Appendices

Appendix A

Best Practices, Orders, Regulations, and Laws

All 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 performance standards to be used in the design of new federal commercial and multifamily high-rise buildings. Some of the guidelines are relevant to retrofits. 10CFR434 establishes the "base case" for a building, such as defining insulation levels and lighting requirements. This code is based on ASHRAE/IESNA Standard 90.1-1989.

Following ASHRAE Standards is considered good practice. The three ASHRAE Standards that are most often used in building design and operations are Standards 90.1, 62, and 55. There are two methods for complying with the recommendations of these Standards: a *prescriptive method* and a *performance method.* When using the prescriptive method, the designer strictly follows the guidelines laid out in the Standard, such as complying with a recommended constant level of ventilation air provided to a space. When using the performance method, the designer makes certain that the overall building performance meets the intent of the Standard. For example, a designer using the performance method may specify more or less ventilation air to a space than that recommended in the prescription portion of the Standard to account for variable occupancy. Complying with the intent of the Standards using the performance method often results in buildings that consume less energy and still maintain comfortable indoor conditions.

- ***ASHRAE/IESNA Standard 90.1,*** "Energy Standard for Buildings Except Low-Rise Residential Buildings." Standard 90.1-1989 is the basis for the Federal Energy Code 10CFR434, the energy conservation standard for federal buildings. Standard 90.1-2001 is the revised version of Standard 90.1-1989. Revisions include considerably more stringent lighting requirements and an alternative method for comparing energy-efficiency design strategies. DOE is developing another update to 10CFR434 using the new ASHRAE/IESNA Standard 90.1-2001 as the model. Standard 90.1-2001 is more aggressive than 90.1-1989 or 10CRF434 for laboratory buildings with fume hoods having a total exhaust rate greater than 15,000 CFM because it requires variable air volume (VAV) supply and exhaust systems or heat recovery.
- ***ANSI/ASHRAE Standard 62-1999,*** "Ventilation for Acceptable Indoor Air Quality." This Standard specifies minimum ventilation rates and indoor air quality that will be acceptable to human occupants. Limiting contaminants in indoor air and providing adequate quantity of outdoor air should achieve acceptable IAQ. The Standard specifies alternative procedures to obtain acceptable air quality: the ventilation rate procedure and the indoor air quality procedure.
    - Ventilation Rate Procedure: Acceptable air quality is achieved by providing ventilation of the specified quantity to the space. For example, 20 CFM/person is required for the AVERAGE (not peak) occupancy in offices.
    - Indoor Air Quality Procedure: Acceptable air quality is achieved by controlling known contaminants to the space. This procedure incorporates both quantitative and subjective evaluation of contaminants. Indoor carbon dioxide (CO_2) levels are often used as an indicator of the concentration of human bioeffluents with this procedure. An indoor-to-outdoor differential concentration not greater than 700 ppm of CO_2 indicates that the comfort (odor) criteria related to human bioeffluents are likely to be satisfied.

ASHRAE Standard 55-1992 Addendum –1995, "Thermal Environmental Conditions for Human Occupancy." The purpose of this Standard is to specify the combination of indoor space environmental and personal factors that will produce thermal environmental conditions acceptable to 80 percent or more of the occupants within the space.

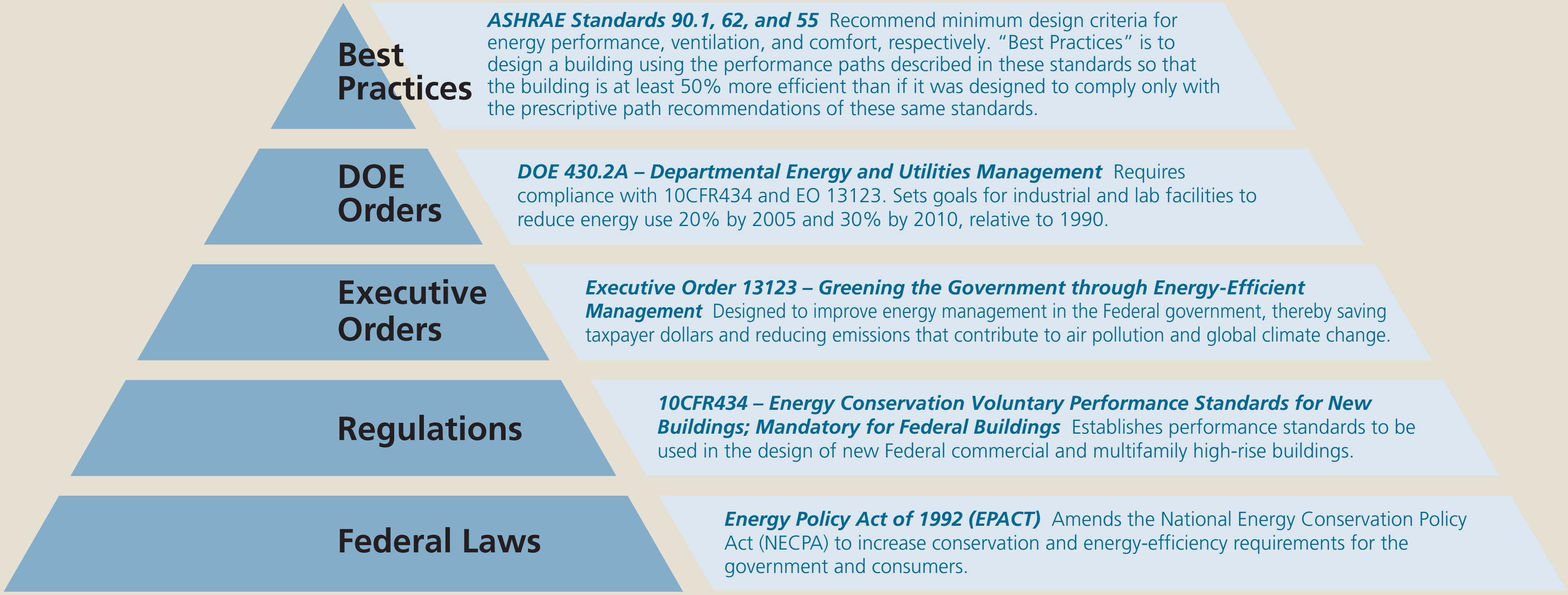
The Laws, Executive Orders, DOE Orders, and regulations in the following sections all encourage energy efficiency and sustainable design.

Best Practices, Orders, Regulations, and Laws Overview

Federal laws, Executive Orders (EO), 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.

- ***Best Practices*** result in a building that costs at least 50 percent less to operate than a code compliant building
- ***DOE Orders*** are issued by DOE and apply only to DOE facilities.
- ***Executive Orders*** are the president's directives to the agencies.
- ***Regulations*** establish procedures and criteria by which decisions shall be made and actions carried out.
- ***Laws*** are the will of the American people expressed through their elected representatives.

DOE Orders, Executive Orders, Regulations, and Federal Laws 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.



Best Practices	***ASHRAE Standards 90.1, 62, and 55*** Recommend minimum design criteria for energy performance, ventilation, and comfort, respectively. "Best Practices" is to design a building using the performance paths described in these standards so that the building is at least 50% more efficient than if it was designed to comply only with the prescriptive path recommendations of these same standards.
DOE Orders	***DOE 430.2A – Departmental Energy and Utilities Management*** Requires compliance with 10CFR434 and EO 13123. Sets goals for industrial and lab facilities to reduce energy use 20% by 2005 and 30% by 2010, relative to 1990.
Executive Orders	***Executive Order 13123 – Greening the Government through Energy-Efficient Management*** Designed to improve energy management in the Federal government, thereby saving taxpayer dollars and reducing emissions that contribute to air pollution and global climate change.
Regulations	***10CFR434 – Energy Conservation Voluntary Performance Standards for New Buildings; Mandatory for Federal Buildings*** Establishes performance standards to be used in the design of new Federal commercial and multifamily high-rise buildings.
Federal Laws	***Energy Policy Act of 1992 (EPACT)*** Amends the National Energy Conservation Policy Act (NECPA) to increase conservation and energy-efficiency requirements for the government and consumers.

Codes: *LANL is on federal land, but it is considered good practice to follow local and state codes. The following codes currently apply in New Mexico: 1997 New Mexico Building Code,1997 Uniform Building Code (UBC), 1997 New Mexico Plumbing and Mechanical Code, 1997 New Mexico Uniform Mechanical Code, 1997 New Mexico Uniform Plumbing Code,1999 New Mexico Electrical Code.*

DOE Orders

DOE 430.2A – Departmental Energy and Utilities Management requires following 10CFR434 and Executive Order (EO) 13123. Sets goals for industrial and lab facilities to reduce energy use 20 percent by 2005 and 30 percent by 2010, relative to 1990. Sets goals for other buildings to reduce energy use 40 percent by 2005 and 45 percent by 2010, relative to 1985. 430.2A requires DOE facilities to have a documented Energy Management Program and an Energy Management Plan, to report energy cost and consumption to the Energy Management System 4 (EMS4), and to submit a energy efficiency/sustainable design report for all new buildings of 10,000 gross square feet or more, or with an estimated energy use of 500 million BTU/yr.

DOE 413.3- Program and Project Management for the Acquisition of Capital Assets "Sustainable Building Design." New federal buildings must meet or exceed energy-efficiency standards established under EPACT PL Section 101 (10CFR434). Sustainable building design principles must be applied to the siting, design, and construction of new facilities."

Executive Orders

Executive Order 13221, "Energy-Efficient Standby Power Devices," July 31, 2001. This Order requires a federal agency, when it purchases products that use external standby power devices, or devices that contain an internal standby power function, to purchase products that use no more than one watt in their standby power-consuming mode.

Executive Order 13148, "Greening the Government through Leadership in Environmental Management," April 21, 2000. This Order includes requirements for federal agencies to integrate environmental management into decision making, conduct compliance audits, emphasize pollution prevention, reduce use and releases of toxic chemicals, reduce use of ozone-depleting substances, and use environmentally sound landscaping techniques. It authorized agencies to participate in utility incentive programs; it required federal agencies to train and use energy managers; it directed the Office of Management and Budget to issue guidelines for accurate assessment of energy consumption by federal buildings; and it directed GSA to report annually on estimated energy costs for leased space.

Executive Order 13123, "Greening the Government through Energy-Efficient Management," June 3, 1999. This Order is to improve energy management in the federal government, thereby saving taxpayer dollars and reducing emissions that contribute to air pollution and global climate change. Specific requirements include a 30 percent reduction of greenhouse gas emissions from facility energy use by 2010 compared to 1990 levels; a 30 percent reduction of energy use per gross square foot by 2005 and a 35 percent reduction by 2010 compared to 1985 levels for general use buildings (including office buildings); a 20 percent reduction of energy use per gross square foot by 2005 and a 25 percent reduction by 2010 compared to 1985 levels for industrial and laboratory buildings; use of renewable energy and support for the Million Solar Roofs Initiative; Applying sustainable design principles to the siting, design, and construction of new facilities; conducting energy and water audits for 10 percent of their facilities each year; purchasing ENERGY STAR and other efficient products; and water conservation. EO13123 requires an annual energy report to the president.

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 the three 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 percent, 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 percent 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 to a building design can result in a building that is 50 percent more efficient than a building designed to be merely compliant with the prescriptive ASHRAE standards.

Executive Order 13101, "Greening the Government through Waste Prevention, Recycling, and Federal Acquisition," September 14, 1998. Requires acquisition of environmentally preferable products and services, recycling, and waste prevention. This order created a Steering Committee and a Federal Environmental Executive. It requires EPA to update the *Comprehensive Procurement Guideline* and publish *Recovered Materials Advisory Notices;* develop guidance on environmentally preferable purchasing; and assist agencies in conducting pilot projects using these guidelines. It requires the USDA to prepare a list of biobased products and encourages Federal agencies to consider purchasing these products.

Executive Order 12902, "Energy Efficiency and Water Conservation at Federal Facilities," March 8, 1994. This Order has been superseded by Executive Order 13123.

Code of Federal Regulations

10CFR434, "Energy Conservation Voluntary Performance Standards for New Buildings; Mandatory for Federal Buildings," establishes performance standards to be used in the design of new federal commercial and multifamily high-rise buildings. Some of the guidelines are relevant to retrofits. 10CFR434 establishes maximum energy consumption for new buildings, including insulation levels, lighting requirements, and HVAC system efficiencies. 10CFR434 is based on an ASHRAE/ IESNA Standard 90.1-1989. This code has a number of differences from Standard 90.1-1989, such as more stringent lighting requirements. DOE also is initiating another update of the federal commercial code, using the new ASHRAE/IESNA Standard 90.1-2001 as the model. Note that the ASHRAE/IESNA Standard 90.1-2001 is more stringent and is recommended to be followed as the minimum code.

10CFR436, "Federal Energy Management and Planning Programs," establishes procedures for determining the life cycle cost-effectiveness of energy-conservation measures, and for setting priorities for energy conservation measures in retrofits of existing federal buildings. Subpart B establishes an ESPC program to accelerate investment in cost-effective energy conservation measures in federal buildings.

Federal Laws

Energy Policy Act of 1992 (EPACT). By amending the National Energy Conservation Policy Act (NECPA), this Act increased conservation and energy-efficiency requirements for the government and consumers. Specifically, it requires federal agencies to reduce per-square-foot energy consumption 20 percent by 2000 compared to a 1985 baseline; it provided authorization for DOE to issue rules and guidance on Energy Savings Performance Contracts (ESPCs) for federal agencies; it authorized agencies to participate in utility incentive programs; it required federal agencies to train and utilize energy managers; it directed the Office of Management and Budget to issue guidelines for accurate assessment of energy consumption by federal buildings; and it directed GSA to report annually on estimated energy costs for leased space.

National Energy Conservation Policy Act (NECPA) of 1978. NECPA specified the use of a life-cycle costing methodology as the basis for energy procurement policy and specified the rate for retrofit of federal buildings with cost-effective energy measures. Title V of NECPA was codified as the *Federal Energy Initiative.*

Resource Conservation and Recovery Act (RCRA) of 1976. RCRA 6002 established a federal mandate to "Buy Recycled." RCRA 1008 and 6004 require all federal agencies generating solid waste to take action to recover it.

Energy Policy and Conservation Act (EPCA) of 1975. EPCA was the first major piece of legislation to address federal energy management. This law directed the president to develop a comprehensive energy management plan. EPCA has largely been superseded by later legislation.

References

American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE), ***www.ashrae.org***

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

Additional Resources

Illuminating Engineering Society of North America (IESNA), ***www.iesna.org***

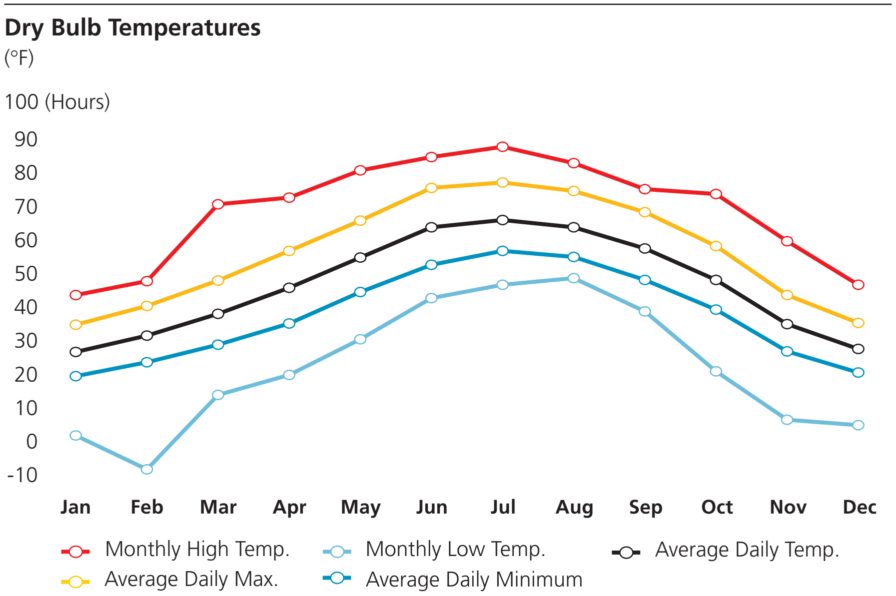
Institute of Electrical and Electronics Engineers (IEEE), ***http://standards.ieee.org/index.html***

Million Solar Roofs, ***www.millionsolarroofs.org***

Appendix B

Climate Charts

This appendix gives an overview of the weather at Los Alamos. Using 30-year historical weather data collected at Los Alamos, a typical meteorological year (TMY) weather file was created for Los Alamos. The graphs in this appendix summarize this TMY data and show weather parameters, such as temperature, wet bulb temperature, heating degree days, and cooling degree days. In addition to the graphs, the appendix provides monthly averages for many key weather variables.

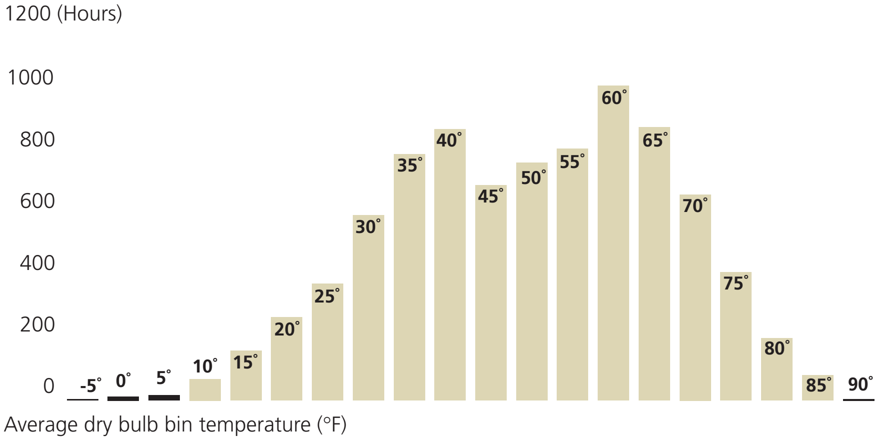


Dry Bulb Temperatures

This graph shows the minimum, maximum, and average monthly dry bulb temperatures. The Los Alamos annual dry bulb temperatures are ideal for climate-sensitive building design and operation.

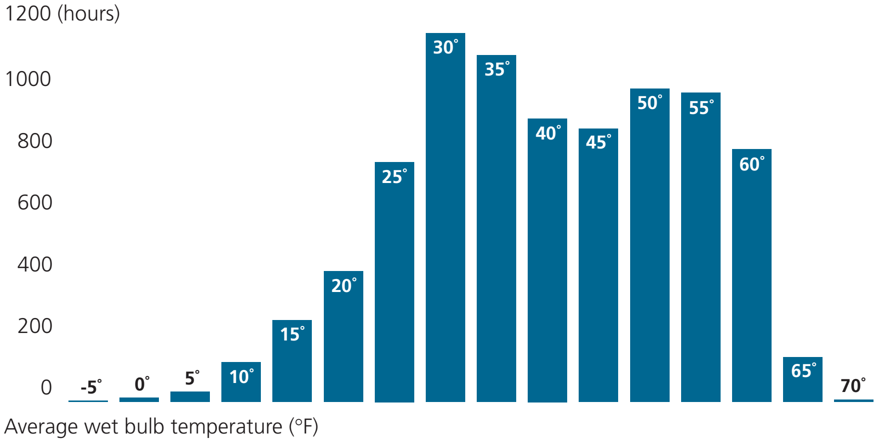
Dry Bulb Temperature Bins

(5°F Bins)



Wet Bulb Temperature

(Range of 5°F)



Dry Bulb Temperature Bins

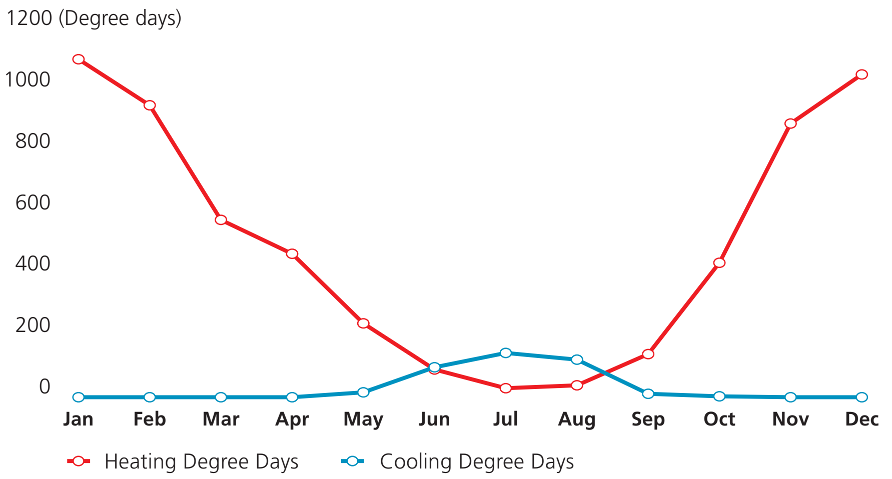
This graph separates the number of hours per year that the dry bulb temperature is in certain temperature ranges. The ranges, or bins, include temperatures that are ±2.5°F of the temperatures shown for each bin (e.g., the temperature in the 55°F bins ranges between 52.5°F and 57.5°F). The graph indicates that there are only 700 hours when the dry bulb temperature exceeds 75°F, signifying low annual cooling loads. Minimizing lighting loads (by using daylighting), equipment loads, and solar gains will further reduce the cooling loads.

Wet Bulb Temperature Bins

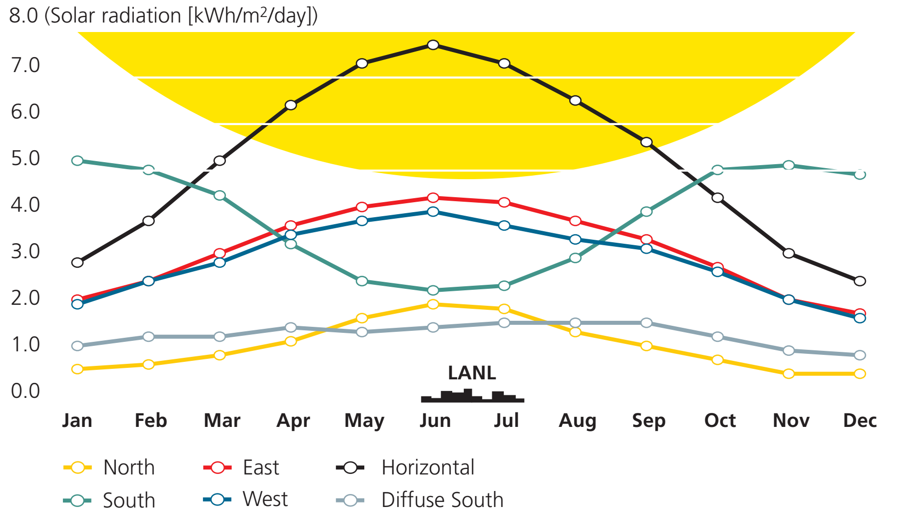
This graph shows the number of hours per year that the web bulb temperature is in certain temperature ranges. The ranges, or bins, include temperatures that are ±2.5°F the temperatures shown for each bin (e.g., the temperature in the 35°F bins ranges between 32.5°F and 37.5°F). The graph shows that the wet bulb temperature is less than 40°F during 4500 hours per year, indicating that 55°F chilled water can be achieved by using cooling towers and heat exchangers for most of the year. Because the wet bulb temperature is less than 65°F most of the year, economizers are a good solution for meeting cooling loads at a low cost. Evaporative cooling systems may also be a good cooling solution, except during the approximately 150 hours per year when the wet bulb temperature exceeds 65°F.

Heating and Cooling Degree Days

(Base 65°F)



Global Solar Radiation



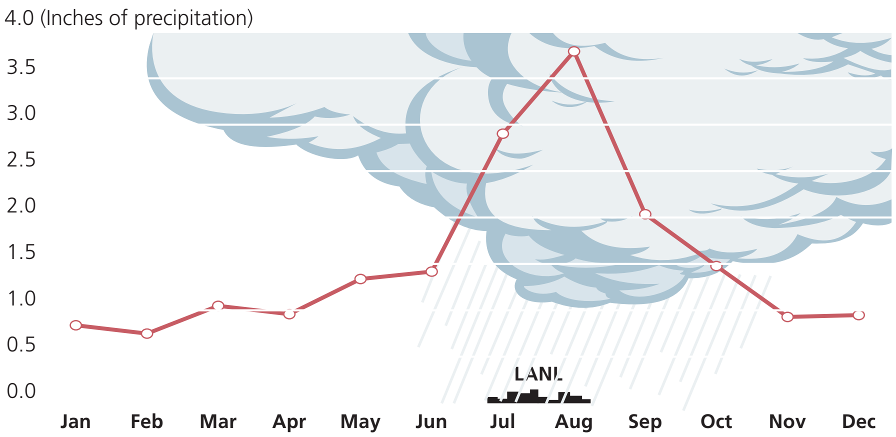
Heating and Cooling Degree Days

This graph shows the monthly heating and cooling degree days (base 65°F). The heating and cooling degree days indicate building heating and cooling loads for this climate. The data show that there are 3,198 heating and 259 cooling degree days. Buildings are heating-dominated. Ensure that the building cooling loads are small by minimizing lighting loads (by using daylighting), equipment loads, and solar gains.

Global Solar Radiation and South Diffuse Radiation

This graph shows the daily average global solar radiation on a horizontal surface and on vertical surfaces facing each of the cardinal directions. It also shows diffuse solar radiation on a south-facing surface. The Los Alamos solar resources are excellent for photovoltaic (solar electric) and solar thermal systems. East- and west-facing surfaces receive a large amount of solar energy during the summer months, indicating that east- and west-facing window areas should be minimized to minimize local overheating (increased cooling loads) and glare (uneven and uncomfortable lighting conditions). Horizontal skylights should be avoided because of the large solar heat gains during summer. This climate is excellent for daylighting buildings, particularly using south- and north-facing windows with solar load control (e.g., overhangs). The diffuse radiation data for a south-facing surface exemplify how overhangs completely shading south-facing windows can significantly reduce the annual solar gains through those windows.

Average Precipitation



Average Precipitation

This graph shows the average inches of precipitation per month. The average annual rainfall is 18 inches. Note that most of the rainfall occurs in July, August, and September, which also are the warmest months of the year and the time of the year when water is most needed for other purposes such as landscaping. Rainwater provides an excellent source of soft water for uses such as cooling tower make-up water and irrigation if a rainwater capture system is used. The data in this graph are average monthly precipitation data between 1937 and 1997 as reported on the National Climatic Data Center Web site (http://lwf.ncdc.noaa.gov/oa/climate/online/coop-precip.html).

Interpreting the Climate Table

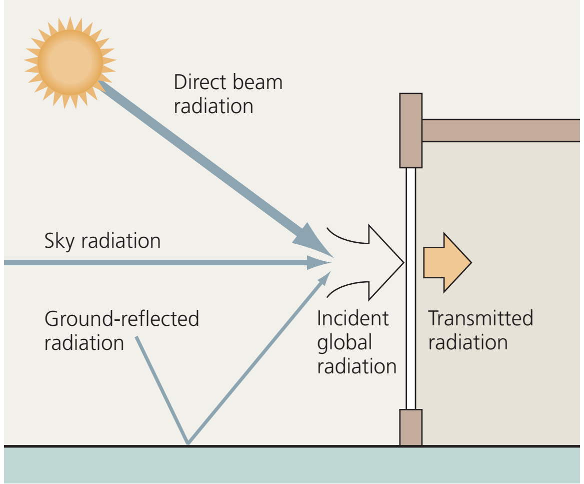
Station Description

Information at the top of the table describes the location (or station) described by the data in the table.

Solar Radiation

Incident solar radiation. The table gives the monthly and yearly average global radiation, clear-day global radiation, and diffuse radiation for windows on five surfaces: a horizontal window and vertical windows facing north, east, south, and west.

Global radiation is the total radiation received by the window and is the sum of the direct-beam radiation, sky radiation, and radiation reflected from the ground in front of the surface. Clear-day global radiation represents the global radiation obtainable under clear skies.



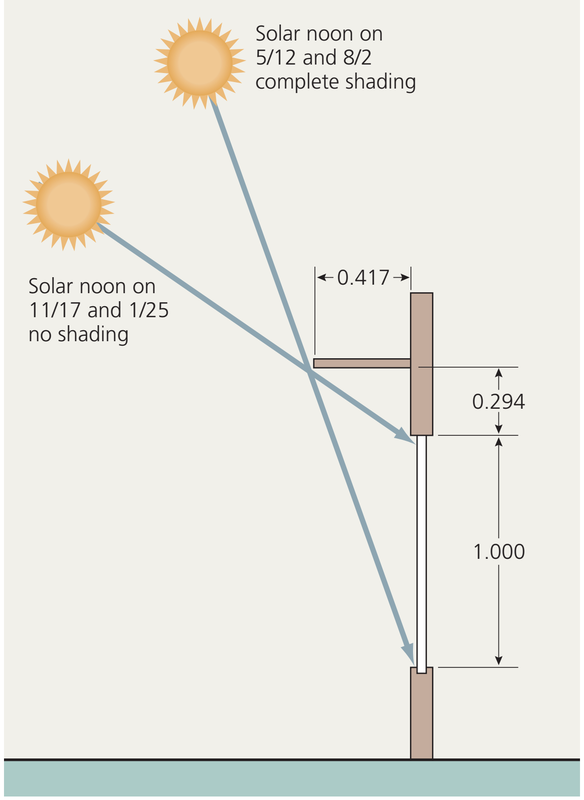
Incident global solar radiation includes direct-beam, sky, and ground-reflected radiation.

The diffuse radiation data do not include the direct beam radiation component. Diffuse radiation is the sum of sky radiation and radiation reflected from the ground in front of the surface. The ground-reflected radiation was calculated using monthly averages of ground reflectivity or albedo.

Transmitted solar radiation. The solar radiation transmitted into an occupied space is less than the radiation that strikes the outside of a window because of reflections and losses by the glass. The data are for windows with conventional, clear, double glazing and a glass thickness of 0.125 in. (3.18 mm).

The table contains values for unshaded and shaded vertical windows on five surfaces: a horizontal window and vertical windows facing north, east, south, and west. Unshaded values are for windows with no external shading. Shaded values are for windows shaded by the roof overhang. The shading geometry, shown with the table, is not applicable for the horizontal surface; consequently, shaded transmitted solar radiation values for a horizontal surface are not included.

The shading geometry is generally a function of the latitude, but consideration also is given to heating and cooling requirements. For south-facing windows, the shading geometry provides guidance for the appropriate dimensions of roof overhangs. However, situations may require a different geometry, depending on the balance between heating and cooling loads for the particular building and factors such as required window sizes and building practices. For east- and west-facing windows, overhangs are not particularly effective in preventing unwanted heat gain. Additional shading strategies such as vertical louvers may be needed.



Shading geometry (in dimensionless units) and sun positions for south-facing windows at 36° north latitude.

Climatic Conditions

The following tables contain average climatic condition information listed monthly and yearly.

Degree days indicate heating and cooling requirements of buildings. They are defined as the difference between the average temperature for the day and a base temperature. If the average for the day (calculated by averaging the minimum and maximum temperature for the day) is less than the base value, then the difference is designated as heating degree days. If the average is greater than the base value, the difference is designated as cooling degree days.

The clearness index (K_t) is the global horizontal solar radiation divided by its extraterrestrial horizontal radiation. Clouds decrease the amount of solar radiation reaching the Earth, which lower the K_t values. Lower K_t values indicate more cloud cover than higher K_t values.

Illuminance

The illuminance table contains diurnal profiles of the average illuminance incident on five surfaces (a horizontal window and vertical windows facing north, east, south, and west) for four months of the year and consists of two data values. The first value is the average illuminance for mostly clear conditions (total cloud cover less than 50 percent), and the second value after the slash is the average illuminance for mostly cloudy conditions (total cloud cover equal to or greater than 50 percent).

The last line in the illuminance table indicates the percentage of time during the hour that the location is mostly clear (M. Clear). These values, along with the illuminance values, can be used to determine the average hourly illuminance:

Average illuminance = [(M. Clear) x
(illuminance for mostly clear) + (100 – M. Clear) x
(illuminance for mostly cloudy)] ÷ 100

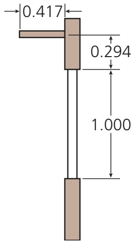
The illuminance data represent the illuminance received during the preceding hour. For example, data for 3 p.m. include the illuminance received from 2 p.m. to 3 p.m. local standard time. (To convert to daylight savings time, add 1 hour.)

English Unit Climate Tables

Station Description

Location:	Los Alamos, NM
Station number:	723654
Latitude (N):	35.9
Longitude (W):	106.3
Elevation (ft):	7149

Shading Geometry in Dimensionless Units



Average Incident Solar Radiation (BTU/ft²/day)

		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Horiz.	*Global*	951	1236	1648	2029	2314	2441	2314	2060	1775	1395	1014	824	1680
	Diffuse	254	349	444	571	602	634	666	666	507	349	254	222	475
	Clear-day Global	1173	1522	1997	2473	2758	2853	2758	2473	2092	1617	1205	1046	1997
North	*Global*	222	254	317	412	571	666	634	475	380	285	190	190	380
	Diffuse	222	254	317	412	444	507	507	444	380	285	190	190	349
	Clear-day Global	190	222	254	380	571	729	666	444	349	254	190	158	380
East	*Global*	697	824	1014	1205	1331	1395	1363	1236	1109	919	697	602	1046
	Diffuse	254	349	412	507	539	602	602	571	475	349	254	222	444
	Clear-day Global	856	1046	1236	1458	1553	1585	1553	1458	1331	1078	856	761	1236
South	*Global*	1648	1585	1395	1078	824	761	792	983	1300	1585	1617	1553	1268
	Diffuse	380	444	444	507	475	507	539	539	539	444	349	317	444
	Clear-day Global	2187	2124	1775	1300	888	761	824	1109	1617	1997	2124	2124	1553
West	*Global*	666	824	951	1141	1236	1300	1205	1109	1046	888	697	571	983
	Diffuse	285	349	412	507	571	602	602	571	507	349	254	222	444
	Clear-day Global	856	1046	1268	1458	1553	1585	1553	1458	1331	1078	856	761	1236

Average Transmitted Solar Radiation for Double Glazing (BTU/ft²/day)

		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Horiz.	*Unshaded*	634	856	1173	1490	1680	1807	1680	1490	1268	983	697	539	1205
North	*Unshaded*	158	190	222	285	349	412	380	317	254	190	127	127	254
	Shaded	127	158	190	254	317	380	349	285	254	190	127	127	222
East	*Unshaded*	475	602	729	856	951	1014	983	888	792	666	475	412	729
	Shaded	444	539	666	792	856	888	888	824	729	602	444	380	666
South	*Unshaded*	1236	1141	951	666	475	412	444	602	856	1141	1205	1173	856
	Shaded	1236	1078	761	444	317	349	349	380	666	1014	1205	1173	729
West	*Unshaded*	475	571	697	824	888	919	856	792	761	634	475	412	697
	Shaded	444	539	634	729	792	824	761	697	666	571	444	380	634

Average Climatic Conditions

Element	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Temp. *(deg F)*	30.0	34.9	41.4	49.1	58.1	67.1	69.3	67.1	60.8	51.4	38.3	30.9	50.0
Daily Min *(deg F)*	22.8	27.0	32.2	38.5	47.8	55.9	60.1	58.3	51.4	42.6	30.2	23.9	41.0
Daily Max *(deg F)*	38.1	43.7	51.3	60.1	69.1	78.8	80.4	77.9	71.6	61.5	46.9	38.7	59.9
HDD, *base = 65°F*	594	461	400	260	124	27	5	12	74	222	439	580	3198
CDD, *base = 65°F*	0	0	0	0	12	69	97	65	16	0	0	0	259
Hum Ratio *(#w/#day)*	0.0022	0.0025	0.0028	0.0034	0.0048	0.0059	0.0081	0.0087	0.0065	0.0044	0.0029	0.0023	0.0045
Wind Spd. *(mph)*	3.1	4.3	5.6	6.5	6.1	5.6	4.9	4.0	4.7	4.7	3.8	3.4	4.7
Clearness Index K_t	0.61	0.61	0.63	0.64	0.65	0.66	0.64	0.63	0.63	0.64	0.61	0.58	0.63

Average Incident Illuminance for Mostly Clear/Mostly Cloudy Conditions (klux-hr)

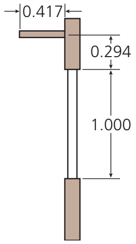
	March					June					Sept					Dec				
	9am	11am	1pm	3pm	5pm	9am	11am	1pm	3pm	5pm	9am	11am	1pm	3pm	5pm	9am	11am	1pm	3pm	5pm
Horiz.	44/32	78/59	88/70	70/55	31/23	69/57	97/84	105/92	88/73	51/42	52/39	83/66	88/73	69/57	29/22	20/13	49/34	55/39	37/26	4/3
North	9/9	12/13	13/14	12/13	7/7	13/15	15/17	15/17	15/17	19/18	11/12	15/17	15/17	14/15	8/8	6/5	9/9	10/10	8/8	2/2
East	81/49	57/43	13/14	12/13	7/7	83/65	54/50	15/17	15/17	11/12	81/51	54/43	15/17	14/15	8/8	52/24	43/27	10/10	8/8	2/2
South	39/26	68/51	77/61	61/46	27/18	13/15	34/32	39/37	27/26	11/12	39/28	66/52	72/58	55/43	21/14	47/22	86/51	93/57	72/41	15/6
West	9/9	12/13	20/20	67/50	73/43	13/15	15/17	26/26	70/59	81/60	11/12	15/17	29/27	72/55	69/39	6/5	9/9	22/17	56/33	22/9
M.Clear (% hrs)	57	52	45	40	41	72	66	49	43	42	63	57	49	42	48	58	54	51	50	50

Metric Unit Climate Tables

Station Description

Location:	Los Alamos, NM
Station number:	723654
Latitude (N):	35.9
Longitude (W):	106.3
Elevation (m):	2179

Shading Geometry in Dimensionless Units



Average Incident Solar Radiation (kWh/m²/day)

		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Horiz.	*Global*	3	3.9	5.2	6.4	7.3	7.7	7.3	6.5	5.6	4.4	3.2	2.6	5.3
	Diffuse	0.8	1.1	1.4	1.8	1.9	2	2.1	2.1	1.6	1.1	0.8	0.7	1.5
	Clear-day Global	3.7	4.8	6.3	7.8	8.7	9	8.7	7.8	6.6	5.1	3.8	3.3	6.3
North	*Global*	0.7	0.8	1	1.3	1.8	2.1	2	1.5	1.2	0.9	0.6	0.6	1.2
	Diffuse	0.7	0.8	1	1.3	1.4	1.6	1.6	1.4	1.2	0.9	0.6	0.6	1.1
	Clear-day Global	0.6	0.7	0.8	1.2	1.8	2.3	2.1	1.4	1.1	0.8	0.6	0.5	1.2
East	*Global*	2.2	2.6	3.2	3.8	4.2	4.4	4.3	3.9	3.5	2.9	2.2	1.9	3.3
	Diffuse	0.8	1.1	1.3	1.6	1.7	1.9	1.9	1.8	1.5	1.1	0.8	0.7	1.4
	Clear-day Global	2.7	3.3	3.9	4.6	4.9	5	4.9	4.6	4.2	3.4	2.7	2.4	3.9
South	*Global*	5.2	5	4.4	3.4	2.6	2.4	2.5	3.1	4.1	5	5.1	4.9	4
	Diffuse	1.2	1.4	1.4	1.6	1.5	1.6	1.7	1.7	1.7	1.4	1.1	1	1.4
	Clear-day Global	6.9	6.7	5.6	4.1	2.8	2.4	2.6	3.5	5.1	6.3	6.7	6.7	4.9
West	*Global*	2.1	2.6	3	3.6	3.9	4.1	3.8	3.5	3.3	2.8	2.2	1.8	3.1
	Diffuse	0.9	1.1	1.3	1.6	1.8	1.9	1.9	1.8	1.6	1.1	0.8	0.7	1.4
	Clear-day Global	2.7	3.3	4	4.6	4.9	5	4.9	4.6	4.2	3.4	2.7	2.4	3.9

Average Transmitted Solar Radiation for Double Glazing (kWh/m²/day)

		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Horiz.	*Unshaded*	2.0	2.7	3.7	4.7	5.3	5.7	5.3	4.7	4.0	3.1	2.2	1.7	3.8
North	*Unshaded*	0.5	0.6	0.7	0.9	1.1	1.3	1.2	1.0	0.8	0.6	0.4	0.4	0.8
	Shaded	0.4	0.5	0.6	0.8	1.0	1.2	1.1	0.9	0.8	0.6	0.4	0.4	0.7
East	*Unshaded*	1.5	1.9	2.3	2.7	3.0	3.2	3.1	2.8	2.5	2.1	1.5	1.3	2.3
	Shaded	1.4	1.7	2.1	2.5	2.7	2.8	2.8	2.6	2.3	1.9	1.4	1.2	2.1
South	*Unshaded*	3.9	3.6	3.0	2.1	1.5	1.3	1.4	1.9	2.7	3.6	3.8	3.7	2.7
	Shaded	3.9	3.4	2.4	1.4	1.0	1.1	1.1	1.2	2.1	3.2	3.8	3.7	2.3
West	*Unshaded*	1.5	1.8	2.2	2.6	2.8	2.9	2.7	2.5	2.4	2.0	1.5	1.3	2.2
	Shaded	1.4	1.7	2.0	2.3	2.5	2.6	2.4	2.2	2.1	1.8	1.4	1.2	2.0

Average Climatic Conditions

Element	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Temp. *(deg C)*	-1.1	1.6	5.2	9.5	14.5	19.5	20.7	19.5	16	10.8	3.5	-0.6	10
Daily Min *(deg C)*	-5.1	-2.8	0.1	3.6	8.8	13.3	15.6	14.6	10.8	5.9	-1.0	-4.5	5.0
Daily Max *(deg C)*	3.4	6.5	10.7	15.6	20.6	26.0	26.9	25.5	22	16.4	8.3	3.7	15.5
HDD, *base = 18.3°C*	594	461	400	260	124	27	5	12	74	222	439	580	3198
CDD, *base = 18.3°C*	0	0	0	0	12	69	97	65	16	0	0	0	259
Hum Ratio *g/kg*	2.2	2.5	2.8	3.4	4.8	5.9	8.1	8.7	6.5	4.4	2.9	2.3	4.5
Wind Spd. *(m/s)*	1.4	1.9	2.5	2.9	2.7	2.5	2.2	1.8	2.1	2.1	1.7	1.5	2.1
Clearness Index K_t	0.61	0.61	0.63	0.64	0.65	0.66	0.64	0.63	0.63	0.64	0.61	0.58	0.63

Average Incident Illuminance for Mostly Clear/Mostly Cloudy Conditions (klux-hr)

	March					June					Sept					Dec				
	9am	11am	1pm	3pm	5pm	9am	11am	1pm	3pm	5pm	9am	11am	1pm	3pm	5pm	9am	11am	1pm	3pm	5pm
Horiz.	44/32	78/59	88/70	70/55	31/23	69/57	97/84	105/92	88/73	51/42	52/39	83/66	88/73	69/57	29/22	20/13	49/34	55/39	37/26	4/3
North	9/9	12/13	13/14	12/13	7/7	13/15	15/17	15/17	15/17	19/18	11/12	15/17	15/17	14/15	8/8	6/5	9/9	10/10	8/8	2/2
East	81/49	57/43	13/14	12/13	7/7	83/65	54/50	15/17	15/17	11/12	81/51	54/43	15/17	14/15	8/8	52/24	43/27	10/10	8/8	2/2
South	39/26	68/51	77/61	61/46	27/18	13/15	34/32	39/37	27/26	11/12	39/28	66/52	72/58	55/43	21/14	47/22	86/51	93/57	72/41	15/6
West	9/9	12/13	20/20	67/50	73/43	13/15	15/17	26/26	70/59	81/60	11/12	15/17	29/27	72/55	69/39	6/5	9/9	22/17	56/33	22/9
M.Clear (% hrs)	57	52	45	40	41	72	66	49	43	42	63	57	49	42	48	58	54	51	50	50

Appendix C

Green Building Adviser

This appendix contains a list of strategies generated by the *Green Building Advisor* (GBA), a software tool used in brainstorming and learning about sustainable design solutions. GBA solicits a limited set of inputs about a project and uses those inputs to query its database of green building strategies for those most likely to be relevant to the project.

A user of GBA can then click on any strategy in the list to learn more about that strategy. The information available about each strategy might include:

- A detailed explanation;
- Links to case studies of projects in which the strategy was implemented;
- Links to potentially synergistic and/or conflicting strategies;
- Listings and links to resources for more information;
- Links to listings of products that might be used to implement the strategy; and
- Other specifics about the strategy.

The following report was exported from GBA. It includes the inputs that describe the prototype LANL building, the climate data provided for Los Alamos, and an edited version of the list of strategies generated by the program. The strategies are organized under five major topic areas (similar to the structure of the LEED™ Rating System): Site & Ecosystems, Energy Use, Water Use, Materials & Resources, and Indoor Environmental Quality. Within each topic area, the strategies are organized into subtopics and headings. Within each subtopic, the strategies and headings also are grouped into relevance categories: “Strongly recommended” and Moderately recommended.”

GBA is available from BuildingGreen, Inc. More information about the program is available online at ***www.GreenBuildingAdvisor.com***.

Green Building Advisor Project Report

Project Information

Prototype Office Building at LANL for Sustainable Design Guide

Project Data

- Site location: (NM) Los Alamos
- Project type: New
- Scope of work: Whole building
- Building type: Commercial office
- Size of site: 1–3 acres
- Building footprint: 20–50% of site
- Status of site: Greenfield
- Community density: Suburban/rural
- Building size: 12,000 - 50,000 square feet
- Number of floors: 2
- Type of construction: Steel
- Foundation: Slab on grade
- Window coverage: Typical number of windows

Location Climate Data (customized for Los Alamos)

- Average low temp for coldest month of year [F]: 22.7
- Average high temp for warmest month of year [F]: 78.9
- Average daily temp for entire year [F]: 49.9
- HDD [65 F base]: 6017
- CDD [65 F base]: 345
- Annual days of freezing: 115
- Annual precipitation [inches]: 18
- Annual days of precipitation: 92
- Average windspeed [mph]: 4.7
- Average relative humidity [%]: 60
- Annual sunshine [hours]: 5496.9
- Elevation [feet]: 7149
- Latitude: 35.88
- Longitude: -106.28

Recommended Ecosystem Strategies

Site Selection and Ecosystems

Strongly Recommended

Comparing properties prior to purchase

- Hire a landscape architect or other specialist to evaluate prospective properties
- Assess property for integration with local community and regional transportation corridors

Avoiding properties with excessive impacts

- Avoid contributing to sprawl
- Reevaluate greenfield development
- Avoid properties that interfere with wildlife corridors
- Avoid building on flood-prone properties
- Avoid properties where damage to fragile ecosystems cannot be avoided
- Avoid properties with excessive slopes
- Avoid non-sewered sites if environmentally responsible on-site system is not feasible
- Avoid properties that would require excessively long and excessively damaging access roads

Selecting a property with opportunities for minimal environmental impacts

- Look for opportunities for infill development
- Select brownfield sites for development
- Select already-developed sites for new development
- Look for a property where infrastructure needs can be combined

Assessment of site for building and infrastructure placement

- Assess regional climatic conditions
- Investigate microclimate (specific variations from regional climatic conditions)
- Create a map of physical elements on the site (structures, topography, soils, hydrology)
- Create a map of vegetation on site, including notation of significant specimens
- Create a wildlife/habitat survey, including links to offsite habitat corridors
- Carry out a careful wetlands survey
- Identify most degraded or ecologically damaged areas of a site

Avoiding building sites with excessive impacts

- Avoid building on or degrading wetlands
- Avoid damaging significant historic or prehistoric sites
- Avoid sites with excessive slopes

Siting buildings and infrastructure on a property to minimize environmental impacts

- Select an already-developed portion of a site for new development
- Locate the building(s) on the most degraded part of the site
- Site access roads or driveways to help maintain identifiable edges on the property
- Look for opportunities to combine needs with infrastructure
- Select building sites that make use of existing infrastructure
- Choose building sites to minimize impact of on-site wastewater system
- Site development carefully to protect significant ecosystems
- Avoid building in flood-prone areas

Siting buildings and infrastructure for other benefits

- Follow natural contours with roadways, utility lines, etc.
- Protect and celebrate a site's uniqueness
- Site buildings to help occupants celebrate the natural beauty
- Site building(s) where existing vegetation can reduce energy use
- Provide for solar access

Moderately Recommended

Comparing properties prior to purchase

- Investigate property for possible contaminants (e.g., toxic or hazardous wastes, dumps)

Assessment of site for building and infrastructure placement

- Hire a landscape architect to help with siting of buildings and infrastructure
- Research past human uses of the site

Siting buildings and infrastructure on a property to minimize environmental impacts

- Site buildings where lowest biodiversity is present
- Site buildings to minimize access road length

Siting buildings and infrastructure for other benefits

- Site buildings to minimize visual impacts, including from roadways and neighboring buildings

Land Development and Ecosystems

Strongly Recommended

Confining development impact

- Minimize development impact area
- Minimize building footprint
- Restrict vehicle access during construction to reduce damage to vegetation
- Fence off a wide area around trees to be protected

- Avoid storage of building materials or soil in areas where tree roots could be damaged
- Limit parking area

Construction impacts

- Establish long-term relationship with responsible excavation and sitework contractor
- Institute a reward or penalty system to provide incentive for contractor to protect the site
- Designate appropriate staging areas for construction-related activities
- Schedule construction carefully to minimize damage to vegetation and ecosystems
- Minimize soil erosion from construction activities
- Disperse parking to avoid flattening large areas
- Use the smallest excavation and sitework machinery that will do the job
- Stockpile topsoil during excavation and sitework
- Avoid grade change around trees
- Provide terracing or large-diameter wells to protect tree roots from grade change
- Tunnel under trees for utility lines
- Before concrete pours, designate a location for cleaning out concrete trucks

Integration with site resources and limitations

- Celebrate and enhance existing landscape features
- Integrate on-site wastewater treatment system with landscape design

Moderately Recommended

Confining development impact

- Cluster buildings to preserve open space and protect habitat

Integration with site resources and limitations

- Install composting toilets

Avoiding need for chemical treatment

- Avoid burying woody debris near building(s)
- Design buildings to provide easy visual inspection for above-ground termite tubes
- Use the least toxic treatment methods and materials for pest control around new buildings
- Prevent termite access to structure
- Use bait system for termite control

Stormwater and Ecosystems

Strongly Recommended

Reducing impervious surfaces

- Minimize width and length of roadways
- Use planted swales instead of curbs and gutters
- Avoid contiguous impermeable surfaces
- Use modular block paving

Managing stormwater

- Contour slopes for reduced runoff

Moderately Recommended

Reducing impervious surfaces

- Use dispersed parking
- Design a green roof system
- Consider porous turf-paving systems on low-traffic parking and driveway areas
- Install gravel paving in a matrix to retain permeability
- Install porous asphalt or concrete

Managing stormwater

- Utilize sheet flow
- Incorporate surface infiltration basins in landscapes
- Use subsurface infiltration basins
- Design a constructed wetland for pollutant removal from stormwater

Landscaping and Ecosystems

Strongly Recommended

Ecosystem restoration

- Convert turf areas to native desert, prairie, or woodland ecosystem
- Remove ecologically damaging non-native (invasive) species
- Install landscape buffers along streams with native vegetation
- Use bioengineering practices for erosion control along waterways

Landscape plantings

- Salvage native plants during construction
- Landscape with indigenous vegetation
- Landscape with plants that provide wildlife forage or habitat
- Use plantings to stabilize soils and control erosion
- Plant trees to shade parked vehicles
- Minimize turf area

Moderately Recommended

Landscape plantings

- Landscape with edible plants

Regional Integration and Ecosystems

Strongly Recommended

Protection of global ecosystem

- Minimize ozone-depletion potential of refrigerants in cooling systems
- Avoid rigid or blown foam insulation made with an HCFC blowing agent

Responsible planning

- Ensure that development fits within a responsible local and regional planning framework

Support for appropriate transportation

- Provide showers and changing areas for bicycle and pedestrian commuters
- Provide access to public transportation
- Provide vehicle access to support car and vanpooling
- Provide incentives for non-automobile commuting options

Moderately Recommended

Protection of global ecosystem

- Avoid carpet cushion made with HCFC blowing agents

Responsible planning

- Carry out mixed-use development

Support for appropriate transportation

- Design development to have pedestrian emphasis rather than automobile emphasis
- Provide safe access for bicyclers and pedestrians
- Provide storage area for bicycles
- Incorporate traffic-calming measures
- Provide for electric vehicle charging

Recommended Energy Strategies

Building Envelope Energy Use

Strongly Recommended

Walls

- Minimize wall area through proper building massing
- Achieve a whole-wall R-value greater than 25

Foundations

- Use slab perimeter insulation with an insulating value of R-7 or greater
- Use sub-slab insulation with a minimum insulating value of R-5

Windows and doors

- Use exterior doors with rated R-values of R-4 or greater
- Use windows with a whole-unit U-factor less than 0.32 (greater than R-3.0)
- Avoid divided-lite windows to reduce edge losses

Infiltration

- Use continuous air barriers
- Keep all mechanical, electrical, and plumbing systems within the air and vapor barriers
- Minimize plumbing, electrical, and other penetrations through the building envelope
- Use air lock entries
- Seal all penetrations through the building envelope
- Seal all joints with caulks or gaskets
- Use appropriate caulks and sealants for different applications
- Use windows with infiltration rates no greater than 0.03 cfm/ft
- Minimize pressure difference between the building and the outside
- Pressure-test the building envelope using the mechanical system
- Perform duct leakage testing

Roofs

- Achieve a whole-roof R-value greater than R-35
- Design roof system with consistent thermal integrity
- Design roof system with raised rafters or trusses to avoid cold corners

Heating, Cooling, and Ventilation Energy Use

Strongly Recommended

Minimize solar heat gain

- Orient the building properly
- Utilize heliodon studies to optimize shading strategies

Minimize non-solar cooling loads

- Provide high-low openings to remove unwanted heat by stack ventilation
- Provide an open floor plan and openings located to catch prevailing breezes
- Use operable windows
- Reduce internal heat gains by improving lighting and appliance efficiency

Cooling systems

- Use chillers with high-efficiency screw compressors or scroll compressors
- Specify low-pressure-drop cooling coils
- Use an air-side economizer
- Use water-cooled mechanical cooling equipment
- Site condensing units in areas with adequate ventilation

- Locate cooling systems in areas accessible for maintenance and service
- Keep cooling equipment, especially air handlers and coils, in conditioned space
- Commission the HVAC system

Minimize heating load

- Site the building for southern exposure

Heating systems

- Use high-efficiency, condensing oil or gas boilers and furnaces
- Size heating systems appropriately
- Use modulating burners in boilers
- Keep heating equipment in conditioned space
- Design heating distribution systems for a large temperature drop
- Use hot water heat distribution
- Use modular boilers that can be staged to meet varying loads
- Locate heating equipment in an accessible place for maintenance and service

Ventilation systems

- Draw supply air from favorable microclimates around the building
- Use solar ventilation air preheat
- Use enthalpic heat-recovery ventilation
- Use air distribution strategies with high-ventilation effectiveness

Distribution systems

- Consider using an access floor system
- Seal ducts
- Size ducts for low-pressure drop
- Size pipes for low-pressure drop
- Specify turning vanes or large radius bends in duct work
- Keep duct work out of unconditioned space
- Insulate duct work located in unconditioned space
- Minimize bends in duct work
- Use variable frequency drives for fans
- Increase area/specify low-face-velocity filters
- Use high-efficiency pumps and motors
- Use high-efficiency fans and motors
- Size fans and pumps properly to meet the loads

Controls and zoning

- Provide sufficient sensors and control logic
- Use thermostats with night setback
- Locate thermostats in a central area out of the direct sun
- Use direct digital control (DDC) systems
- Use occupancy-based conditioning controls
- Create zones that unite spaces with similar thermal requirements
- Locate spaces used after normal occupancy hours near one another
- Provide separate HVAC systems for spaces with distinct heating and cooling loads

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Moderately Recommended

Cooling systems

- Use accurate simulation tools to design cooling system
- Use AC systems with a high efficiency rating
- Use low-temperature cooling air distribution
- Design chilled-water loops for a large temperature rise

Heating systems

- Use sunspace passive solar heating
- Use roof-pond passive solar heating
- Preheat intake combustion air with exhaust products

Ventilation Systems

- Use displacement ventilation
- Use demand-controlled ventilation

Controls and zoning

- Use variable-volume air distribution systems
- Zone the building for modular HVAC control

Lighting Energy Use

Strongly Recommended

Daylighting

- Use south-facing windows for daylighting
- Do not shade the south side of the building with trees
- Orient the floor plan on an east-west axis for best use of daylighting
- Locate frequently used areas on the south side of the building
- Design an open floor plan to allow exterior daylighting to penetrate the interior
- Use low partitions near the exterior glazing to promote daylight penetration
- Use large exterior windows and high ceilings to increase daylighting
- Use large interior windows to increase daylighting penetration
- Use north/south roof monitors and/or clerestories for daylighting
- Use light pipes and/or active tracking skylights for daylighting

Interior design
- Use light colors for surfaces and finishes

Light levels
- Design for no more than 1.0 watts/square foot
- Use light levels appropriate for different tasks
- Use different task and ambient lighting
- Minimize outdoor lighting

Light sources
- Specify Energy Star-rated lighting equipment
- Use LED or other super-efficient exit signs
- Use high-efficacy T8 fluorescent lamps
- Use high-efficacy T-5 fluorescent lamps
- Use high-pressure sodium lamps for area lighting when color rendition is not important
- Use solar-powered pathway lights

Ballasts
- Use high-efficiency electronic fluorescent lamp ballasts
- Use automatic-dimming electronic fluorescent lamp ballasts in conjunction with daylighting
- Tandem wire ballasts to control two luminaires

Luminaires
- Use high-efficiency luminaires
- Use the luminaire efficiency rating (LER) to compare different styles and models
- Use luminaires that accommodate high-intensity discharge lamps
- With outdoor lighting, specify luminaires that direct light downward

Controls
- Use on/off photoelectric daylight sensors
- Use modulating photoelectric daylight sensors
- Use occupancy sensors
- Use timers to control lighting
- Use door-impact switches in closets
- Use small-scale switching zones
- Use switches with 1, 2, 3 lamp operation

Moderately Recommended

Daylighting
- Use building elements to redirect daylight and control glare
- Use skylights for daylighting
- Locate floor openings under top-lighting to increase daylighting penetration

Interior design
- Use the lowest ceiling height that permits proper use of the space
- Use reflective suspended ceilings

Light sources
- Use halogen infrared reflector lamps for track lighting where necessary

Ballasts
- Use linear reactor ballasts with metal halide lamps

Luminaires
- Illuminate signs from above only

Controls
- Put outdoor lighting on motion-detector controls or timers
- Use dimming switches

Appliances and Equipment Energy Use

Strongly Recommended

Motors
- Use computer software to assist in motor selection
- Use adjustable-speed drives (ASDs)
- Align motor and shaft as precisely as possible
- Correct for low power factor
- Use high-efficiency belts

Computers and office equipment
- Use Energy Star copiers and fax machines
- Use Energy Star computer equipment
- Use laptop computers
- Use an occupancy sensor to turn off computer peripherals when the office is unoccupied

Refrigerators and freezers
- Allow sufficient airflow around refrigerator and freezer condenser coils
- Don’t set refrigerator and freezer temperatures lower than necessary

Elevators and escalators
- Use variable-frequency drives and high-efficiency motors for elevators and escalators
- Use control systems that de-energize cabs during low-use periods

Vending machines
- Use energy-efficient vending machines

Moderately Recommended

Motors

- Use energy-efficient motors
- Use two-speed motors
- Size motors appropriately
- Size electrical cables for motors appropriately

Water Heating Energy Use

Strongly Recommended

Minimize hot water load

- Use water-efficient faucets

Water heaters

- Use water heaters with energy efficiency ratings in the top 20 percent
- Use solar water heaters
- Use a boiler to heat water
- Use waste heat from mechanical systems to heat water

Standby heat loss

- Minimize the length of hot water piping
- Insulate hot water piping
- Use heat trap valves
- Provide different water temperatures for general and sanitary uses

Moderately Recommended

Water heaters

- Use heat-pump water heaters
- Use demand water heaters

Energy Sources Energy Use

Strongly Recommended

Photovoltaics

- Use a photovoltaic (PV) system to generate electricity on-site
- Use building-integrated photovoltaics (PV) to generate electricity on-site
- Arrange for sale of excess electricity into the grid
- Design roof surfaces to accommodate future PV installations

Moderately Recommended

Ground-coupled systems

- Use earth sheltering
- Use earth tubes to preheat or pre-cool ventilation air
- Use ground-source heat pumps as a source for heating and cooling
- Use surface water as a sink for direct cooling
- Use deep well water as a sink for direct cooling
- Use surface water as a sink for mechanical cooling

Other alternative sources

- Develop or take advantage of district heating

Recommended Water Strategies

Landscaping and Water Use

Strongly Recommended

Xeriscaping—planting for low water use

- Convert turf areas to native ecosystem
- Select plants for drought tolerance
- Arrange plantings in groups according to water needs
- Improve soil quality to increase water retention
- Use mulch to improve water retention
- Utilize non-plant landscaping

Irrigation

- Recycle greywater for landscape irrigation
- Use water-efficient irrigation fixtures

Moderately recommended

Irrigation

- Use appropriate grading to retain irrigation and reduce runoff
- Use automatic controls to improve efficiency and effectiveness of irrigation system
- Use a moisture meter to control outdoor irrigation

Plumbing/Fixtures and Water Use

Strongly Recommended

Keeping waste separate from water

- Use composting toilets
- Specify waterless urinals

Low-water-use fixtures

- Use low-flow toilets
- Use foot-pedal faucet controls
- Install faucet aerator on kitchen faucet
- Use automatic faucet controls for lavatories

Hot water delivery to fixtures

- Design floorplan to minimize length of hot water piping
- Insulate hot water pipes to reduce water waste during warm-up
- Size water supply pipes appropriately, assuming use of water-efficient fixtures

Moderately Recommended

Wastewater and greywater recycling

- Design buildings to use treated wastewater for non-potable uses

Hot water delivery to fixtures

- Specify on-demand hot-water recirculation system to avoid water waste
- Install point-of-use hot water heaters

General Water Uses

Strongly Recommended

Education

- Educate building management and employees about water conservation

Rainwater collection

- Collect and store rainwater for landscape irrigation

Controlling leaks

- Reduce excessive water delivery pressure

Moderately Recommended

Financial incentives

- Check for rebates on water-conserving fixtures and landscaping
- Check for rebates on water-conserving appliances

Controlling leaks

- Carry out careful water leakage audit and fix any leaks

Recommended Resources & Materials Strategies

Resource Efficiency and Resources & Materials

Strongly Recommended

Reduce material use

- Design and build for phased construction
- Determine whether varying functions can be accommodated in shared spaces
- Group or stack bathrooms and other water-using spaces
- Minimize space devoted exclusively to circulation
- Consider the use of structural materials that do not require application of finish layers

Longevity

- Provide to contractors (or require from designers) detailed and complete plans and specs
- Provide anchoring in exterior walls for future addition of intermediate stories
- Use materials and systems with low maintenance requirements
- Keep materials dry during construction
- Use landscaping and grading to divert water from the building
- Design and build components with constituent parts of equivalent longevity

Transporting materials

- Prefer materials that are sourced and manufactured within the local area
- Have materials transported by the most efficient means available

Moderately Recommended

Longevity

- Use an access floor to facilitate reconfiguring of spaces and cabling systems
- Implement or request of contractors a total quality management program such as ISO 9000
- Seek to engage subcontractors who are certified by recognized organizations

C&D waste management and Resources & Materials

Strongly Recommended

Job site recycling

- Investigate local infrastructure for recycling
- Seek a waste hauler who can separate recyclables out of commingled waste
- Require a waste management plan from the contractor
- Before concrete pours, designate locations or uses for excess concrete

Moderately Recommended

Job site recycling

- Designate a recycling coordinator
- Require weekly job-site recycling training
- Set up labeled bins to keep recyclable materials separate
- Require that subcontractors keep their wastes separate

Future Waste Minimization and Resources & Materials

Strongly Recommended

Reusable components

- Design for disassembly at end of life
- Build with reusable modular units
- Use materials with integral finish

Recyclable materials

- Facilitate recycling by avoiding materials with toxic components
- Use biodegradable materials

Recycling by occupants

- Specify recycling receptacles that are accessible to the occupants

Moderately Recommended

Reusable components

- Design with refinishable components

Recyclable materials

- Avoid composite materials to facilitate recycling
- Select products that manufacturers will take back for recycling
- Consider green leasing of materials and furnishings

Recycling by occupants

- Design a physical in-house composting system

Materials by CSI Division and Resources & Materials

Strongly Recommended

Division 2 – Sitework

- Enhance existing features in landscaping
- Use natural-fiber erosion-control mats
- Use geotextiles with high levels of recycled content
- Use retaining wall systems with high levels of recycled content
- Use porous pavement systems with high levels of recycled content

Division 2 – Site furnishings

- Use living fencing
- Avoid conventional preservative-treated wood
- Use recycled-plastic benches or picnic tables
- Use recycled-plastic wheel stops and speed bumps
- Specify tree grates with high recycled content

Division 2 – Landscaping

- Use organic compost
- Specify mulch made from post-consumer waste
- Specify landscape ties, headers, edgers of recycled plastic
- Specify recycled-content pipe for irrigation

Division 3 – Concrete

- Use reusable forms
- Replace up to 30% of the cement in concrete with flyash
- Specify vegetable-based form-release oil

Division 4 – Unit masonry

- Use clay brick made from contaminated soil or industrial waste products

Division 5 – Metals

- Specify aluminum products made from high levels of recycled scrap
- Use the most efficient section to optimize material use
- Specify heavy steel framing with highest recycled content
- Design to avoid thermal bridging when using light-gauge steel for building shell

Division 6 – Wood

- Choose naturally rot-resistant wood species for exposed applications
- Avoid endangered wood species and species from sensitive habitats
- Use wood products from independently certified, well-managed forests for rough carpentry
- Use salvaged wood for rough carpentry
- Use trusses for roofs and floors
- Use wood products from independently certified, well-managed forests for finish carpentry
- Use salvaged wood for finish carpentry
- Avoid wood products made with urea-formaldehyde binder
- Use agricultural-waste-fiber panels for millwork and interior finish

Division 6 – Plastics

- Specify recycled wood-plastic composite lumber to substitute for preservative-treated wood
- Specify recycled-plastic lumber as a substitute for preservative-treated wood

Division 7 – Insulation

- Avoid rigid foam insulation made with HCFCs
- Avoid sprayed-in foam insulation made with HCFCs
- Protect workers from exposure to glass fibers

Division 7 – Roofing & Siding

- Prefer the most durable roofing material
- Ensure that flashing details are as durable as the roofing
- Select a roofing system that allows the membrane to be replaced without replacing insulation

Division 8 – Windows

- Optimize energy performance of glazing systems
- Choose frame and sash materials with low thermal conductivity
- Select durable window assemblies
- Use pan flashing under all windows

Division 8 – Doors

- Select insulated doors for optimal thermal performance

Division 9 – Flooring & floor coverings

- Specify wood flooring from independently certified forestry operations
- Specify salvaged flooring or flooring from salvaged wood
- Ensure that concrete slabs are dry before installing flooring
- Use a solvent-free, water-resistant adhesive recommended by manufacturer
- Avoid carpet in areas that are susceptible to moisture intrusion
- Avoid urea-formaldehyde-based underlayment
- Avoid lauan plywood underlayment
- Specify carpet made with recycled-content face fiber
- Specify carpet tiles made with recycled-content backing
- Specify carpet tiles that can be resurfaced for reuse
- Use only very-low-VOC carpet adhesives
- Use hook-and-loop tape rather than adhesives

Division 9 – Paints & Coatings

- Specify zero-VOC interior latex paints
- Specify recycled paint
- Maximize direct-to-outdoors ventilation when applying paint

Division 10 – Specialties

- Use plastic toilet partitions made from recycled plastic

Division 16 – Electrical

- Size electrical cables appropriately
- Specify only low-mercury fluorescent lamps

Moderately Recommended

Division 2 – Sitework

- Minimize width of roadways

Division 2 – Landscaping

- Use imported fill or topsoil from nearest available source
- Specify mulch made from materials removed during sitework

Division 3 – Concrete

- Save lumber from forms for reuse in framing and sheathing
- Use precast structural concrete components
- Use recycled materials as aggregate in the concrete

Division 5 – Metals

- Seek alternatives to aluminum
- Use salvaged steel members
- Use light-gauge steel for interior partitions

Division 6 – Wood

- Use wood treated with less-toxic preservatives than the standard CCA or ACZA
- Use engineered wood products for rough carpentry
- Use engineered wood products for finish carpentry
- Seal all surfaces of composite woodwork made with urea-formaldehyde-based binders

Division 7 – Insulation

- Prefer formaldehyde-free batt insulation
- Prefer insulation with high recycled content

Division 7 – Roofing & Siding

- Prefer roofing materials with high levels of recycled content
- Prefer recyclable roofing materials
- Consider using hardboard siding

Division 7 – Sealants

- Use dry adhesive tape instead of wet sealants where feasible

Division 8 – Windows

- Choose frame and sash materials made from recycled materials

Division 9 – Wall & ceiling finishes

- Use wallboard from manufacturers that utilize gypsum from job-site scraps
- Use gypsum board made with higher percentages of synthetic gypsum
- Specify gypsum wallboard from suppliers that take back scrap for recycling
- Use site-mixed rather than premixed joint compounds

Division 9 – Flooring & floor coverings

- Specify prefinished wood or bamboo flooring
- Specify bamboo flooring instead of hardwood
- Specify floor tiles with recycled content
- Use true linoleum flooring
- Use natural cork flooring
- Use recycled-content vinyl flooring
- Avoid adhering carpet directly to concrete floor
- Wait three or more days after painting to install carpet
- Specify natural fiber carpets
- Specify carpet from manufacturers who will recycle used carpet

Division 9 – Paints & Coatings

- Specify paints made from plants and minimally processed minerals

Division 15 – Mechanical

- Run air ducts only to interior of each room, not to building perimeter

Recommended Indoor Environmental Quality Strategies

Control of Outdoor Pollution and Indoor Environmental Quality

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Strongly Recommended

Avoiding pollution sources

- Locate building away from sources of pollution
- Research previous uses of the site
- Use least-toxic pest-control before and during construction

Preventing entry of pollutants

- Locate outdoor air intakes away from pollution sources
- Seal openings in building envelope and interstitial spaces to control migration of contaminants
- Design so that it is easy to prevent soil gas entry
- Check for and minimize radon within the structure
- Design entry to facilitate removal of dirt before entering building
- Avoid carpet and other hard-to-clean floor surfaces near entry

Comfort and Indoor Environmental Quality

Strongly Recommended

Thermal comfort

- Use glazing with a low Solar Heat Gain Coefficient
- Maintain relative humidity levels between 30% and 60%
- Provide occupants with the means to control temperature in their area

Visual comfort – building envelope features

- Orient the floor plan on an east-west axis for best control of daylighting
- Use large exterior windows and high ceilings to increase daylighting
- Use skylights and/or clerestories for daylighting
- Incorporate light shelves on the south facade

Visual comfort – interior features

- Design open floor plans to allow exterior daylight to penetrate to the interior
- Use low partitions near the exterior glazing to promote daylight penetration
- Install large interior windows to allow for the transmission of daylight
- Locate floor openings under skylights to increase daylight penetration
- Place primarily unoccupied spaces away from daylight sources

Visual comfort – Internal light sources

- Use electronic ballasts with fluorescent lighting
- Provide occupants with control of light in their area
- Provide illumination sensors

Acoustical comfort – Managing occupant noise

- Specify acoustically absorbent materials to lower reflected noise levels
- Use moving water to create a pleasant acoustic environment

Acoustical comfort – Managing mechanical system noise

- Select and install mechanical equipment based on specific (low) sound level targets
- Use transfer grills only when acoustic transmission is not an issue
- Seal air passages in partitions and ceilings, and around doors

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Moderately Recommended

Thermal comfort

- Use glazing with a minimum U-value of 0.33 when occupants will be adjacent to windows

Visual comfort – building envelope features

- Choose interior and exterior glazing to maximize daylight transmission

Visual comfort – interior features

- Select only white to midrange finishes to maximize reflectance of light
- Maintain a ratio no greater than 10 to 1 between brightest and darkest visible surfaces

Acoustical comfort – Controlling outdoor noise

- Install acoustical glazing to reduce sound transmission
- Consider exterior noise when designing for operable windows

Acoustical comfort – Managing occupant noise

- Minimize sound transmission between rooms with appropriate detailing and material densities

Acoustical comfort – Managing mechanical system noise

- Control noise with large-volume, low-velocity air systems instead of lined ducts

Ventilation and Air Distribution and Indoor Environmental Quality

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Strongly Recommended

Ventilation and filtration systems

- Provide occupants with access to operable windows
- Design for optimum cross-ventilation through window placement
- Specify ventilation rates that meet or exceed ASHRAE Standard 62-1999
- Locate airflow monitoring devices on the outdoor air side of air handling units

Managing pressure relationships

- Ensure that exhaust fans and air handlers do not depressurize building cavities or the soil
- Keep negative pressure in attached garages
- Avoid backdrafting by using sealed-combustion or power-vented combustion devices
- Enclose gas-fired HVAC/hot water systems and vent them to the exterior

Distribution systems

- Use duct mastic instead of duct tape
- Keep air supply and return vents clear of obstruction
- Specify external duct insulation rather than internal

Direct exhaust from high-source locations

- Provide local exhaust ventilation for rooms with high-emitting sources
- Designate a separate, well-exhausted smoking lounge if smoking is to be allowed

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Moderately Recommended

Ventilation and filtration systems

- Provide heat-recovery ventilation
- Design ventilation system to exchange both heat and humidity between incoming and outgoing air

Distribution systems

- Use hard-surface acoustic controls in ducts

Direct exhaust from high-source locations

- Install a quiet, effective fan in bathrooms
- Use special equipment for ventilating locations with high heat loads

Moisture Control and Indoor Environmental Quality

Strongly Recommended

Foundations – rainwater and groundwater

- Use foundation perimeter rainwater collection system to divert water from the building
- Prevent water migration from beneath slab-on-grade or below-grade floors
- Use landscaping and grading to divert water from the building

Foundations – humidity, condensation and water vapor

- Avoid use of linoleum and vinyl flooring over uncured concrete and below-grade slabs

Walls, roofs, doors, and windows – rainwater and groundwater

- Keep insulation and other construction materials dry
- Seal exterior walls and provide overhangs to prevent bulk water (rain) penetration

Walls, roofs, doors, and windows – humidity, condensation

- Design building envelope to avoid thermal bridging
- Use windows that provide R-2 or better over their entire surface
- Provide special envelope and mechanical detailing for high-moisture-source spaces
- Locate vapor retarding layers toward the interior or near the thermal center of the wall

Mechanical systems

- Design ductwork to allow access for cleaning
- Seal any ductwork running through unconditioned space with mastic
- Provide easy access to coils, filters, and drain pans
- Insulate outdoor air ducts in conditioned space

Moderately Recommended

Foundations – rainwater and groundwater

- Use drainage to lower the water table around the building

Pollution from Materials and Indoor Environmental Quality

Strongly Recommended

Identification

- Review the Material Safety Data Sheet when evaluating construction materials

Elimination

- Specify low-mercury fluorescent lamps
- Avoid products that may release mineral fibers
- Use finishes that are easy to clean using mild surfactants and water
- Use only non-solvent-based adhesives
- Use water-based wood finishes
- Avoid the use of adhesives when installing gypsum board

Reduction

- Avoid urea formaldehyde particleboard
- Use only very low or no-VOC paints
- Use only solvent-free floor finishes for wood and stone

Moderately Recommended

Identification

- Procure green-label-certified carpet
- Test carpets for VOC emissions or procure test results

Elimination

- Specify vegetable-based form-release oil for concrete forms

Reduction

- Apply a sealer to any panel products made with urea-formaldehyde

Construction, Commissioning, and Operations and Indoor Environmental Quality

Strongly Recommended

Absorption of pollutants

- Minimize exposure of textiles and uncoated paper to high VOC concentrations

Pollutant migration

- Ensure that materials containing mineral or glass fibers are properly installed and contained

Ventilation during construction

- Use adequate ventilation during installation and curing of thermal insulation
- Ensure good ventilation during high-VOC-source applications

- Provide adequate ventilation whenever construction activities are occurring in confined space
- Provide temporary filters on any permanent air-handling devices used during construction
- Purge the building of VOCs during furniture installation prior to move-in

Commissioning

- Commission the mechanical and electrical systems prior to occupancy

Maintenance

- When using water for cleaning, ensure that materials can dry quickly
- Avoid air handler designs that provide convenient but inappropriate storage space
- Design for easy access to HVAC components
- Specify routine maintenance for HVAC system and check performance of system
- Specify use of only nontoxic cleaning products
- Design isolated storage closet for cleaning and maintenance products

Facility policies

- Establish a problem reporting and resolution process
- Establish specific construction or renovation protocols for preventing future IAQ problems
- Use least-toxic pest-control strategies

Moderately Recommended

Absorption of pollutants

- Store gypsum board during construction in a well-ventilated area
- Warehouse carpet unrolled to allow airing
- Wait three or more days to install carpet and other furnishings after painting

Pollutant migration

- Minimize the generation of airborne particulates during construction

Facility policies

- Recommend a non-smoking policy for the building

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Appendix D

Site-Wide Metering Program at LANL

The main objective of the Site-Wide Metering Program is to measure electric, gas, water, steam, and other fuel commodities usages at the Laboratory. The guiding principles are:

- If we can measure it, we can manage it.
- If we can show the customers how much energy they are consuming and how much they are paying for it, they will have incentive to save energy.

The goal of the Site-Wide Metering program is to automate all meter readings; use the latest technology meters that will read and process electric, gas, and water meter data in the same meter; and transmit data via the local area network. As a by-product, the same real time energy use data and other technical data can be transmitted to the customers for their own use to manage their loads and to look at power quality.

FWO-UI is currently developing and evaluating installed metering systems from two competing manufacturers. The type of meters and network communications system will be similar to the type of meters and system that have been on the market for at least six to ten years and are currently being used in other facilities like Sandia National Laboratory, Intel, and Hewlett-Packard. The system will be completely automated, thus eliminating the need for meter readers, and minimize data transfer and handling. An automated utility billing system will be developed.

The meters and network system will be self-diagnostic and will not require maintenance except direct replacement of defective meters. No site calibration is required. The meters will have I/O modules for analog and digital inputs for metering of water, gas, and steam in the future.

The following is FWO-UI's plan to implement a site-wide metering program:

Strategy

1. Completely develop and evaluate working metering network systems in three different size and system configurations from two competing manufacturers. Utilize the meter manufacturer's Engineering Product and Technical Support to develop and design additional systems specific to applications at LANL.

   Funds will be used directly to purchase and install meters. Planning and supervision will be done by the Energy Manager/Electrical Engineer under FWO-UI's Energy Management Program.
2. Duplicate the systems developed in other priority areas starting with big energy users.
3. Network each system via local area network for remote readout, alarms, and controls by building groups and FM units. The LEDA project at TA-53, Material Science Bldg at TA-3, TA-48 Bldg.1, and TA-3-261 Otowi Building electric meters are now networked via local area network.
4. Develop the network system Lab-wide with two main client/server computer stations with options for any group user to install a client computer station for readout only and/or controls for load management or voluntary load shedding. (A client/server computer station is now installed at Utilities Group Bldg 481 and at the Power Plant.)
5. Develop a Web page for all customers to see their real time and historical energy use.
6. Develop customized automatic (programmed) utility billing system for all FMs.

Funding Plan

1. Budget $250K from special projects funds each year to purchase and install meters for a five-year metering program. Larger allocations will shorten the program to 3 or 4 years.
2. Utilize Utility's Capital Re-investment Funds savings from Energy Savings Retrofit Projects and ESPC projects.
3. Share part of the meter installation costs with the using groups.
4. Allocate a small percentage of the utility tax increase for metering.

Procurement Plan

1. Purchase meters through GSA pricing procurement.
2. Purchase start-up, training, and special installations directly from meter manufacturers.

Installation Plan

1. Meter installation will be done as part of the meter procurement by factory-authorized technicians and by the support services subcontractor under Special Projects' Work Orders. Installations will be done by buildings or group of buildings in coordination with the Facility Manager's staff.
2. Perform a few meter installations utilizing factory-authorized service technicians with the support services subcontractor support. The support services subcontractor will use this opportunity for on-the-job training on meter installations. A dedicated crew of two support services subcontractor electricians will be sent for meter installation training at the manufacturer's plant. After training, all meter installations will be done by this dedicated crew.
3. Installations of the communication wires, local area network gateway or telephone modems, and connection to the local area network bus will be done by the support services subcontractor in coordination with the Facility's Network Administrator.

Operations

1. FWO-UI's Energy Manager and Budget/Billing Staff will oversee the metering program functions.
    - Develop and test the metering program system configuration
    - Procure meters and issue work orders or purchase requests for installation
    - Provide technical support and field verification of meter locations and spaces being metered
    - Provide technical customer support for load management and energy savings
    - Provide temporary power profile metering and verify readings
    - Provide trending historical energy use data to the customers
2. FWO-UI's FM Implementation Team will perform the utility rate structuring and utility billing functions in coordination with BUS-3.
    - Support and interface with LANL accounting system
    - Analyze the existing utility metering data
    - Develop the billing recharge system for implementation by accounting (BUS-3)
    - Provide customer service to ensure that customers are being billed correctly, accurately, and billing allocations are reasonable and fair.
    - Ensure that correct and accurate data are delivered to the accounting systems in a timely manner
3. The Support Services Subcontractor will:
    - Implement and maintain the meter reading database
    - Ensure accuracy of all meter readings and timeliness of reporting
    - Respond to meter malfunction alarms
    - Inspect and verify meter installations and calibrations
    - Install new meters and temporary power profile metering, and replace old or defective meters
    - Maintain a record of all meter locations and the buildings or spaces being metered
4. Meter Standard

    The following are the LANL-approved electric meters:

    - PowerLogic Circuit Monitor SQ D Model No. 3020CM2350
    - IQ Analyzer Cutler-Hammer Model No. 6230

Appendix E

LEED Checklist

LANL GPP Building Example

Use this worksheet as a tool for determining the potential LEED score for a project. The points below are based on the score a typical LANL GPP Building might receive. For new projects, photocopy this sheet for planning discussions, and write over the top of the grayed out points. Points that end up in the question mark category can be moved in either direction when making a final decision about whether to pursue them.

Yes	?	No	LEED Criteria	Actions/Comments	Reference Chapter
			Sustaining Sites		
X			**Site Prerequisite: Erosion & Sedimentation Control** Meet EPA-BMP or local soil erosion standards with a sediment and erosion control plan, meeting the following objectives: prevent loss of soil during construction and prevent sedimentation of storm sewer or receiving streams and/or air pollution with dust and particulate matter.		4, 9
1			**Site Credit 1: Site Selection** Do not locate facility: 1. On prime farmland, 2. On land whose elevation is lower than 5 ft. above 100 year flood, 3. Land which provides habitat for species on the Federal/State threatened or endangered list, 4. Within 100 ft. of any wetland, or 5. On land which was public parkland without trade.		4
		1	**Site Credit 2: Urban Redevelopment** Increase localized density to conform to existing or desired density goals by utilizing sites that are located within an existing minimum development density of 60,000 sf/acre (2 story downtown development).	Not applicable to LANL sites.	–
		1	**Site Credit 3: Brownfield Redevelopment** Develop on a site classified as a Brownfield and provide remediation as required by EPA's Sustainable Redevelopment of Brownfields program requirements.	Not applicable to most LANL sites.	–
		1	**Site Credit 4.1: Alternative Transportation, Public Transportation Access** Locate building within ½ mile of a commuter rail, light rail, or subway station or ¼ mile of 2 or more bus lines.	Currently, only one bus line is available.	4, 5
1			**Site Credit 4.2: Alternative Transportation, Bicycle Storage & Changing Rooms** Provide suitable means for securing bicycles, with convenient changing/shower facilities for use by cyclists, for 5% or more of building occupants.		
		1	**Site Credit 4.3: Alternative Transportation, Alternative Fuel Refueling Stations** Install alternative-fuel refueling station(s) for 3% of the total vehicle parking capacity of the site. Liquid or gaseous fueling facilities must be separately ventilated or located outdoors.		
1			**Site Credit 4.4: Alternative Transportation, Parking Capacity** Size parking capacity not to exceed minimum local zoning requirements AND provide preferred parking for carpools or van pools capable of serving 5% of the building occupants, OR, add no new parking for rehabilitation projects AND provide preferred parking for carpools or vanpools capable of serving 5% of the building occupants.		

Yes	?	No	LEED Criteria	*Actions/Comments*	*Reference Chapter*
			Sustaining Sites, continued		
	1		**Site Credit 5.1: Reduced Site Disturbance, Protect or Restore Open Space** Limit site disturbance including earthwork and clearing of vegetation to: a) 40 ft. beyond the building perimeter b) 5 ft. beyond primary roadway curbs, primary walkways, and utility trenches c) 25 ft. beyond pervious paving areas that require additional staging areas to limit compaction in the paved area; OR, on previously developed sites, restore a minimum of 50% of the remaining open area by planting native or adapted vegetation.	Standard construction practices would have to be changed.	4, 9
	1		**Site Credit 5.2: Reduced Site Disturbance, Development Footprint** Reduce the development footprint (including building, utilities, access roads and parking) to exceed the local zoning's open space requirements for the site by 25%.	No local zoning requirements.	
	1		**Site Credit 6.1: Storm Water Management, Rate or Quantity** Implement a stormwater management plan that results in: No net increase in the rate and quantity of stormwater runoff from existing to developed conditions; OR, if existing imperviousness is greater than 50%, implement a stormwater management plan that results in a 25% decrease in the rate and quantity of stormwater runoff.		8
		1	**Site Credit 6.2: Stormwater Management, Treatment** Treatment systems designed to remove 80% of the average annual post development total suspended solids (TSS), and 40% of the average annual post development total phosphorous (TP), by implementing EPA-BMPs.		
	1		**Site Credit 7.1: Landscape & Exterior Design to Reduce Heat Islands, Non-roof** Provide shade (within 5 years) on at least 30% of non-roof impervious surface on the site, including parking lots, walkways, plazas, etc., OR, use light-colored/high-albedo materials (reflectance of at least 0.3) for 30% of the site's non-roof impervious surfaces, OR, place a minimum of 50% of parking space underground OR use open-grid pavement system (net impervious area of less than 50%) for a minimum of 50% of the parking lot area.		4, 5, 7, 8
1			**Site Credit 7.2: Landscape & Exterior Design to Reduce Heat Islands, Roof** Use Energy Star Roof-compliant, high-reflectance AND high emissivity roofing (initial reflectance of at least .65, 3-year-aged reflectance of at least .5, and emissivity of at least 0.9) for a minimum of 75% of the roof surface; OR, install a "green" (vegetated) roof for at least 50% of the roof area.	LANL roof specifications already meet these requirements.	
1			**Site Credit 8: Light Pollution Reduction** Do not exceed IESNA foot-candle level requirements as stated in the Recommended Practice Manual: Lighting for Exterior Environments, AND design interior and exterior lighting such that zero direct-beam illumination leaves the building site.	Already comply with New Mexico Night Sky Protection Act.	D, F
5	4	5	**SUBTOTAL FOR SUSTAINABLE SITES**		

Yes	?	No	LEED Criteria	Actions/Comments	Reference Chapter
			Water Efficiency		
1			**Water Credit 1.1: Water Efficient Landscaping, Reduce by 50%** Use high efficiency irrigation technology, OR, use captured rain or recycled site water, to reduce potable water consumption for irrigation by 50% over conventional means.	Can install landscaping without a permanent irrigation system	8
1			**Water Credit 1.2: Water Efficient Landscaping, No Potable Use or No Irrigation** Use only captured rain or recycled site water for an additional 50% reduction (100% total reduction) of potable water for site irrigation needs, OR, do not install permanent landscape irrigation systems.		
		1	**Water Credit 2: Innovative Wastewater Technologies** Reduce the use of municipally provided potable water for building sewage conveyance by at a minimum of 50%, OR treat 100% of wastewater on site to tertiary standards.		–
	1		**Water Credit 3.1: Water Use Reduction, 20% Reduction** Employ strategies that in aggregate use 20% less water than the water use baseline calculated for the building (not including irrigation) after meeting Energy Policy Act of 1992 fixture performance requirements.	This is easily achievable with waterless urinals and/or low flow faucets.	6
	1		**Water Credit 3.2: Water Use Reduction, 30% Reduction** Exceed the potable water use reduction by an additional 10% (30% total efficiency increase).		
2	2	1	**SUBTOTAL FOR WATER EFFICIENCY**		
			Energy and Atmosphere		
X			**Energy Prerequisite 1: Fundamental Building Systems Commissioning** Implement all of the following fundamental best practice commissioning procedures: ▪ Engage a commissioning authority. ▪ Document design intent and the basis of design documentation ▪ Include commissioning requirements in the construction documents. ▪ Develop and utilize a commissioning plan. ▪ Verify installation, functional performance, training and documentation. ▪ Complete a commissioning report.		10
X			**Energy Prerequisite 2: Minimum Energy Performance** Design to meet building energy efficiency and performance as required by ASHRAE 90.1-1999 or the local energy code, which ever is the more stringent.		6
X			**Energy Prerequisite 3: CFC Reduction in HVAC&R Equipment** Zero use of CFC-based refrigerants in new building HVAC&R base building systems. When reusing existing base building HVAC equipment, complete a comprehensive CFC phase-out conversion.		6

Yes	?	No	LEED Criteria	Actions/Comments	Reference Chapter
			Energy and Atmosphere, continued		
			Energy Credit 1: Optimize Energy Performance		6
			Reduce design energy cost compared to the energy cost budget for regulated energy components described in the requirements of ASHRAE Standard 90.1-1999, as demonstrated by a whole building simulation using the Energy Cost Budget Method:	LANL standard GPP building already exceeds ASHRAE 90.1-1999. 30% and perhaps higher is achievable.	

Yes	?	No	Level	New	Existing
2			1	**20%**	**10%**
2			2	**30%**	**20%**
	2		3	**40%**	**30%**
	2		4	**50%**	**40%**
		2	5	**60%**	**50%**

			Energy Credit 2: Renewable Energy		6
			Supply a net fraction of the building's total energy load (as expressed as a fraction of annual energy cost) through the use of on-site renewable energy systems.		

Yes	?	No	Level	Fraction
	1		1	**5%**
		1	2	**10%**
		1	3	**20%**

	1		**Energy Credit 3: Additional Commissioning**		10
			In addition to the Fundamental Building Commissioning prerequisite, implement the following: 1) Conduct a focused review of design prior to the construction documents phase 2) Conduct a focused review of the construction documents when close to completion 3) Conduct a selective review of contractor submittals of commissioned equipment 4) Develop a re-commissioning management manual 5) Have a contract in place for a near-warranty end or post occupancy review Items 1, 2, and 3 must be performed by a firm other than the designer.		
1			**Energy Credit 4: Ozone Depletion**		6
			Install building HVAC and refrigeration equipment and fire suppression systems that do not contain HCFC's or Halon.	Can specify chillers with R134a or 407C.	

Yes	?	No	*Energy and Atmosphere, continued*		
	1		**Energy Credit 5: Measurement and Verification** Comply with the long term continuous measurement of performance as stated in Option B: Methods by Technology of the U.S. DOE's International Performance Measurement and Verification Protocol (IPMVP) for the following: ■ Lighting systems and controls ■ Constant and variable motor loads ■ Variable frequency drive (VFD) operation ■ Chiller efficiency at variable loads (kW/ton) ■ Cooling load ■ Air and water economizer and heat recovery cycles ■ Air distribution static pressures and ventilation air volumes ■ Boiler efficiencies ■ Building specific process energy efficiency systems and equipment ■ Indoor water risers and outdoor watering systems.		6, 10
		1	**Energy Credit 6: Green Power** Engage in a two-year contract to purchase power generated from renewable sources that meets the Center for Resource Solutions (CRS) Green-e products certification requirements.	Green power is not available.	–
5	7	5	**SUBTOTAL OF ENERGY AND ATMOSPHERE**		
			Materials and Resources		
X			**Materials Prerequisite 1: Storage & Collection of Recyclables** Provide an easily accessible area that serves the entire building and is dedicated to the separation, collection and storage of materials for recycling including (at a minimum) paper, glass, plastics, and metals.		5
		1	**Materials Credit 1.1: Building Reuse, Maintain 75% of Existing Shell** Reuse large portions of existing structures during renovation or redevelopment projects. Maintain at least 75% of existing building structure and shell (exterior skin, excluding window assemblies and framing).	Does not apply to most new construction projects.	–
		1	**Materials Credit 1.2: Building Reuse, Maintain 100% of Shell** Maintain an additional 25% (100% total) of existing building structure and shell.		
		1	**Materials Credit 1.3: Building Reuse, Maintain 100% Shell & 50% Non-Shell** Maintain 100% of existing building structure and shell AND 50% of non-shell (walls, floor coverings, and ceiling systems).		
1			**Materials Credit 2.1: Construction Waste Management, Divert 50%** Develop and implement a waste management plan, quantifying material diversion by weight. Recycle and/or salvage at least 50% (by weight) of construction, demolition, and land clearing waste.	LANL is already doing this. Need to extend to contractors through contract language.	9

Yes	?	No	*Materials and Resources, continued*		
1			**Materials Credit 2.2: Construction Waste Management, Divert 75%** Recycle and/or salvage an additional 25% (75% total by weight) of the construction, demolition, and land clearing debris.	LANL is already doing this. Need to extend to contractors through contract language.	9
1			**Materials Credit 3.1: Resource Reuse, Specify 5%** Specify salvaged or refurbished materials for 5% of total building materials.		5, 7
		1	**Materials Credit 3.2: Resource Reuse, Specify 10%** Specify salvaged or refurbished materials for 10% of total building materials.		
1			**Materials Credit 4.1: Recycled Content, Specify 25%** Specify a minimum of 25% of building materials that contain in aggregate a minimum weighted average of 20% post-consumer recycled content material, OR, a minimum weighted average of 40% post-industrial recycled content material.	Achievable and required by Executive Order 13101.	5, 7
	1		**Materials Credit 4.2: Recycled Content, Specify 50%** Specify an additional 25% (50% total) of total building materials that contain in aggregate, a minimum weighted average of 20% post-consumer recycled content material, OR, a minimum weighted average of 40% post-industrial recycled content material.		
1			**Materials Credit 5.1: Local/Regional Materials, 20% Manufactured Locally** Specify a minimum of 20% of building materials that are manufactured regionally within a radius of 500 miles.	This is consistent with LANL directive for business development in northern New Mexico.	5, 7
		1	**Materials Credit 5.2: Local/Regional Materials, of 20% Above, 50% Harvested Locally** Of these regionally manufactured materials, specify a minimum of 50% that are extracted, harvested, or recovered within 500 miles.		
		1	**Materials Credit 6: Rapidly Renewable Materials** Specify rapidly renewable building materials for 5% of total building materials.		–
1			**Materials Credit 7: Certified Wood** Use a minimum of 50% of wood-based materials certified in accordance with the Forest Stewardship Council guidelines for wood building components including, but not limited to framing, flooring, finishes, furnishings, and non-rented temporary construction applications such as bracing, concrete form work and pedestrian barriers.	Achievable and required by Executive Order 13101.	5, 7
6	1	6	**SUBTOTAL OF MATERIALS AND RESOURCES**		

Yes	?	No	*Indoor Environmental Quality*		
X			**IEQ Prerequisite 1: Minimum Indoor Air Quality (IAQ) Performance** Meet the minimum requirements of voluntary consensus standard ASHRAE 62-1999, Ventilation for Acceptable Indoor Air Quality and approved Addenda.		6
X			**IEQ Prerequisite 2: Environmental Tobacco Smoke (ETS) Control** Zero exposure of nonsmokers to ETS by prohibition of smoking in the building, OR, by providing a designated smoking room designed to effectively contain, capture and remove ETS from the building.		6
1			**IEQ Credit 1: Carbon Dioxide (CO_2) Monitoring Control** Install a permanent carbon dioxide (CO_2) monitoring system that provides feedback on space ventilation performance in a form that affords operational adjustments, AND specify initial operational set point parameters that maintain indoor carbon dioxide levels no higher than outdoor levels by more than 530 parts per million at any time.	Direct Digital Controls (DDC) are already required. Incorporating CO_2 monitoring and feedback should not be difficult.	6
1			**IEQ Credit 2: Increase Ventilation Effectiveness** For mechanically ventilated buildings, design ventilation systems that result in an air change effectiveness (E) greater than or equal to 0.9 as determined by ASHRAE 129-1997. For naturally ventilated spaces demonstrate a distribution and laminar flow pattern that involves at least 90% of the room or zone area in the direction of air flow for at least 95% of hours of occupancy.		6
			IEQ Credit 3: Construction IAQ Management Plan Develop and implement an Indoor Air Quality (IAQ) Management Plan for the construction and pre-occupancy phases of the building as follows:		6, 9, 10,
1			**IEQ Credit 3.1: Construction IAQ Management Plan, During Construction** During construction, meet or exceed minimum requirements of the SMACNA IAQ Guideline for Occupied Buildings under Construction, AND protect stored on-site or installed absorptive materials from moisture damage, AND replace all filtration media immediately prior to occupancy. Filtration media shall have a MERV of 13.		
	1		**IEQ Credit 3.2: Construction IAQ Management Plan, Before Occupancy** Conduct a minimum two-week building flush-out with new filtration media at 100% outside air after construction ends and prior to occupancy, OR conduct a baseline indoor air quality testing procedure consistent with current EPA protocols.	Scheduling prior to occupancy may make this difficult to achieve.	

Yes	?	No	*Indoor Environmental Quality, continued*		
			IEQ Credit 4: Low-Emitting Materials Meet or exceed VOC limits for adhesives, sealants, paints, composite wood products, and carpet systems as follows:		5, 7
1			**IEQ Credit 4.1: Low-Emitting Materials, Adhesives & Sealants** Adhesives must meet or exceed the VOC limits of South Coast Air Quality Management District Rule #1168, AND all sealants used as a filler must meet or exceed Bay Area Air Quality Management District Reg. 8, Rule 51.		
1			**IEQ Credit 4.2: Low-Emitting Materials, Paints** Paints and coatings must meet or exceed the VOC and chemical component limits of Green Seal requirements.		
1			**IEQ Credit 4.3: Low-Emitting Materials, Carpet** Carpet systems must meet or exceed the Carpet and Rug Institute Green Label Indoor Air Quality Test Program.		
	1		**IEQ Credit 4.4: Low-Emitting Materials, Composite Wood** Composite wood or agrifiber products must contain no added urea-formaldehyde resins.		
1			**IEQ Credit 5: Indoor Chemical Pollutant Source Control** Design to minimize cross-contamination of regularly occupied areas by chemical pollutants: Employ permanent entryway systems (grills, grates, etc.) to capture dirt, particulates, etc. from entering the building at all high volume entryways, AND provide areas with structural deck to deck partitions with separate outside exhausting, no air recirculation and negative pressure where chemical use occurs (including housekeeping areas and copying/print rooms), AND provide drains plumbed for appropriate disposal of liquid waste in spaces where water and chemical concentrate mixing occurs.		5, 6
		1	**IEQ Credit 6.1: Controllability of Systems, Perimeter** Provide a minimum of one operable window and one lighting control zone per 200 sf for all occupied areas within 15 ft. of the perimeter wall.	Operable windows are not specified for LANL buildings.	5, 6
	1		**IEQ Credit 6.2: Controllability of Systems, Non-Perimeter** Provide controls for each individual for airflow, temperature, and lighting for 50% of the non-perimeter, regularly occupied areas.	Thermostats are typically provided for small numbers of offices (4-10), but not individually.	
1			**IEQ Credit 7.1: Thermal Comfort, Comply with ASHRAE 55-1992** Comply with ASHRAE Standard 55-1992, Addenda 1995 for thermal comfort standards including humidity control within established ranges per climate zone.		6

Yes	?	No	*Indoor Environmental Quality, continued*		
	1		**IEQ Credit 7.2: Permanent Monitoring System** Install a permanent temperature and humidity monitoring system configured to provide operators control over thermal comfort performance and effectiveness of humidification and/or dehumidification systems in the building.		6
1			**IEQ Credit 8.1: Daylight and Views, Daylight 75% of Spaces** Achieve a minimum Daylight Factor of 2% (excluding all direct sunlight penetration) in 75% of all space occupied for critical visual tasks, not including copy rooms, storage areas, mechanical, laundry, and other low occupancy support areas. Exceptions include those spaces where tasks would be hindered by the use of daylight or where accomplishing the specific tasks within a space would be enhanced by the direct penetration of sunlight.		5
	1		**"IEQ Credit 8.2: Daylight and Views, View for 90% of Spaces** Direct line of sight to vision glazing while seated from 90% of all regularly occupied spaces, not including copy rooms, storage areas, mechanical, laundry, and other low occupancy support areas.		
9	5	1	**SUBTOTAL OF IEQ**		
			Design Process and Innovation Points		
	4		**Innovation in Design Credit 1.1 - 1.4:** Up to four points available.	Example: Give trailers to contractor in value for clearing utilities.	
1			**Innovation Credit 2: LEED Accredited Professional** At least one principal participant of the project team that has successfully completed the LEED exam.		
1	4	0	**SUBTOTAL OF DESIGN PROCESS & INNOVATION**		
28	23	18	**TOTAL LEED SCORE**		

Platinum = 52+ points
Gold = 39-51 points
Silver = 33-38 points
Certified = 26-32 points

For additional details, please refer to the following resources on http://www.usgbc.org

- LEED Green Building Rating System
- LEED Credit Checklist
- LEED Documentation Requirements
- LEED Reference Package

Appendix F

Building Simulations

Using Computerized Energy Simulations to Design Buildings

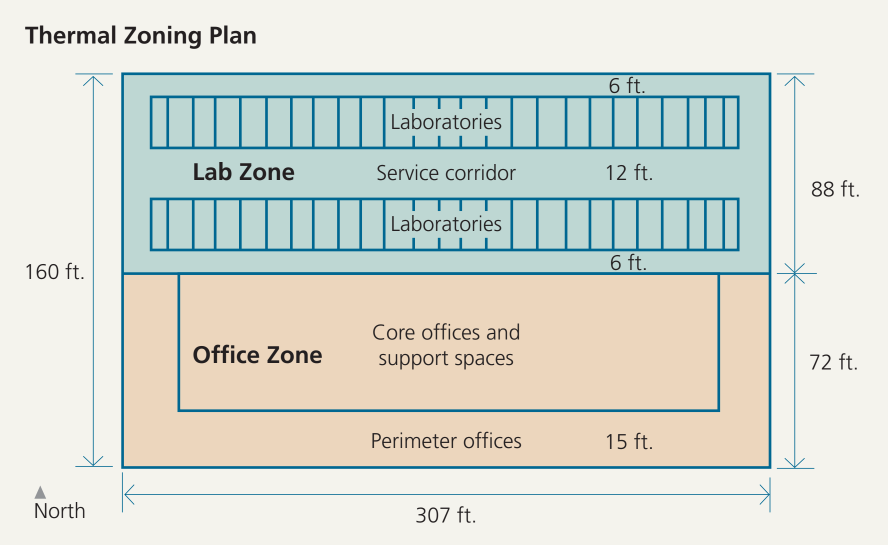
Computer simulation tools are an essential component of the whole-building design process. Designers depend on these tools to understand factors affecting the performance of the particular building they are designing, assist with decisions relating to building massing and adjacencies, determine the optimal combination of design solutions, predict the actual building performance, and identify performance problems after construction and commissioning are completed. To achieve these benefits, designers should begin depending on computer simulations of the proposed building early in the design process.

This discussion presents an example where a simulation-based energy design process (see Chapter 4) was applied beginning with the conceptual and schematic design for the Solar Energy Research Facility (SERF), a laboratory and office building located at the National Renewable Energy Laboratory in Golden, Colorado.

During pre-design, little if anything is known about the building geometry. As a result, designers simulated a very simple shape for the base-case building. To simulate the base-case building, designers only need to know the typical information available after preliminary architectural programming (see Chapter 2). Such information includes building type, size, location, utility rate structure, height constraints, square footage for different functions, special needs associated with various functions such as vibration, ventilation, and environmental control requirements for labs, types of equipment and processes to be housed in the various spaces, and so on. In this example, the base-case building is modeled as two zones—an office zone and a lab zone—to evaluate the very different load profiles for those major functions. Later in design, when more is known about building geometry, it will be necessary to model using more zones to ensure energy performance and comfort in all major spaces in the building.


Warren Gretz

The Solar Energy Research Facility, a 115,000-sq.ft. laboratory and office building at the National Renewable Energy Laboratory in Golden, Colorado.

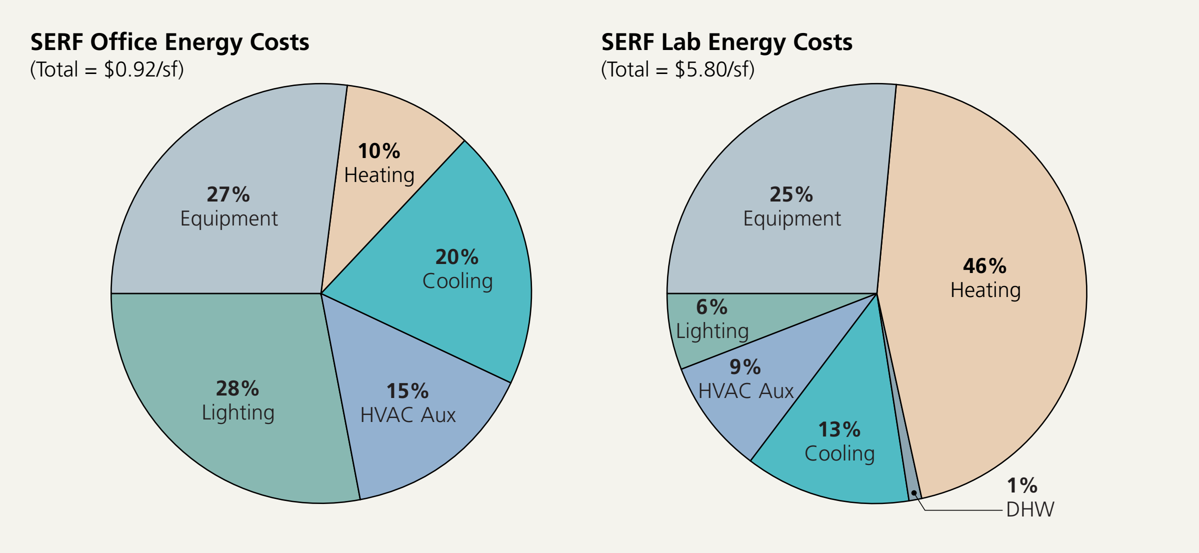


Simple base-case building schematic of the SERF. Designers described two zones, an office zone and a lab zone, to evaluate the very different load profiles for those major functions.

The annual predicted area normalized energy cost for the energy code compliant base-case building representing the SERF shows that in the office spaces, lighting, equipment, and cooling are the dominant loads. In the lab spaces, heating and lab equipment are the dominant loads. Also, it is noteworthy that total energy costs in the lab spaces are about six times those in the office spaces. It is evident from these data that the energy issues are very different for the offices and labs, and that there will be profound energy implications associated with various architectural strategies. Thus, an architectural concept that organizes office and lab space together in close proximity (often the preference of the scientists) will require much more energy then a concept that divides these functions into separate zones.

In addition, zoning the labs separately from the offices offers opportunities to further address the very different energy issues of these spaces through both architectural and mechanical interventions. Once a detailed hourly annual simulation is completed for the base-case building, it is possible to explore hourly patterns on typical seasonal days and evaluate summer and winter peak energy loads. It is also possible to disaggregate the loads into component loads such as ventilation loads, solar loads through windows, heat transfer through envelope elements, latent and sensible loads, etc.

Charting the results of the base-case simulation analysis is a good starting point to show where to investigate further for additional design solutions. A deeper look at the simulation results for the SERF base-case building reveals that the major reason for the large heating loads is the large outside air requirement for air quality safety in the labs. Also, the hourly data indicate that the bulk of these heating loads occur on winter nights, thus ruling out simple passive or air-based solar heating strategies.



Annual predicted area normalized energy cost for SERF base-case building.

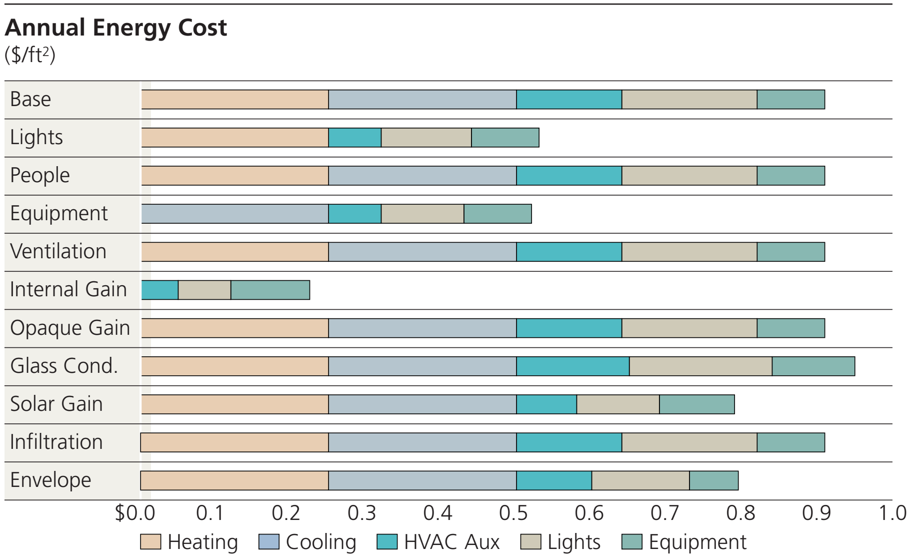
Office Spaces

- Daylighting to reduce electrical lighting and cooling loads.
- High-efficiency electric lighting where extensive daylighting is not possible.
- Architectural facade features, such as light shelves, to avoid direct-beam sunlight and maintain acceptable contrast ratios for visual comfort.
- Solar heat gain avoidance, such as properly sized external window shading devices and proper selection of glass optical and thermal properties. (Shading devices may be combined with light shelves where appropriate.)
- Occupancy and photo sensors to turn lights off when not needed.
- High-efficiency office equipment, such as flat-screen monitors and laptops with docking stations instead of desktop computers.
- Indirect/direct evaporative cooling.

Laboratory Spaces

- Exhaust air heat recovery because of the large outside air requirements (up to 12 air changes per hour in some labs).
- High-efficiency motors and variable speed motors because of the large pumping and fan power requirements.
- High-efficiency electric lights and occupancy sensors.
- Indirect evaporatively cooled water for removal of process heat from lab equipment and machines (provided by oversized cooling towers).
- High-efficiency chillers.
- Short direct duct runs to minimize pressure drop and fan power.
- Large diameter, low pressure ducts to minimize fan power.

One of the biggest benefits of an energy simulation is the ability to test various parameters on the overall building performance to see where the major savings may occur. If elimination of a load has little effect on the annual energy cost of the base-case building, then it is not worth trying to reduce that load in the design. For example, one parameter such as wall insulation can be set to an extremely high value to see if it would have a significant impact on the annual performance. The designer may determine that perhaps reducing the window solar heat gain coefficient might be more advantageous than doubling the wall insulation.



Elimination parametric study for the SERF office space. The first bar at the top shows the disaggregated annual energy costs of the base-case building. Each successive bar represents just one parametric change from the base-case building (except the bars labeled Internal Gain *and* Envelope*) and shows the annual energy costs after eliminating the load indicated by the labels on the y-axis. The bars labeled* Internal Gain *and* Envelope *represent the cumulative effect of eliminating all internal gain, and all envelope loads respectively.*

The parametric analysis for the SERF showed that eliminating ventilation loads has very little effect on the office base-case building, while eliminating lighting loads and equipment loads has a pronounced effect. Eliminating solar gains also has an important effect, indicating the value of designing in to reduce solar gain. A similar chart for the labs would show different sensitivities as one might expect.

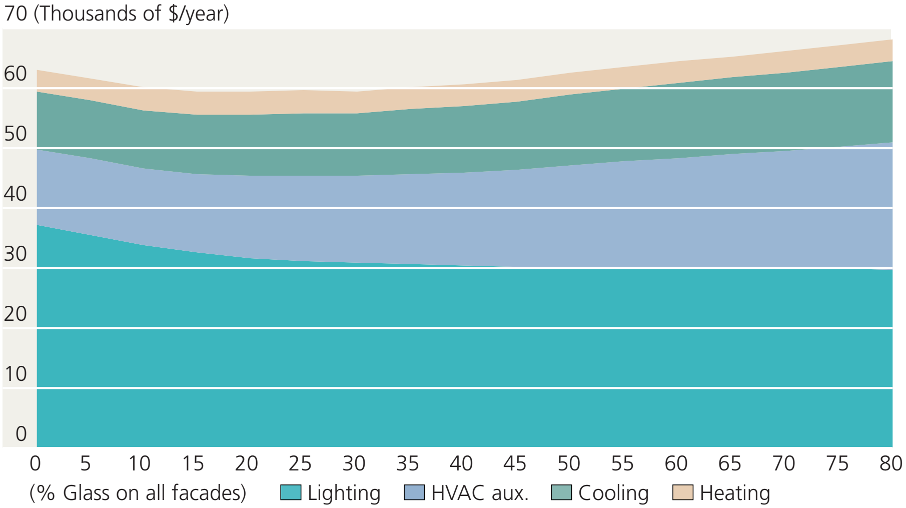
It is also helpful to use the simulation to explore comfort, as well as energy cost and energy use. The parametric analysis indicated that reducing glass conduction does not help annual energy cost. However, such a strategy may have a beneficial comfort effect for those people stationed near windows on the perimeter.

With this kind of information, it is possible for the design team to propose and test concepts for siting, orientation, massing, and overall architectural organization that hold promise for minimizing energy costs, loads, and peaks while maintaining comfort. Each alternative should be simulated as the geometry becomes more defined. In this way, the quantitative energy implications of the design decisions are known and can be used to select among alternatives.

Even though much of the overall architecture is now defined, many questions remain to be answered such as how much glass, what glass properties, and what geometry and size for shading devices and light shelves? Here again, the simulation assists in answering such questions quantitatively. For example, past a certain point when comparing building energy costs to total glass area, the decrease in lighting cost is offset by the increase in cooling and cooling fan costs. There is an optimum, and that optimum is frequently less than the glass area seen in many conventional buildings. Many architects are surprised at how little glass area it takes to daylight a building. This example does not tell the whole story. A number of such simulation runs would be needed to explore the interactions between orientation, glass area, glass type, shading device geometry, and light shelf geometry.

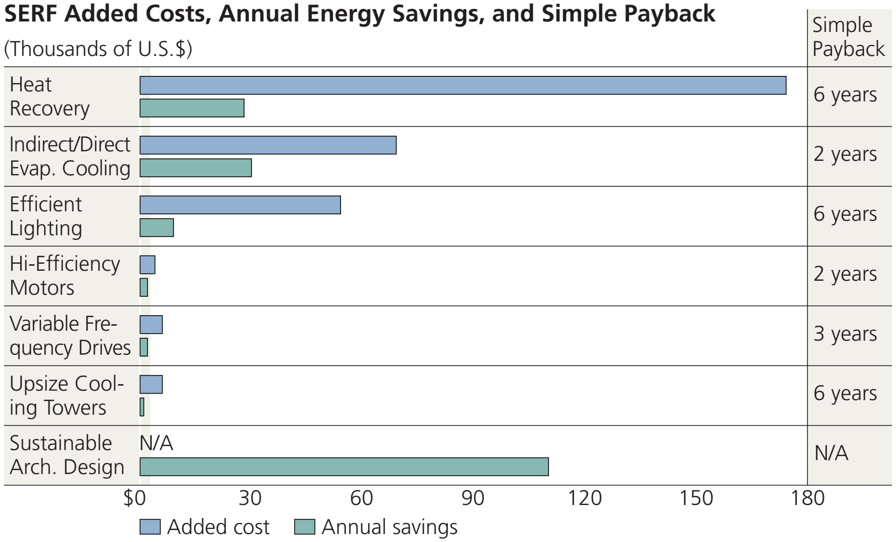
As the design progresses, the cost of construction versus the reduction in energy cost needs to be considered. The exact economic analysis approach depends

Glazing Area – Economic Analysis



Simulation results showing effect of glass area on annual energy costs. The figure shows the sum of annual heating, cooling, ventilation, and lighting costs on the y-axis as a function of the percent of glass area on all facades using low E-glass on the x-axis. Past about 15% to 30% glass, the decrease in lighting cost is offset by the increase in cooling and cooling fan costs.

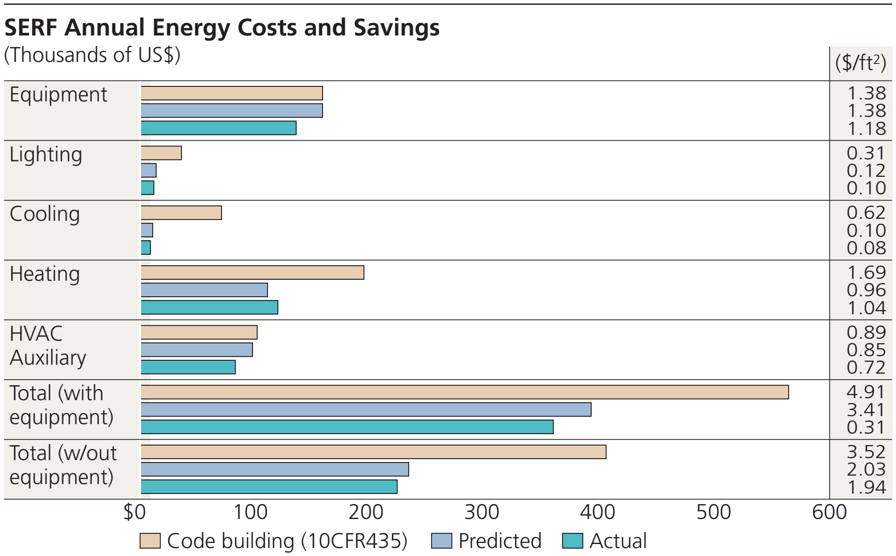
SERF Added Costs, Annual Energy Savings, and Simple Payback



Partial economic analysis for energy-efficiency strategies included in the SERF design on the client and may vary from simple payback to more sophisticated net present value or life-cycle cost analysis. If budgetary constraints become severe, such an analysis will help to determine which strategies deliver the most "bang for the buck."

With this kind of simulation-based quantitative approach to the energy design of buildings, it is possible to reduce energy cost and use far below that of typical code-compliant buildings. In the SERF example, actual savings compared to if the building had merely met code, are close to $2,000,000 from the time the building was first occupied. Predictions slightly underestimated the actual measured savings.

> The computer analysis should respond to the local utility rate structures and compare results based upon energy cost. Basing the analysis on energy units does not reflect variations in pricing such as time-of-use charges, demand charges, ratchet clauses, and other creative pricing structures developed by the utilities. While LANL currently benefits from a flat rate structure for electricity, this situation may change in the future. Another benefit of a full-year energy simulation is that it can be used to verify energy code compliance.



Annual energy cost comparison of the SERF between the simulated base-case building, the building design, and the actual building after almost 10 years of operation. The energy cost savings compared to the base-case building are 36% and 45% when including and excluding the equipment loads, respectively.

Building Energy Simulation Tools

A number of sophisticated computer simulation tools that can be used to design and analyze high-performance buildings. Several of these tools are discussed in this appendix.

Energy Plus

Energy Plus is the newest and most comprehensive of the public-domain building energy simulation programs under development by the U.S. DOE. The program combines the best aspects of DOE2 (described below) and BLAST in a flexible, object-oriented programming environment. As of this writing, the program does not have a friendly user interface; however, a number of private software houses are working on interfaces. The program combines calculation of loads, systems, plant, and controls in each time step thereby facilitating more accurate and flexible simulation of energy fluxes, temperatures, and control strategies.

DOE2

The DOE2 program is a large, detailed, public-domain energy-analysis program. It is available on a range of platforms from mainframes to desktop computers. The program can handle complex variables such as the orientation of surfaces, the order of materials in construction, thermal storage, ventilation effects, the intermittent operation of HVAC equipment, daylighting, and internal and external shading to name just a few. Hourly energy use and costs can be generated for an entire year or for partial year periods. It requires an hourly weather file and can accept a variety of weather data file formats. The main problem with DOE2, however, is the complex input language known as Building

Description Language (BDL). This cryptic input structure will take some time to master! Many private software vendors have developed friendlier user interfaces that simplify input by avoiding BDL but one still needs to know the fundamentals of DOE2 to understand what it is doing and how to read the input and output files. A number of private energy consultants specialize in energy modeling with DOE2 and other programs. It is advisable to require the use of such an energy consultant in the solicitation documents used to obtain architectural and engineering services at LANL.

DOE2 is structured in four components. The first component calculates the loads in the building loads. Detailed building description and location information is entered into the Loads component. The loads module then produces an hourly file of all building loads, which is then passed to the System section. "Systems" describes the thermal zones, controls, and HVAC systems, and calculates the response of the mechanical systems to the load along with zone temperatures and loads-not-met conditions. The third component is the Plant section, which defines the central equipment such as boilers and chillers. The final component is the Economic section, where utility and equipment cost information is defined. Each section has a wide range of structured output reports to track the energy performance of the building. The main advantage of DOE2 is that it has an extensive library of mechanical systems and can be used to model multi-zone buildings with complex mechanical systems and control strategies.

Energy-10

The Energy-10 software program was developed to meet energy-analysis needs of designers in the early stages of a project where critical decisions are made. The Windows-based program is appropriate for small to medium-sized building up to 10,000 square feet with one or two thermal zones. The companion manual "Designing Low-Energy Buildings," is a useful guide to using the program and provides a good overview of basic energy-saving strategies. The emphasis is on passive solar design techniques. The program can compare 16 energy-efficient strategies ranging from daylighting, thermal mass, and high-efficiency HVAC to evaporative cooling. It uses a local climate file and local utility information. The goal of the program is to provide the designer with a fast tool for comparing energy strategies early in the design process. The trade-off for speed and ease of use is a lack of flexibility for modeling more complex buildings and mechanical systems.

The basic structure of the program is to first create a predesign reference building using minimal inputs. The basic inputs include building location (weather file), utility rates, building use, HVAC system type, floor area, and number of floors. From this basic information, the program creates two buildings: one reference case and one low-energy case that includes selected energy-efficiency strategies. Graphical output shows the difference in thermal performance. While many defaults are applied in these early models, the user can adjust all defaults. The various passive solar strategies can then be applied to the low-energy case and a rank order of benefit can be produced. This helps to direct the designer's efforts to those strategies that will produce the greatest benefit. Design revisions can be applied to the model as refinements are made during the design process.

References

Building Energy Software Tools Directory, *www.eren.doe.gov/buildings/tools_directory*

DOE-2.1E, *http://SimulationResearch.lbl.gov*

Energy Plus, *www.eren.doe.gov/buildings/energy_tools/energyplus*

Energy-10, *www.SBICouncil.org*

Appendix G

Sun Path Diagram

A *sun path diagram* (or sun chart) is a two-dimensional representation of the three-dimensional movement of the sun across the sky for a particular latitude (see Figure 1). Sun charts can be used in conjunction with tools like a *profile-angle protractor* (Figure 5) to evaluate when a building or other feature will be shaded at different times during the year.

This appendix will explain how sun path diagrams and profile-angle protractors work, and will walk you through an example showing how these two tools can be used. Note that the sun path diagram will change depending on your latitude. This sun path diagram can be used for 36°N, which is the latitude of Los Alamos National Laboratory.

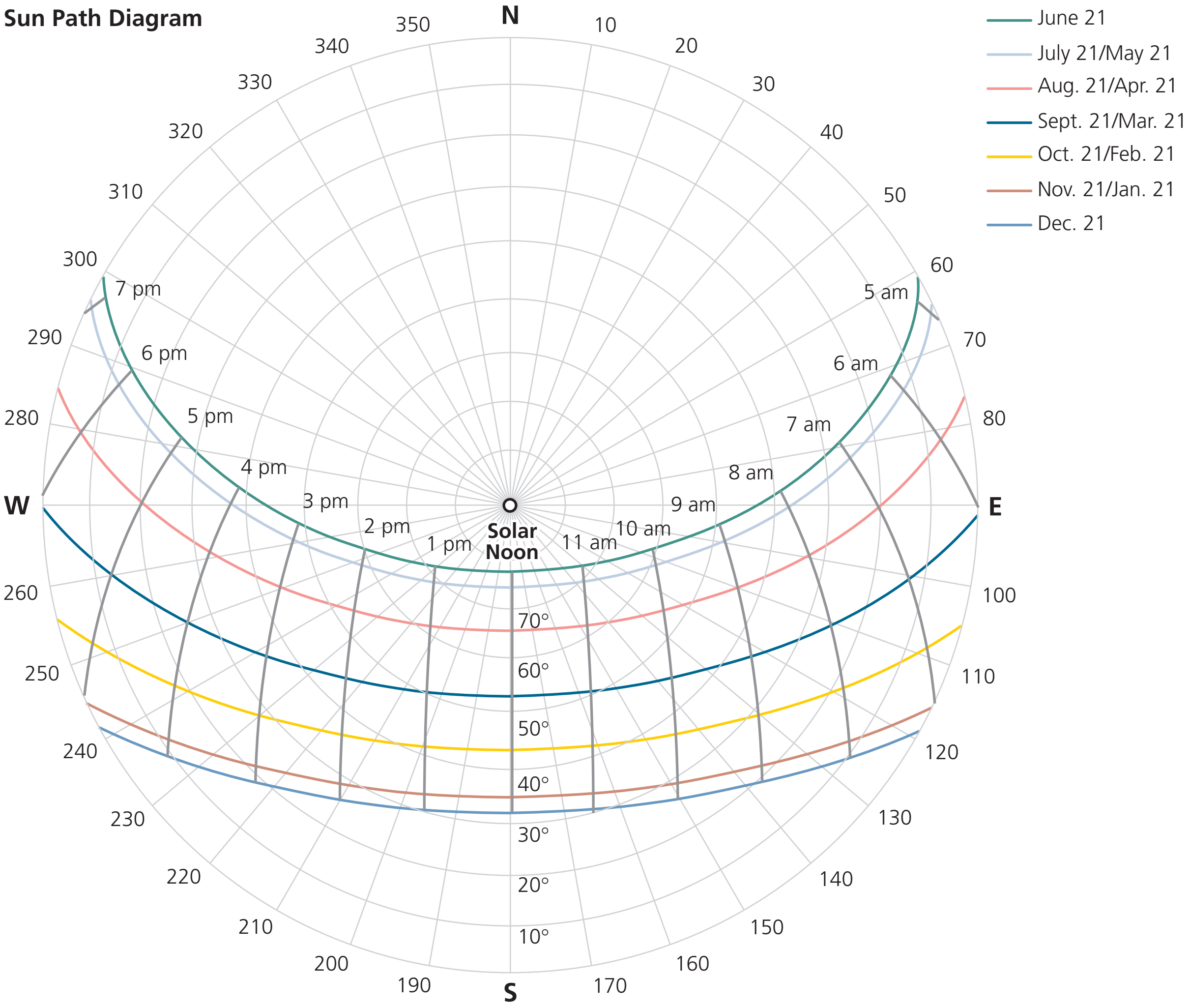


***Figure 1** – Sun Path Diagram for 36° N (Latitude of LANL)*

The three-dimensional diagram below can help you visualize the sun's path across the sky, and how that path is translated into two-dimensional space on a sun path diagram.

Picture yourself standing in a place with an unobstructed view of the horizon in all directions. The sky is a dome overhead, through which the sun arcs – and the angle that the arc makes with the horizon changes with the seasons. The horizon that you see is represented by the brown circle on the three-dimensional diagram; the sun's path is represented by the gray arcs. Note how the position of the sun's path changes through the year. The dashed brown lines are the projection of the gray arcs onto the two-dimensional space of the brown circle. Thus, the brown circle and the dashed lines form the sun path diagram – a two-dimensional, visual representation of the three-dimensional sky dome (Figure 1).

Note that the numbers on the gray arcs represent the sun's position at that particular time of day. θ is the vertical angle between the horizon and the sun (the solar altitude); θ here is shown for 2 p.m. on the Equinox. If you draw a vertical line from the sun's position at 2 p.m. on the Equinox, you can see how this sun position would plot on the sun path diagram. The angle b represents the solar azimuth as measured clockwise from south; the angle α is the solar azimuth as measured clockwise from north.

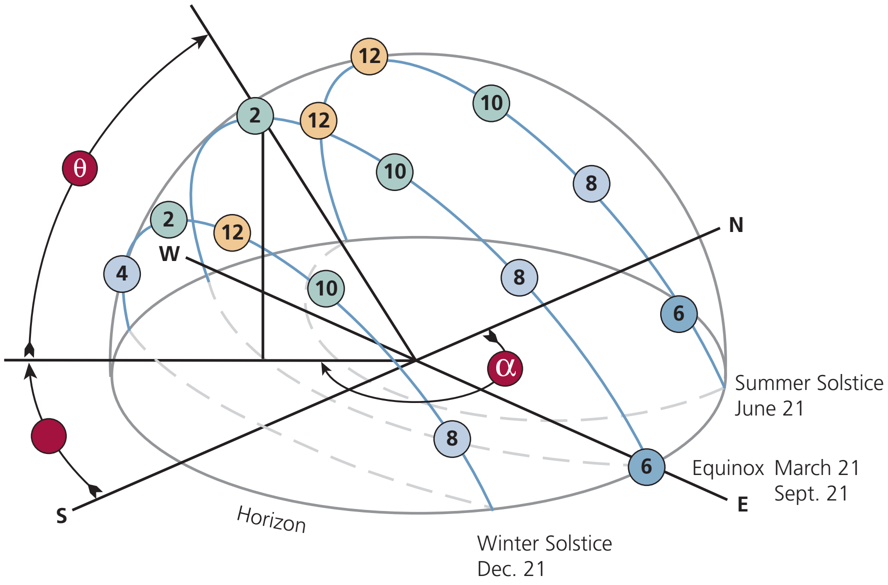


***Figure 2** – 3-Dimensional Diagram of the Sun's Path where*

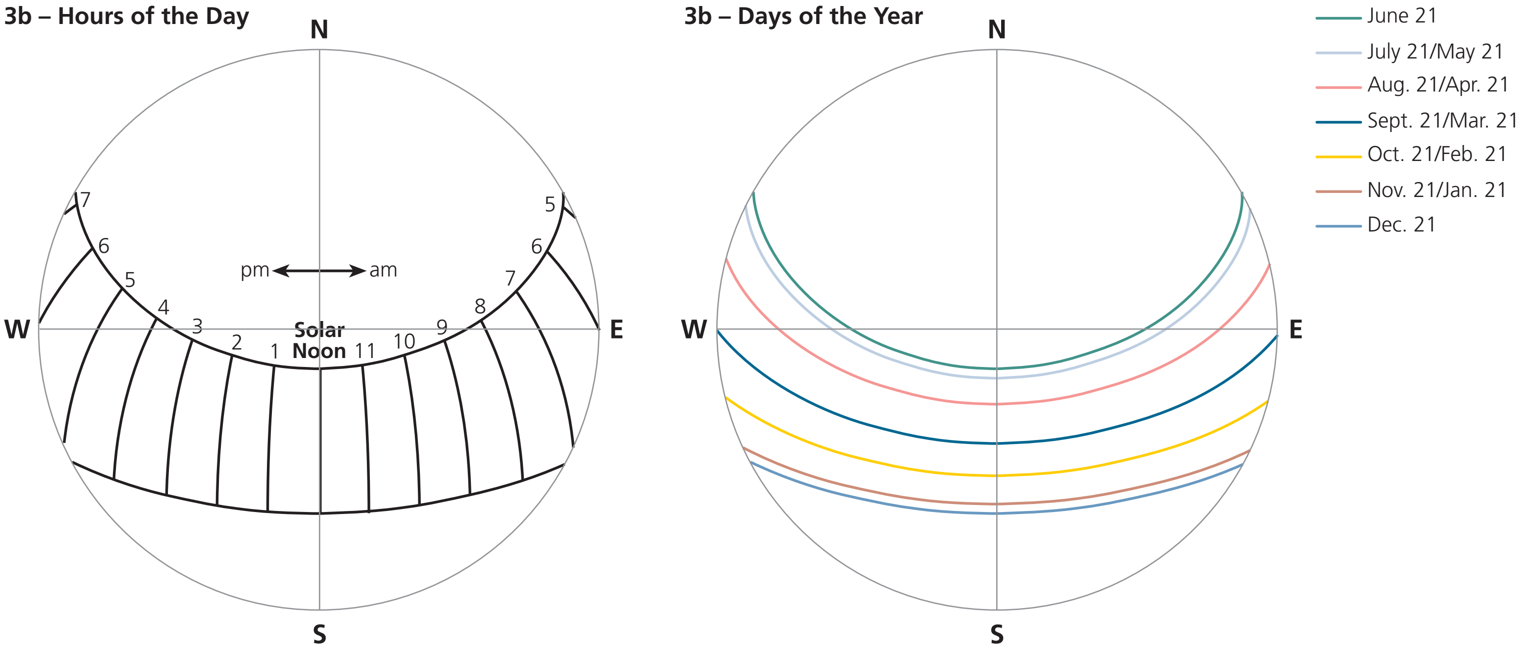
α = *solar azimuth, an angle between 0° and 360° measured from the north in a clockwise direction to the vertical plane of the sun*

β = *solar azimuth, an angle between 0° and 360° measured from the south in a clockwise direction to the vertical plane of the sun*

θ = *solar altitude angle, the vertical angle between the horizon and the sun. The concentric circles inside the Sun Path Diagram represent the angle* θ *(see Figure 1).*

② = *sun's position at the time of day indicated within the circle*

Now let's look at the way the sun moves across the sky, both daily and seasonally. You can see that trace of the sun's path is characterized by two types of motion on the diagram – horizontal and vertical. The vertical lines in Figure 3a show the seasonally changing position of the sun at a fixed time of day, while the horizontal lines in Figure 3b show the sun's daily movement through the sky at a fixed time of year. Thus, sun locations are plotted using the intersection of the horizontal and vertical arcs (i.e. at a particular time, at a particular time of year).



3b – Hours of the Day

3b – Days of the Year

Figure 3a, 3b *– Sun Path on the Sun Path Diagram for 36° N (Latitude of LANL)*

Now you can apply the information from Figures 1-3 to figure out where the sun would be at a specific date and time for this latitude (36°N). As an example, use the sun path diagram in Figure 4 to determine where the sun would be on December 21 at 9 a.m.; then find the compass location, the solar altitude angle θ, the solar azimuth angle α (measured from north), and the solar azimuth angle β (measured from south) for that sun position. To figure out where the sun would be, first locate the gray, horizontal arc representing the sun's path for December 21. Trace the path until it intersects the vertical line for "9 a.m." Now that your sun position is plotted (yellow dot), you can read the rest of the data directly off the chart. Your compass location is southeast; the solar altitude angle is about 18°; the solar azimuth angle α is about 138°; and solar azimuth angle β is about 318°.

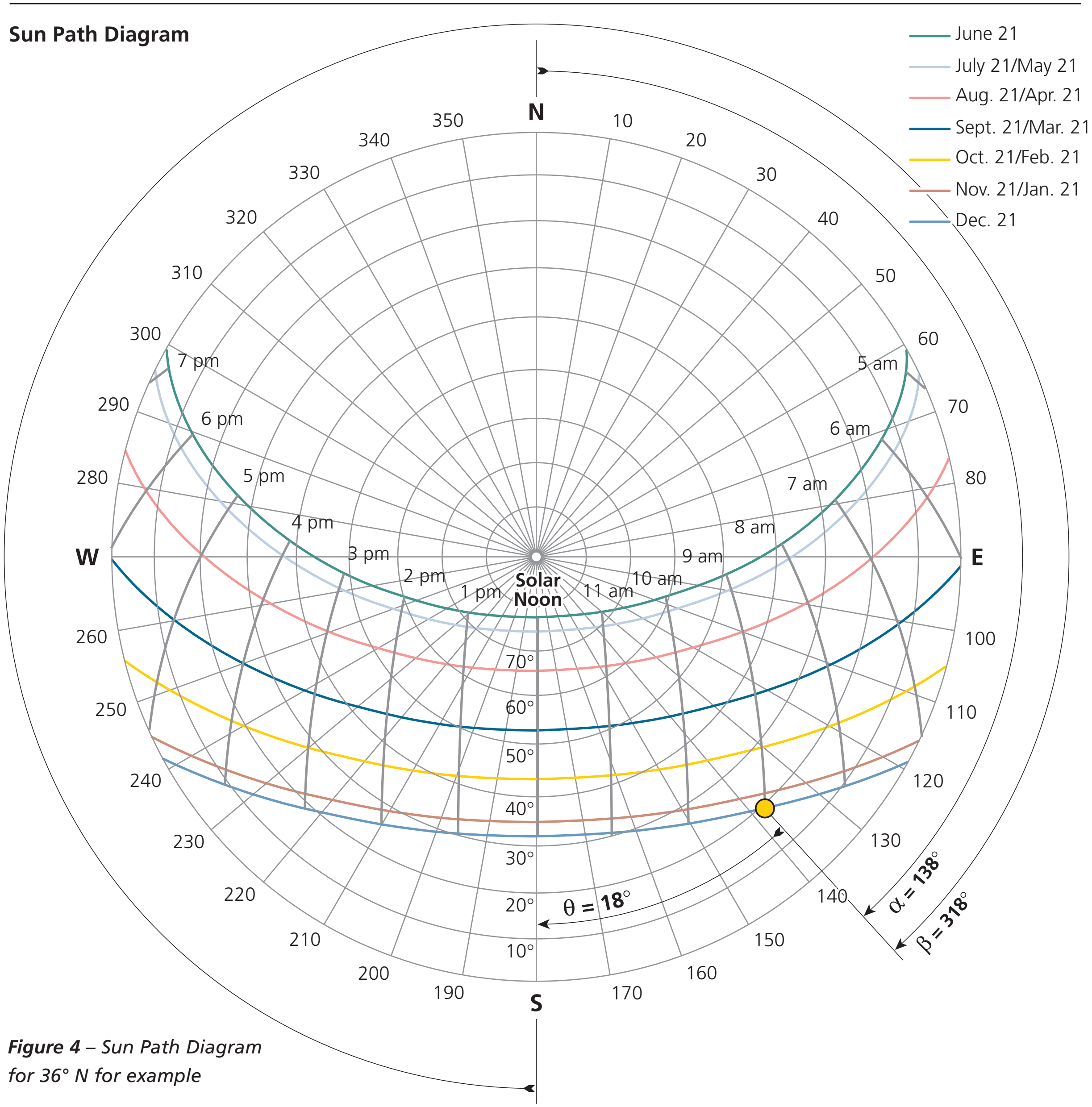


Figure 4 – Sun Path Diagram for 36° N for example

To figure out the shading on a building from another building, overhang, or other obstacles, you can use the sun path diagram in conjunction with a second tool – a profile-angle protractor (Figure 5). The profile-angle protractor overlays the sun path diagram by matching the diagram centers; the profile-angle protractor can then rotate on top of the sun path diagram.

Profile-Angle Protractor

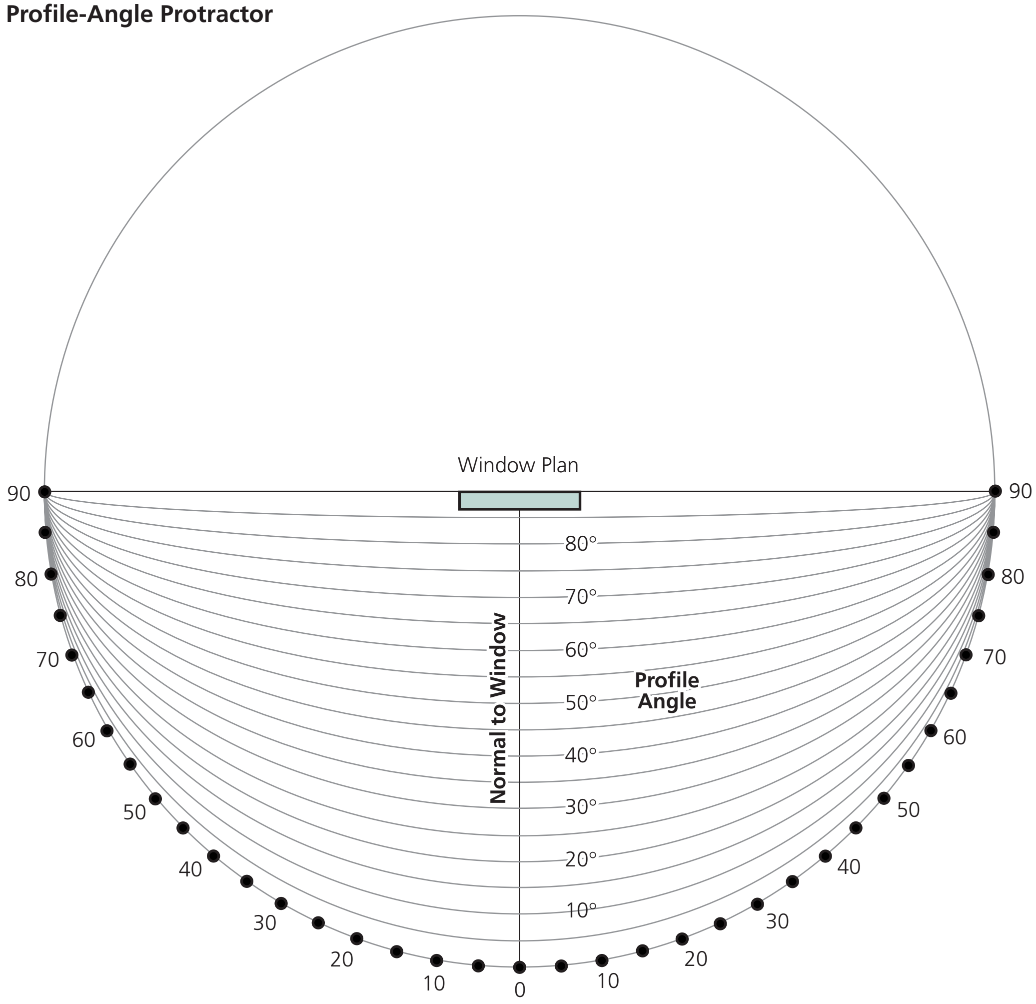


Figure 5 *– Profile-Angle Protractor*

Figures 6-8 provide an example of how to use a profile-angle protractor and a sun path diagram to determine when the wall below a window on one building is shaded by an adjacent building. Note that while the sun path diagram is specific to a particular latitude, the profile-angle protractor can be used for any latitude.

The window on building 1, which is located at 36°N latitude, faces 20° west of true south. We will determine the shading below point A, which is at the center bottom of the window. The plan and elevation views for both buildings are shown in Figure 6.

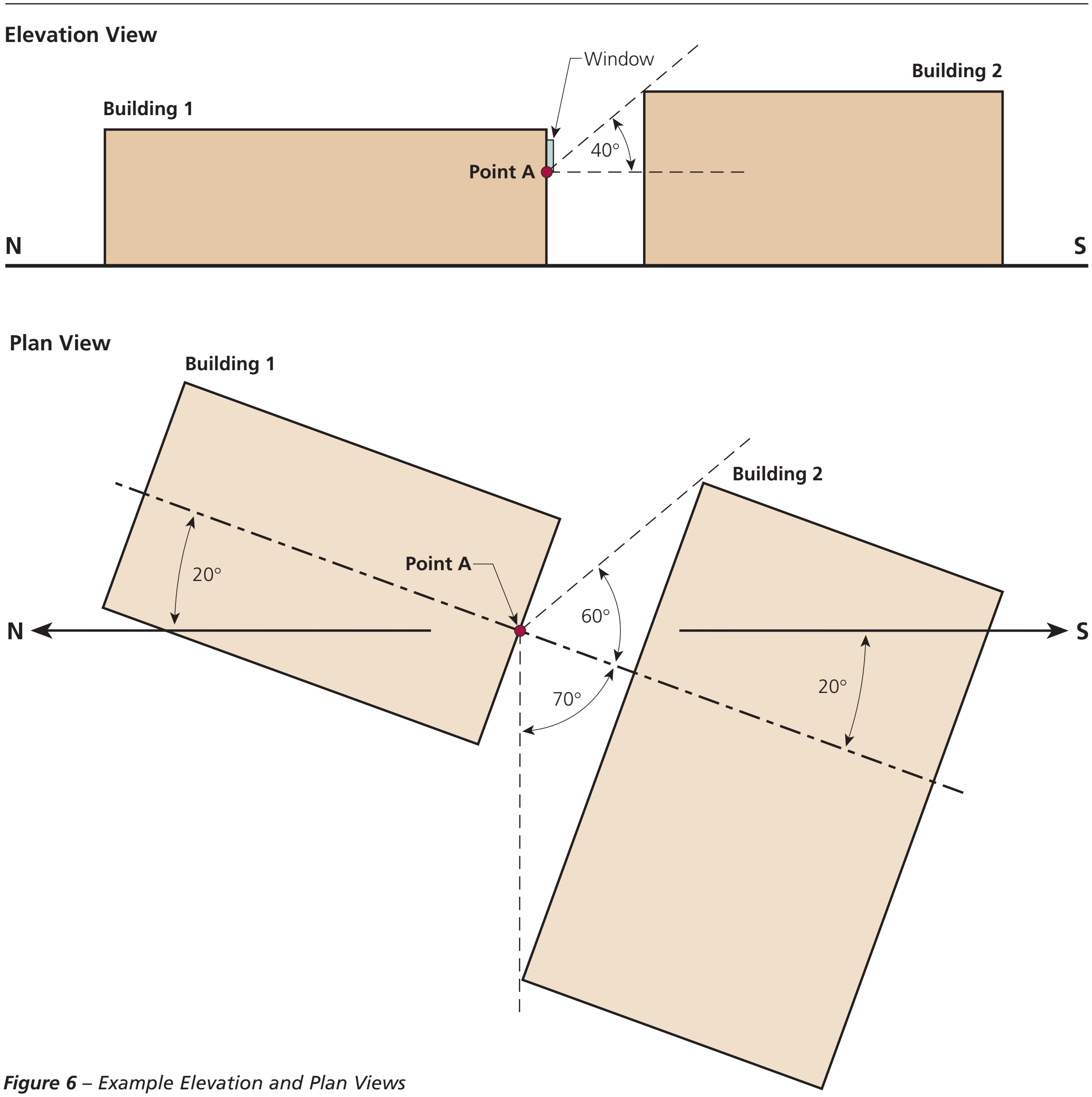


Figure 6 *– Example Elevation and Plan Views*

To prepare a map of the shading below point A (Figure 6), begin by drawing the window on the profile-angle protractor. Next, find the 40° line (which is the angle between point A and the top of building 2) on the protractor and darken it. Using a ruler, draw in the angles from point A to the corners of building 2. The angle on the right (east) will be 60° from the line that is normal to the window; the angle on the left (west) will be 70° from the line that is normal to the window. Building 2 will shade the wall below point A on building 1 when the profile angle is greater than 40°. Knowing this, you can now shade in the protractor (Figure 7).

Profile-Angle Protractor

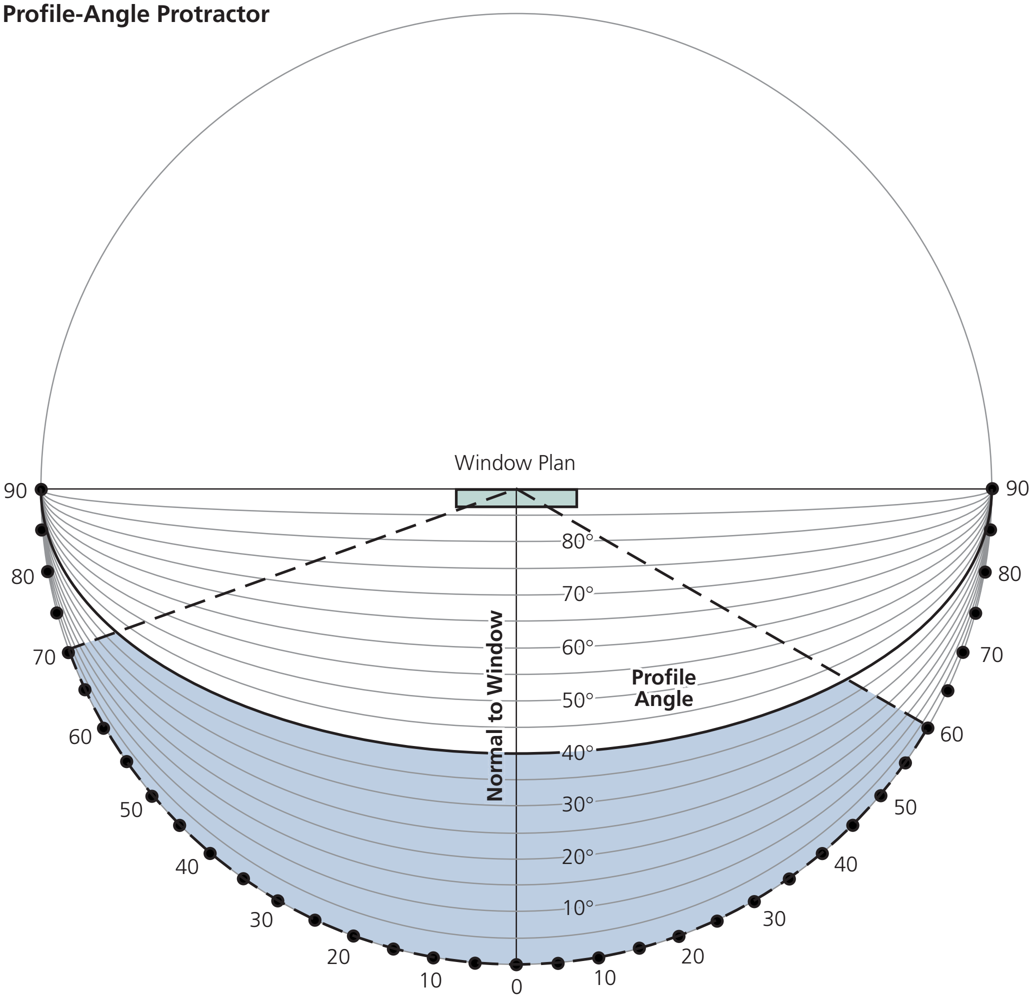


Figure 7 *– Shaded Profile-Angle Protractor*

We can now lay the profile-angle protractor developed in Figure 7 over the sun path diagram to determine the months of the year and hours of the day during which the wall below point A (Figure 6) will be shaded by building 2. First, align the protractor on top of the sun path diagrams by matching the center points of both circles. Second, rotate the profile-angle protractor so that the line that is normal to the window is aligned with the 200° line on the sun path diagram. The profile-angle protractor is rotated 20° west of south because the orientation of point A on the window of building 1 is 20° west of south. When the colored arcs (which represent sun paths for different times of the year) enter the shaded area, the building below point A will be in the shade (Figure 8).

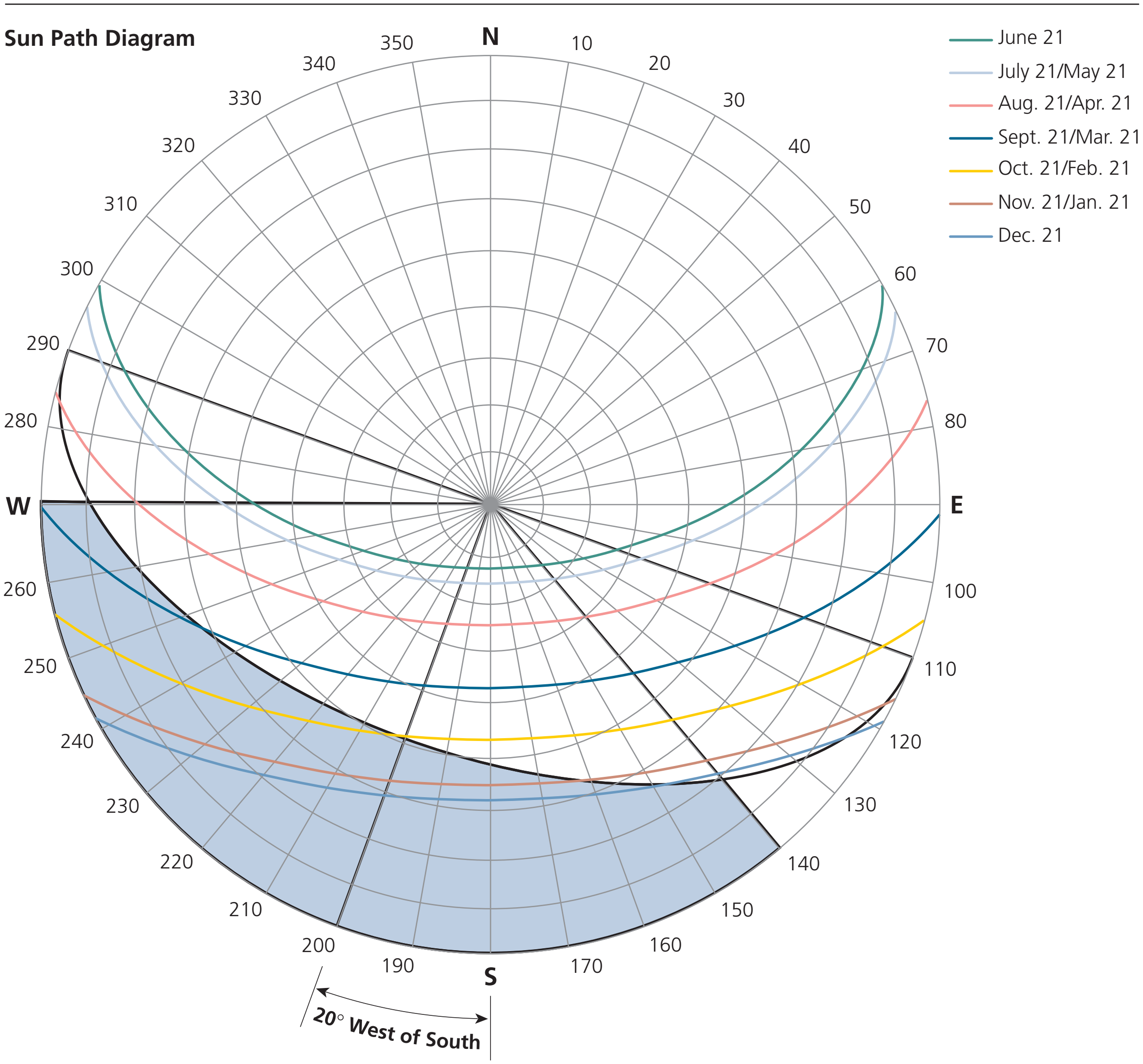


***Figure 8** – Profile-Angle Protractor Overlaid on a Sun Path Diagram (36° N)*

Appendix H

Reduce, Reuse, and Recycle Options

Reduce, Reuse, and Recycle Options for LANL Construction Waste

Potential Waste Materials	Segregate and Dispose	Reuse/Recycle	Waste Minimization
Asphalt	Stockpile in a designated area on-site. If known or suspected to be contaminated: ■ Segregate, label, and store hazardous waste in a <90 day storage area. ■ Segregate and label radioactive waste. Uncontaminated disposal at LA County Landfill or Rio Rancho Landfill (industrial waste). Radioactive waste disposal TA-54 Area G.	FWO-SWO Recycling Program Nambe Recycling Facility LA County Recycling Center LANL FWO- Utilities and Infrastructure (may accept crushed asphalt to meet its needs) Uncontaminated asphalt may be crushed and utilized as base course material.	Saw cut minimum perimeter of asphalt to be removed per construction drawings. Remove and segregate contaminated asphalt (if any) from recyclable (uncontaminated) asphalt.
Concrete	Stockpile in a designated area on-site. If known or suspected to be contaminated: ■ Segregate, label, and store hazardous waste in a <90 day storage area. ■ Segregate and label radioactive waste. Uncontaminated disposal at LA County Landfill or Rio Rancho Landfill (industrial waste). Radioactive waste disposal TA-54 Area G.	FWO-SWO Recycling Program Nambe Recycling Facility LANL FWO- Utilities and Infrastructure (may accept crushed asphalt to meet its needs) Uncontaminated concrete may be crushed and utilized as base course materiel	Remove only those areas indicated on the construction drawings. Remove and segregate contaminated concrete (if any) from recyclable (uncontaminated) concrete. Procure concrete in quantities consistent with the construction drawings and EPA Affirmative Procurement specifications.
Soil	Stockpile in a designated area on-site. If known or suspected to be contaminated: ■ Segregate, label, and store hazardous waste in a <90 day storage area. ■ Segregate and label radioactive waste. Uncontaminated disposal at LA County Landfill or Rio Rancho Landfill (industrial waste). Hazardous waste disposal at a Subpart C RCRA landfill. Radioactive waste disposal TA-54 Area G.	Use uncontaminated soil as fill at the construction site. FWO-SWO Recycling Program Nambe Recycling Facility	Remove per elevations indicated by the construction drawings. Remove and segregate contaminated soils (if any).

Table continues **>**

Reduce, Reuse, and Recycle Options for LANL Construction Waste

Potential Waste Materials	*Segregate and Dispose*	*Reuse/Recycle*	*Reduce*
Electrical Conduit/ Wire/Equipment	Stockpile in a designated area on-site. If known or suspected to be contaminated: ■ Segregate, label, and store hazardous waste in a <90 day storage area. ■ Segregate and label radioactive waste. Uncontaminated disposal at LA County Landfill or Rio Rancho Landfill (industrial waste). Radioactive waste disposal TA-54 Area G	LANL Equipment Salvage Program (BUS, Property Management). FWO-SWO Recycling Program	Remove and segregate reusable conduit and wire from equipment.
Wood	Stockpile in a designated area on-site and disposal at LA County Landfill.	FWO-SWO Recycling Program LA County Landfill – to be chipped.	Avoid use of wooden pallets for storage of construction materials. Minimize use of wooden framing and forming materials.
Paper Products (cardboard and paper)	Stockpile in a designated area on-site and dispose of at the LA County Landfill.	FWO-SWO Recycling Program Nambe Recycling Facility LA County Recycling Program	Procure construction materials and equipment in bulk to minimize packaging. Remove all possible packaging materials before entering controlled area to prevent generation of radiological waste.
Plastic (numbered containers, bags, and sheeting)	Stockpile in a designated area on-site and dispose of at LA County Landfill.	FWO-SWO Recycling Program Nambe Recycling Facility TEWA technology Corporation	Procure construction materials and equipment in bulk to minimize packaging. Remove all possible packaging materials before entering controlled area to prevent generation of radiological waste.
Metal (sheeting, ducting, fence, pipe, valves)[a]	Stockpile in a designated area on-site. If known or suspected to be contaminated: ■ Segregate, label, and store hazardous waste in a <90 day storage area. ■ Segregate and label radioactive waste. Uncontaminated disposal at LA County Landfill or Rio Rancho Landfill (industrial waste). Radioactive waste disposal TA-54 Area G.	LANL Metal Recovery Program: ■ Uncontaminated scrap lead, silver, cadmium, copper, tin, iron, brass, aluminum, stainless steel, mixed steel FWO-SWO Recycling Program Reuse pipe and valves at appropriate facilities.	Remove hazardous constituents from recyclable metals (e.g., remove lead-soldered wires from metal equipment).

[a] Note that metal debris released from radiological areas must comply with the metal recycling moratorium requirements contained in ESH Notice 0052.

Table continues **>**

Reduce, Reuse, and Recycle Options for LANL Construction Waste

Potential Waste Materials	*Segregate and Dispose*	*Reuse/Recycle*	*Reduce*
Paints, Stains, Solvents, and Sealant	Stockpile in a designated area on-site. If known or suspected to be contaminated: ■ Segregate, label, and store hazardous waste in a <90 day storage area. ■ Segregate and label radioactive waste. Uncontaminated disposal at LA County Landfill or Rio Rancho Landfill (industrial waste). Radioactive waste disposal TA-54 Area G.	Contractor should check with FWO waste management coordinators to see if excess materials may be used at the facility.	Procure non-hazardous substitutes to traditional solvents, paints, stains, and sealant (see "green seal" products at ***www.greenseal.org***). Procure only the materials that are needed (just-in-time purchasing). Sequence work to minimize waste generation through material use on successive tasks.
Equipment (pumps, instrumentation, fans)	Stockpile in a designated area on-site. If known or suspected to be contaminated: ■ Segregate, label, and store hazardous waste in a <90 day storage area. ■ Segregate and label radioactive waste. Uncontaminated disposal at LA County Landfill or Rio Rancho Landfill (industrial waste). Radioactive waste disposal TA-54 Area G.	LANL Equipment Salvage Program (BUS, Property Management). FWO-SWO Recycling Program	

ecycled paper.