Sizzling Green:
Integrated design process for greener institutional kitchens

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ABSTRACT: Kitchens have long been identified as cauldrons of energy consumption because of their function. For smooth and efficient performance, medium-to-large-scale kitchens traditionally required a plethora of food and mechanical equipment running in unison, consuming 2.5 times more energy per square foot than other commercial or institutional buildings. Growing demands in the food-service market and the increased use of technology have made it imperative that sustainable design practices be incorporated in designing institutional kitchens. This can be attained by implementing Integrated Design Process at project inception. This paper describes how Integrated Design Process has been highly successful in designing two institutional kitchens—both 30,000 square feet—for the Department of General Services, State of California. They are proposed to serve as main central kitchens for Napa State Hospital and Porterville Developmental Center. Both projects are mandated to receive a minimum LEED–NC 2.2 Silver Certification, thereby representing two pioneer projects in sustainable kitchen design in the United States. The construction documents are complete for the Porterville project and Design Development is complete for Napa. Both projects are equally significant, but more frequent reference is made to the Porterville project due to its final coordination.
Keywords: institutional kitchens, Integrated Design Process, LEED-NC 2.2, energy efficiency

INTRODUCTION

According to the 2004 North American Association of Food Equipment Manufacturers (NAFEM) Size and Shape of the Industry Study, energy costs were one of the top three concerns for primary equipment operators and major food service stakeholders. These were identified as personnel (67%), profitability (42%), and energy costs (32%).The total energy consumption in a food service facility is typically 30% for cooking, 19% for refrigeration, and 10% for sanitation. Combined, they represent roughly 60% of the energy routinely consumed in a food service facility. In 1999, the Commercial Building Energy Consumption Survey (CBECS) reported that the total energy consumed by food service buildings was around 447 trillion BTU/year. Another study in the same year by the Boston-based Consortium for Energy Efficiency (CEE) stated that buildings dedicated to food service consumed 241,200 BTU/sq. ft., while the closest end use consumed 202,000 BTU/sq. ft. Figure 1 provides a graphic illustration of relative energy consumption intensity by building activity. Because lighting and HVAC are typically the dominant energy consuming end uses in food service facilities, the food service sector thus offers an opportunity for exploring a variety of other design alternatives like effective air circulation techniques, and innovative technologies for cooking, sanitation, and refrigeration.

Depending on the approach, the total savings potential available to food service facilities from implementing energy-efficient strategies and technologies could be between 10% and 30%.

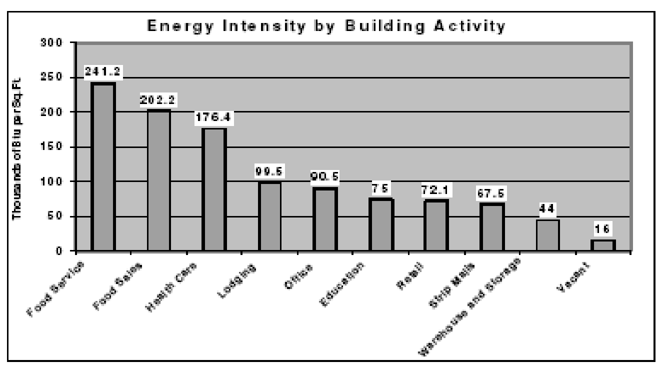

Figure 1: Energy Consumption Intensity by Building Activity.

INTEGRATED DESIGN PROCESS

Developing sustainable, energy-efficient buildings requires meticulous attention to multiple systems and their interdependence. Institutional kitchens are no exception. However, these relationships are hard to address by using the standard design practices because then, the engineers and consultants are asked to create systems for a design that may already include general massing scheme, orientation, exterior appearance, and basic materials. This will influence and may obviously limit what they are able to achieve.

Therefore, a different course, often referred to as the Integrated Design Process, (IDP) needs to be followed to achieve a project's sustainability and energy-efficiency goals. The Integrated Design Process capitalizes on the expertise of each team member from the beginning to create the best possible building for the site and program. The IDP can be best explained by the following points (see Fig. 2):

The three basic principles of the Integrated Design Process are:

- Clear and continuous communication
- Rigorous attention to detail
- Active collaboration among all team members

The main strategies behind the IDP are:

- Emphasize the integrated process
- Think of a building as a whole
- Focus on life cycle assessment
- Work together as a team from the beginning
- Conduct assessments (threats/vulnerabilities and risk analysis) to help identify requirements and set goals
- Develop tailored solutions that yield multiple benefits while meeting requirements and goals
- Evaluate solutions
- Conduct commissioning and post-occupancy evaluation

The strategies above can be well executed through the following process. Steps specific for the projects described in this paper are also included.

- Assemble the design team
- Examine the program; establish performance targets and strategies
- Hold design workshops/eco-charrettes
- Consider site development issues
- Develop design concept
- Develop circulation and food equipment plan
- Select building structure
- Develop building envelope design
- Develop preliminary lighting and power design
- Develop preliminary heating, ventilation, and cooling system designs
- Select materials
- Use energy-efficient food processing equipment
- Complete design and documentation
- Develop QA strategies for construction
- Develop QA strategies for operation
- Conduct monitoring & Commissioning

THE PROJECT

Here we describe the Integrated Design Process for two State of California projects under the Department of General Services—informally known as the DGS. With the advent of the USGBC® (United States Green Building Council) and LEED™ (Leadership in Energy and Environmental Design), the state of California has been a forerunner of sustainable developments from the very beginning. To further that, the DGS has begun design of the two greenest institutional kitchens in the United States. Both of these are 30,000 square feet. They

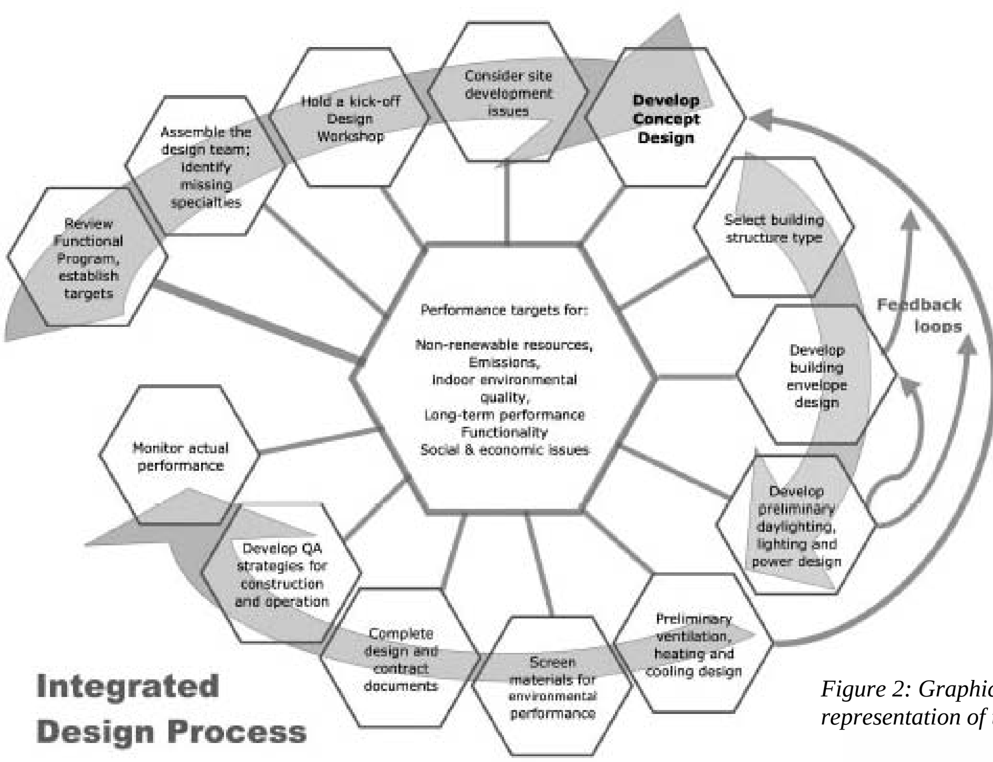

Figure 2: Graphical representation of the IDP process.

serve as the main central kitchens for the Porterville Developmental Center and the Napa State Hospital, located in Porterville and Napa, California, respectively. These new main central kitchens will supply satellite kitchens scattered about their respective campuses. As part of the State of California's Green Building mandate, both projects must be at least LEED 2.2 Silver Certified. Owing to the nature and complexity of the project and the sustainability goal for LEED Silver Certification, the Integrated Design Process seemed not only the right, but the only possible approach to reach this goal. The investments in these new central kitchens are made with a vision that provides for labor savings and new energy-efficient equipment standards. In a nutshell, both kitchens will be pioneering benchmark designs for others to follow.

FUNCTIONAL REQUIREMENTS AND BASIC FLOW OF THE FOOD-SERVICE PROCESS

Before delving into details of the project's sustainable, integrated approach, it is essential to explore some basic functional requirements of a modern, efficient food service and understand its flow. Each kitchen produces 1,200 to 1,500 meals per day and serves smaller satellite kitchens located on the campus. The production employs a process called a blast/chill operation, which produces food over a four- to five-day cycle. The blast/chill system lets the kitchen consistently serve quality meals in a timely fashion. This allows chilled food products to be stored for reheating later. The kitchens have storage facilities with a capacity to hold enough meals for21 to 28 days. Storage areas consist of palletized dry storage facilities, a bulk freezer with pallet racks, meat freezer, and dairy and produce coolers with thaw boxes for defrost. Preparation areas are designed for both produce and meat preparation, including can openers and ingredient control located next to dry storage. The design also provides standard production cooking for the blast-chilling process, with an inventory-control cooler designed for bulk food storage. All prepared and production-cooked items are normally held for future serving dates. Inventory food products are held in a bulk freezer, then transferred to a dispatch cooler and readied for cart storage. When ready, bulk pan carts are delivered via refrigerated trucks to satellite kitchens designed for cooking/chilling/reheating, then served on trays. A small tray line in the main kitchen is required for patient tray service to skilled nursing facility (SNF) units or other specialty wards. In the Napa kitchen, however, the food is delivered in trays to the satellite kitchens. In this scenario, the food gets delivered to the satellite kitchens in bulk trays instead of pan carts. When delivered, carts containing either pans or trays will be connected to a refrigeration/reheating docking station and held until meal serving time. Chilled bulk food is then reheated and served on a counter in the satellite kitchens. When reheating is complete, trays are served to patients with cold food items and a beverage on tray server counters in each satellite dining facility. After meals are served, all soiled trays are cleaned in the satellite serving kitchens. All SNF trays and bulk pans are returned for cleaning at the central kitchen. The patient tray service operation comes with one reheating unit in the SNF and one test station in the central kitchen. Bulk delivery carts come in sets of three for on-time production and delivery services. The blast–chill system is designed to operate conveniently for staff and patients, yield a consistent product, and provide a satisfactory patient environment overall. This system also offers temperature monitoring and reporting from food arrival to serving, thereby assuring public health. The blast–chill system has been implemented and tested for long-term durability and economy. Figure 3 depicts a basic food service involving both main-central and smaller satellite kitchens.

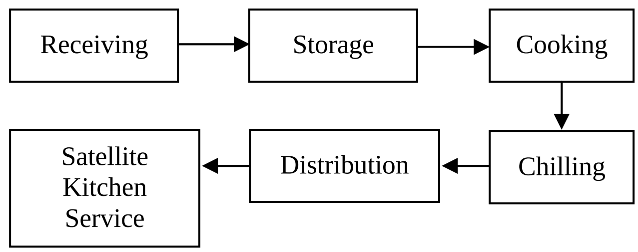

Figure 3: Flowchart describing a basic food-service process.

THE APPROACH

Our approach was to follow the steps discussed in the Integrated Design Process section to the letter and perform everything in a timely manner. Here, we discuss all steps that have been implemented up to this point.

Assess site conditions We performed geotechnical and hazmat tests and presented reports with the usual due diligence, as well as Phase II Environmental Site Assessment (ESA) and Environmental Impact Reports (EIR) for both projects. The site for the Napa Kitchen was previously developed and some remediation work is required before construction. The site in Porterville is a Greenfield site.

Examine program; establish performance targets and strategies The building program and the functionalities were thoroughly researched. Case studies of similar existing kitchens were performed to understand the functioning and circulation of the same. The Coalinga State Hospital Main Central Kitchen was studied. Though it was not LEED certified but it is still one of the most efficient kitchen facilities of this scale to be built in California. Sustainability was another performance target mandated by law that all new public buildings larger than 10,000 square feet shall be designed, constructed, and operated to achieve LEED Silver Certification or higher.

Assembling the design team and conducting design charrettes and eco-charrettes We assembled the entire design team, consisting of architects; LEED consultant; structural, civil, MEP, geotechnical, hazmat engineers, and food service consultants, and then conducted a design charrette. The owners, clients, and all the stakeholders participated and addressed all relevant issues. It was this collaborative, focused brainstorming session held at the beginning that encouraged exchange of ideas and information and allowed truly integrated design solutions to emerge. All participants were encouraged to question and address problems beyond their field of expertise. The charrette was particularly helpful in complex situations wherein many people represented the interests of the client with conflicting needs and constituencies. Participants were educated about the issues and resolution enabled them to "buy into" the schematic solutions.

The eco-charrette was a similar exercise wherein all sustainable goals related to the project were discussed. The charrette included an introduction to the LEED process and strategies. A conceptual design gradually gelled wherein factors like the local climate, building orientation, use of recycled materials, commissioning, energy-efficient HVAC equipment, natural ventilation, improved indoor air quality, daylighting strategies, green housekeeping, and the like, were unearthed and each topic debated until a consensus satisfactory to everyone emerged. Their results under girded the entire Integrated Design Process, and also the project. Both charrettes combined represented a 2-to-3–day rigorous brainstorming exercise that resulted in:

- Clear and distinct design and scheduling project goals and targets
- Clear and distinct project sustainability goals
- A basic conceptual design that integrated input from every project stakeholder
- Commitment to continuous, clear, communication and active collaboration among all team members
- Familiarity with every project member

One of the most fascinating discussions that we had during our charrette was the idea of green roofs, which we had to table after going deep into the climatic, maintenance, and financial issues. But this is a good example that not every idea can be bought.

Development of the conceptual design At this stage, all the information from the design and eco-charrettes started to unite. Various site, climate, solar, neighborhood, daylighting, and optimum-orientation studies were done, yielding concrete design strategies. Functional, spatial, and circulation analyses were also done with the food service consultants. They were then married with system requirements, and the first building form thus evolved. This was in itself a much-refined form because almost everything had been considered in schematic design phase. Excerpts of the analyses appear in Figures 4.1–4.4.

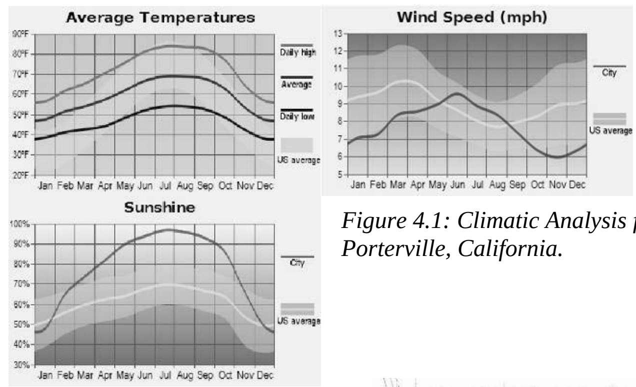

Figure 4.1: Climatic Analysis for Porterville, California.

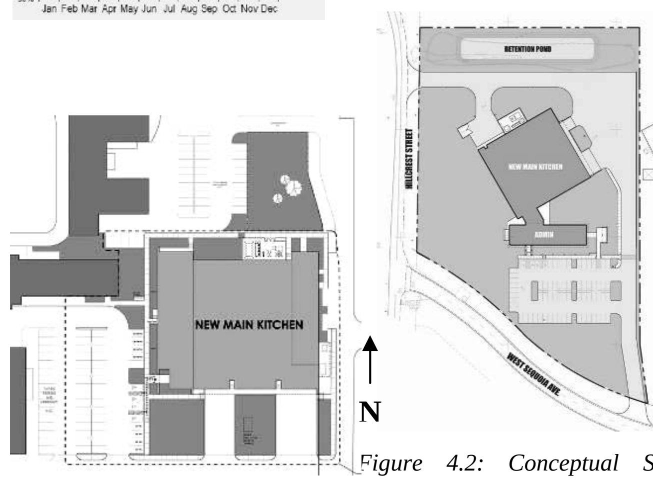

Figure 4.2: Conceptual Site Plans for Porterville (Left) and Napa (Right)

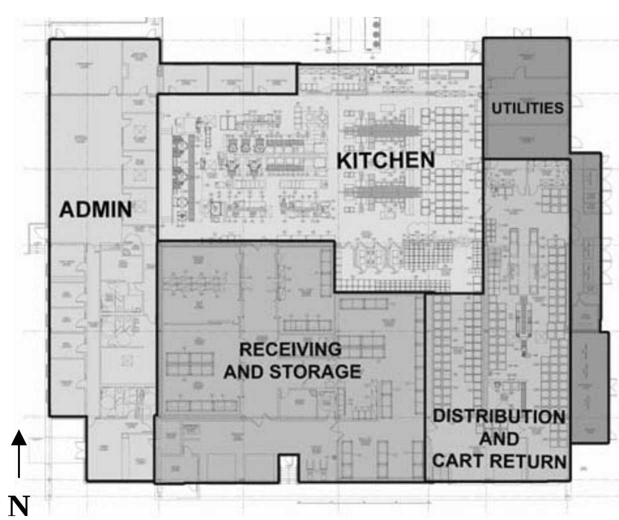

Figure 4.3: Functional and Circulation plan for Napa Main Kitchen

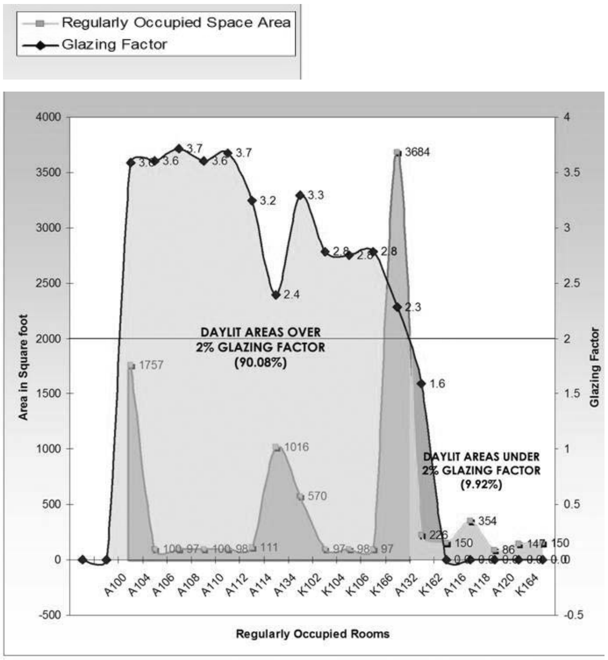

Figure 4.4: Chart showing comparison of Daylit regularly occupied spaces in the Porterville Main Kitchen Design with the non-Daylit ones

Daylight and views The architectural design affords the buildings' occupants a connection between indoor spaces and the outdoors. We used a minimum glazing factor of 2% (in a minimum of 75% of all regularly occupied areas, as required by LEED NC 2.2, Indoor Environmental Quality, Credit 8.1, Daylight and Views). This introduced daylight and views into the regularly occupied areas of the building. We calculated the glazing factor as follows:

$$\text{Glazing Factor} = \frac{\text{Window Area [SF]}}{\text{Floor Area [SF]}} \times \text{Window Geometry Factor} \times \frac{\text{Actual } T_{vis}}{\text{Minimum } T_{vis}} \times \text{Window Height Factor}$$

Tvis = Visual Transmittance (percentage of light transmitted). We have calculated that both projects are well above the LEED threshold. Figure 4.4 shows the calculated glazing factor chart for Porterville's main kitchen, where about 90% of the total regularly occupied areas are daylit with a minimum glazing factor of 2%. Solar-tracking skylights have been specified, which will track the sun to harvest full-spectrum daylight throughout the day.

Mechanical (HVAC) design and commissioning Salient features designed and specified for the Porterville main kitchen project are as follows:

- Packaged chiller, steam boiler hydronic heat, and variable air volume (VAV) terminal units:
  - Heating: 80% thermal efficiency
  - Cooling: 13.48 energy efficiency ratio (EER)
  - Economizer: 100% outdoor air
  - Indirect/direct evaporative preconditioning of outdoor air on some units
  - Cooling: 13.48 energy efficiency ratio (EER)
- Packaged cooling only:
  - Heating: 78% AFUE (annual fuel utilization efficiency) assumed
  - Cooling: 13.0 SEER (seasonal energy efficiency ratio)
  - Economizer: 100% outdoor air
- Ductless split-system cooling only:
  - Heating: 78% AFUE assumed
  - Cooling: 13.1 SEER

The lighting power density (LPD) used for the Porterville Project is 0.754 Watts/sf. A whole building commissioning plan has been prepared according to the owner's project requirement (OPR) and the basis of design (BOD).

Envelope design The following table details out the envelope and the building skin components of the Porterville kitchen project.

2x6 walls	Metal frame, R-21 + filled cavity insulation
2x8 walls	Metal frame, R-30 + filled cavity insulation
Glazing	Dual pane, low-e coating, <0.5 air space operable, 0.61 U-factor
Solar heat gain, all orientations	SHGC = 0.40
Roof (flat) N/A	R-30 exterior insulation
Skylights	Single-pane metal frame, 1.98 U-factor
Solar heat gain (SHGC)	0.83

Figure 5 displays the energy model for the Porterville Main Kitchen Project prepared in Equest. Adding all the above features, the design case yielded about 24.7% in energy cost savings.

Material selection and food service equipment Recycled materials have been specified for almost all the possible building components, from structural steel to recycled plastic lockers in the locker rooms. Heat-island effect is reduced by using cool white roofing. Specified paints, adhesives, and sealants are specified to contain 0% volatile organic compounds (VOC). All wood used in the building is specified to be Forest Stewardship Council (FSC) certified. Building materials have been specified as those extracted and manufactured regionally within a radius of 500 miles from the site. Only linoleum and anti-slip resinous flooring that meets or exceeds VOC requirements for floor coatings have been specified for the project. The majority of food processing equipment, including ice makers and refrigerators, are either Energy Star certified or are equipment approved by Fisher-Nickel (Fishnick) or Pacific Gas and Electric's (PG&E's) Food Service Technology Center.

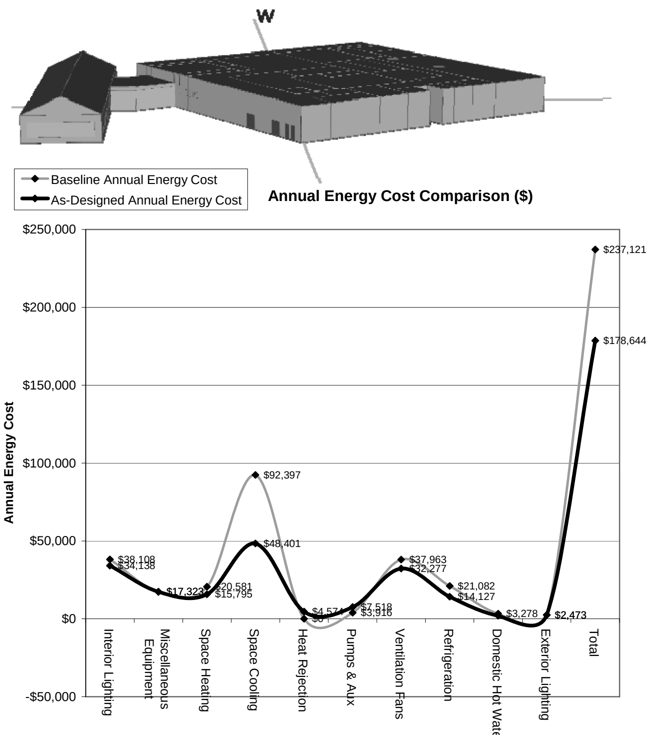

Figure 5: E-quest energy model for the Porterville Kitchen (Top) and the Annual Energy Cost Comparison chart (Bottom). The Design case provides up to 24.7% in energy cost savings over the base case scenario.

CONCLUSION

From the sustainability standpoint, both the Porterville and the Napa kitchen projects are well within the sustainability goal of achieving LEED Silver Certification. This along with the systems and circulation has been possible through implementing the Integrated Design Process and sticking to it. There were—and will be—challenges because this is very new, but the solution lies in proper communication and taking the responsibility as a team and not as individuals.

As the energy demands in recent times become more and more strained, developing working models where people learn to rely on and trust each other has become imperative. The Integrated Design Process is surely one such proven working model that is still very nascent. It will be interesting to see what developments future technologies bring to IDP, thereby promoting sustainable, healthy buildings and construction projects

RENDERINGS

Figure 6: Rendering of the Main Central Kitchen at Porterville

Figure 7: Rendering of the Main Central Kitchen at Napa

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