Working Draft

BUSINESS PLAN FOR DEEP ENERGY EFFICIENCY AT SCALE— INTERIOR LIGHTING RETROFITS IN ACADEMIC, ADMINISTRATION, RESIDENTIAL AND LABORATORY BUILDINGS

UNIVERSITY OF CALIFORNIA, RIVERSIDE

UC CARBON NEUTRALITY INITIATIVE

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BP.1 Preface

This is a business plan for deep energy efficiency lighting retrofits at scale in academic, administration, residential and laboratory buildings. The plan includes a value proposition and financing analysis, including metrics on the basis of *per million gross square feet* of buildings. Planning is based on representative space-types and reference projects within the UC system.

This planning methodology enables acceleration of retrofit efforts to scale by allowing consideration of a comprehensive portfolio of retrofits based on planning–level metrics, while planning for and financing detailed project design as a part of project implementation.

BP.2 Executive Summary

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• This plan can reduce greenhouse gas emissions (GHG) from interior lighting in University of California, Riverside academic, administration, residential and laboratory buildings by 65%.

• This plan is part of an overall portfolio of deep energy efficiency retrofits at scale that can reduce Scope 1 and 2 GHG emissions by one-third to one-half. Such a program is the foundation of an overall strategy to meet the goal of UC Carbon Neutrality Initiative goal of zero net GHG emissions from buildings and vehicle fleet by 2025.

• This plan can be implemented between now and 2025.

• The $2.0 million cost (net of incentives) of lighting energy efficiency retrofits (*per million gross square feet of buildings*) might be financed with UC bond-based loans, or derived from as little as $0.95 million of seed funding (*per million gsf of buildings*) with a strategy of spinning-up re-investment.

• Seed funding may be available from utility budget surplus, green donors, or other sources.

• Utility incentives are available to subsidize project costs. Implementing 2.1 million gsf in 2016-2017 will meet the threshold for expanding available incentives from $500,000 to $750,000 for 2017-2018.

• The avoided energy cost is $225,000 per year (*per million gsf of buildings*). This is fully available as budget surplus in 2025-2032, depending on financing strategy.

• Additional benefits include reduced maintenance costs, reduced hazardous waste, extended useful life of campus lighting systems, and improved lighting quality.

• Costs for in-house project development and project management staffing necessary to implement this retrofit program are included in cost estimates and financing strategies.

• In-house staffing of 0.3 FTE energy and project management professionals (*per million gsf of buildings*) between now and 2025 is commensurate with delivery of this lighting retrofit portfolio. This is in the context of a need for 1.2 FTE energy and project management professionals (*per million gsf of buildings*) for an overall deep energy efficiency retrofit portfolio.

BP.3 Context/Value Proposition

This business plan for deep lighting energy efficiency retrofits at scale is part of campus planning in conjunction with the UC Carbon Neutrality Initiative (CNI). This plan is part of an overall portfolio of energy efficiency retrofits that can reduce Scope 1 and 2 GHG emissions by one-third to one-half. Such a program of energy efficiency retrofits is the foundation of an overall strategy to meet the UC CNI goal of zero net GHG emissions from buildings and vehicle fleet by 2025.

The University of California, Riverside historically has opted for one-time payments from the electrical utility for the installation of Thermal Energy Storage in lieu of general energy efficiency rebates. In part, this has been a deterrent to wide-scale energy efficiency programs requiring capital expenditures. In UCR's recent three year electricity contract with Riverside Public Utility, incentives are now available in conjunctions with a standard time-of use electricity rate. Incentives are initially capped at $500,000 for 1 September 2016 through 31 August 2017. This will increase to $750,000 for 2017-2018 if 5 million kWh per year of efficiency reductions are achieved in 2106-2017.

Comprehensive interior lighting retrofits in this plan are estimated to avoid electricity use of 2.4 million kWh per year and greenhouse gas emissions by 782 metric tons of CO_2e per year (*per million gsf of building area*). These reductions are 65% of the interior lighting baseline.

Retrofits for 2.1 million gsf of floor area in 2016-2017 will capture 5 million kWh of avoided energy use, enabling more incentives for 2017-2018.

There will be significant long-term financial benefits to the campus. The avoided energy cost is $225,000 per year (*per million gsf of buildings*). Utility incentives are anticipated to cover $143,000 – $191,000 of the cost *(per million gsf of buildings). The balance of project costs can be financed with* 15-year UC bond-based loans. In this scenario at least $34,000 per year *(per million gsf)* of the avoided energy cost is available net of debt service.

Net project costs might also be derived from as little as $0.95 million - $1.1 million of seed funding (*per million gsf of buildings*) with a strategy of spinning-up re-investment.

Lighting system maintenance and operational costs are anticipated to decrease on balance. The remaining useful life of campus lighting systems will be extended. Finer control of heating ventilation and air-conditioning systems may be enabled by occupancy sensors used as part of networked lighting controls. Campus lighting quality will be improved.

Installing ballast-compatible plug-in LED lamps in existing fixtures in 162,000 gsf of buildings slated for demolition in 3-5 years will further reduce energy use by 241,000 kWh per year and GHG emissions by 79 MT CO2e per year. The $62,000 cost might be covered by the first year of revenues from the first 2.1 million gsf of comprehensive retrofits.

BP.4 Planning Assumptions and Metrics

This plan uses planning assumptions and metrics based on lighting retrofit projects implemented on other UC campuses.

Scope and Measures

Most linear fluorescent fixtures and compact fluorescent lamp-based downlight fixtures will be fully re-built with LED technology including elimination of existing ballasts and lamp holders and installation of new optics. Some other lighting fixture types will be fully re-built or replaced with LED technology.

In certain scenarios, fluorescent lamps will be replaced with new ballast-compatible plug-in LED-based lamps, leaving in place the existing fixture and ballast[1]. Ballast compatible plug-in LED lamps do not offer as much reduction in maximum power draw, offer as much control potential, or promise as much durability as do full fixture replacement or rebuild options. However first costs that are lower by an order of magnitude sometimes make them a compelling choice[2].

Most fixtures will get new networked lighting controls enabling the full tuning capabilities of LED lighting. Control granularity will average approximately 3 fixtures per zone. In some cases, local controls with less capability may be employed, lowering project costs and resulting in less avoided electricity use and GHG emissions.

Such comprehensive retrofits are typically affordable for circulation space (e.g., corridors) and 90% of general spaces (classrooms open, offices, and labs)—with existing incentives and financing mechanisms. Similar retrofits for private spaces (e.g., offices) are not as easily financeable at this time[3]. Similar upgrades to private spaces might be pursued over time with utility surplus created by other energy efficiency projects, by considering HVAC interactive effects and maintenance savings in financing, and/or by integrating projects with HVAC control.

The estimates in this plan cover 62% of the highest use interior lighting fixtures in academic, administration, residential, and laboratory buildings over 20,000 f^2. This represents 78% of campus buildings including all of the major residential halls, academic spaces and laboratories, except for the Greenhouses.

Space that will have major renovations between now and 2025—that will replace or substantially upgrade lighting systems—have been identified and designated for separate funding. Buildings

[1] For buildings with an expected life of 2-5 years. The LED lamps will produce fewer savings in GHG emissions and electricity use, but will be have a much shorter ROI, a quicker deployment and are easily salvageable at the end of the building's life.

[2] Retrofit options that rewire existing lamp holders are not commonly seen around the UC system. These options are not recommended because they create complex safety protocols.

[3] Networked fully tunable lighting controls are almost always appropriate in circulation and general space types. Several considerations make project design more situation dependent for private offices. Baseline energy use per fixture is low relative to other space types and task lighting approaches are highly applicable. Private office scenarios may be highly suitable for application of networked controls to heating, ventilation and air-conditioning control.

that will be demolished within two years of this plan being implemented should not be included in the DEEP Lighting retrofit. Spaces that will be demolished between 3-5 years after implementation should use the easy Installation approach of ballast-compatible plug-in lamp replacement.

Project Design

For planning purposes, assumptions about nominal project designs are described in Table BP-1. These project designs are based on actual UC projects—representing a most-likely design within a wide range of design approaches. **Detailed surveys and space-specific project designs should be completed as a part of the project development step of implementation.**

Table BP-1 Assumptions for Nominal Project Designs

	Space-type	LED full fixture output (1) (fixture lumens)	LED full fixture power (Watts)	Average top-trim high level
4 ft linear	Circulation (e.g., corridors	4,200	37	80%
4 ft linear	General (e.g., open office, classroom)	4,200	37	60%
4 ft linear	Laboratory	4,700	42	65%
4 ft linear	Private	4,200	37	60%
Downlight	Circulation	1,800	20	90%
Downlight	General	1,800	20	90%

Notes: 1) LED fixtures or full LED re-build kits with optics are rated in terms lumens leaving the fixture (fixture lumens). This is as opposed to fluorescent lamps rated in terms of lamp output within the lighting fixture.

Baseline Power

The assumptions for the nominal base case power of incumbent fixtures are:

- 59 Watts ballast input for a 2 lamp x 4 foot linear fluorescent fixture with electronic ballast and F32T8 lamps, and
- 38 Watts ballast input for a 2 lamp x 18 Watt CFL down light.

Several other base cases will be encountered for linear fluorescent fixtures, most with higher power draw. Improvements in efficiency for these fixtures will generally be higher than planning assumptions.

Baseline and Controlled Hours of Operation

For planning purposes, estimates of nominal baseline and controlled hours of operation are listed in Table BP-2 for a variety of space types, along with the range encountered in various UC reference projects.

Table BP-2 Assumptions for Baseline and Controlled Hours of Operation

Space-type	Baseline hours/year	Controlled— Fully Tunable Networked Controls equivalent high output hours/year
	planning assumption (reference range)	
Circulation (e.g., corridors)	8,423 (2,182-8,760)	1,752 (946-5,471)
General (including Laboratory)	5,598 (3,276-7,919)	2,400 (2,400-2,584)
Private	3,000 (992-4,554)	1,440 (555-3,188)

Space-type Distribution and Fixture Counts

The Building Type Distribution and nominal fixture counts *(densities per million gsf of buildings)* used for planning purposes are listed in Table BP-3. These planning assumptions are conservative because they are based on lamp counts and the assumption of two-lamp fixture equivalents. Other fixture types will be encountered, mostly 3- and 4 –lamp fixtures. This will tend to lower the actual retrofit fixture count and project costs.

Table BP-3 Assumptions for Space Distribution and Nominal Fixture Densities

per million gsf of buildings	Interior 2' x 4ft linear fluorescent 2-lamp equivalents			Interior 2x 18 W CFL downlight equivalents
	Buildings with Labs	Academic/Administration Buildings	Overall	
	70% floor area by building	30% floor area by building		
Corridors			2,250	330
General Non-Lab (1)	4600	2750	4,025	190
General Lab	0	3650	1,115	
Private	3750	4150	3,865	
Subtotal			11,255	520
Service			1,150	50
Total			12,405	570

Notes: 1) Total general fixture equivalent density (lamp count) is lower in laboratory buildings because lab buildings are on average newer with sharper lighting designs
2) Fixture density is based on surveys at UC Santa Barbara

Project Costs

Project cost assumptions are listed in Table BP-4. Cost assumptions are based on a synthesis of reference projects on UC campuses. A full LED re-build kit including optics for recess-mount fixtures (troffers) is the basis for planning assumptions. Other fixture types will tend to increase costs. This will be offset by conservatively high fixture count assumptions.

Table BP-4 Assumptions for Project Cost Per Lighting Fixture (3 fixtures per zone)

	Fixture Materials Cost (full LED re-build kit with optics for recess-mount fixture)	Fixture Installation Cost	Controls Materials Cost	Controls Labor Cost	Project Development and Management Cost (1)	Total Cost
4' linear	$122	$31	$70	$33	$36	$292
Large Downlight	$121	$28	$70	$33	$35	$287

Notes: 1) 14% project development and management cost

Project Performance

Project economic performance by fixture and space-type is summarized in Table BP-5— for UC Riverside's applicable electricity price of $0.0944 per kWh. The threshold for improving a debt-finance portfolio is an ROI greater than 11%—corresponding to the overall debt finance portfolio maximum debt service of 85%. Considering space-types individually, circulation spaces meet this threshold while other spaces typically do not. Bundling space-types, as in a typical project design, circulation and 90% of general space types together meet the threshold with incentives. At this time the lower return on investment from private spaces makes it more difficult to include these fixtures in a financeable retrofit portfolio.

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Table BP-5 Summary Project Performance By Fixture and Space-Type

	Space Type	Project Cost per Fixture (without incentives)	Annual Energy Savings Per Fixture	Annual Cost Savings Per Fixture (1)	ROI (with $0.06 per kWh/yr incentives)
4' linear	Circulation	$292	445	$42	15.9%
4' linear	General	$292	277	$26	9.5%
4' linear	General Lab	$292	265	$25	9.1%
4' linear	Private Offices	$292	145	$14	4.2%
Downlight	Circulation	$287	289	$27	10.1%
Downlight	General	$287	170	$16	5.8%

Notes: With electricity cost of $0.0.0944 per kWh

Ballast-Compatible Plug-in Lamps

Project Economic performance for ballast-compatible plug-in lamps is summarized in Table BP-6.

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	Space Type	Project Cost per Fixture (without incentives)	Annual Energy Savings Per Fixture	Annual Cost Savings Per Fixture (1)	Simple Payback Period (without incentives)
4' linear	Circulation	$32	194	$18	20 months
4' linear	General	$32	129	$12	31 months
4' linear	General Lab	$32	129	$12	31 months
4' linear	Private Offices	$32	69	$6.50	59 months
Downlight	Circulation	$24	147	$14	20 months
Downlight	General	$24	83	$7.80	37 months

Notes: (1) With electricity cost of $0.0.0944 per kWh
Easy Installation replacing lamps only; maximum simple payback of five years required.
For simplicity analyzed as two small downlights for each large downlight in the comprehensive retrofit scenario.

BP.5 Financing Scenarios

Two primary financing options for comprehensive fixture retrofits are debt financing with UC bond-funded loans (the Statewide Energy Partnership) and spin-up reinvestment (a form of "green revolving fund"), both utilizing the budget surplus created from the avoided energy cost resulting from the retrofits. Utility incentives are available and should be sought to subsidize part of the project costs.

Financing scenarios for comprehensive fixture retrofits are quantified in Table BP-6, including both debt and spin-up reinvestment options. Loans and spin-up reinvestment are considered separately in this analysis, but can be combined.

Debt Financing

UC bond-funded loans have been used to finance the majority of UC campus energy efficiency retrofits to-date. The planning parameters are 5% interest rate for 15-years with a maximum 85% debt-service ratio. Retrofit of major space types excluding private offices can be accomplished with available incentives of $0.06-0.08 per kWh per year and debt-financing below the 85% debt service ratio limit, reducing energy use and greenhouse gas emissions from major space types to 35% of baseline (65% reduction).

Assuming 2017 project implementation, the full avoided energy cost resulting from retrofits becomes available as budget surplus in 2032 for debt financing scenarios.

Spin-up Reinvestment

A spin-up reinvestment version of revolving funds is an alternative or complement to debt financing. These scenarios can be considered if debt capacity is an issue. Seed funding is required for these scenarios. After the use of seed funding at the outset to finance first project phases, subsequent phases are funded out of the energy budget surplus created by the initial phases. Spin-up reinvestment scenarios can also take advantage of incentives. Incentives increase the return on investment and increase the multiplier on the seed funding. As with debt financing, the incremental benefit of incentives can allow: expansion of scope to more buildings with a given amount of seed funding, expansion of scope to include private office space, or higher energy efficiency in project design.

Multipliers on seed funding of 1.9-2.1 are available, depending on the scenario. Seed funding of $0.95 million - $1.1 million *per million gsf* will result in overall investment of $2.1 million dollars (net of incentives) *per million gsf* over 8 years.

For planning purposes lower bound spin-up reinvestment scenarios conservatively assume

- an annual reinvestment cycle,
- a delay of one year in capturing avoided energy costs flowing initial investment.
- a reserve maintained on the energy budget surplus, in each year corresponding to 4% of the first year surplus.

Higher multipliers and lower seed funding amounts may be achievable with: a shorter re-investment cycle, quicker project delivery resulting in a shorter delay in capturing avoided energy costs, and/or a lower reserve on the energy budget surplus.

With spin-up re-investment, avoided energy costs are fully available as energy budget surplus immediately when re-investment ends in 2025—assuming phasing resulting in completion of retrofits in conjunction with the carbon neutrality goal.

Combination of Debt and Spin-up Reinvestment Financing

Debt funding scenarios in Table BP-6 assume none of the avoided energy cost net of debt service is re-invested in new projects. Re-investing the 15+% of avoided energy cost net of debt service creates a hybrid scenario that lowers the amount of debt required for a given portfolio scope, and delays the availability of these net proceeds as budget surplus until re-investment ends in 2025.

Economic Performance of Ballast-Compatible Plug-in Lamps

The economic performance of ballast compatible plug-in lamps is summarized in Table BP-8. For simplicity this is analyzed as two small downlights for every large downlight in the comprehensive fixture retrofit scenarios.

Table BP-7: Financing Scenarios

All quantities are *per million gsf* of Academic/Administration, Residential & Laboratory Buildings

Interior Lighting Retrofits

Complete Re-build to LED Including Optics

Networked Fully-Tunable Controls
(average 3 fixture per zone granularity)

Circulation Spaces and 90% of General Spaces
(not including private spaces (e.g., offices)
(not including service spaces)

Finance Scenario	Total Cost	Incentives (3)	Net Cost		Seed Funding Spin-up Reinvest Multiplier	Annual Residual Energy Use/ Cost Residual % of baseline	Annual Avoided Energy Use/ Cost Year fully available as budget surplus	Annual Residual GHG Residual % of baseline	Annual Avoided GHG	Debt Service Ratio (DSR) Annual Avoided Energy Cost Net of DSR
						Annual Interior Lighting Baseline 3.6 million kWh $344.000		Annual Interior Lighting Baseline 1,196 MT CO_2e		
	$ million				$ million	kWh	kWh	MT CO2e		
Bond-Based Loans	$2.14	($0.14)	$2.00		N/A	1.3 million $119,000 35%	2.4 million $225,000 2032	413 35%	782	85% $34,000
Spin-up Reinvest Normal or Fast	$2.14	($0.14)	$2.00	Norm	$1.1 1.9	1.3 million $119,000 35%	2.4 million $225,000 2025	413 35%	782	N/A
				Fast	$0.95 2.1	1.3 million $119,000 35%	2.4 million $225,000 2025	413 35%	782	N/A

Notes:
1 Scope is all major space types except private spaces (e.g., offices)
3 Incentives are lowest incentive offered by RPU for lighting retrofit of $0.06 per kWh/year

Table BP-8: Ballast-Compatible Plug-in Scenario for Buildings to be Demolished in 3-5 Years

162,000 *gsf* of Academic/Administration, Residential & Laboratory Buildings to be demolished in 3-5 years Ballast-compatible Plug-in LED lamps Major Space Types (Circulation, General. Private) (not including service spaces (2))						Annual Interior Lighting Baseline 0.59 million kWh $56.000		Annual Interior Lighting Baseline 194 MT CO_2e		
Finance Scenario (3)	Total Cost	Incentives (3)	Net Cost		Seed Funding Spin-up Reinvest Multiplier	Annual Residual Energy Use/ Cost Residual % of baseline	Annual Avoided Energy Use/ Cost Year fully available as budget surplus	Annual Residual GHG Residual % of baseline	Annual Avoided GHG	Debt Service Ratio (DSR) (3) Annual Avoided Energy Cost Net of DSR
	$ million				$ million	kWh	kWh	MT CO2e		
	$0.062		$0.062		N/A	0.35 million $33,000 59%	2.4 million $23,000	115 59%	79	

Notes:

1 Scope is all major space types including private spaces (e.g., offices)
2 Service spaces can be added by increasing values by 10%—if assumptions are similar
3 Loan financing and incentives are not assumed to be available for ballast compatible plug-ins

BP.6 Implementation Plan

BP.6.1 Staffing

Plan to establish energy retrofit project delivery staffing levels commensurate with all anticipated retrofit project activity including but not limited to interior lighting:

- Necessary staffing is estimated to be 0.3 FTE per million gsf of buildings for interior lighting (within a range of 0.2 to 0.4). UCR could allocate 1.5 FTE from new Energy Management staff to develop and implement easy installation ballast compatible plug-in projects, as well as oversee pilot projects for selecting comprehensive LED lighting retrofit project designs.
- This is in the context of an overall retrofit portfolio for all end-uses requiring 1.2 FTE per million gsf of buildings (within a range of 0.8 to 1.6).

Variability within the range can depend on the amount of survey work that is done in house and the amount of documentation required (e.g., for incentives). The effort required includes project development that typically draws from energy management staff, as well as project management that may also draw from other campus staff (e.g., capital projects).

Staff needs for project development and part of project management overlap with general energy management staffing. General energy management staffing needs are thought to be 0.6 to 1.0 FTE per million gsf. The fraction of this dedicated to retrofit portfolio delivery depends on the fraction of the comprehensive campus retrofit portfolio that has already been implemented and the fraction of portfolio delivery staff that is drawn from other campus departments.

The cost of this staffing is included in overall project cost estimates and financeable. If there is not currently a significant level of retrofit project activity, some seed funding may be necessary to initiate scaling-up of staffing. Start-up cost is minimized by the deferring of detailed project development to later stages of project development, using the planning-level metrics in this plan to secure initial allocations of funding.

These staffing estimates are based on:

- surveys of energy management staff at higher education universities including UC,
- 7-16% of overall project costs needed for project development and management (8-20% adder to materials and installation costs), and
- an eight-year timeframe to implement the portfolio in conjunction with the 2025 carbon neutrality goal.

Overall UC campus experience is that in-house staffing is the best way to deliver an energy efficiency retrofit portfolio. Installation and survey work may be successfully outsourced. However, efforts to outsource project development decisions or project management have met with limited success. UCR intends to use a Best Value RFQ/RFP process for identifying design and installation team.

BP.6.2 Implementation Steps

- Select a scope/financing scenario
    - Building list (e.g., not slated for major renovation or demolition) See Appendix A
    - Commitment to plan

- Develop first phase project(s) based on the metrics in this plan
    - Assess current availability of incentives and value for enhanced incentives
    - Pursue/allocate loans, green revolving funding, spin-up reinvestment seed funding and RPU lighting incentives

- Develop detailed project documentation
    - Surveys
    - Pilot project design
    - Detailed project design
    - Bid packages
    - Measurement and verification plans

- Implement projects including procurement and project management

- Implement measurement and verification including:
    - Analysis for debt service and /or spin-up reinvestment accounting
    - Documentation for incentives
    - Improvement of project design for subsequent phases

- Integrate upgraded lighting controls into operations
    - Shift maintenance resources from re-lamping to operations management
    - Integrate surplus into financial planning

- Develop and implement subsequent project phases

BP.6.3 Phasing Considerations

If the project portfolio is debt financed, phasing can be optimized to consider:

- integration into whole-building retrofit projects covering multiple end-uses
- capturing GHG reduction and cost reductions net of debt service as early as possible

If the project portfolio is fully or partly spin-up reinvestment financed, phasing needs to consider:

- timing of availability of energy budget surplus for project funding
- possible scheduling of higher return-on-investment spaces or buildings early to maximize the multiplier on seed funding

Easy Installation ballast compatible plug-in projects and parking lot lighting retrofits can begin as soon as this plan is approved. This phase will have limited impact on the pilot phases or the implementation of comprehensive fixture retrofit projects, but will take dedicated time from campus staff.

BP.6.4 Procurement Considerations

Installation

Economies of scale, continuity, and competition are achievable to control installation costs.
Phased installation:

- Pilot phase with three qualified proposers
- Easy Installation ballast-compatible plug-in projects
- Phase 2 installation in conjunction with solar carport LED lighting installation
- Phase 3 installation timed with level of kWh savings needed to maximize RPU incentives

Materials

Much of the available economies of scale for materials are already captured from typical building-scale projects, or from installation vendor aggregation of purchases. Still, planning may be able to reduce costs by aggregating materials purchases within other phasing constraints.

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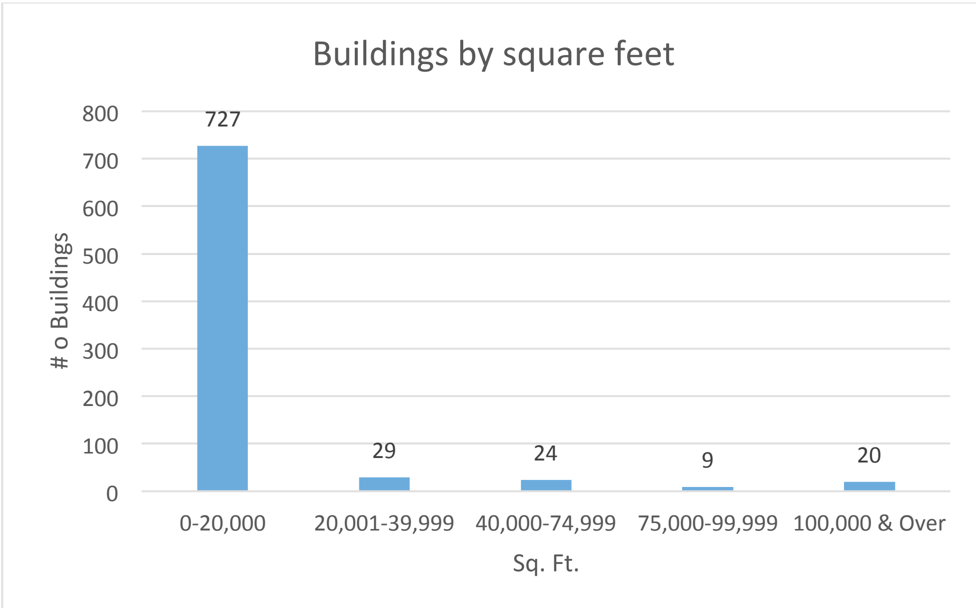
Appendix A—Supporting Data



Likelihood of Major Renovation

Building	GSF	Expected date of renovation
Pierce Hall	141,355	2018
Batchelor Hall	106,259	2018
Bookstore	32,139	2016

Likelihood of demolition

Building	GSF	Expected date of demolition
Fawcett Lab	21,001	2018
Highlander Hall	51,781	2016

A large number of buildings under 1,000 f² are scheduled for demolition in 2017. These were not included given they fell outside of the parameters of qualification for DEEP.