

**Applying Decision Support Tools For
Eco-Industrial Park Planning:
A Case Study in
Burlington, Vermont**

**A Project Under Development for the
Urban and Economic Development Division
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by

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INTRODUCTION

For the Urban and Economic Development Division of EPA's Office of Policy, Planning and Evaluation, Industrial Economics, Incorporated (IEc) is developing analytical tools to aid planners and decision makers in the design and planning of eco-industrial parks (EIP). The suite of three tools includes: (a) information and search mechanisms for identifying viable sets of facilities for co-location at an EIP; (b) a graphical user interface based in Windows; and (c) capabilities for sensitivity analysis and "What if..." evaluations. The tools support a wide range of planning scenarios depicting tradeoffs among different planning objectives, including environmental, economic, and employment objectives. The flexible and interactive design of the tools provides a powerful framework for addressing questions during EIP design and planning stages about sustainability, planning objectives, and potential park composition.

Each of the tools is designed to support a particular stage in the planning process:

1. Facility Synergy Tool (FaST)

FaST provides the most basic information required for the planning of an eco-industrial park - where to find reusable non-product outputs (including energy and water) for particular uses, and where to send non-product outputs that are currently not being used. FaST is a database of industry profiles that describe the inputs and outputs of different types of facilities that could be included in an EIP. The information provided by FaST allows users to select a palette of potential facilities for a park.

1. Designing Industrial Ecosystems Tool (DIET)

DIET is a linear programming optimization model, designed to aid decision makers and planners in identifying configurations of industrial facilities that exhibit economic and environmental potential for an EIP. DIET helps assess the viability of different combinations of industrial and non-industrial facilities and demonstrates the tradeoffs between environmental performance, jobs, and cost savings. Working with DIET, users can interact with FaST to select additional facilities for evaluation, or with REaLiTy(to evaluate the feasibility of identified facility linkages.

1. Regulatory, Economic, and Logistics Tool (REaLiTy)

REaLiTy(, which is in an early stage of development, provides regulatory, economic, and logistical guidance on the uses and reuses of material and energy flows in an eco-industrial park. This information is particularly valuable in assessing the viability of a proposed material or energy exchange and for identifying potential areas for regulatory flexibility. REaLiTy(will be updated with information collected during IEc's work with EIP planners and participants.

Throughout this project, IEc is working with EIP planners, facility personnel, and community representatives on the design and development of the decision support tools. This brochure describes application of the suite of tools in a representative case study area: Burlington, Vermont. The case study illustrates how the screening models allow stakeholders to explore decisions and issues in an interactive and flexible analytical framework. In addition to the information the tools provide (i.e., potential linkages, rough estimates of benefits, regulatory constraints), much of their value comes from the collaborative decision-making process they help to facilitate. As part of this incremental and collaborative process, in later stages of EIP planning, more detailed issues lying outside the three screening tools must be addressed, e.g., covenants, working relationships, engineering design specifications.

This brochure begins with an introduction to the planning scenario and park context in Burlington. The brochure then walks through an example using the three tools to help decision makers in Burlington identify potential facility linkages and investigate options for their proposed EIP. The case study example outlines potential material/energy/water exchanges and includes estimates of cost savings, waste minimization, and job creation under different park scenarios. After investigating potential barriers to the exchanges identified for Burlington, the brochure concludes with a discussion of how the tools can best be used in a community decision-making process.

BACKGROUND ON THE BURLINGTON EIP

The proposed site for the Burlington EIP is a 10-acre section in the Intervale, a multiple-use area largely comprised of community gardens, recreational space, and wetlands. Proponents of the EIP value its potential to create living wage jobs with training and education opportunities, to promote local self-sufficiency, and to serve as a model of sustainable development using the industrial ecology principle of closing the industrial process loop (i.e., using waste streams as inputs for complementary industrial processes). Those opposed to the EIP cite the loss of valuable recreational space and increased levels of traffic, noise, and pollution. Debates at community meetings clearly demonstrate that planners would benefit from interactive, analytical tools for exploring park scenarios and developing a common vision for the site.

ANCHOR FACILITIES AT THE BURLINGTON EIP

One of the first steps in planning an EIP involves understanding the current composition of facilities, businesses, and activities in the surrounding area. Because they already exist and operate in the area, "anchor facilities" play a major role in determining the nature and character of the proposed EIP. Planners need to recruit additional facilities, businesses, and activities that will feed into the current input, product, and non-product output (NPO) streams to make the park an effective industrial eco-system. Fitting in with the needs and uses of

the Intervale, plans for the Burlington EIP have centered on agriculture, greenhouses, and green energy. Four principal anchor facilities/activities that currently exist in the Intervale directly affect the nature of the proposed EIP: (a) an electric power generating station, (b) agricultural lands, (c) a waste wood depot, and (d) a composting facility.

The wood-burning McNeil Station is the main anchor facility for the proposed Intervale EIP. Since 1984, the McNeil Station has been operated by the municipally-owned utility, Burlington Electric Department (BED). Development of the "green-powered" plant came out of a commitment by the city of Burlington to look toward renewable biomass fuels as a source of electrical energy. McNeil Station burns wood chips, bark, and sawdust from regionally grown wood. Eighty percent of the wood that fuels McNeil comes from lower quality trees and harvest residues monitored by BED foresters to ensure that clear-cutting is limited in use and acreage.¹

The largest component in the Intervale in terms of acreage is private and community-owned farming. Approximately 400 acres in the Intervale are dedicated to growing a variety of products, including flowers, artichokes, mesclun, and other vegetables. The Community Farms project cultivates approximately 35 of these acres through a cooperative farming program. Located adjacent to the farms is Gardener's Supply, an agricultural tools and supply distribution company. Gardener's Supply is owned and operated by Will Raap, one of the original promoters of the Intervale EIP. Raap is also the founder of the Intervale Foundation, a non-profit organization financially supported by Gardener's Supply. The Intervale Foundation was responsible for clean-up the 700-acre floodplain in 1986, and has overseen projects and land management issues in the years since.

The Intervale Foundation also manages a large-scale composting project. The Intervale Composting Project collects over 2,000 tons of yard, leaf, and food waste a year from area residents and businesses. The resulting product provides valuable composting material to farms and gardens in the Intervale. Also tapping into local waste streams, the fourth anchor facility is the Waste Wood Depot. Run by the Chittenden Solid Waste District, the Waste Wood Depot collects wood waste materials and provides woodchips to fuel its neighbor, the McNeil Power Station.

IDENTIFYING POTENTIAL LINKAGES

Planners can build facility profiles to characterize the input/output flows of the facilities in and around the EIP. Figure 1 provides an example of an information profile for a representative composting facility. Profiles of this type are useful for identifying linkages among facilities currently existing in an area and for targeting potential recruits for the EIP. To aid in this search, the FaST database contains representative profile information on a range of industrial and non-industrial facilities. By entering information on anchor or selected facilities into FaST, proposed linkages can be confirmed, quantitative estimates can be provided, and facilities offering matches can be targeted for recruitment.

¹ *Creating the Sustainable City: The Case of Burlington, Vermont*. Draft version dated March 10, 1997. Distributed by the Mayor's Office in Burlington.

Figure

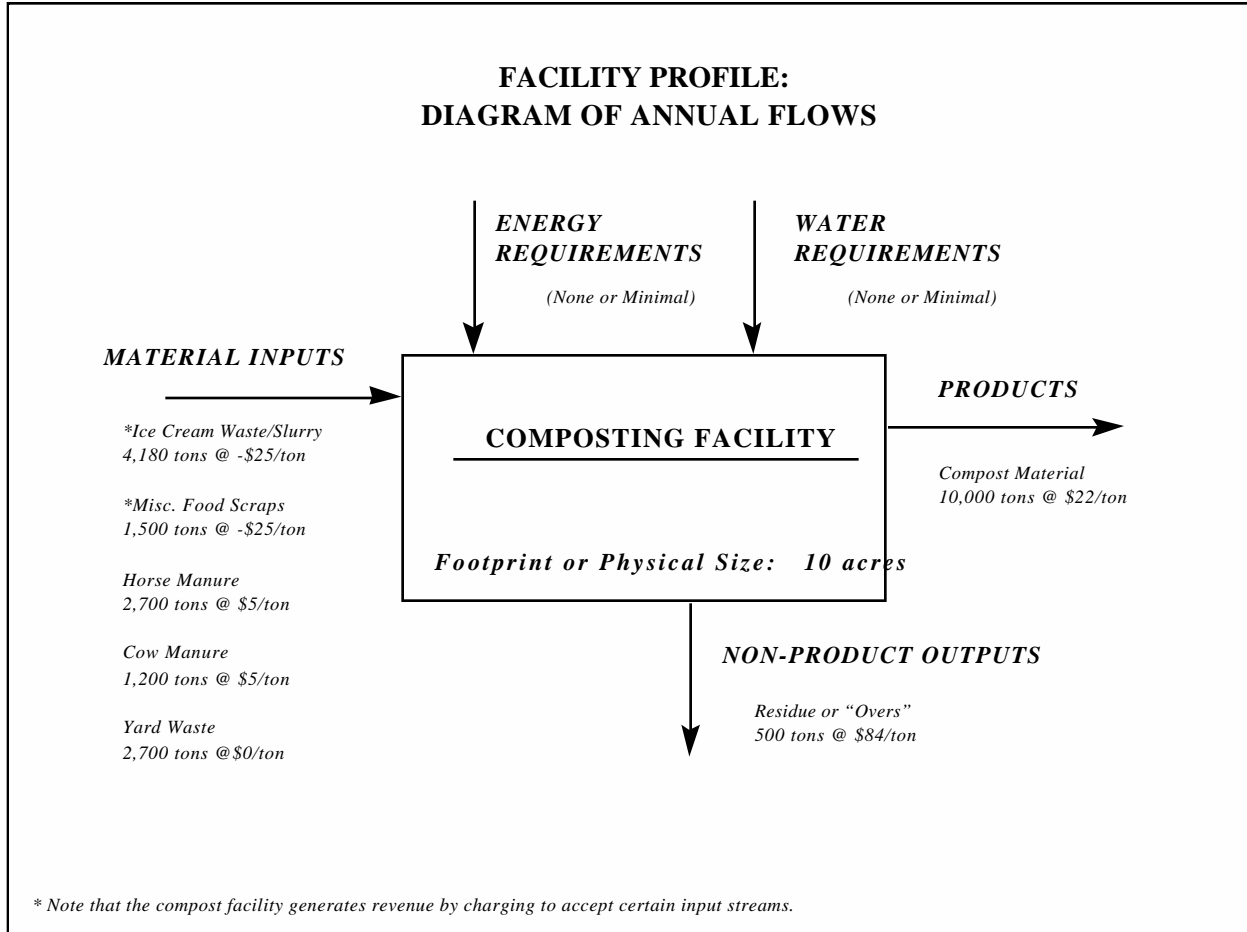
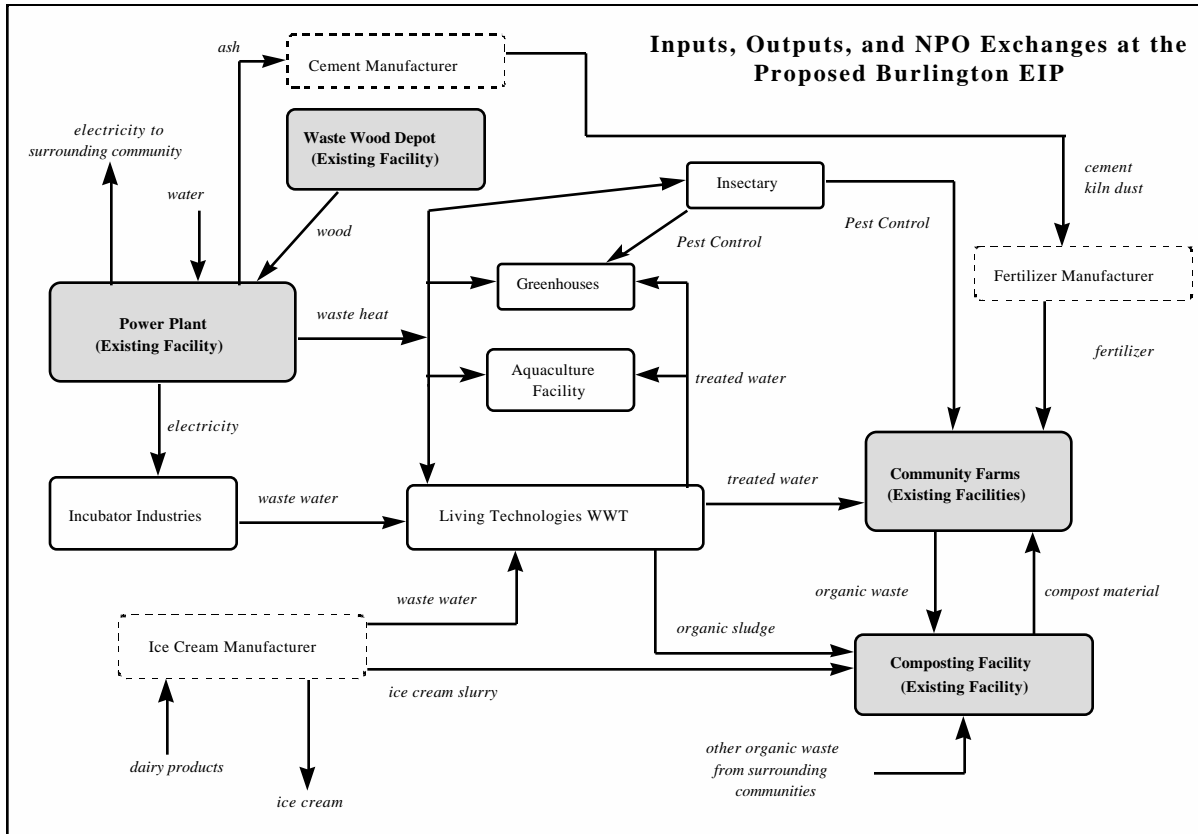


Figure 2 illustrates some of the potential linkages identified by the FaST database based on the anchor facilities in the Intervale EIP. The linkages shown in this diagram encompass a wide range of possibilities. A few of the linkages are already in place (e.g., woodchips from the Waste Wood Depot to McNeil Station). Others, in particular the waste heat supplied from McNeil Station, were identified in the initial conceptualization of the park. Several of the linkages shown extend beyond the physical boundaries of the proposed EIP to connect to material streams in the surrounding region. However, all linkages depicted in Figure 2 center on the four anchor facilities (McNeil Station, Waste Wood Depot, Community Farms, and Composting Project) marked with shaded boxes in the diagram. Boxes drawn with dotted lines represent facilities located off-site in other areas in and around Burlington that could participate in the park exchanges. The remaining boxes represent facilities that could be located on the 10-acre site in the Intervale.

Figure



Potential linkages fall into three general categories: energy, water, and materials. In the Burlington EIP, resource sharing through energy and water use and reuse will play a major role in determining the EIP's success. With the McNeil Station as one of the principal anchor facilities, the waste heat generated in the production of electricity represents a potentially valuable resource. The resulting steam and hot water can be used to heat auxiliary facilities such as a greenhouse, aquaculture facility, or insectary. Burlington is also the home of Living Technologies, innovative designers of wastewater treatment facilities using plants and microbes to treat organic wastewater.² This connection has helped to make water use and reuse a second major focus of the Burlington EIP. A wastewater treatment facility could be designed to accept water from the McNeil Station, incubator

² A Living Machine(is an effective and economical system for biological treatment of high strength industrial wastewater and sewage. Dr. John Todd, an internationally recognized biologist, pioneered the development of Living Machines(.

industries, or other local manufacturers and treat it for use in the several of the facilities on-site.³

A subset of the potential material exchanges identified for the Burlington EIP are listed below. A few of these linkages are already in place and operating in the EIP. Others are being discussed under current design schemes, while the remaining ones are possibilities to pursue in later planning stages.

- (**Waste Wood.** The Waste Wood Depot plays an important role in supplying input material to the McNeil Station. The Depot accepts waste wood from construction and demolition companies, local residents and stores, and foresters managing area forests. Untreated wood is chipped for use in the McNeil Station after nails and other foreign objects have been removed. Wood and yard waste that cannot be used in the power plant may be sent directly to the composting facility.
- (**Ice Cream Slurry.** The Intervale Compost Project currently accepts ice cream slurry from a local ice cream manufacturer. The compost piles are specifically designed and managed to best handle this particular input stream.
- (**Local Yard and Food Waste.** The composting facility plays a valuable role in collecting yard and food waste from local residents, restaurants, and farms and using it to create a usable product.
- (**Compost Material.** The numerous community and privately owned farms located in the Intervale can use composting material from the Intervale Compost Project.
- (**Fly Ash.** Ash is a waste product of the McNeil Station's wood chip burning process. This ash can be transferred to one of the cement manufacturing facilities within the Lake Champlain vicinity for use as an input to their manufacturing processes.
- (**Cement Kiln Dust.** Innovative fertilizer companies have developed a process for using recycled cement kiln dust as a binding ingredient in their fertilizer products. While the fertilizer companies currently in the Burlington area do not use this innovative process, given the focus on agriculture in the Intervale and Burlington's goals for sustainable agriculture, this may be one alternative to pursue.

³ Because the design of the Living Machine™ wastewater treatment facility is process-specific, it is difficult to model in general terms the parameters of this system. Burlington currently plans to initiate construction of a Living Machine™ within the Intervale site in May 1998. A local brewery approached planners about the possibilities of participating in the EIP, and plans for the Living Machine™ focus on designing the facility to treat the brewery's waste water. Once this connection is established, a facility profile for the resulting Living Machine™ can be developed and further analysis done on water use and reuse possibilities in the Intervale EIP.

- (**Fertilizer.** With the large number of farms in the area and the potential expansion into greenhouses, local production of fertilizer would contribute to Burlington's goal for local food production and self-sufficiency. An innovative fertilizer manufacturing process such as that described above can also make use of the cement kiln dust NPO.

- (**Pest Control Insects.** With their focus on sustainability, Burlington is interested in supporting organic farming practices. Insectaries growing pest control insects may offer a viable alternative to chemical pesticides. Located on wetland areas and adjacent to the Winooski River, environmentally sensitive farming practices are especially important to sustainable use of the Intervale.

ESTIMATING COST SAVINGS

Once potential linkages are identified, data on the complete set of facilities are exported to DIET for further evaluation. DIET is designed to help planners and decision makers investigate the estimated benefits of different EIP scenarios designed to meet community planning objectives. Based on the anchor facilities identified for a site, DIET suggests viable sets of facilities for either co-location at the site or for participation in the EIP. DIET helps planners and community decision makers select those facilities that best capture eco-efficiencies through energy, water, and material exchanges. Figure 3 shows a screen capture from DIET outlining one possible scenario for the Burlington EIP. In this example, ten facilities have been selected: fertilizer manufacturer, aquaculture facility, Living MachineTM wastewater treatment facility, cement manufacturer, community farms, compost project, greenhouses, insectary, the McNeil Station, and the Waste Wood Depot.

The table in Figure 3 reports suggested footprints or physical sizes for the selected facilities. The first column in the table lists the allowable maximum size for the facility. The second column reports the allowable minimum size. The third column reports the suggested size for the facility in the particular park configuration described in the current solution. This information helps planners investigate how variations in physical size affect the results of each scenario. Size constraints also limit those facilities that can co-locate on the 10-acre Intervale site (e.g., greenhouse, aquaculture, Living MachineTM, insectary). Other facilities may be selected for participation in the EIP, but because they are already located either in the Intervale or in the surrounding area, they will not take up any space on the new site. The user can investigate the effect of different facility sizes on the resulting park configuration. For example, allowing the compost project in Burlington to expand beyond its current size by taking over some of the community farm area increases the amount of food scraps, slurry, and organic waste that can be handled at the facility and made into compost material. Allowing the expansion of the compost project also provides more job openings within the park and increases the overall cost savings to the park as a whole. Of course, increasing the size of the compost project entails reducing the amount of land in the Intervale available for other activities. Planners can use DIET to investigate the trade-offs involved in this and similar scenarios.

Figure

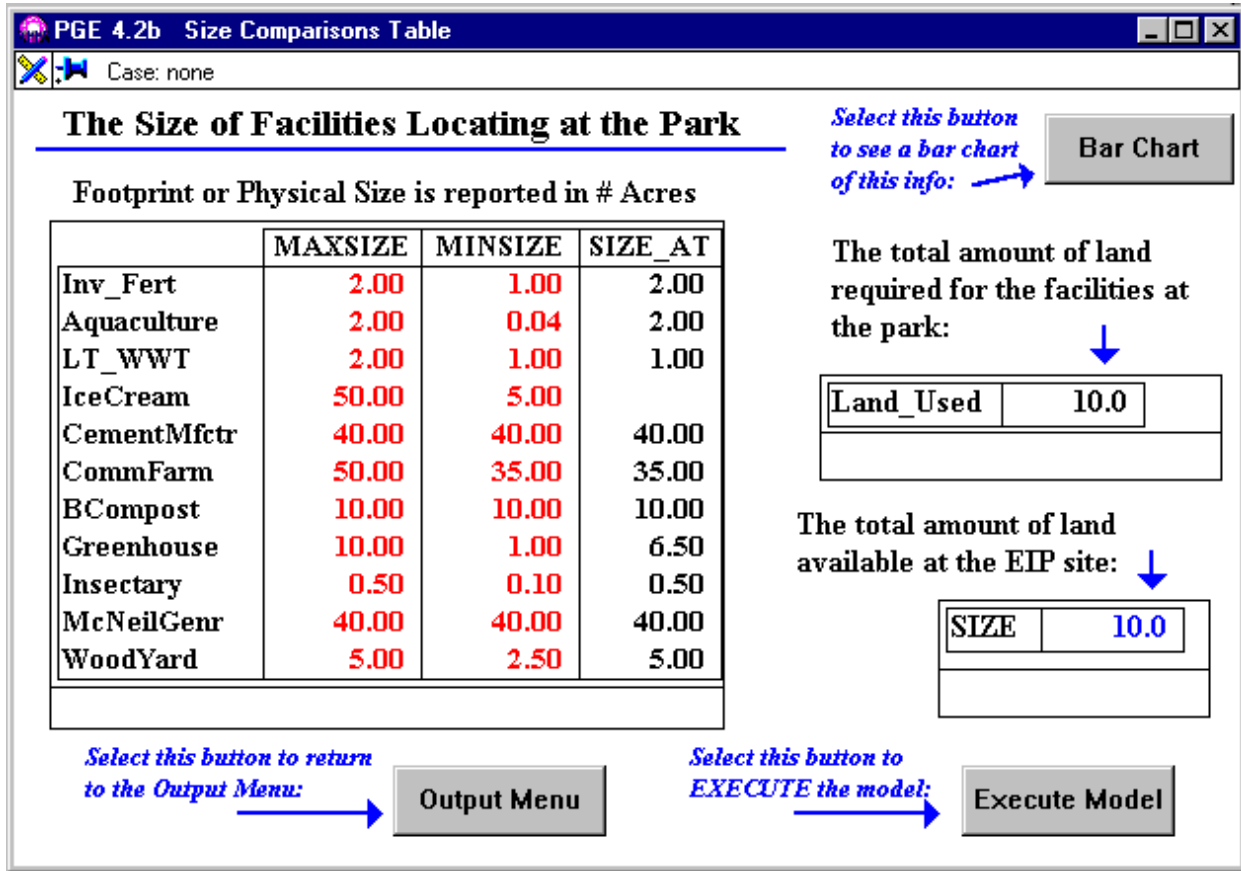


Table 1 lists the potential material and energy exchanges identified by DIET for the Intervale EIP. Using the potential linkages identified by FaST, DIET suggests specific park scenarios and provides quantitative estimates of the flows and linkages among facilities given their respective processes and production levels. As discussed in more detail later, suggested park configurations take into account the way community stakeholders weight their planning options and define constraints on the park site and prospective facilities.

Table 1

Table 2 identifies rough estimates of cost savings calculated by DIET for facilities participating in the proposed Intervale EIP. In DIET, input savings refer to potential savings to a facility if it were to purchase products or reuse NPO materials from other facilities in the EIP, as opposed to using raw materials or input materials purchased off-site or from non-participating facilities. Treatment, storage, and disposal (TSD) savings refer to savings incurred when a participating facility can exchange its NPO materials with other facilities, and no longer has to pay for handling or disposing of the materials.

As seen in Table 2, estimated cost savings range from small amounts for the Insectary (a low-cost facility to begin with) to larger savings estimated for the Cement Manufacturer. The estimated savings tie back to the linkages within the park (Figure 2). The Cement Manufacturer can expect to save on disposal of cement

kiln dust if arrangements can be made with a fertilizer company to use this material as one component of their product. The Cement Manufacturer also saves money by reusing the fly ash from the power plant as an input to its processes. The Fertilizer Company benefits from savings associated with using cement kiln dust (produced as a NPO by the Cement Manufacturer) as a binding ingredient in its product.

The Greenhouse, Insectary, and Aquaculture Facility all benefit from the waste heat generated by the power plant. In most greenhouse facilities, especially in a colder climate like Vermont, heating costs are by far the largest costs incurred, making waste heat quite valuable. The Community Farm saves money by acquiring compost material from the neighboring compost project rather than bringing in material from suppliers located off-site. The McNeil Station, in turn, saves by using wood chips from the Waste Wood Depot and from reducing their costs to cool wastewater before releasing it to the river. Under the current setup, the Waste Wood Depot saves money and generates revenue by charging for its services as a waste collection site.

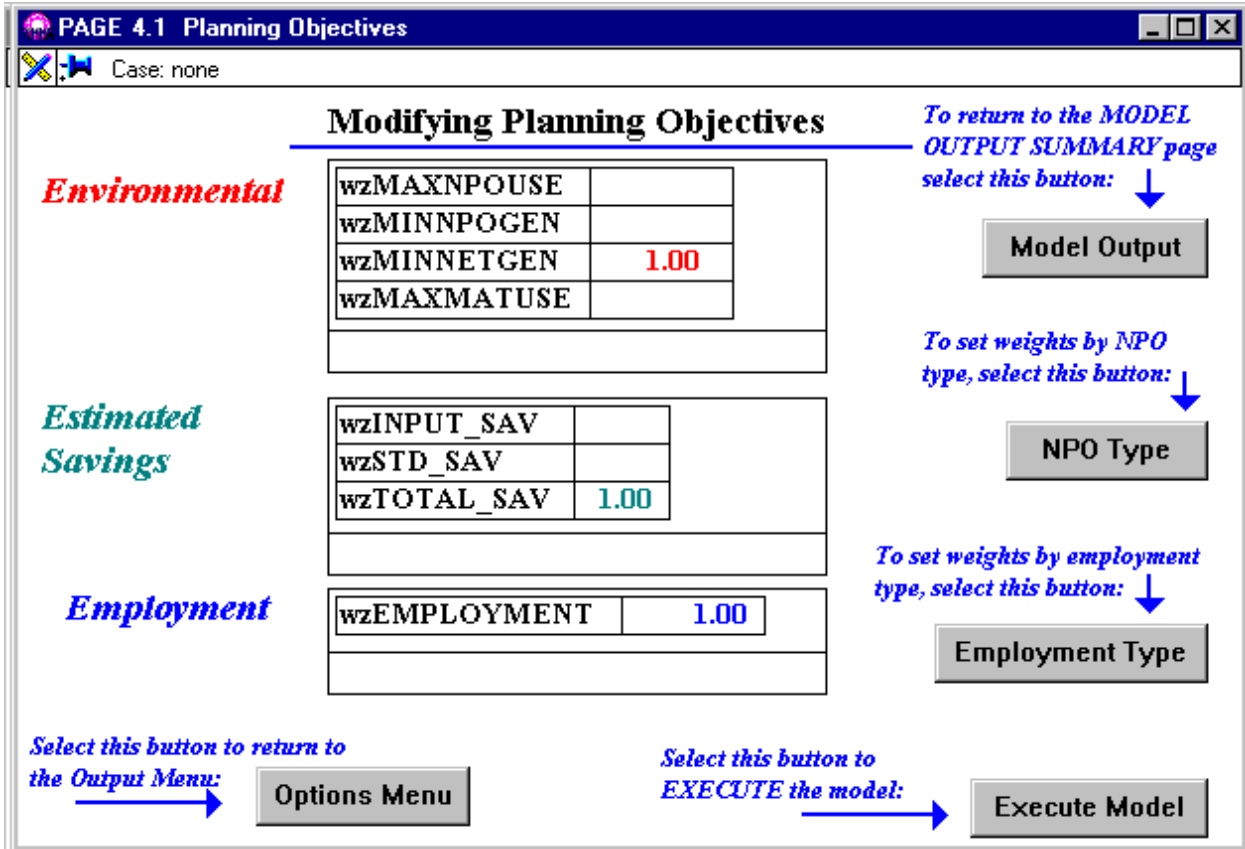
Facilities	Savings on Input Material Purchases (\$)	Savings on NPO Treatment, Storage, and Disposal (\$)	Total Savings at Each Facility (\$)	Percent of Overall Savings in the Park (%)
Aquaculture	3,000	NA	3,000	0.2
Community Farms	30,000	1,000	31,000	1.6
Cement Company	10,000	940,000	950,000	50.0
Fertilizer Company	560,000	NA	560,000	29.5
Greenhouse	5,600	1,200	6,800	0.4
Insectary	5	NA	5	0.0
McNeil Power Station	115,000	230,000	345,000	18.2
Waste Wood Depot	NA	11,500	11,500	0.6
Approximate Total Savings	700,000	1,200,000	1,900,000	100.0

EXPLORING TRADE-OFFS THROUGH "WHAT IF?..." ANALYSIS

The DIET optimization model allows communities to conduct "What if?..." analyses in a flexible and interactive environment. The model supports multiple planning objectives and allows stakeholders to vary the relative weights of these objectives. Figure 4 contains an image of the DIET screen where users set relative weightings for the objectives. This screen contains three tables, one each for environment, cost savings, and employment. The environment and cost savings categories can be broken into sub-categories recognizing different ways to measure progress in each. Weights also can be assigned to distinguish between different NPO

materials or different job categories.⁴

Figure



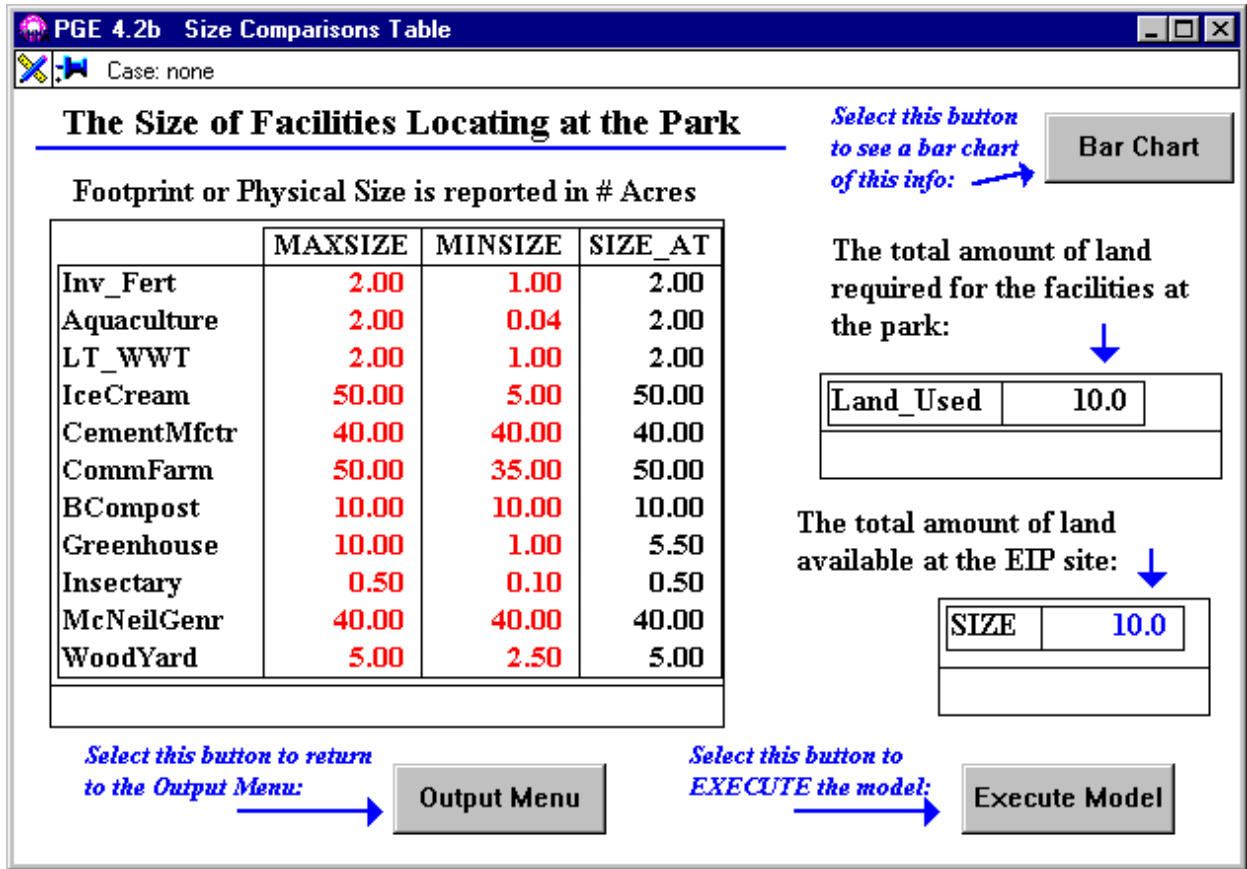
When equal weights are assigned to the planning categories of environment, cost savings, and job creation, the resulting patterns of activity for the facilities being assessed is shown in Figure 3. Under the scenario portrayed in Figure 3, the model estimates approximately 500 people will be employed across all the facilities participating in the park. If, however, the community wishes to create the largest number of possible jobs given the available set of facilities, a different type of park results (Figure 5). In this scenario, the most labor intensive facilities are selected for the park at their largest possible sizes (e.g, a large ice cream manufacturer is brought into the park and the size of the community is increased to its maximum allowable size of 50 acres). The scenario in Figure 5 estimates approximately 800 people employed at the facilities

⁴ For a detailed description of the planning objectives and how the weighting scheme works, refer to the *Tools for Eco-Industrial Park Planning: User's Manual*.

participating in the park. Communities particularly interested in job creation at the park will want to use the model to investigate the breakdown of jobs by category and by facility.

Varying weights on the planning objectives in this manner, or changing the value of any of the model input parameters, allows the community to explore the effects on the resulting park configuration and associated benefits. Facilities can be built into the park or restricted from participating in the park. The effects of changes (e.g., varying the minimum and maximum allowable sizes for the facilities or the amount of land available at the site) can be estimated. Other types of changes also are easily simulated within the structure of DIET. For example, changes in facility processes can be simulated by altering the data on input and output flows "on screen." During the planning stages for an EIP, planners and community stakeholders can take advantage of the interactive and flexible design of DIET to explore all of these options and many more.

Figure



RECOGNIZING POTENTIAL CONSTRAINTS

Identifying potential facilities and evaluating possible planning scenarios is only the first stage in the EIP planning process. In order to make identified linkages viable, planners must be aware of potential regulatory, economic, and logistical barriers to their implementation. Running potential exchanges through the REaLiTy(database may help planners identify these constraints and take steps to address them before they become barriers in the planning process. Figure 6 shows a portion of a report from REaLiTy(offering information on cement kiln dust, one of the potential exchanges identified in the Burlington example. The report highlights the regulatory status of the material under current and up-coming RCRA standards. An important logistical constraint to recognize is that cement kiln dust as a by-product is highly variable, in amount and in properties, according to the manufacturing process and the specific needs of the local/regional market.

Figure

Regulatory, Economic, and Logistical Support Tool
REaLiTy

<i>Material</i>	<i>Originating Industry</i>	<i>Constraints</i>		
		<i>Regulatory</i>	<i>Economic</i>	<i>Logistical</i>
cement kiln dust (CKD)	cement manufacturers	upcoming promulgation of RCRA Subtitle C standards for CKD threatens tighter controls-- CKD is currently exempt under Bevill amendment; now regulated to varying degrees by state statutes and agencies as non-haz. or haz. waste depending upon content		amount produced and properties highly variable according to manufacturing process; market is regionally sensitive: only useful for ag. applications where soil is acidic; in high demand where haz. treatment co.'s -- market not highly developed elsewhere

Other potential constraints requiring further investigation in the Burlington case study include:

- (**Seasonal and Temporal Fluctuations.** With its focus on agriculture and food production, the planners of the Burlington EIP must be sensitive to the seasonal nature of many of the facilities' processes. In addition, under current procedures the McNeil Station does not operate every day. Facility input/output streams must be designed to handle these seasonal and temporal fluctuations or back-up systems should be secured.
- (**Process-Specificity of Wastewater Treatment.** Design of the Living MachineTM wastewater treatment facility identified for the Burlington EIP is highly dependent upon the waste streams it is to treat. Before committing to the capital costs of building the facility, planners should secure as least one primary waste water flow (e.g., the local brewery).
- (**Altering Processes and/or Products by Changing Inputs.** As with any EIP, if one facility changes its processes, identified exchanges throughout the park may no longer be viable. Planners must be aware of which facilities and/or processes are crucial to the overall viability of the park. The DIET model can help evaluate such sensitivities in the park configurations.

VALUING THE PROCESS OVER THE OUTPUT

When working with the tools for EIP planning, it is important to remember that they are intended for use as "screening" tools to support collaborative decision making in the initial stages of EIP planning and design. As with any models, their output is only as good as the input data on which they run. For example, the cost savings estimates or the job creation numbers are not meant to be taken as guarantees by planners, community

stakeholders, or facility personnel. Output from the models provides users with *a general framework* of how certain decisions and constraints may affect the overall performance and configuration of the resulting EIP.

The true value of the models comes not only from their output or quantitative estimates, but from the interactive framework they provide for communities struggling to make decisions. Used in an iterative and collaborative process, the tools help communities come together around the decision-making table to: (1) identify new possibilities for better environmental performance, economic savings, and employment creation; (2) explore trade-offs among planning objectives under different park scenarios; and, (3) understand the impact of land use development decisions and EIP alternatives on their long-term goals for environmental and economic sustainability.

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Table 1

Potential Exchanges for the Burlington EIP

Generating Facilities	Receiving Facilities							
	Aquaculture	Cement Company	Community Farms	Compost Facility	Fertilizer Company	Greenhouse	Insectary	McNeil Power Station
Community Farms				2,500 lbs Plant Waste				
Cement Company					20,000 lbs Cement Kiln Dust			
Compost Facility			1,300 lbs Compost			200 lbs Compost		
Greenhouse					24,500 lbs Plant Waste			
Insectary	10,000 Mites Pest Control		25,000 Mites Pest Control			4,000 Mites Pest Control		
McNeil Power Station	43,000 BTU's Waste Heat	5,000 lbs Fly Ash				64,000 BTU's Waste Heat	4,600 BTU's Waste Heat	
Waste Wood Depot					3,000 lbs Wood Waste			9,000 lbs Wood Chips