



Total Resource and Energy Efficiency
Management System for Process Industries

Deliverable 4.4

User guide for getting started with industrial symbiosis

Date: 05/12/2017

WP4 Industrial Symbiosis

T4.4 User guide to engage in industrial symbiosis

Dissemination Level: Public

Website project: <http://maestri-spire.eu/>

© The Authors, 2017

The text and images in this report are licensed under a [Creative Commons Attribution 4.0 International License](https://creativecommons.org/licenses/by/4.0/), which permits use, distribution and reproduction in any medium, provided the original work is properly cited.



Total Resource and Energy Efficiency Management System for Process Industries

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 680570



Author

Name: Maria Holgado
Organisation: UCAM

Name: Steve Evans
Organisation: UCAM

Document history

VERSION	DATE	AUTHOR	DESCRIPTION
0.1	07.11.2017	M. Holgado	Table of Contents / working document
1.0	28.11.2017	M. Holgado, S. Evans	Final version

Internal review history

REVIEWED BY	DATE	DESCRIPTION
Hans-Joachim Weintz	04.12.2017	Revision by JWO (over version 1.0)
Antonio Coelho	05.12.2017	Revision by MCG (over version 1.0)

Document details

FILE NAME	VERSION
MAESTRI-D4_4_v1.docx	1.0

DOCUMENT OWNER	ORGANISATION
Maria Holgado	UCAM

Executive Summary

The MAESTRI project aims to tackle improvements in the impact of manufacturing activities at both company level and system level in order to achieve significant results. A holistic approach will enable process monitoring and optimization, as well as focus on an integrated and cross-sectorial interaction that can have a greater impact within the process industry. MAESTRI project encompasses an Industrial Symbiosis (IS) approach, which, within the scope of sustainable manufacturing for process industries, fosters the sharing of resources (energy, water, residues and recycled materials) between different processes of a single company or between multiple companies.

Findings from previous MAESTRI activities indicate that there is a need to provide companies with structured and systematic ways to uncover the latent value in waste resources and to support the adaptation to each particular business context and the identification of opportunities at local / regional level.

This document presents a User Guide to Engage in Industrial Symbiosis, linked to the Toolkit for Industrial Symbiosis (T4IS) presented in previous Deliverable D4.3. Toolkit for Industrial Symbiosis. The User Guide is developed to serve as an introductory / supporting material for the use of the T4IS by companies. The T4IS is built upon four guiding questions, the four HOW TOs: How to SEE waste, How to CHARACTERISE waste, How to VALUE waste and How to EXPLOIT waste. These guiding questions represent the main steps in a development process for IS exchanges. The User Guide introduces the concept of IS and an overview of the steps based on the HOW TO questions.

The focus of WP4 within MAESTRI project is to provide companies with methods and tools to develop self-organising IS to the extent that this is possible. This User Guide constitutes an easy-to-read brief document for practitioners to find selected information on what the concept of industrial symbiosis is, how to develop an IS project and some recommendations to increase its likelihood of success. This User Guide completes the delivery of the MAESTRI approach to support companies in their journey towards implementing IS-based solutions.

Table of contents

Executive Summary	3
List of figures and tables	5
Abbreviations	5
Definitions	5
1 Introduction	6
1.1 Background.....	6
1.2 What is the User Guide?	7
1.3 User Guide development process	7
2 User Guide to Engage in Industrial Symbiosis through the T4IS	9
2.1 Description	9
2.2 Guide pages	10
3 Concluding remarks	12
References	13

List of figures and tables

Figure 1 Overview of the activities within the design process for the user guide	7
Figure 2 Example of Quick Guide from the EPSRC Centre for Innovative Manufacturing in Industrial Sustainability	8

Abbreviations

CAS	Chemical Abstracts Service	IS	Industrial Symbiosis
CASRN®	Chemical Abstracts Service Registry Number	NACE	Nomenclature générale des Activités économiques dans les Communautés Européennes
CPA	Classification of Products by Activity	T4IS	Toolkit for Industrial Symbiosis
EWC	European Waste Catalogue		

Definitions

By-product > a production residue that is not a waste, also referred to as non-waste by-product. It is a substance or object, resulting from a production process, the primary aim of which is not the production of that item; the substance or object's use is certain, possible without further processing and it is produced as an integral part of the production process (EUROPEAN COMMISSION, 2007)

Industrial Symbiosis (IS) > It encourages companies to adopt a collaborative approach in all aspects of their business so that resources can be recovered, reprocessed and reused elsewhere in the industrial network either by themselves or by other companies (WRAP, 2014).

Product > all material that is deliberately created in a production process (EUROPEAN COMMISSION, 2007)

Secondary outputs > this term refers to outcomes of production processes that are not deliberately produced, not only material outputs

Waste > It is any substance or object which the holder discards or intends or is required to discard (EUROPEAN COMMISSION, 2008).

1 Introduction

This section provides an introduction to the work done within task 4.4 “User guide to engaging in industrial symbiosis” and to the structure and purpose of the User Guide.

1.1 Background

Industrial Symbiosis (IS) is “*principally concerned with the recovery and reuse of wastes (materials, water, or energy) from one industry as alternative input in a neighbouring facility*” (VAN BERKEL, 2009). There are different types of IS related exchanges. They can occur as a one-off material waste exchanges between two parties or in more continuous flows exchanged within factory or organisation boundaries or between different companies with certain geographic proximity (CHERTOW, 2000). The entities participating in IS could be either companies or factories as IS opportunities arise at process level (LOMBARDI and LAYBOURN, 2012). Therefore, the IS concept can cover both, the cases in which IS opportunities are realised by a single company (intra-firm IS) and those realised in partnership with other companies (inter-firm IS).

The high degree of characterization needed for the design of IS in different contexts means practitioners would benefit from support (e.g. tools and methods) developed specifically to address contextualization challenges for IS design and planning. Concretely, there is a need to support companies to develop IS in a spontaneous manner, i.e. without external intervention nor facilitation. This is the overall purpose of WP4 “Industrial Symbiosis” within MAESTRI project. This purpose led all activities done and summarised in previous Deliverables¹:

- Deliverable D4.1 “Report on challenges and key success factors and gap analysis for industrial symbiosis” (HOLGADO and EVANS, 2017) reviewed the main challenges and success factors in engaging with and implementing an IS approach to improve resource efficiency.
- Deliverable D4.2 “Prototype library of case studies linked to a waste database” (BENEDETTI ET AL., 2017) described a prototype library of case studies and a linked exchanges database developed to gather new ideas and identify potential IS application opportunities.
- Deliverable D4.3 “Toolkit for industrial symbiosis” (HOLGADO ET AL., 2017) describes the Toolkit for Industrial Symbiosis (T4IS) built upon four guiding questions - the four HOW TOs - representing the main steps in a development process for IS exchanges.

The T4IS is a set of tools and methods proposed to support companies developing IS applications. The different tools constitute a self-guided process that companies can use for identifying potentially exploitable wastes and value creation strategies. The toolkit builds on 4 guiding questions, which represents key steps to develop an IS opportunity:

- **How to see waste** concerns how to be aware, recognise and discover wasted resources within the manufacturing process and facilities;

¹ All deliverables are available to download in MAESTRI website: <https://maestri-spire.eu/downloads/technical-materials/>

- **How to characterise waste** relates to how to describe the character and properties of those identified wasted resources;
- **How to value waste** concerns how to determine the estimated or assigned worth for the wasted materials;
- **How to exploit waste** relates to how to utilise and make the best use of the wasted materials.

The T4IS addresses the need for tools and methods to support self-organised IS. It represents a self-guided process that companies can use for identifying potentially exploitable wastes and value creation strategies. It is envisaged to need initially some facilitation and training from T4IS developers and afterwards companies will be able to use it themselves after the initial facilitation and training sessions.

1.2 What is the User Guide?

The User Guide is a brief high-level summary for practitioners. It is envisaged to provide an introduction to the IS concept and an overview of the T4IS steps in order to support the understanding of these steps to engage in industrial symbiosis. It is not meant to be a comprehensive document. The guide serves as a simplified overall explanation of the HOW TO questions framed as steps within the T4IS.

This User Guide is helpful for managers in manufacturing and process industry that: (1) are interested to learn about the IS concept in order to get a first insight on what it means and what benefits could bring to their company; (2) are planning to start an IS project by using the T4IS. In the latter case, the User Guide can serve as a reference document to engage internal stakeholders in the IS project and to communicate the T4IS overview and steps to those involved in the project development and implementation.

1.3 User Guide development process

The User Guide development process can be defined in 3 main phases (Figure 1): design, content development & test, final revision. Phases are described herein.



Figure 1 Overview of the activities within the design process for the user guide

The design phase included a search for current templates and uses of short guides in sustainability related research centres and institutions. After the analysis of different options, a proposed template was developed that contains space for stating the key learnings / takeaways, space for text and figures describing the steps to engage in industrial symbiosis as well as space for specific highlights of significant quotes and a final summary of learnings / actions to undertake in the form of a checklist. The template structure provides additional information regarding the target audience, keywords and contact information.

The key sources of inspiration for the development of this template were the EPSRC Centre for Innovative Manufacturing in Industrial Sustainability Quick Guides (see example in Figure 2) and the Carbon Trust quick guides (<https://www.carbontrust.com/resources/guides/>).



Figure 2 Example of Quick Guide from the EPSRC Centre for Innovative Manufacturing in Industrial Sustainability

The content development & test phase was done closely with the design of the T4IS steps and primary tools, thus, allowing to identify the key points for understanding T4IS most relevant to practitioners. Moreover, it is strongly inspired by the analysis of capabilities required for an IS project done in collaboration with MAESTRI industrial partners. This analysis was performed as part of a full-day workshop in the format of a 2-hour session to identify capabilities acquired and required by companies to support the implementation of an IS project. The workshop is described in more details in section 1.4.1 “Initial workshop for toolkit development” of previous deliverable D4.3 “Toolkit for industrial symbiosis” (HOLGADO ET AL, 2017).

The testing approach for the user guide during its development included discussions and partial testing of ideas during the T4IS development process.

The final revision phase has been done internally within UCAM team and MAESTRI project team and externally, by exposing non-MAESTRI companies to the logic behind the T4IS and the user guide working version. Feedback was positive and small minor adjustments were made for the user guide final version described in this document.

2 User Guide to Engage in Industrial Symbiosis through the T4IS

This section presents the structure of the user guide to engage in industrial symbiosis through the T4IS and shows the two pages composing the guide itself.

2.1 Description

The user guide has five distinguishable sections:

The *heading* includes MAESTRI logo and key information about the audience and the keywords that can characterise the content of the user guide.

The *initial part* at the top of the first page, includes the title, which is followed by the key learning points or takeaways from the content of the guide. The three key learning points that practitioners can obtain from this guide has been framed as:

1. Learn about the concept of IS
2. Understand how to develop an IS project
3. Understand how to increase the likelihood of success

The *main text* conforms the body of the user guide. This text provides an overview of the concept of IS and introduces the T4IS steps that companies can follow to develop a successful IS project. Colours and spaces to highlight significant quotes are used to underline specific key content.

The *final section* includes a list of recommended actions to increase the likelihood of success in IS projects when using the T4IS.

The *footer* contains details on where to find more information, the contact person and website link for MAESTRI project. It also contains SPIRE logo, acknowledgment of funding and disclaimer from the European Commission.

The approach taken for the design of the structure and the creation of the content of the T4IS and use guide answers the needs identified in previous WP4 "Industrial Symbiosis" activities. The descriptive text and the recommended actions to successfully use the T4IS were selected to lead companies towards direct ways of developing the necessary capabilities required for IS projects. These capabilities were summarised in Deliverable D4.3 "Toolkit for industrial symbiosis" as:

- Having dedicated team for specific waste streams;
- Leveraging on cross-functional knowledge;
- Better time management;
- Creating employee engagement for IS;
- Creating networks in anticipation of new waste streams;
- Ability to replicate good sales team for waste streams.

These necessary capabilities can be somehow developed by following the T4IS steps and the recommended actions to successfully use the T4IS.

2.2 Guide pages

Front page of the User Guide



Practical Guide

Developed by Dr Maria Holgado, University of Cambridge

Audience: production managers, environmental managers, waste managers, R&D managers.

Keywords: circular economy, manufacturing, industrial symbiosis, industrial sustainability, resource productivity

User Guide to engage in industrial symbiosis through the T4IS

In this User Guide you will

- 1 Learn about the concept of industrial symbiosis
- 2 Understand how to develop an industrial symbiosis project
- 3 Understand how to increase the likelihood of success

Industrial symbiosis means, in practical terms, the recovery or reuse of secondary outputs from production processes as alternative inputs to other production processes. This happens at the level of production process, thus, the entities involved in the exchanges can be processes within the same factory, processes from different factories belonging to one company or processes from factories belonging to different companies.

One of the main challenges for its wide application is the high degree of contextualisation of the potential symbiotic solutions. In this regard, the appropriateness of the solutions to a certain context is strongly influenced by a set of factors, such as the type of production processes of companies involved in the symbiotic exchange, the geographical landscape and industrialization approach of the region and specific sectorial and / or national regulations and policy.

Within the MAESTRI project, a stepwise process has been developed to support the identification and analysis of potential symbiotic solutions, the Toolkit for Industrial Symbiosis (T4IS). The T4IS constitute a self-guided process to engage in industrial symbiosis and develop symbiotic exchanges. It supports the identification of possible alternative uses for exploitable wastes and their value creation strategies,

independently of the business context. Thus, it is framed in a very flexible way, in order to provide support in multiple cases and contexts.

The T4IS seeks to change how companies look at their waste, by considering that everything has potential to have or create value. Thus, the entire T4IS uses the term "waste resource" as an initial attempt to change companies' perception of waste and support the mind-set shift towards seeing waste as a new type of resource for companies. The T4IS guides companies along four steps framed as "How to" questions. A brief overview of these steps is provided herein.

The T4IS - a self-guided process to engage in industrial symbiosis and develop symbiotic exchanges.

How to see waste. A systematic analysis of value captured, destroyed and missed in production processes lays the foundation to identify waste resources. This step results in a comprehensive list of resources within production processes and facilities that can be potentially subject to industrial symbiosis, such as waste streams, secondary outputs and input resources.

How to characterise waste. The previously listed resources, specifically waste streams and secondary outputs, are categorised following a method based on widely known classifications

Back page of the User Guide

at European level (i.e. EWC, CPA and CAS Registry Number®). This is complemented with operational data to fully understand their nature and remaining properties, such as their chemical and physical characteristics, their substitutability or replacement potential, their hazardous behaviour and the needed mitigation and neutralisation actions.

How to value waste. The valorisation of waste resources (i.e. waste streams and secondary outputs) follows different strategies. This allows further flexibility to understand knowledge gaps related to possible symbiosis opportunities for each waste resource independently. An analysis is proposed based on different information sources in order to figure out: the potential market value of the resource or its separated components; the existence of implemented symbiotic exchanges involving the resource; the possibility to find solutions in the closest company network.

How to exploit waste. Actions to better exploit the valorised resources in the previous step are defined here. This involves identifying and understanding the exchange partner as well as configuring and developing the value creation and delivery system to make the best use out of the waste resources.

The T4IS addresses the need for tools and methods to support self-organised industrial symbiosis. Companies looking at innovating their operations can initiate the process by selecting a production area for analysis. The T4IS supports the definition of opportunities and the analysis of ideas to obtain higher value from the resources within that area. The use of the T4IS is envisaged to need initially some expert facilitation and training from T4IS developers and afterwards companies will be able to use it themselves and integrate the steps in their own innovation processes.

Actions to successfully use the T4IS

Schedule several on-site visits to plant, production areas and shop floor to ensure that all processes are taken into account and details do not get missed.

Dedicate time to select carefully the classification standard to be used for waste and secondary outputs.

Create a multidisciplinary team to work on the T4IS, bringing together expertise on energy and resources efficiency practices, production operations, purchasing and sales operations, business and innovation practices.

Consider the search for symbiotic opportunities as part of the innovation strategy of the company and integrate T4IS activities within company operations for new products / business areas development.

>> More information

MAESTRI Deliverable 4.3 "Toolkit for Industrial Symbiosis", available at: <https://maestri-spire.eu/downloads/technical-materials/>

>> Website

www.maestri-spire.eu

>> Contact person

Prof Steve Evans (se321@cam.ac.uk)

Centre for Industrial Sustainability, University of Cambridge

© Holgado, 2017

SPRE Sustainable Process Industry through
Resource and Energy Efficiency



This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 680570

The sole responsibility for the content of this document lies with the authors. It does not necessarily reflect the opinion of the European Union. Neither the EASME nor the European Commission are responsible for any use that may be made of the information contained therein.

Legal Notice. The information in this document is subject to change without notice. The Members of the project consortium make no warranty of any kind with regard to this document, including, but not limited to, the implied warranties of merchantability and fitness for a particular purpose. The Members of the project consortium shall not be held liable for errors contained herein or direct, indirect, special, incidental or consequential damages in connection with the furnishing, performance, or use of this material. Possible inaccuracies of information are under the responsibility of the project. This report reflects solely the views of its authors. The European Commission is not liable for any use that may be made of the information contained therein.

3 Concluding remarks

IS can provide companies a means to improve their non-labour resource productivity. There is a need to provide companies with tools and methods to support IS development process, especially as regards self-organised IS, and to help them defining actions to be undertaken. These needs were identified in D4.1 “Report on challenges and key success factors and gap analysis for industrial symbiosis” (HOLGADO AND EVANS, 2017) and led the activities within WP4 “Industrial Symbiosis”.

The T4IS aims at providing a self-guided process to support companies to embark into the application of IS approach in their manufacturing operations. The design of the T4IS allows to have a standardised and structured approach to the identification and implementation of IS opportunities, but at the same time to have the flexibility and adaptability required due to the high influence of contextual factors on the process itself.

The T4IS is complemented with the User Guide to engage in industrial symbiosis described in this document. This User Guide makes the T4IS more accessible and facilitate its use by practitioners. The User Guide introduces the concept of IS and an overview of the T4IS steps based on four HOW TO questions: How to SEE waste, How to CHARACTERISE waste, How to VALUE waste and How to EXPLOIT waste.

This User Guide constitutes an easy-to-read brief document for practitioners to get the most essential information on what the concept of industrial symbiosis is, how to develop an IS project and some recommendations to increase its likelihood of success.

The focus of WP4 within MAESTRI project is to provide companies with methods and tools to develop self-organising IS to the extent that this is possible. This User Guide completes the delivery of the MAESTRI approach to support companies in their journey towards implementing IS-based solutions.

References

BENEDETTI, M., HOLGADO, M., EVANS, S. (2017). D4.2 "Prototype library of case studies linked to a waste database". Available at: <http://maestri-spire.eu/downloads/technical-materials/>

CHERTOW, M.R. (2000), "Industrial symbiosis: literature and taxonomy", Annual Review of Energy and the Environment, Vol. 25, No. 1, pp. 313-337.

EUROPEAN COMMISSION (2007), "Communication from the commission to the Council and the European Parliament on the Interpretative Communication on waste and by-products", available at <http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52007DC0059>.

EUROPEAN COMMISSION (2008), "Regulation (EC) No 451/2008 of the European Parliament and of the Council of 23 April 2008 establishing a new statistical classification of products by activity (CPA) and repealing Council Regulation (EEC) No 3696/93", available at <http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2008:145:0065:0226:EN:PDF>.

HOLGADO, M., EVANS, S. (2017). D4.1 "Report on challenges and key success factors and gap analysis for industrial symbiosis". Available at: <http://maestri-spire.eu/downloads/technical-materials/>

HOLGADO, M., EVANS, S., BENEDETTI, M. (2017). D4.3 "Toolkit for industrial symbiosis". Available at: <http://maestri-spire.eu/downloads/technical-materials/>

LOMBARDI, D.R. AND LAYBOURN, P. (2012), "Redefining industrial symbiosis", Journal of Industrial Ecology, Vol. 16, No. 1, pp.28–37.

VAN BERKEL, R. (2009). "Comparability of industrial symbioses", Journal of Industrial Ecology, Vol. 13, No. 4, pp.483–486.

WRAP. (2014). what is industrial symbiosis? <http://www.wrap.org.uk/content/what-industrial-symbiosis> [Last accessed on 28/10/2015]