Make it in Appalachia

Transforming Shuttered Coal Plants into Eco-Industrial Parks

ReImagine Appalachia

Executive Summary

Climate change and growing international concern over its impacts are already fueling global competition in clean energy markets, products, and technologies. With the right resources and attention, the Ohio River Valley of Appalachia, better known as coal country, can emerge as a leader in the new clean economy and a manufacturing hub for the products of the future. This participatory action research is part of the wider "Make it in Appalachia" series, which explores opportunities to build on the region's manufacturing expertise and assets to generate new sustainable opportunities aligned with the well-being of local communities and economies.

The series explores growing markets in the clean economy, for which Appalachia can realistically become a manufacturing hub, leveraging the region's existing strengths, as well as best practices for ensuring the future of the region's manufacturing is more sustainable and fair.

Here, we explore how the region's many shuttered coal plants can be transformed into eco-industrial parks, sites where co-located businesses share resources to increase efficiency, sustainability, and long-term manufacturing profitability.

Appalachia's 57 shuttered coal plant sites lend themselves to eco-industrial redevelopment and present an opportunity to:

1. Build modernized manufacturing hubs with co-located industries as the region moves into new markets, international supply chains are reshored, and domestic manufacturing is rebuilt.
2. Ensure these sites are competitive for the global clean economy of the future by transforming shuttered coal plants into eco-industrial parks, employing best practices in industrial efficiency, energy procurement, and waste management.
3. Establish Appalachia as a hub for a circular economy that is sustainable in the long term, promoting the environmental, social, and economic health of communities.
4. Create equivalent jobs and a tax base for coal plant communities that is equivalent to the one lost with the decline in the coal industry, while also ensuring these sites do not become future blights to those communities.

The assets that make shuttered coal plant sites ideal for eco-industrial development include:

- Large acreage,
- Industrial zoning,
- Heavily reinforced connection to the electrical grid.
- Transportation options (waterways, freight rail, highway access).
- Underground water and sewer connections,
- Proximity to workers with transferable skills,
- Possibility to extract critical minerals and rare earth elements from coal ash ponds

Many shuttered coal plant sites remain unused across the region for various reasons. Eco-industrial parks could attract the funds and excitement needed to push forward redevelopment, cleaning up these sites and preparing them to create new jobs for coal plant communities. Using these preexisting assets in redevelopment reduces both financial costs and the overall carbon footprint of construction compared to greenfield development, positioning them for the environmental certifications increasingly sought by developers, financiers, and tenants.

A wide variety of industries could co-locate at these new eco-industrial park sites. Some examples include building supply manufacturers, biomaterial processors, coal ash separation technologies, electric power companies, and energy service cooperatives, as well as wind turbine manufacturing facilities that produce the longest blades, which require access to navigable water for transportation. Data centers can use waste heat for recycling, providing a valuable resource to adjacent energy-intensive industries in need of that heat.

The basis of the eco-industrial park is the elimination of waste. Waste management personnel or those working with any on-site reuse processing facilities coordinate shared waste stream management services. This ensures that the waste produced as a byproduct of one company's operations can be put to productive use instead of being disposed of. One company's waste becomes another company's raw material. While not all eco-industrial parks in operation today have on-site waste stream sharing systems, this is one of the basic principles of the eco-industrial park.

In today's world of rapid shipping, raw materials and productive inputs (including products at the end of their life) may be shipped; but, like any raw material used as the base in the production of a good, shipping is an additional cost and an addition to the carbon footprint that can be minimized within an eco-industrial park where distances between companies are drastically decreased. Some waste stream pairings are already widespread; for instance, wallboard manufacturers can often be found near coal power plants to take advantage of the synthetic gypsum produced from fly ash created when coal is burned. There are many examples of waste stream sharing and eco-industrial parks worldwide. Projects near and in North Central Appalachia focus on recycling and eliminating waste, including two that are developing into an eco-industrial park:

- **The Solid Waste Authority of Central Ohio (SWACO):** Partners with 400 recycling-reliant businesses in the Columbus Region. Some specific initiatives include:
    - **The Green Economy Business Park:** A 360-acre Green Economy Business Park that will combine research, technology, and advanced manufacturing work and create 2,000 to 3,500 well-paying manufacturing jobs and between $1.6 million and $4.2 million in local tax revenues.
    - **Waste landfill heat to energy:** SWACO also captures the methane produced by its landfill and converts it into an energy source for Central Ohio homes.

- **The Industrial Commons in Morganton, North Carolina**, is a worker-owned facility comprising small and medium-sized textile manufacturers that share a workspace and actively engage with the community.
    - **The Material Return:** Through this initiative, waste fabric is gathered and processed into new products.
    - **Innovation Campus:** The Industrial Commons received a $10 million ARC ARISE grant to redevelop a vacant furniture factory into a 27.87-acre campus with space for startups, business, manufacturing, art, education, and green space.

- **The ReUse Corridor**, an initiative launched by Coalfield Development in 2020, is a coalition of businesses, non-profits, communities, and individuals from throughout Central Appalachia working together to facilitate a sustainable material management system for recycling, upcycling, and reuse. The ReUse Corridor recognizes that large quantities of materials, such as cardboard, electronics, plastics, textiles, and organics, which are typically sent to landfills in Appalachia, can be collected, processed, and redistributed to companies that can turn them into new feedstocks. By addressing both the supply and demand sides of material reuse and providing the logistics to connect communities, companies, and processing facilities, the ReUse Corridor aims to support the emergence of a robust circular economic system in coal country.

At the end of the Biden Administration (December 2024), ReImagine Appalachia researchers identified federal funding opportunities that could help communities develop and companies grow in an eco-industrial park. The Bipartisan Infrastructure Law of 2021 (BIL), the Inflation Reduction Act of 2022 (IRA), and the CHIPS and Science Act, designed to support the growth of clean and efficient manufacturing in Appalachia with direct community involvement, economic and environmental justice principles, and family-sustaining wages, support the basic principles of an eco-industrial park. The status of such programs is not currently clear. One benefit of joining an eco-industrial park is that the collective organization can ease some of the individual pressures faced by small and medium-scale companies, as the group can pool its resources to secure opportunities. Government support, community involvement, cooperation with utilities, effective promotion to attract businesses, shared services and infrastructure, firm trust, and systems for clear communication between member companies are aspects that may help new parks and industries succeed in Appalachia.

While great strides have been made in improving resource efficiency, any system based on consumption rather than on the restorative use of resources entails significant losses along the value chain.

- Excerpt from the Ellen MacArthur Foundation, which has worked for over a decade to accelerate the transition to a circular economy. They outline their main circular principles in a 2015 report, "Towards a circular economy: Business rationale for an accelerated transition."

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Background

On October 16, 2024, ReImagine Appalachia hosted its Second Shuttered Coal Plant Summit to release its handbook on redeveloping shuttered coal plants and discuss opportunities for coal plant redevelopment in the region. One of the breakout sessions at this event focused on converting shuttered coal plants into eco-industrial parks. During this discussion-based session, the existing assets of shuttered coal plants, such as their transportation networks and electrical connections, were highlighted as key advantages for redevelopment. Participants at the session agreed that eco-industrial parks are a redevelopment option that can bring family-sustaining jobs to local communities while growing clean and efficient manufacturing in the region.

The discussion then explored how these sites could become hubs for advancing regional innovation, such as in the growing markets for biomaterials, battery technology, and other cleantech. Rare earth elements and critical minerals, for example, could be extracted from streams laden with acid mine drainage and other coal wastes and recirculated into battery and cleantech supply chains. Large and unwieldy wind turbine blades could be produced on site and shipped by barge via the waterways on which shuttered coal plants sit. Hemp, a promising crop that has a long history of cultivation around Appalachia and currently hindered by a lack of local processing facilities, could be supported by much needed processing capacity established on a shuttered coal plant site - adjacent to acreage where the hemp itself is grown, next to storage facilities where the raw biomass is collected and stored, nearby warehouses from which the processed material is shipped, and co-located with factories that manufacture the processed hemp into resins, materials and products - as well as other facilities and factories that may share heat, cooling, chemical and other wastes of one tenant that become an input for another tenant, such as waste heat from data centers. Renewable energy could also be sited nearby.

Appalachia could revitalize its manufacturing sector by establishing eco-industrial parks at shuttered coal plant sites, thereby encouraging the growth of networks of interdependent manufacturing facilities with complementary organizational and production processes. The proximity of industries enables an increase in overall productivity, driven by the shared use of mutually beneficial infrastructure and the enhanced ability to collaborate. Joint ventures in research, education, finance, and other civic institutions can create localized, integrated economic development strategies that drive regional economic growth.

What is an Eco-Industrial Park?

An eco-industrial park is a shared site at which co-located manufacturers and local businesses work together to share resources including technical services, transportation, infrastructure, energy, and waste streams to reduce costs and waste.[1] Collectively, Eco-industrial parks operate through "**industrial symbiosis**," whereby companies can gain a competitive advantage through the physical exchange of materials, energy, water, and by-products, fostering inclusive and sustainable development.

A key component of eco-industrial parks is the reuse of end products, by-products, and waste streams from one company by complementary manufacturers at the site. This cycling and efficient re-use of materials turns the functions of the eco-industrial park into a circular system. Eco-industrial parks can incorporate manufacturers of different scales, ranging from small companies to larger operations, and span various industries — they are not limited to heavy industry alone.

Through locational proximity, an eco-industrial park can facilitate collaboration, resource co-management, and shared services, infrastructure, and facilities. These features can reduce expenses, increase profit opportunities, improve supply chain security, create demand for services from local businesses, lead to greater customer satisfaction and loyalty, and foster increased resiliency.

The Industrial Commons (https://www.theindustrialcommons.org/) in Morganton, North Carolina, is a worker-owned facility that supports small and medium-sized textile manufacturers around Morganton, North Carolina.[2] Building on the region's long history of textile production, the Industrial Commons provides both social and manufacturing-related services to workers and the surrounding community.

In the main Industrial Commons building, manufacturers share the ample warehouse space to conduct their work. The Industrial Commons also operates a Material Return program, where they process textile waste from a 150-mile radius of Morganton into new products, effectively diverting this prevalent waste stream from landfills. The Industrial Commons produces a range of materials through their Material Return, but one product that may be of particular interest to Appalachian manufacturers is their repurposed textile insulation. A product like this could help reduce waste and produce a product for customers concerned about harsh chemicals.

Figure 1

Reclaimed Textile Waste Products at the Industrial Commons Building

Source: Photo taken by ReImagine Appalachia on a visit to the Industrial Commons

The Industrial Commons also undertakes a significant amount of work with community services in conjunction with their manufacturing operations. The group oversees community art projects, work training programs, bookkeeping services, and other community-building events.

The many successes of the Industrial Commons on both economic and community-building levels emphasize the importance of empowering workers and utilizing the resources and unique heritage of the local community. Future eco-industrial parks in Appalachia should strive to follow the example of the Industrial Commons and focus on uniting local industries and working together to increase opportunity for all.

Benefits of an Eco Industrial Park

At an Eco Industrial Park, "companies can gain a competitive advantage through the physical exchange of materials, energy, water, and by-products, fostering inclusive and sustainable development.

Collective benefits for the economy, environment, and the mutual prosperity of the businesses and people involved include:[3]

- **Environmental:** One of the significant benefits of an eco-industrial park setup is the opportunity to reduce energy and resource waste, as waste streams become inputs for products manufactured by neighboring tenants—a fundamental component of circular manufacturing. As the name 'eco' would imply, this makes eco-industrial parks much more beneficial to the environment, land, and public health than other conventional, non-circular manufacturing processes. This is crucial for the long-term health of the local, regional, and even global environment; however, these sustainable practices are also becoming a necessary business practice as public expectations and consumers become increasingly demanding.

- **Economic:** Once an eco-industrial park is operational and the inputs, outputs, and waste flows are established, the industrial symbiosis of the system is cost-effective. Internationally, this configuration originally evolved as a cost reduction strategy.[4] If the participating businesses are locally based, the success of the eco-industrial park can also have a positive impact on the community, bringing prosperity to the area.

- **Socially,** many eco-industrial parks will engage more with the surrounding community than traditional industrial parks, often exchanging energy and other materials between the community and the eco-industrial park. For example, excess waste heat may be shared with surrounding businesses and homes. The collaborative nature of interaction may facilitate the establishment of shared services, like payroll, shipping and logistics, marketing, and bookkeeping. Some eco-industrial parks actively work to provide social services by opening schools or daycares on-site, implementing employee-ownership models, and engaging in community-building activities. The presence of a functioning eco-industrial park can also increase awareness of sustainable practices, which can prompt new ideas for development within towns and cities.[5]

Trust and collaboration are essential in eco-industrial parks. This spirit of cooperation may be challenging at first because it goes against established business norms based on competition, which are prevalent in the US. Some businesses may worry about relying on waste streams generated by other companies, as the supply may fluctuate according to the business of the different manufacturers. If one manufacturer has a slow month, it could reduce the supply for others. Part of this uncertainty can be addressed by establishing clear and effective modes of communication among businesses so everyone can understand the flow of materials.

The trust and collaboration among tenants can extend to host communities. The Industrial Commons Eco-Industrial campus in North Carolina, as noted above, provides community services alongside their manufacturing operations, including work training programs, bookkeeping services, maintenance personnel, and community-building events. The Environmental Law and Policy Center and other organizations have advocated for the reuse of retired coal plant sites for parklands, open spaces, and community assets.[6]

The sites are so large that integrating bike trails and green spaces next to warehouses and clean manufacturing is not only possible, but also beneficial from several perspectives. While natural amenities cannot alone create an equivalent job and tax base for the communities devastated by coal plant closures, the co-location of natural amenities within and around an eco-industrial park makes good sense, visually showing to the community a clear shift in the way manufacturing is done in the new energy economy.

Figure 2

Elements and Examples of Eco-Industrial Parks

Network of businesses, manufacturers, and/or services companies	Some parks are a mix of residential, office, retail, tech and consulting groups. Others include warehouse/ distribution companies, heavy and light manufacturers, environmental service companies, and industries that re-manufacture and reuse existing products.	Chattanooga, TN; The Green Gold Initiative (Buffalo, NY); Red Hill Ecoplex (Choctaw County, MS); Coffee Creek Center (Chesterton, IN)
Co-location with power plant, access to clean energy resources	Can develop industry network around anchor power plant and/or incorporate energy systems. Examples include parks that convert landfill gas into energy, run a biomass electricity generation plant, co-locate with a gas-fired power plant; demonstrate and promote technologies that use indigenous renewable resources.	Berks County, PA; The Cabazon Resource Recovery Park (Indio, CA);Intervale Food Center (Burlington, VT); Red Hill Ecoplex (Choctaw County, MS)
Offer businesses lower overhead costs, access to infrastructure, incentives	Some attempt to bring new industry into town by offering infrastructure, lower overhead costs, and incentives. Some house companies in a solar-powered or eco-enterprise building. One marine-based park includes an oil recycling business, an ecologically-designed water reclamation system, renewable energy, and a compost business.	Brownsville Eco-Industrial Park (TX); Port of Cape Charles Sustainable Technologies Industrial Park (VA); Franklin County Eco-Industrial Park (NC); Shady Side Eco-Business Park (MD);
Resource recovery facility and joint operations	Nearly all eco-industrial parks facilitate opportunities to identify where one industry's waste can serve as another industry's raw material. Many parks incorporate resource recovery facilities, or centers for reuse, recycling, remanufacturing, and composting. some redistribute usable materlals to the public. One park focuses on selling salvaged building materials. Developers can ID businesses with core capabilities that could benefit from coordinating activities, sharing resources, and participating in joint operations, such as water treatment, reducing dependence on transportation and increasing competitiveness.	East Shore Eco-Industrial Park (Oakland, CA): Green Institute Eco-Industrial Park (Minneapolis, MN); NWLCC-Northwest Louisiana Commerce (Shreveport, LA); Trenton Eco-Industrial Complex (NJ) Civano Environmental Technologies Park (Tucson, AZ)
Maximize use of intermodal transportation of raw materials and waste streams	Transportation is treated as an important element in a number of eco-parks. Port, rail, and interstate access will be used to maximize the intermodal transit of raw materials and waste streams, and facilitate creation of industrial "closed loop' production process.	Fairfield Park (Baltimore, MD); Plattsburgh Eco-Industrial Park (NY)
Process waste streams on site	One park, located within a sustainably harvested forest, processes waste streams on site to avoid transporting waste to overloaded wastewater and solid waste facilities.	Raymond Green Eco-Industrial Park (WA)
Brownfield development	Redevelop a brownfield, former military base, coal plant or existing industrial park into an eco-industrial park. Can include both new development land and redevelopment of former industrial land.	The Green Gold Initiative (Buffalo, NY); Fort Devens (Devens, MA), Port of Cape Charles Sustainable Technologies Industrial

Source: ReImagine Appalachia. "Growing Clean and Efficient Manufacturing" 2020. https://reimagineappalachia.org/wp-content/uploads/2020/10/ReImagine-Appalachia_Manufacturing_10-28-2020-1.pdf

Shared Waste Stream Management Services:
The Key to Circularity within Eco-Industrial Parks

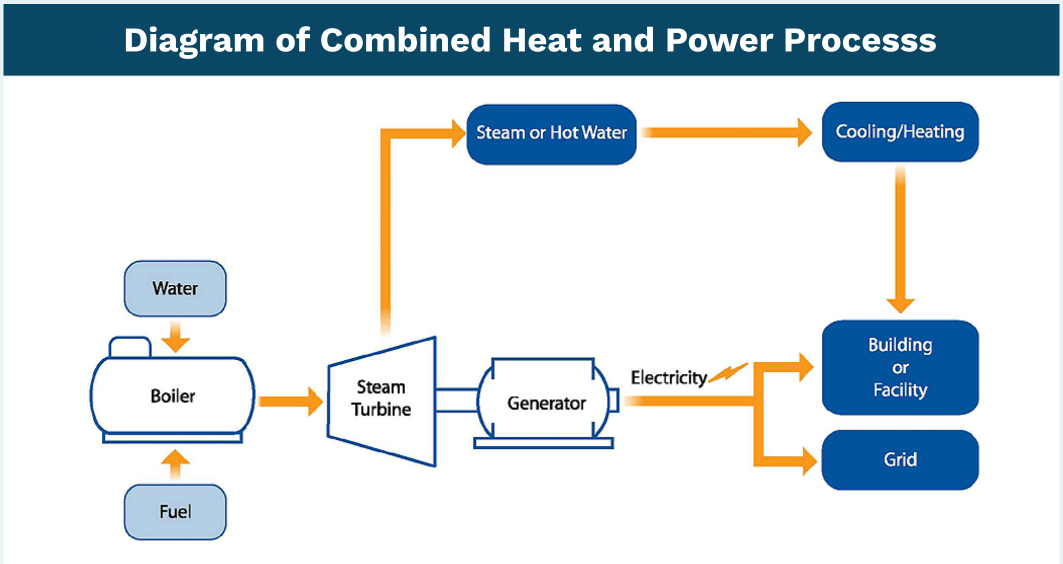
At eco-industrial parks, waste management personnel or those working with any on-site reuse processing facilities coordinate shared waste stream management services. This ensures that the waste produced as a byproduct of one company's operations can be put to productive use instead of being disposed of. Sharing and coordinating the use of waste streams within the park and neighboring community also means that industrial inputs do not have to be gained from an additional outside source. One company's waste becomes another company's raw material. While not all eco-industrial parks in operation today have on-site waste stream sharing systems, this is one of the basic principles of the eco-industrial park.

In today's world of rapid shipping, raw materials and productive inputs (including products at the end of their life may be shipped; but, like any raw material used as the base in production of a good, shipping is an additional cost and an addition to the carbon footprint that can be minimized within an eco-industrial park where distances between companies are drastically decreased. Some waste stream pairings are already widespread; wallboard manufacturers, for instance, can often be found near coal power plants to take advantage of the synthetic gypsum produced from fly ash created when coal is burned.[7]

Well-planned thermal management systems can significantly improve overall efficiency, resulting in cost savings from reduced energy demand. A common and highly effective waste stream to pass on is heat. Heat is produced as a byproduct of many industrial processes, including the burning of coal and natural gas, as well as through data processing. But it is most often dispersed into the air or water instead of being captured and repurposed. This heat loss adds up so that a whole two-thirds of the fuel put into the total U.S. power grid (from combined sources) is wasted as heat.[8] More energy is lost during the generation and transmission of electricity than reaches the end user of that energy. Heat that is simply allowed to dissipate into the atmosphere or water systems represents a considerable loss of economic potential, as that waste heat could be captured and used for other operations, such as heating buildings and greenhouses, molding metals, and processing chemicals.

Combined Heat and Power (CHP) technology, also known as cogeneration, and waste heat recovery systems represent a far more efficient approach to heating and powering industry and commercial businesses. At an eco-industrial park, heat could move through a scaffolding series of operations, each of which requires less heat. For example, heat might first be generated for a heat-intensive process such as steel production. The waste heat from this operation could be captured and used to help support the generation of electricity needed to operate machinery or a data center. The waste heat from generating electricity or operating a data center could continue to be collected and used to heat industrial buildings, as well as greenhouses, grow houses, and fish farms, where food or biomaterial feedstocks could be grown on-site. Replacing the need for generating new heat for every operation with waste heat further increases the entire system's efficiency, lowers energy costs, reduces greenhouse gas emissions, and a company's carbon footprint.

Figure 3



Source: United States Environmental Protection Agency, "What is CHP?" at https://www.epa.gov/chp/what-chp

The CHP facility at an industrial park might resemble a small power plant within the park. The skills needed to operate the plant are the same as for electric utility workers.[9] This type of power production is ideal for a small manufacturing center, as transferring waste heat over long distances is costly and limited to a few miles at most. It can also be suitable for data center tenants, who require significant cooling of the heat generated during data processing. Cooling is usually done by passing warmed water through water-intensive cooling systems using millions of gallons a day or absorption chillers, which use evaporation and coolants to drop temperatures.[10] The overall efficiency of the system and reduction of environmental harm can be optimized by utilizing existing waste heat and ideally also non-potable wastewater available on the eco-industrial site instead of polluting and re-heating fresh drinking water to run absorption chillers.[11] A chemical reclamation plant within the eco-industrial park could also circularize the coolants used on site.[12]

The Eco-Industrial Park in Appalachia: Redeveloping Shuttered Coal Plants

Most probably, the formula for eco-industrial development -- the networked sharing of resources to reduce pollution and waste -- will work anywhere, including in the undeveloped 'greenfields' where manufacturing has never occurred... But we believe the way to minimize environmental impact and demonstrate eco-responsibility is to re-use the brownfields land. That is the ultimate in recycling.

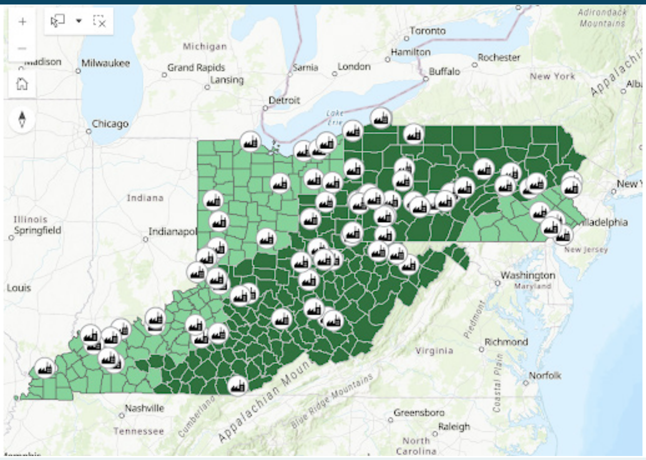
- Edward Cohen-Rosenthal, director of the Work and Environment Initiative at the Cornell Center for the Environment[13]

Shuttered Coal Plants as Eco-Industrial Parks

Shuttered coal plant sites often offer infrastructure such as large tracts of industrially zoned land; transportation options including water, highway, and rail; and significant underground water and sewer connections.[14] There are 57 retired coal plant sites in the four states that make up the Ohio River Valley of Appalachia, also known as coal country (Figure 4). Many shuttered coal plant sites were built along major waterways or with access to railroads and highways, which can be used for transportation. A wide variety of industries could be at these new eco-industrial parks. Some examples include building supplies manufacturers, biomaterial processors, electrical or power companies, and even data centers.

Figure 4

Retired Coal Plant Sites in the Ohio River Valley of Appalachia



Source: Bikash Gupta, ReImagine Appalachia, using data from the Energy Information Administration

These rights allow alternative sources of cheaper power to be installed at the site, facilitating the implementation of renewable energy projects.

The sites could include high voltage direct current (HVDC) converter stations to enhance grid capacity.[15] Further, mostpower lines today use alternating current (AC), but incorporating high voltage direct current power lines (HVDC) enhances energy capacity.[16] HVDC lines have no technical length limitations, which makes them flexible for short distance transmission and ideal for long distance transmission, such as offshore wind farms and other more distant renewable sources.[17] To access the electricity transmitted in HVDC lines, the direct current (DC) must be converted into AC at HVDC converter stations.[18] Shuttered coal power plant sites could provide the space and electrical infrastructure to house these converter stations alongside other co-located manufacturers. The adoption of HVDC technology has been a national priority. At the end of 2024, the United States Department of Energy announced money available for developing HVDC power circuit breakers through its ReImagine Breakers initiative.[19]

All shuttered coal plants must be evaluated for environmental hazards before construction, and many require varying levels of remediation. The cleanup of nearby coal ash ponds can be sped up by turning these liabilities into opportunities, separating critical minerals used in battery and other clean technologies, and repurposing fly ash remnants into cement, eco-bricks, and other building materials. Other than that, the copious acreage and location are like a greenfield development site, but with pre-existing infrastructure already in place (water, sewer, electric and natural gas, fiber optic, roads and ports, etc.).

Reuse of the preexisting assets cuts costs and the overall carbon footprint of construction as opposed to greenfield development, positioning them for the environmental certifications increasingly sought by developers, financiers, and tenants.

APPALACHIAN OPPORTUNITY HIGHLIGHT: MANUFACTURING WIND TURBINE PARTS

Decommissioned coal plants could be repurposed as manufacturing facilities for wind turbine components, among other uses. The growing size of components for wind turbines, including towers, blades, and the nacelles that house the parts that convert blade rotation into electricity, is creating a key bottleneck in the deployment of wind energy. Bigger turbines are more efficient and expand the geographic range of sites where wind farms can be feasible; however, land-based turbine size is now reaching the limits of what can be transported over roads and railways. Offshore turbine parts have already grown too large to transport overland. The need for access to the coast has driven developers to seek expensive coastal land along the eastern seaboard, but limited availability has become a supply chain bottleneck.

The same waterways that once sent coal exports from the Appalachian coalfields around the globe to power the Industrial Revolution could now uniquely position the region to play a role in driving the energy revolution now underway. Land-based and especially offshore wind turbine manufacturing requires extensive facilities and even larger transportation infrastructure. The shuttered coal plants that line the banks of the Ohio River mean that, among inland communities, Appalachia has unique access to both.

Circularity in Appalachia

There are examples of industrial symbiosis in Appalachia that show how these principles can be applied in the region.

The Solid Waste Authority of Central Ohio (SWACO) fosters many projects based on material reuse and leveraging waste streams for the 400 recycling-reliant businesses in the Columbus Region.[20]

- **The Green Economy Business Park:** SWACO began development on its 360-acre Green Economy Business Park in 2020. Once completed, this project will unite research, technology, and advanced manufacturing work on one site so the future participating groups can leverage waste streams and share supply chain management while capitalizing on the growing demand for recycled products.[21] The Green Economy Business Park is expected to create 2,000 to 3,500 well-paying manufacturing jobs and between $1.6 million and $4.2 million in local tax revenues.[22]

- **Waste landfill heat to energy:** besides the Green Economy Business Park and ongoing recycling efforts, SWACO also manages a landfill. This landfill, like all landfills, produces methane, a potent greenhouse gas. Rather than letting this methane go to waste, SWACO captures it and, through a public-private partnership, converts it into an energy source for Central Ohio homes.[23]

The Industrial Commons in Morganton, North Carolina, is a worker-owned facility that supports small and medium-sized textile manufacturers.[24] Building on the region's long history of textile production, the Industrial Commons provides both social and manufacturing-related services to workers and the surrounding community.

- Shared workspace: In the main Industrial Commons building, manufacturers can use the ample warehouse space to conduct their work.
- Fixing what's broken: At the Industrial Commons, some member groups work on repairing broken items.
- The Material Return: This operation converts textiles, a high-volume waste stream generated by the public, and processes the material into new products and yarn that can be reused (Figure 5).
- Gathering inputs: Workers gather 'trash' textiles like old wool socks and industrial scraps from around a 150-mile radius of Morganton. Once the waste textiles are collected, machines in the Industrial Commons building can process these scraps into new products. One product that may interest Appalachian manufacturers is insulation made from repurposed textiles. A product like this could help reduce waste and produce a product for customers concerned about harsh chemicals.

Figure 5

New Products from Trashed Textiles

Source: Photo taken by ReImagine Appalachia on a visit to the Industrial Commons

- Community services: The Industrial Commons also offers community services with its manufacturing operations. The group oversees art projects that highlight community members, such as this mural outside the Industrial Commons building. Other projects include work training programs, book-keeping services, maintenance personnel, and community-building events (Figure 6).

Figure 6

Community-made Mural on the Exterior of the Industrial Commons Building

Source: Photo taken by ReImagine Appalachia on a visit to the Industrial Commons

The many successes of the Industrial Commons on both economic and community-building levels underscore the importance of empowering workers and leveraging the resources and unique heritage of the local community. Future eco-industrial parks in Appalachia should strive to follow the example of the Industrial Commons, focusing on uniting local industries and collaborating to increase opportunities for all.

ReUse Corridor

> ***Long-term success hinges on the ability to engage and educate Appalachia sponsors and stakeholders, and continually expand 'active' materials management capacity, including the number of people involved in shaping ReUse Corridor initiatives***
>
> - ReUse Corridor from the [Strategic Plan (2022-2026)]

The ReUse Corridor, an initiative launched by Coalfield Development in 2020, is a coalition of businesses, nonprofits, communities, and individuals from throughout Central Appalachia and beyond who are working in the circular economy, focusing on reuse, upcycling, and recycling. The initiative has united a range of stakeholders, initially primarily in Ohio, Kentucky, and West Virginia. Still, it has since expanded to include representation from Pennsylvania, Tennessee, and North Carolina, to facilitate a system of sustainable material management that encompasses recycling, upcycling, and other forms of reuse.

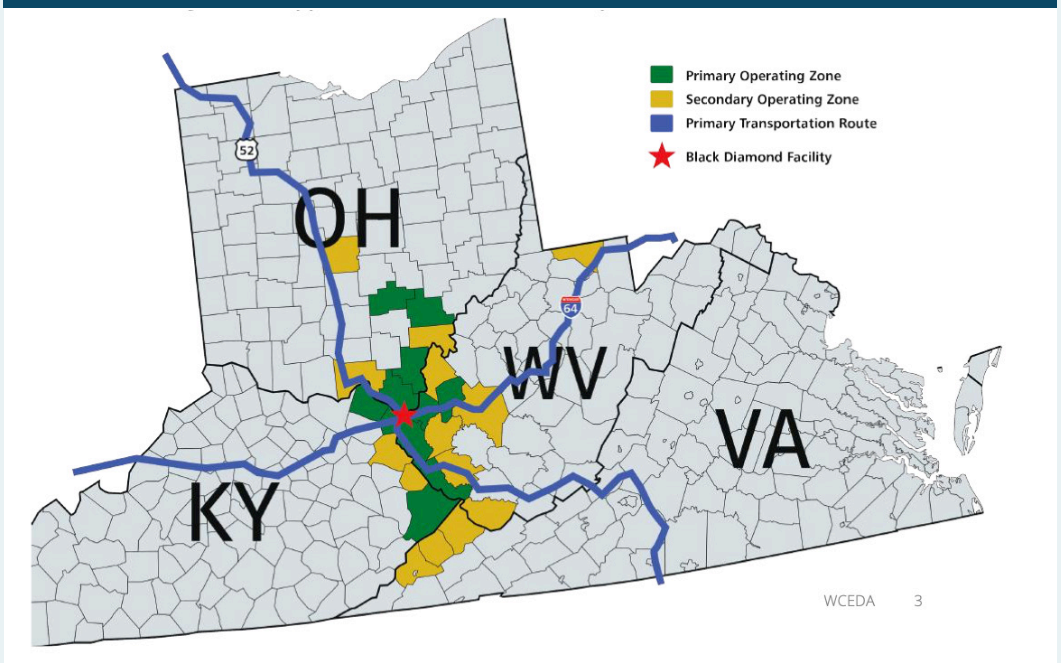
The ReUse Corridor also serves as a working group within the Central Appalachian Network (CAN), a network of practitioners across various economic sectors in Central Appalachia, with particularly significant representation from non-profit organizations. CAN strives to maximize the impact of collective work by fostering peer-to-peer learning and financial opportunities. Through that space, the ReUse Corridor working group starts stakeholder collaborations and resource sharing, holds monthly general and topic-specific meetings, hosts virtual and in-person training sessions, and plans field trips.

The group was formed in response to the regional need for sustainable waste management and to connect stakeholders across the Central Appalachia region, leveraging funding, resources, and collaboration to shape the expanded circular economy market. Appalachia lacks infrastructure for even a linear economy, let alone a circular one, with many in the most rural areas of the region lacking access to trash pickup or convenient disposal, leading to pervasive littering and illegal dumping issues.

Every year, large quantities of valuable materials, including cardboard, electronics, plastics, textiles, and organics, are sent to landfills in Appalachia, where their remaining value is wasted. The ReUse Corridor recognizes these materials can be collected, processed, and redistributed to local companies and organizations that can use them, transforming them into new feedstocks. By addressing both the supply and demand sides of material reuse and providing the logistics to connect communities, companies, and processing facilities, the ReUse Corridor aims to support the emergence of a robust circular economic system within the region, fostering locally based workforce development.

Figure 7

Map of the ReUse Corridor Connected by Roadways Including U.S. Highway 52, or "King Coal Highway," State Route 2, and Interstate 64.



Source: Coalfield Development, at https://coalfield-development.org/wp-content/uploads/2021/08/WCEDA_Strategic_Plan_FINAL_HighRes_04-27-2021-min.pdf, p.3.

The type of active material management system promoted by the ReUse Corridor offers a variety of benefits for the environment, for local economies as job creation and resource conservation, and overall community resilience. The logistics and economics of active material management can become more manageable when the system operates at scale. As such, it is part of the ReUse Corridor's mission to spread education about the value of material reuse to increase regional participation. So far, the ReUse Corridor's methods have proven effective; with 90+ individuals from many states across the region and country on the email list, and between October 2021 and October 2023, they were able to divert over 3142 tons of materials from the landfill.

The ReUse corridor serves as an example of how circular practices can be implemented in a regional setting, encompassing both urban and rural areas. On a regional scale, where stakeholders do not have the luxury of co-location, transportation becomes a significant challenge to consider, especially in the challenging geography of the Appalachian context. The ReUse Corridor's careful calculations on the cost and benefits of road versus rail transportation can help inform best practices for other groups, too. While the geography poses a challenge for transportation of materials and goods in Appalachia, rail infrastructure is a unique competitive advantage that should be used.[25]

Another key strength of the ReUse Corridor is its ability to establish mutually beneficial connections between groups that might not otherwise be aware of each other. Any project looking to incorporate circular economic practices should consciously seek to foster these types of synergistic connections to maximize waste stream reuse.[26]

Moving Forward: Opportunities and Challenges

Eco-industrial parks present their own unique set of challenges. There have been attempts at establishing eco-industrial parks in the US, and the US is a leader in eco-industrial research, but there has not been an equally high success rate.[27] This can be attributed to several factors, including a lack of governmental and public support, especially at the start of the project, insufficient trust and cooperation between park members leading to disconnection and uncertainty.[28]

Planning for the conscious construction of eco-industrial parks – as domestic manufacturing is being revived, corporations are reshoring previously outsourced facilities, and the world transitions to a clean economy – could ensure that new operations are both economically helpful and in line with increasingly expected and required sustainable business practices. Considering the current economic situation within Appalachia and the high number of shuttered coal plants, planning and establishing eco-industrial parks may be more beneficial to the environment and community than gradually transitioning from industrial to eco-industrial parks.

As part of the planning process, it will be essential to involve the community and conduct thorough analyses to attract a successful mix of manufacturers and businesses to new eco-industrial parks. Increasing the number of interactions between different groups, both in person and through the internet, is one strategy that can help spread the word about new eco-industrial developments to interested companies that may want to join. Many significant industrial developments are pre-planned, and lessons can be learned from studying the success of other large-scale operations that have successfully united the various stakeholders involved, including government, investors, workers, and the companies themselves.

An eco-industrial park model that embodies the values of reuse and collaboration is beneficial, but the subsequent planning does not have to be micromanaged in a vacuum; the plan will still naturally develop to match the community's needs. There are frameworks available on the internet that can help guide the development process.

The example of the Industrial Commons, a group of mainly small to mid-sized textile companies in Morganton, NC, reveals that while the sustainable and worker-rights values were predetermined and the textile industry was identified, the exact operations of The Industrial Commons and the array of members was not selected and set in stone at any one point in time.[29] The waste-stream sharing that occurs within eco-industrial parks may seem complicated, but ideally, shared resources will emerge because of new members joining and presenting new opportunities for collaboration. The Industrial Commons was created through several pre-existing partnerships, including the Carolina Textile District, which informed the development of the Industrial Commons' space and services in response to local needs.

Meaningful community involvement in the planning process can help create allies in the community to keep the project. There are and will be challenges related to understanding and perceptions of what an eco-industrial park is, and how it operates. For example, not all private site owners will be willing to accept eco-industrial park development on their land due to perceived risks and uncertainty about how the park will function. There may also be concerns around the profits generated by green businesses that the park may attract. To avoid differences in vision between site owners and eco-industrial park planners, it can be beneficial to seek out sites under municipal ownership, provided the town or city is supportive of the project. Early public support was one factor that helped the Southeastern Ohio Port Authority successfully claim ownership and take on the redevelopment of one and now another shuttered coal plant to create Muskingum River Industrial Park and the upcoming Washington County Multimodal Port Project.

By nature, all eco-industrial parks involve collaboration with multiple groups, which can present additional challenges. One group that will likely be involved is the electric utilities that manage the on-site amenities. Depending on the specific location, these utilities may be large or small, and they may know the principles of an eco-industrial park, which involves sharing and reusing energy and resources. Utilities of all scales should be educated on best practices to support eco-industrial parks, such as adjusting standby rates and providing energy-saving incentives, for instance.[30]

Many shuttered coal plant sites in Appalachia have access to rail, major roads, and rivers, which is an asset that should help attract tenants. This, along with additional infrastructure such as fiber optic connections, sewer systems, and suitable structures for new operations, may need to be updated, upgraded, or installed.

The history of this early US-based eco-industrial park suggests that government support can play a significant role in the success of new, ambitious projects. Successful eco-industrial park projects will take the time to establish clear plans and policies at the local level so they can take full advantage of any programs or assistance offered by larger entities like the federal government.

It can be challenging for new manufacturers to secure federal funding to cover start-up costs, research, and trials of new circular processes at scale when operating independently. One major perk of joining an eco-industrial park for small and medium-sized manufacturers is that the collective organization can ease some of the individual pressures, as the group of manufacturers at the park can pool their resources to secure opportunities while implementing circular processes. An eco-industrial park can also secure funding and large contracts that individual small companies could not acquire, which can again improve the economic strength of participating companies.

Historically, government backing has fostered successful eco-industrial parks in the US and abroad, such as in the somewhat unique example of the Eco-Industrial Park, a 1300 heavy industrial zoned park in Fairfield, MD that made use of Federal and State funding instead of only private funds.

Federal Funding Opportunities

The federal and state funding programs described in the following table represent the status as of the end of the Biden Administration (December 2024). With many changes initiated by the Trump Administration and related challenges in the courts, the future of many programs listed in this section remains uncertain. We expect some programs will be cut, some will shrink, and others will remain unchanged.

Based on these uncertainties, we cannot provide you with an overview that presents the latest status of these programs. Therefore, the information about various funding resources in this section may be subject to change.

With the Bipartisan Infrastructure Law of 2021 (BIL), the Inflation Reduction Act of 2022 (IRA), and CHIPS and Science Act, Congress and the Biden Administration passed a historic package of infrastructure and climate legislation that emphasizes community involvement, economic and environmental justice, and family-sustaining wages. Many of these federal investments are already at work in Appalachia, and there are still appropriated funding streams for communities to receive federal support for redevelopment and job creation.[31]

Federal funds for business development have been allocated through the Bipartisan Infrastructure Law and the Inflation Reduction Act. Small and medium-sized businesses in rural areas and urban neighborhoods, as well as start-ups, once had unprecedented access to capital through these programs. Depending on their final status, opportunities such as these could be used within new eco-industrial park development (Figure 8).

Figure 8

Funding Opportunities as of December 2024				
Federal Funds Related to Clean Energy Manufacturing				
Program	**Department**	**Funding Type**	**Program Description**	**Eligible Recipient**
Advanced Manufacturing Production Tax Credit (§ 45X of the tax code)	DOE/IRS	Tax Credit	The 45X Advanced Manufacturing Production Tax Credit applies to manufacturers of clean energy components such as Photovoltaic components, batteries and certain critical minerals. It is a per-unit tax credit for each clean energy component domestically produced and sold by a manufacturer. It is claimed on federal corporate income taxes. For more information, please check here.	Manufacturer
Qualifying Advanced Energy Project Credit (§48C of the tax code)	DOE/IRS	Tax Credit	The Qualifying Advanced Energy Project Credit program aims to advance clean energy manufacturing and recycling projects, and to help reduce greenhouse gas emissions. The Inflation Reduction Act provided $10 billion in new funding under the 48C tax credit, with at least $4 billion reserved for projects in designated energy communities. Projects selected under this tax credit span across large, medium, and small businesses and state and local governments. This is a competitive tax credit, and its funds are currently exhausted.	Manufacturer
Investment Tax Credit (ITC) (§48E of the tax code)	DOE/IRS	Tax Credit	The ITC provides a tax credit for investments in renewable energy projects, such as solar, small wind, energy storage, fuel cells, microgrid controllers, and combined heat and power properties. A Tax Credit Bonus of 10 percent is added on to the PTC value for projects located in designated energy communities.	Energy asset owner
Production Tax Credit (PTC) (§45Y of the tax code)	DOE/IRS	Tax Credit	The PTC provides tax credits for a 10-year period for the electricity produced from renewable energy sources. An asset owner may claim either the ITC or the PTC for a project, but not both types of credits. A Tax Credit Bonus of 10 percent is added on to the PTC value for projects located in designated energy communities.	Energy asset owner
Energy Efficient Commercial Buildings Deduction	IRS	Tax Credit/ Deduction	Building owners who place in service energy efficient commercial building property (EECBP), or energy efficient commercial building retrofit property (EEBRP) may be able to claim a tax deduction.	Commercial building owners
Battery Materials Processing Grants	DOE	Grant (50% cost share)	The program aims to establish a viable U.S. battery materials processing industry. Funds can also be used to improve our domestic capabilities in the battery manufacturing and recycling industry.	Institutions of higher education, national laboratories, nonprofit and for-profit private entities, state and local governments, and consortia of these entities.
Battery Manufacturing and Recycling Grants	DOE	Grant (50% cost share)	The program aims to establish a viable U.S. battery manufacturing and recycling industry to support the North American battery supply chain.	Institutions of higher education, national laboratories, nonprofit and for-profit private entities, state and local governments, and consortia of entities described.
Battery and Critical Mineral Recycling Program	DOE	Grant	The program is designed to award grants for research, development, and demonstration projects to create innovative and practical approaches to increase the reuse and recycling of batteries.	Institutions of higher education, national laboratories, federal and state research agencies, nonprofit and for-profit private entities, state and local governments, and consortia of entities described.
Advanced Energy Manufacturing and Recycling Grant Program	DOE	Grant	Grants to small/medium manufacturers to build/retrofit industrial or manufacturing facilities to produce/recycle "advanced energy products" in communities with closed coal mines or plants. Can also be used to re-equip manufacturing or industrial sites with tech to reduce their GHG emissions. Currently, no available funds.	Manufacturing firm with: (A) gross annual sales of less than $100,000,000; (B) fewer than 500 employees at the plant site of the manufacturing firm; and (C) annual energy bills which total more than $100,000 but less than $2,500,000.
Industrial Training & Assessment Centers (ITAC) Implementation Grants	DOE	Grant (50% cost share)	The DOE Industrial Training & Assessment Centers (ITAC) Implementation Grant Program provides grants to small- and medium-sized manufacturers (SMMs) to implement recommendations made in ITAC and Combined Heat and Power Technical Assistance Partnership (CHP TAP) assessments since 2018, and in recommendations made in equivalent assessments since 2021. These grants will bolster the American manufacturing base by supporting projects to improve energy and material efficiency, to increase productivity, and to reduce emissions at SMMs.	Commercial building owners

Figure 8, *cont.*

Funding Opportunities as of December 2024				
Federal Funds Related to Clean Energy Manufacturing				
Program	**Department**	**Funding Type**	**Program Description**	**Eligible Recipient**
Electronics Scrap Recycling Advancement Prize (E-SCRAP)	DOE	$3 mil total cash prize; $900k national laboratory support	This three-phase competition will award competitors to substantially increase the production and use of critical materials recovered from electronic scrap (e-scrap), such as mobile phones, home appliances, medical or office equipment, and anything else powered by electricity.	Phase 1: Incubation Individuals, private entities (non- or for-profit), and nonfederal government entities
Wind Energy Tech Recycling Research & Development	DOE	Prize; cooperative agreement	The program awards financial assistance to eligible entities for research, development, and demonstration, and commercialization projects to create innovative and practical approaches to increase the reuse and recycling of wind energy technologies.	Institution of Higher Ed; National Laboratory; Federal and State Research Agencies; Tribe; Tribal organization; research NGO; industrial entity; a consortium of 2 or more entities described here.
Critical Materials Accelerator	DOE/EERE		Critical Materials Accelerator R&D projects funded under this FOA will prototype and mature technologies or processes to address critical material challenges in high impact areas.	
Rare Earth Elements Demonstration Facility Program	DOE	Grant	The program is designed to demonstrate the feasibility of a full-scale integrated rare earth element extraction and separation facility and refinery.	Industry partners, institution of higher education
Smart Manufacturing and Recycling Tactics for States (SMART)	DOE		This program comprises the State Manufacturing Leadership Program and the State and Local Battery Collection, Recycling, and Reprocessing Program. Both are further discussed below.	States, States and local governments, different sub awardees
State Manufacturing Leadership Program	DOE	Grant to state projects,	12 states, among them projects in OH and PA, have been awarded to provide financial assistance to small and medium manufacturers to implement smart manufacturing technologies and practices.	States, Small and medium-sized manufacturers
Port Infrastructure Development Program Grants	DOT	Grant	Projects to improve the resilience and sustainability of ports, including electrification, micro-grids, worker training, etc	Public and Private Ports/Port Authorities
Reduction of Truck Emissions at Port Facilities	DOT	Grant	Grants will be used to reduce truck idling and emissions at ports, including through the advancement of port electrification.	

Conclusion: Transforming Coal Country into a Clean Economy Hub

With the right resources, the Ohio River Valley of Appalachia, also known as Coal Country, can become a leader in the new clean economy and a manufacturing hub for the clean energy and sustainable manufacturing products of the future.

Coal has been the backbone of the conventional extractive economic model in Appalachia for generations. Using coal to generate electricity has declined with the emergence of cheaper sources of energy.

Many coal-burning generators have been retired, and the sites have often remained vacant for decades. These shuttered coal plant sites present great redevelopment possibilities: an opportunity to build eco-industrial parks and establish a circular economy in Appalachia that is sustainable for the long-term environmental, social and economic health of communities.[32]

Transforming shuttered coal plants into eco-industrial parks, where one company's waste is another company's raw material, can make the Appalachian manufacturing sector much more sustainable in an environmental, economic, and social sense for generations to come. Copious acreage, industrial zoning, and extensive infrastructure of many kinds make the shuttered coal plant site ideal for reshoring manufacturers: large tracts of industrially zoned land; transportation options including water, highway, and rail; and significant underground water and sewer connections.[33] Many shuttered coal plant sites were built along major waterways or with access to railroads and highways, which can be used for transportation. They have access to utilities and a connection to the electric grid.

Many are in communities where workers have skills that are transferable to manufacturing and energy production. These are sites where multiple tenants can locate in proximity to one another and share inputs and outputs through a circular manufacturing configuration critical to the future.

Eco-industrial parks can be profitable but need continued education and supportive policy to become an established and preferred configuration and practice. The benefits of such a configuration are broad, with the potential to catalyze change not only on the industrial site but also in the surrounding community. ference between CBD isolate and full-spectrum CBD?"

Appendix I: Eco-Industrial Parks Around the World

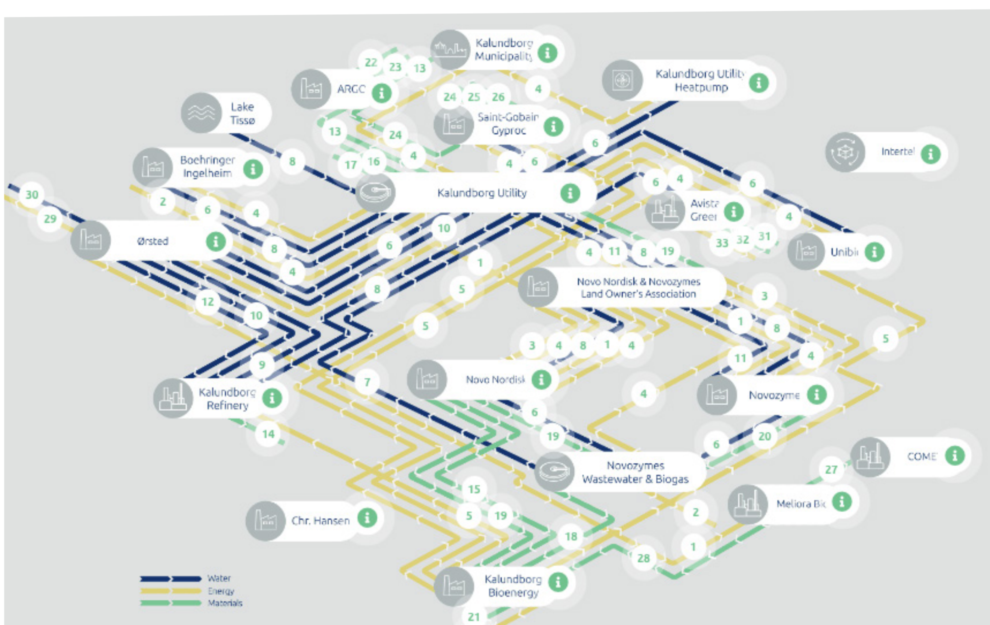
Looking at some of the pioneering eco-industrial parks around the world shows how waste streams can be shared on-site and around the local community.

Kalundborg, Denmark

When it comes to eco-industrial parks, Kalundborg Symbiosis is often regarded as a pioneering model for circular industrial practices. Kalundborg Symbiosis has developed "organically" over 50 years, initially choosing to share resources to reduce costs and maximizing benefits. Now, this eco-industrial park is known as a leader in industrial symbiotic strategies; Kalundborg manages a system of inputs and outputs, which extends excess heat to local homes and businesses in the community.[34]

Figure A-1

Material Flow at Kalundborg Symbiosis



Source: Kalundborg Symbiosis

Figure A-2

Mapped Activity Zones of Kalundborg Symbiosis' Members

Source: Kalundborg Symbiosis

In the graphics included above, notice how Kalundborg Symbiosis' reach extends throughout the local community, bringing the entire area into an industrial ecosystem. The first graphic illustrates the many interactions that occur between the various companies involved in the Kalundborg Symbiosis. This web of facilities and processes almost resembles a living organism, and it will likely continue to develop as new businesses join and introduce new inputs and outputs. A significant part of Kalundborg's success appears to stem from its flexibility and willingness to continually improve the circularity and economics of its system.

By the late '90s, the power plant, oil refinery, plasterboard manufacturing plant, and a biotech production facility were all working with each other and the local municipality as Kalundborg Symbiosis.

Along with expanding the businesses in its network, Kalundborg Symbiosis continues to increase its impact. Around 5000 people are employed by Kalundborg's global private companies, and the symbiosis model prevents large amounts of groundwater usage, CO2 emissions and material waste.[35] According to their website, Kalundborg Symbiosis has also made the local energy supply CO2-neutral.[36]

ECO3, Finland

Located in the Tampere region of Finland, ECO3 is a bio and circular economy business area, which was planned and designed by the City of Nokia along with a collection of public and private companies.[37] Their successful marketing efforts have attracted a robust network of companies, making ECO3 a model for industrial symbiosis.

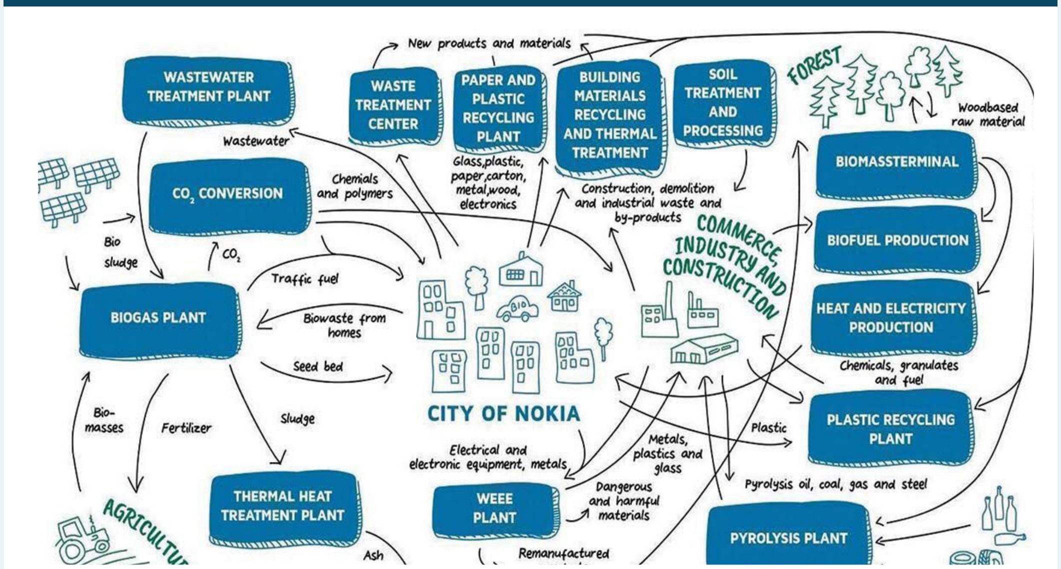
ECO3 is also featured as a case study in a paper investigating the differences between planned and self-organized unplanned Industrial Symbiosis in Finland. A survey conducted by Jarmo Uusikartano, Puja Saha, and Leena Aarikka-Stenroos from Tampere University in Finland found that both processes ultimately involve collaboration between public and private groups. More can be read here: https://www.sciencedirect.com/science/article/pii/S095965262200631X)

ECO3 is remarkable in its ability to unite agriculture, forestry, commerce, industry, and construction with the city itself.

The diagram below illustrates the intricate network of resources that flow through this community and how they can be leveraged by seemingly unrelated industries when united through mutual collaboration. Tracing the bio waste generated in homes in the city of Nokia, for example, reveals that this biowaste travels to the biogas plant where it is converted into fertilizer for agriculture and sludge that can then be used in the thermal heat treatment plant to produce ash for the ash granulation, processing and fertilizer production plant whose products can then make road and construction materials and material for the forest. The forest is then used to supply another range of processes, such as biofuel production for heating and electricity, which fuels the city of Nokia, which continues to produce biowaste, and the cycle continues.

Figure A-3

Material Flow at ECO3's Circular Business Area

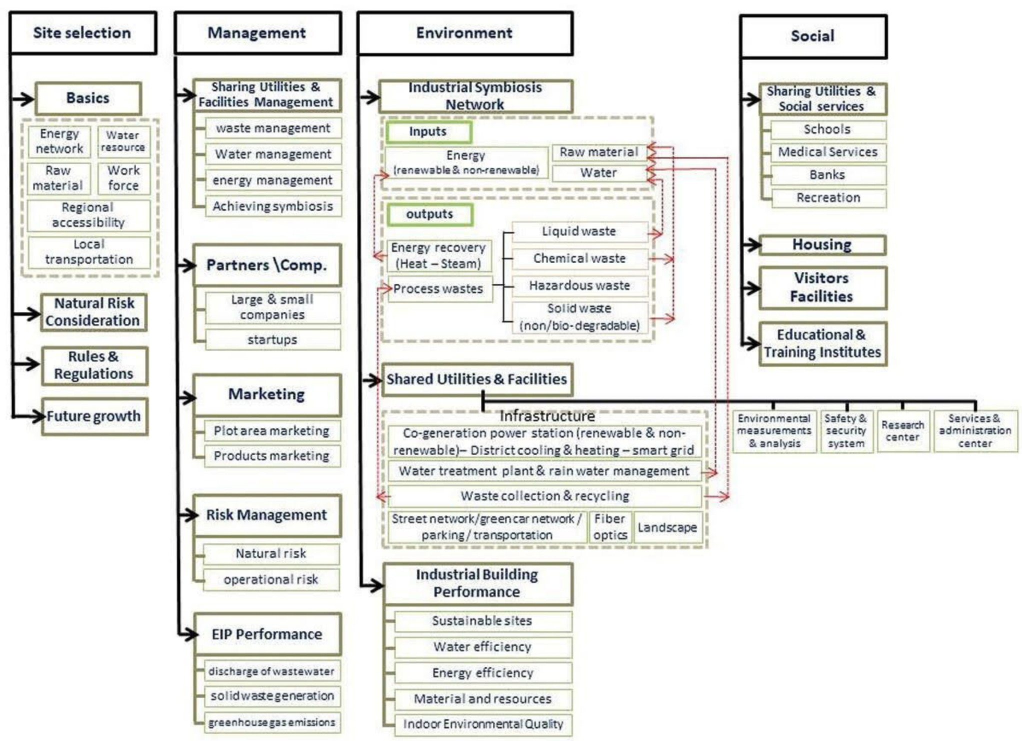


Source: ECO3's circular business area[38]

In an analysis of eco-industrial park development in Egypt, a group of researchers associated with the Architecture & Housing Institute, HBRC in Cairo, created the process shown above in Figure A-3, which outlines the significant steps involved in setting up an eco-industrial park.[39] A similar process could be adapted for eco-industrial park development in Appalachia, with proper clean-up steps added for redevelopment on shuttered coal plant sites.

Figure A-4

“A guiding framework for a new eco-industrial park.”



Source: Nessim, M., Galal, A., Elariane, S., & Adham, R. “A guiding framework for new eco-industrial park.”

Glossary

AC current: Stands for alternating current, and it is the electrical current that is used in most US power lines.

Biomaterial: Renewable materials derived from living sources like wood, hemp and algae.

Biowaste: Organic waste that can decompose such as food scraps and manure.

Brownfield: Unused land that may contain pollutants due to former industrial use.

By-product: An incidental or secondary product made in the manufacture or synthesis of something else.

Carbon footprint: The amount of carbon emitted to complete a task such as manufacturing an item in this context.

Central Appalachia: In the context of this paper, it refers to ReImagine Appalachia's four state region of Pennsylvania, Kentucky, West Virginia, and Ohio.

Circular economy: A term used to describe an alternative economic model that prioritizes reuse as a core principle.

Closed Loop System: A system in which waste is reused and converted into new products to be used.

Coal ash: The byproduct of burning coal, which poses health and environmental concerns.

Cogeneration: Another term for combined heat and power, it describes the process of capturing excess heat and using it to accomplish additional tasks rather than allowing it to dissipate into the atmosphere.

Co-located: On the same site.

Combined heat and power (CHP): Another term for cogeneration, it describes the process of capturing excess heat and using it to accomplish additional tasks rather than allowing it to dissipate into the atmosphere.

Data center: The physical facility where the equipment needed to support data processing, data storage and cloud computing on the internet is housed

DC Current: Stands for direct current, the electrical current that is used in most European countries.

Eco-industrial park: A site at which co-located businesses share waste streams and services to increase efficiency and decrease waste

End product: The final product

Electric grid: The system of power generators and power lines that deliver power for use. It can be challenging to hook new connections to this grid, so existing grid connections are a big asset for site redevelopment

Feedstock: The raw material that goes into producing a product

Greenhouse gas emissions: The amount of heat-trapping elements like carbon dioxide and methane that are released into the atmosphere

Hemp: A member of the cannabis family, hemp fiber, grain, and flowers can be used to make a variety of products for a range of sectors

High voltage direct current (HVDC) converter stations: The station that converts between AC and HVDC electrical currents

HVDC lines: Stands for high voltage direct current. These power lines are ideal for connecting long distances, but they require a HVDC converter station to transfer power into the standard AC power lines for use

Industrial symbiosis: A win-win process in which companies can increase competitive advantage by working together to exchange materials, energy, and waste streams.

Linear economy: An economic model in which raw materials are made into products, used, then discarded as waste

Rare earth elements: Valuable metals used in essential items like cell phones, laptops, electric cars, and defense applications like sonar and lasers- often imported from abroad, which potentially poses a national security threat

Remediation: The process of cleaning up pollutants at a site to return it to a state suitable for its new use

Shuttered coal plant site: The abandoned or unused site at which a coal plant used to operate

Supply chain: All the processes and products involved in producing a final commodity

Waste stream: Unused materials produced during a process intended to create another product

Waste stream sharing: The transfer of a waste stream to another business that can make use of the byproduct material that would otherwise by discarded as waste

Endnotes

1 ReImagine Appalachia. Growing Clean and Efficient Manufacturing, 2020. https://reimagineappalachia.org/wp-content/uploads/2020/10/ReImagine-Appalachia_Manufacturing_10-28-2020-1.pdf

2 The Industrial Commons. “The Industrial Commons.” Accessed February 18, 2025. https://www.theindustrialcommons.org.

3 Green Industry Platform. “Eco-Industrial Parks | Green Industry Platform.” Accessed February 18, 2025. https://www.greenindustry-platform.org/themes/eco-industrial-parks.

4 Kalundborg Symbiosis. “Home - Kalundborg Symbiosis.” Accessed February 18, 2025. https://www.symbiosis.dk/en/.

5 Green Industry Platform. “Eco-Industrial Parks | Green Industry Platform.” Accessed February 18, 2025. https://www.greenindustry-platform.org/themes/eco-industrial-parks.

6 Environmental Law and Policy Center. “End of Year Report 2024.” 2024. https://elpc.org/wp-content/uploads/2024/01/ELPC_End-ofYearReport_2024_online-FINAL.pdf.

7 Eric Dixon. “Repairing the Damage Cleaning Up Hazardous Coal Ash Can Create Jobs and Improve the Environment Appendix C: Coal Ash Reuse,” n.d.

8 Zero Waste Manufacturing: Remediate, Recover, Repurpose, 2022. https://www.facebook.com/ReImagineAppalachia/videos/zero-waste-manufacturing-remediate-recover-repurpose/3366824783640328/.

9 ReImagine Appalachia. “Growing Clean and Efficient Manufacturing” 2020. https://reimagineappalachia.org/wp-content/uploads/2020/10/ReImagine-Appalachia_Manufacturing_10-28-2020-1.pdf

10 HeatCalc. “Heat for Cooling.” HeatCalc. Accessed February 18, 2025. https://heatcalc.com/heat-to-cooling. See also: Dustin Demetriou, “On-Site Cogeneration for Reducing Data Center Primary Energy Use,” Electronics Cooling (blog), August 1, 2023, https://www.electronics-cooling.com/2023/08/on-site-cogeneration-for-reducing-data-center-primary-energy-use-2/ and Eric Olson, Anne Grau, and Taylor Tipton, “Data Centers Draining Resources in Water-Stressed Communities,” The University of Tulsa, July 19, 2024, https://utulsa.edu/news/data-centers-draining-resources-in-water-stressed-communities/#:~:text=Unfortunately%2C%20many%20data%20centers%20rely,thousands%20of%20households%20or%20farms.

11 Carla De Las Casas, Thomas Steinwinder, Ted Douglass, and Rebecca Maco, “Data Center Water Sustainability and Stewardship,” Water Technology, December 3, 2021, https://www.watertechonline.com/water-reuse/article/14215042/data-center-water-sustainability-and-stewardship.

12 Richard Bonner et al., “Understanding PFAS Concerns for Two-Phase Cooling of Data Centers,” Data Center Frontier, February 9, 2024, www.datacenterfrontier.com/sponsored/article/33035570/understanding-pfas-concerns-for-two-phase-cooling-of-data-centers.

13 Segelken, Roger. “New Program in Eco-Industrial Development Aids Cities’ Quest for Economically and Environmentally Sustainable Future | Cornell Chronicle,” December 8, 1996. https://news.cornell.edu/stories/1996/12-1.

14 ReImagine Appalachia, “Handbook on Redeveloping Shuttered Coal Plants.” Accessed February 18, 2025.https://reimagineappalachia.org/coal-redevelopment-overview/.

15 Grid Deployment Office. “What Does It Take to Modernize the U.S. Electric Grid?” Energy.gov, October 19, 2023. https://www.energy.gov/gdo/articles/what-does-it-take-modernize-us-electric-grid.

16 Office of Electricity. “DOE Announces Three Funding Opportunities to Ensure Electricity Grid Resilience, Reliability, and Security.” U.S. Department of Energy, December 12, 2024. https://www.energy.gov/oe/articles/doe-announces-three-funding-opportunities-ensure-electricity-grid-resilience.

17 nationalgrid. “High Voltage Direct Current Electricity – Technical Information,” 2013. https://www.nationalgrid.com/sites/default/files/documents/13784-High%20Voltage%20Direct%20Current%20Electricity%20%E2%80%93%20technical%20information.pdf.

18 Introduction to HVDC, n.d. https://www.youtube.com/watch?v=71Vv_yqo0q0.

19 Office of Electricity. “DOE Announces Three Funding Opportunities to Ensure Electricity Grid Resilience, Reliability, and Security.” U.S. Department of Energy, December 12, 2024. https://www.energy.gov/oe/articles/doe-announces-three-funding-opportunities-ensure-electricity-grid-resilience.

20 SWACO,“Leveraging the Waste Stream.” Accessed February 18, 2025

21 SWACO. “Green Economy Business Park | SWACO, OH.” SWACO. Accessed February 18, 2025. https://www.swaco.org/423/Green-Economy-Business-Park.

22 SWACO. “Green Economy Business Park | SWACO, OH.” SWACO. Accessed February 18, 2025. https://www.swaco.org/423/Green-Economy-Business-Park.

23 SWACO. “Green Economy Business Park | SWACO, OH.” SWACO. Accessed February 18, 2025. https://www.swaco.org/423/Green-Economy-Business-Park.

24 The Industrial Commons. “The Industrial Commons.” Accessed February 18, 2025. https://www.theindustrialcommons.org.

25 ReUse Corridor, “ReUse Corridor Strategic Plan (2022-2026),” April 2021. https://coalfield-development.org/wp-content/uploads/2021/08/WCEDA_Strategic_Plan_FINAL_HighRes_04-27-2021-min.pdf. See p. 70 to read more about the state and gaps within the current transportation system within Central Appalachia; For more on the economics of the circular economy including information on rail, see also ReUse Corridor and Coalfield Development. “Enterprise Recycling Private Sector + Business Supplemental Concepts for APPALACHIAN Reuse Corridor.”

26 This has been a brief overview of the main goals of the ReUse Corridor, but the scope of their operations is large. ReUse Corridor, “ReUse Corridor Strategic Plan (2022-2026),” April 2021. https://coalfield-development.org/wp-content/uploads/2021/08/WCEDA_Strategic_Plan_FINAL_HighRes_04-27-2021-min.pdf. To read more about the ReUse Corridor’s detailed strategic plan to actively manage material streams from collection through processing and manufacturing.

27 Perrucci et al., “A Review of International Eco-Industrial Parks for Implementation Success in the United States.” City and Environment Interactions 16 (December 1, 2022): 100086. https://doi.org/10.1016/j.cacint.2022.100086.

28 Perrucci et al., “A Review of International Eco-Industrial Parks for Implementation Success in the United States.” City and Environment Interactions 16 (December 1, 2022): 100086. https://doi.org/10.1016/j.cacint.2022.100086.

29 From conversations held at an open day hosted by the Industrial Commons

30 ReImagine Appalachia, “Zero Waste Manufacturing: Remediate, Recover, Repurpose.” Facebook, December 2022. https://www.facebook.com/ReImagineAppalachia/videos/3366824783640328/

31 To read more details about search engines and programs that may provide funding opportunities for shuttered coal plant site redevelopment, see Chapter 6 of ReImagine Appalachia, “Handbook on Redeveloping Shuttered Coal Plants.” Accessed February 18, 2025. https://reimagineappalachia.org/coal-redevelopment-overview/

32 For shuttered coal plant site redevelopment steps and considerations see: ReImagine Appalachia, “Handbook on Redeveloping Shuttered Coal Plants.” Accessed February 18, 2025.https://reimagineappalachia.org/coal-redevelopment-overview/.

33 ReImagine Appalachia, “Handbook on Redeveloping Shuttered Coal Plants.” Accessed February 18, 2025.https://reimagineappalachia.org/coal-redevelopment-overview/.

34 Kalundborg Symbiosis, “Home - Kalundborg Symbiosis.” Accessed February 18, 2025. https://www.symbiosis.dk/en/.

35 Kalundborg Symbiosis, “Inspiration.” Kalundborg Symbiosis (blog). Accessed February 18, 2025. https://www.symbiosis.dk/en/inspiration/.

36 Kalundborg Symbiosis, “Inspiration.” Kalundborg Symbiosis (blog). Accessed February 18, 2025. https://www.symbiosis.dk/en/inspiration/.

37 ECO3, “Public - Private Circular - And Bioeconomy Business Platform in Nokia, Finland.” 2018. https://unece.org/fileadmin/DAM/ceci/documents/2018/CICPPP/Presentations/Ermala_ECO3_Presentation._Geneve.pdf

38 ECO3, “Kaaviokuvamme selittää, mitä on bio- ja kiertotalous.” ECO3 (blog). Accessed February 18, 2025. https://eco3.fi/ravinnekierto/kiertojen-kaaviokuva/. Diagram found translated at: Marian Nessim, Abeer Galal, Sarah Elariane, and Rania Adham. “A Guiding Framework for a New Eco-Industrial Park.” HBRC Journal 20, no. 1 (December 31, 2024): 1–22. https://doi.org/10.1080/16874048.2023.2292865.

39 Marian Nessim, Abeer Galal, Sarah Elariane, and Rania Adham, “A Guiding Framework for New Eco-Industrial Park.” HBRC Journal 20, no. 1 (December 31, 2024): 1–22. https://doi.org/10.1080/16874048.2023.2292865.

Bibliography

Amazon Web Services. “What Is a Data Center? - Cloud Data Center Explained - AWS.” Amazon Web Services, Inc. Accessed February 18, 2025. https://aws.amazon.com/what-is/data-center/.

Bianchi, Annaflavia, and Patrizio Bianchi. “Keeping Emilia-Romagna strong: an integrated industrial policy approach” 2019, no. 13 (2019): 65–70.

Bonner, Maria. Zoom call, August 1, 2024.

Bonner, Richard, et al. “Understanding PFAS Concerns for Two-Phase Cooling of Data Centers.” Data Center Frontier, February 9, 2024. www.datacenterfrontier.com/sponsored/article/33035570/understanding-pfas-concerns-for-two-phase-cooling-of-data-centers.

Business Norway. “These Industrial Parks Lead the Way for a Circular Economy.” Business Norway. Accessed February 18, 2025. https://businessnorway.com/articles/these-industrial-parks-lead-the-way-for-a-circular-economy.

Central Appalachian Network. “Home.” Accessed May 2025. https://www.cannetwork.org/.

Ciampoli. “Former Coal Plant Sites Get Second Life with Energy Storage Systems | American Public Power Association.” American Public Power Association, September 11, 2023. https://www.publicpower.org/periodical/article/former-coal-plant-sites-get-second-life-with-energy-storage-systems.

Clinton White House. “Eco-Industrial Park Workshop Proceedings.” February 1997.

https://clintonwhitehouse3.archives.gov/PCSD/Publications/Eco_Workshop.html#ii.

Coalfield Development. “Black Diamond Environmental Cleanup and Redevelopment.” Coalfield Development. Accessed February 18, 2025. https://coalfield-development.org/black-diamond-environmental-cleanup/.

———. “ReUse Corridor.” Accessed February 18, 2025. https://coalfield-development.org/reuse-corridor/.

———. “Creative Reuse,” Accessed May 2025. https://coalfield-development.org/creative-reuse/.

Cradle to Cradle. “Home - Cradle to Cradle Products Innovation Institute.” Accessed February 18, 2025. https://c2ccertified.org/.

De Las Casas, Carla, Steinwinder, Thomas, Douglass, Ted and Maco, Rebecca. “Data center water sustainability and stewardship.” Water Technology, December 3, 2021.

https://www.watertechonline.com/water-reuse/article/14215042/data-center-water-sustainability-and-stewardship.

Demetriou, Dustin Demetriou. “On-Site Cogeneration for Reducing Data Center Primary Energy Use.” Electronics Cooling (blog), August 1, 2023. https://www.electronics-cooling.com/2023/08/on-site-cogeneration-for-reducing-data-center-primary-energy-use-2/.

Desrochers, Pierre. “Eco-Industrial Parks: The Case for Private Planning,” n.d. https://www.perc.org/wp-content/uploads/old/rs00_1.pdf.

Dixon, Eric. “Repairing the Damage Cleaning Up Hazardous Coal Ash Can Create Jobs and Improve the Environment Appendix C: Coal Ash Reuse,” n.d.

ECO3. “Kaaviokuvamme selittää, mitä on bio- ja kiertotalous.” ECO3 (blog). Accessed February 18, 2025. https://eco3.fi/ravinnekierto/kiertojen-kaaviokuva/.

———. “Public - Private Circular - And Bioeconomy Business Platform in Nokia, Finland.” 2018. https://unece.org/fileadmin/DAM/ceci/documents/2018/CICPPP/Presentations/Ermala_ECO3_Presentation._Geneve.pdf.

Economic Development Council Haines City Florida. “What Are the Benefits of Being Located in an Industrial Park?” Economic Development Council Haines City Florida, July 24, 2023. https://hainescityedc.com/blogs/77-What-Are-the-Benefits-of-Being-Located-in-an-Industrial-Park.

Ellen MacArthur Foundation. “Towards a Circular Economy: Business Rationale for an Accelerated Transition (2015).” Ellen MacArthur Foundation, December 1, 2015. https://www.ellenmacarthurfoundation.org/towards-a-circular-economy-business-rationale-for-an-accelerated-transition.

Environmental Law and Policy Center. “End of Year Report 2024.” 2024. https://elpc.org/wp-content/uploads/2024/01/ELPC_EndofYearReport_2024_online-FINAL.pdf.

Epperly, Bay. Interview with Bay Epperly, Associate Director of Creative Reuse 2023 Generation West Virginia Fellow at Coalfield Development, August 1, 2024.

Farrell, John. “Why Is Connecting Clean Energy to the Grid So Hard?” Institute for Local Self-Reliance, February 27, 2023. https://ilsr.org/articles/why-is-connecting-clean-energy-to-the-grid-so-hard/.

Gorman, Will, Julie Mulvaney Kemp, Joseph Rand, Joachim Seel, Ryan Wiser, Nick Manderlink, Fredrich Kahrl, Kevin Porter, and Will Cotton. “Grid Connection Barriers to New-Build Power Plants in the United States | Energy Markets & Policy,” January 13, 2025. https://emp.lbl.gov/news/grid-connection-barriers-new-build-power-plants-united-states.

Grann, Henning. “The Industrial Symbiosis at Kalundborg, Denmark.” In The Industrial Green Game, 117–23. National Academy Press, 1997. https://doi.org/10.17226/4982.

Green Industry Platform. “Eco-Industrial Parks | Green Industry Platform.” Accessed February 18, 2025. https://www.greenindustryplatform.org/themes/eco-industrial-parks.

Grid Deployment Office. “What Does It Take to Modernize the U.S. Electric Grid?” Energy.gov, October 19, 2023. https://www.energy.gov/gdo/articles/what-does-it-take-modernize-us-electric-grid.

HeatCalc. “Heat for Cooling.” HeatCalc. Accessed February 18, 2025. https://heatcalc.com/heat-to-cooling.

Hinton. “Homepage.” Accessed May 2025. https://www.hinton.ca/.

Introduction to HVDC, n.d. https://www.youtube.com/watch?v=71Vv_yqo0q0.

Kalundborg Symbiosis. “Home - Kalundborg Symbiosis.” Accessed February 18, 2025. https://www.symbiosis.dk/en/.

———. “Inspiration.” Kalundborg Symbiosis (blog). Accessed February 18, 2025. https://www.symbiosis.dk/en/inspiration/.

———. “Ørsted.” Accessed February 18, 2025. https://www.symbiosis.dk/en/partnerne-bag-2/orsted/.

———. “Partners.” Kalundborg Symbiosis (blog). Accessed February 18, 2025. https://www.symbiosis.dk/en/partnere-bag/.

Mirata, Murat, and Tareq Emtairah. “Industrial Symbiosis Networks and the Contribution to Environmental Innovation: The Case of the Landskrona Industrial Symbiosis Programme.” Journal of Cleaner Production, 10th Anniversary of the International Institute for Industrial Environmental Economics (IIIEE): Management and policy for sustainable consumption and production, 13, no. 10 (August 1, 2005): 993–1002. https://doi.org/10.1016/j.jclepro.2004.12.010.

nationalgrid. “High Voltage Direct Current Electricity – Technical Information,” 2013. https://www.nationalgrid.com/sites/default/files/documents/13784-High%20Voltage%20Direct%20Current%20Electricity%20%E2%80%93%20technical%20information.pdf.

Navera, Tristan. “SWACO Envisions a New Hub for the ‘circular Economy’ in Grove City.” Columbus Business First, October 13, 2020. https://www.bizjournals.com/columbus/news/2020/10/13/swaco-envisions.html.

Nessim, Marian, Abeer Galal, Sarah Elariane, and Rania Adham. “A Guiding Framework for a New Eco-Industrial Park.” HBRC Journal 20, no. 1 (December 31, 2024): 1–22. https://doi.org/10.1080/16874048.2023.2292865.

Olson, Eric, Grau, Anne, and Tipton, Taylor. “Data centers draining resources in water-stressed communities.” The University of Tulsa, July 19, 2024.

https://utulsa.edu/news/data-centers-draining-resources-in-water-stressed-communities/#:~:text=Unfortunately%2C%20many%20data%20centers%20rely,thousands%20of%20households%20or%20farms.

Office of Electricity. “DOE Announces Three Funding Opportunities to Ensure Electricity Grid Resilience, Reliability, and Security.” U.S. Department of Energy, December 12, 2024. https://www.energy.gov/oe/articles/doe-announces-three-funding-opportunities-ensure-electricity-grid-resilience.

Perrucci, Daniel V., Can B. Aktaş, Joseph Sorentino, Halimat Akanbi, and Jack Curabba. “A Review of International Eco-Industrial Parks for Implementation Success in the United States.” City and Environment Interactions 16 (December 1, 2022): 100086. https://doi.org/10.1016/j.cacint.2022.100086.

QuickBox Fulfillment. “Location, Location: Driving Fulfillment Success | QuickBox.” QuickBox Fulfillment. Accessed February 18, 2025. https://www.quickbox.com/blog/location-location-how-proximity-drives-fulfillment-success.

ReImagine Appalachia. “Coal Plant Redevelopment Chapter 3: Know Your Site.” Coal Redevelopment Overview. Accessed February 18, 2025. https://reimagineappalachia.org/coal-redevelopment-overview/know-your-site/.

———. Cooperatives in the New Energy Economy. March 5, 2024. https://reimagineappalachia.org/wp-content/uploads/2024/03/Cooperatives-in-the-New-Energy-Economy.pdf.

———. Growing Clean and Efficient Manufacturing, October 2020.

https://reimagineappalachia.org/wp-content/uploads/2020/10/ReImagine-Appalachia_Manufacturing_10-28-2020-1.pdf.

———. “Handbook on Redeveloping Shuttered Coal Plants.” ReImagine Appalachia. Accessed February 18, 2025. https://reimagineappalachia.org/coal-redevelopment-overview/.

———. “Recapping ReImagine Appalachia’s Second Annual Shuttered Coal Plant Summit.” ReImagine Appalachia (blog), October 28, 2024. https://reimagineappalachia.org/recapping-reimagine-appalachias-second-annual-shuttered-coal-plant-summit/.

———. “Zero Waste Manufacturing: Remediate, Recover, Repurpose.” Facebook, December 2022. https://www.facebook.com/ReImagineAppalachia/videos/3366824783640328/

ReUse Corridor. “ReUse Corridor Working Group Overview,” https://docs.google.com/presentation/d/1V62nq_o7FHKFE8IW6Or2BvQIjDNZ46K5ehGbEUCufIM/edit?usp=sharing.

———. “ReUse Corridor Strategic Plan (2022-2026),” April 2021. https://coalfield-development.org/wp-content/uploads/2021/08/WCEDA_Strategic_Plan_FINAL_HighRes_04-27-2021-min.pdf.

ReUse Corridor and Coalfield Development. “Enterprise Recycling Private Sector + Business Supplemental Concepts for APPALACHIAN Reuse Corridor,” Updated October 2023. https://coalfield-development.org/wp-content/uploads/2025/03/ReUse-Reports-Combined.pdf

RMI. “Clean Repowering.” RMI. Accessed February 18, 2025. https://rmi.org/insight/clean-repowering/.

Rote, Laura. “WV Black Diamond Project Is an Example of Possibility in Revitalization.” gb&d magazine, November 21, 2022. https://gbdmagazine.com/wv-black-diamond-project/.

Segelken, Roger. “New Program in Eco-Industrial Development Aids Cities’ Quest for Economically and Environmentally Sustainable Future | Cornell Chronicle,” December 8, 1996. https://news.cornell.edu/stories/1996/12-1.

Shelton, Autumn. “Officials Announce Development of Data Center in Downtown Huntington.” West Virginia Press Association (blog), November 1, 2024. https://wvpress.org/breaking-news/officials-announce-development-of-data-center-in-downtown-huntington/.

Southeastern Ohio Port Authority. “Recent projects in Washington County.” Accessed May 2025.

https://www.seohioport.com/recent-projects.

St. John, Jeff. “Zombie Coal Plants Could Threaten the US Energy Transition.” Canary Media, May 14, 2024. https://www.canarymedia.com/articles/fossil-fuels/zombie-coal-plants-could-threaten-the-us-energy-transition.

SWACO. “Green Economy Business Park | SWACO, OH.” SWACO. Accessed February 18, 2025. https://www.swaco.org/423/Green-Economy-Business-Park.

———. “Leveraging the Waste Stream.” Accessed February 18, 2025. https://www.swaco.org/422/Leveraging-the-Waste-Stream.

SWACO’s Big Steps Towards a Sustainable Future. YouTube video, 2021. https://www.youtube.com/watch?v=ylkOZlOG-fg.

Team PA. “About | TeamPA Factory of the Future.” Accessed February 18, 2025. https://pamanufacturingfuture.com/about/.

The Industrial Commons. “The Industrial Commons.” Accessed February 18, 2025. https://www.theindustrialcommons.org.

———. “Innovation Campus Plan.” Fall 2023. https://static1.squarespace.com/static/64e37e015dad7a5cb778af4c/t/6650a1fa96572c4e1e054282/1716560385258/TIC%2BInnovation%2BCampus%2BVision.pdf.

UNIDO. “Eco-Industrial Parks.” UNIDO. Accessed February 18, 2025. https://www.unido.org/our-focus-safeguarding-environment-resource-efficient-and-low-carbon-industrial-production/eco-industrial-parks.

WaterlooEDC. “What Are Location Advantages and How Can They Help My Company?,” September 28, 2023. https://www.waterlooedc.ca/blog/what-location-advantages-how-can-they-help-company.

World Bank. “International Framework for Eco-Industrial Parks v.2,” 2021. https://www.unido.org/sites/default/files/files/2021-04/An%20international%20framework%20for%20eco-industrial%20parks%20v2.0.pdf.