Chapter 2:
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LANL

Chapter 2

Whole-Building Design

Creating a Sustainable Building requires a well-thought-out, participatory process.

Whole-Building Design – the What and How

Sustainable design can most easily be achieved through a *whole-building design* process.

The whole-building design process is a multi-disciplinary strategy that effectively integrates all aspects of site development, building design, construction, and operations and maintenance to minimize resource consumption and environmental impacts. Think of all the pieces of a building design as a single system, from the onset of the conceptual design through completion of the commissioning process. An integrated design can save money in energy and operating costs, cut down on expensive repairs over the lifetime of the building, and reduce the building's total environmental impact.

Process is key. Ensuring that a LANL building will be designed and built in a manner that minimizes environmental impacts while maximizing employee health and productivity should begin with *process* – how you will go about planning, designing, and building it.

Sustainable design is most effective when applied at the earliest stages of a design. This philosophy of creating a good building must be maintained throughout design and construction.

The first steps for a sustainable and high-performance building design include:

- Creating a vision for the project and setting design performance goals.
- Forming a strong, all-inclusive project team.
- Outlining important first steps to take in achieving a sustainable design.
- Realizing sustainable design within the LANL established design process.

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Since this photo of LANL was taken in 1956, the campus has expanded to occupy more than 2,000 buildings on 43 square miles of land.

Articulating and Communicating a Vision

Functional, Operational, and Performance Requirements

A successful building begins with a vision outlining the proposed building function and anticipated long-term uses. A vision for sustainability must also be developed and incorporated into the Functional and Operational Requirement (F&OR) and request for proposal (RFP) documents.

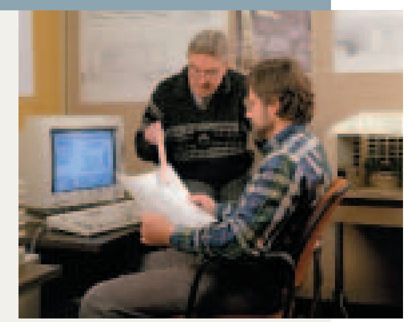
An integrated RFP ensures that energy efficiency and sustainability will be important components of the design process. The selected design-build or design-bid-build contractor begins the conceptual design according to specifications stated in the RFP and assembles an integrated team to carry out the vision.

Central and Southwest Services

A design team discusses a proposed building project. Communication between team members early in the design process increases the opportunities for incorporating sustainable design strategies in the building project.

It is important to create a measurable vision for sustainable building projects. The vision will be a guiding component in the RFP used to solicit the project team. A vision might be to design, construct, and commission a building that achieves a certain U.S. Green Building Council Leadership in Energy & Environmental Design™ (LEED™) rating, obtains New Mexico Green Zia Environmental Excellence Program Recognition, complies with guidance given by the Laboratories for the 21st Century Program, or costs less to operate than similar LANL buildings.

Why require building simulation models in the RFP?



Berkely National Laboratory

During the building design phase, the team must ensure that the sustainable design strategies are integrated holistically into the building design. Effectively integrating the building envelope and systems can only be accomplished by relying on building energy simulation tools to guide design decisions. Simulation results provide insight into how the building is expected to perform. Therefore, it is recommended that the RFP states that the contracted project team is required to use computer simulations throughout the design process.

Paul Torcellini

Constant communication between team members during the entire design and construction process ensures that the building's sustainable design goals will be met.

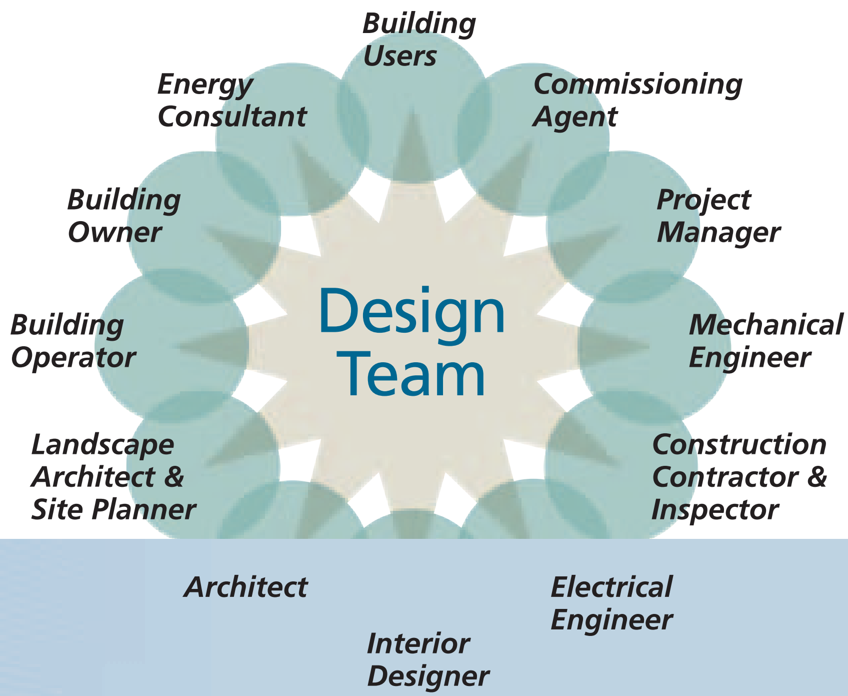
Creating an Integrated Project Team

The key to achieving a sustainable building is to assemble a project team with both the experience and the desire to employ a systematic, integrated design. It is important to take a team-oriented, multi-disciplinary approach in which all members of the project team recognize and commit to the steps and actions necessary to achieve the project vision.

Assemble the project team very early in the design process. The project team comprises contracted experts as well as the LANL project team, including project managers, building owners and/or tenants, energy consultants, inspectors, and facility managers.

The entire project team collaborates to translate the initial project vision into specific design goals. Giving all those who can influence building design an opportunity to develop the design goals will ensure that issues such as life-safety, security, initial budgets, and code compliance are balanced with the energy-efficiency and sustainability features. The goals often reflect the current state-of-the-art of building design.

The LANL project team must agree with the vision that has been established for the project. Input and agreement from everyone is important at this early stage, for it sets the framework for future project success. The team also must be committed to meeting the performance goals they set for the project.



Developing Project Goals

The project team refines the articulated project vision into a set of specific goals and initial design concepts. These goals ensure that the building meets program needs, is cost-effective to operate and maintain, and provides a superior environment to maximize employee productivity.

A "design charrette" is a useful tool for communicating the project vision to members of the project team, brainstorming design goals and specific conceptual solutions to meet these goals, and beginning to incorporate sustainability into the planning and execution phases. The design charrette occurs between the planning and conceptual design phases of the LANL project development process. Conduct a second charrette as soon as an architect is selected. (Criteria for selecting a firm include a requirement that the firm's design proposals demonstrate a commitment to and a vision for sustainability.)

Sample Goals:

- Provide a design that will achieve a 50% reduction in energy use compared to an ASHRAE 90.1-compliant building.
- Provide daylighting to offset electrical lighting loads wherever possible (includes lighting controls).
- Obtain a LEED-Silver rating for the building.
- Design a building that costs the same (or no more than 5% greater) than a conventional building without sustainable features.
- Create a healthy indoor environment that will result in reduced absenteeism while boosting productivity.
- Follow a maintenance plan to ensure efficient operations, including energy management and waste recovery (recycling).
- Follow sustainable construction processes as outlined in Chapter 8.

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A LANL project team engages in a design charrette.

Design and Execution Phases

Discussions at the conceptual design phase extend beyond design and construction to include a process for ensuring that the building operates as designed and that occupant work environment goals are satisfied. Commissioning is a process for achieving, verifying, and documenting that the performance of a building and its various systems meet the design intent and the owner's requirements. The process ideally extends through all phases of a project, from concept to occupancy and operation (see Chapter 9). Plans for commissioning activities and budget are developed during the conceptual design phase.

Also during the conceptual design phase, the project team plans a means for monitoring the building performance. Monitoring performance helps operators quickly identify when the building is not performing as expected, and verify that the building design vision and goals are met. Satisfied occupants are likely to be healthier, more productive, and more creative, so it is of utmost importance to ensure that the building is meeting the users' needs. Conduct post-occupancy surveys to collect information for improving occupant

Paul Torcellini

Design team members confer on strategies for meeting the building performance goals.

Just What is a Design Charrette?

The team "Charrette" is widely used today to refer to an intensive workshop in which various stakeholders and experts are brought together to address a particular design issue. The term comes to us from the French word for "cart." French architecture schools used a cart to collect final studio presentations. As with most students, they often weren't quite finished and would continue working their presentations on the cart as the presentations were collected. The "charrette" became an intense time for putting ideas on paper. Often, the charrette process happens early in the design phase of building projects. Ideas are exchanged, goals established, and consensus is built among those involved with the design process.

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Design charrettes are a good mechanism to start the communication process among the project team, building users, and project management staff. A facilitated discussion allows the team to brainstorm solutions meeting the building user's requests and the sustainability vision for the building design. By the time the charrette concludes, the participants should have identified performance goals in the context of validating the program needs. The result of design charrettes is the foundation for good communication among project team members and the development of unified goals for everyone to work toward.

satisfaction, if necessary, and to document design strategies that should (or should not) be replicated in future LANL buildings.

By the time the preliminary design is completed, the project team membership has grown to include the contracted architectural/engineering or design/build firm. It is important to conduct a second design charrette at this point to include the entire project team. Input from the expanded project team solidifies space and functional requirements, proposes solutions to code issues, identifies all safety and security needs, and sets clear energy goals.

Designing buildings to maximize the potential for good indoor environmental quality (IEQ) often leads to the same solutions for designs that maximize building energy performance. Indoor environmental quality represents the overall condition of the interior space. Factors affecting IEQ include space temperatures, lighting levels, relative humidity levels, noise levels, odor levels, ventilation air rates, perceivable air movement, color contrast, and any other factor that affects human comfort. Using the whole-building design approach, energy-efficiency and passive-solar design strategies can often improve IEQ, if they are incorporated properly into the building design. It is important to consider both the building's energy performance and IEQ when evaluating incorporation of design solutions into the whole-building design.

Warren Gretz

Interior of the Solar Energy Research Facility at the National Renewable Energy Laboratory in Golden, Colorado.

Caution

If whole-building and passive-solar design strategies are not properly incorporated into the building design, they can adversely affect the building's IEQ. For example,

- A daylighting system is ineffective if inadequate light levels are provided to meet the occupants' needs or if glare is a problem on the work surfaces.
- An improperly designed natural ventilation cooling system could introduce outdoor contaminants to the indoor space or pose a security risk.

Decision-Making Process

All phases of design – from the earliest goal setting through final design and creation of construction documents – involve making decisions. Of critical importance is knowing when to make which decisions. If certain decisions are not made during the planning phases, the project team will have to expend time and money later in the process correcting conflicting design decisions, or the project will be deemed to be unsuccessful for not achieving the stated goals. In design and construction, it is always quicker, easier, and cheaper to change things on paper than in steel or concrete. One of the standard adages of the built environment is, "There is never enough time or money to do it right the first time, but always enough to correct the problem when it is detected or to pay for the added costs of energy, maintenance, and repair over the life of the building." A requirement for *cost-effective,* sustainable design is to do the right thing at the right time the first time.

While conventional economic tools have a place in evaluating sustainability features, do not be limited to such analysis. Many costs and associated benefits are not easy to predict or quantify. Energy benefits of sustainable design are relatively easy to measure; many other

Warren Gretz

Decision making is a team effort.

Balancing sustainability with financial constraints

An overriding consideration in decision-making during building design is the "cost-effectiveness" of features. Typically, an economic ranking is applied for prioritizing strategies in a building design that save energy. Traditional economic methods for evaluating criteria are first cost, simple payback, life-cycle cost, or one of the following cash flow analysis methods: discounted payback, discounted cash flow, net benefits or savings, savings-to-investment ratio, or return-on-investment.

Because it is rarely possible to vary the first cost with LANL projects – even if doing so would make good long-term economic sense – this sort of economic analysis is generally limited to evaluation of specific features being considered within an overall design package. For example, eliminating a stormwater detention pond and storm sewers by using a more sustainable strategy of infiltrating stormwater on-site (see Chapter 7) saves a lot of money. The savings can be applied to other aspects of the project to avoid exceeding the overall budget.

benefits are much less quantifiable, so are not well suited to economic analysis. The LANL and contracted project team members need to understand all the obvious and subtle values that will affect decisions about whether or not to include various design strategies. Once these values are understood, the project team can creatively respond to supporting them in producing a sustainable building.

When Values Affect Building Design

LANL strives to apply the best science and technology to make the world a better and safer place. It is important that the LANL facilities provide a comfortable, productive working environment to attract and retain the highest caliber people to achieve this mission. Corporate image, productivity, creativity, health, and environmental quality are examples of values placed on new building projects that can attract and retain LANL employees, while providing superior service to the client, the U.S. Department of Energy and the American public.

Consider the time and money expended to make a new building architecturally pleasing, both outside and inside. In many cases, architectural decisions are not questioned and do not undergo the scrutiny of economic analysis, because achieving an aesthetically appealing design is considered very important. Ideally, values such as optimal energy performance and minimal environmental impact should be equally weighted with the desire for an architecturally appealing building. When this is done, architectural decisions serve a dual role – they achieve an artful building design, and they make a building more sustainable. For example, window overhangs can give a building a unique look as well as reduce summer cooling loads. The project team should collaborate to make the building form enhance the building performance.

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The architectural facade recesses surrounding the south-facing windows also serve as window overhangs to shade the windows and minimize direct solar gains. Placing the windows at the top of these recesses further enhances the effectiveness of these overhangs.

Often, architecture from the past demonstrates how to effectively integrate form and function. The Old Pension Building in Washington, D.C., (now the National Building Museum) is a classic example. The atrium was designed to give the building a certain feel, but it also was strategically designed to provide light and ventilation to the building's entire interior. The height and size of the openings between the atrium and the interior spaces provided essential qualities to the building, including a healthy and comfortable environment. This building was constructed in the 1800s, long before electric lighting and central air-conditioning systems were introduced. The design maximizes the use of daylighting and promotes natural ventilation throughout the building to help occupants stay comfortable during the hot Washington summers. Many of the strategies that were design necessities in times gone by, such as daylighting and natural ventilation cooling, are again being integrated into building envelopes to create low-energy, sustainable buildings for the future.


Maxwell Mackensie


Houchlander Davis Photography

When the old Pension Building (now the National Building Museum) in Washington, D.C., was constructed, the occupants relied on daylighting and natural ventilation for lighting and comfort. These and other sustainable building design features were nearly forgotten when electric lighting and central cooling systems became available.

Writing Sustainable F&OR Documents

In the whole-building design process, a well-written F&OR document is the first concrete step toward achieving a sustainable building. The LANL project team first develops the initial vision for a building project. This process continues with the design charrette, in which the entire project team develops project design goals. The F&OR document is a refinement of those goals.

Typically, the F&OR document includes building requirements based on the site and type of building. Considerations in the selection of a particular site are planning and code requirements that must be followed; climatic, geologic, and topographic conditions that affect the building form; and safety and security issues. It is the project team's ingenuity that effectively melds these factors into a building design that satisfies the owner's criteria and the needs of the occupants.

The F&OR document addresses design elements that will establish the energy performance of the building. Differences in minimum ceiling heights, levels of illumination, temperature requirements, acceptable humidity ranges, air quality levels, ventilation needs, equipment types and operating schedules, building usage patterns, occupant densities, and occupancy schedules create opportunities for different strategies that could improve the overall performance of the building. Defining these differences and understanding their importance relative to established criteria enable the project team to select the best combination of design alternatives that will satisfy the owner and occupants.

Getty Images

Sample questions to ask in developing an F&OR document:

- Why is the building needed?
- What are the performance goals for the building?
- What are the first-cost or life-cycle cost issues?
- What process will be used to design and construct the building? Is a design/build or a design/bid/build process planned?
- Can the established design and construction process successfully meet the project goals? If not, what should be changed and how should it be changed?
- How will the project team verify that all design decisions will help meet the design goals? What design tools will be used (e.g., computer simulation tools for energy and daylighting)?
- How will the project team ensure that the building performs as it was designed (e.g., building commissioning, operation, and maintenance)?
- What safety and security issues must be considered?

By considering basic design criteria early in the design process, it is much easier to create a building that will meet all of its functional needs while ensuring health and safety of its occupants and minimizing energy consumption and negative environmental impacts.

F&OR Document Includes:

- ***Building Function:*** How is the building to be used? Define the uses that relate directly to why LANL needs the building. For example, will the building be an office building, a laboratory building, or a combination office/laboratory building? If laboratories are in the building, what kind of laboratories will they be?
- ***Ancillary Space Requirements:*** What other functions will the building house? Besides spaces to meet the primary needs of the building, most building requirements include circulation space, storage, and restrooms. LANL buildings may also require meeting spaces, break rooms, and other specialty-use spaces.
- ***Code Compliance:*** Even though this is a federal facility, LANL follows the 1997 New Mexico Building Code and the 1997 Uniform Building Code.
- ***Safety and Security:*** Identify all building-specific safety and security issues in the F&OR document to streamline integration of safety and security design solutions into the whole-building design. Addressing these issues later in the process may compromise the building's sustainable design strategies.
- ***Energy and Environmental Goals:*** Clearly state the energy and environmental goals of the project in the F&OR document.

Jim Schafer

The Cambria Office Building, which houses Pennsylvania's Department of Environmental Protection, is a high-performance office building that incorporates energy efficiency and renewable energy design strategies.

Corbis

Examine assumptions carefully

Good F&OR documents address all underlying assumptions. These assumptions need to be challenged and well documented. Conventional design assumptions applied to conditioning computer rooms is a good example of why this is true. Often, temperature limits established during the 1980s are still used today. However, current computer equipment can handle a much wider range of temperatures. The result is that space conditions in computer rooms no longer need to be as tightly controlled, which lowers the first-cost of space conditioning equipment and long-term operating costs.

Deciding on energy targets

The energy target is the easiest to quantify as a goal, but requires the most integration in the design process to achieve. For typical LANL buildings, the energy-performance target can readily be established from existing operating data (with whatever goal of reduction is assumed). If the building or occupancy type is unique, then an energy-performance target must be created from scratch. This target could be based on simulated energy performance of a conceptual building that is designed to typical local standards, that meets applicable energy codes, or that meets a national standard. The target should be based on the percentage reduction in energy consumption or cost of energy that was identified in the project goals.

Another consideration in establishing the energy-performance target is to determine the metrics (the method of measuring energy consumption) by which the design will be judged. Creating a theoretical base-case building that meets programmatic requirements with the ultimate goal defined with respect to minimum standards of Federal Regulation 10CFR434 (based on ASHRAE/IESNA Standard 90.1) is a common approach for federal buildings. A recommended goal for LANL office/laboratory buildings is 40 kBtu/ft^2/yr or less.

A tube of plans arrives at my office via an overnight delivery carrier. I usually stand them up behind my door waiting for the phone to ring. Everyone knows that overnight packages arrive by 10 am. Shortly thereafter the phone rings. "Hello." The voice on the other end of the phone says, "Did you get my plans?" "Yes – they are sitting right here." The voice continues, "We are going out to bid with these tomorrow and we need you to make this an energy-efficient building."

Energy efficiency is often an afterthought, not truly integrated into the building. In this example, it is too late in the process to make any significant changes that will improve the building's energy efficiency. It is never too early to think about energy efficiency and sustainable design.

– Paul Torcellini, Ph.D, PE, National Renewable Energy Laboratory

Specific Sustainable Elements of F&OR Documents

When creating the F&OR document, it is important to address specific solutions for integrating energy efficiency into the building design. At LANL, one of the most important of these will be daylighting. The F&OR document addresses how daylighting relates to such considerations as comfort and temperature constraints and occupancy patterns.

What is daylighting?

Daylighting uses sunlight to offset electrical lighting loads. Daylighting design provides the same or better quality light than electrical light equivalents with no glare or other distracting qualities.

Daylighting helps achieve the building's energy goals by reducing electrical loads – but only if it is properly harvested. Daylighting systems only realize energy savings if the electric lights are dimmed or turned off when sufficient daylighting is available.

Daylighting also can fit in with the goals of creating a healthy, productive space when focus is on optimizing the *quality* of the daylighting design, not just maximizing the *quantity* of daylighting. The design should provide even lighting levels throughout the workspace. High contrast (significant differences between the brightest and darkest areas in a particular area) can cause eyestrain to the occupants of that area. Consider the inherent brightness of surfaces (walls, ceilings, floors, and work surfaces) when deciding on ways to control daylighting through shading or glazing.

Daylighting

Daylighting is one of the best opportunities for reducing energy loads in LANL buildings. Solar irradiance measurements show that Los Alamos receives more than 75 percent of possible sunshine annually. (Possible sunshine is defined as the amount received when the sky is cloud-free, see Appendix B.) In daylit buildings, project teams carefully design the building envelope and consider characteristics of the fenestration to provide high-quality, natural lighting to the interior spaces. In the end, daylighting should substantially reduce electrical lighting loads and simultaneously reduce cooling loads.

Most spaces can be daylit, including offices, laboratories, conference rooms, corridors, and restrooms. Only those spaces that are completely or intermittently dark (e.g., laboratories for light-sensitive research, photography dark rooms, janitorial closets, or utility spaces) should not be daylit. The F&OR documents identify spaces that are not to be daylit and specify that daylighting should be considered in all other spaces. Chapters 4 and 5 discuss daylighting design in more detail.

Robb Williamson

Elements of whole-building design: operable windows for natural ventilation, daylighting, and reflective lighting in Pennsylvania's Department of Environmental Protection, Cambria Office Building.

Comfort and Temperature Constraints

According to ASHRAE Standard 55, it is acceptable for temperatures to vary in normal working spaces. Typically, the allowable range is between 68˚ and 78˚F, but most building operators maintain temperatures of 70˚ to 74˚F.

Specify space temperatures for electronic closets, server rooms, and other utility spaces according to the manufacturers' specifications of the equipment housed in those rooms. Tight temperature constraints lead to higher energy use (see Chapter 5).

Use temperature constraints in the F&OR document to calculate building loads and to size mechanical and electrical equipment. Spaces within buildings can typically be categorized into the following groups:

- ***Occupied spaces,*** or spaces in which people are working all the time (comply with the space comfort criteria described in ASHRAE Standard 55). Tightly control space temperatures in these spaces.
- ***Transitional spaces,*** such as corridors, entryways, and stairwells. Allow the space temperature to vary in these spaces.
- ***Unoccupied or sporadically occupied spaces,*** such as janitorial closets, computer closets, telephone switching rooms, and equipment rooms. These spaces can tolerate large temperature variations (depending on the equipment housed there). Note that computer closets were traditionally kept cool because older computer equipment could not tolerate varying space conditions; most modern computer equipment can withstand larger temperature swings.

Ed Hancock

The atrium at Oberlin College's Adam Joseph Lewis Environmental Center in Oberlin, Ohio.

Robb Williamson

An "outdoor room" saves space at the Zion National Park Visitor Center.

Occupancy Patterns

Understanding occupancy patterns of the various spaces in the building will help determine which spaces to daylight to minimize building energy loads. Daylight spaces that are occupied all the time and place sporadically occupied spaces in the building core where daylighting is not available. Equip sporadically occupied spaces with systems to turn off the lights when the space is not occupied, thereby reducing energy consumption. Note that spaces such as restrooms and corridors typically have high occupancy rates and can tolerate larger variations in temperature.

Ancillary spaces are often the easiest to integrate with the energy-efficient design. Conference and meeting areas can be designed to be daylit. An often overlooked goal is to provide a creative environment for people to think and work in. One method to address this need is to design small meeting alcoves to provide havens for people to think creatively about problems or hold informal meetings.

The Los Alamos climate provides an opportunity to create and use outdoor spaces where employees can work or hold meetings. This amenity can boost productivity and unleash creative energy. Examples of these "rooms" are transitional spaces, such as covered (protection from direct sun and rain) breezeways between buildings, and plazas or patios. An outdoor space can also be a covered extension of a cafeteria or conference room with tables and access to telephone and Local Area Network (LAN) ports to facilitate meetings and efficient work. The cost of creating these spaces is a fraction of building construction costs.

A merely code-compliant building is not an energy-efficient building. In fact, a code-compliant building is the worst building that can be built without breaking the law. An objective with sustainable design at LANL is to exceed the code, not just squeak by. The difference is mediocrity versus high-performance. A national laboratory should have high-performance buildings to create high-performance research from the world's best scientists and engineers.

LANL

This roof garden on the Otowi Building provides a quiet outdoor space for LANL staff to hold informal meetings. Examples of outdoor "rooms" are covered breezeways between buildings, cafeteria and conference room extensions, plazas and patios, preferably with access to telephones and LAN ports. It is important to consider accessibility when designing outdoor spaces.

Fitting Into the LANL Design Process

Several LANL documents detail requirements for design and construction processes. The guiding document is the *Laboratory Implementation Requirement (LIR) 220-03-01.* This LIR directs the Facilities and Waste Operations (FWO) division to publish and maintain the *LANL Engineering Manual* (LEM). Essentially, the LEM implements the LIR. The LEM, arranged by discipline-specific engineering requirements, provides site-specific engineering requirements and guidance for LANL facilities.

Two other documents support the guidance and requirements of the LEM: the *LANL Construction Specifications Manual* (LCSM) and the *Facility Drafting Manual.* The LCSM provides templates for preparation of project-specific construction specifications at LANL.

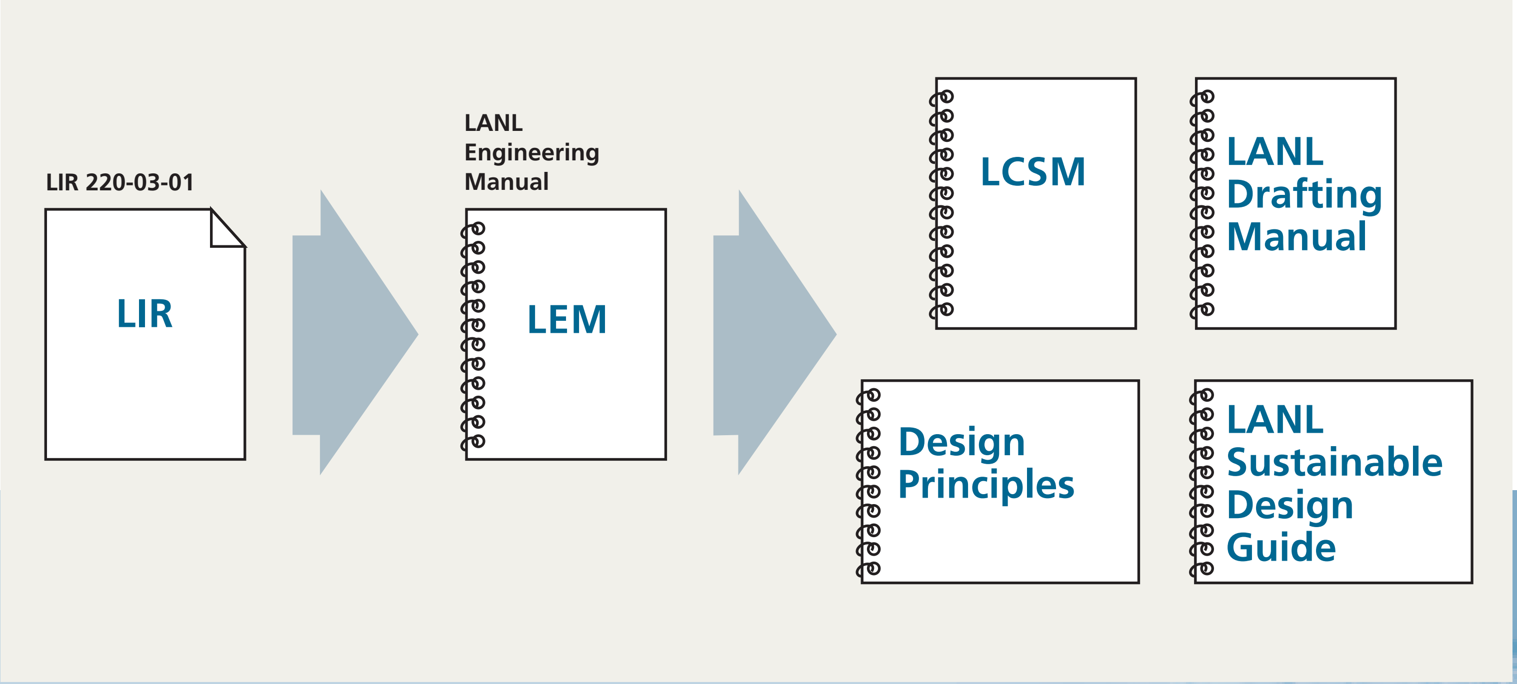
The *LANL Drafting Manual* provides drafting requirements for use when creating construction drawings. These documents are referenced throughout the LEM.

Two companion documents, the *Design Principles* and this *LANL Sustainable Design Guide,* are intended to augment the guidance and requirements provided in LIR, LEM, LCSM, and the *LANL Drafting Manual.* While not required documents, they present guidance and methods to help achieve LANL design and construction goals. Use these tools and methods to guide the integrated design process.

The LEM defines the regulatory basis and LANL requirements during the design stages. The LCSM is the basis for writing specifications that guide building construction.

The *LANL Sustainable Design Guide* and the *Design Principles* have applicability throughout the design and construction processes; LANL and A/E firm should use these resources as tools to assist in the following functions:

- Develop project vision and goals.
- Develop programming documents.
- Prepare and issue Request for Proposal.
- Evaluate site development plans for preparing the site for construction, treatment of the site during construction, and management of the site after construction with a sustainable landscaping and water management plan.



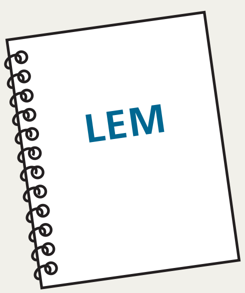
- Develop and evaluate design solutions.
- Evaluate site development plans before, during, and after construction.
- Develop commissioning and building operation plans.
- Evaluate and prepare change orders during construction.
- Educate the building operators on expected building performance and how to identify when the building is not performing as it should.

Without major changes, the whole-building sustainable design process can merge with the current LANL process for designing and constructing buildings. The only additions are to:

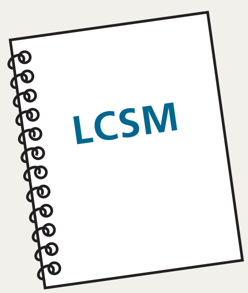
- Involve all LANL players (the project management team, the user, and the LANL decision makers) during the planning phases for all buildings, regardless of size.
- Foster strong communication links between members of the entire project team (e.g., architects, engineers, interior designers, landscape architects, planners, construction contractors, and commissioning agents) from the pre-conceptual phase through the execution phase.
- Follow up after the building is constructed and occupied to commission the building, survey the occupant's satisfaction with the building, and evaluate the building's actual performance to ensure that the original design goals are met.

The following chart recommends how to integrate the whole-building design process into the established LANL project development process. Note that elements of the whole-building design process appear throughout this chart, beginning with the planning phase and continuing through the operations phase.

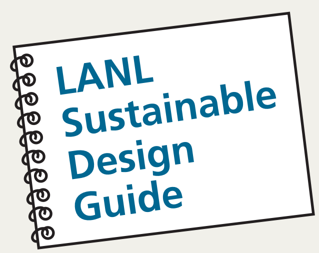
How LANL documents work together (Example: Integrated lighting)



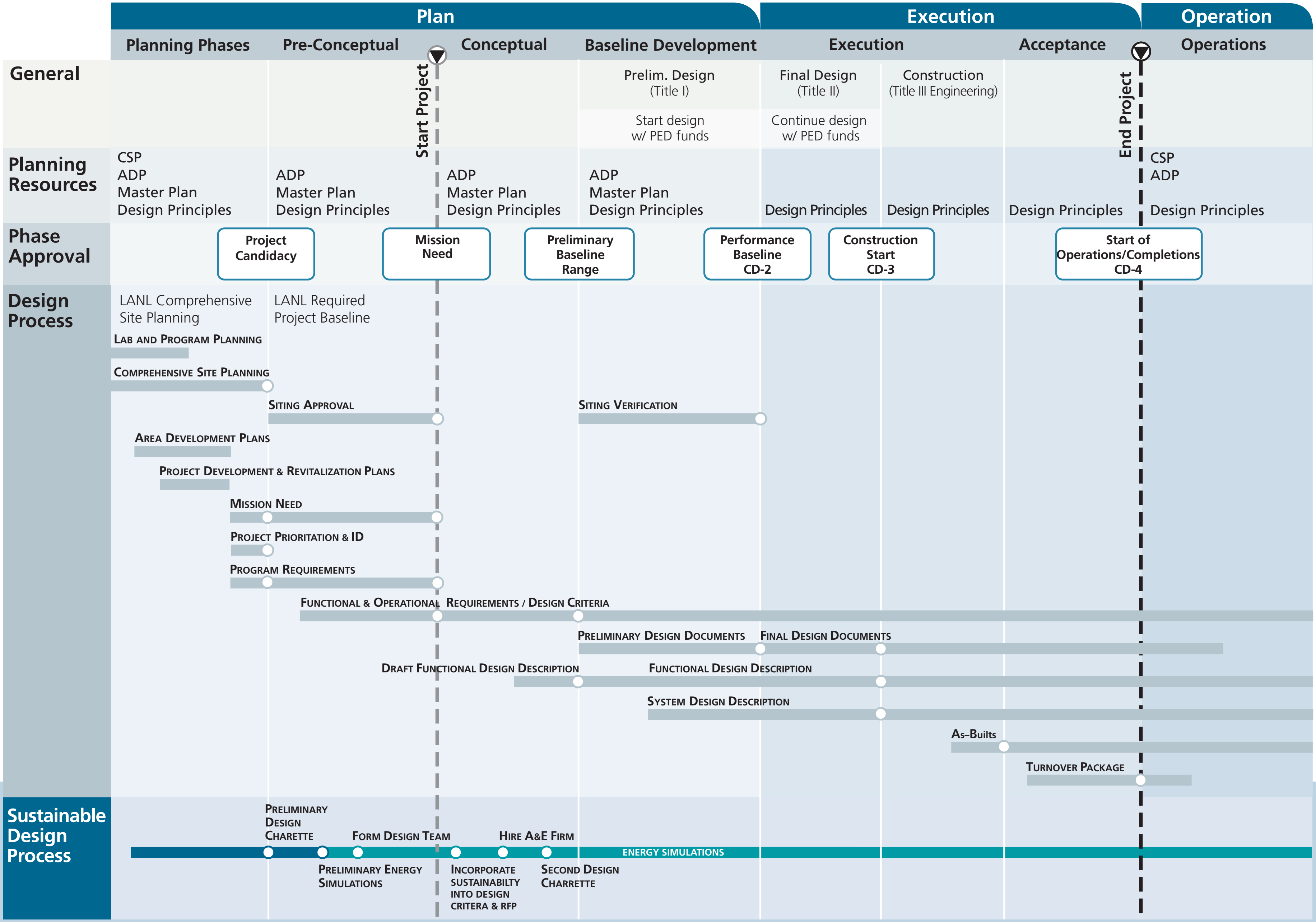
- Specifies interior lighting levels and states a preference for daylit areas and connection to the outdoors.



- Provides minimum requirements for window insulation and glazing type.
- Provides minimum requirements for electric lighting and controls.



- Recommends daylighting and presents strategies and design considerations for good daylighting design.



The project development process with the whole-building design process integrated into it (see page 6 of the Design Principles*).*

Up-front building and design costs may represent only a fraction of the building's life-cycle costs. When just 1% of a project's up-front costs are spent, up to 70% of its life cycle costs may already be committed; when 7% of project costs are spent, up to 85% of life-cycle costs have been committed.

– *Joseph Romm, Lean and Clean Management: How to Boost Profits and Productivity by Reducing Pollution (Kodansha International, 1994)*

Federal laws, Executive Orders, and Executive Memoranda direct federal government facility managers to reduce the energy and environmental impacts of the buildings they manage. In addition, DOE issues Orders that apply to DOE facilities. These laws and regulations require facility managers to be proactive in their efforts to reduce resource consumption, to reuse and recycle materials, and to dramatically reduce the impacts of federal government activities on the environment. More information about laws, orders, and regulations is provided in Appendix A.

Laws, Executive Orders, DOE Orders, and other Regulations all provide a facility manager with the foundation, justification, and mandate to conduct projects designed to improve the energy and environmental performance of their facilities.

- ***Laws*** are the will of the American people expressed through their elected representatives.
- ***Executive Orders*** are the President's directives to the agencies.
- ***DOE Orders*** are issued by DOE and apply only to DOE facilities.
- ***Regulations*** establish procedures and criteria by which decisions shall be made and actions carried out.

All LANL facilities must comply with the Code of Federal Regulations 10CFR434, "Energy Conservation Voluntary Performance Standards for New Buildings; Mandatory for Federal Buildings." This code establishes the minimum performance standards to be used in the design of new federal commercial and multifamily high-rise buildings. Federal buildings constructed to comply with but not do better than 10CFR434 are the least efficient buildings that can legally be constructed. Sustainable building performance should far exceed that of buildings constructed only to comply with 10CFR434.

DOE Order 430.2A, "Departmental Energy and Utilities Management," establishes requirements for incorporating sustainable design principles in new buildings of 10,000 gross square feet or larger. An energy-efficiency/sustainability design report is required for new buildings at the completion of Title II design. The minimum elements of the report are energy-efficiency compliance with 10CFR434, site responsiveness, water conservation, materials sensitivity, healthiness, and environmental releases.

Important Points to Consider

✓ **Project Vision and Design Goals**

- ☐ Complete site analysis to determine the minimum environmental impact.
- ☐ Use computer simulations to direct design decisions.
- ☐ Complete a base-case building analysis to understand design strategies that will have the greatest impact on the building design for the particular building function.
- ☐ Evaluate adjacencies for building functions and how the building interacts with the site.
- ☐ Evaluate use of renewable energy technologies and how they can be incorporated into the building design, either now or in the future.

✓ ***Schematic Design***

- ☐ Integrate the architectural design with the building's energy design. (The building's form should improve the building's performance.)
- ☐ Evaluate all building materials for environmental preference.
- ☐ Reduce building mechanical and electrical systems by incorporating passive solar technologies to help meet space loads and lighting loads. Use computer simulations to guide design decisions to achieve this strategy.
- ☐ Engineer building systems to ensure that their operation does not override benefits of the architectural design (e.g., electric lights should not operate when sufficient daylighting is available).

✓ ***Design Development***

- ☐ Re-evaluate all suggested design changes using computer simulations to ensure that the changes will not detract from meeting the building sustainability goals.

✓ ***Construction Documents***

- ☐ Write specifications clearly to eliminate confusion and on-site interpretation during construction
- ☐ Clearly depict high-performance design strategies in construction drawing details. Comprehensive details result in fewer errors from on-site interpretation of drawings during construction.
- ☐ If design changes are proposed during construction, use computer simulations to evaluate the impacts on building performance and to determine if the changes should be implemented.

✓ ***Occupancy***

- ☐ Commission all building systems prior to occupancy.

✓ ***Post-Occupancy***

- ☐ Check that all systems are operating as intended to meet sustainability goals.
- ☐ Educate building operators so they can ensure that the building continues to perform optimally.

Best Practices in high-performance building design

The worst building that can legally be built is one that just meets the requirements of 10CFR434. However, building minimally code-compliant buildings will not move LANL toward energy efficiency and sustainable design. Generally, buildings fall into one of three performance categories below:

Standard practice/code-compliant buildings: Buildings that meet the requirements of 10CFR434

Better performance buildings: Buildings with an energy cost reduction of 20%, compared to a base-case building meeting the requirements of 10CFR434

High performance for sustainability: Buildings with an energy cost reduction of greater than 50% compared to a base-case building meeting the requirements of 10CFR434.

Design teams create high-performance buildings by following "best practices." For example, applying performance path ASHRAE standards can result in a building that is 50% more efficient than a building designed to merely comply with the prescriptive ASHRAE standards.

	Standard Practice/	Better	High Performance
Selecting the Project Team	○ Sustainability vision not included in the RFP	○ Sustainability vision included in the RFP	○ Sustainability vision important part of the RFP
	○ Team initially consists only of the LANL project team, A/E firm joins the team after Title I and pre-design	○ Team consists of the LANL project team and the A/E firm	○ Better performance plus additional team members representing LANL, ES&H, O&M, and custodial personnel
	○ No goals set	○ Team sets design goals during the conceptual design phase	○ All team members involved in setting project design goals during conceptual design
Sustainable Design (SD) Report	○ Required as Title II submittal per DOE Order 430.2A	○ Specific requirements of SD Report detailed in the F&OR document and RFP	○ Submittals of SD report during Title I and II with final report due at end of Title III
Project Evaluation	○ No post occupancy evaluation conducted	○ Conduct a post-occupancy survey of occupant satisfaction	○ Conduct a post-occupancy survey of occupant satisfaction
	○ No monitoring of energy performance	○ Building level meter installed	○ Monitor building's energy performance to determine how well the project vision was met and for early detection of performance problems, including lighting, HVAC, and plug loads
Environmental Goals	○ No rating goals	○ LEED-certifiable	○ LEED Gold equivalent or higher

Table continues >>

	Standard Practice/	*Better*	*High Performance*
Daylighting	◯ None specified	◯ Identified as a possibility in 50% of the area of the building	◯ Identified as a possibility in 80% of the area of the building
Space Conditioning	◯ All spaces conditioned equally	◯ Broad categories of spaces are defined and conditioned separately	◯ Temperatures are specified on each space with broad tolerances for equipment rooms and hallways
Design/Build Contract Documents	◯ Sustainability goals not mentioned	◯ Documents mention that sustainability is a goal, but no specific objectives are included to support this goal	◯ Energy and environmental goals and objectives are clearly identified in contract documents
Energy Consultant	◯ None involved	◯ A member of the project team oversees sustainable design strategies in addition to his/her other duties	◯ Person contracted to provide energy simulations to help guide the envelope design. Environmental consultation for material selection.

References

Code of Federal Regulations 10CFR434, "Energy Conservation Voluntary Performance Standards for New Buildings; Mandatory for Federal Buildings," ***www.access.gpo.gov/nara/cfr/waisidx_02/10cfr434_02.html***

Construction Project Management (Implementing LIR), Laboratory Implementing Requirements LIR 220-01-01.4

DOE Order 430.2A, "Departmental Energy and Utilities Management," ***www.eren.doe.gov/femp/aboutfemp/pdfs/doeo430_2a.pdf***

The Green Zia Environmental Excellence Program, ***www.nmenv.state.nm.us/Green_Zia_website/index.html***

Laboratories for the 21st Century, ***www.epa.gov/labs21century***

LANL Engineering Manual (LEM), OST-220-03-01-EM, ***www.lanl.gov/f6stds/pubf6stds/xternhome.html***

LANL Construction Specifications Manual (LCSM), ***www.lanl.gov/f6stds/pubf6stds/xternhome.html***

LANL Drafting Manual (FDM), OST-220-03-01-DM, ***www.lanl.gov/f6stds/pubf6stds/xternhome.html***

Site and Architectural Design Principles, ***www.lanl.gov/f/f6/pubf6stds/engrman/4arch/htmls/site_arch.htm***

U.S. Green Buildings Council LEED Program, ***www.usgbc.org***

Additional Resources

Charrettes for High Performance Design, ***www.nrel.gov/buildings/highperformance***

FEMP Resources: Regulations and Legislative Activities, ***www.eren.doe.gov/femp/resources/legislation.html***

High-Performance Buildings Research Initiative Web site, ***www.highperformancebuildings.gov***

Los Alamos National Laboratory, ***www.lanl.gov***

Whole Building Design Guide, ***www.wbdg.org***

FEMP Federal Greening Toolkit, ***www.eren.doe.gov/femp/techassist/greening_toolkit***

Environmental Design Charrette Workbook, American Institute of Architects, Washington, D.C., 1996