# The Business Case for Energy-Efficient Affordable Housing

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## ABSTRACT

This paper describes unique features of the affordable housing market that encourage implementation of energy efficiency measures: 1) the allocation of low-interest financing based on criteria that include rewards for sustainable building materials, and 2) caps for income-qualified tenants on the total amount of monthly rent and utility allowance that enable property owners and tenants to share the benefits of energy efficiency. The paper also demonstrates how these features work though a case study of an affordable housing renovation/rehabilitation project. The findings of an energy analysis by Primen indicate that savings of 30-40% of the total energy bill are achievable with energy efficiency upgrades in the project. These savings enable the developer to request an adjustment to the Utility Allowances to reflect those savings, which, in turn, enable him to financially justify the project to its investors and lenders.

## Introduction

The affordable housing market represents a substantial opportunity for energy conservation. The construction or rehabilitation of a large number of apartment units in an affordable multifamily housing project presents a singular opportunity to install energy efficiency measures on a large scale that would be lost otherwise. Furthermore, the major role that public financing plays in affordable housing development provides mechanisms that explicitly encourage energy efficiency. In addition, regulations governing rents in affordable housing can serve to align the interests of both tenants and property owners in conserving energy.

In California, with a long history of promoting energy efficiency, recent events have spurred even greater interest in multifamily housing. Higher electricity and gas prices in 2000 and 2001 put a substantial burden on residential energy users, particularly low-income renters, and on multifamily property owners. These pressures even threatened the viability of some affordable housing developments. Furthermore, high prices and restricted energy supplies caused the state to rely heavily on conservation to mitigate the worst effects of the energy crisis. While these conditions have subsided in late 2001, the commitment to energy efficiency in California remains strong.

This paper will describe some features of the affordable housing market that encourage implementation of energy efficiency measures. The paper will also demonstrate how they work though a case study of an affordable housing renovation/rehabilitation project. Klein Financial Corporation served as the development and financial consultant to the developer of this project.

Klein Financial Corporation was founded to meet a need in the real estate financing sector for innovative solutions to the lack of affordable housing financing. It provides consulting to both large-scale developers and to public entities. It has structured approximately $2.5 billion in bond financing for private developers and governmental agencies. Its real estate development affiliate, Klein Financial Resources, has developed approximately 388,000 square feet of retail and office space and approximately 3,000 housing units.

Primen, a retail energy market information provider, has served as a consultant to Klein on a number of these projects, providing energy use analysis and recommending energy efficiency upgrades.

## How Energy Efficiency Affects Affordable Housing Project Development

Two features of the affordable housing market have a direct effect on incentives to developers for energy efficiency. First, much of the financing of affordable housing comes from public sources. Second, rents for the affordable units are regulated. These features are established by federal regulations but are implemented by individual states, with each state using somewhat different procedures. The discussion in this paper focuses on the procedures used in California.

Public financing for affordable housing typically takes two forms: low-interest bonds and tax credits. Under federal law, states may issue bonds whose interest is free from federal and state income taxation, and tax credits for affordable housing are also available under federal and state law. Each year, a limited amount of bonds and tax credits may be issued to finance certain private activities, among them development of affordable housing, both new construction and rehabilitation. In California, the California Debt Limit Allocation Committee (CDLAC) has the authority to allocate the state's bond allotment to these projects, and the California Tax Credit Allocation Committee (TCAC) administers the tax credits. Twice or three times a year, CDLAC takes applications, evaluates them according to its criteria, and makes its allocations. (Although not a focus of the project described in this paper, TCAC utilizes similar procedures.) In order to encourage energy efficiency in affordable housing, the CDLAC evaluation criteria now award five points for "sustainable building methods" to projects with energy efficiency at least 15% above California's Title 24 energy standards and up to two additional points to projects that utilize specific energy efficiency or environmental measures (e.g. Energy Star® appliances, occupancy sensors, or non-use of VOC paint). These additional points can represent a significant advantage in a ranking system in which winners and losers can be separated by as little as 1/3 of a point.

The second feature that can encourage energy efficiency is the rent regulation mechanism for the affordable units developed with government subsidies or financing. The monthly rent for these units is capped at an amount set for each county by its Housing Authority based on a percentage of the area median income reduced by an allowance for utilities (assuming the tenant pays them directly and they are not included in the rent) and adjusted for household size. The utility allowance (electricity, gas, water/sewer, and trash) is determined by the Housing Authority using a formula based on utility rates, apartment size, and installed appliances. A typical utility allowance calculation is shown in Table 1. Utility allowances are revised annually to reflect changing utility costs. The incentive for energy efficiency for the property owner arises because, if the owner can reduce the utility allowance though energy conservation measures, the portion of the cap available to pay rent increases while the tenant's overall payment remains fixed at the cap.

**Table 1. Monthly Utility Allowances ($) for Riverside County (East), California**

| Utility or Service | 0-BR | 1-BR | 2-BR | 3-BR | 4-BR | 5-BR |
|---|---|---|---|---|---|---|
| **Electricity** | | | | | | |
| Cooking | 5 | 7 | 9 | 11 | 14 | 16 |
| Domestic Hot Water | 15 | 21 | 27 | 33 | 42 | 48 |
| Space Heating | 30 | 42 | 54 | 67 | 85 | 97 |
| Lighting and Refrigeration | 14 | 20 | 26 | 32 | 40 | 46 |
| Air Conditioning | 7 | 10 | 13 | 16 | 20 | 23 |
| **Gas** | | | | | | |
| Cooking | 1 | 2 | 2 | 3 | 4 | 4 |
| Domestic Hot Water | 3 | 5 | 6 | 8 | 10 | 11 |
| Space Heating | 8 | 11 | 15 | 18 | 23 | 26 |
| **Water** | | | | | | |
| Domestic Use | 10 | 14 | 18 | 22 | 28 | 32 |
| Evaporative Cooler | 8 | 11 | 14 | 17 | 21 | 25 |
| **Trash** | 18 | 18 | 18 | 18 | 18 | 18 |
| **Sewer** | 12 | 12 | 12 | 12 | 12 | 12 |

East County includes Banning, Beaumont, Palm Springs, Indio and surrounding communities all the way to the Arizona border.
This chart became effective August 7, 2000.
The current version of this chart is available at http://www.harivco.org/utilityAllowance.htm

## A Case Study

In 2001, Klein Financial Corporation retained Primen to evaluate the potential for reducing utility costs at an affordable housing renovation/ rehabilitation project for which it was applying for a CDLAC bond allocation. The complex, located in Riverside County, California, consists of 65 one-bedroom apartments and 47 two-bedroom units in eight 2-story wood frame and stucco buildings with slab foundations and flat built-up roofing. It was constructed in 1974. Klein's goal was to determine whether it could reduce utility costs by 30-40%, and thereby convince the Housing Authority of Riverside County to reduce the utility allowance by a like amount. Klein's financial assessment of the project indicated that if such a reduction were feasible and cost-effective, it would make the overall project financially feasible.

### Approach

The energy analysis for the Riverside County project consisted of the following general steps:

1. **Onsite audit.** Perform an onsite audit of the complex and of a sample of the apartments to gather information about building configuration and orientation, construction, existing equipment characteristics, and energy use.
2. **Determination of building characteristics**. Working with the developer, architect, building manager, and general contractor, compile information on building and apartment characteristics including appliances, windows, lighting, and HVAC.
3. **Utility research.** Determine the applicable utility tariffs, utility rebate programs, and Housing Authority utility allowances applicable to the project.
4. **Upgrade type and cost determination.** For each type of apartment in the complex, work with the developer to create a list of applicable energy and water conservation measures, and determine their costs and usage characteristics.
5. **Simulation.** Conduct a simulation study to determine the base energy and water use of each apartment type, the breakdown of that usage by end-use, and the energy and water savings achievable with the identified conservation upgrades. Primen uses EnergyShape, its proprietary energy-modeling software, which is a significantly enhanced version of the widely-accepted DOE-2.2 software, as well as other analytical tools and methods as necessary.
6. **Cost-effectiveness analysis.** Conduct an analysis of the cost effectiveness of each of the identified upgrade opportunities, based on the cost of the upgrades, their useful lives, the energy and/ or water cost savings, and the applicable cost of money. Prioritize the upgrade opportunities based on cost effectiveness of recommended measures.
7. **Report.** In addition to documenting the building characteristics, upgrade opportunities, base energy and water use, cost, and savings potential, and cost effectiveness of the upgrades, also prepare a justification for the proposed revisions of the utility allowances.

**Energy Efficiency Upgrades**

Various energy upgrades were analyzed. The upgrades selected were determined in consultation with the project developer based on budget and feasibility considerations as well as on findings from the on-site energy audit and review of the renovation plans. Equipment specifications were derived from the California Energy Commission's Database of Energy Efficient Appliances, supplemented by manufacturers' data, and where available, Energy Star® models were proposed to the developer. In the analysis of potential energy savings, each upgrade was considered individually, as well as all of them combined. A number of other measures not listed below, were discussed with the developer but were not pursued due to budget or physical constraints.

**Appliances.** Appliance upgrades consisted of refrigerators, ranges, and dishwashers, with specifications shown in Table 2.

**Table 2. Appliance Data**

| Appliance | Current | Proposed Upgrade | Expected Savings (kWh/yr.) |
|---|---|---|---|
| Refrigerator | 1200 kWh/yr | 653 kWh/yr | All Appliances 1040 |
| Ranges (including hood) | 5 kW | 4 kW | |
| Dishwasher | 1 kW | 0.62 kW | |

**Programmable thermostat.** A standard mechanical thermostat (with a cooling set-point of 73°F and a heating set-point of 72 °F) was replaced with a programmable thermostat. The programmable thermostat allowed for a cooling setback temperature of 80 °F and a heating setback temperature of 62°F while the building is unoccupied. It was assumed that the apartment will be unoccupied from 9:00 am to 4:00 pm during weekdays and will be fully occupied on weekends and holidays. Clearly, the actual behavior of the occupants may vary from this assumption. Expected energy savings are 1020 kWh/yr. for a one-bedroom unit and 1260 kWh/yr. for a two-bedroom unit.

**Compact fluorescent lighting.** Currently, “hardwired” incandescent lighting fixtures are installed in the bathroom, kitchen, dining room, exterior patio, and outside the entry door. In some cases, the fixtures vary between apartments. Upgrades were recommended as shown in Table 3:

**Table 3. Lighting Data**

| Location | Current | Proposed Upgrade | Expected Savings (kWh/yr.) |
|---|---|---|---|
| Bathroom | four-lamp fixture (40W/lamp) | two-lamp (CFL) fixture (13W/lamp) | All Lighting 1600 |
| Kitchen | one-lamp fixture (75W/lamp) | one-lamp CFL fixture (13*W/lamp) | |
| Dining Room | one-lamp ceiling fan fixture (75W/lamp) | one-lamp CFL ceiling fan fixture (13*W/lamp) | |
| Exterior Patio Outside Doorway | one-lamp fixture (75W/lamp) | one-lamp CFL fixture (13*W/lamp) | |

* A reviewer noted that perhaps a 20W replacement would have given more comparable illumination.

**Heat pump.** The planned replacement for the existing heat pump was a “Series-1” model. However, several other models were also considered, as they have a better efficiency. The units considered are shown in Tables 4 and 5:

**Table 4. Heat Pump Data for One Bedroom Unit (1.5 ton)**

| Current | Proposed Upgrade | Expected Savings (kWh/yr.) |
|---|---|---|
| SEER 7.4, HSPF 6 | Series-1 SEER 10.0, HSPF 7.0 | 1490 |
| | Series-2 SEER 11.0, HSPF 7.4 | 1880 |
| | Series-3 SEER 12.8, HSPF 7.5 | 2420 |

**Table 5. Heat Pump Data for Two Bedroom Unit (2.0 ton)**

| Current | Proposed Upgrade | Expected Savings (kWh/yr.) |
|---|---|---|
| SEER 7.4, HSPF 6 | Series-1<br>SEER 10.0, HSPF 7.0 | 1820 |
| | Series-2<br>SEER 10.0, HSPF 7.2 | 2290 |
| | Series-3<br>SEER 10.0, HSPF 7.5 | 2680 |

**Flow restrictors.** Flow restrictors can save energy as well as water, by reducing the flow rate of hot water uses such as showers, dish washing, etc. Flow restrictors (or new fixtures with flow restrictors/aerators) can be installed on fixtures that use hot water such as showerheads, bathroom faucets, and kitchen faucets. Savings estimates were based on a study conducted by the Lawrence Berkeley National Laboratory, which shows that based on these uses, a typical household can reduce hot water consumption from 12.3 gallons per day to 9.0 gallons per day. Estimated energy savings are 160 kWh/yr. in a one-bedroom unit and 310 kWh/yr. in a two-bedroom unit.

**Domestic hot water tank insulation.** The existing DHW tank did not have any exterior insulation. The upgraded model assumed that an R-11 insulation jacket was installed. Estimated energy savings are 190 kWh/yr.

**Energy Use and Cost Savings**

Tables 6 and 7 show the simulated energy use for the base (no upgrade) case and the upgrade cases, which include all of the cost-effective efficiency measures discussed above and one of the three heat pump upgrades (Series-1, -2, or -3). The end-uses are listed as they are represented in EnergyShape.

**Table 6. Energy Use ( kWh/yr.), One Bedroom Unit**

| End Use | Base-Case | All w/ Series-1 | All w/ Series-2 | All w/ Series-3 |
|---|---|---|---|---|
| Space Cool | 5430 | 2890 | 2630 | 2260 |
| Heat Reject. | 0 | 0 | 0 | 0 |
| Refrigeration | 1200 | 660 | 660 | 660 |
| Space Heat | 380 | 450 | 420 | 370 |
| HP Supp. | 30 | 20 | 20 | 20 |
| Hot Water | 950 | 700 | 700 | 700 |
| Vent. Fans | 1160 | 1160 | 1160 | 1160 |
| Pumps & Aux. | 20 | 30 | 30 | 30 |
| Ext. Usage | 590 | 130 | 130 | 130 |
| Misc. Equip. | 4470 | 4090 | 4090 | 4090 |
| Task Lights | 0 | 0 | 0 | 0 |
| Area Lights | 2390 | 1480 | 1480 | 1480 |
| **Total** | **16630** | **11620** | **11320** | **10900** |

**Table 7. Energy Use (kWh/yr.), Two Bedroom Unit**

| End Use | Base-Case | All w/ Series-1 | All w/ Series-2 | All w/ Series-3 |
|---|---|---|---|---|
| Space Cool | 6550 | 3510 | 3290 | 2930 |
| Heat Reject. | 0 | 0 | 0 | 0 |
| Refrigeration | 1200 | 660 | 660 | 660 |
| Space Heat | 610 | 660 | 670 | 570 |
| HP Supp. | 40 | 30 | 30 | 30 |
| Hot Water | 1550 | 1180 | 1180 | 1180 |
| Vent. Fans | 1550 | 1550 | 1550 | 1550 |
| Pumps & Aux. | 20 | 30 | 30 | 30 |
| Ext. Usage | 590 | 130 | 130 | 130 |
| Misc. Equip. | 4480 | 4100 | 4100 | 4100 |
| Task Lights | 0 | 0 | 0 | 0 |
| Area Lights | 2830 | 1810 | 1810 | 1810 |
| **Total** | **19430** | **13660** | **13450** | **12980** |

In order to map the end-use categories used in EnergyShape to those used in calculating the Utility Allowances, the following calculations were performed:

- Domestic Hot Water (DHW) equals hot water and pumps & auxiliary.
- Space heating equals space heating, HP supplemental, and a proportional allocation of ventilation fans.
- Air conditioning equals space cooling, heat rejection, and a proportional allocation of ventilation fans.
- Lighting and refrigeration equals refrigeration, ext. usage, task lighting and area lighting.
- Cooking equals miscellaneous equipment less an adjustment for non-cooking uses.

Tables 8 and 9 show the estimated monthly utility costs from the Utility Allowance calculation, the base case, and the three upgrade cases. Notice in particular, the discrepancy in the end-use splits between the Utility Allowance calculation and the base case, which will be discussed below.

**Table 8. Energy Cost (Average $/mo), One Bedroom Unit**

| End Use | Utility Allowance | Base-Case | All w/ Series-1 | All w/ Series-2 | All w/ Series-3 |
|---|---|---|---|---|---|
| Cooking | 7.00 | 9.43 | 8.11 | 8.13 | 8.16 |
| DHW | 21.00 | 7.62 | 5.81 | 5.82 | 5.83 |
| Space Heating | 42.00 | 3.86 | 5.08 | 4.88 | 4.53 |
| Light & Refrigerator | 20.00 | 32.85 | 18.22 | 18.26 | 18.33 |
| Air Conditioning | 10.00 | 51.16 | 31.22 | 29.16 | 26.23 |
| **Total** | 100.00 | 104.93 | 68.45 | 66.25 | 63.07 |
| % Change (UA) | | | 32% | 34% | 37% |
| % Change (Base) | | | 35% | 37% | 40% |

**Table 9. Energy Cost (Average $/mo): Two Bedroom Unit**

| End Use | Utility Allowance | Base-Case | All w/ Series-1 | All w/ Series-2 | All w/ Series-3 |
|---|---|---|---|---|---|
| Cooking | 9.00 | 9.41 | 8.06 | 8.07 | 8.09 |
| DHW | 27.00 | 12.26 | 9.55 | 9.56 | 9.57 |
| Space Heating | 54.00 | 6.17 | 7.51 | 7.73 | 6.88 |
| Light & Refrigerator | 26.00 | 36.08 | 20.64 | 20.67 | 20.72 |
| Air Conditioning | 13.00 | 62.16 | 38.16 | 36.31 | 33.59 |
| **Total** | 129.00 | 126.08 | 83.92 | 82.33 | 78.85 |
| % Change (UA) | | | 35% | 36% | 39% |
| % Change (Base) | | | 33% | 35% | 37% |

The final two rows in each table show the savings of each of the upgrade cases compared with the Utility Allowance (UA) and with the base case (Base), respectively. Notice that the upgrades can achieve Klein's target of 30-40% savings.

While overall energy cost is reasonably similar between the Housing Authority's calculation of the Utility Allowance and the base case, the split among end-uses differs significantly. (The simulated energy use was not adjusted to match the utility allowance, although it was adjusted to match billing data available for the complex.) These differences appear to result from the Housing Authority's use of US HUD factors to split the average monthly bill into end-uses. The HUD factors are national averages that do not account for local climate conditions, but rather, include data for regions of the US in which space heating accounts for a much more substantial part of energy use, and air conditioning much less, than they do in the hot, dry climate of eastern Riverside County, California.

**Water Use and Cost Savings**

Water consumption was determined by counting the number and type of fixtures and water-using appliances (faucets, showers, dishwashers, toilets, etc.), noting whether or not they were "low-flow", and making assumptions about each apartment's occupancy – two people living in the one-bedroom units and three people living in the two-bedroom units.

Typical residential water consumption data was compiled from various sources, including Environmental Protection Agency (EPA), Lawrence Berkeley Laboratory (LBL), various county and city governments and research organizations. Two main types of data were collected: by end-use (in gallons per capita per day), and by activity (e.g., gallons per flush, shower, etc). The data were organized to determine typical consumption with and without various water-saving devices, based on the number of occupants. In addition, technical data on the fixtures and water-using appliances was considered if available.

Using this data, water consumption was estimated for pre- and post-upgrades. Upgrades consisted of the following.

- Low-flow shower heads.
- Aerated faucets in the kitchen and bathroom.
- Water-saving dishwasher.

It was assumed that none of these fixtures and water-using appliances were low-use models before the upgrades, and all of them were low-use models after the upgrades. Water-saving toilets were also proposed to the developer.

Table 10 shows the results of the analysis for a one-bedroom unit with 2 occupants and two-bedroom unit with 3 occupants.

**Table 10. Water Savings (annual)**

| Unit | # Units | Gallons | Percent | Savings |
|---|---|---|---|---|
| 2 BR | 47 | 467,302 | 19% | $325 |
| 1 BR | 65 | 511,037 | 21% | $355 |
| All | 112 | 978,339 | | $680 |

### Cost Effectiveness of the Efficiency Upgrades

The cost-effectiveness analysis computed several indices for each of the efficiency measures, including the following:

- ratio of undiscounted lifetime savings to initial measure cost,
- simple payback period, the number of years required for undiscounted savings to equal initial measure cost,
- net present value (NPV) of initial measure cost and savings during its lifetime, and
- internal rate of return (IRR), the rate which makes the NPV exactly equal to zero.

Since the actual financial parameters of the project have not been disclosed, an illustrative rate of 12% was used in the NPV calculation, and no hurdle rate was set to determine what would be an acceptable IRR.

Tables 11 and 12 show the cost-effectiveness analysis of the recommended upgrades:

**Table 11. Cost Effectiveness (One Bedroom Unit)**

| Measure | Upgrade Cost ($) | Rebate ($) | Annual Savings (kWh/yr) | Annual Savings ($) | Upgrade Life (years) | Lifetime Save/Cost | Simple Payback | NPV @ 12% | IRR |
|---|---|---|---|---|---|---|---|---|---|
| Programmable Thermostat | 75 | 15 | 1020 | 93 | 20 | 30.9 | 0.6 | $632 | 154% |
| DHW Tank Insulation | 20 | | 200 | 18 | 20 | 18.2 | 1.1 | $116 | 91% |
| Compact Fluorescent Lighting | 320 | | 1600 | 145 | 10 | 4.5 | 2.2 | $501 | 44% |
| Series-1 to Series-3 HP | 215 | 0 | 930 | 84 | 20 | 7.9 | 2.5 | $415 | 39% |
| Series-1 to Series-2 HP | 108 | 0 | 390 | 35 | 20 | 6.6 | 3.0 | $157 | 33% |
| Flow Restrictors | 100 | | 160 | 19 | 15 | 2.9 | 5.1 | $33 | 18% |
| Appliances (Refrig, DW, Range) | 778 | 156 | 1050 | 95 | 20 | 3.1 | 6.5 | $90 | 14% |
| Series-1 Heat Pump | 2075 | 120 | 1490 | 135 | 20 | 1.4 | 14.4 | -$944 | 3% |
| | | | | | | | | | |
| All w/ Series-1 | 3368 | 291 | 5300 | 481 | 19 | 3.0 | 6.4 | $468 | 14% |
| All w/Series-1 to Series-2 | 108 | 0 | 300 | 27 | 19 | 4.8 | 3.9 | $93 | 25% |
| All w/Series-1 to Series-3 | 215 | 0 | 720 | 65 | 19 | 5.8 | 3.3 | $267 | 30% |

**Table 12. Cost Effectiveness (Two Bedroom Unit)**

| Measure | Upgrade Cost ($) | Rebate ($) | Annual Savings (kWh/yr) | Annual Savings ($) | Upgrade Life (years) | Lifetime Save/Cost | Simple Payback | NPV @ 12% | IRR |
|---|---|---|---|---|---|---|---|---|---|
| Programmable Thermostat | 75 | 15 | 1260 | 114 | 20 | 38.1 | 0.5 | $795 | 191% |
| DHW Tank Insulation | 20 | | 190 | 17 | 20 | 17.3 | 1.2 | $109 | 86% |
| Compact Fluorescent Lighting | 320 | | 1670 | 152 | 10 | 4.7 | 2.1 | $537 | 46% |
| Series-1 to Series-2 HP | 108 | 0 | 470 | 43 | 20 | 7.9 | 2.5 | $211 | 40% |
| Series-1 to Series-3 HP | 215 | 0 | 860 | 78 | 20 | 7.3 | 2.8 | $368 | 36% |
| Flow Restrictors | 100 | | 310 | 34 | 15 | 5.1 | 2.9 | $133 | 34% |
| Appliances (Refrig, DW, Range) | 778 | 156 | 1040 | 94 | 20 | 3.0 | 6.6 | $83 | 14% |
| Series-1 Heat Pump | 2075 | 120 | 1820 | 165 | 20 | 1.7 | 11.8 | -$720 | 6% |
| | | | | | | | | | |
| All w/ Series-1 | 3368 | 291 | 6230 | 566 | 19 | 3.5 | 5.4 | $1,091 | 18% |
| All w/Series-1 to Series-2 | 108 | 0 | 210 | 19 | 19 | 3.4 | 5.6 | $33 | 17% |
| All w/Series-1 to Series-3 | 215 | 0 | 680 | 62 | 19 | 5.5 | 3.5 | $240 | 28% |

In these tables, the specific measures are ranked in order of decreasing cost-effectiveness using internal rate of return. The Riverside County project receives electric service from the Imperial Irrigation District, and the rebates shown were those in effect at the time of this study in 2001. The final three rows in each table show the overall cost effectiveness of all the upgrades. Three cases are shown. The Series-1 heat pump is the planned replacement for the existing heat pump; its cost-effectiveness is calculated relative to the base case. The Series-2 and -3 heat pumps are considered as upgrades to the Series-1, so their cost-effectiveness is calculated relative to the Series-1. By itself, the Series-1 heat pump is not very cost effective; however, given that a Series-1 will be installed in the renovation, the Series-2 and -3 heat pumps are very cost-effective upgrades, both standing alone and when combined with the other upgrades.

## Conclusions

The findings of this analysis indicate that significant reductions in electricity use can be achieved using cost-effective energy efficiency measures. These reductions will enable tenants at the Riverside County project to significantly reduce their electricity bills. Those findings enable Klein Financial Corporation to request an adjustment to the Utility Allowances to reflect those savings, as follows:

- For a one-bedroom unit, a reduction from $100 per month to $63 per month
- For a two-bedroom unit, a reduction from $129 per month to $79 per month

Those reductions, in turn, enable Klein to financially justify this affordable housing rehabilitation project to its investors and lenders.

The analysis of the Riverside County project represented the first of a series of such analyses, for both new construction and rehabilitation projects, performed by Klein and Primen for developers of affordable housing. Although not all of them have shown such dramatic savings opportunities as the first, the value of energy efficiency is becoming apparent to developers. The unique financial circumstances of the affordable housing market represent an important argument supporting efficient building practices, although they alone may not be conclusive to many developers.

From a market transformation perspective, multifamily housing has always been a difficult market segment for energy efficiency due to "split incentives" between the property owner and the tenants. Generally, if the owner invests in efficiency upgrades, the tenants reap the benefits in the form of lower utility bills, but the owner doesn't share those savings because the market does not usually command higher rents for energy efficient apartments. However, in the affordable housing market, such features as rent caps with utility allowances and public financing through low-interest bonds and tax credits create mechanisms by which the property owners and tenants can share the benefits of energy efficiency. Thus affordable housing presents a striking opportunity to transform the private market, suitably structured, to adopt energy efficiency measures. The recent inclusion of sustainable building methods among the evaluation criteria by the California Debt Limit Allocation Committee recognizes the value of those market transformation opportunities. This action also highlights the importance of engaging government agencies and regulatory bodies outside of those traditionally concerned with energy.

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