Journal of Current Trends in Agriculture, Environment and Sustainability

Katalyst
Publishing Group

Open Access

Research Article

Net Zero through Circular Economy: Insights From the Billund Biorefinery and the Kalundborg Industrial Symbiosis

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Abstract

This paper investigates two Danish circular economy models in use—Billund Biorefinery and Kalundborg Industrial Symbiosis—that support on-site decarbonization through waste and resource management strategies. Billund Biorefinery exemplifies a scalable, energy-positive wastewater treatment model that transforms waste into biogas and valuable resources, supporting net-zero goals in the water sector. Kalundborg Industrial Symbiosis showcases a large-scale, cross-industry collaboration where companies achieve greenhouse gas reductions by sharing resources and by-products, illustrating the potential of circular networks to achieve corporate GHG savings. Patience, trust, and a phased approach is essential for effective industrial symbiosis, and therefore, the Symbiosis Readiness Level framework is explored as a tool to facilitate structured symbiotic relationships across industries. To advance industrial decarbonization, this paper closes by analyzing the operational advantages of adopting the two circular economy models, with a focus on their scalability and applicability across the most relevant sectors.

Keywords: Circular economy, biorefinery, industrial symbiosis, decarbonization, resource efficiency

Part I: Introduction, Research Questions & Research Objectives

Introduction

The need for decarbonization solutions and sector coupling is urgent: The latest WMO report, released in October 2024, highlighted rising concerns as atmospheric CO_2 levels reached 420 ppm—a critical marker indicating that GHG reductions are severely lagging behind Paris Agreement goals [1]. Decarbonization efforts span nearly all sectors but have predominantly focused on expanding renewable energy adoption, enhancing energy efficiency in buildings, and accelerating the transition to electric vehicles.

IRENA's 1.5°C Scenario, outlined in the World Energy Transitions Outlook, charts a pathway to achieving the 1.5°C target by 2050, emphasizing electrification and energy efficiency as critical drivers, supported by renewable energy and green hydrogen. And while these solutions are pivotal in directly reducing emissions, they often overshadow the significant carbon footprint tied to resource extraction, wastewater treatment, and the untapped opportunities in industrial resource exchange—areas that remain promising yet frequently overlooked in the broader decarbonization narrative [2].

To broaden the decarbonization perspective, the two circular economy models examined in the paper offer scalable solutions that are particularly relevant to industries with organic byproducts. That is, from agriculture and food production to paper and pulp, and construction. In general, circular economy models enable industries to minimize waste, reduce dependency on virgin materials, and optimize resource use through practices like waste-to-energy conversion, wastewater harvesting, and cross-industry symbiosis. However, handling solid waste and growing wastewater volumes is not just important in industrial settings.

Solid waste and wastewater management are also critical for maintaining urban health, avoiding diseases and ensuring an adequate quality of living, as cities expand in the developing world. With urbanization accelerating in countries such as Congo, Nigeria,

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Received Date: 22 Nov, 2024
Accepted Date: 27 Nov, 2024
Published Date: 02 Jan, 2025

Citation: Christian Hald-Mortensen (2025) Net Zero through Circular Economy: Insights From the Billund Biorefinery and the Kalundborg Industrial Symbiosis. J Cur Tre Agri Envi Sust 5(3): 1-8.

Angola, China, India and Bangladesh, there is a growing need for tried and tested circular economy solutions for urban settings that address both solid waste, wastewater volumes, decarbonization and better resource use. Also for that reason, the two models, Billund Biorefinery and Kalundborg Industrial Symbiosis are relevant, although they differ in size and scope.

The paper seeks to add value by coming from an operational and practical vantage point, not least because some see the circular economy as elusive and abstract, hard to implement, and necessitating a range of preconditions, before you can move beyond the linear 'take-make-dispose' model.

Research Objectives:

Evaluate how circular economy models—in wastewater management and industrial symbiosis —contribute to GHG reductions and support corporate decarbonization in key industries.

Research Question:

How can circular economy practices in waste management, wastewater management, and industrial symbiosis reduce GHG emissions, enabling corporate decarbonization towards net zero?

Research Methodology:

Several research methods are used to analyze the contribution of circular economy models to decarbonization goals. The paper is based on a literature review that synthesizes existing studies, reports, and frameworks. This method provides an understanding of circular economy principles and their application to industrial decarbonization. The paper is focused on bringing knowledge to audiences such as corporate decision-makers, corporate sustainability officers and government officials. Therefore, descriptive analysis is used to illustrate two circular economy models operating in Denmark. Detailed descriptions of the Billund Biorefinery and Kalundborg Industrial Symbiosis showcase how these models function, and their potential to reduce greenhouse gas emissions. Finally, comparative analysis is used because the paper highlight the two models' operational differences, scalability, and industry potential for implementation in corporate climate strategies.

Part II: Circular Economy Principles for Corporate Resilience Across Supply Chains

Introducing Circular Economy at the Industrial Level

To address resource scarcity and rising material costs, companies are integrating more circular economy practices. These practices reduce dependency on finite resources and mitigate the risk of price volatility. By implementing closed-loop systems, industries such as dairies, electronics, automotive, construction, and textiles can recover materials, reduce waste and water use, and optimize resource use [3,4].

Many companies have noticed their exposure to the risk of higher resource prices, such as silver, steel, aluminum, and energy [5]. A circular economy optimizes material use through recycling which is cost-effective in particular when it comes to valuable resources like steel, aluminum, and rare metals, but also for handling solid waste fractions [6,7]. A circular economy at the corporate level is not achieved in a single step; it often requires phases of actions, and one study perceives a hierarchy of strategies, from a linear approach to most circular. Strategies range from refusing unnecessary products to incinerating materials with full energy recovery. In between comes smarter use, extending product lifespans, and advanced recycling that can reduce waste and resource consumption, enabling direct GHG savings and indirect GHG savings by limiting resource extraction [8,9].

Resource Extraction Is Relevant for More Resilient Corporate Supply Chains

In fact, a recent paper by Anilkumar and Sridharan examine circular approaches in sustainable supply chain management (SCM) by examining economic, environmental, and social drivers that push corporations to build more resilient supply chains and adopt a holistic view of supply chain management [10]. The researchers find that corporations face practical barriers, including regulatory challenges, consumer perceptions, and the absence of dominant business models to advance circular economy further [11,12,13].

The Decarbonization Potential in Energy Recovery in Wastewater Treatment

To move towards a decarbonized waste management system, there has been a significant effort by OECD countries to improve waste management practices [14]. This move has included an increased focus on energy recovery from waste. In an OECD country such as Denmark, the drive for a circular economy comes not just from the waste management sector, but also from the water sector. Here, the Billund Biorefinery and Kalundborg Industrial Symbiosis represent two viable pathways for corporations aiming to integrate circular principles, and use both waste and wastewater as inputs.

In fact, Denmark has ambitious goals in wastewater energy recovery as the water sector seeks to support Denmark's national decarbonization targets. Denmark's Climate Act has set a target of Danish climate neutrality (net-zero) no later than 2050, with an interim goal of cutting Denmark's emissions by 70 percent in 2030 compared to 1990 [15].

Consequently, Denmark aims to make its water sector energy and climate neutral by 2030, with wastewater treatment plants being instrumental in that effort as they become net energy producers [16]. Municipal players such as VCS Denmark in Odense, Aarhus Water and HOFOR in Copenhagen are pushing energy recovery from wastewater further, in order to make the water cycle net energy positive [17].

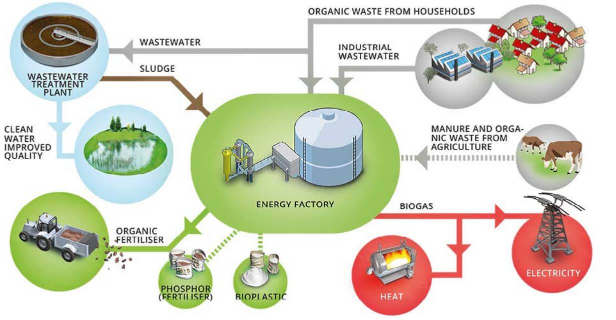

Figure 1: The Billund Biorefinery Model

The Single-Entity Resource Optimization Model (Billund):

Corporations that generate large volumes of organic wastewater or organic by-products (e.g., in the food production, agriculture, forestry and paper industries) can adopt Billund's approach. By establishing on-site biorefineries, companies could transform rich organic wastewater into valuable biogas and recovered nutrients. This model's focus on localized energy recovery and nutrient cycling offers significant benefits for corporations aiming to enhance energy independence, reduce reliance on landfills, and mitigate associated methane emissions.

Methane, a major contributor to climate change, is a byproduct of both wastewater treatment plants and solid waste landfills. Notably, methane possesses a global warming potential 28 times greater than carbon dioxide over a 100-year timescale and is 84 times more potent over a 20-year timescale. Finally, corporations can also support regenerative agriculture by bringing back nutrients to farmers in the value chain.

To pursue energy recovery, rethinking wastewater has been stressed, and in Denmark it is increasingly seen as "resource water", a valuable energy source within a fully circular system. Supported by the Danish Ministry for the Environment, with innovation grants driving technology development and Veolia Environnement as a key partner, the biorefinery serves as a new paradigm in wastewater treatment [18].

As a government EcoInnovation lighthouse project, Billund Biorefinery in Central Jutland in Denmark is a public-private partnership that provides a circular model for integrating waste-to-energy solutions and wastewater treatment.

Billund Biorefinery uses advanced anaerobic digestion to treat both municipal and industrial wastewater, to optimize resource recovery. The facility achieves energy self-sufficiency and generates valuable nutrients that support agricultural and industrial activities in the Billund region [19].

Table 1: Circular Economy Opportunities in Waste and Wastewater Management

Opportunities	Climate Benefits
Enhancing waste management through recycling, reuse, and energy recovery.	Reduced landfill waste and emissions; increased material reuse; lower demand for virgin materials.
Recovering critical materials to strengthen industry resilience.	Lower carbon footprint from reduced need for raw inputs; increased circularity in production cycles.
Integrating closed-loop designs in construction to reduce waste.	Enhanced resource efficiency; reduced carbon impact in the construction sector.
Utilizing wastewater treatment facilities like Billund Biorefinery for energy recovery and resource reclamation.	Offset fossil fuel use through renewable biogas production; reduced methane emissions; nutrient recovery (e.g., phosphates) supporting agricultural and industrial applications.
Expanding advanced anaerobic digestion and thermal hydrolysis technologies in wastewater treatment.	Increased energy output; CO_2-neutral facility operations; potential scalability.

Table 2: Specific Resource and Climate Savings in Billund Biorefinery

Opportunities	Climate Benefits
Category	Value
Projected CO2 Savings	Reduced energy demand (60-70%), and enhanced energy efficiency contribute to lowering CO2 emissions. Note: Specific CO2 or GHG reduction figures are not provided.
Energy Savings	Energy demand reduced by 60-70%; net energy production of 6,800 MWh annually through Exelys™.
Water Savings	15% treated wastewater reused, reducing clean groundwater usage by 75%.
Material Savings	Phosphorus recovery enabled; sludge output reduced with improved soil enhancement characteristics.
Socio-economic Savings	Stabilized operations; energy production for local grids, benefits to local farmers from organic fertilizer use.
Commercial Savings	€9.5M investment with a 9-year payback; reduced operational costs; increased biogas production.

Already, Billund BioRefinery's upgraded biogas plant has achieved a 60% biogas production increase and a 50% sludge reduction, with a payback time of 9.5 years, and also recovers phosphates for fertilizers. This approach showcases strong scaling potential, with Krüger's technology already gaining international traction in South Korea and beyond [20]. Table 1 highlights the opportunities described and the general climate benefits.

Results are noteworthy: Billund BioRefinery produces 2.5 times more energy than it consumes. As a CO_2-neutral facility, it supplies renewable energy to approximately 1,600 households, by integrating advanced anaerobic digestion and a novel solution called thermal hydrolysis (EXELYS™ technology), which reduces sludge by up to 40% [21]. Table 2 highlights the resource and projected GHG emission savings at Billund Biorefinery.

However, updated data on the decarbonization benefits achieved remains unavailable. And the project did not have decarbonization as an end goal:

"Billund Biorefinery was a demonstration project. As the focus was on energy production and incorporating the thermal hydrolysis concept, the idea was that the more energy you could extract from the wastewater sludge, the less CO2 would be released into the atmosphere. But a GHG calculation of Billund Water Utility's CO2 emissions before and after the Billund Biorefinery concept has not been done. The focus has been on resource utilization rather than GHG reductions." - Steen

Sorensen, Head of QA, Billund Water & Energy.

The demonstration project was initiated in 2017, but is now coming to a close: "Billund Biorefinery as a project is shutting down from January 1, 2025, as a recent change in the environmental legislation has prevented municipal boards from doing waste management, and the project rests on a supply of waste. We talk about sector coupling, but the waste management sector is not included in that discussion as of yet". - Thomas Kruse Madsen, CEO, Billund Biorefinery.

In the Danish water sector, Billund Biorefinery represent a well-known Waste-to-Energy (WTE) case supporting the renewable energy transition but for outsiders to the water sector, it may be new that the water sector can contribute to a country's renewable energy mix, thus complementing decarbonization efforts in the energy sector [22]. Scaling the Billund Biorefinery model could yield other societal climate benefits as well, by reducing methane emissions from landfills and from wastewater treatment plants, by capturing methane from sludge decomposition.

Part III: Industrial Symbiosis and Decarbonization Results

The Kalundborg Industrial Symbiosis

Compared to the Billund Biorefinery, industrial symbiosis in Kalundborg is a larger and more complex operation, involving more partners. Industrial symbiosis relies on resource-sharing networks that foster cross-industry collaborations, and by reusing resources and exchanging by-products with each other, companies from different industries reduce reliance on virgin materials and minimize waste [23].

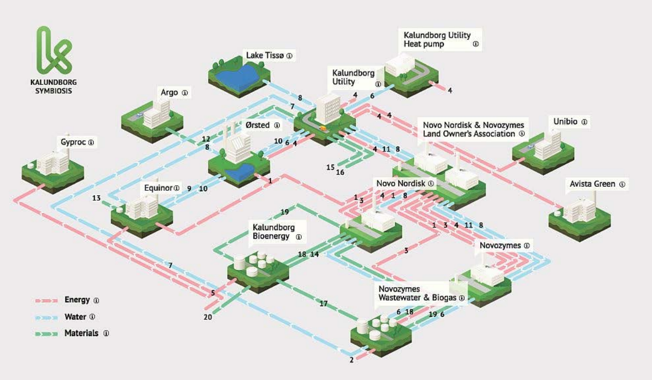

Figure 3: A Visual Representation of the Kalundborg Industrial Symbiosis' Resource Flows

The Cross-Industry Resource Sharing Network Model (Kalundborg):

Corporations within industrial parks with complementary byproducts and industries can adopt the Kalundborg model. By being analytical and identifying opportunities to share by-products and resources such as water, wastewater, and waste heat, corporations can collaborate and enhance on-site operational efficiency, thereby collectively lowering their carbon footprints through material exchange [24]. The Kalundborg Industrial Symbiosis partnership is still growing with new members added in 2022, and the partnership underscores the importance of local commitment to a community-based circular economy [25].

As of 2024, these participants represent various sectors. Key participants include Novo Nordisk, a pharmaceutical company specializing in diabetes and obesity care, and Novonesis (previously Novozymes), a leading biotechnology player known for enzyme production. Energy-related participants such as Equinor Refining Denmark contribute by recovering energy by-products, while Kalundborg Utility manages shared water and heat supplies essential for the community's infrastructure [26].

Kalundborg Municipality, as the local government authority, plays a facilitative role, supporting the circular economy initiatives alongside the plant owned by Gyproc Saint-Gobain, which manufactures gypsum-based building materials that also forms part of the symbiosis.

Waste management is handled by Argo, a dedicated company ensuring efficient waste processing and resource recovery.

Table 3: Specific Resource and Climate Savings in Kalundborg Industrial Symbiosis

Category	Value
CO2, Emissions (2015 Baseline	443,000 tonnes
Projected CO2 Savings (2020)	635,000 tonnes
Energy Savings (2015)	17,589 MWh
Water Savings (2015)	3.6 million m3 (343,000 M3^3 from symbiosis exchange)
Material Savings (2015)	87,000 tonnes
Socio-economic Savings (2015)	DKK 106 million
Commercial Savings (2015)	DKK 182 million

Argo receives waste from all residents and businesses in the Municipality of Kalundborg, including Kalundborg Utility. The recyclable waste is sorted into fractions and subsequently sent to the recycling industry [27]. The company's primary task is to ensure that waste is transformed into resources. The company Biopro contributes through biotechnological processes. Avista Oil, a specialist in oil recycling and re-refining, highlights the inclusion of resource-intensive industries focused on reducing dependency on virgin materials.

The resource exchanges include steam used in one process which is repurposed as district heating, and organic wastewater that undergoes biogas conversion before application as fertilizer. These exchanges contribute to significant CO_2 savings, resource conservation, and economic benefits, advancing circular economy goals. And the climate benefits are worth elaborating: One study developed by the Kalundborg Symbiosis Centre in Denmark uses life-cycle assessment (LCA) and material flow analysis (MFA) to analyze three primary resource flows—energy, materials, and water—within the Symbiosis, and it is presented in Table 3.

The study quantified savings across several resource dimensions. A detailed table illustrates the differences between the Symbiosis scenario (SYM) and a hypothetical reference scenario (REF). The transitioning from coal to woodchips and introducing biogas production significantly improves environmental outcomes. For instance, the adoption of woodchips at Ørsted/Asnæs Power Station in 2019 led to a net CO_2 saving of 685,543 tonnes, compared to the coal-based baseline. Similarly, biogas conversion in 2018 substantially

increased material and energy efficiency, with projected CO_2 savings of 635,000 tonnes annually by 2020 [28].
These findings underline the potential of industrial symbiosis to support decarbonization as this collaboration among 11 public and private companies has achieved substantial greenhouse gas (GHG) reductions, cutting CO_2 emissions by 59,000 tons annually—equivalent to the yearly emissions from 20,000 cars.

This partnership exemplifies a structured and evolving model of industrial collaboration. Established over 40 years ago, it has fostered collaboration between local industrial enterprises to optimize resource use by converting waste streams into valuable inputs. However, can it be applied elsewhere? How could the model by scaled?

Scaling by Applying the Symbiosis Readiness Level

To begin to implement an industrial symbiosis requires thorough analysis, and the Symbiosis Readiness Level (SRL), inspired by NASA's Technology Readiness Levels, assesses how symbiotic industrial processes actually are.

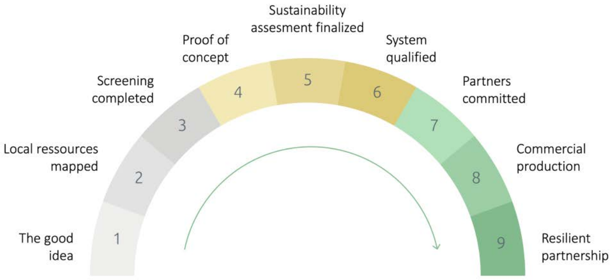

Figure 4: The Symbiosis Readiness Level

This scale was developed by NASA to measure the maturity of a technology from concept through to operational use. The NASA TRL system ranges from level 1, where basic principles are observed, to level 9, where the technology is proven to work in its intended environment (NASA's space program).

Similarly, The Symbiosis Readiness Level gauge the maturity of a symbiotic industrial process, from initial idea to full implementation within a resilient network, The Symbiosis Readiness Level benefits from insights from the Kalundborg Symbiosis as a best-practice case [29].

Assessing and describing each development phase of a project, helps to identify the necessary competencies in legal, economic and environmental aspects. For project facilitators, SRL provides a structured overview of ongoing projects, while also helping to identify barriers. The Kalundborg model has also provided input to the Baltic Industrial Symbiosis project and Nordic Circular Hubs [30].

Table 4 showcases opportunities for resource sharing, highlighting significant CO_2 reductions and circular economy benefits. [31,32].

In examining Denmark's Billund Biorefinery and Kalundborg Industrial Symbiosis models, both showcase circular economy applications but differ significantly in their approach and focus.

Table 4: Industrial Symbiosis and Decarbonization

Industrial Symbiosis Opportunities	Climate Benefits
Resource and by-product sharing among interconnected industrial plants on-site for optimal efficiency	Annual reduction of 586,000 tons of CO_2 emissions, equivalent to the emissions of approximately 127,000 cars in a year, achieving an 80% CO_2 emissions reduction within the symbiosis since 2015.
Collaborative reuse of materials, energy, water, and by-products to harvest more economic savings.	Annual cost savings of $15-20 million, reducing landfill waste by 55%.
Utilize the Symbiosis Readiness Level (SRL) Framework to guide project implementation and foster cross-industry collaboration.	Promoting scalable and sustainable resource-sharing practices that accelerate emissions reductions.

Part IV: Comparative Analysis and Application in Corporate Settings

Comparing the Two Circular Economy Models

The two models highlight key circular economy pathways—Billund's localized, facility-driven energy recovery with a starting point at the wastewater treatment plant, and Kalundborg's broader interconnected, industry-wide resource exchange. While both reduce GHG emissions and align with decarbonization goals, Billund's approach is specialized for organic waste-to-energy, and Kalundborg's model enhances industrial resource loops, indicating broader applications across many industries that want to experiment with circular economy strategies. Table 5 compares the models and their corporate benefits.

Industries with Potential for Applying Two Circular Economy Models

Businesses operating within extraction industries have discovered that a linear extract-design-discard model face some risks. Rising resource costs and increased carbon footprints have made a need for decarbonization more urgent. Particularly, when companies enable the creation of new, valuable materials from reused and upcycled components [33]. Hence, a pivot to a circular economy has become a paradigm worth exploring.

In many countries, recycling value chains are already well developed, but there is considerable room for improvement in terms of maximizing efficiency, quality, and emissions reductions. Embracing a circular model, companies can transform waste into valuable resources, aiding national decarbonization initiatives.

The scaling potential of the two circular economy models is noteworthy. However, progress particularly on setting up industrial symbioses has so far been slow. Barriers such as the need for trust, commitment, cost-efficiency, and incremental

Table 5: Comparison of Two Circular Economy Models and Corporate Benefits

Aspect	Billund Biorefinery Model	Kalundborg Industrial Symbiosis Model	Common Corporate Climate Benefits Across the Two Models
Focus & Operational Scope	Focused on wastewater treatment, biogas production, and energy recovery. Operates as a single facility in a public-private partnership model.	Emphasizes cross-industry resource sharing and by-product utilization. Involves multiple participants collaborating across different industries.	Supports waste reduction and promotes circular resource flows, lowering emissions across industries. Encourages scalable, resilient partnerships with potential for adaptation across industries.
Primary Model	Converts wastewater into biogas for energy, creating a self-sustaining facility with energy-positive outcomes.	Establishes circular loops where industries use each other's waste. A city-wide infrastructure has been built for steam exchange.	Reduces demand for virgin materials, thus cutting emissions and improving resource productivity.
Waste-to-Energy and Energy Output	Converts organic waste or wastewater into biogas to meet on-site and local energy needs, reducing reliance on external energy.	Utilizes waste heat and other energy sources from one industry to supply others, optimizing cross-industry energy usage.	Minimizes reliance on fossil fuels, reduces greenhouse gas emissions, and enhances energy resilience across sectors.
Decarbonization Potential	Achieves direct decarbonization by generating renewable energy, cutting landfill methane, and aiding nutrient recovery for agriculture.	Drives indirect decarbonization through enhanced efficiency and reduced virgin material reliance, collectively lowering CO_2 emissions.	Directly and indirectly mitigates climate impacts through renewable energy production and reduced industrial waste.
Nutrient Recovery	Recycles nutrients from wastewater for agricultural use, closing the loop in food and water resource cycles.	Utilizes industrial by-products as feedstock in other industries, minimizing waste.	Reduces landfill emissions and improves resource productivity through closed-loop nutrient cycles.
Scalability Potential	Demonstrates potential for replicable biorefineries in regions with similar waste streams, broadening impact.	Expands symbiosis networks by adding new industrial partners for broader ecosystem benefits.	Builds resilience against supply chain disruptions and enables long-term reductions in carbon footprint through scalable practices.

Table 6: Industries with Potential for Applying Two Circular Economy Models

Industry	Billund Biorefinery Model (Waste-to-Energy and Resource Recovery)	Kalundborg Industrial Symbiosis Model (Resource and By-Product Sharing)	Corporate Climate Benefits
Agriculture and Food Production	Convert organic waste into biogas; recover nutrients for local farming.	Share by-products (e.g., nutrients, organic waste) for other industries.	Reduced waste, increased energy independence, lower emissions.
Dairy and Livestock	Process manure and organic waste for energy and fertilizers	Share wastewater or biogas with nearby industries.	Reduced methane emissions, enhanced nutrient cycles
Beverage and Brewing	Produce biogas and recover by-products like CO_2 for nearby use.	Collaborate with industries using CO_2 and heat (e.g., greenhouses).	Enhanced waste-to-energy usage, closed-loop by-product management.
Pharmaceuticals and Biotech	Limited application; possible for energy recovery from organic waste.	Share water, steam, and biotech by-products for energy or material use.	Reduced disposal costs, improved circular integration.
Construction and Building Materials	Recycle concrete, wood, and gypsum for new materials.	Reuse construction by-products in other sectors.	Reduced waste, lower demand for raw materials, lower emissions
Paper and Pulp	Utilize organic waste and heat recovery for internal energy needs.	Share heat, organic waste, and water with nearby industries.	Enhanced waste management, lower operational costs.

progress often hinder broader adoption. However, the Symbiosis Readiness Level can guide companies by identifying achievable entry points, fostering experimentation, trust-building, making industrial symbiosis more accessible across sectors [34,35].

Table 6 provides examples that illustrate the potential for diverse industries to benefit from circular economy models, enabling improved sustainability, cost savings, and GHG emissions reductions across sectors. All in all, the journey towards a net-zero economy underscores the vital role of circular economy models, demonstrated through Denmark's Billund Biorefinery, that exemplifies a resource-oriented approach to wastewater treatment, generating biogas and recovering valuable nutrients, thus offsetting fossil fuel reliance.

Meanwhile, Kalundborg's Industrial Symbiosis model integrates diverse industries, where the by-products of one become valuable inputs for another, enhancing efficiency and cutting emissions.

Conclusions

Scaling circular economy models like Billund Biorefinery and Kalundborg Industrial Symbiosis requires deliberate action, policy support, and technical guidance but both models hold substantial potential in both developed and emerging economies.

The Billund Biorefinery's wastewater-to-energy approach, integrating anaerobic digestion and thermal hydrolysis, exemplifies the potential for wastewater management to contribute to decarbonization by generating renewable biogas and recovering critical nutrients like phosphates. This model's energy-positive design offers a scalable solution.

The Kalundborg Symbiosis demonstrates the potential of industrial ecosystems to operationalize circular economy principles by leveraging resource-sharing networks to achieve substantial environmental and economic benefits. Through the integration of life-cycle assessment (LCA) and material flow analysis (MFA), the system showcases how collaborative industrial frameworks can optimize resource flows, reduce emissions, and enhance efficiency.

By fostering cross-sector partnerships, the Kalundborg Industrial Symbiosis has created a scalable and adaptable model, enabling a variety of industries to achieve decarbonization and resilience. This approach highlights the importance of systemic thinking and cooperation in scaling circular economy practices.

Disclaimer

The contents of this research article are not meant to recommend courses of actions or investment decisions on the basis of the issues identified and analyzed. The contents are intended to inform you as a reader, and to identify research and policy gaps for further work. Any financial gain or loss incurred by a reader because of this article will result from decisions taken by the reader as an individual. The opinions expressed in this article are my own as an individual, and do not reflect the opinions of my current employer.

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