PROJECT BRIEF

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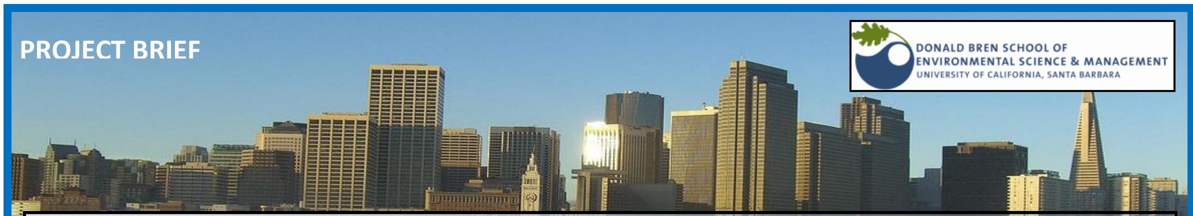

SUSTAINABLE DESIGN, CONSTRUCTION AND OPERATION OF A RESIDENTIAL HIGH-RISE BUILDING IN SAN FRANCISCO

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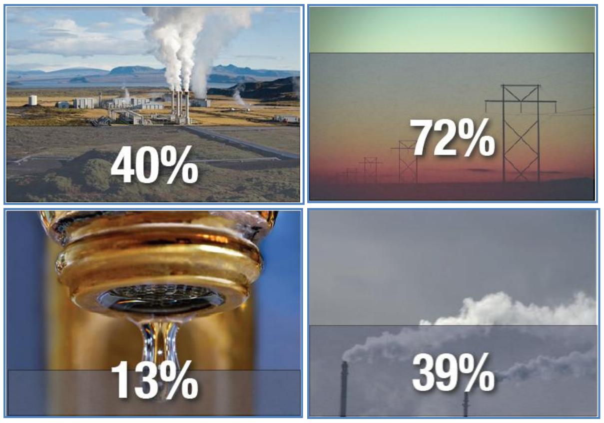
The Project

Our team worked with the ADCO Group, a real-estate developer, on the sustainable design, construction and operation of a proposed luxury condominium tower in San Francisco.

Once built, the 36-story tower will be a hallmark building in the San Francisco skyline

The Built Environment

Buildings in the U.S. account for 40% of primary energy use, 72% of electricity use, 13% of potable water consumption, and 39% of our domestic carbon dioxide emissions.



To address the impacts of the built environment, our goals for this project were to increase the energy and water performance of the building and to justify an integrated building design. These goals will help our client with their objective of achieving LEED Gold certification or better.

Our project responds to three significant drivers:

- Provide financially feasible recommendations that fit within the client’s budget.
- Ensure that our recommendations sustain the transfer of ownership from ADCO to individual condo owners.
- Assure the long-term performance of our recommendations.

Methods

We identified a hierarchy to approach our analyses, prioritized in this order:

1) Load Reduction: reducing the building's demand for energy and water.
2) Efficiency measures: installing more efficient appliances and equipment.
3) Renewables: using alternative sources of energy.

What is Integrated Building Design?

A process that establishes collaboration at the earliest stages of a building's life, beginning with a multidisciplinary meeting known as a charrette. Key stakeholders including the developer, architects, engineers, LEED consultants, contractors, the commissioning agent, and facility managers meet together to establish budget, feasibility, and environmental goals. Communication throughout the design and construction phases helps result in optimal building performance.

Energy Modeling

Energy modeling is the process of simulating how energy will flow through a building, whether that process is via electrical energy or the transfer of heat energy. We calculated energy flows as follows:

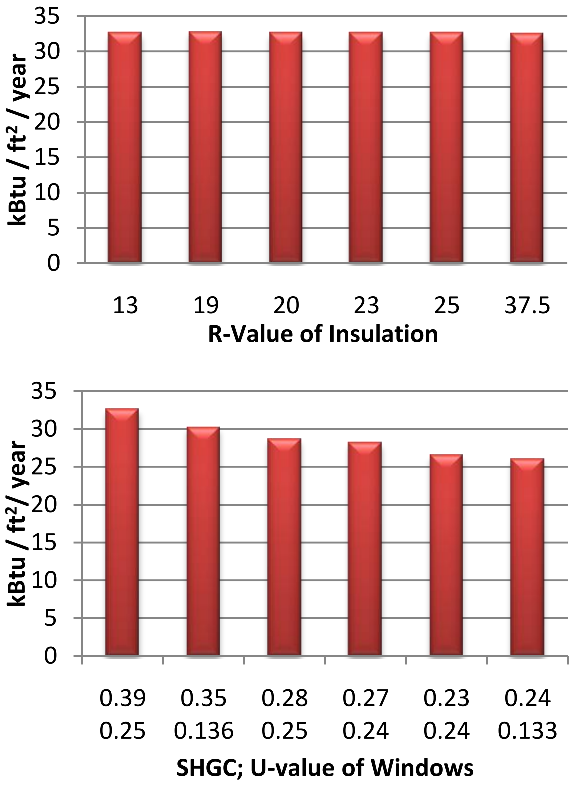
1) Using hourly solar radiation for the site and a slope factor algorithm, we modeled the quantity of solar energy that would strike each face of the proposed building throughout the year. This critical calculation allows optimization of the building envelope for passive design.

Passive Design Principles

- Latitude of the building site
- Orientation to the sun
- Window placement and design
- Use of properly-sized overhangs
- Insulation

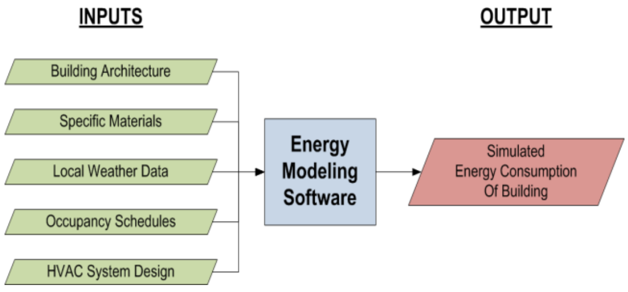
2) To model the more complex interactions that occur once the solar energy reaches the interior of the building, we used the eQUEST software package to predict the energy consumption of the building in response to changes in the envelope design.

Heating and Cooling Energy Consumption



Our models show that increasing exterior-wall insulation beyond R-13 in a building with an 80% glass façade has an insignificant effect on reducing heating and cooling loads in San Francisco's mild climate. For windows, our models show that low solar heat gain is the most important factor in reducing annual energy consumption for the proposed building.

Building Energy Modeling Process



Energy Monitoring

Building monitoring and automation systems (BMAS) are important features of modern high-rise buildings. These systems monitor and control the central energy loads, such as common area lighting, elevators, and heating and cooling systems. However, traditional BMAS do not address the energy efficiency opportunities in individual units. We investigated the feasibility of expanding the BMAS to include submeters, load controllers and dashboards within each unit.

Effect of Monitoring on Human Behavior:

Providing tenants with real-time information about their energy and water usage has led to reductions of 10% to 20%.

-Hammerstrom et al. 2007, Wilson 2008

To analyze the costs and benefits of advanced building monitoring and automation systems (BMAS), we created six design scenarios, each with a different mix of submeters, loads controllers, and with or without an energy dashboard. Using price quotes from electrical contractors, we estimated the total cost of the six energy monitoring scenarios.

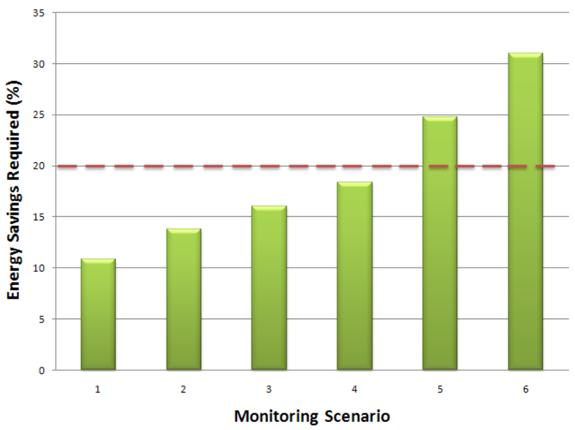
From this estimation of total upfront cost and estimated annual energy costs, we identified the 10-year energy savings that would justify this initial investment. Our analysis shows the energy savings required are easily achievable for several of the BMAS scenarios.

In analyzing case studies of monitoring systems and utility rate projections, we identified a number of important benefits to BMAS that integrates submeters, load controllers and dashboards. Our research shows that Scenario 3 (4 submeters, 3 load controllers, and a dashboard) offers the most potential benefits without significant added costs. The 16.1% energy savings required for a 10-year payback may be easily achievable given the advanced capabilities.

Credit: www.agilewaves.com

Monitorng Scenario	Total Costs ($)	Per Unit System
1	826,000	3 Submeters
2	1,049,000	4 Submeters, Dashboard
3	**1,221,000**	**4 Submeters, 3 Controllers, Dashboard**
4	1,395,000	6 Submeters, 3 Controllers, Dashboard
5	1,880,000	7 Submeters, 5 Controllers, Dashboard
6	2,355,000	9 Submeters, 7 Controllers, Dashboard

Energy Savings Required to Justify 10-Year Payback on Monitoring Scenarios



Case study research finds up to 20% energy savings

Water

To reduce the water load in the building, we calculated baseline water usage using the Federal standard for fixture efficiency. We then calculated the projected water savings from replacing conventional fixtures with more efficient alternatives. We found that by installing more water efficient fixtures and appliances standard within each of the units, we could drastically reduce the building's indoor water usage for a minimal upfront investment.

To determine future water use and savings, we factored an average annual increase in water rate of 11% and a

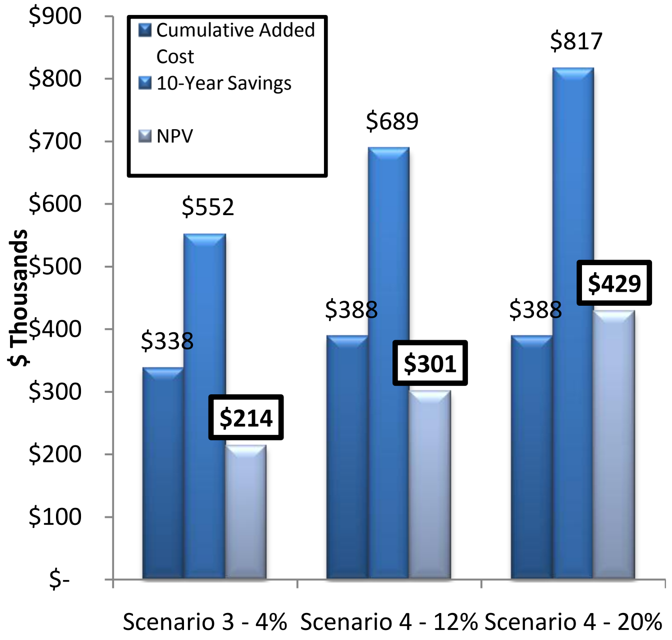
10-year projection into building operations. We modeled four possible scenarios:

Water Scenario	Total Costs ($)	Whole Building System
1	71,000	WaterSense efficient toilets, lavatory faucets, kitchen faucets, and showers
2	134,000	Scenario 1 and EnergyStar dishwashers and clothes washers
3	338,000	Scenario 2 and a Monitoring System without dashboards
4	389,000	Scenario 2 and a Monitoring System with dashboards in each unit

The 10-year values of investment are both positive and approximately equal for Scenarios 1 and 2; however, the addition of Energy Star appliances in Scenario 2 adds a degree of energy efficiency that justifies the added costs.

With the assumption that Scenario 2 will be implemented, we then examined the viability of adding monitoring systems into the units. Based on literature review that shows 4-20% of reduction in consumption from monitor feedback, we modeled a 4%, 12%, and 20% reduction in addition to efficiency gained from Scenario 2 appliances, given the assumption that Scenario 3 would achieve the lowest value due to its lack of dashboards, and Scenario 4 would yield greater reduction from having dashboard feedback.

Investments in Water Monitoring



Scenario 4 demonstrates the highest value of investment. Therefore, our recommendation is the inclusion of Scenario 2 appliances and a monitoring system with dashboards in each individual unit.

Conclusion

Our recommendations for increased energy and water efficiency, monitoring systems and the integrated building design process will help ADCO reduce the environmental impact of this building.

This project will be a useful learning tool for both our client and for other developers seeking to reduce the long-term environmental footprint of future building projects.

Acknowledgements

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