INCUBIS

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Handbook for ENERGY SYMBIOSIS IMPLEMENTATION

This project is funded by the Horizon 2020 Framework Programme of the European Union under Grant Agreement Number 894800

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Executive Summary

INCUBIS. The project

The main objective of the INCUBIS project is to support the decarbonisation of the European industry by 2050 through developing and deploying five Energy Symbiosis Incubators across Europe. Energy Symbiosis (ES) Incubators are entities which provide support to ES case study projects at different development stages. This support is delivered through facilitation and coordination services, with the aim to improve the capacity to activate the implementation of Energy Symbiosis projects.

INCUBIS aims to deliver a range of tools, methods and services to candidate case studies stakeholders and promoters in order to support them in the identification, development, and delivery of energy symbiosis opportunities, train them and build capacity at all levels to achieve sustainable growth of energy symbiosis uptake. The goal is to improve the energy efficiency of industrial agglomerations by unlocking the market potential of energy cooperation and joint energy services.

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The Handbook for energy symbiosis implementation

Energy-based industrial symbiosis implementation enables the decoupling of economic growth from non-renewable resource exploitation, by dealing with the usage of wasted energetic resources of an industry or industrial process as a substitute to the traditionally used by another industrial process. Moreover, energy symbiosis (ES) implementation contributes to the reduction of industrial fossil fuels dependency and the achievement of decarbonisation goals of eco-industrial parks in Europe, while helping industries transition towards a more resilient, competitive, and sustainable industrial model. However, a number of technical and non-technical barriers untap the whole potential of industrial excess heat recovery. Among them, the need for efficient and cost-effective technologies to recover heat losses and to re-use them, the lack of collaborative trust-based environments among industrial partners or the uncertainties linked to complex and multi-stakeholder initiatives such ES projects. The Handbook of ES implementation presents a comprehensive overview of tools and tips to support and facilitate ES in the different European regions, including practical guidelines to deliver facilitation and coordination activities revolving ES opportunities, which have been distilled from the practical experiences from the incubators of the European Union's Horizon 2020 INCUBIS project. Also, this handbook highlights the role and profile of the ES facilitator, as well as providing a compendium of barrier-lifting methods, tools and tips for stakeholder engagement and securement, and a step-by-step ES project lifecycle framework. Ultimately, this Handbook aims to provide support to all those parties, ranging from regional authorities to appointed facilitation agents, taking part in industrial ES implementation projects.

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Lists of acronyms

BAU	Business as usual
EII	Energy intensive industries
ES	Energy Symbiosis
ETS	Emissions trading system
EU	European Union
EUA	European Allowances
GHG	Green House Gases
IS	Industrial Symbiosis
KPI	Key performance indicator
KYC	Know Your Customer
NDA	Non disclosure agreement
WP	Work-package

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Introduction

The global economic rebound derived from the COVID pandemic restrictions, and the Ukraine war have hit European energy markets by dramatically increasing primary energy prices. For energy intensive industries (EII), where energy costs averaged around 20% of total production costs, these extraordinary upwards price pressures are having a profound impact on production costs, with increases by almost 50 percent in some sectors.

In this context, EII are facing the need to urgently put into practice energy innovative efficiency strategies to ensure the sustainability and competitiveness of their business for the future. Energy focused innovative initiatives towards the creation of waste heat utilization networks within industrial parks have a great potential to drive total energy cost reductions.

In fact, Industrial symbiosis (IS) is a potent strategy to support the acceleration of European Green Deal and the achievement of environmental and industrial competitiveness goals at European level, by applying the circular economy principles into the industrial input-output fluxes, as well as favouring collaborative industrial environments. Energy-based industrial symbiosis implementation enables the decoupling of economic growth from non-renewable resource exploitation, by dealing with the usage of wasted energetic resources of an industry or industrial process as a substitute to the traditionally used by another industrial process. Moreover, energy symbiosis (ES) implementation contributes to the reduction of industrial fossil fuels dependency and the achievement of decarbonisation goals of eco-industrial parks in Europe, while helping industries transition towards a more resilient, competitive and sustainable industrial model.

In spite of the progressive technological improvements in terms of energy consumption in energy demanding industrial processes, excess heat still represents a significant amount of energy loss in the overall energetic balance. For instance, when looking at thermal energy only, this fraction makes up about two-thirds of industrial processes' total energy consumption, yet almost one-third of industrial energy needs is dissipated into the environment. For this reason, through Energy Symbiosis collaborations, waste thermal energy could become a valuable resource for other industrial processes, and even for neighbouring industries or urban and domestic users, increasing the overall industrial ecosystem's efficiency.

However, a number of technical and non-technical barriers untap the whole potential of industrial excess heat recovery. Among them, the need for efficient and cost-effective technologies to recover heat losses and to re-use them, the lack of collaborative trust-based environments among industrial partners or the uncertainties linked to complex and multi-stakeholder initiatives such ES projects.

The Handbook of ES implementation presents a comprehensive overview of tools and tips to support and facilitate ES in the different European regions. This handbook includes practical guidelines to deliver facilitation and coordination activities revolving ES opportunities, which have been distilled from the practical experiences from the incubators of INCUBIS project. Also, this document highlights the role and profile of the ES facilitator, as well as providing a compendium of barrier-lifting methods, tools and tips for stakeholder engagement and securement, and a step-by-step ES project lifecycle framework. This Handbook aims to provide support to all those parties, ranging from regional authorities to appointed facilitation agents, taking part in industrial ES implementation projects.

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1 The goal of this Handbook

The general objective of the present document is to establish clear guidelines and recommendations for ES through the Handbook of ES implementation.

This document aims to contribute to the European decarbonization and sustainability goals by shedding light on the ES concept, the ES implementation steps, the milestones associated to the lifecycle of the ES projects, the main barriers ES projects encounter, and the number of recommendations and instructions on how to deliver barrier-lifting services and facilitation actions to accelerate and de-risk the deployment of ES projects.

Particularly, the handbook goals are to feature all the insights gained from the work carried out by the INCUBIS project, with special emphasis on the practical experiences of the regional incubators and the revision of the previously established knowledge base. The Handbook presents a comprehensive framework for ES project development and an overview of tools and tips to support and facilitate ES in the different European regions. This Handbook aims to highlight the role of the facilitator of ES projects, and the tasks of coordination and support roles, defining the specific professional profiles and the main skills required to cover the necessities of ES facilitation services delivery.

2 To whom is the Handbook addressed

The guidelines presented in this handbook are addressed to all those acting within the framework of Energy-based industrial symbiosis. More specifically, the contents of this handbook could serve as a guide and set of recommendations for facilitation teams, industrial park association managers, public regional planners, industrial clusters, or policy makers to develop and implement ES solutions for the recovery of excess thermal energy at industrial sites (Table 1).

Table 1 Target audience and the added value of this handbook.

→ Target audience	→ Added value of this Handbook	
→ Industrial symbiosis facilitators → Industrial park managers, → Site developers, → Industrial clusters, → Chambers of commerce → Companies involved in resource efficiency and industrial symbiosis, especially energy-intensive industries.	→ This guide provides tools and instruments to support and facilitate ES projects, especially from a facilitation team approach. Particularly, this handbook provides a clear definition of the role and professional profile of the facilitation team, as well as a list of actions and recommendations for projects at the ideation and diagnostics phase, where stakeholders engagement is key for the project success. For industrial clusters and associations, this handbook provides information on how to strengthen industrial collaboration and proposes specific actions to encourage industrial stakeholders to embrace collaborative paths and to seize opportunities of energy stream exchanges.	→ The added value of this handbook for target groups includes the following content: → Screening of methodologies and tools for ES opportunities at regional scale → Compendium of lessons learnt in different European regions → Tips for barrier-lifting and facilitation → Clear step-by-step ES implementation framework, with the identified milestones and barriers, as well as recommendations to overcome identified bottlenecks encountered in the process. → Financing barriers and barrier-lifting actions guide. → Alternative tools to support coordination, legal and economic aspects of an ES project

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→ Authorities and regional planners	→ This guide provides information and useful instruments that can provide support to authorities at various levels of regional economic development planning, strategic budget management and decision making.	
→ Policy makers	→ This guide can serve as a compendium of good practices and identified barriers that can contribute and support policymaking to achieve the objectives of Energy transition.	

3 The Handbook of energy symbiosis

The Handbook of ES implementation presents a comprehensive overview of tools and tips to support and facilitate ES in the different European regions. This handbook includes practical guidelines to deliver facilitation and coordination activities revolving ES opportunities, highlight the role and profile of the ES facilitator, as well as providing a compendium of methodologies for ES opportunity identification, tools and tips for stakeholder engagement and securement, and a step-by-step ES project lifecycle framework. This Handbook aims to provide support to all those parties, ranging from regional authorities to appointed facilitation agents, taking part in industrial ES implementation projects.

3.1 Industrial Energy Symbiosis

At European scale, Industrial symbiosis (IS) is considered a potent instrument to support the achievement of environmental and industrial competitiveness goals, by applying the circular economy principles into the industrial input-output flows. Concretely, IS deals with the usage of waste resources or byproducts of an industry or industrial process as a substitute to the traditionally used input resources of another industrial process. Thus, IS is a business strategy which stimulates collaboration between companies in order to generate new business opportunities based on these identified waste resources (whether the waste is in the form of energy, water, heat, transportation, materials, etc.). Consequently, when deployed, IS synergies reduce the amount of traditional input requirements from outside the industrial ecosystem, promoting a circular economy transition and a reduction of the overall greenhouse gas (GHG) emissions.

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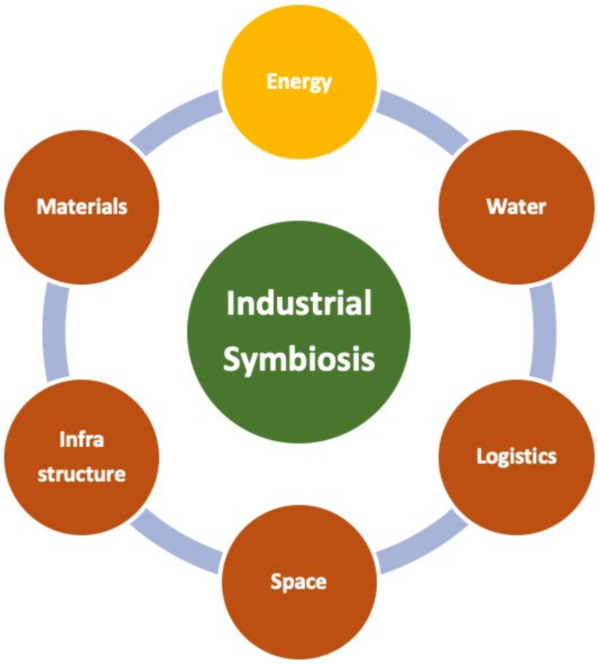

Figure 1 Industrial Symbiosis Resources. (Source: Símbiosy, 2019)

Within the IS framework (Figure 1), energy-based synergies are known as energy symbiosis (ES)[1]. ES is a recognized and effective practice to reduce fossil fuels dependency and decrease the environmental footprint of the industries involved. Energy-based IS can be classified into two separate categories:

1) Waste heat/cold exchange. Excess heat from a process is used by another process, in the same industry or neighbouring one. Also, excess heat can be reused as space heating in urban areas.
2) Bioenergy production. This synergy occurs when organic wastes are used to produce bioenergy or biofuels (biogas, biomass combustion…).

INCUBIS project has focused on the waste heat exchange ES category, although in some of the case studies a mix of ES categories have also occurred in order to ensure the thermal energy supply.

The final goal of ES is to solve inefficiencies in the consumption of energetic resources and energy handling that companies internally do no use on their own:

- ➔ Useless (biological by-products)
- ➔ Lost (excess heat or cold in form of steam or other fluids)
- ➔ Not used or sharable (existing piping or boilers infrastructure that can be reused, or rooftops for photovoltaic or thermal cells).

The key basic aspects in an ES system are:

1. A systemic vision of the industrial site, mimicking the functionality of a natural ecosystem.
2. A dynamic and trust-based network of entities and companies linked to the ES opportunity, including different industrial actors, belonging to different sectors of activity, or governmental and other institutions, including universities and trade associations for example.

[1] Fraccascia, L., Yazdanpanah, V., van Capelleveen, G., & Yazan, D. M. (2021). Energy-based industrial symbiosis: A literature review for circular energy transition. *Environment, Development and Sustainability*, *23*(4), 4791-4825.

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3. Sustainable development is the core concept of energy symbiosis, considering all the branches of sustainability: environmental, social and economic.

Finally, similarly to IS networks, ES projects can be diverse in terms of their nature, emergence, development patterns and content of the transactions. Depending on the way in which these relationships are established and coordinated, networks can be divided according to:

1. Self-organized network: emerging as the result of direct interaction among industrial actors.
2. Managed network: those that have a third-party intermediary (a facilitator) who coordinates the activity. We can find two types of managed networks:
    a. Planned networks, where the networks are formed following a central plan or vision that includes attracting new businesses to purpose-built developments, generally offering shared infrastructures and services.
    b. Facilitated networks, working with existing companies to raise awareness of ES and foster activity.

3.2 The benefits of ES

Energy symbiosis has a wide range of advantages for the different stakeholders involved, ranging from decreased production costs to a public greener business perception, positively impacting both businesses and the ecosystems around them[2].

Socio-Economic benefits

Energy Symbiosis is, together with the other forms of industrial symbiosis, a key enabling component of circular economy, helping industries and industrial parks transition from expensive and unsustainable production systems to viable, income-generating and greener manufacturing designs that have a clear repercussion on the business models.

- Incomes from selling or exchanging industrial excess heat or organic by-products for fuel production.
- Saving costs on production costs by the reduction of external energy consumption.
- Cutting expenses linked to carbon emissions.
- Expanding market outreach and revenue derived from public perception of a more sustainable company.
- Increased and strengthened collaboration environment, more prone to further collaborations among industrial partners and public authorities.

- Since ES works in a systemic approach, there are also territorial economic benefits:

- New business creation & economic development derived from the collaborative approach.
- Maintaining jobs or new jobs created from new supply chains.
- Reduction dependency in energy imported resources while encouraging local resources development.
- Increase in sustainability awareness.
- Stronger regional economies

Environmental benefits

- Reduction of carbon footprint at industrial sites
- Reduction of GHG emissions derived from energy consumption
- Reduction in fossil fuels extraction/usage
- Territorial development into greener industrial model

[2] Marinelli, Simona & Butturi, Maria & Balugani, Elia & Lolli, Francesco & Rimini, Bianca. (2020). Environmental benefits of the industrial energy symbiosis approach integrating renewable energy sources.

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3.3 Highlighting the role of an ES facilitator

The readiness level of each European region to foster and implement ES projects, similarly to IS projects, depends on various factors. For instance, geographical and contextual conditions such as the tradition of industrial collaboration can lead to different regional ES maturity readiness levels. Moreover, ES projects emergence type or the project particular technological solution are influencing factors that contribute in making each ES project unique. In fact, in the pool of incubated ES projects in the different European regions, we observe a large variation in project typology, development stages, barriers, readiness level and project needs.

Given the challenging ES projects' specificities, and aligning to other IS projects[3], facilitation is considered one of the most important aspects to foster the establishment of ES. A coordination or facilitation role that is trusted by all parties involved and has the ability to navigate the middle grounds between stakeholders, can help activate an ES opportunity and assure the success of a project. In fact, facilitated ES networks largely benefit from establishing a central role whose main endeavour is to identify the business opportunities related to excess heat recovery within the industrial ecosystem, as well as to accompany the different stakeholders to implement them, by offering support and advice to overcome the multiple barriers that can hamper an industrial energy symbiosis project implementation. In the INCUBIS project framework, the regional incubators have supported and/or embodied the facilitation team for the incubated ES case studies.

Although the project facilitation role is not crucial for ES implementation, the vast majority of projects incubated by INCUBIS require a facilitation team to accelerate and de-risk the ES opportunities through clear opportunity detection, project roadmaps and barrier-removing actions[4] (Figure 2).

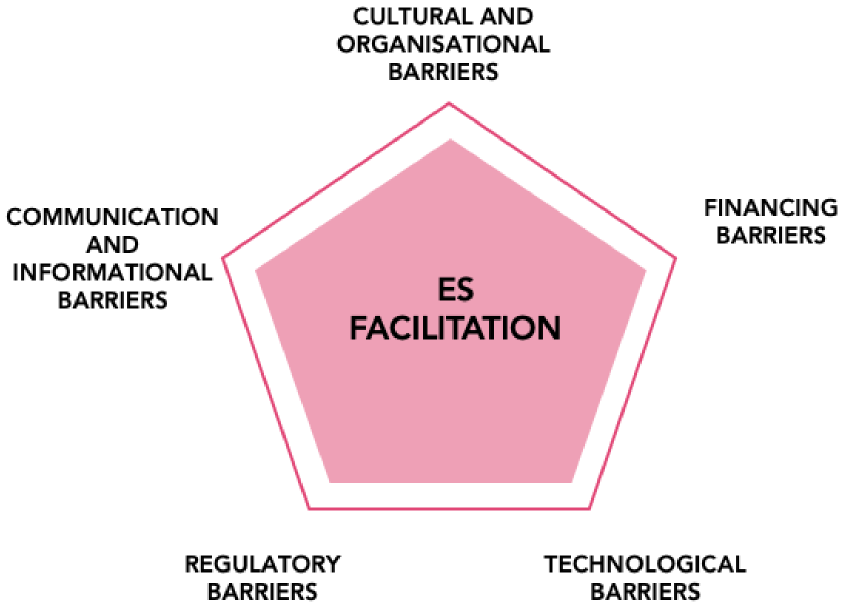

Figure 2 ES facilitation and barriers. Adapted from: Domenech et al., 2018.

[3] Schlüter, L., Mortensen, L., Drustrup, R., Gjerding, A. N., Kørnøv, L., & Lyhne, I. (2022). Uncovering the role of the industrial symbiosis facilitator in literature and practice in Nordic countries: An action-skill framework. *Journal of Cleaner Production*, 134652

[4] Domenech, T., Bleischwitz, R., Doranova, A., Panayotopoulos, D., & Roman, L. (2019). Mapping Industrial Symbiosis Development in Europe_ typologies of networks, characteristics, performance and contribution to the Circular Economy. *Resources, conservation and recycling*, *141*, 76-98.

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3.3.1 *Facilitation activities*

Overall, an ES facilitator figure should deliver facilitation services that provide continuous and maintained added value to keep the different parts involved and committed working collaboratively for the ES project implementation. For this reason, the role of an ES facilitation activities identified should aim to lift each particular barrier encountered, build and maintain the stakeholders network based on trust.

While there are different approaches to facilitate the implementation of an ES project, all of the ES projects include four key facilitation activities that can be mapped to the most commonly identified barriers in ES project development (Table 3).

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Table 2 Key aspects of facilitation activities addressing systematic barriers in ES deployments.

	Main barriers			
Key facilitation activities	Regulatory and legislative barriers	Financial obstacles	Lack of trust on the part of stakeholders	Lack of knowledge and information exchange
Fostering knowledge and expertise networks to deliver specific services for barrier removal.	■	■		
Getting to know the ES potential and estimating the impacts, to be able to identify a viable ES opportunity prior to stakeholders mapping			■	■
Working with companies and the stakeholders of the involved industrial ecosystem to secure the trust-bond and commitment of parties with the project.			■	■
Identifying and communicating benefits, risks, and barriers through the lifecycle of the project	■	■	■	■

1) **Fostering knowledge and expertise networks to deliver specific services for barrier removal.**

The facilitator activities become a driver of ES. The facilitator figure takes the space between companies and public and private sectors involved in an ES project or the detected opportunity, covering those facilitation tasks not belonging to any specific part, and by facilitating the exchange or provision of information to achieve further project development stages. A wide range and specific barrier-removal services can be delivered to ES projects by facilitation teams, especially to those barriers that are encountered at the different phases of the lifecycle of an ES project but represent a bottleneck for the project development. These facilitation activities require a multidisciplinary facilitation team, with knowledge revolving around technical, economic, and regulatory aspects. In parallel, the facilitation team should have a trustable external experts network in order to address specific regulatory and technical aspects relevant to the ES project development but beyond the scope of facilitation activities. See the following section for more detail information.

2) **Getting to know the ES potential and estimating the impacts, in order to identify a viable ES opportunity prior to stakeholders mapping**

Facilitation activities entail the screening of viable collaborative ES opportunities within industrial parks prior to the identification of the relevant stakeholders involved. Different methodologies exist in order to estimate the potentials, or screen the opportunities with limited entry data, in order to be able to present a viable business case to attract companies. The present handbook proposes a number of methods and recommendations revolving ES potential estimates (See sections 4.5 and 4.7).

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Also, the facilitator team should be responsible for estimating short- and long-term impacts and delivering a monitoring and project impact assessment framework that adjusts to the territorial opportunity and ES project needs. The established framework will help assess the progress of the project, and readjust the actions required to consolidate or re-evaluate the objectives set at the beginning of the project (See the proposed methods to establish a viable and consistent monitoring framework and useful KPI in section 4.5).

3) Working with companies and the stakeholders of the involved industrial ecosystem to secure the trust-bond and commitment of all parties with the project

Building trust when developing a complex, multi-stakeholder initiative such as ES projects is always a challenge. In fact, a key barrier encountered in all projects is the lack of trust among stakeholders. In order to build an explicit, trust-based and collaborative commitment among stakeholders, communication and engagement activities are strictly bonded to the facilitation of ES projects. It is crucial to have communication strategies (ex. Assertive communication skills or group work methods) in order to convince interlocutors to join the ES initiative, as well as foster a bank of engagement actions that can help in securing this commitment.

4) Identifying and communicating benefits, risks and barriers through the lifecycle of the project

ES facilitation teams are expected to identify and communicate the benefits, risks and the barriers that will appear along the project development to the key and involved stakeholders.

Identifying and communicating benefits can be delivered through the impact estimates as well as communication activities, in order to raise interest in the territory and convince social opposition.

Facilitators should identify the risks, threats and barriers encountered or foreseen in an ES project which could hamper the business viability. In order to manage and mitigate these risks, it is highly recommended to plan ahead a risk management procedure [5] in order to allow a better preparation for risk response. Overall, the facilitator should not simply detect organisational or project risk, but also communicate the matter to key stakeholders in a timely, easy-to-understand manner, in order to keep the trust-bond with stakeholders and avoid drop-outs due to misunderstandings.

For these reasons communication activities and a structured communication plan to a specific target audience are crucial parts of the success of an ES opportunity.

3.3.2 *INCUBIS digital facilitation support tool*

Additionally, with the objective of providing support to facilitation teams and service delivery to ES projects, the INCUBIS digital platform has integrated different modules to help ES facilitators deliver services and assess the progress of the project and their facilitation action interventions.

The INCUBIS Digital Platform follows the paradigm of the "Virtual Incubators" delivering online Knowledge Intensive Business Services through the integration of suitable ICT tools and modules to support and enable the provision of Energy Symbiosis Facilitation Services in the case study regions.

The INCUBIS Digital Platform provides a working environment assisting the energy symbiosis facilitator along each stage of energy symbiosis project lifecycle building capacity at individual, organisational,

[5] George, C. (2020). The Essence of Risk Identification in Project Risk Management: An Overview. *International Journal of Science and Research (IJSR)*, *9*(2), 1553-1557.

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regional and European levels in order to lift key systemic barriers. In concrete terms, The INCUBIS Digital Platform enables: i) to train stakeholders on methods and tools for ES opportunity detection, communication and stakeholder engagement (Density map, Waste Heat Potential Map, Ranking of best potential ESI partners), ii) to facilitate delivering energy symbiosis projects (Synergies matchmaking and Project management tool), iii) to present standards and best available techniques (Webinars, Training, Mentoring, Best practices) and iv) to build capacity of investors by proposing an investor-oriented taxonomy of energy symbiosis (Investments and Funding portal).

INCUBIS digital platform gathers existing and new resources, including guidelines, tools, best practices, training, etc. to create a place for all energy symbiosis facilitators and public authorities to find the information in a one-stop-shop.

3.3.3 *Facilitation professional roles*

In order to deliver services designed to tackle the barriers identified in different stages of ES projects, the figure of a facilitator must have a technical, economic, and regulatory knowledge base, as well as a trustable external experts' network. This knowledge includes both resource management and project management aspects.

Nevertheless, beyond this knowledge base, the trust-bond between the parts involved in the project and the facilitator is key for the success of the project. Stakeholders' trust-based network is a fundamental aspect that a facilitator must maintain in the different phases of the project in order to ensure and secure commitment of stakeholders to the project.

For this reason, the role of an ES facilitation activities identified in INCUBIS should be a professional team with a wide range of facilitation tools aiming to lift each particular barrier encountered and building and maintaining the stakeholders network based on trust.

Suitable actors identified as potential ES facilitators, which should integrate the neutral role among stakeholders, are described in the following table (Table 3).

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Table 3 Actors identified as potential ES facilitators and examples.

Public authorities or regional planners. At a regional level this actor can act as a facilitator, strategically promoting the transformation of a whole territory based on regional sustainability, decarbonisation or economic development targets.

Bufalvent, of the Incubator from Barcelona, Spain.

In this case study the facilitator and coordination role is embodied by the public water agency, who is involved in the project and located within the industrial park site, following the mandate of the city council. At initial stages the project was in stand by due to the lack of a clear leadership.

Clusters and industrial associations. Clusters and industrial associations are optimal figures to embody the facilitation figure, since they are trusted among the industrial members belonging to the group. Also, these types of organisations already concentrate the wills and needs of the industrial parties, facilitating the catalyzation of solutions based on collaboration. Especially in those regions where there is little or no tradition for industrial collaboration the birth of these type of clustering organisations speeds up the intersectoral cooperation in the field of circular economy deployment[6].

Case study of Leverkusen, of the Incubator from COVESTRO, Germany.

COVESTRO has promoted and supported the creation of an industrial association in an industrial park where they have different industrial facilities. The industrial association birth has helped in identifying common needs and opportunities, as well as applying for ES facilitation support and funding to public authorities.

Case studies of the Industrial Cluster EYDE, Southern Norway

EYDE is an industrial cluster that embodies the role of the facilitator among all its industrial partners. EYDE fosters all the industrial data to regularly assess and propose energy and other resources usage optimization opportunities. The trust bond between the partners and the cluster management facilitates the provision of real industrial data, as well as the commitment of the different partners to the various proposed initiatives around ES.

Trusted external parties such as consultancy firms specialised in facilitation activities. Sometimes industrial partners can appoint the facilitator team (Public or private) in order to assure a neutral role that is trusted by everyone, or alternatively ask public authorities to take this role.

Case study of Ecoenergies, of the Incubator from Barcelona, Spain.

ECOENERGIES expansion's bottleneck was the trust of the potential partners to connect to the heat district network. Ecoenergies and the potential clients have appointed a third trusted party (specialized consultancy firm) to elaborate case-by-base assessments for the inclusion of each industrial partners to the network.

[6] Ormazabal, M., Prieto-Sandoval, V., Puga-Leal, R., & Jaca, C. (2018). Circular economy in Spanish SMEs: challenges and opportunities. *Journal of Cleaner Production*, *185*, 157-167.

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3.4 Industrial Energy Symbiosis finance guide (update)

Accelerating investments into sustainable energy and energy symbiosis is crucial to ensure a climate-neutral Europe in the long-term and to prepare our cities and regions for the current and future impacts of climate change.

Despite huge opportunities for ecological, social and economic benefit, a limited number of energy symbiosis projects have been executed in Europe so far. One of the repeatedly mentioned barriers in the literature is the challenge of financing such projects, not because they are not profitable, but because they are too complex and unfamiliar for most lenders to properly assess risk and profitability. Further, a lack of seed funding for early-stage feasibility work means few projects even make it to the "investment ready" stage, compounding the challenge of de-risking, standardising and streamlining this kind of investment opportunities.

The INCUBIS platform makes available the "Guide on financing and de-risking energy symbiosis projects" to support project promoters, developers, facilitators and other stakeholders that anticipate potential challenges in securing financing for their energy symbiosis projects. The document is designed to support all European energy symbiosis projects, regardless of their context, design, size or stage of development. On the other hand, INCUBIS platform will also include a "Guideline for investors" to finance energy symbiosis, with an energy symbiosis adapted method and tools to evaluate projects and analyse the risk of investments as well as an ES taxonomy based on investment criteria. This guideline aims to build capacity in investors, and in the business community at large, to be able to identify and properly evaluate symbiosis investment opportunities.
The following table identifies the main barriers to scaling up Energy Efficiency Finance and the financial risks of ES opportunities, based in information gathered from investors interviews, as well as the key aspects to overcome these barriers:

Table 4 Main barriers and financial risks for ES opportunities and how to overcome these barriers.

Main barriers
→ Lack of demand.
→ Connecting the public and private sector.
→ Fragmented sector-alignment of actors.
→ Lack of a unified ecosystem of industry players: no agreed set of best practices, standard materials and processes, and regular exchange of information across the energy efficiency financing value chain.
→ Incomplete and fragmented support: initiatives supporting the development, processing, and analysis of project finance exist, but are splintered, inefficient and temporary.
→ Lack of continuous access to well-maintained, standardised materials: EU funded projects and other initiatives are typically specialised, and once they finish, knowledge often becomes dispersed or dormant.
→ Lack of access to training on standardised material: even if materials are well-maintained, project developers may not have the internal knowledge or capacity to access training to learn how to apply these materials.
→ Know Your Customer (KYC).
→ Trust and knowledge.
→ Manpower.
→ ESG demands.
→ Ownership transparency.
Key aspects to overcome these barriers
→ KYC – making the project understandable for the financier.
→ Social marketing (energy awareness) and 360 personalised assistance (technical, administrative, and financial advice).
→ One-stop-shop + people-centric approach + qualified local professionals.
→ Engage the private sector: provide mature leads, assist and reduce administrative tasks, provide user feedback.
→ Engage the community using effective triggers: health, sustainability, explain all benefits, not only economic, use plain communication, making energy visible, building a trusting environment together with the local authorities, local energy communities, etc.

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3.5 Facilitation intervention monitoring and impact delivery framework revisited

In order to document the ES territorial impact and the creation of value derived from ES facilitation interventions, a series of key performance indicators (KPI) and expected results measures are proposed for both, ongoing projects and the identified potential impact of a region/park. Ultimately, a monitoring and impact delivery framework is useful for:

1. Measure progress and achievements or insights on a change of direction;
2. Assure consistency between actions or milestones through the evaluation of outputs, outcomes and expected results;
3. Demonstrating progress in order to communicate accountability to all stakeholders;
4. Provision of estimated expected results in order to attract stakeholders to the project and build a prospective business case.

To serve their purpose, indicators need to be in compliance with a set of criteria that assure the usefulness of the impact measure. For ES projects, this handbook proposes to take special attention to the following criteria for KPI design:

- Defined boundaries: define to what extent we restrict the measurement of the impact/result (location bounded, industrial sector bounded…)
- KPI for performance monitoring can't be designed before the pre-establishment of realistic objectives and expected results, within a result chain.
- Establish the method for the collection, validation and preparation of data to be used for the KPI.
- KPI should encompass the different typologies of measures we aim to assess (Social, economic and environmental)
- Established KPI should be consistent according to the established expected results, interpretable, timeless, reliable and valid for the measure we intend to assess.

Beyond these key aspects, S.M.A.R.T. and R.A.C.E.R. frameworks are considered as transversal and reference criteria for setting realistic and specific goals, as well as designing consistent KPI.

3.5.1 *Estimating the potential impact of a region or industrial park*

A set of specific KPIs are proposed and designed to estimate the long-term potential impact - in environmental, social, economic, and strategic terms - at the local, regional and global level. This type of estimates are very useful in communication and engagement activities at initial phases of an ES opportunity, as well as to identify if a project is territorially relevant and aligns to strategic plans at a regional level. Impacts estimations should include the three aspects of a sustainability model: social impact, environmental impact and economic impact.

Figure 3 Sustainability impact assessment aspects.

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Once an ES opportunity is screened within an industrial park, the expected results for each region / industrial park can be estimated based on the following yearly KPI measures. These KPI estimates need to be calculated by pre-defining a baseline starting point derived from previous years data or BAU projections.

1) Total Primary Energy Savings

How to estimate: GWh/year, calculation of the primary energy consumed by each company avoided due to the ES project.
Usefulness: This measure communicates the total reduction of external energy resources input into the ecosystem in energy power measures.

2) GHG Savings

How to estimate: tCO_2eq/year calculated by multiplying the total energy savings by sector involved in a project by the average emission factor of the sector.
Usefulness: This measure communicates the mitigation of Greenhouse Gases compared to the pre-project situation.

3) Total investment

How to estimate: €M, describes the amount of economic resources - public and private – attracted.
Usefulness: This measure communicates the magnitude of economic activation in a region derived from ES opportunity investments.

4) Economic benefit / savings

How to estimate: €M, describes the net economic benefits generated by invested capital
Usefulness: This measure communicates the magnitude of economic activation in a region derived from ES opportunity investments. The estimate of benefits comprises new business models generated, the business related to the exchange of energy summed to the total savings derived from the ES implementation.

5) Site specific impact measurements

Each industrial site might be interested in a particular impactful measure which is relevant to that particular region. For this reason, we recommend to adjust this long run impact measure to the specificities of each site, always taking into account the basic criteria for the design of useful KPI.

3.5.2 *Facilitation intervention and ES project development monitoring framework*

Although these potential impact measures provide an overview of the impact magnitude of the ES opportunity in the long run, ES project changes and the progress derived from facilitation interventions should also be systematically evaluated as short- and medium-term outputs and outcomes, based on established expected results. Thus, the first step after the impact estimates, is to set the list of realistic and relevant goals to achieve the potential impacts. Looking at the outputs and outcomes, as the initial steps of an expected result-chain, provide early information on whether an ES project is on course to attain these expected goals or whether new interventions or changes are required.

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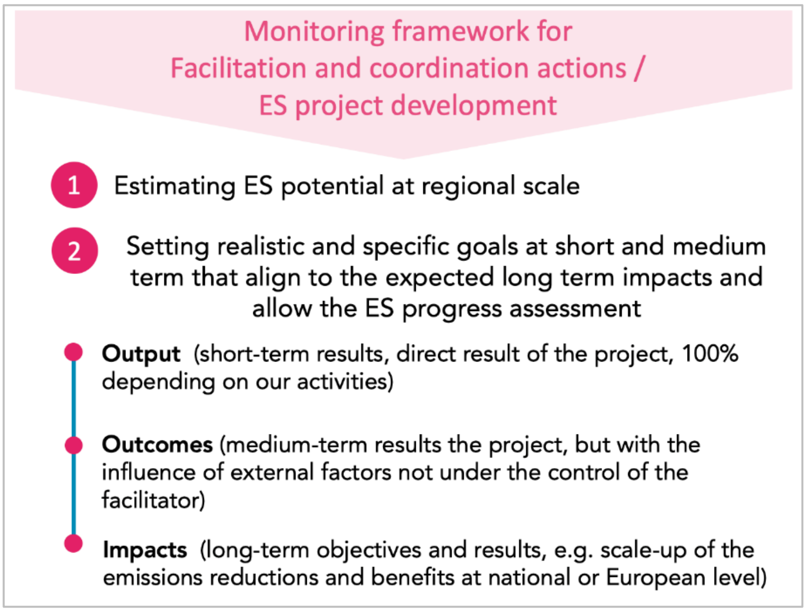

Figure 4 Monitoring framework conceptual scheme.

Additionally, given the fact ES projects are unique and are influenced by a wide range of factors (including geography, industrial sector or regional regulation framework), the indicators used for monitoring progress along the result chain should be set by considering the context in which each project is being implemented. For example, different indicators will apply depending on what is the lifecycle stage of the project, of what are the capabilities of promoters of measuring and monitoring.

In practice, the monitoring procedure and performance assessment should be established before the intervention, whether it is facilitation actions or the performance of the installation itself.

In order to monitor and describe the changes from the delivery of facilitation services or progress of ES projects, we propose a series of KPI that are adjusted to the different levels of the result-chain (Table 5), as an update from the ones presented previously. For the monitoring framework, the different measurable aspects should be considered pre-intervention, during the intervention and after the intervention.

Table 5 KPI proposed for facilitation intervention monitoring and ES project development.

Result chain level	KPI	Description and units
Operational		
Output	Number of ES projects	calculate the number of projects assisted each year
Output	Number of ES opportunities detected	
Output	Number of industrial parks with companies committed to ES projects	
Output	Number of Companies Assisted (yearly).	Calculate the number of companies participating in projects that have received all assistance. It is important to focus on companies' participation in order to grasp the private business dimension generated by the incubator
Financial		

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Outcome	Funds/Capital Attracted	M€. Amount of economic resources - public and private – attracted. Evaluation for each individual project, sum of the investment volume of each individual project
Outcome	Saving energy cost	M€. Savings for each unit of energy consumed avoided, calculation for each project
Outcome	Benefits generated from investments	M€. Economic benefits generated by invested capital
Social		
Impact	Cost per Job Created	M€.
Outcome	Number of new jobs created during the project	The number of jobs created by new projects, sum of the numbers of new jobs per companies participating in the projects. The number of job created can be retrieved from companies and then aggregated at incubator level or, possibly, incubator managers can estimate it
Environmental		
Outcome	Reduction of GHG emissions	tCO_2equivalent/year. KPI calculated by multiplying the total energy savings by sector involved in a project by the average emission factor of the sector
Outcome	Reduction of other pollutants Gg.	Gg. Avoided local pollutants from PM2.5, PM10; NOx, SOx and CO compared to the pre-project situation. Data from national emission factors.
Outcome	Environmental cost effectiveness (ECC)	Ration between Annual CO2 emission savings/Annual cost of project implementation, an environmental effectiveness metric to measure the economic and environmental costs of a project
Energy		
Outcome	Total Primary energy savings	GWh/y. Calculation of the primary energy consumed avoided for each project.
Outcome	Renewable Energy System integration	GWh/y. Calculation of new integrations of renewables in the ecosystem.
Energy symbiosis		
Output	Number of identified synergies (ES opportunities)	GWh of energy symbiosis potential estimated
Output	Number of developed or implemented ES synergies	Linked to primary energy consumption avoided
Output	Number of plant sites that commit to energy cooperation	
Outcome	Number of users connected to the HDC project	
Outcome	Number of stakeholders aware of joint energy services	
Capacity building, training, and knowledge transfer		
Output	Number of courses offered	External courses offered (n/y)
Output	Number of people attended	People attending to the courses (n/y)
Dissemination & communication		
Output	Number of ES communication events	Calculate the number of events organized each year
Outcome	Size of Network	Calculate the number total connections in social media channels
Output	Number of People Attended to Events	Calculate the number of people attending the events

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Output	Number of publications or radio/podcast recordings	Calculate the number of publication developed press releases and printed publications, or number of recordings
Output	Number of posts on social channels.	Calculate the number of posts of the main social channels
Outcome	Number of followers and/or visits of social channels.	Calculate number of followers or visits to posts/tweets
Outcome	Ratio Following / Followers.	Divide the number of accounts that the incubator is following by the number of accounts that follow the incubator
Governance		
Output	No. of public authorities participating	Number of public authorities engaged in the projects
Output	No. of private stakeholders	Number of private stakeholders engaged in the projects
Output (or Outcome if created)	No. of associations/clusters within ES or formed	Number of associations engaged in the project/created derived from the project

3.6 European framework for ES Project development revisited

The European framework for ES aims to provide a new step-by-step methodology for the coordination of ES projects from an ES facilitator view. This approach fosters the steps that embryonic projects require until their deployment, establishing a series of milestones which cover relevant organisational, technical, financial and regulatory aspects. The milestones (M) are indicated as markers that signify a change in the development of the project. Milestones have particular tasks and actions associated, representing key events or achievements that map the forward movements in the project lifecycle. These tasks are proposed with the objective of addressing in a clear manner the different challenges identified from industrial ES projects and the most commonly encountered gaps and needs in the different INCUBIS regions (WP1), with special emphasis on the facilitation and coordination aspects.

Here we present the updated European framework for ES projects development (Figure 5). The framework is divided into the four main sequential phases, following the lifecycle structure of a project: 1) ideation, 2) diagnostics, 3) planification & investments, and 4) implementation & monitoring. In the present revision, INCUBIS proposes a modification of some of the initially proposed tasks and actions, based on the identification of new barriers and challenges encountered in the ES incubated regional projects, and the services delivered.

Parallel to the sequential phases of the project, this handbook proposes a series of transversal ES facilitation actions that align to the different milestones in each of the development phases.

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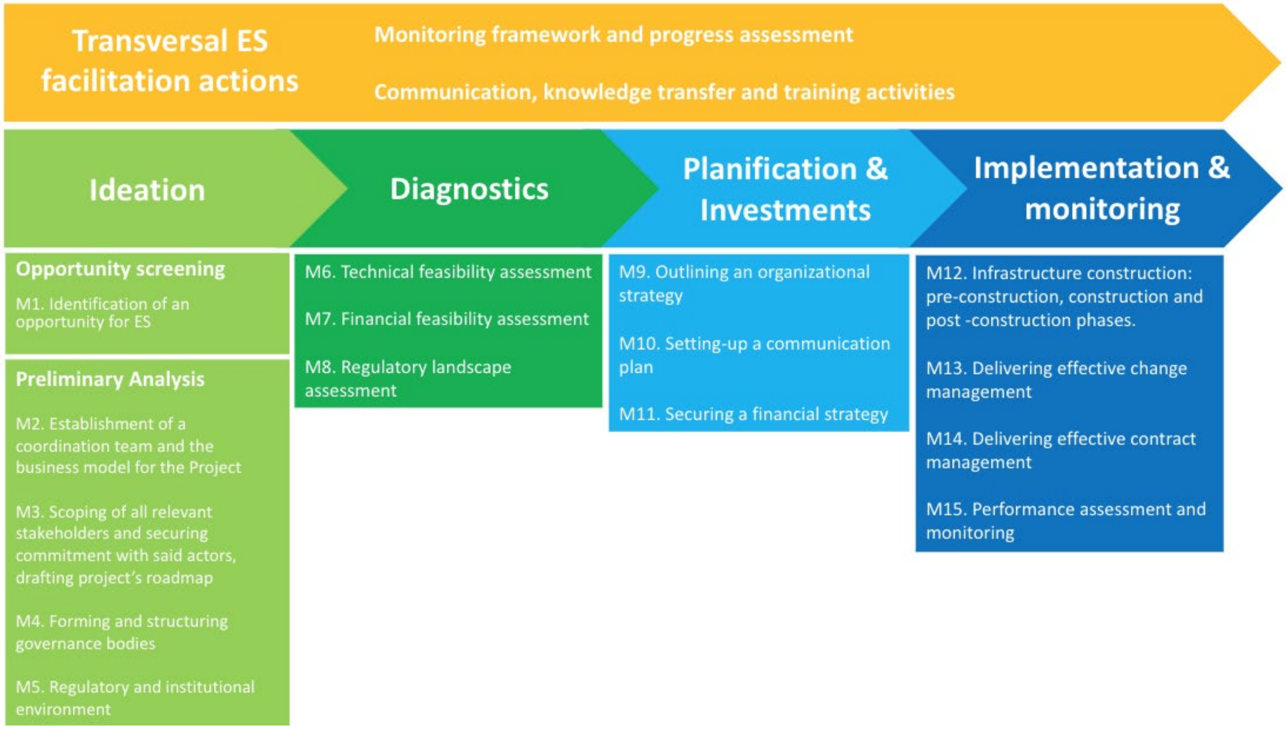

Figure 5 Summary of the European framework for ES project development.

3.6.1 *Ideation phase*

The first step in initiating an industrial symbiosis project consists in the Ideation phase, that includes two secondary phases. First, the opportunity screening phase includes the identification of an opportunity for ES in a region (M1) or scoping out whether there is any viable potential for an ES project. This part can be particularly challenging, since data is not easily accessible. Second, the preliminary analysis phase consists in identifying and establishing a coordinator team and overviewing of the business model (M2); the scoping of all relevant stakeholders, securing commitment and drafting the roadmap of the ES project (M3); as well as forming and structuring the governance bodies (M4); and establishing the regulatory and institutional environment (M5). This phase is of special relevance for the industrial symbiosis incubators of ES projects, since most of the projects require assistance and facilitation support to push forward and raise interest among stakeholders at this stage.

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Table 6 Ideation phase. Milestones, tasks and key barriers.

Milestones	Tasks	Barriers and challenges
M1. Identification of an opportunity for energy symbiosis	Identifying needs, wills or opportunities for energy valorisation within an industrial ecosystem	● Opportunities might not be secured due to lack of interest among the stakeholders involved. ● Not finding haves or wants that match. Lack of industrial engagement and the provision of real-world data concerning energy "haves" and "wants" ● Not identifying opportunities that match real companies' needs. ● Regulation barriers. ● Regional decarbonisation or sustainability strategies not focusing on ES projects can hamper the deployment of ES opportunities. Heat recovery is only one part of a broader decarbonisation objective, and this should be stated as part of the action plans derived from regional public strategies. ● Greenfield developments with anchor tenants under establishment can lead to delays due to undefined production processes and therefore undefined resource flows. ● Industrial data obtention issue.
M2. Establishment of a coordination team and the business model for the project	Setting up a coordination team and the other roles involved in the ES.	● Inexperienced without a well-organised consultation structure or lack of coordination team. Not setting up the coordination structure at the beginning of the project. ● Coordination team not capable of keeping the project dynamic. Inability to express a well-defined leadership. ● Lack of cooperation between partners. Unclear partners' roles. Unequal contribution and interest of each partner. Environment of mistrust between partners.
	Business model draft and funding identification	● Mismatch between the number of members in the coordination team and the size of the project. ● Do not raise enough funds to cover the related employment costs.
	Initiation of activities that foster knowledge sharing and collaboration with actors involved	● The role of the coordination team is restricted to industrial symbiosis and is not adapted to the context.
M3. Scoping of all relevant stakeholders and securing commitment with said actors, drafting	Mapping stakeholders, matching roles and securing commitment	● Not having / not using networks within a defined region to help connect the stakeholders. Lack of quality data to analyse and perform a good mapping.
	Roadmap draft	● Leave risks and money/time cost required in the project unclear. ● Do not provide a concrete understanding to the stakeholders of what the project involves. ● Difficulties organising recurrent meetings with the stakeholders involved (agenda).

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project's roadmap		● Not starting with the communication transversal action plan on the project at this point.
M4. Forming and structuring governance bodies	Forming steering, technical and/or advisory committees and establishing functions	● Do not evaluate the actual or potential involvement in the project of the different stakeholders (before proposing a structure of governance bodies). ● Committee that loses interest derived from problems with the communication channel with the committee.
M5. Regulatory and institutional environmen t	Mapping the current local, national and international regulatory environments	● Not taking into account the current local, national and international regulatory environments before the ideation of the project. ● Not knowing the existing regulations can lead to unpleasant surprises throughout the project. ● Forgetting about tax incentives to cover eventual expenses. ● Not identifying uncertainties within a changing regulatory framework.

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3.6.2 *Diagnostics phase*

The Diagnostics phase focuses on the technical feasibility assessment (M6), in order to determine if the available heat streams within a defined region are compatible with those needed in the same region (matching supply and demand); the financial feasibility assessment (M7) to clarify the costs of acquiring waste heat streams for requesters and potential profits to be made by companies; and the regulatory landscape assessment (M8) in order to understand the current local, national and international regulatory environments.

Table 7 Diagnostics phase. Milestones, tasks and barriers.

Milestones	Tasks	Barriers and challenges
M6. Technical feasibility assessment	Detailed characterization of the energy streams from phase 1.	• Missing industrial data from the entities in the territory that difficult the characterization of energy streams derived from lack of trust
	Matching the temperature, quantity and availability profiles of heat streams. Compatibility of the heat streams with required applications verification.	• Not finding matches within a radius of 30 km (not obtaining compatibility between entities) • Evolution of needs and system stability, requiring a monitoring tool for heat network
	Identifying compatible heat recovery technologies, and analysing the technical, cost and financial, market drivers, risk and environmental criteria.	• Do not previously establish the parameters that are being used in order to reflect the project interests (related to different heat recovery technologies provided).
M7. Financial feasibility assessment	Financial incorporation of the carbon ETS	• Uncertainties with ETS system evolution, impact on business model
	Matching the selling and purchase prices for waste heat	• The selling and purchase prices are not revised during the development of the project.
	Performing an initial business case analysis (CAPEX+OPEX estimates)	• Not conducting initial (and further) estimates for basic project costs can make the project financially infeasible. • The economic viability of the project is not validated and it's needed to find more financing funds.
	Proposing a detailed business model ensuring economic viability	• Economic problems (negative cash flow) can appear throughout the project. • Not using financial tools (payback period, IRR, NVP,...) to help provide further indicators or not efficiently collect all the operating costs, financings, etc. involving the project during its lifetime can lead to economic unviability.
M8. Regulatory landscape assessment	Heat and Electricity trading regulation framework	• Unclear regulation of Emissions trading system (ETS) compensations
	Waste heat symbiosis regulations Structure	

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3.6.3 *Planification & Investments phase*

The Planification & Investments phase includes the outlining of an organisational strategy (M9), for which a management plan is established, in order to create and maintain an environment of trust between stakeholders, setting up a clearly defined leadership and strengthening the stakeholder's commitment. Second, and aligning to the continuous communication tasks carried out by the facilitator team, the project requires a clear Communication plan (M10), which minimises ambiguity, improves relationships between the general public, authorities and stakeholders, and creates a positive vision and a relatable story for the ES project. Third, securing a financial strategy (M11) is required in order to ensure the interests and investments of the main stakeholders.

Table 8 Planification & Investments phase. Milestones, tasks and barriers.

Milestones	Tasks	Barriers and challenges
M9. Outlining an organisational strategy	Creation of a trust environment via activities that foster knowledge sharing and collaboration with actors involved	• Lack of cooperation between partners. Environment of mistrust between partners.
	Roles and responsibilities of each partner clearly defined, strengthen the project participants' leadership and commitment.	• Unclear partners' roles. Unequal contribution and interest of each partner. Not being able to establish a strong leadership.
	Establish a management plan	• The leadership roles and responsibilities of each partner involved should be clearly outlined with commitment to stakeholder dialogue ensured.
M10. Setting-up a communication plan	Identifying objectives and target messages of the communication campaign	• Cultural barriers/issues. • Lack of awareness. • Negative vision on the companies involved in the ES
	Structuring the communication campaign	• Stakeholders' interests are not aligned.
M11. Securing a financial strategy	Creating trust by presenting reliable and convincing business cases to stakeholders	• There are no previous feasible and convincing cases to present
	Identification of potential investors	• Lack of investments (unfavourable context for the flow of investments).
	Detailed financial assessments with various economic indicators	• Some risks can create a barrier for investors: uncertainties, project delays,…
	Provide support to overcome administrative procedures and negotiations	• Lack of a trust-network specialised in administrative procedures • Lack of knowledge of the administrative procedures due to the lack of precedents in the region
	Establishing a financing model	• The public administrations are not interested in the project. • Not finding financing entities or the funds • Challenges in agreeing in the redistribution of economic gain among the partners involved

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3.6.4 *Implementation and monitoring phase*

Finally, the **Implementation and monitoring phase** comprehends the infrastructure construction and all its phases (M12): pre-construction, construction and post-construction. It also includes delivering effective change management (M13), in order to anticipate the changes; contract management (M14), including regular meetings for the partners to communicate on the evolution of the project; and monitoring (M15) to ensure optimal functioning.

Table 9 Implementation and monitoring phase. Milestones, tasks and barriers.

Milestones	Tasks	Barriers and challenges
M12. Infrastructure construction: pre-construction, construction and post -construction phases.	Identifying companies that have the expertise as constructors of heat districts.	• Not having a trustable network of specialists
	Extensive communication, anticipation for the building permit application and management of the tight schedule	• Local communities can go against the project; specially if they are not well-informed. • Obtaining the building permit can take time. Some necessary changes in planning can have economic consequences.
M13. Delivering effective change management	Organisational process evolution (adapting organisational processes), training personnel and communication	• Possible changes are not taken into consideration, so new organisational processes are not implemented. • Not offering training to workers impacted by changes.
M14. Delivering effective contract management	Establish the relations between partners (managed within the framework of the signed contract), with regular communication via indicators and meetings.	• A contract with no flexibility which cannot face unexpected events.
M15. Performance assessment and monitoring	Establishing appropriate KPI for monitoring	• It could be difficult to attract the interest of new stakeholders/companies to join the project once deployed.

3.6.5 *Transversal ES facilitation actions*

In addition, **transversal ES facilitation actions** have also been identified. These transversal actions do not particularly belong to the sequential lifecycle phases of the project, but apply to the whole lifecycle of an ES project and must be adapted depending on the needs and specificities of each project phase. For this reason, they have been included as part of the European framework for ES project implementation.

- ***Monitoring framework and progress assessment***

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Monitoring and ES project progress assessment involves actively reviewing the status of your project as it proceeds, evaluating potential obstacles, and implementing necessary changes at any stage of the project lifecycle. This task requires establishing a monitoring framework for the project development and the facilitation intervention conducted by the facilitation team.

Section 4.5 provides a facilitation intervention monitoring and impact delivery framework, as well as some recommendations on the criteria to design adjusted and useful indicators to an ES project.

- ***Communication, knowledge transfer and training activities***

Communication is a key part of success, as it gives entity and value to the role of the facilitator of industrial ES. Communication ensures that companies remain enthusiastic, as it also increases the number of companies attracted and interested in taking actions based on the principles of the circular economy. Also, beyond the industrial ecosystem and the public authorities, communication activities help disseminate knowledge and raise awareness of the environmental and economic impacts to the general public in order to face potential social opposition to ES development.

Communication activities are of special interest to face the following barriers along the project development.

Table 10 List of barriers associated with barrier-lifting communication activities.

Barrier	Recommended communication action
Social and general public mistrust	General public awareness sessions revolving around the environmental and social benefits of ES and circular economy.
Lack of trust	Trust building communicative actions/habits aiming to forge meaningful effective relationships between facilitators and stakeholders, and among them.
Lack of interest in the region/authorities/companies	Info sessions and workshops to promote and early engagement with potential local stakeholders, using potential impact indicators to demonstrate the ES benefits
Need for an innovative collaborative solution in front of a technological/governance barrier	Workshops/participatory strategies with transectoral actors to come up with innovative solutions.
Lack of engagement and commitment among stakeholders	Workshops and sessions for engagement boosting Compromise letters, agreements and legal binding statements to assure commitment.
Risks and threats foreseen during or encountered in the project development	Communication plan established at the beginning of the project will assure a fast response and increased trust of stakeholders in front of potential shifts and unexpected barriers
Weak story telling	Communication strategy and communication material specifically designed for the project business case
Negative social perception of the ES project or one of the companies	A strong communication strategy whose goal is societal acceptance for ES and the particular project being developed, highlighting the benefits for the region and at global scale. Focusing on the overall impact at a systemic level can reduce the stress upon the negative community perception of certain particular companies.
Internal communication challenge between facilitator team and stakeholders	Existing stakeholder engagement software solutions help facilitator teams stay on track with their commitments by centrally managing all communications regarding the impact their initiatives have on the communities in which they operate. These tools can record stakeholder issues, interests, and concerns as well as manage the assignment of tasks and generation of project reports that help organisations demonstrate commitments have been met.

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3.7 Compendium of tips and methodologies

3.7.1 *Opportunity screening and ES detection steps*

The best way to identify an ES opportunity is to map the industrial ecosystem or the región we are going to work with, quantifying, with the available data, all the energy resources flows (inputs and outputs) that are consumed or generated by the companies involved.
In this phase, we want to:

- Map the companies in the region.
- Identify and quantify energy-based wasted industrial resources that can potentially be converted into input energy resources through Energy Symbiosis.
- Estimate the potential for re-using a wasted energy stream within the industrial ecosystem
- Present and attract the companies the idea and a prospective business case.

The quality of this preliminary assessment depends on the available information on companies and their energy resources. The final goal of this phase is to understand the potential for development with energy wasted resources (to know the uncaptured value of excess energy or bio-waste for business), essential to implement energy-focused sustainable development strategies for both in-companies and territories. Materials and Energy Flow Analysis[7] can help with mapping materials and wasted energy streams, supporting the identification of possible resources for energy-based synergies.
In the end, facilitator teams should be able to answer questions such as:

- Does the company's excess-energy stream already have value in the market?
- Are there other companies interested in receiving this wasted energy as an input?
- Does this have a significant potential impact in economic, environmental and/or social aspects?

However, obtaining energy industrial data or screening a viable ES opportunity based on a collaborative industrial interaction can be challenging. In fact, all these issues are part of the main barriers encountered at the Ideation and diagnostic phases of ES project development, and here we propose some key tips and methodologies to lift these barriers.

❶ Minimal bulk data for ES preliminary estimates, a solution.

Why is it challenging to obtain industrial data?
Industrial data accessibility and compatibility have been described as one of the main barriers for the successful implementation of Industrial Symbiosis projects[8]. Similarly, for ES projects, the industrial data usually required for the opportunities detection is challenging to collect for the following reasons:

1. Information is based on industrial resources or industrial processes details (comprising data on the raw materials used in the industrial processes to the waste, water and energy management), which is not originally generated for resources management purposes, but for taxes and regulation endeavours.

[7] Suh, S. (2005). Theory of materials and energy flow analysis in ecology and economics. *Ecological modelling*, *189*(3-4), 251-269.

[8] Benedict, Martin, Linda Kosmol, and Werner Esswein. "Designing Industrial Symbiosis Platforms-from Platform Ecosystems to Industrial Ecosystems." PACIS. 2018.

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2. This data is usually found dispersed, or located in various public or private entities (energy supplier, public administration in charge of the industrial waste management…).
3. This data can present compatibility issues due to the different languages, codification rules or management systems used in the different industries or data sources.
4. Industries can also be reluctant in sharing this type of data due to the fear of revealing key information to competitors, lack of industrial collaboration culture or lack of a strong trust-bond among the different stakeholders.

INCUBIS digital platform ES screening tool

Being able to get basic bulk data on industrial companies of a region can be very useful for ES preliminary opportunity assessments at regional scale, especially for regional planners, external facilitator teams or public authorities. Given the difficulties in the data acquisition processes, SynerBox tool integrated as *Heat/Cold Potential Map* in the *Industrial Simbiosy Project Management* module (ISPM) of the INCUBIS digital platform estimates the thermal energy consumption and the waste heat potential for each industrial unit using minimal industrial data, which can be obtained through public regional bodies, industrial associations or even purchased in industrial databases. The minimum fields required in these regional lists of industries are:

Table 1 Minimum information fields required for early ES opportunity detection INCUBIS tool.

MUST Fields:	OPTIONAL Fields:
Company Name NACE[9] code (4 digits) Coordinates (long, lat) or address	No. of employees Billing data (€)

Ultimately, SynerBox tool is an early opportunity detection tool which provides an overview of the thermal energy fluxes in a region with minimal bulk industrial information as input. This analysis allows to:

1) Greatly reduce the number of stakeholders and industries to target in later stages of the ES project,
2) Possibility to estimate the impact of an ES opportunity through the proposed KPI in section 4.5, and analyze whether the impact is relevant to the region or industrial park.
3) Provides numerical results and the possibility to build a prospective business case to facilitate stakeholders attraction prior to more detailed technical assessments.

For a more in-depth analysis on the ES relationships and prioritisation of target stakeholders in the ES detected opportunity, another functional tool (based on University of Hull Algorithm) is also included in the platform which allows the ranking of companies. This Energy Symbiosis Opportunity Screening (ESOS) tool is integrated in the *Industrial Symbiosis Project Management* module (ISPM); once you have completed the *Heat/Cold Potential Map* preliminary assessment, it appears as a button inside the company description and requires more in detail industrial processes data for which companies will have to agree to provide.

[9] NACE code refers to the EU classification of economic activities.

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❷ A trust-based environment, the key ally of industrial ES projects

The existence of an industrial association or a cluster greatly contributes to an environment of trust among partners, which is crucial for the identification and prosperity of the ES opportunity. On one hand this collective structure can act as the facilitator, fostering confidential information, being transparent about its goals and creating a cooperative environment with all the industrial partners. Thus, the more open the ES industrial actors are in sharing ideas and information regarding their side streams and by-products with their facilitator-role association/cluster, the more possibilities that are available for ES detection, collaboration or exploring further solutions revolving circular and collaborative business models.

On the other, beyond the data openness, associations/clusters are also advantageous for:

1) looking for funding for an association strategic investment,
2) Proposing innovative solutions that are solving common problems within the industrial partners.
3) As a join actor in front of public authorities

❸ Let's do it together!

Participatory methodologies are very useful to untap collaborative previously undetected ES opportunities or find innovative solutions to ES barriers, while promoting stakeholder engagement and a community sense. Here we provide some strategies for participatory workshops:

Sustainathon
Experience from: EYDE, Industrial Cluster, Southern Norway
Target audience: Technological industrial stakeholders or higher education institutions

This is a collaborative workshop in a large event set-up. A 24-hour competition for teams that are treating "ES or energy efficiency/resources efficiency cases". It is recommended to include more than one higher education institute to recruit students from higher education programs related to innovation and technology. Students and industrial stakeholders can belong to multidisciplinary fields (Some from creative subjects such as architecture, some from business management, some from entrepreneurial fields).

Participants are put into teams and then compete to develop and pitch the best business case towards a feedback panel.

This workshop works up to 70 participants per event.

Hackathons
Experience from: EYDE, Industrial Cluster, Southern Norway
Target audience: Technological industrial stakeholders or higher education institutions

These are similar to Sustainathons, but smaller. Only with shorter timeframes and less broad working groups. Usually on a 6-hour set-up and not crossing between institutes/sectors.

These also end up with pitches, and in some cases architectural models or animations for communication purposes.

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Codecracker Experience from: EYDE, Industrial Cluster, Southern Norway Target audience: All industrial stakeholders, public authorities, regional planners or higher education institutions
It is a method where participants collaborate in smaller working groups to generate ideas individually before digesting them in the group down to one or two prioritized ideas. It is recommended to have 5 – 10 such groups in the room at the same time, working at a fast and strict pace. These ideas are documented in a rough manner and afterwards presented in a plenary session before everybody. These ideas are then mounted on a wall and during a subsequent break (often lunch, allowing the facilitators to prepare for Codecracker pt 2), the participants register their interest to pursue one (sometimes two) of the suggestions by noting their name on the idea. At the end of the break, we are left with names to establish working groups for topics that gathered enough votes. The other ideas are documented and looked at separately. The whole process takes max 45 minutes.
Codecracker pt 2 Experience from: EYDE, Industrial Cluster, Southern Norway Target audience: All industrial stakeholders, public authorities, regional planners or higher education institutions
In the second part of this workshop the working group participants work in a new template where they are noting: their names the status quo the aimed at (future) status what is missing to get there which stakeholders need to be engaged and identify relevant funding opportunities. This process usually takes about 60 minutes and gives us a concept note from which the facilitator can take the next steps towards a pre-project phase, together with the persons and companies who developed the concept.
ES JAM SESSIONS – Companies in symbiosis Experience from: Simbiosy, Barcelona Region, Spain Target audience: All industrial stakeholders, public authorities, regional planners or higher education institutions
This is a collaborative workshop in a large event set-up which requires the use of a digital interactive presentation software tool[10] . The main goal of this workshop is to establish a shared basis among the participants on: What is the circular economy and industrial energy symbiosis, and what are the benefits? Why is it important for me (industrial partner), for the territory/region? Exercise approach to industrial energy symbiosis What are my waste resources in terms of energy – what do I need in terms of energy consumption? Donors-Takers of energy resources

[10] An interactive presentation is one that has some content objects you can interact with: hotspots, navigation, pop-up boxes, animations, etc. This feature helps grab the audience's attention and keep them engaged. Some examples are: iSpring Suit, Nearpod, Prezi, Mentimeter, SlideDog, ClassFlow, among others.

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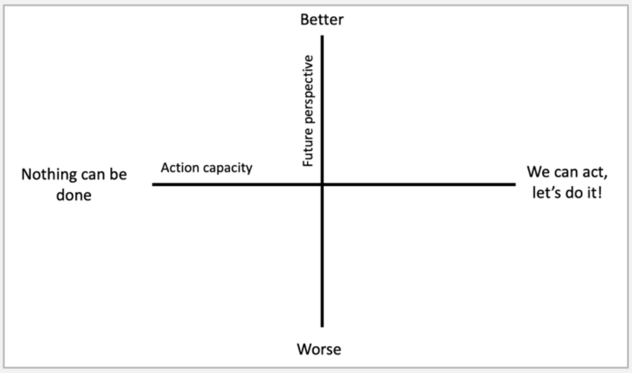
How can I contribute?

How does the session work?
We start the presentation on a digital support (ppt, for instance)
We ask the public to get their phones out and log into the session of the digital interactive presentation software through a password or code.
The first slides and questions should be to get to know each other (icebreakers). Ask about age, industry sector, position in the company, location, size of the company… And the plots are shown on the screen.

- Circular economy and energy simbiosis are explained and some ES collaborative success cases are shown on screen.
- *Market place activity.* Most entrepreneurs and industrial managers have ideas and know about how they could better optimise their resources usage (ideas, intuitions, studies...) but many of these ideas are not put into practice because they do not know who to do it with and/or they do not have enough resources to put it into practice
    - o Give them a couple of minutes to think about what energy flows they use and waste.
    - o Ask them to answer questions related to what are the energy fluxes (input and output), resources and wasted streams in their companies. How much money they spent on energy, whether they have bio-waste potentially usable for fuel production, or whether they know what technology would be needed for waste heat/cold recovery. All this is shown on the screen anonymously, based on a standardised responding system to be able to parametrize all the answers.
- *Pollak Game.* Once we have looked into the available resources and potential wasted streams, we should assess how prone this group of industrial partners is to take an ES opportunity. We ask two questions they need to rate from 0-10.
    - o *Rate the level of optimism: in the next 10 years, do you see your company/territory getting better or worse? (more competitive, more benefits, exploring new markets…)*
    - o *What is your capacity for action to implement the changes in your company/organisation that are needed for a sustainable transition?*

  These two replies are set in two axes, Y and X, and so it is easy to visualise the willingness to adopt ES:



- Finally, the marketplace slide with the energy fluxes and wasted streams is left on screen, and the different partners can interact among them and discuss whether there is any potential ES opportunity worth exploring.

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3.7.2 *Engaging with stakeholders and securing commitment*

ES stakeholder engagement includes ways to attract and involve societal actors, industrial partners, and public authorities who may be affected or involved in the ES project. Initially it is required to map all the stakeholders and define what are the engaging goals for each for the stakeholder groups. In order to assure the effectiveness of the stakeholder engagement actions it is recommended to design an engagement strategic plan. The engagement plan goal is to identify those actions that are productive in terms of involvement and securement of the interest of stakeholders into the ES project. Several challenges appear along the engaging actions, and some tips to overcome these challenges are described below.

4 Attracting attention to an ES opportunity

Attracting stakeholders to an ES opportunity is not a straightforward task. INCUBIS has identified several key factors and engaging strategies that help keeping stakeholders interested and attracted to the ES:

1. Positive experiences of existing ES projects increase the attractiveness and visibility of the ES. Utilising successful ES projects to lead ES development by their example is a good starting point to raise awareness about the existence of a well functioning industrial opportunity. This can be done by presenting success cases, their impactful results and their governance/business models to all stakeholders, or also by visiting neighbouring experiences and allowing the different actors to exchange the experience.

2. Getting authorities on board. Having public authorities/sectoral industrial clusters aligned to the ES opportunity through funding and strategic planning helps support the attraction of industrial partners to the ES opportunity.

3. Clear positive impacts and a prospective business case around the ES opportunity make it easier to attract stakeholders. For this reason, presenting preliminary opportunity screenings of the industrial ecosystem to the stakeholders based on estimates increases the chances of securing commitment and interest among industrial partners. First, this method allows the concretion of the most relevant stakeholders involved in the opportunity. Second, stakeholders get to know the quantified estimated impacts this opportunity will bring to their industries.

4. Sessions with stakeholders focused on knowledge transfer and collaborative work favour identifying and understanding the interest and expectations of the different stakeholders upon the ES opportunity, allowing a more personalised delivery of facilitation and engaging services in later stages of the ES development (especially those which require more engagement and commitment by all parts).

5. New developments bring a lot of uncertainty, and while there is a major potential to plan, design and implement ES from scratch, this is rarely the case since stakeholders are not attracted to such complex projects. The facilitator role objective is to provide a systemic vision of the impacts of the project with and without an ES strategy behind the newfield development. Offering support and advice to policy makers not to rush regulation frameworks in relation to new developments, and plan the inclusion of ES into the development.

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5 Confidentiality

Beyond a trust-based bond among stakeholders and the facilitator team, confidentiality and openness also play a key role in the prosperity of an ES opportunity. Industries traditionally see their neighbours as competitors and are usually reluctant to share data on their valuable industrial processes, consumptions and wasted resources. For this reason, it is also interesting that facilitators are familiar on how to operate around trust agreements and contractual confidentiality obligations in order to keep stakeholders engaged, committed and be able to obtain all the data required to assess technical aspects of the ES opportunity.
When there is a disclosure of confidential information by one party to others (or reciprocal exchange occurs), a confidentiality agreement is recommended (usually referred as NDA, Non disclosure agreement). Essentially, such legally binding agreements are necessary to help protect the parties that disclose information in these situations and avoid confusions over what is considered confidential and what is not.

6 Securing coordination teams and governance

Setting up a clear coordination team, and having an early governance model is an undeniable step towards the success of the ES development. The coordination team figure, and the collaborative structure operative help in creating trust among stakeholders and reducing the perception of complexity.

- A recurrent issue encountered in ES is the lack of leadership or coordination within ES developments. For this reason, a neutral role (such as the facilitator team) is commonly required to push forward and assure its prosperity. When no industrial association or cluster is present among the stakeholders, and there is no interest in creating such figure, the alternative actors that could act as facilitator are either:
  1) agreement to appoint a third party trusted by everyone
  2) public authority/public agency.

- Success-cases governance structures analysis allows obtaining a list of governance options that relate in legal, technical or societal aspects to the ES development. These can be presented in a plenary session, where experts in these fields are present, in order to assess the common denominators, stakeholder interests, needs and particular context that would arise the most suitable model.

- Obtaining at early project stages a basic contract on the fundamentals of the legal aspects of the energy exchange of the ES project, establishing the cooperative relationship between the excess energy suppliers and the takers, will further secure the stakeholders into the ES project if the exchange is clear and favourable to their business.
  - Template contract templates to agree on the fundamentals of an energy exchange project (R-ACES project)

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3.7.3 *Facing the emissions trading system uncertainties*

What is the ETS?

EU ETS stands for European Emission Trading System. It's a «cap and trade» mechanism in place since 2005 to reduce the European industry's CO_2 emissions. In short, CO_2 emissions must be compensated by surrendering CO_2 certificates, referred to as EUA (European Allowances). A certain amount of EUAs are given for free to certain types of industries. Otherwise, they must be bought in auctions. If not enough EUAs are surrendered at the end of the year, fines of 100 euros/t CO_2 not compensated will be applied. The EU ETS covers a growing number of sectors, from heavy industry to aviation and even buildings.

A new reform of the ETS was presented by the European Commission on 14 July 2021 and might enter into force in 2023 or 2024, as part of the "Fit for 55" package. The package aims to reduce net greenhouse gas emissions by at least 55% by 2030 (compared to 1990 levels), and to achieve climate neutrality in 2050. The ETS will also include new sectors, namely road and domestic maritime transport, buildings, agriculture, waste and small industries.[11]

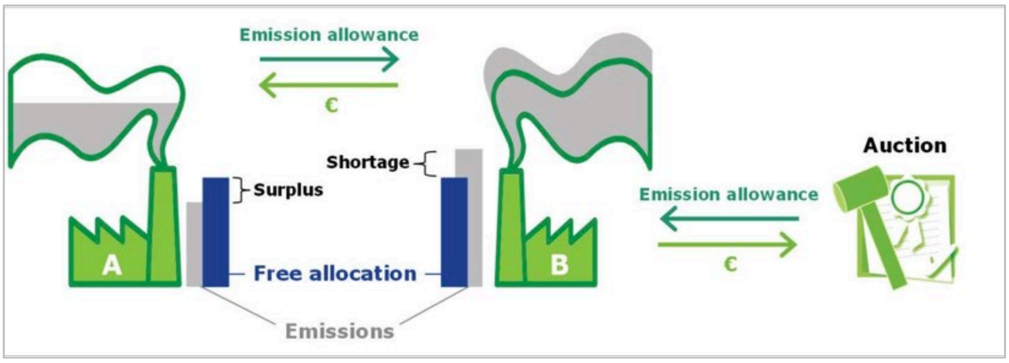

Figure 6 The emission trading scheme. Source: ECA adapted from the European Commission's EU ETS Handbook, 2015.

What industrial activities are concerned by the EU ETS ("ETS installations")?

- Combustion installations are covered when their rated thermal power output exceeds 20 MW, unless operating with 100% biomass. Hazardous and municipal waste treatment facilities are not included in the EU ETS.
- Installations which emit less than 25 kt CO_2/yr and, if applicable, have a rated thermal output of less than 35 MW, excluding emissions from biomass, can opt out of the EU ETS as long as they implement measures that will result in equivalent contributions to emission reductions.
- Installations that emit less than 2.5 kt CO_2/yr can opt out of the ETS

The complete list of ETS installations is provided in Annex 1 of Directive 2003/87/EC.

What is at stake for energy symbiosis?

The cost of carbon on the market has drastically increased over the last few years. Forecasts regarding the cost of carbon vary strongly from one source to another, but most indicate costs exceeding 50 euros/t by 2030, with some extreme scenarios forecasting a cost over 130 euros/t. It goes without saying that financial risks (and opportunities) related to carbon trading will grow accordingly.

[11] Source: www.consilium.europa.eu

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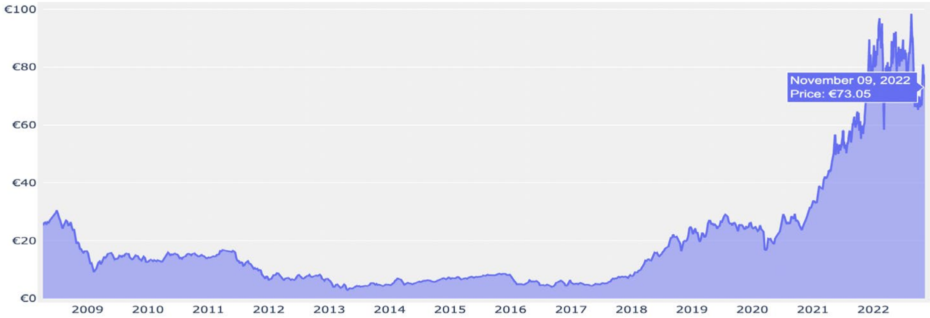

Figure 7 Price of CO2 allowance per ton. Source: https://sandbag.be/index.php/carbon-price-viewer/.

The ETS can play a prominent role in the viability of an industrial heat network or energy symbiosis, depending on the configuration of industries and their individual objectives in terms of reduction of emissions (in some cases, national regulations and policies can even increase the pressure to reduce emissions).

In particular, industries may fear to lose allowances by trading their waste heat to others (see allocation rules in blue box below). Therefore, ETS must be taken into account in the business model if possible, during the early phase of a project to reduce investment risks and help to convince stakeholders to commit.

Free allocations rules in the case of heat exchange between installations

As long as it is not produced by electricity (e.g. electric boilers, electric pumps) or used for electricity production, an ETS installation will receive free allocation for the net measurable heat that is:

- Produced within the same installation
  And/or
- Imported from another EU ETS installation
  And
- Consumed within the installation boundaries, outside the boundaries of any product benchmark (list of 52 products given in Annex 1 of the Free Allocation Rules, see Commission Delegated Regulation (EU) 2019/331)
  And/or
- Exported for district heating purposes
  And/or
- Exported to non-ETS entities other than for district heating purposes

Table 12 below shows different cases of heat exchange and their consequences on allowances

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Table 12 Different cases of heat exchange and their consequences on allowances.

A — Measurable heat → B

If A is a…	And B is a…	Then…
ETS installation	ETS installation	B gets allocated for the heat imported from ETS and consumed
ETS installation	non-ETS installation	A gets allocated for the heat exported to non-ETS
non-ETS installation	ETS installation	The heat is non eligible for free allocation, as it is produced by non-ETS

Source: Guidance Document n°2 on the harmonised free allocation methodology for the EU ETS post 2020: "Guidance on determining the allocation at installation level"

7 Recommendations for incorporating ETS into business model

To integrate ETS in the business model of your energy symbiosis project, we recommend to:

1. Map the relationships between the stakeholders of the symbiosis;
2. Understand the status of stakeholders regarding ETS and if possible, their allowances per benchmark (e.g. heat is one benchmark, waste gas is another, with different conditions for allocation);
3. Estimate potential gains and losses for the different stakeholders, taking into account the evolution of ETS system and propose trade-off schemes to compensate losses;
4. In some cases, industries with high level of GHG production might also want to improve their image and communicate about reductions of emissions, even if this means paying for it;
5. If the system is complex (e.g. industrial cold or heat network involving several energy producers and consumers), collaboration with a legal expert specialised in ETS might be necessary to advise industries and propose trade-offs that are beneficial for everyone.

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