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Climate

Introduction

As with any building project, climate has an enormous impact on building and site energy and water consumption, the potential for on-site electrical power generation, indoor environmental quality in terms of thermal comfort and daylighting opportunities, and the creation of protected outdoor environments as extensions of interior spaces. In order to assess the site-climate design potential designers, users, and building owners need to consider issues revealed by quantitative, scientific data of existing conditions, qualitative regional or microclimatic principles that optimize building form, organization, and materials based on this understanding, and simulations of future design alternatives. This paper discusses the relevant questions and requisite data in considering the role of regional and local climate in the design of the research office buildings for the Technology Park on the Cal Poly campus in San Luis Obispo, California.

Climate-based Inquiry

To consider a building and site as climate-adapted from its inception, a few questions need consideration at the beginning of the architectural programming and design process, such as:

To what extent can on-site solar, wind, daylight, and rainfall resources be utilized to offset imported (especially non-renewable) equivalents in building and site design?

What are the trade-offs of using on-site vs. off-site resources in terms of cost, comfort, or convenience within the design?

How are design priorities strengthened through climate-adaptive architecture? For example, exploring daylight strategies to achieve a well lit space using the bio-dynamics of indirect but changing light in place of static electric lighting.

What are the health and productivity benefits to occupants of using site-climate resources instead of mechanical systems and electric lighting?

How can the building and site design based on regional and local climate conditions be used to inform the building users about place-based, ecological design?

In order to provide a biogeographical context for these questions, an outline of climate interactions for a prototypical site on the Cal Poly campus are given here.

Geography and Climate Region

San Luis Obispo is located at approximately 35° 18' (35.31) North and 120° 39' (120.66) West longitude at an elevation of 330 ft above sea level[1]. The Köppen climate classification is "Csb": a Mediterranean climate with dry summers and mild, wet winters[2]. The California Energy Commission (CEC) climate zone classification is CZ5 for the area that includes the Cal Poly campus. This weather file is based on a combination of actual and ersatz data from Santa Maria, California as the representative city and is used for Title 24 energy compliance and energy modeling purposes.

Solar Resources

Sunlight availability for passive solar heating, solar hot water, and photovoltaics (PV) is excellent. Likewise, solar shading is essential to decrease building cooling requirements. Optimum strategies include direct gain (south windows with thermal mass), indirect gain (Trombe or water walls to the south when views are not critical and building cross section is not too deep), and roof ponds (for flat roofed structures or sloped roof with a sunspace like covering). Solar hot water systems can supply local domestic hot water and space heating if the project is not benefiting from the district heating of the campus Utilidor. Optimum tilt angle for photovoltaics is approximately 28 degrees from horizontal although simulation software should be run to optimize for the building electrical loads, time of day, and seasonal adjustments.

Wind Resources

The dominant wind direction is from the Northwest, with variations due to local terrain. Localized wind patterns created by topography, vegetation or other obstructions on the site (new or existing) can be evaluated either by rules of thumb[3] or using a low speed wind tunnel (available at UC Berkeley or UC Davis by arrangement).

Natural ventilation through cross or stack strategies are suitable to buildings in the region. Air quality issues due to proximity to roadways and agriculture may require filtration for the air stream before it enters the building.

It is unlikely that sufficient wind speed for wind turbines is available at this site that could otherwise be used for electrical generation. The campus has been investigated for wind energy potential and there are suitable sites in the surrounding area.

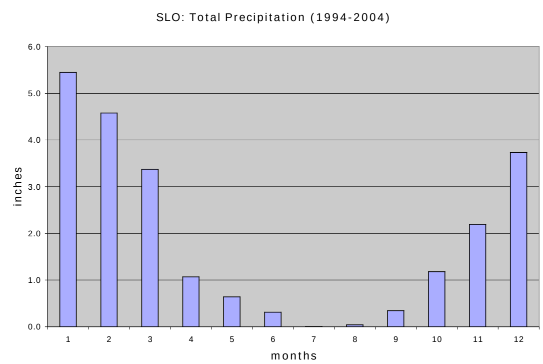
Daylight Resources

Clear sky conditions predominate the area. Altough coastal fog from Morro Bay may approach the campus along the Chorro Valley and Highway 1. This occurs during summer and early fall when hot air masses rising over the Central Valley draw coastal fog inland during many afternoons. Also low cloud formations occasionally occur over the region during the winter. Radiative fog (called "Tule fog" in the Central Valley) is rare for this area. Advective wind patterns often drive clouds to the top of the Santa Lucia and Irish Hills ranges encircling the campus where they stall and hover at the ridgelines with limited measurable effect on sky luminance conditions overhead.

Daylight strategies such as skylighting are excellent with proper shading controls to avoid excessive heat gain. Sidelighting with interior and exterior light shelves that differentiate vision and daylight glazing are also suitable strategies. Interior shades that allow lower glass to be blocked are desirable when computer screens (Video Display Terminals or VDT's) are in high use since sidelight can create glare conditions in these work environments.

Precipitation

Rainfall is moderate in the region occurring primarily during the winter months of January and February with the dry season May through October. Rainfall may vary substantially from year to year with increasing amounts related to *El Nino* events (such as 1997-98), monsoonal flows moving westward from Arizona, and the so called "pineapple express" where storms gather significant moisture from the Pacific Ocean before dropping this moisture over the West Coast. Average rainfall for the region was 22" for the period 1994-2004 which is upwardly biased by the *El Nino*.

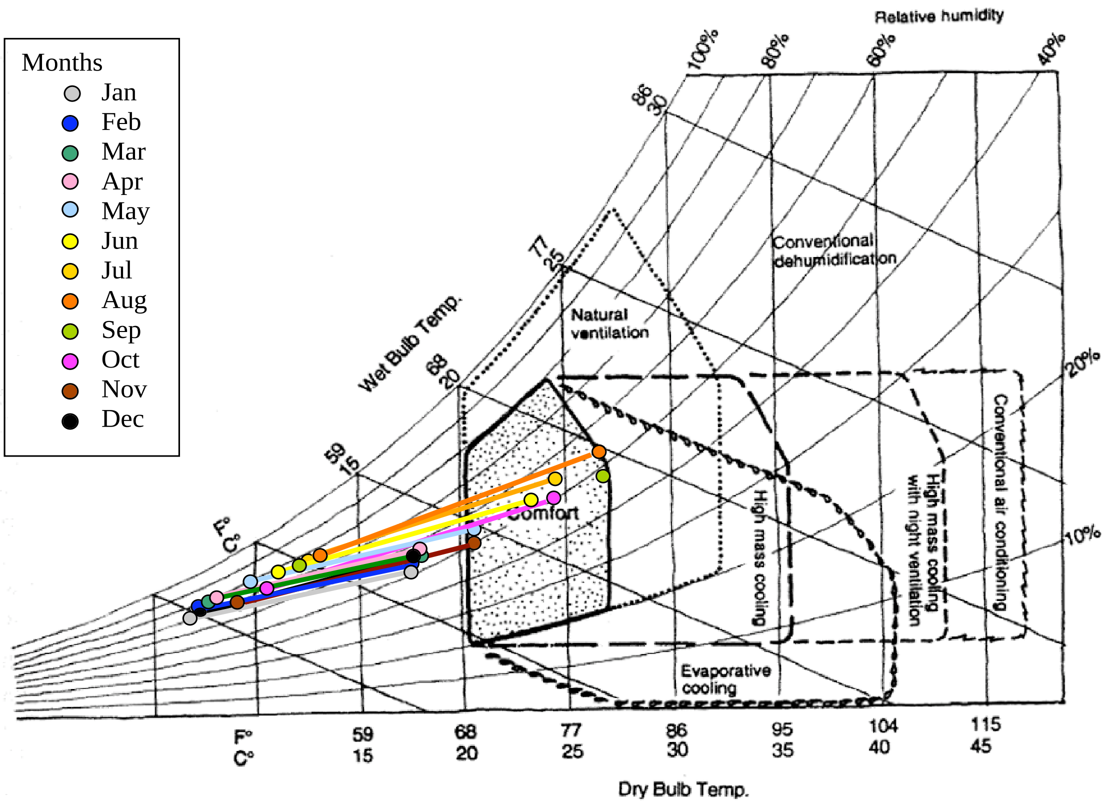


In terms of potential use of the resource, rainwater for irrigation, toilet flushing, and janitorial uses may be considered.

ASHRAE Design Temperatures

Design temperatures are used to properly size mechanical equipment giving weather conditions that occur with relatively high frequency. The closest city in the region for design conditions is Santa Maria, California (34.9 N/120.45 W) as listed in the ASHRAE *Handbook of Fundamentals*. The data are presented in SI units here.

Winter Design Dry Bulb:	99% condition=0.1C
	99.6% condition=1.4C
Summer Design Dry Bulb/	
Mean Coincident Wet Bulb:	1% condition=28C/17C
	2% condition=26C/16C
Summer Mean Daily Range:	10.8C



Plotting average monthly minimum dry bulb temperatures (with maximum relative humidity) and maximum dry bulb temperatures (with minimum relative humidity) on the psychometric chart, gives an indication of the dominate heating and cooling requirements for a residential (skin-load dominated) building in this case for the San Luis Obispo region. Internally load dominated buildings with a lower balance point temperature will experience a greater need for cooling and a lesser need for heating than what is shown on this chart. This chart was created using averaged monthly data for a ten-year period (1994-2004).

Conclusions

The climate of San Luis Obispo is one of the most temperate of the State of California with many days of clear sunny skies coupled with moderate temperatures. Nevertheless, many existing buildings offer neither comfortable conditions nor energy savings in their designs. The challenge of the Technology Park is to recognize the relationship between building site, program, and climate in ways that can optimize site-climate opportunities that enhance human experience, wildlife habitat, environmental resource reserves, as well as the economics of a university building operations and maintenance. A detailed site reconnaissance and interpretation as it pertains to microclimatic features of solar, wind, and light obstructions, using manual techniques as well as computer simulation tools, should be performed once the site and building program are fully determined.

Footnotes

[1]California Irrigation and Management Information System (CIMIS). http://wwwcimis.water.ca.gov/ (accessed 1.31.05)

[2]Steven Marx, editor. (2002) *Cal Poly Land: A Field Guide*. San Luis Obispo, CA: Steven Marx (self-published)

[3]G.Z. Brown and Mark DeKay (2001) *Sun, Wind and Light*. New York: John Wiley & Sons.

[4]American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE). (2001) *Handbook of Fundamentals*. Atlanta, GA: ASHRAE