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Sustainable Science Park Master Planning for Extreme Energy Savings

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Abstract

This paper presents a brief but comprehensive presentation of how science park directors, staff, architects, and engineers can implement a sustainable master planning process for an existing or proposed science park.

Sustainable master planning concepts for science park sites prepares the way for sustainable design of research facilities. For the ultimate successful research facility design it is critical, that early master planning principles facilitate as many passive and sustainable techniques as possible. This approach increases the potential for extreme energy savings related to reduced mechanical systems and increased natural daylighting in the proposed facilities as well as improved quality of spaces. The shape and orientation of the individual sites and ultimately the buildings within the research park have a significant impact on the ultimate energy characteristics of the research facilities.

Introduction

Developing a methodology for sustainable master planning for research facilities and research parks should include the following: 1) site selection; 2) energy efficient building orientation; 3) natural daylighting orientation; 4) reducing site disturbance; 5) storm-water management; 6) water efficient landscaping; 7) water conservation; 8) waste management; 9) reducing heat islands, and 10) light pollution reduction.

The research paper will integrate these sustainable master planning concepts into the following normal master planning analysis: 1) site slope / topography; 2) site hydrology; 3) utility location / availability /capacity; 4) site vegetation; 5) site survey / soils analysis; 6) zoning parameters; 7) flood plain analysis; 8) pedestrian circulation; 9) vehicular circulation; 10) service circulation; 11) vibration analysis; 12) view analysis; 13) site configuration; 14) sun orientation / climate; 15) prevailing wind / future building exhaust; 16) site context – axis; 17) site context – open space; 18) site context – form and materials; 19) environmental impact analysis; 20) historical and cultural conditions; 21) site malfunctions analysis, and 22) site assets and potential. In an effort to implement the master planning as efficiently as possible, an interactive design workshop is documented. This interactive design workshop process was initially developed for use in master planning the U.S. Environmental Protection Agency campuses at their 17 sites across the United States.

The U.S. Green Building Council (USGBC) developed The Leadership in Energy and Environmental Design (LEED™) sustainable design rating system. They released their LEED™ 2.0 information in May of 2000. This system helps organize the information about sustainable opportunities for sustainable site and building designs. The LEED™ system provides for certification of sustainable facilities for organizations that want to demonstrate the level of commitment to a sustainable building approach. The sustainable design approach has been adopted by numerous governmental agencies as well as private organizations. This information provides a good basis to organize the sustainable master planning process.

This paper intends to improve the energy and sustainability performance of science parks, provide for higher quality indoor environments (i.e. with natural daylighting) of future buildings, improve the environmental quality of science parks, improve science park relationships to their surrounding environment, provide a process for conservation of construction resources and protect the environment.

I. LEED™ Rating System and Sustainable Design Team Selection

A. LEED™ Rating System

A good measure of sustainable architectural, engineering, interior design, and landscape concepts is the LEED™, Reference Guide, Version 2.1, November 2002. This information is an assessment system but can also be used as a comprehensive guide for the complete process of planning and designing sustainable facilities. Other issues of master planning and interactive design process not addressed by this reference guide will be the focus of this paper.

The USGBC developed the LEED™ sustainable rating system in 2000. The LEED system has been used in many of projects during its developmental. Several local and federal agencies use this document to develop sustainable projects. Various levels of certification document the level of sustainability. The suite of LEED documents is being steadily expanded to include specific documents for Interiors work and eventually Whole communities.

The LEED™ rating system certification levels:	
LEED™ Certified	26-32 Points
LEED™ Certified Silver	33-38 Points
LEED™ Certified Gold	39-51 Points
LEED™ Certified Platinum	50+ Points

The LEED™ credits and points:		
Section	Credits	Possible Points
Sustainable Sites	7	14
Water Efficiency	3	5
Energy and Atmosphere	6	17
Materials and Resources	7	13
Indoor Environmental Quality	8	15
Innovation and Design Process	2	6
Total	33	69

Sustainable Opportunities Overview:

This LEED certification information can be seen as a list of sustainable opportunities. This list is a checklist that can be used to set goals and objectives before beginning the master planning process. For the full LEED system criteria see www.leedbuilding.org. By reviewing the list at the beginning of the project, the team members get a full understanding of the opportunities and start the consensus building process between each other. An action list with status information and task due dates can be used as a communication tool between team members.

Important sustainable factors in the master planning of research facilities are the following: 1) selection of the sustainable master planning design team; 2) setting sustainable goals; 3) implementing the sustainable site selection process; 4) conducting the site analysis; 5) investigating the sustainable master planning issues; 6) implementing the interactive sustainable master planning design process; 7) defining the orientation of buildings for passive energy savings; 8) work with the engineers to refine building form options to passively save energy; 9) work with the engineers to define potential intake and exhaust concepts; 10) consider rain water retention options; 11) consider environmental psychology principles to promote researcher interaction; 12) evaluation of the master sustainable options; 12) refinement of the sustainable master plan, and 13) development of the process for achieving the final sustainable master plan.

B. Selection of the Sustainable Design Team

Options for selecting the design team: 1) request for qualifications (RFQ) from design professionals; 2) training your existing design professionals about sustainable research master planning; 3) securing professional services to help put a sustainable design team together, and 4) securing a consultant experienced in sustainable research master planning to work with your existing team.

Qualities to look for in consultants and team members: 1) experience in sustainable design of sustainable research facility master planning; 2) experience in sustainable research facilities; 3) experience in interactive design sessions that builds consensus among researchers; 4) site analysis experience; 5) energy analysis and modeling capability, and 6) sustainable landscaping and civil engineering experience. To achieve a proper Integrated Design approach, the team must also include members that will be used later in the building design process such as: 1) architectural and interior designers experienced in sustainable research facilities; 2) specialty lighting consultants; 3) HVAC sustainable design engineering consultants; 4) special sustainable design consultant; 5) cost consultant with experience in sustainable buildings, and 6) specialty engineering consultants with sustainable experience. It is also interesting at this stage to gain some appreciation of how deep into the firms organization has the sustainable ethic penetrated; are their sustainability qualities a marketing exercise or is it a true design ethic of the firm and its designers.

Education of parts of the design team may be necessary if the team chosen does not have sustainable design experience. A training session on sustainable concepts is helpful to elevate the entire team to the same level of knowledge regarding sustainable options.

II. Sustainable Master Planning Design Considerations

A. Goal Setting

After the entire project team and Client representatives have agreed on the sustainable design approach, the team should define the extent of the sustainability that is desired for the project. Will the sustainable concepts include the site selection process? Will the project try to achieve a certain level of LEED™ rating for the site and project? Will special consultants need to be added to the team to achieve the goals set forth by the project team? What funds are available to achieve the sustainable and other project goals? Can some of the sustainability design features be financed from ongoing maintenance and energy cost savings? Are the probable construction costs still within the budget?

The following are simple guidelines:
1) Establish scope of sustainable master planning effort.
2) Define the goals of the sustainable master planning effort.
3) Identify any new sustainable consultants needed for the master planning effort.
4) Verify the scope of the sustainable design options.

B. Implementing the Sustainable Site Selection Process

Start to evaluate the sustainable site selection options if the site selection process is within the scope of the project. Below are descriptions of the basic site options:
1) Environmentally contaminated site
2) Urban site
3) Undeveloped site

Environmentally Contaminated Site

Develop sites that have been identified as environmentally contaminated sites. Develop strategies to remove, resolve, or encapsulate pollution as per U.S. Environmental Protection Agency (USEPA) and other federal, state, and local laws.
1) Review local, state, and federal laws regarding hazardous waste.
2) Define options to remove or resolve pollution.
3) Investigate environmental impact statement requirements and schedules.
4) Investigate costs and schedules involved with pollution resolution.
5) Investigate political and legal parameters related to pollution resolution.
6) Contact U.S. EPA and other government agencies to define planning parameters.
7) Contact specialty land planning firms experienced in Brownfield site work for further requirements.
8) Review site analysis parameters below for either urban or undeveloped sites

Urban Site

Try to use previously developed urban sites for the proposed development, especially ones with structures that can be renovated for the proposed program. This reuse of sites and buildings will preserve undeveloped green space, conserve materials needed for construction, and reduce landfill demand.

1) Investigate sites that use existing infrastructure.
2) Analyze transportation considerations related to the location of the employee's existing housing locations, thereby reducing relocation and transportation costs.
3) Conduct a study as to define the environmental impact of your facility on the surrounding infrastructure.
4) Study the contextual relationship with your proposed development and the surrounding environment.
5) Analyze pedestrian, vehicular, and service circulation on the site development and the community development.
6) Analyze vibration, noise, microwave patterns on site, radio frequency interference, construction activity, air-born particulate, and electrical field parameters related to the site verses the science proposed on the site. Air born particulate, often from smoke stacks, can be very difficult to resolve in sciences or processes that require very clean air quality. (Note: Test vibration when it will be at its maximum level of interference, which is often times during the wettest season.)
7) Review site analysis parameters below.

<u>Undeveloped Site</u>

The use of an undeveloped site should be avoided as much as possible. If this type of site is to be developed, care should be taken with specific attention to preserving the natural vegetation, reducing storm water runoff, protecting species that exist on site and reducing site disturbance. The applicable parameters identified in the Urban and Contaminated sites previously identified should also be analyzed.
1) Protect existing wildlife, especially endangered species.
2) Protect existing wildlife habitat.
3) Analyze existing topography and hydrology.
4) Reduce site disturbance.
5) Reduce storm water runoff.
6) Review site analysis parameters below.

C. Conducting the Site Analysis

1) Site slope / topography analysis
2) Site hydrology
3) Utility location / availability / capacity
4) Existing site vegetation
5) Site survey / soils analysis
6) Zoning parameters
7) Easements and deed restrictions
8) Flood plain analysis
9) Pedestrian, vehicular, and service circulation
10) Vibration analysis
11) View analysis
12) Site configuration
13) Sun orientation / climate
14) Prevailing winds
15) Site axis, open space, form, and materials
16) Environmental conditions
17) Historical or cultural conditions
18) Site malfunctions analysis
19) Site assets and potential

[Haxton, 1998]

D. Investigating the Sustainable Master Planning Issues

<u>Site Planning Overview</u>

If an undeveloped site is selected, as opposed to using an existing site, care should be taken to select a site that will promote passive sustainable design opportunities as well as promote positive master planning principles. Consider the following parameters when selecting a site:

1) Does the shape of the site promote energy efficient facilities on site? In southern climates the passive building will have its long axis in the east-west direction to reduce east-west solar heat gain and facilitate daylighting of the interior spaces.
2) Consider topographic features to promote passive retention of storm water.
3) Promote a building form that has more than one story if possible. Soil bearing capacities will indicate building height and foundation complexity. A form should be selected that meets the functional needs of the project and is compact as possible to reduce mechanical distribution requirements. Reduce the extent of the roof area to reduce the roof heat gain load. Evaluate the building form roof regarding mechanical equipment and systems. What are the anticipated photovoltaic and solar collectors requirements if any?
4) In the case of evaluating science park layouts, consider the future orientation, shape and size of the potential buildings and their related sites.
5) Can existing vegetation be used in a passive way to reduce solar heat gain?
6) Evaluate building massing and its influence on air intakes and exhaust locations.
Note: Review the article in Research Park Forum, December 1999 / January 2000, *The Right Design Features Can Improve Science Parks.*

Site Planning Issues

Solar Orientation
Work with the climate. Reduce solar heat gain (in warm climates) or increase it in colder climates and promoting natural daylighting by orienting the facility main axis in the east–west direction. This orientation reduces the east and west facility exposures that are difficult to control. This orientation permits natural daylighting through the south and north facades. Be very careful of glare from low angle direct sunlight. The use of both vertical and horizontal sun shading devices reduces the direct sunlight that would normally shine on the wall and glass surfaces. Computer analysis is usually used to define the optimal sun-shading device to be used. The light shelves that direct light into the building also need to be designed to obtain the optimal shape and angle needed to bounce the sunlight indirectly into the facility for natural daylighting.

1) Define functional shapes that satisfy the program requirements.
2) Discuss if natural daylighting is a sustainable feature to be incorporated into the building.
3) Conduct computer modeling of glazing and sun-shading devices.
4) Conduct research into any glazing regarding the performance characteristics verses heat gain objectives.
5) Conduct special studies into glazing in the east and west façade walls.
6) Investigate wall strategies to reduce heat gain in the east and west walls (denser materials, mechanical rooms, unoccupied rooms, and rainwater storage units all reduce heat gain into the building).
7) Assess the quality of the space – often it may be advantageous to allow the introduction of some direct sunlight into some areas to provide visual contrast, movement and relief.

Use Natural Wind Patterns
Use of natural wind patterns for ventilation.
1) Analyze wind patterns on site.
2) Design site and building features to use natural breezes.
3) Promote venturi effect with building forms.
4) Promote “stacking effect” of warm air to promote natural ventilation.
5) Potential use of thermal siphon (possibly solar powered) to promote natural ventilation.

Management of Storm Water Runoff

Implement a storm-water management plan. Design the site for no increase in storm-water runoff. Promote designs with storm-water treatment removing a majority of the suspended solids and phosphorous as per EPA standards.

1) Reduce impervious surfaces on site.
2) Provide for storm-water holding areas.
3) Store rainwater from roof areas for future use. Use rainwater for landscape irrigation.
4) Provide indigenous plant material in strategic areas to slow the rate of storm-water runoff.

Water Efficient Designs

Water efficient designs include reduction in water use, treating wastewater on site, and efficient watering for landscape.

1) Use water harvesting and gray-water systems.
2) Reuse of water in equipment.
3) Potential for use of low flow plumbing fixtures.
4) HVAC systems cooling towers use large amounts of water.

Use Existing Vegetation for Shading

The use of vegetation for shading the building is an effective way to reduce heat gain. Deciduous trees used on the southern façade of a building in a cold climate provide shade in the summer months and permits heat gain during the winter months. The following should be investigated for applicability to your specific project.

1) Investigate the use of trellis devices with vegetation to reduce heat gain.
2) Investigate the use of landscape that provides shading of the building to reduce heat gain during the summer months and promote heat gain during the winter months.
3) Vines that are allowed to grow on a building maybe an effective sunshade device to reduce heat gain to an exterior wall.

Engineering Sustainable Site Considerations

The civil and services engineering and architectural team should communicate early in the master planning process to define the optimum solutions for each specific site. The geographic / climate of the site will influence the building's form orientation and shape. It is also important that civil engineering and the landscape architects to provide their input so that the building and site are designed as passively as possible. This reduces cost and total energy consumption. How much storm water retention is needed and where? Can indigenous plants be used to absorb water into the ground to reduce or eliminate water run-off from the site? Can natural wind patterns be used to the benefit of the project?

Preserve Natural Site Features

The site will usually contain site features that are very unique to that particular site. Try to retain and feature these unique site natural elements. Unique landscape features also should be retained if at all possible. Water features part of the site should be integrated into the design solution if at all possible. Shorelines should be preserved and rehabilitated to their natural state as much as possible. Landforms that make a site unique should be integrated into the design solution.

Restore Degraded Habitat Areas, Increase Existing Habitat Areas, and Promote Species Diversity

Restore degraded habitat areas to their original state using native plant species. Investigate endangered species and their potential habitat needs. Attempt to bring back native species. Coordinate the native species concepts into the integrated design concept.

Reduction of Light Pollution
Keep outdoor lighting levels as low as possible while still providing safe and functional site lighting. Think about consolidation of areas that require lighting during the early stages of the master planning process. Consider the ultimate lighting solutions to reduce light pollution. Rather than "flood lighting" areas, develop lighting concepts based on contrast, destinations and reduction of disability glare.

Facility Issues

Building Reuse
Sites and buildings should be investigated for their ability to be reused and renovated. The reuse of existing buildings has the potential to conserve building resources, recycle building products, and reduce landfill demands. With regard to laboratory space; laboratory planning modules that are efficient usually help provide buildings that are efficient. The existing structure needs to be analyzed not only for its ability to meet the program requirements, but also the functional modular planning requirements. The existing structures need to be analyzed for the vibration, structural requirements, HVAC requirements, plumbing requirements, electromagnetic requirements, and any other unique program requirements. Investigate the financial and schedule impact of the renovation.

Promote Energy Conservation Building Forms
With an integrated design approach, the form of the building should attempt to reduce roof areas, to reduce heat gain through the roof. Analysis can be performed to the roof area verses the volume to define the optimal form from a heat gain perspective. There are trade-offs since the site soil may be poor and not easily support the more vertical solutions. The three level research facility solution might be a form to investigate related to both energy conservation and structure solutions given certain soils types. Another reason to promote a compact building form is to reduce the extent of the mechanical ductwork runs.

Engineering Building Considerations
Special care should be given to coordinating engineering and architectural options during the early conceptual phase of the building design phase. The engineering expertise should assess the comfort performance of each functional area and may dramatically influence the passive design aspects and form of the building. With this up front level of expert advise, the architecture will be more climatic responsive and true to its purpose.

In some cases storm water storage elements and mechanical equipment rooms may be used to block solar heat gain. Storage or other low occupancy spaces may also be used to reduce the solar heat gain into the building.

The use of an interstitial design option might be investigated early in the conceptual building design phase to evaluate first cost, schedule, project requirements, and life-cycle costs. It has been found that often the savings of building the mechanical system on an interstitial floor can offset the additional costs of the interstitial approach. The interstitial approach might be much less costly to renovate during the life of the building and provide for less costly maintenance. The use of modular systems that allow easy renovation with minimal waste should be considered.

Select Local Materials with Low Embodied Energy
In master planning the product selection is not the primary decision making; however, very basic thoughts about materials should begin to form. Make decisions that consider local materials with

low embodied energy. Embodied energy is the energy that it took to produce and deliver the product to the site.

III. Interactive Master Planning Approach

The following is a master planning process that helps to build consensus for the master plan since the participants are active members in the design process. The tasks 1 through 7 occur before the interactive design session. Tasks 8 through 10 are in preparation for the interactive design session. Tasks 11 through 22 occur in the interactive design session. Tasks 23 through 25 are completed off-site and represent the documentation portion of the process.

1. **Request for Qualifications (RFQ)**

Request qualifications from design professionals for the project.

2. **Identify qualified firms**

Define the "long list" of potential teams.

3. **Define short list**

Develop a short list of firms of teams to interview.

4. **Interview potential teams**

Design teams should provide proposals for the development of the project. The personal presentations of the team qualifications will help to determine synergy of the client / design team.

5. **Select design team**

Usually the firm will use a single team to complete both the master planning and the facility design.

6. **Finalize contract**

Finalize the contract with the design team and any special consultants.

7. **Define the program**

Prepare for the master planning (some preliminary thoughts about the programming for the master plan should be discussed before meeting with the design team). If a program does not exist, a programming phase may be needed before the master planning. On large projects, a separate programming effort is suggested for smaller projects, the programming (or program verification) can be part of the master planning process. The new design team should complete a program verification phase if the design team has not completed the programming.

8. **Prepare for the Master Planning Interactive Design Sessions**

This preparation usually consists of obtaining existing site plans, utility plans, electrical plans, natural gas plans, sewer plans, storm sewer plans, water plans, flood plain plans telecommunications plans, soils information, infrastructure information (flow rates and capacity), zoning parameters, easements, deed restrictions, topographic information, site hydrology, site survey, soils analysis, vibration information (if vibration is a critical factor), climate information, historic / cultural information, and current plans of existing facilities. Special information unique to the site may also be needed.

9. **Request for Aerial Photos**

To permit the design team to communicate with the researcher / administration team effectively the owner should provide aerial photos of the site, as determined by the architect. The photos are used to produce quick aerial sketches of the various schemes so the researcher / administrative team can fully understand the building massing concepts. Aerial photos are often taken at 1500 feet toward the potential "front" of the site.

10. **Design Team Prepares Graphics for the Interactive Design Session**

A format that uses 11" x 17" paper has worked well since the information can be quickly be reduced to an 8 ½" x 11" booklet. The following information is placed into the 11" x17" format: existing facility floor plans (current use, facility condition, program use), site plan, topographic information, vegetation information, utility information (electrical, natural gas, water, sewer, communication, etc.), historic information, vehicle circulation, pedestrian circulation, service circulation, site hydrology, malfunctions analysis, and site assets analysis. Alternatively, an electronic projection of overlayed information projected onto a white board allows significant input by all (changes can be sketched on the white board as a change/development to the projection) and the results recorded with a digital camera – very sustainable in reducing paper consumption.

11. **Meeting with the Project Director**

The design team meets with the facility director and gains his insight and approval of the interactive design process before the planning process begins.

12. **Project Team Briefing**

Design team goes to the site of the interactive design session (this should be at or near the site since the entire group should tour the site together to gain a collective experience of the current conditions on site). The design team leader briefs the interactive design group regarding the entire interactive design process.

13. **Project Team Tours Site/ Facility**

The entire design, researcher, management team tour the site and existing facilities. The program directors should lead the tour and describe the type of work being performed and the current malfunctions and assets.

14. **Design Team Documents the Site Malfunctions and Assets**.

During the tours the design team takes notes and photographs malfunctions and assets for use during the planning process and the documentation process.

15. **Project Team Develops Goals**

The project team including designers, researchers, and administrative personnel develops Program Goals, Site Goal, and Facility Goals.

16. **Sustainable Overview and Education**

Assuming that a sustainable master planning process is desired, the group is briefed on the sustainable principles and opportunities at this site. If the researcher / administrative personnel are unfamiliar with sustainable concepts an overview session of sustainable information should be presented.

17. **Define Sustainable Project Goals**

The project team will review the opportunities for sustainable master planning design and tentatively decide the extent of the options to be incorporated into the project. If the client team decides that a LEED ™ certification is to be developed for the project, a tentative listing of the potential LEED ™ certification points should be created.

18. **Site and Facility Analysis**

The design team presents the site and existing facility analysis including the site malfunctions analysis and the site assets and potential information. Designers identify optimal locations for building locations related to sustainable parameters.

19. **Concept Sketches**

The design team takes the information generated to date and develops between three to six concept sketches of the major building massing. Each scheme should have a site plan and an aerial view sketch of the site with the scheme design sketched in. The schemes are analyzed regarding the advantages and disadvantages of each. Sustainable concepts should be a part of the presentation of each scheme. The schemes are then evaluated to define how well they satisfy the program, site, facility, and sustainable goals established at the beginning of the process.

20. **Select The Scheme**

The project team discusses each scheme and selects the schemes with the most potential. If the choice is not clear, a scoring system of different weights for the program, site, facilities, and sustainable goals can help in the selection process.

The selection of the master plan can become difficult if two or more schemes are desired by different groups of researchers or administrators. The solution to the selection problem can be quickly resolved by weighting the program, site, facility, and sustainable goals. Each scheme can be scored as to how well it satisfies the goals. The multiplication of the weight times the score will yield a weighted score for each goal. When the goals for each scheme area are added together, the scheme scoring the highest usually is the scheme that is considered as the master plan scheme. In a democratic environment, the above analysis works well; however, the administration might be called upon to make the final decision.

21. **Master Plan Refinement**

When the final scheme has been selected, the scheme should be refined to include the researcher / administrative concerns and suggestions.

22. **Develop Phasing Information**

Once the final master plan is completed and agreed to by the entire master planning team, develop phase by phase plans that document the sequence of steps achieve the master plan.

23. **Develop Cost Per Phase**

As the master plan phasing plans are completed, the cost per phase can be calculated, thereby providing the budget and scheduling requirements to achieve the master plan.

24. **Prepare Draft Master Planning Documentation**

After the master plan is completed, the documentation is completed and will include the following: project overview, program information, existing condition plans, existing site plans, utility plans, site analysis, malfunctions analysis, site assets / potential, circulation analysis, malfunctions pictures / corrective action needed, preliminary schemes, advantages /disadvantages, scheme selection information, phasing information and cost per phase information.

25. **Prepare Final Master Plan Documentation**

The design team will review the draft master plan and suggest changes. Corrections are made to the draft master plan.

VI. Sustainable Master Planning Examples

Included in PowerPoint presentation.

V. Future Trends / Areas for Further Study

Trends in environmental master planning are as follows:

1) Greater reliance on computer usage to analyze different aspects of the master planning process.
2) Increased demand on the part of the public, government, and companies to use an environmental planning process.
3) Greater product selection related to environmental issues.
4) Increases in the number of design professionals becoming knowledgeable in environmental issues.

Areas for Further Study:

1) More information is needed regarding the “greenness” of products.
2) More information is needed regarding the cost effectiveness of environmental master planning concepts.
3) More Life Cycle Cost Analysis for the different environmental master planning concepts is needed.
4) More information is needed regarding life cycle cost analysis of environmental psychology issues.
5) More information is needed using artificial intelligence (AI) systems for analysis of environmental planning issues.

VI. Conclusion

By using passive design and sustainable master planning techniques for science parks, the designers and science park management will help to reduce first costs, conserve resources, and reduce life cycle costs while providing a higher quality research environment. By reducing waste and planning for conservation of materials the design team is improving the entire design and building user process.

The Outcomes – use less of the earth's resources, have a higher quality, more research productive facility and have more money to devote to the core business of Research.

VII. References

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