided a transparent step-by-step methodology for the prioritization of industrial parks for the GEIPP in Viet Nam, and its application subsequently proposed a set of industrial parks for assistance (e.g., technical assistance, capacity-building and advisory services). The tool enabled constructive discussions with national stakeholders and the donor on the final selection of industrial parks to participate in the EIP programme.

The gaps identified through the reviews against the International EIP Framework provide a good basis to scope EIP interventions for a project. Generally, EIP interventions include a combination of technical assistance, specific advisory services, capacity-building and awareness-raising for park management, tenant companies and other national stakeholders (e.g., local and national government agencies).

The EIP selection tool was also tested in Morocco, Colombia and Peru in 2018 and 2019. The utilization of the tool in Morocco highlighted the importance of collecting essential data on industrial parks in a systematic manner during the selection process. A worksheet was therefore added in order to report all basic information about the park and its surroundings (e.g., infrastructure and key challenges affecting the park). All of this basic information is summarized in the tool, which can prove highly useful at a later stage, during the implementation phase of an EIP project. The experience also demonstrated that the tool is useful for scoping further technical interventions. As a result, graphics highlighting the score per category of criteria (e.g., environmental, social) have been added to the tool in order to provide information about the scoping of EIP interventions.

International experiences demonstrate the importance of providing focused and in-depth assistance to a limited number of carefully selected industrial parks that fit the available human and financial resources of the development project/programme, rather than spreading available resources too thinly over too many industrial parks (Park et al., 2016; UNIDO, 2016; UNIDO, 2017; UNIDO, 2019). The EIP Selection Tool can assist in this process.

Criteria of key importance for the successful selection of industrial parks for an EIP project, and which were therefore given a high weight in the scoring phase, are as follows: (1) clear commitment from park management, (2) sufficient resources (e.g., human, financial) of park management to work towards an EIP, (3) sufficient number and diversity of industries located in the park to develop industrial synergies; and (4) the industrial activities in the park are representative of the national economic landscape to ensure replication after the project’s end.

The application of the EIP Selection Tool in Colombia and Peru confirmed the importance of having an objective and transparent selection methodology, with a view to enabling constructive discussions with national stakeholders on the selection of industrial parks to participate in a development project.

5. Industrial Symbiosis Identification Tool: Identification of Opportunities for By-Product Reuses between Companies

This section discusses the rationale, objective, methodology of UNIDO’s Industrial Symbiosis Identification Tool, followed by the results from the tool application in Viet Nam and learnings from other countries.

5.1. Rationale and Objective

Industrial symbiosis engages traditionally separate industries in a collective approach to competitive advantage, involving the physical exchange of materials, energy, water and/or

by-products [27]. The identification of industrial symbiosis opportunities is often conducted through rigorous assessments, including the analysis of industry inputs/outputs, opportunity identification workshops and a desktop review of international experiences. These are all valuable methods that provide a comprehensive set of specific and practical industrial symbiosis opportunities for an industrial park. Before conducting these detailed assessments, it is often highly valuable to generate an indicative list of industrial symbiosis opportunities for an industrial park without a significant time investment. Such an exercise can assist in convincing park management and companies about the potential opportunities and create an interest and commitment to carry out detailed assessments.

The objective of the Industrial Symbiosis Identification Tool is to support the identification of industrial symbiosis opportunities (by-product and waste exchanges) between companies. This tool can be used in fully occupied industrial parks to provide stakeholders with an indication of the symbiosis opportunities related to companies operating in the park. The tool can be used for industrial parks under development, highlighting possible industrial symbiosis between existing and new companies locating to the park, and thereby assisting in the planning of infrastructure and utilities to enable these connections. The tool is based on two approaches that can be conducted in parallel, as explained in the following paragraphs. Alternatively, companies may have already identified a potential industrial symbiosis opportunity but might need more robust evaluation before deciding to invest additional time and effort.

5.2. Methodology

5.2.1. Approach 1: Search on By-Product and Waste

The worksheet “Search by-product” (template provided in Figure 5) is used to identify industrial symbiosis opportunities based on the selection of a specific by-product or waste. The user only needs to make the search selection under “By-product/waste”, based on which other cells are populated automatically. For example, the worksheet can inform the user of which industry can be interested in utilizing the by-product gypsum. The worksheet also informs the user if similar by-product exchanges have already been implemented elsewhere in the world.

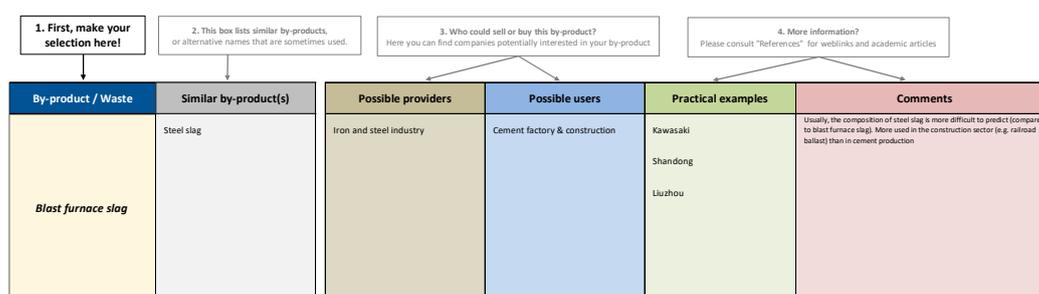


Figure 5. Framework of the Industrial Symbiosis Identification Tool—Search on By-Product or Waste.

5.2.2. Approach 2: Search by Company Type

The worksheet “Search by company” (template provided in Figure 6) is used to identify potential industrial symbiosis options based on the selection of a specific company type. The user only needs to make the search selection under “Select a company”, based on which other cells are populated automatically. Based on the selection, the worksheet generates a list of inputs and outputs related to a specific company type, as well as a list of industries with a potential interest in creating industrial symbiosis. For example, the worksheet can inform the user about alternative raw materials and potential reuses of the by-products/wastes of a cement plant.

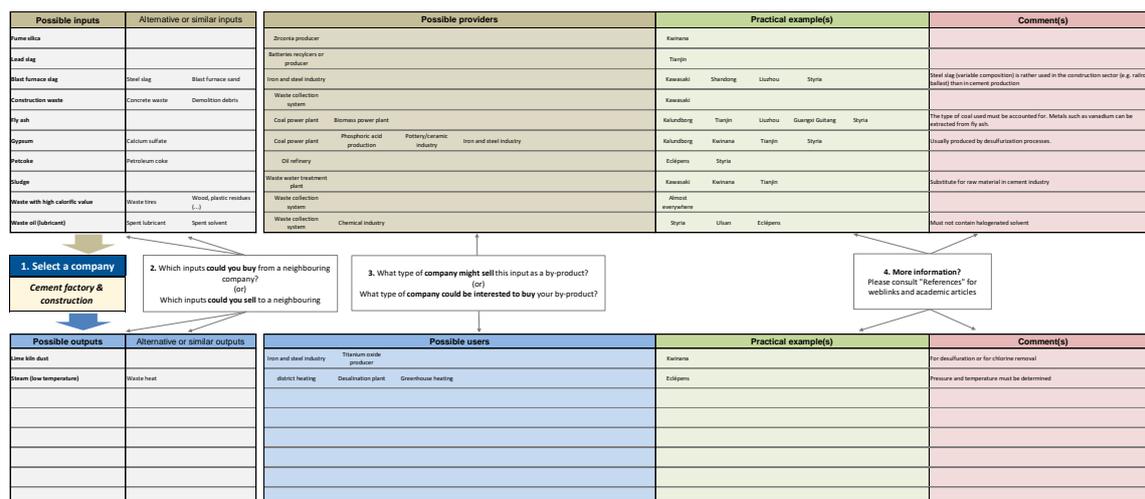


Figure 6. Framework of the Industrial Symbiosis Identification Tool—Search on Company Type.

5.3. Results from Tool Application in Viet Nam

Training on the development and implementation of EIPs was provided by UNIDO to park management and governmental officials in Viet Nam (July 2018). Training topics included, among others, the identification, development and implementation of industrial symbiosis.

The Industrial Symbiosis Identification Tool was used as an interactive exercise during the training. Participants used the tool to identify symbiosis opportunities in the three pilot industrial zones of a UNIDO-GEF project on EIPs (e.g., Khanh Phu, Hoa Khanh and Tra Noc 1 & 2). The short exercise with the tool (15 min) helped to identify concrete opportunities for the three industrial parks, which were then prioritized by the trainees according to their likely achievability and anticipated benefits. The results are presented in Table 3 (company names have been removed for confidentiality). These results were used by the management of the three parks as a basis for more detailed assessments after the training.

Table 3. Result from the application of Industrial Symbiosis Identification Tool during the EIP training in Viet Nam (July 2018).

Achievability	Easy	<ul style="list-style-type: none"> Extract protein from fish wastes of seafood processing companies for the production of animal feed. Use of alcoholic residues from chemical companies and enzyme manufacturers for wastewater treatment plant (carbon source of denitrification bacteria). 	<ul style="list-style-type: none"> Use of by-products and off-spec products from fruit processing by farms raising cows, goats and wild pigs (outside industrial park). Use slag from steel factory as an additive for cement factory. Use kiln slag from steel factory by zinc oxide factory as alternative raw material.
	Medium	<ul style="list-style-type: none"> Use of ammonium sulphate from steel production for fertilizer production. 	<ul style="list-style-type: none"> Use waste heat from steel plant for steaming and drying at garment factory.
	Difficult		<ul style="list-style-type: none"> Transfer excess heat from industrial companies to three paper mills nearby as energy source for their boilers. Use zinc slag from zinc oxide factory by brick factory to make unburnt bricks.
		Low	High
BENEFITS			

5.4. Learnings from Tool Application

The tool is valuable in highlighting the potential for industrial symbiosis in any industrial park based on just the type of company or waste stream. It can quickly identify an initial set of industrial symbiosis opportunities based on international experiences. The opportunities identified were referred to as “tip of the iceberg” options during the training as it is envisaged that many more opportunities for collaborations can be identified if a detailed assessment is conducted. This initial assessment with the tool helped to scope the next activities to develop promising opportunities (e.g., follow-up with companies, feasibility studies), and identification of further symbiosis opportunities through more detailed analysis. The tool has been used by UNIDO to generate ideas during a number of workshops, meetings and trainings in Colombia, Morocco and South Africa.

Experiences to date shows that the use of the tool can trigger constructive discussions among users on collaborations that are not included in the tool (e.g., shared services, supply chain synergies). In other words, the use of the tool helps to create a mind-set of thinking “outside of the box” and generates an understanding that all companies are part of a wider industrial eco-system.

The utilization of the tool highlighted a demand to extend the scope of the tool to other types of industrial synergies (e.g., service synergies, supply chain synergies). Moreover, additional information could be integrated in the tool. For instance, the tool could provide an estimation of the potential financial savings afforded by specific industrial symbiosis opportunities.

6. RECP Monitoring Tool: Measuring Impacts from Company Assessments

The rationale, objective and methodology of the RECP Monitoring Tool are discussed in this section, followed by the results from its application in Viet Nam and learnings from other countries.

6.1. Rationale and Objective

In EIP projects, UNIDO often starts by improving production processes in individual companies through the so-called RECP approach. Projects on EIPs and RECP can be considered successful only if they deliver concrete results and impacts. It is therefore important to monitor the results achieved in a systematic manner. This is particularly the case for development organizations whose core focus is on project implementation.

The objective of the RECP Monitoring Tool is to monitor and report the resource savings and results of RECP assessments undertaken with companies in industrial parks. The tool provides a standardized method to calculate and monitor the economic, environmental and social benefits of RECP opportunities identified and implemented as part of EIP projects.

6.2. Methodology

The worksheet “RECP Monitoring” is used to report systematically the results from the RECP assessments undertaken with companies in industrial parks. The monitoring covers basic information about the RECP options identified and implemented, electricity savings, fuel savings, water savings, materials savings, financial savings and other benefits. Illustrative examples on how to fill in the columns are provided in the tool.

Separate worksheets are included in the tool to summarize the RECP results at company level, as well as the accumulative savings at the industrial park level. These worksheets are automatically calculated based on the RECP monitoring worksheet.

6.3. Results from Tool Application in Viet Nam

The RECP Monitoring Tool was applied to monitor the results from RECP assessments undertaken with 57 companies in the pilot industrial zones participating in the UNIDO-GEF project on EIPs, namely Khanh Phu industrial zone, Hoa Khanh industrial zone, and Tra Noc industrial zones 1 and 2. A summary of these results is presented in Table 4. Initially more than one thousand RECP

options were found, and these were consolidated in 680 concrete and practical RECP options identified, of which 546 were implemented in companies that are still operating today. These RECP options have delivered substantial savings, including electricity, fossil fuels, greenhouse gas emissions, water and materials/chemicals, resulting in financial savings of EUR 2.5 million per year, and almost EUR 10 million mobilized by target companies themselves, with an average payback time of seven to eight months.

Table 4. RECP Monitoring Tool—Results for Viet Nam (operating beneficiary companies in industrial parks, as of April 2019).

	Khanh Phu (Ninh Binh)	Hoa Khanh (Da Nang)	Tra Noc 1&2 (Can Tho)	Total
Number of companies assessed	13	15	25	53
Total number of RECP options identified (number)	213	138	329	680
• Implemented	181	114	251	546
• Planned implementation	8	11	7	26
• Probable implementation	13	5	4	22
• Unlikely	9	8	66	83
Electricity savings (MWh/year)	5406	4984	12,718	23,108
• Implemented	5406	354	11,824	20,784
• Planned implementation	0	101	0	101
• Probable implementation	0	0	287	287
• Unlikely	0	0	607	607
Fossil fuel savings (GJ/year)	115,745	1265	24,682	141,692
• Implemented	115,745	1180	24,308	141,233
• Planned implementation	0	85	375	460
• Probable implementation	0	0	0	0
• Unlikely	0	0	0	0
CO₂ emission reduction (t CO₂/year)	15,718	4588	13,611	33,917
• Implemented	15,718	3,275	12,788	31,781
• Planned implementation	0	920	0	920
• Probable implementation	0	0	264	264
• Unlikely	0	0	559	559
Water savings (m³/year)	11,715	193,366	370,964	576,045
• Implemented	11,715	188,675	268,801	469,191
• Planned implementation	0	130	260	390
• Probable implementation	0	0	0	0
• Unlikely	0	0	0	0
Material/chemicals savings (tonnes/year)	91	787	15	893
• Implemented	91	767	15	873
• Planned implementation	0	10	0	10
• Probable implementation	0	10	0	10
• Unlikely	0	0	0	0
Financial savings (in EUR/year)	951,192	542,678	1 023,834	2 517,704
• Implemented	951,192	389,910	943,457	2,284,559
• Planned implementation	0	121,665	801	122,466
• Probable implementation	0	303	16,563	16,866
• Unlikely	0	0	0	0
Average payback time (years)	0.71	0.29	0.80	0.6
• Implemented	0.71	0.20	0.83	0.58
• Planned implementation	0	1.00	0.27	0.42
• Probable implementation	0.0	0.0	0.0	0.0
• Unlikely	0.0	0.0	0.0	0.0

Note: the benefits reported in this table refer to the actual yearly benefits measured during the last assessment of 2018–2019. These can vary significantly from previous years, since production level fluctuates from year to year and some companies went out of business since the previous assessment.

The tool allowed a consistent report across companies and industrial parks in Viet Nam, as well as other countries in which UNIDO operates, contributing to making results coherent, transparent and comparable. The consolidated results produced by the tool were used by UNIDO to report the identified and achieved savings to the project donor (GEF) and national stakeholders (e.g., the MPI and provincial authorities), as well as providing input for communication materials to promote the effectiveness of RECP approaches to industries (e.g., UNIDO, 2019).

6.4. Learnings from Tool Application

It is most efficient and effective to start using the tool from the beginning of an EIP project. In this way, it serves as an operational tool to guide the ongoing project monitoring and eventual implementation of RECP opportunities. The tool is useful in generating a summary of RECP results to be included in the project progress and final reports for the national stakeholders and the donor. Guidance from the coordinator of the development agency to the national consultant on how to use the tool can be helpful, depending on the complexity of the project and the RECP assessments. This guidance could also address any monitoring priorities of the project donor and the development agency. In this regard, an update to version 2 of this tool has recently been made by UNIDO to increase its user-friendliness and to add more detailed instructions.

The application of the tool also resulted in suggestions for specifying in the reporting sheet more quantitative and qualitative information on the wastewater saved, as well as the addition of the possibility of adding more materials and related quantities that might be saved as a result of a single RECP intervention.

The utilization of the RECP Monitoring Tool in Colombia, India and South Africa confirmed the importance of using it from the very early stages of an EIP project in order to monitor the progress of RECP opportunity implementation. Since such assessments can be undertaken by different experts in the same industrial park, the need emerged to provide clear instructions about the tool's utilization, in order to ensure that experts use the tool in a consistent manner.

7. Conclusions

The application of the EIP tools to date demonstrated their value in contributing to the development and implementation of EIP practices. The lessons learned from the application of each specific tool are discussed in the previous sections of this paper. An overall lesson learned from the tools' application to date is that, rather than a stand-alone solution, the tools are best placed to be used effectively as a supplementary instrument, in conjunction with other pragmatic and detailed implementation approaches such as company assessments to identify and develop company-level resource efficiency and industrial symbiosis opportunities. They are useful to identify "tip of the iceberg" symbiosis or RECP options through interactive stakeholder consultations or workshops, and to guide participants through a step-by-step structured approach. The RECP tool, in particular, was also found to be very useful for project monitoring and in reporting the impacts of EIP interventions in a consistent manner. The added value of the tools is to support decision-making and stakeholder consultation processes on specific EIP topics of interest. The tools can be adapted to suit specific situations, however basic knowledge on EIP concepts is required to use the tools. This is also why UNIDO has been developing supporting handbooks, guidelines and awareness-raising materials on EIPs [4,7,12,24].

The current version of the UNIDO EIP Toolbox represents version 1.0, developed in 2018. The key learnings described in this article are therefore based on the application of the tools over approximately one year. It is envisaged that the set of tools will be updated and expanded to reflect learnings from their ongoing applications in EIP projects in Viet Nam and other countries. In fact, some criteria of the International EIP Framework were found not practical enough, not very relevant or difficult to comply with. UNIDO will regularly improve the toolbox on the basis of suggestions received from the application of the tools. It is hoped that this paper creates further interest among EIP stakeholders and the academic community in applying the freely available UNIDO EIP Toolbox as well as feedback

from users in developing, transition and developed countries to further strengthen and expand the tools. UNIDO welcomes the opportunity to discuss options and available support on EIPs with interested stakeholders.

As part of the Knowledge Management Component of the Global EIP Programme, UNIDO's EIP Toolbox will be updated and further expanded, including the development of additional tools customized to the specific needs of industrial parks and national stakeholders.

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