RESEARCH SUPPORT BUILDING AND INFRASTRUCTURE MODERNIZATION PROJECT

LIFE CYCLE COST ANALYSIS

DEPARTMENT OF ENERGY
SLAC SITE OFFICE

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Contents

List of Tables

Appendix

Revision History

Rev. No.	Date	Revision Description	Pages Modified
Rev. 0	12.2.08	Initial Issue	Not Applicable

List of Acronyms

BLCC	Building Life Cycle Cost
ES&H	Environment, Safety and Health
FIMS	Facilities Information Management System
HVAC	Heating, Ventilation, and Air Conditioning
LCC	Life Cycle Costs
LEED®	Leadership in Energy and Environmental Design
M	Million
NIST	National Institute of Standard and Technology
OMB	Office of Management and Budget
R&D	Research and Development
ROI	Return on Investment
RPV	Replacement Plant Value
RSB	Research Support Building
Sf	Square Feet
SLAC	SLAC National Accelerator Laboratory

1. Executive Summary

SLAC National Accelerator Laboratory (SLAC) has moved from a single program laboratory to a multi-program laboratory. This transition, combined with the condition and age of SLAC facilities, drives the need to consolidate core research functions and modernize key support buildings. The most pressing infrastructure gaps are the lack of appropriate space to consolidate accelerator scientists that are currently spread across the laboratory in outdated facilities, and the inefficiency of these multiple facilities that house several of the Laboratory's key support functions.

SLAC's goals for this Strategic Initiative are to:

- Provide researchers with safe, modern research spaces that are fully suitable for twenty-first century science.

- Provide general purpose research and institutional structures to allow the co-location of research groups with shared interests and mission objectives which are essential to productive and efficient modern research achievements.

- Co-locate researchers to enable interaction among researchers and graduate students who have complementary interests that will support all research programs.

- Locate the Research Support Building in a central location to strengthen ties and interactions between related areas of research and support functions.

As stated in the Mission Need document for the SLAC Research Support Building and Infrastructure Modernization Project (RSB), the following alternatives were proposed for further analysis during conceptual design.

A. *Maintaining the Status Quo (no action)* – Under this alternative, SLAC will continue to operate the current facilities.
B. *Improving Existing Structures* – Under this alternative, no new construction will be performed; instead, existing facilities will be remodeled to eliminate deferred maintenance and address compliance issues.
C. *Decommissioning and Demolishing Current Facilities and Building New Ones to Replace Them* – Under this alternative, all of the facilities currently housing these staff will be demolished and replaced with new construction.
D. *Replacing and Renovating* – This alternative will renovate existing facilities that are structurally and functionally sound, and will replace those that are not with new space.

E. *Performing This Work at Another Location* (i.e., another laboratory or a university)

Three alternatives (A, C, and, D) were selected for the Life Cycle Cost (LCC) analysis. For comparison purposes, Alternative A was carried forward in the quantitative LCC analysis even though this alternative did not address the identified capability gaps. Alternatives B and E were not analyzed due to the fact that neither alternative satisfied the fundamental gaps identified in the Mission Need Statement.

In Alternative B the research groups remain in the same widely separated structures as currently exist and in Alternative E these research groups relocate off site, which is even further away from their peers and the unique support networks that exist at SLAC. Therefore, as previous stated, these options were not carried forwarded.

The total present values resulting from this Life Cycle Cost analysis for the chosen three alternatives are listed below in Table 1.

Table 1: Life Cycle Cost Analysis

Alternative	Description	LCC	Benefits
A	Maintaining the Status Quo (no action)	$179,439k	No personnel moves.
C	Decommissioning and Demolishing Current Facilities and Building New Ones to Replace Them	$185,608k	Provides the new efficient space to combine work groups.
D	Replacing and Renovating	$161,774k	Will result in new modern energy efficient space for accelerator R&D and associated support functions. Most cost effective alternative.

2. Introduction

The purpose of a Life Cycle Cost (LCC) analysis is to evaluate the cost effectiveness of proposed alternatives as defined by Office of Management and Budget (OMB) Circular A-94. Software developed by the National Institute of Standards and Technology (NIST) to perform life-cycle cost analysis in compliance with OMB Circular A-94 was used as the basis for the creation of the analysis spreadsheet used in this report.

This analysis is consistent with Constant Dollars, Cost Effectiveness analysis requirements of OMB Circular A-94. Appendix C to OMB Circular 94, dated February 2006, provides nominal and real interest rates for use in life cycle cost analysis. General inflation was calculated using the formula ((1+Nominal Rate)/(1+real rat))-1

The resulting spreadsheet (Appendix A) is a one page document with input data and comparative analysis results to match the BLCC 5.3-06 Program, Building Life Cycle Costs, as developed by the NIST. The calculations were derived from the BLCC "Users Guide and Reference Manual", the NIST Handbook 135 "Life Cycle Costing Manual", and the Annual Supplement to NIST Handbook 135, the "Energy Price Indices and Discount factors for Life-Cycle Cost Analysis".

The project parameters used in the analysis are summarized below in Table 2. The study period selected was 50 years based on the expected longevity of the new buildings constructed to accomplish the project goals.

Table 2: Project Parameters

Item	Description
Discounting Convention	End of the Year
Dollar Analysis	Constant
Real Discount Rate	3.0%
Base Date	Oct 2008
Service Date	Oct 2014
Study Period	50 years

Electricity, natural gas, and fuel oil costs are based on actual values as reported in Facilities Information Management System (FIMS). Escalation rates are based on the BLCC5 software.

2.1. Data Categories

Evaluation of life cycle cost includes inputs for capital improvement costs, energy and utility costs, operation maintenance and productivity costs, demolition and decontamination and a brief comparative analysis. Specific inputs are defined in the discussions on each alternative that follow.

2.2. Alternative A - Maintaining the Status Quo

Maintaining the Status Quo, SLAC will continue to operate the current facilities.

The existing accelerator science and environmental safety & health (ES&H) staff are housed in 127,995 gross square feet of space distributed throughout the site. Of this square footage, 66,951 square feet consists of trailer/modular buildings in small to medium sized clusters located in five separate areas across the complex. Of the 66,951 square feet of trailers/modular building, 23,235 square feet of these are over 25 years old and 43,716 square feet average 10 years old. The remaining balance of 61,044 square feet of space includes three buildings of conventional construction, all averaging 40 years of age.

A. Capital Improvement Costs

Alternative A recognizes that the existing trailer/modular structures have a productive life span of 25 years to remain economically viable to maintain and in a condition suitable for occupancy by the science and support staff. Within the 50 year cycle of this analysis all of the trailer/modular structures should be replaced twice, but based on experience at this site they usually have a longer life. This analysis assumes they will all be replaced once during the 50 year cycle of this analysis.

A replacement estimate for these structures of $198 per square foot was used in this analysis and is based on current vendor quotes for demolition, procurement and installation of similar trailers which ar**e** Americans with Disabilities Act **(**ADA) compliant and meet current building codes (includes project overhead costs). Additional site upgrades are required to the five sites where these trailers are grouped, including ADA access, foundation upgrades, and utility connections. These costs are added to the estimate for structure replacement, bringing the present value total replacement cost of $341 per square foot for this group of trailer/modular buildings. Multiplying $341 per square foot by the 66,951 gross square feet results in the present value replacement cost of over $22.8M.

The remaining space, 61,044 square feet of conventional buildings, requires no capital expenditures for this alternative. Deferred maintenance for these facilities will need to be completed, as will routine infrastructure renewal activities over the facility life cycle. These costs are captured below as part of operations, maintenance, and productivity.

B. Energy and Utility Costs

The utilities costs were extracted for each identified building as reported in FIMS and summed to determine the reported annual totals. For this analysis, fiscal year 2008 actual utility costs for these buildings were used. This produced annual cost of $528k for electricity, $18k for natural gas, and $22k for water.

C. Operations, Maintenance and Productivity Costs

Operations, maintenance, and productivity costs were calculated as described below.

1. Maintenance data is the sum of the annual actual maintenance costs for these buildings as reported in FIMS for fiscal year 2008.

2. Custodial cost is determined by multiplying the fiscal year 2008 site average custodial contract cost of $1.18 per square foot by the 127,995 total square feet in this alternative equaling $151k.

3. Office & Lab Productivity Loss was determined to be ~5% of 275 staff with an average annual total compensation of $150,000 per person resulting in just over $2M of lost productivity for this alternative due to the inefficient and widely separated spaces they currently occupy. This estimated cost was based on productive gains (improving workflow, improving collaboration, reducing duplication and reduction of numerous trips currently occurring between buildings) of ~0.5 hours per staff member per day.

4. Deferred Maintenance is the actual value for these buildings as reported in FIMS as of October 2008.

5. Infrastructure renewal is a life cycle based estimate of the significant repairs required over the life of these buildings such as roof repairs, HVAC equipment replacements, etc., to maintain them in a condition suitable for occupancy with acceptable reliability. This data is based on an annual average value derived from the Infrastructure Renewal Plan submitted by the Facilities Maintenance group in October 2008. The

Infrastructure Renewal Plan is derived from physical inspections of the SLAC buildings by an external independent vendor, Pacific Partners Consulting Group, which yielded the reported $573k annual investment.

D. Demolition and Decommissioning Costs

This analysis includes the estimate for end of life demolition of all of the structures at the end of the 50 year analysis period to complete the life cycle analysis. It is based on a present value demolition estimate of $76 per square foot multiplied by the 127,995 gross square feet of this alternative equaling greater than $9.7M. The assumption is that the end of life demolition cost of $76 per square foot is an average cost for all demolition and is based on input from other national laboratories with similar demographics and cost indexes.

2.3. Alternative C – Decommissioning and Demolishing Current Facilities and Building New Ones to Replace Them

Under this alternative, all of the facilities currently housing accelerator science and ES&H support staff will be demolished and replaced with new construction.

The scope of alternative C is to improve the 127,995 square feet of existing space for the accelerator researchers and support staff by demolishing and replacing all of the existing space with newly constructed buildings. This alternative replaces 66,951 gross square feet of trailer/modular buildings with one new conventionally constructed building of a range of 53,000 to 58,000 gross square feet. The remaining 61,044 gross square feet is divided among three buildings of conventional construction which will be demolished and replaced in their present locations.

A. Capital Improvement Costs

Alternative C includes demolishing and replacing all of the trailer/modular structures with one new building in an range of 53,000 to 58,000 gross square feet (a reduction of 10,000 total square feet is estimated due to improved space utilization by combining multiple buildings into one) located in the footprint of one cluster of demolished trailers at an estimated cost of $46.9M. This new construction cost is based on contractor estimates received on recently bid projects, similar to this project, including design, contingency and project support. Demolishing these 19,669 square feet of trailers in the existing footprint of this new building is estimated at $900k. The demolition cost of $46 per square foot is based on removal of the existing trailers at the Laboratory within the past year.

The three conventional buildings with a combined square footage of 61,044 gross square feet would then be demolished at a cost of $4.6M (demolition cost of $76 per gross square foot is based on input from other national laboratories with similar demographics and cost indexes). Once these buildings were demolished, the same gross square feet would be replaced in the current locations at an estimated cost of $51.1M. New construction cost is based on contractor estimates received on recently bid projects, similar to this project, including design, contingency and project support.

B. Energy and Utility Costs

The newly constructed buildings would be built to meet sustainability standards and Leadership in Energy and Environmental Design (LEED®) standards resulting in a conservative energy savings of 30% from the existing usage. As a result, the actual energy costs as reported in FIMS for fiscal year 2008 were reduced 30% for this alternative.

C. Operation, Maintenance and Productivity Costs

Costs for operations, maintenance, and productivity were calculated as described below.

1. Maintenance costs were estimated at 2% of each facility's replacement plant value (RPV), which for this purpose was the total estimated construction cost for the new buildings. The assumption is that this calculation results in an annual maintenance estimate of $1.38M for alternative C.

2. Custodial cost is determined by multiplying the fiscal year 2008 site average custodial contract cost of $1.18 per square foot by the 127,995 total square feet in this alternative equaling $151k.

3. Office and laboratory productivity loss has been eliminated due to the upgraded space and configuration achieved by replacing the existing buildings with new.

4. Deferred maintenance is eliminated when the existing buildings are replaced with new. No additional costs need to be captured here.

5. Infrastructure renewal is based on the revised profile of new buildings and the elimination of the multiple trailer/modular structures. The Infrastructure Renewal Plan is derived from physical inspections of the SLAC buildings by an external independent vendor, Pacific Partners

Consulting Group, which yielded the reported $403k per year.

D. Demolition and Decommissioning Costs

This analysis includes the estimate for end of life demolition of all of the structures at the end of the 50 year analysis period to complete the life cycle analysis. It is based on a present value demolition estimate of $76 per square foot multiplied by the 127,995 gross square feet of this alternative equaling greater than $9.7M. The assumption is that the end of life demolition cost of $76 per square foot is an average cost for all demolition and is based on input from other national laboratories with similar demographics and cost indexes.

2.4. Alternative D – Replacing and Renovating

This alternative will renovate existing facilities that are structurally and functionally sound, and will replace those that are not with new space.

It was determined by previous structural and maintenance reviews that those buildings of conventional construction were economically viable to be renovated. It has not been feasible to renovate trailer/modular type buildings due to their significant deterioration and additionally they are small and located in widely separated areas preventing the resolution of the gaps identified in the Mission Need Statement.

The scope of this alternative is to demolish and replace 66,951 square feet of trailer/modular buildings with one new conventionally constructed building in a range of 53,000 to 58,000 gross square feet. The remaining 61,044 sq feet of space is currently divided among three buildings of conventional construction. This space will be renovated within the existing building envelopes to meet the goals of this initiate.

A. Capital Improvement Costs

Capital improvement costs for this alternative consist of demolition, replacement, and renovation as described above.

1. Replacing all of the trailer/modular structures with one new building in a range of 53,000 to 58,000 gross square feet located in the footprint of one cluster of demolished trailers at an estimated cost of $46.9M. This new construction cost is based on contractor estimates received on recently bid projects, similar to this project, including design, contingency and project support. Demolishing these 19,669 square feet of trailers in the footprint

of this new building is estimated at $900k. The demolition cost of $46 per square foot is based on removal of the existing trailers at the laboratory within the past year.

2. Renovate 61,044 square feet of existing buildings 003, 024, and 041 at an estimated cost of $39.3M. This renovation cost is based on contractor estimates received on recently bid projects, similar to this project, including design, contingency and project support.

B. Energy and Utility Costs

The newly constructed building and the renovations would be built to meet sustainability standards and LEED® standards appropriate to their construction resulting in a conservative energy savings of 30% from the existing usage. The actual energy costs as reported in FIMS were reduced 30% for this alternative. The assumption is that once the buildings are remodeled, the energy and utility costs are comparable to that of new construction.

C. Operation, Maintenance and Productivity Costs

Costs for operations, maintenance, and productivity were calculated as described below.

1. Maintenance costs were estimated at 2% of RPV, which for this purpose was the total estimated construction cost for the new buildings. The assumption is that once these buildings are remodeled, all maintenance costs will be comparable to that of new construction. This calculation results in a maintenance estimate of $1.16M for alternative D.

2. Custodial cost is determined by multiplying the fiscal year 2008 site average custodial contract cost of $1.18 per square foot by the 127,995 total square feet in this alternative equaling $151k.

3. Staff productivity loss has been eliminated due to the upgraded space and configuration achieved by replacing the existing buildings with new.

4. Deferred maintenance is eliminated when the existing buildings are replaced with new.

5. Infrastructure renewal is based on the revised profile of new buildings and the elimination of the multiple trailer/modular structures. The Infrastructure Renewal Plan is derived from physical inspections of the SLAC buildings by an external independent vendor, Pacific Partners

Consulting Group, which yielded the reported $403k per year. The assumption is that once the remodel of these buildings and their infrastructure is complete, the project has upgraded to new construction standard. This then aligns these remodeled buildings on the same renewal schedule as that of the new construction.

D. Demolition and Decommissioning Costs

This analysis includes the estimate for end of life demolition of all of the structures at the end of the 50 year analysis period to complete the life cycle analysis. It is based on a present value demolition estimate of $76 per square foot multiplied by the 127,995 gross square feet of this alternative equaling greater than $9.7M. The assumption is that the end of life demolition cost of $76 per square foot is an average cost for all demolition and is based on input from other national laboratories with similar demographics and cost indexes.

3. Summary of Results

The Life Cycle Cost analysis of the three alternatives is summarized in Table 3 below.

Table 3: Comparison of Three Alternatives ($k)

Cost Element	Alternative A	Alternative C	Alternative D
Capital Investment Costs	$22,830	$115,525	$97,300
Energy and Utility Costs	$14,615	$10,266	$10,266
Operations, Maintenance, Productivity Costs	$132,268	$50,090	$44,481
Demolition and Decommissioning Costs	$9,727	$9,727	$9,727
Total Present Value	$179,439	$185,608	$161,774

The Life Cycle Cost comparison of Alternative D to Alternative A in shown in Table 4 below. This analysis shows that the simple payback and Return on Investment (ROI) for Alternative D is the best value.

Table 4: Comparison of Alternative D to Alternative A

Alternative D compared to Alternative A	
Net Savings ($k)	$17,665
Equiv Annual Savings ($k)	$589
Simple Payback	5.5 years
ROI	18.1%

APPENDIX A

SLAC LIFE CYCLE COST ANALYSIS

Research Support Building and Infrastructure Modernization

11-Nov-08

Constant Dollars Analysis - Discount rate is REAL (exclusive of general inflation)

Analyst: B. Skaggs

General inflation and industry-specific inflation (e.g. construction) are NOT taken into account.

	OMB Circ. A-94	BASE CASE		ALTERNATIVE C		ALTERNATIVE D	
Location: SLAC, Menlo Park, CA.	App. C 01/07	ALTERNATIVE A - STATUS QUO		Decommission and demolish current facilites and build new ones		Replace trailer/modular facilities and renovate otherwise sound facilities	
PROJECT LIFE CYCLE ANALYSIS (YEARS)	**50**						
FEMP DISCOUNT RATE (30 YR)	**3.0%**						
		($K)		($K)		($K)	
A. Capital Improvement Costs		**One-Time**	**PV**	**One-Time**	**PV**	**One-Time**	**PV**
1 Replace Trailer and Modular buildings incl ADA upgrades at end of life		22,830	22,830				
2 New building to replace trailers				46,900	46,900	46,900	46,900
3 Demo Trailers				900	900	900	900
4 Rennovate bldg 003, 024 041						39,300	39,300
4 Demo buildings 003, 024, 041				4,600	4,600		
5 Replace buildings 003, 024, 041				51,125	51,125	.	.
6 PED and OPC				12,000	12,000	10,200	10,200
Total Initial Costs		22,830	22,830	115,525	115,525	97,300	97,300
B. Energy & Utility Costs	**Yr**	**Annual**	**PV**	**Annual**	**PV**	**Annual**	**PV**
1 Electricity	50	528	13,585	369	9,494	369	9,494
2 Natural Gas	50	18	463	12	309	12	309
Energy Subtotal	50	546	14,048	381	9,803	381	9,803
3 Water	50	22	566	18	463	18	463
Total Energy & Utility Cost		568	**14,615**	399	**10,266**	399	**10,266**
C. Operation, Maintenance & Productivity Cost Input Data	**Yr**	**Annual**	**PV**	**Annual**	**PV**	**Annual**	**PV**
1 Maintenance	50	925	23,800	1,386	35,661	1,168	30,052
2 Custodial	50	151	3,885	151	3,885	151	3,885
3 Office & Lab Productivity Loss	50	2,062	53,946	.	.		
4 Deferred Maintenance	50	1,395	35,893	.	.	.	.
5 Infrastrcture Renewal	50	573	14,743	403	10,543	403	10,543
6	50	.	.				
7	50	.	.	.	.	.	.
Total Annually-Recurring Costs by BLCC 5.3-07		5,106	132,268	1,940	50,090	1,722	44,481
D. Demolition & Decontamination	**Yr**	**One Time**	**PV**	**One Time**	**PV**	**One Time**	**PV**
1 Demolition & Decontamination at end of life	50	42,642	9,727	42,642	9,727	42,642	9,727
Total Demolition & Contamination		**42,642**	**9,727**	**42,642**	**9,727**	**42,642**	**9,727**
E. Comparative Analysis							
1 Total Present Value of Life Cycle Costs			**$179,439**		**$185,608**		**$161,774**
2 Net Savings from Alternative Compared to Base Case					**($6,169)**		**$17,665**
3 Equivalent Annual Savings					**($206)**		**$589**
4 Simple Payback							**5.5**
5 Return on Investment					.		**18.10%**
6 .							
7 .							.

PV - Present Value

Adapted from National Institute of Standards and Technology *Handbook 135* and
BLCC 5.3-07, Building Life Cycle Cost, April 2007, and is consistent with
- Federal Life Cycle Cost Methodology and Procedures, 1- CFR, Part 436, Subpart A
- Cost Effectiveness analysis requirements of *OMB Circular A-94* .

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