



Leveraging industrial symbiosis for a just transition

A case study of the Port of Aalborg in North Jutland, DK

November 2023

*Regional and
Urban Policy*

Luxembourg: Publications Office of the European Union, 2024

© European Union, 2024



The Commission's reuse policy is implemented by Commission Decision 2011/833/EU of 12 December 2011 on the reuse of Commission documents (OJ L 330, 14.12.2011, p. 39, ELI: <http://data.europa.eu/eli/dec/2011/833/oj>).

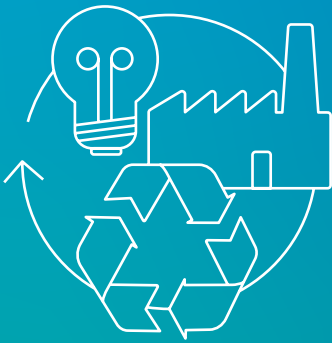
Unless otherwise noted, the reuse of this document is authorised under the Creative Commons Attribution 4.0 International (CC BY 4.0) licence (<https://creativecommons.org/licenses/by/4.0/>). This means that reuse is allowed, provided appropriate credit is given and any changes are indicated.

For any use or reproduction of elements that are not owned by the European Union, permission may need to be sought directly from the respective rightsholders.

Print ISBN 978-92-68-18147-8 doi:10.2776/533910 KN-05-24-490-EN-C

PDF ISBN 978-92-68-18148-5 doi:10.2776/296284 KN-05-24-490-EN-N

Leveraging industrial symbiosis for a just transition – A case study of the Port of Aalborg



Key messages

- Partnerships are the driving force of industrial symbiosis development. The industrial symbiosis of Aalborg thrives because of strong partnerships between the Port of Aalborg, established organisations, and up-and-coming actors, each willing to explore synergies.
- Do not underestimate the importance of facilitation. In Aalborg, a wide range of actors takes on a facilitating role to boost the identification of synergies – be they large companies like Aalborg Portland or knowledge institutions such as Aalborg University.
- Municipalities can be a strong actor in shaping the green industry of the future. The municipality of Aalborg facilitates the creation of industrial symbiosis by providing a long-term vision for the city – thereby introducing stable investment conditions – and by involving its holdings in the project.
- Ports provide a great breeding ground for industrial symbiosis. By their nature, ports are hubs of economic activity that are often home to several large companies. A driven port authority like the Port of Aalborg can orchestrate industrial symbiosis by fostering partnerships and recruiting companies that would complement the project.
- Creating the preconditions for industrial symbiosis can take years, but digital technologies can be a catalyst. The industrial symbiosis in Aalborg is growing step by step, and digital technologies, such as synergy mapping tools, can help Aalborg identify and act on synergies faster.
- SMEs can and should be part of industrial symbiosis projects. The case of Aalborg demonstrates that large companies and SMEs can co-exist and co-benefit in an industrial symbiosis landscape.

1. Introduction: The need for industrial transformation in the EU

The industry sector has been instrumental to the EU's prosperity since its founding days, when the European Coal and Steel Community united the six founding members of the EU. Today, EU industry is in need of a transformation. The European Environment Agency estimates that the industry sector was responsible for 21% of EU greenhouse gas emissions in 2021.¹ The EU recognises that transforming industry is vital to its aim of reaching climate neutrality by 2050, and the sector consequently plays a key role in the European Green Deal.

Industrial emissions have been regulated by the EU Emissions Trading System since 2005, contributing to a 28% reduction in industrial emissions between 2005 and 2020.² However, COVID-19 has spurred an uptick in emissions and a decline of the EU economy. Following the COVID-19 crisis, the European Commission updated the [EU Industrial Strategy](#), including an increased focus on accelerating the green and digital transitions.³ In the wake of the Russian invasion of Ukraine, the European Commission released the [Green Deal Industrial Plan](#)

in 2023 to enhance the competitiveness of Europe's net-zero industry and accelerate the transition to climate neutrality.⁴ It aims to speed up investment for clean-tech production in Europe and simplify the regulatory environment.

One of the ways in which industry can play a leading role in conserving natural resources is by moving towards a circular economy. Several carbon-intensive regions that are supported by the [Just Transition Fund](#) (JTF) are already moving in this direction by implementing circular business models focused on innovation. The [EU Circular Economy Action Plan](#) also proposes several actions to enable greater circularity in the industry sector, and industrial symbiosis is seen as a key solution to maintain competitiveness and reduce emissions.⁵

2. The concept of industrial symbiosis

Marian Chertow, a prominent researcher on the subject, defines industrial symbiosis as engaging “traditionally separate industries and entities in a collaborative approach to resource sharing that benefits both the environment and the economy.”⁶ Resource sharing in industrial symbiosis generally refers to sharing water, energy, and material by-products and wastes across organisations. The term was first used in 1989 to describe the extensive network of cooperating organisations in Kalundborg, Denmark.⁷ Industrial symbiosis in Kalundborg dates back to 1961, and was developed based on commercial agreements between the stakeholders. Today, Kalundborg houses approximately 50 symbiotic exchanges, and it is seen as a prime example of industrial symbiosis.

While the benefits of implementing industrial symbiosis depend on the circumstances and established synergies of each particular case, the approach brings results for environment, economy, and society:



Environment: While almost every industrial symbiosis project observes a reduction in energy use, the range of energy savings tends to vary widely. Many synergies are established around the idea of using one company’s waste as input for a second company, reducing the need for raw materials.



Economy: Many industrial symbiosis projects are economically driven. An analysis of industrial symbiosis projects that receive funding from the European Commission estimated that cost savings were in the range of 20% to 80%, and cost savings were mostly related to a reduction in energy use.⁸



Society: Industrial symbiosis often leads to job creation, which can stem from the expansion of existing businesses or from new business development. Large symbiosis projects, such as Kalundborg, can spark job creation in the operation of the symbiosis itself.

Industrial symbiosis can also offer important benefits for small and medium enterprises (SMEs). Their smaller size allows them to adapt flexibly to the changing circumstances of industrial symbiosis projects. They can offer tools and services, such as ICT tools, to help establish new business models and offer innovation boosts to the symbiosis project.

The analysis of industrial symbiosis projects that receive funding from the European Commission found that industrial symbiosis often develops in steps, as illustrated in Figure 1. The analysis also identifies four ways in which industrial symbioses can develop:

- In a **self-organised** industrial symbiosis project, organisations identify synergies and act on opportunities to share resources themselves in a bottom-up approach.
- An independent intermediary can also work with organisations to identify and develop opportunities for resource sharing. **Facilitated** industrial symbiosis often depends on the intermediary to drive the development of the project.
- **ICT** can also be a driving factor – an ICT system to manage data on resource availability can help users of the software identify synergies.
- Finally, **strategic or planned** industrial symbiosis follows a top-down approach in which a central plan dictates the formation of networks. The public sector often operates as the central body implementing the plan.⁹

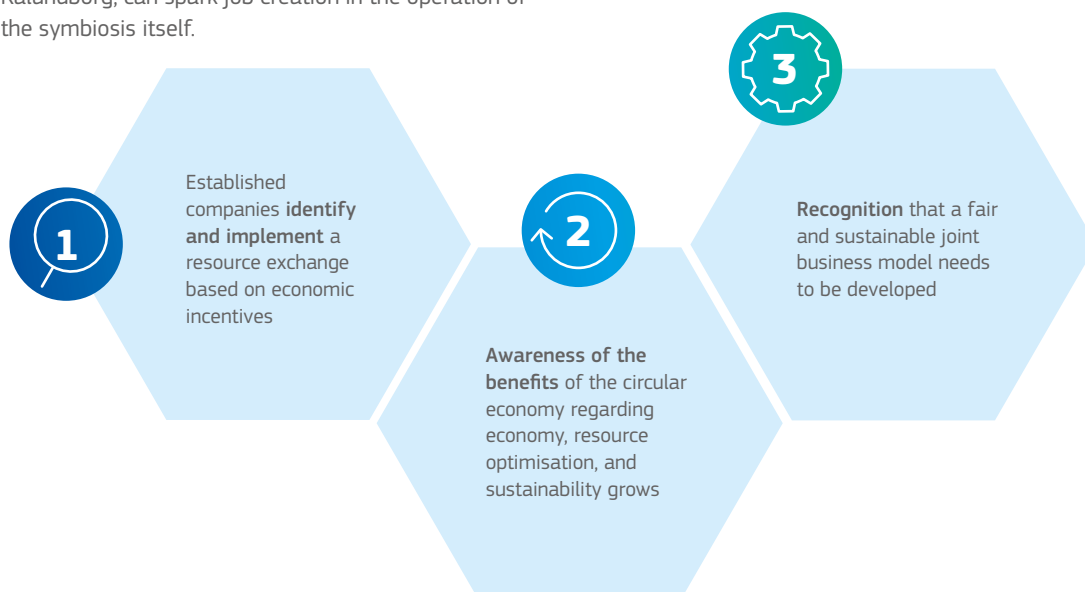


Figure 1: Stepwise development of industrial symbiosis. Based on: European Commission (2020). *Study and portfolio review of the cluster of projects on industrial symbiosis in the Directorate for Prosperity in DG Research and Innovation: Findings and recommendations.*

3. Best practice: The Port of Aalborg in North Jutland, Denmark

3.1 Local context – North Jutland, Denmark

Denmark is one of the frontrunners in the race towards climate neutrality. The country aims to reduce emissions by 70% in 2030, and its projected reduction in emissions from industry is the highest of the 27 Member States, with an expected decrease of 53% between 2005 and 2030. Most of that decrease will come from reducing energy-related emissions in the industry sector.¹⁰

North Jutland – one of the five regions of Denmark – is a carbon-intensive region, defined by a large concentration of cement producers. North Jutland is one of two regions in Denmark particularly at risk of experiencing negative consequences from the transformation to a climate-neutral economy¹¹. Denmark will receive €89 million from the Just Transition Fund (JTF) of the European Commission, and in North Jutland the funding will be used to invest in research and innovation to develop technologies such as carbon capture, utilisation, and storage (CCUS), power-to-X (PTX), and pyrolysis¹². In Denmark, almost 40% of employees work for an SME, and the JTF will help SMEs test and demonstrate circular economy solutions.¹³ As such, the JTF will help North Jutland reduce emissions and scale alternatives to carbon-intensive production at the same time.

Aalborg is the third biggest city of Denmark and the capital of the North Jutland region. Aalborg has some of the largest per capita emissions of the country, which stems from the fact that Denmark's biggest cement producer – Aalborg Portland – is located in the Port of Aalborg. The company is seen as the largest emitter in Denmark and is responsible for an estimated 4% of Denmark's total emissions.¹⁴ Aalborg thus has a significant role to play in bringing down emissions in North Jutland and in Denmark in general, and the municipality aims to move away from fossil fuels by 2050.

3.2 Industrial symbiosis in the Port of Aalborg

The Port of Aalborg describes itself as a hub for green production, knowledge, and testing. The Port plays an active role in the climate transformation by greening its own operations, but also by entering into partnerships and facilitating industrial symbiosis in the connected business park.¹⁵

The seeds of industrial symbiosis in the Port of Aalborg and its environment were sown decades ago and the project continues to develop gradually. As more stakeholders become involved in the project, novel synergies continue to be identified and exploited. The case of Aalborg demonstrates the importance of different actors taking up a facilitating role in the development of industrial symbiosis, as seen in Table 1.

In recent years, joint projects working specifically towards industrial symbiosis development have sped up the formation of synergies. The transformation of the local SME sector has received particular attention, giving Aalborg's symbiosis an injection of green innovation. Notable examples include:




- **Green Resource Ecosystems North Jutland (GRØN)** was a two-year EU project aimed at future-proofing SMEs in North Jutland by helping them engage in industrial symbiosis. The project mapped the potential for synergies of SMEs in the region and acted as a matchmaker to set up the contact with relevant partner companies. The Port of Aalborg, NBE and Aalborg University were amongst the project partners, helping to anchor the identified synergies within the existing ecosystem.¹⁶
- Its predecessor **Sustainable Synergies**, also an EU project, focused specifically on identifying synergies between SMEs in Aalborg East – the area in which the Port of Aalborg is located. The project helped 25 SMEs set up several durable company interconnections in the area and develop green business models, leading to an estimated reduction of 10,000 tonnes CO₂.¹⁷
- Initiated by the Port of Aalborg and Aalborg University in 2016, **Miljo++** is an incubator for SMEs wanting to explore sustainable business models. Miljo++ aims to make Aalborg the logical choice for sustainable businesses by focusing on industrial symbiosis, innovation, and entrepreneurship. Collaboration between businesses, authorities and knowledge institutions is central to the project. Today, Miljo++ is also focusing on involving bigger companies and promoting internationalisation to attract businesses working on sustainable solutions.¹⁸

Building on the strong partnerships developed in Aalborg, several innovative projects are currently being developed to help North Jutland move away from carbon-intensive production. Notable examples include:

- Many of the above partners – including Aalborg University, the Port of Aalborg, and Aalborg Portland – are involved in GreenCem, a **CCUS** test project at Aalborg Portland's cement plant. As part of the test project, efficient reuse by surrounding companies will be explored.¹⁹
- The waste company Reno-Nord and the district heating network of Aalborg are involved in building one of the world's first commercial **PTX** plants. The plant will start operating in 2028 and aims to produce up to 130,000 tonnes of green methanol per year. An electrolysis plant will produce hydrogen, and CO₂ from waste incineration by Reno-Nord will be used to convert it to green methanol. Excess heat will feed into Aalborg's district heating network.²⁰
- To accommodate CCUS and PTX projects, the University of Aalborg has just moved its test facility from the campus to a 3,000 m² area in the Port area. The test facility will combine the expertise of the University of Aalborg on the subject with the experience of a cluster of companies working with the technologies.²¹

The Just Transition Fund will also be of help in scaling CCUS, PTX, and other innovative projects, in turn contributing to making Denmark and the EU climate-neutral by 2050.

Table 1: Examples of actors taking up a facilitating role in the industrial symbiosis of Aalborg.

Type of facilitating role	What?	In the Port of Aalborg
Anchor 	<p>Marian Chertow describes anchors in the following way: “just as shopping malls are built around several large department stores that anchor the commercial development within, one or two large industries can provide the same critical mass for an eco-industrial park.” Anchors provide vital resource and energy flows for the surrounding companies, and power plants often serve as the anchors of industrial symbiosis.²²</p>	<p>Given its size and its importance in Aalborg’s economy, the cement producer Aalborg Portland serves as an anchor tenant. The company is involved in several resource exchanges. For example, Aalborg Portland has been using the sand the Port of Aalborg collects from dredging for cement production for several decades.</p> <p>The power plant Nordjyllandsværket also has the critical mass to be an anchor – it provides heat to Aalborg’s district heating network, delivers electricity to many companies, and receives chalk slurry from Aalborg Portland.²³</p>
Coordinator 	<p>Coordinators create the enabling conditions for industrial symbiosis to develop by promoting communication between the different actors. They take on project management tasks and can contribute to creating an institutional framework, which can help in establishing political support. Coordinators also provide a long-term perspective.</p>	<p>The municipality of Aalborg is a coordinator. The municipality carries a lot of weight as it also owns Nordjyllandsværket, the Port of Aalborg, the district heating network, and several more utility companies, all holding significant potential for resource sharing. Its climate commitments also shape the development of Aalborg’s industrial symbiosis.</p> <p>As a local leader in sustainable business development, the Network for Sustainable Business North Denmark (NBE) also acts as a coordinator. As a public-private cooperation of municipalities in North Jutland, Aalborg University, and private companies, NBE offers green services such as sustainability screenings, organises networking events to build trust between organisations, and spreads information on industrial symbiosis. NBE also led an industrial symbiosis project, which has resulted in several synergies in Aalborg.²⁴</p>
Orchestrator 	<p>Having an active and central position and many connections is necessary for an actor to take on the role of orchestrator. Orchestrators encourage interactions between actors, identify synergies, and recruit tenants.</p>	<p>The Port of Aalborg plays a major role in industrial symbiosis development as it is responsible for recruiting companies to settle in the business park. The Port’s sustainability vision guides its recruitment choices. In addition, the Port sustains connections to the many companies operating in the area, promotes cohesion, and leads on several industrial symbiosis projects, as described below.</p>

Key resources

- The [Hubs4Circularity Communities of Practice](#) is an EU network of partners from industry, regions, and cities to facilitate industrial symbiosis. The [knowledge platform](#) offers toolkits and guidebooks.
- The [SCALER](#) project, which took place from 2017 to 2020, also aimed to increase the uptake of industrial symbiosis in Europe. The project produced a set of [resources](#), including best practices, tools, and guidelines.
- The main aim of the [EPOS](#) project was to enable industrial symbiosis across sectors, focusing specifically on the steel, cement, chemicals, minerals and engineering sectors. The project developed a [toolbox](#) for symbiosis development, which is available for users after sign-up.
- The [Cambridge Value Mapping Tool](#) of the University of Cambridge helps users identify uncaptured value in their resource flows.

This document was prepared by researchers at Guidehouse having conducted desk research, interviews and surveys. Any information and views contained in the present document do not reflect the official opinion of the European Commission. Reuse is authorised provided the source is acknowledged.

This document is part of a series presenting information and lessons learned on policy approaches at national, regional or local level supporting a just transition to a climate-neutral economy. The Just Transition Platform (JTP) assists EU Member States and regions to unlock the support in this transition. Visit the [JTP website](#).

Endnotes

- 1 European Environment Agency (2022). [Trends and projections in Europe 2022](#).
- 2 Ibid.
- 3 European Commission (2021). [EU Industrial Strategy](#).
- 4 European Commission (2023). [The Green Deal Industrial Plan – Putting Europe's net-zero industry in the lead](#).
- 5 European Commission (2020). [Circular Economy Action Plan – For a cleaner and more competitive Europe](#).
- 6 Taking Stock of Industrial Ecology (2016). [Scholarship and practice in industrial symbiosis: 1989-2014](#). Book chapter.
- 7 Ibid.
- 8 European Commission (2020). [Study and portfolio review of the cluster of projects on industrial symbiosis in the Directorate for Prosperity in DG Research and Innovation: Findings and recommendations](#).
- 9 Ibid.
- 10 European Environment Agency (2020). [Trends and projections in Europe 2022](#).
- 11 Denmark (2021). Territorial Just Transition Plan – North Jutland and South Jutland.
- 12 Ibid.
- 13 European Commission (2022). [EU Cohesion Policy: €89 million for a just climate transition in Denmark](#).
- 14 COWI (2020). [Aalborg Portland looks into possibilities of carbon capture](#).
- 15 Port of Aalborg. [Sustainability](#).
- 16 State of Green (2022). [Aalborg project hailed as one of Denmark's most innovative green projects](#).
- 17 Sustainable Synergies (2020). [Growth and synergies in Aalborg East](#).
- 18 Miljø++. [Business development through sustainable solutions](#).
- 19 GreenCem. [GreenCem – the project](#).
- 20 State of Green (2021). [Power-to-X plant in Aalborg will produce green methanol from local waste-based CO₂](#).
- 21 State of Green (2023). [Test facility in Aalborg will accelerate production of future green fuels](#).
- 22 Annual Review of Energy and the Environment (2000). [Industrial symbiosis: Literature and taxonomy](#).
- 23 University of Aalborg (2018). [An ecosystem analysis of industrial symbiosis development in Aalborg, Denmark](#). Master thesis.
- 24 Ibid.

