



Approaches for Developing an Eco-Industrial Park in the City of Rosemount

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1. Introduction

The City of Rosemount is exploring opportunities to establish an eco-green business park to promote sustainable economic development. The city has a partnership with the University of Minnesota as part of the Resilient Communities Project and has requested for a preliminary report on factors to consider to develop such an industrial park.

Our report provides examples of integrative and locally relevant best practices, policies and case studies that provide lessons for developing an eco-green business park, or eco-industrial park, in the City of Rosemount. The report aims to provide recommendations that are economically feasible as well as have the least impact on the environment.

While the geographic location of the park is still under discussion, our report assumes that zoning laws will be developed to meet the needs of the industrial park as well as surrounding businesses and communities. Additionally we assume that the City of Rosemount is acting as both the developer of the industrial park as well as the regulator.

2. Contextual factors of City of Rosemount

The City of Rosemount is located in Dakota County, Minnesota and is 15 miles south of the Twin Cities metropolitan area with an area of nearly 36 square miles. More than 500 acres of land zoned as industrial or commercial have been reserved for future development. The city has a well-developed transportation system including rail, air, barge, and freeway access. Additionally, four major highways link Rosemount to Minneapolis and St. Paul (Rosemount Minnesota, 2015).

Although the specific site and size of the park await finalization, our recommendations are based on the economic development goals of Rosemount as outlined in the Comprehensive Land Use Plan 2030. One-third of the land in the city is developed with ample land available for commercial and industrial development. Most of the undeveloped land within the city is currently used for agricultural purposes with some aggregate mining. According to the plan, the city aims to promote commercial renewal and rehabilitation in the downtown area and along the Highway 42 while promoting new commercial development along appropriate transportation corridors such as Akron

Avenue and County Highway 42 and US Highway 52. The City also seeks to promote use of renewable resources by creating sustainable development and building green.

Key businesses in Rosemount include Flint Hills Resources (Pine Bend Refinery), SKB (an industrial waste containment facility), Hawkins Chemical, Greif Brothers (multiwall bags). The City also has a business park with tenants such as Geometrix and Proto Labs. Significant employers in the area include the Rosemount School District and Flint Hills Resources (Rosemount Minnesota, 2015).

3. Understanding Eco Industrial Parks

Defining Eco-Industrial Park

An eco-industrial park (EIP) is a community of manufacturing and service businesses located together on a common property. Other names for similar initiatives include eco-industrial development projects, eco-green business parks, industrial ecosystems or by-product exchanges. For the purpose of this report we will use the terminology eco-industrial park (EIP). Member businesses seek enhanced environmental, economic, and social performance through collaboration in managing environmental and resource issues. By working together, the community of businesses seeks a collective benefit that is greater than the sum of individual benefits each company would realize by only optimizing its individual performance.

Eco-Industrial Park: Implementing Industrial Ecology

In a traditional industrial system, economic activities act in an open system where raw materials are drawn from the environment and large amounts of waste and pollution are returned along with products. The products that firms market may only comprise a small portion of outputs their production process creates. This system results in negative externalities like wasted resources and accumulation of toxic materials.

The alternative is to view processes in a closed loop system. This viewpoint will highlight the full life-cycle of materials, outputs and by-products. Practices like reuse, recycling, and resource-sharing represent actions in this direction. This perspective is often referred to as industrial ecology. Industrial ecology attempts to understand the

potential for environmental improvement in industry using analogy of industrial systems to natural ecological systems. Industrial ecology operates at three levels.

- *Firm level.* At this level, industrial ecology is represented by environmentally-friendly design and production, pollution prevention, and eco-efficiency. At this level individual businesses seek to apply these practices within the business and increase their profit.
- *Across firms level.* Industrial symbiosis and life-cycle analysis are the components of industrial ecology in this level. Businesses and industries work in collaboration and exchange material, energy and information. They seek to reduce raw material input in the production process and utilize one another's by-products, waste and other surplus.
- *Regional or global level.* Industrial ecology explores the material and energy flow, dematerialisation, and decarbonisation, i.e. industrial metabolism.

EIPs are industrial systems that reflect the principles of industrial ecology by attempting to create a closed loop system through industrial symbiosis processes. There are three different types of exchanges that can take place in industrial symbiosis network, according to Chertow (2008):

- *Utility/infrastructure sharing* – the pooled use and management of commonly used resources such as steam, electricity, water, and wastewater. The main feature is that a group of firms jointly assumes the responsibility for providing utility services or infrastructure, such as water, energy or heat provision systems (i.e., co-generation plants), or wastewater treatment plants, a task generally undertaken by municipal authorities or specialized companies.
- *By-product exchanges* – the use of traditionally discarded materials or waste as substitutes for commercial products or raw materials. By-product exchanges may enhance a firm's resource efficiency by taking advantage of the intrinsic economic value of 'wastes', and are key in transitioning from linear to circular

material and energy flows in industrial systems, a fundamental goal of industrial ecology. Some by-product exchanges may involve the cascading reuse of materials or energy across many different applications where each successive application requires a lower quality of the material.

- *Joint provision of services* – involves firms collectively meeting their ancillary needs, which relate to materials and services not directly related to the core business of a company. Fire suppression, security, cleaning, catering, and waste management are examples of ancillary services that have environmental implications.

These three types of exchanges are also associated with different scales where the exchange may take place. Utility or infrastructure sharing, including water and sewer service, district heating and power, would typically be implemented by large scale entity like a municipal or regional government, but an industry consortium could also be appropriate. Joint provision of services would be best applied by a smaller scale group. Appropriate entities could include a business improvement district, port authority, developer, or an individual business park. Since by-product exchanges must be suited to a firm's specific inputs and outputs, this type of exchange would likely be negotiated between individual firms.

For these exchanges to take place between businesses, several factors have to be in place. Firms must be in close geographic proximity to make it possible for exchanges to take place with minimal logistical cost. Firms must be able to share information and be aware of the possible linkages in resource streams. The resources being exchanged must be produced in a dependable and steady manner (Ehrenfeld,1997). Together, these conditions support an exchange that is economically, environmentally and socially beneficial for all parties.

EIPs may be organized around industrial themes such as a renewable energy EIP, a petrochemical EIP or an agro EIP, depending on the type of existing industry in the area or the immediately available resources. Some of the key steps in planning for an EIP are (Cote & Cohen-Rosenthal, 1998):

1. Define the community of interests and involve that community in the design of the park.
2. Reduce environmental impact or ecological footprint through substitution of toxic materials, absorption of carbon dioxide, material exchanges and integrated treatment of wastes.
3. Maximize energy efficiency through facility design and construction, co-generation, and cascading.
4. Conserve materials through facility design and construction, reuse, recovery and recycling.
5. Link or network companies with suppliers and customers in the wider community in which the EIP is situated.
6. Continuously improve the environmental performance by the individual businesses and the community as a whole.
7. Have a regulatory system which permits some flexibility while encouraging companies to meet performance goals.
8. Use economic instruments which discourage waste and pollution.
9. Employ an information management system which facilitates the flow of energy and materials within a more or less closed-loop.
10. Create a mechanism which seeks to train and educate managers and workers about new strategies, tools and technologies to improve the system.
11. Orient its marketing to attract companies which fill niches and complement other businesses.

Industrial Symbiosis in Kalundborg, Denmark

The small sea-side town of Kalundborg, Denmark is commonly used as an example of a highly evolved industrial symbiosis network. The relationships observed in Kalundborg have evolved over several decades and is the result of sequential business deals between the companies involved. This cluster of companies and their resource sharing was discovered in the late 1980s and described in international press (Chertow 2007).

Kalundborg remains one of the most popular and successful examples of industrial symbiosis to this day.

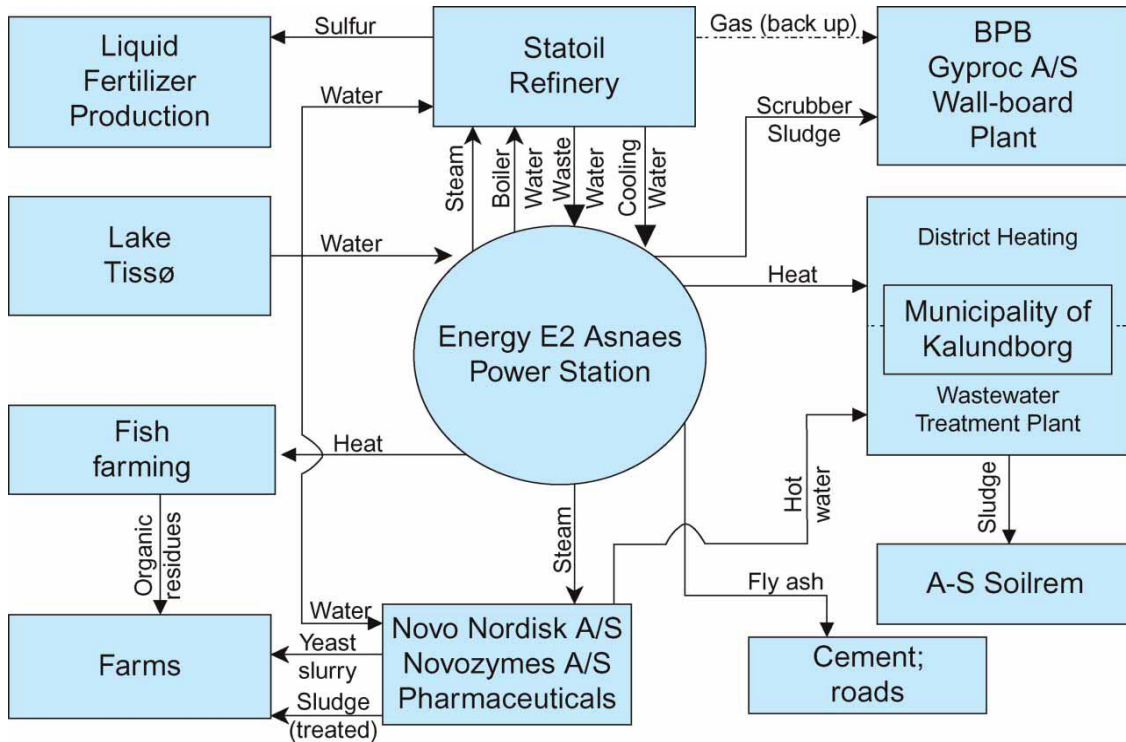
Asnaes Power Station, a coal power plant; Statoil, an oil refinery; Novo Nordisk, a pharmaceutical and enzyme manufacturer; and Gyproc, a plasterboard manufacturer are the four major enterprises that form the heart of this system. Other local businesses and the town of Kalundborg serve tertiary roles. In addition, several firms outside of the local area participate in the system by providing raw materials or receiving by-product outputs.

Currently, there are many exchanges taking place in Kalundborg that include each type of exchange described by Chertow. Several of the exchanges will be described in detail here and the whole system is illustrated in figure 1.

Steam from Asnaes is distributed to homes in Kalundborg, Novo Nordisk, and Statoil. Since the installation of this district heating system, the town has been able to eliminate the use of 3,500 oil-fired residential furnaces. Novo Nordisk decided to rely on steam from Asnaes for all of its steam requirements rather than upgrade its own boiler system. Waste heat from the power plant is also used to heat fish farms, which are operated by Asnaes. Since all of this steam and heat is being utilized for other purposes, the amount of heat pollution discharged into the sea has been reduced (Ehrenfeld 1997).

Other waste products from the power plant include sludge and gypsum. The sludge produced from the fish farms is sold as fertilizer. Gypsum, produced from the plants sulfur dioxide scrubber, is sold to Gyproc. The plant supplies over two-thirds of Gyproc's gypsum needs, thus reducing pressure on surface extraction (Ehrenfeld 1997).

Figure 1: Overview of industrial symbiosis at Kalundborg, Denmark (Chertow 2008)



Evaluation of Kalundborg has resulted in several key findings. First, these relationships developed organically over many years from independent business negotiations. Environmental regulations did play a role in encouraging resource exchanges and disincentivize waste. Though not important early on, a coordinative function was found to be helpful to encourage and facilitate further exchanges (Chertow 2007).

The exchanges at Kalundborg serve to illustrate the benefits of industrial symbiosis but it is unlikely that a system with a similar level of sophistication could be replicated in Rosemount in the near-term. This system was the result of decades of events and negotiations and it will take decades to develop something similar in Rosemount.

4. Components of Eco Industrial Park and Relevance for City of Rosemount

As the definitions and examples provided above suggest, EIPs have several components that interact with each other to work in symbiosis, reduce waste and energy use, and make the park a highly efficient production site. While it is beyond the scope of this report to address each of these components (and nor are all the final components for a potential EIP in the City of Rosemount identified yet), the report does provide an overview of four key components and case studies that illustrate their benefits.

Material Exchange

Secondary Effluent Treatment and Water Reuse

Description

Water is a core resource that is central to many industrial and manufacturing processes. Increased water regulation and water scarcity have combined to push industries to be more innovative about water use. Recycling and exchange of water is often found at the center of symbiotic industrial relationships.

Treated effluent has been used in the United States for many purposes over the last few decades. This practice is known by several names including water reuse, water recycling, and water reclamation. Western states have been leading the innovation of effluent reuse practices in the country due to their heightened vulnerability to drought and water shortage. Population increases, shifting climatic patterns, and land use changes have exacerbated water supply shortages.

Some communities and regions have begun to use reclaimed effluent to supplement or in some cases, replace traditional water supplies. A few have fully integrated dual water systems – in these cases a city provides one potable water source and one greywater source to properties. It is more common for reclaimed water to be used for a specific function, like irrigation of recreational fields or cooling water for a power plant. Other

uses may include: augmentation of natural water bodies, aquifer injection, greywater building use, and potable use. Some areas, like El Paso, inject effluent back into the ground and allow it to recharge the aquifer.

Case Study: Municipal System

The San Antonio Water System is one of the most extensive water reclamation systems in the U.S. The city has developed extensive infrastructure for delivery of reclaimed water including 130 miles of pipeline, storage tanks, and water recycling centers. The city plans for reclaimed and recycled water to account for nearly 40 percent of the city's total water supply by 2030. These sources currently make up about 15 percent of its supply (San Antonio Water System 2012).

The city's water reuse began in 1930 and the water recycling system was expanded in the fifties and sixties to cool electrical power plants. Several recent factors have contributed to the expansion of the system. Most notable are: prolonged drought, increased water demand, and restrictions on pumping from certain aquifers.

The city's reclaimed water is used for several purposes, including (EPA Water Reuse Guidelines, page 485):

- 51% for discharged into rivers and streams
- 16% for golf course irrigation
- 19% for government buildings and other irrigation
- 14% for industrial and cooling

The reclaimed water is treated at three facilities and distributed through pipes ranging in size from 24 to 42 inch diameter. This pipe network is at capacity with agreements for the purchase of reclaimed water. Commercial rates are about \$1.00 /1,000 gallons and \$1.50-3.00 /1,000 gallons for potable water. The system was funded through the existing capital program with support from state loans.

Case Study: Public-Private Partnership

Minnesota is known as the land of 10,000 lakes and has historically had an abundance of water. Recent events in Minnesota including the drawdown of the Prairie du Chien aquifer and the dropping lake level of White Bear Lake have spurred a stronger public interest in Minnesota water conservation. It is unlikely that Minnesota will face immediate water shortages to the scale of those occurring in other parts of the county; nevertheless there are several examples of water reuse in the state.

The Minnesota Pollution Control Agency has guidelines for municipal wastewater reuse and has adopted California standards for treatment of reclaimed effluent. The standards are focused on the protection of public health. Even treated effluent contains pathogens and microorganisms. The standards require a higher level of treatment for uses that have a greater risk of human exposure.

According to the EPA, 60 percent of water used in Minnesota is for power generation and two-thirds of potable water in Minnesota is supplied by groundwater. If Minnesota faces water shortages, which lead to rate increases, power companies and large industries would likely be affected the most.

Perhaps due to these factors, most examples of effluent reuse projects in Minnesota are conducted by private businesses or as public private partnerships. A water reclamation facility was constructed in Mankato to treat effluent from its wastewater treatment plant for use at two power generation facilities. In this case, Calpine Corp. and Mankato Energy Center were able to use the city's effluent and avoid purchasing potable water to use in their processing. The city of Mankato was also able to meet more stringent phosphorus restrictions due to the additional treatment (American City and County 2008). Use of reclaimed water has reduced use of the local aquifer by 130 million gallons per year, though both the power plant and treatment facility have greater capacity.

Other large scale industrial water reuse examples are Buffalo Lake and Fargo (MNTAP 2010), (City of Fargo 2015).

The ultra-filtration skid (left) and reverse osmosis unit (right) are part of Fargo's advanced water treatment facility. This facility has allowed the city to supply Tharaldson

Ethanol with over 500 million gallons of water that could have otherwise may have depleted surface water, drinking water, or groundwater reserves. Both photos from: <http://www.cityoffargo.com/CityInfo/Departments/Wastewater/WaterReclamation/>



A more progressive example of effluent reclamation is exhibited by the Shakopee Mdewakanton Sioux Community. The community built their own water reclamation facility in 2006. The reclaimed water is used for landscape irrigation and is diverted into constructed wetlands. The community has also completed a pilot study of effluent injection into the aquifer and may expand this in the future (Shakopee Mdewakanton Sioux Community 2009).

Application to Rosemount

Rosemount does not face the same challenges that led to development of San Antonio's robust water reclamation system. However, it does have several unique attributes that could help facilitate adoption of effluent reclamation practices.

The Empire Wastewater Treatment Plant is located just south of the city and its effluent is discharged into the Mississippi River via a pipe that runs through Rosemount. Additionally, this pipe runs near the UMore property and the Pine Bend refinery which could both be potential users of reclaimed water. Pine Bend already has a water recycling system in place but all of this water is currently supplied by private wells (Flint Hills Resources 2015).

The Draft Water Resources Policy Plan, developed by Metropolitan Council, outlines several strategies for reuse of effluent – these strategies could help guide the development of a water reclamation system in Rosemount. The Draft 2040 Wastewater Plan calls for

\$500 million for wastewater reclamation and reuse in its long-term capital improvement program. The plan also includes a recommendation for collaboration with the University of Minnesota to demonstrate wastewater reuse at UMore Park (Metropolitan Council 2015).

The first step to develop an effluent reclamation system in Rosemount is finding a partner with enough demand for water to justify investment in a new treatment system. It is possible that UMore or Pine Bend could provide this type of catalyst. Fargo and Mankato could serve as case studies for this type of partnership. A public-private cost sharing approach with regional, state, and/or federal funding support would be the most practical way to fund the initial capital cost.

The second step would be to develop the system in a way that allows for future expansion and tie-ins from other businesses. This utility could be limited to the eastern industrial district on the eastern side of Rosemount. It is possible that a reclaimed water utility could provide an incentive for industries to locate in Rosemount, as long as the rate for reclaimed water is less than potable water. Agricultural irrigation and irrigation of recreational areas could be other potential uses of reclaimed water once a system is developed. Residential demand is also possible but it would likely not be cost effective due to the low density pattern of development.

Exchange of Other Materials

There may be opportunities for existing or new businesses in Rosemount to capitalize on exchange of materials other than water. Materials used in industries already located in the city include agricultural products and construction materials. There may be many other resource streams that are unknown or undiscovered at this time. The availability of these materials is highly dependent on the types of industries that locate in the city and may or may not be viable components of industrial symbiosis. Exchange of materials, other than water, can be initiated by private firms, though the city could play a supporting or coordinating role to encourage these connections.

Energy use

Energy needs within the EIP can be supplied by utilizing these approaches, individually or often combined.

- Maximizing energy efficiency through facility design or rehabilitation
- Achieving higher efficiency through inter-plant energy flows
- Cogeneration
- Energy cascading
- Using renewable sources

Renewable energy

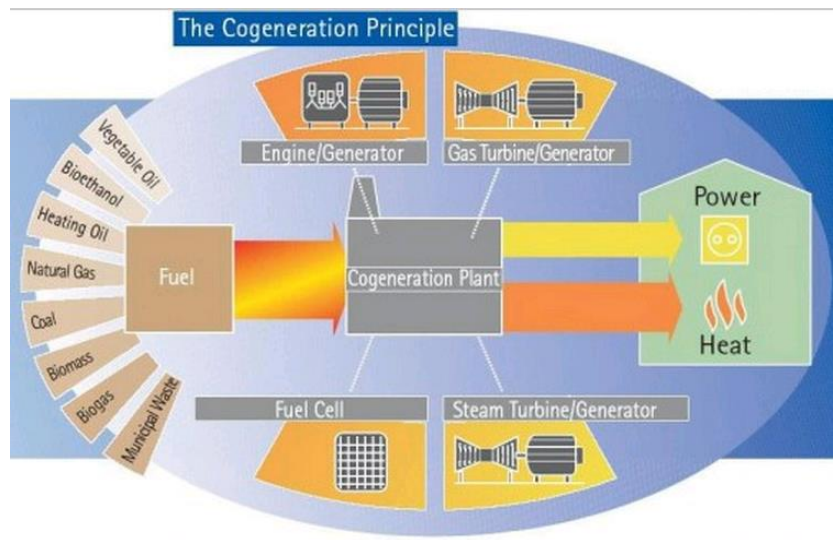
With more renewable energy resource utilization comes lower operating and utility costs for businesses as they occupy the EIP. While this approach works well for lower cost energy sources such as varyingly scaled Solar Geothermal Panels, Photovoltaic Solar Panels, Solar Hot Water, Solar Electricity, Solar Process Space Heating & Cooling (particularly relevant for commercial/industrial-scale usage), low-impact hydro-electric, and small scale wind power projects, it becomes much more risky and difficult to invest in and set up a \$1 million full-scale wind turbine. A viable alternative may be found by turning to the Lake Erie Business Park in Port Clinton, Ohio. There, the developers started small with simple and low-risk solar panels to make a noticeable difference in business' utility bills, as well as their green footprint. However, the developers have six locations zoned and cleared for full-scale wind turbine. Once the proper number of businesses occupy the park, the full-scale wind turbines will be a fiscally feasible environmentally responsible energy source. (Lake Erie Business Park, 2010).

For Rosemount, an approach equivalent to Lake Erie Business Park may consist of retrofitting the EIP with reliable, cheaper, small-scale Wind Turbines (see work sheet: <http://windlibrary.org/items/show/1021>) and solar panels. As the EIP develops and begins to bring in positive returns from lessees, funds may be used to launch other renewable energy pilot projects.

Cogeneration

A balance between using renewable energies and material exchange may be implemented by using cogeneration (Combined Heat and Power or CHP) in the EIP setting.

Cogeneration is the mechanism of capture and use of otherwise wasted heat from the electrical generating process.



Cogeneration not only has the ability to take in various forms of fuel, but also produces various outputs (but primarily heat and electricity) to either serve the needs of different buildings in the EIP, to sell back into the electrical grid, or to possibly expand into other commercial sectors of the City.

The reason a District Heating System may want to look for other areas to sell or redistribute the power produced is because they are only recommended to build above the measurement of 0.5MW/m in output per unit of length (Cogeneration and District Heating, 2005). However, there are number of benefits for possessing a co-generator for a District Heating System. “Cogeneration optimizes the energy supply to all types of consumers, with the following benefits for both users and society at large (What is cogeneration?, 2015):

- Increased efficiency of energy conversion and use. Cogeneration facilities have up to 80% energy efficiency, where traditional energy production yields approximately 30% energy efficiency.
- Lower emissions to the environment, in particular of CO₂, the main greenhouse gas.
- Large cost savings, providing additional competitiveness for industrial and commercial users, and offering affordable heat for domestic users.
- An opportunity to move towards more decentralized forms of electricity generation, where plants are designed to meet the needs of local consumers, providing high efficiency, avoiding transmission losses and increasing flexibility of system use. This will particularly be the case if natural gas is the energy carrier.
- Improved local and general security of supply. Local generation, through cogeneration, can reduce the risk of supply shortage or interruption during the times of unforeseen circumstances such as natural disasters and provides more reliable supply of electricity and heating to the local consumers.
- An opportunity to increase the diversity of generation plant, and provide competition in generation. Cogeneration provides one of the most important vehicles for promoting energy market liberalization.

Land use

Green Buildings

According to the US Environmental Protection Agency (US EPA), a *Green Building* is “a structure that is environmentally responsible and resource-efficient throughout its life-cycle. These objectives expand and complement the classical building design concerns of economy, utility, durability, and comfort. Green buildings are designed to reduce the overall impact of the built environment on human health and the natural environment by:

- Efficiently using energy, water, and other resources
- Protecting occupant health and improving employee productivity
- Reducing waste, pollution and environmental degradation

Anderson template is an important practice to consider when planning for green buildings within the park. This method recommends the historical experience of ancient pueblo peoples of the Greater Southwest U.S., which they angled their homes to face in a Southwest direction in order to maximize direct winter sunlight exposure and to minimize direct summer sunlight exposure. Being aligned on the East-West Axis with the sun's path in a manner that directs sunlight toward the floor creates a reflection and a more equal distribution of natural lighting throughout the room. This reduces the need for artificial lighting. In a building in which there is an appropriate amount of insulation, and insulation made from the correctly recommended material, direct and indirect sunlight refracted through commercial-office-grade glass and throughout the building will also assist in warming the buildings. With this practice in place, energy consumption is reduced.

The US EPA, recommends site rooftop gardens/vegetation as another ecologically-aware design method for green buildings (EPA, 2015). This practice provides shade and removes heat from the air through evapotranspiration. Additionally, the green roof reduces temperatures of the roof surface and the surrounding air which in turn suppresses energy consumption and costs in the summer, and acts as an additional layer of insulation in the winter.

Greater levels of vegetation directly on top of or on the sides of buildings also increases the quality of air, the aesthetic of the workplace, the health of employees, all of which in turn increases productivity. Evidence of the growing acceptance around the benefits of green/solar roofs may be found in France where in March 2015, the nation passed legislation mandating all new commercial buildings be at least partially covered in either plants or solar panels. A research team at the Michigan State University found that although a green roof is costlier than a conventional roof, it will save about \$200,000

over its lifetime. Approximately two-thirds of the savings come from decreased energy needs. (Cheeseman, 2015)

Landscaping

Being that Rosemount's prospective EIP is an *ex-nihilo* model (*ex-nihilo*: designing an EIP on a green field and "out of nothing"), it is integral that the prospective park "Minimize local environmental impacts by integrating the EIP into the local landscape, hydrologic setting, and ecosystems" (Fleig, 2000). Integrating the EIP into the local landscape should look very similar to what was done in Portage, IN where "storm-water runoff will stay on the site, soaking into the swale planted with native grasses and plants, which will filter the runoff before it returns to the ground table. Native prairie is peppered throughout the park." (Fleig, 2000). In addition, existing, native trees should be retained when possible. Such approaches to indigenous vegetation also minimizes landscape maintenance, assists in controlling erosion, help mitigate pollutants and odors, as well as offering climate protection for the area. The above mentioned Anderson Template also discusses creating a network for storm-water runoff that links parking lots built with porous concrete paving (less heat retention, less susceptible to wear-and-tear during seasonal shrink-swell cycles) to these native-vegetation swale and channels as a way of retaining as much runoff as possible for natural treatment and recharging the groundwater.

By identifying where water naturally flows and pools, sunlight naturally shines, winds naturally blow, and vegetation naturally grows, the occupants of the EIP may efficiently utilize, maintain, and possibly even renew/resuscitate the natural systems within its land. Knowing what and how the natural systems in place interact allows the EIP to tap into the site-specific renewable energies that do not deplete the natural system resources, which simply allows the park to have less environmental and ecological impact.

District Stormwater Management

Many new industrial developments and business parks devote a significant portion of land to stormwater management. There are many best practices for stormwater management but they are typically implemented by individual landowners and operate in

isolation from one another. In the U.S. the application of best practices is regulated under the National Pollutant Discharge Elimination System (NPDES) permit program, which is administered by individual states. Co-location of stormwater facilities could allow businesses to develop a larger portion of lots and have more flexibility during site design.

There are several cases where efforts have been made to manage stormwater cooperatively across parcel boundaries and jurisdictions. However, cases in the U.S. must operate within the NPDES regulatory framework. An Alternative Urban Areawide Review (AUAR) or Stormwater Management Plan (SWMP) can be used to make a more holistic evaluation of stormwater management.

A variety of methods could be used at different scales to manage stormwater in a unified manner. Some of the most extensive cooperative efforts have been implemented abroad. The Co-operative Stormwater Management Initiative leverages partnerships across multiple agencies to manage water at a district and watershed level (Alberta Water Smart 2014). This partnership completes projects at a range of scales best suited to the need. Regional support and expertise is provided to local governments and businesses to develop individualized solutions. The partnership also facilitates completion of infrastructure development that benefits multiple land managers. These types of development occur at the district or site scale. This initiative focuses on collaboration and flexibility.

This approach has also been used in more limited geographic contexts as illustrated by a plan for an EIP in Hinton, Alberta (Eco Industrial Solutions 2005). Hinton is a city of about 10,000 people in a relatively remote portion of Alberta, just east of the Canadian Rockies. Eco-green business parks are most often associated with supply-chain networks and shared resources and the plan for Hinton's EIP extends this thought process to stormwater management. The plan includes guidelines that consider how stormwater can be used with other effluent and gray water systems. The plan specifies that 40 percent of the lot area must be permeable - permeable surfaces include green roofs.

The application of some of the Alberta practices in Rosemount may be limited due to the difference in regulatory structure. The focus on a collaborative and flexible approach could be helpful to foster innovation of unique and efficient solutions. Individual

industries and businesses could benefit from the expertise and guidance from district or regional stormwater authority.

The presence of aggregate extraction is a unique aspect of Rosemount that could aid in the development of a collaborative stormwater approach. Mining companies have a 40-year lease to mineral rights in the area and it is expected that mining will continue for some time. These mining operations have large environmental impacts and require sensitive stormwater management. However, once mining is completed the abandoned pits could be a resources and asset to a treating and retaining stormwater. One local example of a reclaimed mine are in Minnesota is Maple Grove. This area has similar characteristics as Rosemount as an outer suburb with a large aggregate mining operation. The mining in Maple Grove is nearly complete while mining is just beginning in Rosemount. Also the wave of urbanization is nearly past Maple Grove while it is just reaching Rosemount.



Town Green Park between West Arbor Lake and the Maple Grove Library, Maple Grove, MN. from <http://mlcmn.org/about-us/our-cities/maple-grove/>

Maple Grove has made the reclamation of these mine areas a centerpiece of its community. The Arbor Lakes and Centennial Lakes areas are located in the central business area of the city. These old mine basins have substrate with high infiltration characteristics and now serve as the key component of the area's stormwater management (City of Maple Grove 2009). The artificial lakes have also become an asset as open

space featuring parks and trails. The stormwater management of this area could serve as a model for the future of the prospective EIP and Rosemount.

Application of the planning framework used in Alberta could be useful to facilitate a sustainable stormwater management plan in Rosemount's industrial districts. This could serve as the basis for partnerships between businesses and the city to develop cooperative infrastructure. Ultimately, vacant aggregate mines may provide the most substantial resource for stormwater management in Rosemount. The reclamation of these large basins could eliminate the need for individual stormwater facilities.

Marketing

Marketing is a crucial element in the success of an EIP. Marketing attracts potential participants by informing them about benefits and provides information to members of the community. EIPs provide a basis for industrial recruitment, diversify the industrial base, encourage the development of new industries, and improve the competitiveness of existing companies (Martin, Weitz, Cushman, Sharma, & Lindrooth, 1996).

Convincing businesses to participate in an EIP is not an easy task. The EIP development committee/organizers will need to identify relevant incentives that EIP offers for the organizations involved. These may include:

- Increased efficiency in various operations: Efficient use of materials and energy resources leading to cost reduction
- Ecologically-aware design and planning that helps reduction in waste, remove obsolescent infrastructure and minimizing environmental impact
- Central location, connected via various forms of transport

First, organizations can reduce production costs due to increased efficiency in various parts of its operations such as by-product use and shared energy use. Second, sharing costs for common services could also help achieve economic efficiency. Such services could include but are not limited to waste management and information management. For instance, a certain manufacturer is able to redirect or sell by-products, once a waste, to a neighboring industry if the appropriate network is established. Depending on the size of

the firms, gaining access to information can be costly and EIPs offer the option of integrating technical assistance and other information service provision through information management structure within the park (Indigo Development, 2010). Additionally, the location of the EIP could help the firm reduce transportation costs for accessing raw materials and sending out goods produced.

Further, the local government is able to provide tax incentives that will benefit the participating organizations economically. The City of Rosemount already has a Downtown Improvement incentive programs and could consider using a similar program to stimulate participation. The Minnesota Department of Employment and Economic Development also offers funding programs for local governments to incentivize businesses through small business loans that may be applicable for participating businesses.

The overall economic benefits by participating in EIP can be quantified and are an incentive for organizations to move to EIPS. These include (Martin, Weitz, Cushman, Sharma, & Lindrooth, 1996):

- change in annual profit
- change in the cost of production per unit
- change in productivity
- return on investment

EIPS also contribute to local communities and these benefits can be measured by capturing:

- value added by manufacture
- total number of production workers
- worker wages

These efficiencies are possible because participating in an EIP allows organizations to take advantage of economies of scale and scope, helps improve the flow of information between customers and suppliers, and reduces costs of complying with regulatory requirements. Economies of scope are possible when one organization can produce

different products more cheaply when compared to separate organizations producing goods separately. This happens because the first organization has access to raw materials, infrastructure etc needed for production and is able to benefit from economies of scale - reduction in costs with an increase in scale of production.

Case study: Herman Miller Marketplace

The Herman Miller Marketplace Building is located in the city of Zeeland, Ottawa County, Michigan state. Zeeland had an estimated population of 5,605 in 2001 and home to industries in the fields of office furnishings, automotives and aerospace. The Herman Miller marketplace is a relevant case study for the City of Rosemount, because it is an example of a project where the developer sought to stimulate community development by bringing together multiple small businesses while maintaining environmental standards. It has a Leadership in Energy & Environmental Design (LEED) gold rating. It developed out of a need to consolidate resources and construct one efficient and high-performing facility. An EIP in Rosemount would be driven by similar, if not exactly identical needs. While this best practice will focus on the business and social aspects, the case study reflects how economic, social and environmental goals could be achieved.

The Herman Miller building was designed as a green building not only out of environmental considerations but also economic considerations. Over the years green building costs have started to become equal with traditional building costs. Additionally market demand has led to the costs becoming lower, leading to a decrease in the return on investment. The City of Rosemount needs to develop these projections for potential businesses for the EIP as economic incentives. The designing process of the marketplace consisted of architecture and design team. In addition to ensuring construction of a green building, it also helped reduce future costs of energy consumption.

Reliable and accurate projections of costs and value metrics of the building and additional costs such as energy consumption will be an important tool for the City of Rosemount to convince businesses. These should include:

- Building costs, including tenant improvements
- Furniture, Fixtures & Equipment

- Operations costs based on months of occupancy
- Churn costs

The Herman Miller Marketplace has also built organizational and worker effectiveness and satisfaction, as demonstrated by surveys. This has stemmed from various factors such as quality of lighting, better workspace layout, and greater comfort and personalization. This is an additional incentive for businesses looking potentially to relocate to the EIP, as employee satisfaction leads to a longer employment lifecycle and improves overall efficiency.

Information Management

Description

Research on EIPs notes the importance of robust information management structure formed by a certain “coordinating” body, often centers, as mandatory to support the initiative of sustainability (Côté, 1997, Behara 2012). The centers serve as networking and information sharing hub dedicated to gather, analyze, and distribute the information on sustainable practices that implicate the industrial ecology concept for the stakeholders of the EIP. The stakeholders may include prospective or existing businesses of the park, industrial and business associations, educational and research organizations, the city and the community.

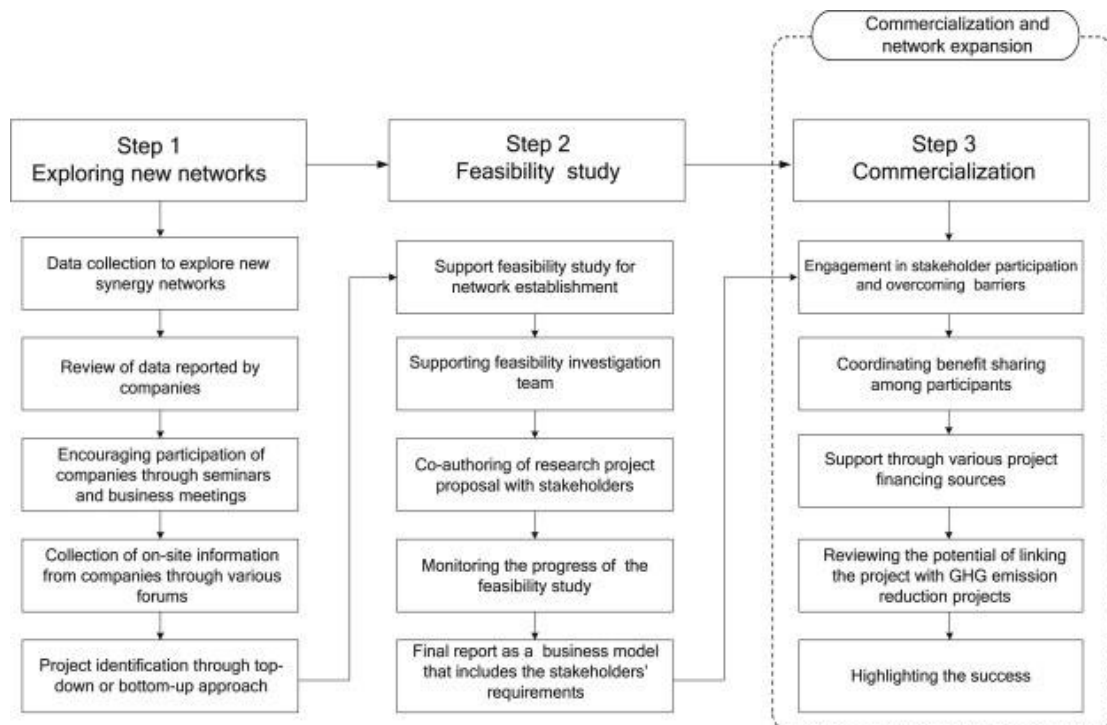
The effective functioning of an EIP will depend extensively on the flow of materials and energy both within the park and between the park and the community it serves. Also, the sustainable and regulatory compliant practices in land use and technology are the important constituents. Therefore, the information management coordinating body establishes a “database” which potentially includes data on sustainable technologies, regulatory framework, incentive programs, inventory of by-products and effluents in close proximity, energy surplus and demand in the industries and in the community. Also, the technical assistance and training could be provided through this structure. This coordinating body can be organized and supported by the EIP management agency or by the municipality.

Two case studies highlight the implementation of Information Management structure in the EIP. The Ulsan Eco-Industrial Park Center was established to explore the industrial symbiosis potential in the existing industrial park. The Eco-Efficiency Center and the EcoStar program in Devens, Massachusetts were initiated with similar purpose, but mainly focuses on firm level industrial ecology application.

Case Study: Ulsan Eco-Industrial Park Center

The Ulsan Eco-Industrial Park Center was established to explore potential industrial symbiosis and establish such networks in South Korean industrial capital, Ulsan. Ulsan is a major industrial city which consists of nearly 1000 companies. The center devised the “Research and Development into Business” framework and discovered 40 industrial symbiosis opportunities within Ulsan. Thirteen of the networks are established and in operation and the rest are under feasibility study and inter-firm negotiation process. (Behera et al., 2012)

Figure 2: The Research and Development into Business Framework



Step 1: The potential industrial symbiosis networks are identified, either by a top-down or bottom-up approach. In a top-down approach, raw data is collected from the local and central government agencies based on the production and waste emission information of the companies. In a bottom-up approach, on-site input and output data of the companies are collected from the company managers by visiting the companies directly, and through various forums, such as: petrochemical technology forums, organic sludge recycling forums, and waste and by-product recycling forums, new water forums, and EIP innovation forums, with members selected from companies, universities and local government entities.

Step 2: The businesses are recruited to participate in a potential synergy network, followed by a feasibility study. A feasibility investigation entails an assessment of the potential uses of by-products, an assessment of the techno-economics and environmental feasibilities, and a conceptual design for the particular network type. Based on the results from feasibility investigation, a convincing business model (the final report of the feasibility investigation) is developed for the implementation of the synergy network. The key elements of the business model are outlined as follows:

- (i) clear indication of a network to recycle resources among companies
- (ii) initiative to start business between companies that supply, demand and recycle by-products
- (iii) presenting companies with potential demand
- (iv) implementation of the developed technology. The business model includes all the liabilities and rights related to the investments and benefits of the stakeholders.

Step 3: Once the businesses accept the results of the business model, the EIP center manages negotiations among the participating companies, overcoming barriers related to finances or any existing laws that may possibly hinder the implementation of the projects. To overcome the financial barriers, the EIP center attracts financial support for the newly developed synergy networks based on their business model. Policy funds from the central and local governments can be availed either with a subsidy or at a nominal rate of interest for the projects contributing to water and energy saving, and waste recycling. Alternatively, the businesses between the symbiosis partners can also be financed through

the private investment. The symbiosis networks can also be formed without subsidies if the concerned parties have enough potential to invest in the project. The businesses are attracted by the economic benefits of the projects, which are proportionately shared by the companies based on their investments to the projects. Also, the reduction in long-term environmental impacts is an important motivation.

Case study: Devens Eco-Efficiency Center and EcoStar program, Devens Massachusetts

EcoStar program and Devens Eco-Efficiency Center in Devens, Massachusetts are two entities that illustrates the potential to increase participation through information management structure of EIP. The EcoStar program was first initiated. However, the program currently is administered by the Eco-Efficiency Center. The Devens, Massachusetts is a community established following the closure of Fort Devens, the U.S. Army base. During the redevelopment discussion of the former army base property, the concept of industrial ecology, zero emissions industry and zero-waste systems were promoted and the Devens community committed to sustainability.

Devens Eco-Efficiency Center, a non-profit organization, was established in 2008 and has a purpose to promote sustainability by providing businesses with the information of best practices for increasing resource efficiency and preventing pollution.

The center organizes variety of events and activities, which include:

- *Workshops.* The event raises awareness of strategies to implement more sustainable operational practices.
- *Environmental Health and Safety Roundtable.* This monthly open forum is for the professionals with environmental health and safety responsibilities to gather and discuss experiences, trends and best practices, and explore ways to collaborate to best protect the health of employees, customers, and the environment.

- *Walk-through Review.* The review guides businesses toward sustainability by providing them with a report that highlights opportunities for improved resource efficiencies and savings.
- *Recycling and Waste Reduction Assistance.* The center provides assistance in the development, improvement or expansion of a recycling program and waste reduction plan by auditing their waste stream and initiating further activities.
- *The Great Exchange.* An award-winning forum that enables businesses and nonprofits to repurpose waste streams and unwanted items that have reuse potential.
- *Energy Efficiency Assistance,* including outreach materials, employee education, conservation savings analysis, consumption benchmarking, energy efficiency reviews and comprehensive facility audits. These activities can lower annual energy costs by 10-25% and save companies thousands of dollars.
- *EcoStar Achiever.* EcoStar Achiever certification is awarded to companies that improve performance in 15 pre-defined areas. EcoStar helps members reduce costs, minimize ecological impacts, improve community and customer relations, and gain a unique competitive advantage.
- *Earth Day Celebration.* This activity enables businesses and environmental entities in the to share information on their initiatives and efforts to protect local resources through sustainability and environmental exhibitions. Annually, 20-25 exhibitors participate and attract over 100 representatives from the area.
- *Educational Tours.* The tour sites include recycling facilities, renewable energy manufacturers and low-impact development sites.

The EcoStar program was officially launched in 2005 with the mission to assist the local businesses and organizations reduce their environmental impacts and operating costs by providing education, technical assistance and promoting collaboration between businesses.

In 2002, a steering committee comprised of citizens, business representatives, government officials and environmental advocates to develop a program that would help

strengthen the EIP concept and assist organizations in forming partnerships for sustainable future in Devens. As the result of their research, the committee found that local businesses and organizations were more likely to participate in a program that would provide technical assistance and recognition for implementing efficiency measures and pollution prevention initiatives. The Steering Committee began developing EcoStar, a voluntary, environmental achievement and certification program which is jointly funded by the Devens Economic Commission and the Solid Waste Planning Grant provided by Massachusetts Department of Environmental Protection.

The EcoStar certification consists of 25 standards and a participant that incorporates 15 of them into their operation earns the recognition of “EcoStar Achiever.” The members utilize “EcoStar Action Guide” that describes approaches to improve environmentally friendly performance in the process. The program and standards focus on toxic chemical use reduction, purchasing of greener products, water and energy efficiency, recycling and waste minimization, and other sustainability efforts. EcoStar also encourages collaboration between firms to improve resource efficiency and support environmental protection.

The EcoStar program provides several benefits to its members. These include:

- Copy of the *EcoStar Action Guide*
- Assisting members to identify and set relevant goals for sustainability
- Free registration for monthly training workshops and technical assistance
- Business to business networking within the Devens area
- Access to EcoStar Exchange, an online tool for redirecting and reusing materials and products
- Cost-savings from efficient practices (e.g., energy and waste management cost savings)
- Public recognition and rights to the EcoStar logo for branding advantages for EcoStar Achievers
- Improved health and safety of employees and community.

EcoStar program is recognized as a promoter of both business and the environment, and more than 30 organizations from Devens and surrounding communities have joined the program. Current members are consisted of businesses, industries, and private and public entities.

Application to Rosemount

Information management structures are an essential and applicable component for the case of City of Rosemount. Similar to the Ulsan Eco-Industrial Park Center, the city can establish information management structure and utilize the Research and Development framework. According to this framework, the city can organize forums and business meetings to explore potential industrial symbiosis opportunities by bringing the existing local businesses together. Also, these forums can attract future tenants from other areas to the project. Further, this structure will lead the information sharing and networking in the park.

The experience of Devens, Massachusetts community demonstrates the importance of community engagement and educational purpose of the information management structure. The city of Rosemount can initiate a program that is similar to EcoStar program in order promote sustainability and industrial ecology practices. This initial process will introduce the benefits and feasibility of industrial symbiosis and establish the aspiration to join the prospective industrial park. Also, educational tours and other trainings will advocate environmental awareness, importance of energy efficiency and recycling through community participation. Ultimately, the structure has a potential for driving sustainability initiative in the community.

5. Conclusion

A critical element in defining an EIP is the interactions among its member businesses and between them and their natural environment (Eco-Industrial Parks, 2006). EIP development integrates business success, environmental excellence, and community connections to create economic opportunities and improved ecosystems. Its manifestation in the community is the result of the local partnerships between government agencies,

community members, businesses, and industrial developers (Deppe & Schlarb). Developing an EIP is a complex process and requires coordination across multiple stakeholders.

Some of the challenges in setting up an EIP include estimating benefits and costs, identifying businesses that will work in symbiosis, finding appropriate technologies, ensuring a supportive regulatory framework and finally convincing businesses to move their operations (Martin, Weitz, Cushman, Sharma, & Lindrooth, 1996).

A successful EIP will allow a group of firms to reduce their wastes and emissions more than they would be able to do than if they acted alone. This assertion, made by Gunter Pauli, has led to the Zero Emissions Research Initiative which aims to reduce firms' emissions to zero while improving profitability (Ehrenfeld 1997). To achieve this goal firms must coordinate with each other to understand each other's resource-waste processes. Only then will they be able to act appropriately to optimize their own process and capitalize on existing resource flows. A coordinating body could use this information to seek complementary industries to fill voids in the existing resource network.

Trust among private parties is important to develop EIPs since development of symbiotic industrial relationships depends on alliances or formal contracts. This may be a difficult barrier to overcome in the U.S. where there is a strong culture of privacy in business (Ehrenfeld 1997). Firms that choose to enter into a resource exchange must know they can rely on the opposing party since their business and bottom line depends on all parties meeting their obligations of the arrangement. Due to this factor, the resources being exchanged will most often have to be produced constantly, and in a reliable manner. Transaction costs will be much higher for sporadic exchanges of materials that are produced infrequently or in small quantities. Public institutions or planners could help facilitate conversations and develop relationships within private industry.

Several reviews of eco industrial parks have shown that many planned EIPs have failed to meet expectations while many successful EIPs developed organically. It is now commonly accepted among policy makers and academics, that planned industrial

symbiosis has resulted in many failures (Chertow 2007). Many planned EIPs in the U.S. were initiated following the U.S. President's Council on Sustainable Development in the 1990s. Of the 15 planned EIPs, four are open, four have failed, and 7 remain as planned. Success is debatable even among the projects identified as open. All of these projects have experienced setbacks like a change in scope of project, failure to meet defined objectives, and financial difficulties. One of these cases is the Green Institute in the Phillips neighborhood in Minneapolis. The building remains in use but it lost a key tenant in 2011 and no longer fits the definition of an EIP well (Gilyard 2011).

Successful cases that meet the definition and objectives of industrial symbiosis do exist and most are the result of independent negotiations in the private sector. Kalundborg and several parks in Australia, Austria, Germany, Finland, and the U.S. have developed this way. Industrial symbiosis at these locations was not recognized by the members of these exchanges but 'discovered' by those from the outside (Chertow 2007). This emphasizes that industrial symbiosis must be economically viable and should be used to create additional efficiencies and reduce the cost of doing business. While there is no one way to successfully engineer an EIP, there are several common factors found in each of these examples, they: built on an existing successful economic base, supplemented existing industries and resources flows, capitalized on unique locational advantages, and allowed businesses to continue operating in spite of challenges like increased resource costs and tighter environmental regulations.

For the City of Rosemount, there are several elements that need to be short listed, if not finalized to visualize a potential EIP. These include location, economic incentives, aims of the city for economic growth, environmental sustainability and social equity and more. The City also needs to decide whether it will play a central role in developing the EIP or prefer to outsource it, possibly to a private developer. Once all of these are decided, identifying the kinds of businesses and organizations that would be a good fit and benefit from the EIP will be the next step.

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