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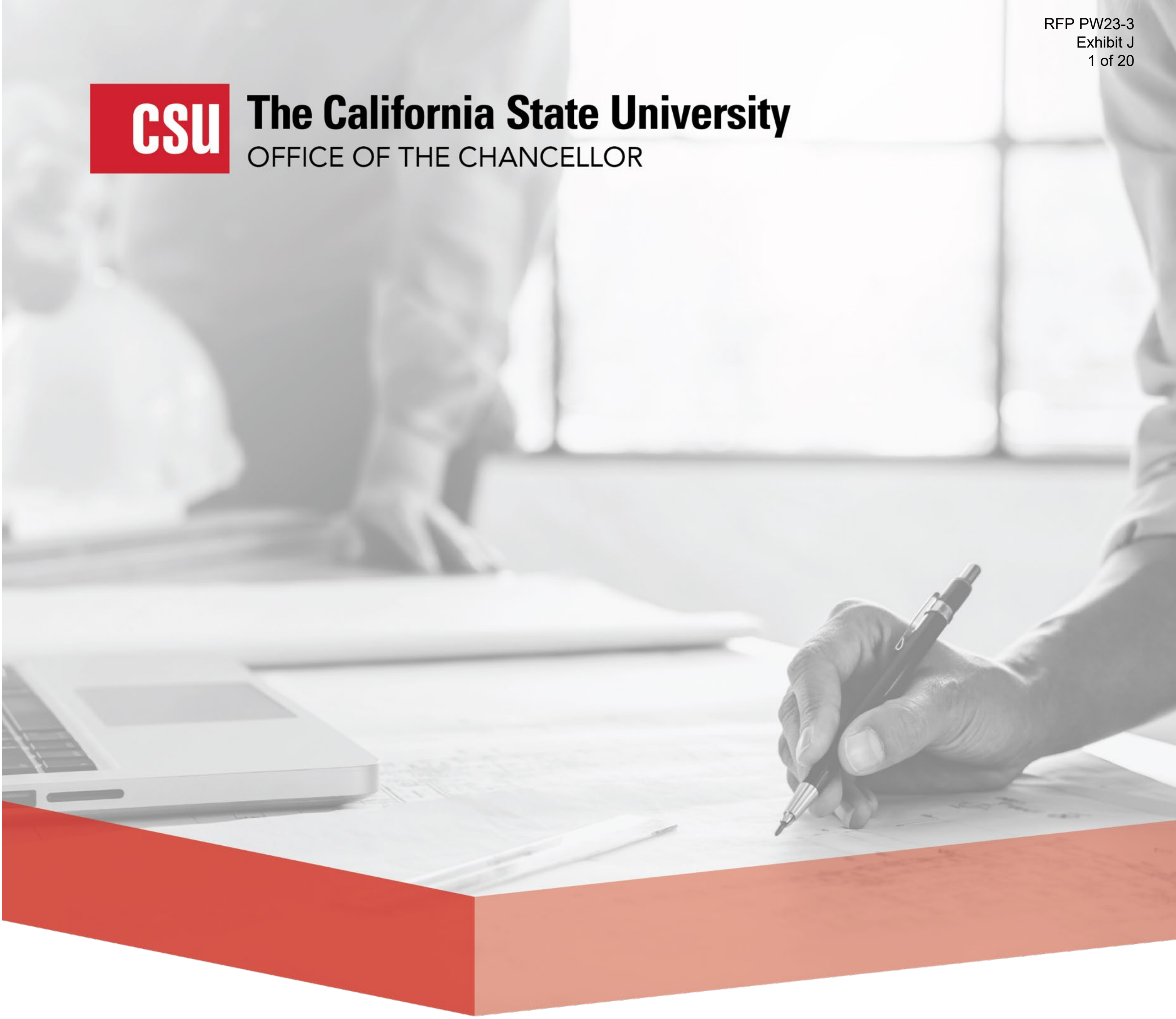

Mechanical and Electrical Basis of Design Guidelines

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The California State University (CSU) gratefully acknowledges the effort and work of Jai Agaram, John Andary, Douglas Effenberger, Kent Peterson, Steven Strauss, and Steve Taylor.

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SECTION 1:
Introduction

This document provides supplemental information that will be helpful in developing a Basis of Design report.

A written Basis of Design report (BOD) is a required design team deliverable for each CSU major capital project. BOD report submittals are required at each design phase. The BOD is one of the key documents that is part of the Mechanical or Electrical Systems review associated with CSU capital projects and A&E teams are encouraged to submit the same during each phase of design for campus and Mechanical and Electrical Systems peer review.

The Basis of Design information provides to all parties involved with a project at each phase in its design process an understanding of the underlying thinking driving the selection of specific components, assemblies, and systems. Campus concurrence of the BOD report at each phase provides assurance to the design team of Campus concurrence of design approach decisions.

The BOD document is expected to be developed and revised incrementally by the design team at each design phase. The BOD is considered complete upon the completion of the Contract Documents package, however if a major system change occurs during construction the BOD would be need to be appended and confirmed by the Campus as part of a change order process.

BOD reports will be relied upon by the Campus to support the commissioning process for the project. BOD reports are not intended to be a part of the Construction Documents, but BOD decisions will inform their composition and of course the ultimate project outcome.

Who Develops the BOD Document?

A&E teams are the primary author(s) of the BOD document. Depending on the nature of the project, part of the information related to existing campus infrastructure systems will likely be provided by the campus or the campus consultants. However, the A&E teams take the lead in identifying information required and obtain the same.

BOD may also be developed by proponents of energy projects (such as solar Photovoltaic, Battery Energy Storage, energy efficiency upgrades, etc.). This guideline recommends that before a Power Purchase Agreement (PPA) is executed on any type of energy service contract, a BOD per the outline stated in this guideline be developed to help review the merits of the proposed energy infrastructure projects.

Companion Guideline Documents for Reference:

Owner's Project Requirements Template

Campus Mechanical and Electrical Standard Requirements for New Construction and Renovation Capital Projects

Utilities and Infrastructure Master planning Guidelines

Outdoor Lighting Design Guide

Metering Guidelines

Types of Major Capital Projects

Major Capital Projects may be broadly categorized as follows.

a. Building projects
    i. New buildings
    ii. Renovations
b. Utility/Infrastructure Projects
    i. Central plants (e.g., chillers, boilers or a combination thereof)
    ii. Substation Upgrades
    iii. New distribution systems or renovations to distribution systems (e.g., hot water loop expansion/repair, chilled water loop expansion/repair, electrical distribution system upgrade)
    iv. Transportation projects such as but not limited to complete streets, active transportation infrastructure and parking garages
c. Energy Projects/Power Purchase Agreements
    i. Photovoltaic systems (rooftops, parking lot canopies, ground mount, etc.)
    ii. Battery Energy Storage
    iii. Energy Efficiency upgrades
    iv. All other energy projects

Each BOD report shall address each of the following points. These are organized under Section A, B and C below, corresponding to the project categorization noted above.

SECTION 2:

BOD for Building Projects (New & Renovation)

Adequacy of Utilities/Infrastructure to Serve New Building Loads

Very early in the building development process (prior to or during the 75% Schematic phase), an initial estimate must be developed to determine impact of the building on each major utility. The Basis of Design document should preferably establish that the required infrastructure evaluation has been completed by the campus to confirm that the current campus infrastructure can support the proposed project. This initial check should include the following at the minimum:

a. Adequacy of campus infrastructure (e.g., chiller plant & distribution, boiler plant & distribution, electric substation & distribution, potable water, recycled water, sewer capacity and active transportation, etc.)

b. Adequacy of supplies from the local serving utility (e.g., PG&E, SCG, SCE, LADWP, Water utility and sewer utility, etc.)

Where a part of the infrastructure is currently being expanded to accommodate the proposed building, the BOD must state the time frame and assumptions associated with making required capacity available in time for the commissioning of the new building.

Sustainable Building Measures

a. Identify sustainability targets for this project. At what LEED level will the project be certified? If not, why not? Identify the decision makers.

b. Identify photovoltaic generation or other renewables that are available for this project. These sources need not necessarily be on campus to be part of this campus project.

c. Identify design strategies for meeting California Building Code Energy and CALGreen requirements. Identify LEED approach and point targets sought.

d. Identify how this project responds to campus pledges, I.e. President (or past president) Campus Climate Commitments, Trustees Policy on Sustainability, systemwide energy use intensity guidance, etc.

e. CSU is required to report Carbon Emissions estimates. Provide estimated annual estimated carbon emissions based on this project's estimated annual energy consumption modified by the projected energy sources to be employed. Identify realistic options that can be incorporated into this project to alter its carbon emissions. Use CPDC form 1-4.5 to calculate these emissions. https://www.calstate.edu/cpdc/Facilities_Planning/forms.shtml

f. Identify how this design achieves project program requirements and how this is/will be addressed in the Construction Documents.

Basis of Design Plumbing Systems

a. Provide a description of each planned plumbing sub-system. Include: sanitary sewer, waste and vent, storm water management, domestic water, compressed air and gases, natural gas, reclaimed water, irrigation, and other systems as may occur. Identify special features and assumptions within each. I.e. Reclaimed water agreements that outline future reclaimed water availability.

b. Discuss reasoning for selection of plumbing systems and materials. Provide a brief rationale for each sub-system.

c. Provide equipment and systems sizing calculations.

d. Discuss where campus guidelines and directives influenced design of plumbing systems.

e. Identify assumptions used in the proposed plumbing systems design.

f. Identify metering and sub-metering proposed for this project.

g. Identify potable water, storm water and reclaimed water systems. Identify project infrastructure necessary to support the required flow/capacity for meeting the expected building load.

h. Identify how and where this project minimally meets or where design consciously will exceed code minimum requirements. Explain rationale for decisions.

i. Identify how this design achieves project program requirements and how this is/will be addressed in the Construction Documents.

HVAC Systems

a. Describe HVAC system options/types considered/employed. Identify extent of project reliance on thermal storage, cogeneration including cogeneration phase down/out dates, and integration of alternative energy sources, both on site and off site. Relate to sustainable project requirements.

b. Identify indoor air quality design considerations/constraints/requirements, including provisions during operations in the event of urban-wildland interface wildfires.

c. Describe interaction of the HVAC system with the building envelope, lighting, and other systems. Identify to what extent load is shed before it enters the building. Identify integration/reliance on architectural or site features for building performance. I.e., overhangs, external sunscreens, shading devices, landscape, topography, etc.

d. Describe project connection assumptions to campus central plant chilled water and hot water supply. Identify system connection assumptions, central plant capacity and allocation decisions to serve this project versus holding capacity for other projects.

e. Describe proposed building automation systems. Identify feature set. Identify readily available feature sets not provided. Identify rationale for providing/not providing various functionality.

f. Identify reasoning for the of proposed HVAC systems. This should be a short statement for each system (heating, cooling, fluid distribution, etc.) and include supporting information such as the requirements of codes/standards, design criteria, i.e., energy performance, indoor environmental quality, reliability, maintainability, first cost and lifecycle costs, carbon emissions, energy source, and campus directives.

g. Identify project performance assumptions and concerns.

h. Identify assumptions for calculations/sizing, including diversity factors, safety factors, redundancy, space usage and occupancy (both proposed and projected), ventilation rates, plug loads, lighting loads, power density, glazing and shading device characteristics, thermal insulation and vapor transmission, envelope reflectivity, material densities, utility rates, power generation sources, pressurization requirements.

i. Provide performance based energy calculations for overall building and envelope, mechanical system and lighting components for the building. Secure concurrence by assigned MRB peer reviewer if a prescriptive approach is proposed.

j. Identify energy modeling approach. Identify software (including version). Identify analysis and simulation models considered (heat loss, cooling load, duct pressure, pipe sizing, energy usage, control strategies). Identify manufacturers' sizing services where used.

k. Describe environmental conditions, including indoor and outdoor design conditions and air quality, interior pressure relationships, airflow velocity targets, and acoustic performance requirements/targets.

l. Identify impacts of project site constraints, building orientation in context, building shape in context, enclosed space relative to external walls and characterize efficiency.

m. Identify HVAC operational assumptions, space usage, operational schedules, and diversity of use, annual operation and maintenance budget, characterization of relative complexity to operate as proposed.

n. Identify codes, standards, guidelines and other references that influenced the design of HVAC systems, including campus standards and design guidelines.

o. Identify Campus Project Requirements, including a specific listing of how each Project Requirement is addressed in the Construction Documents.

p. Identify how systems selected are supporting campus & project sustainability targets.

q. Description of metering and sub-metering proposed for this project.

r. Identify how and where this project HVAC design minimally meets or where design consciously will exceed code minimum requirements. Explain rationale for decisions.

s. Identify how this design achieves project program requirements and how this is/will be addressed in the Construction Documents.

Fire Protection Systems

a. Provide description of system options considered. I.e., Fire sprinkler, fire alarm, pre- action systems, clean agent systems, fire pump need, onsite water storage, supplemental power to support fire suppression systems. If sprinklers are not proposed, identify why. Identify the decision makers. Provide CDBO statement of concurrence.

b. Identify Point of connection with existing fire water infrastructure and identify nearest fire hydrants that would be used for fire water flow tests. Evaluate adequacy of required fire water flows using existing infrastructure.

c. Identify passive/active design measures considered/incorporated.

d. Discuss the thought process for setting the building construction type and how this impacts fire life safety system requirements.

e. Where atriums is part of the project feature set, identify smoke evacuation assumptions/approach.

f. Identify reasoning for selection of proposed fire protection system. Identify to what extent campus guidelines and directives influenced/limited/advanced the selection of fire protection systems.

g. Confirm if the design documents require a fire alarm and fire sprinkler design as a part of the primary building design review, I.e. the fire alarm and sprinkler design is not a design built system and is not deferred submittal. If design build/deferred approach is proposed indicate that CDBO concurrence was obtained.

h. Identify urban-wildland fire interface risks and provisions in design for protection of life and property fire risks.

i. Identify how and where this project fire protection systems design minimally meets or where design consciously will exceed code minimum requirements. Explain rationale for decisions.

j. Identify how this design achieves project program requirements and how this is/will be addressed in the Construction Documents.

Electrical Systems

a. Provide a description of electrical service from the campus infrastructure. Identify campus electrical infrastructure capacity to serve this project. I.e. does the existing infrastructure readily or minimally accommodate this new proposed project demand?

b. Provide a description of electrical power distribution system.

c. Identify design voltages, assumed VA/square foot for each area in the building and assumptions for calculations/sizing electrical capacity, including diversity factors, safety factors and redundancy.

d. Identify electrical modeling approach. Identify software (including version). Identify analysis and simulation models considered (photometric calculations, load calculations, short circuit and arc flash calculations). Identify manufacturers' sizing services where used.

e. Describe interior and exterior lighting systems, control strategies, and proposed illumination levels for each area.

f. Describe of metering and sub-metering in the design of the electrical distribution system.

g. Describe renewable energy generation components and their interface with the building electrical system as well as campus wide electrical system.

h. Describe proposed grounding system.

i. Describe emergency power system for egress lighting and any other equipment requiring back up power. Identify power for elevators relative to fire code requirements. CSUCO case study 2 - 10KW Tesla powerpacks were far cheaper than diesel generator.

j. Identify telecommunications, fire alarm and security systems. Identify interconnection to the campus network.

k. Discuss codes, standards, guidelines, regulations, and other references that influenced the design of electrical systems.

l. Identify how campus guidelines and directives influenced the design of electrical systems.

m. Discuss how mechanical system design basis influenced the design of the electrical system.

n. Identify how and where this project electrical systems design minimally meets or where design consciously will exceed code minimum requirements. Explain rationale for decisions.

o. Identify how this design achieves project program requirements and how this is/will be addressed in the Construction Documents.

SECTION 3:

BOD for Utility/Infrastructure Projects

Central Plants

a. Provide list of campus-wide buildings served by the central plant, showing derivation of overall central plant loads. Discuss existing central plant peak Btu/GSF and peak GSF/ton when evaluating future loads. Discuss diversity factors used in determining aggregate loads from building specific loads.

b. Identify low as well as high extremes in loads and their expected duration over the year.

c. Identify best estimates of future building development assumed to be connected to the central plant and include the same in establishing capacity required at the central plant.

d. If energy storage (TES) is proposed, discuss utility rate structures, time of use periods and TES sizing strategy. Discuss if proposed sizing is at the economic and carbon emissions optimum level, based on annual level loads, rate structure, etc.

e. Review historical metered data and EUI guidelines on campus and discuss if the load estimates have considered the metered data. Discuss validity and accuracy of historical data and any attempts made at verifying the accuracy of existing data used to establish capacity requirements.

f. For chilled water and hot water flows, identify delta-T between supply and return water and discuss opportunities where delta-T can be increased for making the most of existing distribution systems.

g. Identify bottlenecks in adding capacity. These could include limitations in building foot print, site space availability, distribution capacity, electrical substation capacity, noise limitations, etc.

h. Discuss redundancy criteria used in configuration of plant equipment.

i. Discuss how the proposed central plant configuration will satisfactorily meet the extremes in loads noted above (low limits as well as high limits).

j. Discuss optimization if any, related to operation of the central plant to help achieve high operating efficiencies, including improved scheduling, unoccupied zone setbacks, etc.

k. Where chillers are involved, discuss choice of refrigerants based on current regulations and availability of refrigerants.

l. Where chillers and boilers are within the same building, discuss methods implemented to avoid refrigerant leaks from getting exposed to high combustion flame temperatures. Discuss permitting issues.

m. Determine operations and maintenance cost impact of major choices made with respect to the central plant equipment. For instance, are there new service contracts required, special equipment required, special chemical treatment required to help maintain the system.

n. For large chillers discuss choice of 12 KV versus 480 V rated equipment for instance and present choice of one versus the other from an overall cost and maintenance standpoint.

o. Where boilers are involved, discuss potential for low carbon emissions (electrification) of heating and air quality permitting requirements and confirm that the choice of boilers can be permitted.

p. Discuss all utilities related to the central plant and demonstrate how the proposed plant expansion or addition can function with the available (or known) limitations on existing utilities/infrastructure systems.

In addition to the specific items noted above, please review applicable items under Section A, many of which would also apply to this category of projects.

Substation Upgrades

a. Present existing campus load profiles based on measured data. The load profiles would include 24-hour load profiles for at least one year or more.

b. Present campus-wide building list identifying existing buildings that contributed to the existing electrical demand.

c. Identify best estimates of future load growth based on best available information on new buildings planned over the next 10-years.

d. Identify potential demand limiting load controllers, demand response capabilities considered.

e. Discuss overall sizing strategy for equipment and the extent of spare capacity provided.

f. Determine site constraints, visual impact and sensitivities related to location of substation gear.

g. Discuss access and service requirements pertaining to substation equipment and address how the selected site is suitable based on consideration of all of the above factors.

h. Discuss redundancy used in selecting the proposed choice of substation equipment and overall electrical systems design.

i. Discuss metering as well as any remote monitoring capabilities required

j. Discuss safety and security issues related to the overall substation and any additional measures incorporated related to the same.

k. Discuss utility interconnection issues and any special provisions made consistent with utility interconnections.

l. Determine operations and maintenance cost impact of major choices made with respect to the substation equipment. For instance, are there new service contracts required, special equipment required to maintain new or upgraded sub-station equipment.

m. Discuss cooling and ventilation requirements and HVAC systems that are provided for the same.

In addition to the specific items noted above, please review applicable items under Section A, many of which would also apply to this category of projects.

Hydronic or Steam Distribution Systems

For projects that provide major repairs to existing distribution systems or expand existing systems to cover new areas/buildings, discuss the following in the BOD document.

a. Modeling methodology for sizing various systems including piping, expansion joints and anchors.

b. Loop system redundancy planned in distribution systems. For instance, if there is a major failure of loop in one segment, what is the maximum % of buildings that would be impacted? Is there a specific criteria that would stipulate that no more than X% of the campus buildings should be impacted regardless of where a loop may have a break?

c. Fluid flow velocity and pressure drop limits used in design.

d. Temperature based limits for system components and material / joint choices to meet temperature limits of the operating distribution system.

e. Delta-T assumed for the sizing of hydronic heating and cooling piping.

f. Type of construction: direct buried, utilidor, tunnels, etc.

g. Choice of materials and connections and corrosion protection schemes considered for anything subject to corrosion due to direct contact with soil.

h. Pipe thermal expansion/contraction and associated choice of expansion loops and joints.

i. Extent of isolation valves planned and service complexity expected at valve locations.

j. Expected means for vent lines and insulation/corrosion protection of all vent lines and fittings.

k. Labelling/identification schemes for manholes, vaults, isolation valves, etc.

l. Safety issues in medium and high-pressure steam distribution systems and how handled.

m. Instrumentation/Monitoring of leaks in hydronic distribution systems.

n. Managing the unknowns in underground utilities during construction.

o. Extent of surveys completed to determine interference from underground utilities.

p. Expected phasing of work during construction to minimize service disruptions.

q. Temporary / rental equipment needed to preserve continuity of service to critical loads.

SECTION 4:

BOD for Energy Projects

Rooftop Photovoltaic Projects

For projects that involve placing PV on rooftops, provide the following.

a. Basis for sizing the PV system on the roof. This would include verified structural limits to accommodate PV related gravity, wind and seismic loads.

b. Economic analyses previously completed to support design and construction of the project.

c. Any expected changes to the rate schedule (Such as migration to Option R under Net Energy Metering to help mitigate the negative impact of high demand charges).

d. Design approach on limiting maximum DC side voltage to 600 V or less.

e. Potential shading issues, if any, associated with other roof mounted equipment, adjacent trees or taller structures in the vicinity of the PV project site.

f. Choice of combiner and inverter locations, including consideration of type of enclosures

g. Method of connection to the existing building switchboard (i.e., load side versus source side connections and adequacy of existing switchboard to accommodate added PV generation source).

h. Identify the planned utility interconnection type and method of compliance with utility Rule 21. If no-export type complete hourly generation and time of use analysis to ensure no to limited curtailment of the most carbon emitting generation equipment.

i. Safety issues related to access to roof mounted systems and service access around PV panels and inverters or other PV related equipment placed on roof

j. Fire department access to roof and required clearances between PV arrays to allow service personal or fire protection personnel to access various building systems from roof.

k. Describe the various mounting options and how they impact the ability to replace the roofing in the future.

Carport/Canopy Mounted Photovoltaic Projects

For projects that involve placing PV on carport structures, provide the following:

a. Basis of sizing PV systems including consideration of the overall capacity of existing electrical infrastructure to which the carport PV would be interconnected.

b. Economic analyses previously completed to support design and construction of the project.

c. Any expected changes to the rate schedule (Such as migration to Option R under Net Energy Metering to help mitigate the negative impact of high demand charges).

d. Identify the existing and planned utility interconnection type and method of compliance with utility Rule 21. If no-export type of interconnection complete hourly generation and time of use analysis to ensure no to limited curtailment of the generation equipment.

e. Design approach on limiting maximum DC side voltage to 600 V or less.

f. Minimum height of the carport based on expected vehicles to be parked in the lot.

g. Extent of trees in and around the proposed area that may cause shadows and the proposed extent of trees that would need to be removed or relocated.

h. Potential for shading effects due to tall structures in the vicinity.

i. Typical rendering of how the PV structure would look (especially important to avoid "barn" type appearance which can be objectionable in many areas). Present a 3-D rendering early in the process to help visualize the realistic appearance of the overall structure.

j. Neighborhood sensitivities – such as visibility of the structure from nearby homes or businesses

k. Fire truck access and turning radius into the structure and pathways in and around the structure.

l. Adequacy of lighting and illumination requirements under the canopy, including control of lighting systems during nights. Adequacy of security cameras and infrastructure.

m. Signage of parking bays beneath the PV structure.

n. Investigations conducted related to existing utilities in the parking lots.

o. Risks, if known, related to potential hazardous waste / contaminated soil in existing parking lots.

p. Site drainage provisions related to new canopy mounted structures.

q. Underground electrical conduit routes for connecting PV to the existing electrical infrastructure.

r. Security/protection of outdoor mounted electrical equipment including central inverters, transformers, and switchboards

Fuel Cell Projects/Other Complex Energy Purchase Agreements

California policy is to achieve carbon neutrality no later than 2045. CSU policy is being updated to set a carbon neutrality goal as well. To achieve this goal, no additional investment in fossil fuel infrastructure can be made.

Utility interconnection agreements (Rule 21) require fossil fuel generation equipment to avoid exports. The most restrictive generation asset determines the interconnection types. If campus is a no-export type of interconnection, complete hourly generation and time of use analysis to ensure no to limited curtailment of the generation equipment.

CSU campuses receive proposals that entail purchase distributed energy resources. These are often in the form of Power Purchase Agreements that may include electricity as well as thermal energy sales. These transactions are complicated to evaluate unless a "full energy, carbon emissions and economic picture" is presented on the proposed system, including any interaction the proposed system would have on the existing and planned purchased utility mix and distributed energy resource mix. Prior to an agreement being executed related to such proposals, the following minimum written analysis is required:

a. Review "Business As Usual" (BAU) utility usage, rates and costs carefully. Typically this involves review of annual (full year) usage and costs.

b. Analyze the proposed system's electrical output and thermal output performance over full calendar year.

c. Confirm generation versus load numbers over weekdays, weekends, as well as nights when demand is low. Avoid export and curtailment.

d. Develop a "Business with Project" (BWP) model that illustrates the overall impact of energy and demand on campus.

e. Analyze projected BWP cost carefully, while considering all reasonable costs including cost of the proposed PPA transaction, unavoidable demand or standby costs incurred by the campus, and other energy usage charges associated with utilities not provided by the proposed project.

f. Consider all additional utilities, maintenance, capital reserves costs (e.g., greater needs for water or added maintenance)

g. Analyze BAU versus BWP scenarios associated with the proposed PPA arrangement to determine if the proposed PPA deal has financial benefits to the campus.

Developers and A&E teams who propose such projects should provide the campus with such a detailed evaluation to assist in making the right choices at the campus level